2019

THE IMPACT OF QUALITY MANAGEMENT ON THE THERMAL PERFORMANCE OF SOCIAL HOUSING IN THE UNITED KINGDOM

JOÃO PAULO ULRICH DE ALENCASTRO

PHD

THE IMPACT OF QUALITY MANAGEMENT ON THE THERMAL PERFORMANCE OF SOCIAL HOUSING IN THE UNITED KINGDOM

ULRICH DE ALENCASTRO, JOÃO PAULO

Award date:
2019

Awarding institution:
University of Plymouth

UNIVERSITY OF PLYMOUTH

THE IMPACT OF QUALITY MANAGEMENT ON THE THERMAL PERFORMANCE OF SOCIAL HOUSING IN THE UNITED KINGDOM

by

JOÃO PAULO ULRICH DE ALENCASTRO

A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Art, Design and Architecture

March 2019

Copyright statement

UNIVERSITY OF PLYMOUTH

THE IMPACT OF QUALITY MANAGEMENT ON THE THERMAL PERFORMANCE OF SOCIAL HOUSING IN THE UNITED KINGDOM

by

JOÃO PAULO ULRICH DE ALENCASTRO

A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Art, Design and Architecture

March 2019

Acknowledgements

First of all, I would like to express my gratitude to my supervisors Dr Alba Fuertes and Professor Pieter de Wilde. Their advice, guidance and supervision from the very early stages of this research until the final lines of this thesis. Their patience, experience and knowledge have been invaluable to me.

I would also like to express my appreciation to all participants who agreed to take part is this study. I am grateful for their time, collaboration and openness.

I would like to acknowledge the financial support provided by the Brazilian National Council for Scientific and Technological Development (CNPq) under the Science without Borders research programme (Project reference: 203105/2014-1).

Personally, I would like to thank my parents for the love, care and for being a constant source of inspiration. I would also like to thank my friends from the University of Plymouth, in special Dr Rory Jones, Dr Adorkor Bruce-Konuah and Omar Al-Hafith for the help and support in so many ways. Special thanks to my long-time friend Dr Julio Cordioli, who also inspired me and incentivised me to submit my PhD proposal. His support was very important at that time.

Above all, I am thankful for the unconditional love and support from my wife Simone and my daughters Julia and Martina. They provided me with the strength that kept me going through this journey.

Author's declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

This study was financed with the aid of a studentship from the Brazilian National Council for Scientific and Technological Development (CNPq) under the Science without Borders research programme (Project reference: 203105/2014-1).

Publications and presentations at conferences:

1. Alencastro, J., Fuertes, A., & de Wilde, P. 2017. The relationship between quality defects and the thermal performance of buildings. *Renewable and Sustainable Energy Reviews* (http://dx.doi.org/10.1016/j.rser.2017.08.029).

2. Alencastro, J., Fuertes, A., & de Wilde, P. 2017. Delivering energy-efficient social housing: implications of the procurement process. *Engineering Procedia* (http://dx.doi.org/10.1016/j.proeng.2017.03.103).

3. Alencastro, J., Fuertes, A., Fox, A. & de Wilde, P. 2017. The impact of quality on energy performance of buildings: Quality management in social housing developments. Proceedings of the 9th International Conference on Applied Energy, Cardiff, United Kingdom. *Energy Procedia* (https://doi.org/10.1016/j.egypro.2019.01.784).

4. Alencastro, J., Fuertes, A., & de Wilde, P. 2016. Improving the quality management systems for energy-efficient social housing projects. Proceedings of the 32nd Association of Researchers in Construction Management (ARCOM) conference, Manchester, United Kingdom.

Word count of main body of thesis: 76,222

Signed:

Date: 10th of March of 2019

JOÃO PAULO ULRICH DE ALENCASTRO

THE IMPACT OF QUALITY MANAGEMENT ON THE THERMAL PERFORMANCE OF SOCIAL HOUSING IN THE UNITED KINGDOM

Abstract

In 2017, the domestic sector in the UK accounted for approximately 28% of final energy consumption, 63% of this energy was used for space heating. Therefore, to achieve the UK Government carbon emission targets it is pivotal to reduce the heating energy use in housing sector by upgrading the thermal performance of the existing housing stock and building new energy-efficient dwellings. In 2017, housing associations were responsible for providing 16% of the new dwellings in the UK housing sector to a part of British society encompassing 73% of the lowest household incomes (lowest and second lowest quintiles). Apart from the commitment of reducing carbon emissions by building thermal efficient homes, social housing associations also have the challenge of reducing fuel poverty amongst social renters. Therefore, due to the importance of Housing Associations to the UK housing sector in terms of reducing carbon emissions and fuel poverty, this thesis focuses on social housing projects.

Construction defects in the domestic sector, especially those occurring in the building fabric, are acknowledged to contribute to the energy performance gap of buildings. Discontinuity of insulation layers, gaps in the vapour/air barriers and thermal bridging through building elements lead to undesired heat loss, and thus to the increase of energy use for space heating. Unfortunately, there is strong body of evidence showing that despite the number of quality management procedures put in place in social housing projects, defects affecting the thermal performance of dwellings are still a major issue to be managed. Within this context, this research sets out to investigate how quality management plans related to thermal performance of dwellings are defined and implemented in social housing projects in the UK. Understanding how established quality management procedures are addressing quality defects affecting the thermal performance of social housing is the first step to enable the development of measures to improve the thermal performance of dwellings.

In order to investigate the process of development and implementation of Project Quality Plans in social housing projects in the UK, this thesis relied on five case studies located in the South and South West of the UK. However, the companies involved in the case studies

operate locally, regionally and nationally, providing a wide range of the applied quality management procedures to be investigated. The data collection and analysis were guided by a framework based on the existing literature on quality management. This framework was developed following the five key categories within quality management plans (i.e. definition of quality requirements, quality risk assessment, quality resources assessment, definition of quality metrics and control and quality compliance procedures), providing a method for the comparison between the case studies findings, as well as to the existing knowledge. It also allowed the identification of trends across the case studies in the development and implementation of Project Quality Plans with focus on the thermal performance of the dwellings.

In terms of the contribution to knowledge, this research provides a summary of the challenges encountered in relation to the development and implementation of Project Quality Plans with focus on the thermal performance of dwellings. The findings of this thesis assert that the lack of an objective definition of quality goals and especially compliance procedures at the first stages of Project Quality Plans promotes a domino effect that compromises the application of quality procedures focused on mitigating thermal related quality defects. The analysis of detailed evidence collected from the five social housing case studies suggests that in the majority of the projects the deployed quality management procedures focused on visual quality issues, allowing defects with the potential to impair the thermal performance of the dwellings to remain uncorrected. Despite a range of quality control procedures administered by the client, contractor and independent agents, they did not systematically prevent and appraise such defects neither during preconstruction phase, nor during the construction stage. In addition, actions focused on offsetting the identified challenges are proposed as means to mitigate the quality issues affecting the thermal performance in social housing projects.

List of contents

List of acronyms

AECOM	Architecture, Engineering, Consulting, Operations, and Maintenance (Company)
BPIE	Buildings Performance Institute Europe
BRE	Building Research Establishment
BREDEM	Building Research Establishment Domestic Energy Model
BREEAM	Building Research Establishment Environmental Assessment Method
BSI	British Standards Institution
BSRIA	Building Services Research & Information Association
CFSH	Code for Sustainable Homes
CO_2	Carbon dioxide
DBEIS	Department for Business, Energy and Industrial Strategy
DUKES	Digest of UK Energy Statistics
HA	Housing Association
HCA	Homes and Communities Agency
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
KPI	Key Performance Indicators
MHLG	Ministry of Housing and Local Government
NEF	National Energy Foundation
OGC	Office of Government Commerce
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PQP	Project Quality Plans

QMS	Quality Management System
SAP	Standard Assessment Procedure
UK	United Kingdom

List of tables

List of figures

Chapter 1

Introduction

1.1 Introduction

This chapter begins with an overview of the research (section 1.2). A presentation of the research context is then provided (section1.3). Furthermore, the research aims and objectives are presented (section 1.4), leading to the outline of the thesis structure (section1.5). Finally, the thesis scope is defined (section 1.6).

1.2 Thesis overview

This thesis documents research undertaken to improve knowledge and understanding of the process of developing and implementing Project Quality Plans with focus on achieving the correct thermal performance of dwellings in social housing projects in the UK. The Project Quality Plans refer to the process of managing the achievement of defined quality standards in construction projects. This process spans from early stages activities of a project, such as the strategic briefing, throughout the practical completion of the construction process. Moreover, the analysis of the development and implementation of quality programmes permeates the multiple categories within Project Quality Plans, such as the definition of quality requirements, quality risk assessment, quality resources assessment, definition of quality metrics and control, and quality compliance procedures.

According to recent studies developed by researchers such as NEF (2016), Palmer et al. (2016), Hansford (2015), Zero Carbon Hub (2014a), Bell et al. (2010), the occurrence of quality defects still poses a significant challenge to the effort of bridging the buildings' energy performance gap. Despite the many Project Quality Plans and Quality Policies proposed and implemented in the construction industry in the last decade, other issues are prioritized prior to energy performance (Zero Carbon Hub, 2014b).

Tofield (2012) and Auchterlounie (2009) state that the quality programmes currently in place in the UK construction industry are reactive to the clients' perception of quality and are designed to mainly focus on aesthetics defects which are likely to raise warranty claims. On the other hand, defects which can impair the ability of buildings to thermally perform as expected lie hidden alongside other more visible defects and are taken from granted as part of the construction process outcome (Tofield, 2012). According to many researchers (NEF, 2016, Zero Carbon Hub, 2014a, Hoonakker et al., 2010, Tofield, 2012), the conventional quality plans in place will not deliver the desired increase in quality needed in order to deliver energy efficient buildings.

This thesis asserts that to improve the efficiency of Project Quality Plans in mitigating the quality issues with the ability to undermine the thermal efficiency of buildings, it is vital to identify and understand the challenges and shortcomings of the quality programmes currently applied in social housing projects. Only then, new quality management approaches can be developed and implemented towards achieving thermal related quality objectives. Therefore, this research relied on data collection and analysis of a sample of five social housing projects in the UK, where information derived from multiple sources (i.e. interviews with key project stakeholders; documents, reports and technical information; defects data collected by means of surveys on-site; and observations during team management meetings and construction site visits). For the purpose of the analysis and comparison of data deriving from the multiple case studies a framework based on quality management theory and research was devised and implemented.

It is expected that the research reported in this thesis will contribute to the current body of knowledge by providing: (i) identification of the challenges and shortcomings faced in the development and implementation of Project Quality Plans and how these plans address the quality issues impacting in the thermal performance of dwellings in social housing projects in the UK; (ii) evidence based recommendations focused on the mitigation of thermal related quality issues which aims to support housing associations in the UK achieving their desired quality objectives related to energy performance. The research contributions also aim to provide recommendations to support policy and industry guidelines in order to improve the thermal performance in the UK social housing sector.

In addition, the academic research community working in the field of quality in construction, as well as energy performance in housing, will benefit from the results of this research. To those researching quality in construction, the findings of this research will provide them with evidence of the current challenges faced by social housing projects to deliver quality in their building projects, and the limitations of the current quality management programmes. To those investigating the energy performance gap, this research will provide them with additional evidence of the potential causes that support the performance gap associated with quality.

1.3 Research context

1.3.1 Climate change and UK policies for housing

Climate change is one of the greatest challenges in the world today, imposing global consequences for the environment (IPCC, 2014), the economy (Stern et al., 2006) and the human wellbeing and health (Antonella, 2017). The existing scientific evidence has revealed an upward trend towards the increase of global average temperatures over the past century, as a consequence of the emission of greenhouse gasses from human activities. The main greenhouse gas responsible for anthropogenic global warming is carbon dioxide (CO_2) (IPCC, 2014) and its primary source leading to the increase of CO_2 atmospheric concentration is the combustion of fossil fuel. For instance, the share of energy produced from fossil fuel in the UK in 2016 was 81.5% (DUKES, 2017).

Globally, buildings are acknowledged to play a large role in the current energy use worldwide, being responsible for 40% of primary energy consumption and thus for 40% of the total amount of greenhouse gas emissions (IEA, 2016). In 2017, the domestic sector in the UK accounted for approximately 28% of final energy consumption (DBEIS, 2018a), 63% of this energy was used for space heating (DBEIS, 2018b). Therefore, to achieve the carbon emission targets it is pivotal to reduce the heating energy use in the sector by upgrading the thermal performance of the existing housing stock and building new energy-efficient dwellings.

In this regard, in 2008 the UK government committed to a legally binding target of reducing by 80% the 1990 carbon emissions levels by 2050 (HM Government, 2008). This initiative was entailed by a number of mandatory and voluntary standards and codes for sustainable design and construction of buildings, aiming to increase the energy efficiency in the domestic sector. The Approved Document Part L1a – Conservation of fuel and power in new dwellings (HM Government, 2013), is part of UK Building Regulations and defines standards of energy use and carbon emission contributions, setting requirements of heat gains and losses in new dwellings. In recent years, Part L1a has been experiencing a number of updates, uplifting the required performance targets in order to improve the energy performance of new dwellings. The current version of this statutory regulation was released in 2013 and amendments were incorporated in 2016.

As a mandatory compliance procedure, Part L1a relies in the application of the Standard Assessment Procedure (SAP) (BRE, 2013). The SAP has been used as proof of compliance, mostly regarded to the design stage, as a simplified version of the Building Research Establishment Domestic Energy Model (BREDEM) (Anderson et al., 2001). This assessment methodology is based on energy balance. It takes into consideration the factors affecting the energy performance of dwellings, including building materials, thermal insulation, solar heat gains through openings, heating system efficiency and type of fuel used, heat loss mechanisms such as air permeability, and energy consumption. For the latter, SAP does not take into consideration the unregulated energy consumptions, such as the energy use for electrical appliances (Sodagar and Starkey, 2016). Ultimately, the application of SAP results in a rate expressed on a scale of 1 (highly inefficient) to 100 (highly efficient), based on the calculation of annual energy use and carbon emissions of the assessed dwelling against notional performance parameters (MHLG, 2018).

As per the construction stage the proof of compliance is provided by systematic site inspections of works in specific key stages of the construction process, in addition to air pressure tests at practical completion (HM Government, 2013). The process of compliance to Building Regulations through site inspections are currently undertaken by Building Control Bodies, who are independent approved inspectors appointed by the client or the contractor. Lately, this method of compliance has been criticised due to the lack of objectivity and transparency in the achievement of requirements and the intrinsic conflict of interests due to the commercial relationship between inspectors and hiring parties, such as the contractor (Hackitt, 2018). Moreover, criticism regarded to the insufficient availability of resources to fund such quality control activities have been established (Greenwood et al., 2017).

In addition to the mandatory Building Regulations compliance, voluntary standards and codes such as Passivhaus, BREEAM and Code for Sustainable Homes were created to address the increasing requirements for energy performance of dwellings. The uptake and application of such standards and codes has played an important role in raising awareness within the construction industry in regard to actions required to reduce the energy use in the domestic sector, and consequently the CO_2 emissions (Sodagar and Fieldson, 2008).

In the social housing sector, the Code for Sustainable Homes used to be largely adopted due to the fact that Local and Regional Authorities embraced the code as a policy embedded in their Planning strategic plans, especially when projects were publicly funded by government agencies such as Homes & Communities Agencies (HCA). Like many other sustainability assessment methodologies, the Code for Sustainable Homes provided a number of broad categories where credits were awarded according to the six levels of performance targets to be complied with. The last version of the code was issued in 2010, however in 2015 it was abolished by the UK Government and its underpinning rules are expected to be incorporated in the next update of the Building Regulations (Jones et al., 2017, Pretlove and Kade, 2016). The result of the Code for Sustainable Homes scrap was considered by researchers such as Greenwood et al. (2017) a setback to the effort of achieving higher energy performance in new dwellings in the UK housing sector, leaving the mandatory building regulations as the sole requirement in terms of energy performance compliance.

1.3.2 Social housing in the UK

The housing market in the UK has been under pressure in recent decades due to the country's rising population. For instance, in mid-2017 the UK population reached a new-high of 66 million people, presenting a continuous growth between 0.6 and 0.8% per year since 2005. It is projected that in 2029 the population will surpass 70 million (National Statistics, 2018).

According to the projection for housing demand from 2011 to 2031, 245,000 new dwellings per year are necessary to relieve the pent up demand in the English housing sector (Holmans, 2013). However, in the 2016/2017 financial year, 163,000 new housing units were made available to the English housing market (Ministry of Housing, 2018). One of the main reasons which led to the mismatch between demand and supply of housebuilding in UK is the fact that from 1970s onwards local councils decided to withdraw their participation in the production of new dwellings, thus increasing the pressure on private house builders and housing associations (Jefferys et al., 2014).

The social housing associations in the UK, also known as Registered Social Landlords, are independent non-profit organisations who rely partially on government funding and partly through private finance to fund the construction of new dwellings (McManus et al., 2010). The social housing associations play an important role in the housing sector in the UK, as well as being an essential part of the country's social security net, providing affordable letting to a substantial portion of the population.

In 2017, the social rented sector accounted for 17% (4 millions) of households (MHLG, 2018). In terms of the economic and demographic aspects, in 2017 the social housing sector presented the highest "inactive" (unemployed, long term illness or disability) rate (21%) amongst occupants of other housing sectors such as private rent and outright ownerships. In the same period, 73% of social renters were concentrated in the lowest and second lowest income quintiles, where 59% were in receipt of Housing Benefit (MHLG, 2018).

In addition to existing economic strains of the portion of the population relying on social rent, a phenomenon denominated fuel poverty affected in 2016 11% of the households (2.55 million) in England. A household is considered fuel poor when the required fuel costs are above the national average and if this amount is spent, the residual household income is left below the official poverty line. In a simplified fashion, Sameni et al. (2015) defines fuel poverty when “a household spends more than 10% of its total income in energy”.

In 2017, housing associations were responsible for providing 16% of the new dwellings in housing market, presenting a growth of over 25% since 2012 (Ministry of Housing, 2018). As a consequence of the accelerated increase of housing production, shortages on skills and workforce has been observed as a factor undermining the overall quality of residential projects (Gambin et al., 2012). In addition, the recent decrease of funding from UK government (Jefferys et al., 2014) and the requirement of housing associations to reduce social renting by 1% each year for the following four years since 2016 (HM Treasury, 2015) have contributed to mount up the pressure even further on the ability of housing associations to supply the sector with new homes at an ever stricter energy performance standards.

As a consequence of the strains posed towards housing associations regarding the growing demand of new housing units, increasing construction costs and the lack of appropriated resources, achieving the desired levels of quality has been a challenging task (McManus et al., 2010). According to the Home Builders Federation 2016/17 survey (Home Builders Federation, 2018), 99% of the occupants of new-build dwellings reported quality issues, where eleven or more defects per home were described by 41% house occupants.

As stated by researchers such as Hopkin et al. (2016) and National Energy Foundation’s report on energy performance in social housing projects (NEF, 2016), social housing providers are seeking ways to improve their quality management plans and to learn from recurring defects. However, they recognize themselves lacking a clear understanding of the best practices which would lead them to attaining the desired quality standards and thus achieving desired thermal performance targets (NEF, 2016).

In line with the objectives undertaken in the Climate Change Act 2008 (HM Government, 2008), in the recent years the UK social housing sector has engaged in a large scale effort to reduce carbon emissions, mitigate fuel poverty and increase the comfort level for their tenants (NEF, 2016). In fact, in 2016 the social housing sector presented higher average of SAP ratings (67), against the average of both private rented and owned occupied dwellings (61) (MHLG, 2018). However, recent studies on actual energy consumption indicate that the energy savings intended from the thermally efficient retrofits and new-built homes are falling short (NEF, 2016, Hansford, 2015, Bell et al., 2010). Unless consistent measures are undertaken in the social housing sector aiming to help social housing projects to achieve expected thermal performance levels, the reductions of energy demand and CO_2 emissions targeted by the Climate Change Act 2008 (HM Government, 2008) will not be met.

1.3.3 The thermal performance in construction projects and the role of quality management

Despite the amount of effort invested in this large scale endeavour in the housing sector to increase the energy efficiency in new-built homes, recent studies suggest that the energy savings envisioned by the tightened Building Regulations, energy performance standards and sustainability codes are not matching their original targets (Palmer et al., 2016, Johnston et al., 2015, Zero Carbon Hub, 2014a, Wingfield et al., 2011).

This mismatch between the energy performance as predicted at design stage and as measured once the building is in operation is known in the construction sector as the buildings' energy performance gap (Hansford, 2015, Zero Carbon Hub, 2014b). Researchers such as de Wilde (2014) and Carbon Trust (2011) group the reasons for the performance gap according to root causes originated in the design and construction processes, as well as in the operational phase of the building. In respect with the design stage the issues are related to the miscommunication among clients, design teams and builders regarding the expected results of the building performance as whole, as well as the lack of a broad understanding of the underlying technical aspects leading to the performance gap (Bell et al., 2010, Lowe et al., 2007, Bell et al., 2005). Another important aspect is the impossibility to fully predict the buildings' future use and the behaviour of its occupants, consequently leading to unrealistic input parameters into the still ongoing development of modelling softwares (de Wilde, 2014, Menezes et al., 2012). Furthermore, there are issues regarding the construction process such as site management, quality control and workmanship (Gorse et al., 2012, Atkinson, 2002). The buildings' constituent parts and elements can ultimately fail to meet the design specification and resulting performance due to workforce's lack of information, skills or motivation. In addition, the potential of changing orders by clients or value engineering can lead to unexpected decrease of the performance of buildings' components (Zero Carbon Hub, 2014b, Auchterlounie, 2009, Josephson and Hammarlund, 1999). In the operational stage, the occupants' behaviour is often cited as an important element contributing to the performance gap (Jones et al., 2017). There also may be issues with the buildings' energy management systems, which can be particularly complex and unfriendly to use, thus affecting the performance of the buildings' systems (Tofield, 2012).

Among a wide number of contributing factors to the energy performance gap (de Wilde, 2014), poor quality management and the occurrence of defects have also been acknowledged (Gorse et al., 2012, Tofield, 2012, Wingfield et al., 2011). It is broadly claimed that the origins of these root causes are related to the "traditional construction model" (Zero Carbon Hub, 2014b, Wingfield et al., 2011). As stated by Tofield (2012) *"The principal cause of the energy performance gap is the 'traditional construction model' where there is poor teamwork across the design and construction process, leading to hidden* *defects that compromise energy performance as well as, in many cases, to overly-complex buildings that are difficult to manage and often create uncomfortable and unproductive internal environments."*

Defects in buildings' fabric, most of them being hidden defects, lead to undesired air permeability and thermal bridging as well as the decrease of thermal resistance, and consequently leading to excessive heat loss (Johnston et al., 2015, Bell et al., 2005). According to Zero Carbon Hub (2014b), the construction industry has already many quality management programmes in place; however, they prioritise other issues above energy performance. For researchers like Tofield (2012) and Auchterlounie (2009) the focus of current Project Quality Plans in the construction industry is reactive to warranty claims raised by clients and occupants, mostly regarded to visible and aesthetics defects which have little impact in the energy use in buildings. As stated by Jraisat et al. (2016) and Karim et al. (2005), the key to the achievement of quality goals through the implementation of Project Quality Plans is the objective definition and communication of quality requirements and the identification of the risks associated to the process of obtaining the expected quality goals. In that sense, there is a need for an increased focus on thermal performance aspects when developing and implementing quality management programmes. It is pivotal to ensure the prevention and correction of defects undermining the achievement of the desired thermal performance quality objectives in construction projects.

1.4 Research aims and objectives

This research aims to improve knowledge and understanding of the process of developing and implementing Project Quality Plans with focus on the thermal performance in social housing projects in the UK.

It particularly focuses on identifying (1) the challenges faced by UK social housing providers to define and implement Project Quality Plans and (2) to propose recommendations regarding appropriate practices towards achieving the defined quality objectives related to building thermal efficiency.

To achieve the research aims, the project has the following objectives:

1. Identify and examine the challenges encountered in a sample of UK social housing projects in the implementation of quality management procedures which prevent their new-build projects to reach the expected thermal performance levels.

2. Examine the limitations of existing quality assurance frameworks, formal and informal quality programmes, applied to help organizations to deliver thermally-efficient housing according to performance specifications.

3. Provide the construction industry with recommendations aimed at improving the implementation of Project Quality Plans with focus on the thermal performance of social housing projects in the UK.
4. Provide recommendations to support policies and statutory regulations aimed at improving the thermal performance of social housing projects in the UK.

1.5 Thesis structure

This thesis has seven chapters. The chapters that follow this introduction are outlined below.

Chapter 2. Literature review

Provides a review of previous and current studies on the relationship between quality issues and the attained performance outcomes in construction projects. The review also explores the existing framework of quality management applied in construction projects, regarding the different stages of the development and implementation of Project Quality Plans.

Chapter 3. Research methodology

Outlines the methodology used in this thesis in order to achieve the main aim and objectives of this study. This includes the description of the applied research design and methods to collect, process and analyse data obtained in this study.

Chapter 4. Results: Challenges to the development and implementation of Project Quality Plans with focus on the thermal performance

Presents this thesis results in respect to the identification of the quality management procedures adopted in a sample of the social housing projects in the UK. The purpose of this chapter is to identify the challenges experienced in the case studies analysed in this study that undermine the development and implementation of their Project Quality Plans with focus on the thermal performance of dwellings.

Chapter 5. Validation

Assesses the validity and replicability of the research results, by confirming that the identified challenges are also acknowledged by other professionals outside the undertaken case studies as well as the academics in the field, and evaluate the likelihood of occurrence and impact of the challenges in the achievement of thermal-related quality objectives in social housing projects in the UK.

Chapter 6. Discussion

Discusses the actual research findings with respect to existing studies on quality management in construction projects, as well as the results emerging from the validation process. Additionally, it establishes recommendations to overcome the identified challenges, in respect the main project participants: the housing associations, contractors and building control bodies.

Chapter 7. Conclusions

Presents the summary of the key findings of this thesis and discusses the thesis' contribution to knowledge. The limitations of the current research are outlined and the recommendations for future research are highlighted.

1.6 Scope

Although the buildings' energy performance gap is known to be generated by a number of root causes such as the use of incorrect methods of modelling and simulation to predict energy use (de Wilde, 2014) or adequate prediction of building use and occupant behaviour (Menezes et al., 2012), this research focused on the aspects related to the effect of quality defects on unexpected heat loss of dwellings (Johnston et al., 2015, Bell et al., 2005). Moreover, this thesis focused on the Project Quality Plans applied in the design, pre-construction and the construction processes of social housing projects in order to prevent and remediate the occurrence of defects impacting on the thermal performance of dwellings' fabric. However, it was not part of the scope of this thesis to quantify the increment of energy use due to occurrence of defects, nor try to measure the heat loss resulting from the identified quality issues.

Although one of the data collection methods applied in this research relied on the identification of defect occurrences through surveys administered in the cases studies, the main aim was to identify different types of defects associated with thermal performance as means to support or challenge the findings obtained from other data collection methods. It was not part of the scope of this thesis to quantify the frequency or severity of defects occurrences related to the thermal performance of building fabric.

In terms of the building elements affected by defects that have the potential to undermine the thermal performance of buildings, this research explored solely elements and materials part of the building envelope which were constructed or assembled on-site. This research did not explore the quality management procedures of items manufactured offsite such as timber frame panels. Although it is acknowledged that the quality of these materials can impact on the overall thermal performance of the dwellings, the procedures put in place to assure the achievement of quality standards of off-site manufactured products were not managed by the case studies' stakeholders. Therefore, the quality management of offsite elements were out of the scope of this research, as they pertain to distinct unit of analysis not included in this thesis.

This research focused on investigating the domestic sector due to the fact that the residential building stock corresponds to 75% of the total building stock in Europe, for instance, where the impact of quality issues is more tangible and representative. The non-residential building stock comprises a more heterogeneous sector compared to residential sector and thus researches' key findings tend to be less replicable (Tofield, 2012, BPIE, 2011, Egan, 1998). Moreover, this study focused on studying social housing projects due to the fact that social housing providers have a keen interest in delivering energy-efficient housing due to their long term relationship with their tenants and a genuine effort to reduce fuel poverty (NEF, 2016). Pretlove and Kade (2016) state that "social housing providers, as landlords, are expected to provide a level of support to tenants" in terms of maintaining the housing units and dealing with occupants concerns. In addition, the social housing associations perceive the delivery of expected quality as a long term benefit, as means to reduce operational and maintenance costs. Therefore, the disclosure of sensible data related to the applied Project Quality Plans and resulting quality for research purposes was considered by housing associations' stakeholders as potential means to help improve the achievement of quality objectives in future projects.

Chapter 2

Management of quality in construction projects

2.1 Introduction

This chapter presents a literature review undertaken to examine existing research that has investigated the occurrence of quality defects affecting the thermal performance of buildings. According to previous studies, the investigation of this research topic can occur through the exploration of two main areas: (i) quality defects in construction projects and (ii) quality management procedures put in place in order to prevent and remediate the occurrence of quality issues.

The first part of this review focuses on the defects in the construction industry (section 2.2). It begins investigating the definition of quality defects in the construction environment used in previous research (section 2.2.1). It continues with a review of previous research focusing on studies' general features, such as the date of publication, the country where the study took place, stage of the project when data was collected, the data collection method and the sample size (section 2.2.2). Section 2.2.3 describes the major findings regarded to construction defect attributes; major causes and influencing factors; impact of defects on project's performance, including the impact on building's thermal behaviour. This section of the literature review is based on the research article written by the author of this thesis: Alencastro et al. (2018).

The second part of this review explores the main aspects of quality management in construction projects (section 2.3). It begins with a review of the challenges faced in the projects when developing and implementing quality management procedures (section 2.3.1). It continues focusing on the main aspects of Project Quality Plans and its categories, such as the definition of quality requirements; quality risk assessment; quality resources assessment; quality metrics and control; and quality compliance (Section 2.3.2).

Finally, the findings of the review are summarised (section 2.4). The review highlights the existing gaps in knowledge and establishes the need to better understand the underlying factors related to the occurrence of defects affecting the thermal performance of social housing projects in the UK.

2.2 Defects in the construction industry

Historically there has been a continuous and prolonged interest by building science and research in regard to construction quality issues due to their effects in how buildings suit their intended purposes (Josephson and Hammarlund, 1999, Sommerville, 2007, Egan, 1998). For instance, according to 2015 UK Construction KPI Annual Report (Davis et al., 2015) around 31% of the projects could not meet their original budgets and 60% had schedule overruns. There are many intertwined reasons which lead projects to unexpected outcomes and certainly quality issues play an important role in that matter.

The occurrences of defects can generate immediate negative impacts throughout the construction process and in the performance of buildings at their operational stages. Quality issues are deemed to increase production costs up to 23% of projects' contract value (Davis et al., 1989, Burati et al., 1992, Josephson and Hammarlund, 1999, Mills et al., 2009, Barber et al., 2000, Love and Edwards, 2004b) and can lead schedule overrun up to 20% (Love, 2002). Buildings' energy performances can also be affected by the occurrence of defects. For instance, according to research developed by (Carbon Trust, 2011) in 28 case studies in the UK, the operational use of energy was up to five times higher than estimated at the design stage mainly due to quality issues in the buildings' envelope. Another study developed by Zero Carbon Hub (Zero Carbon Hub, 2010) regarding thermal assessment of a UK located housing development indicates that in all the dwellings undertaken in the research the measured heat loss was higher than predicted. Besides, quality issues can cause important damage to the builder's reputation and decrease customers' satisfaction, when buildings fail to meet expectations (Pan and Thomas, 2015, Mills et al., 2009, Taylor et al., 2014, Georgiou et al., 1999).

Despite the subject of quality management in the construction industry has received considerable attention in the last two decades; there is a growing body of evidence that shows the existence of recurrent quality issues due to recurrent causes (Georgiou et al., 1999, Georgiou, 2010, Sommerville and McCosh, 2006, Bell et al., 2005, Auchterlounie, 2009, Lowe et al., 2007, Zero Carbon Hub, 2014a, Forcada et al., 2015).

2.2.1 Definition of quality defect in construction

In both academia and industry, different terms such as 'defect' (e.g. Forcada et al. (2014) and Macarulla et al. (2013)), 'snag' (e.g. Auchterlounie (2009) and Sommerville (2007)), 'fault' (e.g. Ilozor et al. (2004)) and 'failure' (e.g. Davis et al. (1989)) are used to describe imperfections on an element or an item that constitutes a building system. Although with a slight different meaning, the terms ‘quality deviation’ (e.g. Burati et al. (1992), Davis et al. (1989)) and ‘non-conformance’ (ISO, 2005) are also used.

Similarly, different definitions to describe the term defect exist. For example, Georgiou et al. (1999) defines defect as a “shortcoming or falling short in the performance of a building element” or “a situation where one or more elements do not perform its/their intended functions”. Watt (2007) refers to defect as “failing or shortcoming in the function, performance, statutory or user requirements of a building, and might manifest itself within the structure, fabric, services, or other facilities of the affected building”.

Unfortunately, the lack of differentiation of these terms and definitions, and the interchangeable use between studies, have led to inaccurate identification of defects, quantification of the associated costs and definition of the most appropriate mitigation strategies (Mills et al., 2009). For the purpose of this thesis, the term *defect* is defined based on Watt’s definition (Watt, 2007). However, it is worth mentioning that not all the studies included in this review defined the term defect in such an objective way.

2.2.2 Previous studies investigating quality defects in construction projects

This literature review aims to provide a comprehensive state of the art on quality defects in construction. It provides an analysis of the literature in terms of previous research’s findings related to the defects’ characteristics and attributes; the major causes and influencing factors; and the consequences of defects occurrences on the project and building performance.

Table 2-1 classifies the reviewed studies by the year when the study was published, the country where the study took place, the building type (domestic or non-domestic), stage of the project when the data was collected (construction, handover, or post-handover), the method used to collect the data (researcher, third party, contractor, or building occupant), and the sample size (both number of projects involved and buildings/dwellings studied).

The majority of previous studies (79%) focused on residential buildings. In Europe the studies explored domestic building projects located in Portugal (Silvestre and de Brito, 2011), Spain (Forcada et al., 2015, Forcada et al., 2014, Forcada et al., 2013a, Forcada et al., 2013b, Macarulla et al., 2013, Forcada et al., 2012), Sweden (Josephson et al., 2002, Josephson and Hammarlund, 1999), and UK (Hansford, 2015, Davis et al., 2015, Johnston et al., 2015, Pan and Thomas, 2015, Johnston et al., 2014, Taylor et al., 2014, Zero Carbon Hub, 2014a, Zero Carbon Hub, 2014b, Taylor et al., 2013a, Taylor et al., 2013b, Tofield, 2012, Carbon Trust, 2011, Wingfield et al., 2011, Bell et al., 2010, Zero Carbon Hub, 2010, Auchterlounie, 2009, Energy Saving Trust, 2009, Lowe et al., 2007, Sommerville, 2007, Watt, 2007, Sommerville and McCosh, 2006, Bell et al., 2005, Sommerville et al., 2004, Atkinson, 2002, Bordass et al., 2001, Harrison, 1993, Bresnen et al., 1990, Bonshor and Harrison, 1982). Internationally, the domestic building projects studied were located in Australia (Aljassmi et al., 2014, Georgiou, 2010, Mills et al., 2009, Ilozor et al., 2004, Love and Edwards, 2004b, Love, 2002, Love and Li, 2000, Georgiou et al., 1999), China (Palaneeswaran et al., 2007), Malaysia (Abdul-Rahman et al., 2014), Singapore (Hwang et al., 2014, Hwang et al., 2009, Chong and Low, 2006, Chong and Low, 2005), and United States (US) (Wanberg et al., 2013).

A smaller number of studies (37%) focused on non-domestic buildings. In Europe, the studies focused on commercial, educational, governmental and industrial buildings in Sweden (Josephson et al., 2002, Josephson and Hammarlund, 1999); and commercial, educational, governmental, health, industrial and infrastructure projects in the UK (Davis et al., 2015, AECOM, 2012, Tofield, 2012, Carbon Trust, 2011, Watt, 2007, Bordass et al., 2001, Barber et al., 2000, Bresnen et al., 1990). At an international level, there are studies investigating quality in commercial, educational, governmental and industrial facilities in Australia (Love and Edwards, 2012, Love and Edwards, 2004b, Love, 2002, Love and Li, 2000); commercial and infrastructure projects in Canada (Battikha, 2008, Fayek et al., 2004); governmental buildings in China (Palaneeswaran et al., 2007); infrastructure projects in Iran (Jafari and Love, 2013); educational buildings in Nigeria (Oyewobi et al., 2011); commercial, health, industrial, infrastructure and governmental buildings in Singapore (Hwang et al., 2014, Hwang et al., 2009, Chong and Low, 2006, Chong and Low, 2005); and commercial, governmental and industrial facilities in the US (Wang et al., 2014, Wanberg et al., 2013, Burati et al., 1992).

Noteworthy, 24% of the studies analysed in this review studied both domestic and non-domestic buildings and in 8% of the studies the type of the building analysed was not mentioned. The concentration of studies undertaken in residential buildings might be due to the fact that the residential building stock in Europe, for instance, corresponds to 75% of the total building stock (BPIE, 2011). In addition, the reasons and impacts of quality issues in domestic building are more tangible and representative. The non-residential building stock comprises a more complex and heterogeneous sector compared to residential sector and thus researches' key findings tend to be less replicable (BPIE, 2011, Tofield, 2012, Egan, 1998).

Quality defects are identified and collected by different stakeholders and through different methods depending on the stages of the building project. For example, during the construction process, quality defects are usually collected by the main contractor by means of internal quality inspections at different checkpoints in the programme of works, incoming material inspections, and internal and/or external audits. Once the construction is complete, quality issues may be identified as a result of building performance surveys by specialized consultants (e.g. thermographic survey of the building fabric and airtightness test), by both the contractor and the project client at the pre-commissioning stage prior to the practical completion of the works (normally 2 weeks before handing over the building), and by the project client and warranty providers at the final commissioning and handover, when the building is deemed completed and ready for occupation. At post-handover, when the building is occupied and operational, defects are normally gathered through client, owner or building occupants' complaints during the defects liability period, normally 12 months after handover in which the contractor is responsible for any defect occurring in the building. In 47% of the studies reviewed, data was collected during the construction phase; 22%, at handover, and 41%, at post-handover. Some studies, however, collected data in more than one stage (20%). For instance, Chong and Low (2005) analysed data from both construction and post-handover stages to understand the different causal factors of visible and latent defects. In respect to the data collection methods used, in 61% of the reviewed studies data was collected by the researchers; 22% by a third party (insurance companies, warranty providers or independent inspection companies); 14% by constructions companies (non-conformances records); and 11% by the occupants through warranty claim forms. It is noteworthy mentioning that in only 12% of the studies the researchers relied on more than one source of data. In 8% of the studies analysed, the data collection method could not be identified. Several researchers claim that there are structural differences in regard to the perceived quality between end-users and trained professionals; and between contractors' building surveyors and independent inspectors (Sommerville et al., 2004, Auchterlounie, 2009, Sommerville and McCosh, 2006). For example, Sommerville et al. (2004) studied the quantity of defects recorded in the post-handover stage in 600 residential units in the UK. The study suggested that independent inspectors working on behalf of the customer are more effective and accurate in identifying defects than the contractor. The researchers also stated that "this is of great concern and shows either lack of knowledge, awareness, and inexperience on behalf of the identifier or a lack of care and a poor attitude towards quality on behalf of the contractor" and therefore it is important to bear in mind the data collection method when comparing studies.

The building cases sample size varies from study to study. When data is collected by the researchers, sample size is generally smaller, ranging from 1 to 420 cases (e.g. housings units), and the focus relies on an in-depth analysis of the subject of the research. For instance, Johnston et al. (2014) collected data from 3 dwellings and assessed the thermal performance of the buildings' fabric in comparison to their previous predictions. Love and Edwards (2004b) analysed data from 2 developments, with a total of 44 dwellings, to understand the impact of defects on costs and schedule overruns. Studies in which data is collected by third parties, construction companies' records and occupants' warranty claim forms provided bigger samples. Generally, these studies implemented a holistic approach towards defects' characteristics or causal factors to find replicable and representative findings. For example, Ilozor et al. (2004) used data collected by an independent inspection company in 42,753 dwellings in order to stablish the type of defects and the affected building elements providing an extensive overview of the housing sector in Victoria, Australia.

Table 2-1 Summary of the literature in quality defects in construction projects

			Building type		Stage of data collection			Data collection method				Sample size	
Researcher	Year	Country	Domestic	Non-Domestic	During Construction	Hand-over	Post-handover	Researc	Third party	Contractor	Occupant	# of projects	# of subjects
Aljassmi et al. (2014)	2014	Australia	X				X		X			4	-
Love and Edwards (2012)	2012	Australia		X			X	X					23
Georgiou (2010)	2010	Australia	X		X		X		X				100
Mills et al. (2009)	2009	Australia	X				X				X	-	-
Ilozor et al. (2004)	2004	Australia	X				X		X				4,753
Love and Edwards[a] (2004a)	2004	Australia	-	-	-	-	-		X	X		-	161
Love and Edwards[b] (2004b)	2004	Australia	X	X	X			X				-	44
Love (2002)	2001	Australia	X	X			X			X		-	161
Love and Li (2000)	2000	Australia	X	X	X			X				2	44
Georgiou et al. (1999)	1999	Australia	X			X			X			-	1,772
Battikha (2008)	2008	Canada		X	X			X				2	2
Fayek et al. (2004)	2004	Canada		X	X			X				1	1
Palaneeswaran et al. (2007)	2007	China	X	X	X			X				2	2
Kalamees (2007)	2007	Estonia	X			X		X				-	32
Aissani et al. (2016)	2016	France	X	X			X	X				-	-
Jafari and Love (2013)	2013	Iran		X	X			X		X		1	1
Abdul-Rahman et al. (2014)	2014	Malaysia	X				X	X				-	310
Ahzahar et al. (2011)	2011	Malaysia	-	-	-	-	-	X				-	41
Aiyetan (2013)	2013	Nigeria	-	-	-	-	-	X				-	120
Oyewobi et al. (2011)	2011	Nigeria		X			X		X	X	X	25	25
Silvestre and de Brito (2011)	2011	Portugal	-	-			X	X				-	37

Note: Some studies did not have available information for all aspects of Table 2.2-1.

			Building type		Stage of data collection			Data collection method				Sample size	
Researcher	Year	Country	Domes-tic	Non-Domestic	During Construc-tion	Hand-over	Post-handover	Researcher	Third party	Contrac-tor	Occupant	# of projects	# of subjects
Hwang et al. (2014)	2014	Singapore	X	X	-	-	-	X	X	X	X	381	-
Hwang et al. (2009)	2009	Singapore	X	X	-	-	-		X			359	-
Chong and Low (2006)	2006	Singapore	X	X	X		X		X			74	-
Chong and Low (2005)	2005	Singapore	X	X	X		X		X			74	-
Forcada et al. (2015)	2015	Spain	X		X	X	X			X	X	16	2,179
Forcada et al. (2014)	2014	Spain	X		X					X		68	-
Forcada et al. [a] (2013a)	2013	Spain	X				X				X	7	533
Forcada et al. [b] (2013b)	2013	Spain	X				X				X	7	533
Macarulla et al. (2013)	2013	Spain	X		X		X			X		3	218
Forcada et al. (2012)	2012	Spain	X				X				X	-	95
Josephson et al. (2002)	2002	Sweden	X	X	X			X				7	-
Josephson and Hammarlund (1999)	1999	Sweden	X	X	X			X				7	-
Palmer et al. (2016)	2016	UK	X		X	X	X	X	X			-	76
van Dronkelaar et al. (2016)	2016	UK		X	X	X	X		X			-	62
Zero Carbon Hub (2016)	2016	UK	X		X			X				-	-
Hansford (2015)	2015	UK	X		X	X	X	X				-	-
Davis et al. (2015)	2015	UK	X	X	-	-	-	-	-	-	-	-	-
Johnston et al. (2015)	2015	UK	X			X		X					25
Pan and Thomas (2015)	2015	UK	X			X	X			X		8	327
Zero Carbon Hub (2015)	2015	UK	X		X			X				-	-
Taylor et al. (2014)	2014	UK	X			X	X	X				-	2

Note: Some studies did not have available information for all aspects of Table 2.2-1.

			Building type		Stage of data collection			Data collection method				Sample size	
Researcher	Year	Country	Domes-tic	Non-domestic	During Construc-tion	Hand-over	Post-handover	Researcher	Third party	Contractor	Occupant	# of projects	# of subjects
Johnston et al. (2014)	2014	UK	X			X		X				2	3
Zero Carbon Hub [a] (2014a)	2014	UK	X		-	-	-	X				9	97
Zero Carbon Hub [b] (2014b)	2014	UK	X		X		X	X				21	200
Taylor et al. [a] (2013a)	2013	UK	X		X			X				-	-
Taylor et al. [b] (2013b)	2013	UK	X			X		X				1	4
AECOM (2012)	2012	UK		X	-	-	-	-	-	-	-	-	-
Gorse et al. (2012)	2012	UK	X			X	X		X			-	-
Hopper et al. (2012)	2012	UK	X			X	X	X				-	2
Tofield (2012)	2012	UK	X	X	-	-	-	X				-	2
Carbon Trust (2011)	2011	UK	X	X			X	X				-	28
Wingfield et al. (2011)	2011	UK	X		X	X	X	X				1	420
Bell et al. (2010)	2010	UK	X		X		X	X				1	6
Zero Carbon Hub (2010)	2010	UK	X		-	-	-	-	-	-	-	-	-
Auchterlounie (2009)	2009	UK	X				X				X	-	-
Energy Saving Trust (2009)	2009	UK	X			X	X	X				-	-
Lowe et al. (2007)	2007	UK	X			X		X				1	2
Sommerville (2007)	2007	UK	X		-	-	-	-	-	-	-	-	-
Watt (2007)	2007	UK	X	X	-	-	-	-	-	-	-	-	-
Sommerville and McCosh (2006)	2006	UK	X			X			X			-	1,696
Bell et al.(2005)	2005	UK	X		X			X				16	-
Sommerville et al.(2004)	2004	UK	X			X			X			-	600
Atkinson (2002)	2002	UK	X		X			X				1	61

Note: Some studies did not have available information for all aspects of Table 2.2-1.

			Building type		Stage of data collection			Data collection method				Sample size	
Researcher	Year	Country	Domes-tic	Non-domestic	During construction	Hand-over	Post-handover	Researcher	Third party	Contractor	Occupant	# of projects	# of subjects
Bordass et al. (2001)	2001	UK	X	X			X	X				16	-
Barber et al. (2000)	2000	UK		X	X			X				2	-
Harrison (1993)	1993	UK	X		X			X	X			18	-
Bresnen et al. (1990)	1990	UK	X	X	X	X	X	X		X		138	-
Bonshor and Harrison (1982)	1982	UK	X		X			X				15	-
Wang et al. (2014)	2014	US		X			X	X				1	1
Na et al. (2013)	2013	US	X				X	X				1	-
Wanberg et al. (2013)	2013	US	X	X	X	X		X		X		32	-
Hoonakker et al. (2010)	2010	US	-	-	-	-	-	X				-	208
Burati et al. (1992)	1992	US		X		X		X				9	-
Davis et al. (1989)	1989	US	-	-	X			-	-	-	-	5	-

Note: Some studies did not have available information for all aspects of Table 2.2-1.

2.2.3 Quality defects in construction projects

Different approaches have been adopted in previous studies to identify and understand the defects occurrences, their causes and related impacts on the construction industry. Whilst there are researchers focusing on the quality defects on specific building elements (Aïssani et al., 2016, Hansford, 2015, Taylor et al., 2014, Taylor et al., 2013a, Taylor et al., 2013b, Silvestre and de Brito, 2011, Energy Saving Trust, 2009, Lowe et al., 2007), such as the insulation layer applied on a building façade (Aïssani et al., 2016, Hansford, 2015), others focus on the building as a whole (Forcada et al., 2015, Pan and Thomas, 2015, Forcada et al., 2014, Abdul-Rahman et al., 2014, Zero Carbon Hub, 2014a, Forcada et al., 2013a, Forcada et al., 2013b, Macarulla et al., 2013, Forcada et al., 2012, Wingfield et al., 2011, Georgiou, 2010, Mills et al., 2009, Chong and Low, 2006, Bell et al., 2005, Chong and Low, 2005, Fayek et al., 2004, Ilozor et al., 2004, Josephson et al., 2002, Bordass et al., 2001, Love and Li, 2000, Georgiou et al., 1999, Josephson and Hammarlund, 1999, Harrison, 1993, Bonshor and Harrison, 1982).

Regardless the scope of the analysis, the majority of the studies reviewed rely on a defect classification method which allows a categorisation of the defects based on their attributes, causes or related impacts (Watt, 2007). The definition of an effective classification system of quality defects has been acknowledged as being a challenging task, as it may vary depending on the needs and aims of each research analysis, as well as the project peculiarities in relation to specific local building culture and technology deployed; managerial practices; and weather conditions which might influence the generation of defects (Abdul-Rahman et al., 2014, Macarulla et al., 2013).

The following subsections provide a synthesis of the findings in the literature according to: (i) the defects attributes; (ii) the defects' major causes and influencing factors; and (iii) the impacts of these defects on the project performance indicators as well as the building energy performance.

2.2.3.1 Defect attributes

Previous studies analyse the defects by means of the following attributes: (i) defect type; (ii) affected building element; (iii) location in the building where the defect was manifested; and (iv) the trade or subcontract involved in the defect occurrence. A synthesis of the quality defects attributes most commonly mentioned in the literature is provided in Table 2-2, along with the list of studies which indicated these findings.

Table 2-2 Summary of the quality defects attributes in construction projects

Defects attributes	Most agreed findings	Previous studies
Defects type	*Incorrect installation* *Missing item* Surface appearance / Cracking on plaster *Gaps in the buildings' fabric / Cracking on external walls / Poor installation of insulation elements*	(Aïssani et al., 2016, NEF, 2016, Zero Carbon Hub, 2016, Forcada et al., 2015, Pan and Thomas, 2015, Zero Carbon Hub, 2015, Abdul-Rahman et al., 2014, Forcada et al., 2014, Zero Carbon Hub, 2014a, Forcada et al., 2013a, Forcada et al., 2013b, Macarulla et al., 2013, Na et al., 2013, Gorse et al., 2012, Hopper et al., 2012, Ahzahar et al., 2011, Silvestre and de Brito, 2011, Wingfield et al., 2011, Georgiou, 2010, Mills et al., 2009, Battikha, 2008, Kalamees, 2007, Palaneeswaran et al., 2007, Watt, 2007, Chong and Low, 2006, Chong and Low, 2005, Ilozor et al., 2004, Bell et al., 2005, Bordass et al., 2001, Georgiou et al., 1999, Harrison, 1993)
Number of defects per housing unit	2.29 – 28.3 average number of defects per housing unit	(Pan and Thomas, 2015, Forcada et al., 2012, Sommerville and McCosh, 2006, Georgiou et al., 1999)
Affected building element	*External walls* Partitions *Closure components (doors and windows)* *Floors* *Roofs*	(Aïssani et al., 2016, Zero Carbon Hub, 2016, Forcada et al., 2015, Zero Carbon Hub, 2015, Abdul-Rahman et al., 2014, Zero Carbon Hub, 2014a, Forcada et al., 2013b, Forcada et al., 2012, Na et al., 2013, Hopper et al., 2012, Wingfield et al., 2011, Mills et al., 2009, Battikha, 2008, Palaneeswaran et al., 2007, Chong and Low, 2006, Chong and Low, 2005, Bell et al., 2005, Atkinson, 2002, Watt, 2007, Bordass et al., 2001, Bonshor and Harrison, 1982, Harrison, 1993)
Location in the building	Rooms/bedroom Bathroom Kitchen	(Pan and Thomas, 2015, Forcada et al., 2014, Forcada et al., 2013b,

	Lounge/Hall/Corridor *External doors* *Building envelope (façade, roof and structure)*	Forcada et al., 2012, Hopper et al., 2012, Kalamees, 2007)
Trade or subcontractor involved	Plumbing *Carpentry/door and windows closures* *Brickwork / Partitions and enclosures* Structure	(Georgiou et al., 1999, Battikha, 2008, Palaneeswaran et al., 2007, Forcada et al., 2014, Forcada et al., 2015, Forcada et al., 2013b)

3 Note: Highlighted in italics, those attributes with a potential effect on the building energy performance

The definition of a defect taxonomy has been extensively explored with the purpose to establish a comprehensive and standardised list of defects to be used by construction companies and researchers during data collection and analysis (Forcada et al., 2015, Pan and Thomas, 2015, Abdul-Rahman et al., 2014, Forcada et al., 2014, Forcada et al., 2013a, Forcada et al., 2013b, Macarulla et al., 2013, Ahzahar et al., 2011, Silvestre and de Brito, 2011, Georgiou, 2010, Mills et al., 2009, Watt, 2007, Chong and Low, 2006, Chong and Low, 2005, Ilozor et al., 2004, Georgiou et al., 1999, Harrison, 1993).

Forcada et al. (2014) established a classification system for residential building projects in Spain consisting of 12 types of defects in 68 housing developments: affected functionality; detachment; flatness and levelness; incorrect installation; misalignment; missing; others; soiled; stability/movement; surface appearance; tolerance error and water problems. The researchers found that incorrect installation was the most recurrent type of defect during the construction stage, accounting for 24% of the occurrences.

Similarly, Macarulla et al. (2013) identified 15 different defect types, including: affected functionality; inappropriate installation; biological action; broken/deteriorated; chemical action; detachment; soiled; flatness and levelness; misaligned; missing; stability/movement; surface appearance; water problems; tolerance errors and others. Using this classification system, the researchers compared the defects types identified in the construction and post-handover stages of 3 projects (218 housing units) in Spain and concluded that whilst the most recurrent type of defect during the construction stage was inappropriate installation (with a frequency of 32%), at post-handover, the most observed type of defect was missing item or task, accounting for 55% of the occurrences. Similarly, Forcada et al. (2013a, 2013b) also concluded that the most frequent type of defect collected at post-handover was missing item or task, appearing in 37% of the cases in seven Spanish housing schemes.

Georgiou (2010) classified the defects according to the categories: cracking; damp; drainage; external leaks; incomplete; internal leaks; miscellaneous; no defects; regulations; structure adequacy; water hammer; window sill gap and workmanship. The researcher analysed the quality defects observed during the construction and post-handover stages of 100 domestic building projects in Australia and concluded that workmanship and incomplete were the most frequent defects, accounting for 40% and 20% of the occurrences, respectively. Noteworthy, the definition of the term workmanship used by the Georgiou (2010) suggests the same defect nature as inappropriate installation or incorrect installation used by other researchers (Forcada et al., 2014, Macarulla et al., 2013), corroborating their findings.

Chong and Low (2006) proposed a defect classification system focused on the main building elements, including: internal walls; external walls; floor; doors; windows; plumbing and sanitary defects; roofs; mechanical and electrical and ceilings. For each building element, different defect types were identified. The researchers analysed data from 74 domestic and non-domestic buildings in Singapore and identified that the one of the most recurrent defect was plaster crack on walls and partitions, accounting for 37% of the defects.

Similarly, Abdul-Rahman et al. (2014) identified a vast list of defects, totalizing 25 different anomalies, which the most frequent included: cracking in external walls; failure of the water supply system; dampness to concrete walls and leakage of pipes. The researchers state that cracking in external walls is the major defect occurrence in 310 affordable housing units in Malaysia.

In line with the previous studies, Forcada et al. (2015) found that surface appearance was the most recurrent defect, accounted for 64% of defects collected at handover in 2,179 Spanish housing units.

Others researchers like Bordass et al. (2001), Bell et al. (2005) and Wingfield et al. (2011) focused on quality defects affecting building thermal performance and found out that the most common defects were related to gaps in the buildings' fabric and poor installation of insulation elements. Several types of defects were identified in the studies including: missing cavity closers; gaps in insulation at jambs and sills; inadequate sealing, no insulation behind cavity tray; discontinuity of insulation layer; gaps between floor and walls junctions, structural thermal bridging; services thermal bridging; punctured or missing vapour/air barrier; services penetration without sealing; malfunction in mechanical ventilation and MVHR devices.

Undoubtedly the number of defects in a project is one of the most important factors to measure quality in construction and it has been widely used as a key indicator by the building industry (Auchterlounie, 2009, Harrison, 1993). According to Georgiou et al. (1999)

who studied records from 1,772 houses in Australia, the number of defects per dwellings built by owner builders ranges from 0 to 21, with an average of 2.73 per house. While the dwellings built by registered builders presented a range from 0 to 16 defects per house, with an average slightly lower of 2.29. Also exploring a large sample of 1,697 houses in the UK, Sommerville and McCosh (2006) found a range of defects per house between 1 and 389 occurrences. The average number of defects per house was 44 however the study identified a considerable variation of number of defects between dwellings. Pan and Thomas (2015) compared defects from houses and flats and concluded that in houses the number of defects ranged from 0 to 47 per dwellings with an average of 10.6, whereas in flats the range of occurrences was between 0 and 20 and an average of 6.9. Using a similar approach, Forcada et al. (Forcada et al., 2012) found that the averages of defects per detached house and per flat were 21 and 28.3.

The wide variation amongst the number of defects could be explained by differences in the building type, the construction method used, the management procedures undertaken, and the data collection methods used.

Quality defects are also analysed in the literature according to the building element affected. The majority of studies in the review (Forcada et al., 2012, Harrison, 1993, Bonshor and Harrison, 1982, Forcada et al., 2015, Forcada et al., 2014, Abdul-Rahman et al., 2014) suggest that walls, partitions and closure components (doors and windows) are the building elements where defects are more likely to occur. Forcada et al. (2012) stated that 43% of the defects studied were detected in partition and closure elements: 14% affecting internal walls, 15% found on doors and 14% on windows. Similarly, Forcada et al. (2015) analysed a different data set and found that internal walls accounted for 60% of the occurrences. Abdul-Rahman et al. (2014) measured the frequency of defect occurrences on specific building elements and concluded that external walls had the highest manifestation of defects. Chong and Low (2006, 2005) found that defects are most likely to occur on floors, accounting for 17% of the affected elements. Differently, Mills (2009) stated that roofs are the building element where more quality defects occurred (10%).

The location or area in the building where defects are observed is another attribute used to analyse, plan and improve quality assurance in building projects. Forcada et al. (2013b, 2012) concluded that the top five areas affected in residential units in Spain are: rooms/bedrooms (21% - 22%); bathrooms (17%); kitchens (15%); lounge (11%) and hall/corridor (7% - 8%). Pan and Thomas (2015) determined that most recurrent locations of defects manifestation in their study in the UK are: kitchens (15%), bathrooms (14%), external doors (10%) and building envelope (9%). Contrary to the previous studies where locations correspond mostly to internal areas, Forcada et al. (2014) identified that general accounted for 54% of the locations involved in defect occurrences, followed by exterior areas (10%). According to the researchers' definition, general is a category of location which is related to the building's envelope, including façade, roof and structure.

Although less frequently, some researchers also analyse the defects occurrences based on the trades and subcontractors involved. According to Georgiou et al. (1999), the trade most involved in defects generation is plumbing, which appeared to be responsible for up to 26% of the occurrences. This was followed by carpentry (23%), brickwork (15%), plasterer (10%), finishes (10%), miscellaneous (8%), external works (6%) and electrical (2%). Other trades commonly identified in the literature are those responsible for partitions and enclosures (51%) (Forcada et al., 2015), structure (29%) (Forcada et al., 2014) and door and windows closures (28%) (Forcada et al., 2013b).

2.2.3.2 Major causes and influencing factors

According to Egan (1998), a 20% annual reduction in the number of defects occurrences at handover would be necessary to assure sustained improvement in buildings' quality. In order to fulfil this objective it is vital not only to define, quantify and classify quality issues but to identify the root causes and influencing factors that lead to defects (Love and Edwards, 2012, Battikha, 2008, Fayek et al., 2004).

Different approaches to analyse and classify the major causes of defects and influencing factors in construction projects have been used in the literature (Georgiou, 2010, Sommerville and McCosh, 2006, Georgiou et al., 1999, Burati et al., 1992, Davis et al., 1989). Table 2-3 presents the findings grouped by major causes and influencing factors.

Table 2-3 Summary of the major causes of defects and influencing factors in construction projects

Causes and influencing factors	Most agreed findings	Previous studies
Origin of defects	*Change, error, omission or damage*	(Aïssani et al., 2016, van Dronkelaar et al., 2016, Palmer et al., 2016, Hansford, 2015, Forcada et al., 2013a, Jafari and Love, 2013, Gorse et al., 2012, Love and Edwards, 2012, Ahzahar et al., 2011, Silvestre and de Brito, 2011, Hwang et al., 2009, Battikha, 2008, Palaneeswaran et al., 2007, Fayek et al., 2004, Love and Edwards, 2004b, Atkinson, 2002, Barber et al., 2000, Love and Li, 2000, Josephson and Hammarlund, 1999, Burati et al., 1992)

Sources of defects	*Workmanship, design, management, machinery, material or lack of protection of already installed items*	(Aïssani et al., 2016, Palmer et al., 2016, van Dronkelaar et al., 2016, Hansford, 2015, NEF, 2016, Aljassmi et al., 2014, Hwang et al., 2014, Wang et al., 2014, Zero Carbon Hub, 2014b, Zero Carbon Hub, 2014a, Aiyetan, 2013, Forcada et al., 2013a, Jafari and Love, 2013, Na et al., 2013, Gorse et al., 2012, Tofield, 2012, Ahzahar et al., 2011, Silvestre and de Brito, 2011, Wingfield et al., 2011, Hwang et al., 2009, Battikha, 2008, Kalamees, 2007, Palaneeswaran et al., 2007, Sommerville, 2007, Watt, 2007, Chong and Low, 2006, Chong and Low, 2005, Fayek et al., 2004, Love and Edwards, 2004b, Atkinson, 2002, Josephson et al., 2002, Bordass et al., 2001, Love and Li, 2000, Barber et al., 2000, Josephson and Hammarlund, 1999, Harrison, 1993, Burati et al., 1992, Bresnen et al., 1990, Bonshor and Harrison, 1982)
Size of building	Number of bedrooms in dwellings	(Pan and Thomas, 2015, Sommerville and McCosh, 2006, Sommerville et al., 2004)
Building type	Flat / House	(Mills et al., 2009, Love and Edwards, 2004a)
Construction method	Masonry / Timber frame	(Pan and Thomas, 2015)

Note: Highlighted in italics, those causes and influencing factors with a potential effect on the building energy performance

Origin and source are intimately related when it comes to defect occurrences. Whilst the origin is deemed to be the act by which a defect is generated, the source is considered to be the actor or the activity involved in the defect occurrence, including workmanship, design, management, machinery, material or lack of protection of already installed items (Aïssani et al., 2016, Wang et al., 2014, Jafari and Love, 2013, Hwang et al., 2009, Fayek et al., 2004).

Previous studies have identified change, error, omission or damage as the origin of defects (Forcada et al., 2013a, Barber et al., 2000, Love and Li, 2000, Love and Edwards, 2012). Change is a directed action of modifying the currently defined requirements and may include the design, construction process, existing scope of contract, plans and specification or operational capability of the building. According to Love and Li (2000), changes in the design are responsible for 54% of the defects costs. Similarly, Fayek et al. (2004) suggest that changes and reviews in design and engineering are responsible for 55% of the number of defects occurrences and 62% of the rework costs. Noteworthy, in both studies the cases analysed are facilities of highly complex engineering requirements such as offshore projects and mining facility. Therefore, it is reasonable to assume that changes in the design are more likely to occur.

The term error is understood as any activity or a building element which is designed, manufactured, performed or installed incorrectly, resulting in the mismatch of the previous requirements. Barber et al. (2000) estimates that 50% of the defects resulted from design errors. Burati et al. (1992) state that design errors originated 30% and 24% of defects' in new projects and retrofits, respectively. Similarly, Silvestre and de Brito (2011) claim that design errors are responsible for 60% of the anomalies in facades of buildings. With slightly different findings, Love and Li (2000) and Josephson et al. (2002) concluded that defects (55% of the recorded occurrences) originated from errors during the construction stage related to poor workmanship.

The term omission relates to an activity or a building element which has been left out during the design, the manufacturing or the construction process. According to Forcada et al. (2013a), omission and workmanship are responsible for 42% of the origins and 64% of the sources of defects collected at the posthandover stage in the housing sector in Spain.

Finally, damage is defined as a physical harm affecting a building element in terms of usefulness or expected operational standards. Although this category does not stand as one of the most frequent origins of defects it still has an important contribution towards the resulting impacts of quality issues. For instance, Forcada et al. (2013a) and Love and Li (2000) suggest that damage is responsible for 18% and 23% of defects, respectively, and are strictly related to workmanship and management.

In addition, Josephson and Hammarlund (1999) suggest five other categories, including knowledge, information, motivation, stress and risk. The study suggests that 50% of defects were generated due to lack of motivation and manifested through forgetfulness and carelessness.

Atkinson (2002) concluded that management, including poor formal communication and lack of closer supervision by site and design managers, is the most important source of defects, responsible for a 63% of the defects. Similarly, other researchers (Love et al., 2016, Aiyetan, 2013, Jafari and Love, 2013, Battikha, 2008, Palaneeswaran et al., 2007, Love and Edwards, 2004b) claim that poor planning, poor supervision, inadequate inspection and checking procedures and lack of quality focus are the underlying factors of defects.

The relationship between defects occurrences and particular buildings' characteristics has also been explored by previous studies. Sommerville and McCosh (2006), Pan and Thomas (2015) and Sommerville et al. (2004) identified a positive correlation between the number of defects and number of bedrooms in dwellings. However, the correlation between the floor area of the building and the number of defects in projects other than housing has not been confirmed by previous studies.

Pan and Thomas (2015) and Forcada et al. (2012) analysed the possible correlation between the number of defects and the type of the building in the housing sector. Although both studies provided a positive correlation validated by statistical analysis their findings are different. Whilst Pan and Thomas (2015) determined that the mean defects per dwelling are higher in houses (10.6) rather than in flats (6.88); Forcada et al. (2012) claim that the mean number of defects per flat (28.3) is higher than in detached houses (21). The different findings might be explained by the distinct data collection methods used in the two studies. Pan and Thomas (2015) used data collected by the construction company itself, while Forcada et al. (2012) analysed data from occupant complaint forms.

Moreover, in regard to the correlation between the number of defects and the build method, Pan and Thomas (2015) found that the average number of defects reported in houses built using masonry methods (10.22) was lower than the houses built using timber frame methods (11.26). However, such a difference was observed not to be statistically significant.

2.2.3.3 Impact of quality defects on construction projects performance

The impact of quality defects on construction project performance can be synthesised in the following categories: (i) project cost; (ii) project programme; (iii) customer satisfaction; (iv) industry reputation; and (v) health and safety. Table 2-4 provides a list of researchers studying these relationships.

Table 2-4 Summary of the perceived impact of quality defects on construction project performances

Project performance aspects	Most agreed findings	Previous studies
Cost	The budget overruns due to defects rectification range from 3.23% to 23%.	(Davis et al., 2015, Hwang et al., 2014, Jafari and Love, 2013, Oyewobi et al., 2011, Hwang et al., 2009, Mills et al., 2009, Palaneeswaran et al., 2007, Fayek et al., 2004, Love and Edwards, 2004b, Love and Edwards, 2004a, Josephson et al., 2002, Love, 2002, Barber et al., 2000, Love and Li, 2000, Josephson and Hammarlund, 1999, Burati et al., 1992, Bresnen et al., 1990, Davis et al., 1989)

Programme	The programme overruns due to defects rectification reach 7.1% to 20.7%.	(Davis et al., 2015, Hwang et al., 2014, Oyewobi et al., 2011, Love and Edwards, 2004a, Josephson et al., 2002, Love and Li, 2000, Barber et al., 2000, Bresnen et al., 1990)
Customer satisfaction	The correlation between defects occurrences and customer satisfaction is well established.	(Davis et al., 2015, Forcada et al., 2015, Pan and Thomas, 2015, Forcada et al., 2012, Tofield, 2012, Hoonakker et al., 2010, Auchterlounie, 2009, Bresnen et al., 1990)
Industry reputation	The impact of defects occurrences on construction companies' reputation is identified.	(Davis et al., 2015, Forcada et al., 2015, Pan and Thomas, 2015, Forcada et al., 2012, Tofield, 2012, Auchterlounie, 2009, Sommerville and McCosh, 2006, Sommerville et al., 2004)
Health and safety	The correlation between defects occurrences and lower health and safety levels is well established.	(Wanberg et al., 2013, Hoonakker et al., 2010, Watt, 2007, Love and Edwards, 2004a)

The relationship between quality, project programme and cost has been the subject of extensive research. The cost associated with quality defects, i.e. the cost of rework, has been approached differently in previous research. While some studies solely determine the direct costs associated with defect rectification, such as extra material and workforce expenditures (Jafari and Love, 2013, Oyewobi et al., 2011, Hwang et al., 2009, Palaneeswaran et al., 2007, Love and Edwards, 2004b, Josephson et al., 2002, Josephson and Hammarlund, 1999, Burati et al., 1992, Davis et al., 1989), others combine the direct and the indirect costs, which also include costs such as overheads, accommodation and subsistence costs (Davis et al., 2015, Mills et al., 2009, Fayek et al., 2004, Love and Edwards, 2004a, Love, 2002, Love and Li, 2000, Bresnen et al., 1990). In addition, while some studies present the rework costs as a percentage of the projects' contract value (Oyewobi et al., 2011, Jafari and Love, 2013, Palaneeswaran et al., 2007, Love and Edwards, 2004b, Davis et al., 1989, Barber et al., 2000, Love and Edwards, 2004a, Love, 2002, Love and Li, 2000, Davis et al., 2015, Bresnen et al., 1990), others calculate them as a percentage of the projects' construction costs (Josephson and Hammarlund, 1999, Josephson et al., 2002, Hwang et al., 2009, Fayek et al., 2004, Mills et al., 2009). Love (2002) studied 161 domestic and non-domestic Australian projects and concluded that the average direct and indirect costs of rework were, respectively, 6.4% and 5.62% of the projects original contract value, and contributed to 52% of the projects total cost growth. Similar results were found by Barber et al. (2000), who studied two non-domestic projects in the UK and concluded that the direct and indirect defects costs were 6.6% and 3.6%

respectively. However, these costs would rise to 16% and 23% when adding the delay costs, such as contract delay fines. Josephson and Hammarlund (1999) analysed the cost of rework in 6 domestic and non-domestic building projects in Sweden and concluded that defects direct costs can reach up to 9.4% of the production costs. When considering the construction errors only (not including rework caused by design changes), these costs contributed to cost overruns of 4.4% and schedule overruns of 7.1% (Josephson et al., 2002). Moreover, Oyewobi (2011) compared costs overruns associated with non-residential new build and retrofit building projects and found that the new build projects presented higher correction costs (5.06%) than the retrofit projects (3.23%). Differing from previous studies, Hwang et al. (2009) concluded that rework costs rarely influenced the overall cost increase in projects with contract values greater than $100 million. According to Hwang et al. (2009), this might be explained by the fact that the large construction costs of these projects might make them relatively less sensitive to the direct rework costs.

Quality defects have also been identified as one of the causes for schedule overruns (Davis et al., 2015, Love and Edwards, 2004a, Josephson et al., 2002). For instance, the 2015 UK Industry Performance Report (Davis et al., 2015) states that only 40% of the projects were completed on time, being rework one of causes for the schedule overruns. Love and Edwards (2004a) suggest in a study undertaken in 161 construction projects in Australia that the mean schedule growth due to defects correction was 20.7%. Josephson et al. (2002) suggest in a study of domestic and non-domestic projects in Sweden that the schedules overrun due to defects were 7.1%.

The relationship between quality defects, customer’s satisfaction and industry reputation has also been acknowledged in previous research (Davis et al., 2015, Forcada et al., 2015, Pan and Thomas, 2015, Forcada et al., 2012, Tofield, 2012, Hoonakker et al., 2010, Auchterlounie, 2009, Sommerville and McCosh, 2006, Sommerville et al., 2004, Bresnen et al., 1990). Auchterlounie (2009) found that 57% of 300 new UK houses studied partially failed or completely failed to meet the clients’ expectations. The main reasons for the customer’s dissatisfaction were related to finishings and aesthetics defects rather than technical defects, such as roofing, services, etc., which were expected to be previously checked by professionals and inspected by the warranty provider. Other examples of quality defects not properly addressed are described in Forcada et al. (Forcada et al., 2012, Forcada et al., 2015). The researchers identified defects recorded during handover which had not been appropriately rectified and consequently resulted in customer complaints. Differing from previous studies, Davis et al. (2015) and Bresnen et al. (1990) found that the majority of customers, 81% and 87% respectively, were satisfied or very satisfied with the overall quality of the dwellings.

A smaller number of studies have also acknowledged a correlation between quality and health and safety. Hoonakker et al. (2010) studied 208 contractors in the UK and concluded that in 71% of the cases the implementation of quality assurance procedures helped to improve on-site health and safety levels. Similarly, Wanberg et al. (2013) studied 32 domestic and non-domestic projects in the US and concluded that the first-aid rate was positively correlated to the number of defects, suggesting that the lower the quality performance (i.e. the higher the number of defects), the higher the likelihood to experience health and safety incidents on-site. Love and Edwards (2004a) explained this relationship stating that as rework activities increase, safety may be compromised as the pressure to complete the project on time and in budget also increases.

2.2.3.4 Impact of quality defects on building energy performance

Quality defects have also been acknowledged as having a negative impact on the buildings energy performance resulting in a higher energy consumption. These defects can be grouped in three distinct categories: (i) design defects; (ii) implementation or workmanship defects during the construction stage; and (iii) lifetime defects. Table 2-5 provides the list of studies for each category and the most agreed findings.

Table 2-5 Summary of the perceived impact of quality defects on building energy performance

Defects categories	Most agreed findings	Previous studies
Design defects	Lack of literacy among the project team Poor detailing Poor design change management Thermal bridging issues not addressed Buildability issues	(Palmer et al., 2016, van Dronkelaar et al., 2016, NEF, 2016, Zero Carbon Hub, 2016, Hansford, 2015, Zero Carbon Hub, 2015, Wang et al., 2014, Zero Carbon Hub, 2014b, Zero Carbon Hub, 2014a, AECOM, 2012, Gorse et al., 2012, Tofield, 2012, Carbon Trust, 2011, Wingfield et al., 2011, Bell et al., 2010, Zero Carbon Hub, 2010, Energy Saving Trust, 2009, Lowe et al., 2007, Bell et al., 2005, Bordass et al., 2001)

Implementation or workmanship defects during the construction stage	Thermal bridging Air permeability Discontinuity of insulation layer Gaps on vapour and air barriers	(Aïssani et al., 2016, Palmer et al., 2016, van Dronkelaar et al., 2016, Zero Carbon Hub, 2016, Hansford, 2015, Johnston et al., 2015, Zero Carbon Hub, 2015, Johnston et al., 2014, Taylor et al., 2014, Wang et al., 2014, Zero Carbon Hub, 2014b, Zero Carbon Hub, 2014a, Na et al., 2013, Taylor et al., 2013a, Taylor et al., 2013b, AECOM, 2012, Gorse et al., 2012, Hopper et al., 2012, Tofield, 2012, Wingfield et al., 2011, Bell et al., 2010, Kalamees, 2007, Bell et al., 2005, NEF, 2016)
Lifetime defects	Sealing degradation Moisture retention Materials lifespan	(Aïssani et al., 2016, van Dronkelaar et al., 2016, Palmer et al., 2016, Wingfield et al., 2011, Kalamees, 2007)

According to Zero Carbon Hub (2014a, 2014b), during the design stage, there is a lack of focus and understanding on the implications of the design decisions on the building energy performance. Uncertainty in setting design parameters can lead to design mistakes and inaccuracy of materials' specification. This lack of awareness of the design team is likely to impact various aspects of the energy performance of buildings (van Dronkelaar et al., 2016). For instance, Palmer et al. (2016) investigated the building project of 76 UK homes and concluded that the lack of literacy of the design team towards energy related aspects, added to an uncoordinated approach of the different design disciplines, resulted in non-intended thermal bridges and buildability issues which increased the air permeability of the buildings' envelope. Similarly, Hansford (2015) states that the building physics are not widely nor fully understood by design professionals, resulting in inadequate design solutions and poor detailing. The researcher investigated external wall insulation retrofit projects undertaken in UK dwellings and confirmed that the occurrence of design defects resulted in thermal bridging. Wingfield et al. (2011) studied 420 new homes in the UK and suggested that unrecognized heat loss mechanisms during the design stage (air leakage and thermal bridging through party walls and other construction cavities) undermined the expected building energy performance. Other researchers (Palmer et al., 2016, Energy Saving Trust, 2009, Bell et al., 2005) suggest that there are also design defects related to the quality and accuracy of the information embedded in construction drawings and details which can result in incorrect interpretation and unnecessary amendments by the team working on-site. If not addressed with the right knowledge, these misunderstandings can result in faulty construction details which affect the expected building energy performance. Design changes have also been identified as a contributing factor. Palmer (2016), van Dronkelaar (2016) and AECOM (2012) agree that in both domestic and non-domestic sectors there is lack of a robust design change management system. These researchers highlight that changes of specification are frequently motivated by value engineering, supplier's change or client's requests. Unfortunately, the impact of these changes on the original designed energy performance of the building is rarely assessed as part of the process.

According to AECOM (2012) and Bordass et al. (2001), the in-use energy consumption of a building can be severely affected by the quality of its construction, mainly due to defects in the building's envelope and services. Johnston et al. (Johnston et al., 2015), for instance, measured the thermal properties of 25 new dwellings in the UK and concluded that the whole fabric U-value was 1.6 greater than predicted in the design stage, caused by discontinuity of the insulation panels, due to poor workmanship management. Similarly, Bell et al. (Bell et al., 2010) found that the overall heat loss in 6 new-build dwellings in the UK was 54% higher than predicted, even though high levels of insulation were used to minimize the space heating demand. The study also identified that the average air permeability measured was 133% higher than desired, contributing significantly to heat loss. Similarly, a study undertaken by Zero Carbon Hub (Zero Carbon Hub, 2010) on 16 UK houses indicated the heat loss was higher than predicted in all the measured dwellings. Both studies claimed that poor quality during the buildings fabric installation was the main reason for the thermal bridging, thermal bypass and air permeability causing unexpected heat loss rates. Similarly, in the latest report on energy performance of social housing projects in the UK (28 housing development), the National Energy Foundation (2016) found that 67% of the projects failed to achieve the intended thermal transmittance of the external walls, 89% did not meet the roof/ceiling U-values, and 54% of the cases failed to achieve the desired air tightness. The defects deemed responsible for this underperformance were related to lack of continuity of the insulation layers, thermal bridges and services penetrations in the fabric without effective sealing.

In an attempt to quantify the thermal resistance losses caused by defects in the external wall insulation layer, Aissani et al. (2016) assessed four common workmanship errors (i.e. groove, opening, crush and sheath passage) through experimental measurements under laboratory conditions and finite element modelling. The findings of the study suggested that flexible insulation materials (e.g. mineral wool) were more affected by defects than rigid panels and in those cases the thermal performance losses due to defects occurrences reached up to 40% in the measured zone (300 x 300mm). Johnston et al. (2014) compared the designed and in situ U-values obtained by heat flux measurements and co-heating tests in 3 dwellings in the UK and demonstrated that defects during the construction process affected the overall energy performance. The most recurrent defects were lack of continuity of the insulation layer, gaps in the vapour and air control barriers and thermal bridging through window lintels. The findings of the study showed that the measured U-values of the fabric elements (i.e. external wall, ground floor and roof) deviate in different proportions from their relative designed targets, suggesting that different types of defects can be more or less harmful to the fabric's thermal performance.

In respect of the lifetime defects, Wingfield et al. (2011) investigated 420 dwellings in the UK for over 6 years (from design to post-occupation evaluation) and established a correlation between the degradation of the buildings fabric overtime and the decline of the energy performance of buildings. The results showed that air permeability of the dwellings increased overtime, in some cases up to 30%. The reduction of the airtightness occurred due to drying, shrinkage and settlement mainly in the intermediate floor perimeters (sealing and barrier elements) but also in other constructions junctions (e.g. wall/windows interfaces), mostly in timber floors and on wooden elements (e.g. window sills). Palmer et al.(2016) studied 76 UK homes and the results highlighted the concerning practice of "plugging" gaps in the building fabric with sealant after the construction completion, instead of addressing the air permeability defects with a long term solution. Similarly, Kalamees (2007) investigated 32 detached houses in Estonia and concluded that the utilisation of materials with different lifespans or inadequate interfaces contributed to increase air permeability overtime. As a consequence, the increase of the air penetration and decay of the vapour and air control barriers promoted moisture retention in the insulation layer, and thus an increased building fabric thermal transmittance (Wingfield et al., 2011, van Dronkelaar et al., 2016). Moreover, Aissani et al. (2016) also claim that flexible insulating materials (e.g. mineral wool) tend to collapse over the years after installation when applied on a vertical surface. According to the study, a collapsed or crushed insulation panel at 0.5% of its total volume results in the loss of 12% of its initial performance.

The impact of quality defects on the building energy performance has been acknowledged in previous studies, mostly in relation to those defects affecting the thermal behaviour of the buildings' envelope which contributes to an increased heat loss (van Dronkelaar et al., 2016, Gorse et al., 2012). According to the reviewed studies the most recognised heat loss mechanisms are thermal bridging (e.g. high transmissivity of structural elements through the fabric), undesired increases of thermal transmittance (e.g. discontinuity of insulation layer) and unexpected air permeability (e.g. gaps in the air barrier) (Palmer et al., 2016, Johnston et al., 2015, Taylor et al., 2014). Each one of them are related to quality defects originating in the design and construction process or linked to the decay of the buildings' envelope properties overtime. Some studies claim that the diverse types of defects affect the thermal performance in different levels (Johnston et al., 2014, Taylor et al., 2013a). However, there seems to be scarce information in terms of quantifying which type of defect has greater impact in the building energy use, both in relation to the actual contribution to heat loss and in respect to the frequency of occurrence in construction projects. In fact, at one end there are punctual studies aiming to quantify the heat loss caused by specific defects through simulation and modelling (Aïssani et al., 2016, Na et al., 2013). At the other end, there are studies which determine the overall heat loss or the whole building air leakage (Bell et al., 2010, Kalamees, 2007). Further studies that investigate the information which lies between these two extremes is still required if appropriate preventive measures to avoid defects affecting the buildings' energy performance are to be developed and implemented.

In that sense, it becomes necessary to explore the knowledge on current quality management in construction in order to identify and assess the procedures put in place to prevent and identify the occurrence of defects affecting building performances, in particular the thermal performance of the buildings' fabric.

2.3 Quality management in construction projects

The occurrence of defects in construction projects has the potential to undermine the achievement of defined performance indicators such as client satisfaction, budget, programme, including the achievement of thermal performance targets. Therefore, over the past decades the construction industry has relentlessly applied a number of management processes and procedures to enable and facilitate the achievement of defined quality standards (Harris et al., 2013).

The forefathers of modern Quality Management such as Deming (2000), Crosby (1996), Kanji (1996) and Juran (1993), determined that the success of these group of processes and activities applied by organisations to ensure that the final outcome of a product or service complies with defined standards depends mainly on four aspects. The first aspect is concerned about the definition and appropriate communication of quality objectives, ensuring that the "customer needs" are fully understood by all involved in the project and are incorporated in the managerial procedures (Deming, 2000, Juran, 1993). The second aspect is related to the establishment of quality policies. They should work as the back bone that links the processes and procedures undertaken in the number of activities necessary for the delivery of services or products with the core values of an organisation and its strategic goals (Deming, 2000, Kanji, 1996). According to Deming (2000), the adopted quality policy must be part of the organisation ethos, permeating all levels of a company. The third aspect is regarded to the assignment of responsibilities in terms of ensuring the proper application of processes and activities in line with quality objectives and policies (Crosby, 1996). The fourth aspect entails the importance of measuring quality outcomes as means to allow continuous improvement (Crosby, 1996, Kanji, 1996). The process of establishing quality metrics to objectively assess quality outcomes, allows the identification of trends of faulty production and service delivery processes, contributing to the improvement of ongoing or future projects. Under the light of this four major aspects of quality management, standardised Quality Management Systems (QMS) such as ISO9001 (BSI, 2015) and PMBOK (Project Management Institute, 2001) were built upon.

According to Harris et al. (2013), in recent decades the construction sector has experienced a slow shift of approach towards the occurrence of quality defects. Instead of reacting from the quality outcome achieved in construction projects, construction companies began to acknowledge quality management programmes as strategic business functions. A more proactive approach has been observed, with focus on the prevention of defect occurrences, rather than concentrating effort on the remediation of non-conformances. However, studies from researchers such as Alencastro et al. (2018), Auchterlounie (2009), Sommerville (2007) Sommerville and McCosh (2006) and Bordass et al. (2001), suggest that the former scenario is still prevalent. For instance, Auchterlounie (2009) in a study investigating recurring quality issues in the UK private house building industry, states that the sector has a reactive approach in respect to the occurrence of quality defects. Quality management procedures are designed and put in place as a consequence of the number of warranty claims and the clients' perceived quality, most of the times focusing on visible and cosmetic defects. As a result, the recurring theme in this study was the insufficient time allocated to the site management team to actually supervise and check the technical aspects of the work throughout the construction process.

2.3.1 Challenges of quality management in the construction sector

In recent decades there has been a continuous effort by the construction industry to apply quality management knowledge acquired from manufacturing and other industrial sectors to improve performance (McIntyre and Kirschenman, 2000). However, the ultimate quality of buildings is often not in accordance with the specification, with insufficient attention from Quality Management Systems (QMS) towards defects affecting the energy performance of buildings (Johnston et al., 2015, Tofield, 2012).

Even though the theoretical basis for effective quality assurance is well established, actual quality management practices in the construction industry fails to deliver expected outcomes because their main effort is focused on mitigating visual defects, which are likely to raise warranty claims and cause occupant dissatisfaction in the short term (Tofield, 2012, Auchterlounie, 2009). On the other hand, defects that impair the ability of buildings to achieve the expected thermal performance quality criteria, such as the discontinuity of the insulation layer or gaps in the vapour/air barrier which allow undesired air permeability, are often taken for granted as an acceptable outcome of the construction process (Tofield, 2012). According to recent studies (NEF, 2016, Palmer et al., 2016, Wingfield et al., 2011, Bell et al., 2010), the impact of defects on the energy performance of buildings are undeniable. For instance, Bell et al. (2010) found that the overall heat loss in new-build homes in the UK was 54% higher than predicted, often due to poor installation of the buildings fabric. Similarly, NEF's report on energy performance of social housing projects (NEF, 2016) indicated that up to 67% of buildings surveyed failed to meet the expected external walls U-values and air permeability rates.

However, implementing QMS in the construction sector has often proved challenging. The challenges emerge from the nature of the construction industry itself, where projects are one offs and implemented in unique circumstances, including a high level of organizational and technical complexity (Jraisat et al., 2016, Tofield, 2012, Kanji and Wong, 1998). Many standardized QMS, such as ISO 9001 (BSI, 2015) and PMBOK (Project Management Institute, 2001) have been deployed by construction companies, in order to obtain higher quality levels. However, researchers such as Jraisat et al. (2016), Karim et al. (2005), Landin (2000) and Moatazed-Keani et al. (1999) have questioned the compatibility of standardized QMS within the construction industry, suggesting that such solutions often do more harm than good. The researchers claim that the introduction of these standardised QMS result in excessive bureaucracy and lacking focus on specific issues that vary from project to project, such as the technical characteristics, statutory requirements and procurement routes in terms of assignment of responsibilities.

Issues that the construction industry has yet to master include the understanding that the consistency of quality programmes outcomes are closely related to a successful identification of a project's core requirements and quality objectives within the planning stage of quality programmes (Jraisat et al., 2016, Briscoe et al., 2004, Juran, 1993). Construction projects often fail to identify the project's core requirements and quality objectives, thus undermining the progress of subsequent stages of the quality management process. The focus on client needs and their perception of quality is central to plan quality management procedures, as suggested by the forefathers of modern quality management and standardised QMS. However, it needs to be taken into consideration that solely focusing on clients' appreciation of quality as the main quality indicator might not be enough (Auchterlounie, 2009). It must be considered that clients might lack sufficient technical knowledge to fully appreciate the expected quality outcomes of products as complex as buildings (Karim et al., 2005). Furthermore, the construction industry has yet to fully appreciate that project quality plans should be part of the working packages in the tendering process of projects, in order to allow the bidders to fully understand which quality requirements need to be achieved and how to comply with the requirements in terms of content, format and appropriate timing (Forcada et al., 2017, Alencastro et al., 2016, Harris et al., 2013). As a consequence, all too often conflicts of interests occur when project quality requirements are established solely by the main contractor on construction projects, without the active participation of the clients and the supply chain (Lai et al., 2002, Landin, 2000). According to Karim et al. (2005) and Moatazed-Keani et al. (1999), for the construction industry to address quality management issues, a better understanding of the framework needed for an effective quality programme planning must be developed.

Studies on organisational effectiveness of standardised Quality Management Systems, such as Karim et al. (2005) in Australia, Landin (2000) in Sweden and Moatazed-Keani et al. (1999) in the UK provide significant evidence of the lack of success on achieving desired quality outcomes. According to Karim et al. (2005), the main negative aspects of the implementation of ISO 9000 reported by stakeholders of construction companies were: the increase of paperwork (95%), bureaucracy (87.7%), increased cost (53.2%), reduced operational flexibility (40%) and staff dissatisfaction (39.7%). An important finding of this study is the lack of consistency in terms of final quality outcomes and the reduction of quality defects. The majority of the surveyed companies presented varying quality results in their projects without any discernible pattern. Similar findings were stated by Landin (2000). It was observed that the increased bureaucracy also has the potential to stifle managerial and technical innovation. Moreover, the respondents of this study, team leaders and employees of 12 construction companies, regarded ISO 9001 as too difficult to understand, too comprehensive and generic to provide proper support in the project level.

As a result according to the aforementioned studies, constructions companies tend to find more effective to develop their own quality management procedures, structured according to the companies principles and quality policies. In addition, these quality management procedures can be tailored to specific technical characteristics of projects, taking form of a formal or informal Project Quality Plan. Nevertheless, acquiring certification of a standardised QMS such as ISO 9001 is still a common practice in the construction sector, at least in the high management level of the companies. It counts as prequalification for government projects and renders credibility and reputation towards clients and other companies of the sector (Karim et al., 2005, Quazi et al., 2002).

2.3.2 Project Quality Plans in construction projects and its categories

Studies in quality management suggest that the key success factors of quality programmes are related to their ability to deal with the uniqueness of construction projects, as well as the fragmented and adversarial nature of the construction industry (Hoonakker et al., 2010, Saad and Siha, 2000, Kanji and Wong, 1998). In that sense, the development and application of Project Quality Plans enable the incorporation of not only the technical characteristics of projects but also provide the opportunity to include other stakeholders such as the client, consultants and the supply chain (Chan et al., 2004, Landin, 2000).

As a result, Project Quality Plans are developed for an individual project. According to Harris et al. (2013) and Landin (2000), quality plans are negotiated for each project separately, being highly dependent on the requirements of the client, the adopted procurement route and the nature of the project. However, they have to abide to quality policies and rely on a structure that, that either formally or informally, entails the basic concepts of the theoretical framework of quality management.

Established research, such as Harris et al. (2013), Kanji (1996) and Juran (1993), has shown that the uptake of such framework entails the definition five key categories:

- Quality requirements;
- Quality risk assessment;
- Quality resources assessment;
- Quality metrics and control;
- Quality compliance.

Although these five key categories are presented as a sequence of logical processes of the Project Quality Plan, Jraisat et al. (2016) and Chan et al. (2002) state that due to the complex nature of the construction projects, these stages are not to be understood as clear cut and are not expected to follow a neat chronological sequence. As a project unfolds, some of these categories might be revisited, altering the dynamic of the development and implementation of Project Quality Plans.

2.3.2.1 Definition of quality requirements

The definition of the quality objectives entails the recognition of the relevant functions and performance attributes of the resulting building which will be pursued by the Project Quality Plan (BSI, 2015, Harris et al., 2013). In that sense, the identification and understanding of the requirements of clients, occupants, statutory authorities and regulators are key to develop and implement quality plans which help to deliver the expected quality standards (Jraisat et al., 2016).

Studies undertaken by Karim et al. (2005) and Briscoe et al. (2004) investigated client-led approaches towards the integration of the construction supply chain and improvement of quality management programmes in projects in Jordan and the UK. The studies point to the active participation of clients as the central driver of the process of defining quality objectives and consequently forming the basis for the other categories of Project Quality Plans. However, researchers such as Ahzahar et al. (2011), Auchterlounie (2009) and Landin (2000) found in studies regarded to the implementation of quality assurance procedures and resulting quality outcomes that clients’ requirements can be often complex and expectations uncertain, leading to undesired amount of changes and misinterpretation along the projects process. In addition, the researchers also state that clients may not be fully aware of the technical aspects of requirements and often fail to follow up the demands made, due to lack of managerial consistency.

On the other hand, the process of quality requirements definition led mainly by contractors present potential conflict of interests. According to studies undertaken by Tofield (2012) in the UK and Landin (2000) in Sweden on the application of quality programmes, contractors tend to focus on visual and perceptible defects that may become complaints, resulting in cost and compromised reputation during the twelve months of liability period of which they are responsible for corrective measures. Love and Edwards (2004a) also state in a study on the determinants of rework in construction projects that contractors tend to concentrate efforts of quality assurance procedures on post completion, confirming that quality objectives are mainly focused on visible defects at the end of the construction process.

In addition, although there is a specific Project Quality Plan category regarded to quality compliance in terms of practical procedures towards a number of key stages of design and constructions phases, the quality requirements category also refers to how defined objectives should be complied with in a formal fashion as a result of the application of the Project Quality Plan (BSI, 2015, Lester, 2014, BSI, 2011). In that sense the preliminary definition of the quality compliance procedures is vital for the tendering process. Bidders should know what is expected from them in terms of the quality standards and compliance procedures, in order to be able to factor in the necessary resources for the development and implementation of the quality assurance framework embedded in the Project Quality Plan (Jraisat et al., 2016, BSI, 2011, OGC, 2007).

2.3.2.2 Quality risk assessment

The risk assessment process is regarded to the identification of threats and opportunities that may influence the development and implementation of Project Quality Plans. Thus, the risk assessment process has an impact on the achievement of the defined quality requirements (BSI, 2015, Project Management Institute, 2001). This process should also explore managerial and technical issues that might lead to the occurrence of quality defects. As a result, it establishes priority in terms of addressing to major risks and set guidelines for prevention of undesired non-conformances or faulty managerial practices.

In that sense, Ruparathna and Hewage (2015), Briscoe et al. (2004) and Kanji and Wong (1998) suggest that the risk assessment processes should enable the participation of all parties which could impact or be impacted by the projects process. This collaborative approach aims to allow input regarded to potential risks emerging from the perspectives of different project stakeholders. However, the findings of studies such as Gorse et al. (2012), Karim et al. (2005) and (Quazi et al., 2002) suggest that the general practice of risk assessment to be otherwise. In a study examining the impact of defects on the energy performance of 25 dwellings in the UK, Gorse et al. (2012) concluded that the absence of important project stakeholders in the early stages of the projects, undermined the recognition of recurring defects affecting the thermal performance of the dwellings that could have been avoided during the design and construction processes. In studies exploring key success factors for the implementation of quality management systems, Karim et al. (2005) and Quazi et al. (2002) found similar results. The researchers found that the lack of participation of key stakeholders during the definition of quality assurance procedures and risk assessment resulted in greater occurrence of defects which could be avoided otherwise.

Apart from the issues entailed by the lack of input and participation of key stakeholders, other studies focused on the identification of risks to the achievement of expected quality objectives. For instance, Battikha (2008), Atkinson (2002) and Josephson and Hammarlund (1999) exploring the connections between quality management procedures and the occurrence of defects in the construction sector in Canada, UK and Sweden investigated the sources of information used in risks assessment processes. The studies concluded that risk assessment processes relied mostly on the participants' experience and level of awareness, rather than the use of a structured approach based on lesson learned from previous projects or the support of an organised defect database. Atkinson (2002), Holt et al. (2000) and Josephson and Hammarlund (1999) focused on the risks related to managerial issues of the construction process. With similar findings these researchers stated that due to poor communication between the supervisory teams and the workforce the level of awareness of quality requirements and recurring defects was affecting the achievement of the expected quality. In regard to technical issues, Josephson et al. (2002) and Love and Li (2000) stated that 55% of the defects identified in their studies were originated due to poor workforce's technical knowledge and capability.

2.3.2.3 Quality resources assessment

The quality resources assessment explore the identification and provision of essential resources to develop and implement Project Quality Plans (Harris et al., 2013, Juran, 1993). According to the propositions of ISO 9001 (BSI, 2015) at this category of Project Quality Plans, the organisations involved in the project need also to establish the roles and responsibilities among the project participants in terms of who is responsible to undertake and exert the authority over each of the stages of the implementation of the quality program. In that sense, the capability of those involved, the financial resources and possible external support required must be assessed.

In terms of the allocation of necessary resources in order to enable the achievement of quality objectives through the application of the quality plan, researchers such as Josephson et al. (2002), Kanji (1996) and Feigenbaum (1991) suggest three main stages in project process. The first one, denominated *prevention costs*, entails the cost of any activity involved in the identification and assessment of quality related risks, or spent in actions to prevent the occurrence of defects, such as upskilling of the workforce or managerial teams. The second one, *appraisal costs*, encompasses the costs of quality checking and monitoring, such as quality control activities. The last one, denominated *failure costs*, are regarded to remediation and correction costs. These cost can be attributed to reworks occurred during the construction process or post-handover.

According to Josephson et al. (2002), Kanji (1996) and Feigenbaum (1991), among the three stages of quality programmes that resources are allocated, only *failure costs* can potentially be avoided. By investing more resources on prevention, thus reducing the risks of the occurrence of defects, not only the costs of remediation can be dramatically reduced but also the costs of appraisal can be optimised. However, the studies of Auchterlounie (2009) focusing on the recurrent quality issues in the UK house building industry and Sommerville and McCosh (2006) investigating defects of 1,696 new houses in the UK, concluded that the majority of resources and emphasis of quality programmes were allocated in the appraisal and correction activities at practical completion of the construction process. This was due to the reactive approach of this sector of the industry to the clients' perceived quality, focused on visible defects. In addition, Brooks and Spillane (2016), Atkinson (2002) and Holt et al. (2000) agreed to the fact that the lack of resources allocated to preventive measures compromises the development of awareness about the quality objectives and recurrent defects to be avoided, impacting negatively in the achievement of the expected quality standards. Tofield (2012) and Kanji and Wong (1998) also state that the companies of the construction industry fail to acknowledge the mutual benefits of investing in the upskilling of managerial and technical capabilities of the workforce and supply chain.

2.3.2.4 Definition of quality metrics and control

The quality metrics category is the operational definition that describes, in specific terms, the quality requirement attributes and acceptance criteria (BSI, 2015, Project Management Institute, 2001). It also defines how the quality control procedures will assess these attributes, defining sampling approaches, adequate checking procedures and methods, as well as establishing milestones for monitoring quality and frequency of inspection (Harris et al., 2013).

Harris et al. (2013) states that the successful implementation of quality control procedures depend on the proper translation of quality goals into objective and measurable quality attributes and acceptance criteria. The more subjective the acceptance criteria is, the more variation on the final quality outcomes are to be expected. In that sense, under the perspective of energy performance of buildings, the performance attributes commonly adopted in statutory regulations such as the Part L1a of UK Building Regulations are the levels of building air permeability, overall and individual thermal transmittance (u-values) of building fabric elements, as well as the thermal conductivity of building elements (HM Government, 2013). These performance attributes are adopted as a translation of the required quality objectives, such as Carbon emissions rates in relation to the use of energy in new buildings and fabric energy efficiency rates. However, as pointed by researchers such as Johnston et al. (2015) and Taylor et al. (2013a) in studies assessing energy efficiency in domestic building in the UK, only air pressure tests implemented to assess air permeability are economically feasible to be applied on ordinary projects. Other tests such as co-heating tests and heat flux tests applied to assess performance attributes such as thermal transmittance and thermal conductivity are time and resources consuming. Alternatively, quality control activities such focus on the identification of quality defects recognised to undermine the achievement of the defined performance attributes (Gorse et al., 2012).

For this purpose quality control procedures are devised and implemented. Studies such as Johnston et al. (2014), Gorse et al. (2012) Sommerville (2007), Sommerville and McCosh (2006) and Josephson et al. (2002) focused on the drivers of rework in the UK housebuilding sector and Swedish domestic and non-domestic buildings, identified the need to develop quality checking tools to guide and support quality control procedures. For instance, Sommerville and McCosh (2006) whose study investigated the occurrence of defects in 1696 new dwellings in the UK, concluded that the lack focus of quality checklists in the identification of specific quality issues contributed to the occurrence of recurrent defects throughout the investigated projects.

Standardised quality management frameworks such as ISO9001 (BSI, 2015) and PMBOK (Project Management Institute, 2001) also suggest that in addition to the use of quality checklists it is equally important that quality inspections are planned and implemented according defined frequency and iteration. The efficacy of the use of quality checklists are dependent to the consistency of quality control inspections (Tofield, 2012, Atkinson, 2002). Atkinson (2002) whose study focused on the pathology of building defects in the UK housing sector, states that the lack of consistency of quality inspections, leading to overly distant quality control activities during the construction stage can mask the identification sources and origins of defects. Thus, undermining the recognition of defect generation mechanisms which compromises the prevention and remediation of quality issues. In that sense, the ISO9001 framework also suggests that the quality monitoring should take place at appropriate timing regarding key stages of the project process where defects affecting the achievement of quality objectives are more likely to occur.

2.3.2.5 Quality compliance procedures

The quality compliance procedures aim to define how the monitored quality attributes and the achievement of quality requirements will be reported and communicated to the project participants. It also entails setting the procedures for the analysis of the results which will help to formulate corrective actions and potential improvements for the following processes within the current project and for the subsequent projects (BSI, 2015, Battikha, 2008).

The culminating point of the implementation of quality control procedures is determined by the process of reporting and communicating the attained levels of quality to the interested parties. For such, a structured approach is needed to allow that the quality results reported can be properly analysed and tracked whenever more information is required from specific aspects or parts of the assessed building elements. According to Harris et al. (2013) and Griffith and Watson (2003), the quality results can usually be reported by means of documents, such as quality reports, quality checklists and performance reports (e.g. air pressure tests results). In respect to quality issues impacting the thermal performance of buildings, the established procedures for quality compliance are strongly reliant to how quality control activities and tools investigate defects impacting on the thermal behaviour of building fabric. Gorse et al. (2012), Tofield (2012) and Bordass et al. (2001) explored the recurring quality issues in residential and non-residential projects in the UK. These studies identified that the persistent occurrence of quality issues affecting the thermal performance of buildings are linked to the lack of focus and awareness of projects stakeholders on these specific type of defects, especially during risk assessment and quality control activities.

The adoption of a pre-defined method of reporting quality should entail aspects such as format (i.e. type of document and template), scope of assessed building elements included in the report, and the specific timing when the quality compliance document needs to be made available to project stakeholders. Jraisat et al. (2016) suggests that failing to observe one or more of those aspects can severely undermine the analysis and comparability of the quality results reported. This study also states that construction projects are often lacking of uniform standard of reporting overall quality. Thus, incurring in a more subjective approach instead of relying on objective procedures of assessing the achieved quality levels of projects.

As a result of the analysis of the quality results, whenever non-conforming outcomes are identified, corrective measures should be implemented (Harris et al., 2013). According to the quality management framework suggested by standardised QMS such as ISO9001 (BSI, 2015), there are two levels of corrective measures. The first level is regarded to acting on the correction of defects during the ongoing processes of the current project, ensuring that the quality requirements of products or services are met (Gorse et al., 2012, Griffith and Watson, 2003). The second level takes into consideration a systemic approach. It focus on identifying the sources of defect genesis and acts on preventing the recurrence of specific quality issues in the Project Quality Plan and Quality Management System levels (Battikha, 2008).

As such, the forefathers of quality management (e.g. Deming (2000), Crosby (1996), Kanji (1996) and Juran (1993)) coined this process as *continuous improvement*, which is entailed by four main steps that summarises the quality control and compliance procedures. The first step is regarded to gathering the quality results. The second step focuses on identification and analysis of patterns of defect occurrences. The third step explores the root causes related to recurrent defects. Finally, the fourth step entails the development of preventive measures for ongoing and future projects, ensuring that the lessons learnt are properly shared and applied as a rich source of information as a way to promote continuous improvement of the achieved quality results.

2.4 Summary of findings

This chapter has provided on overview of literature regarding the characteristics and impact of defects on construction projects. It also summarises the existing knowledge on quality management in the construction sector.

The review on quality defects has shown that despite the number of studies investigating the characteristics and impacts of defects on strategic key performance indicators on construction projects, there is a shortage of studies and sufficient information to provide a full understanding of the specific defects origin mechanisms and their impacts on the thermal behaviour, and thus energy consumption of buildings. Additionally, although the theoretical basis for development and implementation of quality management frameworks are well established, there is a gap of knowledge in the specific challenges regarded to achieving quality objectives related to the thermal performance of dwellings.

Therefore, in order to address the identified knowledge gap in regard to the apparent inability of conventional Project Quality Plans to drive the reduction of quality issues affecting the thermal performance in domestic projects including social housing, two main questions were formulated to drive the subsequent stages of this thesis:

1. Why, despite the number of quality management procedures applied in social housing projects, defects affecting the thermal performance of buildings are still occurring?
2. What are the necessary enhancements in Project Quality Plans to improve the thermal performance of social housing in the UK?

Chapter 3

Research methodology

3.1 Introduction

This chapter presents the research methodology developed and applied to this study, justifying the methods chosen in order to meet the research aim and objectives of this thesis defined in Chapter 1.

This chapter is divided in four parts. The first part presents the philosophic stances and research approach which underpin this research, explaining the epistemological considerations and the research strategies (sections 3.2 and 3.3). The second part describes the methodology implemented in order to collect the necessary data to achieve the research objectives (sections 3.4 and 3.5). The third part outlines the methods deployed to process and analyse the data collected and presents the method applied to validate the research outputs and contributions (sections 3.6 and 3.7). Last part provides a brief summary of this chapter (section 3.8).

3.2 Research Philosophy

Research practice is determined and influenced by the researcher's understanding of the world. Creswell (2013) coined the term *worldview* as the basic set of beliefs that guide action. To the researcher, the worldview is the general philosophical orientation about the world and the nature of research that a researcher brings to a study. According to Robson (2011), this set of beliefs should define the way data from a specific phenomenon will be collected, analysed and used. The types of beliefs held by individual researchers will define the type of research approach undertaken.

Even though the researcher's philosophical orientation may remain hidden in the research, it still needs to be identified as it strongly influences the definition of the research approach and methodology. Gummesson (1991) states that no researcher is capable of achieving absolute truth or point of view from a studied phenomenon, therefore the specific philosophical stance must be declared by the researcher so scientific rigour can be assured. Stating the philosophical stance undertaken in a research project and explaining how it leads to an adequate methodology is of major relevance in a doctoral research project (Remenyi, 1998). According to Easterby-Smith (2002) understanding the "philosophical issues" helps researchers to clarify which research designs are suitable to the research problem, to identify the type of evidence is needed, as well as how to gather and interpret data. Moreover, the researcher states that the knowledge of research philosophies also allows researchers to adapt research designs according to specific demands or constraints.

In that sense, it is vital to understand specific demands and characteristics of the defined research problem. According to Sekaran (2013) and Gummesson (1991), researchers exploring management of operations involving multiple organisations must pay a special attention to the social interactions involving key stakeholders. To the researchers these interactions underpin the decision-making process related to the definition of objectives, allocation of resources and establishment of management practices in the operation level. Mogendorff (2016) and Zheng et al. (2016) for instance, identified in recent studies that the management of construction projects is grounded in network-based organizational collaboration. Given this key aspect to be explored in studies investigating management phenomena such as this research, researchers such as Bryman (2012) and Robson (2011) state the application of social research principles provides the methods which enable researchers to investigate and to explain management phenomena from the perspective of social interactions. The use of social research can help to explain actual management structures in construction projects, identifying the key characteristics of a construction project organisation, exploring the potential threats to the achievement of the projects goals (Zheng et al., 2016). Moreover, social research helps to explain the intricacies of project management as a live process, relying on the project participants' experiences, rather than solely focusing on the final results.

For that reason, it is vital to acknowledge the different fields of research philosophies when defining the design of scientific research. According to Bryman (2012), the major philosophy branches in social research are ontology and epistemology. In short words, ontology focuses on the assumptions the researchers make about the nature of reality or a phenomenon, while epistemology explores the general set of assumptions about the best ways to enquire the nature of reality or a phenomenon (Bryman, 2012, Thorpe, 2004, Easterby-Smith, 2002).

In attention to the aims of this research, the most pertinent philosophical assumptions to be addressed are the ones related to epistemological basis. The epistemological fundamentals relate to the aspects of procuring knowledge, particularly with regards of the methods applied and the reliability of the research design. The epistemological positions which dominate construction management and social research are positivism and interpretivism (Cooper, 2014, Bryman, 2012, Gummesson, 1991).

The positivism approach is a descriptive category which advocates the application of natural sciences methods where science must be conducted free of personal values, in an objective way (as opposed to subjective) without relying on sensation, reflection or intuition (Easterby-Smith, 2002). Bryman (2012) states that the doctrine of positivism is very difficult to outline in a precise manner because it is being used in a number of different ways by scholars. However, the researcher suggests that the most usual purpose of this epistemological position is the generation of hypothesis based on existing theories, which can be tested and therefore contribute to current knowledge. In contrast, the interpretivism approach uses a more personal interpretative process applied to understanding reality or phenomena within social science (Gummesson, 1991). Also referred as constructivism and hermeneutics, this doctrine seeks to determine "reality" through people perceptions and experiences as a result of their social interactions, rather than through objective and external facts (Easterby-Smith, 2002). In interpretivism, the task of the researchers is to understand the multiple social constructions towards a given phenomenon. Consequently, they ought to apply research methods such as interviews and observation which allow them to acquire multiple perspectives (Robson, 2011). The research participants' understanding of the phenomenon helps the researcher to construct the "reality" and therefore answer to the research key questions.

For the purpose of this research the most suitable epistemological stance was the interpretivism. The research presented in this thesis requires having an initial understanding of the intricacies of social relationships between construction projects stakeholders (i.e. clients, contractors, subcontractors, consultants and building control officers), as well as identifying the challenges they encounter when implementing quality management procedures.

In terms of the relationship between theory and data, there is as important question to be answered on which should come first (Figure 3-1). Researchers like Bryman (2012) and Easterby-Smith (2002) argue that the approaches around this question are the deductive and inductive theories. In the deductive approach, the researcher deduces a hypothesis regarded to a phenomenon, based on what is known about a particular domain of enquiry. This hypothesis entails the theoretical considerations of this domain which will be translated into researchable entities. Once data is collected and the findings are analysed, the hypothesis is confirmed or rejected, thus providing a revision of the existing theory (Bryman, 2012). In opposition, in the inductive approach the theory is the outcome of the research findings and discussions. The researcher draws inferences out of the research data analysis to formulate a theory which requires further testing and validation (Easterby-Smith, 2002). Bryman (2012) also states that the definitions of deductive and inductive strategies are not as clear-cut as presented. To a large extent the deductive approach entails elements of induction in its final step of confirming or rejecting existing theories; as deductive aspects can be used to inform the initial stages of the inductive approach.

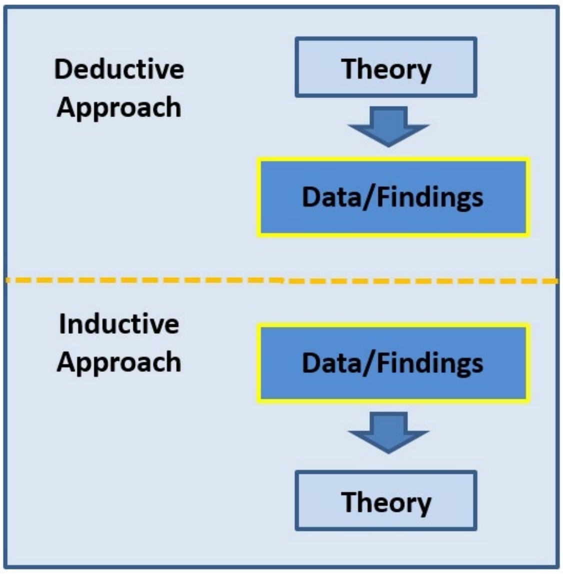


Figure 3-1 Deductive and inductive approaches (adapted from Bryman (2012))

According to Gummesson (1991), the rigidities of the processes inherent to positivism which tries to explain causal relationships within phenomena through objective facts and the detachment of the researcher, pose a challenge when studying social sciences. According to Thorpe (2004) and Easterby-Smith (2002), social sciences deal with human behaviour and social relationships which are led by feelings, perceptions and interpretations of the world, consequently, it is pointless to fit these complexities into objective theories or definite laws.

This research applied a deductive-inductive approach (Figure 3-2). In the initial stages of the research, the deductive stance was applied through the literature review, firstly, to inform the researcher in respect to the research domain and the definition of the research problem, establishing the context and scope of the study; and secondly, to assist the development of the initial conceptual tags embedded in the conceptual framework, guiding the process of data collection and analysis (research design). The inductive approach was applied in the process of revising and validating the data collection protocol and later, drawing inferences from the collected data in order to code and group data into categories within conceptual tags, which in turn form the conceptual framework. The inductive approach was also used in the development of the empirical model, which explains the targeted phenomenon by identifying the challenges encountered in the case studies in the process of developing and implementing project quality plans. In addition the inductive approach was applied in the proposition of actions to overcome the identified challenges and the development of the final recommendations.

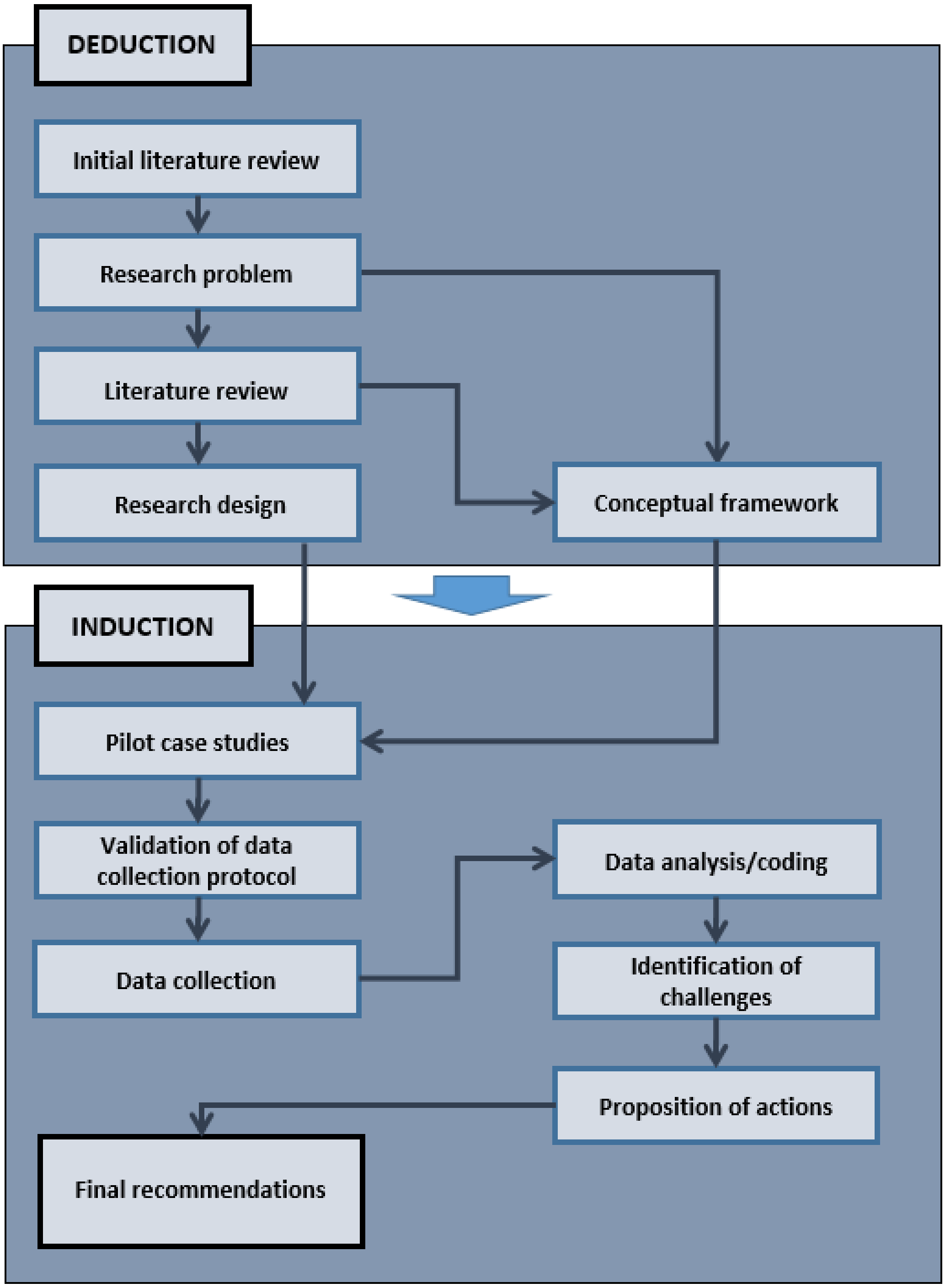


Figure 3-2 Deductive and inductive flow diagram

3.3 Research approach

3.3.1 Qualitative research

When undertaking research it is important to choose an adequate methodology, which allows and ensures that the research aims and objectives can be met and the findings can be validated (Bryman, 2012). In that sense, the research nature, its objectives and the availability of resources will largely determine the research approach and design (Creswell, 2013).

The research methodology review suggested different types of methods such as experiment, case study, archival analysis, action research and process modelling (Creswell, 2013, Bryman, 2012, Yin, 2009). These different types of research strategies can be grouped into two classical epistemological approaches: qualitative and quantitative research.

These two research strategies differ from each other in their epistemological foundations, in terms of their adopted relationships between data and theory (deductive-inductive) and their stances on the epistemological considerations as discussed in the previous section. The contrasts are basic, nevertheless fundamental ones (Table 3-1).

Table 3-1 Qualitative x Quantitative approach (adapted from Easterby-Smith (2002))

	Qualitative approach	**Quantitative approach**
The researcher	Experiences the phenomena observed	Must be independent
Explanations	Aim to increase general understanding of the phenomenon	Must demonstrate causality
Research progress through	Gathering rich data from which concepts are induced	Hypothesis and deductions
Concepts	Should incorporate stakeholders perspectives	Need to be operationalized so that they can be measured
Unit of analysis	May include the complexity of the 'whole' phenomenon	Should be reduced to the simplest terms
Sampling requires	Small numbers of cases chosen purposively for specific reasons	Large numbers selected randomly
Generalization through	Theoretical abstraction	Statistical probability

The quantitative strategy is a research approach that is used for testing objective theories, where the quantification of the study variables is emphasized (Creswell, 2013, Bryman, 2012). This strategy entails a deductive approach which leads to fairly four discrete stages in the research process (Easterby-Smith, 2002). The first stage encompasses the process of deducing hypotheses from the existing theories where variables will be identified and used in the following stage of data collection. In the data collection stage the procedures and protocols must be administered in the same way in a rigorous manner where the researcher must keep a safe distance from the respondents or subjects in order to avoid bias. The data analysis stage should be conducted in a separate time and place from the data collection process and usually employ statistical methods of analysis. The final stage implies the confirmation or rejection of hypotheses previously assumed. In this research approach the findings can be replicable and generalised to a greater population due to the statistical robustness and the objectivity employed in the process (Creswell, 2013, Easterby-Smith, 2002).

In contrast, the qualitative strategy emphasises the generation of theories based on an inductive approach exploring the understanding and meaning that an individual or a group assign to a social phenomenon (Gummesson, 1991). Differently from the quantitative approach, in this strategy there is no evident separation between the different stages of the research. According to Easterby-Smith (2002) once the research problem is identified, it is possible to experience a more interactive process between data collection and analysis where understandings and findings from the initial data collection procedures can be incorporated in future iterations in order to explore emerging ideas. Thus, a more flexible research approach is required. In that sense, data collection strategies such as semi-structured interviews are recommended. As stated by Easterby-Smith (2002) “it is perfectly legitimate to change questions asked as a consequence of the information gained”. However, despite the enquiry tools should be flexible, a research protocol should be developed and rigorously followed in the way of how and from whom information is collected, recorded, treated and catalogued so the research procedures can be reproduced in later iterations (Yin, 2009, Easterby-Smith, 2002). Within the qualitative strategy, the theory emerging from the inductive approach can be only generalised, provided appropriate testing, to similar research units and phenomena alike, being this process referred by scholars as analytical or theoretical generalisation (Yin, 2009).

Due to the dynamic and diverse nature of the construction sector, in addition to the complexity of the quality management process involving a wide range of stakeholders, the qualitative approach was adopted for the research design.

To achieve this thesis objectives, a series of qualitative research methods were employed and they are further explained in section 3.5. These research methods, which are the techniques used to collect and analyse data (Yin, 2009), were applied within different case studies and involved methods such as semi-structured interviews, collection of quality management documentation, observations and construction defects surveys. As the literature review suggests, these are the main research methods that have previously been used in quality management studies (Tofield, 2012, Wingfield et al., 2011, Hoonakker et al., 2010, Auchterlounie, 2009, Bell et al., 2005, Landin, 2000)

Table 3-2 shows how the thesis' research questions have guided the choice of research methods to generate qualitative data.

Table 3-2 Data required for the thesis research questions

RESEARCH QUESTION	OBJECTIVES	RESEARCH METHODS
Q1. Why, despite the number of quality management procedures applied in social housing projects, defects affecting the thermal performance of buildings are still occurring?	Identify and examine the challenges encountered in a sample of UK social housing projects in the implementation of quality management procedures which prevent their new-build projects to reach the expected thermal performance levels.	Literature review Semi-structured interviews Quality management documentation Observations Defect identification surveys Grounded theory analysis
	Examine the limitations of existing quality assurance frameworks, formal and informal quality programmes, applied to help organizations to deliver thermally-efficient housing according to performance specifications.	Literature review Semi-structured interviews Quality management documentation Observations Defect identification surveys Grounded theory analysis
Q2. What are the necessary enhancements in Project Quality Plans to improve the thermal performance of social housing in the	Provide the construction industry with recommendations aimed at improving the implementation of Project Quality Plans with focus on the thermal performance of social housing projects in the UK.	Literature review Grounded theory analysis Focus groups

UK?	Provide recommendations to support policies and statutory regulations aimed at improving the thermal performance of social housing projects in the UK.	Literature review Grounded theory analysis Focus groups

3.3.2 Data collection approach

The current study is closely aligned with the explanatory design (Creswell, 2013, Bryman, 2012, Robson, 2011), in which qualitative data is used to identify and explore in detail a phenomenon.

This research chose the analysis of multiple case studies to explore and explain the challenges posed the process of development and implementation of quality plans with focus on the thermal performance of buildings in the UK social housing projects.

For the purpose of this study, five case studies of new-built social housing developments were selected. As the chosen methodology supports an analytical generalization rather than statistical approach, there is no necessity to use quantitative formulas for determining the quantity of cases which provides confidence for the generalization of findings or the internal variation. Yin (2009) states that for multiple case studies a minimum of two cases are needed, thus the number of case studies chosen in this study (five) is considered to be appropriate to be confident on the results. In addition, Bryman (2012) and Corbin and Strauss (2008) stated that the analytic induction process designed to seek the explanation of a phenomenon requires data collection until no new ideas and concepts emerge from the research iterations (data collection and analysis), stage known as theoretical saturation. The theoretical saturation of this research study was deemed sufficient in Case Study 4. However, one more case study iteration was undertaken, i.e. Case Study 5, in order to confirm that no new ideas and concepts other than the ones already acknowledged would emerge.

The case studies were located in three different regions in the United Kingdom, involved different construction methods and energy performance requirements, and the number of housing units per development varied from 28 to 121. During the data collection phase, the projects were in multiple stages of the construction phase. The detailed selection and description of the cases studies is presented in section 3.4.

The main method for data collection chosen for this research was semi-structured interviews with specific projects' stakeholders. According to researchers such as Bryman (2012) and Tracy (2013), the use of interviews is the most commonly applied method in qualitative research and allow the researcher to acknowledge and understand the aspects regarded to the studied phenomena through the eyes of the participant/interviewee, providing a different perspective other than researcher's own viewpoint. Whenever the researcher has a fairly clear identification of the research problem and formulated research questions and objectives the preferred interview type is semi-structured (Bryman, 2012). In this approach the investigator uses the questions as an interview guide. Creswell (2013) and Tracy (2013) state that the interview questions should cover predefined areas of interest. The researchers also stress the fact that the questions should be designed as open ended, allowing adequate leeway for the interviewee to articulate ideas. For this purpose, semi-structured interviews was chosen as the preferred method because it provides adequate means of obtaining a holistic understanding of the phenomenon targeted through the perspective of the projects' stakeholders. In addition, by using semi-structured interviews the researcher ensures a replicable structure through the list of questions which is necessary to ensure cross-case analysis and comparability.

Three interviews per project were undertaken with participants representing the housing association, the contractor and the quality officer responsible for the implementation of the quality management procedures. The aim of administering three interviews per case study was to obtain different perspectives on how the quality management plans were developed and implemented, providing a holistic understanding of the problem identified by the research questions.

In order to avoid biased conclusions resulting from the interviews, empirical investigations must rely on multiple sources of evidence, with data needing to converge in a triangulated fashion (Creswell, 2013) (Figure 3-3). For that matter, additional data was collected by means of: (i) quality management documentation (quality policy and plan, checklists, etc.); (ii) observations during management project team meetings and construction site visits; and (iii) construction defects identification surveys undertaken by the researcher during the construction process. These additional sources of information were used to confirm or to challenge the findings emerging from the semi-structured interviews and are described and detailed in section 3.5.

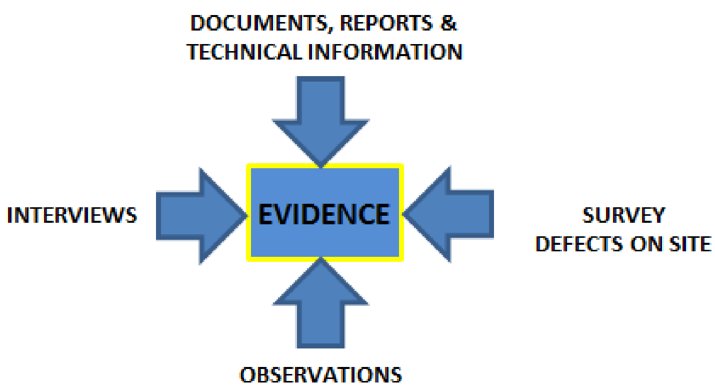


Figure 3-3 Data sources

According to Creswell (2013) and Bryman (2012), the use of (i) documentation for data collection is fairly one of the most heterogeneous sources of information. In that sense, the search for relevant documents which can contribute to a research can be time consuming and not a straight forward process (Bryman, 2012). The major advantage of this source of data is that they are non-reactive sources of information (Creswell, 2013). The chances of documents being biased by the researcher are insignificant, since the document was not produced for the purpose of the research. In addition, the information contained in documents is a reflection of the participants understanding or acknowledgement of specific facts or occurrences, as well as representing the underlying reality of an organisation (Gummesson, 1991). For the purpose of this research, documentation related to the quality management procedures used in the projects being analysed in the case studies were requested to the project team and reviewed by the researcher.

According to Creswell (2013) and Yin (2009) the use of (ii) observations for data collection allows the researcher to obtain information as it occurs, where unusual aspects or aspects which have not been acknowledged by researcher can be noticed. The observations can be used as an exploratory method to identify new concepts or ideas, indicating emerging concepts or interactions among the participants which cannot be explored through other data collection methodologies (Yin, 2009, Corbin and Strauss, 2008). Creswell (2013) states that there are three types of observations where the role of the researcher might influence the interaction: (i) the observer is a participant of the interaction but his/her role as a researcher is concealed; (ii) the observer is contributing in the interaction and his role as researcher is known to the others participants; and finally, (iii) the observer is not a participant of the interaction, however his role as a researcher is known to the other participants. For the purpose of this research, the third observation approach was implemented and therefore the participants of the managerial team meetings and site visits were aware of the presence of the researcher, who did not actively participated in the discussions and simply acted as an observer.

Finally, according to Yin (2009) and Robson (2011), the use of (iii) surveys in qualitative research are usually applied as complementary data source. The information gathered through this method helps investigators to substantiate or review predictive assumptions elaborated by the analysis of data collected by other sources (in this research, from semi-structured interviews, quality management documentation and observations). The main goal of the application of this method is to describe incidence or prevalence of occurrences within the phenomenon being investigated. Easterby-Smith (2002) also states that the use of the survey method in qualitative research is designed to translate predictions into actual facts, but not necessarily as a way to demonstrate frequency of occurrences.

For every data collection method used, data collection protocol and forms were specifically designed by the researcher to drive the data collection process in a structured manner. These can be reviewed in section 3.5.

3.3.3 Data analysis approach

In terms of the data analysis in qualitative approach, researchers such as Bryman (2012), Partington (2000) and Miles (1979) state that treating and interpreting data is not a straightforward process due to the large amount of unstructured textual material deriving from interviews transcripts, observations memos and documents. Miles (1979) described data analysis in qualitative approach as an “attractive nuisance”. If on one hand a researcher can be attracted by the richness of information provided by the large amounts of data, on the other hand it is difficult to find analytic paths through the thicket of data. Creswell (2013) and Bryman (2012) stress that an unambiguous set of rules and procedures must be adopted in the process of handling, analysing and also interpreting the findings deriving from data, if a meaningful significance of research contributions are to be achieved. For this purpose, the adopted data analysis methodology in this research is Grounded Theory.

This methodology entails the explanation of a phenomenon, through the development of a theory grounded in data, which was systematically collected and analysed (Corbin and Strauss, 2008, Glaser and Strauss, 1967). In that sense, a framework based on existing knowledge was devised (section 3.3.3.1) providing the structure for systematic data analysis iterations, enabling cross-case analysis (Figure 3-4). Glaser and Strauss (1967) coined this process as *constant comparison* and it entails the process of keeping a close connection between the concepts which emerged from the coding of data to the key aspects found in existing knowledge which formed the tags of the conceptual framework. It also entails that the established framework set the categories by which case studies were analysed against each other as a way to establish patterns of causal relationship among concepts part of the conceptual tags, which in turn aimed to explain the studied phenomenon through the development of an empirical model (section 4.7).

Following the data analysis procedures proposed by Grounded Theory, the first method implemented was coding the data. As previously stated, the process of coding entailed the analysis of the transcripts of the semi-structured interviews, quality management documents and observation memos, where data was broken down and organized according to the established conceptual tags, as suggested by Bryman (2012) (Figure 3-5). At this first stage of coding (called Open coding), data from each case study was conceptualized and categorised by means of constant comparison to the conceptual framework separately from other cases (Strauss and Corbin, 1990). The initial list of codes or labels by which data was categorised were developed through key aspects identified in the literature review, as recommended by Robson (2011), Bryman (2012) and Corbin and Strauss (2008). However, Stall-Meadows and Hyle (2010) recommend that the researcher should keep an open mind for different codes that might emerge during this first iteration.

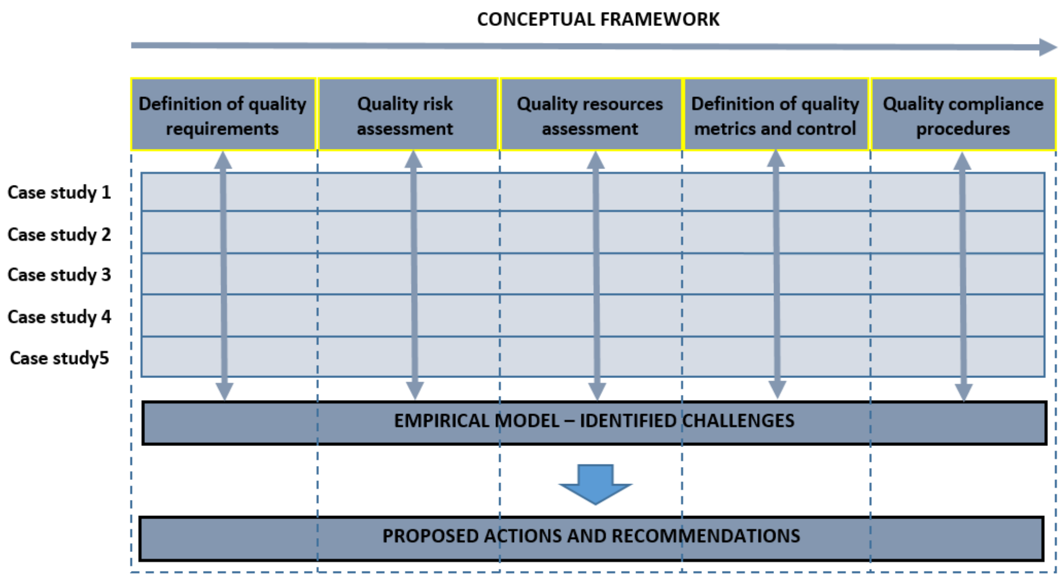


Figure 3-4 Conceptual framework and constant comparison

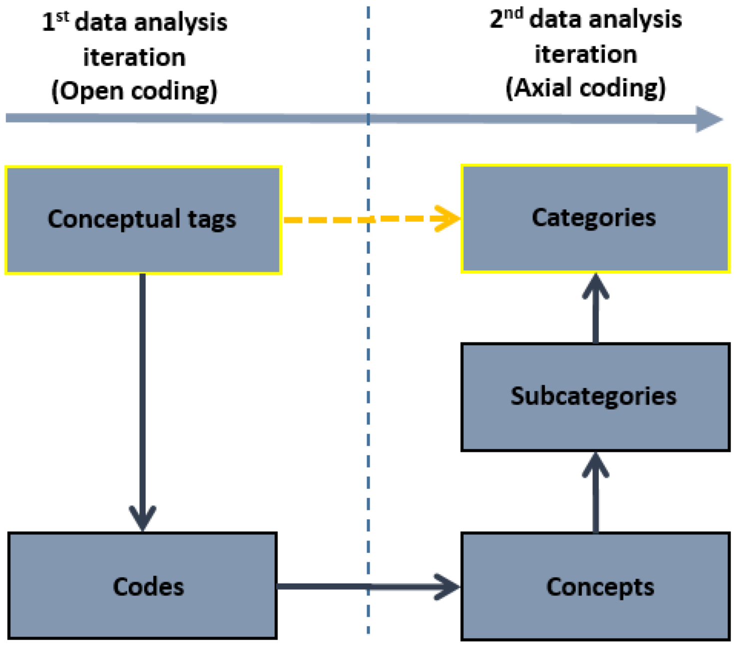


Figure 3-5 First and second iterations of data analysis

In terms of the practical application of the process of open coding phase, this study adopted the traditional approach where coding was undertaken by reviewing semi-structured interviews' transcriptions and the additional sources of data, where sections of the text were highlighted and reorganised according to the defined list of codes, without the use of software such as NVivo. The decision of not using the support of software in coding process was due to the fact that the number of interviews were manageable within the available timespan for data analysis. And most importantly, due to the fact that researchers such as Bryman (2012) and Fielding et al. (1998), state that the use of software for coding often result in over fragmentation of textual material and loss of context, which in turn undermines the process of defining the causal relationships among concepts.

The second iteration of data conceptualization is known as Axial coding. In this iteration the scope of analysis was expanded from a single case investigation against the framework to a cross-case analysis (Charmaz, 2006, Strauss and Corbin, 1990), where similar codes in terms of content and context were grouped into concepts (Figure 3-5). Moreover, at this stage the connections between different concepts, within and across conceptual tags, were established, underpinning the causal relationship between the identified concepts (Corbin and Strauss, 2008, Partington, 2000), which in turn helped to explain the phenomenon targeted by the research questions. Once concepts and their causal relationships were established the conceptual tags became the different categories which formed the empirical model.

The third iteration of data analysis, named Selective coding, aimed to identify core categories of concepts around which all other categories were integrated. Through the process of selective coding a storyline was revealed (Charmaz, 2006, Strauss and Corbin, 1990), framing the analytical account which explained the main sources of the challenges found in the case studies, in regard their processes of implementing quality procedures to prevent and correct thermal performance related defects.

Encompassing the principles of multiple case-studies' methodology stated by Yin (2009) and Creswell (2013), key concepts emerged by merging similar codes. Secondary sources of data, i.e. quality management documents, observations and defect identification surveys, were then used as a way to confirm or challenge the proposed populated conceptual framework. Moreover, the secondary data source also helped to establish the causal relationships between concepts and categories, providing the necessary context. The triangulation of data was implemented in order to substantiate and provide robustness to the development of concepts, categories and their inter-relationships. As a result the empirical model which explains the phenomenon studied was developed through the identification of challenges encountered in the process of developing and implementing projects' quality management procedures.

As per the final contributions of this research, the establishment of the empirical model highlighted the process by which the challenges to implementing project quality plans with focus on thermal performance were generated. Using these key aspects identified in the empirical model as a starting point, the proposed recommendations were formulated by addressing these issues in form of action guides. This actions were grouped according to the structure of the conceptual framework, based on the sequential stages of developing Project Quality Plans devised from the literature review.

3.3.3.1 Conceptual framework

According to Miles and Huberman (1994) and Creswell (2013), a conceptual framework in qualitative research is the orienting ideas which guide the data collection and analysis processes. In that sense, the establishment of the conceptual framework is always dependent on the research problem, scope and objectives.

For scholars, such as Glaser and Strauss (1967) and Stall-Meadows and Hyle (2010) which defend a more purist stance, researchers on qualitative research should rely on an exploratory approach, where new concepts can be identified, unbiased by previous knowledge. However, Miles and Huberman (1994) argument that no matter how unstructured and inductive the research approach is, the investigator always, consciously or unconsciously, bring his own pre-concepts and background knowledge to the process of collecting and analysing data. Corbin and Strauss (2008) also state that whenever the researcher has a clearly defined problem and scope, the use of a conceptual framework based on existing knowledge provides insights and direction in the definition of the data collection and analysis methods. As such, for the purposes of this research, the conceptual framework proposed was devised as the sequential process of development of quality plans for construction projects. It is based on the research problem, questions and objectives where key aspects of existing knowledge identified in the literature review were represented by means of conceptual tags.

According to Miles and Huberman (1994) conceptual frameworks are formed by conceptual tags, which are “a sort of anticipatory data reduction”. These tags or “bins” which were deducted from theory, served as clusters of information, orienting data collection and enabling the analysis of related data obtained from multiple case studies. This structure helped the organisation of the data coming from different sources, and later providing a frame for the analysis iterations (Robson, 2011).

The conceptual tags were identified through the literature review. Five tags were established and they represent the key stages of the process of planning and implementing quality in construction projects (section 2.3.2):

1) Definition of quality requirements;
2) Quality risk assessment;
3) Quality resources assessment;
4) Definition of quality metrics and control;

5) Quality compliance procedures.

The development of the conceptual framework and its conceptual tags were used to define the nature and type of information needed from the case studies and the methods by which data was collected and analysed. Moreover, the concepts which populated the tags and the establishment of their correlations paved the way for the establishment of the empirical model.

3.3.4 Research process

This section provides an overview of the research process used for the thesis data collection, processing and analysis. It involves three stages: (i) define, design and prepare; (ii), collect and analyse; and (iii) analyse and conclude (Figure 3-6).

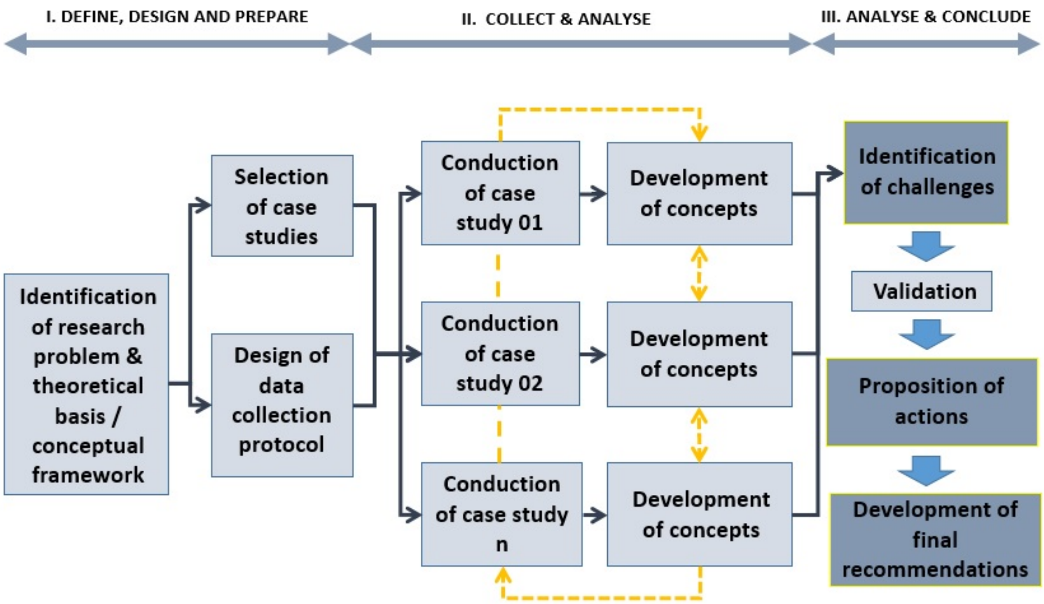


Figure 3-6 Overview of the thesis research process

Stage I. Define, design and prepare is where the research problem was identified along with questions and objectives, and when the research strategies were established in order to link the data to be collected to the research aims. The research design also determined the logical sequence that connects the empirical data to the research questions and the fulfilment of its objectives, through the application of adequate methods of data collection and analysis (Yin, 2009). The main idea was that the key findings of each of the case studies could be grouped and analysed using the theoretical basis as a conceptual framework, establishing patterns of causal relationship through several data analysis iterations, also known as constant comparisons (Bryman, 2012). This conceptual framework was developed combining an extensive critical review of the state of the art literature in the research topic, focusing on quality management in construction projects and the effect of defects in the thermal performance of buildings.

Also in this stage, the case studies selection criteria were defined based on the context and likeliness of the cases towards the research topic, the availability of data, the locality and limitations of the research project resources (section 3.4).

To collect data in an appropriate fashion, data collection protocols were designed in order to assure the reliability and validity of the findings. According to Yin (2009) data must be collected from multiple sources avoiding biased information that could affect the case studies analysis. In that sense, data was collected from semi-structured interviews (three interviews for each project with stakeholders representing the housing association, the contractor and the quality officer), documents related to quality management (quality policies, checklists, etc.), observations from management meetings and site visits and from defects identification surveys undertaken by the researcher during the case studies' construction process. For each of the data sources a specific data collection procedure was developed (section 3.5).

The stage II. Collect and analyse entailed the processes of collecting and analysing the data deriving from the case studies simultaneously, where each iteration of data collection procedures were informed by previous data analysis, as oriented by Grounded Theory (Bryman, 2012, Corbin and Strauss, 2008). The data collection process took place in the stages of the design, pre-construction and construction of the case studies. The regime of data collection was undertaken until the no new relevant aspect of the targeted phenomenon was provided, where data collection has reached theoretical saturation (Bryman, 2012). Concluding this stage, data analysed from the semi-structured interviews was distilled into concepts grouped within the tags of the conceptual framework.

The stage III: Analyse and conclude consisted on the crossed analysis between the concepts emerging from the interviews data analysis and the secondary sources of data (i.e. quality management documentation; observations of management project team meetings and construction site visits; and construction defects surveys). As a result the empirical model emerged, establishing the relevant challenges found in social housing projects in the development and implementation of quality plans with focus on the thermal performance of dwellings.

Hence, the identified challenges were discussed against previous studies related to quality management in construction projects and the effect of defects on the thermal behaviour of buildings. The discussion brought the analysis of the research results to the strategic level where guidelines to the quality assurance process were devised. In that sense, a list of actions were proposed in order to address the challenges and help social housing projects to achieve the desired thermal performance.

The validity assessment of the academic contribution as per the identification of challenges to the process of implementing quality plans was achieved by means of the administration of 3 focus groups (section 3.7). During the focus groups the identified challenges were presented and discussed with the participants. The feasibility of the analytical generalisation of the phenomenon explanation (challenges) was validated. Suggestions and remarks which emerged during the process of validation through the focus group were discussed in Chapters 5 and 6.

3.3.5 Reliability and validity

According to researchers such as Creswell (2013), Bryman (2012), Robson (2011) and Easterby-Smith (2002) the two most important criteria used for evaluating social research are reliability and validity.

Reliability reflects the concern of whether the research results are repeatable. It refers to the consistency of the measurement procedures to provide similar results if the research design and methodology should be repeated by another investigator (Bryman, 2012). Easterby-Smith (2002) states that since qualitative social research "construct" reality by explaining a phenomenon, which is constantly changing and is based on personal and individual assumptions of the social agents involved in the phenomenon, the likeliness of obtaining the exact same results when repeating the procedures of a previous study is low. For this reason it is important that the research design and methods are adequate in order to provide an accurate measurement of reality and to avoid bias. Overall, the data collection and analysis methods must be transparent, expressing plainly the logic which underpins the procedures adopted, especially when flexible research design is being employed (Robson, 2011, Easterby-Smith, 2002).

Validity is the process of evaluating the integrity of the emerging conclusions from a piece of research (Gibbs, 2008). Thus, the validity evaluation process should ensure that the research methods truly measure what was previously set to be measured and how truthful the conclusions are according to the available data. According to Miles and Huberman (1994), the use of case study methodology commonly encounter scepticism and validity issues due to possible lack of rigour and bias, where the conclusions are not supported by statistical generalisation. In order to counter these issues and establish a reasonable level of quality in empirical social research, Yin (2009) suggest the implementation of four strategies:

- Construct validity: relates to identifying during the research design and data collection stages the appropriate operational measures according to the concepts being explored, using multiple sources of evidence and establishing chain of evidence.

- Internal validity: this strategy regards to establishing causal relationships between two or more variables in study, by identifying patterns of cause and effect which will support explanation building of a certain phenomenon during the data analysis phase.
- External validity: refers to defining during the research design the domain to which the research findings can be generalised (e.g. to theory, to similar case studies, to a wider population).
- Reliability: relates to demonstrate that the research operations follow a data collection protocol where data collection procedures are clear and can be repeated in the same fashion. Additionally, it also ensures that the data collected is recorded properly and the information used in the research can be easily tracked to its source.

Following the strategies suggested by Yin (2009), and in order to ensure Construct validity, the research presented in this thesis adopted the employment of multiple methodologies, i.e. multiple case studies and grounded theory, due to the fact that no single method is always best for all situations within the study of a phenomenon and the use of multiple methods complement the strengths and weaknesses of each individual approach (Fellows and Liu, 2015, Patton, 2015). Similarly, the data collection strategy relied on multiple data sources (e.g. semi-structured interviews, project quality documentation and construction defects surveys) where evidences were established through triangulated data analysis.

Moreover, Internal validity was ensured by undertaking a chain of evidence, beginning with the findings of an in-depth literature review, followed by the multiple case studies analysis and constant comparison method between the findings of each case study. This approach allowed the triangulation of data within case studies individually and amongst them, providing the identification of key concepts of the process of defining and implementing quality management procedures and further the establishment of cause and effect relationships among these key concepts.

The triangulation of the literature review findings and case study results not only helped to build the phenomenon explanation (achieving research objectives), but also indicated that the research problem was not specific to the case studies undertaken is this research and can be experienced in other construction projects which are inserted in very similar context and conditions, ensuring External validity. However, within the context of this research, External validity could not be ensured to the list of quality management recommendations established to overcome the identified challenges. Yin (2009) states that the theory emerging from the research must be tested by two or even three new case studies, where similar keys concepts should be found. Unfortunately the timespan and resources available for this research did not allow a testing approach where these recommendations would be implemented in two or more case studies and their outcomes could be measured afterwards. To overcome this limitation, a validation procedure focused on validating the findings of this research was devised through the employment of multiple focus groups with scholars and industry stakeholders (section 3.7).

To ensure the Reliability of the research procedures, a case study data collection protocol was devised (Creswell, 2013, Bryman, 2012, Yin, 2009) and data analysis were undertaken using the methodology proposed by grounded theory (Corbin and Strauss, 2008, Partington, 2000, Glaser and Strauss, 1967).

3.3.6 Research Ethics

Whenever undertaking real world research involving people, ethical considerations must be carry out in order ensure that no physical or psychological harm is inflicted in the research participants (Robson, 2011). The ethical aspects present in this research were identified and properly addressed in accordance to the University of Plymouth ethics policies. In that sense, an ethical protocol was devised, addressing to the following principles (Bryman, 2012, Robson, 2011):

- Informed consent;
- Openness and honesty;
- Right to withdraw;
- Debriefing;
- Confidentiality;
- Protection from harm;

In order to obtain an informed consent from the research participants, an information sheet was produced and made available. This document aimed to explain in advance the scope and the purpose of the research project, as well as to inform the uses of data collected, which would impact in the willingness of the participants to collaborate. Moreover, a consent form was provided to each participant so a formal consent could be collected and properly stored. In addition, during the recorded semi-structured interviews participants had the opportunity to state their consent to participate in the research.

The principle of openness and honesty underpinned the use of the information sheet and the formal consent ensuring that the participants were totally aware of how information would be collected, treated and stored. Also, channels of communication were established where telephone number and email address were provided.

The aforementioned documents also informed the right of the participants to withdraw from the research at any time up to a set deadline (e.g. 2 weeks from the interviews), without providing any reason or explanation. The participants were informed that they could ask for the destruction of the data collected without any negative consequences.

In addition to the information sheet all the participants received a verbal debrief about the objectives of the research, its scope, the use and treatment of the data collected, as well as their right to withdraw.

In order to ensure the confidentiality of participants' identity (stakeholders and companies) the research committed to comply with the Data Protection Act (HM Government, 2018). Personal data were associated with an arbitrary reference number. The only exception to this policy took place in the validation process regarding the focus group, where confidentiality and anonymity could not be maintained. In that occasion, all participants were asked if they would agree to their identity being exposed. Specific consent form and invitation letter were produce to clearly inform the participants about this issue. Nevertheless, all the data collected in the focus group was treated and used in anonymity, protecting participants' identities.

The data collected for the purpose of this research project will remain stored in accordance to University of Plymouth statement: "The University's research ethics policy states that data should be securely held for a minimum of ten years after completion of the research project. Electronic data will be stored on password protected computers or laptops and individual files and/or discs must be encrypted. Hard copies of data must be stored in locked filing cabinets and disposed of securely when no longer required."

During the ethical issues assessment undertaken by this research it was acknowledged that none of the methods and procedures applied on this research would cause any kind of physical or psychological harm to the participants. No Health and Safety risk assessment were required due to the fact that the semi-structured interviews administered took place in the participants place of work were Health and Safety procedures were already in place. In regard of the focus group, the activity was undertaken in the University of Plymouth environment and no risks were identified.

All documents (e.g. information sheets, invitation letters and consent forms) used in this research are presented in the Appendix A.

3.3.7 Risk assessment

The risks associated with this thesis concerned both the case studies' participants and the thesis' author. In respect to the participants of the case studies, the risks involved were related to the disclosure of personal and professional information. In order to offset these risks, the research data collection methods and analysis were submitted and approved by the University of Plymouth Ethical Committee, as informed in section 3.3.6. In regard to risks involving Health and Safety of the research participants including the author of this thesis, since all data collection methods applied in the study took place in the research collaborators' local of work, no additional measures were required other than the ones already put in place by the companies involved.

3.4 Selection and description of the case studies

The discussion of sampling in qualitative research tends to revolve around the notion of purposive sampling. This type of sampling is essentially related to the selection of an unit of analysis (which may be ethnical groups, companies, type of projects, trades etc.) which will best assist the researcher to understand the phenomenon involved in the problem targeted by the research's questions (Creswell, 2013, Bryman, 2012). Bryman (2012) also suggests that the selected cases should have different characteristics to each other, so the samples' key findings can be diverse and contribute to a richer analysis. Moreover, there is a secondary set of selection criteria related to the convenience, access and geographical location which should match the available resources and the research time frame for data collection (Bryman, 2012, Yin, 2009).

This research focused on a sample of new-built social housing development projects being undertaken by housing associations located in the United Kingdom. Following Bryman (2012) recommendations, the selected case studies involved different construction methods, project value and size, as well as being undertaken by different housing associations and project teams.

The first stage of the selection process of the case studies was to identify housing associations in the United Kingdom which would like to collaborate with the research project. Fort this purpose a letter introducing the research aims and in kind collaboration required was prepared (Appendices A.2 and A.3) and emailed to a list of pre-selected housing associations. The criteria used to devise the list of housing associations to be contacted was based on the research available resources and the companies' geographical location. The pre-selected housing associations and their projects should be in a maximum of 4-hour drive from Plymouth, Devon. In total, 18 housing association were contacted. In addition, 8 companies from the construction sector, most of them being contractors, were also approached and asked to indicate potential case studies aligned to the research objectives. A total of 5 housing associations manifested interest to participate in the research.

The second stage of selecting case studies was to identify which projects in each housing association would not only sit within the research scope and unit of analysis, but also be adequate in terms of timing towards the research's data collection defined timespan. A set of criteria were established to select the most suitable case studies for the purpose of this research:

- The case study should be a new-built construction project (as oppose to refurbishment);
- All participants of the project (e.g. housing association stakeholders, designers, consultants, contractors and subcontractors) would agree to the disclosure of the required information through the proposed data collection procedures, granting access not only to documents but also to construction site and design and managerial meetings, providing the ethical principles declared in the presentation letter were followed;
- The case study's construction phase should coincide with the research data collection period.
- At the period of data collection, the case study should present different stages of the construction phase, i.e. foundation, substructure, infrastructure, first and second fix, especially during the defect survey data collection method;

In total, five case studies were selected where their original denominations were substituted by Case study 1 to 5, in line with the research ethical approach. The five case studies are presented in relation to the project information and the project team characteristics:

Case study 1 - This social housing project was located in Cornwall and involved the construction of 28 housing units, with project's total cost of £3,100,000 (Figure 3-7 and Figure 3-8). This project was a housing association led, where social provider owned the land and procured the contractor through a traditional procurement route. The tender process implemented was a negotiated one, once the contractor company is owned by the housing association. Both housing association and contractor work in a regional level, predominately in Cornwall.

Figure 3-7 Case study 1 general view (Source: Taken by this thesis' author)

Figure 3-8 Case study 1 site layout (Source: contractor Case study 1)

Case study 2 – This project was also located in Cornwall, encompassing the building of 39 housing units, totalising £4,000,000 of contract (Figure 3-9 and Figure 3-10). This project was commissioned and managed by the housing association, where the adopted procurement route was design and build. The contractor was awarded through a negotiated tender process, due to the fact that both housing association and contractor pertain to the same group. The two companies concentrate theirs works in Cornwall area.

Figure 3-9 Case study 2 general view (Source: Taken by this thesis' author)

Figure 3-10 Case study 2 site layout (Source: contractor Case study 2)

Case study 3 - This project was located in Devon, where 67 dwellings were built at a cost of £8,300,000 (Figure 3-11 and Figure 3-12). This was housing association led development and the procurement route adopted was design and build. The tender process applied to select the contractor was competitive bidding. The housing association commissions and administers assets only in the area of Plymouth Local Authority, however the contractor works in the national level.

Figure 3-11 Case study 3 general view (Source: Taken by this thesis' author)

Figure 3-12 Case study 3 site layout (Source: housing association Case study 3)

Case study 4 - This development was located in Devon and involved the construction of 72 housing units, with a total cost of £10,000,000 (Figure 3-13 and Figure 3-14). This case study was also a housing association led project, where a two stage design and build procurement route was adopted. The tendering process implemented was a combination of qualification and value-based selection criteria. The social provider involved in this case study works solely in Plymouth local authority area. On the other hand, the awarded contractor undertakes contracts in the UK's Southwest and South regions.

Figure 3-13 Case study 4 general view (Source: Taken by this thesis' author)

Figure 3-14 Case study 4 site layout (Source: housing association Case study 4)

Case study 5 - This case study is located in Wiltshire and encompasses the construction of 121 dwellings, of which 40 were acquired by the housing association, by an agreed value of £5,000,000 (Figure 3-15 and Figure 3-16). In that sense, this project is a developer/contractor led. In this case the developer owns the land and commissioned the contractor (which pertain to the same economic group of the developer) through a design and build procurement route. The housing association in this case study manage assets in the UK's South and Southwest regions, whereas the contractor works in the southern half of the country.

Figure 3-15 Case study 5 general view (Source: Taken by this thesis' author)

Figure 3-16 Case study 5 site layout (Source: housing association Case study 5)

A summary of the main project characteristics and companies involved in the case studies selected for this research is presented in Table 3-3.

Table 3-3 Summary of the case studies included in this research

	Case study 1	Case study 2	Case study 3	Case study 4	Case study 5
Project information					
Location	Cornwall	Cornwall	Devon	Devon	Wiltshire
Number of units	28	39	67	72	40 (121)*
Contract value (£)	3,100,000	4,000,000	8,300,000	10,000,000	5,000,000
Type of contract	Traditional	Design and build	Design and build	Design and build	Acquired from the market
Project tenure	Social rent Shared ownership Open market	Social rental Shared ownership Open market	Social rent Shared ownership	Social rent Shared ownership	Social rent Shared ownership
Architectural typology	Terraced (2 storey)	Terraced (2 storey)	Terraced (2/3 storey)	Terraced (2/3 storey)	Terraced (2 storey)
Main construction technology (external walls)	Timber frame + block	Timber frame + block	Single leaf timber frame	Block + external insulation	Block +brick
Energy performance target	CSH4**/ Building regulations Part L1a	Building regulations Part L1a	Building regulations Part L1a	Passivhaus standard	Building regulations Part L1a
Construction duration	Feb/2016 Jan/2017	Feb/2016 Feb/2017	Jul/2016 Jan/2018	Nov/2016 May/2018	Oct/2016 Oct/2018
Data collection duration	Dec/2015 Feb/2017	Dec/2015 Mar/2017	Dec/2015 Jul/2017	Dec/2015 Feb/2018	Jul/2017 Oct/2017

Project team characteristics					
Housing association number of assets	4,500	4,500	16,000	16,000	55,000
Housing association geographical area	Cornwall	Cornwall	Plymouth local authority	Plymouth local authority	South and Southwest
Main contractor number of employees	60	60	5,696	450	800
Main contractor geographical area	Cornwall	Cornwall	Whole UK	Southwest and South of UK	Southwest, South and Southeast of UK

* This case study is a developer led development of 121 housing units where 40 dwellings were acquired by the housing association.
** CSH4 stands for Code for Sustainable Homes Level 4

3.5 Data collection

As outlined in the previous section, qualitative data were collected during the research presented in this thesis. Qualitative data were collected by semi-structured interviews to key project stakeholders; complemented by data obtained from quality management project documentation; observations during project managerial meetings and site visits; and defect identification surveys during site visits. These methods of data collection were applied on each case study included in this thesis.

The research methods are outlined sequentially in the following sections. Firstly, the structure and administration process of the semi-structured interview is described in section 3.5.1. It is followed by the secondary data collection methods consisting of the quality management project documentation presented in section 3.5.2, the observations during project managerial meetings and site visits described in section 3.5.3 and the defect identification surveys presented in section 3.5.4.

3.5.1 Semi-structured interviews

The purpose of conducting the semi-structured interviews was to gather information from the main stakeholders involved in the case studies. They aimed at identifying the process of development and implementation of Project Quality Plans as means of achieving thermal performance levels of dwellings as designed and most importantly to help the researcher to acknowledge the challenges embedded in this process.

The interviews were conducted between February 2017 and September 2017 by the thesis author (Ulrich de Alencastro) during the data collection phase.

3.5.1.1 Interview location and participants

As the development and application of quality management procedures relies on multiple stakeholders involved in the project, it was considered essential to undertake interviews in each case study with the project participants representing the client (housing association), the major contractor and the quality officer responsible for the implementation of the quality plan.

A face-to-face interview at the interviewee's offices was the preferred method as it allowed the opportunity to check other project documentation which helped to clarify some of the concepts being discussed.

3.5.1.2 Interview procedure

Prior to the scheduled interview, all the interviewees were emailed some background information about the overall purpose of the research, the main purpose of the interview, as well as the content of the interview, in order to allow time for reflection on the relevant aspects that would be discussed during the interview. The interviews were designed to take between 30 and 45 minutes.

Before the interview commenced the interview's purpose was explained again and permission was gained from the interviewee to record the interview with a digital voice recorder. All the interviews were recorded for later transcription and analysis with the formal consent of the interviewees, as oriented by the ethical principles undertaken in this research (section 3.3.6). The interview began by introducing the first group of questions which were related to general information about the interviewee, the project used as case study and the company the interviewee worked for. This first approach not only provided the background information of the interviewee and the company involved in the case study, but also was used as way to "break the ice" and allow the interviewee to become more comfortable with the interview process. Hence, the second group of questions were introduced in accordance to the previously identified areas of the process of implementing Project Quality Plans. The questions were used as prompts to probe areas of interest of the research topic, exploring the challenges identified by the interviewees. In general, the interview allowed the participants to discuss broadly their views and opinions in an open-ended manner, allowing the data to emerge naturally. The average duration of the interviews was around 39 minutes.

At the end of the interview the researcher provided a short summary of the discussions and the project stakeholders were thanked for their participation.

In total 15 interviews were undertaken, completing 3 interviews to key project stakeholders for each case study. A compilation of the process of interviews is presented in Table 3-4.

Table 3-4 Summary of the semi-structured interviews

Case study/ interview	**Date**	**Duration (minutes)**	**Stakeholder's role**	**Company (on behalf of)**
1.a	20/02/2017	49	Quality coordinator	Housing association
1.b	20/02/2017	49	Development manager	Housing association
1.c	25/02/2017	49	Site manager	Contractor
2.a	20/02/2017	49	Quality coordinator	Housing association
2.b	20/02/2017	49	Development manager	Housing association
2.c	24/03/2017	44	Site manager	Contractor
3.a	16/03/2017	43	Project manager	Housing association
3.b	28/03/2017	63	Quality officer	Housing association
3.c	12/06/2017	36	Assistant site manager	Contractor
4.a	03/05/2017	28	Head of Development	Housing association
4.b	04/05/2017	35	Quality officer	Contractor
4.c	21/06/2017	38	Senior site manager	Contractor
5.a	12/09/2017	43	Quality officer	Housing association
5.b	12/09/2017	55	Project manager	Housing association
5.c	12/09/2017	34	Site manager	Contractor

3.5.1.3 Interview content

The semi-structured interview was organised in three parts (see full content of the interview form in Appendix B.1).

The first part was designed to provide the interviewee with a brief description of the research project and instructions about the interview procedures. This part also reminded the participant about the ethical aspects including the right to withdraw, the confidentiality and anonymity of the data collected once presented in the thesis and research publications.

The second part aimed at obtaining general information of the interviewee's background and role in the project, as well as information regarded to the project used as case study and the company the interviewee worked for. The information requested included:

- Interviewee's name (information not used to keep the research anonymous);
- Professional qualification;
- Years of professional experience;
- Role in the project/housing association;
- Housing association name (information not used to keep the research anonymous);
- Number of assets (housing units);
- Geographic area;
- Number of ongoing projects;
- Quality accreditation of the organization;
- Name of the project (information not used to keep the research anonymous);
- Number of housing units of the project;
- Project purpose (e.g. letting, shared ownership, open market);
- Project overall cost;
- Stage of the project process (e.g. design, construction, handover);
- Project duration;
- Project procurement route.

The third part of the interview contained the questions which covered the core areas of the research scope (Creswell, 2013, Tracy, 2013). Multiple questions were defined for each of the five main areas of Project Quality Plans identified in the literature review (conceptual tags): (i) definition of quality requirements; (ii) quality risk assessment; (iii) quality resources assessment; (iv) definition of quality metrics and control; and (v) quality compliance procedures. These areas were briefly described to the participant in order minimise any ambiguity or misinterpretation of the questions posted (Bryman, 2012).

The questions related to the first subject area *Definition of quality requirements* aimed at identifying the quality objectives defined for each case study project which derived from the aspirations and set of criteria of the client (housing associations), occupants (potential tenants), statutory authorities and regulators. The questions also aimed to identify how the defined set of quality requirements were documented and communicated to the different participants of the project. The following questions were asked in relation to Definition of quality requirements:

Q1. Has the project a formal quality plan? Is it specific for this project or a standard used by the housing association/major contractor?

Q2. In terms of the quality requirements established for the project, are energy performance aspects part of the scope of the quality plan?

Q3. What are the requirements regarded to energy performance?

Q4. Are the requirements related to energy performance part of the strategic goals of the organization or only specific for the project?

Q5. How the defined requirements are documented and communicated to the participants of project?

The questions related to *Quality risk assessment* were developed to identify how threats and opportunities that may impact in the achievement of the defined quality requirements were identified and assessed and which participants collaborated in this process. The questions also aimed at understanding the challenges identified in the process of implementing quality management procedures. The following questions were asked in relation to Quality risk assessment:

Q6. Which stakeholders are involved in the process of defining the quality requirements related to the energy performance of the project? When does it happen in the project timespan?

Q7. Is there a process in place to assess the risks related to managerial and workforce capabilities and technical issues which can affect the achievement of the requirements related to energy performance?

Q8. To what extent the managerial team and workforce understand the impact of construction defects on the energy performance of buildings of the project?

Q9. What are the challenges faced when implementing quality management procedures towards achieving the desired energy performance of the building?

The questions related to *Quality resources assessment* aimed at identifying the provision of essential resources to implement the quality management plan, the roles and responsibilities assigned to the project participants, as well as the financial or/and external support to undertake the quality management procedures. The following questions were asked in relation to *Quality resources assessment*:

Q10. Who is responsible for developing and implementing quality management procedures?

Q11. Is there a specific team in place to ensure the achievement of the quality requirements related to energy performance?

Q12. Is there a specific procedure in place to create awareness of the quality requirements related to energy performance among the participants (e.g. induction, training, skills accreditation)?

Q13. Does your company (housing association/contractor) provide a proper environment and all the necessary resources in order to achieve the quality requirements proposed for the project? What else should or could be provided?

The questions related to *Quality metrics and control* were developed to identify operational definition of the quality requirement attributes under the thermal performance of buildings perspective (e.g. air permeability rates, U-values of building elements or number of defects identified during the construction process). The questions also seek to identify how the quality control process put in place assessed these attributes and which sampling approaches, milestones for monitoring and checking procedures were implemented. The following questions were asked in relation to *Quality metrics and control*:

Q14. Which thermal performance attributes are considered by the quality plan/project?

Q15. Does the project have a procedure for construction defect identification and collection in place?

Q16. How and when are the performance attributes and defects monitored and collected?

Q17. What is the sampling approach used to the assess quality in terms of the number of housing units to be monitored?

The questions related to *Quality compliance procedures* aimed at establishing how the monitored quality attributes and the achievement of quality requirements were reported and communicated to the project participants. The questions also sought to understand how the procedures adopted to analyse the compliance of the quality standards triggered corrective actions and possible improvements within the project timespan and for the subsequent projects. The following questions were asked in relation to *Quality compliance procedures*:

Q18. How quality compliance is reported in terms of content, format and frequency (e.g. reports, meetings, audits)?

Q19. Does the project have specific procedures to analyse the reports and defect records? Which stakeholders participate in this process?

Q20. How and when feedback is provided to the different participants?

3.5.1.4 Interview pilot

The interview procedure was tested on several of the researcher's colleagues. The tests were helpful to develop the skills necessary to draw information from the participants and to identify any misunderstanding with the questions. The test interviewees were not experts in the field but they did demonstrate that the method could collect the data required as they understood the context of the questions asked as well as the purpose of each question. The pilot also allowed the researcher to practice the introduction of the interview, the time keeping skills and overall organisation of the interview.

3.5.2 Quality management documentation

Project documentation specific to the Project Quality Plan implemented in the cases studies was also used for the purpose of this research. The purpose of collecting and analysing project documentation was to identify the formal procedures implemented, based on the established quality management procedures. Moreover, the collected data was also used to support or challenge the information deriving from the project stakeholders' interviews.

In order to get access to the quality management documentation, the case studies' project managers from both housing associations and contractors were contacted and informed of the purpose and use of documents, as well as the ethical principles which guaranteed anonymity and data protection. Once permission to share the documentation was granted, the requested documents were made available by the case studies' project managers themselves, by the construction site managers and by the quality officers on behalf of the housing associations and contractors.

The following documents were requested and used for each case study:

- Housing association's quality policy and quality plan

These documents are prepared by the housing association's Head of Development and encompasses the definition of strategic and project specific quality requirements, including the quality objectives and compliance procedures related to the thermal performance of the projects' dwellings.

- Sections of contracts and tendering packages documentations related to quality delivery

These documents are prepared by the housing association's project manager and, among other purposes, are used to communicate the contracting companies the quality objectives and compliance procedures of specific projects.

- Quality control tools (e.g. checklists)

These documents are prepared and used by both housing associations and appointed contractors in the process of quality assessment of defined building elements.

– Quality reports and compliance

These documents are prepared or commissioned by housing associations and appointed contractors in the process of communicating quality compliance or reporting quality issues.

The documents collected and analysed for each case study can be appreciated in Table 3-5.

Table 3-5 Documents collected and analysed.

Case study	Type of document	Source
1	Quality requirements/thermal performance	Housing association
	Quality reports	Housing association/Contractor
	Quality control (e.g. checklists)	Housing association/Contractor
2	Quality requirements/thermal performance	Housing association
	Quality reports	Housing association/Contractor
	Quality control (e.g. checklists)	Housing association/Contractor
3	Quality policy	Housing association
	Quality requirements/thermal performance	Housing association
	Quality reports	Housing association/Contractor
	Quality control (e.g. checklists)	Housing association/Contractor
4	Quality policy	Housing association/ Contractor
	Quality requirements/thermal performance	Housing association
	Quality reports	Housing association/Contractor
	Quality control (e.g. checklists)	Housing association/Contractor
5	Quality requirements/thermal performance	Housing association
	Quality reports	Housing association/Contractor
	Quality control (e.g. checklists)	Housing association/Contractor

3.5.3 Observations from project managerial team meetings and site visits

The major objective on applying this data collection method was to identify emerging concepts through observation during managerial project team meetings and construction site visits in each case study, without influencing the course of the discussions and activities being undertaken.

The observations were conducted between December 2015 and September 2017 by the thesis author (Ulrich de Alencastro) during the data collection phase.

3.5.3.1 Observations location and participants

The observations of the managerial meetings with the project team took place in two locations. The meetings which occurred prior to the beginning of the construction phase were located at the housing association's main office. After beginning of the construction process the meetings took place at the construction site office of the respective case studies.

In the majority of the cases, the participants of these meetings were representatives of the housing association (i.e. development manager, project manager and quality officer), employer's agent (on behalf of the housing association), consultants, contractor (i.e. project manager, site manager).

In regard to the observations in the construction site visits, they consisted in observing the activities involving the construction management and quality management procedures undertaken by the site management team and quality officers on behalf of the housing association.

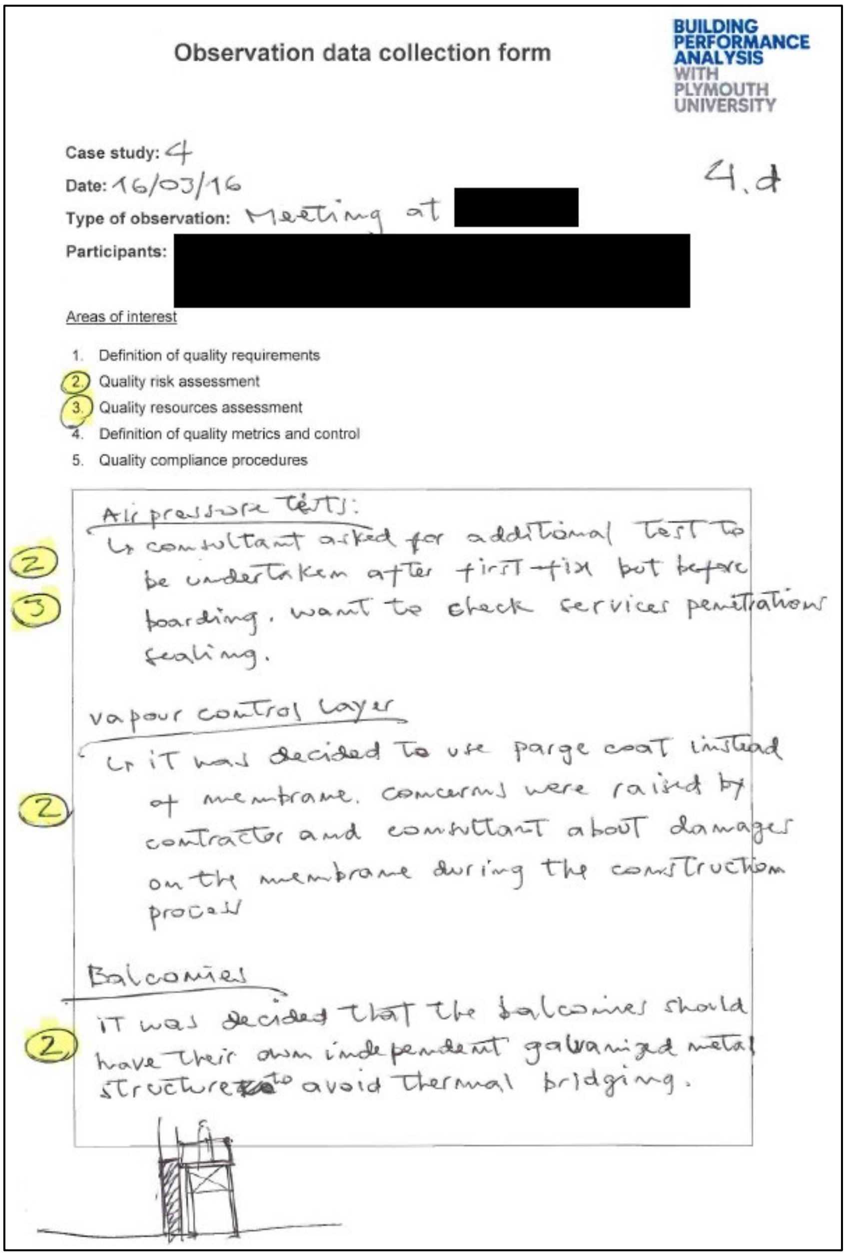
3.5.3.2 Observations procedure

In order to arrange the observations of managerial meetings, contact via email was made with the housing association's project manager, where the purpose and use of data to be collected in the meetings, as well as the ethical principles which guaranteed anonymity and data protection were informed. The purpose of the observations were initially to gather additional information of the process of risk assessment which would input information to the quality control tools. In addition, it also sought to gather information regarded the process of developing the Project Quality Plans, where roles and responsibilities as well as quality control procedures were defined and assigned to the project participants. Moreover, it was recognised that information gathered during construction review meetings could provide additional insight to the process of quality result analysis and consistency of quality control procedures. In that sense, project managers were asked to inform the researcher about meetings encompassing the aforementioned desired information during the design, pre-construction and construction stages.

In relation to site visit observations, they were undertaken in the same dates of either managerial meetings or construction defects surveys. The latter occurred mostly during superstructure and first fix construction stages, due to the fact that quality defects affecting the thermal performance of the building's fabric are more likely to occur in these stages according to literature, as explained in section 2.2.3.

Before the observation sessions started (either the project team meetings or the site visits), the participants were provided with a brief explanation about the research objectives and how the information collected would be used, ensuring that all data and participants would be treated in anonymity, following the ethical principles of this research (section 3.3.6).

None of the observations in meetings were recorded by a voice recorder device, due to the fact that transcription process would be difficult and onerous, given the number of participants and the wide range of topics discussed. Alternatively, as part of the data collection protocol for this method, a memo structure was developed in order to provide the observer (i.e. the author of this thesis) with focus on the identified areas of interest, enabling the identification of concepts in both meetings and site visits observations (Corbin and Strauss, 2008, Miles and Huberman, 1994). A data collection form was develop to cover the five main areas under study (i.e. definition of quality requirements, quality risk assessment, quality resources assessment, definition of quality metrics and control and quality compliance procedures) identified in the literature review as being related to the process of implementing quality management procedures and its challenges. An example of this data collection form is presented in Figure 3-17.



Observation data collection form

BUILDING PERFORMANCE ANALYSIS WITH PLYMOUTH UNIVERSITY

Case study: 4

4.d

Date: 16/03/16

Type of observation: Meeting at [redacted]

Participants: [redacted]

Areas of interest

1. Definition of quality requirements
2. Quality risk assessment
3. Quality resources assessment
4. Definition of quality metrics and control
5. Quality compliance procedures

Air pressure tests:
↳ consultant asked for additional test to be undertaken after first-fix but before boarding. want to check services penetrations sealing. (2) (3)

vapour control layer
↳ it was decided to use parge coat instead of membrane. concerns were raised by contractor and consultant about damages on the membrane during the construction process (2)

Balconies
it was decided that the balconies should have their own independent galvanized metal structure to avoid thermal bridging. (2)

Figure 3-17 Section of observation data collection form

For each case study at least two observation sessions were undertaken. A summary of the project team meetings and site visits attended for each cases study, the dates, attendees and main purpose of the event when they took place are described in Table 3-6.

Table 3-6 Observations undertaken.

Case study	Name and Date of the observation	Type	Attendees	Main purpose of the event
1	a.16/12/2015	Meeting	Housing assoc. Contractor	Pre-construction activities
	b. 22/03/2016	Meeting Site visit	Contractor Subcontractors	Construction review
	c. 27/04/2016	Meeting	Housing assoc. Contractor	Construction review
	d. 21/07/2016	Site visit	Contractor Subcontractors	Construction review
	e. 06/12/2016	Site visit	Contractor Subcontractors	Construction review
	f. 24/02/2017	Meeting Site visit	Contractor Subcontractors	Construction review
2	a. 16/12/2015	Meeting	Housing assoc. Contractor	Design review and pre-construction activities
	b. 26/04/2016	Meeting Site visit	Contractor Subcontractors	Construction review
	c. 21/07/2016	Meeting Site visit	Contractor Subcontractors	Construction review
3	a. 09/12/2015	Meeting	Housing assoc. Contractor Consultant Design team	Design review and risk assessment
	b. 22/04/2016	Meeting	Housing assoc.	Pre-construction activities

			Contractor Consultant Design team	
	c. 25/01/2017	Meeting Site visit	Housing assoc. Contractor	Construction review
4	a. 09/12/2017	Meeting	Housing assoc. Contractor Consultant Design team	Project brief and risk assessment
	b. 22/01/2016	Meeting	Housing assoc. Contractor Consultant Design team	Design review and risk assessment
	c. 18/02/2016	Meeting	Housing assoc. Contractor Consultant Design team	Design review and risk assessment
	d. 16/03/2016	Meeting	Housing assoc. Contractor Consultant Design team	Design review and risk assessment and pre-construction activities
	e. 13/04/2016	Meeting	Housing assoc. Contractor Consultant Design team	Design review and risk assessment and pre-construction activities
	f. 23/09/2016	Meeting	Housing assoc. Contractor	Design review, risk assessment and pre-construction activities

			Consultant Design team	
	g. 13/10/2016	Meeting	Housing assoc. Contractor Consultant Design team	Design review, risk assessment and pre-construction activities
	h. 06/01/2017	Meeting Site visit	Housing assoc. Contractor Consultant Design team	Construction review
	i. 04/05/2017	Meeting Site visit	Housing assoc. Contractor Consultant Design team	Construction review
	j. 21/06/2017	Meeting Site visit	Housing assoc. Contractor Consultant Design team	Construction review
	l. 27/09/2017	Meeting Site visit	Housing assoc. Contractor Consultant Design team	Construction review
5	a. 12/09/2017	Meeting Site visit	Housing assoc. Contractor Employer's agent	Construction review

3.5.4 Construction defects surveys

For the purpose of this research, quality construction defects with the potential to affect the thermal performance of the dwellings were surveyed and identified during construction site visits. The defects identification was used as way to confirm or confront the findings from the interviews, quality management documentation and observations in each of the case studies. The defect collection provided valuable information in respect to the development and implementation of quality assurance procedures during the construction process.

The construction defects surveys were conducted between March 2016 and September 2017 by the thesis author (Ulrich de Alencastro) during the data collection phase.

3.5.4.1 Construction defects surveys location

In order to maximise the collection of data, the sites selected to participate in this study presented different stages of construction simultaneously, i.e. infrastructure, superstructure up to first and second fix, in alignment to the construction phase timespan encompassed by this research.

During the survey, the researcher was accompanied by site managers, assistant site managers and quality officers working on behalf of the housing association.

3.5.4.2 Construction defects surveys procedure

In order to gain access to the construction sites of the case studies, contact was made with the construction site managers which were previously indicated by the contractors' project manager. The purpose and use of data to be collected in the surveys, as well as the ethical principles which guaranteed anonymity and data protection were informed, prior to the site visits and before the administration of the surveys. Additionally, the permission to take pictures in order to gather photographic evidence was verbally requested and granted by the site manager on the occasion of the data collection procedure. Prior to the first site visit in each construction site, a basic Health and Safety induction was provided by the site management teams.

Most of the surveys took place at the construction phases of superstructure and first fix, where most of defects affecting the thermal performance of building's fabric are reported in the literature of quality management and defects (Chapter 2). However, as informed in section 3.4, the projects undertaken in this research presented different stages of construction process simultaneously. Even though the efforts of the surveys were concentrated in aforementioned construction stages were the targeted defects were more likely to occur, stages such as the infrastructure and second fix were also explored.

Robson (2011) states that, although the use of visual material is widely used as an objective way to illustrate targeted issues, it is likely to provide the researcher's particular view of reality. As way to counter this limitation, a protocol and data collection form was developed, providing a structured approach for the collection of data during the site visits, limiting the impact of personal bias to the defects identification process.

In order to produce a data collection form which would not be limited by the investigator's understanding of the potential occurrence of defects, a defect taxonomy was developed. The defect taxonomy was meant to explore the most reported defects in the literature that affect the thermal performance of the building's envelope. It aimed at providing the investigator with an extensive repertory of quality issues to be explored during the surveys on-site. Based on the defect classification methodology developed by Forcada et al. (2015), Forcada et al. (2014), Forcada et al. (2013a), Forcada et al. (2013b), Macarulla et al. (2013) and Josephson and Hammarlund (1999), the defect taxonomy was structured according to the following main categories:

(i) Heat loss mechanisms (e.g. thermal bridging, air permeability);

(ii) Source of the defect (e.g. workmanship, design, etc.);

(iii) Origin of the defect (e.g. error, omission, etc.);

(iv) Type (e.g. incorrect installation, missing item, etc.);

(v) Affected building element (e.g. external wall, roof, etc.);

(vi) Trade involved (e.g. brickwork, insulations, etc.).

Moreover, for each defect identified in the taxonomy the correspondent source of the information was logged, making possible to identify whether a defect was reported in one or more publications, as shown in Figure 3-18.

	Heat loss mechanism	Defect/Key problem	Source	Origin	Type	Building element/Areas	Trade	Paper/Report
19	Air Leakage	Gaps or hole in the plasterboard in order to accommodate fittings	Workmanship	Error	Incorrect installation	External walls	Services	20
	Air Leakage	Gaps or hole in the plasterboard in order to accommodate fittings	Workmanship	Error	Incorrect installation	Internal walls	Services	20
20	Thermal Bridging	High timber concentration	Design	Lack of information	Inadequate solution	External doors and windows/external wall junctio	Designer	20
	Thermal Bridging	High timber concentration	Workmanship	Error	Incorrect installation	External doors and windows/external wall junctio	Insulations	20
21	Heat loss though insulation layer	Inadequate cavity filling around the openings - Gaps and lack of insulation la	Workmanship	Error	Incorrect installation	External doors and windows/external wall junctio	Insulations	9, 10, 14, 20, 22, 23
	Heat loss though insulation layer	Lack of continuity of insulation - gaps between insulation boards or blankets	Workmanship	Error	Incorrect installation	Ceiling	Insulations	9,, 20, 22
22	Heat loss though insulation layer	Lack of continuity of insulation - gaps between insulation boards or blankets	Workmanship	Error	Incorrect installation	Exterior wall	Insulations	9, 20, 22
	Heat loss though insulation layer	Lack of continuity of insulation - gaps between insulation boards or blankets	Workmanship	Error	Incorrect installation	Roof	Insulations	9, 20, 22
23	Heat loss though insulation layer	Lack of continuity of insulation due to DPC/cavity tray	Workmanship	Error	Incorrect installation	Intermediate floor/external wall junction	Insulations	20
24	Heat loss though insulation layer	Lack of continuity of insulation due to lintel/cavity tray	Workmanship	Error	Incorrect installation	Intermediate floor/external wall junction	Insulations	14, 20
25	Heat loss though insulation layer	Lack of continuity of insulation layer between rafters	Workmanship	Error	Incorrect installation	External wall/eaves junction	Insulations	20
	Heat loss though insulation layer	Lack of continuity of insulation layer between rafters	Workmanship	Error	Incorrect installation	Roof	Insulations	20
26	Heat loss though insulation layer	Lack of continuity of insulation layer due to misalignment of the inner leaf bas	Workmanship	Error	Misalignment	Ground floor/external wall junctions	Structures	20
27	Heat loss though insulation layer	Lack of continuity of insulation layer in the dormers	Workmanship	Omission	Missing	Roof	Insulations	20
28	Air Leakage	Lack of continuity of plaster adhesive in order to seal the plasterboard lining	Workmanship	Error	Incorrect installation	External walls	Partitions an	20
29	Heat loss though insulation layer	Lack of insulation in external wall/eaves junction	Workmanship	Omission	Missing	External wall/eaves junction	Insulations	14, 20, 22
30	Thermal Bridging	Lack of insulation in steel purlins	Design	Omission	Missing	Roof	Insulations	20
	Thermal Bridging	Lack of insulation in steel purlins	Workmanship	Omission	Missing	Roof	Insulations	20
31	Air Leakage	Lack of taping of joints of insulation boards	Workmanship	Omission	Missing	External walls	Insulations	20
	Air Leakage	Lack of taping of joints of vapour control layer	Workmanship	Omission	Missing	External walls	Insulations	20
32	Air Leakage	Lack of taping of joints of vapour control layer	Workmanship	Omission	Missing	Internal walls	Insulations	20
	Air Leakage	Lack of taping of joints of vapour control layer	Workmanship	Omission	Missing	Roof	Insulations	20
33	Air Leakage	Lack of taping the insulation joints of ventiltated rafter void roof	Workmanship	Omission	Missing	Roof	Insulations	20
34	Thermal Bridging	Lack of use of lightweight block bellow the edge of the slab	Design	Omission	Missing	Ground floor/external wall junction	Designer	20
	Thermal Bridging	Lack of use of lightweight block bellow the edge of the slab	Workmanship	Error	Incorrect installation	Ground floor/external wall junction	Foundations	20
	Air Leakage	Lack of vapour control layer	Workmanship	Omission	Missing	External walls	Services	20
35	Air Leakage	Lack of vapour control layer	Workmanship	Omission	Missing	Internal walls	Services	20
	Air Leakage	Lack of vapour control layer	Workmanship	Omission	Missing	Roof	Services	20
36	Air Leakage	Lack of vapour control layer return into window/external doors reveals	Workmanship	Omission	Missing	External doors and windows/external wall junctio	Insulations	20
37	Heat loss though insulation layer	Loose insulation layer in partial cavity fill	Workmanship	Error	Incorrect installation	External walls	Insulations	20
38	Thermal Bridging	Misalignment between window/external door and insulation layer	Design	Lack of information	Inadequate solution	External doors and windows/external wall junctio	Designer	20
	Thermal Bridging	Misalignment between window/external door and insulation layer	Workmanship	Error	Misalignment	External doors and windows/external wall junctio	Insulations	9, 14, 20, 22
39	Heat loss though insulation layer	Missing insulation in the dormers	Workmanship	Omission	Missing	Roof	Insulations	20
40	Thermal Bridging	Missing insulation at MVHR ducts	Workmanship	Omission	Missing	Ceiling	Insulations	10
	Thermal Bridging	Missing insulation at MVHR ducts	Workmanship	Omission	Missing	Internal wall	Insulations	10
41	Thermal Bridging	Missing insulation at the ceiling	Workmanship	Omission	Missing	Ceiling	Insulations	10, 20
42	Heat loss though insulation layer	Missing insulation at the intermediate floor level perimeter	Workmanship	Omission	Missing	Intermediate floor/external wall junction	Insulations	9, 20
	Heat loss though insulation layer	Missing insulation at the intermediate floor level perimeter	Design	Lack of information	Missing	Intermediate floor/external wall junction	Designer	9, 20, 22
43	Thermal Bridging	Missing insulation at the slab perimeter	Workmanship	Omission	Missing	Ground floor/external wall junction	Insulations	20
44	Thermal Bridging	Missing insulation in steel lintel flanges	Design	Lack of information	Inadequate solution	External doors and windows/external wall junctio	Designer	20, 22
45	Heat loss though insulation layer	Missing insulation in timber frame panels	Workmanship	Omission	Missing	Exterior wall	Insulations	10
46	Heat loss though insulation layer	Reduced insulation layer thickness due to joist ends protrusion	Workmanship	Error	Incorrect installation	Intermediate floor/external wall junction	Structures	20
47	Thermal Bridging	Residual mortar droppings in partial cavity fill/cavity tray	Workmanship	Error	Carelessness	External walls	Brickwork	20
	Air Leakage	Ruptures and displacements in the vapour control layer	Workmanship	Damage	Carelessness	External walls	Services	20
48	Air Leakage	Ruptures and displacements in the vapour control layer	Workmanship	Damage	Carelessness	Internal walls	Services	
	Air Leakage	Ruptures and displacements in the vapour control layer	Workmanship	Damage	Carelessness	Roof	Services	20
49	Thermal Bridging	Use of uninsulated cavity closer around the openings	Design	Lack of information	Inadequate solution	External doors and windows/external wall junctio	Designer	20

Figure 3-18 Section of defect taxonomy

The taxonomy contained a list of over 50 different types of defects affecting the building's fabric. For practical reasons when the data collection form was developed, the list of potential defects was condensed, and defects with similar descriptions where grouped. For instance, the defect type *Lack of continuity of insulation*, condenses several similar types such as gaps between insulation boards or blankets and inadequate cavity filling around openings. Besides the different types of defects investigated during the construction sites visits, the data collection form also provided a list of building elements to be checked. The protocol also required that basic information (i.e. case study, date of the survey and housing unit) regarded the project was properly registered.

Once a defect was identified during the survey, the investigator used the form to record the general type of defect and the building element affected, as well as reporting a detailed description of the issue alongside with photographic evidence. The overall aim of this protocol was to collect different types of defects during the surveys, rather than quantifying the number of occurrences. An example of the data collection form used during the surveys can be seen in Figure 3-19 to Figure 3-23.

Case study: 1
Date: 27/04/16
Plot: 12

BUILDING PERFORMANCE ANALYSIS WITH PLYMOUTH UNIVERSITY

Type / Building element	Ground floor	Ground floor/external wall	External wall	External wall/openings	Openings (doors and windows)	Internal walls	External wall/upper floors	Upper floors	External walls/eaves	External walls/roof	Ceiling	Other
Discontinuity of insulation layer	1	1										
Missing insulation		2										
Damaged insluation (e.g. crushed, soiled, wet)		1										
Air pockets between insulation and wall face		1										
Inadequate insulation around service penetration												
Missing insulation in pipes and ducts												
Missing vapour/air barrier												
Gaps and ruptures in the vapour/air barrier			3									
Inadequate installation of the vapour/air barrier			[illegible]			4						
Inadequate sealing around services												
Missing/inadequate cavity closer												
Residual material in wall cavities												
Gaps between walls and openings (doors and windows)												
Inadequalte sealing - 2nd fix												
Others												

Description

1	Ill fitted insulation boards between slab perimeter and ext. wall.
2	Insulation between slab perimeter and ext. wall partially missing.
3	Ruptures in vapour control layer.
4	Vapour barrier in party wall poorly installed.
5	
6	
7	
8	
9	
10	
11	
12	

Figure 3-19 Example of construction defect survey data collection form and respective photographic evidences

Figure 3-20 Picture 1: Ill fitted insulation boards between slab perimeter and external wall

Figure 3-21 Picture 2: Insulation layer between slab perimeter and external wall partially missing

Figure 3-22 Picture 3: Ruptures in vapour control layer

Figure 3-23 Picture4: Vapour barrier of party wall poorly installed

The quantity of construction site surveys undertaken in each cases study, the dates when they took place and the number of types of defects with potential to affect the thermal performance of the dwellings' envelope can be observed in Table 3-7.

Table 3-7 Summary of construction defects surveys.

Case study	**Date of survey**	**Number of defects types**	**Defects types recorded**	**Stage of construction**
1	22/03/2016	4	Damaged insulation (e.g. crushed, wet)	Superstructure
			Air pockets between insulation and wall face	First fix
			Gaps and ruptures in the vapour/air barrier	
			Missing/inadequate cavity closer	
	27/04/2016	8	Discontinuity of insulation layer	Superstructure
			Missing insulation	First fix
			Damaged insulation (e.g. crushed, wet)	
			Air pockets between insulation and wall face	
			Gaps and ruptures in vapour/air barrier	
			Inadequate installation of vapour/air barrier	
			Missing/inadequate cavity closer	
			Residual material in wall cavities	
	10/05/2016	12	Discontinuity of insulation layer	Superstructure
			Missing insulation	First fix
			Damaged insulation (e.g. crushed, wet)	
			Air pockets between insulation and wall face	
			Inadequate insulation around service penetration	
			Missing insulation of pipes and ducts	
			Gaps and ruptures in vapour/air barrier	
			Inadequate installation of vapour/air barrier	
			Inadequate sealing around services	
			Missing/inadequate cavity closer	
			Residual material in wall cavities	

			Gaps between walls and openings (doors and windows)	
	21/07/2016	10	Discontinuity of insulation layer	Superstructure
			Damaged insulation (e.g. crushed, wet)	First fix
			Air pockets between insulation and wall face	Second fix
			Inadequate insulation around service penetration	
			Missing insulation of pipes and ducts	
			Gaps and ruptures in vapour/air barrier	
			Inadequate sealing around services	
			Residual material in wall cavities	
			Gaps between walls and openings (doors and windows)	
			Inadequate sealing - 2nd fix	
	06/12/2016	4	Discontinuity of insulation layer	Superstructure
			Air pockets between insulation and wall face	First fix
			Inadequate sealing around services	Second fix
			Inadequate sealing - 2nd fix	
2	26/04/2016	4	Damaged insulation (e.g. crushed, wet)	Superstructure
			Gaps and ruptures in vapour/air barrier	First fix
			Inadequate installation of vapour/air barrier	
			Residual material in wall cavities	
	21/07/2016	9	Discontinuity of insulation layer	Superstructure
			Damaged insulation (e.g. crushed, wet)	First fix
			Air pockets between insulation and wall face	Second fix
			Missing insulation of pipes and ducts	
			Gaps and ruptures in vapour/air barrier	
			Inadequate installation of vapour/air barrier	
			Inadequate sealing around services	
			Missing/inadequate cavity closer	
			Residual material in wall cavities	
3	25/01/2017	8	Discontinuity of insulation layer	Superstructure

			Missing insulation	First fix
			Damaged insulation (e.g. crushed, wet)	Second fix
			Air pockets between insulation and wall face	
			Missing insulation of pipes and ducts	
			Missing vapour/air barrier	
			Gaps and ruptures in vapour/air barrier	
			Inadequate installation of vapour/air barrier	
4	04/05/2017	0		
	21/06/2017	2	Damaged insulation (e.g. crushed, wet)	Superstructure
			Others	First fix
	27/09/2017	3	Discontinuity of insulation layer	Superstructure
			Air pockets between insulation and wall face	First fix
			Inadequate installation of vapour/air barrier	
	21/02/2017	1	Inadequate installation of vapour/air barrier	Superstructure
				First fix
5	12/09/2017	5	Discontinuity of insulation layer	Superstructure
			Missing insulation	First fix
			Inadequate installation of vapour/air barrier	Second fix
			Missing/inadequate cavity closer	
			Residual material in wall cavities	

3.5.4.3 Construction defects survey pilot

In order to validate the data collection form and overall protocol to be used during the construction defects surveys, a pilot was undertaken in the first survey in Case study 1, in March 2016. In this occasion data was collected as expected and the form proved to be useful, systematising the data collection procedure. Moreover, it was confirmed that the form contained all the defects observed on the construction site, relevant for this research. The use of the form, complemented by the photographic evidence, proved sufficient for the purpose of this data collection method.

3.6 Data processing and analysis

The data processing and analysis of the qualitative data collected in the data collection phase of the thesis research process employed a number of different techniques. The methods of data processing and analysis are outlined in the following sections for each of the data sources used in this thesis.

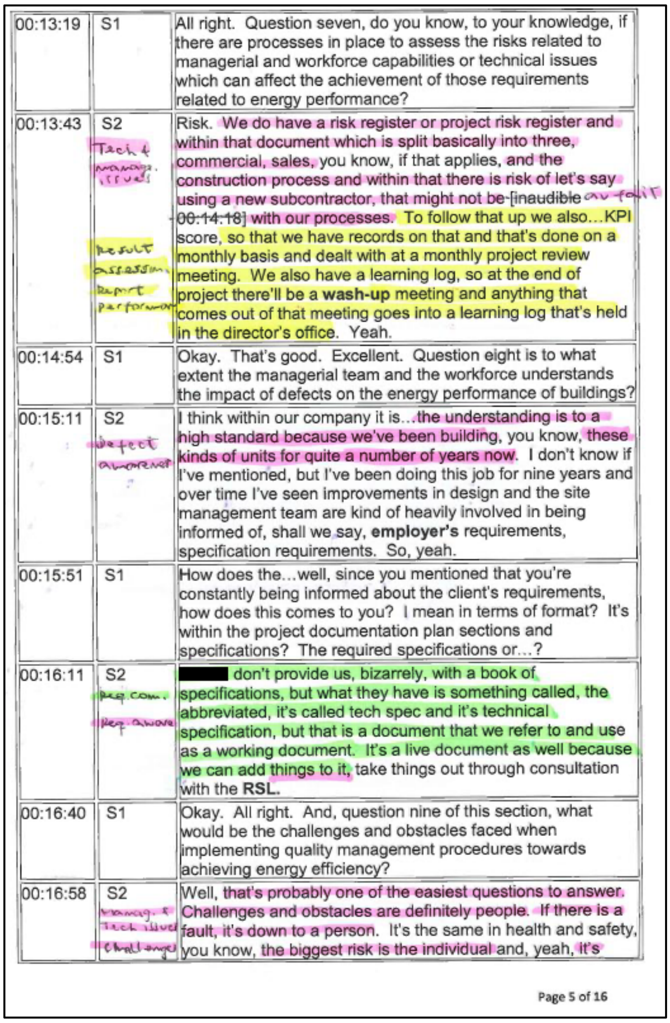
This section presents the process by which data collected led to the identification of the key challenges found in the projects in the process of managing quality issues related to the thermal performance of dwellings.

The coded information was analysed and the sections of data with similar content were merged into concepts. Although, clear cuts between concepts were not to be expected because they were induced from the intertwined processes of quality management in real world projects. In addition, the relationships of cause and effect were also established between concepts of different conceptual tags, which in turn became the sequential categories forming the empirical model. The use of data emerging from the semi-structured interviews was used as primary source of data which led to the definition of concepts within the five main categories of the conceptual framework. Whereas the use of the secondary sources of data (i.e. quality management documentation, observation memos and defects surveys) aimed to confirm or challenge the findings from the semi-structured interviews. Ultimately, the combined analysis of the multiple sources of data led to the identification of the major challenges encountered in the process of development and implementation of Project Quality Plans with focus on the thermal performance of dwellings' fabric.

3.6.1 Semi-structured interviews

The data collected during the semi-structured interviews were converted by an outsourced transcription service into individual Microsoft Word documents for each interview. The transcriptions of the interviews were checked by the author by listening to the interview audio records and comparing with the transcriptions provided. Any errors in the interview transcriptions identified were corrected in the document.

Data processing and analysis followed the procedures set by Grounded Theory methodology. The information contained in the transcripts was broken down, coded and clustered using the conceptual tags of the conceptual framework: (i) definition of quality requirements; (ii) quality risk assessment; (iii) quality resources assessment; (iv) definition of quality metrics and control; and (v) quality compliance procedures. As shown in Figure 3-24, the initial process of coding aimed to identify relevant data sections according to each of the conceptual tags. The process entailed the use of five colours, one for each of the tags. Then, the highlighted data sections were coded to enable further data analysis iterations and clustering of converging data.



00:13:19	S1	All right. Question seven, do you know, to your knowledge, if there are processes in place to assess the risks related to managerial and workforce capabilities or technical issues which can affect the achievement of those requirements related to energy performance?
00:13:43	S2 Tech & manag. issues Result assessm. Report performance	Risk. We do have a risk register or project risk register and within that document which is split basically into three, commercial, sales, you know, if that applies, and the construction process and within that there is risk of let's say using a new subcontractor, that might not be [inaudible ~~00:14:18~~] with our processes. To follow that up we also…KPI score, so that we have records on that and that's done on a monthly basis and dealt with at a monthly project review meeting. We also have a learning log, so at the end of project there'll be a **wash-up** meeting and anything that comes out of that meeting goes into a learning log that's held in the director's office. Yeah.
00:14:54	S1	Okay. That's good. Excellent. Question eight is to what extent the managerial team and the workforce understands the impact of defects on the energy performance of buildings?
00:15:11	S2 Defect awareness	I think within our company it is…the understanding is to a high standard because we've been building, you know, these kinds of units for quite a number of years now. I don't know if I've mentioned, but I've been doing this job for nine years and over time I've seen improvements in design and the site management team are kind of heavily involved in being informed of, shall we say, **employer's** requirements, specification requirements. So, yeah.
00:15:51	S1	How does the…well, since you mentioned that you're constantly being informed about the client's requirements, how does this comes to you? I mean in terms of format? It's within the project documentation plan sections and specifications? The required specifications or…?
00:16:11	S2 Req. com. Req. aware	[redacted] don't provide us, bizarrely, with a book of specifications, but what they have is something called, the abbreviated, it's called tech spec and it's technical specification, but that is a document that we refer to and use as a working document. It's a live document as well because we can add things to it, take things out through consultation with the **RSL**.
00:16:40	S1	Okay. All right. And, question nine of this section, what would be the challenges and obstacles faced when implementing quality management procedures towards achieving energy efficiency?
00:16:58	S2 manag. & Tech issues Challenges	Well, that's probably one of the easiest questions to answer. Challenges and obstacles are definitely people. If there is a fault, it's down to a person. It's the same in health and safety, you know, the biggest risk is the individual and, yeah, it's

Page 5 of 16

Figure 3-24 Initial coding process of the interview transcripts.

Further iterations of coding analysis were conducted to merge similar codes into key concepts. In order to enable these data analysis iterations, the data sections highlighted in the initial coding process were then extracted from the interview transcripts and grouped within the respective tags (Figure 3-25). The following step of the analysis process examined the relationships between data clusters (concepts and conceptual tags within the conceptual framework) to reveal the challenges and opportunities encountered by the participants of case studies in the process of managing quality issues related to thermal performance of buildings.

Interviews 2.c
Coding 01 Grouping v02

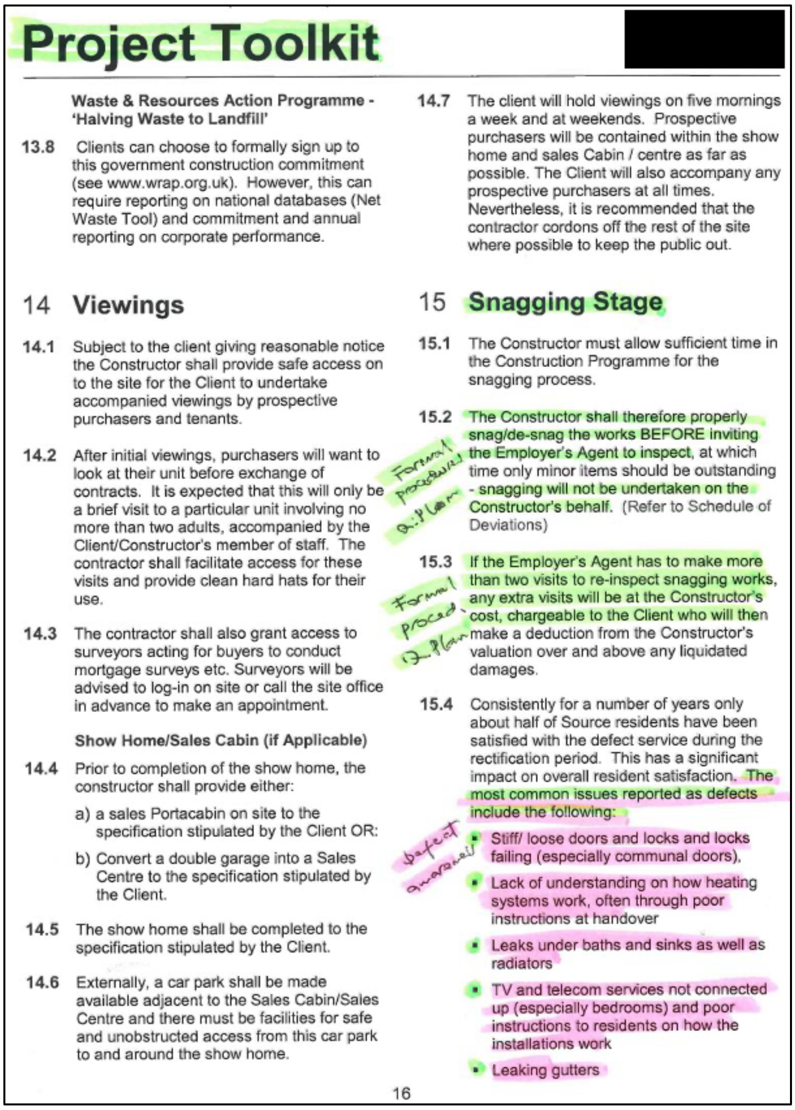
10/07/17

Time	Tag - Definition of quality requirements	Code
00:02:42	We have ISO. I don't know the—exactly what numbers but we have a few accreditations from ISO….I'm not sure the particular accreditations	Quality policy
00:05:45	I'm not aware of a quality plan, etc. but it is knowing that our aim generally is zero defects.	Quality plan Formal procedures
00:06:06	Obviously, being housing association units, the more energy efficient they are, tend to be cheaper to run for the tenants that are in there and that's always a higher priority on their (housing association) brief—design briefing.	Requirements Requirement communication
00:06:34	Obviously, we've got our building regs (sic) to be compliant with the (SAP) assessment, etc. ... I don't know the exact figures but they're set quite high, the insulation, etc. and the timber frames works over and above building regs (sic).	Requirements
00:08:17	(Question - how those defined requirements are documented and transmitted to the participants of the project?) Through *housing association*'s technical specification. It is handed over to us when we're tendering the work then.	Requirement communication
00:09:04	…it was all set out from the start, with the design brief to the architects and engineers with the client. … we have a pre-construction manager in our office which—because we're part of the same organisation, he's highly involved even at that stage before we get awarded the contracts. … making sure that *housing association* as our client, are getting everything that they require and expect so we do have quite a high input into the initial stage, the design stage to make sure it fulfils the group's requirements.	Requirement communication
00:11:46	We tried to find the good pool of subcontractors. We shortlist probably three for each trade that we like to use, obviously without overloading. They're fully briefed on what is expected at those, before we actually let the subcontract to them. It is quite an extensive liaisons process before they get the contract to make sure that they're fully aware of what is required, all the details, etc. … it's keeping our key subcontractors, and know what we expect, know what we build and we don't change our products very often for *housing association*. We might change the house types but the details and items like that stay the same once we find a good detail or a good product.	Requirement communication Quality policy

Figure 3-25 Initial coding process of interview transcripts.

3.6.2 Quality management documentation

As aforementioned in section 3.5.2, the documentation provided by housing associations and contractors was gathered and organised by document type (e.g. client requirement and quality checklists) for each of the case studies. The first iteration of data processing consisted in selecting the documents that had information related to quality assurance procedures and provided understanding to the process of how Project Quality Plans were developed and implemented. The following step consisted in implementing the coding procedures according to the aforementioned conceptual framework (Figure 3-26).



Project Toolkit

[redacted]

Waste & Resources Action Programme - 'Halving Waste to Landfill'

13.8 Clients can choose to formally sign up to this government construction commitment (see www.wrap.org.uk). However, this can require reporting on national databases (Net Waste Tool) and commitment and annual reporting on corporate performance.

14 Viewings

14.1 Subject to the client giving reasonable notice the Constructor shall provide safe access on to the site for the Client to undertake accompanied viewings by prospective purchasers and tenants.

14.2 After initial viewings, purchasers will want to look at their unit before exchange of contracts. It is expected that this will only be a brief visit to a particular unit involving no more than two adults, accompanied by the Client/Constructor's member of staff. The contractor shall facilitate access for these visits and provide clean hard hats for their use.

14.3 The contractor shall also grant access to surveyors acting for buyers to conduct mortgage surveys etc. Surveyors will be advised to log-in on site or call the site office in advance to make an appointment.

Show Home/Sales Cabin (if Applicable)

14.4 Prior to completion of the show home, the constructor shall provide either:

a) a sales Portacabin on site to the specification stipulated by the Client OR:

b) Convert a double garage into a Sales Centre to the specification stipulated by the Client.

14.5 The show home shall be completed to the specification stipulated by the Client.

14.6 Externally, a car park shall be made available adjacent to the Sales Cabin/Sales Centre and there must be facilities for safe and unobstructed access from this car park to and around the show home.

14.7 The client will hold viewings on five mornings a week and at weekends. Prospective purchasers will be contained within the show home and sales Cabin / centre as far as possible. The Client will also accompany any prospective purchasers at all times. Nevertheless, it is recommended that the contractor cordons off the rest of the site where possible to keep the public out.

15 Snagging Stage

15.1 The Constructor must allow sufficient time in the Construction Programme for the snagging process.

15.2 The Constructor shall therefore properly snag/de-snag the works BEFORE inviting the Employer's Agent to inspect, at which time only minor items should be outstanding - snagging will not be undertaken on the Constructor's behalf. (Refer to Schedule of Deviations)

Formal procedures Q:Plan

15.3 If the Employer's Agent has to make more than two visits to re-inspect snagging works, any extra visits will be at the Constructor's cost, chargeable to the Client who will then make a deduction from the Constructor's valuation over and above any liquidated damages.

Formal proced. Q Plan

15.4 Consistently for a number of years only about half of Source residents have been satisfied with the defect service during the rectification period. This has a significant impact on overall resident satisfaction. The most common issues reported as defects include the following:

Defect awareness

- Stiff/ loose doors and locks and locks failing (especially communal doors).
- Lack of understanding on how heating systems work, often through poor instructions at handover
- Leaks under baths and sinks as well as radiators
- TV and telecom services not connected up (especially bedrooms) and poor instructions to residents on how the installations work
- Leaking gutters

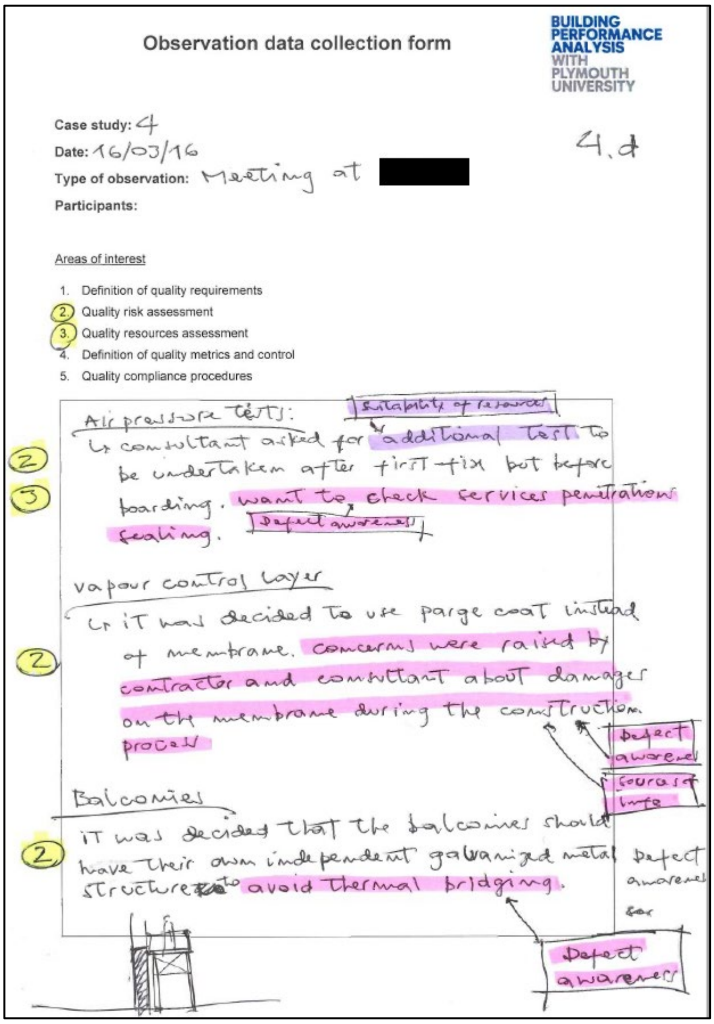
16

Figure 3-26 Initial coding process of interview transcripts.

Once relevant data was analysed and categorised into the tags, further analysis iterations took place in combination with data deriving from other sources.

3.6.3 Observations from project team meetings and site visits

Processing and analysing data gathered during project team meetings and site visits observations consisted, firstly, of the identification of the meetings and site visits memos that would provide additional information to the understanding of the targeted phenomena. Hence, information from the memos were coded in accordance to the conceptual framework (Figure 3-27), enabling cross-analysis between the different sources of data and later between the case studies.



Observation data collection form

BUILDING PERFORMANCE ANALYSIS WITH PLYMOUTH UNIVERSITY

Case study: 4

Date: 16/03/16

Type of observation: Meeting at [redacted]

Participants:

4.d

Areas of interest

1. Definition of quality requirements
2. Quality risk assessment
3. Quality resources assessment
4. Definition of quality metrics and control
5. Quality compliance procedures

Air pressure tests: Suitability of resources

↳ consultant asked for additional test to be undertaken after first-fix but before boarding. want to check services penetrations sealing. Defect awareness

Vapour control layer

↳ it was decided to use parge coat instead of membrane. concerns were raised by contractor and consultant about damages on the membrane during the construction process. Defect awareness. Source of info

Balconies

it was decided that the balconies should have their own independent galvanized metal structure to avoid thermal bridging. Defect awareness. Defect awareness

Figure 3-27 Initial coding process of meetings and site visits memos.

3.6.4 Construction defects surveys

The processing and analysis of data collected by means of construction defects site surveys had a different approach from the previous data collection procedures. The taxonomy and data collection form used to identify defects at the construction site provided a focused approach of defects affecting the thermal performance of the dwellings fabric. In that sense, no pre-selection procedure was required to mine relevant data sections, due to fact the data gathered was already collected with a specific purpose and classification structure. The data processing task required after the site visits was to link the defects recorded using the form with the photographic evidence. Moreover, the defects identified were then analysed against with the applied quality control procedures, in terms of the information embedded in the checklists and the inspection regime adopted. The aim was to assess the consistency of quality control instruments to identify defects and the adequacy of quality inspections frequency.

3.7 Validation procedures

In order to assess the validity of the results of this thesis, a procedure was devised and implemented. The adopted procedure was the administration of focus groups with industry professionals and researchers. In total three focus groups were undertaken with the participation of nine ~~experienced~~ participants, such as project managers, site managers, consultants, building surveyors and researchers.

The selection of the participants took into consideration three main criteria. The first criterion was regarded to the participants' knowledge in the unity of analysis of this thesis. The participants should have previous experience and participation in social housing projects in the UK. This was pivotal for the verification of the identified challenges. The second criterion was that participants should not have had any involvement in the case studies undertaken in this research. This prevented biased data to be collected and used in the validation process. Moreover, it allowed that the challenges identified in the case studies of this research could be validated by other professionals from the construction sector than the ones involved in the case studies of this thesis. The third criterion was regarded to convenience. This was concerned to the willingness and availability of the professionals to participate in the focus groups in the designated dates. In addition, the selection of participants also aimed at choosing professionals from the different parties involved in social housing projects. The main idea was that as much stakeholders as possible could be represented in the validation process, thus enriching the discussions around the research results.

In total fifteen professionals and researchers were contacted by means of electronic mail, where a brief explanation of the research objectives and the aims of the focus groups were provided. As a result, 7 professionals and 2 researchers manifested interest to collaborate. In order to accommodate availability of date and location convenience, three focus groups were organized and administered. Moreover, a pilot focus group was undertaken with four academics, where the focus group protocol was tested and revised. The duration of the activities was designed to take two hours.

The validation process was divided in three stages and a questionnaire was devised in order to provide guidance to the focus groups activities (Appendix B.7). The first stage aimed to explain the objectives of the focus group activity in terms of the use of the information collected and the ethical approach adopted, such as the participants' right to withdraw. Moreover, the participants were provided with a brief explanation of the research context and main objectives.

In the second part the main idea was to verify if the challenges identified in the research case studies were also experienced by the participants, and therefore the thesis results could be extrapolated to other social housing projects. For that matter, through the focus group questionnaire, two questions were asked for each of the challenges:

1. How do you rate on a scale of 1-10 the likelihood for this challenge to happen?*
2. How do you rate on a scale of 1-10 the impact this challenge poses to the successful development and implementation of Project Quality Plans with focus on the thermal performance of dwellings?*

* Please rate 0 if you have never experienced or have any knowledge about the posed challenge.

Question 1 aimed to assess whether the participants have experienced each of the challenges in their previous experiences in residential projects. Question 2 focused on assessing the perceived impact of the challenges on the implementation of Project Quality Plans and consequent achievement of the quality objectives regarding the thermal performance of the dwellings.

In the last stage of the focus groups, apart from providing written answers to the questions posed in the questionnaire, participants were invited to discuss their previous experiences regarded to the challenges identified in this thesis. Participants also had the opportunity to report other challenges that had not been listed in this study.

Finally, the findings of the focus groups were analysed and compiled, as presented in Chapter 5. Challenges were assessed, where mean values and standard deviations were established. Moreover, relevant aspects emerging from discussions were summarised and used in the discussion chapter (Chapter 6).

3.8 Chapter 3: Summary

The research design and methodology used in this research to meet the aim and objectives of this thesis and answer the research questions defined in Chapter 2 have been presented and described. This research has employed a qualitative approach which has collected mainly qualitative data.

The different research methods used to collect the data for this thesis were employed across different case studies of new-built social housing projects. The data used in this thesis have been collected by means of semi-structured interviews to key project stakeholders; from quality management project documentation; observations during project managerial meetings and site visits; and defect identification surveys at construction site visits.

This chapter has also outlined the two phases of data processing and analysis used. Phase 1 comprised the processing and analysis of data emerging from semi-structured interviews, where the concepts explaining the targeted phenomena were established. Phase 2 entailed the processing and analysis of data obtained from the other sources of data, which were used to corroborate the findings from the interviews. As a result of multiple data analysis, the challenges affecting the process of developing and implementing Project Quality Plans emerged. At both phases the data analysis method implemented was Grounded Theory.

The methods used to verify and validate the research results are also presented. Three focus groups where administered with construction industry professionals and academics, where the research results were explored and scrutinised.

Ethical considerations and the potential threats to the validity of the results have been identified and the actions taken to reduce error have been described.

The subsequent two chapters present the results of this research. Chapter 4 provides the results used to answer research questions Q1, which relate to the identification of the challenges posed to the process of development and implementation of project quality plans with a focus on the thermal performance of buildings' fabric. Chapter 5 answers research question Q2 and presents a list of actions to address to the identified challenges.

Chapter 4

Results: Challenges to the development and implementation of Project Quality Plans with focus on the thermal performance

4.1 Introduction

This chapter presents the research results from the analysis of a number of data sources related to the case studies being researched in this thesis, including: (i) interviews with key project stakeholders; (ii) documents, reports and technical information; (iii) defects data collected by means of surveys on-site; and (iv) observations during team management meetings and construction site visits.

This section aims to present the results in respect to the emerging challenges according to the five categories and their subcategories of the defined Project Quality Plan framework (i.e. definition of quality requirements, quality risk assessment, quality resources assessment, definition of quality metrics and control and quality compliance procedures) presented in sections 2.3.2 and 3.3.3.

4.2 Definition of quality requirements

Previous studies have identified the definition of quality requirements as the stage in a construction project where quality objectives mostly encompassing the client's aspirations and statutory requirements are defined. It is also at this stage where the quality compliance methods are established, driving the process of determining the formal procedures and guidelines expected to assess the achievement of the defined quality objectives. Equally important in this process is how quality requirements are communicated to other participants of the project, in order to prompt the actions towards the delivery the quality objectives and implementation of the compliance procedures.

The following concepts of the Definition of quality requirements category are being explored in this section: (i) Requirements (Jraisat et al., 2016, BSI, 2015, Harris et al., 2013, Briscoe et al., 2004, Deming, 2000, Juran, 1993); (ii) Requirements' communication (BSI, 2015, Auchterlounie, 2009, Deming, 2000); (iii) Quality Policy (Deming, 2000, Kanji, 1996); (iv) Quality Plan (Jraisat et al., 2016, Karim et al., 2005, Landin, 2000); (v) Formal Procedures (Karim et al., 2005, Quazi et al., 2002, Moatazed-Keani et al., 1999); (vi) Guidelines (Karim et al., 2005, Quazi et al., 2002, Moatazed-Keani et al., 1999); and (vii) Frameworks (Jraisat et al., 2016, BSI, 2015, Harris et al., 2013, BSI, 2011).

4.2.1 Findings from interviews with key project stakeholders

This section presents the answers to the interview questions 1 to 5 (section 3.5.1), which had been purposely formulated to explore the seven concepts related to the Definition of quality requirements mentioned above. The analysis of the interview transcripts revealed that the seven concepts had been acknowledged by at least one of the case studies.

The analysis of the data collected from interviews identified that in all case studies "employer's requirements" regarded to general quality objectives were defined. The defined requirements were communicated to the other participants of the project by means of a standard technical specification document in Case studies 1, 2 and 5 (Table 4-1, Data sections 1 and 2), and the project toolkit in Case studies 3 and 4 (Table 4-1, Data sections 3 and 4). Moreover, it was observed that the established quality requirements were included as part of the tendering documentation as well as part of the projects contracts. It is important to state that specifically in Case study 5, the asset development policy of the housing association was predominately intended to buy housing units from the open market developers instead of commissioning and managing the construction of their new assets. Consequently, little input was provided in terms of the definition of the quality requirements. However, the housing association would only acquire new assets providing they meet the company's defined quality standards (Table 4-1, Data section 5).

Table 4-1 Sample of sections of the interview transcripts related to the category Definition of quality requirements

	Data sections from Interview transcripts	Related concepts
1	There was a document that was produced by *housing association** which is a little bit more than employer's requirements. It's very specific in terms of design and quality … that's quality across the board whether it be thermal performance or aesthetics.(Interview 1.c – Site manager, 00:07:04)	Quality policy Requirements
2	So we have a sort of standard technical specification that all of our projects have got to meet and that are sort of agreed and basically produced by us at management team and various other stakeholders. So that forms part of the contract documents and part of the employer's requirements. So I guess that would be our sort of our plan sort of thing. (Interview 2.a – Quality coordinator, 00:08:27).	Quality policy Quality plan Requirements Requirements' communication Guidelines
3	It would come back to the toolkit, the actual quality standard. And that would be across the board to any of our projects. …So, that's the quality standard, what we would expect. (Interview 3.b – Quality officer, 00:05:34).	Requirements Requirements' communication Quality policy
4	We have the design and project toolkits which encompass our employer's requirements. They have been amended to meet Passivhaus standards which was a requirement made as part of our bid for the lands to Plymouth City Council. They sold us the site for one pound on delivery of a Passivhaus Standard project. So it was moulded, the requirements were moulded by *Passivhaus consultant**. (Interview 4.a – Head of development, 00:04:14).	Requirements Requirements' communication Quality policy
5	It's building regulations and then it meets added development standards, so it means code for sustainable homes level three. There's a (name of the housing association)'s specification which all units need to meet as well an agreed specification, contract specification. (Interview 5.b – Project manager, 00:03:49).	Quality policy Requirements Requirements' communication

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

As per the specific requirements related to the thermal performance of the projects' dwellings, in Case studies 1, 2 and 3 the targets to be met were the statutory ones, which are mandated by funding agencies. In that sense, the thermal performance targets pursued in these projects were the ones specified by UK Building Regulations Part L1a - Conservation of fuel and power in new dwellings (HM Government, 2013) (Table 4-2, Data sections 6, 7 and 8). In Case study 5, apart from complying with the Building regulations, it the project initially intended to meet the Code for Sustainable Homes level 3 (Table 4-2, Data section 9). However, when the funding agencies refrained from requiring these standards as mandatory, the project mainly focused on achieving Building Regulation Part L1a. In Case study 4, the defined thermal performance targets to be achieved were the Passivhaus standards (BRE, 2016). The decision to pursue Passivhaus accreditation was made due to an agreement compromised between the housing association and the local city council. The land was sold by the local council by a symbolic price to the housing association in the condition that the project would meet Passivhaus standards (Table 4-2, Data section 4).

Table 4-2 Sample of sections of the interview transcripts related to the category Definition of quality requirements

	Data sections from Interview transcripts	**Related concepts**
4	We have the design and project toolkits which encompass our employer's requirements. They have been amended to meet Passivhaus standards which was a requirement made as part of our bid for the lands to Plymouth City Council. They sold us the site for one pound on delivery of a Passivhaus Standard project. So it was moulded, the requirements were moulded by *Passivhaus consultant**. (Interview 4.a – Head of development, 00:04:14).	Requirements Requirements' communication Quality policy
7	We're going back to building regs (sic), but I believe that building regs (sic) have taken on some of the good points that came out of a code for sustainable homes and they've kind of met half way. (Interview 1.c – Site manager, 00:31:57).	Requirements
8	You could say the primary driver is the legislation which we have to meet that first. … The energy conservation in the main is linked to the building regs (sic) approved documents because that's what the underlying requirement is. (Interview 3.b – Quality officer, 00:08:54).	Requirements Quality policy
9	Yes, they have to sort of achieve or exceed building regulations. And they have to comply with code for sustainable homes level 3. They are generally the driving performance criteria. (Interview 5.b – Project manager, 00:05:12).	Requirements Quality policy

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In terms of the Quality policy which permeates the different projects of each housing association, it was observed a legitimate interest in improving the levels of energy efficiency of their new assets in all Case studies. Ultimately, they overall aim at improving the occupants' living standards and reduce energy bills as well as fuel poverty (Table 4-3, Data section 10). However, as explained by the project manager of the housing association in Case study 4, due to financial constraints led by cuts in social renting values and limited funding, the adoption of more ambitious thermal performance targets were suspended (Table 4-3, Data section 10). In fact, in the recent past, housing associations of all case studies had commissioned projects to comply with the Code for Sustainable Homes level 4, 5 and 6, which encompassed the achievement of higher energy performance targets than established by Part L 1a – Building Regulations (Table 4-3, Data sections 11 and 12). However, as a reflex of the financial constraints faced by housing associations, the current adopted quality objectives and compliance requirements concerning the thermal performance of the dwellings is set only to achieve the minimum statutory requirements by means of the building control body's final approval as the main compliance procedure (Table 4-3, Data section 13).

Table 4-3 Sample of sections of the interview transcripts related to the category Definition of quality requirements

	Data sections from Interview transcripts	**Related concepts**
10	(Question - So can you say that those energy performance requirements are part of the strategic goals of the organization or only specific for the project?) They were originally and I had originally thought that it would be, I had imagined that building regs (sic) would go in this direction. And I had imagined it would be really good to… an early example, to better understand how it works and perhaps to inform how design standards but in the intervening period we had the rent cuts which cost us over £20 million. So the focus is being far more on delivery of units rather than high levels of energy specification. But the reason why we are interested in that in principle is because we're interested in our tenants and having as low energy bills as possible, so because we're housing people on limited means and also it helps on pay the rent. (Interview 4.a – Head of development, 00:06:27).	Requirements Quality policy
11	We used to do (higher standards of energy performance as a strategic goal)…well, predominantly community agency funding stipulated a code level three. We've done a couple of projects of code level four, but generally it would always be for that code level three. Since that's the normal requirement and sort of that funding, it's just building regulations, isn't it, now to meet the requirements of that. (Interview 1.b – Development manager, 00:10:41).	Requirements Quality policy

12	We've, our most...well, I have to be honest, energy efficient homes, there was a scheme called *name of the project** which is in South Gloucestershire in Bristol. And it was going to be a code level six. That then got downgraded. But basically the intention was that to be carbon neutral. …So yeah, originally, it's meant to be a lot higher. We, I think it's probably code four now. Or a bit more, really. And I think across *housing association** the highest one I could think of is code level four other than that one. (Interview 5.b – Project manager, 00:06:10).	Requirements Quality policy
13	…it needs to obtain NHBC quality control certification and secured by the design part II accreditation, which is the security aspect of the building. (Interview 5.c – Site manager, 00:04:11).	Requirements Quality policy

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Concerning the identification of quality plans designed to ensure the achievement of the defined quality objectives, the case studies presented different set of procedures as frameworks and guidelines, which are presented in the following sections of this chapter. The development and implementation of a holistic approach towards ensuring the achievement of the defined quality standards could not be identified (Table 4-4, Data sections 14 and 15). Apart from Case study 4, all case studies lacked of a formal project quality plan encompassing the five categories identified in the literature review (i.e. definition of quality requirements, quality risk assessment, quality resources assessment, definition of quality metrics and control and quality compliance procedures). Only in Case study 4, the development of a bespoken Project Quality Plan was a requirement established in the early procurement stages, as a request from the housing association and the Passivhaus consultant. In fact, all housing associations and contractors involved in the case studies, except for the contractor of Case study 5, have accredited Quality Management Systems (QMS) such as ISO 9001 and 14001. However, the principles underpinning the accredited QMS could not be fully observed in the development and implementation of the projects' quality plan. It was observed that the implementation of the QMS in the companies participating in the case studies were limited to the central management processes, as stated by the quality officer of Case study 5 (Table 4-4, Data section 16). Moreover, most of the interviewees could not identify which QMS their company was accredited to, demonstrating that the formal procedures of the quality systems did not fully permeate the quality assurance procedures put in place at the project level (Table 4-4, Data sections 17 and 18). For instance, the consistency of procedures implementation, which is an important aspect checked in QMS audits, could not be observed during quality control activities in most of the case studies, as evidenced in sections 4.4 (Quality resources assessment) and 4.5. (Definition of quality metrics and control).

Table 4-4 Sample of sections of the interview transcripts related to the category Definition of quality requirements

	Data sections from Interview transcripts	Related concepts
14	I'm not aware of a quality plan, etc. but it is knowing that our aim generally is zero defects. (Interview 2.c – Site manager, 00:05:45).	Quality plan Formal procedures
15	We have our own (quality management procedures) but it's not formalised, if you know what I mean. It's down to the individual surveyor's experience. Now obviously, if somebody else is doing my job if I went sick or left the job, then they would have to pick it back up. They would have to make themselves familiar with the specification. So, we don't have anything formal in that sense. (Interview 3.b – Quality officer, 00:51:15).	Quality plan Formal procedures
16	We do (have an accredited QMS) as a company but it's not specifically related to this site. (Interview 5.a – Quality officer, 00:01:55).	Quality policy Guidelines
17	I think we do, but I'd need to find out that for you because I'm not sure it's specifically for our department, but I know as a…as a whole we do have quality marks. (Interview 3.a – Project manager, 00:02:58).	Quality policy Guidelines
18	…we haven't got ISO as such. We've got the standard sort of QA but that's in-house, it's not…. Although saying that actually, we are…we might have ISO 9001 actually off the top of my head. And I'm not sure to be honest. (Interview 3.b - Quality officer, 00:02:35).	Quality policy Guidelines

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Even though a formal quality plan concerned to the thermal performance objectives could not be identified in Case studies 1, 2, 3 and 5, sets of formal procedures, guidelines and frameworks were established. For instance, in Case studies 3 and 5 the contractor's site management team had a quality assurance framework developed by the company's central management. This one was adapted to the project only in Case study 3. The quality assurance framework oriented the site team in relation to the construction key stages and building elements where the quality inspections should take place (Table 4-5, Data sections 19 and 20). However, it was not clear whether this set of formal procedures encompassed the quality objectives related to the thermal performance, as discussed in section 4.5 (Definition of quality metrics and control).

Table 4-5 Sample of sections of the interview transcripts related to the category Definition of quality requirements

	Data sections from Interview transcripts	Related concepts
19	We also got our own internal checks as we go along, so we have a quality manual, I think we got that quality manual. … We got a quality manual which takes us through every single stage which we need to check. (Interview 5.c, 00:06:12).	Formal procedures Guidelines Frameworks
20	Well, we have quality checklist for every stage built. So the groundwork is split into four sections and once that work has been done, it's then signed off by the foreman and then signed off by ourselves. (Interview 3.c, 00:08:15).	Formal procedures Guidelines Frameworks

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Overall, the findings resulting from the analysis of the concepts related to Definition of quality requirements could be summarised in two main subcategories: Quality objectives and compliance and Formal procedures (Table 4-6). Whilst Quality objectives and compliance encompasses the definitions in the strategic level and communication of the thermal performance targets to be achieved in each project, the Formal procedures concept establishes the set of procedures in the operational level to achieve the quality objectives, through the implementation of either formal or informal Project Quality Plans.

These two concepts are explored in the next section through the analysis of additional data obtained from the projects' documentation and observations in construction site visits and managerial meetings.

Table 4-6 Definition of Quality requirements emerging subcategories

Subcategories	Concepts
Quality objectives and compliance	Requirements
	Requirements' communication
	Scope
	Quality policy
Formal procedures	Quality plan
	Formal procedures
	Guidelines
	Frameworks

4.2.2 Findings from project documentation, defect surveys and observations from construction site visits and managerial meetings

The process of defining the quality requirements and establishing the procedures by which quality targets can be assessed and reported, acted as the planning exercise for the following stages of the process of delivering quality in the case studies.

The previous analysis made evident that in all case studies a clear definition of the quality objectives was provided by the housing association or developer in the early stages of the project. In that sense, it is fair to state that these objectives were part of tendering documentations and contractual requirements. Corroborating this statement, Figure 4-1 and Figure 4-2 present the summary of Case study 4 client's requirements embedded in the project's invitation to tender document, where the quality objectives regarded to the thermal performance of the project's dwellings were specified. In addition to the quality objectives, it is also possible to identify the quality compliance process through the section "Certification Criteria".

EMPLOYERS REQUIREMENTS

Contents

Volume 1 – Instructions

Instructions to Tenderers (including Evaluation Criteria and Form of Tender)

Volume 2 – Source Documentation

0) Project Brief
1) Project Toolkit
2) Design Toolkit
3 – 10) Checklists, Warranties etc.

Volume 3 – Plymouth Community Homes Specific Requirements

1) Schedule of Deviations to SDP Project Toolkit
2) Social Value Toolkit

Volume 4 – General Conditions

0) Pre-Contract Services
1) Preliminaries
2) Contract Particulars and Amendments

Volume 5 – Passivhaus Requirements

0) Passivhaus Requirements
1) Certification Criteria Residential
2) Airtightness Requirements
3) Air Infiltration Calculation
4) MVHR Requirements
5) Passivhaus Briefing – [redacted]

Figure 4-1 Section of Case study 4 Invitation to Tender documentation (Source: housing association Case study 4)

Passivhaus Requirements for Contractor

Passivhaus

Passivhaus buildings provide a high level of occupant comfort whilst using very little energy for heating and cooling. They are built with meticulous attention to detail and rigorous design and construction according to principles developed by the Passivhaus Institute in Germany, and can be certified through an exacting quality assurance process.

The new-build Passivhaus Standard requires:

- a maximum space heating and cooling demand of less than 15 kWh/m²year or a maximum heating and cooling load of 10W/m²
- a maximum total primary energy demand of 120 kWh/m²/year
- an air change rate of no more than 0.6 air changes per hour @ 50 Pa
- the frequency of overheating is to be limited to 10% of hours above 25 deg C
- the above figures are to be assessed using the PHPP (Passive House Planning Package); the reference area is the 'treated floor area' (TFA) as defined in the latest PHPP manual.

Figure 4-2 Section of Case study 4 client's requirements (Source: contractor Case study 4)

However, in Case studies 1, 2, 3 and 5 the challenge posed to the achievement of the quality objectives regarded to thermal performance was that the defined compliance process did not encompass the quality assurance procedures undertaken by neither the housing associations nor the contractors. Figure 4-3 and Figure 4-4 make evident the fact that the ultimate quality compliance requirement was to obtain the Part L1a of the UK Building Regulations approval, where the quality control and compliance confirmation was assigned to a third party, i.e. building control body. Thus, the establishment of quality objectives and compliance process defined the approach of the development and implementation of the projects' quality plans, especially in the assessment of risks, allocation of resources and the emphasis applied on the quality control procedures, as discussed in the following sections of this chapter.

8	A copy of all operations manuals +manufacturers guarantees or warranty certificates for all products especially mechanical, electrical & service installations, roof coverings, damp proof treatments, wall tie replacement and windows.
9	A certificate/ letter of approval issued by Building Control at Practical Completion
10	Confirmation the Planning Department that the development has been completed in accordance with planning consent
11	A copy of NHBC (or similar) Site Record Book, & any certificates & letters confirming approval at Practical Completion
12	Confirmation from the Structural Engineer stating that structural works have been satisfactorily completed.
13	A SAP rating assessment for each dwelling.

Figure 4-3 Section of Case study 3 client's requirements indicating the quality compliance process (Source: housing association Case study 3)

HANDOVER DOCUMENTS SCHEDULE FOR COMPLETION OF AFFORDABLE HOUSING UNITS [redacted]

[redacted]

DATE PREPARED : [redacted]

	PLOT NUMBER	62	63		61	64		3	5	6	7	8	
1	NHBC CML	✓	✓		✓	✓		✓	✓	✓			
2	NHBC Insurance Certificate	✓	✓										
3	Building Control Final Certificate	✓	✓						✓				
4	EPCs	✓	✓		✓	✓		✓	✓	✓			
5	As-built SAPs	✓	✓		✓	✓		✓	✓	✓			
6	Air Tests	✓	✓		✓	✓		✓	✓	✓			
7	Code Design Stage Certificates	✓	✓		✓	✓		✓	✓	✓	✓	✓	
8	Code Final Certificate or Letter of Comfort	✓	✓		✓	✓				✓			
9	Secured by Design Part 2	✓	✓		✓	✓							
10	Conveyance Plans	N/A	N/A		N/A	N/A		N/A	N/A	N/A	✓	✓	
11	Planning Conditions discharged	✓	✓		✓	✓				✓			
12	Section 38 Technical Approval	✓			✓					✓			
13	Section 104 Technical Approval	✓			✓					✓			
14	Section 278 Technical Approval	N/A			N/A					N/A			
12	Handover Pack:												
	- Boiler benchmark certificate	✓	✓		✓	✓		✓	✓	✓	✓	✓	
	- Landlords gas safe certificate	✓	✓		✓	✓		✓	✓	✓	✓	✓	
	- Electrical installation certificate	✓	✓		✓	✓		✓	✓	✓	✓	✓	
	- Home User Guide	✓	✓		✓	✓		✓	✓	✓	✓	✓	
	- M&E info and instructions	✓	✓		✓	✓		✓	✓	✓	✓	✓	
	- Copy of CML	✓	✓		✓	✓		✓	✓	✓	✓	✓	
	- Copy of EPC	✓	✓		✓	✓		✓	✓	✓	✓	✓	

Figure 4-4 Required compliance required by housing association of Case study 5 for handover process (Source: housing association Case study 5)

In terms of formal procedures, in most case studies the quality objectives and the quality control procedures focusing on defects with potential to impact on thermal performance of the buildings were defined and implemented by building control bodies. Although, the quality control procedures applied by building control bodies used a standard and structured approach, only five key stages where stablished for quality control inspections, as shown in site inspection record book (Figure 4-5). It is also important to acknowledge that from the five inspections stages, two of them (i.e. Drainage and Pre-handover) provided very few, if none, opportunities to identify quality issues affecting the thermal performance of the dwellings.

	Foundations			Drainage			Superstructure			Pre-plaster			Pre-handover		
	Date		NHBC	Date		NHBC	Date		NHBC	Date		NHBC	Date		NHBC
Plot	Inspected	Accepted	initials	Inspected	Accepted	initials	Inspected	Accepted	initials	Inspected	Accepted	initials	Inspected	Accepted	initials

Figure 4-5 Section of Building control inspection record book - key stages quality inspections (Source: contractor Case study 5)

The incentives and motivations for housing associations and contractors to develop a thorough project quality plan with focus on thermal performance of buildings were diminished, due to the fact the ultimate compliance procedure was assigned to building control bodies. Through the analysis of the formal procedures applied in the projects, especially concerning allocated resources and quality control procedures, it became evident that the efforts put in place to ensure the achievement of the quality standards focussed mainly on the final stages of the construction process. As observed in the project toolkit of Case study 3 (Figure 4-6), the only formal procedure related to quality control activities required by the housing association to the contractor were the snagging procedures in final stages of the construction process. Instructions such as shown in Figure 4-6 could not be observed in previous stages of the construction process in none of the case studies.

15 Snagging Stage

15.1 The Constructor must allow sufficient time in the Construction Programme for the snagging process.

15.2 The Constructor shall therefore properly snag/de-snag the works BEFORE inviting the Employer's Agent to inspect, at which time only minor items should be outstanding - snagging will not be undertaken on the Constructor's behalf.

15.3 If the Employer's Agent has to make more than two visits to re-inspect snagging works, any extra visits will be at the Constructor's cost, chargeable to the Client who will then make a deduction from the Constructor's valuation over and above any liquidated damages.

Figure 4-6 Section of project toolkit defining formal procedures of the snagging process (Source: housing association Case study 3)

Corroborating the focus of quality control procedures on the final stages of construction, Figure 4-7 presents a section of a quality checklist devised and implemented by the housing association in Case study 3. In fact, the only structured quality inspection administered by the housing association took place during the snagging stage. Figure 4-7 also indicates that in addition to the snagging procedures undertaken by the quality officer of the housing association, the inspections procedures should also be administered by an independent building surveyor (employer's agent). As shown in the checklist (Figure 4-7), the main focus was the mitigation of visual defects which were more likely to be identified by building control bodies during their last inspection and tenants during the operational stage. It is worth acknowledging that at this stage of the construction process, defects affecting the thermal performance of the dwellings are enclosed within the building fabric and cannot be spotted only through visual inspection.

	Agent	Client
Lounge		
Plaster /Dry lining complete	☐	☐
Emulsion to C&W Satisfactory	☐	☐
Decoration to woodwork satisfactory	☐	☐
Window working and key in lock	☐	☐
Door working correctly	☐	☐
Ironmongery working and fully screwed	☐	☐
4 No double sockets minimum	☐	☐
T / V & - B/T socket fitted-Tested	☐	☐
Focal point fire spur (if applicable)	☐	☐
Lights working and bulbs fitted	☐	☐
Radiator fitted securely	☐	☐
Vent to storage areas (if applicable)	☐	☐
Hall		
Plaster / Dry lining satisfactory	☐	☐
Emulsion to wall/ ceiling satisfactory	☐	☐
Woodwork painted satisfactory	☐	☐

Figure 4-7 Section of snagging checklist devised by housing association (Source: housing association Case study 3)

In Case study 4, the quality standards related to energy performance and compliance procedures were also defined by a third party, i.e. the Passivhaus Institute. However, as observed in the Invitation to Tender document (Figure 4-8) sent to potential contractors in the early stages of the tendering process, the responsibility of developing a quality plan and providing compliance evidence was contractually assigned to the contractor. As a consequence, it triggered the development of a bespoken project quality plan. In fact, this was the only project whose project quality plan underwent the five different stages entailed by conceptual framework devised in this research.

In the event that the Tender passes the minimum requirements, it will then be scored and weighted according to the evaluation criteria noted in the table below.

	Quality		
1	Quality and Employers Requirements – Design Approach The Tenderer shall provide a statement on the proposed methodology for achieving a Passivhaus certified construction, including how the contractor proposes to manage sub-contractors to provide the quality and design requirements. [No page limit]		25%

Figure 4-8 Section of Case study 4 Invitation to tender document (Source: housing association Case study 4)

4.2.3 Challenges identified related to the definition of quality requirements

This section presents the challenges to the development and implementation of project quality plans with focus on the thermal performance of domestic buildings identified from the analysis of the data related to the Definition of quality requirements.

1. **Lack of definition of quality compliance procedures among the quality objectives, other than those defined and implemented by building control bodies.**

In Case studies 1, 2, 3 and 5, data suggested that quality objectives related to the thermal performance of the dwellings were defined following the specifications of the UK Building Regulations as the minimum standard. However, the ultimate quality control and compliance procedure concerned to the thermal performance were assigned to building control parties, and consequently no compliance method was defined for quality assurance processes implemented by representatives of the housing associations and contractors.

2. **Lack of control of the ultimate compliance process and associated quality control, due to this process being assigned to third parties (i.e. building control bodies).**

Because the ultimate compliance procedure for the quality objectives related to thermal performance were assigned to the building control bodies, the housing associations had no control over the process of assessing and reporting quality compliance. Consequently, the definition of the necessary evidence for quality compliance and resources applied in the process of quality control were neither tailored to the project, nor aligned to the housing associations' long-term objectives.

4.3 Quality risk assessment

Quality risk assessment in construction projects is described by the literature as the process of identifying the issues which are recurrent in similar projects and have the potential to undermine the achievement of the quality objectives established in the projects quality requirements. It also includes the identification of the potential managerial risks to the process of developing and implementing the Project Quality Plan. Quality risk assessment requires information from relevant sources, such as the projects participants and data from similar projects, to be gathered and analysed, enabling the formulation of adequate solutions to mitigate the foreseen issues.

The following concepts of the Quality risk assessment category are explored in this section: (i) Stakeholders' participation (Ruparathna and Hewage, 2015, Briscoe et al., 2004, Kanji and Wong, 1998); (ii) Interest parties (Gorse et al., 2012, Karim et al., 2005, Quazi et al., 2002); (iii) Sources of information (Gorse et al., 2012, Battikha, 2008, Atkinson, 2002); (iv) Database (Battikha, 2008, Atkinson, 2002); (v) Suitability of information (Battikha, 2008, Atkinson, 2002, Josephson and Hammarlund, 1999); (vi) Technical issues (Josephson et al., 2002, Love and Li, 2000); (vii) Challenges (Love et al., 2004, Atkinson, 2002, Holt et al., 2000), (viii) Managerial issues (Atkinson, 2002, Holt et al., 2000); (ix) Defects awareness (Battikha, 2008, Atkinson, 2002, Josephson and Hammarlund, 1999) ; (x) Requirement awareness (BSI, 2015, Battikha, 2008, Atkinson, 2002, Josephson and Hammarlund, 1999); (xi) Capabilities (Greenwood et al., 2017, BSI, 2015, Josephson et al., 2002, Love and Li, 2000).

4.3.1 Findings from interviews with key project stakeholders

This section presents the answers to the interview questions 6 to 9 (section 3.5.1), which had been purposely formulated to explore the eleven concepts related to Quality risk assessment mentioned above. The analysis of the interview transcripts revealed that the eleven concepts had been acknowledged by almost all of the case studies.

Regarding the procedures put in place to assess the risks and challenges to the process of achieving of the quality objectives, Case studies 1 and 5 interviewees mentioned that important participants of the project, such as the contractor in Case study 1 (Table 4-7, Data section 18), or the housing association representatives in Case study 5, did not contribute with relevant information to prevent the generation of defects during the design process or enhance buildability aspects through appropriate detailing. In the other case studies the procurement route adopted allowed the participation of the other project stakeholders in the technical definition of the early stages of the design process.

Table 4-7 Sample of sections of the interview transcripts related to the category Quality risk assessment

	Data sections from Interview transcripts	Related concepts
18	*Housing association** appoints designers and then *contractor** just purely build, so we've got no input in design as a builder.(Interview 1.c – Site manager, 00:06:02)	Stakeholders' participation

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In respect to the process of identifying technical issues, such as potential defects to be designed out or to be looked for during the construction phase by means of quality control procedures, the interviews revealed that the housing association in Case studies 1 and 2 relied mostly on a defect monitoring system containing information deriving from the post-occupation stage collected by the new tenants (Table 4-8, Data section 19). In Case study 3, the main source of information used to foresee potential defects were the forums organised during the design stage, with the project's interested parties such as stakeholders from asset and maintenance teams of the housing association, as well as representatives of the residents committee. The main objective of the forums were to identify the most recurrent defects found at the operational stages of the housing units (Table 4-8, Data section 20). Case study 5 interviewees mentioned that the contributions coming from the housing association previous experiences were very limited due to the nature of the project; it was led by a developer. From the contractor/developer perspective, the site manager interviewed was not sure about how or if the feedback provided was treated or used in the risk assessment of future projects despite having a system in place to report quality issues to central management (Table 4-8, Data section 21).

Table 4-8 Sample of sections of the interview transcripts related to the category Quality risk assessment

	Data sections from Interview transcripts	**Related concepts**
19	So we've got a defects monitoring system. So everything, you know, tenants ring in and report a problem. It's raised in the system and logged and it gets fired off to the contractor to rectify, but we'll compile those stats. And we look for sort of patterns as well across projects and also compare what the common quality issues… So you know what to look out for and that helps inform what we go and look at on site as well. (Interview 1.b – Development manager, 00:43:41).	Technical issues Defect awareness Source of information Suitability of information
20	We also hold design forums internally. So we bring stakeholders in from our asset team and our repairs team as well to kind of influence the design, because obviously we have to think about longevity and how we're going to manage those units after their built. And we do bring residents into that as well as that stage. (Interview 3.a – Project manager, 00:13:54).	Stakeholders' participation Risk assessment timing Sources of information
21	Our construction managers' levels, you almost don't get the chance to feedback your information unless you're doing it constantly throughout the job… and that then depends if your company does it at the other end… (Question - Do you have like a specific area where this feedback goes to, coming from different job sites, into one area or if somebody…?) I don't know but it could do with that but I don't think so. (Interview 5.c – Site manager, 00:32:22).	Sources of information Challenges

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Case study 4 interviewees mentioned that, being a project where achieving Passivhaus accreditation was a contractual requirement, an experienced consulting company was commissioned to assess potential risks. Consultants collaborated in the design stage and in the process of developing the quality control tools and procedures by identifying the most recurring defects affecting the thermal performance of buildings (Table 4-9, Data section 22). Interviewees acknowledged that the consultants also played an important role in helping with the process of evidence gathering for the Passivhaus accreditation process. On top of that, the contractor also involved the traders in the process of developing the quality control tools, recognising that the subcontractors, as being the specialists on the trade, would also bring important contributions to the process of foreseeing defects (Table 4-9, Data section 23). Both senior site manager and quality officer stated that this initiative also contributed to increase the levels of awareness of the workforce on the quality requirements, thus improving the commitment to deliver the desired levels of quality.

Table 4-9 Sample of sections of the interview transcripts related to the category Quality risk assessment

	Data sections from Interview transcripts	**Related concepts**
22	We're doing a lot of training courses on Passivhaus, dos and don'ts, have a check for mistakes on Passivhaus and the sort of troubleshooting guide on Passivhaus. This is where you are from failures, this is where you are of your air leakage problems, any thermal bridging tends to be here, here and here. So, *Passivhaus consultant** have done a lot of training with my site team and the supply chain, the subcontractors, their site supervisors so we are all fully aware of how the insulations are supposed to be fitted to the outside of the building, how it interferes between the windows and doors works with the insulation and the air tapes and the inside block work to reduce the thermal bridges… (Interview 4.c – Senior site manager, 00:14:34).	Sources of information Opportunities Requirement awareness Defects awareness
23	So there are no skeletons in the closet and we will sit down and there will be a small group of us that will sit down with the subcontractor after their pre-let meeting and we would develop the checklists that you've seen before. We will develop the checklist. So we are checking something that I know what I'd be looking for in terms of quality management but they're the specialise at their trade so they would also know what they are going to do in their operation that could potentially affect the fabric of the building thus impacting on the Passivhaus standards. (Interview 4.b – Quality officer, 00:13:50).	Sources of information Opportunities Requirement awareness Defects awareness

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

When discussing the implementation of quality management procedures using either a formal or informal quality plan, the interviews suggested that the main managerial issue relied on the inconsistent communication and information conveyance to all levels of professionals involved in the process of construction. For instance, according to information provided by the site manager of Case study 1 (Table 4-10, Data section 24) and the project manager on behalf of the housing association of Case study 3 (Table 4-10, Data section 25), there were doubts of how effectively subcontractors' managerial team conveyed the quality requirements to the operatives, due to number of unconformities found in the construction process, which were in dissonance with the design drawings. Although meetings with subcontractors were organised to discuss the project's quality objectives, interviewees suggested that the information did not filter down to the trade gangs adequately. Another issue mentioned during the interviews of Cases studies 1 and 5 was the difficulty to sustain long-term relationships with subcontractors in order to increase the synergy and the level of understanding of the desired quality targets. The contractor in Case study 5 mentioned that the challenges faced when trying to keep working with the same group of subcontractors was the fact that the company could not offer a steady sequence of work for all traders and, whenever the ongoing flux of construction activities is continuous, the subcontractors moved on to other projects (Table 4-10, Data section 26). In Case study 1, it was stated that even though the contractor managed to use the same tier of subcontracting companies to retain the levels of awareness developed over time, the significant turnover of operatives in these companies provided a constant inflow of new labourers unfamiliar with the project's quality objectives and procedures. Thus, it became a managerial challenge since the workforce was constantly changing and the effort to maintain awareness was lost (Table 4-10, Data sections 27 and 28).

Table 4-10 Sample of sections of the interview transcripts related to the category Quality risk assessment

	Data sections from Interview transcripts	**Related concepts**
24	We have…before they even come to site, we have a preambular where everything's laid out in document form for them to…we talk it through them, you know, this is what we expect. … It's not good enough to for me to go out on site and see something wrong that's not to the work's information and then turn around and say, "But, that's what we've always done." That's not acceptable, you know, they've got to read the project's works information, yeah. And, we find a lot of that, we find a lot with the operatives "Well, that's what we've always done," and it's so wrong. (Interview 1.c – Site manager, 00:25:30).	Requirement awareness Managerial issues Technical issues Challenges
25	I mean, most project managers understand it (impact of defects) and also the architects we appoint… So they've signed up to the design and project toolkit. … So I think they also have an understanding of our requirements. …that should therefore translate into what the construction drawing issue is. … But again, I don't think it's always…it's a bit like Chinese Whispers where it get relayed differently on site and people get the wrong end of the	Requirement awareness Managerial issues Technical issues

	stick. So that's why it's helpful to have clerk of works there to try and pull the site managers up sometimes. Because the site managers are super busy and they're trying to coordinate everything. I don't want to make excuses for them, but sometimes they can take their eye off the ball on one thing or you could have a particular trade whose…one guy is really clued up, spot on and is cracking on great, but somebody else isn't doing quite so well, you know? (Interview 3.a – Project manager, 00:22:04).	Challenges
26	We try to set up a system… we do a kind of master programme… to weekly try and provide them (subcontractors) with continuity at work to enable us to retain exactly the same staff if we can. To bring the learning curve up all those things, so it's very difficult because sometimes particularly at year ends with companies, with budgets, it's an all or nothing scenario rather than a steady progression of work. (Interview 5.c – Site manager, 00:26:30).	Challenges Managerial issues
27	Challenges and obstacles are definitely people. If there is a fault, it's down to a person…. the biggest risk is the individual and it's managing that. …we use sort of a bank of subcontractors … there's still a risk there because they're employing different people… there's a lot of churn in the industry, and that's difficult to manage. (Interview 1.c – Site manager, 00:16:58).	Challenges Managerial issues Requirement awareness
28	The churn isn't usually at management level issue, it's usually at the operative level, so, we usually get the same supervisors, the same contracts managers, but different operatives and that's the difficult one. (Interview 1.c – Site manager, 00:18:15).	Challenges Managerial issues Requirement awareness

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Interviews undertaken in Case studies 4 and 5 mentioned that the level of technical knowledge and capabilities of the subcontractors and traders also posed a challenge to the effort of achieving the defined quality objectives (Table 4-11, Data sections 29 and 30). As stated by the site manager of Case study 5, "general education across the whole industry needs to be improved without a doubt". Case studies 3 and 4 interviewees mentioned the speed of the programme and budget as another challenge related to the achievement of the quality objectives. As stated by the quality officer of Case study 4, in contracts where the budget was too tight, subcontractors were hard-pressed to finish construction activities as soon as possible and as a result quality was compromised (Table 4-11, Data section 31). The assistant site manager and the quality officer responsible for implementing the quality control procedures in Case study 3, also mentioned that time and budget constraints could pose challenges to the activity of monitoring quality and to allowing enough time to undertake tasks appropriately (Table 4-11, Data sections 32 and 33).

Table 4-11 Sample of sections of the interview transcripts related to the category Quality risk assessment

	Data sections from Interview transcripts	Related concepts
29	I'll manage guys on site who are tradesman and that's the difficult thing. … Yeah, the general education across the whole industry needs to be improved without doubt. (Interview 5.c – Site manager, 00:24:23).	Challenges Managerial issues Technical issues
30	The biggest obstacle for me is getting the supply chain because Passivhaus in the UK is a fairly new concept. … There is not a lot of large scale developments that are doing it so, my biggest problem that we've had is the education process with the supply chain and actually getting them to cost the job in allowing the time in for quality checks and doing things methodically and correct instead of just banging up the building as quick as possible. (Interview 4.c – Senior site manager, 00:17:07).	Challenges Managerial issues Technical issues
31	I suppose…Pace, speed of the programme and the fact a lot of our supply chain will use subcontractors themselves so they will be working on a price. So in order for them to achieve their money, the quicker they work, the more money they earn but it is being able to buy the supply chain package at the right sort of price so that we still maintain the quality. So essentially, they can still earn a good living by slowing down and making sure it's right. (Interview 4.b – Quality officer, 00:10:30).	Challenges Managerial issues
32	Control of the site, I think? Time, we're very lucky here because it's an affordable housing site. Purely affordable house and a lot of sites are obviously a hybrid, with open market. And so what then becomes an issue then is time because you are rushing the houses… Therefore, quality I think sometimes under time pressure can then become lax… (Interview 3.c – Assistant site manager, 00:20:08).	Challenges Managerial issues
33	I think one of the things, one of the biggest impact on quality is price. …we have a contract sum that's fixed. … Their subcontract labour is then going to be on a lower price. And that's when you start to get, "I haven't got enough time." If I do that job properly I'm going to make no money. So, what happens is quality could slip. If you have a subcontractor who starts to think, "Oh, I'm under pressure. I've cut this job to the bone. I'll only make money if I put in less work." (Interview 3.b – Quality officer, 00:40:16).	Challenges Managerial issues

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Overall, the findings resulting from the analysis of the concepts related to Quality risk assessment could be summarised in three main subcategories: Stakeholders' participations; Sources of information; and Technical and Managerial issues (Table 4-12). Stakeholders' participation encompassed the establishment of the participants of the risk assessment process and the analysis of their input to the development of the project quality plan. Sources of information, analyses the additional sources of information and their contributions on identifying recurrent defects and potential risks. And finally, technical and managerial issues entails the different challenges, managerial and technical, posed to the process of implementing project quality plans and achieving quality objectives.

Table 4-12 Quality risk assessment emerging subcategories

Subcategories	Concepts
Stakeholders' participations	Stakeholders' participation
	Interested parties
Sources of information	Sources of information
	Database
	Suitability of information
Technical and Managerial issues	Challenges
	Technical issues
	Managerial issues
	Defects awareness
	Requirement awareness
	Capabilities

4.3.2 Findings from project documentation, defect surveys and observations from construction site visits and managerial meetings

The process of assessing the project risks associated to the achievement of the quality objectives relied on the identification of technical issues that have a potential to undermine the predicted thermal performance of the dwellings. It also entailed the identification of managerial issues which could compromise the effectiveness of the implementation of the projects' quality plan.

During the managerial meetings attended in the early stages of case studies 2, 3, 4 (Observation 2.a, 3.a and 4.b to 4.g in Appendix B.4), it was identified that the procurement route adopted enabled the contractor to participate in the process of foreseeing technical issues, especially at the design stage. In Case study 3, it was observed that in addition to the participation of the usual stakeholders (i.e. design team, contractor and project management team), the risk assessment inputs were extended through the collaboration of the maintenance teams and tenants' representatives. This helped to increase the scope of the risk assessment. In addition, the business model of the project also influenced how housing associations provided information to complete the risk assessment process. Specifically in Case study 5, where the project was commissioned by the developer, it was observed in the managerial meeting attended (Observation 5.a in Appendix B.4) that the housing association had very little, if not any, input in the risk assessment process.

At the stage of risk assessment, the collaboration of the different project participants is fundamental to identify the potential construction defects that if not designed out or avoided during the construction stage could undermine the thermal performance of the dwellings at the operational stage. In Case study 4, the risk assessment activities extended to the design and pre-construction stages and they were not restricted only to the early stages of the project, as in the other case studies. According to observations 4.b to 4.g in Appendix B.4, the process of risk assessment took place monthly during the design process review meetings. The meetings were attended by representatives from the housing association, city council, design teams, consultants, employer's agent and the contractor. In addition to assessing the proposed technical solutions and potential risks involved, the risk assessment activities also encompassed the identification and delivery of key managerial activities, as observed in the meeting minutes (Figure 4-9). In this meeting, for example, it was recognised that subcontractors should also contribute to the process of defining quality control checklists, not only because of their specialist knowledge, but also as an additional way to raise awareness towards the project's quality objectives.

2.14	DP stated that MiS would develop a Quality Strategy. The order and sequencing of one unit will be developed. This will establish quality check points. MiS and their subcontractors to develop passivehaus quality check sheets.	DP

Figure 4-9 Section of Case study 4 meeting minute (Source: housing association Case study 4)

Apart from the sources of information previously mentioned, which relied basically on the professionals' knowledge, awareness and experience, Case studies 1, 2 and 5 also had available the housing associations' defect records to provide information related to defects to be avoided in both design and construction stages. However, these defect logs have been fed by the new tenants' reports from the post-handover stage, mostly during the twelve months of contractor liability period, where mostly visible defects were reported. At this stage, defects related to thermal performance were already hidden within the buildings' fabric and their identification was only possible in case of severe manifestation such as of mould growth or noticeable draughts. As an example, Figure 4-10 presents a section of the Case study 3 project toolkit, which introduces the most common defects reported by residents. As it can be observed, none of the issues listed are related to the thermal performance of the dwellings, for the reasons explained above.

15.4 Consistently for a number of years only about half of Source residents have been satisfied with the defect service during the rectification period. This has a significant impact on overall resident satisfaction. The most common issues reported as defects include the following:

- Stiff/ loose doors and locks and locks failing (especially communal doors),
- Lack of understanding on how heating systems work, often through poor instructions at handover
- Leaks under baths and sinks as well as radiators
- TV and telecom services not connected up (especially bedrooms) and poor instructions to residents on how the installations work
- Leaking gutters

Figure 4-10 Section of project's toolkit inputting common issues reported by residents to risk assessment process (Source: housing association Case study 3).

In terms of the technical and managerial issues, it was identified in all the case studies that the process of communication between the different levels of project participants was presented as one of the most relevant challenges to the achievement of the projects' quality objectives. Due to this lack of communication, the levels of awareness of the expected quality standards and the impact of specific defects to the ultimate thermal performance of the dwellings were not sufficient. Moreover, the technical knowledge and abilities of the operatives on-site were also identified as another challenge to the achievement of the projects' quality objectives. From site visit observations (Observations 1.b, 1.d to 1.f, 2. B, 2.c, 3.c, 4.h to 4.l and 5.a in Appendix B.4) and confirmed by the defects collected through site surveys, it was noted that defects affecting the thermal performance of the dwellings fabric occurred in all the case studies in multiple occasions. Figure 4-11, Figure 4-12 and Figure 4-13 exemplify the type of defects collected during the site surveys, which are mostly related to discontinuity of insulation layer, gaps in the vapour and air barriers and thermal bridging. The occurrence of this kind of quality issues corroborates the aforementioned lack of awareness among site operatives towards the quality objectives and specific defects affecting the thermal performance of buildings.

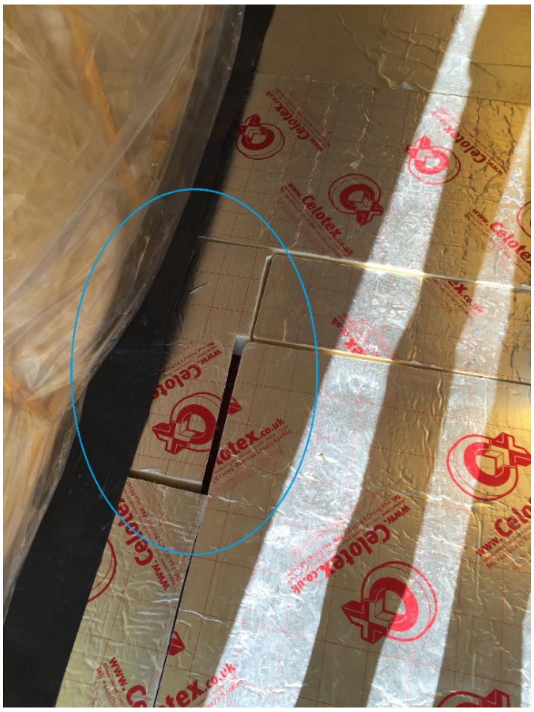


Figure 4-11 Discontinuity of insulation layer identified in Case study 3 (Source: Taken by this thesis' author)

Figure 4-12 Ruptures in vapour control membrane identified in Case study 1 (Source: Taken by this thesis' author)

Figure 4-13 Thermal bridging due to debris in cavity tray identified in Case study 5 (Source: Taken by this thesis' author)

It was also observed that the risks of programme and budget constrains also compromised the efficacy of the project quality plan implemented, where the allocation of inadequate resources and time undermined the fulfilment of the quality control activities. This could be observed in multiple levels, both in the activities undertaken by the site management team and the building control bodies. Figure 4-14 shows inconsistency of building control site inspections in Case study 5, due to a lack of available inspectors for key stages of the project were quality control should take place. Moreover, the project programme was too tight and could not afford the suspension of the construction activities until the quality check was undertaken.

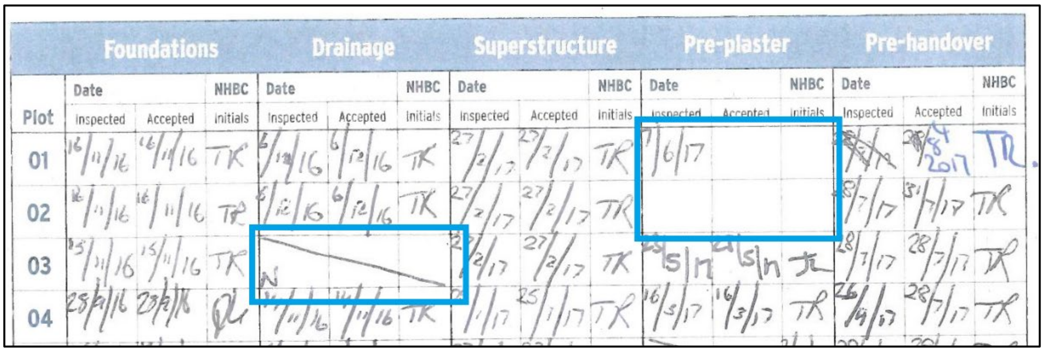


Figure 4-14 Missing quality inspections identified in Case study 5 (Source: contractor Case study 5)

4.3.3 Challenges related to quality risk assessment

This section presents the challenges to deliver the desired thermal performance of domestic buildings identified from the analysis of data related to the Quality risk assessment.

3. **Lack of participation of important project stakeholders (e.g. housing association and contractor), limiting the input of relevant information and collaboration in the process of risk assessment.**

In Case study 1, due to the traditional procurement process adopted, the contractor was appointed after the design stage, and therefore was not able to contribute with the process of identifying the risks for the achievement of the quality objectives. In Case study 5, on the other hand, the project was commissioned and managed by the developer, and the housing association had little input to the process of risk identification and assessment.

4. **Housing associations' defect records used for the project risk assessment mostly contained defects reported at the post-occupation stages by the dwellings' tenants.**

In addition to the information provided by the project stakeholders based on their knowledge, experience and awareness, in Case studies 1, 2 and 5 the use of defect records also contributed to the risk assessment process. However, the defect record systems used contained tenants' reports of quality issues identified mostly at the 12 months of the contractor's liability period. Thus, at this stage, defects affecting the thermal performance of the dwellings were enclosed within the fabric and were not identifiable through visual inspections.

5. **Lack of use of previous defect records to inform and influence the risk assessment process.**

In Case studies 3 and 4, the risk assessment relied only on the information provided by the projects' stakeholders. Both case studies lacked of an input from a defect database containing previous similar projects records, which could have increased the chances of foreseeing technical and managerial issues.

6. **Difficulties in sustaining a consistent communication process, impacting on the levels of quality objectives and specific defects awareness.**

In all case studies, the low levels of awareness of the quality objectives and relevant defects were deemed a consequence of the process of communication and how information filtered down from the client, to contractor, to subcontractor and finally to site operatives and trade gangs. It was identified that the weak link of the process of communication was between subcontractor's supervisors and operatives.

7. Operatives general level of technical knowledge and capabilities.

It was recognised in Case studies 1, 4 and 5 that the site operatives general level of technical knowledge and capabilities posed a challenge to the achievement of quality objectives.

8. Difficulty of retaining technical information and awareness with subcontractors due to high level of staff turnover and discontinuity of projects' sequence.

In case studies 1 and 5, the challenge of retaining technical information and awareness in the subcontracting companies was caused by frequent staff turnover, resulting in a constant inflow of new operatives unfamiliar with projects' requirements. Additionally, it was also observed that due to discontinuity of projects' sequence it became difficult to maintain the same trade gangs throughout the whole construction process where the trade was needed.

9. Tight programme and budget can potentially compromise the administration of quality control procedures.

As identified and reported in case studies 1, 3 and 4, the pressures over programme and budget impacted the application of quality control procedures as planned. Limited resources allocated to professionals to complete site inspection affected the regime of quality checks in the defined key stages of the construction process. In addition, the established hold points for quality checks could not be maintained because quality inspectors were not available to visit the site on the requested dates. Due to inflexible and tight programme, construction activities were carried on regardless the lack of quality inspection.

4.4 Quality resources assessment

Previous studies have identified the quality resources assessment as the stage where the approach towards the application of quality assurance procedures is established. At this stage the roles, responsibilities and authority of each project participant are defined, as well as the appointment of external support when considered necessary. Moreover, this stage also involves the assessment of the resources necessary to enable the administration of the activities mostly related to quality control and workforce empowerment, such as training and awareness development.

The following concepts of the Quality resource assessment category are explored in this section: (i) Roles (BSI, 2015, Harris et al., 2013); (ii) Responsibilities (BSI, 2015, Harris et al., 2013); (iii) Authority (BSI, 2015); (iv) Internal resources (BSI, 2015, Harris et al., 2013, Project Management Institute, 2001) ; (v) External support (BSI, 2015); (vi) Suitability of resources (Josephson et al., 2002, Kanji, 1996, Feigenbaum, 1991); (vii) Awareness development (Brooks and Spillane, 2016, Atkinson, 2002, Holt et al., 2000); (viii) Upskilling (Brooks and Spillane, 2016, Kanji and Wong, 1998).

4.4.1 Findings from interviews with key project stakeholders

This section presents the answers to the interview questions 10 to 13 (Chapter 3, section 3.5.1), which had been purposely formulated to explore the eight concepts related to Quality resources assessment mentioned above. The analysis of the interview transcripts revealed that the eight concepts had been acknowledged by almost all of the case studies.

Findings from the interviews transcripts suggested that multiple layers of quality control procedures were resourced, and roles and responsibilities were assigned, in order to ensure the achievement of the desired quality requirements. As aforementioned in section 4.2 (Definition of quality requirements), the ultimate authority in terms of awarding the final quality compliance concerning to the quality objectives related to thermal performance was given to building control bodies, in exception of Case study 4.

In cases studies 1, 2, 3, and 5, interviewees explained that from the contractors' side the quality control process was undertaken by internal resources, through the site manager and assistant site manager along with their other daily managerial activities. They also mentioned that during certain stages of the construction process the effectiveness of the quality control procedures were compromised due to the lack of appropriate allocated time and human resources (Table 4-13, Data sections 34 and 35). In Case study 4, due to the fact that the achievement of Passivhaus accreditation was reliant on the delivery of strict quality standard, a dedicated quality officer was assigned in addition to the usual managerial team to monitor specific building elements where defects were likely to occur, as highlighted in the risk assessment stage (Table 4-13, Data section 36).

Table 4-13 Sample of sections of the interview transcripts related to the category Quality resources assessment

	Data sections from Interview transcripts	Related concepts
34	I had, shall we say, difficulty at the front end of the job, so as a site manager, I'm on my own until the timber frame goes up and then I get a site assistant who will be going out and do the QA checks… I wouldn't like to say that the company let me down, but something happened that let me down and what I was finding was I did not have continuity with my assistant site manager. So, I get one for weeks, then he'd go and then I'll get somebody else and you can't run a site like that because everyone's having to learn that little bit more. (Interview 1.c – Site manager, 00:27:41).	Roles Responsibilities Suitability of resources Constraints
35	But on another layer is the subcontractors have to sign off all their work to say that they've carried out the work in accordance with the specification. … And they weren't doing that at early stages that's why that insulation got missed. … And they've implemented (the quality control procedures), it's probably there in the first place but it didn't happen because of time constraints probably (Interview 3.b – Quality officer, 00:34:32).	Roles Responsibilities Suitability of resources Constraints
36	Then, from a managerial point of view, we have employed an extra person which we wouldn't normally have on another scheme to specifically check the QA and work through the QA process along, checking if all these air-barrier penetrations are closed off, fully sealed, and if everything is built to a good quality. (Interview 4.c – Senior site manager, 00:12:27).	Roles Responsibilities Defects awareness

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In case studies 1, 2, 3 and 4, the housing association representatives interviewed explained that a quality officer was deployed to undertake quality inspections on their behalf. The frequency of the site visits varied from case to case, from daily visits in Case study 3 (Table 4-14, Data section 37), two to three times per week in Case study 4 (Table 4-14, Data section 38), or weekly site visits in case studies 1 and 2 (Table 4-14, Data section 39). The purpose of the site visits was not only to check the achievement of the established quality criteria but also to assess the programme progression (Table 4-14, Data section 39). In addition, in case studies 1, 2, 3 and 4 the housing associations also commissioned a building surveying company for the process of snagging, once the dwellings were deemed completed (Table 4-14, Data section 40). According to the interviewees, the rationale behind this request was that a quality assessment undertaken by an independent company was necessary to provide transparency and credibility to process of appraising quality to the other project stakeholders (Table 4-14, Data section 41). In respect to Case study 5, a building surveying company was also commissioned to undertake the snagging process as the employer's agent. However, as part of their role representing the housing association, they held monthly meetings with the site management to monitor the corrective actions towards defects that were spotted by the building control body (Table 4-14, Data section 42).

Table 4-14 Sample of sections of the interview transcripts related to the category Quality resources assessment

	Data sections from Interview transcripts	**Related concepts**
37	I've got a presence on-site on a regular daily basis and I know everybody, I'm checking that detail. So, I'm by default I'm giving them, it's going into their heads and "I know *quality officer** wants all joints taped. He doesn't want breaks in the insulation, he wants it continuous, I know he checks". So that then reinforces that. (Interview 3.b – Quality officer, 00:22:54).	Roles Responsibilities Awareness
38	It's the clerk of works, as additional independent eyes going over the site two or three times a week maybe even daily in critical times. Visiting and ensuring that what's designed and been approved by the *Passivhaus consultants** is actually being delivered on site to the correct quality. (Interview 4.a – Head of development, 00:12:04).	Roles Responsibilities
39	That's a typical supervisor's report on a monthly basis. So I'll visit every week, minimum. Sometimes it requires more, but generally weekly and then every four weeks I'll put a report together… just an overview and you'll see the number of operatives that are on site, it's particular snap shot of the visited site. If there's any defects it will be on there, that I want them to put straight. I mean, I don't want anybody wondering that I just pulled one out of the blue. And then it's just a general update for the client to see how the program is going forward and where they are in regards to the program. And then there's a couple…a bit of weather and a couple of photos. (Interview 1.a – Quality coordinator, 00:35:37).	Roles Responsibilities
40	When we get to the end of the project…towards the end of the project before we get to practical completion, when the contractor is comfortable they've completed the build, they then ask for our employer's agent to come in and start the snagging process. (Interview 1.b – Development manager, 00:33:57).	Roles Responsibilities External support
41	These are an independent company (employers' agents). So it's independent of us and the contractor. So we appoint them. So…which is another…to keep that transparency. …that's why they carry out the snagging as well as the responsibility sits with them. (Interview 2.a – Quality coordinator, 00:36:27).	Roles Responsibilities External support

42	We have monthly meetings where we lead and review all of those areas (building regulations and code for sustainable homes). So we can review any issues that NHBC, because they regularly inspect any issues, RI's that they flag up, we will query just to make sure if that there are some. If not, brilliant. But if there are some then we need to make sure that site management is dealing with those and getting those cleared. (Interview 5.a – Quality officer, 00:21:41).	Roles Responsibilities External support

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In respect to the quality control required to achieve UK Building Regulations approvals, more specifically Part L1a - Conservation of fuel and power in new dwellings, approved inspectors were commissioned by the contractors/developers to inspect the sites in all case studies (Table 4-15, Data section 43). The frequency of quality control activities took place according to key stages determined by the building control bodies (Table 4-15, Data section 44). Interviews revealed an issue related to resources constraints within building control bodies. The number of approved inspectors were mentioned to be insufficient and often they were not available to undertake inspections whenever housing units of the project reached a defined key stage for quality check. As a result, interviews revealed that a number of housing units were not inspected in certain key stages of construction due to the fact that subcontractors did not want to be penalised for programme delays in case of having to wait for the availability of the building control inspector. The lack of resources and time constraints also impacted on the regime of inspection in terms of sampling. The available timeslot for the site inspection did not allowed the appraisal of all the dwellings expected for the each visit, leaving some dwellings unattended (Table 4-15, Data sections 45 and 46).

Table 4-15 Sample of sections of the interview transcripts related to the category Quality resources assessment

	Data sections from Interview transcripts	**Related concepts**
43	There's an inspection regime put in place by the building control (BCB) which is not necessarily local authority building controls; we can appoint an independent. And again, that's probably down to cost as well. (Interview 1.c – Site manager, 00:21:40).	Roles Responsibilities External support Suitability of resources
44	*Warranty provider** looks after our warrantees. So from building regs (sic) it's local authority building control inspectors or an approved inspector	Roles Responsibilities

	which is *Inspector** which will visit our sites more regularly. For different stages of the build, they go around checking the foundations, and each days just as we go up through to wall plate and then come back at the end for the finishing. Whereas Premier tend to come for all stages of the build because they're going to warrantee the build. (Interview 2.b – Development manager, 00:33:04).	External support
45	They are very busy. I mean I think there's only four of them in *building control body** covering the whole of Plymouth, so that's not a lot really. … I would say they are probably a little bit overstretched and obviously it does have a knock-on effect to our programme sometimes and it's the responsibility of the builder to obviously not go forward with the build, and I think a lot of people because the time constraints are inclined to continue to the next stage before the building control officer has been to sign it off. (Interview 3.c – Assistant site manager, 00:23:41).	Suitability of resources
46	They've (building control body) got KPIs themselves to actually physically hit themselves, so what did they miss? 1 out of 99 probably, so if you add 100 pre-plasters in the pack, you might miss one or two out of a 100, let's say. (Interview 5.c – Site manager, 00:20:33).	Suitability of resources

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In respect to the quality checks necessary for the provision of warranty, in case studies 1 and 2 a building surveyor was appointed by the warranty provider, which visited the site in a monthly basis (Table 4-16, Data section 47). In the other case studies, the quality assessment required by the warranty provider were undertaken by the same professionals working on behalf of the building control bodies.

Table 4-16 Sample of sections of the interview transcripts related to the category Quality resources assessment

	Data sections from Interview transcripts	**Related concepts**
47	We give a warranty on these houses. And, they're not building inspectors, but they will just come in once a month and take a snapshot in time. And, …if they pick anything up, hopefully they don't, it will go in the book and they will be able to ask us to action that, but they don't check on whether that's being done, so…. (Interview 1.c – Site manager, 00:24:01).	Roles Responsibilities External support

In terms of resources deployed to increase awareness of quality requirements and impacts of defects on the thermal performance of the dwellings, the interviews revealed that different initiatives were put in place in the case studies. As relevant projects' information was embedded in contractual and design documentation, in all cases except for Case study 4 the housing associations expected, but did not formally require that additional activities were undertaken with the workforce on-site (Table 4-17, Data section 48). Thus, the interviews revealed that in Case studies 1, 2, 3 and 5, apart from the initial site inductions, no other initiatives could be identified in terms of upskilling or increasing awareness of the site operatives. Moreover, it was apparent in case studies 1, 2 and 5 that the only formal induction provided to the operatives was mostly regarded to Health and Safety issues (Table 4-17, Data sections 49 and 50). In fact, the site management upheld meetings with the subcontractors' supervisors on a weekly basis, however the main focus was the planning and achievement of construction programme milestones. In Case study 4, the concern about the level of technical knowledge across the supply chain and site managerial team jeopardising the achievement of the thermal performance targets, led the contractor to deploy initiatives to improve workforce's technical capabilities and increase awareness with the construction operatives. As stated by the project manager, training courses ran by the Passivhaus consultant were put in place. The site managerial team and subcontractors' supervisors received technical training and were made aware of the potential quality issues which could undermine the ultimate thermal performance of the dwellings (Table 4-17, Data section 51). Moreover, inductions were organized with the subcontractors, where the quality control procedures were presented and the participants were invited to collaborate in the development of the quality checking tools (Table 4-17, Data section 52).

Table 4-17 Sample of sections of the interview transcripts related to the category Quality resources assessment

	Data sections from Interview transcripts	**Related concepts**
48	It's difficult for us to give that across (create awareness) because we're not at their toolbox talks. And I would imagine the likes of *site manager** would be able to feedback better, but it's passed on from us on the client side, the quality control side. … The contractor will be encouraged to implement that from all of our designers, external consultants, to achieve the end product. So that's…so that talks its way down from each layer, doesn't it, and I'd like to think that's happening. Although I don't attend the toolbox talks. (Interview 2.a – Quality coordinator, 00:28:44).	Awareness
49	So, every operative receives a health and safety induction, but I bring a little bit into it sort of saying, you must consult the works' information because that's probably the only time you're going get a one to one with that person. (Interview 1.c – Site manager, 00:25:30).	Awareness

50	…we use toolbox system mainly for health and safety… We don't use that (toolbox talks to increase requirements and defects awareness) but it would be a good tool if we have the time. (Interview 5.c – Site manager, 00:25:36).	Awareness Suitability of resources
51	It's down to having the procedures in place and giving the guys the knowledge. We're doing a lot of training courses on Passivhaus, dos and don'ts, have a check for mistakes on Passivhaus and the sort of troubleshooting guide on Passivhaus. … So, *consultant** have done a lot of training with my site team and the supply chain, the subcontractors, their site supervisors so we are all fully aware…(Interview 4.c – Senior site manager, 00:14:34).	Awareness Upskilling
52	I do a QA presentation (to the subcontractors). We will also, as the super structure commences, we'll have an induction by our Passivhaus advisors, *consultant**, and it will be an ongoing—during the course of the pre-let meetings as well… We will develop a QA sheet along with their assistance but we have the fundamental knowledge from *consultant's name** consultants to be able to make sure that everybody buys in to this Passivhaus scheme. (Interview 4.b – Senior site manager, 00:05:45).	Awareness

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Overall, the findings resulting from the analysis of the concepts related to Quality resources assessment could be summarised in three main subcategories: Process approach; Provision of resources; and Development of competences (Table 4-18). Process approach relates to the assignment of roles, responsibilities and authority of each of the projects participants in order to implement the defined project quality plan. Provision of resources encompasses the assessment of the allocated resources, identifying where project participants relied on the internal resources or employed external support. And finally, Development of competences explores the resources put in place in order to empower subcontracting teams, by providing upskilling activities and increasing the levels of awareness towards the projects' quality requirements.

Table 4-18 Definition of Quality resources assessment emerging subcategories

Subcategories	**Concepts**
Process approach	Roles
	Responsibilities
	Authority
Provision of resources	Suitability of resources
	Internal resources
	External support
Development of competences	Awareness development

4.4.2 Findings from project documentation, defect surveys and observations from construction site visits and managerial meetings

It was confirmed from observations in team meetings attended in the early stages of Case studies 1, 2 and 4 (Observations 1.a, 2.a and 4.a and 4.b in Appendix B.4) that, as part of the definition of the project quality plan, either by means of formal or informal approaches, roles and responsibilities were assigned to the different projects' participants. These encompassed professionals pertaining the interested parties (e.g. housing associations and contractors) or from external companies (e.g. building control bodies or building surveying companies). It was perceived in the team meetings that the concept of overlapping quality control procedures undertaken by multiple parties was expected to maximise the chances of achieving the quality objectives. However, the procedures put in place lacked of specific focus concerning quality issues related to the thermal performance of buildings and ultimately the only accountable process of quality control which was deemed necessary to achieve compliance was undertaken by external parties, i.e. building control bodies. In Case study 4, a different approach was undertaken due to the fact that the contractor was made responsible for developing a bespoken project quality plan and providing evidence for the quality compliance process, as evidenced in the project's tender document (Figure 4-15). Thus, a specific and focused approach was devised and implemented, taking into consideration the risks assessed in the previous stages of the project quality plan. For instance, a specific work group was assigned with the task of developing a plan for quality control procedures, where the existing contractor quality assurance plan was enhanced with additional information deriving from the risk assessment iterations (Observation 4.f in Appendix B.4).

In the event that the Tender passes the minimum requirements, it will then be scored and weighted according to the evaluation criteria noted in the table below.

	Quality		
1	Quality and Employers Requirements – Design Approach The Tenderer shall provide a statement on the proposed methodology for achieving a Passivhaus certified construction, including how the contractor proposes to manage sub-contractors to provide the quality and design requirements. [No page limit]		25%

Figure 4-15 Assigned contractor responsibilities over the process of defining a project quality plan. (Source: housing association Case study 4)

In order to assure the achievement of the quality objectives, resources were allocated for the purpose of assessing managerial and technical risks and monitoring the construction process. Especially in the latter, it was observed that the suitability of the resources provisioned were not adequate, and consequently the established quality control procedures could not be undertaken as expected. The inadequacy of resources was identified in two levels. The shortage of human resources in the site management teams and building control bodies undermined the ability of the quality control inspections to assess the dwellings' quality as proposed by the adopted sampling regime and quality control procedures. In addition, considering time as a resource, constrained programmes resulted in hold points for inspection not being respected and construction activities being carried on regardless the fact that the quality check had not been undertaken. For instance, Figure 4-16 provides evidence of missing quality checks in the defined key stages of the construction process of Case study 5. Thus, as exemplified by Figure 4-17, it is reasonable to state that defects occurrences went undetected and uncorrected throughout the construction phase.

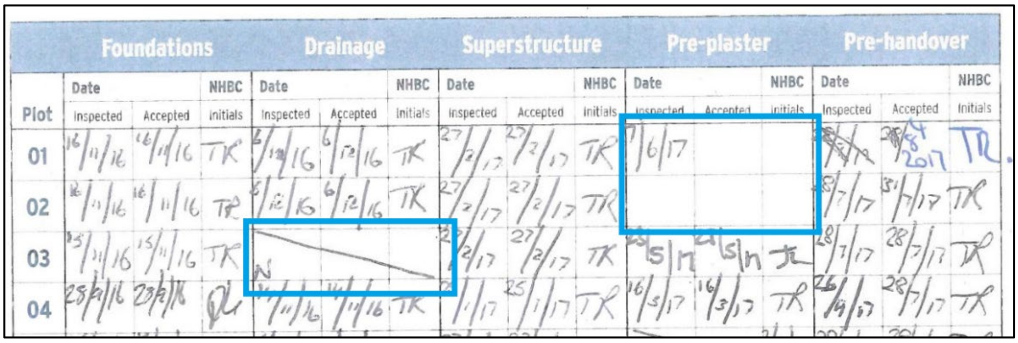


Figure 4-16 Section of building control body's inspection record book showing missing quality control checks in certain key stages (Source: contractor Case study 5)

Figure 4-17 Remaining insulation discontinuity defect spotted at pre-handover stage of Case study 2 (Source: Taken by this thesis' author)

In terms of the resources applied to increase the levels of technical capability and awareness towards the projects' quality requirements, only in Case study 4 the administration of technical trainings and inductions was observed. As presented in Figure 4-18, Passivhaus consultants were commissioned by the contractor to provide training sessions for the site management team and subcontractors in order to introduce the best construction practices to deliver the expected quality objectives and to highlight the specific defects to be avoided. In case studies 1, 2, 3 and 5, meetings between site management team and subcontractors supervisors were held. However, the main purpose was the planning of construction activities and the discussion of programme milestones, as observed in meetings in the construction sites (Observations 1.f, 2.c, 3.c and 5.a. in Appendix B.4).

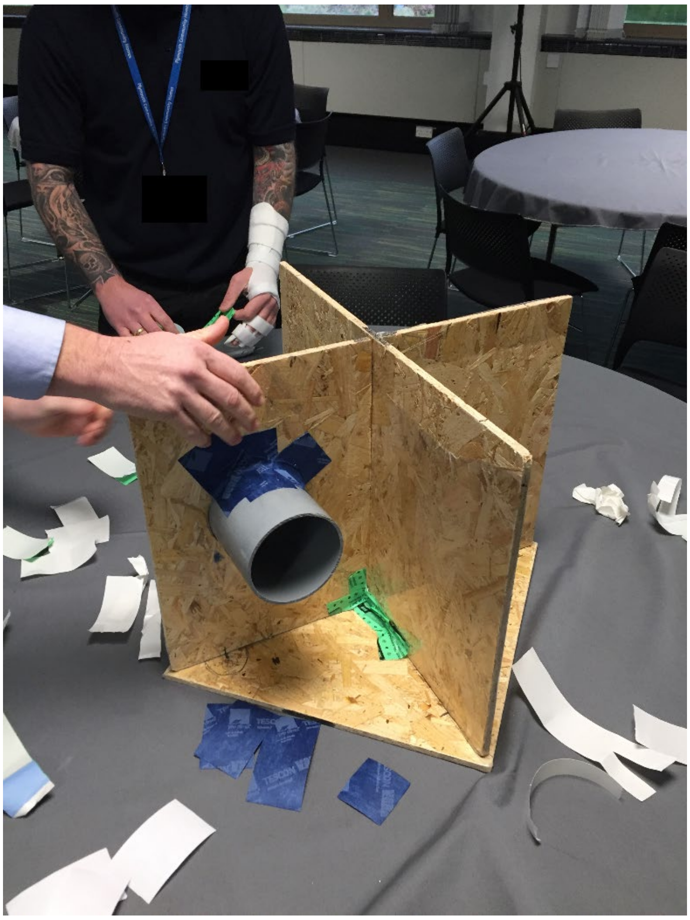


Figure 4-18 Passivhaus training session undertaken in Case study 2 (Source: Taken by this thesis' author)

4.4.3 Challenges related to quality resources assessment

This section presents the challenges to the development and implementation of project quality plans with focus on the thermal performance of domestic buildings identified from the analysis of the data related to the Quality resources assessment.

10. Due to the approach adopted for quality compliance, the project quality plan implemented lacked of specific focus concerning quality issues related to thermal performance.

In case studies 1, 2, 3 and 5, the ultimate quality compliance related to the thermal performance of dwellings was assigned to building control bodies. As a consequence, housing associations and contractors concentrated their efforts to undertake quality assurance procedures mostly on the final stages of the construction process. At that stage, defects affecting the thermal performance of the dwellings were enclosed within the building fabric and could not be detected through the deployed procedures.

11. Lack of appropriate resources (i.e. time and staff) allocated by the contractor and building control bodies for quality control procedures.

It was identified in case studies 1, 2, 3 and 5 that the deployed resources for the quality control procedures compromised the administration of the projects quality plan, undermining the ability of the defined procedures to detect defects and thus, impacting on the achievement of the quality objectives.

12. Lack of specific training and upskilling activities with the purpose of increasing awareness of the quality objectives and potential risks, as well as technical capabilities.

In case studies 1, 2, 3 and 5 it was observed that the only formal activity with the purpose of informing the workforce about a relevant topic were the health and safety inductions. Training sessions and upskilling activities aiming to develop technical knowledge and capabilities, as well as increasing the levels of awareness toward the projects' quality objectives, were only observed in case study 4.

4.5 Definition of quality metrics and control

The Definition of quality metrics and control stage is described in literature as the process where the quality requirement attributes related to the thermal performance of buildings are established in the operational level of quality assurance process. Based on the defined acceptance criteria, the quality control procedures are devised, encompassing the timing, frequency and the sampling of quality inspections, as well as the tools used for the process of quality appraisal.

The following concepts of the Definition of quality metrics and control category are explored in this section: (i) Energy performance attributes (HM Government, 2013); (ii) Acceptance criteria (BSI, 2015, Project Management Institute, 2001); (iii) Quality control timing (BSI, 2015, Tofield, 2012, Atkinson, 2002); (iv) Quality control frequency (BSI, 2015, Project Management Institute, 2001); (v) Quality control sampling (Harris et al., 2013); (vi) Quality control tools (Johnston et al., 2014, Gorse et al., 2012, Sommerville, 2007, Sommerville and McCosh, 2006, Josephson et al., 2002), (vii) Defect identification (Gorse et al., 2012, Tofield, 2012).

4.5.1 Findings from interviews with key project stakeholders

This section presents the answers to the interview questions 14 to 17 (Chapter 3, section 3.5.1), which had been purposely formulated to explore the seven concepts related to Definition of quality metrics and control mentioned above. The analysis of the interview transcripts revealed that all seven concepts had been acknowledged by almost all of the case studies.

Interviews from Case studies 1, 2, 3 and 5 explained that the energy performance attributes to be monitored and complied with had been defined based on the UK Building Regulations, including minimum dwelling overall U-value, as well as for specific building elements; and maximum air permeability rate and carbon emission rates (Table 4-19, Data section 53). Apart from the thermal performance attributes defined by the UK Building Regulations, no other energy performance targets were adopted, except in Case study 4. In fact, it was mentioned by the Development manager and Quality coordinator of two of the case studies that aiming for the Code of Sustainable Homes level 3 and 4 was becoming usual practice in the past projects. However, since the funding agencies refrained from requiring them, the compliance with the UK Building Regulations became the only energy performance attributes targeted (Table 4-19, Data section 54). Case study 4 also complied with the energy performance attributes established in Passivhaus standards, which superseded the ones embedded in the Part L1a of the UK Building Regulations.

Table 4-19 Sample of sections of the interview transcripts related to the category Definition of quality metrics and control

	Data sections from Interview transcripts	Related concepts
53	And particularly if we're using government funding there are certain criteria we have to meet with design. SAP assessments and code for sustainable homes just recently left us, but a lot of items have gone from code into the building regulation. So it's statutory requirements that we need to meet as well and the criteria standard as well. (Interview 1.b – Development manager, 00:09:43).	Energy performance attributes
54	Predominantly community agency funding stipulated a code level three. We've done a couple of projects with code level four, but generally it would always be for code level three. Since that's the normal requirement and sort of that funding, it's just building regulations, isn't it, now to meet the requirements of that. (Interview 2.a – Quality coordinator, 00:10:41).	Energy performance attributes

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In the case studies where the energy performance attributes were defined by the UK Building Regulations, interviewees declared that the quality acceptance criteria in the design stage was defined by achieving the minimum performance targets set by the Part L1a through the administration of the Standard Assessment Procedure (SAP) calculations (Table 4-20, Data section 53). Additionally, technical detailing of the projects should be reviewed and approved by building control bodies, according to their technical manual (Table 4-20, Data section 55). As per the design stage in case study 4, the senior site manager stated that the compliance to the defined energy performance attributes were assessed through the application of the Passivhaus Planning Package methodology.

In terms of the quality control at the construction phase, the process of obtaining the approval of Part L1a of the UK Building Regulations was administered through inspection and acceptance of the quality levels of the housing units by building control bodies. According to the site manager of case study 5, the quality control timing and frequency of inspections were established at five pre-defined key stages of the construction process, i.e. foundations, drainage, superstructure, pre-plaster (first-fix) and pre-handover (Table 4-20, Data section 56).

For the quality control sampling approach, it was a statutory requirement that all the housing units were to be inspected. However, in multiple occasions site managers declared that key stage inspections in some of the housing units were missed or a sampling approach was adopted in different projects, due to insufficient human resources for site visits and tight programmes, where hold points were not respected (Table 4-20, Data sections 57 and 58).

Table 4-20 Sample of sections of the interview transcripts related to the category Definition of quality metrics and control

	Data sections from Interview transcripts	**Related concepts**
55	They (building control body) will be sent a full set of drawings prior to commencement on site where they undertake a plan check then any issues that they have then pre-construction, they pick out any details, any change needs to be in line with their building regs (sic) documents (Interview 2.c – Site manager, 00:23:30).	Energy performance attributes Acceptance criteria
56	…so the *building control body** checks the plot at superstructure which could be a joist level or roof level and then he also checks it at pre-plastered which shows the stud work, whether metal or timber and looks at the work just before the plaster boarding starts. He also then checks it for a final which is ready for a CML which is going to give you the final certificate and he also does a draining test at that time and that gives you the final	Quality control frequency Quality control timing Acceptance criteria

	certificate and that's the three stages he does. He also checks foundations as well. (Interview 5.C – Site manager, 00:07:11).	
57	They are very busy. I mean I think there's only four of them in building control body* covering the whole of Plymouth, so that's not a lot really. … I would say they are probably a little bit overstretched and obviously it does have a knock-on effect to our programme sometimes and it's the responsibility of the builder to obviously not go forward with the build, and I think a lot of people because the time constraints are inclined to continue to the next stage before the building control officer has been to sign it off. (Interview 3.c – Assistant site manager, 00:23:41).	Quality control sampling
58	I don't know how they (building control body) actually work themselves but if they missed something… it's not at all the case, if they miss it, they miss it. They've got KPIs themselves to actually physically hit themselves, so what did they miss? 1 out of 99 probably, so if you add 100 pre-plasters in the pack, you might miss one or two out of a 100, let's say. (Interview 5.c – Site manager, 00:20:33).	Quality control sampling

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In terms of defect identification and the use of tools to structure the quality control activities, the content of the interviews suggested that building control bodies did not rely on the application of quality checklists. Instead, the inspections were supported by a technical manual and the inspectors' knowledge, where the acceptance criteria was somewhat subjective.

Also as part of the quality control tools, in all case studies except in case study 4 the content of interviews suggested that the air pressure tests were administered in just one occasion, near the dwellings' practical completion (Table 4-21, Data section 59). In case study 4, the air pressure tests were not only used to fulfil statutory requirements, but also as an important procedure to identify defects and address corrective actions whenever needed, prior to advancing to the following construction stages. In that sense, three air pressure tests were undertaken in each housing unit: after the completion of the building fabric but prior to internal fixing installations, after first fix and post completion (Table 4-21, Data section 60).

Regarding the sampling approach, in case studies 1 and 4 all housing units were air pressure tested (Table 4-21, Data sections 59 and 60). According to the Quality officer of Case study 3, the air testing executed only complied with the percentage per housing type requested by the building regulation (Table 4-21, Data section 61). The sampling approach for air permeability tests in the case studies 2, 5 could not be established due to conflicting information obtained from housing associations and site management teams.

Table 4-21 Sample of sections of the interview transcripts related to the category Definition of quality metrics and control

	Data sections from Interview transcripts	Related concepts
59	And all our buildings are air tested at the end of the build. So if there's any leakage or weakness in the buildings that will flag up at that stage. (Interview 1.a – Quality coordinator, 00:17:59).	Quality control timing Quality control frequency Quality control sampling
60	Yeah, every unit's got three (air) tests, so post completion of the fabric of the building. … So prior to any internal fixings and mechanical and electrical fitting, we do an air test. If there is any issue, we've got a bare fabric internally to be able to remediate any potential leaks. Once we've completed that, mechanical and electrical, we'll then do their first fix. And make sure that their penetrations through the building are thoroughly sealed. When they are thoroughly sealed we know we have maintained the integrity of the building. And then it's down to final fitting inside. So once again completion of mechanical and electrical, you've only got the first fix of the internal partitions. There's gonna (sic) be limited areas where we could be leaking through the fabric. As long as we past the second air test, we're then comfortable to continue the internals and then the final air test is post completion of the property. (Interview 4.b – Quality officer, 00:28:18).	Defect identification Quality control timing Quality control frequency Quality control sampling
61	I don't think we would insist on "Well, hang on a minute, we want every plot air tested because you've got, not only the time but the cost." They've built into their price to have the certain number required under building regs (sic) to have tested. (Interview 3.b – Quality officer, 00:55:38).	Quality control sampling

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In terms of the quality control procedures applied by the site management team in the construction stage, the content of interviews reveals that in all case studies the quality checking procedures were administered whenever trade gangs' working packages were deemed completed. In accordance to the quality policy established in each case study, the subcontractors' payment release was conditioned to the sign off of the quality checklists by the contractors' site management team, thus defining the timing and frequency of quality inspections (Table 4-22, Data section 62). For instance, the regime of quality inspections in Case study 5 were defined by eleven key stages of the construction process (Table 4-22, Data section 63). Through the perspective of identifying thermal performance related defects, in Case study 4 the subcontractors' elements of work to be checked were established in smaller packages by the senior site manager. Generally, the construction activities were defined about two-day build duration (Table 4-22, Data section 64). The purpose was to allow the appraisal of quality in specific building elements, which otherwise would be covered or hidden by other building materials at the time of the inspection, whenever the working package was too lengthy.

Table 4-22 Sample of sections of the interview transcripts related to the category Definition of quality metrics and control

	Data sections from Interview transcripts	Related concepts
62	And there's a string of signing off process which is linked to payments as well. So, the contract can't get paid from element of works until one of the monitor or QA team have been in and signed off. (Interview 4.c - Senior site manager, 00:13:03).	Quality control timing Quality control frequency
63	So I'll just show you an example and you can see on there but so for instance if you go into plot one and you see forms and then you have different forms, your bill stage 11 would be finals, bill stage 9 is test and commission, so just before painting, bill stage 8 the second fix, 7 is plaster, 6 is first fix, stage 5 is when it's roofed and if you went into roofed and you've seen all the checks, you would check all of these items. (Interview 5.c – Site manager, 00:11:33).	Quality control timing Quality control frequency
64	So, basically we've broken everything down, so the subcontractor gets paid for an element of work which is normally about a two-day build duration. After that, after finished that, I'm going to sign it off the claimed payment for that element of works. (Interview 4.c – Senior site manager, 00:21:15).	Quality control timing Quality control frequency

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In terms of the sampling approach adopted, interviews revealed that in all case studies every single housing unit was planned to be assessed in defined stages of the construction process. However, through the analysis of data there were evidences especially manifested in case studies 1 and 3, that due to resources constraints the quality policy regarding sampling approach could not be fully established (Table 4-23, Data sections 65). Another relevant observation made by the ite managers of Case studies 1 and 2 is that the internal leaf of the external walls were composed by pre-fabricated timber frame with built-in insulation enclosed by vapour proof membrane. Thus, the quality of the thermal insulation installation could not be verified by the site management team, relying on the quality standards of the offsite production (Table 4-23, Data section 66).

Table 4-23 Sample of sections of the interview transcripts related to the category Definition of quality metrics and control

	Data sections from Interview transcripts	Related concepts
65	I had, shall we say, difficulty at the front end of the job, so as a site manager, I'm on my own until the timber frame goes up and then I get a site assistant who will be going out and do the QA checks along with the supervisor of that trade... I was let down by…I wouldn't like to say that the company let me down, but something happened that let me down and what I was finding was I did not have continuity with my assistant site manager. So, I get one for weeks, then he'd go and then I'll get somebody else and you can't run a site like that. (Interview 1.c – Site manager, 00:27:41).	Quality control timing Quality control frequency Defect identification
66	And, the other thing is because the insulation is installed in the timber frame in the factory… we've got no way of knowing. It's a closed panel, but we've got no way of knowing… they would put the membrane on and then insulate and then they would turn the frame over and I was thinking, "When that's vertical, does the insulation drop?" So, we have no way of knowing that because when it comes to site, we've got to assume that that…. Yeah, a difficult one… (Interview 1.c – Site manager, 00:33:17).	Quality control timing Quality control frequency Defect identification

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In terms of the quality control tools deployed by site management teams, interviews identified that the quality control activities in all case studies were supported by the use of checklist sheets. In case studies 1, 3 and 4 these quality control tools were site specific, where they were developed by the site management team in case study 1 (Table 4-24, Data section 67) or developed upon existing standard documents which were adapted to encompass the additional requirements, specific to the project (Table 4-24, Data sections 68 and 69). In the remaining cases (Case studies 2 and 5) the quality control tools used by the site management teams were developed by the contractors' central management, designed to be used across different projects. In fact, it was observed that this practice was not appreciated by the site management team of case study 5, due to the fact that this generic approach, rather than a bespoken one, was often not synchronized with the construction sequencing and was "not true" to the construction methods applied (Table 4-24, Data section 70).

Table 4-24 Sample of sections of the interview transcripts related to the category Definition of quality metrics and control

	Data sections from Interview transcripts	Related concepts
67	We do have some QA sort of tick sheets, you know, which we create ourselves because every site is different. We have site-specific QA sheets which we create as we go along. (Interview 1.c – Site manager, 00:27:41).	Quality control tools Defect identification
68	(Question - Are those checking lists developed by the company? *Contractor**?) Yeah. They are part of business management system. So yeah, the standard by *Contractor** and then on each site if there's any additional requirements or anything specific to the site then it's tweaked. (Interview 3.c – Assistant site manager, 00:09:40).	Quality control tools Defect identification
69	We've got standard documents but we—they are basically in a text free format. So, we can change them. It's what we do 'cause (sic) every project is different. (Interview 4.c – Senior site manager, 00:23:10).	Quality control tools Defect identification
70	It's a new system, it could be improved. … the way you can improve this is to improve the checklist to be true to the working… to the actual format or order of work, sometimes the list is not quite in sync in the order of work that you actually build in particular. It's like generic almost rather than bespoke for the thing that you do. …and then certain things are checked at different times, so it's not down to a fine science, it then becomes more hindrance than a tool. (Interview 5.c – Site manager, 00:08:17).	Quality control tools Defect identification

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Moreover, in case studies 4 and 5, interviews revealed that a new platform for quality control was in the process of implementation. In addition to the traditional paper based quality checklists used in Case study 4, a digital platform was introduced which provided an efficient access to technical design and detail information while site inspections were being undertaken. It also provided a defect register platform which triggered and monitored corrective actions (Table 4-25, Data section 71). On the other hand, in Case study 5, the perception of the potential contributions of the new system was negative. Due to the fact that the checklists used were not site specific, the site management team found difficult to deploy the digital platform. Instead of using the portable electronic devices for quality checking, the site management team opted to use the traditional paper based checklists and later updated the information on the digital platform, resulting in a time consuming activity which was not considered in the overall workload (Table 4-25, Data section 72).

Table 4-25 Sample of sections of the interview transcripts related to the category Definition of quality metrics and control

	Data sections from Interview transcripts	Related concepts
71	We've got checking sheets. We've also got an online till called Field View… he's (the assistant site manager) mapped all the drawings and all the house types. So, you could break the drawings down into different rooms so then you can go through, take a picture, put a little dot on the drawing, link it to that picture and send it straight off to the subcontractor. It's a really cool piece of kit. It's user friendly, very easy, and it also logs everything. So, the subcontractor has to close it out before we can go and check it. So, it's all logged automatically… Software manages everything. (Interview 4.c – Senior site management, 00:26:53).	Defect identification Quality control tools
72	It's a great system (tablet's checklist system) but sometimes, we actually physically check on things on site and then the computer almost becomes a hindrance because you go on and really done the work on site, looked at it, checked it and we need to actually report on it actually in the tablet and it almost becomes a hindrance because at the moment, you're working on site, doing, making people do and then you've got a report on the work you've just done to prove to others it's done but it takes our time, so it's not a realistic working tool for us yet. (Interview 5.c – Site manager, 00:08:17).	Quality control tools Defect identification

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Interviews from case studies 1, 2, 3 and 4 mentioned that the quality control procedures undertaken during the construction stage on behalf of the housing association were assigned to quality officers resourced internally from the companies. Differently, in Case study 5 it was not possible to identify a professional from the housing association actively undertaking quality control inspections. Alternatively, an employer's agent was commissioned to monitor the corrective actions towards defects reported by the building control body. In terms of the quality control timing and frequency, in case studies 1 and 2 the quality officers visited the construction sites once a week. In Case study 3, the site inspections were undertaken on a daily basis. In Case study 4, the site visits took place between two to three times per week. In respect to Case study 5, the visits were held on a monthly basis. Regardless the frequency of site visits for quality control, in all of the cases the quality control procedures were undertaken through the use of a standardized report template, which presented a structure to collect data related to the construction programme progress, but did not systematised the collection of defects which could potentially affect the thermal performance of the dwellings, such as the use of quality checklists (Table 4-26, Data section 73). The snagging process was the only quality control phase where the professionals working on behalf of the housing association were provided with a structured approach to collect defects such as the use checking list. This was mentioned by interviewees in case studies 3 and 4 (Table 4-26, Data section 74). However, at this stage of the construction process, any defects occurring in the buildings' fabric would be enclosed and not identifiable by a visual inspection (Table 4-26, Data section 75).

Table 4-26 Sample of sections of the interview transcripts related to the category Definition of quality metrics and control

	Data sections from Interview transcripts	**Related concepts**
73	That's a typical supervisor's report on a monthly basis. So I'll visit every week, minimum. Sometimes it requires more, but generally weekly and then every four weeks I'll put a report together… just an overview and you'll see the number of operatives that are on site, it's particular snap shot of the visited site. If there's any defects it will be on there, that I want them to put straight. I mean, I don't want anybody wondering that I just pulled one out of the blue. And then it's just a general update for the client to see how the program is going forward and where they are in regards to the program. And then there's a couple…a bit of weather and a couple of photos. (Interview 1.a – Quality coordinator, 00:35:37).	Defect identification Quality control frequency
74	We have various of the checklist which we use on schemes which highlights particularly areas of defects but that usually to do snagging stage and we also have regular standards clerk of works reports which they complete every week. (Interview 4.a – Head of development, 00:16:02).	Defect identification Quality control frequency Quality control timing
75	When we get to the end of the project…towards the end of the project before we get to practical completion, when the contractor is comfortable they've completed the build, they then ask for our employer's agent to come in and start the snagging process. (Interview 1.b – Development manager, 00:33:57).	Quality control timing Defect identification

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Overall, in exception of Case study 4, the interviews showed that the approaches adopted by the building control bodies, site management teams and housing associations' quality officer to identify the defects impacting on the thermal performance of the dwellings relied mostly on the experience and the level of awareness of the professionals involved, rather than a structured quality control procedure with a particular focus on the thermal performance of the buildings.

Overall, the findings resulting from the analysis of the concepts related to Definition of quality metrics and control could be summarised in two main subcategories: Quality attributes and criteria; and Quality control procedures Table 4-27. Whilst Quality attributes and criteria encompassed the definitions of quality attributes and acceptance criteria used to underpin the quality control procedures, Quality control procedures explored the timing and frequency that quality control activities were deployed, as well as the sampling approach adopted. Additionally, it also identified the quality control tools employed to identify defects.

Table 4-27 Definition of quality metrics and control emerging subcategories

Subcategories	**Concepts**
Quality attributes and criteria	Energy performance attributes
	Acceptance criteria
Quality control procedures	Quality control timing
	Quality control frequency
	Quality control sampling
	Quality control tools
	Defect identification

4.5.2 Findings from project documentation, defect surveys and observations from construction site visits and managerial meetings

The quality attributes in respect to the energy performance of the buildings and the criteria for quality compliance established in the case studies derived from pre-defined quality standards such as Part L1a of the UK Building Regulations and from the Passivhaus standard. In that sense, the attributes in particular were clear and were well-known by all projects' participants from the early phases of the case studies. Figure 4-19 and Figure 4-20 show parts of project documentation from Case studies 2 and 4, where quality attributes were presented.

EXTERNAL WALLS - RENDERED BLOCK CLADDING
WHERE TIMBER FRAME

100mm dense concrete block using cement lime mortar mix 1:6 finished externally with thru colour render. 50mm clear cavity. 15mm wood fibre Sheathing board prefixed (externally only) to 140mm f/s timber studs at MAX 600mm Ctrs. Reflective breather membrane prefixed to external board face to lap dpc upstands.
Continuous air/vapour barrier is factory fitted internally to timber studs & all joints on site to be taped & sealed
38mm thick timber batten site fixed to inside face of 140mm closed panel wall system to allow for service runs, lined internally with 12.5mm Gypsum Fibre Board, to be sealed & skimmed
Mineral wool insulation insulation, 140mm thick, factory fitted into voids between studs.
Above construction to achieve a MIN "U" value of 0.24W/m2k. (Timber Manufacturer to issue Building Control with proof) All insulation to external walls factory fitted.
External Wall Panel to sit on hyload DPC. (width to suit walls)

Figure 4-19 Quality attributes for thermal performance declared in Case study 2 client's requirement (Source: housing association Case study 2)

Design Component	Limiting value
Walls, Roof, Floor (U-values)*	≤0.15 (W/m^{2}K)
Glazing unit	≤0.8 (W/m^{2}K)
Installed glazing	≤0.85 (W/m^{2}K)
Doors	≤0.8 (W/m^{2}K)
Infiltration (ach^{-1})	≤0.6 @ n_{50}

Figure 4-20 Quality attributes for thermal performance specified in Case study 4 (Source: housing association Case study 4).

Some of the defined performance attributes such as the rates of air permeability were measurable, thus tested and checked against the defined acceptance criteria, as shown in Figure 4-21 from the Case study 1 project documentation. However, defined performance attributes such as the thermal transmissivity of the overall building fabric or of specific building elements were only verified against the established criteria in the design stages, through the use of the SAP calculations and Passivhaus Planning Packages.

Building and Test Details

Building or Plot No:	15
Tested Building Address:	[redacted]
Footprint (GFA, m^2):	46.20
Envelope Area (m^2):	227.37
Date of Test:	2016-11-15

Temporary sealing:

Trickle vents, kitchen and bathroom extractors sealed.W/C's filled with water,Sinks and waste pipes filled with water,Internal doors open and external windows closed,

Deviations:

None

Mastic Sealing Status:

External Walls Only (inc. sanitary ware)

Test Data and Result

This is to certify that the above named dwelling/building has been tested for air permeability by a registered provider in accordance with ATTMA {ATTMA TSL1 (Method B)}, subject to the above statements regarding temporary sealing and 'test deviations'.
This certificate is a short form report. If a full compliant report is required, please contact the testing company. Enquiries about this certificate should be made to: Scheme Manager, ATTMA, St Mary's Court, The Broadway, Amersham, HP7 0UT or visit www.attma.org.

The key Leakage characteristics of the building are:

Result (AP_{50}):	4.53 $m^3.h^{-1}.m^{-2}$ @ 50 Pa
The result achieved meets the Design Air Permeability requirement.	

Design air permeability:	5.00 $m^3.h^{-1}.m^{-2}$ @ 50 Pa	Flow Exponent, n:	0.700
Correlation of results, r^2:	0.99599	Air flow coefficient, C_{env}:	66.2 $m^3.h^{-1}$ Pa

Figure 4-21 Air pressure test result for one of the dwellings in Case study 1 (Source: contractor Case study 1)

Concerning the construction phase, the assessment through actual testing (e.g. co-heating tests or heat transfer tests) was not required and thus not implemented in none of the case studies. The compliance to the established acceptance criteria was made through the quality control procedures by the deployment of quality control tools (e.g. quality checklists). At this stage it was identified that the main challenge was not defining the quality acceptance criteria, but translating them into quality control procedures and tools and defining the adequate timing for inspections. Whenever potential defects acknowledged in the risk assessment stage were included in checklist, the acceptance criteria often relied in subjective parameters. Figure 4-22 exemplifies the use of terms such as "complete" as an acceptance criteria which does not provide objective assessment guidance. Ultimately, concerning to awarding compliance, it is down to the quality officer to interpret the acceptance criteria. Only in Case study 4, potential defects were thoroughly mapped and the acceptance criteria were translated into measurable parameters in the checklists, as shown in Figure 4-23.

Carpentry/Insulation

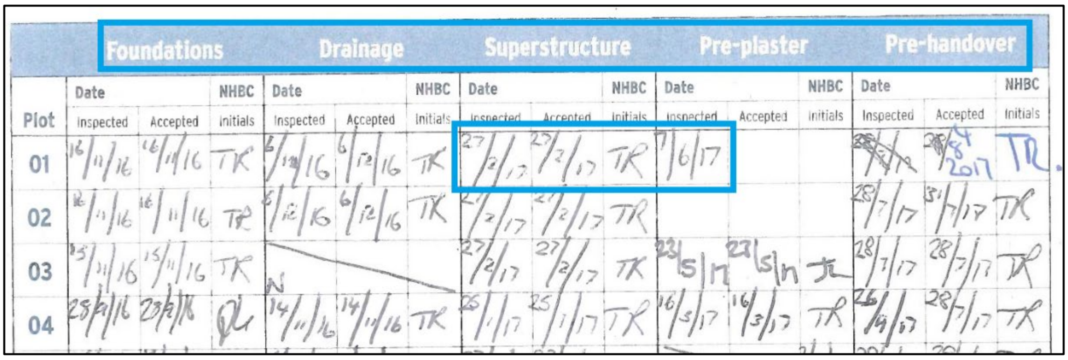
#	Check Item	Status
1	06/25 Studwork set out correctly (300mm spacing to baths and showers)	Pass
2	06/26 Staircase installed per Standard detail and CQM and exposed soffit boxed for stepped drylining	Pass
3	06/27 Window boards fitted square with correct overhang for finishes	Pass
4	06/28 Door openings correctly set out with margins for full architraves etc.	Pass
5	06/29 Insulation to stud walls between bed rooms bathrooms etc. installed	Pass
6	06/30 Noggins and patresses for plasterboard, radiators, sanitaryware, boilers, kitchens, etc. installed	Pass
7	06/31 Shower cubicles formed using tray templates as per CQM.	Pass
8	06/32 Correct insulation board used at sloping ceilings or where required (refer to construction specification)	Pass
9	06/33 All insulation and sound proofing complete (partitions and SVPs)	Pass

Figure 4-22 Quality checklist used in Case study 5 (Source: contractor Case study 5)

	✓	N/A
1. Setting out completed to co-ordinants – Double checked from all boundaries/roads and other plots by engineer and site manager		
2. Excavation to depths provided by engineer		
3. Type1 and sand blinding installed level and true		
4. Insulattion laid flat and tight (gaps no greater than 3mm, service penetrations foam sealed		
5. DPM laid in accordance with specification, lapped and taped with both double sided butile tape and jointing tape		
6. Reinforcement laid in accordance with structual engineers details		
7. L.A.B.C./Building Control inspected and approved (pre-concrete)		
8. Concrete and steel placed in accordance with engineers' design		
5. L.A.B.C./Building Control inspection after concrete pour		
9.Foundations checked steps/gauge/overlap/ Rebates for door thresholds are in correct position and clean/ square		
10. Concrete to be level and clean to avoid contras from Bricklayers		

Figure 4-23 Foundation quality control sheet with clear definition of acceptance criteria of continuity of insulation layer (Source: contractor Case study 4)

In respect to the quality control procedures undertaken by the building control bodies, the quality control timing and frequency were defined in five key stages of the construction process, as presented in Figure 4-24. The main challenge in this approach is the long period of time between the key stages for inspection. For instance, Figure 4-24 shows that in Plot 1 there were more than three months between the inspections of the key stages Superstructure and Pre-plaster, without interim quality assessments.



Plot	Foundations			Drainage			Superstructure			Pre-plaster			Pre-handover		
	Date Inspected	Date Accepted	NHBC Initials	Date Inspected	Date Accepted	NHBC Initials	Date Inspected	Date Accepted	NHBC Initials	Date Inspected	Date Accepted	NHBC Initials	Date Inspected	Date Accepted	NHBC Initials
01	16/11/16	16/11/16	TK	6/12/16	6/12/16	TK	27/2/17	27/2/17	TR	7/6/17			[illegible]	4/8/2017	TR
02	16/11/16	16/11/16	TR	6/12/16	6/12/16	TK	27/2/17	27/2/17	TR				28/7/17	31/7/17	TK
03	15/11/16	15/11/16	TK	N			27/2/17	27/2/17	TK	23/5/17	23/5/17	[illegible]	28/7/17	28/7/17	TK
04	28/9/16	28/9/16	[illegible]	14/11/16	14/11/16	TK	25/1/17	25/1/17	TK	16/3/17	16/3/17	TK	26/9/17	28/7/17	TK

Figure 4-24 Quality control timing and frequency undertaken by the building control bodies (Source: contractor case study 5)

The implications in this approach were that important building elements concerning thermal performance of the fabric could be covered by other construction materials at the time of the quality check due to the long interval between inspections. Thus, making difficult defect identification only through visual inspection. As observed in Case study 5 for example, issues such as the accumulation of debris in the cavity tray (Figure 4-13), which lead to undesired thermal bridging, would not be spotted in the pre-plaster inspection due to the fact that cavity closers were already installed at that stage and consequently blocking the visualisation of any issues (Figure 4-25).

Figure 4-25 Cavity closer installed blocking the identification of defects in the wall's cavity (Source: Taken by this thesis' author)

In addition, the inspector on behalf of the building control bodies also had an extensive amount of quality attributes to check, encompassing not only the requirements of Part L1a but also the assessment of other parts of the UK Building Regulations, such as Part B – Fire safety and Part E – Resistance to the passage of sound, as identified in Observations 2.c and 5.c (Appendix B.4).

In respect to the quality control tools, the use of quality checklists by approved inspectors could not be verified. The inspectors relied in the fact that the design was previously approved in accordance to standardised detailing (e.g. Technical manual and Robust details approved document). The identification of defects on the site was dependent mostly on their experience, knowledge and level of confidence in the contractor. Figure 4-26 corroborates the fact the only quality tool used during site inspection were a standardised site visit report, where identified defects were reported, but the document did not offer guidance for quality detection.

Site visit report

Page no [illegible]

Developer name: [redacted]

Builder name: [redacted]

Site: [redacted]

Inspector: [redacted] Site Manager: [redacted]

Reportable items/observations	Plot/ block	DPR	NHBC initials	Date actioned	Builder's initials
12/09/2017, Stage: Floor structure, **Potential for structural failure,** Timber and concrete upper floors, Incorrect installation of joist hangers, Standard 2017 6.4 13, Details: Please ensure that the correct joist hangers are being used to support the floor trimmer to the steel joist.	3/018	8	[illegible]		

Figure 4-26 Standardised site visit report used by building control bodies (Source: contractor Case study 5).

The general quality control approach adopted by the contractor and their site management teams were aligned with the quality policy defined in the early stages of the projects. Quality inspections were administered with defined frequency and timing, set to occur when working packages and construction stages were deemed completed by subcontractors. As observed during site visits (Observations 1.d, 1.e, 4.h and 4.I in Appendix B.4) and evidenced in Figure 4-27, the general practice for quality control procedures was that both contractor and subcontractors' representatives were expected to use the provided quality checklists and sign them off if quality reached the desired level. Quality was checked and approved firstly by the subcontractor's supervisor and secondly by the representative of the site management team. Once this was completed, the payment would be released and the subsequent working package would be started. The challenge posed to this approach in the majority of the case studies was that the length of the working packages and thus the time between the formal inspections were too long. For instance, Figure 4-28 and Figure 4-29 indicate that the period between quality inspections was over a month. Thus, it is reasonable to state that defects affecting the performance of the building envelope remained unchecked and uncorrected, due to overlaying of construction elements. Another relevant aspect noticed in respect to lengthy working packages were the overwhelming number of items to be checked in the inspection routine, impacting in the effectiveness of the task.

10. Concrete to be level and clean to avoid contras from Bricklayers		
Type of foundation		
Contractor		

✱ The plot must be cleared of all surplus material and all waste in order for
✱ The above works have been checked and completed to N.H.B.C. standards and building regulations applicable to this plot.
✱ All works left safe for others.

Comments:

SITE MANAGER	**CONTRACTOR**
Name:	
Signed:	
Date	

Page 2

Figure 4-27 Quality checklist used in case study 4 entailing signing off by the site management team and subcontractor (Source: contractor Case study 4)

Build Stage 05 - Roofed - House - Traditional

Form Reference	F32296.58
Owned By	[redacted]
Date	27/07/2017 20:12:00
Status	Passed
Project Name	[redacted]
Project Reference	
Location	[redacted] Plots 71 to 80>PA

Figure 4-28 Quality checklist for key stage 5 used in Case study 5 (Source: contractor Case study 5)

Build Stage 06 - First Fix – House - Traditional

Form Reference	F32296.71
Owned By	[redacted]
Date	31/08/2017 21:06:04
Status	Passed
Project Name	[redacted]
Project Reference	
Location	[redacted] Plots 71 to 80>PA

Figure 4-29 Quality checklist for key stage 6 used in Case study 5 (Source: contractor Case study 5)

Concerning the quality control checklists used by site management teams, Case studies 2 and 5 they had been developed by the contractors' central management. Case studies 1, 3 and 4 had site-specific quality control checklists developed entirely by the site management team (Case study 1) or had been adapted from standard versions to meet the projects specific characteristics. In both situations, in exception of the quality checklists used in Case study 4, the quality control tools deployed were lacking of focus in respect to building elements and defects affecting the thermal performance of the dwellings' fabric. For instance, Figure 4-30 presents the checklist used to assess quality compliance for Mechanical and Electric works at First fix. In the document there is no guidance towards assessing gaps in the vapour control layer or displacement of insulation layer due to pipe or ductwork penetration in the building's fabric, which could lead to air permeability and heat loss. Another example can be observed in Figure 4-31. Although the items to be checked refer to aspects relevant for the thermal performance, such as the use of cavity closers at the top end of blockwork, there is no reference made towards assessing the continuity of the insulation layer at the roof level.

M&E sign off Record 1st Fix Plot no Date	
All pipework installed and completed as per Drawings and specification issued	
System filled with water and tested - pipework clipped and lagged -	
SVPs and extract connected to roof vents – solid sleeves through blockwork for extract fans to allow for render and waterproof finish.	
Pipework Penetrations sleeved through blockwork	
All sockets / pipework installed and completed as per drawings and information issued	
All sockets / Fuse boards set to allow for follow on trades (i.e. plaster boarding)	
TV Ariel installed	
External lighting / power cables brought out in correct locations ready for follow on trades (render)	
Plot cleaned of all material ready for follow on trades	
Comments	

Figure 4-30 Checklist used in Cases study 1 lacking of focus on quality issues related to thermal performance of the building fabric (Source: contractor Case study 1).

Build Stage 05 - Roofed - House - Traditional

Form Reference	[redacted]
Owned By	[redacted]
Date	27/07/2017 20:12:00
Status	Passed
Project Name	[redacted]
Project Reference	
Location	[redacted] Plots 71 to 80>PA

Form Location — Plot 74

External (before scaffold strike)

#	Check Item	Status
1	05/01 RWPs located over movement joints (where possible)	Pass
2	05/02 Weep vents at 450mm & clear from mortar	Pass
3	05/03 Leadwork neat & tidy, correct Code and patination oil applied	Pass
4	05/04 Roof tile fixing and pointing neat & tidy to correct specification and per CQM	Pass
5	05/05 Extract vent terminals correct location, number and size	Pass
6	05/06 Flat roof membranes installed under door cills as detailed by waterproofing membrane manufacturer	N/A
7	05/07 Flat Roofs and balconies Inspection Report issued by waterproofing membrane manufacturer	N/A
8	05/08 Gutters installed with correct bracket spacing and all fixing holes used. Cleared of debris and stickers removed.	Pass

Internal

#	Check Item	Status
1	05/09 Roof bracing installed as design	Pass
2	05/10 Valley constructed as CN standard detail	Pass
3	05/11 Loft hatch frame and maintenance board installed as CN Standard Detail	Pass
4	05/12 Blockwork fully flushed (particularly party wall)	Pass
5	05/13 All joists correctly fitted to hangers and all fixing holes used	Pass
6	05/14 Joist block ends fitted	Pass
7	05/15 Chipboard floor level, flat and glued as S9 of SSMW	Pass
8	05/16 Any timber or steel built into blockwork fully mastic sealed	N/A
9	05/17 Chipboard floor perimeter expansion gap clean and 10mm width	Pass
10	05/18 Rigid insulation installed at eaves as Standard Details and CQM	Pass
11	05/19 Cavity closures sealed to blockwork	Pass
12	05/20 Chimney smoke test carried out and certificate issued (photo required)	N/A
13	05/21 Underfloor heating pipes filled tested and terminations to manifold position temporarily protected in robust casing	N/A
14	05/22 Screed level, no cracks, perimeter upstand insulation not bridged	N/A
	Have Service Connections/Meter Installation request forms been completed?	Yes

Housing Standards Inspection List

Figure 4-31 Checklist used in Cases study 5 lacking of focus on quality issues related to thermal performance of the building fabric(Source: contractor Case study 5)

Contrary to the previous examples, the quality control checklists used in Case study 4 were devised encompassing the most relevant quality issues affecting the thermal performance of the dwellings at each stage of construction, through the input of information from the risk assessment process. For instance, in the pipework stage, the document indicates the need to check on the vapour seal whenever pipes protrude the building fabric, thus mitigating defects related to air permeability (Figure 4-32).

Project Number __________ Project Title ____

Description of items or areas checked ____

CHECKLIST 532: PIPEWORK – FINAL FIX AND INSULATION

Preparation:		
1	☐	Materials delivered to site comply with specification
Pipework Final Fix:		
2	☐	Radiators, fan coils etc, installed as drawings
3	☐	Air vents fitted as required
4	☐	Air control/balancing valves installed
5	☐	Strainers installed where required
6	☐	Flexible connections to plant and equipment comply to specification and drawings
7	☐	Pressure test system
8	☐	Pressure gauges, pressure switches and sensors etc have been installed
9	☐	Record drawings are accurate
10	☐	Access panels are suitable for valves
Insulation Installation:		
11	☐	Vapour seal is continuous and undamaged
12	☐	Metal cladding to pipework has been provided where required
13	☐	Boxes to valves, strainers and flanges have been fitted as specification

Figure 4-32 Checklist used in Cases study 4 providing of focus on quality issues related to thermal performance of the building fabric (Source: contractor Case study 4).

Even though in this Case study 4 a robust quality control checklist was devised, issues regarded to the consistency of the application of the control tools were identified. It was observed through the site surveys that the occurrence of defects remained unreported during busy periods of time. For example, it was discussed and decided during the design and risk assessment stages (Observation 4.d in Appendix B.4) that the use of parge coats as vapour control barrier was less susceptible to damages and ruptures than the use of membranes. Moreover, it was also decided that due to risk of cracking in the wall corners, an air tight tape should be applied over primer coat to ensure adherence (Figure 4-33). However, as shown in Figure 4-34 the procedure of applying primer coat prior to the application of air tight tapes was not followed in certain occasions and the quality control procedure failed to spot the issue.

Figure 4-33 Application of air tight tape over primer coat to overcome the risk of cracks of the parge coat in wall corners (Source: Taken by this thesis' author)

Figure 4-34 Defect potentially affecting air tightness undetected (Source: Taken by this thesis' author)

Regarding the quality control procedures undertaken by professionals on the behalf of the housing associations consisted of regular site inspections, rather than being set by miles stones. The quality control tools deployed were template reports driven by the programme progress, as shown in Figure 4-35. The adoption of this approach posed a challenge for defect identification because the templates used did not offered a structured guidance neither related to specific defects to be looked for, nor to specific building elements where the defect could occur.

Inspection Date: 27/04/17 Time of visit: 09:30HRS COW: [redacted]

Weather: Sunny Temp:10ºc Wind: None

Site visit Number: 14 Contractor: [redacted]

Plots Completed (72 Plots in total)		
Rented	Shared Ownership	Total
0/49	0/23	0/72

Progress of Works

Plot Number	Observations	Overall Progress
Block A Plots 1-12 Block B Plots 13-16	Plot drainage complete. Slab insulation and membrane is in hand	6%
Block C Plots 17-23	Ground floor superstructure is 95%.	14%
Block D Plots 24-28	Slab reinforcement in hand. Concrete poured on 2 plots.	5%
Block E Plots 29-34	Plot drainage complete.	3%

H&S and Accidents	None	
Site Issues and defects		
Welfare on site	Site Office Toilets Canteen Meeting room	
Rectification notices issued/outstanding	Ref number	Status
	BOD01	Signed Off
Labour on site	Site Team MJL Balfour Beatty REB Utilities	
Material Issues	None	
L.A.B.C	Carrying out inspections – nothing to note.	
A.O.B	None	

Figure 4-35 Sections of site visit report template used by housing association's quality officer.

4.5.3 Challenges related to the definition of quality metrics and control

This section presents the challenges to deliver the desired thermal performance of domestic buildings identified from the data analysis which relate to the Definition of quality metrics and control.

13. Lack of objectivity in translating quality acceptance criteria of performance attributes (e.g. thermal transmissivity of buildings fabric) into quality control tools.

In case studies 1, 2, 3 and 5 it was identified that although the quality acceptance criteria of thermal performance attributes were defined in the early stages of projects, quality control tools failed to translate them in to objective criteria, and therefore, less susceptible to interpretation.

14. Quality checking hold points overly distant to each other, affecting the identification of defects in certain building elements due to accumulated construction stages.

It was observed in most of the case studies that the identification of quality defects were undermined by the adopted timing and frequency of quality control inspection. Due to the long periods of time between the quality control inspections, several elements of work were already completed. Thus, building elements relevant to the fabric's thermal performance which needed checking were superposed by other construction materials, making visual inspection difficult.

15. Definition of lengthy working packages which concentrate an overwhelming amount of construction aspects to be checked at a time, compromising the efficacy of the quality control activities.

Slightly similar to the previous challenge, the accumulated building elements to be checked led to an overwhelming number of quality checks to be administered at each time of a quality control activity.

16. Lack of use of quality checklist to support and structure quality control activities undertaken by quality officers on behalf of housing associations and building control bodies.

In all case studies, it was identified that inspectors of building control bodies and quality officers working on behalf of the housing associations did not relied on structured procedures to undertake quality control inspections, apart from the snagging process. The resources put in place did not encompassed the use of quality checklists relying solely on their knowledge, experience and awareness. Due to the amount of building elements and defects to be checked at each key stage of the construction process, the implementation of a structured quality appraisal would provide focus and consistency to the process of quality control.

17. Lack of consistency of quality checklists due to being not site specific and generic in terms of construction method and sequencing.

In case studies 2 and 5, it was observed that the quality tools used in the quality control procedures did not encompassed all the necessary building elements and defects to be checked, due to being not site specific. Moreover, some of the items embedded in the checklists did not match the construction method sequencing. Thus, compromising the adequate application of the quality control tool.

18. Quality checklists deployed did not encompassed at least the most recurrent quality issues affecting the thermal performance of the dwellings' fabric.

In case studies 1, 2, 3 and 5, it was identified that the quality checklists deployed by site management teams, did not offered a comprehensive guidance to the detection of defects undermining the ability of the building fabric to perform as predicted.

19. Lack of consistency on the application of quality control procedures.

In all case studies it was observed that due to appropriate allocation of resources the quality control procedures devised by the project quality plan could not be fully administered. In several cases quality inspections could not be undertaken, where defects identified by the site surveys data collection procedure remained uncorrected.

4.6 Quality compliance procedures

Quality compliance procedures is defined as the stage where the results of the quality control procedures are reported. It is in this stage when the quality results are assessed and analysed, triggering corrective measures. Also at this stage, the process of communicating the quality compliance is defined, providing relevant information to the learning process within the project, as well as enabling continuous improvement based on the lessons learned in previous projects.

The following concepts of the Quality compliance procedures category are explored in this section: (i) Quality reports (Harris et al., 2013, Griffith and Watson, 2003); (ii) Performance report (Harris et al., 2013, Griffith and Watson, 2003); (iii) Result assessment (Jraisat et al., 2016, BSI, 2015, Gorse et al., 2012); (iv) Corrective actions (BSI, 2015, Project Management Institute, 2001); (v) Compliance communication (BSI, 2015, Battikha, 2008); and (vi) Continuous improvement (BSI, 2015, Battikha, 2008, Project Management Institute, 2001, Kanji and Wong, 1998).

4.6.1 Findings from interviews with key project stakeholders

This section presents the answers to the interview questions 18 to 20 (Chapter 3, section 3.5.1), which had been purposely formulated to explore the six concepts related to Quality compliance procedures mentioned above. The analysis of the interview transcripts revealed that all six concepts had been acknowledged by all the case studies.

Interviews of all the case studies suggested that the process of granting quality compliance was entailed by the appraisal of workmanship quality through the application of quality control procedures. From the perspective of the contractors, in all case studies the process of reporting quality was through the use of quality checklists, when the defined key stages of construction were deemed completed by a trade gang. Providing the site management team responsible for the quality control was satisfied with the quality standard inspected, the key stage of the construction process was signed off and quality compliance was achieved (28, Data sections 76 and 77). According to the interviewees, whenever a defect was identified, the checklist could not be signed off and corrective actions were required to the responsible subcontractor. In respect to quality issues related to thermal performance, interviews revealed that the ability of the quality appraisal procedures to identify defects and to trigger corrective actions depended mostly on the managerial team's experience and awareness, in exception of what was observed in Case study 4.

Table 4-28 Sample of sections of the interview transcripts related to the category Quality compliance procedures

	Data sections from Interview transcripts	**Related concepts**
76	So every single plot from one through to 72 has its own individual file. In that file, it will have subheadings starting from ground works onto masonry then it will be carpentry etc. And on each of those subheadings, they will have the developed check sheets and on that check sheet are the series of checks that we would go through. It's the responsibility of the subcontractor or their foreman to take that check sheet and make sure that each individual element is installed as correctly and as worded within the document, they then sign that one off to say they're happy with it, I will then make a visit on site and I will check that off and countersign it. … If I've got any issues, I'll fill out a comment sheet. I won't sign it off and that becomes a live defect form. They need to remediate it, they would sign it off as complete and I would sign off the element of works. (Interview 4.b – Quality officer, 00:15:18).	Quality reports Result assessment Compliance communication Corrective actions
77	Well, we have quality checklist for every stage built. So the groundwork is split into four sections and once that work has been done, it's then signed off by the foreman and then signed off by ourselves. And that's how we release payment and it's also how we check the quality. (Interview 3.c – Assistant site manager, 00:08:15).	Result assessment Compliance communication

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Interviewees representing the housing association stated that quality reports completed during regular site visits and inspections undertaken by quality officers and employer's agents were developed and submitted to the site management team and housing association's stakeholders. Corrective actions would be required if defects were spotted

(Table 4-29, Data section 78). As stated previously, the quality appraisal administered by the professionals on behalf of the housing associations did not presented a structured approach towards identifying thermal performance related defects (Table 4-29, Data section 79).

Table 4-29 Sample of sections of the interview transcripts related to the category Quality compliance procedures

	Data sections from Interview transcripts	Related concepts
78	And on a weekly basis I do my site report. And if I find anything on-site that I'm not happy with and I don't think it's going to be picked up or treated seriously, I will minute it as you want to call it, you know, and you could say minute it or put it in the report. (Interview 3.b – Quality officer, 00:54:04).	Quality reports Result assessment Corrective actions
79	We have our own (quality management procedures) but it's not formalised, if you know what I mean. It's down to the individual surveyor's experience. Now obviously, if somebody else is doing my job if I went sick or left a job, then they would have to pick it back up. (Interview 3.b – Quality officer, 00:34:32).	Quality reports Result assessment Corrective actions

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In respect to the process of obtaining quality compliance towards Part L1a of the UK building regulations, the interviews revealed that the appointed building control bodies inspected the housing units according to established key stages of the construction process. Whenever the approved inspectors found that the workmanship of the designated building element assessed met the quality standards set in the building control bodies' technical manual, the key stage was cleared and the construction process was resumed. If a quality issue was identified a "reportable item" was raised, where the defect was described and corrective actions were then required in order to clear the stage (Table 4-30, Data section 80).

Table 4-30 Sample of sections of the interview transcripts related to the category Quality compliance procedures

	Data sections from Interview transcripts	Related concepts
80	Off the top of my head, I can't remember all the stages. … So when he (approved inspector) is expected to come, is to do that stage of inspection. It might be a pre-plaster or whatever. He will need to note the plot number	Quality reports Result assessment

	in that book and sign to show this has been inspected. …if they're trying to inspect plot 52, at pre-plaster stage they may walk the site and spot something that they will pick up and note. Hence, a RI or reportable item is raised. We'll then check that and ask them (contractor) if there are any issues at all, because that will prevent them in clearing to the next stage. (Interview 5.a – Quality officer, 00:27:21).	Corrective actions

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In addition to the quality reports aforementioned, interviews from all case studies stated that the only performance reports provided were regarded to air pressure tests put in place to assess the air permeability of the dwellings. In case studies 1, 2, 3 and 5, the air tests were administered at the practical completion stage of the construction process (Table 4-31, Data section 81). According to the Quality officer of Case study 4 performance reports regarded to air permeability were provided and analysed at the intermediary stages of construction (Table 4-31, Data section 82).

Table 4-31 Sample of sections of the interview transcripts related to the category Quality compliance procedures

	Data sections from Interview transcripts	**Related concepts**
81	And all our buildings are air tested at the end of the build. So if there's any leakage or weakness in the buildings that will flag up at that stage. (Interview 1.a – Quality coordinator, 00:17:59).	Performance reports Result assessment
82	Yeah, every unit’s got three (air) tests, so post completion of the fabric of the building. … So prior to any internal fixings and mechanical and electrical fitting, we do an air test. If there is any issue, we’ve got a bare fabric internally to be able to remediate any potential leaks. Once we’ve completed that, mechanical and electrical, we’ll then do their first fix. And make sure that their penetrations through the building are thoroughly sealed. When they are thoroughly sealed we know we have maintained the integrity of the building. And then it’s down to final fitting inside. So once again completion of mechanical and electrical, you’ve only got the first fix of the internal partitions. There’s gonna (sic) be limited areas where we could be leaking through the fabric. As long as we past the second air test, we’re then comfortable to continue the internals and then the final air test is post completion of the property. (Interview 4.b – Quality officer, 00:28:18).	Performance reports Result assessment Corrective actions

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In relation to the process of assessing the achievement of the quality requirements and addressing identified defects, the interviews revealed the use of three distinct approaches. In all case studies monthly project meetings were held and attended by the main stakeholders, i.e. projects managers from the housing association and the contractor, employer's agents, design team representatives and the site management team. The main purpose of these meetings were to assess programme progression and issues which had the potential to compromise the achievement of the project' milestones. At this strategic meetings, quality issues raised by the quality officers' report, the quality checklist administered by the site management team or "reportable items" from the building control bodies were discussed. However, only outstanding quality defects which posed threats to programme progress or could potentially cause severe impact to the projects' budget were addressed (Table 4-32, Data section 83). In Case study 5, the Quality officer revealed that, the main focus were the defects spotted by building control body, which if not properly corrected would incur in delays in the programme (Table 4-32, Data section 84). Defects considered less harmful to the achievement of programme milestones were treated directly with the subcontractor's supervisory team. In case studies 1, 2, 3, 4, meetings between the site management team and subcontractors' supervisors took place on weekly basis. Differently, in Case study 5 meetings were undertaken every fortnight. The meetings were used mostly to discuss issues related to health and safety and to plan the following construction activities. However, aspects regarded to quality would be only discussed whether a specific concern might affect the programme (Table 4-32, Data section 85).

Table 4-32 Sample of sections of the interview transcripts related to the category Quality compliance procedures

	Data sections from Interview transcripts	**Related concepts**
83	So as part of the contract we have monthly project progress meetings. Yeah, on site. As part of that, any more sort of strategic issue, such as design issues for example… So as a requirement it's usually the project manager, so me, the site project manager or build manager, the employer's agent, any of the design team, normally the QS as well. But generally the clerk of works report that we get weekly will feed into that project as well where there's (sic) things that are outstanding. (Interview 3.a – Project manager, 00:39:46).	Quality reports Result assessment Corrective actions Feedback
84	We have as we just had, we will have monthly meetings where we will lead and review all of those areas (building regulations and code for sustainable	Quality reports

	homes). So we can review any issues that (building control body), because they regularly inspect any issues, RI's (reportable item) that they flag up, we will query just to make sure if that there are some. If not, brilliant. But if there are some then we need to make sure that site management is dealing with those and getting those cleared. Otherwise, there is no chance of them achieving sign off and be able to build. (Interview 5.a – Quality officer, 00:21:41).	Result assessment Corrective actions Compliance communication
85	So meetings with the subcontractors…we've had very demanding two weekly programmes which are very detailed programmes that we've put out, so we've got them in today to go through as much as we can to see if they're going to hit and meet those demands but also the issues that might affect the demands of that programme, so if there are or aren't any mistakes or the constantly recurring stuff that if we can eradicate those it will make things move faster and smoother and maybe hit out targets. (Interview 5.c – Site manager, 00:30:08).	Result assessment Corrective actions

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Concerning the quality compliance communication, interviewees from case studies 1, 2, 3 and 5 stated that the ultimate compliance procedure towards the projects' quality objectives related to the thermal performance was the building control bodies' final approval towards Part L1a of the UK building regulations. Firstly, the approval was granted when the proposed design met, through the SAP calculations, the expected energy performance established by Part L1a. The final approval was then awarded at the end of the construction process once all the required site inspections indicated that the quality standards were met and the defined rates of air permeability were confirmed. In relation to quality compliance communication issued by the site management team, in most of the case studies the contractor did not have a legal obligation to submit their quality control results nor reports to the employer (Table 4-33, Data section 86). In Case study 4, the compliance procedure also included proof of the proposed design meeting the minimum energy performance targets through the application of the Passivhaus Planning Package. In addition to the air pressure tests undertaken during construction, evidence that the workmanship was able to meet the design specifications were also required to the contractor. Thus, a final summary report containing signed off checklists and key stages photographic evidence of specific predefined construction elements was developed and submitted to an independent assessor who ultimately was responsible to confer the accreditation (Table 4-33, Data section 87).

Table 4-33 Sample of sections of the interview transcripts related to the category Quality compliance procedures

	Data sections from Interview transcripts	Related concepts
86	…we will get copies of all their quality documents and sign-offs. So, we will put that together in a pack at the end. But that's something we've arranged with *contractor**. But I don't necessarily think it might be across the board with all contractors. (Interview 3.b – Quality officer, 00:57:26).	Compliance communication
87	They (Passivhaus accreditors) have given me their requirements as documented proof to the certifier that we need to follow. So for me the key is photographic evidence… I tend to take a lot photographs and I'll keep a full photographic log of each stage of the process… (Interview 4.b – Quality officer, 00:31:51).	Quality reports Compliance communication

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

In order to establish a continuous improvement cycle of the project quality plans, different approaches were identified during the interviews of the housing associations and contractors. In all case studies, except Case study 5, lessons were learnt from the quality and performance reports at the post-completion stage during quality review meetings, involving the stakeholders from the housing association and the contractor (Table 4-34, Data sections 88, 89 and 90). In Case study 5, this project review was not a usual practice endorsed by the contractor and developer. According to the site manager, the final construction stages of projects were usually overlapped with the initial stages of a new project, resulting in no time available for site management teams to discuss and identify quality issues that could be avoided in future projects (Table 4-34, Data section 91). In addition to the project review meetings, the housing associations of all case studies also had a defect record system. This recording system aimed at collecting the defects occurring mostly in the twelve months of contractors' liability period at post-handover, which are normally reported by new tenants (Table 4-34, Data sections 92 and 93). The contractor interviewed in Case studies 2 stated that the defects identified during the construction phase were logged in a defect register system which contained other projects' records from the same housing association (Table 4-34, Data sections 94). However, due to the stage of the implementation of this new platform, it did not contributed to the risk assessment stage of this particular project.

Table 4-34 Sample of sections of the interview transcripts related to the category Quality compliance procedures

	Data sections from Interview transcripts	Related concepts
88	Because like I say, you do have a…an end of project review. So you can see how you would perhaps do things differently next time. (Interview 3.a – Project manager, 00:42:25).	Result assessment Continuous improvement
89	We have a post-contract review also at end of defects. Again, looks across the time, looks at the KPIs. Looks at lessons learned, gets feedback from our asset team as well as our housing management team. And feedback from the resident, in theory to provide learning for future changes and design specification. (Interview 4.a – Head of development, 00:26:33).	Result assessment Feedback Continuous improvement
90	So a full bill completion review and that's the standard document as part of our BMS system and it's just got the standard minutes that we go through when we look what we make good in the project and what was the negative and then obviously we try and take up to our next job. (Interview 3.c – Assistant site manager, 00:32:35).	Result assessment Continuous improvement
91	There's always time as an issue at the end of the project, you're going on to the next one, the time is just fully spent. Having a full feedback meeting would go down very well but I get to do one in the last 10 years. So the time between the end of the project and the start of a new one would be good to feedback and maybe eradicate lots of design issues, lots of construction issues to take into the next project. … We kind of finish one job and then we move into the next and they almost lap over. (Interview 5.c – Site manager, 00:30:53).	Result assessment Feedback Continuous improvement
92	So we've got a defects monitoring system. So everything, you know, tenants ring in and report a problem. It's raised in the system and logged and it gets fired off to the contractor to rectify, but we'll compile those stats. And we look for sort of patterns as well across projects and also compare what the common quality issues… So you know what to look out for and that helps inform what we go and look at on site as well. (Interview 1.b – Development manager, 00:43:41).	Result assessment Feedback Continuous improvement
93	So at the end of the project we retain our attention some during the 12 months after the new project finishes. So we have a reporting procedure for residents to let us know if there's issues. Again, if there was anything wrong with any of the installations… they normally call our call centre. And then the call centre assess whether that needs to be reported as a defect to the contractor. (Interview 3.a – Project manager, 00:36:08).	Result assessment Feedback Continuous improvement

94	So we got a running table for each project. If there are any open defects and closed defects, which is another method of us identifying a trend and patterns across all of our sites as well. (Interview 2.c – Site manager, 00:28:18).	Result assessment Continuous improvement

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

Overall, the findings resulting from the analysis of the concepts related to the Quality compliance procedures could be summarised in three main subcategories: Quality results; Result analysis and actions; and Continuous improvement (Table 4-35). Quality results encompasses the method by which the quality results and air permeability performance results are reported. Result analysis and actions explores the way the quality results reported are assessed to define corrective actions, as well as the method by which quality compliance are communicated to the project participants. And finally, Continuous improvement explores the process of how information related to the process of achieving the quality objectives are collected and analysed in the projects in order to enable continuous improvement in the companies' level and future projects.

Table 4-35 Quality compliance procedures emerging subcategories

Subcategories	**Concepts**
Quality results	Quality reports
	Performance report
Result analysis and actions	Result assessment
	Corrective actions
	Compliance communication
Continuous improvement	Continuous improvement

4.6.2 Findings from project documentation, defect surveys and observations from construction site visits and managerial meetings

In the majority of the case studies the main challenge to report the achievement of quality objectives related to the thermal performance of the buildings fabric was the lack of a structured approach with focus on specific defects. Figure 4-36 and Figure 4-37 provides evidence that the main focus of the reports developed by quality officers on the behalf of housing associations was the projects' programme progress. Nevertheless, defects related to thermal performance were eventually spotted. The defect identification process relied mostly on the quality officers' experience and awareness which varied from case to case, impacting in the credibility of the quality reports due to the lack of consistency and objective approach. This was observed not only in the quality control procedures undertaken by the housing associations, but also with contractors and the building control bodies. For instance, the site reports provided by building control body of Case study 5, “reportable items” were raised, where the defect was described and references were made to the corresponding standard detail to be met through corrective measures. However, as shown in Figure 4-38 no guidance was provided towards the identification of specific defects or building elements.

job title: [redacted]
job no: [redacted]

date prepared: 14.07.16
by: [redacted]

The following observations were recorded from a visit made to this site.
Temperature; 16^{c} Conditions; Dry/Sunny

General Overview:
Plots 1 to 6 – roofing works complete, external blockwork, window/door installation, 1st fix plumbing and carpentry works all on-going.
Plots 7 to 10 – roofing complete with window/door installation, external blockwork, plasterboarding, 1st fix M&E and carpentry works all on-going.
Plots 11&12 – external blockwork, windows installed & plasterboarding works complete with external rendering, internal plastering and door installation on-going.
Plots 13 to 14 – external blockwork, party wall boarding & 1^{st} fix plumbing complete with external rendering/decoration, 1^{st} fix electrical & carpentry works all on-going.
Plot 15 – external blockwork, window/door installation, plasterboarding & 1^{st} fix complete with external render/decoration on-going.
Plots 16 to 18 – plasterboarding & porch installation works all complete with external rendering & internal decoration/plastering on-going.
Plots 19 to 21 – scaffold struck external rendering/decoration and 2^{nd} fix carpentry works all on-going.

Road formation complete to base tarmac.

Utilities – BT stores on site with small amount of ducting installed on road crossings.

Note: as mentioned in the site meeting, Contractor to protect any soils as per DEFRA`s requirements on soil excavated and stockpiled during construction.

Defects: Plot 7, repair required to timber frame membrane in kitchen area adjacent sink position.
Plots 13/14 gable end rendering requires small amount of repair works, also a couple of damaged roof tiles need replacing.

General note: weep vents required on all cavity trays above meter boxes and window/door openings.

Health & Safety: Nothing to report.

Contractors site supervision: [redacted] 4 x Blocklayers, 0 x Ground Workers, 2 x Roofers, 2 x Electricians, 2 x Plumbers, 5 x Plasterers, 7 x Carpenters, 2 x Window Fitters, 1 x Decorators, 2 x Cladding Installers, 4 x Plasterboarders, 1 x Fork Lift Driver, 2 x Scaffolders and 1 x Labourer.

Figure 4-36 Sections of site visit report template used by housing association’s quality officer in Case study 1 lacking of structured defect identification method (Source: housing association Case study 1)

[redacted]

Inspection Date: 23/01/17 Time of visit: 11:30HRS COW: [redacted]

Weather: Sunny Temp: 9ºc Wind: Slight

Site visit Number: 20 Contractor: [redacted]

Plots Completed (67 Plots in total)		
Rented	Shared Ownership	Total
0/42	0/25	0/67

Progress of Works

Plot Number	Observations	Overall Progress
37 & 38 RT	Boarding out in hand, roof tiles in hand & works to dormer in hand. 1st fix M&E in hand & floor screed complete.	45%
39 & 40 RT	Boarding out in hand (50%). Dormer cladding in hand. There is no VCL provided as per the design in the loft room (JT informed & email sent to GTP 24.0.17)	50%
41 & 42 RT	Boarding out in hand (80%).Stonework slips complete. Roof covering to dormer & roof tiles in hand. There is no VCL provided as per the design in the loft room (JT informed & email sent to GTP 24.0.17) Ceiling to 41 fully boarded & will need to have VCL retro fitted.	50%
43 RT & 44 OM	Block & beam complete & dolly blocks for internal partition sole plates in hand. No change 5th week.	10%
45 & 46 SO	Dolly blocks for internal partition sole plates set. No change 1st week.	12%

Figure 4-37 Sections of site visit report template used by housing association's quality officer in Case study 3 lacking of structured defect identification method (Source: housing association Case study 3)

Reportable items/observations	Plot/ block	DPR	NHBC initials	Date actioned	Builder's initials
12/09/2017, Stage: Floor structure, **Potential for structural failure,** Timber and concrete upper floors, Incorrect installation of joist hangers, Standard 2017 6.4 13, Details: Please ensure that the correct joist hangers are being used to support the floor trimmer to the steel joist.	3/018	8			
12/09/2017, Stage: Floor structure, **Potential for structural failure,** Timber and concrete upper floors, Incorrect installation of joist hangers, Standard 2017 6.4 13, Details: Please ensure that the correct joist hangers are being used to support the floor trimmer to the steel joist.	3/019	8			
12/09/2017, Stage: Floor structure, **Potential for structural failure,** Timber and concrete upper floors, Incorrect installation of joist hangers,	3/020	8			

Figure 4-38 Sections of building control body's site visit report template used in Case study 5 lacking of structured defect identification method (Source: contractor Case study 5)

During the construction defect surveys undertaken, some defects were identified which had not been corrected. This was explained due to the fact that quality control tools (i.e. checklists and report templates) did not encompass the most recurrent defects with potential to undermine the buildings' thermal performance. Figure 4-39 to Figure 4-44 present the occurrence of defects in housing units which were assessed and their quality standards deemed satisfactory. Thus, the identification of this type of defects corroborate the fact that, apart from Cases study 4, project quality plans did not provided a structured approach towards the prevention and correction of defects associated with the thermal performance of dwellings' fabric.

Figure 4-39 Ill-fitted insulation layer presenting air pockets and gaps in Case study 2 (Source: Taken by this thesis' author)

Figure 4-40 Discontinuity of insulation layer and ruptures of vapour control membrane in Case study 1 (Source: Taken by this thesis' author)

Figure 4-41 Discontinuity of insulation layer in Case study 1(Source: Taken by this thesis' author)

Figure 4-42 Ruptures in vapour control layer in Case study 2 (Source: Taken by this thesis' author)

Figure 4-43 Discontinuity of insulation layer in Case study 3 (Source: Taken by this thesis' author)

Figure 4-44 Missing insulation around pipes in Case study 5 (Source: Taken by this thesis' author)

In case studies 1, 2, 3 and 5, apart from defects spotted by building control bodies where corrective actions were required, localised defects deemed less important and with no direct effect to the programme were not discussed in the managerial levels, thus not triggering systemic corrective actions. For instance, Pictures displayed in Figure 4-45 and Figure 4-46 were taken in different phases of Case study 1. Even though the defects were collected 6 months apart from each other, the Figures show that ruptures in the fabrics' vapour control layer were a recurrent type of defect which was not properly addressed throughout the construction process.


Figure 4-45 and Figure 4-46 Ruptures in vapour control layer in Case study 1 (Source: Taken by this thesis' author)

The major challenge posed to the process of continuous improvement was the fact that in most of the projects, except for case study 2, the snagging process was the only process where defects identified at the construction phase were logged and used as an input for the risk assessment stages of future projects (Figure 4-47). Moreover, all the housing associations involved in the case studies presented defect record system based on tenants' reports. However, the defects reported were mostly related to visual defects or malfunction of the dwellings services, as observed in the early stages managerial meetings of the case studies (Observations 1.a, 2.a, 3.a and 4.a to 4.f in Appendix B.4). Only severe manifestations motivated by latent defects were reported, whereas hidden defects affecting the dwellings fabric and thermal performance, which offered less visible symptoms, remained undetected and uncorrected.

Bathroom	Agent	Client
Plaster / Dry lining satisfactory	☐	☐
Decorations to C& W satisfactory	☐	☐
Decorations to woodwork Satisfactory	☐	☐
Window working and key in lock	☐	☐
Door / Ironmongery working and fully screwed	☐	☐
Flush domed light fitting and bulbs fitted	☐	☐
Radiator fitted securely	☐	☐
Bath & Panel, taps secure and fitted correctly	☐	☐
Check waste traps for leaks (COMMON DEFECT!)	☐	☐
Shower fitted (TEST)	☐	☐
Shower curtain / screen fitted	☐	☐

Figure 4-47 Ruptures in vapour control layer in Case study 1 (Source: Taken by this thesis' author)

4.6.3 Challenges related to the quality compliance procedures

This section presents the challenges to deliver the desired thermal performance of domestic buildings identified from the data analysis which relate to Quality compliance procedures.

20. Quality reports lacking of focus on reporting quality issues related to the thermal performance of buildings as they are mostly developed upon checklists and site visit report templates.

In case studies 1, 2, 3 and 5, the quality reports failed to report on quality issues that had not been corrected during the construction process. This was due to the fact that the quality control procedures implemented did not drive the process of identification of defects affecting the thermal performance of dwellings fabric.

21. Defects affecting the thermal performance, which posed no apparent threat to programme and were not spotted by building control bodies, were not discussed in the managerial meetings.

The established managerial environment for the analysis of quality results did not encompass the discussion of defects which posed no apparent threat to accomplishment of the projects' programme. Thus, several defects affecting the thermal performance which were identified at the construction stage did not have the opportunity to be properly assessed and addressed at a managerial level.

22. Ultimate compliance procedure assigned to building control bodies.

The fact that the final compliance procedure was assigned to building control bodies alleviated the responsibility of housing associations and contractors' representatives to put in place compliance procedures to assess the achievement of quality objectives related to the thermal performance of dwellings.

The final quality compliance approval in respect to the thermal performance of the dwellings assigned to building control parties drove the process of the development and implementation of project quality plans undertaken by the housing associations and contracting companies.

23. Lack of structure to feedback defects occurrences identified during the construction stage, which could be used as a source in the risk assessment stages of future projects.

Apart from Case study 2, the other case studies did not provide a structure for compliance communication where defects identified during the construction stage could be logged, analysed and stored to be used as a source of information and reference during the risk assessment stages of future projects, and consequently, enabling the process of continuous improvement.

4.7 Summary of the challenges to Quality Project Plans

Table 4-36 provides a list of the 23 challenges identified in the process of developing and implementing project quality plans with a focus on achieving the desired thermal performance of the dwellings. Table 4-36 also indicates which challenges were identified in each of the case studies, establishing the similarities and differences in the project quality plans across the projects studied in this thesis.

Table 4-36 List of challenges and case studies

Categories	Subcategories	Challenges identified	Case study 1	Case study 2	Case study 3	Case study 4	Case study 5
Definition of quality requirements	Quality objectives and compliance	1. Lack of definition of quality compliance procedures among with the quality objectives, other than those defined and implemented by building control bodies.	✓	✓	✓		✓
	Formal procedures	2. Lack of control of the ultimate compliance process and associated quality control, due to this process being assigned to third parties (i.e. building control bodies).	✓	✓	✓		✓
Quality risk assessment	Stakeholders' participation	3. Lack of participation of important project stakeholders (e.g. housing association and contractor), limiting the input of relevant information and collaboration in the process of risk assessment.	✓				✓
	Sources of information	4. Housing associations' defect records used for the project risk assessment mostly contained defects reported at the post-occupation stages by the dwellings' tenants.	✓	✓			✓
		5. Lack of use of previous defect records to inform and influence the risk assessment process.			✓	✓	
	Technical and managerial issues	6. Difficulties in sustaining a consistent communication process, impacting on the levels of quality objectives and specific defects awareness.	✓	✓	✓	✓	✓
		7. Operatives general level of education and technical capabilities.	✓			✓	✓
		8. Difficulty of retaining technical information and awareness with subcontractors due to high level of staff turnover and discontinuity of projects' sequence.	✓				✓
		9. Tight programme and budget can potentially compromise the administration of quality control procedures.	✓		✓	✓	✓

Quality resources assessment	Process approach	10. Due to the approach adopted for quality compliance, the project quality plan implemented lacked of specific focus concerning quality issues related to thermal performance.	✓	✓	✓		✓
	Provision of resources	11. Lack of appropriate resources (time and staff) allocated by the contractor and building control bodies for quality control procedures.	✓	✓	✓		✓
	Development of competences	12. Lack of specific training and upskilling activities with the purpose of increasing awareness of the quality objectives and potential risks, as well as technical capabilities.	✓	✓	✓		✓
Definition of quality metrics and control	Quality attributes and criteria	13. Lack of objectivity in translating quality acceptance criteria of performance attributes (e.g. thermal transmissivity of buildings fabric) into quality control tools.	✓	✓	✓		✓
	Quality control procedures	14. Quality checking hold points overly distant to each other, affecting the identification of defects in certain building elements due to accumulated construction stages.	✓	✓			✓
		15. Definition of lengthy working packages which concentrate an overwhelming amount of construction aspects to be checked at a time, compromising the efficacy of the quality control activities.	✓	✓			✓
		16. Lack of use of quality checklist to support and structure quality control activities undertaken by quality officers on behalf of housing associations and building control bodies.	✓	✓	✓	✓	✓
		17. Lack of consistency of quality checklists due to being not site specific and generic in terms of construction method and sequencing.		✓			✓
		18. Quality checklists deployed did not encompassed at least the most recurrent quality issues affecting the thermal performance of the dwellings' fabric.	✓	✓	✓		✓
		19. Lack of consistency on the application of quality control procedures.	✓	✓	✓	✓	✓
Quality compliance procedures	Quality results	20. Quality reports lacking of focus on reporting quality issues related to the thermal performance of buildings as they are mostly developed upon checklists and site visit report templates.	✓	✓	✓		✓

	Result analysis and actions	21.	Defects affecting the thermal performance, which posed no apparent threat to programme and were not spotted by building control bodies, were not discussed in the managerial meetings.	✓	✓	✓		✓
		22.	Ultimate compliance procedure assigned to building control bodies.	✓	✓	✓		✓
	Continuous improvements	23.	Lack of structure to feedback defects occurrences identified during the construction stage which could be used as a source in the risk assessment stages of future projects.	✓		✓	✓	✓

4.8 Chapter 4: Summary

This chapter presented the key findings related to the challenges encountered in new-built social housing projects to develop and implement project quality plans with focus on the thermal performance of dwellings.

Twenty-three different challenges were identified and classified into five main categories of project quality plans (i.e. Definition of quality requirements; Quality risk assessment; Quality resources assessment; Definition of quality metrics and control; and Quality compliance procedures). This was achieved by means of a detailed and iterative case study analysis of five case studies and multiple sources of data (i.e. stakeholders' semi-structured interviews, project documentation, construction site defect surveys and observations of managerial meetings and construction site visits).

Chapter 5

Validation

5.1 Introduction

This chapter summarises the validation of the research results. The challenges posed to the development and implementation of Project Quality Plans in social housing projects identified in Chapter 4 are discussed with construction industry professionals and academics. The main purpose of the validation was to confirm that the identified challenges are also acknowledged by other professionals outside the case studies as well as the academics in the field, and assess the likelihood of occurrence and impact of the challenges in the achievement of thermal-related quality objectives.

This chapter is divided in three parts. The first part presents the participants of the focus groups, in terms of their roles in construction projects, the type of companies they work for, their work location and their experience in number of years working in the construction sector. The second part presents the validation of the likelihood and impact of the challenges in the implementation of Project Quality Plans. The third part presents the relevant insights from the open discussions in the focus groups where new challenges were identified and proposed by the participants.

5.2 Participants

The participants of the focus groups were selected according to two main criteria. They must have had previous experience in residential projects in the UK and have not had any involvement in the case studies investigated in this research. In total 9 participants collaborated in the three focus groups undertaken between May and June 2018 (Table 5-1). In terms of the roles of the participants in the construction sector, the focus groups had the collaboration of 2 project managers, 1 project coordinator, 1 site manager, 2 building surveyors, 1 consultant and 2 academics. The companies these professionals were working for during the focus groups encompassed social housing associations, construction management company, contracting company, energy efficiency consulting company, building control body and university. The geographical areas where the participants undertake their professional activities were London area, Devon, Southwest of the UK and the whole of the UK. In terms of the professional involvement in the construction sector, participants presented experience varying from 4 to 40 years.

Table 5-1 Participants of focus groups

Participant	Role	Company type	Location	Experience
1	Project coordinator	Social housing	Devon	6 years
2	Project manager	Social housing	London area	15 years
3	Academic	University	Devon	25 years
4	Consultant in energy efficiency	Consultancy	UK	10 years
5	Academic	University	Devon	20 years
6	Building surveyor manager	Building control body	Devon	30 years
7	Building surveyor	Building control body	Devon	4 years
8	Project manager	Construction management	Southwest	11 years
9	Site manager	Contractor	Southwest	15 years

5.3 Validation of the identified challenges in Project Quality Plans

As shown in Table 5-2, the mean values and standard deviations of the answers provided by the participants of the focus groups are presented according to the 5 categories of Project Quality Plans identified in this study: definition of quality requirements, quality risk assessment, quality resources assessment, definition of quality metrics and control and quality compliance procedures. Henceforward, the five highest and lowest averages of likelihood of occurrence and impact of the challenges in the achievement of quality objectives are discussed.

Table 5-2 Summary of the answers (Mean values and Standard Deviations (SD)) to the likelihood and impact of the challenges

Challenges identified	Question 1. **Likelihood** Mean value (SD)	Question 2. **Impact** Mean value (SD)
1. Lack of definition of quality compliance procedures among with the quality objectives, other than those defined and implemented by building control bodies.	7.6 (1.3)	7.7 (1.5)
2. Lack of control of the ultimate compliance process and associated quality control, due to this process being assigned to third parties (i.e. building control bodies).	7.8 (1.6)	8.6 (1.2)
3. Lack of participation of important project stakeholders (e.g. housing association and contractor), limiting the input of relevant information and collaboration in the process of risk assessment.	5.4 (2.1)	6.6 (3.0)
4. Housing associations' defect records used for the project risk assessment mostly contained defects reported at the post-occupation stages by the dwellings' tenants.	6.8 (2.1)	7.1 (2.6)
5. Lack of use of previous defect records to inform and influence the risk assessment process.	6.9 (2.0)	7.1 (2.0)
6. Difficulties in sustaining a consistent communication process, impacting on the levels of quality objectives and specific defects awareness.	7.4 (1.5)	7.7 (1.7)
7. Operatives general level of technical knowledge and capabilities.	8.6 (1.5)	9.3 (0.9)
8. Difficulty of retaining technical information and awareness with subcontractors due to high level of staff turnover and discontinuity of projects' sequence.	7.7 (1.7)	9.1 (0.6)
9. Tight programme and budget can potentially compromise the administration of quality control procedures.	8.8 (1.1)	9.0 (1.0)
10. Due to the approach adopted for quality compliance, the project quality plan implemented lacked of specific focus concerning quality issues related to thermal performance.	7.7 (1.4)	8.1 (2.0)
11. Lack of appropriate resources (time and staff) allocated by the contractor and building control bodies for quality control procedures.	8.0 (1.7)	8.9 (0.8)

12.	Lack of specific training and upskilling activities with the purpose of increasing awareness of the quality objectives and potential risks, as well as technical capabilities.	8.4 (1.2)	8.8 (1.0)
13.	Lack of objectivity in translating quality acceptance criteria of performance attributes (e.g. thermal transmissivity of buildings fabric) into quality control tools.	7.3 (1.7)	7.6 (1.7)
14.	Quality checking hold points overly distant to each other, affecting the identification of defects in certain building elements due to accumulated construction stages.	6.9 (2.0)	7.8 (1.7)
15.	Definition of lengthy working packages which concentrate an overwhelming amount of construction aspects to be checked at a time, compromising the efficacy of the quality control activities.	7.5 (1.4)	8.4 (1.7)
16.	Lack of use of quality checklist to support and structure quality control activities undertaken by quality officers on behalf of housing associations and building control bodies.	7.7 (1.7)	8.1 (1.5)
17.	Lack of consistency of quality checklists due to being not site specific and generic in terms of construction method and sequencing.	7.1 (1.1)	7.5 (1.6)
18.	Quality checklists deployed did not encompassed at least the most recurrent quality issues affecting the thermal performance of the dwellings' fabric.	7.1 (1.7)	7.7 (1.6)
19.	Lack of consistency on the application of quality control procedures.	7.1 (1.4)	8.0 (1.9)
20.	Quality reports lacking of focus on reporting quality issues related to the thermal performance of buildings as they are mostly developed upon checklists and site visit report templates.	8.1 (1.3)	8.4 (1.0)
21.	Defects affecting the thermal performance, which posed no apparent threat to programme and were not spotted by building control bodies, were not discussed in the managerial meetings.	8.1 (1.4)	8.8 (1.0)
22.	Ultimate compliance procedure assigned to building control bodies.	7.8 (1.6)	8.4 (1.3)
23.	Lack of structure to feedback defects occurrences identified during the construction stage which could be used as a source in the risk assessment stages of future projects.	8.0 (1.6)	8.0 (1.9)
	Overall mean value	**7.6**	**8.1**

The validation of the research findings shows that all the identified challenges in respect to the implementation of Project Quality Plans were acknowledged by the participants of the focus groups, suggesting that the research results are relevant to the ~~construction industry~~ UK social housing sector and not only specific to the case studies. The overall average for likelihood of occurrence of the challenges and their impact in the achievement of quality objectives were 7.6 and 8.1, respectively. These averages confirm that the challenges identified in the case studies that undermined the implementation of Project Quality Plans and thus the achievement of quality objectives associated with the thermal performance of the dwellings were also experienced by professionals involved in similar projects in the UK. In addition, the location and the amount of experience of the participants did not seem to influence the average and standard deviations of the answers, as no trends could be identified that suggest otherwise. However, the analysis parametrised by mean and standard deviation may not present normal distribution of data. This is due to the small sample undertaken. Therefore, it is not adequate to draw sweeping conclusions as scores can be potentially different if another sample is to be administered.

The challenges with higher scores of likelihood of occurrence were Challenges 7, 9, 12, 20 and 21. Challenge 9, related to projects' tight programme and budget impacting on the implementation of quality control procedures and quality of workmanship, scored average of likelihood of 8.8, being the highest rated challenge of all. The low standard deviation presented in this challenge (1.1), denotes the agreement of the focus groups' participants about this challenge being a frequent issue undermining the achievement of quality objectives. The second highest likelihood average was assigned to Challenge 7. It reflects upon the general level of operatives' technical knowledge and capabilities posing a threat to the achievement of expected quality standards. Challenge 7 was attributed an average of 8.6, also with a low standard deviation of 1.5. The third highest likelihood average was Challenge 12, is related to the lack of specific training and upskilling with the purpose of increasing awareness and technical capabilities. The average of likelihood of 8.4 and standard deviation of 1.2 corroborate the fact the lack of training and support for operatives contribute to the underachievement of quality objectives in the construction sector, including the ones related to thermal performance. Challenge 20 presented the fourth highest average in likelihood (8.1) with low standard deviation (1.3), indicating that quality reports lacking of focus on reporting quality issues related to the thermal performance are also experienced in projects other than the ones part of this thesis. The fifth highest average of likelihood of occurrence was Challenge 21. The given average of likelihood of 8.1 with also low standard deviation (1.4) indicate that defects affecting the thermal performance which posed no apparent threat to the projects' programme were not discussed in managerial meetings is a current issue according to the focus groups participants.

The challenges with the lowest scores of likelihood of occurrence were Challenges 3, 4, 5 and 14. Challenge 3, which received the lowest likelihood rate (average of 5.4), is related to the lack of participation of important project stakeholders in the identification of risks to the achievement of quality objectives. The relatively low likelihood of occurrence scored by the focus groups participants is consistent with the research findings which found that only two out of the five case studies investigated presented this issue. However, the standard deviation of 2.1 indicates that the focus group participants have different opinions in this matter. Seven participants provided a score of 6 or more, whilst other two provided scores of 2. The rationale behind the scores of the latter two participants is that they work for management companies which strive to ensure the participation of all stakeholders in the process of risk assessment. Therefore, they tend not to experience situations where projects participants are kept apart from the risk assessment process. Although Challenges 4, 5 and 14 are amongst the lowest averages of likelihood, they presented averages of 6.8 (Challenge 4) and 6.9 (Challenges 5 and 14) slightly lower than overall average of 7.6, indicating that referred challenges were acknowledged by all the focus group participants with varying likelihood.

The challenges that presented the highest scores for potential impact in the implementation of Project Quality Plans were Challenges 7, 8, 9, 11 and 12. Challenge 7 is related to the impact of operatives' general level of technical knowledge and capabilities undermining the achievement of quality objectives related to the thermal performance of the dwellings. The average rate of impact assigned to this challenge was 9.3 with low standard deviation of 0.9, denoting that this issue was commonly experienced by all the focus group participants. Challenge 8, is related to the difficulty of retaining technical information and awareness among subcontractors' staff due to constant workforce turnover and the discontinuity of projects' sequence. The average impact of 9.1 and standard deviation of 0.6 corroborate that the focus groups participants acknowledged this challenge as having a profound impact in the fulfilment of projects' quality requirements. Challenge 9 presented average impact of 9, with also a low standard deviation of 1, indicating that of tight programmes and budgets compromising the administration of quality control procedures and the quality of workmanship are also experienced in other projects outside this study. In regard to Challenge 11, the given average impact of 8.9, with the low standard deviation (0.8) indicate that the lack of appropriate resources undermining the quality control procedures undertaken by contractors and building control bodies is an issue frequently experienced by the focus groups participants. Challenge 12 is regarded to the lack of specific training and upskilling activities aimed at increasing the awareness of the quality objectives and technical capability. Focus groups participants attributed an average impact of 8.8 for this challenge, also with a low standard deviation of 1, confirming that the impact of this challenge in the achievement of expected quality standards is acknowledged in other projects not part of this thesis.

The challenges with the lowest scores of impact in the achievement of the quality objectives regarding the thermal performance of the dwellings were Challenges 3, 4, 5, 13 and 17.

Challenge 3, which received the lowest impact rate (average of 6.6), is related to the lack of participation of important project stakeholders in the identification of risks to the achievement of quality objectives. The standard deviation of 3 indicates that the focus group participants diverge in the impact of this challenge. The majority of the participants provided an impact rate of 8 or more. However, two of the participants scored impact of 2. During the open discussions, the reasons supporting these scores became evident. Two project managers stated that the due to the scarce technical knowledge on thermal performance of some project stakeholders, their lack of participation in the risk assessment process would not impact severely in the identification of challenges to the implementation of Project Quality Plans, nor in the achievement of quality objectives. Challenge 4 is the second lowest impact score and is related to fact the Housing Associations' defect record systems used in the risk assessment relied mostly on defects reported at the post-occupation stages and provided little information on quality issues affecting the thermal performance. The assigned impact average of this challenge was 7.1, with a moderate standard deviation of 2.6. Apart from two participants which assigned an impact rate of 3 claiming that the input of information should be provided by specialists, the rest of the participants scored 8 or more. Challenge 5 is regarded to the lack of defect record used as a source of information impacting in the risk assessment. The given impact average was the same of the previous challenge (7.1), with a standard deviation of 2, following the same reasons that the aforementioned challenge. Challenges 13 and 17 presented average impacts of 7.6 and 7.5, respectively, with moderate standard deviations of 1.7 and 1.6. Although these challenges appear amongst the five lowest rated averages of impact, they were assigned scores slightly lower than the overall average of 8.1

5.4 Open discussions

The focus group activities enabled an environment for open discussions after the completion of the questionnaire regarded to the challenges. The open discussions were conducted in order to explore the core findings of the thesis in line with the participants own experiences and identify any possible new challenges which had not been identified in the case studies.

The acknowledgement of the lack of definition of compliance procedures affecting the achievement of thermal-related quality objectives was unanimous among the focus groups participants. Moreover, the over-reliance on building control bodies for quality control activities, being almost the sole quality awarding party was also recognised as an additional factor compromising the achievement of quality objectives related to the thermal performance of the dwellings.

All participants expressed their concerns about the ability of building control bodies to properly undertake their activities of quality appraisal, due to the limited resources available. In particular, the two participants who work for building control bodies were emphatic about their need to prioritise the appraisal of building elements that can potentially offer risks to occupants' safety and life, such as the dwellings' structure and fire protection aspects. It was stated that the available time for site inspections does not allow the full implementation of the quality control procedures devised by the UK Building Regulations. For instance, a sampling approach has been undertaken instead of the inspection of all the dwellings of the project. Moreover, in respect to the thermal performance, the efforts are concentrated in assessing the design and the SAP calculations, being "very difficult to check the delivery of technical details onsite", due to significant lack of time and human resources. The lack of an independent and rigorous quality appraisal was highlighted as another contributing factor to the inefficacy of quality assurance procedures undertaken by building control bodies.

It was agreed that housing associations play an important role in defining quality objectives and should be more actively involved in the process of defining quality compliance procedures. However, an additional challenge was identified by some of the participants. Two project managers, one working for a housing association and the other for a project management company, manifested a concern regarding the current technical knowledge of housing association technical staff. According to the participants' experience, housing associations' technical staff might be lacking the expertise regarding the thermal performance of dwellings. In addition, the skills gap of the workforce was also recognised as presenting a major risk to deliver the expected quality standards. According to the participants, the ever tighter project budgets and programmes have a negative impact on the motivation of the subcontractors to commit to delivering higher levels of quality.

Overall, as a result of the discussions there was a consensus that the construction sector is slowly recognising the benefits of early stages participation of the different project participants. However, achieving full collaboration among the parties is still a challenge, especially at the risk assessment stage. According to one of the project managers, "it is common to see contractors holding back information of what could go wrong for fear to be accounted for later in the construction phase". As shared by the participants, the blame culture and fragmented nature of the construction industry still pose challenges to the implementation of joint efforts in order to achieve desired quality outcomes.

5.5 Chapter 5: Summary

This chapter presented the validation of the research results. Through the administration of focus groups it was possible to acknowledge that the key findings identified in this thesis were also experienced by the professionals and academics of the UK construction sector. Therefore, the results of this thesis could be generalised to similar projects of the social housing sector in the UK.

This chapter was divided in three parts. The first part presented selection criteria and the demographic distribution of the participants of the focus groups, as per their roles in the construction industry, their company type, their location in the UK and their professional experience in terms of number of years. The second part presented the average rates provided by the focus groups participants in relation to the likelihood of occurrence and impact of the identified challenges to the process of implementation of Project Quality Plans. The third part summarised the relevant insights obtained from the open discussions with the participants of the focus groups.

Chapter 6

Discussion

6.1 Introduction

This chapter summarises the findings of the thesis, in accordance to the research objectives and questions presented in Chapters 1 and 2. This chapter starts with the discussion of the findings of this research in relation to the challenges encountered in the process of development and implementation of Project Quality Plans to achieve the desired thermal performance in social housing projects in the UK. The current findings are compared with existing studies on quality in construction projects, as well as the results of the validation process. Finally, recommendations to overcome the discussed challenges are proposed, providing specific references to each of the main project participants: the housing associations, contractors, building control bodies and the construction industry as whole.

6.2 Challenges of Project Quality Plans

To answer the following research question, the findings presented in Chapter 4 are discussed according to the five stages of Project Quality Plans.

Q1. Why, despite the number of quality management procedures applied in social housing projects, defects affecting the thermal performance of buildings are still occurring?

6.2.1 Definition of quality requirements

As observed and analysed in the previous chapters, the stage of defining the quality objectives and compliance procedures was the main driver of the process of assuring and delivering quality in the investigated case studies. Similarly, in a study involving 328 stakeholders of the housing sector, Jraisat et al. (2016) state that “project requirements are the key factors that define quality in the process of construction”. The definition of the project’s requirements in terms of quality objectives and compliance procedures investigated in this thesis, paved the way to the establishment of Project Quality Plans in terms of the identification of potential risks, allocation of resources, development and application of quality control procedures and the process of assessing quality outputs, thus granting compliance. The key challenges posed to the process of defining the project's quality plan were:

1. Lack of definition of quality compliance procedures among the quality objectives, other than those defined and implemented by building control bodies.
2. Lack of control of the ultimate compliance process and associated quality control, due to this process being assigned to third parties (i.e. building control bodies).

Concerning Challenges 1 and 2, it was found that all the case studies had a clear definition of quality objectives concerning the thermal performance of the dwellings through the requirements of the building regulations as a minimum requirement. However, except for Case study 4, the case studies were lacking of bespoken compliance procedures which should take into consideration the specific technical and managerial issues of each project. The only guideline in place in terms of compliance procedures was to obtain statutory approval granted by building control bodies, where both the housing association and the contractor had little, if any, control of the quality assurance procedures and resources put in place.

As identified in the stakeholders' interviews and also supported by Jones et al. (2017) and Pretlove and Kade (2016) whose studies explored the impact of building regulations and codes for sustainability in social housing projects in the UK, the adoption of statutory requirements as the only thermal performance requirement was due to the fact that the funding agencies refrained, from 2015 onwards, from requiring more ambitious energy performance standards than the UK Building Regulations, such as the Code for Sustainable Homes levels 4, 5 and 6. The challenges (1 and 2) identified in this approach, which undermined the achievement of quality objectives related to thermal performance of the dwellings, were also experienced by the focus groups' participants. There was a consensus in recognise the negative impact of assigning the quality control and compliance procedure solely to a third party. In fact, the inefficacy of building control bodies on assessing the achievement of quality requirements although granting statutory approval, is something of great concern also manifested in other studies. For instance, the National Energy Foundation's report on energy efficiency of social housing projects in the UK (NEF, 2016) shows that 33% of the 48 projects investigated presented external walls' u-values above the building regulations threshold, even though all the projects were awarded with statutory approval. Moreover, in the light of the tragedy occurred in the fire of Grenfell Tower in June 2017 (BBC, 2018), an independent report was commissioned to Dame Judith Hackitt by the Secretary of State for Housing, Communities and Local Government (Hackitt, 2018). The report indicates that the UK's regulatory system suffers from an inadequate oversight and enforcement tools. Hackitt (2018) highlighted the weaknesses of the current structure of building control bodies in terms of the scarce resources and the inspectors' ability to undertake quality control activities. Moreover, the researcher mention the conflict of interest of building control bodies to use the enforcement methods for fear of losing long-term businesses. This statement was also manifested by the head of development of the housing association in one the case studies. It is important to acknowledge that although building control bodies are considered independent parties, their income comes from the contracting companies who hire them to assess quality and provide statutory approval. Anecdotally, a building control body's surveyor, participant of one the focus groups, confirmed the scarcity of resources, stating that quality control regime of assessing all housing units of the surveyed project is not being followed as it should. The focus group participant revealed that building control activities are being undertaken through sampling due to lack of human resources. The establishment of the number of site visits and houses inspected are defined in accordance to the level of confidence they have on the contractor to deliver the expected quality standard. Moreover, due to resources constraints the priority of inspections is concentrated on the fire safety regulation – Part B of the Building Regulations, as a consequence of Grenfell Tower fire, where the "thermal performance isn't looked at in the same way as other requirements".

It is necessary to acknowledge that the defined quality objectives regarded to the thermal behaviour of buildings were based on measurable performance attributes, such as air permeability rates and building fabric thermal transmissivity (u-value). Nevertheless, even though being objective and measurable attributes, achieving the quality compliance was not a straightforward process. In the case of the assessment of the air permeability rates, the air pressure tests administered can objectively demonstrate whether the dwelling is achieving or not the set performance attribute. However, when tested only in the final stages of construction as observed in case studies 1, 2, 3 and 5 and in line with the building regulation's defined procedures, whenever mismatching performances are identified it becomes very difficult to indicate which building element is faulty and provide proper corrective action with a long term effect (Johnston et al., 2015, Kalamees, 2007). Wingfield et al. (2011) identified in their study of 420 dwellings in the UK that the late identification of mismatching rates of air permeability led to the use of sealant to plug gaps in the internal layers of the building fabric in order to achieve the desired air tightness and hence to comply with statutory targets. Through Post Occupation Evaluation, Wingfield et al. (2011) observed that the technical solution adopted did not provide a long-lasting effect and therefore the air tightness performance deteriorated over time.

As per the assessment of the building fabrics' thermal transmissivity, the research results indicate that no objective compliance procedure could be observed in the construction stage in most of the case studies. In fact, the thermal transmissivity of the building's fabric is measurable and can be assessed by different tests such as co-heating test (Johnston et al., 2015) and the use of thermal imaging to identify the occurrence of defects (Taylor et al., 2014, Fox et al., 2014). However, due to issues regarded to duration and cost of the tests, as well as the availability of the dwellings to be tested make the application of the tests unfeasible in most of multiple dwelling projects (Johnston et al., 2014).

As revealed by the research results, although the majority of the companies investigated in this study had obtained an internationally accredited Quality Management System (QMS), such as ISO 9001, the definition of quality compliance procedures, in particular, were defined at project level and influenced by the project team, rather than being defined through the principles of standardised QMS. Anecdotally, the majority of the case studies' participants could not name their companies' accredited QMS. Similarly, Hoonakker et al. (2010) acknowledged in a study encompassing 208 contractors of the domestic and non-domestic sector that 62% of the study's respondents were not aware of their companies' accredited QMS or formal quality programmes. Researchers such as Quazi et al. (2002) and Landin (2000) and Moatazed-Keani et al. (1999) also recognised that stakeholders of construction companies in Singapore, Sweden and UK found standardised QMS as being often abstract and difficult to apply at the project level, preferring to develop their own quality assurance procedures. The research results also demonstrated the lack of connection between the companies' accredited Quality Management Systems, such as ISO 9001 and the development and implementation of the Project Quality Plans. As identified in the stakeholders' interviews and secondary sources of data, QMS were limited to the central management activities where their underpinning principles could not be fully observed in the quality assurance procedures administered in the projects' level. Principles such as the definition of clear methods for assessing quality and the necessary rigour on applying the defined procedures were often neglected. According to a study developed by Quazi et al. (2002) which assessed the contribution of QMS in the achievement of quality objectives in construction projects, ISO 9000 accreditation did not have substantial impact on quality management procedures and quality results. This was due to the fact that the major motivation for obtaining the standard QMS accreditation was to fulfil clients' and funding agencies' requests, rather than genuinely uptaking standardised QMS as a platform to increase quality (Quazi et al., 2002, Moatazed-Keani et al., 1999).

6.2.2 Quality risk assessment

Quality risk assessment related to the process of identifying and assessing the major risks to the achievement of the quality objectives. It provided a vital contribution to the definition and implementation of the Project Quality Plan, especially in respect to allocation of resources and quality control procedures. The most important challenges posed at this stage were:

3. Lack of participation of important project stakeholders (e.g. housing association and contractor), limiting the input of relevant information and collaboration in the process of risk assessment.

4. Housing associations' defect records used for the project risk assessment mostly contained defects reported at the post-occupation stages by the dwellings' tenants.
5. Lack of use of previous defect records to inform and influence the risk assessment process.
6. Difficulties in sustaining a consistent communication process, impacting on the levels of quality objectives and specific defects awareness.
7. Operatives general level of education and technical capabilities.
8. Difficulty of retaining technical information and awareness with subcontractors due to high level of staff turnover and discontinuity of projects' sequence.
9. Tight programme and budget can potentially compromise the administration of quality control procedures.

It was observed that, in two case studies, the involvement of important project participants in the early stages of design and pre-construction activities, including the development of Project Quality Plans, could not be established. The lack of participation of the contractor, in Case study 1, and the housing association, in Case study 5, negatively impacted in the process of the identification of risks to the achievement of the desired thermal performance. This occurred due to the fact that quality issues experienced by the two participants in previous projects were not shared and used as source of information. Similarly, Gorse et al. (2012) examined the impact of defects in the energy performance of 25 dwellings in the UK and concluded that the lack of participation of important project stakeholders in the early stages of the projects impacted in the level of understanding of the thermal performance in relation to defects to be designed out and checked during the construction process. Karim et al. (2005) and Quazi et al. (2002) also observed in studies exploring the development and implementation of quality plans in residential and non-residential projects in Australia and Singapore that the absence of key project stakeholders input in the definition of quality assurance procedures resulted in a greater number of defect occurrences.

The results of this research also indicated that, in none of the case studies, the process of assessing risks with potential to undermine the thermal performance of the dwellings relied on defect logs containing information collected from previous projects. In fact, in three case studies the use of defects logs could be identified, however they contained defects reported by occupants mostly during the 12 months of contractor liability period. At this stage, defects affecting the thermal performance were already enclosed within the building fabric and thus could not be easily identified solely by visual inspection. Taylor et al. (2013a), Hopper et al. (2012) whose studies focused on the thermal efficiency of dwellings in the UK and the identification of defects related to heat loss, stated that the post-construction detection of defects undermining the fabric thermal performance can only be undertaken through specialist surveys, such as thermal imaging. As a result, in most of the cases the risk assessment process relied mostly on the experience and levels of awareness of the project participants, as also observed in other studies exploring the links between quality management procedures and the occurrence of defects in construction projects in the UK, Canada and Sweden (Battikha, 2008, Atkinson, 2002, Josephson and Hammarlund, 1999). The personal contribution of the project participants was invaluable, however the lack of a structured defect register feeding to the risk assessment process undermined the ability to appraise relevant quality issues related to the thermal performance of the dwellings, as identified in the quality control tools analysed in this study. Pan and Thomas (2015) Forcada et al. (2014), Macarulla et al. (2013) and Georgiou (2010) whose studies aimed to examine the origin and causes of defects in residential buildings in the UK, Spain and Australia, also observed that the lack of a structured approach towards of reporting and categorising collected defects has the potential to compromise the use of the information gathered across different projects.

In respect to challenges 6, 7 and 8, they are directly related to construction site operatives' level of awareness of the quality requirements and associated risks. In addition, the findings of this study also identified concerns related to their technical capabilities to deliver the expected quality outputs. The difficulties related to sustaining consistent communication between supervisory teams and trade gangs was also observed by Atkinson (2002), Holt et al. (2000) and Josephson and Hammarlund (1999) as an important factor affecting quality in construction projects. In respect to the general level of the operatives' knowledge and technical capabilities, Josephson et al. (2002) and Love and Li (2000) stated that 55% of defects collected in their studies were originated due to workforce's poor levels of technical expertise. This was also acknowledged by Greenwood et al. (2017) whose study pointed the skills shortages across professionals involved in housing projects in the UK impacting in the delivery of energy-efficient homes. The research findings also identified that the challenges of retaining technical information and quality objectives awareness were caused due to the high level of subcontractor operatives' turnover. Previous studies have also recognised that efforts towards retaining knowledge in construction projects are often undermined by staff turnover and discontinuity of working sequence (Tan et al., 2006, Love et al., 2004, Loosemore et al., 2003, Tulacz, 2001).

The research findings also found that, in three case studies, risks associated to pressure on budget and programme have the potential to impact negatively on the application of quality control procedures. It is important that housing associations and contractors understand that achieving desired quality standards always comes with a cost and requires adequate time for the construction process and the administration of quality control procedures.

6.2.3 Quality resources assessment

Quality resources assessment unfolds challenges regarded to quality assurance approach where resources were distributed differently between the different phases of the project process. The main challenges identified were:

10. Due to the approach adopted for quality control compliance, the Project Quality Plan implemented lacked of specific focus concerning quality issues related to thermal performance.
11. Lack of appropriate resources (time and staff) allocated by the contractor and building control bodies for quality control procedures.
12. Lack of specific training and upskilling activities with the purpose of increasing awareness of the quality objectives and potential risks, as well as technical capabilities.

Previously, it was identified that the main focus in terms of Project Quality Plans applied by the housing association and the contractors was to reduce the occurrence of visible defects in the late stages of construction, which were more likely to become complaints by the tenants. In that sense, the research results are similar to the findings of Auchterlounie (2009). The study focusing on the recurring quality issues in the UK housing sector suggests that the emphasis on the mitigation of visual defects is due to the fact that quality programmes undertaken in housing projects are a “reactive approach” to the occupants’ perceived quality. As a consequence, the defects affecting the thermal performance of the dwellings fabric lie hidden alongside other visible defects and are taken for granted as part of the construction process. Thus, the majority of effort and resources identified in the case studies were applied in the stage of practical completion of the dwellings through the snagging process assigned to employers’ agents, independent building surveyors in addition to housing associations’ and contractors’ own quality checking procedures undertaken by their own quality officers. As stated by Sommerville and McCosh (2006) in an analysis of quality issues of 1,696 new UK homes, “visible-snags are the general industry focus and the ones which receive most media attention and yet they may be the lesser evil”.

On the other hand, the quality appraisal of defects affecting the thermal performance of buildings during the construction phase were mostly undertaken by building control bodies. However, results also identified that the shortage of resources implemented by the building control bodies in terms of the frequency of quality checks and availability of quality officers to undertake the quality control procedures impacted negatively in the identification of quality issues related to the thermal performance (Challenges 10 and 11). The lack of resources for quality control affecting the identification and correction of defects could not be clearly identified in other studies. However, Greenwood et al. (2017), whose study assessed the collaboration of policies and building regulations in the delivery of low and zero carbon homes in England, suggest that building control bodies are indeed facing resources constraints, and thus impacting on their undergoing activities.

The research results also revealed the lack of resources allocation for the purpose of increasing awareness of quality objectives and associated risks, as well as for the improvement of technical capabilities. Only in Case study 4 upskilling activities were put in place other than the initial health and safety inductions. However, in all the case studies, the interviews revealed that projects' stakeholders recognised the workforce's level of technical knowledge and capability as a major risk to the achievement of quality objectives. The results from the focus groups also confirmed the concern about the general level of technical ability impacting on the quality outputs. As a matter of fact, the identified challenge regarded to this issue (Challenge 7) was rated as one of the top challenges in terms of likelihood of happening and impact on the implementation of Project Quality Plans. Previous studies on quality management and defects origin and causes in the UK housing sector also observed the meagre allocation of resources in the prevention of defects occurrences. Tofield (2012) and Kanji and Wong (1998), for instance, stated that due to the fragmented nature of the construction industry, companies still fail to recognise the mutual benefits of investing in the upskilling and empowerment of the workforce. The studies of Brooks and Spillane (2016), Atkinson (2002) and Holt et al. (2000) converge in the fact that the lack of awareness of the quality objectives to be achieved not only compromise the delivery of the expected quality but also undermine the workforce's motivation and pride.

6.2.4 Definition of quality metrics and control

The stage of defining the quality metrics and quality control procedures was identified as the operationalisation of the Project Quality Plans, i.e. the actual quality assessment. In that stage, quality checking tools were implemented and the frequency of quality control activities were established. The main challenges encountered in this stage were:

13. Lack of objectivity in translating quality acceptance criteria of performance attributes (e.g. thermal transmissivity of buildings fabric) into quality control tools.
14. Quality checking hold points overly distant to each other, affecting the identification of defects in certain building elements due to accumulated construction stages.
15. Definition of lengthy working packages which concentrate an overwhelming amount of construction aspects to be checked at a time, compromising the efficacy of the quality control activities.

16. Lack of use of quality checklist to support and structure quality control activities undertaken by quality officers on behalf of housing associations and building control bodies.

17. Lack of consistency of quality checklists due to being not site specific and generic in terms of construction method and sequencing.

18. Quality checklists deployed did not encompassed at least the most recurrent quality issues affecting the thermal performance of the dwellings' fabric.

19. Lack of consistency on the application of quality control procedures.

The issues entailed in the challenges 13, 17 and 18 are related to the inability of quality control tools to provide a structured guidance to the identification of specific defects, as well as the objective assessment of the quality attributes related to the thermal performance of the building fabric. The quality control tools analysed within this study (e.g. quality checklists) revealed that in most of the case studies they did not provide an objective acceptance criteria; in times they were too generic, not encompassing the particular characteristics of the projects in terms of construction method and sequencing; and they did not offer guidance to the identification of specific defects by missing the most recurrent quality issues affecting the thermal performance of the fabric. Previous studies in the domestic sector in the UK and Sweden also identified the importance of checklists to guide the process of quality control (Johnston et al., 2014, Sommerville, 2007, Sommerville and McCosh, 2006, Josephson et al., 2002). Sommerville and McCosh (2006), for instance, found that the lack of focus of quality checklists in the identification of specific defects contributed to recurrent occurrences of quality issues throughout the investigated projects.

In respect to the issues regarded to Challenges 14 and 15, research findings revealed that the quality control regime adopted by contractors in 4 out of 5 case studies, and undertaken by building control bodies in all cases, impacted on the assessment of quality results as well as on the identification of defects. Thus, compromising the achievement of quality objectives. Quality control activities were administered through a small number of key stages inspections overly distant to each other. Consequently, each quality inspection concentrated an overwhelming amount of information to be collected. Moreover, due to the accumulated construction works undertaken in between the inspections, building elements relevant to the thermal performance of the dwellings were already hidden by overlaying construction materials. In that sense, the visual identification of the quality standard and defects could not be established. Although Atkinson (2002), in his study of the pathology of building defects in the UK housing sector, suggests that overly distant quality control inspections can mask the identification of defects sources and origins, studies providing a direct relationship between the frequency of quality control inspections and identification of defects affecting the thermal performance of building fabric could not be found.

The issues identified in challenges 16 and 19 are mostly regarded to operationalisation of quality control procedures. In some cases, the use of structured approaches providing guidance to the process of quality assessment, such as the use checklists, could not be identified. This was obvious especially in the quality control inspections undertaken by building control bodies, impacting on the identification and consequent correction of thermal related defects as evidenced by the on-site defect surveys implemented in this research. In addition, in all case studies the administration of quality control procedures at specific key stages presented a lack of consistency. It was observed that important inspections were not undertaken by the site management team and the building control bodies due to inadequate allocation of resources. Hackitt (2018) in a recent review of the UK Building Regulation also identified the inadequacy of regulatory oversight and enforcement tools undermining the delivery of quality in construction projects. Researchers such as Auchterlounie (2009) also identified the lack of use of structured approaches where the identification of defects in the investigated projects mostly relied on the inspector's experience and awareness. This researcher highlights the difference between "objective and perceived quality", where consistency of quality control procedures depends on a structured approach providing focus and inspection routine.

6.2.5 Quality compliance procedures

Quality compliance procedures encompassed, firstly, the process of reporting quality. Afterwards, the results reported were assessed, triggering corrective actions within the project but also potentially contributing to future projects. The key challenges posed to the process of implementing the project's quality compliance procedures were:

20. Quality reports lacking of focus on reporting quality issues related to the thermal performance of buildings as they are mostly developed upon checklists and site visit report templates.
21. Defects affecting the thermal performance, which posed no apparent threat to programme and were not spotted by building control bodies, were not discussed in the managerial meetings.
22. Ultimate compliance procedure assigned to building control bodies.
23. Lack of structure to feedback defects occurrences identified during the construction stage which could be used as a source in the risk assessment stages of future projects.

The challenges found at this stage are a consequence of the decisions made in the stage of defining the quality objectives and compliance procedures. As expected and evidenced by challenges 20 and 22, in the majority of the case studies, little focus was provided on the identification and consequent reporting of defects related to the thermal performance on the dwellings. The respective quality control procedures were assigned to building control bodies suffering from inadequacy of resources and lacking of a structured approach for assessing and reporting the achievement of the quality objectives. Eventually, defects were identified, triggering corrective measures. However, it is fair to state that many remained undetected and thus not remediated as evidenced in the section 4.6 (Quality compliance procedures). Gorse et al. (2012) Tofield (2012) and Bordass et al. (2001), whose studies shed light in the recurring quality issues in residential and non-residential buildings in the UK, also identified that the persistent occurrence of defects affecting the thermal performance of buildings' fabric are a result of the lack of focus and awareness from the project stakeholders, especially during the quality control and quality compliance phases. To Tofield (2012), "until recently, such defects have been unseen and ignored", are very likely to remain "not found and fixed before and after occupation".

In respect to challenge 21 and 23, the research findings revealed that, apart from Case study 4, the discussion of quality issues only occurred whenever they affected the achievement of the programme milestones or impacted on the project's budget, during the managerial meetings undertaken at the construction stage. This understanding was also recognised by Jraisat et al. (2016), who state that contractors employ more effort on completing the works on time and on budget than focusing on achieving the defined quality standards. Moreover, only in Case study 3, a formal structure for feedback of the identified defects during the construction stage was observed. In the other case studies, detected defects were dealt within the projects, but no formal procedures of sharing the learned lessons with other projects could be observed, impacting on potential continuous improvement. The lack of a structure to feedback defect occurrences was also experienced by all the focus group participants, denoting that this issue is a common challenge faced in the residential sector. Moreover, the use of information deriving from a structured defect record was not a common practice in all the case studies investigated in this research. As also observed by Jraisat et al. (2016) and Gorse et al. (2012) the construction industry lacks of continuous and consistent appraisal of final quality, where the lack of uniform process of assessment of the quality results allows subjective and non-comparable reports. The consequence of this inconsistency of retaining data and subsequent processing and use of relevant information in future projects is that benchmarking across different projects within companies cannot be established and consequently the process of continuous improvement towards achieving and improving buildings' thermal performance cannot be reached.

6.3 Facilitating the achievement of thermal-related quality objectives

A motivation for undertaking the research presented in this thesis was to identify opportunities to improve the quality procedures of construction projects to deliver the thermal performance of buildings as initially designed. This motivation directed the second research question:

> Q2. What are the necessary enhancements in Project Quality Plans to improve the thermal performance of social housing in the UK?

It is believed that the findings obtained in this research might be used to help inform housing associations and contractors in commissioning and developing Project Quality Plans, as well as potential UK policies and building regulations and standards. The following recommendations aim at improving the quality standards of the construction sector at the same time as delivering energy efficient buildings, as well as directing future research in this area. The following sections suggest possible methods of improving quality standards towards delivering building thermal efficiency in light of the quality plan stages established in this research. It should be noted however that this study has focused on relatively small numbers of case studies and it is accepted that it would be unwise to draw sweeping conclusions from the analysis or to make strong statements concerning policies to improve quality standards in the UK housing sector.

6.3.1 Housing associations

The research results revealed that the early stages of the development of Project Quality Plans, in respect to the definition of quality objectives and the compliance procedures in particular, are the major drivers of the process of achieving the desired quality requirements in construction projects. The definitions of the performance attributes, the methods of assessment, evidence of compliance and the assignment of responsible parties shape the approach undertaken in the processes of risk assessment, resources allocation and quality control.

The housing associations are the entities that commission, maintain, manage and ultimately own the dwellings resulting from the projects. Therefore, it is reasonable to recognise that they should be responsible not only for the definition of the projects' quality objectives but also for the establishment of their own quality compliance procedures, which would be assigned to the contractor and third parties such as independent building surveyors. Researchers such as Karim et al. (2005) and Briscoe et al. (2004) claim that active client participation in the process of establishing quality objectives and compliance is vital to drive the process of quality assurance, as well as to increase contractors' levels of awareness towards the risks involved in achieving the desired standards of quality.

Moreover, possible conflict of interests also occur when compliance procedures are only defined by contractors. As acknowledged by Landin (2000) in a study exploring the development of quality assurance methods in construction projects, without the active participation of the client, contractors tend to focus on the visual defects which become complaints during the 12 months of liability period. As was also identified in this thesis, Love and Edwards (2004a) state that contractors focus on post production quality control, where defects affecting the thermal performance of the buildings are already enclosed within the building's fabric and are not likely to be detected nor corrected.

The research also highlights that it is equally important that, from the early stages of the project, contractors and subcontractors are made fully aware by the housing associations of what is expected from them in terms of the quality requirements, but also how and when evidence of quality compliance should be reported. The compliance procedure must be designed to determine that the contractor is responsible for providing evidence that the workmanship is undertaken at the desired level, where specific building elements are free from the defects highlighted in the stage of risk assessment. It is fundamental that these requirements are embedded in contractual documentation where the awarded contractor is legally bound to deliver the expected quality outcomes. Moreover, the compliance procedure should ensure that building elements are compliant with the approved technical drawings and the specifications of the project (BRE, 2016, Gorse et al., 2012). The application of quality assurance procedures that culminates in the quality compliance activities should translate the established targets and performance attributes. As aforementioned, the way to solve the identified lack of focus on quality defects affecting the thermal performance of the dwellings is to define, prior to the application of quality control procedures, which building elements and specific defects must be inspected and evidence collected as part of the compliance process. This also applies to initiatives such as the implementation of Soft Landings and BIM, where the integration of the design and construction of an asset with the operation phase aims to improve building performance (Tuohy and Murphy, 2015, BSRIA, 2012, Way and Bordass, 2005). Without the identification of performance attributes, key technical features and defects to be monitored, the implementation of such methodologies might incur in the same lack of focus of the current Project Quality Plans, as identified in this thesis.

It is equally important to acknowledge that construction projects are in most of the cases one-offs, built by a temporary group of participants, using different construction methods (Hoonakker et al., 2010, Kanji and Wong, 1998). In that sense, housing associations must be able to adjust quality objectives and compliance procedures to the particularities of projects in regard to their construction methodology and sequencing. In addition, the use of Project Quality Plans is more suited to accommodate the particularities of each project, rather than the inflexible standardised QMS. Karim et al. (2005) also stated that the success factor to the development of quality assurance procedures are down to the project level and not linked to standardised QMS.

Even though the findings of this research suggest that the adoption of client-led compliance procedures increase the chances of achieving the quality objectives and drive the process of quality assurance, Jraisat et al. (2016) observe that this is not a straightforward process. According to the researcher, “customers’ requirements are often complex and expectations uncertain”. In line with this statement, previous studies also recognised that clients are not fully aware of the requirements they should place on the supply chain and often fail to follow up the demands they made (Ahzahar et al., 2011, Auchterlounie, 2009, Karim et al., 2005, Landin, 2000) Moreover, as observed by a housing association’s project coordinator in the validation focus groups (Chapter 5), housing associations might lack the required expertise and knowledge to establish themselves the objectives and compliance procedures regarding the thermal performance of buildings. Thus, in order to be able to propose appropriate compliance procedures as a way to structure the process of ensuring quality, housing associations must enable the upskilling of their technical staff, as well as to rely on the collaboration of external support, such as experienced consultants.

Another important part of the process of developing the Project Quality Plans is the assessment of risks with potential to undermine the achievement of the defined quality objectives. In order to overcome the challenges related to the lack of participation of projects stakeholders at that stage, it is vital that housing associations adopt a procurement route and business model which promote the collaboration and input of information from all the project participants at the early stages of the project process (Ruparathna and Hewage, 2015, Briscoe et al., 2004, Kanji and Wong, 1998). Apart from the welcomed input of information, this cooperative process among participants aims to align different management backgrounds and project objectives of the companies involved and thus generating commitment among the different parties. In respect to the quality issues affecting the thermal performance of the dwellings, in addition to the input of obvious participants (e.g. contractor, consultants, design team and employer’s agent) it is also important to involve other parties with experience of specific working trades and knowledge on the dwellings’ operation in the long term, such as subcontractors and housing association maintenance team and tenants’ representatives.

The housing association through the implementation of Project Quality Plan must ensure that quality checklists, quality reports and photographic records, are properly administered, produced and reported, taking in to consideration the defects and building elements identified as key to the achievement of the expected thermal performance. Quality compliance can be only established whenever all required evidence is provided, as also acknowledged by Tofield (2012). Additionally, the use of structured processes for quality control such as the use of checklists based on specific defects and building elements ensure that quality control activities are not only reliant on inspectors' knowledge, experience and level of awareness.

In respect to the allocation of resources for the implementation of Project Quality Plans, project quality requirements and compliance procedures provided by housing associations must be made available in the early stages of the tendering process. That should allow the costs of implementing the quality plan to be factored in the bidding proposals, as also indicated by the standard procurement procedures set by the British Standard BS 8534:2011 (BSI, 2011) and the Procurement and contracts strategies developed by the Office of Government Commerce (OGC, 2007). In that sense, the value of the project contract needs to be coherent with the quality objectives and should encompass the implementation costs of Project Quality Plans. The paradigm of aiming for the best quality standard at the lowest cost and time possible needs to be revised, as also suggested by Tofield (2012) and Hoonakker et al. (2010) in their studies of the barriers and benefits of quality management in construction projects. Invariably the financial gains obtained by low design, construction and management costs can be offset by the resources needed for defect correction and increased costs of operation and maintenance due to occurrence of defects (Auchterlounie, 2009, Love and Edwards, 2004a, Mills et al., 2009).

In terms of the assessment of the quality results, housing associations must ensure that an environment for the discussion of thermal related quality issues is established on a regular basis. Without a formal analysis procedure based on the reported issues, appropriate corrective actions cannot be triggered, as also identified by Fayek et al. (2004) in a study focused on identifying procedures to assess construction reworks. Moreover, corrective measures should not be confined within the project, it must be extrapolated to the managerial levels of both housing association and contractor, in order to enable the lessons learned in one project be assimilated and contribute to future projects (Hopkin et al., 2016). In that sense, it is proposed that the housing association must assign the contractor with the task of keeping a log of quality issues during the construction process. Hence, the defects identified are reported to the housing association, who is responsible to categorise and store the information in a defect database for further analysis of frequency of occurrence, patterns of origin (i.e. issues with design or workmanship) and their potential links to issues reported by occupants in the operational stage of the dwellings. As suggested by Macarulla et al. (2013), a standardised method of quality result analysis should be put in place in order to allow the assessment of different projects over time, making the data collected comparable. The analysis of quality issues identified at the construction phase offer links to the initial stages of risk assessment of the Project Quality Plan and design development, stressing the need of a sense of continuity, reinforcing the idea that quality management is an ongoing process. The achievement of quality objectives demand system thinking and continuous improvement where the housing association is the only party involved in all the projects and thus should ensure that the accumulated knowledge is analysed and use in future projects. Contractors, designers and consultants might vary from project to project in social housing schemes and will not have a long term association with the built assets, apart from the 12 months of liability period.

6.3.2 Contractors

The quality control and compliance procedures adopted in four of the five case studies in this research provided little focus on the prevention and remediation of defects impacting on the thermal performance of dwellings. This was due to the fact the ultimate compliance procedure was assigned to building control bodies and very little responsibility for providing compliance evidence was requested to contractors. The validation process adopted in this thesis corroborates that the lack of focus on the prevention and remediation of quality defects affecting the thermal performance of the dwellings have been experienced by the focus groups participants and can be extrapolated to other residential projects in the UK.

In order to address to this recurrent lack of focus, a number of different measures must be put in place. The definition of compliance procedures established by the housing association, as aforementioned, certainly provide guidance to the achievement of the quality objectives. However, these measures are not sufficient on their own. The contractor must be responsible to develop and implement operational measures such as the increase of quality objectives awareness and quality control to ensure the delivery of the quality objectives, in line with the project's characteristics and the contractor and subcontractors' managerial background.

Studies in quality management of construction projects developed by Josephson et al. (2002) and Feigenbaum (1991) suggest that the resources applied for the achievement of quality standards are divided in three main areas: prevention, including investment on upskilling activities and risk assessment; appraisal activities, such as quality control; and correction measures when defects are detected. According to the researchers, from the three areas, only resources allocated for remediation activities are avoidable. Through the investment on prevention, not only the costs involved in corrective measures can be reduced, but the investment on appraisal can also be optimised over time. Unfortunately, the thesis' findings show otherwise. Although the quantification of resources used for different stages of the quality management in the investigated case studies was not part of the scope of the study, it was evident that the majority of resources were allocated to the quality control and remediation activities in the late stage of the construction process. Thus, the research results regarding the allocation of resources for different stages of quality programme show a similar national trend in the construction industry, where very little resources are allocated on the prevention of quality issues (Tofield, 2012, Josephson et al. 2002).

Moreover, the lack of acknowledgement of the impact of defects produces significant consequences on projects quality costs as well, affecting the definition of resources allocation. According to Jraisat et al. (2016), "unfortunately, contractors rarely have a realistic idea of how much profit they are losing by not attaining an acceptable level of quality". If defects during the construction process were to be properly identified and the costs of corrective measures adequately accounted for, it would perhaps help to drive the allocation of resources for the prevention activities as a way to reduce defect occurrences over time and thus improve the thermal performance, as well as profits, reputation and help to decrease operation and maintenance costs.

In order to overcome the identified problems related to the lack of information and awareness of the quality objectives and the risks associated with the occurrence of defects, it is vital to have a formal administration of inductions and training sessions directed to subcontractors' supervisors and operatives. The need to increase upskilling activities for the site operatives in order to bridge the skills gap was also identified in the studies undertaken by Zero Carbon Hub (2014b) and Atkinson (2002). According to Zero Carbon Hub (2014a), the upskilling of the workforce is vital to address the "performance gap illiteracy". The proposition is that the existing inductions for health and safety purposes should be redesigned in order to also encompass the explanation of Project Quality Plan, where objectives and compliance with thermal-related quality requirements are detailed. The inductions should also convey the main risks related to defects occurrences, thus increasing the levels of information and awareness. The main idea is that every operative has at least one formal induction where they are informed about what is expected from them, how and when their work will be assessed and which quality issues should be avoided. The need for clear objectives and expectations are the key to obtain engagement of the workforce and thus increase the chances of attaining the project's quality goals (Zero Carbon Hub, 2014b, Atkinson, 2002). The frequency of additional inductions and upskilling sessions should be dependent on the interim assessment of the levels of quality delivered and operatives' turnover. Contractors need to establish the provision of resources for the following inductions, toolbox talks or technical capabilities upskilling sessions if considered necessary. In addition, construction planning activities should take into consideration ways to keep subcontractors' working packages continuous, retaining trade gangs familiar to the project and its requirements as much as possible.

As a way to provide guidance and increased focus on the thermal performance of the dwellings' fabric, it is vital that quality control tools developed by the contractor are designed to provide unequivocal interpretation of the acceptance criteria. The defined acceptance criteria must be unambiguous in order to enable the achievement of the desired quality standards. The wording of the items embedded in the checklists should not leave room for interpretation or rely on common sense (Hoonakker et al., 2010). They should present the desired attributes of the acceptance criteria and incorporate the most relevant defects that are likely to occur in the inspected building element. Sentences found in quality checklists of some case studies, such as “insulation boards should be installed properly”, take for granted that quality inspectors and operatives share the same technical knowledge and level of awareness towards the quality acceptance criteria. On the other hand, sentences such as “insulation laid flat and tight (gaps no greater than 3mm), service penetrations foam sealed” observed in one of the case studies’ checklist provides clear acceptance criteria, informing which specific parts of the building element should be checked and the maximum tolerance in case of defect identification. In addition, quality control procedures must be site specific, in line with the construction method adopted and coherent to the implemented construction sequencing. Moreover, the development or adaptation of quality control tools (i.e. checklists) must incorporate the input and collaboration subcontractors’ supervisors in addition to the contractor’s site management team. This joint effort aims not only to benefit from traders expertise, but also to promote awareness, engagement and commitment from the subcontractors.

In order to provide consistency of quality control inspections, a continuous and systematic quality control process is preferred. In that sense, more frequent quality control inspections are required, demanding the allocation of appropriate resources to support quality control activities. It is important that the most relevant defects identified through the process of risk assessment and key stages of the construction process are used to set the frequency and timing of quality control checks. As stated by Alencastro et al. (2018) in a study reviewing the relationship between quality defects and the thermal performance of buildings, recognising the key stages of the construction process for quality inspections is key for the identification of specific defects affecting the thermal performance of buildings. In addition, since subcontractors’ payment releases are conditioned to the achievement of the established quality objectives, the definition of subcontractors working packages should follow the adopted quality control frequency. As observed in case study 4, subcontractors’ working packages were generally designed to last no more than one week, thus setting the frequency of inspections and amount of building elements to be checked. The use of smaller working packages tend to reduce the pressure on programme and budget because the hold points are spread along the construction timespan. If an eventual payment hold up occur due to inadequate quality, it does not impact in the whole contract payment release.

In addition, it is suggested that a protocol for defect record must be implemented by contractors in order to ensure that quality defects experienced in one project can be prevented in the design and construction stages of future projects. Whenever defects are identified, apart from the photographic record, information such as the description of the defect, the source (e.g. workmanship, design), origin (e.g. error, omission, damage), type (e.g. incorrect installation, missing element), building element (e.g. external wall, roof) and trades involved (e.g. carpentry, plumbing) must be collected and properly stored. Then, this information should be provided to the housing association for the risk assessment of future projects and further analysis against other projects, thus enabling continuous improvement. The contractor could also use this data to improve quality control tools, establish benchmarks for quality performance across different projects, as well as to establish its preferred tier of subcontractors.

6.3.3 Building control bodies and building regulators

The assignment of building control bodies to undertake the ultimate quality control and compliance proved to be inefficient and ineffective, due to the lack of resources and unstructured approach of quality control and compliance. According to the focus groups discussions, the fact that statutory requirements were the only quality requirement to be achieved towards the thermal performance of the dwellings was an issue identified not only in this research but a phenomena occurring across the industry in the residential sector.

In order to offset the issues related to the lack of consistency of quality appraisal by building control bodies, a continuous and systematic quality control process must be enabled. In that sense, more frequent quality control inspections are required in key stages of the construction process, demanding the allocation of appropriate resources to support quality control activities. It is important that the most relevant defects affecting the thermal performance are mapped by the building control bodies and are used in the quality appraisal procedures. Additionally, the use of structured processes for quality control such as the use of checklists based on specific defects and building elements ensure that quality control activities are not only reliant solely on inspectors' knowledge, experience and level of awareness and are driven by objective criteria.

The compliance procedure of measurable performance indicators through the air pressure tests to assess the dwellings' air permeability normally takes place in the near completion stages of construction. It is suggested that an additional compulsory air pressure test should take place just after first fix and before internal wall lining. At that stage, the air pressure test would indicate eventual problems with the installation of the building fabric, such as gaps in the air and vapour barrier layers and poor sealing workmanship in services penetration in the building envelope. As stated by Wingfield et al. (2011) and Bell et al. (2010), administering performance tests during the construction process enables not only the identification of defects affecting the thermal performance but also allow a technically sound corrective action at a minimum cost.

It is equally important to address the lack of independence and conflict of interest between the building control bodies and contractors (Hackitt, 2018). Contractors should not be allowed to choose and assign the building control bodies responsible to assess and confer the final quality compliance certificates. The commercial relationship between the parties undermine the ability of the building control bodies to fully exercise their enforcement tools and to fully appreciate of the requirements of the building regulations for the fear of losing future jobs. In that sense, a truly impartial and independent quality appraisal is necessary to provide credibility to the process of building regulation compliance.

6.3.4 Construction industry

The research results suggest that the current quality management approaches observed in the majority of the case studies, also experienced by the focus groups' participants and confirmed by previous studies (e.g. NEF (2016), Zero Carbon Hub (2014b), Tofield (2012) Auchterlounie (2009)) are not fully suited to address the quality issues undermining the thermal performance of dwellings. The over-reliance on building control bodies to award quality compliance proved itself to be insufficient to ensure the achievement of quality objectives. In that sense, housing associations must take the responsibility to procure quality by defining quality objectives and compliance procedures. This does not mean that housing associations should develop full Project Quality Plans and prescribe all the activities entailed by it. On the contrary, contractors must be allowed and encouraged to propose the allocation of resources and definition of the PQP tactics, such as the quality control procedures, to enable the achievement of the quality objectives, in line with the determined compliance protocol. This flexibility on the application of quality assurance procedures is required to accommodate not only the managerial characteristics of contractors and subcontractors, but also to adapt to the project specific construction method and particularities. On one hand, housing associations' long-term strategic objectives related to thermal performance quality attributes and compliance procedures are established and conveyed to contractors by means of the quality policy in the early stages of the procurement and tendering processes. On the other hand, the awarded contractor is responsible to define the operational phases of the Project Quality Plan with the contribution and collaboration of the other project participants, such as the design team, consultants, subcontractors and maintenance team.

In order to enable this shift of approach of the current quality management procedures towards the achievement of the quality objectives related to thermal performance, a significant change of culture must be undertaken, as also recognised by other studies (Tofield, 2012, Zero Carbon Hub, 2014b). The first aspect that needs changing is the lack of focus on quality results as a consequence of the existing pressure on programme and budget. Previous studies revealed that the lack of focus on quality and resulting occurrence of defects can cause programme and budgets overruns up to 20.7% and 23%, respectively (Mills et al., 2009, Love and Edwards, 2004a, Barber et al., 2000). In that sense, an increased focus on quality management could reduce the number of defects occurrences, thus alleviating the pressure on project's timespan and cost. If quality was achieved first time, the resources and time required for rework would decrease, consequently contributing to the achievement of the desired thermal performance of the dwellings.

Another aspects to be taken into consideration is the impact of defects on the operational and maintenance costs, as well as the tenants' wellbeing and quality of life. This provides an extra incentive for housing associations to embrace this change of culture and increase the focus on quality, due to the fact that social housing providers own the assets and consequently are responsible for the maintenance costs. Moreover, housing associations have a vested interested in the well-being of their tenants due to their long-term relationship, who would benefit from decreasing operational costs such as energy bills and reduce fuel poverty.

The second aspect which needs attention is the current levels of technical knowledge of the workforce and the housing associations' technical staff. The need of upskilling in both layers of project participants is vital to streamlining the current quality culture in construction projects. Apart from the obvious gains regarding the increase of technical knowledge, competences and awareness of quality objectives and associated risks, the consistent upskilling also provides an intrinsic motivation and a sense of pride to the successful completion of the assigned tasks, thus reinforcing the shift on the quality culture (Brooks and Spillane, 2016, Holt et al., 2000). Although the empowerment of the workforce is an inevitable process to the achievement of the quality objectives, the benefits can only be perceived in the long-term. In the short term, the approach where housing associations reclaim the responsibility of prescribing the quality objectives and compliance, is fundamental to drive the development and implementation of Project Quality Plans which lead the achievement of projects' quality requirements.

Additionally, in order to enable the change of the quality culture within the construction industry, the no-blame philosophy must be embraced. The current fragmented nature of construction projects where the stakeholders do not share the same objectives has led to conflict and litigation, and ultimately to mismatching quality requirements and key performance indicators (Hoonakker et al., 2010, Auchterlounie, 2009, Kanji and Wong, 1998). Firstly, it is important that the different parties involved in construction projects recognise and understand why the current quality management approach has contributed to the buildings energy performance gap.

Table 6-1 provides a summary of the recommendations relating to research question 2. The table summarises the proposed actions related to housing associations and contractors in the development and implementation of Project Quality Plans with focus on the thermal performance of dwellings' fabric. Moreover, the table also propose recommendations to building control bodies in order to ensure that the requirements of building regulations are fully met.

Table 6-1 Summary of recommendations: Research question 2.

Recommendations
Housing Associations 1. In addition to the quality objectives, it is equally important that the housing associations define their own compliance procedures as part of the Project Quality Plan, based on the particularities of their projects and long term objectives. 2. Housing associations must control the compliance procedures by defining the necessary evidence (e.g. signed off quality checklists and photographic evidence). 3. Ensure that the technical staff has the necessary knowledge and support to establish the quality objectives and compliance procedures in line with the housing association's Quality Policy. 4. Ensure that project's budget and programme are suited for the application of the Project Quality Plan. 5. Adoption of procurement route and business model which enables collaboration between projects participants in early stages of the design and pre-construction. 6. Housing associations should inform quality objectives and compliance procedures in the early stages of tendering process, allowing implementation costs to be included in bidding proposals provided by contractors. 7. Enable risk assessment procedures with focus on the thermal performance of the dwellings. 8. Ensure that an environment for the discussion of thermal-related quality issues is established on a regular basis throughout the construction stage. 9. Require that contractors develop and report a defect log with a standard format, where information from different projects can be analysed and compared. 10. Enable a continuous environment for the analysis of quality results, where systemic solutions can be devised and implemented across in projects, thus promoting continuous improvement. **Contractors** 11. Develop and implement the operational stages of the Project Quality Plan such as quality control tools and procedures, based on the quality objectives and compliance procedures devised by the housing association, the highlighted quality issues and building elements in the risk assessment process and the knowledge acquired in previous projects. 12. Quality control tools should be site specific, entailing the construction method and sequence adopted in the project. 13. The wording of the quality control tools should encompass the defined quality acceptance criteria in an objective way. The use of subjective and broad terms which leave room to interpretation must be avoided.

14. Quality checking key stages should be defined on determined specific building elements and defects providing a focused approach and in line with the quality control checklists.
15. The working packages part of subcontractors contracts need to reflect the defined quality checking key stages, once payment release are conditioned to quality compliance.
16. Allocate resources for preventive measures such as training and upskilling the workforce in order the increase technical capabilities. In addition, health and safety inductions should be revised to encompass information regarded the Project Quality Plan, thus increasing the awareness of quality objectives and compliance procedures.
17. A protocol for defect record must be developed and implemented in order enable benchmarking and continuous improvement.

Building control bodies and building regulations

18. Allocate adequate resources to ensure consistency of quality inspections on-site.
19. Identify recurrent quality issues affecting the thermal performance of dwellings to inform frequency and timing of quality inspections.
20. Enable the development of quality control tools, such as checklists in order to structure and provide focus on the thermal-related defects and key building elements in the quality inspections.
21. Increase the number of performance tests, such as air pressure test, during the construction stage.
22. A different method of funding building control bodies should be adopted in order to ensure truly independent quality appraisal and correct application of enforcement tools when necessary.

Chapter 7

Conclusions

7.1 Introduction

This study aimed to improve the knowledge and understanding of the process of developing and implementing Project Quality Plans with a focus on thermal performance in social housing projects in the UK. The research presented in this thesis used qualitative approach, using data collected from five new-built social housing projects. Data were collected by multiple methods, i.e. semi-structured interviews; quality management documentation; observations of project management meetings and construction site visits; and construction defects surveys.

This chapter presents a brief summary of the key findings of this thesis in relation to the study's research aim and objectives (section 7.2). This is followed by a description of thesis' contributions to knowledge (section 7.3) and finally, limitations of the research are outlined along with recommendations for future research (sections 7.4 and 7.5).

7.2 Main findings

7.2.1 Challenges of implementing Project Quality Plans with focus on thermal performance

The main aim of this thesis was to explore the reasons why quality defects affecting the thermal performance of dwellings still occur despite the number of quality assurance procedures put in place in social housing projects in the UK. Therefore, two objectives were devised:

1. Identify and examine the challenges encountered in a sample of UK social housing projects in the implementation of quality management procedures which prevent their new-build projects to reach the expected thermal performance levels.

2. Examine the limitations of existing quality assurance frameworks, formal and informal quality programmes, applied to help organizations to deliver thermally-efficient housing according to performance specifications.

Figure 7.1 summarises the main identified challenges, as well as the limitations of the investigated quality assurance frameworks. The issues were grouped according to the sequence of the five categories of Project Quality Plans, suggesting where the participation of each project stakeholders was predominant.

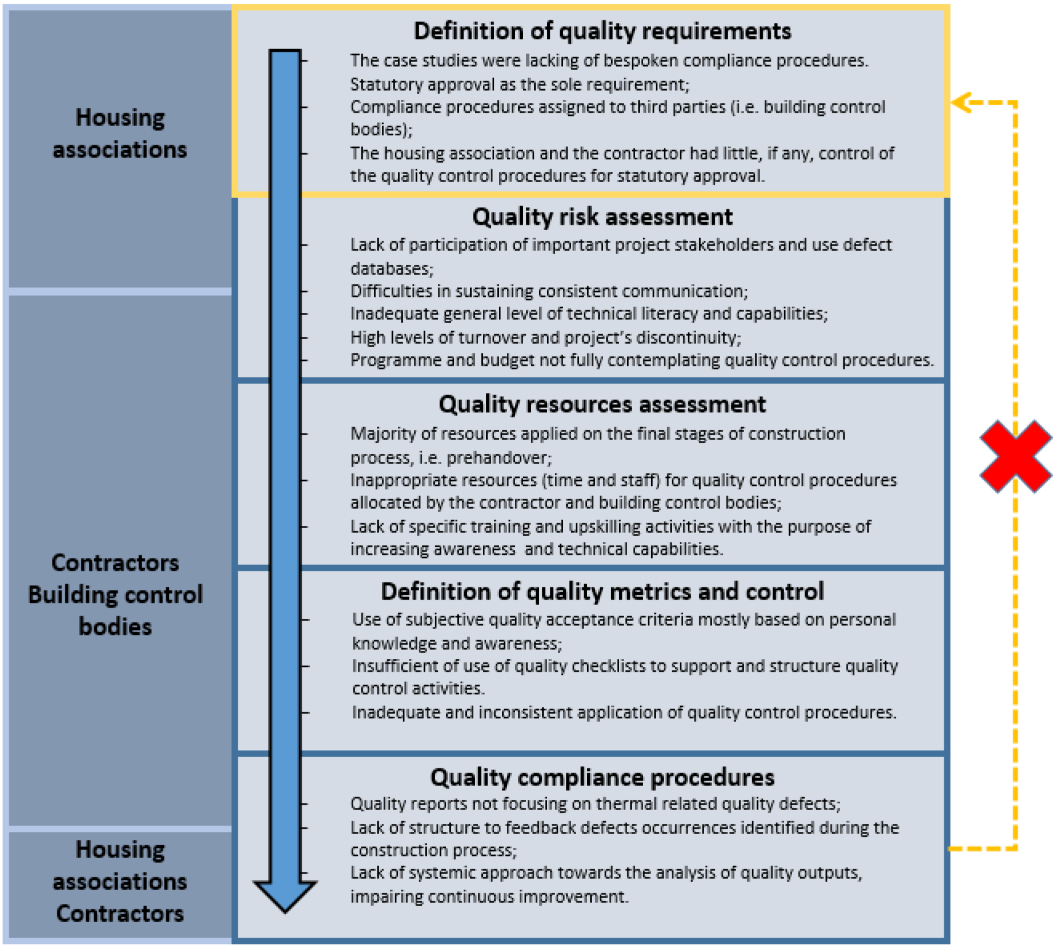


Figure 7-1 Challenges of the implementation Project Quality Plans with focus on thermal performance

The current research results suggest that in respect to the establishment of quality programmes with focus on thermal performance, social housing projects in the UK tend to adopt statutory requirements as the sole set of quality objectives and compliance procedures. As a consequence, the case studies investigated revealed that the ultimate quality compliance procedure was normally assigned to third parties, i.e. building control bodies. From one hand, the quality objectives related to the thermal performance set by the building regulations were clear and well known to all stakeholders from the early stages of the projects. On the other hand, the research findings showed that the compliance procedures were not administered as expected and lacking of consistency, especially concerning the frequency of site inspections. In the investigated case studies, and also experienced by the participants of the research findings' validation process, the established quality control activities undertaken by building control bodies lacked of a structured inspection protocol, compromising the full appraisal of quality issues affecting the thermal performance of the dwellings. Moreover, the regime of site inspections proved to be inadequate. Site inspections were overly distant from each other, thus undermining the ability to identify specific defects and building elements key to the achievement of the desired thermal performance. Only five checking stages were required to be undertaken throughout the whole construction process. Relevant defects affecting the thermal performance were already hidden within the building fabric at the time of the inspection.

The adoption of statutory approval as the ultimate quality compliance, and the assignment of building control bodies to provide the quality control of quality issues associated to the thermal performance of the dwellings, impacted on the development and implementation of Project Quality Plans undertaken by housing associations and contractors. The research findings made evident that the Project Quality Plans were devised mainly to mitigate visible quality defects which were likely to be identified by tenants and thus become complaints to be dealt with. In most of the case studies, resources for quality appraisal procedures were concentrated in the final stages of the construction process, where defects affecting the thermal performance were already enclosed within the building fabric, remaining undetected and incorrected. As the quality assurance related to thermal issues was reliant on the building control bodies, the risk assessment and quality control procedures put in place by the housing associations and contractors were lacking of focus on specific defects and building elements with potential to undermine the thermal performance of the dwellings.

Another important challenge to the achievement of the projects' quality objectives was the workforce's current level of knowledge and technical capabilities. The shortage of skills across the industry is a matter great concern manifested by all case studies' participants and corroborated by the focus groups' participants. In addition, the research findings showed the lack of resources and effort for upskilling activities and increase of awareness of quality objectives, compliance procedures and risks associated. In conjunction with the construction sector's high levels of staff turnover, these issues contributed to the difficulties of sustaining consistent communication and the retention of technical information during the project.

The research results also identified challenges towards the analysis and use of the information deriving from quality control and compliance. In the majority of the case studies the identified defects affecting the thermal performance which did not offer threats to programme and budget were not discussed in the managerial meetings. Consequently, lessons learned could not be shared to other professionals from the same companies, affecting the development of systemic solutions. In addition, the majority of the projects did not have a structured defect log during the construction stage, impairing the ability to share the defects and contribute to future projects, as well as enable a proper quality result assessment.

7.2.2 Recommendations to support the achievement of quality objectives related to thermal performance

This thesis also sought to identify the opportunities in quality programmes and plans to facilitate the achievement of quality objectives related to the thermal performance of social housing projects. It should be noted, however, that this study has focused on relatively small numbers of case studies and it is accepted that it would be unwise to draw sweeping conclusions from the analysis or to make strong statements concerning policies to improve quality standards in the UK housing sector. Therefore, two objectives were devised:

3. Provide the construction industry with recommendations aimed at improving the implementation of Project Quality Plans with focus on the thermal performance of social housing projects in the UK.
4. Provide recommendations to support policies and statutory regulations aimed at improving the thermal performance of social housing projects in the UK.

Through the analysis of the thesis findings it becomes evident the importance of defining the project's quality requirements regarding the thermal performance of the dwellings at the early stages of the project process. Equally important is that the quality compliance procedures are objectively defined. The establishment of quality assessment criteria and the method of compliance reported need to be established early in the process, driving the development of the Project Quality Plan to what concerns allocations of resources and the identification of the risks to the achievement of the quality objectives.

Even though projects might only aim at complying with the Building Regulation regarding the thermal performance, alternative compliance procedures must be devised in order to ensure the achievement of the quality objectives. In that sense, housing associations, being the parties who commission, manage, maintain and own the assets resulting from the projects, must lead the establishment of the quality objectives. Equally important, housing associations must define the compliance procedures part of the Project Quality Plan, in line with their quality policy and strategic objectives, but also encompassing the projects' technical characteristics and uniqueness.

In order to do so, housing associations must promote and incentivise the upskilling of their technical staff, increasing the understanding of the managerial and technical aspects key to the achievement of the thermal performance in construction projects, as shown in Table 7-2. In addition, a systematic assessment of quality results must enable the use of the lessons learnt in past projects to contribute in the appraisal of risks in future projects. It is recommended that the housing association commission the contractor to implement a defect log system during the construction phase, where information of quality issues are collected in standardised fashion, facilitating the comparison of quality results across different projects, thus enabling the continuous improvement and the achievement of quality objectives in ongoing and future projects.

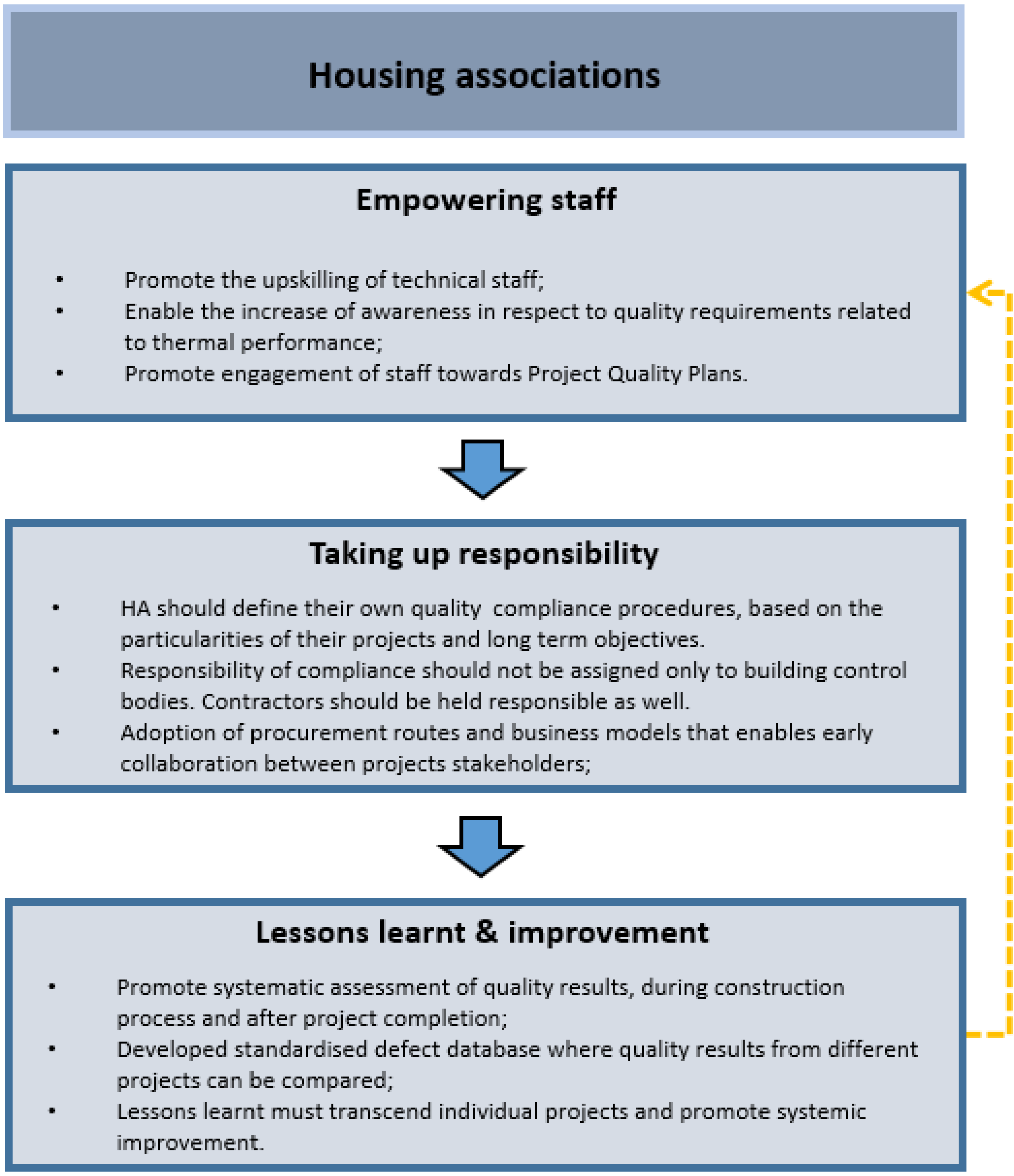


Figure 7-2 Recommendations for housing associations

In respect of the contractors, guided by the defined quality objectives and compliance procedures devised by housing associations, must be responsible for developing and implementing the operational procedures of the Project Quality Plan, as presented in Table 7-3. In that sense, enabling the participation of the project's stakeholders and relying on information deriving from previous projects in the quality risk assessment is crucial to the definition of the operational activities and the allocation of necessary resources. A thorough risk assessment helps to establish a focused quality control procedure, such as the definition of the frequency of quality inspections and development of quality control checklists with unambiguous criteria and objective wording which encompass at least the most recurrent defects affecting the thermal performance of the dwellings' fabric. It is also vital that contractors allocate appropriate resources for preventive measures. Time and effort should be put in place in activities aiming at increasing the workforce's technical capabilities and awareness towards the quality objectives and compliance procedures. In order to reduce the occurrence of defects at the construction phase, it is vital that the activities such as inductions, training and tool box talks encompass the discussion of most frequent quality issues and other associated risks undermining the achievement of the desired thermal performance. It is key to the achievement of quality objectives that the workforce is fully aware of what is expected of them and are technically capable to deliver the required standard of quality. In addition, upskilling activities also helps to promote commitment and motivation among the workforce, thus increasing the chances of achieving the quality objectives.

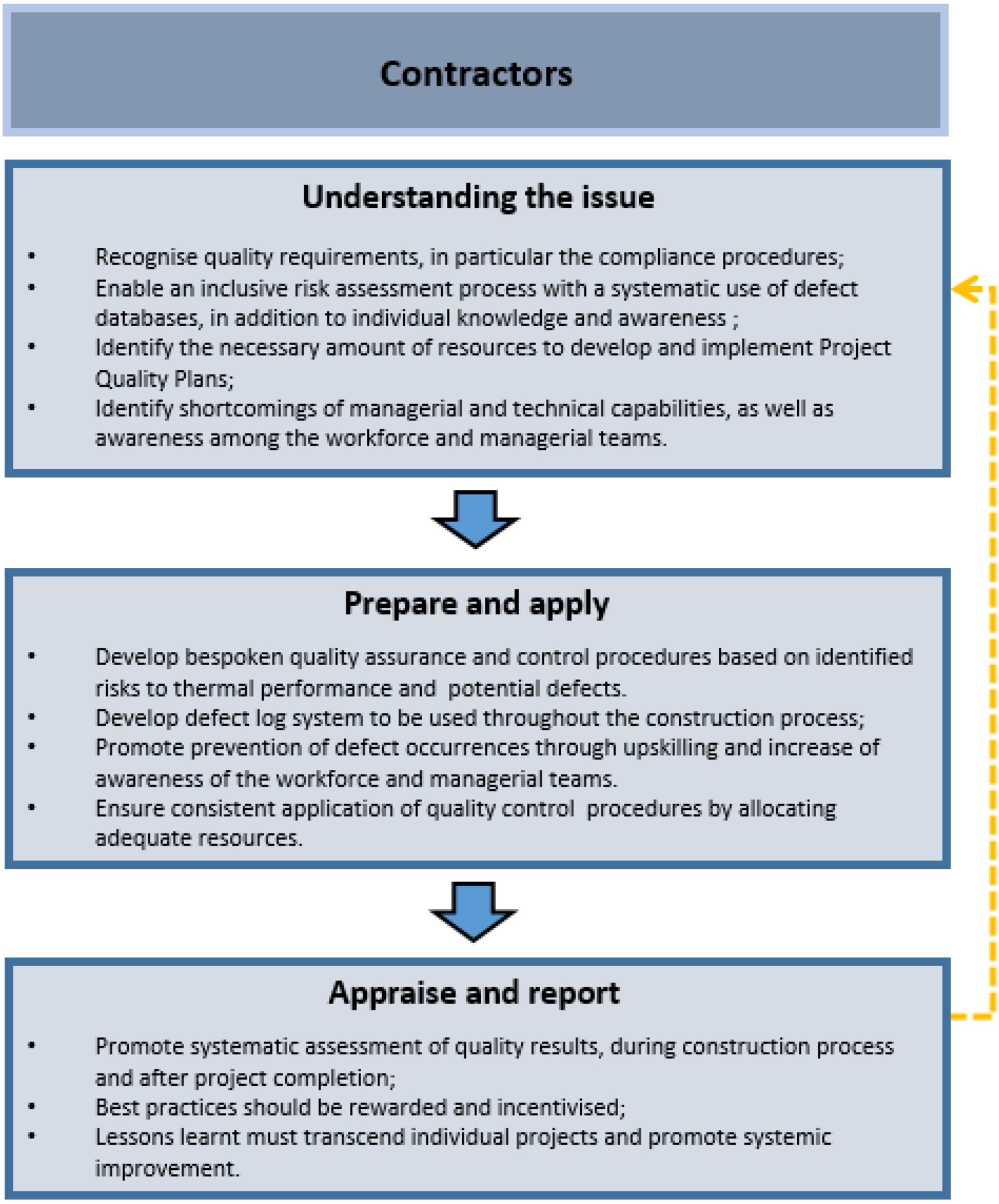


Figure 7-3 Recommendations for contractors

In respect to the opportunities identified to improve statutory regulations concerning the thermal performance of dwellings, most of the recommendations are related to the implementation of quality control and enforcement tools, as shown in Table 7-4. Firstly, a different method of funding building control bodies' activities must be adopted, ensuring that a transparent and independent quality appraisal is undertaken. Contractors should not be able to choose who the quality inspection parties will be for the statutory compliance procedure of the projects, thus avoiding possible conflict of interests between building control bodies and contractors. As long as contractors remain being the parties paying for the building control bodies' services, the credibility of quality appraisal can be questioned. In addition, the resources allocated for quality appraisal activities must be in line with the devised regime for quality control. A sufficient amount of resources must be provisioned to ensure that the quality control activities are undertaken systematically and consistently. All the defined key stages of the construction process and all the housing units must be objectively inspected, as established by the Building Regulations compliance procedures. Secondly, quality control procedures must be structured with inspection tools such as the use of quality checklists, in order to provide guidance and focus on specific building elements and recognised defects affecting the thermal performance of the dwellings. Thirdly, it would be beneficial to the achievement of quality objectives related to thermal performance to increase the number of air pressure testing. At least one more air pressure test could be administered right after first fix completion, but before the conclusion of the building envelope. At that stage defects affecting the air permeability could be identified and corrected at minimal cost with an adequate technical solution.

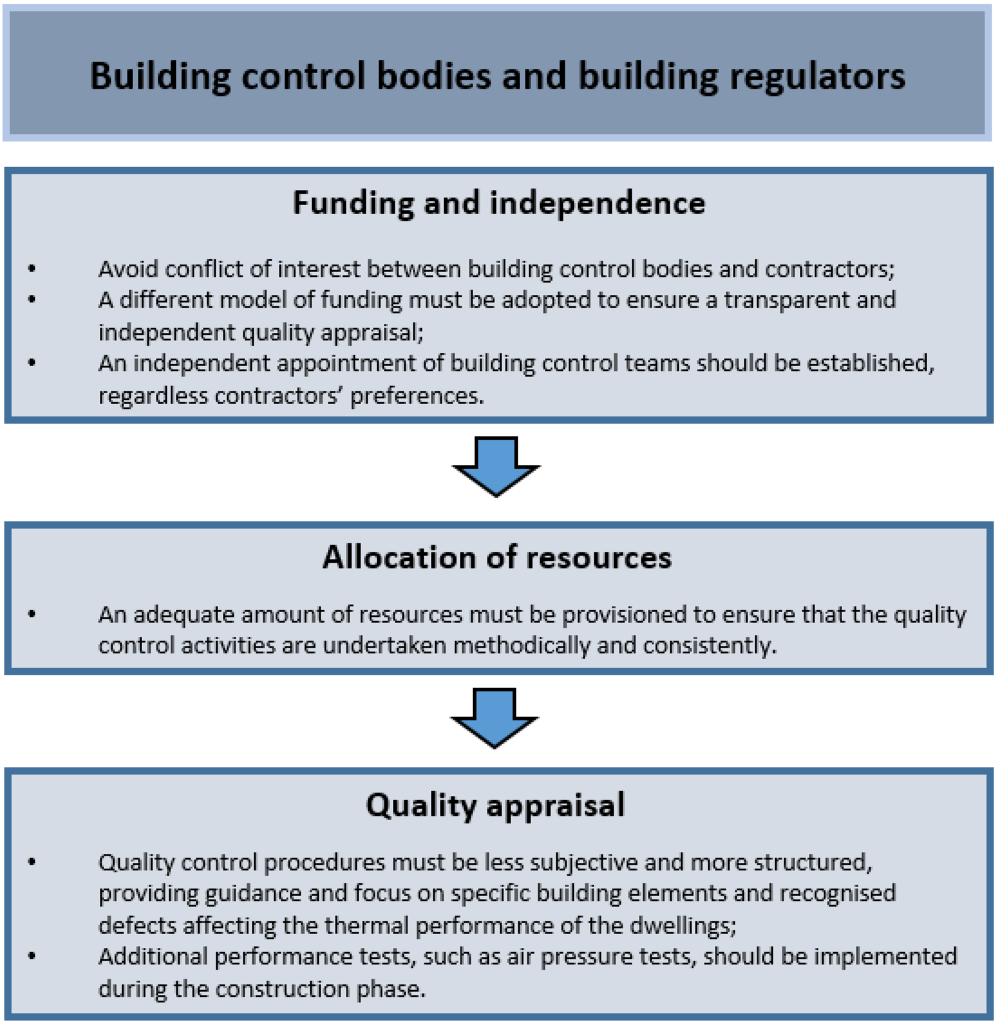


Figure 7-4 Recommendations for building control bodies and building regulators

7.3 Contributions to knowledge

The contributions to knowledge of this thesis are summarised in this section. The main contributions are:

- Improved understanding of the development and implementation of Project Quality Plans and its relation to the occurrence of defects impacting on the thermal performance of social housing projects in the UK.
- Recommendations to overcome the identified challenges in the development and implementation of Project Quality Plans with focus on thermal performance.
- Evidence of building fabric defects affecting the thermal performance of buildings.

To those researching quality management and energy efficiency in the construction sector, the findings of this research provide evidence of the current challenges to deliver the quality requirements related to thermal performance in social housing projects in the UK. In total 23 challenges were identified, evidencing the limitations of the current quality frameworks.

This research has provided a detailed analysis of the relationship between the different categories within Project Quality Plans (i.e. definition of quality requirements; quality risk assessment; quality resources assessment; definition of quality metrics and control; and quality compliance procedures). It has investigated the impact of these categories on each other, in the process of pursuing the achievement of quality requirements.

One particular contribution of this thesis is to highlight how the definition of compliance procedures in the early stages of the projects has the potential to drive the focus on quality issues related to thermal performance in the subsequent stages of Project Quality Plans. The identified lack of focus of Project Quality Plans towards the mitigation of thermal related defects in the investigated case studies was found to be due to the sole adoption of statutory approval as the ultimate quality compliance procedure. The thesis' results suggest that this decision determined how Project Quality Plans approached quality issues impacting in the thermal performance of social housing by shifting the responsibility of the compliance procedures from the contractor to third parties such as building control bodies. As identified in this thesis, current procedures and resources deployed by building control bodies do not provide a systematic and consistent appraisal of quality issues related to the thermal performance of dwellings.

In addition, this thesis contributes with the existing body of knowledge in quality management by providing recommendations that can potentially help industry stakeholders and policy makers to find ways to overcome the identified challenges, thus improving the thermal performance in social housing projects in the UK. The research findings suggest that it is pivotal that housing associations take up the responsibility of defining their own quality compliance procedures or adopt existing standards such as Passivhaus in addition to statutory requirements and compliance procedures. This would ensure that contractors are held responsible for the development of operational stages of Project Quality Plans with adequate focus on thermal performance, in line with the compliance procedures devised by housing associations. This would enable the identification of risks to the achievement of the referred quality requirements and the identification of adequate resources to both prevent and remediate the occurrence of defects.

Another contribution to knowledge is the presentation of additional evidence of building fabric defects affecting the thermal performance of social housing in the UK. This thesis has mapped over 50 different types of defects through existing publications and has recorded a total of 15 defect types occurring in the building fabric. The identification of defects in the case studies corroborate the fact that the awareness of such quality issues needs to be increased in the construction sector through the upskilling of workforce and managerial teams. In addition, the identification of such defects also expose the limitations of existing quality management procedures to tackle the ongoing issues of thermal performance in social housing projects.

7.4 Limitations

The limitations of this research have been previously mentioned throughout this thesis, especially in the methodology and the discussions chapters. The limitations of this study have been identified by the researcher as being related to three main areas, which are presented as follows.

Firstly, this study has focused on a relatively small number of case studies. Although the analysis of the collected data demonstrated that saturation was reached in terms of emerging concepts, it would not be wise to draw sweeping conclusions from the results of this thesis. In addition, the investigated case studies are located in the South and Southwest of the UK, where the other geographical areas of the country were not included in this study due to funding constraints. However, studies in this field of research (e.g. NEF, 2016, Palmer, 2016) that undertook wider samples of case studies across different areas of the country do not identify any significant influence of the location on the research findings. Moreover, the parties involved in the case studies (e.g. housings associations, contractors, designers, consultants and building control bodies) undertake projects regionally and nationally, applying the same managerial procedures studied in this thesis.

Secondly, in terms of validating the thesis' results, researchers such as Bryman (2012) and Yin (2009) state that in respect to the methodology adopted (i.e. multiple case studies and Grounded Theory), the emerging findings should be tested in two or three new case studies, where similar keys concepts should be found. Due to resources and time constraints an alternative validation process was adopted. The validation method undertaken in this thesis involved the application of focus groups with industry professionals (i.e. project managers, site managers, designers, consultants, building surveyors and researchers) from similar projects in the UK. The validation process concluded that the findings of this research were also experienced by professionals involved in similar construction projects. However, statistical validation was not attempted. This is due to the fact that the normal parametrical distribution was not likely to occur in such a small sample.

Thirdly, the limitations are also regarded to the replicability of this research and the ability to obtain equal findings. Although the methods of data collection and analysis were devised and administered with rigour, the inferences and the inductive approach which led to this thesis' findings was primarily based on the believes and understanding of the case studies' stakeholders on the topics explored. Therefore, as clearly stated by Bryman (2012) and Robson (2011) people's believes and understanding are framed by time. According to the researchers, it is very likely that people's opinion and stances may change and evolve over time, as well as companies' processes and procedures. Therefore, it is reasonable to expect that if the methods for data collection and analysis applied on this research are to be replicated, even with the same stakeholders and case studies, findings may be slightelly different.

7.5 Future research

This thesis identified six future research ideas, which are presented and justified in this section.

Firstly, following the recommendations of Bryman (2012) and Yin (2009), the findings of this thesis could be tested in new case studies. This would either increase the generalisation of the research results or perhaps enable the identification of new emerging concepts, thus contributing to a greater understanding of the challenges faced in the implementation of Project Quality Plans with focus on thermal performance in social housing projects in the UK.

Secondly, the use of the methodology framework devised in this research could be used to explore the implementation of Project Quality Plans in different setups of affordable housing projects. For instance, Hansford (2015) stated that the refurbishment of existing social housing schemes has also been experiencing the occurrence of defects undermining the thermal performance. In addition, researchers such as Wingfield et al. (2011) and Bell et al. (2010) whose studies investigated the energy performance of new affordable housing in the private sector, identified quality defects as one of the main issues affecting the thermal performance of dwellings. Moreover, other housing typologies such as building blocks were reported to be facing challenges in achieving thermal related quality requirements due to the occurrence of defects (NEF, 2016). Therefore, it seems reasonable to investigate the quality management procedures applied in these housing setups so challenges to the efficiency of PQP can be identified and addressed.

Thirdly, the results of this research suggest that the general level of knowledge and technical capabilities across the different layers of the workforce pose a great challenge to the achievement of quality objectives. In that sense, future research could focus on assessing the level of understanding and awareness of professionals regarding the technical aspects impacting on the thermal performance of dwellings. Future research in this area might provide relevant insights in order to identify the knowledge gaps and provide guidance to the development of upskilling activities, such as the use of virtual reality combined with BIM models.

In regard to the quality issues impacting in the achievement of the desired thermal performance, this thesis focused on linking the identified defects to the process of implementation of Project Quality Plans. The main purpose was to map the shortcomings of current quality management frameworks. However, the establishment of the frequency of defect occurrences was not part of the scope of this thesis. In that sense, future research could provide vital information for the process of risk assessment in future projects by determining the most recurrent defects. This would provide project stakeholders with a sense of priority in terms of which defects require more emphasis in the development and implementation of Project Quality Plans and the uptake of training activities.

In addition, future research could also focus on investigating the impact of each defect type on the thermal performance of dwellings' fabric. The quantification of the heat loss originated by different types of defects and their variations would help stakeholders and academics to understand the severity of each defect, consequently helping to define preventive and corrective measures, part of the Project Quality Plans.

Finally, this thesis has identified several challenges faced in Project Quality Plans in respect to the application of quality control procedures. Often, the application of these procedures are inconsistent due to the lack of resources and awareness of the quality inspectors, thus compromising the appraisal of quality standards. An alternative to overcome these challenges may be the application of automated data acquisition for quality control purposes. Although this field of research is still incipient, few studies such as Vaha et al. (2018) suggest that the application of improved sensor technologies and the widening use of Building Information Modeling may offer new possibilities in terms of replacing the intensive use of human resources in repetitive tasks such as the quality appraisal of construction works.

Appendices

This section contains background and supportive information that are relevant to this study and have been referred to within the thesis chapters. The contents are as follows:

Appendix A: Research ethics documents

Appendix A contains the documents submitted for ethical approval and used in the research to comply with University of Plymouth Ethics Policy.

A.1: Ethical approval form;

A.2: Research information sheet;

A.3: Invitation letters;

A.4: Consent forms.

A.1: Ethical approval form

RESEARCH WITH PLYMOUTH UNIVERSITY **FACULTY OF ARTS AND HUMANITIES** **Arts and Humanities Research Ethics Sub-committee** **APPLICATION FOR ETHICAL APPROVAL OF RESEARCH**	**(For ArtRESC use only)** **Application No:**	
	Chairs action (expedited)	Yes/ No
	Risk level **-if high refer to UREC chair immediately** **Cont. Review Date**	High/ low / /
	Outcome (delete as necessary)	**Approved/ Declined/ Amend/ Withdrawn**

ALL PARTS OF THIS FORM MUST BE COMPLETED IN FULL IN ORDER TO GAIN APPROVAL. Please refer to the guidance notes.		
1.	Investigator: João Paulo Ulrich de Alencastro	If Student, please name your Director of Studies or Project Advisor: Prof. Pieter de Wilde Course/programme: MPhil/PhD Architecture, Design and Environmental Building
	Contact Address: Roland Levinsky Building 301 School of Architecture, Design and Environment Plymouth University Drake Circus PL4 8AA Tel: 01752 566121	E mail: joao.ulrichdealencastro@plymouth.ac.uk
2	Title of research: The Building Energy Performance Gap: the Role of Construction Management and Inspection Techniques	
3.	Nature of approval sought (Please tick relevant boxes) **Note 2* a) PROJECT:☒	b) TAUGHT PROGRAMME (max. 3 years):☐
	If a,) please indicate which category: *Funded/unfunded Research (staff)* ☐	*Undergraduate*☐

	MPhil/PhD, ResM, BClin Sci, EdD ☒ *Or Other (please state)* ☐ *Taught Masters* ☐
4.	a) Funding body (if any): Science without Borders/CNPQ – Ministry of Science, Technology and Innovation of Brazil. b) If funded, please state any ethical implications of the source of funding, including any reputational risks for the university and how they have been addressed. **Note 3* N/A
5.	a) Duration of project/programme: 3 years b) Dates: 01/06/15 – 01/06/18
6.	Has this project received ethical approval from another Ethics committee? Yes☐ No ☒ a) Committee name: b) Are you therefore only applying for Chair's action now? Yes☐ No ☒
7.	Attachments (if required): a) Application/Clearance (if you answered Yes to question 6) Yes☐ No ☒ b) Information sheets for participants Yes☒ No ☐ c) Consent forms Yes☒ No ☐ d) Sample questionnaire(s) Yes☐ No ☒ e) Sample set(s) of interview questions Yes☐ No ☒ f) Continuing review approval (if requested) Yes☐ No ☒ g) Other, please state:
**1. Principal Investigators are responsible for ensuring that all staff employed on projects (including research assistants, technicians and clerical staff) act in accordance with the University's ethical principles, the design of the research described in this proposal and any conditions attached to its approval.* **2. In most cases, approval should be sought individually for each project. Programme approval is granted for research which comprises an ongoing set of studies or investigations utilising the same methods and methodology and where the precise*	

number and timing of such studies cannot be specified in advance. Such approval is normally appropriate only for ongoing, and typically unfunded, scholarly research activity. **3. If there is a difference in ethical standards between the University's policy and those of the relevant professional body or research sponsor, Committees shall apply whichever is considered the highest standard of ethical practice.* **4. Approval is granted for the duration of projects or for a maximum of three years in the case of programmes. Further approval is necessary for any extension of programmes.*

8.	**If you are staff**, are there any other researchers involved in your project? Please list who they are, their roles on the project and if/how they are associated with the University. Please include their email addresses. N/A
	If you are a student, who are your other supervisors? Dr. Alba Fuertes Have you discussed all ethical aspects of your research with your DoS prior to submitting this application? Yes☒ No ☐
9.	When do you need/expect to begin the research methods for which ethical approval is sought? 01/12/2015
	How long will this research take and/or for how long are you applying for this ethical approval? * 3 years.
10.	Please provide a 200 word description of the project. Buildings are acknowledged to play a large role in the current energy use across the EU. It is generally assumed that buildings are responsible for up to 40% of the overall energy consumption and thus for 40% of the total amount of greenhouse gas emissions in Europe. Moreover, there is a strong body of knowledge that indicates the existence of a mismatch between the buildings energy performances as predicted at design stage and as measured once the building is in operation. Recent studies, like Tofield (2012) and Bell (2005) claim that quality issues are important drivers to poor performance of the buildings, especially in respect to a buildings envelope and its

<table>
<tr><td></td><td colspan="3">thermal behaviour. Small defects, many of them hidden, in the insulation and vapour control layers of buildings enable undesirable air infiltration, thermal bridging and thermal bypass, hence leading to excessive heat loss and thermal comfort issues. Set within this context, the aim of this research is to explore construction quality issues in social housing retrofit processes. The ambition is to develop management and inspection recommendations based on a defect taxonomy which would assist designers, site managers and researchers to ensure proper responses whenever and wherever defects occur. Amidst the complexities of the construction environment it seems vital to know what to inspect and when to do it whether quality requirements as well as predicted performances are to be accomplished.</td></tr>
<tr><td>11.</td><td colspan="3">Please describe all methods and procedures which involve human participants in this project (You should specify subject populations and recruitment method, etc.):
Note: If you have indicated that you are using questionnaires or semi-structured interviews, etc. you are expected to attach indicative samples to this application.

In order to fully understand the generation process of quality issues which compromise the thermal performance of buildings, this research will develop a taxonomy of the related defects. The preliminary version of the taxonomy will be produced based on an in-depth literature review and will be enriched and complemented by exploratory visits to construction sites and through unstructured interviews with industry experts. The aim in this stage is to ensure that the taxonomy covers all the types of defects related to the thermal behaviour of buildings. Once a robust version of the taxonomy is developed, a validation process will be undertaken. This process will be led by a workshop with industry experts who will be invited to test the taxonomy by classifying defects according to the proposed structure. Besides, a survey will be administered to the industry's stakeholders in order to assess their level of awareness about the implications of defects towards buildings' thermal behaviour and their actual quality management procedures.</td></tr>
<tr><td rowspan="3">12.</td><td colspan="3">Please answer either YES or NO to <u>ALL</u> questions below by placing an X in relevant box.</td></tr>
<tr><td>Do any of your research methods include research:</td><td>YES</td><td>NO</td></tr>
<tr><td>With vulnerable groups – for example, children and young people, those with a learning disability or cognitive</td><td></td><td>X</td></tr>
</table>

	impairment, or individuals in a dependent or unequal relationship?		
	With vulnerable groups – for example, children and young people, those with a learning disability or cognitive impairment, or individuals in a dependent or unequal relationship?		X
	That involves sensitive topics – for example, participants' sexual behaviour, their illegal or political behaviour, their experience of violence, their abuse or exploitation, their mental health, or their gender or ethnic status?		X
	With groups where permission of a gatekeeper is normally required for initial access to members – for example, ethnic or cultural groups, native peoples or indigenous communities?		X
	That involves deception or which is conducted without participants' full and informed consent at the time the study is carried out?		X
	That involves access to records of personal or confidential information, including genetic or other biological information, concerning identifiable individuals?		X
	That may induce psychological stress, anxiety or humiliation or cause more than minimal pain?		X
	That involves intrusive interventions – for example, the administration of drugs or other substances, vigorous physical exercise, or techniques such as hypnotherapy (i.e. interventions that your participants would not normally encounter, or which may cause them to reveal information which causes concern, in the course of their everyday life)?		X
	If you answered yes to any of the above questions, please provide further details of these potentially ethically sensitive aspects of your research.		

13.	**Ethical Protocol:** Please write an ethical protocol using the following the headings: a) Informed Consent; b) Openness and Honesty; c) Right to Withdraw; d) Protection from Harm; e) Debriefing; f) Confidentiality; g) Professional Bodies whose ethical policies apply to this research. You must include a statement under each heading, indicating how you will ensure this research addresses each clause of Plymouth University's Principles for Research Involving Human Participants. (Please note that your application will be returned to you if you have not done so, thus holding up the approval process). **If you have indicated that you will be using Information Sheets or Consent Forms, etc. you must attach an indicative draft version to this application and complete Question 7 accordingly.** ***Please refer to Guidance Notes when completing this section.*** A) Informed Consent: An **Information Sheet** will be made available to all participants, where will be explained in advance the scope and the purpose of the research project. The aim is to inform the uses of the information to be collected which might affect the participants' willingness to take part and to ensure the participants' right of withdrawal. A **Consent Form** will be provided to each of participants in order collect their formal consent. Alternatively, in the cases of recorded interviews the interviewees will be given the opportunity to state clearly their consent to participate in the research. B) Openness and Honesty: The researcher will be totally open and honest in regard to the scope and the purpose of the research project towards the participants. The researcher will also explain openly how the data collected will be used and treated. All the procedures will be clearly informed and deception will not be used as a method involving human participants. C) Right to Withdraw: As mentioned previously, the participants will be informed of their right to withdraw from the research and the process to do so by two means: by the Information Sheet

	and by the Debriefing. In both cases the participant will be informed that they can withdraw from the project **at any time up to a set deadline**, likely to be within 4 weeks of the interview, workshop or the survey response. D) Protection from Harm: None of the procedures or methods used in the research will cause any sort of physical or psychological harm on the participants. In the event of taking a participant to a construction site where he/she is not directly involved (i.e. not managed by the company he/she works for), a **H&S risk assessment** will be undertaken and presented to the participant prior to the visit. Appropriate Personal Protection Equipment (PPE) will be supplied/request to the participant. E) Debriefing: All participants will receive a verbal debrief about the purposes of the research, the use and treatment of the data collection, and their right to withdraw prior to the start of any activity. Besides, a written document (Information Sheet) will supplement this conversation providing the researcher's contacts details, in case of further communications become necessary. F) Confidentiality The researcher will ensure the confidentiality of all participants' identity and data collected through the research procedures. Personal data will be associated with an arbitrary participation number and the researcher will comply with the Data Protection Act (1998). An exception to this policy will be implemented for the workshop, where confidentiality and anonymity will be difficult to maintain. Before the activity starts the participants will be asked whether they agree to their identity being exposed to the other members of the workshop. Participants, who do not agree, will not participate in the workshop. The workshop consent form will specifically highlight that anonymity cannot be maintained during the activity participation. Participants will need to agree to their identity being exposed during the workshop on the consent form. Inability to provide anonymity during the workshop will also be made clear in the recruitment letters for the workshop. However, data collected during the workshop will be treated in confidentially and anonymity, using Participant numbers and the professional role to identify the participants instead of using their real names.

In the event of reporting on information gathered on construction sites, and not having the consent of the contractor to identify the name of the project/company, the site as well as the company will be identified by a generic name, e.g. Contractor A or Project A, etc.

The data collected during the project will be stored in accordance with the following statement: “The university’s research ethics policy states that data should be securely held for a minimum of ten years after the completion of the research project. Electronic data will be stored on password protected computers or laptops and individual files and/or discs must be encrypted. Hard copies of data must be stored in locked filing cabinets and disposed of securely when no longer required.”

G) Professional Bodies whose ethical policies apply to this research.

The researcher’s primary goal is to engage with the participants in responsible manner, guaranteeing that the ethical guidelines of the Social Research Associations - SRA (http://the-sra.org.uk/research-ethics/ethics-guidelines/) will be undertaken.

14. **Declarations:**

For all applicants, your signature below indicates that, to the best of your knowledge and belief, this research conforms to the ethical principles laid down by Plymouth University and by the professional body specified in 6 (g).

For supervisors of PGR students:

As Director of Studies, your signature confirms that you believe this project is methodologically sound and conforms to university ethical procedures.

	Name(s)	**Signature** (electronic is acceptable)	**Date**
Applicant	João Paulo Ulrich de Alencastro		28/10/15
Other Staff Investigators	Dr. Alba Fuertes		02/11/15

	Director of Studies (if applicant is a postgraduate research student):	Prof. Pieter de Wilde		29/10/2015

Completed Forms should be forwarded BY E-MAIL to Claire Butcher (claire.butcher@plymouth.ac.uk), Secretary to the Faculty Research Ethics Committee no later than 2 weeks before the meeting date.

You will receive approval and/or feedback on your application within 2 weeks of the meeting date at which the committee discussed this application.

RESEARCH
WITH
PLYMOUTH
UNIVERSITY

Outcome of Application for Ethical Approval of Research

Applicant's Name:	João Paulo Ulrich de Alencastro
Staff or Student:	PhD student
Title of Research Project:	The Building Energy Performance Gap: the Role of Construction Management and Inspection Techniques
Date of Faculty of Research Ethics Committee Meeting	18 December *As an exception this application has been considered outside of the full meeting. The date of notification of outcome is Monday 7th December*
Faculty Research Ethics Committee Decision:	Approved with conditions
Notes:	1. Informed Consent: The Informed Consent form is not required. The Information Sheet needs to be checked/revised to ensure that it includes any relevant information that would have only been included on the Informed Consent form. 2. Right to Withdraw: Please clarify the time period for withdrawal of consent to make it inconsistent. It listed as 14 days on the Information Sheet and Informed Consent form and 4 weeks on section 13C. 3. Information Sheet: please provide some further description of A) the type of activities and B) what is required of the participants.

A.2: Research information sheet

BUILT ENVIRONMENT WITH PLYMOUTH UNIVERSITY

RESEARCH INFORMATION SHEET – INTERVIEW

Name of the Investigator: João Paulo Ulrich de Alencastro, PhD candidate at Plymouth University.

Address: Roland Levinsky Building 301, School of Arts, Design and Architecture, Plymouth University, Drake Circus, Plymouth, Devon, PL4 8AA.

Email: joao.ulrichdealencastro@plymouth.ac.uk

Telephone: 01752 585192

Fax: 01752 585155

Title of Research:

The Building Energy Performance Gap: The Role of Construction Quality Management

The Environmental Building Group at Plymouth University, through the PhD Research Project of Mr João Alencastro, would like to thank you and your company for collaborating in this research project which is focused on the Project |Quality Plans (PQP) used by Housing Associations (HA) in new residential projects.

The research aims to identify the obstacles and challenges encountered by HA when implementing PQP. It has a special interest on the quality issues which undermine the ability of buildings to achieve the designed thermal performance. The expected outcome of this study is to identify the main challenges encountered and propose actions aiming to support HA in delivering energy-efficient housing and thus helping to mitigate fuel poverty and carbon emissions.

In order to undertake the research, we require the collaboration and support of Housing Associations in respect to data collection. This collaboration will take place through interviews with the project's stakeholders (e.g. project manager, quality manager, site manager) which are expected to take no longer than 45 minutes. Additionally, to support and provide a clearer understanding of the data collected from the interviews, the participants are also asked to make available the documentation related to the quality management process of the project (quality plans, quality reports, checklists). No financial support is required.

The researcher will ensure the anonymity of all participants (interviewees and HA) and the confidentiality of the data collected through the research procedures. The researcher will comply with the Data Protection Act (1998) and the requirements of the Plymouth University Ethics Committee.

You can request access to any data held by the research project that relates to your personal collaboration by contacting the researcher.

The data collected during the research project will be stored in accordance with the following statement: “The University’s research ethics policy states that data should be securely held for a minimum of ten years after the completion of the research project. Electronic data will be stored on password protected computers or laptops and individual files and/or discs must be encrypted. Hard copies of data must be stored in locked filing cabinets and disposed of securely when no longer required.”

None of the methods or procedures in the research will inflict physical or psychological harm.

The participant has the right to withdraw at any stage of the research up to 14 days from the interview. To do so, please contact the investigator.

If you are dissatisfied with the way the research is conducted, please contact the researcher: joao.ulrichdealencastro@plymouth.ac.uk. If you understand the problem has not been resolved, please contact the Administrative Assistant to the Faculty of Arts and Humanities Ethics Committee: Claire Butcher at claire.butcher@plymouth.ac.uk.

A.3: Invitation letters

BUILDING
PERFORMANCE
ANALYSIS
WITH
PLYMOUTH
UNIVERSITY

Dear Sir/Madam

The Built Environment Department at University of Plymouth, through the PhD Research Project of Mr João Alencastro, would like to invite you and your company to collaborate in a research project focused on the Project Quality Plan (PQP) used in social housing projects.

The research aims to identify the obstacles and challenges encountered in social housing projects when implementing PQP. It has a special interest on the quality issues which undermine the ability of buildings to achieve the designed thermal performance. The expected outcome of this study is to provide recommendations which aim to support social housing projects to deliver energy-efficient housing and thus helping to mitigate fuel poverty and carbon emissions.

In order to undertake the research, we require your collaboration and support in respect to data collection. This collaboration will take place through interviews with the project's stakeholders (e.g. project manager, quality manager, site manager) which are expected to take no longer than 30 minutes. The topics as well as the questions to be administrated in the interviews will be sent prior to the meetings.

Additionally, to support and provide a clearer understanding of the data collected from the interviews, the participants are also asked to make available the documentation related to the quality management process of the ongoing project (quality plans, quality reports, checklists). No financial support is required.

The researcher will ensure the anonymity of all participants (interviewees and HA) and the confidentiality of the data collected through the research procedures. The researcher will comply with the Data Protection Act (1998) and the requirements of the Plymouth University Ethics Committee.

If you or your company would be interested in collaborating, please contact us by replying to this email or by calling the phone numbers below.

We look forward to hearing from you.

Kind regards,

João Alencastro

Researcher / PhD Candidate
01752 585192 / 07775805381
Environmental Building Group | School of Architecture, Design and Environment
301 Roland Levinsky Building | Plymouth University | Drake Circus | Plymouth | PL4 8AA| UK

A.4: Consent forms

BUILT ENVIRONMENT WITH PLYMOUTH UNIVERSITY

CONSENT TO PARTICIPATE IN RESEARCH PROJECT - INTERVIEW

Name of the Investigator: João Paulo Ulrich de Alencastro, PhD candidate at Plymouth University.

Address: Roland Levinsky Building 301, School of Arts, Design and Architecture, Plymouth University, Drake Circus, Plymouth, Devon, PL4 8AA.

Email: joao.ulrichdealencastro@plymouth.ac.uk

Telephone: 01752 585192

Fax: 01752 585155

Title of Research:

The Building Energy Performance Gap: The Role of Construction Quality Management

Brief Statement of purpose of the research and procedures:

The research project aims to explore the obstacles and challenges encountered by Housing Associations (HA) when implementing Project Quality Plans (PQP). It has a special interest on the quality issues which undermine the ability of buildings to achieve the designed energy performance. The topics to be explored in the interviews reflect the theoretical framework of PQP. The expected outcome of this study is to provide recommendations which aims to support HA in delivering energy-efficient residential projects and thus helping to mitigate fuel poverty and carbon emissions.

The data collection procedure undertaken at this stage is a semi-structured interview which will take approximately 60 minutes. The interviews start with the description of the basic information of the interviewee, the HA and the project which provides the background for the interview. Hence, the questions are clustered into five groups according to the PQP constructs (i. Requirements, ii. Risk assessment, iii. Resources, iv. Quality metrics and v. Quality compliance).

Acknowledgements

I have been provided and read the Research Information Sheet.

The objectives and procedures of this research have been explained to me.

I understand that my participation is voluntary and that I may refuse to participate or withdraw from part or all of the study, at any time up to 14 days from the present date, without giving a reason and without negative consequences. I am also aware that I can ask for the destruction of the data collected from this interview.

I understand that my anonymity is guaranteed, as well as the anonymity of my company.

I agree the interview to be recorded by an audio device.

I understand that I may decline to answer any question presented.

I understand that the place where the interview will be administered does not offer any risk to my wellbeing and thus health and safety measures are not required.

Under these circumstances, I agree to participate in the research.

Name: ………………………………………….

Signature: .... Date: ....…………..

Appendix B: Data collection documents

Appendix B contains the documents used for data collection and sections of data collected.

B.1: Semi-structured interview questionnaire;

B.2: Semi-structured interviews transcriptions;

B.3: Observations form;

B.4: Observation data;

B.5: Construction defects survey form and taxonomy;

B.6: Sample of construction defects survey;

B.7: Focus groups questionnaires.

B.1: Semi-structured interview questionnaire

BUILT ENVIRONMENT WITH PLYMOUTH UNIVERSITY

Research title: The building energy performance gap: the role of construction quality management
Data collection procedure: Semi-structured interview
Date:

Thank you for collaborating with this study. This research project aims to explore the obstacles and challenges encountered by Housing Associations (HA) when implementing Project Quality Plans (PQP). The study has a special interest on the quality issues which affect the ability of buildings to achieve the designed thermal performance. The topics to be explored in the interview reflect the theoretical framework of PQP. The interviews start with the description of the basic information of the interviewee, the HA and the project which provides the background for this data collection procedure. Hence, the questions are clustered into five groups according to the PQP constructs (i. Requirements, ii. Risk assessment, iii. Resources, iv. Quality metrics and v. Quality compliance).

<u>General information</u>

a. Interviewee name (information not used to keep the research anonymous);
b. Professional qualification;
c. Years of professional experience;
d. Role in the project/Housing Association;
e. Housing Association name (information not used to keep the research anonymous);
f. Number of assets (housing units);
g. Geographic area;
h. Number of ongoing projects;
i. Quality accreditation of the organization;
j. Name of the project (information not used to keep the research anonymous);
k. Number of housing units of the project;
l. Project purpose (e.g. letting, shared ownership, open market) ;
m. Project overall cost;
n. Stage of the project process (design, construction, handover);

o. Project duration;
p. Project procurement route.

Quality planning constructs and derived questions

1. Definition of quality requirements

At this stage of the QP the definition of the quality objectives which take place based on the requirements of the future clients, the Housing Association itself and statutory/regulatory requirements, including the ones related to energy performance.

Questions:

Q1. Does the project have a formal quality plan? Is it specific for this project or a standard used by the HA/major contractor?

Q2. In terms of quality requirements established for the project, are energy performance aspects part of the scope of the quality plan?

Q3. What are the requirements regarded to energy performance?

Q4. Are the requirements related to energy performance part of the strategic goals of the organization or only specific for the project?

Q5. How the defined requirements are documented and transmitted to the participants of project?

2. Quality risk assessment

This section of QP aims to identify the threats and opportunities that may impact in the achievement of the quality requirements. The risk assessment process explores managerial issues (competences of the management team, involvement of relevant stakeholders in the QP development and the timing of the QP development in relation to project timespan) and technical issues (competences of the design team and workforce; and analysis of recurrent quality issues from previous projects). As a result, it stablishes priority in terms of addressing to major risks and set guidelines for prevention and reduction of the undesired non-conformances.

Questions:

Q6. Which stakeholders are involved in the process of defining the quality requirements related to the energy performance of the project? When does it happen in the project timespan?

Q7. Is there a process in place to assess the risks related to managerial and workforce capabilities and technical issues which can affect the achievement of the requirements related to energy performance?
Q8. To what extent the managerial team and workforce understands the impact of defects on the energy performance of buildings of the project?
Q9. What are the challenges and obstacles faced when implementing quality management procedures towards achieving the energy efficiency?

3. Quality resources assessment

As part of the QP, the analysis of the necessary resources to implement the QMS starts by defining the roles and responsibilities of the project participants in the quality management process. If in the previous topic (2. Risk assessment) the need of upskilling is identified, proper resources should be allocated (e.g. training, skills accreditation). Moreover, the analysis of resources should identify the necessary infrastructure and support necessary for the implementation of the QMS (e.g. software, equipment, IT support, external support).
Questions:
Q10. Who is responsible for developing and implementing quality management procedures?
Q11. Is there a specific team in place to ensure the achievement of the quality requirements related to energy performance?
Q12. Is there a specific procedure in place to create awareness of the quality requirements related to energy performance among the participants (e.g. induction, training, skills accreditation)?
Q13. Does your company (HA/contractor) provide a proper environment and all the necessary resources in order to achieve the quality requirements proposed for the project? What else should or could be provided?

4. Definition of quality metrics and control

A quality metric is an operational definition that describes, in specific terms, the project's energy performance attributes (e.g. U-values, air permeability rates) and how the quality control process will measure them, defining sampling, milestones for testing and checking procedures. In addition, it sets the procedures for non-conformances identification in terms of defect types and frequency of occurrence.

Questions:

Q14. Which thermal performance attributes are considered by the quality plan/project?

Q15. Does the project have a procedure for defect identification and collection in place?

Q16. How and when are the performance attributes and defects monitored and collected?

Q17. What is the sampling approach used to the assess quality in terms of the number of housing units to be monitored?

5. Quality compliance procedures

The quality compliance section of the QP defines how monitored performance indicators and defect records will be reported and communicated to the participants of the project. It also set the procedures for the assessment of the results, as well as for the corrective actions.

Questions:

Q18. How quality compliance is reported in terms of content, format and frequency (e.g. reports, meetings, audits)?

Q19. Does the project have specific procedures to analyse the reports and defect records? Which stakeholders participate in this process?

Q20. How and when feedback is provided to the different participants?

B.2: Semi-structured interviews transcriptions;

Interview 1.a and 1.b – Transcript

Timecode	Speaker	Transcript
00:00:01	S1	So just before we get started, I just wanted to make sure that you all got an information sheet which is one of the requirement of the ethics committee of our university. And then if you could please sign the consent as well. As I said before, all the information here is to be treated in complete anonymity. And after the information will be released, as you say, of course the interpretation and so on.
00:00:42	S2	What's today's date?
00:00:42	S1	Today is the 20th.
00:00:46	S2	20th?
00:00:47	S1	Yeah.
00:02:14	S1	All right. Well the interview names of both of you I already know. What is the professional qualification of you guys?
00:02:25	S3	I'm a chartered architectural technologist.
00:02:33	S1	And you, Development Manager*?
00:02:33	S2	Working towards Master's degree and also RICS accreditation.
00:02:38	S1	Okay, perfect. All right. And years of professional experience?
00:02:43	S3	I've been in construction since 1984.
		(Overlapping conversation)
00:02:55	S3	Being with Housing Association* for the last 16 years.
00:03:03	S1	Which is good, it's excellent.
		(Overlapping conversation)
00:03:06	S3	Just caught me before I retired.

00:03:13	S2	So I've been with Housing Association* for about four years and in this role about two and a half years now in housing development.
00:03:18	S1	Okay. Excellent. Wow, that's good. Your role in this project or in the housing association, you're the development manager?
00:03:28	S3	Yeah, yeah. Design and quality coordinator. Because of my architectural background, I still on occasion have a design process to fulfil. So small schemes.
00:03:43	S1	Okay. And well I guess we always work with a project as a background for all this kind of information. Or the answers we will be talking about. So in that case we're working with Case Study 1* and Case Study 2*.
00:03:56	S3	Which is perfect.
00:03:57	S2	Yeah, that's fine.
		(Overlapping conversation)
00:04:00	S1	Okay, perfect, okay.
		(Overlapping conversation)
00:04:06	S1	With Site Manager* and, gosh…
00:04:11	S2	Site Manager*.
00:04:11	S1	Yeah, exactly. And well the housing association name we all know, Housing Association*. What is the number of assets you have right now?
00:04:23	S2	Must be pushing…
00:04:24	S3	Three thousand, three and a half thousand is it?
00:04:27	S2	It's between three and a half and 4,000 now. I forget exactly, but it's around that sort of mark.
00:04:35	S1	Okay. And the number of ongoing projects at the moment?
00:04:40	S3	Development?
00:04:43	S1	Yeah. Under construction or under design?

00:04:44	S2	We've got about six or seven on site and then another 12, 15 coming through the pipeline.
00:04:54	S1	Wow.
		(Overlapping conversation)
00:04:56	S1	That's excellent. A lot of jobs. Okay. Does the organisation have any quality accreditation like ISO or…
00:05:09	S2	Yes. It's got a number of those. We can get those details for you, but Professional* deals with that. It's got a whole host of different ISO…
		(Overlapping conversation)
00:05:20	S3	Yeah, it's got several. I forget how…
		(Overlapping conversation)
00:05:28	S1	All right. The project we talked about. The number of housing units, I have all the details from the projects. Okay. Do you remember…well, roughly…the project of [inaudible 00:05:44]?
00:05:45	S3	Yeah, actually I [inaudible 00:05:48] just over 3 million Pounds.
00:05:50	S1	Okay. In Case Study 1*, yeah?
00:05:52	S3	Yeah, just over three million.
00:05:53	S1	And Case Study 2*?
00:05:54	S2	I don't know that one.
00:05:56	S1	That's okay, I can find that out.
00:05:59	S2	I can forward you that one afterwards.
00:06:00	S1	And the stage of the project now is…
00:06:03	S3	Both sites are completed actually. Case Study 1* completed on the 15th of January, wasn't it?
00:06:17	S1	And the procurement of wood for the two of them?
00:06:21	S2	So we've got an in house contractor…Contractor*…they are part of the Housing Association* Group. And so all of our own build schemes that we

		do in house are procured through them and are built out through them. We have sort of external opportunities, don't we? We buy off the shelf units from developers [inaudible 00:06:41]. In which case you go out and buy them from the various developers. And anything you develop and actually build ourselves goes through Contractor*.
00:06:50	S1	Okay.
00:06:53	S3	What we have to do is a get a value for money statement from our employer's agents. So honestly, make sure that the costs are in line with market and then risk appetite and everything.
00:07:02	S1	Okay. And the design and responsibilities are to Contractor*, or you do it here and then pass it on to them?
00:07:13	S3	So it's changed. So we've gone from any contract where Housing Association* would sort of appoint the architect and the engineer and we'd work up that initial design, but to sort of realise some VAT savings and push the design liabilities and risk onto the contractor which is on a build contract. That some of come across together good now, but if we're looking at Fraden in particular, that would have been done by us initially.
00:07:41	S1	Okay. So traditional kind of route, okay. Excellent. I'll go to the quality planning constructs…well, going to the requirements and objectives. May I ask if Case Study 1* and Case Study 2*, do they have formal quality plan or is…or is something more informal that you have a particular way to do it and then you don't have to put it on specific plan?
00:08:14	S2	So when we talk about our quality plan, are we referencing to requirements and tech specifications and things like that?
00:08:25	S1	Yes.
00:08:27	S2	So we have a sort of standard technical specification that all of our projects have got to meet and that are sort of agreed and basically produced by us at management team and various other stakeholders. So that forms part of the contract documents and part of the employer's requirements. So I guess that would be our sort of our plan sort of thing.
00:08:46	S1	Okay. So those requirements come from a broader perspective. I mean, you really don't deal with a particular requirement for this or that development? It's pretty much one that you have for all the…

00:09:00	S2	Yeah, yeah. I mean, it sort of gets evolved slightly and tweaks are made to each year based on, you know, if you want to make some cost savings in an area. And it would serve as one…
00:09:13	S2	To, you know, managing the project or there's an ongoing maintenance issue that we've identified. So that's how that's sort of document involved, but generally we'd use that across the run of projects. And including if we get in early enough, when we say we buy units off developers, if we get in early enough in the process and go through planning, [inaudible 00:09:35] given that document they'll still abide by that [inaudible 00:09:38] and everything. So it's quite, you know, the sort of document we use.
00:09:43	S3	And particularly if we're using government funding there are certain criteria we have to meet with design. SAP assessments and code for sustainable homes just recently left us, but a lot of items have gone from code into the building regulation. So it's statutory requirements that we need to meet as well and the criteria standard as well.
00:10:06	S2	And I guess in the past as well. We had those particular funding streams where we need to adhere to certain criteria, that would then from part of the design proof we'd give across even to the architect or the contractors I would say.
00:10:20	S1	So you both answered the second question. That would be about in terms of quality requirements established for the project. High energy performance aspects part of the scope of the quality plan and then you just said you used to go for the [inaudible 00:10:37] homes? Do you use level four?
00:10:40	S3	We have done…
00:10:41	S2	We used to do…well, predominantly community agency funding stipulated a code level three. We've done a couple of projects that code level four, but generally it would always be for that code level three. Since that's the normal requirement and sort of that funding, it's just building regulations, isn't it, now to meet the requirements of that.
00:11:04	S1	So am I right to say that for Case Study 1* wise and Case Study 2* as well, you go for building regs in terms of energy performance targets, in terms of U values and so on?
00:11:16	S2	Yes.
00:11:16	S3	Yeah.

00:11:16	S1	Okay. That's pretty much the third, but do the requirements regarding to energy performance so building regs. So this is pretty much you've answered already. What other requirements related to energy performance are part of the strategic goals of the organisations…from the organisations…or only specific for the project? You said that you are constantly tweaking your general quality plan. That according to the information and the specifications that you get from year to year and that this plan is used for pretty much all your new developments, right?
00:11:57	S2	Yeah correct, yeah., that's
00:11:59	S1	Okay. And with this process, after finding those requirements, how is this information documented and submitted to the participants after the project? I mean, design wise for instance?
00:12:19	S3	We've recently set up a management program called **ASITE** and all of the project information is now loaded onto that site. And all members…strategic members of that team…have access to the information package. I do know that you guys have a system as well. How else can we operate as we go forward because the upfront part of the developments now, it's going to be interesting where that information will sit. Because if we're going to have Contractor* appointing the consultants, a lot of the upfront information will be on ASITE as well. [Inaudible 00:13:02] it wasn't, was it? It was sitting in the development filing system. So that has changed slightly, I'd say.
00:13:09	S2	Yeah. So…and that is not just important being on that system, it forms part of the contract documents as well. So whenever we are negotiating contract with Contractor* or contractor or whatever, they will be aware of…
		(Overlapping conversation)
00:13:29	S2	…to a technical specification for departments X.
00:13:34	S1	And ultimately this is the only way that you can make sure that you have to comply with…
		(Overlapping conversation)
00:13:41	S1	…positions that have been made.
00:13:42	S3	Because quite often, you know, things will come back and they'll all say well we haven't done that. And they'll say well why don't we have to do it? It's here.

00:13:50	S1	Yeah, that's right. Okay. Going to risk assessment which is a very interesting part. Which stakeholders are involved in the process of the finding this quality requirement related to performance? And when does it happen in the project's time span?
00:14:13	S3	We're part of the Advantage South West group. And there's a couple of parts to ASW. There's…I attend a platform called Design Innovation Group and we have standard house types. And a lot of the information put in those standard house types together comes from residents, from all the respective organisations, members of ASW, so we get a lot of information fed in and fed into our house types. So when we construct, we fully…potential residents are fully informed of how we're going to build, what suits, what type of properties, layout and that incorporates thermal insulation and sustainable products. And we also have a procurement arm at Advantage South West where we procure lots of our elements…kitchens, heating systems, bathrooms. And because we buy in large numbers it reduces a lot of the costs as well.
00:15:21	S1	Okay, that's really important with information you've been managing to deal with.
00:15:25	S3	Yeah. I mean predominantly our heating systems that we're using are like an air source heating type system. Which is quite sustainable and efficient and the U values to match, obviously to be building regs minimum standards.
00:15:45	S1	Okay. Do you have a process in place to assess the risks related to managerial and work force capabilities or technical issues which can affect the achievements of those requirements related to energy performance? That's pretty much what you've been talking about, right?
00:16:05	S3	Yeah.
00:16:07	S1	So we have this group of people that discuss…
00:16:09	S3	We…during construction, we obviously…the contractor is fully aware of our specifications. We also have a premier warranty provider that visits our site and checks our construction phase. Obviously myself, the asset team at Housing Association* who will eventually take on the properties have an investment obviously in the properties and an interest in what's being built. In house we have a technical forum which all members have a vested interest in the new build and after the build. And there will be an ideal

		platform there for any input into items, elements that they'd like to see in the new dwellings.
00:16:59	S1	Okay. So you have an overlapping activities or groups fo people going to the construction site…
		(Overlapping conversation)
00:17:06	S3	Not…a lot of consultation goes into our builds, doesn't it? Predominantly to the standard house types and specifically schemes for civic. Sometimes we can have input as well. And if things are not quite working, there's opportunity to make tweaks and changes in that.
00:17:26	S2	Yeah, definitely.
00:17:27	S1	Okay. The next question is to what extent the managerial team and workforce understands the impact of the defects on the energy performance of the buildings, of the buildings of the projects? Well, you said they fully understand the specifications that they have to comply with and deliver at the end of the day. So I assume that they are fully aware of what non-conformance can impact on the energy performance.
00:17:59	S3	Yeah, definitely. And all our buildings are air tested at the end of the build. So if there's any leakage or weakness in the buildings, that will flag up at that stage. So they're working to that final test. So it's critical they detail correctly on the site and build those details out correctly. Yeah, we use one method of construction and we build predominantly timber frame, as you've seen. And, again, it's…
00:18:31	S1	It's mind blowing.
00:18:31	S3	Yeah. And it's really critical the details on why for that form of construction to get that quality.
00:18:41	S1	I mean, exploring a little bit of the implementing what you said, we have several different layers of quality check made by different people. What would be the challenges and obstacles that you face when implementing those quality managing procedures towards achieving energy efficiency? Can you think about any challenges?
00:19:11	S2	I guess it's just having so many trades working on a development, isn't it? It's a knock on…because you've got so many bodies on it, you know, somebody dings something, somebody, you know, bridges a gap or…I think there are also so many processes go into construction process. I think

		you've got a lot of opportunity for things to go unseen and once it's boarded up, you can have as many eyes as you wish, but you know, they can't watch everything, can they? I think…and you're on site every week. And, you know, we can't be the police of these things
		(Overlapping conversation)
00:19:46	S3	What we try to do is educate and particularly with our site management teams, the likes of myself, we're not reliant on our building regs inspectors and our premier inspectors, but they go to make up that team, looking at the project continually. So…and the more you can make the site operatives aware of what you're trying to achieve, then they have an understanding as well. So the contractor has regular toolbox talks you call them on the side, so those are areas where you can implement to the operatives what we're trying to archive. So there are several layers where people are very vigilant on site, but Craig's right, trying to get it 100 percent is very difficult. This is where the testing at the end of the build comes in. So if you're not quite detailing correctly, the air pressure test is not going to work. Because we are as vigilant as we can be, we tend to…we can tell when we're testing that they are pretty there
		(Overlapping conversation)
00:20:51	S2	I think…just another thing springs to mind. A former site manager said to me last week, I think managing the sub-contractors can also be a challenge when you've got defects that are related to the site generally or to energy performance and they are not going to fix that workmen. Shit can happen on the final product. Because he said to me, our guys…this is in the direct report workforce our own, you know, they're employed by Contractor* and getting paid by Contractor*…they do something wrong, they'll come and say sorry boss, I did that wrong. However the difficulty comes when you've got a sub-contractor at the sort of price is less likely to come back and say I just dinged that or I just did that. So..
00:21:39	S1	They want to be gone…
		(Overlapping conversation)
00:21:42	S2	I think the opportunity not necessarily to cover things up, but I think there's more open and honesty with the direct workforce than if you've got a lot more sub-contractors. So I think that difference in culture can…that can be an obstacle, maybe.
		(Overlapping conversation)

00:21:56	S1	So to you the process is making people aware and creating environment…
		(Overlapping conversation)
00:22:01	S2	And you want your [inaudible 00:22:01] and people not working for you directly just to come and talk to you, don't you?
		(Overlapping conversation)
00:22:08	S3	We're not there to be critical, we're there to improve. And make sure the building for the correct specification. It all comes back to that specification. And the more people that are looking at that build process on site, the more chance we've got of achieving those specifications. And that's what we try and get across.
00:22:30	S2	And I guess it wouldn't be good if…I think we've got pretty good payment terms and a pretty good reputation in the industry, so I think they're quite good at amassing a group of sub-contractors that want to work for them regularly. So I thin by building up that rapport with the regular sub-contractors for regular work is positive as well, isn't it?
00:22:50	S3	And the other critical thing is they're part of the group. Our contractor is part of the Housing Association* Group. So it's in their interest to make sure they get that right as well.
00:23:00	S2	Because they don't want to come back and rectifying defects.
00:23:02	S3	Yeah. The last thing they need isn't it?
00:23:05	S1	And with this policy about being good payers and contracting for, well, good values, does give you good advance stage of working with your [inaudible 00:23:21] sub-contractors instead of going around and having different people working for you? Can you manage to work with the same people?
00:23:27	S2	I think so. I mean, I couldn't name specifics, but I know of…I've heard project managers talk about one or two sort of carpentry and mason gangs that said well how much work can you guarantee me over the next two years? Because I don't want to go and work for [inaudible 00:23:41]. You know, I don't want to…don't pay me for 90 odd days and I don't live like that. You know, pay me well each month. I think it's quite evident, really.
00:23:52	S3	Yeah, we've got an attractive works program. We're in a fortunate position where we self-generate a lot of our work. We also do get funding along the way, but we work hard at that. And we've got a nice bubble in the way

		program for the next few years. And that's attractive to sub-contractors. To be able to work in the same area and not have to go away to work. So that puts them…
00:24:17	S1	Huge step towards having this no blame…
		(Overlapping conversation)
00:24:24	S1	Yeah, that's excellent. So going towards resources. Who's responsible for developing and implementing the quality managing? Well this is pretty much answered now. You do a quality plan and then Pete here is responsible for implementing this…and checking them over, looking…
00:24:49	S3	I work alongside these guys as well in putting those specifications together to make sure we get that work. I actually chair a platform
		(Overlapping conversation)
00:25:00	S3	When that's discussed by all respective parties that have a vested interest in a build whether it be the asset team, the contractor, the client. Every person who's interested in that build attends that platform and we discuss it together. Sometimes it can be a bit long winded, but we generally get the answer that's the right answer for the project or the projects. So yeah, that works quite well.
		(Overlapping conversation)
00:25:33	S3	Yeah, we made a point of having this meeting on a quarterly basis. And just…even if it's just to get together and go across…we have some regular topics on there. We have a guy who attends from ASW, the procurement group. He'll give us a feedback, we have a defect section to see if there are any defects that regularly pop in so we can discuss that and decide how we can eradicate that going forward.
00:26:02	S1	And who participates again in this kind of meeting, in this discussion?
00:26:06	S3	I chair the platform. The developer who manages attends, dealing with the projects, the contractor and sends across his contracts managers so we've got three of those guys that come to the meeting. We've got the person who looks after their defects on our bills attends, we've have the asset team, the manager from the asset team attends and we've got our services unit who look after the maintenance look after the properties have a representative. And also the [inaudible 00:26:40]…anyone really who's involved in the product whether it be, everyione feedback. And if we take a

		decision, if we change a specification element, everyone's had participation in that change.
00:26:59	S1	Buyer comes as well?
00:26:59	S3	Yes, yeah…
		(Overlapping conversation)
00:27:02	S1	Buyer comes in?
		(Overlapping conversation)
00:27:07	S1	Then they have their say as well…
00:27:09	S3	Yeah, because if they can make a say on a particular item and it's…what we sometimes would do, this is a specific item we'd like you to build out, but if you could put forward…because we're on design build now…a likewise or similar product for a lesser price, we will definitely be interested in that and that's a great area we have when we discuss that.
00:27:33	S2	Yeah. And equally the Maintencace Team doing the leads and doing the day to day repairs, they can pick up issues with products down the line. Like say these mats are…they're rusting out after three years. Why is this happening and then Quality Coordinator* can talk to the procurement manager, you know, about addressing that with the manager out west. And it's a good forum, it gets everything out in the open rather than having lots of little conversations. I think you get a desired result pretty quickly, don't we?
00:28:00	S1	Okay. Going to put up [inaudible 00:28:05] because you've already answered, but I'm just particularly interested in, well, getting the link of what you just said. Do you have any specific procedure, I mean, to create awareness to the workforce, to the guys through the boots on the ground if we can say it this way about those defects that might affect the performance or things like that? Because we're talking about the contractor which is from the same group and I assume this is pretty much more approachable because you have well vested interest, you have a common interest in that. How do you deal with that with a sub-contractor?
00:28:44	S3	It's difficult for us to give that across because we're not at their toolbox talks. And I would imagine the likes of Site Manager* would be able to feedback better, but it's passed on from us on the client side, the quality control side. I would put that out there with them on site, but definitely talk to traders

		going around. If I'm not comfortable with their names, I will talk them through and say…but that will definitely happen on toolbox tools. The contractor will be encouraged to implement that from all of our designers, external consultants, to achieve the end product. So that's…so that talks its way down from each layer, doesn't it, and I'd like to think that's happening. Although I don't attend the toolbox talks, but I'm sure Site Manager* will be able to answer that…
00:29:32	S2	Yeah. You can probably get that from Site Manager* won't it?
00:29:35	S1	Okay. Do you think you could do anything differently in terms of creating this environment that we've been talking about? Do you think…is there any kind of infrastructure or maybe a different way to approach things in terms of talking to people? Do you think anything could be different? I mean, you're pretty sure that you're deploying all the necessary efforts towards…
00:30:09	S3	I think there's always room for improvement. I don't think that you can rest on your laurels. I think we're doing a reasonable job, if I'm honest, but I'm always open to opportunities to improve that…improve those methods, definitely. We're going for a phase in house as we speak, I can't speak too much about it where we're potentially restructuring. And I think the end result potentially of that is that we improve our systems and the way we work. So, yeah, I don't think we ever stop doing that. I think we're always looking…
00:30:49	S1	Continuous improvement…
		(Overlapping conversation)
00:30:50	S3	Yeah, exactly that. I don't think we'll ever sit back…I've been here 16 years and that's the beauty with this business. We're always evolving, we're always improving. We're always looking to improve the product.
00:31:06	S1	Clearly. Well, the next step here guys is about the quality metrics which is pretty much the more detailed information. And it's pretty much going down to building regs. So which energy performance attributes are considered by your quality plan? I would say that well, as you said, if you go for building regs, you have air permeability rates and you have the U-values. Do you have any other performance type that you look for or something different from the building regs?
00:31:39	S2	Water usage, that would be encompassed in building regs.
		(Overlapping conversation)

00:31:45	S3	We…previous to this obviously we were code for sustainable homes and that was driven a lot by the HCO funding. Since they disbanded the codes, a lot of those standards have naturally gone across to building regs. So at this present moment in time, we look to achieve building regs as a minimum. Going forward, that might well change. We might be looking to achieve higher standards, but at the present, it seems to be building regs, doesn't it, really?
00:32:15	S1	You just mentioned that 100 percent of housing units on the development are air tested, right?
00:32:21	S2	Yes.
00:32:23	S1	So yes, it's more than the building regs to have a certain amount, 30 percent of the…
		(Overlapping conversation)
00:32:30	S3	We test all of ours, yes, you're right. You need to test us? That's correct. So that is an over and above, really.
		(Overlapping conversation)
00:32:37	S1	That's good and I mean, it gives the message to the field works that [inaudible 00:32:43] after units will be tested.
		(Overlapping conversation)
00:32:51	S1	It can be quite effective, I suppose?
00:32:52	S3	Yeah, for sure.
00:32:54	S1	And for u-values, you have, what, the guys from building regs from [inaudible 00:33:02]?
00:33:04	S3	No. Premier look after our warrantees. So from building regs it's local authority inspectors or an approved inspector which is JR will visit our sites more regular. For different stages of the build, they go around checking the foundations, and each days just as we go up through to wall plate and then come back at the end for the finishing. Whereas Premier tend to come for all stages of the build because they're going to warrantee the build. And HBC.
00:33:34	S1	Okay. You have what, 10 years' warrantee extended?

00:33:40	S3	Yeah. This is more your forte, isn't it? We get our warrantees is it 10 years?
00:33:45	S2	Ten years usually, yeah.
00:33:48	S1	Okay, perfect. Do you have….in this project…specific procedure for defect identification and collection?
00:33:57	S3	Yeah. When we get to the end of the project…towards the end of the project before we get to practical completion, when the contractor is comfortable they've completed the build, they then ask for our employer's agent to come in and start the snagging progress. Or our project managers depending on how the setup is. They'll then attend site, myself will come initially to check to see what standards they've implemented. Bear in mind I'm not from the outside so I know what kind of standard they've been working to. And I will snag the buildings to make sure the quality is there. And they will return to do the back snagging and provided everyone's on board, the client attends as well for these sessions and then we'll get practical completion.
00:34:50	S2	I think taking a step back, you obviously do your weekly site visits and produce a report every fortnight?
00:34:57	S3	A bit longer. Probably more monthly now
		(Overlapping conversation)
00:35:00	S2	So if you have a defect section there, you pick up and you give it to the contractor each month.
		(Overlapping conversation)
00:35:05	S3	Yes. So we're vigilant all the way through the build. So yeah, that's part of my role to produce that report.
00:35:10	S2	And when the employers' agent go around with the snagging you have a list, you run through and you our have requirements from the technical specifications and project requirements. So you know, you'll be working through…it's a horrible task. It's a horrible, mind numbing task. Yeah, so I mean that's during the build and then post build we have the 12 months defects period when the tenants will phone us with an issues, any defects.
00:35:37	S3	That's a typical supervisor's report on a monthly basis. So I'll visit every week, minimum. Sometimes it requires more, but generally weekly and then every four weeks I'll put a report together, just an overview and you'll

		see the number of operatives are on site that particular snap shot of visit site. If there's any defects it will be on there that I want them to put straight. I mean, I don’t want anybody wondering that I just pulled one out of the blue. And then it's just a general update for the client to see how the program is going forward and where they are in regards to the program. And then there's a couple…a bit of weather and a couple of photos. And some of our EAs do that as well, won't they, our project managers?
00:36:26	S2	Yeah, yeah.
00:36:27	S3	These are an independent company. So it's independent of us and the contractor. So we appoint them. So…which is another…to keep that transparency. So…and then they'll come in and they'll carry…that's why they carry out the snagging as well and if the responsibility sits with them, yeah?
00:36:47	S1	So an independent…
		(Overlapping conversation)
00:36:52	S3	It keeps that transparency of the whole build. And then once we've cleared the defects and practical completion happens, we like to give a 12 month defect period generally, don't we? Whereas you can have a six month period. We do get six months sometimes and [inaudible 00:37:08]. It's now 12 is it, but we have in the past had six month defects periods. We tend to work for a 12 month period. And then what will happen, we'll go back as I found out, we'll go back in 12 months and every property…
00:37:25	S2	We send them letters to each of the residents. So we just work in a time slot to go see them.
00:37:30	S3	But don't they sign something to say that they're happy with the finishes…
00:37:34	S2	So we go through the property with them. We identify any outstanding defects that are reported. Anything we can pick up as well to the trained eye. That gets produced as a final end of defects report. The contractor then has to work through that, complete all those jobs and the tenant has to sign if they're happy and then we have to sign if we're happy and then that's defects closed.
00:37:56	S3	I will then produce in the previous form contract because we were working with the former contract…I will then produce what we call a defect certification to finish the job. And that's the end of it, isn't it?

00:38:11	S2	Yeah.
00:38:13	S3	Apart from if there was any latent defects which we don't seem to get very often.
00:38:16	S2	Not very often, no.
00:38:19	S1	Towards sampling, I assume that while I've been there and once we were there, so you run over the 100 percent of the housing units, right? You don't do simply like…
00:38:36	S3	Yeah. I do…I have several methods. I purge items as well. So particularly roofing, I might have a purge on roofing. We might be looking at the M&E on the project. So generally I go for a look, but specific visits, I'll be looking at the M&E and I'll take the drawings and I'll literally go through them. Me and Craig have recently done this at Water Lane. When we checked to make sure we're getting exactly what we want. So we're doing that quality check to make sure the right amount of sockets are in the rooms, et cetera, et cetera. So there are specific visits as well where we pick out items that we want to look at. And I try to keep the contractor on their toes as I'll purge an item every so often and I'll go across all the sites and I'll either look at specifications, roofing was classic, wasn't't' it? Because there was an issue in roofing at Fraddon roofing. And I introduced this company years ago. I wanted to see from our design a specific specifications for the roofs. I wasn't seeing it and no one was seeing it. And what was happening, the contractor was going to the sub-contractor and asking for a quote to do the roof finishes and the responsibility of the specification was with that sub-contractor. And I wasn't comfortable with that. I wanted to see a specification as part of the project information package.
		(Overlapping conversation)
00:40:01	S3	Yes, exactly, so we knew what we were getting. So that…that brought a few things out, didn't it? And that's all settled down now. So, yeah…
00:40:09	S1	You know what you expect as a reasonable job.
00:40:13	S3	Yeah, exactly.
00:40:17	S1	I don't know, I guess the most important thing is to have clear information that people know what is being expected from them.
00:40:23	S3	And implementing that information. As critical, as you rightly said, we've got quite a lot of work on the go now and you've got from the ground, in the

		ground, drainage information. It can be a large package and getting to oversee all of that, as difficult for one person and that's why I try and get everyone on site to work as a team. So we're all going in the same direction.
00:40:47	S1	You mentioned that you have sensitive topics in the construction process that you do the specific site visits and you've mentioned roofing. Do you have any other items that you…
00:41:04	S3	Drainage is quite critical in the ground. I like to make sure that the drainage is implemented correctly. That's quite a good area because that's overseeing by building control. They have a vested interest in that as well. We've had problems in the past with ponding, pooling of waters, particularly in gardens. When we've gone over and above with our gardens and we've got quite high specs for ground finishes. And how we look after the spoiled heaps. So when we clear a site and we store soil that's going to go back as top soil or sub soil for gardens, it's specifically controlled. And it comes under a [inaudible 00:41:48] for document. So we want a better product going back to those gardens and there's a specification the way we implement that product so that it improves the drainage of our rear gardens because there's an issue with that.
00:41:48	S1	That's definitely a sensitive topic because otherwise if you don't get it right the first time…
		(Overlapping conversation)
00:42:12	S2	Yeah, and not only that, it's a hard one to solve. It's really expensive [inaudible 00:42:19]. It's not an easy one.
00:42:20	S3	It's not cheap to solve on site, but it's cheaper to do it while you're doing the construction phase then it is to go back retro and try and implement it.
00:42:27	S2	Dealing with, you know, upset customers and impact on them and…
		(Overlapping conversation)
00:42:35	S3	Which is where the technical forum comes in to it's own. Because we get that feedback from the end users. So we know if things are working and if they're not. We might not like it sometimes what we hear, but we can act on that. And that makes a big difference, doesn't it? And that keeps us on our toes and that keeps everyone on their toes.
00:42:54	S1	Yeah, for sure. According to the last little bit of this conversation which is about quality compliance. How do you report quality compliance? I mean,

		in which format and frequency? You said you have these quarterly meetings where you get information from the sense of things that went well and pretty much didn't went well and you had to…
00:43:22	S3	Defect is another one. If we have any issues, it comes through that defect process. So we pick up on that. And again, that's reported back to that platform. And it's also acting on, isn't it, before it even gets to the technical forum. This is more your doing, you're geared up for this, aren't you?
00:43:41	S2	Yeah. So we've got a defects monitoring system. So everything, you know, tenants ring in and report a problem. It's raised in the system and logged and it gets fired off to the contractor to rectify, but we'll compile those stats. And we look for sort of patterns as well across projects and also compare what the common quality issues we have on external…you know, off the shelf units we buy versus our own build.
00:44:14	S1	So you know what's…
00:44:15	S2	Yeah, what to look out for and that helps inform what we go and look at on site as well, I think. So that's one way of doing it. Obviously keep our eyes on the ground for that. We have site meetings, don't we as well where we talk through all sorts of items, really. Mainly [inaudible 00:44:33] conforming to the project generally. I'm trying to think of what other forms or methods we use.
00:44:41	S1	The input for this defect assessment platform that you just mentioned, the input comes from the tenant's complaints?
	S2	Yes.
	S1	From the snagging process as well?
	S2	Yes.
	S1	Is there another source for input?
00:44:57	S2	I guess we do a post completion review meeting. So once the project is finished…well, a few months out of completion…we'll sit down with employer's agent, the architect, the engineer, the client, the contractor, Pete will sit in on it. And we'll talk about what went well with the project and generally it's like standard items that we've worked through. What can be improved about not just the construction, but also the design aspects. It is really important, what worked well, what could we have changed to improve, you know, the ergonomics of the development as well, isn't it?

		And apart from that having some stats of defects that we've picked up from customer's report. I mean, so it's a lesson in that, lessons done.
00:45:46	S3	What we've found with those completion meetings, they're very valuable, but they're very specific to that scheme. And sometimes the information wasn't being spread across the whole group. And the…I keep harping on the technical forum, but that gives us a platform to take items from those meetings now to put across to everybody. So rather than it being scheme specific. And the other thing that's coming off the back of those, we can also take it up because I'm a vehicle for the ASW design innovation group. So items can also come with me now to that platform as well. So it's sharing that information which we did all right before, but I think that's improved it. And the other one, I'm pretty sure we still do it, is the KPIs, key performance indicators. Which is…I don't know if that still is as prevalent because we used to do that as part of the code assessment, wasn't it? I'm not sure if we're still…are we still…
00:46:54	S2	I think so.
00:46:55	S3	Maybe that has changed, but maybe that's something…that was part of those post completion views as part of that KPI process.
00:47:05	S1	Do you have a set a contractor's participating in this post completion…
00:47:09	S3	Not sub-contractors.
		(Overlapping conversation)
00:47:14	S3	…sub-contractor.
00:47:17	S2	But, I mean, I guess if we're going to use a regular set of contractors going forward, might not be a bad to invite some of the bigger M&E for instance…
		(Overlapping conversation)
00:47:40	S3	They predominantly provide our frames. So we have used a couple of other contractors in the past
		(Overlapping conversation)
00:47:51	S3	The whole package.
00:47:55	S1	I mean, they supply and install for you (timber frame), right?

00:47:56	S3	Yes. Yeah. Which again, you can go towards the quality control because it's their product. And they're installing their product. So you don't…so their knowledge of how that product needs to be installed, so that's another quality aspect.
00:48:12	S1	Exactly, exactly. And you certainly rely on that.
00:48:15	S3	Yeah, definitely. And it's things like windows we procure from Riching and I do believe the installers now are our preferred installers as well, aren't they? So again, a lot of the products are supplied and installed by the manufacturer which helps.
00:48:38	S1	Yeah. It's…well, guys, this is pretty much what I've wanted in terms of information. And it's invaluable, it's really good. It's really…it's a lot of information to digest now, but…

(00:48:59)

(End of Audio)

Duration 49 minutes

Interview 1.c – Transcript

Timecode	Speaker	Transcript
00:00:01	S1	So, to start with I just want to make sure that you got previously this information sheet and then the consent form for participating in this research as well. (Clears Throat) And then, well, as we said, you have the right to not answer any or all the questions if you don't like to or if you don't find it appropriate.
00:00:26	S2	Okay, no problem.
00:00:27	S1	So, basic information, our starting point. So, your name is *Site manager**.
00:00:33	S2	That's correct.
00:00:34	S1	Your professional qualification?
00:00:36	S2	I am a qualified site manager.
00:00:40	S1	Okay. Years of professional experience?
00:00:43	S2	I've been doing this role approximately nine years.
00:00:49	S1	Okay. Well, your role here in this…well, actually, the project we're talking about is about *Project* * even though we're in a different site today.
00:00:58	S2	Okay, yeah.
00:00:59	S1	So, your role in the project is?
00:01:02	S2	I was the site manager at *Project* *, building 21 units for registered social land lord or housing association along with seven open market units and the housing association name was *housing association**.
00:01:24	S1	All right.
00:01:26	S2	Number of assets, housing units, I'm not sure. I couldn't answer that one because I just worked for the building arm of the *housing association**. So, I'm not privy to that, but I should imagine that it is thousands, not just hundreds.

00:01:46	S1	Yeah, don't worry I can this information on the website.
00:01:48	S2	Yeah, okay. The geographic area….
00:01:55	S1	Which the housing association works, it's really Southwest, right?
00:02:00	S2	It's purely Cornwall. I don't think they've made inroads into Devon as yet, so I think it's just purely Cornwall as a whole, so yeah.
00:02:10	S1	Okay, do you have an idea of the number of ongoing projects at the moment?
00:02:15	S2	*Housing association** as a group will purchase houses on the section 106, so that they will purchase from some of the private developers. So, whether you would account that as an ongoing project, possibly. I only know of one at the minute, I'm sure there are more. *Contractor** who I work for which is part of the *housing association** Group are currently building approximately six projects. They've got about six projects on the go for *housing association**.
00:02:59	S1	All right. Do you know if *Contractor** have a quality accreditation like ISO 9000 and things like that?
00:03:09	S2	Yes, we do, we've got ISO 9000 and…I can't think of which. It's off the top of my head. It's mostly to do with the company's procedures. So, procedures as a whole. Yeah, that includes people's roles and our finances, you know, everything is audited. Absolutely everything is audited and we also have ISO accreditation on the way we deal with the environment as well.
00:03:52	S1	Okay. The name of the project is *Project** or do you have another different name for *Project** or you…what do you call it right now?
00:04:00	S2	No, we just called it *Project**, it was [inaudible 00:04:02].
00:04:04	S1	Okay. And, the number of housing units you've mentioned already.
00:04:08	S2	Yes.
00:04:09	S1	And, you've mentioned already what is the project purpose in terms of shared ownerships and open markets and I think that's all.
00:04:15	S2	Yeah, I didn't mention the shared ownership in the prior question when I got carried away, but there were, as I said, 21 for the [inaudible 00:04:25] of

		which six were on the shared ownership scheme, the rest being like social rented.
00:04:32	S1	Okay. Do you have a rough idea of the project overall cost?
00:04:39	S2	*Project* * I think was about 3.1 million.
00:04:43	S1	Okay. Well, the stage of the process now is….
00:04:48	S2	It's handed over. Yeah, it was a good handover, it was clean. And, post-handover, I get to know about the defects and obviously defects are costly to the building industry which I had to keep them to a minimum. And, up to press, obviously people have moved in now and we're hearing very little other than, and I've got to stress this because it's a new technology, we're having problems with some of the air source heat pumps (ASHP).
00:05:26	S1	Okay. All right. The project duration took you…?
00:05:34	S2	It was 48 weeks, but it did run over and that was due to very bad weather at the front end of the job which we were able to claim an extension of time for, so….
00:05:51	S1	Do you know about which was the procurement route adopted in this project? Is it traditional or design and build?
00:06:02	S2	Oh, it's… *housing association** appoints designers and then *Contractor** just purely build, so we've got no input in design as a builder, but that has now changed going forward. So, from now on *Contractor** are….
00:06:24	S1	Will have a say in the….
00:06:25	S2	Yeah, we're design and build now basically. So, we appoint the designer and architects, engineers, and so, you know, basically sell the whole package to *housing association**.
00:06:38	S1	Okay, all right. Well, the first bit of the interview is about requirements in terms of quality. So, for that project, did you have a formal quality plan or it is…which was specific for the project or a standard used by the housing association or the contractor?
00:07:04	S2	Yeah, there was a document that was produced by *housing association** which is a little bit more than employer's requirements. It's very specific in terms of design and quality and, you know, that's quality across the board

		whether it be, you know, thermal performance or, you know, aesthetics, so yeah.
00:07:33	S1	Okay. In terms of those quality requirements established for the project, are energy performance aspects part of the scope of this quality plan?
00:07:43	S2	Absolutely, yeah. We have not only got to perform in line with the local authority building regulations, but yeah, they're a little bit over and above and they look into various methods of heating on that scheme, it was air source heating. It's a good product for the end user in terms of monetary saving and obviously it's great for the environment. What more can I say about that one?
00:08:25	S1	Well, it's pretty much you've answered question three which were about, what are the requirements for quality energy, you just mentioned it so it's awesome.
00:08:34	S2	(Laughs) I'm always a step ahead of the game.
00:08:35	S1	It's good, it's good actually. Actually all of those questions you see they're kind of intertwined and they all kind of overlap each other. So, most of the questions are answered in one answer here, one answer there, but you pretty much covered all of the other ones. Well, the fourth question is about, are those requirements related to energy performance part of the strategic goals of the organisation or only specific for the project?
00:09:09	S2	I would say that they're part of the strategic goal for the organisation. We have like a little…I don't know what you call it, a group, if you like, that represents the organisation and that's dealing with green issues. So, yeah, we'll have a meeting every quarter roughly and try and get the whole company involved in sort of our ideas. ASHP too was kind of borne out of that group, so yeah.
00:09:44	S1	Okay. So, how do those define requirements in terms of energy performance that as you've mentioned before are documented and transmitted to the participants of the project? How does the information get here in the construction site and passed on to the other participants?
00:10:03	S2	Right, define the requirements of documented…yeah. I don't know if this applies, but the end user receives a home user guide which will have all the information about how the house performs including its rating, SAP rating, that sort of thing. With the end user, [inaudible 00:10:28] is another thing.
00:10:30	S1	Yeah, it's definitely a grey issue.

00:10:33	S2	But, going back on that, looking at in that sort of retrogressive, it's during the build, the operatives and companies or subcontractors that we use are now very *au fait* (familiar) with our products and I know that what we're trying to achieve in a good quality build, when I'm talking about quality, I'm probably talking about thermal performance. So, if they've got to perforate the building or whatever they know that they've got to make sure that the insulation is not compromised, you know, and it's even to the point of loft insulation. You know, there is a right time to lay loft insulation and that is after the electrician has installed the TV area. It's one of those things that we've learned, you know, over the years, you know, you want to be putting that down last so it's not compromised, very important.
00:11:38	S1	Yeah and moving on to the part of risk assessment, which is question six, do you know which stakeholders are involved in the process of defining those quality requirements related to energy performance and when does it happen in the project time span? All those definitions about the performance targets that you have to comply in terms of specifications and so on, do you participate? Well, you mentioned before that….
00:12:14	S2	We get…. Right. As I've mentioned before, *Contractor** are building for *housing association** and *housing association** have one of their representatives if not more because they appoint an agent to oversee our work and they also have a supervisor that checks our work on a weekly basis. So, yeah, there's just no shocks basically, you know, because everything's checked, you know, stage by stage by stage.
00:12:45	S1	Okay, all right. But, as you've mentioned before, now it's changing, but to you, I don't know about *Project* *, *Contractor** has no contribution so to speak in the design process defining those requirements?
00:13:01	S2	Not at the moment, but that is changing. So, yeah, we're heavily dependent on other people's information and we haven't been using, you know, the same designers. They vary from project to project and everyone's got their own spin on it.
00:13:19	S1	All right. Question seven, do you know, to your knowledge, if there are processes in place to assess the risks related to managerial and workforce capabilities or technical issues which can affect the achievement of those requirements related to energy performance?
00:13:43	S2	Risk. We do have a risk register or project risk register and within that document which is split basically into three, commercial, sales, you know, if that applies, and the construction process and within that there is risk of let's say using a new subcontractor, that might not be au fait with our

		processes. To follow that up we also…KPI score, so that we have records on that and that's done on a monthly basis and dealt with at a monthly project review meeting. We also have a learning log, so at the end of project there'll be a wash-up meeting and anything that comes out of that meeting goes into a learning log that's held in the director's office. Yeah.
00:14:54	S1	Okay. That's good. Excellent. Question eight is to what extent the managerial team and the workforce understands the impact of defects on the energy performance of buildings?
00:15:11	S2	I think within our company it is…the understanding is to a high standard because we've been building, you know, these kinds of units for quite a number of years now. I don't know if I've mentioned, but I've been doing this job for nine years and over time I've seen improvements in design and the site management team are kind of heavily involved in being informed of, shall we say, employer's requirements, specification requirements. So, yeah.
00:15:51	S1	How does the…well, since you mentioned that you're constantly being informed about the client's requirements, how does this comes to you? I mean in terms of format? It's within the project documentation plan sections and specifications? The required specifications or…?
00:16:11	S2	*Housing association** don't provide us, bizarrely, with a book of specifications, but what they have is something called, the abbreviated, it's called tech spec and it's technical specification, but that is a document that we refer to and use as a working document. It's a live document as well because we can add things to it, take things out through consultation with the RSL (Registered Social Landlords).
00:16:40	S1	Okay. All right. And, question nine of this section, what would be the challenges and obstacles faced when implementing quality management procedures towards achieving energy efficiency?
00:16:58	S2	Well, that's probably one of the easiest questions to answer. Challenges and obstacles are definitely people. If there is a fault, it's down to a person. It's the same in health and safety, you know, the biggest risk is the individual and, yeah, it's managing that. What we've done, and I think I've mentioned this already, is that we use sort of a bank of subcontractors, so we don't employ one firm to do one job, we'll employ several firms to do one task, you know, because we don't like putting all our eggs in one basket. But, because we use the same people over and over again, over the years, they've learned, they've become au fait with what's expected and the only thing, there's still a risk there because they're employing different people,

		you know, people over churns, there's a lot churn in the industry, and that's difficult to manage.
00:18:10	S1	All right. Okay, we you have a constant flux of different and new people coming in and out.
00:18:15	S2	Yeah. I mean, there are the same old faces, but it's usually, the churn isn't usually at management level issue, it's usually at the operative level, so, you know, we usually get the same supervisors, the same contracts managers, but yeah different operatives and that's the difficult one.
00:18:37	S1	Okay, moving forward towards resources. So, question 10. So, who's responsible for developing and implementing those quality management procedures?
00:18:53	S2	Within our company, it starts at the top with the director and at the top from the client's management team as well. And, as I've mentioned before, the RSL (Registered Social Landlords). will employ an external body that's monitoring quality and that just isn't…I mean these are professional people that are coming in to survey us and assess quality performance, and because it's not just about aesthetics, it's not about whether the paint's [inaudible 00:19:38] or not, it's about whether that property works or not, you know. Do the doors close properly, windows close properly? You know, is the insulation put into…details you know.
00:19:49	S1	Okay, at what stage do independent surveyors…?
00:19:56	S2	They're appointed right at the start, but their surveyor will only start coming in towards the end of the project. So, obviously, a surveyor's costly and that is a difficult one because if the client supervisor is not doing their job and the site manager is not doing their job then the surveyor comes in and they can absolutely hammer you with…or baffle you with science and that could be a problem on handover. Fortunately, I've never had to…I've not heard of it happening, but I could see it happening. I know of it happening with some of the nationals, you know, like southern 106 RSLs, you know, because they're not au fait with the product.
00:20:47	S1	Okay. So, the…as you said, because of costs they end up coming more frequently at the end of the process?
00:20:56	S2	Yeah, and it's not good for your business that. I've always said that, you know, your name is only as good as your last job in construction.
00:21:07	S1	Definitely, I agree with you.

00:21:09	S2	Yeah, and unfortunately, it's so easy to get bad name for yourself and, you know, I'm of the [inaudible 00:21:17] you know, if you don't know the product, don't touch it.
00:21:21	S1	Okay. About…can I ask you, well, just to explore a bit of the local authority's quality control, how often they come in and at which stages of the construction. If they come, would they rely on your reports or how does it happen?
00:21:40	S2	There is an inspection. There's an inspection regime put in place by the building control which is not necessarily local authority building controls; we can appoint an independent. And again, that's probably down to cost as well, but the people that I've worked with, so this is just personal experience of being quite thorough with the inspection regime, some are a bit fair, yeah. And, if you just bear with me a second I can read out the list of…. (Pause) So, the inspection regime starts with excavations for foundation and then we got ground floor construction which in timber frame probably in any construction there is an element of insulation then the next inspection is damp proof course, the drainage is inspected, the cavity walls lintel level, timber frame first floor, because we are building with timber frame rather than traditional build, and the roof is inspected and then completion.
00:23:02	S1	All right.
00:23:04	S2	So, yeah, I think the important one, in terms of which I think they all should see is the pre-plaster in inspections so that would be, you know, the timber frame, first floor, insulation floor, that kind of…because where the building can fail from thermal performance. Obviously damps, that's water ingress and that's another story, but yeah, in terms of thermal performance the important inspection, for me, is pre-plaster.
00:23:39	S1	Okay, all right. So, question 11 was about having a specific team in place to ensure the quality and as you mentioned you have a building control coming in and then near the end of the process, they have the independent building surveyors again?
00:24:01	S2	Yeah, and because we give a warranty on these houses. So, warranty comes with these houses and we don't use an NHBC, we use premier guaranty. And, they're not building inspectors, but they will just come in once a month and take a snapshot in time. And, you know, if they pick anything up, hopefully they don't, you know, it will go in the book and they will be able to ask us to action that, but they don't check on whether that's being done, so….

00:24:32	S1	Mm-hmm, they just come and have, as you said, a snapshot and get an idea of how things are going.
00:24:39	S2	Yeah. So, we do have a team sort of, but you haven't got someone there full time, that is just purely reliant…because it's day to day, minute by minute, it's reliant on the site management team, so….
00:24:55	S1	Okay, all right. Question 12 is about, we've talked a little bit about this, it's about if there's a specific procedure in place to create awareness of quality requirements related to energy performance among the participants. I mean in terms of induction, training, skills accreditation or it's more like informal daily basis conversations or toolbox conversations, things like that?
00:25:30	S2	Yeah, we have meetings. Actually, we have a weekly planning meeting with all our subcontractors, but that's just for the supervisors to make sure that, one, that they're doing it when they should be doing it, you know, and they can obviously talk to one another so that that can happen so that we're actually, you know, being a bit more lean with our work processes. It's also an opportunity to bring up any issues that they might be having in terms of build. We have…before they even come to site, we have a preambular where everything's laid out in document form for them to…we talk it through them, you know, this is what we expect, you know, details, you know, team [inaudible 00:26:25], consult drawings. It's not good enough to for me to go out on site and see something wrong that's not to the work's information and then turn around and say, "But, that's what we've always done." That's not acceptable, you know, they've got to read the project's works information, yeah. And, we find a lot of that, we find a lot with the operatives, "Well, that's what we've always done," and it's so wrong. So, that is one thing that I bring up at induction. So, every operative receives a health and safety induction, but I bring a little bit into it sort of saying, you must consult the works' information because that's probably the only time you're going get a one to one with that person.
00:27:13	S1	Yeah, definitely. I can agree with you. In your opinion, question 14, does the company, *Contractor**, provide a proper environment and all the necessary resources in order to achieve quality and the quality requirements proposed for the project or should something else be provided in terms of giving you the right resources to assure quality?
00:27:41	S2	Because we were talking about *Project* * where I had, shall we say, difficulty at the front end of the job, so as a site manager, I'm on my own until the timber frame goes up and then I get a site assistant who will be going out

		and do the QA checks along with the supervisor of that trade and we do have some QA sort of tick sheets, you know, which we create ourselves because every site is different. There some similarities, but there are some anomalies as well, so yeah, so we have site-specific QA sheets which we create as we go along. Because we're talking about *Project* *, I was let down by…I wouldn't like to say that the company let me down, but something happened that let me down and what I was finding was I did not have continuity with my assistant site manager. So, I get one for weeks, then he'd go and then I'll get somebody else and you can't run a site like that because…
00:28:55	S1	No, I can imagine.
00:28:56	S2	…everyone's having to learn that little bit more. Yeah. They just seem to think that, you know…and it's just one failing that I can think of because in the main, you know, the company's a pretty good company, a good build company and got a good name for itself, but that said, me personally, I was let down on that project and I had…. (Overlapping Conversation)
00:29:19	S1	I understand what you mean, they have a learning curve and then when these people are getting their knowledge of the project as a whole, they move on to another one.
00:29:26	S2	Because the project evolves and you've got to live it, that's what I do, I live it.
00:29:30	S1	Yeah, that's it. And, it takes a while for to absorb all the characteristics and the things that you should be aware of.
00:29:36	S2	Absolutely. I've got easiest job in some respects of the site team because I see it from the ground whereas some of the assistants will come in and he's got a bit of learning to do before he can move on.
00:29:51	S1	Definitely.
00:29:53	S2	And if you haven't got continuity, all that learning is lost.
00:29:57	S1	Okay.
00:29:59	S1	Moving on to quality metrics and question 15, which are the performance attributes are considered by quality planning project? I mean, you know you have…at the end of the road, you have to check for a pressure test, for example, this is one of your performance attributes, the other ones are

		related to U values which are defined in the design. Okay? Do you see any other targets that must follow or comply with?
00:30:35	S2	Not that I'm aware of. I mean, that will probably be something more dealt with by the design team and the project manager.
00:30:45	S1	Okay, all right.
00:30:48	S2	With energy performance, I know in the design because I've been privy to some pre-construction meetings in terms of timber frame and the insulation and U values associated and I know that you can put sort of a less quality…is quality the right word? Let's say you can put a timber frame with a less robust insulation in, but you have to make that up elsewhere. You know, it's all about balancing.
00:31:23	S1	Yeah, [inaudible 00:31:23] give you this kind of liberty to compensate off certain…. (Overlapping Conversation)
00:31:26	S2	Yeah, that's right. Yeah. And, I know they…I know, like in terms of timber frame that the actual frames are…there is not just one timber frame, there are several and they've all got like a rating. Yeah, so.
00:31:37	S1	All right, okay. And you mentioned that this specific project, *Project* * I mean, are you following, do you comply with building regs (sic) since you don't have any more the code for sustainable homes in place anymore? So, are you going back to…?
00:31:57	S2	We're going back to building regs (sic), but I believe that building regs (sic) have taken on some of the good points that came out of a code for sustainable homes and they've kind of met half way. So yeah, I believe that building regs (sic) have taken on some of those points that got covered, yeah.
00:32:25	S1	And question 16. We're going back to a couple of minutes ago when you were talking about your ticking sheets that you use to check quality. Do you have a similar procedure for defect identification?
00:32:43	S2	Yes, we do. We have a snagging sheet basically. So, that wouldn't be used until the end, sort of towards the end of the project, and I think the snag sheet is whilst it will pick up, you know, do the doors and windows work correctly, yeah, so that's about energy performance as well, it will be too late at that point to be checking insulation other than what's in the roof…
00:33:16	S1	Yeah, because they're all covered now.

00:33:17	S2	…because it's all closed in. And, the other thing is because the insulation is installed in the timber frame in the factory…
00:33:26	S1	All right, that's…. (Overlapping Conversation)
00:33:27	S2	…yeah, we've got no way of knowing. It's a closed panel, but we've got no way of knowing that that without a [inaudible 00:33:35]. And, the query I had was because I know me and you went to a visit at the timber frame factory and one thing that I remember, what I took away from that was when they turned the frames over, I don't know if you recall, they would put the membrane on and then insulate and then they would turn the frame over and I was thinking, "When that's vertical, does the insulation drop?" Yeah. So, we have no way of knowing that because when it comes to site, we've got to assume that that…. Yeah, a difficult one.
00:34:07	S1	Yeah, that's right. I remember another issue when you have close to the edges you have one batten perpendicular to the other one and then you have to make sure that the insulation goes on the back of this one. (Overlapping Conversation)
00:34:22	S2	Yeah, I know that timber itself has an insulation value and I'm not an expert on it, but what was…as we were just discussing, is a 140 mil void to fill with insulation, then does that…because you're halfing it, because of that perpendicular batten you're halving the thickness in effect. Do they compress that insulation to put that in that gap? Because if they're compressing it, then it's not performing as it should, as it would at 140 or are they cutting the insulation to…? (Overlapping Conversation)
00:34:56	S1	But again, down to the construction site, you have to take it for granted that the guys in the factory did their job properly, right? There's not much to do. (Overlapping Conversation)
00:35:03	S2	We used to sign off the Robust Details sheet and a pattern Robust Details where there was a detail about exactly that sort of scenario that we have just been talking about, and I refused to sign that because I couldn't put my name to something I cannot see. Yeah.
00:35:30	S1	Yeah. Well, question 17 is pretty much when the performance attributes are monitored and the defects are collected as well and you just mentioned this pretty much on the end of the process where you do the snagging into one.
00:35:46	S2	Yeah, like I said, we inspect the properties at the end, but they are subject to a defects period. So, currently with the RSL, it's a year's defects period,

		and in the past, I'm not speaking about *Project* *, I'm talking about before *Project* * because we've learned lots of things before we got to *Project* *, it became clear that insulation was so important that the detail was absolutely spot on to the works information because I recall in a couple of houses black mould growing and the only way that black mould would grow is if you've got a cold bridge…
00:36:36	S1	Yeah, exactly.
00:36:37	S2	…because the insulation's not adequate.
00:36:40	S1	Yeah, the detail was not working.
00:36:41	S2	Yeah, and the detail's not done as per the works' information, so yeah, that isn't a good one.
00:36:50	S1	Okay. About…well, question 18 is about the sampling approach used to assess the quality in terms of the number of housing units to be monitored. I remember about…in terms of their pressure for instance, you test 100% of the units, right?
00:37:09	S2	Yes, we do.
00:37:10	S1	So, you do much more than the building regs (sic) ask you for?
00:37:14	S2	Yes, absolutely. That is an employer's requirement, and also, with sampling for a test, which sampling comes in when you're only testing a percentage. Then they would have…they have to add out to the average reading. So, let's say we've got five houses that we need air tests for, but we could do it on sampling so it would be two out of five, but then you take the average of the two and then you've got to add a score of two for the three that haven't been tested, so you could be over, you could be under, so it is easier to just test the whole lot.
00:38:03	S1	Okay, and it's more reliable as well, yeah.
00:38:06	S2	Yeah, and the thing is if it fails, you know, if your sampling fails then you've got to pay for a whole new visit again. Yeah, so you might as well just do it.
00:38:17	S1	Yeah, that's right.
00:38:19	S2	So, it's a false economy not to.

00:38:21	S1	Yeah, and in terms of defects collections and inspection, you pretty much run the whole development on your own?
00:38:31	S2	Right, in terms of…after the project's complete, as I've mentioned before, there's a year's defects period. Within that, we've got…we'll get phone calls from the client, from the end user, and they're passed on to us because we've got to deal with any potential defects. But, we have a log and that log is not just a record of when we attended or when the call came in, it's also about looking or identifying where problems might be so we know where to look at for the next development, all part of the company learning log.
00:39:19	S1	All right this is really important because it's continuous improvement right? It's the only way for you to….
00:39:23	S2	Yeah, absolutely. We have…there's currently a girl in the office, I', not saying it's just a girl can do that job, but a lad could do it just as well, and yeah, she's full time on it. So, she's not only, you know…what's the word I'm looking for? Getting the guys out to address the defects, but she's also monitoring and collecting information and using that data to find out where our weaknesses are, if you like, if any.
00:40:03	S1	Okay. Yeah, well, I think the only way for you to improve is to identify opportunities or where you should be performing a little bit better here.
00:40:12	S2	Yeah, that's right, yeah.
00:40:13	S1	That's really….
00:40:15	S2	And, that's fed back to us, so it's not just kept within the office, you know. We have site management or site managers' team briefings and whatnot, you know, and that's fed back to us so that we know what to look out for on site.
00:40:29	S1	Okay. All right. So, you mean you can say that the experience of the site manager or let's say the site inspector that it's completely important in terms of knowing what to look for and what kind of issues that might go wrong that you have to be aware of.
00:40:52	S2	Absolutely. The biggest thing, I mean the biggest tool that we've got is communication. And, if everyone's talking to one another and, yeah, that's the only way you're going things…I would say, you know, aim high and you'll get somewhere near. Yeah.

00:41:12	S1	(Chuckles) Yeah, that's true. Well, the last bit is about quality compliance, and question 19 is…asks about how quality compliance is reported in terms of content format and frequency. So….
00:41:31	S2	Right, we do have, like I've mentioned before and we have it on our last schemes is a project meeting and within that…that's monthly. So, we have a monthly project meeting. We always do that before the client's meeting, so we're not going into the client's meeting like go…. (Overlapping Conversation)
00:41:52	S1	On the blind, yeah.
00:41:53	S2	Yeah. I mean, we cover every aspect of the projects in that meeting, but including quality. So, yeah, have we got any issues, you know, we might have a quality issue with, I don't know, red on barrier and the insulation detail in the floor or wherever, so that is recorded because it would be…it's a minuted item within a meeting which is going to be actioned and then that would probably also go within the client's supervisor's report because he's got a little bit of input. And, it's a two-way thing as well, you know, because he'll ask me, "Do you know any defects out there?" Well, we're not about covering defects. We're about…we're both as a team, as a project team, we're all about getting this building out to a high standard.
00:42:49	S1	It's not about putting blames, right? It's about a creating a solution, yeah.
00:42:50	S2	No, it's not. It's about solutions, yeah.
00:42:55	S1	Okay.
00:42:58	S2	I don't know if I've answered all that question fully, but yeah, we've got [inaudible 00:43:02] meetings. Audits, yeah, we do have audits. We have external auditors come in and they will come in and they go through everything obviously. (Laughs) Yeah, it's a full audit, yeah, just for a site visit, you know. And, they do go through everything. So, you know, are filling in our QA sheets? Yes, we are, tick a box, you know. It's…yeah.
00:43:29	S1	Okay. Question 20, regards do you have specific procedures to analyse the reports and the defects records? You've mentioned that you get together every month and then you go, you run through those, well, defects and things that might come up?
00:43:54	S2	Actually, yeah, there's a table of defects and it's a bar chart and you can see where the main defects are.

00:44:01	S1	Yeah, and who participates in those meetings?
00:44:03	S2	That will be project managers, site managers, managing director, so it's that kind of level. But, if we got issues with let's say for example, windows, then we've probably got an issue with the supplier. It's probably, you know, if you've got…it's probably not the install, it might be the product itself so then we can go back to them and say, "Look, what's happening?"
00:44:27	S1	So, it's pretty much on to the next and last question which is question 21. How is this feedback provided to the different parts of the project when needed?
00:44:39	S2	Yeah, we report back, good and bad. So, we…actually it came in too late for *Project* *, but now we've got something called A-Site, I don't know if you're familiar with A-Site.
00:44:55	S1	No.
00:44:56	S2	It's somewhere where you can store the works' information, but it's also somewhere where you can log defects or you can keep your photographic records in there. It's just a complete package that everyone who's invited into A-Site for that project gets to look…they can see everything. So, there's no excuse for not…
00:45:25	S1	Not running.
00:45:26	S2	…not knowing, yeah. But, that's a new thing and, you know, we've got to…well, even I've got to learn a little bit more about it, but our subcontractors have got to learn how to use it. Because it's something new, they're frightened of it, you know, and it's always the same with something new. And, it goes back to those….
00:45:45	S1	How do you call it again? Air Site?
00:45:47	S2	A.
00:45:48	S1	A-Site.
00:45:48	S2	Yeah, so it's A for alpha. A dash Site.
00:45:51	S1	Okay.
00:45:52	S2	Yeah.

00:45:52	S1	And, what is the format? It's paper-based or software?
00:45:56	S2	No, it's out there in the ether. Yeah, it's software, yeah. And, yeah, you just tap in your project on it and then that will…if you've got an invite to that project, then you can look in on that project. But, as a company-wide thing, there are many projects on A-Site.
00:46:18	S1	All right.
00:46:18	S2	Yeah, but if you haven't got an invite to that one, so it stops from people being nosy and whatnot.
00:46:25	S1	Yeah and who can, for example, for a specific project like *Project* *, if you have this platform, who is authorised to upload information?
00:46:35	S2	Well, we have one dedicated guy in the office, he's on pre-construction. I'll say, one dedicated guy on his team who will collect…he collects all the information. Right. When we come to cut the ground or just prior to that, that is then handed over to the site team and then it will be the project manager then who will collect information rather than the pre-construction manager because as you know, things change, you know we get revisions on drawings as the site evolves, so….
00:47:13	S1	Okay, so you have a…well, a place that is continually being fed with new information from the whole process so stakeholders can go there and assess the situation.
00:47:27	S2	Yeah, yeah, and we know and in turn they know who's not looking at drawings, who's not looking at that information because if you haven't been looking you'll get a reminder every morning at half past seven, yeah. (Laughs)
00:47:39	S1	Okay, okay. Just to make sure that you have the last version of the files.
00:47:43	S2	Yeah, and the person who has ownership of that project, namely the project manager, he can also see who's not doing their bit because it will come up, "Oh look, there's a big batch out there, with a big bar in it. Oh, they have not looking the drawings, there's no wonder their details are wrong." You know, it's…I'm not saying that that happens, but…. (Overlapping Conversation)
00:48:04	S1	Yeah, so it's a management tool.

00:48:05	S2	It's a great management tool and we can also…you know, we can go out on a site with our phone, the details are on, photograph, e-mail it to the subcontractor, but then we e-mail it blind copy to A-Site then we've got a record of it because we find that logging photographs is so difficult.
00:48:30	S1	Yeah, it is.
00:48:31	S2	It's job on its own, but photographic evidence because the camera doesn't lie.
00:48:36	S1	Yeah, exactly.
00:48:37	S2	And, photographic evidence is so key to a project.
00:48:40	S1	Indeed, it's a very powerful tool?
00:48:42	S2	Yeah.
00:48:44	S1	Thank you very much for the information.
00:48:50	S2	You're welcome.
00:48:50	S1	It's invaluable.

*Complying with the principles of ethics of the research, the names of the participants and companies were omitted.

[00.48.52]

Interview 2.a and 2.b – Transcript

Timecode	Speaker	Transcript
00:00:01	S1	So just before we get started, I just wanted to make sure that you all got an information sheet which is one of the requirement of the ethics committee of our university. And then if you could please sign the consent as well. As I said before, all the information here is to be treated in complete anonymity. And after the information will be released, as you say, of course the interpretation and so on.
00:00:42	S2	What's today's date?
00:00:42	S1	Today is the 20th.
00:00:46	S2	20th?
00:00:47	S1	Yeah.
00:02:14	S1	All right. Well the interview names of both of you I already know. What is the professional qualification of you guys?
00:02:25	S3	I'm a chartered architectural technologist.
00:02:33	S1	And you, Development Manager*?
00:02:33	S2	Working towards Master's degree and also RICS accreditation.
00:02:38	S1	Okay, perfect. All right. And years of professional experience?
00:02:43	S3	I've been in construction since 1984.
		(Overlapping conversation)
00:02:55	S3	Being with Housing Association* for the last 16 years.
00:03:03	S1	Which is good, it's excellent.
		(Overlapping conversation)
00:03:06	S3	Just caught me before I retired.

00:03:13	S2	So I've been with Housing Association* for about four years and in this role about two and a half years now in housing development.
00:03:18	S1	Okay. Excellent. Wow, that's good. Your role in this project or in the housing association, you're the development manager?
00:03:28	S3	Yeah, yeah. Design and quality coordinator. Because of my architectural background, I still on occasion have a design process to fulfil. So small schemes.
00:03:43	S1	Okay. And well I guess we always work with a project as a background for all this kind of information. Or the answers we will be talking about. So in that case we're working with Case Study 1* and Case Study 2*.
00:03:56	S3	Which is perfect.
00:03:57	S2	Yeah, that's fine.
		(Overlapping conversation)
00:04:00	S1	Okay, perfect, okay.
		(Overlapping conversation)
00:04:06	S1	With Site Manager* and, gosh…
00:04:11	S2	Site Manager*.
00:04:11	S1	Yeah, exactly. And well the housing association name we all know, Housing Association*. What is the number of assets you have right now?
00:04:23	S2	Must be pushing…
00:04:24	S3	Three thousand, three and a half thousand is it?
00:04:27	S2	It's between three and a half and 4,000 now. I forget exactly, but it's around that sort of mark.
00:04:35	S1	Okay. And the number of ongoing projects at the moment?
00:04:40	S3	Development?
00:04:43	S1	Yeah. Under construction or under design?

00:04:44	S2	We've got about six or seven on site and then another 12, 15 coming through the pipeline.
00:04:54	S1	Wow.
		(Overlapping conversation)
00:04:56	S1	That's excellent. A lot of jobs. Okay. Does the organisation have any quality accreditation like ISO or…
00:05:09	S2	Yes. It's got a number of those. We can get those details for you, but Professional* deals with that. It's got a whole host of different ISO…
		(Overlapping conversation)
00:05:20	S3	Yeah, it's got several. I forget how…
		(Overlapping conversation)
00:05:28	S1	All right. The project we talked about. The number of housing units, I have all the details from the projects. Okay. Do you remember…well, roughly…the project of [inaudible 00:05:44]?
00:05:45	S3	Yeah, actually I [inaudible 00:05:48] just over 3 million Pounds.
00:05:50	S1	Okay. In Case Study 1*, yeah?
00:05:52	S3	Yeah, just over three million.
00:05:53	S1	And Case Study 2*?
00:05:54	S2	I don't know that one.
00:05:56	S1	That's okay, I can find that out.
00:05:59	S2	I can forward you that one afterwards.
00:06:00	S1	And the stage of the project now is…
00:06:03	S3	Both sites are completed actually. Case Study 1* completed on the 15th of January, wasn't it?
00:06:17	S1	And the procurement of wood for the two of them?
00:06:21	S2	So we've got an in house contractor…Contractor*…they are part of the Housing Association* Group. And so all of our own build schemes that we

		do in house are procured through them and are built out through them. We have sort of external opportunities, don't we? We buy off the shelf units from developers [inaudible 00:06:41]. In which case you go out and buy them from the various developers. And anything you develop and actually build ourselves goes through Contractor*.
00:06:50	S1	Okay.
00:06:53	S3	What we have to do is a get a value for money statement from our employer's agents. So honestly, make sure that the costs are in line with market and then risk appetite and everything.
00:07:02	S1	Okay. And the design and responsibilities are to Contractor*, or you do it here and then pass it on to them?
00:07:13	S3	So it's changed. So we've gone from any contract where Housing Association* would sort of appoint the architect and the engineer and we'd work up that initial design, but to sort of realise some VAT savings and push the design liabilities and risk onto the contractor which is on a build contract. That some of come across together good now, but if we're looking at Fraden in particular, that would have been done by us initially.
00:07:41	S1	Okay. So traditional kind of route, okay. Excellent. I'll go to the quality planning constructs…well, going to the requirements and objectives. May I ask if Case Study 1* and Case Study 2*, do they have formal quality plan or is…or is something more informal that you have a particular way to do it and then you don't have to put it on specific plan?
00:08:14	S2	So when we talk about our quality plan, are we referencing to requirements and tech specifications and things like that?
00:08:25	S1	Yes.
00:08:27	S2	So we have a sort of standard technical specification that all of our projects have got to meet and that are sort of agreed and basically produced by us at management team and various other stakeholders. So that forms part of the contract documents and part of the employer's requirements. So I guess that would be our sort of our plan sort of thing.
00:08:46	S1	Okay. So those requirements come from a broader perspective. I mean, you really don't deal with a particular requirement for this or that development? It's pretty much one that you have for all the…

00:09:00	S2	Yeah, yeah. I mean, it sort of gets evolved slightly and tweaks are made to each year based on, you know, if you want to make some cost savings in an area. And it would serve as one…
00:09:13	S2	To, you know, managing the project or there's an ongoing maintenance issue that we've identified. So that's how that's sort of document involved, but generally we'd use that across the run of projects. And including if we get in early enough, when we say we buy units off developers, if we get in early enough in the process and go through planning, [inaudible 00:09:35] given that document they'll still abide by that [inaudible 00:09:38] and everything. So it's quite, you know, the sort of document we use.
00:09:43	S3	And particularly if we're using government funding there are certain criteria we have to meet with design. SAP assessments and code for sustainable homes just recently left us, but a lot of items have gone from code into the building regulation. So it's statutory requirements that we need to meet as well and the criteria standard as well.
00:10:06	S2	And I guess in the past as well. We had those particular funding streams where we need to adhere to certain criteria, that would then from part of the design proof we'd give across even to the architect or the contractors I would say.
00:10:20	S1	So you both answered the second question. That would be about in terms of quality requirements established for the project. High energy performance aspects part of the scope of the quality plan and then you just said you used to go for the [inaudible 00:10:37] homes? Do you use level four?
00:10:40	S3	We have done…
00:10:41	S2	We used to do…well, predominantly community agency funding stipulated a code level three. We've done a couple of projects that code level four, but generally it would always be for that code level three. Since that's the normal requirement and sort of that funding, it's just building regulations, isn't it, now to meet the requirements of that.
00:11:04	S1	So am I right to say that for Case Study 1* wise and Case Study 2* as well, you go for building regs in terms of energy performance targets, in terms of U values and so on?
00:11:16	S2	Yes.
00:11:16	S3	Yeah.

00:11:16	S1	Okay. That's pretty much the third, but do the requirements regarding to energy performance so building regs. So this is pretty much you've answered already. What other requirements related to energy performance are part of the strategic goals of the organisations…from the organisations…or only specific for the project? You said that you are constantly tweaking your general quality plan. That according to the information and the specifications that you get from year to year and that this plan is used for pretty much all your new developments, right?
00:11:57	S2	Yeah correct, yeah., that's
00:11:59	S1	Okay. And with this process, after finding those requirements, how is this information documented and submitted to the participants after the project? I mean, design wise for instance?
00:12:19	S3	We've recently set up a management program called **ASITE** and all of the project information is now loaded onto that site. And all members…strategic members of that team…have access to the information package. I do know that you guys have a system as well. How else can we operate as we go forward because the upfront part of the developments now, it's going to be interesting where that information will sit. Because if we're going to have Contractor* appointing the consultants, a lot of the upfront information will be on ASITE as well. [Inaudible 00:13:02] it wasn't, was it? It was sitting in the development filing system. So that has changed slightly, I'd say.
00:13:09	S2	Yeah. So…and that is not just important being on that system, it forms part of the contract documents as well. So whenever we are negotiating contract with Contractor* or contractor or whatever, they will be aware of…
		(Overlapping conversation)
00:13:29	S2	…to a technical specification for departments X.
00:13:34	S1	And ultimately this is the only way that you can make sure that you have to comply with…
		(Overlapping conversation)
00:13:41	S1	…positions that have been made.
00:13:42	S3	Because quite often, you know, things will come back and they'll all say well we haven't done that. And they'll say well why don't we have to do it? It's here.

00:13:50	S1	Yeah, that's right. Okay. Going to risk assessment which is a very interesting part. Which stakeholders are involved in the process of the finding this quality requirement related to performance? And when does it happen in the project's time span?
00:14:13	S3	We're part of the Advantage South West group. And there's a couple of parts to ASW. There's…I attend a platform called Design Innovation Group and we have standard house types. And a lot of the information put in those standard house types together comes from residents, from all the respective organisations, members of ASW, so we get a lot of information fed in and fed into our house types. So when we construct, we fully…potential residents are fully informed of how we're going to build, what suits, what type of properties, layout and that incorporates thermal insulation and sustainable products. And we also have a procurement arm at Advantage South West where we procure lots of our elements…kitchens, heating systems, bathrooms. And because we buy in large numbers it reduces a lot of the costs as well.
00:15:21	S1	Okay, that's really important with information you've been managing to deal with.
00:15:25	S3	Yeah. I mean predominantly our heating systems that we're using are like an air source heating type system. Which is quite sustainable and efficient and the U values to match, obviously to be building regs minimum standards.
00:15:45	S1	Okay. Do you have a process in place to assess the risks related to managerial and work force capabilities or technical issues which can affect the achievements of those requirements related to energy performance? That's pretty much what you've been talking about, right?
00:16:05	S3	Yeah.
00:16:07	S1	So we have this group of people that discuss…
00:16:09	S3	We…during construction, we obviously…the contractor is fully aware of our specifications. We also have a premier warranty provider that visits our site and checks our construction phase. Obviously myself, the asset team at Housing Association* who will eventually take on the properties have an investment obviously in the properties and an interest in what's being built. In house we have a technical forum which all members have a vested interest in the new build and after the build. And there will be an ideal

		platform there for any input into items, elements that they'd like to see in the new dwellings.
00:16:59	S1	Okay. So you have an overlapping activities or groups fo people going to the construction site…
		(Overlapping conversation)
00:17:06	S3	Not…a lot of consultation goes into our builds, doesn't it? Predominantly to the standard house types and specifically schemes for civic. Sometimes we can have input as well. And if things are not quite working, there's opportunity to make tweaks and changes in that.
00:17:26	S2	Yeah, definitely.
00:17:27	S1	Okay. The next question is to what extent the managerial team and workforce understands the impact of the defects on the energy performance of the buildings, of the buildings of the projects? Well, you said they fully understand the specifications that they have to comply with and deliver at the end of the day. So I assume that they are fully aware of what non-conformance can impact on the energy performance.
00:17:59	S3	Yeah, definitely. And all our buildings are air tested at the end of the build. So if there's any leakage or weakness in the buildings, that will flag up at that stage. So they're working to that final test. So it's critical they detail correctly on the site and build those details out correctly. Yeah, we use one method of construction and we build predominantly timber frame, as you've seen. And, again, it's…
00:18:31	S1	It's mind blowing.
00:18:31	S3	Yeah. And it's really critical the details on why for that form of construction to get that quality.
00:18:41	S1	I mean, exploring a little bit of the implementing what you said, we have several different layers of quality check made by different people. What would be the challenges and obstacles that you face when implementing those quality managing procedures towards achieving energy efficiency? Can you think about any challenges?
00:19:11	S2	I guess it's just having so many trades working on a development, isn't it? It's a knock on…because you've got so many bodies on it, you know, somebody dings something, somebody, you know, bridges a gap or…I think there are also so many processes go into construction process. I think

		you've got a lot of opportunity for things to go unseen and once it's boarded up, you can have as many eyes as you wish, but you know, they can't watch everything, can they? I think…and you're on site every week. And, you know, we can't be the police of these things
		(Overlapping conversation)
00:19:46	S3	What we try to do is educate and particularly with our site management teams, the likes of myself, we're not reliant on our building regs inspectors and our premier inspectors, but they go to make up that team, looking at the project continually. So…and the more you can make the site operatives aware of what you're trying to achieve, then they have an understanding as well. So the contractor has regular toolbox talks you call them on the side, so those are areas where you can implement to the operatives what we're trying to archive. So there are several layers where people are very vigilant on site, but Craig's right, trying to get it 100 percent is very difficult. This is where the testing at the end of the build comes in. So if you're not quite detailing correctly, the air pressure test is not going to work. Because we are as vigilant as we can be, we tend to…we can tell when we're testing that they are pretty there
		(Overlapping conversation)
00:20:51	S2	I think…just another thing springs to mind. A former site manager said to me last week, I think managing the sub-contractors can also be a challenge when you've got defects that are related to the site generally or to energy performance and they are not going to fix that workmen. Shit can happen on the final product. Because he said to me, our guys…this is in the direct report workforce our own, you know, they're employed by Contractor* and getting paid by Contractor*…they do something wrong, they'll come and say sorry boss, I did that wrong. However the difficulty comes when you've got a sub-contractor at the sort of price is less likely to come back and say I just dinged that or I just did that. So..
00:21:39	S1	They want to be gone…
		(Overlapping conversation)
00:21:42	S2	I think the opportunity not necessarily to cover things up, but I think there's more open and honesty with the direct workforce than if you've got a lot more sub-contractors. So I think that difference in culture can…that can be an obstacle, maybe.
		(Overlapping conversation)

00:21:56	S1	So to you the process is making people aware and creating environment…
		(Overlapping conversation)
00:22:01	S2	And you want your [inaudible 00:22:01] and people not working for you directly just to come and talk to you, don't you?
		(Overlapping conversation)
00:22:08	S3	We're not there to be critical, we're there to improve. And make sure the building for the correct specification. It all comes back to that specification. And the more people that are looking at that build process on site, the more chance we've got of achieving those specifications. And that's what we try and get across.
00:22:30	S2	And I guess it wouldn't be good if…I think we've got pretty good payment terms and a pretty good reputation in the industry, so I think they're quite good at amassing a group of sub-contractors that want to work for them regularly. So I thin by building up that rapport with the regular sub-contractors for regular work is positive as well, isn't it?
00:22:50	S3	And the other critical thing is they're part of the group. Our contractor is part of the Housing Association* Group. So it's in their interest to make sure they get that right as well.
00:23:00	S2	Because they don't want to come back and rectifying defects.
00:23:02	S3	Yeah. The last thing they need isn't it?
00:23:05	S1	And with this policy about being good payers and contracting for, well, good values, does give you good advance stage of working with your [inaudible 00:23:21] sub-contractors instead of going around and having different people working for you? Can you manage to work with the same people?
00:23:27	S2	I think so. I mean, I couldn't name specifics, but I know of…I've heard project managers talk about one or two sort of carpentry and mason gangs that said well how much work can you guarantee me over the next two years? Because I don't want to go and work for [inaudible 00:23:41]. You know, I don't want to…don't pay me for 90 odd days and I don't live like that. You know, pay me well each month. I think it's quite evident, really.
00:23:52	S3	Yeah, we've got an attractive works program. We're in a fortunate position where we self-generate a lot of our work. We also do get funding along the way, but we work hard at that. And we've got a nice bubble in the way

		program for the next few years. And that's attractive to sub-contractors. To be able to work in the same area and not have to go away to work. So that puts them…
00:24:17	S1	Huge step towards having this no blame…
		(Overlapping conversation)
00:24:24	S1	Yeah, that's excellent. So going towards resources. Who's responsible for developing and implementing the quality managing? Well this is pretty much answered now. You do a quality plan and then Pete here is responsible for implementing this…and checking them over, looking…
00:24:49	S3	I work alongside these guys as well in putting those specifications together to make sure we get that work. I actually chair a platform
		(Overlapping conversation)
00:25:00	S3	When that's discussed by all respective parties that have a vested interest in a build whether it be the asset team, the contractor, the client. Every person who's interested in that build attends that platform and we discuss it together. Sometimes it can be a bit long winded, but we generally get the answer that's the right answer for the project or the projects. So yeah, that works quite well.
		(Overlapping conversation)
00:25:33	S3	Yeah, we made a point of having this meeting on a quarterly basis. And just…even if it's just to get together and go across…we have some regular topics on there. We have a guy who attends from ASW, the procurement group. He'll give us a feedback, we have a defect section to see if there are any defects that regularly pop in so we can discuss that and decide how we can eradicate that going forward.
00:26:02	S1	And who participates again in this kind of meeting, in this discussion?
00:26:06	S3	I chair the platform. The developer who manages attends, dealing with the projects, the contractor and sends across his contracts managers so we've got three of those guys that come to the meeting. We've got the person who looks after their defects on our bills attends, we've have the asset team, the manager from the asset team attends and we've got our services unit who look after the maintenance look after the properties have a representative. And also the [inaudible 00:26:40]…anyone really who's involved in the product whether it be, everyione feedback. And if we take a

		decision, if we change a specification element, everyone's had participation in that change.
00:26:59	S1	Buyer comes as well?
00:26:59	S3	Yes, yeah…
		(Overlapping conversation)
00:27:02	S1	Buyer comes in?
		(Overlapping conversation)
00:27:07	S1	Then they have their say as well…
00:27:09	S3	Yeah, because if they can make a say on a particular item and it's…what we sometimes would do, this is a specific item we'd like you to build out, but if you could put forward…because we're on design build now…a likewise or similar product for a lesser price, we will definitely be interested in that and that's a great area we have when we discuss that.
00:27:33	S2	Yeah. And equally the Maintencace Team doing the leads and doing the day to day repairs, they can pick up issues with products down the line. Like say these mats are…they're rusting out after three years. Why is this happening and then Quality Coordinator* can talk to the procurement manager, you know, about addressing that with the manager out west. And it's a good forum, it gets everything out in the open rather than having lots of little conversations. I think you get a desired result pretty quickly, don't we?
00:28:00	S1	Okay. Going to put up [inaudible 00:28:05] because you've already answered, but I'm just particularly interested in, well, getting the link of what you just said. Do you have any specific procedure, I mean, to create awareness to the workforce, to the guys through the boots on the ground if we can say it this way about those defects that might affect the performance or things like that? Because we're talking about the contractor which is from the same group and I assume this is pretty much more approachable because you have well vested interest, you have a common interest in that. How do you deal with that with a sub-contractor?
00:28:44	S3	It's difficult for us to give that across because we're not at their toolbox talks. And I would imagine the likes of Site Manager* would be able to feedback better, but it's passed on from us on the client side, the quality control side. I would put that out there with them on site, but definitely talk to traders

		going around. If I'm not comfortable with their names, I will talk them through and say…but that will definitely happen on toolbox tools. The contractor will be encouraged to implement that from all of our designers, external consultants, to achieve the end product. So that's…so that talks its way down from each layer, doesn't it, and I'd like to think that's happening. Although I don't attend the toolbox talks, but I'm sure Site Manager* will be able to answer that…
00:29:32	S2	Yeah. You can probably get that from Site Manager* won't it?
00:29:35	S1	Okay. Do you think you could do anything differently in terms of creating this environment that we've been talking about? Do you think…is there any kind of infrastructure or maybe a different way to approach things in terms of talking to people? Do you think anything could be different? I mean, you're pretty sure that you're deploying all the necessary efforts towards…
00:30:09	S3	I think there's always room for improvement. I don't think that you can rest on your laurels. I think we're doing a reasonable job, if I'm honest, but I'm always open to opportunities to improve that…improve those methods, definitely. We're going for a phase in house as we speak, I can't speak too much about it where we're potentially restructuring. And I think the end result potentially of that is that we improve our systems and the way we work. So, yeah, I don't think we ever stop doing that. I think we're always looking…
00:30:49	S1	Continuous improvement…
		(Overlapping conversation)
00:30:50	S3	Yeah, exactly that. I don't think we'll ever sit back…I've been here 16 years and that's the beauty with this business. We're always evolving, we're always improving. We're always looking to improve the product.
00:31:06	S1	Clearly. Well, the next step here guys is about the quality metrics which is pretty much the more detailed information. And it's pretty much going down to building regs. So which energy performance attributes are considered by your quality plan? I would say that well, as you said, if you go for building regs, you have air permeability rates and you have the U-values. Do you have any other performance type that you look for or something different from the building regs?
00:31:39	S2	Water usage, that would be encompassed in building regs.
		(Overlapping conversation)

00:31:45	S3	We…previous to this obviously we were code for sustainable homes and that was driven a lot by the HCO funding. Since they disbanded the codes, a lot of those standards have naturally gone across to building regs. So at this present moment in time, we look to achieve building regs as a minimum. Going forward, that might well change. We might be looking to achieve higher standards, but at the present, it seems to be building regs, doesn't it, really?
00:32:15	S1	You just mentioned that 100 percent of housing units on the development are air tested, right?
00:32:21	S2	Yes.
00:32:23	S1	So yes, it's more than the building regs to have a certain amount, 30 percent of the…
		(Overlapping conversation)
00:32:30	S3	We test all of ours, yes, you're right. You need to test us? That's correct. So that is an over and above, really.
		(Overlapping conversation)
00:32:37	S1	That's good and I mean, it gives the message to the field works that [inaudible 00:32:43] after units will be tested.
		(Overlapping conversation)
00:32:51	S1	It can be quite effective, I suppose?
00:32:52	S3	Yeah, for sure.
00:32:54	S1	And for u-values, you have, what, the guys from building regs from [inaudible 00:33:02]?
00:33:04	S3	No. Premier look after our warrantees. So from building regs it's local authority building control inspectors or an approved inspector which is JR will visit our sites more regular. For different stages of the build, they go around checking the foundations, and each days just as we go up through to wall plate and then come back at the end for the finishing. Whereas Premier tend to come for all stages of the build because they're going to warrantee the build. And HBC.
00:33:34	S1	Okay. You have what, 10 years' warrantee extended?

00:33:40	S3	Yeah. This is more your forte, isn't it? We get our warrantees is it 10 years?
00:33:45	S2	Ten years usually, yeah.
00:33:48	S1	Okay, perfect. Do you have….in this project…specific procedure for defect identification and collection?
00:33:57	S3	Yeah. When we get to the end of the project…towards the end of the project before we get to practical completion, when the contractor is comfortable they've completed the build, they then ask for our employer's agent to come in and start the snagging progress. Or our project managers depending on how the setup is. They'll then attend site, myself will come initially to check to see what standards they've implemented. Bear in mind I'm not from the outside so I know what kind of standard they've been working to. And I will snag the buildings to make sure the quality is there. And they will return to do the back snagging and provided everyone's on board, the client attends as well for these sessions and then we'll get practical completion.
00:34:50	S2	I think taking a step back, you obviously do your weekly site visits and produce a report every fortnight?
00:34:57	S3	A bit longer. Probably more monthly now
		(Overlapping conversation)
00:35:00	S2	So if you have a defect section there, you pick up and you give it to the contractor each month.
		(Overlapping conversation)
00:35:05	S3	Yes. So we're vigilant all the way through the build. So yeah, that's part of my role to produce that report.
00:35:10	S2	And when the employers' agent go around with the snagging you have a list, you run through and you our have requirements from the technical specifications and project requirements. So you know, you'll be working through…it's a horrible task. It's a horrible, mind numbing task. Yeah, so I mean that's during the build and then post build we have the 12 months defects period when the tenants will phone us with an issues, any defects.
00:35:37	S3	That's a typical supervisor's report on a monthly basis. So I'll visit every week, minimum. Sometimes it requires more, but generally weekly and then every four weeks I'll put a report together, just an overview and you'll

		see the number of operatives are on site that particular snap shot of visit site. If there's any defects it will be on there that I want them to put straight. I mean, I don't want anybody wondering that I just pulled one out of the blue. And then it's just a general update for the client to see how the program is going forward and where they are in regards to the program. And then there's a couple…a bit of weather and a couple of photos. And some of our EAs do that as well, won't they, our project managers?
00:36:26	S2	Yeah, yeah.
00:36:27	S3	These are an independent company. So it's independent of us and the contractor. So we appoint them. So…which is another…to keep that transparency. So…and then they'll come in and they'll carry…that's why they carry out the snagging as well and if the responsibility sits with them, yeah?
00:36:47	S1	So an independent…
		(Overlapping conversation)
00:36:52	S3	It keeps that transparency of the whole build. And then once we've cleared the defects and practical completion happens, we like to give a 12 month defect period generally, don't we? Whereas you can have a six month period. We do get six months sometimes and [inaudible 00:37:08]. It's now 12 is it, but we have in the past had six month defects periods. We tend to work for a 12 month period. And then what will happen, we'll go back as I found out, we'll go back in 12 months and every property…
00:37:25	S2	We send them letters to each of the residents. So we just work in a time slot to go see them.
00:37:30	S3	But don't they sign something to say that they're happy with the finishes…
00:37:34	S2	So we go through the property with them. We identify any outstanding defects that are reported. Anything we can pick up as well to the trained eye. That gets produced as a final end of defects report. The contractor then has to work through that, complete all those jobs and the tenant has to sign if they're happy and then we have to sign if we're happy and then that's defects closed.
00:37:56	S3	I will then produce in the previous form contract because we were working with the former contract…I will then produce what we call a defect certification to finish the job. And that's the end of it, isn't it?

00:38:11	S2	Yeah.
00:38:13	S3	Apart from if there was any latent defects which we don't seem to get very often.
00:38:16	S2	Not very often, no.
00:38:19	S1	Towards sampling, I assume that while I've been there and once we were there, so you run over the 100 percent of the housing units, right? You don't do simply like…
00:38:36	S3	Yeah. I do…I have several methods. I purge items as well. So particularly roofing, I might have a purge on roofing. We might be looking at the M&E on the project. So generally I go for a look, but specific visits, I'll be looking at the M&E and I'll take the drawings and I'll literally go through them. Me and Craig have recently done this at Water Lane. When we checked to make sure we're getting exactly what we want. So we're doing that quality check to make sure the right amount of sockets are in the rooms, et cetera, et cetera. So there are specific visits as well where we pick out items that we want to look at. And I try to keep the contractor on their toes as I'll purge an item every so often and I'll go across all the sites and I'll either look at specifications, roofing was classic, wasn't't' it? Because there was an issue in roofing at Fraddon roofing. And I introduced this company years ago. I wanted to see from our design a specific specifications for the roofs. I wasn't seeing it and no one was seeing it. And what was happening, the contractor was going to the sub-contractor and asking for a quote to do the roof finishes and the responsibility of the specification was with that sub-contractor. And I wasn't comfortable with that. I wanted to see a specification as part of the project information package.
		(Overlapping conversation)
00:40:01	S3	Yes, exactly, so we knew what we were getting. So that…that brought a few things out, didn't it? And that's all settled down now. So, yeah…
00:40:09	S1	You know what you expect as a reasonable job.
00:40:13	S3	Yeah, exactly.
00:40:17	S1	I don't know, I guess the most important thing is to have clear information that people know what is being expected from them.
00:40:23	S3	And implementing that information. As critical, as you rightly said, we've got quite a lot of work on the go now and you've got from the ground, in the

		ground, drainage information. It can be a large package and getting to oversee all of that, as difficult for one person and that's why I try and get everyone on site to work as a team. So we're all going in the same direction.
00:40:47	S1	You mentioned that you have sensitive topics in the construction process that you do the specific site visits and you've mentioned roofing. Do you have any other items that you…
00:41:04	S3	Drainage is quite critical in the ground. I like to make sure that the drainage is implemented correctly. That's quite a good area because that's overseeing by building control. They have a vested interest in that as well. We've had problems in the past with ponding, pooling of waters, particularly in gardens. When we've gone over and above with our gardens and we've got quite high specs for ground finishes. And how we look after the spoiled heaps. So when we clear a site and we store soil that's going to go back as top soil or sub soil for gardens, it's specifically controlled. And it comes under a [inaudible 00:41:48] for document. So we want a better product going back to those gardens and there's a specification the way we implement that product so that it improves the drainage of our rear gardens because there's an issue with that.
00:41:48	S1	That's definitely a sensitive topic because otherwise if you don't get it right the first time…
		(Overlapping conversation)
00:42:12	S2	Yeah, and not only that, it's a hard one to solve. It's really expensive [inaudible 00:42:19]. It's not an easy one.
00:42:20	S3	It's not cheap to solve on site, but it's cheaper to do it while you're doing the construction phase then it is to go back retro and try and implement it.
00:42:27	S2	Dealing with, you know, upset customers and impact on them and…
		(Overlapping conversation)
00:42:35	S3	Which is where the technical forum comes in to it's own. Because we get that feedback from the end users. So we know if things are working and if they're not. We might not like it sometimes what we hear, but we can act on that. And that makes a big difference, doesn't it? And that keeps us on our toes and that keeps everyone on their toes.
00:42:54	S1	Yeah, for sure. According to the last little bit of this conversation which is about quality compliance. How do you report quality compliance? I mean,

		in which format and frequency? You said you have these quarterly meetings where you get information from the sense of things that went well and pretty much didn't went well and you had to…
00:43:22	S3	Defect is another one. If we have any issues, it comes through that defect process. So we pick up on that. And again, that's reported back to that platform. And it's also acting on, isn't it, before it even gets to the technical forum. This is more your doing, you're geared up for this, aren't you?
00:43:41	S2	Yeah. So we've got a defects monitoring system. So everything, you know, tenants ring in and report a problem. It's raised in the system and logged and it gets fired off to the contractor to rectify, but we'll compile those stats. And we look for sort of patterns as well across projects and also compare what the common quality issues we have on external…you know, off the shelf units we buy versus our own build.
00:44:14	S1	So you know what's…
00:44:15	S2	Yeah, what to look out for and that helps inform what we go and look at on site as well, I think. So that's one way of doing it. Obviously keep our eyes on the ground for that. We have site meetings, don't we as well where we talk through all sorts of items, really. Mainly [inaudible 00:44:33] conforming to the project generally. I'm trying to think of what other forms or methods we use.
00:44:41	S1	The input for this defect assessment platform that you just mentioned, the input comes from the tenant's complaints?
	S2	Yes.
	S1	From the snagging process as well?
	S2	Yes.
	S1	Is there another source for input?
00:44:57	S2	I guess we do a post completion review meeting. So once the project is finished…well, a few months out of completion…we'll sit down with employer's agent, the architect, the engineer, the client, the contractor, Pete will sit in on it. And we'll talk about what went well with the project and generally it's like standard items that we've worked through. What can be improved about not just the construction, but also the design aspects. It is really important, what worked well, what could we have changed to improve, you know, the ergonomics of the development as well, isn't it?

		And apart from that having some stats of defects that we've picked up from customer's report. I mean, so it's a lesson in that, lessons done.
00:45:46	S3	What we've found with those completion meetings, they're very valuable, but they're very specific to that scheme. And sometimes the information wasn't being spread across the whole group. And the…I keep harping on the technical forum, but that gives us a platform to take items from those meetings now to put across to everybody. So rather than it being scheme specific. And the other thing that's coming off the back of those, we can also take it up because I'm a vehicle for the ASW design innovation group. So items can also come with me now to that platform as well. So it's sharing that information which we did all right before, but I think that's improved it. And the other one, I'm pretty sure we still do it, is the KPIs, key performance indicators. Which is…I don't know if that still is as prevalent because we used to do that as part of the code assessment, wasn't it? I'm not sure if we're still…are we still…
00:46:54	S2	I think so.
00:46:55	S3	Maybe that has changed, but maybe that's something…that was part of those post completion views as part of that KPI process.
00:47:05	S1	Do you have a set a contractor's participating in this post completion…
00:47:09	S3	Not sub-contractors.
		(Overlapping conversation)
00:47:14	S3	…sub-contractor.
00:47:17	S2	But, I mean, I guess if we're going to use a regular set of contractors going forward, might not be a bad to invite some of the bigger M&E for instance…
		(Overlapping conversation)
00:47:40	S3	They predominantly provide our frames. So we have used a couple of other contractors in the past
		(Overlapping conversation)
00:47:51	S3	The whole package.
00:47:55	S1	I mean, they supply and install for you (timber frame), right?

00:47:56	S3	Yes. Yeah. Which again, you can go towards the quality control because it's their product. And they're installing their product. So you don't…so their knowledge of how that product needs to be installed, so that's another quality aspect.
00:48:12	S1	Exactly, exactly. And you certainly rely on that.
00:48:15	S3	Yeah, definitely. And it's things like windows we procure from Riching and I do believe the installers now are our preferred installers as well, aren't they? So again, a lot of the products are supplied and installed by the manufacturer which helps.
00:48:38	S1	Yeah. It's…well, guys, this is pretty much what I've wanted in terms of information. And it's invaluable, it's really good. It's really…it's a lot of information to digest now, but…

(00:48:59)

(End of Audio)

Duration 49 minutes

Interview 2.c – Transcript

Timecode	Speaker	Transcript
00:00:00	S1	The first thing that we always like to keep the records that you got information sheets which we got here and then the consent to participate as well and then you understand the main points within these documents. So, the basic information, starting with your name.
00:00:22	S2	Yeah, Site manager*.
00:00:24	S1	Okay. And your professional qualification?
00:00:26	S2	My qualification is an NVQ 4 in site supervision.
00:00:32	S1	Okay. Your professional experience.
00:00:37	S2	13 years with Contractor*, four of those in site management role and the other nine as a carpenter.
00:00:47	S1	Okay. Your role—we're using Case Study 2* as the background for this interview, right? So, in that development, you were?
00:00:59	S2	As a site manager.
00:01:00	S1	As a site manager. Okay. Well, do you have in mind roughly the number of assets in the housing association?
00:01:09	S2	Total stock operation?
00:01:10	S1	Yeah. Yeah.
00:01:12	S2	Well over 4,000.
00:01:14	S1	Over 4,000. Okay. In Project* was...
00:01:18	S2	40.
00:01:18	S1	40. Okay. So did the geographic area which the house association works?
00:01:25	S2	Cornwall.
00:01:25	S1	Cornwall.

00:01:26	S2	Yeah. Just Cornwall based.
00:01:28	S1	Okay. Number of ongoing projects at the moment?
00:01:32	S2	Through Contractor* which is all build inside, we've got Another project*, Another project*, Another project*, and Another project*. Four live projects for Housing Association* with another four or five in the pipeline to start in the next four to five months.
00:01:59	S1	Okay. Contractor* works exclusively for Housing Association*?
00:02:02	S2	Not exclusively. We're owned by Housing Association* but we do take on external works as well.
00:02:07	S1	Okay.
00:02:08	S2	We've unfortunately didn't get awarded the contract but we intended to work for Another housing association. Unfortunately, we weren't successful on that but we have had more, more and more interest from other housing associations to build our product that we build for Housing Association*.
00:02:29	S1	Yeah, while we have the expertise in the area. Okay. Do you have the quality accreditation in the organisation? I mean, ISO 9001 and the likes?
00:02:42	S2	Yeah. We have ISO. I don't know the—exactly what numbers but we have a few accreditations from ISO. We've got an order next Wednesday as it happens but the ISO accreditation. I'm not sure the particular accreditations but...
00:02:58	S1	Oh, I can check in the, you know, website anyways. No worries. Do you remember the project purpose in terms of housing units letting share on the sheet for open market in Project*?
00:03:11	S2	It was a mix three different tenures. There were 21 rentals, 11 shared ownerships and 8 open market sales.
00:03:22	S1	Alright. Okay. Do you remember the project overall cost?
00:03:27	S2	4 million.
00:03:27	S1	4 million.
00:03:28	S2	Almost to the dot.
00:03:29	S1	Okay. So in terms of the stage of the project, it's a hand over?

00:03:38	S2	Yeah. Yeah. Currently, we handed it over on the 15th of February.
00:03:42	S1	Okay. And duration of the project?
00:03:44	S2	12 months.
00:03:45	S1	12 months. Okay. The procurement route of the development?
00:03:52	S2	Is in sense of us working for Housing Association*?
00:03:55	S1	Yeah. Yeah. It was, I mean, design and build or traditional?
00:03:59	S2	Ah, yes. Design and build.
00:04:00	S1	Design and build.
00:04:01	S2	…project. That was the first design and build project that we'd taken on for Housing Association*. It was a partial design and build because we were going the design and build route with Housing Association* but the contracts had already been signed for Case Study 2* so we've novated the designs—Housing Association*'s designs over to Contractor* but going forward, all our products will be for design and build.
00:04:30	S1	Alright. So when you signed—the contract signed—the design…
00:04:37	S2	Yeah. It was already in place. Yeah. Housing Association* had previously appointed the architects, engineers, and they've notated them over to us.
00:04:48	S1	So you're the—all the design team were novated to you.
00:04:52	S2	Yeah, yeah.
00:04:53	S1	Okay. So in terms of questions, I have separated the questions grouping five main groups and the first one is regarded to your requirements and objectives in terms of the quality plan. So does that project had a formal quality plan and if it was a specific for the project or was a standard one?
00:05:24	S2	Yeah, a standard sort of relationship with Housing association*. Our aim you know in all projects as zero defects which I think anyone can aspire to but actually achieves zero defects on any product is hard.
00:05:42	S1	Yeah. Exactly. It is.
00:05:45	S2	Yeah, I'm not aware of a quality plan, etc. but it is knowing that our aim generally is zero defects.

00:05:54	S1	Okay. Okay. The question two is about in terms of quality requirements established for the project, are energy performance aspects part of the scope of this quality plan?
00:06:06	S2	Yes. Yes. Obviously, being housing association units, the more energy efficient they are, tend to be cheaper to run for the tenants that are in there and that's always a higher priority on their brief—design briefing.
00:06:26	S1	Okay. So do you remember any specific requirements regarding to energy performance?
00:06:34	S2	Obviously, we've got our building regs (sic) to be compliant with the (SAP) assessment, etc. but the SAP calculations on the timber frames, I don't know the exact figures but they're set quite high, the insulation, etc. and the timber frames works over and above building regs (sic) as well as was heat pumps is a general requirement by Housing association* which are quite energy efficient.
00:07:08	S1	Alright. This is the reason why they specify to use the air heat plants?
00:07:13	S2	Yeah, because they're not the most cost effective to install or the easiest of units to or systems to install on your own but the benefit of, you know, potential saving on your heating bills is high.
00:07:36	S1	Question four is regarded to if those requirements related to energy performance, they are part of the strategic goals of the housing association or was only specific for the project?
00:07:52	S2	No. Of course, the whole association that sort of their aims and targets to build almost renewable or used renewable energy sources where as much as possible to say.
00:08:05	S1	Okay. Alright. And the last question for this section is how those defined requirements are documented and transmitted to the participants of the project?
00:08:17	S2	Through Housing association*'s technical specification. It is handed over to us when we're tendering the work then.
00:08:25	S1	Alright. Okay. Well, the second section is about risk assessment which the name says it all. How do you assess the possible—the things that might affect the energy performance and then you have to deal with it during the process? So the question six is which stakeholders are involved in the process of defining the quality requirements related to energy performance

		of the project and when does it happen? Well, I remember you mentioned that the procurement—in terms of procurement, you have the design already set up and then the objectives are defined by the client, right?
00:09:04	S2	Yes. Yeah. It's all, on Project*, on that scheme, it was all set out from the start, with the design brief to the architects and engineers with the client. Having said that, we have a pre-construction manager in our office which—because we're part of the same organisation, he's highly involved even at that stage before we get awarded the contracts for design—not necessarily design and the house design in the scheme, making sure that Housing association* as our client, are getting everything that they require and expect so we do have quite a high input into the initial stage, the design stage to make sure it fulfils the group's requirements.
00:09:51	S1	So you can use your previous experience to input…
00:09:56	S2	Yeah. We do have quite a large input into the design stage. I mean, they're not always receptive to it but we do try and push them down the right route.
00:10:09	S1	Okay. Is there a process in place to assess the risks related to your managerial and workforce capabilities or technical issues which can affect the achievements of the requirements related to energy performance?
00:10:30	S2	I mean, I'm not 100% sure on that but I would presume that our pre-construction manager, he does all the initial drawing checks, design checks and its process of just going back to Housing association*'s technical specification cross checking everything that is in there. It's relayed across all the drawings and the designs, more on the M&E designs are quite crucial to that where especially using the air source heat pumps, etc. and anything that he may miss, once it comes over to the site team, the construction team, project manager, site manager, we are constantly reviewing the drawings for any changes or any issues that we foresee that are not feasible to build or cannot be built. Probably in a lot of the scenarios that may stack up on the drawings but the actual buildability of it or achievement on site can be quite difficult.
00:11:35	S1	Okay. And what can you tell me about the subcontractors of the—while you told me that you tried to work with them as much as possible.
00:11:46	S2	Yeah. We tried to find the good pool of subcontractors. We shortlist probably three for each trait that we like to use, obviously without overloading. They're fully briefed on what is expected at those, before we actually let the subcontract to them. It is quite an extensive liaisons process before they get the contract to make sure that they're fully aware of what is

		required, all the details, etc. and from the side of actually building it, to the commercial side of it as well that they've got enough money in there, in the contract, to do that but as we said earlier for us, it's keeping our key subcontractors, and know what we expect, know what we build and we don't change our products very often for Housing association*. We might change the house types but the details and items like that stay the same once we find a good detail or a good product…
00:12:52	S1	In that sense, to what extent your managerial team, and the workforce, the subcontractors understand the impact of defects on the energy performance of buildings.
00:13:15	S2	Depending on the project we're working on, but we have, we promote sort of CPDs on various different products that we use. We put a few of our site managers through sustainability courses which as we do a lot of timber frames, it was a two- or three-day course and it highlighted all the key areas where your energy and heat loss, etc. on a timber frame. Because timber frames are sort of our bread and butter they are what we are good at so we do a lot of training and sort of we have monthly managers meetings which is where you get time for—obviously we've got few schemes on the go. We don't always communicate between the site managers and project managers but these monthly meetings, we can sit down for an hour any issues if found on one site, we can discuss and someone's aware of one another site so across the borders, all the defects that someone sees as an issue are passed on to the rest of site managers.
00:14:30	S1	Okay. And this—those meetings cross sites how often do you…
00:14:37	S2	Once a month.
00:14:37	S1	Once a month?
00:14:38	S2	Yeah, once a month every fourth or Thursday. So they…
00:14:45	S1	So everybody goes to you (crosstalk)
00:14:48	S2	Yeah. Yeah. All of our project managers, all of our site managers and that is more of an in-house skill one given in our office. We also have, with Housing association*, technical forum every three months which is where we can discuss products that we're using for Housing association*, because Housing association* is—they're quite good at specifying what products they want to put a lot of time in to, looking at what products they want, where they can get the best warranties, the best guarantees, the best performance. And a tech forum every three months is where we can put

		our side across any changes or why it's not working. If it's working well, a lot of feedbacks. So, it's a good place to review all of the designs and the details and products for Housing association*.
00:15:35	S1	So you have a formal opportunity to discuss and share experiences about that.
00:15:40	S2	And that (technical forums) is with obviously Gilbert Good there, ours operations manager, project managers, Pete Wallace which is sort of their technical supervisor, Housing association*'s asset manager who looks after all the stock after we've handed it over to him and a few owners of the key figures in the group.
00:15:58	S1	Okay. Perfect. To finish this section, in your opinion, what are the challenges and obstacles faced when implementing those quality management procedures towards achieving energy efficiency?
00:16:13	S2	Costs.
00:16:14	S1	Costs?
00:16:15	S2	Yeah. It's constant battle with clients who want the better product for less money.
00:16:23	S1	Yeah, well, it's the main rule, right?
00:16:26	S2	Yeah. They need to be built as cost effectively as possible but perform as well as they can and that is a sort of a barrier that we to see, that we're up against all the time, because we could suggest a lot better products but money is not always there to use it or to use them.
00:16:44	S1	Have you experienced in this development or another one, cost engineering that affects changing specifications of insulation layers and so on and so forth, things related to energy performance?
00:17:02	S2	Yes, we have them—we did, at Project* not necessarily on the energy performance side of things. On the scheme we are on now in Bodmin, we've gone down the route where we can give Housing association* a cost saving on the insulation and the timber frames. I think we can almost reduce the thickness of the insulation by 50% but still be compliant with the SAP assessments and building regs (sic). They may not be as energy efficient as the previous units we've done but the loss of energy performance compared to the cost saving is inevitable.

00:17:42	S1	Yeah, it's inevitable. Third section is about the resources that you need to deploy this quality program. So, who's responsible for developing and implementing the quality management procedures in Project*?
00:18:08	S2	It'd be sort of a joint effort between our own site team, really. We got our standard quality management forms, etc. that we do sign off for after each trade to make sure if it's installed properly as per the details.
00:18:27	S1	Those checking sheets are provided by the—it's a standard quality check issued…
00:18:34	S2	Yeah, standard Housing Association* form (sign off check sheets) that's been produced as a joint effort by us and higher management. Also, we have Clerk of Works* which is the sort of clerk of works role that works for Housing Association*, the client, and he does a weekly visit from the client's side to make sure that everything's going into the details, the quality is high enough standard…
00:19:00	S1	He does a report every fortnight of every week.
00:19:04	S2	He does report every fortnight but the site was every week so every second visit, he'll populate a report. Formulate a report.
00:19:12	S1	And from your side as a site manager, do you have the checking lists or quality the report or something like that?
00:19:20	S2	Yeah, we have our sign off sheets. We are developing an itemised check list sign that we are looking at now but I think we've got one for window installation. So far, we're looking for each trade now to have a tick. This is done, this is done, this has been done well as per detail and our onsite team really that is responsible for that. You'll have your site manager, your assistant site manager going around checking this.
00:19:47	S1	So in that sense which is question 11 is asking you if you have a specific team in place to ensure the achievement of quality related to energy performance and this is pretty much (crosstalk)
00:20:00	S2	The onsite team.
00:20:07	S1	Okay. Onsite team. Do you have any specific procedure in place to create awareness of the quality requirements related to energy performance?
00:20:21	S2	Yeah, the technical forums. The client, every three months, and our internal site managers, maintenance.

00:20:28	S1	And do you have something towards the subcontractors as well?
00:20:36	S2	I'm not so sure towards energy performance. Details which are all part of the building performance accredited list of details that will follow, near there. When they start onsite, their contracts manager or their managing director would have had all the details prior to getting their contract letter and generally we find to make sense, for instance, there'll be two or three gangs that will start at various times. They are brought in probably a day before they start in site and we will go through all the details to make sure they've got all the information in there, they're familiar with all the information and requirements of how we want it built and what needs to be built.
00:21:21	S1	Okay. Question 14 is about, well, it's a personal question asking you if does the company, meaning houses association or other contractor, provided proper environment and other necessary resources in order to achieve the quality requirements proposed for something else that should be provided that is not now. I mean…
00:21:49	S2	No, to be honest. Contractor* are pretty good at backing the site team. Maybe on some of our smaller jobs, we don't have a big enough site team. I think it's key to get an assistant on the site early. The earlier the better, but this is having the time to put in the check if everything that has been when built correctly and their details are being followed.
00:22:18	S1	Okay. So let me ask you something. Who was in Case Study* responsible for building control?
00:22:28	S2	It was Building control party*. Private building control company and Premier warranty.
00:22:35	S1	Okay. It's an accredited inspector?
00:22:37	S2	Yeah, yeah. I mean it's just cost effective to use that.
00:22:41	S1	And then they work for you guys for the whole set of ongoing projects right now, right?
00:22:49	S2	No. It's someone different on this time. We got LABC on this project, Building control party* are doing to cover all other schemes. Yeah, unfortunately it's all just cost driven.
00:22:59	S1	They do.

00:23:00	S2	They'll give us a quote for fee to warrant either the schemes and the houses but from onsite sort of things are just down to the site manager and the assistant site manager to get these inspections in place, etc.
00:23:15	S1	Can you walk me through how they (building control bodies) provide you with the Final Certificate, how they go through assessing and signing you off for building regs (sic) concerns?
00:23:30	S2	They (building control body) will be sent a full set of drawings prior to commencement on site where they undertake a plan check then any issues that they have then pre-construction, they pick out any details, any change needs to be in line with their building regs (sic) documents or we use premier for our warranties and they've got a quite extensive technical manual. They do a pre-plan check and almost to make sure that all the details are sufficiently there. And from our side, all our site managers got a copy. All our contracts managers got a copy of pre-construction, so we should be doing a bit of research into that being au fait with their requirements as well. And then we go through the building control side rather than the warranty side. They all come to site during the initial site visit whenever we start onsite. They'll do most of their risk assessment on the site. Hold out any key areas that they want to inspect. They will give us a form of their standard inspection stages which will be foundations, and then you'll get lots of frames for up to the DPC tray to set, then they'll do an inspection pre-plasterboard so it's actually first fix, and it will go from almost plaster board into a final inspection to the handover and they have a key area that they want to see as a roof and you start setting the roof and someone fixing the slate or tiles which lays obviously on old jobs they perceived to be the highest risk in those areas. If they see any other risk, they'll highlight another area, specifically to the site that they want to inspect.
00:25:32	S1	Okay, so they provide you with this framework for a site inspection and then you fill it up…
00:25:39	S2	In their visit there is almost is just like a table and they'll have your plot numbers on the left-hand side. Your stages of inspection along the top and they'll come in and when they've seen it, they'll sign it, photograph it and that all then be kept on their records. We just have a record of what they've been up.
00:25:58	S1	Okay.
00:25:59	S2	And then they'll do their final inspection prior to occupation and give us—

00:26:03	S1	Okay.
00:26:04	S2	the completion certificate hopefully.
00:26:05	S1	Alright, yeah. Fingers crossed (laughs). Alright. Well, the next section is a little bit more related to the way you comply with the quality requirements so we call it the quality matrix. I mean, in terms of energy performance attributes, which are considered in the quality plan and project, do you, well, you said you comply with building regs (sic), right? So it's fair for me to say that those attributes are related to U-values—
00:26:37	S2	Yes.
00:26:38	S1	—with regard to the design and then do air pressure test…
00:26:41	S2	Air pressure testing, yeah. Like you said, U-values, we have them sound tested.
00:26:48	S1	Okay.
00:26:49	S2	Air tested.
00:26:50	S1	Alright.
00:26:50	S2	SAP assessments etc.
00:26:52	S1	Okay.
00:26:54	S2	And then the anything over and above that would be specifically inspected by the client if anything is required.
00:27:01	S1	Okay. Well, question 16 is related to if you have a procedure for defect identification and collection in place, use this framework from the building control or you have an extra…
00:27:15	S2	We've got our own system in place, an internal system—
00:27:22	S1	Yeah.
00:27:21	S2	—which is fairly new to us. It's through an online server called ASITE.
00:27:30	S1	Okay.
00:27:31	S2	And there's a defect log on there and anything that the site manager sees defective work or any of the project team—

00:27:40	S1	Okay.
00:27:41	S2	They can take couple of photos on their phone, email it to the subcontractor and CC in a specific email address and they will be, just for instance, Project*@defectslog.asite.
00:27:58	S1	Okay.
00:27:59	S2	This will then go on to an online server which everyone in our company's got access to.
00:28:04	S1	Alright.
00:28:06	S2	And it will come up defect open with a couple of pictures and the report you sent. Now, until that's actioned by the subcontractor, we can't close that defect log.
00:28:17	S1	Okay.
00:28:18	S2	So we got a running table for each project. If there are any open defects and closed defects, which is another method of us identifying a trend and patterns across all of our sites as well. If we find—we can find the just the same contractors who are doing the same defective work on the same task on every site, like installing DPC trays, if he keeps doing that wrong repeatedly across all of our sites.
00:28:46	S1	Yeah.
00:28:47	S2	We know that's a key area that we need to bring them in and…
00:28:51	S1	Okay, so you're looking for patterns of non-conformances...?
00:28:57	S2	Which also helps not necessarily the energy performance but our defect after hand over, or 12-month defect period, which is more—yeah, the quality side. If we can mitigate half of those defects, we can save half the money we spend on defects.
00:29:13	S1	Indeed. Indeed.
00:29:14	S2	So, yeah. It's looking more now is key this year is when we've really started to look at it and put procedures in place for defect management.
00:29:27	S1	Okay, wow, this is quite a robust system.

00:29:30	S2	I think we worked out something in the region of £300,000 a year if you have to put a figure on defective work.
00:29:39	S1	That's good.
00:29:40	S2	So the more houses we do, the more the more service we do that figure. If we don't change now, that figure could grow which when you got proportion, £300,000 to £400,000 of profits a year to go back and put work right is a lot of money.
00:29:54	S1	Defect is I mean, well, I have this opinion that we should look more into preventing defects because we can get a lot of money. I mean… (crosstalk)
00:30:04	S2	And the route we are going down to prevent rather than fix it after.
00:30:09	S1	Exactly. Exactly.
00:30:09	S2	We've also got—she's not new to the company. She was doing another role, but she is now a defects coordinator.
00:30:17	S1	Okay.
00:30:19	S2	She is called Name* and she deals more with defects after handover.
00:30:27	S1	Okay.
00:30:28	S2	And she is constantly logging every defect we get and picking up trends and patterns so we can pick up right around a major issue of windows, or round a major issue with carpentry work. So that as after—almost an after sales after the site team have left, she is to review and those defects come in so we can pick up the patterns there and try and resolve that.
00:30:53	S1	So she links the defects that were to include by the site team and then links with the defects which were raised by the tenants, occupants, or whatever.
00:31:03	S2	Yeah, let's just say we've got...
00:31:05	S1	Cool. That's interesting.
00:31:06	S2	On her data (the defect coordinator), she finds right, and this will be across all of our sites. We're having a major issue of windows. Let's just say water ingress on the sides of windows, etc. We go back through each site now.
00:31:20	S1	Okay.

00:31:22	S2	And look at all the defects that we've logged.
00:31:24	S1	Uh-hmm.
00:31:25	S2	And is it workmanship? Detail? And pick up the patterns there.
00:31:30	S1	Okay. Oh, this is super impressive. This is very helpful.
00:31:34	S2	This is, yeah, our director is really keen on this issue and is high on his priority list to try to mitigate defects.
00:31:43	S1	So it's about spending money in a proper way. Question 17 is about how and when those performance attributes and defect are monitored and collected. Like you said, the air pressure testing, you've done them once when you completed the housing units?
00:32:11	S2	Yeah, once the build is 95% complete.
00:32:17	S1	Okay.
00:32:18	S2	Once we have second fix, windows and doors are in and everywhere has been sealed up. We get the air test done, sound test done which to be honest, we don't really have any issues with our details, they are generally quite robust and it never becomes a problem.
00:32:39	S1	Do you test (air pressure test) a 100% of the housing units?
00:32:41	S2	No, only certain percentage of certain house types.
00:32:48	S1	Okay, so what, building regs (sic) recommend, right? Which is 50% of the housing types or three housing types or three units—
00:32:57	S2	Yeah, three units. So many, yeah.
00:32:59	S1	—whichever the less?
00:33:00	S2	Yeah, we just comply with the building regs (sic) requirement.
00:33:03	S1	Okay. In terms of defect collection, can I say that the defect collection procedure takes place when you're signing off the trades?
00:33:14	S2	Yeah, signoff. Yeah. Or anything that we notice on our, sort of, daily wander around the site.

00:33:20	S1	Okay, and this defect collection procedure, do you have a framework to do that?
00:33:27	S2	Yes. It's the ASITE server we are talking about. This whole part goes onto that.
00:33:32	S1	Okay.
00:33:33	S2	To that system which is our main or number one system for logging all defects.
00:33:42	S1	Okay. But to collect them to—I mean, to identify them, you basically use your experience and what you can see. Do you have a…
00:33:50	S2	Yeah. We—I mean, all of our site management on site should be 100% up-to-date with all the details.
00:33:59	S1	Yeah.
00:34:00	S2	So it's just a matter of knowing what you're building. Learning all your details, taking it all in, and then what you keep an eye from onsite.
00:34:10	S1	This is a clear advantage by using your strategy of repeating the construction technology and the construction methodology that you've been using because…
00:34:20	S2	Yeah, because you use the knowledge of that detail.
00:34:21	S1	Indeed.
00:34:23	S2	And as we've said before, it's not—they're not 100% the same on every site. There are generally minimal tweaks but the principal and the details are the same.
00:34:33	S1	Well, that's really good. It's a very good strategy actually. Instead of going inventing the…
00:34:40	S2	Change in every site you go on.
00:34:42	S1	Exactly. Well, the last bit is about quality compliance which you've talked about already. So, I won't waste too much of your time. You said that the quality compliance, how is the quality compliance reported in terms of content, form, and frequency. You've told me that you have the ASITE portal that use as a defect log. Okay, you have the sign off checking sheets.

		Alright. You have the reports that you have to send to the building control too, am I missing...
00:35:24	S2	We talked earlier about the defects coordinator, that's why we have monthly defect meetings as well.
00:35:31	S1	Yup, okay.
00:35:33	S2	Uhm, it tells on about health and safety meeting once a month in our office and she will tell on back of that for an hour which is where she relays all that data that she's collected on our key areas of defects to us and they're out for discussion and we can change it what we see the changes are, what patterns are, or what we think are the causes of these defects.
00:35:55	S1	Alright, okay. And so the specific procedure to analyse the report are your monthly meetings to talk about defects and how to prevent them, how to tweak designs details and so on. Okay, apart from the people, which I assume are the site managers which participate of those meetings, how the rest of the project participants get a feedback on all those issues?
00:36:30	S2	Unfortunately, this is when they've done it wrong.
00:36:32	S1	Okay, alright.
00:36:36	S2	I mean, we don't, we tend to stay away from changing the detail half way through a project.
00:36:44	S1	Alright.
00:36:45	S2	Even if there are some issues with that.
00:36:47	S1	Okay.
00:36:48	S2	We will stick on that project and change it on the next one. We don't like to change a lot through the project to avoid any form of confusion. So, they are all subcontractors etc. either if they've done it wrong.
00:37:04	S1	Okay.
00:37:05	S2	That we pulled up on it straight away, make them change it. Failing that, it's just—when they tender in that scheme, any different details we will highlight any specific changes to what they or major changes to what they would generally expect to be building for us.
00:37:22	S1	Okay and how they received this kind of information, I mean...

00:37:26	S2	They tend to stage between our estimate and our QS as...
00:37:30	S1	Okay.
00:37:31	S2	There's a lot of liaison and they've probably awarded a contract.
00:37:35	S1	Well, I have been on your shoes previously and understand that sometimes still with quality with subcontractor is not something easy to go around because...how do you deal with this, trying to change this blame culture to something that you are trying to get people together to collaborate and understand that this is something good and it's good to report defects because we can work on them and then.
00:38:06	S2	It might sound a bit harsh but getting on to subcontractors directly when they start on site. If they're doing it wrong—
00:38:12	S1	Yeah.
00:38:13	S2	—it comes down and it is down again and they will soon realise that, it's costing them money.
00:38:18	S1	Alright.
00:38:19	S2	And ultimately to a subcontractor that is what they are concerned about.
00:38:22	S1	Alright.
00:38:23	S2	Obviously there's their reputation and their quality, but in the product that they are building, how that performs… I don't see that they pay much interest in that, so the only way that you can get across to subcontractor is by costing them money.
00:38:41	S1	Through money, yeah. In the pocket, yeah.
00:38:42	S2	And they will soon learn that they will build it right the first time.
00:38:45	S1	Okay.
00:38:46	S2	How important is that we stick to the details that we contracted the building.
00:38:50	S1	Okay. Alright.
00:38:51	S2	This seems to be the only interest they have.

00:38:58	S1	It's not easy, it's an easy task. It's difficult to get everybody aligned towards the same objective.
00:39:06	S2	I mean they—the subcontractors don't buy into it for the end product. They buy into it to do their piece of it and get their money out of it.
00:39:12	S1	Yeah. And move on to the next one, right?
00:39:14	S2	Yeah. So it's hard to trying get to change that mentality, trying to get them to buy into it to the end product but sometimes anyway you can try to change that mind set by costing them money.
00:39:28	S1	Yeah, just let me ask you some personal question, I mean, everywhere, in my country, here and in other places we have an issue about providing the proper skill to the subcontractors so you can prevent the defects by upskilling people and then…I've been asking this to construction companies and the answer is always like: why should I invest in people's education when they don't work for me and then they will be working with another company...
00:40:18	S2	And unfortunately that is the... We will work with the subcontractor to help them, not—we won't financially support them. I don't if you're aware of it in England CSCS cards that we have?—There is a big change coming into that. You usually should be able to work on the building site with just a labourer's card not a green card or skilled operative's card. Now, that's changed this year. You've got to have the qualification.
00:40:59	S1	Yeah.
00:41:00	S2	You can't work on a building site for more than 12 months without having a qualification, which is a lot of older people that never had the qualifications, they just have done it for thirty years. They are going to come and start to have troubles and a lot of the really younger lads that really not academically minded. They just think they're going to start labouring on the building site and without having any formal qualification. So I mean that's a battle for us as well because effectively half of our subcontract workforce which certainly can't work on our site, unless you get a qualification which we are working quite closely with them. I say not that we're going to financially back them but working quite closely with them to get them in the right places where the right training providers to get these qualifications rather than just saying it's your problem. You sort it out and come back to us.

00:42:08	S1	Show them the way but it doesn't mean that you have to pay for the qualification but you can get there.
00:42:13	S2	Yeah. We can get them in the right direction because we have got quite a big influence with Cornwall college etc. We work quite closely with them and ask one of the girls in our office. She has got a few connections actually. She used to work there, so she is quite good at getting them in touch with the right training providers.
00:42:34	S1	Yeah. Alright, that's good.
00:42:36	S2	Which that on the one of your previous questions and that about subcontractors and the quality of their work.
00:42:45	S1	Uh-hmm.
00:42:46	S2	And everyone will go out and this will be prove their qualification.
00:42:48	S1	Yeah.
00:42:49	S2	And now it's stepping that direction and everyone will be confident and qualified in the work they are doing.
00:42:57	S1	I mean it's a good move if the government can help people to finance their education.
00:43:05	S2	That's the thing that could be like they were—it can be like £1500 to sort of get this qualifications and the right cards to young self-employed blokes, that is a lot of money.
00:43:21	S1	It is. It is.
00:43:23	S2	So, yeah, I don't know what the government if they are to doing anything—I presume there will be some training grounds etc. but...
00:43:37	S1	I think it's very appropriate. Well then, thank you very much.
00:43:38	S2	No problem.
00:43:39	S1	This is it.

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

[00.43.44]

[End of Audio]

Interview 3.a – Transcript

Timecode	Speaker	Transcript
00:00:00	S1	So just before we get started, I just wanted to make sure that you got the research information sheet.
00:00:07	S2	Yes, I did. Yeah.
00:00:09	S1	Yeah. And we have your consent singed off already.
00:00:13	S2	Mm-hm.
00:00:14	S1	So starting with the basic information which is the first step. Let me get just a pen which I have here. This is about basic information, about your name…
00:00:30	S2	Yeah.
00:00:30	S1	*Project manager*.*
00:00:31	S2	So I'm *Project manager**.
00:00:32	S1	All right. Your professional qualification?
00:00:35	S2	So I have a degree in business, but no specific professional qualification in development as such.
00:00:41	S1	Okay.
00:00:41	S2	It's a kind of learned thing. I've been in housing for over…can't remember now. I want to say…well, about 16 years I've been in housing in different roles.
00:00:50	S1	All right. Okay.
00:00:50	S2	So I've kind of seen all elements really.
00:00:55	S1	Which is good. It's provide you with a…a…
00:00:57	S2	Yeah, a sort of…
00:00:58	S1	…holistic view of the…the whole process, yeah?

00:00:59	S2	Yeah, yeah. It does. It does help me actually with the development to kind of have been on the management side of housing as well, to try and see how people live on estates and stuff. So it helps with the design.
00:01:09	S1	Okay. Yeah.
00:01:09	S2	So design stage, yeah.
00:01:11	S1	Your role right now in the housing association?
00:01:15	S2	I'm a development officer.
00:01:16	S1	Okay. And well, of course, we know the housing association name is *Housing association**.
00:01:20	S2	Mm-hm.
00:01:22	S1	And do you know roughly the number of assets?
00:01:24	S2	It's about 14 and a half thousand, I think, at the moment.
00:01:26	S1	It is?
00:01:27	S2	Because obviously people keep buying them. So…
00:01:30	S1	Yeah.
00:01:31	S3	Well, I can check it in the…
00:01:33	S2	Yeah, yeah. I think it's roughly about 14 and a half.
00:01:35	S3	Yeah.
00:01:35	S2	Maybe slightly higher.
00:01:41	S1	And the geographic area?
00:01:42	S2	Currently just the Plymouth Local Authority area.
00:01:46	S1	Okay.
00:01:47	S2	Obviously because we were stock transfer. So we…we took our stock from the local authority…
00:01:46	S1	Okay.

00:01:46	S2	…about six years ago.
00:01:48	S1	All right.
00:01:48	S2	So we're completely Plymouth-centric at the moment, but we are looking to move into the [inaudible 00:01:53] area…
00:01:54	S1	Okay.
00:01:54	S2	…as obviously opportunities within Plymouth start to dry up.
00:01:58	S1	Okay.
00:01:58	S2	We'll be looking to expand slightly.
00:02:00	S1	All right. Okay.
00:02:01	S2	Yeah.
00:02:02	S1	Do you…you were talking in the…in the lift here about several numbers of different projects you're involved with. Will you…
00:02:09	S2	Yeah. We've currently got about five ongoing projects with more in the pipeline.
00:02:14	S1	Okay.
00:02:14	S2	So we've got the…obviously the *Project** development, Passivhaus…
00:02:19	S1	Mm-hm.
00:02:19	S2	…phase three. We've also got phase two of the regeneration program that's ongoing as well and we're just looking to…
00:02:26	S1	*Another project**, yeah?
00:02:27	S2	Yeah, start the consultation of phase five. We're looking also to deal with the *Another project** site. And that's just in the final stages of…of contract negotiations.
00:02:38	S1	Okay.
00:02:39	S2	So we've got quite a lot on the…on the go at the moment.
00:02:41	S1	On the pipeline. Yeah.

00:02:42	S2	Yeah, yeah. It's quite hectic. But it's good, it's good. It's nice to be busy.
00:02:46	S1	Indeed. Yeah. Well, the name of the…before that, do you have any quality accreditation in terms of the organization as a whole?
00:02:58	S2	I think we do, but I'd need to find out that for you…
00:03:00	S1	Thank you.
00:03:00	S2	…because I'm not sure it's specifically for our department, but I know as a…as a whole we do have quality marks. But I'd need to go back and check that for you if that's okay.
00:03:08	S1	Okay. No problem, yeah, of course.
00:03:10	S2	Yeah.
00:03:11	S1	Well the project that we are talking about, which is…will provide us with the…the background for the answers, is the *Project**, right?
00:03:19	S2	Mm-hm.
00:03:20	S1	The number of housing units?
00:03:23	S2	On that project is 67.
00:03:25	S1	Yeah.
00:03:26	S2	And there are 42 for rent and 25 for shared ownership. There's no open market on them.
00:03:32	S1	Okay. All right. Do you have in mind roughly the…the project overall cost?
00:03:37	S2	Yeah, it's 8.29 million.
00:03:40	S1	Okay.
00:03:41	S2	Yeah.
00:03:42	S1	All right. And the stage of the process…of the project process?
00:03:45	S2	It is currently in construction and the project duration is about 18 months…
00:03:50	S1	Okay.
00:03:51	S2	…from start. So it started last July…

00:03:53	S1	All right.
00:03:54	S2	…and running till April next year.
00:03:56	S1	Okay.
00:03:57	S2	Yeah.
00:03:57	S1	Okay. And the procurement route?
00:03:59	S2	Was a competitive tender.
00:04:00	S1	Competitive tender? All right.
00:04:01	S2	Yeah, yeah. Through OJEU, so obviously because of the scale of the…
00:04:05	S1	Okay.
00:04:05	S2	…will be EU compliant sort of tender so…
00:04:07	S1	All right. Yeah, yeah. So…okay. All right.
00:04:15	S2	Does that make sense?
00:04:16	S1	Yeah, yeah, yeah.
00:04:17	S2	Just because it's such a large sum. I think once it's over 1 million it has to through the EU tender process.
00:04:22	S1	Indeed, yeah.
00:04:23	S2	Yeah. So…but it was competitive, yeah.
00:04:24	S1	Okay. All right. Let me ask you about the first question which is related to the requirements and objectives…
00:04:33	S2	Mm-hm.
00:04:33	S1	…of the quality planning. Does the project have a formal quality plan? Or is this specific for the project or a standard use by the housing association or the major contractor?
00:04:46	S2	Okay. So it doesn't specifically have a formal quality plan, as we touched on previously. It's…it's…we have a set design and project toolkit which we use.

00:04:56	S1	Okay.
00:04:57	S2	Which is a…a toolkit that was collaboratively designed by Source Partnership which is…
00:05:06	S1	Okay.
00:05:06	S2	…is made up of several housing associations. So it was *Housing association**, *another Housing association**, *another Housing association**…
00:05:16	S1	Mm-hm.
00:05:17	S2	… *another* H*ousing association**. Lots of housing associations got together and collaboratively worked through…
00:05:21	S1	Okay.
00:05:21	S2	…a design and project toolkit.
00:05:23	S1	Right, to provide input for…
00:05:24	S2	Yeah.
00:05:24	S1	…the development of this.
00:05:25	S2	That actually then sort of drives…is the basis for…for what we work for to design and build up the project.
00:05:32	S1	Okay.
00:05:33	S2	However, obviously, for specific projects that sometimes has deviations attached to it which…you know, for say Passivhaus for example…
00:05:40	S1	Yeah.
00:05:41	S2	…would have deviations attached to that because of the…
00:05:43	S1	The requirements, yeah.
00:05:43	S2	…type of developments, yeah.
00:05:44	S1	Mm-hm.

00:05:45	S2	So we then tweak it a little bit for each specific project. But it's the basis that we use for our…
00:05:50	S1	Okay. It's your framework let's just say.
00:05:52	S2	It is, yes. Yeah.
00:05:53	S1	Yeah, it's your starting point and from that point on you build up into the peculiarities of each project.
00:05:58	S2	Yeah, yeah. That's right, yeah.
00:05:59	S1	Okay. In terms of…question two, in terms of quality requirements established for the project, are energy performance aspects part of the scope of the quality plan?
00:06:10	S2	Specifically for *Housing association**, they used to be part of *Housing association**'s drivers in terms of wanting to build properties to high code.
00:06:17	S1	Okay.
00:06:18	S2	However, due to obviously financial restraints and…and restrictions that have been imposed by government in the last few years and the sort of weakening of the need to provide such high code levels for grant funding and what have you, and the high costs of developments, we…we've fallen back in line with providing sort of code requirements to meet planning requirements.
00:06:43	S1	Okay.
00:06:43	S2	So just the basic and also building control mainly.
00:06:49	S1	Okay, which is building regulations part L, yeah.
00:06:50	S2	Yeah. So…so that's…unfortunately that's just the way that things are being driven these days.
00:06:56	S1	Yeah.
00:06:57	S2	So we did have to…we were working a scheme up originally to meet code around code 4…
00:07:03	S1	Mm-hm.

00:07:04	S2	…sort of levels. But the cost implications were such that we had to drop straight back.
00:07:06	S1	I can imagine. And this is a phenomenon that I've been able to acknowledge across…
00:07:12	S2	Mm-hm.
00:07:12	S1	…other…other housing associations.
00:07:13	S2	Yeah.
00:07:14	S1	I mean, I have another one in Cornwall for instance that used to work with the code for sustainable homes level 4…
00:07:21	S2	Yeah.
00:07:21	S1	…as a target.
00:07:22	S2	Yeah, yeah.
00:07:23	S1	But then they…they moved back for…just to complying with building *regs (sic) (sic)*because of the costs, yeah.
00:07:27	S2	I think the issue for us in Plymouth as well is the fact that we…we can put a sum normally on a…on a house unit as such, but there's such a lot of unknowns about the ground conditions in Plymouth.
00:07:38	S1	Yeah.
00:07:38	S2	And obviously we're dealing with a lot of brown field sites.
00:07:40	S1	Mm-hm. Yeah.
00:07:41	S2	So As soon as you start having all those unknowns and all those risks…
00:07:45	S1	Yeah.
00:07:45	S2	…it ends up hitting the thing you can control which is the build costs.
00:07:48	S1	Definitely. That happened with the *another Housing association**, yeah?
00:07:51	S2	Yeah, yeah. And also with *Housing association**.
00:07:52	S1	Okay.

00:07:53	S2	So…yeah.
00:07:54	S1	Yeah, you had some contamination in the soil due to the…
00:07:56	S2	We did. Yeah, yeah. We did, yeah.
00:07:58	S1	…to the garages that used to be there.
00:07:59	S2	The garages were there and also because it was an old school site we found an old swimming pool (laughter)…
00:08:05	S1	Oh God.
00:08:06	S2	…and bits and bobs of asbestos as well. So…
00:08:09	S1	Oh no, that's bad.
00:08:10	S2	It generally is.
00:08:12	S1	Heads up costs, yeah.
00:08:13	S2	I suppose it's just because of the age of the buildings and they were just levelled to ground.
00:08:16	S1	Mm-hm.
00:08:16	S2	Of course nobody digs out and scrubs out the foundations and things like that so it can start to mount up.
00:08:20	S1	Yeah. Okay. Going to question three. So you've mentioned that…No, I'm going to skip this because…just confirming what you said in question two...
00:08:31	S2	Mm-hm.
00:08:32	S1	…it's about the requirements which are regarded to energy performance.
00:08:34	S2	Yeah.
00:08:35	S1	And so that you have to comply with the building regulations and the…
00:08:36	S2	So we…yeah. So we…we undertake SAP calculations…
00:08:40	S1	Okay.
00:08:40	S2	…for the…for the project. And then obviously produce EPCs for each individual unit.

00:08:43	S1	All right.
00:08:44	S2	But yeah, that's as far as it kind of goes these days really and obviously meeting building control. But that's all part and parcel of that anyway.
00:08:51	S1	Okay.
00:08:52	S2	Yeah.
00:08:53	S1	Okay. So question four is about there…if those requirements are related to energy…related to energy performance are part of the strategic goals of the…of the housing association or specific for the project? So pretty much as you mentioned.
00:09:09	S2	Yeah.
00:09:09	S1	Apart from the *Case study 3** which is Passivhaus and the other one.
00:09:11	S2	Yeah, yeah, which is obviously Passivhaus or passive standards at the moment to try and get the…to achieve that. But yeah, we do try and push to obviously do more if budget allows. But it's just the fact that the cost implications have…
00:09:24	S1	Yeah, indeed.
00:09:24	S2	…have to do more…
00:09:26	S1	Yeah, it's super reasonable, yeah.
00:09:27	S2	Mm-hm.
00:09:30	S1	Again, in terms of the definition of those requirements which are compliant with building regs (sic)…
00:09:36	S2	Mm-hm.
00:09:37	S1	…how are those requirements documented and transmitted to the other participants of the projects?
00:09:44	S2	Okay. So obviously building control and planning requirements are all part and parcel of the tender process.
00:09:48	S1	Yeah.

00:09:48	S2	So the…the design and project toolkit is also released at tender stage as well.
00:09:53	S1	Okay.
00:09:53	S2	So any potential tenders would have all that information to be able to cost and price up that work…
00:10:00	S1	Okay.
00:10:00	S2	…with the specific requirements of the associations.
00:10:03	S1	All right.
00:10:03	S2	So…and if there's any specific deviations, like the Passivhaus site…
00:10:07	S1	Mm-hm.
00:10:07	S2	…that would also be part and parcel of the tender…tender process.
00:10:11	S1	Okay.
00:10:12	S2	So…so hopefully they would have all that information…
00:10:15	S1	Mm-hm.
00:10:15	S2	…at that point.
00:10:17	S1	Okay. So I'm just confirming what you just said. During the tendering process all the requirements and the information necessary for the tenders…
00:10:26	S2	Mm-hm.
00:10:26	S1	…in terms of quality…of quality requirements regarded to energy…
00:10:30	S2	Mm-hm. Yeah.
00:10:31	S1	…performance are pretty much there in that stage.
00:10:32	S2	Yeah, because normally the…the housing association would take the project up to contract stage.
00:10:38	S1	Right.
00:10:38	S2	So as project managers we would manage that…the design process.

00:10:42	S1	All right.
00:10:42	S2	All the planning process…
00:10:44	S1	Okay.
00:10:44	S2	…along with our employer's agents who we…we obviously recruit to…to administer the contract side. But they work with us from the get go.
00:10:52	S1	Okay.
00:10:53	S2	So they would normally help us along that line. So when we get to tender stage, all the…all the relevant design…
00:11:02	S1	Mm-hm.
00:11:02	S2	…requirements and all those sorts of things are all included in that tender pack…
00:11:06	S1	All right.
00:11:06	S2	…that goes out to potential…
00:11:08	S1	Mm-hm.
00:11:08	S2	…contractors. And then it makes up part of the contract documents as well.
00:11:12	S1	Okay. Are the…are the design team novated to the…to the major contractor once the…
00:11:18	S2	They are…we…we…as part of our project toolkit, we don't have a specific requirement to novate, but we recommend that they are.
00:11:26	S1	Okay.
00:11:26	S2	So where, for example, we've had Passivhaus and now we're digressing to a different project but we have novated the design team and obviously the contractor was recruited earlier to work with us.
00:11:38	S1	Yeah.
00:11:38	S2	In terms of the campus site, the…the contractor opted not to novate and used another architect.
00:11:47	S1	Okay.

00:11:47	S2	Again, I think a lot of that is often cost driven or also where they've got a good relationship with a particular firm that can help…
00:11:53	S1	Okay.
00:11:54	S2	…translate things properly.
00:11:57	S1	All right.
00:11:57	S2	But we still have quite an active role in that in the sense that we're always consulted on any…
00:12:02	S1	Mm-hm.
00:12:02	S2	…any sort of construction phase design issues or when they issue a new document. We're always consulted so we can actually look at the drawings and make sure that they meet our requirements.
00:12:13	S1	Okay. To what stage does the design process moves forward until the tendering process get in to place? I mean, how much design detailing and technical definitions you have left after the tendering process?
00:12:33	S2	Normally after…
00:12:33	S1	Or you have the full package…
00:12:34	S2	Well, normally after the tendering process there's a lot of work required to do sort of discharge planning conditions and those sorts of things.
00:12:39	S1	Okay.
00:12:40	S2	Because normally we…we achieve planning, but then it's passed to the contractor…because it's…we normally let the contractor in a design and build basis…
00:12:47	S1	Yeah, okay.
00:12:47	S2	…then when you pass that responsibility to the contractor.
00:12:49	S1	Super reasonable, yeah.
00:12:50	S2	Yeah.
00:12:50	S1	I think it's…well, in my humble perspective it's…it works pretty much better because well…

00:12:54	S2	Mm-hm. Yeah, yeah.
00:12:55	S1	…they have the involvement and they pretty much know what they…
00:12:58	S2	Mm-hm.
00:12:59	S1	…rather be doing in terms of technical decisions.
00:13:02	S2	Yeah.
00:13:02	S1	Instead of having a full package ready to go and then you have no saying about this.
00:13:05	S2	Mm-hm. Mm-hm. Yeah.
00:13:07	S1	Excellent. In terms of risk assessment, which is pretty much trying to foresee which kind of things that might go wrong during the process that might…
00:13:20	S2	Mm-hm.
00:13:22	S1	…undermine the possibility to achieve the targets that you've…that set in the previous stage. Which stakeholders are involved in the process of defining the quality requirements? Well, this is pretty much what we were talking, right?
00:13:38	S2	Yeah.
00:13:39	S1	If we have the…the major contractor participating…
00:13:44	S2	Mm-hm.
00:13:44	S1	…he has to design and build kind of a…a…a tendering…not tendering, but a procurement process. You have them contributing to the design…the final design stage, right?
00:13:54	S2	Yeah. We also…during the…when we are working the scheme up to get to planning stage, we also hold design forums internally.
00:14:03	S1	Okay.
00:14:03	S2	So we bring stake holders in from our asset team and our repairs team as well to kind of influence the design, because obviously we have to think about longevity and how we're going to manage those units after their built.

00:14:16	S1	Okay.
00:14:16	S2	And often they come up with some really good ideas about how to practically design things, you know, where you keep all the plumbing in one location rather than having bathrooms down here and…just general things so that the properties function better…
00:14:28	S1	Yeah.
00:14:29	S2	…from a…from a maintenance respect but also probably from a…from a…an efficiency perspective as well.
00:14:35	S1	Okay, okay.
00:14:36	S2	So that's quite helpful. And we do bring residents into that as well as that stage. So just to help with the design. So that's quite a helpful…helpful point during that stage. So hopeful when we do get to tender stage we're at quite a good point in the design that we've…we've kind of thought of…tried to think of everything.
00:14:54	S1	All right.
00:14:55	S2	It doesn't always work, but…
00:14:55	S1	Okay.
00:14:58	S2	And then obviously during the contract stage the contractor's responsible for ensuring that they adhere to our toolkit…
00:15:06	S1	Mm-hm.
00:15:06	S2	…obviously because they've signed up to that as part of the contract.
00:15:09	S1	Yeah.
00:15:09	S2	And then they (contractor) are responsible for trying to discharge and deal with the building control and…and planning side.
00:15:15	S1	And in that sense is there room for the contractors to contribute in terms of the…the design decisions once you have the toolkit already established and the basics for the…
00:15:22	S2	Yeah. I mean yeah, as part of the contract they (contractor) can make changes to that (design). So at that point they can…they can make

		changes and give us their contractor's proposals which can erase or delete elements.
00:15:33	S1	Okay.
00:15:34	S2	And there's that term of negotiation. Because obviously from there it's the cost implication a lot of the time…
00:15:39	S1	Yeah, indeed.
00:15:39	S2	…with the housing association properties. We ask for a lot more than a standard property. For example, you know, *Housing association** tend to request specific…specific products…
00:15:53	S1	Mm-hm.
00:15:53	S2	…which isn't always, you know…or we give them a selection of different because we…we tend to prefer say, for example, Worcester Bosch boilers because they're more efficient. So we always ask them to put them in.
00:16:03	S1	Okay, yeah.
00:16:04	S2	There's obviously a cost implication with that.
00:16:05	S1	Indeed.
00:16:05	S2	So they'll always try not to do that (laughter).
00:16:07	S1	Yeah, yeah, yeah. While you're thinking about the long run, right? The maintenance and then…
00:16:10	S2	Yeah, yeah. Yeah, yeah. And our relationship with them. So…yeah, so there's lots sort of to-ing and fro-ing a little bit once we've appointed a contractor or…or selected a contractor before we actually formally appoint them and sign contracts and there's a bit of…
00:16:24	S1	Mm-hm.
00:16:24	S2	…negotiation about what's in and what's out. And that's where we make the list of deviations…
00:16:29	S1	All right.
00:16:29	S2	…from the toolkit.

00:16:30	S1	That's the fine tuning of the process, right?
00:16:32	S2	Yes, yeah.
00:16:34	S1	Okay. We…about risks, we talked about…pretty much about what happens in…in terms of the design process. Do you have in place other processes that would assess risks related to your managerial and workforce capabilities or technical issues…
00:16:56	S2	So…
00:16:57	S1	…which can affect the achievement?
00:16:59	S2	I mean, the…we'd assume that obviously building control and all the relevant warranty, so if it's LABC or NHBC would monitor the quality onsite.
00:17:11	S1	Okay.
00:17:11	S2	But we also internally have a clerk of works…
00:17:14	S1	All right.
00:17:14	S2	…who work for us to monitor the actual site-based work, make sure that things are being built in accordance with either building control…
00:17:23	S1	Mm-hm.
00:17:23	S2	…which obviously takes precedence over our toolkit, and in terms of health and safety and also just our toolkit to make sure that we get the finished product that we've obviously paid for.
00:17:32	S1	Okay.
00:17:33	S2	So that's generally…and in…in terms of…well, it's any works on site but you know if we're building to code, for example at Passivhaus, then we would make sure that…
00:17:42	S1	Yeah.
00:17:41	S2	…you know, things were being done correctly.
00:17:43	S1	Okay.
00:17:43	S2	So it's just another pair of eyes really. Because like…

00:17:45	S1	All right, someone on your behalf that is…is there.
00:17:48	S2	Yeah, because I think from…you know, I know a lot of…I know a lot of housing associations have actually removed the clerk of works role. But they go out on site every day for us.
00:17:59	S1	Mm-hm.
00:17:59	S2	So they see a lot of everything that's going on and they can see stuff that's happening…
00:18:03	S1	Yeah.
00:18:03	S2	…before it's covered up.
00:18:05	S1	Yeah. Indeed, that's the main issue about the energy related things because…
00:18:07	S2	Yeah, yeah. You know sometimes…it's…yes, definitely because a lot of the time it's to do with insulation, it's to do with, you know, appropriate construction to avoid air gaps and…
00:18:16	S1	Exactly.
00:18:17	S2	Yeah, and that sort of thing.
00:18:17	S1	Because once you have the plaster boards in place you cannot…
00:18:21	S2	No.
00:18:22	S1	…assess those kinds of defects.
00:18:23	S2	So that's really helpful, I think. That...you know, they're (clerk of works) our eyes and ears really and them my…my role is to then deal with it back here if there is an issue, to try and manage that through the contract…
00:18:34	S1	Okay.
00:18:35	S2	…and through our employer's agent. So…I mean, ideally we would hope that the contractor would be monitoring quality.
00:18:42	S1	Mm-hm.
00:18:43	S2	And I know that they (contractor) tend to favour these days having, say, like two units that they quality control…

00:18:50	S1	Yeah.
00:18:50	S2	…more intently. So that they then set that as the benchmark for the other units.
00:18:54	S1	Okay.
00:18:54	S2	Which I think can sometimes work quite well.
00:18:57	S1	So…
00:18:58	S2	And that's what we're doing at *Project**.
00:19:00	S1	Okay.
00:19:01	S2	Yeah. We're hopefully going to have a couple of units which we use as our benchmark units…
00:19:05	S1	Yeah.
00:19:05	S2	…to try and keep quality. So does that answer your question? Sorry.
00:19:10	S1	Yes. No, no, completely.
00:19:11	S2	Yeah?
00:19:12	S1	And…and as well provide me some information from the…the next topic which is about resources and I will just go a little bit forward to that topic just because we talked about…
00:19:22	S2	Okay. Sorry. Yeah, yeah, okay.
00:19:23	S1	No, it's completely all right. I mean…so just summing up, we have several layers of quality control here. You said…
00:19:29	S2	Mm-hm.
00:19:29	S1	…you have the…your clerk of works working on behalf of the…of the…of the housing association. So your eyes onsite.
00:19:35	S2	Yeah, yeah.
00:19:36	S1	All right. You have the quality management procedures undertaken by the…the major contractor, right?

00:19:43	S2	Mm-hm.
00:19:44	S1	And then they have building control as well.
00:19:46	S2	Mm-hm.
00:19:46	S1	Okay. And then do you have any more…do you have, for instance, surveys for the snagging process at the end of the road now?
00:19:56	S2	Yeah, yeah. So the…we also have the employer's agent…
00:19:59	S1	Okay.
00:19:59	S2	…who works for us as the contract administrator. So we employ them but they obviously manage the contract for us. So they're another…
00:20:04	S1	Randall & Simonds?
00:20:05	S2	Yes.
00:20:06	S1	Okay.
00:20:06	S2	It's on…on here. So they would obviously be another pair of eyes. But they come at it from a more holistic area of looking at all the contracts side of it as well.
00:20:15	S1	Okay.
00:20:16	S2	So they obviously pull the contractor up, with feedback from our clerk of works often, about what they're contractually obliged to do.
00:20:25	S1	Okay.
00:20:25	S2	So that's also quite helpful. But yeah, at the end of the build process, then we do snag.
00:20:31	S1	Mm-hm.
00:20:32	S2	Contractor normally does their own snag, then we go in and do an official snag and then de-snag…
00:20:37	S1	Okay. All right.
00:20:38	S2	…before handover. So…

00:20:41	S1	This is…well, the next…I'm sorry, I interrupted you.
00:20:44	S2	No, no. It's fine. I was just gonna say that's…but for me that…that's kind of a late in the day time to find lots of really…
00:20:52	S1	Mm-hm. Yeah.
00:20:54	S2	…major things. So it's great that we can try and nip it in the bud a lot earlier.
00:20:57	S1	That's…that's for sure. That's one of the things that's I've been looking in terms of quality management procedures. Not only house associations, but across the industry, that we focus a lot on the…on the client, on the occupant. Which is great because of course they are the core of our business, right?
00:21:15	S2	Yeah.
00:21:16	S1	So most of the quality management procedures are focusing in…I wouldn't say…lots of people call this cosmetic defects, but I wouldn't call it because they're not only cosmetics. Because if a doorknob is not working it's not…
00:21:29	S2	No, no.
00:21:28	S1	…cosmetic stuff it's functional stuff that should be corrected.
00:21:32	S2	Mm-hm.
00:21:32	S1	But as you mentioned it's pretty much in the end of the day.
00:21:36	S2	Mm-hm.
00:21:37	S1	And then defects that we relate to energy performance like…
00:21:39	S2	Like the latent defects. So…yeah.
00:21:41	S1	…discontinuity of insulation layers for instance.
00:21:43	S2	Mm-hm.
00:21:44	S1	You cannot look at them anymore once you have reached the end of the process.
00:21:47	S2	No, that's it. Mm-hm. Yeah.

00:21:50	S1	This is question eight. To what extent the managerial team and workforce understand the impact of defects on energy performance of buildings in this specific project?
00:22:04	S2	Well I think…I mean, most project managers understand it (impact of defects) and also the architects we appoint because they are also part of a framework. So we have a framework of architects that we can go to. So they've signed up to the design and project toolkit. So I think they also have an understanding of our requirements.
00:22:24	S1	Yeah.
00:22:25	S2	And therefore…that should therefore translate into what the construction drawing issue is. And hopefully therefore everything should follow…
00:22:37	S1	All right.
00:22:37	S2	…where it's managed properly on site. But again, I don't think it's always…it's a bit like Chinese Whispers where it get relayed differently on site…
00:22:45	S1	Indeed, indeed.
00:22:45	S2	…and people get the wrong…wrong end of the stick. So that's why it's helpful to have clerk of works there to try and pull the site managers up sometimes. Because the site managers are super busy…
00:22:55	S1	Yeah, indeed. It's crazy.
00:22:55	S2	…and they're trying to coordinate everything.
00:22:57	S1	Yeah.
00:22:59	S2	It's…I don't want to make excuses for them, but sometimes they can take their eye off the ball on one thing…
00:23:04	S1	Yeah.
00:23:04	S2	…or you could have a particular trade whose…one guy is really really clued up, spot on and is cracking on great, but somebody else…
00:23:13	S1	Yeah.
00:23:13	S2	…isn't doing quite so well, you know?

00:23:15	S1	Yeah. I perfectly understand that. I've…I've…I am now back to academia, but from, I don't know, last 13 years I worked with project management and then at a certain point I worked as a site manager. And I completely understand that it's…it's not a lack of interest or lack of…
00:23:32	S2	No, no. It's just trying to…so you've got all these plates and you're trying to spin them all.
00:23:35	S1	Exactly, exactly.
00:23:36	S2	And it's hard work, isn't it? And…
00:23:37	S1	It is, it is. And you work with priorities.
00:23:41	S2	Yeah.
00:23:41	S1	I mean, you cannot fight in so many fronts at the same time. So you prioritize as much as you can.
00:23:47	S2	Mm-hm.
00:23:48	S1	But…and then it's reasonable that something here and there will…will…
00:23:51	S2	But we're all human, aren't we? Everybody has off days as well.
00:23:54	S1	Indeed.
00:23:55	S2	And you know…so I think, you know, collectively everybody tries to do…I'd rather pick somebody up on something early doors and get it rectified than beat them with it afterwards to say you didn't do that or what have you.
00:24:10	S1	Yeah. Yeah.
00:24:11	S2	So it's…I think it's…it's the project team need to work collectively really. So try and…
00:24:14	S1	Exactly, exactly. I do agree with that. I think the blaming approach is…has no…is pointless because it doesn't take us anywhere.
00:24:22	S2	No. For example at the *Project** site, we've got a slight issue with a few units where we've…we've over specked a vestibule area and it's kind of made the kitchen difficult to work…
00:24:36	S1	Yeah.

00:24:36	S2	…with the units and things. But there's no point blaming the site for that or the…or the contractor because ultimately we also signed off on those design drawing early.
00:24:45	S1	Yeah.
00:24:46	S2	So we've all tried…we're all trying to work together now to make it work.
00:24:49	S1	Yeah, yeah. I think cooperation…
00:24:50	S2	And there's no point….yeah. There's no point. We are where we are with it, you know. We've got units out the ground. We can't really…
00:24:57	S1	Indeed.
00:24:57	S2	So yeah. Clearly if people don't pull their finger out and sort stuff out then I do end up beating them. But (laughter)…but first of all I try and, you know, get stuff sorted without being…
00:25:13	S1	Yeah. Well…
00:25:14	S2	…aggressive about it. But yeah, I think…I think the managerial team do have a handle on it. But again, you know, I know what's required, it's just sometimes it's such a large document (design and project toolkit)…
00:25:27	S1	Indeed.
00:25:26	S2	…things get missed. So, you know, it's…it's really extensive.
00:25:31	S1	Indeed, indeed.
00:25:32	S2	A lot of it's common sense. But I…I find myself having to refer to it all the time. And again, on site you don't always have that luxury of "I must go and check the toolkit".
00:25:43	S1	Exactly, exactly.
00:25:44	S2	So yeah. But…but the information's there, it's just whether people always take it on board.
00:25:52	S1	In that sense, what in your opinion would be the challenges and obstacles faced when you're implementing the quality management procedures set by your toolkit or in terms of the things related to energy performance of the housing units?

00:26:10	S2	Well, you don't want to make them (design and project toolkit) too onerous…
00:26:15	S1	Okay.
00:26:16	S2	…so that people don't read them I guess.
00:26:19	S1	Okay.
00:26:19	S2	That's the problem as well, they need to be relevant…
00:26:22	S1	Okay.
00:26:22	S2	…and useful…
00:26:23	S1	All right.
00:26:25	S2	…because you can just…you can have too much information, can't you? And then…
00:26:31	S1	Yeah, that's…
00:26:31	S2	…it isn't particularly helpful. So I don't…I think it needs to be pertinent to the project and relevant. And accessible to people as well so they feel as if they're able to refer to it and it's easy to refer to.
00:26:44	S1	Mm-hm.
00:26:45	S2	Otherwise it's not really very useful.
00:26:47	S1	Yeah.
00:26:51	S2	I suppose the challenge is as well, like I was just saying about managing the information sharing on site.
00:26:59	S1	Yeah.
00:27:00	S2	So, you know, it comes from the project team and it's got to then be related to the site manager, who's probably not been in the early stage negotiations, so they're not sure what's actually been agreed. They've probably not got all the contract particulars on site.
00:27:14	S1	All right.

00:27:15	S2	So then they've got to have that information. Then they've got to rely that to subcontractors, it's normally the managers. And then the managers relate to their workers and…
00:27:23	S1	Yeah. It's the contractor's…
00:27:24	S2	So it's trying to manage the information sharing process as well I think is sometimes quite tricky.
00:27:30	S1	Okay. I mean, in terms of…in terms of the density of the information, the amount of information and how do you transmit them to people on the construction site.
00:27:39	S2	Yeah, I think so because for me as well sometime I think sequencing can be slightly off on site.
00:27:47	S1	Mm-hm.
00:27:48	S2	So that, you know, you have certain contractors or certain trades in before other trades are quite done. And I know that just happens like that because of programming and, you know, time is of the essence with a major contractor. They want to get in, they want to get out.
00:28:02	S1	Yeah, exactly.
00:28:03	S2	But sequencing doesn't always…I found it with *Project** where they'll have somebody coming in to do something when something else hasn't been done quite…or quite finished yet.
00:28:14	S1	All right.
00:28:14	S2	And then there's that process of well, that's going to delay me because stuff's in my way and other people are trying to work around other people. And it…to me it's just a bit of a recipe for disaster.
00:28:27	S1	Yeah, it's…it's chaos, yeah.
00:28:29	S2	Yeah. So I just think it's good if…it's good if it can feed into sequencing. But I think, again, the information needs to be relevant perhaps to particular trades on site.
00:28:43	S1	Okay. All right.

00:28:46	S2	But then they'll need to have an understanding of what other people are doing. Because the impact that they can do something wrong can then impact on somebody else being able to do their job.
00:28:54	S1	It's a…it's a snowball, right.
00:28:56	S2	Yeah.
00:28:56	S1	Sometimes it can work like that and…another thing that I…well in my times, that I found really difficult to manage is once you have a trade finish the work and then you go there, check the qualities, sign off.
00:29:10	S2	Mm-hm.
00:29:11	S1	And then you have another…the following one. And then to do his job he end up wrecking the previous work.
00:29:18	S2	Yeah, yeah, yeah.
00:29:19	S1	And then you go there to check it and his work is fine, but the mess that he left behind him in the other people's trade work is quite…
00:29:26	S2	Yeah, that's what concerns me and…yeah, so I think it's…the good thing about the *Project** project, like I say, is that they're intending to benchmark two units.
00:29:37	S1	Okay.
00:29:38	S2	So they'll use them as one that they really go to town on in terms of the clerk of works will say whether stuff's acceptable and they'll monitor…the assistant site manager up there is responsible for quality assurance.
00:29:51	S1	Okay.
00:29:51	S2	So she's going to have to monitor that to the nth degree on those particular units.
00:29:55	S1	Okay.
00:29:55	S2	And then once they've got those correct they'll know what to…what all the others need to be like.
00:30:00	S1	What is…what is the name of the…the…the site manager assistant there? It's a lady…

00:30:04	S2	It's *Assistant site manager*…
00:30:05	S1	*Assistant site manager**, yeah.
00:30:06	S2	*Assistant site manager**, yeah. *Assistant site manager**…is it *Assistant site manager**…hold on.
00:30:11	S1	There are two guys. A young…
00:30:15	S2	Is it *Assistant site manager**?
00:30:16	S1	A lad and a…
00:30:17	S2	*Assistant site manager** and then there's *Site manager**. Though…
00:30:19	S1	Yeah, *Site manager** is the site manager, right?
00:30:20	S2	Yeah. The Scouser.
00:30:24	S1	The what?
00:30:24	S2	The Liverpudlian. I just want to see if I can find that…
00:30:29	S1	Difficult to get to him. He's a very busy man.
00:30:32	S2	Very busy. Always busy. Unless he wants to speak to you.
00:30:36	S1	Yeah, well that's a different…I think that's not pretty much the case…
00:30:40	S2	Yeah.
00:30:41	S1	…in my…
00:30:43	S2	*Assistant site manager**.
00:30:49	S1	All right.
00:30:49	S2	Mm-hm.
00:30:49	S1	In terms of resources, going a little bit further down. We talked about who's responsible for developing…the quality management procedure is just your toolkit…
00:31:01	S2	Yeah.

00:31:02	S1	…that you previously developed and then you tweak it regarding to the peculiarities of the project. You said there's a specific team in place on behalf of the housing association, right? I'm just summarizing here…
00:31:15	S2	Mm-hm.
00:31:15	S1	…because the questions I think you have already answered, which is your clerk of works…
00:31:20	S2	Mm-hm, yeah.
00:31:21	S1	…your eyes on site. You said about creating specific procedures that you create awareness in terms of quality requirements related to energy performance. You said this is one of the…the difficult stuff in terms of quality…or in terms of information transmission across the…the participants of the project.
00:31:42	S2	Mm-hm.
00:31:47	S1	In your…in your personal opinion, does the housing association or the major contractor provide the proper environment and all the necessary resources in terms of achieving quality requirements proposed by the project? Do you think that could…
00:32:03	S2	Yeah, as far as possible.
00:32:08	S1	Yeah.
00:32:09	S2	I mean, it has to be reasonable, doesn't it, and proportional. So it has to be…it has to be sat along with all the other things they have to take into consideration. So I think from that perspective yes, they do.
00:32:16	S1	Okay.
00:32:16	S2	Yeah. There's probably…there's always means for improvement, isn't there, and there's things you could probably do differently.
00:32:21	S1	Of course, yeah.
00:32:22	S2	And…and when you reflect on the project at the end, there's always things that you criticize yourself for not doing well and things that went really well.
00:32:31	S1	Yeah.

00:32:32	S2	But…but there's…like I said to you, it's…and you commented just now that there's so much you have to consider…
00:32:38	S1	Yeah.
00:32:38	S2	…that, you know, quality is there along with all the others…health and safety and all the other bits and pieces that need to be considered. So yeah, I think from…I think we probably do a better job than other…some others. Yeah.
00:32:49	S1	Okay. Yeah, yeah. That's true.
00:32:52	S2	Mm-hm.
00:32:53	S1	Well, in terms of quality metrics, which is the specific performance attributes that you have to deal with…
00:32:58	S2	Yeah, mm-hm.
00:32:58	S1	…in terms of complying with what was targeted in the beginning, can you tell a little bit about the energy performance attributes that are considered in your quality plan? I mean, you've said already that you comply with the building regs (sic).
00:33:15	S2	Mm-hm.
00:33:16	S1	And then is it…can I say that these performance attributes are the ones set up by the building regs (sic)?
00:33:23	S2	Yeah. So we normally…we obviously comply with building regulations and also we have to meet the planning…the local authority's planning requirements. I think it's…at the moment it's core strategy policy 20…
00:33:39	S1	Okay.
00:33:39	S2	…which requires 15 percent renewables…
00:33:42	S1	Okay.
00:33:42	S2	...on development sites.
00:33:43	S1	All right.
00:33:44	S2	So generally we achieve that through PV installation.

00:33:47	S1	Okay.
00:33:49	S2	On this particular project we're installing them on the shared ownership properties.
00:33:54	S1	Okay.
00:33:55	S2	Purely from a cost perspective of the fact that if you…if we install them on the rent side then obviously there's the maintenance side of that and things like that. So we've…we've passed that on to the shared owners.
00:34:07	S1	Okay.
00:34:09	S2	It's…it's quite complicated but it's all to do with how things are grant funded.
00:34:13	S1	All right.
00:34:13	S2	And if you install PVs you can't recoup any of the money on rented units from…from installation of PV. So we've opted to put them on the shared ownership properties on this particular scheme.
00:34:22	S1	Okay, so you don't…you don't get involved in the maintaining…
00:34:25	S2	Yeah, Mm-hm.
00:34:26	S1	…maintenance, yeah.
00:34:28	S2	But…yeah, so as I say, the drivers originally when we set us out on this project were to have a higher energy performance and specification.
00:34:42	S1	Mm-hm.
00:34:42	S2	But unfortunately due to cost it's fallen back in line with building control…
00:34:47	S1	Okay.
00:34:48	S2	…and planning policy.
00:34:49	S1	Okay.
00:34:50	S2	Yeah.
00:34:50	S1	In terms of complying with building regulation and then building control…
00:34:55	S2	Mm-hm.

00:34:56	S1	…in terms of air permeability tests and pressure tests, do you work on the sampling basis proposed by the building regulation which is, if I'm not wrong, three units per housing type or 50 percent, whichever the less.
00:35:15	S2	Yeah, I think…just give me a minute here to see…we…the…the contractor normally appoints the sustainability consultants who normally do the calculations for us. But yeah, I'm assuming that they must comply with building control.
00:35:30	S1	Okay.
00:35:31	S2	So we don't generally do anything over and above as far as I know.
00:35:34	S1	Okay. And in terms of sampling, do you do the air tests in every each house or just as the minimum recommended by building regulation?
00:35:42	S2	I think it says…yeah, we wouldn't really. I'm just trying to look to see if they've done…it looks as if on here…sorry for this [inaudible 00:35:52].
00:35:53	S1	Yeah, no worries.
00:35:53	S2	But it looks to me like they just do house types.
00:35:57	S1	Okay.
00:35:57	S2	So it's quite small.
00:35:58	S1	Okay, so they comply with…
00:35:59	S2	So they just do…yeah.
00:36:01	S2	…the amount set by the building regulation which is…
00:36:03	S2	Mm-hm. Yeah.
00:36:05	S1	…fair enough, yeah.
00:36:06	S2	Yeah.
00:36:08	S1	Okay. In terms of defects identification, especially speaking in the ones that will affect energy efficiency, do you have in place a procedure for identification and collection of those defects?
00:36:23	S2	Yeah, we do. So at the end of the project we retain our attention some during the 12 months after…

00:36:37	S1	Okay.
00:36:37	S2	…the new project finishes.
00:36:38	S1	Okay.
00:36:39	S2	And during that time the contractor's responsible for defect…its liable for defects.
00:36:46	S1	Yeah.
00:36:47	S2	So we have a reporting procedure for residents to let us know if there's issues. Again, if there was anything wrong with any of the installations or…
00:36:55	S1	Mm-hm.
00:36:57	S2	…you know…
00:36:57	S1	So those reports are feed by the…the occupants. I mean, if they found…
00:37:02	S2	Yes. Yeah.
00:37:02	S1	…find that something's not working properly or they see some kind of…then they will fill in the form.
00:37:06	S2	Mm-hm. That's it. Yeah, they…they normally…they normally call our call centre.
00:37:10	S1	All right.
00:37:11	S2	And then the call centre assess whether that…that needs to be reported as a defect to the contractor.
00:37:17	S1	Okay.
00:37:18	S2	And there's a set procedure to inform the after care service.
00:37:21	S1	All right. Okay.
00:37:22	S2	Which isn't always great.
00:37:25	S1	Yeah, no one wants to get back to the...
00:37:26	S2	Well, we hope there's no one there. So they inform them. If not it will go through to our repairs…repairs service…

00:37:33	S1	Okay.
00:37:33	S2	…if it was obviously tenant fault or something that's been caused by tenant…
00:37:39	S1	Mm-hm.
00:37:39	S2	…error.
00:37:40	S1	All right.
00:37:41	S2	But usually speaking they would, yeah, report it through. So we also have a…a means…it all goes through our call centre so that we can monitor it.
00:37:52	S1	Okay.
00:37:52	S2	So then our…our team of policy and performance can download a report for us.
00:38:00	S1	Mm-hm.
00:38:00	S2	And we also try and ask the contractor…
00:38:03	S1	Mm-hm.
00:38:03	S2	…to do the same for us, to provide us with a monthly report so we know what level of calls they're getting.
00:38:09	S1	All right. And then you possibly can use this information for the following project…
00:38:11	S2	Mm-hm, yeah.
00:38:13	S1	…as a field work…a look back.
00:38:14	S2	Yeah. Yeah, sometimes to do that. But we also have a…prior to the…we also do an inspection…
00:38:23	S1	Mm-hm.
00:38:24	S2	…at end of defects (liability period) as well. Because obviously people ring up and report leaks or things like that. But sometimes if they've got a slight settlement crack or whatever, that's picked up at end of defects.
00:38:34	S1	Yeah.

00:38:35	S2	And prior to that we send out a…a questionnaire.
00:38:39	S1	Mm-hm.
00:38:40	S2	So a tenant satisfaction questionnaire…
00:38:42	S1	All right. Okay, that's…
00:38:42	S2	…which they can fill in and we can get feedback on whether they like their house in terms of layout, size…
00:38:50	S1	Mm-hm.
00:38:49	S2	…storage, noise.
00:38:53	S1	Okay. Size they…I believe that they always ask for more, right?
00:38:56	S2	Yeah, they always ask for more storage. They always ask for more storage. But yeah, we do send out a satisfaction questionnaire as well and we get quite a good response really. I think the last response maybe it was about 37 percent which for questionnaire's quite good.
00:39:06	S1	Yeah, that's really good.
00:39:07	S2	We've got about 92 percent satisfaction at the moment, so that's quite good.
00:39:12	S1	Yeah, well, pretty much talking about the last topic which is quality compliance.
00:39:17	S2	Mm-hm.
00:39:17	S1	And then…so can you talk about how…in which format the output provided by the clerk of works and the…the ones that were undertaken by the major contractor, how does it gets back to you in terms…I mean, speaking as a housing association stakeholder.
00:39:44	S2	Okay.
00:39:44	S1	Do you have reports? It's…
00:39:46	S2	Yeah, so as part of the contract we have monthly project progress meetings.
00:39:53	S1	Okay.

00:39:54	S2	Yeah, on site. As part of that, any more sort of strategic issue, such as design issues for example…like yard doors on some of the projects you're still bottoming out some design issues.
00:40:06	S1	Mm-hm.
00:40:06	S2	So that's normally factored there. Clerk of works provide weekly reports…
00:40:12	S1	Okay.
00:40:12	S2	…[inaudible 00:40:12] as well.
00:40:19	S1	Okay.
00:40:20	S2	And also on a yearly basis we have an audit to look at…so rather than…you mentioned the ISO what is it? Nine?
00:40:25	S1	Yeah, 9000.
00:40:26	S2	Yeah. We don't really comply with that. But we have like a…our own sort of internal audit…
00:40:31	S1	Okay.
00:40:32	S2	…which looks at specific elements of our…
00:40:34	S1	Mm-hm.
00:40:35	S2	…of our department. So for this…for this financial year it was to look at our approval process for variations to contract, where we've asked for additional items to be added and things like that. So they specifically target areas to look at.
00:40:52	S1	All right.
00:40:53	S2	But yes, so we have audits yearly, the project meetings monthly and the clerk of works provide reports weekly.
00:41:01	S1	Okay. Who participate in those…in those…
00:41:05	S2	The project meetings?
00:41:05	S1	Yeah.
00:41:06	S2	So as a requirement it's usually the project manager, so me…

00:41:11	S1	Right.
00:41:11	S2	…the site project manager or build manager…
00:41:13	S1	Mm-hm.
00:41:14	S2	…the site manager normally…
00:41:16	S1	Mm-hm.
00:41:17	S2	…the employer's agent, any of the design team, normally the QS as well.
00:41:25	S1	Okay.
00:41:26	S2	So sometimes there's quite a few of us. Yeah.
00:41:28	S1	Yeah, yeah. Well, got to…it's interesting because every conclusion you get you…you can recover.
00:41:33	S2	So that's quite helpful to tease some things out. But generally the clerk of works report that we get weekly will feed into that project as well where there's things that are outstanding.
00:41:43	S1	Yeah.
00:41:43	S2	Yeah.
00:41:44	S1	And the…and the findings that you…or the conclusions that you get from those project meetings, do you use those information to the ongoing project or are you saving this information for the following one?
00:41:58	S2	Normally it helps to deal with things during the project.
00:42:01	S1	Okay.
00:42:02	S2	Some things are quite project specific so it will help to…I always find it helpful when things are minuted (laughter).
00:42:08	S1	Yeah, yeah. Definitely.
00:42:10	S2	So people know what their action points are. So normally it helps to…to deal with things during the project. But also it will help to inform how you…
00:42:20	S1	Mm-hm.

00:42:20	S2	…deal with things…
00:42:21	S1	All right.
00:42:22	S2	…in another…in another project as well I think.
00:42:24	S1	Okay.
00:42:25	S2	Because like I say, you do have a…an end of project review.
00:42:30	S1	Mm-hm.
00:42:30	S2	So you can see how you would perhaps do things differently next time.
00:42:34	S1	Okay, perfect.
00:42:34	S2	Yeah.
00:42:35	S1	Well, I think we're…we're at the end of this interview.
00:42:41	S2	Okay.
00:42:41	S1	Thank you very much…
00:42:42	S2	That's okay.
00:42:43	S1	…for your time and collaboration. It's very helpful for me in terms of my research.
00:42:46	S2	Okay.
00:42:47	S1	Thank you very much.

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

(00.42.49)

(End of Audio)

Duration 43 minutes

Interview 3.b – Transcript

Timecode	Speaker	Transcript
00:00:00	S1	And just before we get started I just want to make sure that you've got, prior to this interview, the information sheet.
00:00:09	S2	Yes, I did. Yeah.
00:00:10	S1	And the consent of participation as well.
00:00:11	S2	Yeah.
00:00:12	S1	Okay. All right. So, I've grouped the questions according to the theoretical framework of quality management systems. And the first bit is regarded to basic information. I mean, so your name is Quality officer*.
00:00:30	S2	That's correct. Quality officer*, yeah.
00:00:32	S1	Your professional qualification?
00:00:33	S2	I'm an associate member of The Chartered Institute of Building.
00:00:37	S1	Okay. Years of professional experience?
00:00:42	S2	Seven years trade, 30 years as a surveyor.
00:00:45	S1	Okay.
00:00:45	S2	So 37 years in total in construction.
00:00:48	S1	Just one thing I forgot to tell you, if we can address the questions using the Case Study 3* as the background.
00:00:56	S2	Yeah, if you want to base it on Case Study 3*, yeah, fine. That's fine, yeah.
00:01:02	S1	Okay, so the role, what is your role in the project?
00:01:06	S2	My role is clerk of works or if you want to call it by another name is the building quality supervisor.
00:01:13	S1	Okay.
00:01:14	S2	But clerk of works is my real, my job title.

00:01:17	S1	All right. And then number of first off, housing units?
00:01:21	S2	Sixty-seven.
00:01:21	S1	Sixty-seven, okay. Geographic area of the housing association I mean, in terms of….
00:01:30	S2	It's North Plymouth, it's Southway.
00:01:34	S1	Okay, all right. And do you know the number of ongoing projects?
00:01:39	S2	What, in Housing association*?
00:01:41	S1	Yeah.
00:01:42	S2	Three hundred and fifty-two plots.
00:01:44	S1	Okay.
00:01:44	S2	Yeah, 352 plots at various stages either in construction or under construction or planning's in approval and contractors are under contract. So, that was only mentioned yesterday in a meeting, we have 352. Yes, the most we've ever had, yeah. And that's….
00:02:04	S1	A lot of work ahead.
00:02:05	S2	Oh, a lot of work now. So, yeah, 352 active, technically active plots.
00:02:12	S1	Okay. That's a lot going on. So, not an easy task to keep everything on target.
00:02:19	S2	Just don't think about it. If you think about it, you'll never do it.
00:02:23	S1	Yeah, you have to go….
00:02:24	S2	So, you just get on with it, go with the flow.
00:02:26	S1	Yeah. Are you aware of any quality accreditation here in Housing association*? I mean, ISO or…?
00:02:35	S2	Well, yeah, we haven't got ISO as such. We've got the standard sort of QA but that's in-house, it's not…. Although saying that actually, we are…we might have ISO 9001 actually off the top of my head. And I'm not sure, to be honest.

00:02:54	S1	Okay. I can check it out.
00:02:55	S2	Yeah, you can check it out anyway. But I know we have an annual review.
00:03:00	S1	All right.
00:03:00	S2	But it may not be the 9001. We have on our letterheads that we have, used to be BSI, then it was Veritas, and they change on a regular basis but yeah, you need to double check that to be honest.
00:03:14	S1	Okay. Do you know what roughly the numbers, the project overall cost?
00:03:22	S2	For Case Study 3*?
00:03:24	S1	For Case Study 3*, yeah.
00:03:25	S2	This is off the top of my head. I think it's around about 8 million.
00:03:30	S1	Okay.
00:03:30	S2	Yeah, something like that seems to ring a bell.
00:03:33	S1	All right. And the stage of the project process, you're under construction stage?
00:03:37	S2	Yeah, we're in construction stage. We've had our first two plots in final so they've been decorated. And we're not…because of the way the handover is, we've not got phase, we can take all the plots in one hit. But we're not likely to do that but that's how the contract's been written. So, yeah, we're in various stages of construction but every plot is out of the ground.
00:04:01	S1	Okay. And the project duration?
00:04:05	S2	June, July next year is sort of like the planned completion date for handover of everything.
00:04:13	S1	And when did you start?
00:04:16	S2	We started on site this summer, demolition of the garages because it was…formerly it was a site that had been taken down to slab, the school. But to allow access we had to demolish the garage block. Now start on site, I think it started around about August, September time. That's just off the top of my head. Obviously, if I decided to look, I can find the date we've started but off the top of my head, it's late summer, early autumn or September.

00:04:54	S1	Do you remember which procurement route was chosen for this project?
00:04:58	S2	I didn't get…it'll be probably. I didn't get involved, I don't get involved in procurement but it would be under the JCT terms I would imagine.
00:05:05	S1	All right, okay.
00:05:08	S2	Standard contract stuff really.
00:05:10	S1	Okay, all right. Well, the first of the second group of questions is regarding to the requirements and objectives to the quality plan. So, does the project have a formal quality plan and is it project specific or standard?
00:05:34	S2	It would come back to the toolkit, the actual quality standard. And that would be across the board to any of our projects.
00:05:47	S1	All right.
00:05:47	S2	So, we weren't picking sources used across the board at the moment.
00:05:51	S1	Okay.
00:05:53	S2	So, that's the quality standard, what we would expect.
00:05:59	S1	Okay. And in terms of quality requirement established for the project. Are energy performance aspects part of the scope of this quality plan?
00:06:10	S2	Yes, they would be because they would be quality in that building regs (sic) would have to apply anyway. So, we'd have to meet building regs (sic) to get building regulation approval. But what we do as an organisation, we do try to go over and above minimum standards. So, some of the U-value is, particularly at Case Study 3*, is higher. So, we've got a better…we've got a higher level of insulation than what we would require on the building regs (sic) just because we've had the opportunity to do it. So, we do go and exceed building regs (sic) where we can. We're practical really and where the cost allows as well.
00:06:51	S1	Okay. And this…we'll get there a little bit later. So, you just mentioned the requirements regarding to energy performance, they are a bit higher than established by the building regs (sic). Is it linked to the former code for sustainable homes or it's something that you pick…?
00:07:15	S2	I think it's something…obviously, when code was in place, we would go over and above the minimum. So, we tended to go for code four as opposed to the code three which would be the standard requirement. But

		no, it's not. I think it's partly as an organisation, we want to be green if we want to reduce our carbon footprint and our residents' carbon footprint and also, we want to reduce our residents' bills. So, I think it's something that's built in the Housing association* that we won't just go to the minimum, where possible we'll go over and above and you know, that's how I see it.
00:07:56	S1	Okay, all right.
00:07:58	S2	That's answered the question?
00:08:00	S1	Yeah, yeah. Sure. And those requirements related to energy performance are they the strategic goals of the organisation or are they specific for the project?
00:08:13	S2	I would say they're specific for the project however, they do link in with the goals and aspirations of the organisation. So, they go together really, in tandem really. One needs the other I guess. Because if we had a scheme that met the minimum standards of building regs (sic) and we had feedback later on that our tenants' or our residents' bills were a lot higher than what they expected. Somebody from our board for example with the senior management team, were building these new houses and they're costing a bomb to run. We don't want to go into that, so that's where the two are linked. So, yeah, I would say they're linked.
00:08:54	S1	Okay.
00:08:54	S2	Yeah, I would say obviously, yeah, you could say the primary driver is the legislation which we have to meet that first.
00:08:59	S1	Which is embedded on the toolkit (Overlapping Conversation).
00:09:02	S2	Yeah, you got it, in the toolkit, you got it in building regs (sic) and you've got your standards whether it be LABC technical standards or NHBC technical standards. The energy conservation in the main is linked to the building regs (sic) approved documents because that's what the underlying requirement is. But also, these also go to standards a little bit higher, if that makes sense.
00:09:25	S1	Yeah. And how those, defined requirements related to energy performance are documented and transmitted to the rest of the participants of the project?
00:09:38	S2	Well, obviously, every plot has an EPC.

00:09:41	S1	All right.
00:09:41	S2	So, the EPC will be when the plot is completed and we've taken handover and technical completion's been achieved and we now own and manage the properties. At that technical completion stage, we will be given an EPC certificate and we would expect it to meet the minimum designed rating. And if it didn't, then there'd be obviously questions asked but they all tend to meet that anyway.
00:10:10	S1	Okay. Can I assume that this toolkit is included in the documentations for the tendering process?
00:10:20	S2	From…yeah. Well, when the design, it's not so much the tendering, it'll be at design stage. So, when we're doing, when we're instructing an architect's practice to draw up some initial designs, we will be giving them an indication of what EPC, what that rating we would expect, what SAP we would expect the plots to make. So, if they came in that D we wouldn't be very happy. So, we tend to be A's and B's.
00:10:50	S1	Okay, so that's the band that you require for the design?
00:10:52	S2	Yeah, we tend to aim for that, yeah. We wouldn't be looking at C's and D's because it's over construction and invariably building regs (sic) nowadays we look at low energy light fittings. You know, and you'll have combi boilers, room stats, TRVs. So, we would be covering off that as well.
00:11:16	S1	Okay. Let me ask you something, it's a bit away from the topic but it's just out of curiosity. I've seen in some of the design documents that you have two architecture offices working in this or am I wrong? I mean, I saw Mitchell's drawings and I saw a different….
00:11:37	S2	Yeah, the way it works, when they're drawing up a scheme for funding they will use, they could use Mitchell's for example. So, they will do the initial brief, they will work on the initial brief. They will produce plot…they will produce drawings for planning so we get planning approval. Once that approval's been gained and we're looking at more detail and we've funding for it, the detail could be drawn up by another architect. So, we may…that would be possibly through to a tendering process you know, employing consultants. And an architect as a consultant just the same as an M&E consultant is and whatever. So, that's why you see changes. Yeah, often or not it doesn't always…Mitchell's may start it but Strive for example, may come in and do the detail drawings for building regs (sic). But planning, normally we use another architect's practice. We may have some…. I'll be

		honest with you, I can't answer all those questions in detail because I'm not part, I don't get involved with that process.
00:12:47	S1	Okay, all right.
00:12:48	S2	That tends to be our design team, the likes of Project manager* and Tina and whatever.
00:12:54	S1	Okay.
00:12:55	S2	My role is eyes and ears on the site, technical. And a lot of these decisions are already made. But I do, I do as clerk of works, as part of my role is to review the drawings.
00:13:06	S1	Okay.
00:13:06	S2	So, if there's something that I'm not happy with, I can flag it. But invariably, building regs (sic) has already been sought and approved. But I do get involved in the design process but not in the detail my colleagues do.
00:13:23	S1	All right. Well, now moving to the next section which is regarding to risk assessment in terms of trying to identify what can go wrong during the design or the construction process. So, do you know which stakeholders are involved in the process of defining the quality requirements related to energy performance of the project and when does it happen?
00:13:47	S2	You're saying defining? So, you mean somebody's actually going to sit down and say, "This is what we wanted to…?" Well, it'll be at initial design stage. So, we would be given, as I said earlier, we would be given instruction that we'd expect the plots to meet like high SAP rating. And anything less than like maybe a B would be unacceptable. And obviously, building regs (sic) is a given. But we would try to go over and above that. So, it's set at an early stage but it'd be set by the development team.
00:14:21	S1	Okay, all right. So, the development team is responsible for setting those requirements and parameters.
00:14:27	S2	Yeah, as they do off the back of source and off the back of…. They would get the HCA, the homes and community agency who fund this. They have their own criteria as well that we have to meet, so sustainability is one of them.
00:14:45	S1	All right.

00:14:46	S2	So, that would be a starting point and then it would build from there.
00:14:50	S1	Okay. So, this process has been…I mean, those decisions have been made before the tendering process, before the contractor is on board?
00:14:59	S2	Yeah. You would be a fool to do it the opposite way around because they would cost… would then escalate and you wouldn't either get what you expected or what you asked for at a later stage. No, the process would be you would iron this out prior to going out to price.
00:15:18	S1	Okay. is it reasonable for me to say that this happens because if you decide to comply with building regs (sic) and building regs (sic) set up the proper measures in order to comply with the performance targets which are set prior so you don't' need to go over it because you have already a clear…?
00:15:38	S2	No, it's already a given from the design…. You know you're not going to get building regs (sic) approval if you don't meet those requirements. So, that's a given. But what we would do is rather than get the minimum and submit it and then say, "Oh, we'll bump it later. Let's get the SAP rating up," we would've made that decision at an early stage. But our target tends to be A's and B's.
00:16:04	S1	All right. And the question seven is about, is there a process in place to assess risks related to technical issues or managerial and workforce capabilities which might affect the achievement of those requirements?
00:16:24	S2	Yeah, we've got quite a few levels of…. We have obviously every project has to meet building regs (sic), so we have either local authority building control will do the building control or it might be approved inspectors, NHBC or whatever. So, that's the first line of defence. So, not line of defence, but that's the first line would be your statutory requirements, so that would be your building regs (sic).
00:16:56	S1	Okay.
00:16:57	S2	Then you have to meet the requirements of the homes and community agency, the housing quality indicators. So, again, energy efficiency is in there.
00:17:06	S1	All right.
00:17:07	S2	Although we don't build to code now, we are building to code in reality with the exception of things like water butts and stuff like that which was an additional thing. But all your water usage or your energy usage would be

		the same. So, we've got building regs (sic), we've got the HCA requirements, we've got what's in the design toolkit.
00:17:29	S1	Okay.
00:17:30	S2	We've also got the NHBC standards, the LABC standards and I know what's on the drawings, what should it be built…I know what it should be built to. So, I see that, I check that. But also, you've got building control checking as well to ensure they meet the building regs (sic). And also, another layer is we have employer's agents, do you know what an employer's agent is?
00:17:56	S1	Yeah, Employer's agent*.
00:17:58	S2	Yeah, yeah, exactly. Employer's agent* is the employer's agent. So, we have that level as well, they're looking at it contractually.
00:18:04	S1	Okay, Employer's agent*
00:18:04	S2	Employer's agent*. Employer's agent* goes every now and again. So, we've got quite a few eyes and ears on the ground. And including obviously, site managers, you know. They have a role to pay because they're obviously paying a contractor to build to a certain spec. And if they're not, they're getting short-changed and we're not getting we're expecting. So, there should be enough eyes and ears to pick.
00:18:30	S1	Can you walk me through how you demonstrate or how you comply with building regs (sic) (sic)? I mean, you have the inspectors coming by. Which stage they are on the site?
00:18:46	S2	Yeah, they are…you've got the statutory stages with building regs (sic) (sic). So, you've got footings, foundations, you've got DPC, you've got your insulation, you'll have wall plate, you'll have roof and then drains and then completion. But they, as part of their role when they're doing their walkabout, they know what thickness and type of insulation is required in the wall to meet, to have the U-value to meet the building regs (sic) (sic). They know what insulation is required in the floor slab and the roof. So, they are looking at that as well as myself. So, if I see a specification for a cavity wall with 70 mm PIR insulation Celotex and I get there and it's 50, then I know that they're not meeting their specification.
00:19:44	S1	And I think overlaying inspections is beneficial.
00:19:49	S2	Yeah, definitely. Yeah. There's a lot of benefits in that (overlapping inspections). And I work quite closely with building control. Fortunate I am

		an ex-building control, but it doesn't take nothing for me to pick a phone up. But then again, I've got that relationship already in place anyway from the previous job I had. But on-site, if the other…I'll give you a good working…I'll give you an example of a bit of anecdote. We had vapour control layer was designed to be just a polythene sheet…
00:20:24	S1	All right.
00:20:25	S2	…and with Celotex.
00:20:28	S1	Okay.
00:20:29	S2	On the drawing, I think it was 25 mm. And I went to say and there was something completely different that they were using, I said, "Well, what's going on? Why have you divert-…it was they had, "Oh, we've changed the designs so that we can achieve a higher U-value on the walls. And they used a multifoil which acts as a vapour control layer and increases the U-value of the walls.
00:20:54	S1	Indeed.
00:20:55	S2	So, I saw it, I said, "Yeah, it's a BBA accredit product." I looked at the text, yes, in conjunction with 150 mm a ROCKWOOL insulation, it meets and exceeds building regs (sic) (sic).
00:21:10	S1	All right.
00:21:11	S2	But then I insisted that we had that direct from building control, so building control….
00:21:15	S1	They should approve the change.
00:21:17	S2	Yeah, they approved the changes. So, the architect submitted a variation then if you want to call it that an amendment and building control signed it off.
00:21:28	S1	Okay.
00:21:28	S2	So, what we've done there is, and that wasn't us, that was the actual constructor, that was Contractor* who instigated that. Well, it wasn't Contractor* to be honest, it was the architect. So, they'll tell you, "We've got a product that cost either the same amount of money or maybe a little bit more but it achieves a better U-value," so that's what they've done. So,

		we're exceeding the U-values on the walls for building regs (sic) by using this product. It's a little bit of innovation there really.
00:21:56	S1	Okay, okay.
00:21:57	S2	All right.
00:21:58	S1	All right, well, everything that brings benefits are always welcome, right?
00:22:04	S2	And then moving forward, we've got another scheme out Another project which is about to start, same type of construction. Well, that lesson learnt there will be used, yeah.
00:22:15	S1	Okay, excellent. Yeah, this is one of the things I would like to talk to you a bit further down the road. To what extent the managerial team and workforce understand the impact of defects on the energy performance of buildings?
00:22:35	S2	Well, I make a point when I do my site inspections, I'm on-site daily. I'm very hands-on, I work…. I know virtually all the operatives, all the people on-site by name. And….
00:22:52	S1	I could experience that.
00:22:54	S2	Yeah, exactly. And I think by doing that, you're…. because I've got a presence on-site on a regular daily basis and I know everybody, I'm checking that detail. So, I'm by default I'm giving them, it's going into their heads and I know Quality officer* wants all the tapes joint, or all the joints taped. He doesn't want breaks in the insulation, he wants it continuous, I know he checks. So that then reinforces that. So, it's done by the fact that I've got a presence on site every day. I think if I didn't attend site every day like some housing associations don't have a clerk of works, they rely on the employer's agent only. So, the employer's agent may turn to site every two or three weeks. In those interim periods, you're going to miss stuff. And unless site management are on top of it, you're going to end up with possible breaches of the building regs (sic).
00:23:56	S1	Indeed, yeah.
00:23:57	S2	Even if building regs (sic) don't see it, you're going to end up with maybe at a later date, you're going to end up with some cold bridging, you're going to end up with condensation issues. So, I like to think the fact that I'm on-site every day or try to get on-site every day and the way I work, I'm instilling that by stealth if that makes sense.

00:24:15	S1	All right, yeah.
00:24:16	S2	It's a bit of psychology.
00:24:18	S1	Yeah, indeed.
00:24:19	S2	Because they know I check so they know they're not going to take…. Because as soon as they…. In early doors, first two plots, they boarded some ceilings and I went and had a good look and I could see they hadn't underdrawn with the correct amount of… they'd left a set of Celotex out completely.
00:24:39	S1	Okay.
00:24:40	S2	That was stopped and I made…they took down all the boards and they had to redo it, "Oh, we didn't realise," the usual excuses.
00:24:49	S1	Yeah, yeah.
00:24:50	S2	But once that had been picked up and they'd….
00:24:52	S1	They're aware for the next one.
00:24:53	S2	They had a major wake up. From then on in they did it instead of put their hands up and they said, "Oh, yeah, we didn't. Thanks Quality officer*."
00:25:04	S1	And sometimes it's just a matter of being present and the…
00:25:06	S2	Right place, right time, yeah. And that's what it comes down to really.
00:25:11	S1	About this for building regs (sic) a bit specifically, how often they go to the construction site?
00:25:18	S2	Building regs (sic), normally if you….
00:25:20	S1	But if you mean the inspector….
00:25:21	S2	Yeah, the building control inspectors, yeah. If you want an inspection for a statutory inspection you would make a call…. So, come and check. Before I pour my footings, I want the ground conditions checked. Before I start a building superstructure, I want you to check the DPCs and the DPMS and all that. So, they're the statutory ones. But if you're insulating, you would say, "Look, I'm about to close up. Do you want to come out?" So, it depends. It's as and when required really. I don't think when I worked in

		building control, we didn't have you'll go to that site once a week or twice a week. What you did is you risk assessed it.
00:26:01	S1	All right.
00:26:01	S2	So, if you had a builder that you could trust and you know it's going to do the job properly, you would have less frequent visits. But if you had a builder you're a little bit unsure of or last time I was here they left insulation out or they didn't tape it, you would provide more frequent inspections.
00:26:21	S1	And do they…on top of that, on top of this relationship built on trust, do they get your quality reports or from the contractors?
00:26:32	S2	No, no. But I would, if…. The way I work, because I get to know the building control surveyor whether it would be approved inspectors say like NHBC, or whether it would be local authority, I would…I've got their phone number. I would pick the phone up and say, "Look, Greg, Steve or whatever, I've had a look. Can you have a quick gander at the junctions of…or the cavity close? I'm not too happy about it. Because I could approach site and say, "I'm not too happy." Yeah, but that's what's specified, Quality officer* and I'm going, "Well, I don't actually think that's what's specified."
00:27:11	S1	Okay.
00:27:12	S2	And I can use building control as well as an extra bit of leverage if necessary. But I've not had to do that because site know that I know my stuff. Site knows that I visit regularly. Site know that I don't miss things normally. The guys know it. So, overall, I think it comes…if you want to sum it up, it comes down to like an ethos if that's the right word. If you instil that pride and that you've got to have the quality, you've got…. If it says this is the insulation, you use it. If it says it has to be butted tightly together, it's butted tightly together. If it says it has to be taped, it has to be taped.
00:27:55	S1	Okay. And then you will be there to check it out.
00:27:57	S2	Yeah. And I think that that's what works. If the builder knows that they can cut…. Because in construction they are there to make money. If they can get away with or if they think they can get away with missing out work, the job's done faster. A contractor might make a saving on material, "Oh, look at the Celotex we've got left. We must've over ordered," in actual fact, they haven't put it in, so, you know. And, yeah, if you can get that across early, that's when you get good quality.

00:28:30	S1	In that sense, what would be the challenges and obstacles when implementing the quality plan that you set out to…?
00:28:39	S2	I think the main thing would be how often you can attend site. It's time constraints really
00:28:46	S1	Definitely.
00:28:47	S2	Yeah. I think my biggest enemy is time.
00:28:49	S1	Yeah. And do you think this applies to the approved inspectors as well?
00:28:54	S2	Yeah, of course it does and building control. Building control, they normal, if you ring before 9:00 in the morning—you're getting bonus stuff here by the way, you're getting bonus stuff about building control. If you ring, it used to be if you ring before 9:00 in the morning you're guaranteed same day inspection.
00:29:12	S1	All right.
00:29:13	S2	So, you (building control inspector) may on the, say it's a Tuesday, Monday night you may have only got five visits, but in Tuesday morning 8:30 three ring in so now you've got seven or eight.
00:29:26	S1	Okay.
00:29:27	S2	So, your day has now got more busy (sic) so you'll spend less time on the site. So, the same would apply to me but what I try to do is I try to plan my…at this present moment I've got two sites. It's likely I might have a third site.
00:29:40	S1	All right.
00:29:41	S2	But what I'll do to accommodate that is I would spend less time in the office and I will start more on site earlier and I would leave…I leave from site now, so I would have to adapt my working day to accommodate that so that in my mind so that the quality didn't slip.
00:30:00	S1	Okay.
00:30:01	S2	Does that make sense?
00:30:01	S1	Yeah, yeah, for sure.

00:30:02	S2	That’s me personally. Whether other people are doing it for other organisations and other housing associations I don’t know, but my biggest enemy is time.
00:30:10	S1	All right. Well, this is enlightening. I completely agree with you and I….
00:30:16	S2	If I spent…if I were at Case Study 3* and I sat, I went straight to site 7:00 in the morning, I left site 4:00 at night, I spent all day on site, great. But reality is I’ve got that site, I’ve got North Prospect, I might have another site.
00:30:34	S1	And then you have all your reports to be done.
00:30:35	S2	And then I’ve got my reports, I’ve got general admin, I’ve got the fact that I have to review schemes, we’ve got up and coming schemes, future schemes that I get asked to look at. There might be some technical issues that I need to look at. So, you have to balance. But my priority and luckily the manager, Project manager*, he will support me on that. He says, “Quality officer*, you’re our eyes and ears on the ground. You need to get out on the site rather than….” If he saw me sat in the office all day he’s going to be on my case saying, “What are you doing sat in here at 2:00 in the afternoon?”
00:31:11	S1	Okay.
00:31:12	S2	So, yeah, I think…I try to get on site as much as I can.
00:31:17	S1	That’s the best strategy I suppose.
00:31:20	S2	It’s the only way to do it. Because you can’t trust everybody and you can’t trust the site management. Not that I’d like to, but people…they haven’t got time either.
00:31:30	S1	Yeah, indeed.
00:31:31	S2	They’ve got time constraints. The lady who does the quality management.
00:31:37	S1	Assistant site manager*?
00:31:37	S2	Assistant site manager*, that’s it.
00:31:38	S1	Is it the one that we met? I shook hands with her the other day when I visited the site.
00:31:44	S2	Yes.

00:31:45	S1	The young lady, yeah?
00:31:45	S2	Yeah. Well, she's doing all the quality, she's doing all the internals. So, she'll be looking at quality and one of them obviously is insulant energy conservation.
00:31:56	S1	All right.
00:31:57	S2	But if she…even then, she hasn't got. But I set aside, we have an appointment on a Wednesday and on Friday that's set in stone, it's diarised we spend at least an hour if not, two hours doing what we call a quality walkabout.
00:32:13	S1	Okay.
00:32:14	S2	So, myself and Assistant site manager* will walk the site and we will go in to plots and we will pull things apart, we will look at stuff and double check. So, that's been set up to ensure that that time is there.
00:32:27	S1	Okay.
00:32:28	S2	And as well as me going on site on a daily basis pulling stuff.
00:32:33	S1	Do you know if…? Well, I can talk to her about that, but do you know if she has other attributions apart from the quality checking and managing?
00:32:43	S2	Yeah, well, she'll probably be looking at…she will, she's got the health and safety side. She's got the time, you've got your project management from timescales whether you're on track or slippage. She'll probably get, although they got a QS on site, she may get involved in measures and make sure the quantities that they ask for is what they get.
00:33:08	S1	Okay. So, the next section is about resources which we talked about it already. So, just summing up, so in terms of the person, the people responsible for developing and implementing quality you have from the side of the client, yourself. You have the…
00:33:29	S2	Employer's agent.
00:33:30	S1	…the employer's agent. All right. Which goes every three or four weeks as you say?
00:33:36	S2	The employer's agent, Employer's agent* will probably go to site every…he'll go to site, if he gets concerned he'll go to site more frequently. But invariably I would say this is anecdotally, every couple of weeks. He

		might do every week now and again. But because I'm there, he can be more confident that I'm going to pick stuff up. And I think it works with my management as well. My management are confident that I'm picking stuff up, as my job, as my role and I want to do it as well. But I think if we didn't have the clerk of works role and you relied on the employer's agent, the employer's agent would then have to do more frequent visits maybe, longer duration visits.
00:34:24	S1	So, on top of those two layers we still have…
00:34:28	S2	Still you got your site management.
00:34:30	S1	…the site management which is….
00:34:32	S2	Yeah, you've got your site managers overall, so they would be employed by Contractor*. But on another layer is the subcontractors have to sign off all their work to say that they've carried out the work in accordance with the specification. So, once they've insulated, before they board—I'm just giving you an example—before they board, they will sign off, we've now insulated. As far as we're concerned, we've insulated to the specification. That would then go to the office site management and then they would come down. And they weren't doing that at early stages that's why that insulation got missed. Because I picked it up, it gave them a bit of a, "Oh, you know, perhaps we should." And they've implemented, it's probably there in the first place but it didn't happen because of time constraints probably. So, they then go down, if they're happy with the work, they then sign off. Yeah, you can close up now. The same goes for me. I will go down and say, "Don't board, because that's not my role, that's site." But if I'm there and I'm not happy with something, then I will pull it up. This is again a bit of anecdotal evidence. The other day I found some, this was sound insulation, not insulation for energy conservation on a party wall. It looked like they had slashed the mineral wool so I said, "You can't close that up until you've sorted it out." Took a photograph, all it takes is an email or whatever. But I tend to work on trust. So, if I tell site, Assistant site manager* for example, "Plot 67 has got damage. You need to sort it." If I go back the next day and it's still not done, I'll chase it. But if I go back the next day again and it's still not done or it's covered up, I'm going to say, "Can you prove that it was sorted?" But [Inaudible 00:36:21] about the relationships and trust between you and the contractor.
00:36:27	S1	And top of all this you still have the approved inspector on behalf...
00:36:30	S2	Yeah, on top of all this you still got building control, yeah.

00:36:32	S1	Building regulation…
00:36:33	S2	And on top of that….
00:36:34	S1	Building control body.
00:36:36	S2	Yeah. For example, we're talking about Case Study 3*. Case Study 3* have got local authority building control doing the building regs (sic) but we've also got the warranty under the LABC. So, they're providing the warranty and the building control service, so it's in their interest. They are underwriting the warranty for the next 12 years. It's in their interest to make sure it's bang on.
00:36:59	S1	Spot on, yeah.
00:37:00	S2	Because they don't want to come back with issues with condensation or mould growth or cold bridges in six months' time and have to have everything opened up and find that insulation's been missed out. And then they're going to have jump up the money to pay for the remedial work.
00:37:16	S1	And if I'm not wrong you have an extended warranty.
00:37:19	S2	Every two years, we add 2 years to the 10 so we normally get 12, yeah.
00:37:25	S1	Okay. I'll skip some questions because we have already talked and we don't need to be over it again. Okay. This is specifically, this is a question regarded to… if you have a specific procedure in place in order to create awareness of the quality requirements related to energy performance among the participants, I mean, contractors, subcontractors, like inductions or things like that, toolbox talks.
00:37:57	S2	Yeah, yeah. Well, toolbox talks, that's something that the site undertake. When they let a contract to a subcontractor, they will sit, the QS will sit down, site management will sit down with them. And I've sat in on a few lets or their pre-lets and whatever. They will make the contractor very clear of what their requirements are.
00:38:23	S1	All right.
00:38:24	S2	"This is the spec, this is what we expect to see." And they will keep a close eye on them. And I will keep a close eye on them as well. So, if I find something on site I'm not happy with, I will report that back through site management and they will bring in the contractors, they may do another toolbox talk or it might be a bit more formal. They may write an email or a

		formal letter to the contractor saying that. Or, I could [Inaudible 00:38:51] I'm not happy and I'm not going anywhere, I can go to my colleagues or my colleagues in building control or whatever and say, "Look, I'm not happy. Can you have a look? And they might actually issue a rectification notice or whatever the equivalent is for the NHBC which would be a you know, default notice, so.
00:39:16	S1	Okay.
00:39:17	S2	And then they would have to formally discharge those.
00:39:20	S1	Okay.
00:39:22	S2	And they don't want to get into that because their management, I would imagine Contractor*'s management, they would check. They're regularly getting rectification notices from building control. They're not going to be very happy, are they?
00:39:37	S1	Indeed.
00:39:38	S2	Because quality's dropped, hasn't it?
00:39:39	S1	Yeah. And what are your thoughts? I mean, is it fair enough for me to say that we have a shortage of subcontractors nowadays and then this can in a way affect quality?
00:39:57	S2	Yeah, it can impact on quality. What are my thoughts in what way? Do I think it makes a difference?
00:40:04	S1	Well, no. I mean, do you think you can link sometimes the shortage of the workforce related to skills and…?
00:40:16	S2	Yeah. I think one of the things, one of the biggest impact on quality is price.
00:40:21	S1	All right. Okay.
00:40:24	S2	Now, we let…we have a contract sum that's fixed. Now, that developer has to factor in profit, no doubt because they're not doing it because they love it, they're doing it to make money. And if they let like the boarding contract to a contractor and they've really got that contractor to tighten their prices. Their subcontract labour is then going to be on a lower price. And that's when you start to get, "I haven't got enough time." If I do that job properly I'm going to make no money.

00:41:02	S1	All right, I see.
00:41:04	S2	That's my view. So, what happens is quality could slip. If you have a subcontractor who starts to think, "Oh, I'm under pressure. I've cut this job to the bone. I'll only make money if I put in less work." Do you see what I mean?
00:41:23	S1	Yeah, yeah.
00:41:24	S2	And that's what I look at. And I don't care, "Tough," is what I say. I'd be quite hard about it and mercenary, I'll say, "I don't care. You've under-priced the job. That's my problem, that's yours. You will ensure that that work is completed properly. And if it isn't, you'll be taking it all down and you'll lose even more money." So, yeah. And skills, yes, you do have a number of…. To be honest, it's not a highly skilled job putting insulation in. But you have to do it properly and that's where I come in and where site comes in to make sure that they're not putting slithers of insulation in rather than putting full or miscutting sheets, lots of joints. Or instead of putting in the required 70 mm for example, they're putting in 50 because 50 is cheaper but from outside you wouldn't know. So what you do is, I walk around site and I look at all the palettes, I look at all the materials. I know what's on site and I make sure that's what's specified. If I get on site and I'm specified 70 mm PIR insulation and I'll only see palettes of 30, I'm going to be rather suspicious, something's not right. But yes, I think there is a link to the skill shortage definitely, but I think there's also a link to competitiveness.
00:42:48	S1	Indeed. In that sense I don't know, I'm talking about my own experience, but most of the things I could identify as a defect generator here and back in my country working as the site manager as well, is that (Clears Throat) that sometimes the trader is there, he's done his work properly, you signed him off. And then the next one, in order to make his own thing, he will screw the other trades work.
00:43:19	S2	Yeah. No, you're right. You've got other trades…that's exactly what happens.
00:43:25	S1	And then they just….
00:43:26	S2	Electricians, I caught…an electrician was about to cut the vapour control layer to insert some cables.
00:43:32	S1	Exactly.

00:43:32	S2	And I said, "What are you doing?" "Well, we always do this." I said," You won't do it here. If I catch you doing it, there's going to be trouble." "Oh, so I have to take the time to surface mount it in pipe. Well, that will take me longer," and I said, "Well, we've got a service void, that's what it's for." And they ended up putting all there--and I do check—they ended up putting all there, where it was needed in conduit, in pipe. Whereas on other sites they've honestly cut the vapour control layer and stuffed it in behind.
00:44:04	S1	Yeah, exactly.
00:44:04	S2	So, yeah, the same thing. You can have the guys doing the insulation, tidy job, bang on, spot on as it is but a plumber can come along, take some of the insulation out.
00:44:16	S1	Yeah, that's the difficult thing to deal with.
00:44:18	S2	And then you've now broken that chain and you've lost your thermal…you've lost your U-value of that wall and that particular…you've got a cold bridge maybe.
00:44:31	S1	Yeah, indeed.
00:44:32	S2	And it's about people understanding a lot of—this is me speaking from my experience—a lot of contractors, not all of them, but a lot of them will come to site and they…all they ever do is block work. And you say, "Well, hang on a minute. The way you've built that lintel in had you've bridged across." "Yeah, but it's easier for me to do that." "Yeah, but now, you've created a problem." "Have I?" "Well, you've made a direct link to outside." "Oh."
00:45:00	S1	And then we get back to the skills shortages.
00:45:03	S2	Yeah. So, I think if you are not…I think everybody should have an understanding of reasons why. I know it's slightly off topic, but when I worked in the disability section and I was access consultant, I used to sit there with the plumbers on site and I'd say, "This is why we have a grab handle here. This is why the toilet pan is 500 mm off the wall," and I would actually show them. "If you're a wheelchair user you want to wash and dry your hands while you're seated on the pan." As soon as you do that, a little lightbulb lights up in their head.
00:45:37	S1	"Aha!"

00:45:38	S2	"That's the reason why." And the same goes for the brekkies. Don't leave snots on your cavity, don't bridge a cavity A) because water penetration and B) thermal. So, yes, it is about….
00:45:51	S1	So, they miss the bigger picture.
00:45:53	S2	Yeah. They concentrate on what they're doing but they don't look at the bigger picture and that's where it gets lost. If you don't look at the bigger picture, you're going to end up tripping yourself up.
00:46:05	S1	And this is you can get only with education and training.
00:46:07	S2	And this is why when a contract starts, my busiest time as clerk of works is when the contract first starts. Because you've got people in site, I've never met them before and they've never met me, so they're testing the boundaries. How far can we go? What can we get away with? Or maybe not even what can we get away with, "Oh, I didn't realise we had to do that. From now on, Quality officer*, I will do that and I will put right that as well." And the same goes for site. They know I'm on and I think this is where it's important. To enable quality to be in place you need competent people like myself and you need competent site management and supervision.
00:46:45	S1	Then we get to the time constraints because to create this level of trust and to allow you the time to explain people why things are this way and not that way takes time.
00:46:56	S2	So, site managers, there's different site managers. Some are more experienced than others. Some are more quality orientated than others, some just look at the build and, "I've got to finish." They look at targets, "I want to finish plot one, two, three and four by this date," and that's what they concentrate on. And then sometimes quality will slide because of that, but the backstop if you want to call it that is me…
00:47:20	S1	Okay.
00:47:21	S2	…building control…
00:47:22	S1	All right.
00:47:24	S2	…and then the employer's agent. So, there's three people who would say "Hang on a minute chaps. I know you're rushing and tearing here but your quality's dropping. And I'm not going to take sign off, I'm not going to sign anything off until you sort that out.

00:47:38	S1	Yeah, that's true.
00:47:40	S2	And once we start getting down that route, if I refuse to sign something off or we refuse to take handover because it's not up to the quality, we're now into liquidated damages or whatever you want to call it, you're staying in a contractor financially as well as time and as well as messing around having to put it all right. Does that make sense?
00:48:03	S1	Yeah, yeah.
00:48:04	S2	That's the big stick that you don't really want to use until you have liquidated ascertained damages. That's the final straw. But some contractors might accept that as just part of the job.
00:48:19	S1	But then?
00:48:20	S2	Yeah, and then who's to say in six months' time still in defects period, we're getting the contractor back to open up an area that's got a problem with cold bridging.
00:48:30	S1	Yeah, exactly.
00:48:31	S2	Or, say that doesn't happen for 12 months, say 6 years down the line we got an issue with thermal conductivity of a material and you have got a cold bridge, we'll get the LABC or the NHBC in. Look what's happened here.
00:48:48	S1	And that's the main difference between, well, I did some exploratory research in the beginning and I talked to some private builders and this is definitely the main difference between working with housing associations and private builders because once they build, they have liability to walk away and this is it. But you guys have to deal with it on the long-term.
00:49:12	S2	And for the record, I can tell you now that we provide a higher quality finish and standard build than what the likes of the main house builders do. The likes of Persimmons, the likes of Bovis. Why has Bovis set aside £17 million to cover defects? Because Bovis have got themselves in into a rut. They've had no quality control and all they've been looking at is generating profit. And this is documented and this is in the press, this is documentary evidence. And a lot of customers are unhappy and their reputation is not brilliant. Contractor* are looking to buy, I don't know if you're aware of that, to buy out Bovis, you know that? Yeah?
00:49:58	S1	Yeah, I do. I knew it well that the clients creating a Facebook page about, 'We're against Bovis.'

00:50:06	S2	Yeah, you go on YouTube and put Bovis and some of the stuff, okay. Some of the stuff, it's not the end of the world but it's how people perceive it. Now, if I was going to buy a Bovis home and I'd done my research and I Google Bovis and this webpage has come up with all the…I'll be thinking, "I don't think I'll use them." So, yeah, so I think we as a housing association have a better quality product than what you get on open market because of the robust procedures and QA and inspections that we have in place.
00:50:37	S1	All right.
00:50:38	S2	And I think that's brilliant.
00:50:40	S1	That's for sure.
00:50:42	S2	I'm glad you mentioned that. It's important, isn't it?
00:50:45	S1	The next session is about the quality metrics. I mean, how do you set up the attributes and how do you check them out in terms of quality? So, the performance attributes we've talked about, well, at the minimum complying with building regs (sic) in terms of U-values and air permeability, right. So, the following question is, do you have a procedure for defect identification and collection in place?
00:51:15	S2	Yeah, when each contractor and Contractor*, in this instance, they have their own QA process. Now, when I first arrive on any site, the first thing I say to the site manager, "Who's going to be doing quality management?" In this particular case internals is Assistant site manager*.
00:51:32	S1	Okay.
00:51:34	S2	And then I will have, "what procedures do you…what system do you use?" And then they show me every plot has a folder and in that folder is a checklist against the specification. So, at every stage before sign off to allow them to board and close up, there'll be documentary evidence that Assistant site manager* has been on site with the subcontractor. The subcontractor has signed it off is…I'm happy with it. And then Assistant site manager* will look at it and sign. But that's set up by the contractor, by the developer. Because don't forget, these are design and build contracts.
00:52:14	S1	Okay.
00:52:15	S2	So, we have to be…we don't take any risk while they're under construction. The only time we take the risk is when we take the handover. So, if they make cockups, after cockup, after cockup financially, we're not in any issue.

		It's down to the contractor. We won't take those plots until we're 100% happy that the quality is there. If the quality is at fault, we won't sign them off.
00:52:40	S1	Okay.
00:52:41	S2	And the first job is, they set those (quality management procedures), we have our own but it's not formalised, if you know what I mean. It's down to the individual surveyor's experience.
00:52:52	S1	All right.
00:52:52	S2	So, I know what I'm looking at and I don't sit there and go, "Oh, I know it's 70 mm Celotex because I've already remembered what the specification says and what the work drawings, construction drawings show me a section", it's in my mind. I know exactly what they make up. Now obviously, if somebody else is doing my job if I went sick or left a job, then they would have to pick it back up. They would have to make themselves familiar with the specification. So, we don't have anything formal in that sense. Because it's a design and build, we expect the contractor to have those systems in control and in place. But we, as the employer if you want to call it that or the client I should say, we have a vested interest because it's our money and our plots at the end of the day, we will ensure that those systems are robust and fit for purpose and that they are actually being used. Does that make sense?
00:53:51	S1	Yeah, indeed. Well, I've….
00:53:54	S2	Well, you've seen this.
00:53:55	S1	Yeah, you've sent me one of those, one of your reports where you have the progress and what are the issues that you've been able to identify and collect.
00:54:04	S2	And on a weekly basis I do my site report. And if I find anything on-site that I'm not happy with and I don't think it's going to be picked up or treated seriously, I will minute it as you want to call it, you know, and you could say minute it or put it in the report. And if it's really, when we have…we have a client meeting every month. And at that client meeting that issue will be raised.
00:54:30	S1	Okay.

00:54:31	S2	And then there'll be actions to…someone will have to follow it up and then we'll have to have proof. But I try and not let it go that far because I feel I've possibly failed in my role then if I've let it go and it's got to the point where it's now a big issue. My role as clerk of works is to be there at an early stage and to pick up the issues early on so that it don't get into big problems.
00:54:54	S1	Okay. So, in terms of defect collection, I can say that you go 100% of the housing units to check them all, right?
00:55:06	S2	Yeah, I don't do samples, I do every one.
00:55:07	S1	Okay. And what about the air pressure test?
00:55:13	S2	Well, the air pressure test, that's something that I don't instigate because obviously, it's a requirement of building regs (sic) to have a certain element…I can't remember, is it 10% off the top of my head, no?
00:55:25	S1	It's 50% or three housing units from the same type whichever the less. So, if you have I don't know, 20, you can either do three of them.
00:55:38	S2	That's something that we wouldn't have any…you know, we would expect that the contract has to meet the requirements of building regs (sic). I don't think we would insist on, "Well, hang on a minute, we want every plot air tested because you've got, not only the time but the cost." They've built into their price to have the certain number required under building regs (sic) to have tested. I think it would be unreasonable for us to come along and say, "Well, we want every plot…"
00:56:11	S1	Tested.
00:56:12	S2	Yeah. Unless there was an issue. If they started testing and they found that they were failing the air leakage and the air permeability, then it could be a design issue. Or it could be a quality issue or a bit of both. And then maybe we may have to negotiate with the contractor, "Well, we feel for the next month, we feel that you should double the air tests if that's required." And if they say, "Well, you're going to have to pay up," we'd have to address that.
00:56:42	S1	Okay. And in terms of the sampling to the air tests which you have minimal requirements for the building control bodies, who pick the housing units that will be tested?
00:56:56	S2	Building control.

00:56:57	S1	Building control?
00:56:58	S2	Yeah, I would imagine.
00:56:59	S1	They handpick the ones that they think are…?
00:57:01	S2	Yeah, building control you know, they call the shots, don't they? They're signing it off.
00:57:07	S1	Yeah, that's for sure.
00:57:08	S2	So, they would call it. If I went to a site, if I was a building control surveyor and I wanted to do air permeability tests and the contractor said, "I'll tell you what, plots one, two and three will be the ones that you need to do." I'll go, "Hang on a minute. Why are you taking me there? I'd want to pick my own." So, I assume building control do exactly the same.
00:57:26	S1	All right. Well, the last section and final one is, just trying to wrap it up in one package, I mean. At the end of the process, how the quality compliance is reported in terms of content format or frequency?
00:57:47	S2	I don't think we as a housing association, we haven't got any formal like detailed other than my site report.
00:58:00	S1	Okay.
00:58:01	S2	And other than maybe ad hoc stuff and maybe an email here or an email there or a report here, a report there. We wouldn't keep that information because the contractor, as part of their QA process would've done that. But we will be getting from Case Study 3* for example, I know because I've already asked, we will get copies of all their quality documents and sign-offs. So, we will put that together in a pack at the end. So, if anything does occur in the future, we've got…. But that's something we've arranged with Contractor*. But I don't necessarily think it might be across the board with all contractors. But they've offered, in fact, they've offered it up.
00:58:42	S1	Okay, all right.
00:58:42	S2	And the same with Kiers. They're going to do the same, "Well, you can have…we'll scan them for you and give them electronically."
00:58:50	S1	But don't you have like a formal process in place to analyse all these things that…?

00:58:54	S2	Not formal.
00:58:55	S1	If just anything comes up that requires attention?
00:58:57	S2	Yeah, not formal, yeah. I think the role that I have, part of my role is to look for trends, is to look for ongoing, hang on a minute, this is a reoccurring issue.
00:59:10	S1	Okay.
00:59:12	S2	But because I've obviously been consulted at the technical stage if you want to call it that or that side of the drawings, drawing reviews. If they revise a detail like that detail with the vapour control layer which has a built-in insulant as well, and that's up to…. I use my experience to analyse that and say, "No, I'm happy with that." But if there's ongoing issues, I would like to think that I would pick them up early or if…. I'm only human.
00:59:44	S1	Yeah.
00:59:45	S2	If I didn't pick it up and it got missed, at least at a later stage I could go, "Hang on a minute, we had a problem with this type of plot and it was in this particular area." And that's where they brought in that new steel for example, and they've obviously not applied adequate insulation for the steel. So, yeah, that's the way I look at it. I don't think….. But I suppose it's…the trouble is, is how much detail do you go into. Because we're talking about time
01:00:16	S1	Yeah, again, we come to the….
01:00:18	S2	It comes back to time and money if you want to call it that. And if I spent all day analysing everything to the nth degree, I wouldn't go on site and I would miss all the quality. I could sit in the office all day long, bring a spreadsheet up, put every plot on it, put every day that I went there, what I looked at, a little photograph of it, I wouldn't do anything.
01:00:42	S1	No, you wouldn't have time.
01:00:44	S2	You wouldn't have the time. So, it's a balance really.
01:00:45	S1	If you had like two or three of you.
01:00:47	S2	Yeah. Or what you would need to do is then increase the number of personnel who were acting as clerk of works or building quality managers

		so that you could do that. But then by increasing the number of people, you then have to increase the on costs, so then it's additional salaries.
01:01:08	S1	Yeah, indeed.
01:01:08	S2	So, we're back to money, we're back to time. It's a bit of balance really.
01:01:12	S1	Yeah, it's a very thin line.
01:01:14	S2	Yeah, it is a thin line but I hope, and this is not like singing my own praises, but I hope that when I was appointed, my manager when he interviewed me looked at my experience, qualifications and background and turned around and said, "Well, actually, a safe pair of hands. This guy knows what he's doing. Risk analysis, risk assessment." If they were a little bit concerned about me like, "Hang on a minute, Quality officer*, you've missed stuff. We're a little bit concerned you may not have that knowledge." And another thing with Housing association* if I want training, then I know I've only got to ask.
01:01:57	S1	Oh, cool. That's excellent.
01:01:57	S2	But I'm—touch wood—but I'm confident that I'm at that age, I've been in the game 37 years, I've seen a lot, I've been on both sides of it, I've been on a lot of it, I'm a practical person as well which I think is a great help being that I'm ex-trade. I'm aware of all the shortcuts because I've done them myself. Yeah. And I feel quite proud of that and pleased about that if that makes sense.
01:02:27	S1	Yeah, it did.
01:02:28	S2	And I think it comes across on site, with the people on site, the site management, the subcontractors. They know that I know what I'm talking about.
01:02:39	S1	This is irreplaceable
01:02:40	S2	Yeah. And if I didn't, if I was straight out of uni or I've never done this role, maybe I worked in Tesco's before and I've just got in a building surveying degree and I've had no practical experience, they will push you and they will try to trip you up. Because I've already experienced all that and, "Oh, he does know his stuff." So, yeah, no I'm quite happy where I am now.
01:03:08	S1	Okay. Well, thank you very much, it's been amazing. Thanks for your time.

01:03:13	S2	Has that been useful?
01:03:14	S1	Yeah, completely. I mean, I have to digest them all (Overlapping Conversation).
01:03:17	S2	Well, you've obviously got in your head hat you feel is the…and time, money is…we are up against it, aren't we?
01:03:30	S1	Indeed.
01:03:30	S2	Contractors are up against targets.
01:03:32	S1	Yeah.

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

[01.03.32]

[End of Audio]

Duration 63 minutes and 32 seconds

Interview 3.c – Transcript

Timecode	Speaker	Transcript
00:00:00	S1	I cannot check on everything you know.
00:00:01	S2	Yeah. I know.
00:00:02	S1	So just before we get started, there's a slight procedure just to make sure that you got upfront information sheet and the consent to participate and the questions as well. Right?
00:00:15	S2	Yeah.
00:00:16	S1	Okay. We always start with basic questions. So could you please tell me your name?
00:00:25	S2	Yeah. It's Assistant Site Manager*.
00:00:26	S1	Yeah. Your professional qualification?
00:00:28	S2	So, I am an assistant site manager with a foundation degree in Construction Management.
00:00:34	S1	Okay. Your time of professional experience?
00:00:41	S2	Well, I've worked for Contractor* for six years since being qualified.
00:00:46	S1	Yeah?
00:00:47	S2	Well, I'd say for six years.
00:00:49	S1	Okay. Perfect. Okay. Your role here is said already. You've said already you're the company you work for. The number of assets here is 60...
00:01:04	S2	67.
00:01:05	S1	67. Right. Okay. And Contractor* works in all the country?
00:01:11	S2	Yeah.
00:01:12	S1	Or specifically here in South West?
00:01:13	S2	No. We're a national company, yeah.

00:01:15	S1	Okay. Alright. Do you recall within the area you're working with, number of ongoing projects from the top of**...**
00:01:24	S2	I would say probably between 20 and 30 in that region.
00:01:29	S1	Okay.
00:01:30	S2	Yes. We have quite a lot of sites.
00:01:32	S1	Okay. Devon & Cornwall as well.
00:01:34	S2	Devon & Cornwall for our South West region but then we have different regions throughout the country.
00:01:41	S1	Alright. Perfect. And so do you know if Contractor* has any quality accreditation? I mean ISO or…?
00:01:52	S2	Yeah. ISO9001 I think. I believe.
00:01:55	S1	Okay. Yeah.
00:01:56	S2	And yeah.
00:01:57	S1	Alright. Okay. Perfect. And the name of this project is Case Study 3?
00:02:05	S2	Yeah.
00:02:07	S1	Okay. We will just skip to the questions that you can help me.
00:02:16	S2	Yeah. That's okay.
00:02:19	S1	So just a question, the procurement root of this development, do you remember? Is it design and build or…?
00:02:24	S2	Yeah. It's JCT design and build.
00:02:26	S1	Okay. Okay. We always start with quality requirements for this specific development so I'm—does the project have a formal quality plan or is it just specific for this project or a standard use by Contractor*?
00:02:48	S2	Right. So within our business management system, we have this here.
00:02:52	S1	Right.
00:02:52	S2	Which is a standard project quality plan, but then it's amended.

00:02:57	S1	Alright.
00:02:58	S2	To be project specific.
00:03:01	S1	Okay.
00:03:01	S2	Okay. So what we have is this sort of section where the employee's requirements in which is obviously what makes it different to every other site.
00:03:10	S1	Alright.
00:03:11	S2	And then it's just how we plan to carry things out so that's an eight-page document which you're welcome to take away with you.
00:03:17	S1	Oh, excellent. Thank you very much. So you started with your own standard quality management plan and then you tweak it towards the toolkit and the client's requirements. Alright.
00:03:28	S2	Yeah. Uh-hmm.
00:03:29	S1	Okay. In terms of those quality requirements in this quality plan, do you have energy performance aspects encompassed by this plan?
00:03:40	S2	Yes. So, we have the CS20 energy assessment which we have to abide by as well as code a sustainable home.
00:03:47	S1	Alright.
00:03:48	S2	And that's included within the quality plan and—yeah, it's included within quality plan really. I think I've printed that out for you as well which is all about SAPs and the like. So it's basically a calculation. It might go there actually (Crosstalk)
00:04:08	S1	Alright. (Crosstalk) fine.
00:04:12	S2	But I will find that for you and you'll be able to have a look at that.
00:04:14	S1	Alright.
00:04:15	S2	Okay?
00:04:15	S1	Okay. Perfect. So those are the requirements regarding to energy performance you said. So you pretty much here compliant to building regs or you have extra...?

00:04:27	S2	Yes. So it's compliant to building regulations, LABC and warranty.
00:04:32	S1	Alright.
00:04:33	S2	LABC warranty and building control, and code for sustainable homes.
00:04:40	S1	Do you remember which level was it?
00:04:42	S2	Four? I think?
00:04:44	S1	Four? Okay.
00:04:44	S2	Yes.
00:04:45	S1	Yeah.
00:04:46	S2	I might have to check that one. I'm pretty sure it's four.
00:04:47	S1	No. It's okay. Okay. So, do you consider those energy performance targets part of the strategic goals for the housing association and for Contractor*?
00:05:04	S2	Yeah. So, it's part of our company ethos to be sustainable.
00:05:08	S1	Alright.
00:05:09	S2	So and we even if our client don't require an energy target…
00:05:19	S2	We would still have one anyway.
00:05:20	S1	Okay.
00:05:20	S2	Yes. We would still need code.
00:05:21	S1	That's pretty good. It's quite...
00:05:24	S2	And obviously, the client wants that as well, so…
00:05:27	S1	Okay.
00:05:28	S2	Yup.
00:05:29	S1	And so you said, well, although the target that the energy performance requirements are transmitted by the toolkit or you have a specific document that is it's... that obviously...

00:05:41	S2	So – obviously, our design team at procurement stage will meet the code requirements along with any additional requirements that might be in the client's project toolkit.
00:05:52	S1	Alright.
00:05:53	S2	And then that is how they derive what is needed on site. For example, the PV panels, etc.
00:06:00	S1	Okay. Well, the next group of questions are regarded to risk assessment and then it's where probably we then identify what are the issues that might impair the ability of the building to performance predicted.
00:06:13	S2	Right. Okay.
00:06:14	S1	So in terms of that, which stakeholders are involved in the process of defining the quality requirements related to energy performance? Do you when does it happen and the project type span?
00:06:27	S2	Throughout really. I would say. Yeah.
00:06:28	S1	Throughout really. Okay.
00:06:31	S2	So obviously we have AES who are energy assessors. So they provide the u-values. They provide the PEAs and they also provide our air testing and acoustic testing. Okay. And they do our calculations for PV panels. So, they were on from the beginning. So, I would say the stakeholders would be to AES and the project team because obviously we need to improve that. The employee's agent, he then checks on the process throughout so each month as you've seen that today, they'll come and they do a project review as well as intermittent visits throughout the month to obviously check on our progress and then obviously the clients themselves.
00:07:19	S1	Okay. Those energy assessors as you call, are they a consultant company? They work for Contractor* or on behalf of Contractor*?
00:07:23	S2	Yeah. That will make like subcontractor and independent subcontractor.
00:07:32	S1	Okay. Can you tell me which company is helping you out with this…?
00:07:37	S2	Yeah. It's then AES.
00:07:39	S1	AES?

00:07:40	S2	Yeah. AES. I did print that…
00:07:44	S2	Do you know where I put them? Is it there?
00:07:47	S2	Yeah. I did print out a sample of what they do, but I don't know where it's gone.
00:07:52	S1	Alright.
00:07:53	S2	But I will get that for you in a moment.
00:07:54	S1	Okay. Perfect. AES. All right. Okay. So, do you have a process in place to assess the risks related to your managerial and workforce capabilities and technical issues which can affect the achievement of the requirements related to energy performance?
00:08:15	S2	Well, we have quality checklist for every stage built.
00:08:21	S1	Alright.
00:08:21	S2	Okay. So the groundwork is split into four sections and once that work has been done, it's then signed off by the foreman and then signed off by ourselves.
00:08:32	S1	Okay.
00:08:33	S2	And that's how we release payment and it's also how we check the quality. So after the groundwork has been signed off, the timber frame as they got their own individual checklist, the insulators have their checklist. The roof has theirs. So it's how PV have those. So we have that which one is obviously the quality as we're building and then we obviously have the procedures at the end.
00:08:59	S1	Alright.
00:09:00	S2	Throughout that, we have—in order to get our warranty certificate we have to have a final bill completion and how would you say it? Inspection
00:09:12	S1	Alright.
00:09:13	S2	By an LABC and Monta and then there he will check—the PV panels have been tested. He'll check if the air test has been passed.
00:09:27	S1	Alright.

00:09:27	S2	And he will check the acoustic levels.
00:09:30	S1	Okay. Excellent. Are those checking lists developed by the company?
00:09:38	S2	Yes.
00:09:38	S1	By Contractor*.
00:09:40	S2	Yeah. They are part of business management system. So yeah the standard by Contractor* and then on each site if there's any additional requirements or anything specific to the site—
00:09:55	S1	You tweak it.
00:09:55	S2	—then it's tweaked. Yes.
00:09:57	S1	Alright. Okay.
00:09:57	S2	That's what those folders here are.
00:09:58	S1	Okay.
00:09:59	S2	So I'll show you an example. You see, we got all the different models and then there's probably units that's not yet better. So you've got your foundation board. You've got your timber frame board. So it has a vapour barrier that has been installed correctly—that type of thing, has DPC installed.
00:10:29	S1	Alright.
00:10:30	S2	Okay. So and then it goes right through and then to finish one of this, the handover, we would have the following certificates say your electrical, your plumbing, your EPC. Your solar panel, air pressure test.
00:10:45	S1	Oh, excellent.
00:10:46	S2	LABC building control, robust details if applicable. The client certificates and warranties.
00:10:53	S1	Okay. Let me ask you something which is something that I've been looking into my case studies which is, well, in terms of quality compliance, you rely a lot on those documents that helped you out to identify which are the issues that you might be looking for and the other stuff and the other stream, I mean, it's pretty much the experience of the people on the ground.

00:11:18	S2	Definitely. Yeah.
00:11:19	S1	And then sometimes it's not uncommon that people on the ground like the clerk of works or the site manager identify issues that are not included in the checklists. So, do you have a procedure to feedback to your central management team that provides you with those quality tools?
00:11:41	S2	Right. What we do have is a building management meeting.
00:11:47	S1	Okay.
00:11:48	S2	And we also have a quality manager who is based in our head office so we are supposed to have on monthly basis and to feedback to him.
00:11:57	S1	Alright. Okay. Great. Yeah.
00:11:58	S2	Yeah. Also, at the end of a project, we have something called a build review meeting which is basically where we go through what went wrong and what went right.
00:12:09	S1	Okay. Yeah.
00:12:11	S2	We learn from the site. Obviously, every site you learn something new about build—
00:12:15	S1	Something important because you can feedback the system for the next projects, right?
00:12:18	S2	Yeah. I've got templates of all of that as well of all the minutes and stuffs so I can always give you that as an example.
00:12:25	S1	Oh, excellent. That would be fantastic.
00:12:27	S2	Yeah.
00:12:30	S1	Well, moving forward let me see, in your opinion to what extent the managerial team and the workforce in the site understands the impact of defects on the energy performance of buildings?
00:12:48	S2	I'd say it's probably—it's based around the core of what we do because… and if the building envelope isn't effective, then effectively we don't get paid. So if that air pressure test fails or if the acoustic test fails or PV panels don't work, then the site is not finished. So it's the basis of everything that we do really.

00:13:13	S1	Okay.
00:13:14	S2	Yeah.
00:13:14	S1	Alright. Well, it's quite clear that you guys from the managerial team are pretty much aware of that.
00:13:21	S2	Yeah, definitely.
00:13:22	S1	And do you think the guys from the subcontractor teams have the same understanding? How do you get them to understand that?
00:13:30	S2	Yeah. They normally quite good obviously and electricians are normally the ones who source the PV panels and then energy—artificial energy so they're quite clued up on it and all the subcontractors are bought into the same process that if the unit fails and they don't get paid as well. So it's all based around this checklist and if they are not signed off and if they're not effective, if they are not doing their job, then they'll be required to go back in and finish it.
00:14:10	S1	Okay.
00:14:11	S2	So, it's all kind of bought into it really, and you can't get paid until the site is signed off.
00:14:17	S1	It sounds reasonable. Yeah.
00:14:18	S2	Yeah, exactly.
00:14:19	S1	Let me ask you another thing that I quite come across quite frequently which is, well, one of the case studies I've been looking at, they have pretty much the procedure of signing off and checking once they have done their work and then for instance you had guys applied the vapour barrier. It's all good, all checked and all done, you signed off those guys. You move on to the next housing unit and then you have guys from I don't know M&E or other guys coming from another gang, and then they go along with the pipes and then scratching the vapour barrier and things like that, but then once you get back there, you see that the vapour barrier is not all right again but it's not fault from the guys who installed it.
00:15:06	S2	Exactly. Yeah.
00:15:07	S1	How do you manage these kinds of stuff?

00:15:09	S2	It's all based around counter charging and it's that me and John keep on top of that. So, for example, if we go into the house that it's already boarded and there's been an electrician whose gone and fish for some wires and he has created a whole in the plasterboard, we wouldn't obviously—and then we require the borders to come back and patch that wall for example, and we were… the charge that we get for him coming back and patching that wall, we would counter charge to the electricians, okay, so they are less inclined to make a whole unless it's necessary and you can obviously take that back to first fix when this vapour barrier is knocked or the... For example, the screed—people laying the screed and obviously they are going over the gas carcass and showing that, you know, that's how it works.
00:15:59	S1	Okay. A little more sensitive thing because well, I have previously experienced just like you working in construction sites and sometimes it's kind of difficult to put those kind of procedure forward because at the same time you need them to correct this and you need to make them aware of the consequences of, well, damaging previous work but at the same time you need them for the next job, so you need to create this kind of relationship of, okay, there is always a proper way to…
00:16:32	S2	Damage limitations.
00:16:33	S1	Yeah.
00:16:34	S2	Definitely. And that's one of our main problems actually because obviously, we need people to go back and do the snagging and put right what they've done wrong. However, we still need them to move forward to build and so it's just the case that they need to be made aware from the very start that they are accountable for anything, any damage that they cause.
00:16:55	S1	Yeah. Perfect.
00:16:56	S2	And they are the ones who have to fix it. A lot of the time the subcontractor whose original work will go back and obviously amend it and they normally come to an agreement amongst themselves before it gets the counter charge stage, and just because they understand that, you know, if you did this for me, I'll do that for you.
00:17:16	S1	Yeah. That's…
00:17:17	S2	But I won't…I completely agree that it's the hardest thing to monitor on site.

00:17:23	S1	Because sometimes, well, what we are told to do things by the book, right? Like the proper procedures, sometimes you have this bit of flexibility because you don't want to.
00:17:36	S2	Yeah.
00:17:36	S1	Well. You need to but it's kind of complicated.
00:17:40	S2	Yeah.
00:17:42	S1	Okay. Towards resources, so in this construction site, who is responsible for implementing these quality management procedures? I understand that housing associations has their own, they have the employer's agent. You have your own—can you talk a little bit about this?
00:18:00	S2	Yes, that's fine. So we've all got different—obviously, we've all got responsibility on the site. However, we've all got different responsibilities. So Quality Officer* look at it from the client's point of view. He is the clerk oft works. He comes around every day which is brilliant. So he checks quality every day. He almost acts to us—to me and John as another set of eyes which is brilliant. He feedbacks to us and then we obviously go off what he says. So, Quality Officer* side of things, he will submit report once a week and the actions from myself and Site Manager*. So that's good from the client's point of view and the client's agent once a month, where bringing forward any of his issues, and then me and John. So, we have a subcontractor weekly meeting where we then cascade it down to our subcontractors. You will have then the responsibility to abide by these checklists.
00:18:56	S1	Okay.
00:18:59	S2	I oversee the sign of this checklist. So I keep a log of where all of it—where all the checklist are, were they up to date, who is behind, you know, have been checked this time? So that's my role and then John's role is basically, he is the head of that really.
00:19:19	S1	Okay.
00:19:19	S2	So we've all got a responsibility.
00:19:23	S1	Okay. So, all right. Okay. I could say that you have overlapping procedures in terms of assuring quality which is good policy I suppose because…

00:19:37	S2	Yes, we've got—the client directly himself through the clerk of works. We've got the employer's agent and the client on the monthly basis and they also do KPI, key performance indicators. We have, our build manager holds a monthly meeting with ourselves as well, and me and John hold a meeting with our subcontractors on a weekly basis as well as throughout the week as abiding by the quality checklist.
00:20:07	S1	Okay.
00:20:07	S2	Yeah.
00:20:08	S1	What would you say would be the challenges or the obstacles to implement these quality management procedures in your opinion?
00:20:19	S2	Control of the site, I think? Time, we're very lucky here because it's an affordable housing site.
00:20:27	S1	Alright.
00:20:28	S2	Purely affordable house and a lot of sites are obviously a hybrid, with open market.
00:20:35	S1	Alright.
00:20:36	S2	So it would be a selling into our Linden brand and we're also building a centre of the site for social housing.
00:20:44	S1	Alright.
00:20:44	S2	And so what then becomes an issue then is time because you are rushing the houses—the open market houses to get obviously the people to get the cash in the bank. Therefore, quality I think sometimes under time pressure can then become lax and whereas on our site, it's all about the program and we've got the time really and yeah. There's more speed I think than anything obviously because it's timber frame and it puts the houses up quicker and it's then ensuring that they're closed off in adequate time.
00:21:28	S1	Yeah. I think quality and time sometimes struggling against each other.
00:21:33	S2	Definitely.
00:21:34	S1	I think that's my perception that of course you need to finish as quicker as you can but…

00:21:41	S2	It's the cost, time and quality triangle, let's say so, I would say that we've got time on this site which ensures the quality. The cost therefore hasn't been affected but what happens a lot in an open market is that we can't have the time, so the quality goes but the cost goes up because the quality is gone.
00:22:05	S1	Yeah, you have to come back and…
00:22:08	S2	Yeah. Remediate
00:22:09	S1	Remediate, yeah. If you could, can you appoint other procedures that could be implemented?
00:22:19	S2	Yeah.
00:22:20	S1	What would be then?
00:22:21	S2	So for the control of the quality on site.
00:22:26	S1	Yeah.
00:22:27	S2	Yeah. I mean, we could, and I think moving forward, we've decided to create a stronger snagging procedure so that when we've actually got to the point where the houses are a built envelope that we—the same as the quality checklist. We have a similar checklist for actually signing the houses off. Which would be a bit more robust than what we've already got.
00:22:50	S1	Okay. Regarded to the building envelope and the building fabric?
00:22:55	S2	Yeah. Yeah.
00:22:56	S1	Okay.
00:22:57	S2	Well, I mean our quality procedure is quite set in place really. Obviously, it can always be improved and I would say to improve on our next site, we would make the checklist even more site specific—
00:23:13	S1	All right. Okay.
00:23:13	S2	—and have input from the subcontractors.
00:23:16	S1	Yeah. I totally agree of you.
00:23:17	S2	Yeah.

00:23:18	S1	Let me ask you something that's always around my head which is—well, we have the building control body which here is LABC. Well, they are providing you with warranty and are they the guys who are doing the building control here?
00:23:31	S2	Yeah. Yeah, they're doing the building control and warranty here.
00:23:34	S1	Okay. And how often do they come here because I understand those guys are super busy—
00:23:41	S2	They are very busy.
00:23:42	S1	—in their job.
00:23:42	S2	Yeah. I mean I think there's only four of them in LABC covering the whole of Plymouth so that's a lot really.
00:23:49	S1	Wow! Wow!
00:23:50	S2	Yeah.
00:23:51	S1	Yeah. That's so overwhelming.
00:23:52	S2	Yeah, it is. So we have—ours is LABC inspector* and she comes whenever—if we call her, she'll be here pretty much the same week and if there's something that we need her to inspect and it holds up the building programme, we have to hold the building programme because it's—she is obviously the be-all and end-all. I would say they are probably a little bit overstretched and obviously it does have a knock-on effect to our programme sometimes and it's the responsibility of the builder to obviously not go forward with the build, and I think a lot of people because the time constraints are inclined to continue to the next stage before the building control officer has been to sign it off.
00:24:40	S1	Okay.
00:24:42	S2	And but LABC inspector* is very good. She comes out when we ask her to. We've not really had any problems with her and she'd just drop in on ad hoc basis as well.
00:24:51	S1	Okay. That's good.
00:24:52	S2	So, yeah. It's quite good.

00:24:54	S1	And which stage of the construction process she is more…she should visit you guys more?
00:25:03	S2	Yeah. I would say probably when we are pouring the foundations because she has to check every foundation and just to check that we obviously poured the correct amount of concrete and that it's set before we start laying the DPC.
00:25:16	S1	Because it's a critical stage I agree.
00:25:19	S2	Yeah. I'd say and that—and probably at handover as well. Once the windows are in, that seems to be you know, so fire escape routes and each house she wants to inspect as well and not just the house type.
00:25:36	S1	Okay.
00:25:37	S2	Especially with timber frame.
00:25:39	S1	Alright. Perfect. Okay, moving forward we talked about the procedures you take towards quality and the things that relates to energy performance but as well I would like to understand, if you could tell me, what are the performance attributes that are considered by the quality plan? You talked about the air permeability test, right?
00:26:07	S2	Yeah, yeah. So do you mean in regard to the U-values and what would make the U-values?
00:26:13	S1	Yeah, U-values and basically what the building regs ask us which are U-values and air permeability.
00:26:19	S2	Right. Yeah. That is why I actually did print off for you because at the top of my head it's quite a lot to reel off. In fact, here it is. So this here is your designed SAPs and so we take into consideration the ground floor U-values, obviously, what's submitted from the floor. external plain roof, window value and window glazing, front door more to usage and then...what else we got here. So these are the houses, that what lose on each.
00:27:10	S1	What do you mean by you lose?
00:27:13	S2	Oh, sorry because, yeah, so what we—so this is our U-value.
00:27:16	S1	Okay.
00:27:16	S2	So the…

00:27:20	S1	Okay. Well, so this is what you've got from the design stage, right?
00:27:24	S2	Yes. Yeah.
00:27:24	S1	Okay. Okay.
00:27:25	S2	So this was bought.
00:27:27	S1	In terms of air testing, do you guys test in terms of sampling, do you test sample that is required from the building regs or you test 100% of the units?
00:27:40	S2	We test every unit. Yeah.
00:27:41	S1	Every unit. Okay, that's great.
00:27:42	S2	Yeah every unit is air tested. Yeah.
00:27:45	S1	Okay. Do you do one test once the building has been completed?
00:27:51	S2	Yeah. So just before we get the LABC warranty build completion and inspection carried out so as the job is actually fully complete, we will then get the air test people in which AES
00:28:05	S1	Alright.
00:28:05	S2	And now there will be a test and then we'll know if it pass or fail.
00:28:10	S1	Okay. For the building control bodies, you submit 100% of the units or just the sample that they require.
00:28:19	S2	Yeah. 100% of the units.
00:28:21	S1	Okay.
00:28:21	S2	Yeah.
00:28:22	S1	Excellent. Well, that's really good. In this quality checking procedures that you talked about the checking list and so on well, do you have a proper procedure to identify defects? Well, because you have the checking and then once you identify the defects, what do you do with that?
00:28:48	S2	Right. So with our defects, we—so during the build, we won't sign off the checklist until that defect is amended.
00:28:58	S1	Okay.

00:28:59	S2	So when they come for payment at the end of the month and if it gets that far and they cannot put in for that works at all—so if they have done first fix, the quality is incorrect and they will not get paid for that first fix and so it's the same as kind of what I've said earlier. So, that's how we do it going forward through the projects and through the build and then on the final, we have something here for the confirmation of bill completion.
00:29:33	S1	Alright.
00:29:34	S2	Okay. And this is basically our snagging procedure. So, I do this, I go through every room within the house and if there's anything that is incorrect so, are all radiators fitted and working correctly? Are all thermostats fitted to the radiator? Blah, blah, blah go through all and then the final retention for that house will not be given to the subcontractor until that is signed off.
00:30:01	S1	Okay. Alright. Do you keep a photographic record of the defects for your own purpose or you can…?
00:30:15	S2	Yeah. When we go around and say, for example, when I'm snagging the houses, so I am—I'll go in. I put red dots for the painters and any of our subcontractor. I will take photos of the defect and then when I will then send out a list of all the defects and the subcontractors, then, contractually have five days to complete these defects from my email to subcontractors. So it would say for example, I don't know, make good of—for example, let's say broken mirror and there will be a picture of broken mirror and that's how we...
00:31:01	S1	Okay. Excellent. Wow!
00:31:02	S2	Manager that
00:31:03	S1	Yeah, wow! Excellent. Okay. And for the last section is for quality compliance.
00:31:12	S2	Okay. Yeah.
00:31:13	S1	So as far as I could understand so that the methodology for a quality compliance is about the signing off the quality checking sheets, right? So, you said you have a weekly meeting with contractor and subcontractors here in the site office.
00:31:38	S2	Yeah, it's just next door in our meeting room every Monday at 2:00.

00:31:41	S1	Okay. Excellent. So, you can raise all the issues that you've been able to collect from the previous week and set out for the following one.
00:31:51	S2	And that's the point where I have a spreadsheet that tells me exactly what plots have been signed off in regard to the checklist.
00:31:57	S1	Okay.
00:31:59	S2	And it's a green, amber, and red system. So, green is that it's been signed off. Amber is that it's due within the next two weeks in accordance to the build programme and then red is if it's not been signed off. So it's outstanding and I watched them to complete – they will just get the signature.
00:32:15	S1	Alright. Alright. Yeah. And the other stuff – just to finish up and just to make sure I understood. Once you finish the construction, well, the project and then you have all these documentation about quality and defects, you send it back through the site manager to the central office so they can feedback?
00:32:35	S2	Yeah. Yeah. So obviously we archive them (signed off checking lists) anyway and these will be issued to our client but in regard to feedback here, we have—at the end of the project, we have a bill completion review. So a full bill completion review and that's the standard document as part of our BMS system and it's just got the standard minutes that we go through when we look what we make good in the project and what was the negative and then obviously we try and take up to our next job.
00:33:11	S1	Okay. The last question I would like to ask you is—so as being assistant site manager, you deal with all sorts of things from programme to payments to quality assurance, in your opinion, do you think you have a balanced time for each one of those duties? I mean…
00:33:39	S2	I would say that it's important that from the beginning of the site that we have things like the weekly meeting set in place then because as the site progresses and as your workload progresses obviously if that's not in place from the beginning—
00:33:56	S1	Yeah, for sure.
00:33:56	S2	—and you're not inclined to carry it forward and we've been looking on this job that we have done that and I will do that going forward throughout my career. You see it's so important, but it's very difficult as a site manager to pigeonhole your time, to say that I'm gonna (sic) do my paperwork in the

		mornings and then gonna (sic) go out in the afternoons and it's kind of not like that so you have to kind of working on the role really.
00:34:24	S1	Yeah.
00:34:25	S2	It's juggling.
00:34:26	S1	I ask you this question because, well, I finished my Masters like 12 years ago and then I started work in the industry throughout last two years ago when I started my PhD and one of my critics to academics towards quality management and construction management as whole is that people tend to think that people sometimes, mismanagement can occur because people are not aware or they don't have enough information or they just don't care and I always like to point that's not the case. It's always a matter of time constraints—
00:35:04	S2	Exactly.
00:35:05	S1	—which is completely overwhelming. I mean you in your position have so many things to be done in just one day of work and then it can be quite tricky to be out there checking for every detail—
00:35:18	S2	Definitely.
00:35:18	S1	—and quality issue that you might understand that can become an issue.
00:35:22	S2	Yeah. It's that well when you've got such an ownership on health and safety so then keep your own quality as well because you have to think things like health and safety and costs and profiling in front to ensure that quality is also within that. I think it's key because obviously that's where time—to be honest, time, cost, and health and safety will down to quality.
00:35:42	S1	Yeah, yeah, yeah, yeah. That's for sure. Alright. Okay. Well, thank you very much. That's really helpful.
00:35:48	S2	Okay. No problem.
00:35:50	S1	We will stop here. Just put that aside.

*Complying with the principles of ethics of the research the names of the participants and companies were omitted.

[00.35.57]

[End of Audio]

Duration 35 minutes and 57 seconds

Interview 4.a – Transcript

Timecode	Speaker	Transcript
00:00:00	S1	Okay. Well, just before we get started, I need to make sure that you've got the information sheet.
00:00:09	S2	I did and I signed the bill.
00:00:11	S1	Okay, the consent to participate. Alright. So as we talked about, this interview starts with basic information regarding to yourself and your company. So the first question is your name.
00:00:24	S2	Head of Development*.
00:00:25	S1	Alright, your professional qualification?
00:00:30	S2	It's Chartered Institute of Housing.
00:00:31	S1	Okay.
00:00:32	S2	It's not a construction based one. It's more on housing management.
00:00:35	S1	Alright and your years of professional experience?
00:00:40	S2	I should have said that I've got an MA in Housing—
00:00:41	S1	Okay.
00:00:42	S2	—in Bristol. So, yeah.
00:00:43	S1	Alright. Okay and how many years you've been working?
00:00:47	S2	Since in development since 1992.
00:00:49	S1	Wow. Okay. Huge, huge experience. And your role in the housing association?
00:00:57	S2	Here as head of development.
00:00:59	S1	Okay. On the top of your head, do you remember the number of assets in the house association?
00:01:06	S2	About 14,000 in management.

00:01:08	S1	Okay and during the geographic area...
00:01:13	S2	Just Plymouth at the moment—
00:01:14	S1	Just Plymouth.
00:01:13	S2	—although it's expanding to the Travel to Work Area which is defined by no more than half an hour travel.
00:01:21	S1	Okay. Alright. So you're expecting to expand the following.
00:01:25	S2	Yeah. Currently, all our projects are based in Plymouth.
00:01:28	S1	Okay. Alright. The number of ongoing projects at the moment?
00:01:32	S2	We have 355 units under construction at the moment.
00:01:36	S1	Alright.
00:01:37	S2	We have completed to date 335. So at the moment, it's the peak of delivery.
00:01:42	S1	Okay.
00:01:44	S2	We only established in 2009, so we've only been in the existence of 7 years.
00:01:51	S1	Okay. Alright. Do you have any quality accreditation here in the housing association?
00:01:59	S2	Yeah, we got...
00:02:04	S1	Oh, it's alright. I can check on your website anyways.
00:02:07	S2	Yeah, we've got quite few but the key one is the Environmental Management System.
00:02:13	S1	Okay.
00:02:14	S2	EMS, I think, I can't remember which number 2000 or whatever but yeah we do.
00:02:18	S1	Okay. Yeah, I can check on your website anyways. Well, the name of the project that we're working here is Case Study 4*, right?
00:02:27	S2	Uh-hmm.
00:02:28	S1	Okay, the number of housing units?

00:02:31	S2	72.
00:02:33	S1	And the project purpose, I mean in terms of number of lettings, shared ownership, open market…
00:02:41	S2	Right.
00:02:42	S1	Yeah, well, don't worry. I have all these numbers it's just a formality.
00:02:46	S2	23 shared ownership I think, the remaining affordable rent, let me just check if I got it right... Yup, 23 shared ownership, 49 for affordable rents. So all affordable housing.
00:02:58	S1	Okay. Excellent. Do you remember the project overall cost?
00:03:03	S2	Yup, the total scheme cost is 11.6 million.
00:03:10	S1	Okay.
00:03:11	S2	So 160,958 per unit, total scheme cost.
00:03:17	S1	Alright the stage of the project process?
00:03:20	S2	Currently on site.
00:03:21	S1	Currently on site and the duration?
00:03:24	S2	Due to complete in May 2018, so it's about another 12 months to go.
00:03:34	S1	The projects procurement route?
00:03:37	S2	It was at JCT design and build two-stage competitive tender.
00:03:42	S1	Alright. As you can see, a lot of those questions I already know the answer, but I'm sorry for that—
00:03:48	S2	That's okay.
00:03:49	S1	—it's just a formality for the research procedures. So the first area that I would like to talk to you is about the requirement and objectives of the quality planning. So does the project have a formal quality plan and is this specific for this project or a standard used by the housing association?
00:04:14	S2	We have the design and project toolkits which encompass our employer's requirements. They have been amended to meet passivhaus standards—

00:04:22	S1	Alright.
00:04:23	S2	—which was a requirement made as part of our bid for the lands to Plymouth City Council.
00:04:28	S1	Okay.
00:04:29	S2	They sold us the site for one pound on delivery of a Passivhaus Standard project.
00:04:34	S1	Okay, so...
00:04:37	S2	So it was moulded, the requirements were moulded by Passivhaus consultant*.
00:04:42	S1	Okay.
00:04:43	S2	And the employer's requirements—and the employer's agent.
00:04:47	S1	Okay. Passivhaus consultant* is the Passivhaus Consultancy Company.
00:04:51	S2	Based in Plymouth.
00:04:52	S1	Alright. So okay, in terms of quality requirement established for the project, are energy performance aspects part of the scope of the quality plan?
00:05:02	S2	Well, our standard requirement seek—specifically seek code level 4 energy performance in terms of the building.
00:05:09	S1	Alright.
00:05:10	S2	That is our only current and it still remains current requirement in terms of energy performance.
00:05:16	S1	And Passivhaus Accreditation, well, does it work as your energy performance standard as well, can you talk a little bit how was the decision to…why you decided to go for the passive house accreditation?
00:05:35	S2	Because it gave us the site and we know the city council were keen to have an example of our environmental scheme.
00:05:42	S1	Okay.
00:05:43	S2	So that we bid for and they gave—they sold us land on that basis. It's a very difficult site. There is no open market option in any case.

00:05:51	S1	Okay.
00:05:53	S2	But in terms, we are not seeking full certification. We are seeking passivhaus principles, that's what the land contract says.
00:05:59	S1	Uh-hmm.
00:06:00	S2	And that requires MVHR system and the main design principles to be met. It doesn't actually specify full certification.
00:06:07	S1	Yeah.
00:06:07	S2	But we've always thought of maximising the amount of certified properties.
00:06:12	S1	Alright. Okay. And so can we say that the requirements regarded to energy performance are the requirements set for the passivhaus standard?
00:06:24	S2	Yeah. Passive house standards, yeah.
00:06:27	S1	Okay. So can you say that those energy performance requirements are part of the strategic goals of the organization or only specific for the project?
00:06:46	S2	They were originally and I had originally thought that it would be, I had imagined that building regs would go in this direction.
00:06:53	S1	Uh-hmm.
00:06:53	S2	And I had imagined it would be really good to… an early example, to better understand how it works and perhaps to inform how design standards but in the intervening period we had the rent cuts which cost us over £20 million. So the focus is being far more on delivery of units rather than high levels of energy specification.
00:07:12	S1	Okay.
00:07:13	S2	But the reason why we are interested in that in principle is because we're interested in our tenants and having as low energy bills as possible, so because we're housing people on limited means and also it helps on pay the rent.
00:07:28	S1	Alright. Okay. So once defined those requirements and decided to go as close as you can get to a passivhaus accreditation or the passive house principles as you said, how this information or how this decision was transmitted to the other participants of the project?

00:07:50	S2	Right at tender stage in terms of contractor, it was made clear.
00:07:53	S1	Okay.
00:07:54	S2	That's what we're seeking.
00:07:55	S1	Okay.
00:07:56	S2	And also the employer's agent as though we didn't—I think we selected the employer's agent and architect based on their experience in a Cornwall scheme, where they had already delivered a passivhaus project and right from the beginning the selection of the consultants and the contractor to some degree was based on experience of similar projects.
00:08:13	S1	Okay.
00:08:14	S2	Although actually Contractor* had very limited experience but they won in terms of quality management—
00:08:19	S1	Uh-hmm.
00:08:21	S2	—in their bid.
00:08:21	S1	Okay, so your... Let me say, your selection or methodology was not only based on price but as well as in the quality and experience of the contractors and even—
00:08:32	S2	Well, they passed the framework, the consultant framework.
00:08:37	S1	Okay.
00:08:38	S2	But price wasn't the consideration for using them. It was experience.
00:08:42	S1	Okay. Excellent. In terms now moving forward to risk assessment which we talked a little bit earlier which is trying to identify the risks which might impair your effort to work towards achieving passivhaus accreditation or getting closer to the passivhaus principles. Which stakeholders were evolved in the process of defining the quality requirements related to energy performance and when does it happen in the project time span?
00:09:17	S2	We employed the Passivhaus consultant* and they were involved all the way through. The bigger threats the project proceeding were wider issues to deal with the site itself.
00:09:28	S1	Alright.

00:09:29	S2	And in terms of not achieving it, it has more to do with budget cuts elsewhere that was an impinge on the design standards we are seeking to achieve.
00:09:40	S1	Alright. Okay.
00:09:41	S2	Is that makes sense?
00:09:42	S1	Yeah, totally. I remember, well, I participated in the design stage pretty much.
00:09:47	S2	And we had some major cost issues to do with the big slope that potentially put in jeopardy and it did in terms of reducing some of the insulation standards or various other things.
00:09:57	S1	Yeah and you had a close relationship with Passivhaus consultant* and the designers to appropriately check with the passivhaus aspects.
00:10:05	S2	A number of times they did the full check and in the most recent checks look like the whole scheme might be certifiable, which is good.
00:10:13	S1	Alright, was there a process—In the beginning of the process or during the process to what extend the managerial team and the work force understood the impact of defects on the energy performance of buildings on this project.
00:10:39	S2	Do you mean the contractor or the people physically delivering the product on site?
00:10:44	S1	Yeah.
00:10:45	S2	Well, I guess the one unusual thing we did was to have that Passivhaus consultant* joint training session, although it was just after site work began but it was before critical passivhaus works were carried out. That's a two-day course that we all attended and one of the key aspects of that was looking at potential defects and looking at things which jeopardise us being able to reach certification standard to do with insulation and to do with air tightness in particular.
00:11:14	S1	Yeah.
00:11:15	S2	And on visiting, practically visiting is an example, didn't we?
00:11:19	S1	Yeah, we did and I haven't seen this kind of procedure taking place in any other case study that I'm working with. Yeah.
00:11:28	S2	No, I mean, yeah because it's new to all of us.

00:11:32	S1	Yeah.
00:11:33	S2	Including the contractor actually. Who haven't actually done this, but had a very good track record of delivering high quality on sites but it was new to all of us. Apart from, yeah the—well Passivhaus consultant* obviously and the consultants, the architects, and the employer's agent but that was it.
00:11:49	S1	Yeah. Alright . Overall, what are the challenges and obstacles faced when implementing these quality management procedures towards achieving the energy efficiency that you...
00:12:04	S2	I guess the key thing we have to make sure we achieve this, apart from of course that we all went on, it's the clerk of works, as additional independent eyes going over the site two or three times a week maybe even daily in critical times.
00:12:17	S1	Uh-hmm.
00:12:18	S2	Visiting and ensuring that what's designed and been approved by the Passivhaus consultant* is actually being delivered on site
00:12:25	S1	Okay.
00:12:25	S2	To the correct quality.
00:12:27	S1	If I can recall properly, during the tendering process or in the working packages, you had as a housing association you've said—well, you've required from the contractor, the awarded contractor that you should deliver or develop and deliver proper quality management procedure, right?
00:12:51	S2	And actually the contractor which we selected had the highest cost attached to that and they came… the reason well, probably the main reason they were selected, because they were the most—one of the most expensive, was they had an additional oversight and they had a big air testing regime that they proposed.
00:13:10	S1	Okay.
00:13:13	S2	It did make them one of the most expensive ones but gave us assurance that despite the lack of experience in delivering passivhaus that they would have the framework place to delivery.

00:13:20	S1	Okay. Excellent. So can we say that we have pretty much two ways of quality control, one delivered by the contractor due to this requirement that was being made since the beginning and the other one is your clerk of works that...
00:13:40	S2	And the training they've undergone together with the contractors as they shared understanding on what needs to be achieved or what the dangers are.
00:13:46	S1	Alright. Okay. Let me go now to the resources part. So that's pretty much we've already answered which is who is responsible for the developing and implanting the quality management procedures? We just talked about it. Then, the following question is...
00:14:08	S2	But the one thing should have added is, of course there is an independent testing at the end, we've appointed another independent passivhaus consultant that will carry out those checks as is required for certification.
00:14:17	S1	Yeah, yeah. I mean with the passivhaus, the consultant that is working on your behalf being a passivhaus accredited they cannot—
00:14:27	S2	Do the rest, yeah.
00:14:28	S1	—do the rest of the testing and accreditations because, of course….
00:14:32	S2	Which is right.
00:14:33	S1	Yeah, yeah exactly. That is one of the—well, a little bit going out of our topic specifically but one of the things that I found about the building control bodies, that sometimes they use local authorities but other times they use accredited inspectors which is… they hire this people to check them out so it's—
00:14:56	S2	NHBC is worse than that. It's funded by the private developers themselves.
00:15:00	S1	Yeah.
00:15:01	S2	That's their own, you know, organisation in many ways so that they are in a little bit conflicts of interest straightaway.
00:15:06	S1	Yeah, definitely.
00:15:07	S2	So we use local authority building control here I think.
00:15:10	S1	Yeah, I think so.
00:15:12	S2	Yeah, they were cheaper.

00:15:13	S1	Yeah. Alright. So here is, again, we have already answered the specific team in place to ensure the achievement of quality requirements related to energy performance so we have—as you said we have the contractor team doing their own thing, you have your own eyes on site which is the clerk of works.
00:15:36	S2	Employer's agents as well.
00:15:38	S1	Employer's agents as well and this independent passivhaus consultant on behalf of the housing association, right? Okay. Is there a specific procedure in place to create awareness of quality requirements? We have talked about the course provided by Passivhaus consultant* to make people aware of the potential defects and the ways to avoid them. Alright.
00:16:02	S2	We have various of the checklist which we use on schemes which highlights particularly areas of defects but that usually to do snagging stage and we also have regular standards clerk of works reports which they complete every week.
00:16:14	S1	Alright.
00:16:15	S2	Beyond that, I cannot think much else. They have training programs they do in NHBC building regulation training.
00:16:23	S1	Okay.
00:16:24	S2	I cannot think much beyond that.
00:16:27	S1	Okay.
00:16:27	S2	Housing contract provisions itself, which shall we see have a whole raft of ability for us, as client, to be able to open up works and stop works and inspect works.
00:16:39	S1	Okay. Alright. Do you believe that the housing association or the contractor provide a proper environment and all the necessary resources in order to achieve the quality requirement proposed? Should anything else be provided if possible or...?
00:17:02	S2	I cannot think we would have the resources to do much more to be honest. Since the resources we have, we are lucky that we do have the clerk of works.
00:17:08	S1	Okay.

00:17:09	S2	And although there is only two them, they are looking now at let say 355 units but because there are only four or five large schemes—
00:17:18	S1	Alright.
00:17:19	S2	—it means they can spend considerable amount of time on site.
00:17:21	S1	Okay.
00:17:23	S2	I hope that answer your question, I don't know else what I can done.
00:17:25	S1	Alright.
00:17:26	S2	Maybe we could have paid the employer's agent even more or more to do additional inspections which perhaps we should have done.
00:17:34	S1	Okay. Okay going forward towards quality metrics which are the operational definition, operational measures pretty much related to quality control. So do you remember which are the energy performance attributes considered by the quality plan? I mean, we talked about air permeability.
00:18:01	S2	Air testing is 0.6 whatever.
00:18:04	S1	Yeah, we have u-values for building elements (crosstalk- which I can't remenber) me neither, required by the passive house. Apart from those two ones which are pretty much the most important, do you remember anything?
00:18:16	S2	Comfort levels, wasn't it? The level of comforts and that was one of the key ones, the air quality—is it air quality?
00:18:24	S1	Yeah.
00:18:24	S2	But certainly that air quality one in a comfort criteria.
00:18:27	S1	Alright, okay so you're going to...
00:18:29	S2	And there was the energy used per metre squared annually.
00:18:33	S1	Okay.
00:18:35	S2	And that there is energy used in heating as well as total energy used per metre squared.
00:18:39	S1	Okay.

00:18:40	S2	I think it was 80? 80 kilowatts per metre squared for a total something light that.
00:18:44	S1	Yeah, free passive house should be 40 I supposed.
00:18:47	S2	Or was it 40 for energy take, wasn't it? And then the overall was 120 totally.
00:18:52	S1	Yeah, exactly.
00:18:53	S2	Total load.
00:18:54	S1	Yeah. That's—.
00:18:55	S2	Which I exceed in my house and it was nowhere near passivhaus.
00:18:57	S1	Yeah? Yeah, okay.
00:18:59	S2	Yeah, I've checked with my kids.
00:19:01	S1	So am I—can I say that all the energy performance requirements are regarded to the passivhaus standards or do you have anything else?
00:19:12	S2	Well there are all superseded by passive house. All the other ones which relate to the Code level 4 building fabric.
00:19:20	S1	Yeah, passivhaus is a bit more stringent and more, okay. Does the project have a procedure for defect identification and collection place?
00:19:34	S2	Yeah, kind of—the clerk of works has a notification process where they'll notify the employer's agent and well firstly notify the contractor on site and then at monthly site meetings, you know, bring out all the issues that have come up.
00:19:47	S1	Yeah.
00:19:48	S2	And 9 times out of 10, in fact, every time with Contractor* as soon as anything has been spotted, they've immediately rectify it.
00:19:53	S1	Alright.
00:19:54	S2	If they don't, then there is a more formal process and that only involves informing the employer's agent who act as a contract administrator—
00:20:01	S1	Yeah.
00:20:02	S2	—to formally issue instructions but, yeah, I guess that's as far as it goes.

00:20:07	S1	Okay. Well, that's important to have something to follow up to and check whether things are being corrected and...
00:20:23	S2	Yes. It's not like a turnkey contract where you only turn up in the end or—
00:20:25	S1	Yeah.
00:20:26	S2	—you know, you have no rights to stop work or inspect, but we do JCT formal contract.
00:20:31	S1	Okay. Alright. So the next question is about how and when the performance attributes monitored and collected. You were talking about several stages for air permeability test.
00:20:48	S2	Yeah and this is part of the Myspace detail which I can no longer remember.
00:20:52	S1	Yeah.
00:20:53	S2	But I know they were gonna (sic) produce one unit early and thoroughly air test it.
00:20:56	S1	Okay.
00:20:57	S2	To find any issues—
00:20:58	S1	Alright.
00:20:59	S2	—and then rule out theses air tests along a single terrace.
00:21:02	S1	Okay.
00:21:03	S2	But it's quite early on that they're gonna (sic) do an air testing. I cannot remember the detail because I'm not the project manager.
00:21:09	S1	Yeah, sure, it's not your area. Okay. Well, I'll be with them tomorrow with Quality Officer* and Senior Site Manager*.
00:21:23	S2	Of course, the one thing we did have is that this little Wendy house set up, a little house on site to test the windows.
00:21:29	S1	Yeah.
00:21:30	S2	And test some—I mean in its own ways a little mini sort of air test, not just the windows but in the end it becomes air test and everything.

00:21:38	S1	Have you done it already? Yes?
00:21:40	S2	The test has been carried out. I haven't seen the formal results yet.
00:21:43	S1	Okay.
00:21:44	S2	And I think our windows are okay so the first time the test was carried out, our windows had a lower performance on the negative air test.
00:21:51	S1	Okay.
00:21:52	S2	Positive air test was the same. I might have that the wrong way.
00:21:55	S1	Alright. Okay.
00:21:56	S2	I'm waiting now for the results. So what we've done instead of top hung windows, we've made them side hung and we've changed their lock.
00:22:03	S1	Uh-hmm. Okay. Alright. Moving forward to quality compliance. So how quality compliance is reported in terms of content, format and frequency?
00:22:15	S2	So we get a weekly clerk of works report—
00:22:18	S1	Alright.
00:22:18	S2	—that goes to the project manager.
00:22:20	S1	Okay.
00:22:21	S2	The project manager will attend sites maybe every other week or every week but at the four weekly site meetings, that's when quality issues are discussed, you know, those issues are raised.
00:22:35	S1	Uh-hmm.
00:22:36	S2	But for us, we have a weekly site report. We also have a KPI system.
00:22:39	S1	Okay.
00:22:40	S2	At site meetings where quality, time, cost, health and safety and various other things are monitored and parties score each other.
00:22:49	S1	Uh-hmm.
00:22:49	S2	We have an agreed score that comes back to the main KPI sheet we have—

00:22:54	S1	Okay.
00:22:54	S2	—people to look at. Like for me, I don't visit projects, but I can look across all the projects.
00:22:59	S1	Alright, I—
00:23:00	S2	And see basic KPI return, really.
00:23:03	S1	This is the one that the employer's agent administer at the end of each meeting?
00:23:09	S2	Yeah. And then it goes onto a spread sheet and it's just agree, you know, a rag rated—
00:23:15	S1	Alright.
00:23:16	S2	—collection system we have here.
00:23:19	S1	Okay. Alright. Do you have specific procedure in place to analyse the reports and defect records and which stakeholders participate in this process?
00:23:33	S2	Well, we do have residence—after 12 months after hand over, we do a resident survey—
00:23:39	S1	Okay.
00:23:40	S2	—and we ask about their satisfaction with defects service.
00:23:44	S1	Okay.
00:23:45	S2	Obviously, we have—we write the tenants, we send them the—tell them that we're going to visit and carry out the inspection.
00:23:52	S1	Okay.
00:23:53	S2	The inspection is carried out by the clerk of works, so hopefully the one that actually constructed the scheme and one of those questions is about the satisfaction defect rectification service and we don't do very well to be honest. So Housing Association* is there and so it's increased slightly but it's running about only 50% satisfaction.
00:24:14	S1	Okay. Alright. So you have this framework that has been used across other associations—

00:24:22	S2	Other associations that we share information, we benchmark but then also we're able to see which contractors are performing or how well.
00:24:30	S1	Okay.
00:24:31	S2	So we're able to analyse the satisfaction rate or different contractors and that should inform the amount of retentions we take. In fact, it informed Spectrum to stop working altogether with (contractor). They just said—
00:24:41	S1	Alright.
00:24:42	S2	—"no more because there's so many defects", but it should inform the contracts we set up in the terms and we have a standard contract that all the partners work on and we have tightened up you know the administration charges and the sorting out the defects ourselves during that 12-month period and at the end, the defects are rectified.
00:25:10	S1	It's excellent. This shared information is really good—
00:25:13	S2	Very rare and it won't happen in the future unfortunately. This sort of partnership is no longer going to exist in the future.
00:25:18	S1	Yeah.
00:25:19	S2	But the number of us hope to carry on this work so Sovereign isn't—well, hopefully Magnet and ourselves and maybe West Country or maybe some other associations will carry on this work.
00:25:35	S1	Alright. Yeah. I think it's good for those guys here as well to—
00:25:40	S2	Yeah.
00:25:41	S1	—know how do they sit in this, yeah?
00:25:46	S2	Yup. So it's kind of—yeah. They will have access to this information either comparing other so...
00:25:54	S1	So this is for your internal consumption so to speak?
00:25:59	S2	It is, yeah.
00:26:00	S1	Okay. And it doesn't go to all contractors and things like that? It's just for your interest—

00:26:05	S2	Well, in theory, this source group housing association has had a number of frameworks, consulted frameworks and contractual frameworks. In theory, this was then feedbacked to the contractor's framework as well.
00:26:18	S1	Okay. Alright. So that's pretty much the following question how and when feedback is provided to the different participants. So you do it not on the basis of the specific project but it comes back in this general...
00:26:33	S2	This provides benchmarking between housing association and different contractors, but we have a post-contract review also at end of defects. Again, looks across the time, looks at the KPIs.
00:26:47	S1	Uh-hmm.
00:26:48	S2	Looks at lessons learned, gets feedback from our asset team as well as our housing management team.
00:26:53	S1	Alright.
00:26:54	S2	And feedback from the resident, in theory to provide learning for future changes and design specification.
00:27:00	S1	Okay. Alright. Okay, perfect. Well, this is it. I'm going to stop here.

[00.27.12]

[End of Audio]

Duration 27 minutes 12 seconds

Interview 4.b – Transcript

Timecode	Speaker	Transcript
00:00:00	S1	So for research proceedings, first I just want to make sure that you received upfront the research information sheet…
00:00:13	S2	Yeah.
00:00:14	S1	And that you are alright with the consent to participate in the research as well and have signed it.
00:00:17	S2	Absolutely. Yeah.
00:00:19	S1	Okay. So we have pretty much six areas on this interview. First of all is the basic information about yourself and the project and the company. And then we will walk through five different main groups of the theoretical methodology related to quality planning Okay. So, your name please.
00:00:56	S2	Quality Officer*.
00:00:57	S1	Alright. And your professional qualification?
00:00:59	S2	Developed professional qualification. I'm a dry liner by trade so it's—it's practical experience on site.
00:01:05	S1	Okay. Your years of experience?
00:01:09	S2	In construction, in excess of 20.
00:01:11	S1	Okay. Your role here in this project?
00:01:14	S2	I'm a site manager.
00:01:15	S1	Alright. Well, the company name.
00:01:21	S2	It's Contractor*.
00:01:21	S1	Alright. Well, this next question doesn't regard to you. The geographic area which the company works. Whole country or—
00:01:32	S2	Everything south of Gloucester.

00:01:34	S1	Okay.
00:01:35	S2	Yeah, all the way down through to Cornwall. We do sort of skirt into the edge of London.
00:01:40	S1	Okay.
00:01:41	S2	And we do pick up Wales as well so it's sort of the southwest sort of side of Gloucester.
00:01:50	S1	Okay. Do you have any quality accreditation in your company?
00:01:56	S2	Not as an accreditation to me personally.
00:01:59	S1	Alright. And the company, do you know? ISO…
00:02:02	S2	I don't believe so.
00:02:03	S1	Okay, well, I can check it on the website, anyways.
00:02:05	S2	Yeah, sure.
00:02:06	S1	No worry—no worries about it. Well, the name of this project?
00:02:09	S2	This is—it's Case Study 4* for Housing Association*, it's—we know it as Case Study 4* Passivhaus scheme.
00:02:19	S1	Okay. And the project purpose in terms of number of letting, shared ownership, open market.
00:02:26	S2	There's 23 shared ownership. The rest of it is social housing.
00:02:30	S1	Okay. All affordable housing schemes?
00:02:33	S2	Yeah. You got it, yeah.
00:02:34	S1	Okay. Do you have on the top of your mind the project overall cost?
00:02:38	S2	It's circa 10 mill.
00:02:40	S1	Okay. Well, you're… the stage of the process, you're on site, the project duration?
00:02:51	S2	I think it's 84 weeks total.
00:02:52	S1	Okay.

00:02:53	S2	Programme weeks.
00:02:54	S1	Alright.
00:02:55	S2	We're in week 24.
00:02:58	S1	Okay. So pretty much have something around 12 months still to go.
00:03:03	S2	Yeah, yeah. May, next year we complete.
00:03:06	S1	Okay. So do you remember the project procurement route?
00:03:11	S2	I wasn't involved at that stage.
00:03:13	S1	Okay. Alright. The first bit is about the requirements and objectives of the quality plan or the quality programme as we could call. Does the project have a formal quality plan?
00:03:28	S2	It—it does, yeah.
00:03:30	S1	It is specific for this project or it's something that—
00:03:34	S2	It is specific for this project. It's an uplifted version of our policies and procedures. And so we've—we've accentuated on what we already have globally throughout the company.
00:03:51	S1	Alright. In terms of those quality requirements established for the project. Are energy performance aspects part of the scope of this quality plan?
00:04:03	S2	Energy performance, I think, in terms of energy performance, yes, at design stage.
00:04:08	S1	Alright.
00:04:09	S2	Clearly, at design stage, to reach the Passivhaus criteria and in terms of what we actually do on site, it's controlled by the QA procedure that we'll talk about. And then ultimately, air testing will indicate—that will be the clear indication as to whether we've been successful or not.
00:04:30	S1	Okay.
00:04:31	S2	Or when we've been successful, I should say, should I?
00:04:34	S1	Okie dokie. Do you remember what are the requirements regarding to energy performance?

00:04:41	S2	Top of my head, no.
00:04:42	S1	Okay. Well, you just said it's regarding to air permeability, air pressure tests?
00:04:49	S2	Yeah, yeah.
00:04:50	S1	Okay.
00:04:51	S2	And so, I mean, the criteria we need to meet on the air pressure test is 0.6.
00:04:56	S1	Okay.
00:04:56	S2	Air changes per hour so it's a—it's tight margins.
00:04:59	S1	Alright. It is. So it's pretty much to comply with the requirements of the Passivhaus standards, right?
00:05:06	S2	You're quite right, yeah.
00:05:07	S1	Okay. Are those, as I said, the next question would be if those requirements are part of the strategic goals of your organisation or specific for the project. You mentioned that specifically for the Passivhaus. But then you started from your previous quality planning and then upgraded it and uplifted it, as you said, towards the Passivhaus standards and how those requirements are documented and transmitted to the rest of the participants, meaning the subcontractors and people involved in the construction site?
00:05:45	S2	I do a QA presentation. We will also, as the super structure commences, we'll have an induction by our Passivhaus advisors, Passivhaus consultant*, and it will be an ongoing—during the course of the pre-let meetings as well, they have… their attention's brought to the sign up process which is linked back to payment so the whole thing is sort of neatly tied up really early during the sort of tender stage for the subcontractors.
00:06:21	S1	So this is a critical part—
00:06:23	S2	Absolutely.
00:06:24	S1	—to make everybody aware of what is expected and—
00:06:27	S2	Yeah.
00:06:28	S1	—and the financial consequences of...

00:06:31	S2	You've got it, yeah.
00:06:32	S1	Alright.
00:06:33	S2	Essentially, it's quality or no payment.
00:06:35	S1	Okay. Okay. So pretty much day one everybody should be aware of what is required and expected. Okay. Moving forward to the risk assessment, which stakeholders were, in that case, involved in the process of defining the quality requirements regarding to energy performance and when does it happen? Well, you mentioned that you've assessed all the requirements during the design stage and at which point you guys, as a contractor, participated in this process?
00:07:13	S2	For me personally, I wasn't involved in the process at all, but we have the design manager along with Senior Site Manager*, the project manager, and the commercial team all put the project together on paper before we obviously hit the ground. So we hit the ground with a finalised design ensuring that we've met all of the correct, sort of on paper, the correct the standards to reach the Passivhaus requirements.
00:07:43	S1	Okay. Alright. Is there a process in place to assess the risks related to managerial and workforce capabilities and technical issues as well which can affect the achievement of those requirements related to energy performance?
00:08:02	S2	Is there a process in place? I mean we obviously document the quality as we sort of proceed through each sequence of the construction.
00:08:17	S1	Let me rephrase it. How did you assess the possible or the potential issues that would compromise your effort towards achieving...?
00:08:27	S2	Once again, it was design stage. So I mean if something looked over complicated that could be engineered out of the design, classic example Juliet balconies. That would have penetrated the fabric of the building and did not need to be there so we've actually gone with an architectural railing system to provide the image of a Juliet balcony but it doesn't actually serve the same purpose of a Juliet balcony so it's engineering out and that could have compromised the structure and integrity of the building and achieving that Passivhaus criteria.
00:09:06	S1	So you assess the potential risks towards thermal bridging in that case or air infiltration and so on and so forth in the design stage.

00:09:18	S2	Yeah.
00:09:18	S1	Excellent. Regarding to your opinion, to what extent the managerial team and the work force understand the impact of defects on the energy performance of buildings in this project?
00:09:35	S2	As I say, once again this all goes back to the very early stages of tendering for subcontractors. The criteria is set in stone. We will develop a QA sheet along with their assistance but we have the fundamental knowledge from Passivhaus consultant* to be able to make sure that everybody buys in to this Passivhaus scheme. So I think everybody is fully conversant as to what they need to do and any defect will simply not resolve in payment for them because it has got a potential impact for us and our construction.
00:10:15	S1	Alright. And what would be the challenges and obstacles that you might face or if you were already facing when implementing this quality management procedures towards achieving the energy efficiency?
00:10:30	S2	I suppose…Pace, speed of the programme and the fact a lot of our supply chain will use subcontractors themselves so they will be working on a price. So in order for them to achieve their money the quicker they work, the more money they earn but it is being able to buy the supply chain package at the right sort of price so that we still maintain the quality. So essentially, they can still earn a good living by slowing down and making sure it's right.
00:11:00	S1	Okay.
00:11:01	S2	And that's again going back to design stage and subcontract procurement that's where that sort of began.
00:11:09	S1	Yeah, the problem is always the issue because it has two edges sword, right?
00:11:14	S2	Yeah, so I mean we obviously have a finish date and we have to achieve that finish date, otherwise penalties are involved but ultimately, we don't want to rush it so that we miss the final detail so, yeah.
00:11:31	S1	Definitely. Okay. About the resources that you need to deploy this quality management procedures, who is responsible for developing and implementing the quality management procedures?
00:11:48	S2	Our operations manager is passionate and I mean passionate about construction, health and safety and now quality. Quality costs the business tens of thousands of pounds a year.

00:12:04	S1	Uh-hmm.
00:12:05	S2	So on that basis, Dave, he has developed this ITP (Inspection and Test Plan) which I think we've come through before and he is extremely passionate about it. So ultimately Operation Manager* was the spring board, he's sort of challenged me with the quality champion role on site.
00:12:27	S1	Alright.
00:12:27	S2	So I implement and I have worked with this supply chain to develop the quality check sheets and I work very closely with them on site and I have to say in terms of the fact that I sign things off personally.
00:12:44	S1	Yeah?
00:12:45	S2	It's extremely apparent on site when I walk around that people know my position and they know that they're not gonna (sic) get away with cutting corners so. Yeah, spring board from Dave but essentially it's my role.
00:13:01	S1	Alright. Okay. So, well next question would be about the specific team to ensure that the quality is being achieved, you've just answered that, there is no need to go further on that. You mentioned, there is another question that—because this is all intertwined so—
00:13:22	S2	Yeah sure.
00:13:23	S1	—most of the question overlap each other so specific procedure is in place to create awareness about the quality requirements, you said it's written on stone because people must know upfront the requirements and how they will comply with that.
00:13:35	S2	That's right, yeah. Yeah.
00:13:37	S1	So we go a little bit further about the onsite procedures and quality checking so you develop those quality checking's with the subcontractors. So in a way to get them involved in...
00:13:50	S2	People around, yeah. So there are no skeletons in the closet and we will sit down and there will be a small group of us that will sit down with the subcontractor after their pre-let meeting and we would develop the checklists that you've seen before. I'm happy to give you a few of those for—
00:14:10	S1	Yeah.

00:14:11	S2	—reference. We will develop the checklist. So we are checking something that I know what I'd be looking for in terms of quality management but they're the specialise at their trade so they would also know what they are going to do in their operation that could potentially affect the fabric of the building—
00:14:30	S1	Yeah.
00:14:31	S2	—thus impacting on the Passivhaus standards. So it's really involving them early on, develop the check sheet, that check sheet as we all know links back to their payments so they know their stages.
00:14:45	S1	Uh-hmm.
00:14:47	S2	If they haven't got something right within that stage and there's a cross on their check sheet, they're not getting their draw. So it really is involving them from the outset.
00:14:58	S1	Okay, so can you walk me through the procedure that you have in applying those quality sheets, I mean the checking sheets? How is the procedure, they check themselves?
00:15:12	S2	Yeah, every single plot. I have devised a plot file.
00:15:17	S1	Alright.
00:15:18	S2	So every single plot from one through to 72 has its own individual file. In that file, it will have subheadings starting from ground works onto masonry then it will be carpentry etc. And on each of those subheadings, they will have the developed check sheets and on that check sheet are the series of checks that we would go through. It's the responsibility of the subcontractor or their foreman to take that check sheet and make sure that each individual element is installed as correctly and as worded within the document, they then sign that one off to say they're happy with it, I will then make a visit on site and I will check that off and countersign it. So if I find the masonry—the masonry they take the sheet out with them. So they sign off all the individual aspects of that workload and I countersign to say that I'm happy.
00:16:20	S1	Okay.
00:16:21	S2	If I've got any issues, I'll fill out a comment sheet. I won't sign it off and that becomes a live defect form.
00:16:27	S1	Okay.

00:16:27	S2	They need to remediate it, they would sign it off as complete and I would sign off the element of works.
00:16:34	S1	And the items to be checked are pretty much the same in theirs checklist and yours? Do you work in pretty much the same structure?
00:16:39	S2	It's the same checklist with two signatures required at the bottom. So as I say, jointly developed, has a checking schedule—
00:16:49	S1	Alright.
00:16:50	S2	—by myself and the subcontractor prior to arrival on site. The workforce themselves carry out the works with the knowledge of this check sheet. Their foreman would then sign off their supply chain to work, before offering it to me for confirmation.
00:17:07	S1	Alright. Okay. Let me ask you something that—well, I've worked as a site manager and some of the times you pretty much do that and then once the trade is done you go there and check yourself and then the next trade guy comes in and sometimes they mess up the work of the previous one, so how do you deal with that?
00:17:34	S2	Because we get the signature at the bottom of each element of work, we are signing off to say that at that stage of time, the surface or the element of work preceding the next subcontractor was in good order.
00:17:49	S1	Yeah.
00:17:49	S2	So if a preceding—the following subcontractor comes in and damages a joining surface, the onus goes back to the responsible party and we would probably go back to the previous subcontracted to put right the error. So it's kind of like a contra charging type of culture.
00:18:13	S1	So before they get started, they have to sign off that what they're looking at prior to their work is pretty much ok.
00:18:21	S2	Absolutely right. So that would be what I've broken down as a key trade handover. So from going from a superstructure of the construction.
00:18:33	S1	Yeah.
00:18:34	S2	So we've now got masonry. We've got the floors in. We've got the roof on, before the carpenter goes inside to start doing their first fix is a key trade handover for me.

00:18:44	S1	Okay.
00:18:45	S2	So the carpenter is going in, they're looking around, they're just checking visually themselves that they're happy with everything that's inside and they're accepting responsibility.
00:18:55	S1	Alright. Alright. So they cannot—well, I'm not saying that it happens frequently but they cannot blame the previous one it was damaged when we got here—alright, perfect. It's really, really good. The next thing I would like to ask you is do the Passivhaus accreditation process works in parallel to your quality checking's and your quality reports?
00:19:24	S2	Yeah.
00:19:25	S1	Do they come at key stages to check themselves or the...?
00:19:29	S2	They do yeah, what we've actually done is we've got fortnightly visits from Passivhaus consultant*. Their last correspondence to me was actually particularly good and in terms of what we're doing on the site appears to be touching on exemplary so they are absolutely confident that the quality process in place is going to achieve everything they need to be able to pass on to the warrantors.
00:20:01	S1	Okay.
00:20:02	S2	And so yeah they were very happy and fortnightly visits and we will also have them involved at the first air test.
00:20:10	S1	Okay.
00:20:11	S2	So should there be any issues which I'm sure there won't be, then they will be there to assist us with identifying where potentially we could have problems but and their involvement will be very much just to ensure that we achieve the correct results.
00:20:29	S1	Okay, excellent. So I assume about the sampling approach I assume that going towards Passivhaus, you have to check and test the 100% of the housing units, right?
00:20:48	S2	Yeah.
00:20:49	S1	You don't have like a sampling approach or...?
00:20:53	S2	No spot checking, it's checking every element.

00:20:55	S1	Alright.
00:20:56	S2	And that's the way these check sheets come through. Plot by plot, item by item, masonry for example. There's four lifts of masonry and each lift is checked independently per property and if defective remediation carried out prior to be able to start the next lift.
00:21:17	S1	Okay. Let me ask you a personal question. Obviously, you've been involved in several other projects prior to this one, how do you feel that this extensive quality management procedures put in place in this project specifically relates to the previous ones and is it possible to replicate this model to other projects even though you might not be working with Passivhaus but just complying with building regs?
00:21:50	S2	I've come from literally the opposite end of the scale from this job where the quality management was I would say non-existent and the defects I personally spent 18 months working on personally and the defects are still continued on that site to this day. So we are touching on towards two years now as completion where we're still remediating defects where quality wasn't implemented, people were allowed to defer from design and ultimately it's cost a lot of money, untold amount of man hours and so I've worked the two opposite ends of the scale.
00:22:40	S1	Uh-hmm.
00:22:41	S2	So is it possible to do this all sort of procedure moving forward? It should do.
00:22:47	S1	Yeah.
00:22:48	S2	Linking ACE or tailoring a subcontractor's package to a payment draw and if the quality is not to the correct standard, you don't get paid should be the way everybody should work because then it just drives to the get it right first time.
00:23:05	S1	So let me ask you just one more question related to this topic, do you believe that the appraisal costs are much more, much lower than the correction costs?
00:23:20	S2	Absolutely, yeah.
00:23:21	S1	So it's reasonable that we focus on appraisal and making people aware so you get it done right first time.

00:23:19	S2	You got it right, yeah.
00:23:30	S1	Okay. I strongly agree with you, it's my personal opinion and I keep asking myself why is that the case that the whole sector doesn't share this kind of view because at the end of the day it's all about the money, right?
00:23:47	S2	It is about the money.
00:23:48	S1	So if it's cheaper to prevent defects from occurring, then correct them afterwards.
00:23:55	S2	Because cheaper is quicker.
00:23:56	S1	Yeah.
00:23:58	S2	You leave a happy client.
00:23:59	S1	That's it.
00:24:00	S2	You leave a happy client, you've got a chance to repeat business and you leave a client with hundreds of defects that needs your builder's crawling all over that property post completion. You're souring grapes, aren't you? So yeah, the quality from the outside is in my mind as important as health and safety. We put a lot of money into health and safety because of the culture of no blame, no claim and all the rest of it is the same sort of emphasis should be put on the quality.
00:24:35	S1	Do you think this is a trend starting in the construction sector or it will take several years to work? That more people will get to the same conclusion that we...share?
00:24:46	S2	It depends on the builder because you obviously you get your sort of national builders, you get your medium sized builders and you get your smaller companies and I think the smaller companies in terms of being able to value engineer that into their pricing structure, they'd probably not win the work whereas medium to large builders should really be going down that route.
00:25:10	S1	Yeah.
00:25:11	S2	That's my kind of considered opinion.
00:25:13	S1	One of those days I was talking to a friend of mine that works for NHBC and he was telling me that their report from last year pointed that 93% of their warranted schemes—well, 93% of the tenants reported quality issues

		towards occupation. So it's almost 100% of the units presented some sort of defect that were detected by the tenants or the occupants, sorry. But then when they are talking about thermal performance, of course, the defects are not visible. So there is another universe of defects laying uncorrected. I'm quite interested in ways QA can be deployed like in this project. You are pretty much aware and making everybody aware and putting procedures in place, that you can prevent them to happen and if they happen you detect that and correct them before.
00:26:10	S2	I think the key for development like this, is the design. If the design is flawed, the building will be flawed.
00:26:16	S1	Yeah.
00:26:17	S2	And you know you're gonna (sic) get interfaces and problems throughout the development where there is a design in place but actually it doesn't quite work.
00:26:26	S1	Yeah.
00:26:27	S2	So those are the dangerous times where you start deviating away from drawings.
00:26:31	S1	Okay.
00:26:32	S2	And but to-date we've not found any.
00:26:35	S1	Okay.
00:26:36	S2	I would like to think that we don't, but that's construction. It is an organic product, isn't it? So...
00:26:44	S1	Indeed. And can you say that this should be a matter of literacy because I tend to think that people doesn't mistakes in the design process intentionally.
00:26:56	S2	Uh-hmm.
00:26:57	S1	So what would be the issue, more training, more education for designers to be aware of what can go wrong?
00:27:04	S2	I think it's down to training for design, but I mean we are talking about a 72 unit Passivhaus development. We have a designer who's had an involvement of the interface between the designer and the advisors and then of course you've got to bring the commercial team into it. So whereas

		the advisors may have a belt and braces approach. The designer may have a slightly more commercially friendly approach to the solution. So it's sort of bringing those guys to meet in the middle to achieve a detail that's gonna (sic) work but may not cost the belt and braces approach.
00:27:48	S1	Alright, so again we get to the point off early collaboration, towards achieving what we are set to.
00:27:55	S2	Absolutely.
00:27:56	S1	Okay. Getting a little bit back to quality compliance. So I imagine that quality compliance for you at the end of the road is getting the Passivhaus accreditation but how do you do it, in the process of getting things done? I mean you have several air testing stages?
00:28:18	S2	Yeah, every unit's got three tests, so post completion of the fabric of the building.
00:28:25	S1	Okay.
00:28:26	S2	And there is an air test. So prior to any internal fixings and mechanical and electrical fitting, we do an air test.
00:28:35	S1	Alright.
00:28:36	S2	If there is any issue, we've got a bare fabric internally to be able to remediate any potential leaks.
00:28:42	S1	Alright.
00:28:44	S2	Once we've completed that, mechanical and electrical, we'll then do their first fix.
00:28:49	S1	Alright.
00:28:49	S2	And make sure that their penetrations through the building are thoroughly sealed. When they are thoroughly sealed we know we have maintained the integrity of the building.
00:28:59	S1	Okay.
00:29:00	S2	And then it's down to final fitting inside. So once again completion of mechanical and electrical, you've only got the first fix of the internal partitions. There's gonna (sic) be limited areas where we could be leaking through the fabric.

00:29:14	S1	Alright.
00:29:15	S2	As long as we past the second air test, we're then comfortable to continue the internals and then the final air test is post completion of the property.
00:29:25	S1	Okay.
00:29:27	S2	In theory, we should certainly not be any worse than the second test.
00:29:32	S1	Okay. Alright. Apart from the double signing off of the checking sheets that we have talked about, do you have internal meetings with subcontractors or the Passivhaus consultant from time to time to check what has been doing and what's going on in terms of…
00:29:56	S2	Every week we hold a subcontract meeting and during those subcontract meetings we have a—what's the word I'm looking for? A formula that we work through. We'll go through health and safety. We'll go through progress on site and one of the headings is quality.
00:30:18	S1	Okay.
00:30:19	S2	So during those meetings if there is something that has been raised as a quality concern or an issue, it will be raised in that meeting. That may mean an interface between one, two, or three different trades and as we've got everybody around the table at the same time, we can thrash out a solution and implement during a course of that week, the following week, following the minutes being distributed, the work needs to be remediated so we can get it signed off. So there is a quality start and then there's a sign off during the following week.
00:30:52	S1	Okay, so having follow-up procedure—
00:30:57	S2	That's right.
00:30:57	S1	—to well check everything that was raised and then you can check if it was properly corrected. Alright. Okay, at the end of the process do you have a final meeting or something like that to add up to the future projects or is this something...?
00:31:19	S2	To be honest with you, I mean that's a long way down the road for us. Providing we are successful at this one and you know maybe if the client has another project for us to go on to, but as long as we've got a good relationship with the supply chain and everybody has done a good job then you know of course we'd be more than willing to re-employ the same team

		to move onto another job. We have a team that actively [inaudible 00:31:44] to the business so it's really up to them to secure work for us when we complete this one.
00:31:51	S1	Okay. Alright, just the last question, just to make sure that I got it right, about the Passivhaus consultant that clears off every stage that you have been producing, do they work on the basis of your own quality reports based on the checking sheets and so on or they have their own structure for assessment?
00:32:14	S2	They have given me their requirements as documented proof to the certifier that we need to follow. So for me the key is photographic evidence, I think...
00:32:33	S1	On specific, building elements and junctions.
00:32:36	S2	I tend to take a lot photographs and I'll keep a full photographic log of each stage of the process, so this is foundations we're looking at now. Any issues that have been identified, so there was some gaps identified along the edge of the insulation that needed expanding foam applied. Once again, any gaps that were too large and again, you've got full photographic log at each stage of the process, for each elements of work to completion. And then that closes out that section, testing on drainage as a final process. So for every element of work is there, to provide the floor slabs, is quite a lengthy document. It's the same with blockwork.
00:33:30	S1	That's a lot of work.
00:33:31	S2	It's a lot of work but it's repetitive so it makes it easy but it does show that we're diligent in our approach and just make sure that you know we're checking each process…each stage of process. We can document it, we can prove it.
00:33:48	S1	Alright.
00:33:49	S2	So, yeah.
00:33:50	S1	Excellent. Excellent. Well, thank you very much for your time and I think this is invaluable information that is important to me.

[00.34.04]

[End of Audio]

Duration 34 minutes and 4 seconds

Interview 4.c – Transcript

Timecode	Speaker	Transcript
00:00:01	S1	So just before we get started I just want to make sure that you have got the questions, the consent, and the information sheet?
00:00:08	S2	Yes, I got all of that.
00:00:09	S1	Okay, so we start with the basic information, about your name?
00:00:15	S2	Yeah and it is Senior Project Manager*.
00:00:19	S1	Yeah, and your professional qualifications?
00:00:21	S2	I got a BSC in Construction Management. I've also got a HND in architecture and I'm a member of the CIOB.
00:00:36	S1	And the numbers of years of professional experience?
00:00:48	S2	Probably 18 years.
00:00:53	S1	Alright, and your role in this project?
00:00:57	S2	Senior project manager for Contractor*.
00:01:03	S1	And your geographic area where Contractor* work?
00:01:16	S2	Predominantly southwest. We are expanding into and around London and the southwest coast and we go up to about Birmingham and South Wales.
00:01:29	S1	Okay, that's fine. Yeah, that's huge.
00:01:30	S2	Yeah.
00:01:31	S1	On the top of your head do you remember the number of ongoing projects that My-space is dealing with?
00:01:36	S2	For Contractor*, currently we have got 16 live jobs in the minute. All live projects.
00:01:45	S1	All regarding to your housing developments or commercial as well?

00:01:50	S2	Mainly housing developments or with some sort of housing development attached. So, for instance the majority of what we do, Housing Association but we are doing a scheme in Bath where we are building a casino with, I forget, 16 apartments attached to it which is how we've ended up with that scheme. It's got a small residential attached.
00:02:15	S1	Does Contractor* have a quality accreditation? I mean ISO or...?
00:02:21	S2	Yes, we're quality accredited with ISO and I'm not sure the—just one minute, I've got a message.
00:02:27	S1	Well, I could check, you know, in your website.
00:02:29	S2	Yes, we are accredited. I think it is 14001.
00:02:33	S1	Okay. So, it has the environmental part as well?
00:02:37	S2	Yeah.
00:02:37	S1	So the name of the project, you call it Case Study 4*. Do you have any other name that you use?
00:02:44	S2	Passivhaus scheme is another name that's being used as and it's the only one that we're doing at present but mainly Case Study 4*.
00:02:55	S1	So you have here 72 housing units right?
00:02:58	S2	Yes, 72 dwellings.
00:03:03	S1	For rent and shared ownership?
00:03:04	S2	Yeah, mixed tenure on that. We have 23 shared ownership and the rest of the 72 are there for rent only, for social market.
00:03:16	S1	Okay, do you recall the project overall cost?
00:03:18	S2	£10.4 million?
00:03:22	S1	Okay, so the stage of the project we know already. You're under construction there.
00:03:26	S2	Yeah.
00:03:27	S1	And the project duration?

00:03:28	S2	It's 78 weeks.
00:03:30	S1	78 weeks. And you have started December of last year?
00:03:34	S2	21st of November last year and hand over is 25th of May 2018.
00:03:40	S1	Okay, alright. The project procurement route is design and build, right?
00:03:46	S2	It was a two-stage tender and so Contractor* was selected out of three contractors on the stage 1. We had to do an interview. We passed the interview and we were invited to go through and price the stage 2 part of the tender which is more in depth to get the design sorted out before we actually started on site and firm up the price before the construction phase.
00:04:09	S1	Okay, alright. So the first, now we get started to the more interesting questions, I suppose. The first part is regarding the requirements and objectives of quality. So do you have a specific formal quality plan for this project?
00:04:32	S2	Yeah, project specific quality plan. All Contractor* schemes have project specific plans. We have a generic form which then we adapt to select the various different construction methods we're carrying over on any particular scheme.
00:04:48	S1	Okay, so you adapt towards the construction technology deployed and as well as the requirements related to energy performance, for instance?
00:04:57	S2	Yeah, so we look at – let's pick something – windows. Everything will have to be from the windows. We'd need the CE markings to make sure that they're past the relevant U-values for whatever scheme. We got the product guarantees from the suppliers and any warranties. So, we'd gone through the whole spectrum of conformance.
00:05:24	S1	Alright. In terms of the quality requirements regarded to energy performance, what would be those?
00:05:34	S2	That was CS20. It was part of a planning package we had to do a report with Passivhaus consultant* partnership, our consultant for Passivhaus element of the work. Had to do a report to Plymouth County Council which is labelled up CS20 for some reason and that basically stipulates the houses are being designed to be 20%-27% better than building regs performance or energy performance.

00:06:12	S1	So you are following Passivhaus principles but you're not obliged to get an accreditation? How does it work?
00:06:23	S2	It was part of the contract setup. Our contract obligations on this scheme are to quote... "The Passivhaus principles only". So, the contract would have been formed on the Passivhaus principles, deemed to mean we have got good levels of insulation, with minimal thermal bridges and there is a form list basically stating we… "CS20 form by Passivhaus consultant* low-energy building product list dated 18 July will also be required to be used as reasonable… Contractor* will endeavour to achieve full Passivhaus standards". So, we're not actually contracted to get certification.
00:07:15	S1	Yeah?
00:07:17	S2	But by default we'd get everything passed. We'll get a certification.
00:07:20	S1	Alright. So you're aiming for the certification anyways, even if the contract does not—?
00:07:25	S2	Yeah. The contract doesn't require it but from a personal point of view we go in for full certification on everything.
00:07:36	S1	So, may I say that those energy performance requirements specific to this scheme don't translate into your company targets? It's just something specific for the projects, right?
00:07:54	S2	Yeah, this is just specific for this project. Yeah.
00:07:58	S1	Okay, so can you tell me about how those requirements were developed or when was the process of making a decision about going towards Passivhaus?
00:08:16	S2	Passivhaus was an aspiration of Housing Association*. They wanted the low-energy scheme and they wanted the flagship project. So, they already had Passivhaus consultant* on board with Architect* to advise on the Passivhaus principles and they are looking for the energy saving aspects of going passive for the fuel poverty that a lot of their tenants have. So, they were looking at it as sort of future proofing for lower gas bills basically. Passivhaus consultant* came up with this CS20 document which I can give you a copy of, you might have that, which basically states the Passivhaus, all the building regs, that the buildings perform a lot better even if they don't achieve the certification, they still perform a lot better than what you'd just normally...

00:09:19	S1	The next stage is regarding to risk assessment and perhaps opportunities and it is regarded to those issues that might compromise the achievement of the aspirations that you are aiming for. So, the first thing is which of the stakeholders were involved in the process of defining the quality requirements, you mentioned that Passivhaus consultant* was right at the beginning of the process. This was something required by the city council and the...?
00:09:49	S2	So what it is, stakeholders are Plymouth City Council, Passivhaus consultant* partnership, Housing Association*. So, the Housing Association*, planned the low-energy scheme, one partnership came up with the concept and Plymouth City Council came up with the requirements… are part of their energy performance and then Passivhaus consultant*—they're basically the three and then four, if you count the architect as well. You know, Architect* who came up with, yeah, so basically Plymouth City Council came up with a set of requirements. Passivhaus consultant* advised what we need to achieve for Passivhaus which was over and above Plymouth City Council and then we made that happen within Architect*'s designing a Passivhaus building.
00:10:42	S1	Alright, okay. Towards more specifically about the risks which might be involved. Did you have a process in place towards assessing the potential risk related to managerial or workforce capabilities and technical issues that could affect the achievement of the targets?
00:11:05	S2	Yeah, there were quite few workshops during the second stage pricing element of the job on design and where we have potential design risks in particular floor joists penetrating the air-tight barrier, because our biggest risk is achieving the 0.6 air changes per hour as far as we can see. If the building is fully wrapped in insulation, it's fully wrapped in insulation and we can see that as a big risk area. The big risk for us is achieving the 0.6 air changes and looking at the design in detail and that in-and-out at that early stage everywhere we got penetrations. If we have got a penetrations, how we air-seal our penetrations. There is a lot of thought that went into that in that process and I think we have got a good design as it is now. Then, from a managerial point of view, we have employed an extra person which we wouldn't normally have on another scheme to specifically check the QA and work through the QA process along, checking if all these air-barrier penetrations are closed off, fully sealed, and if everything is built to a good quality.
00:12:18	S1	Okay, so the procedures regarding to checking quality, specifically speaking about issues related to thermal performance, you rely on your

		checking sheets which were tweaked from your original documentation or checking lists, and then you have this person now—what is the frequency of these checking?
00:12:40	S2	If, well, daily really. Well it will be when we start… during fit out process, it will be daily. (Sidetalk)
00:13:03	S2	Yeah, once we start the fit out process, then we've got the airtight shell intact and we've tested it and the building is fully sealed and it is hitting the 0.6 or below, you know, it is a daily task to go around checking on the M&E contractor, checking on the carpenter, checking on dry liner to make sure everything there is installed in the first fix element of works, they are not damaging the air barriers. And there's a string of signing off process which is linked to payments as well. So, the contract can't get paid from element of works until one of the monitor or QA team have been in and signed off. But we also incorporate Passivhaus consultant*, Architect*, Local Authority Building Control, in as sort of full independent. Actually, Housing Association* has now got their Clerk of Works. There are five independent checks that would come in alongside us and check for their own benefit as well.
00:14:04	S1	Okay. Well, I am always comparing what I have been seeing here to all the cases that is which I am looking and pretty much we also have this overlapping quality control procedures but I think as far as I can see, what could you tell that is the thing that drives you differently from other schemes in terms of assuring quality towards energy performance?
00:14:34	S2	In particular, it's having the right team here for me as well, but it's down to having the procedures in place and giving the guys the knowledge. We're doing a lot of training courses on Passivhaus, dos and don'ts, have a check for mistakes on Passivhaus and the sort of troubleshooting guide on Passivhaus. This is where you are from failures, this is where you are of your air leakage problems, any thermal bridging tends to be here, here and here. So, Passivhaus consultant* partner have done a lot of training with my site team and the supply chain, the subcontractors, their site supervisors so we are all fully aware of how the insulations are supposed to be fitted to the outside of the building, how it interferes between the windows and doors works with the insulation and the air tapes and the inside block work to reduce the thermal bridges and sort of not just the window fitters but the block layers and the carpenters all know what the details are on the window so, and it's the collaboration of everybody to make sure we've got a formal team that's fully behind the Passivhaus, basically.

00:15:47	S1	Yeah. So then, you understand that in your opinion that your managerial team and workforce are fully aware of the potential of the defects on undermining the ability of the buildings to perform as predicted.
00:16:00	S2	Yeah. So if somebody puts or bridges the insulation, so we end up with a thermal break or there is some metal fixing somewhere where it shouldn't be and it affects the thermal performance of the building, everybody is fully aware of the impact that will have on any modelling or air leakage so, and the understanding of the importance of—well, if they had done something, they understand the importance for telling us there and then. There is a no blame culture that we keep drumming into them. If you make a mistake, lets us know. It's easier to fix that now than having to take work down at the end which will cost a lot more.
00:16:40	S1	Oh yeah, if they—
00:16:41	S2	So, yeah.
00:16:42	S1	That's brilliant. One more thing regarding this area, what would you say are the charges and obstacles faced when implementing the quality management procedures or when implementing the project as a whole towards Passivhaus accreditation?
00:17:07	S2	The biggest obstacle for me is getting the supply chain because Passivhaus in the UK is a fairly new concept. There is a lot of single dwelling bespoken projects that have happened on a small scale—none on a big scale, definitely not in the southwest. There is not a lot of large scale developments that are doing it so, my biggest problem that we've had is the education process with the supply chain and actually getting them to cost the job in allowing the time in for quality checks and doing things methodically and correct instead of just banging up the building as quick as possible. It needs to be done properly.
00:17:49	S1	Were those issues reason for price rising comparing to your previous works?
00:17:55	S2	Yeah. For me, yes. And that's why we're being quite open with our supply which is good for the two-stage tender process. You've got the second stage timing. You've got sort of like, I don't know, 12 weeks before you actually start to bring your subcontractors through that learning curve and this is how we need to build it, this is why we need to build it that way, and you need to allow it for that. You work through the design process and bring them along with you and everybody is then fully aware of what they need to do and they allow it for that so when the guys come to site, they know

		they've got an enhanced price to do something, there's a reason for that. And they've got the hold points they need to check and do it properly.
00:18:41	S1	Yeah, I guess this probably is the trickiest part to get everybody on board and meet—
00:18:46	S2	Yeah, it is getting everybody on board and getting it done right the first time so that you're not constantly taking stuff down and putting it back up again, because that really affects programme.
00:18:54	S1	Alright.
00:18:55	S2	Yeah, we had a bit of a learning curve on Block J. So there is a block of three houses which we were using as a test pad. Smallest block, the worst performing block. So, that one was just passing from the model. And so, I want to get that one done, tested as quick as possible, if that one passes on the air change, we were flying on everything else.
00:19:15	S1	Alright. And then there is a proper way to show...
00:19:18	S2	Yeah?
00:19:19	S1	...the guys how is it expected to be done.
00:19:22	S2	Yeah, the air taping, the DPC detail around the ground floor where you've got the slab insulation coming around the outside of the slab and then the wall insulation coming down and meet it. There is a detail around the doors. It's the test bed getting all the final tweaks. So, it all works on theory, on paper.
00:19:43	S1	Yes, sure. Well, (Crosstalk) you can check how it's—
00:19:45	S2	Yeah, make sure all the little tweaks get sorted out on the smallest block.
00:19:50	S1	So you proceed with air testing once you have air barriers and the closures installed?
00:19:57	S2	Yeah, we're parging everything at the minute in Block J and that plywood comes at the end of this week to put up on the underside of the roof trusses. So, towards the end of next week we'd have done all the air taping on the block and the air testing at one of the properties and seeing if we get less than 0.6.
00:20:19	S1	Fingers crossed, yeah?

00:20:19	S2	Yeah.
00:20:20	S1	I think that you're doing everything by the book. I mean it's… (Crosstalk)
00:20:22	S2	(Crosstalk) Yeah, they're really pleased with the way it's going on so there's no issues. It's all good.
00:20:32	S1	Well, moving towards resources. So, this is a bit redundant but anyways I think it's important. Who is responsible for developing and implementing the quality management procedures?
00:20:43	S2	Ultimately me.
00:20:44	S1	Yeah?
00:20:45	S2	So I've passed on the mantle to one of the site managers, Kev Freeman. He's looking after the quality plan as a whole and then he is implementing the QA sign-offs and then the rest of the team will do their spot inspections and then feedback to Kev just to keep the whole process in line.
00:21:07	S1	Okay. I assumed that this first Block-J that you mentioned, you're using as well to check your quality control procedures as well as checking tools and...?
00:21:15	S2	Yeah. Basically checking everything and checking if the payment strategies working. So, basically we've broken everything down so the subcontractor gets paid for an element of work which is normally about a two-day build duration. After that, after finished that I'm going to sign it off in the claimed payment for that element of works. So, it seems all to be working quite well at the minute.
00:21:35	S1	Okay. Just a matter of curiosity. You mentioned that you have several overlapping quality control procedures, the clerk of works from the Housing Association, you guys and the employer's agent as well and so on. Do you have—well, mismatching information from your reports and the others?
00:22:14	S2	No, it tends to be a joint effort. So, say for instance the clerk of works is here at the minute, from the Housing Association*, he can go around with either Assistant Site Manager* or Quality Officer* and it's a joint walk around. Everybody is fully aware of what's happened.
00:22:27	S1	Alright, okay. Well, it's good. I'm fond of the no blame culture. (Crosstalk) I mean everybody working together towards—

00:22:33	S2	Yeah, that's it. (Crosstalk) Yeah. And so, that's what I said to Housing Association*. We're not hiding anything. You'd come in, you walk around with us, anything that you spot, let us know and likewise, Jeremy (clerk of works) he's been around on one of our QA signoff so he's witnessed what our process is for checking rooms. So, luckily, it finishes into these first lifts. So we'd go in with a tape measure and a level and make sure all the joints are fully filled and the walls are up straight and the windows are in the right positions and we check everything. So, he's witnessed what we are checking.
00:23:10	S1	Okay. I am particularly interested in how do you develop these...? How do you call it? ITPs...?
00:23:19	S2	ITP? Inspection and Test Plan.
00:23:23	S1	Yeah, ITP. Right, yeah. Are you developing this as you go or do you have...?
00:23:29	S2	We have standard documents.
00:23:31	S1	Standard documents and then you will...?
00:23:36	S2	Yeah.
00:23:33	S1	...be tweaking the details? Yeah, so. (Pause)
00:23:49	S2	Yeah, we've got standard documents but we—they are basically in a text free format. So, we can change them. It's what we do 'cause (sic) every project is different. So, for instance you'll have standard masonry block work and they've got eight or nine activities that you check as a matter of course we then added ours… 'cause (sic) ours is standard blocks laid flat. Most of the job should have a cavity wall construction so we wouldn't need those elements to check. So, we'd just adapt blocks laid flat, fully filled beds, level and plumb externally because you know getting external wall insulation flat. So, the air, 'cause block, the concrete block got a tolerance +/- 8 mm difference on the block just on conformity. So the blocks are not all identical. So, we tilt the tolerance out on the inside face 'cause we're parging everything.
00:24:42	S1	Yeah.
00:24:43	S2	So, externally, it's all perfectly flat so the insulation can go flat against the wall with no air gaps.

00:24:48	S1	Yeah, excellent. No air pockets.
00:24:50	S2	So, it's stuff like that that we're checking. It's fully filled beds, the walls are plumb. 'Cause that's the other thing. Passivhaus should be +/- 3 mm, building regs and NHBC requirements shouldn't be +/- 10 over a two meter level.
00:25:09	S1	Uh-hmm.
00:25:10	S2	So, Passivhaus is massively over and above what you wouldn't get away with on the standard building.
00:25:17	S1	So you don't get worried about building regs or...
00:25:20	S2	No, as long as we're building them into Passivhaus and we're checking the Passivhaus, we'll get the others by default and of course we're over and above what we need to be.
00:25:30	S1	So, roughly speaking you have an inner leaf made of block and then an outer leaf, with no cavity, that…
00:25:40	S2	Yeah and so we've got 210 mm of insulation, it's—
00:25:43	S1	10 mm?
00:25:44	S2	210. It's uhm...
00:25:46	S1	210, sorry.
00:25:47	S2	Yeah, 2010 mm of insulation to the outside of the block work and that is glued and mechanically fixed, thermally broken fix which is, it's more to ensure, yeah that—
00:26:06	S1	Alright. Moving towards a quality metrics. So the energy performance attributes that you're considering are the ones prescribed by Passivhaus, which are the u-your values for all the envelope elements, you have the air permeability, do you have anything else in that? So basically U-values and air permeability, right?
00:26:27	S2	That's it, yeah. It is u-values and air permeability. Yeah, building needs to be thermally modelled. So, yeah, it's making sure that you haven't heat loss and u-values all add up and then the rest of it is on air permeability and air changes prior and that's it really. Yeah.

00:26:47	S1	Alright. Well, about the specific procedure for defect identification, we talked about the checking sheets.
00:26:53	S2	Yeah, we've got checking sheets. We've also got an online till called Field View which is... I am not sure whether Kev showed you the last time we were here was—
00:27:03	S1	It was out of battery. In fact—
00:27:06	S2	Alright. It might be charged up but he would be able to show you he's mapped all the drawings and all the prototypes. So, you could break the drawings down into different rooms so then you can go through, take a picture, put a little dot on the drawing, link it to that picture and send it straight off to the subcontractor.
00:27:19	S1	Alright.
00:27:19	S2	It's a really cool piece of kit. It's user friendly, very easy, and it also logs everything. So, the subcontractor has to close it out before we can go and check it. So, it's all logged automatically so we don't have to—
00:27:33	S1	So you don't have to go checking and then taking pictures then put them up in a report, send it, hand it over to your subcontractors?
00:27:44	S2	No.
00:27:44	S1	It's just a software that a managers log?
00:27:47	S2	Software managers everything. So, basically, for instance you go out to plot 50 and then go ahead and just click on this link, Passivhaus, Block-J, plot 50, and then ground floor or first floor, 'cause (sic) that's how he's mapped it.
00:28:00	S1	Yeah?
00:28:01	S2	As you click on ground floor living room, bring up the living room on to the screen and then you can just drop a cursor or a defect or a snag or whatever it is, photograph, and then just link that straight to the subcontractor, they're already on the database.
00:28:14	S1	Oh, great.
00:28:25	S2	And then off it goes.

00:28:16	S1	Oh! That's...
00:28:18	S2	You got seven days to return it and then they'll close it out. If they don't close it, it flags up, sends them an early warning notice that "you haven't closed your defects, you've got 30 defects over the whole scheme"—
00:28:29	S1	Alright?
00:28:29	S2	It's then closing out and then it works great for the subcontract maintenance, 'cause (sic) you've got X amount of defects, you've got X amount of defects, you've got the rest of them to sort them out and then close them out.
00:28:39	S1	What is the name of this software again?
00:28:40	S2	Field View.
00:28:41	S1	Field View. Alright. But again, one of the things that I've been realising over the research is that those tools and those procedures are excellent.
00:28:53	S2	Yeah?
00:28:54	S1	But if you don't have the proper background on creating awareness and on that exactly what you said before, making people aware, what to look for and when to look for...
00:29:02	S2	Yeah?
00:29:03	S1	All those quality control tools and nice stuff and technology...
00:29:09	S2	Yeah. That's just supplementary really. You need the training to know what you're looking for.
00:29:13	S1	Exactly.
00:29:15	S2	And you know where—and that's the sort of information Passivhaus consultant* partnership is giving us, 'cause (sic) they've been doing Passivhaus for the last X amount of years, they know exactly where all the problems are. So, yeah, "we always have problems here, this is where we could have potential problems, you need to watch out for this, this is why we got the air taping".
00:29:32	S1	Uh-hmm?

00:29:33	S2	'Cause (sic) we had a session in Plumer House with HOUSING ASSOCIATION*, Passivhaus consultant* brought a lot of them.
00:29:39	S1	Yeah, I was there. Yeah, it was.
00:29:40	S2	Yeah, you were. We were messing around with the air tapes and stuff. Yeah.
00:29:43	S1	Brilliant.
00:29:44	S2	Yeah. They showed us how to do it.
00:29:45	S1	Uh-hmm.
00:29:45	S2	Yeah, it's good.
00:29:53	S1	Okay. How about monitoring performance? You mentioned, well, you didn't mention but I got from the previous meetings that you are planning to have different air testing regarding to important keys stages of the construction process?
00:30:12	S2	Yeah, we have hold points throughout the program process. Yeah, actually with... yeah, so we have... (Flips Pages) Yeah, I've got different hold points throughout the build process for every plot. Yeah, so for instance I've got building air-tight test, QA hold points and when we had done that and then the second one I've got after the first fix. So, we create the air-tight envelope, we test it, make sure it passes, and then we let the following trades then go in and do all their first fix, M&E, carpentry, dry lining, and then we test it again.
00:31:23	S1	Alright. Just to see if the...?
00:31:24	S2	Yeah. Before we close anything up.
00:31:36	S1	Alright.
00:31:37	S2	So, we'll know, if anybody has made a hole or we got an issue. So, we test it to make sure it passes. As soon as it passes, move on. So, we got the hold points set up through the project to check and stop and then move on.
00:31:41	S1	Alright. Let me ask you something. One of the issues I used to have when I worked as a site manager which is…you have a gang that have done the work. You go there, you check it all, sign them off, pay them off, all good, done and dusted. They're out. And then the second guy—well, the next gang will go there, they are moving around pipes or I don't know timber and

		then they scrape the vapour barrier and things like that. And then you go after that check their work, it's alright but then they damage the previous one and then sometimes you have a grey area where you cannot identify who was responsible for that damage. How are you guys planning to deal with that?
00:32:26	S2	That comes down to the way I have done the programme, is one in one out, so there's no overlapping trade.
00:32:32	S1	Okay, alright.
00:32:32	S2	So that's the only way I could get that done because of that, so there's no grey area. So, as soon as one contractor is finished you check it off, sign it off and then the following day, the next one goes in.
00:32:44	S1	So you don't have multiple teams working at the same housing unit?
00:32:45	S2	No. The houses are small enough. I've got a two-day stagger in between houses. So, you start with one house, move on to the next house and then that's just a production line basically.
00:32:57	S1	So there's no way that you can get away with the...?
00:32:59	S2	No. You'd done the damage we'll check it off at the end of the day.
00:33:02	S1	Yeah?
00:33:03	S2	Just to make sure everything is fine. Something will get missed—
00:33:07	S1	Yeah, well, that's part of the process.
00:33:08	S2	But hopefully we'll get 98% on it.
00:33:13	S1	But I mean just by the fact that you have this procedure, the guys there know that there's no way that things will go unseen.
00:33:18	S2	No.
00:33:20	S1	Because there's no way that the blame could be thrown to someone else.
00:33:26	S2	Yeah. With the little iPads it's just check the problem, take the picture, it's done.
00:33:31	S1	Alright.

00:33:32	S2	Yeah, and the time to write basically, because it's dated and timed. So, you were in that day, at that time, that's... sorry, you were in there, you are responsible.
00:33:42	S1	It's a bit redundant my next question but about sampling approach, I understand that if you are aiming towards Passivhaus accreditation, you are going to monitor and test every single...?
00:33:55	S2	Every single. Yeah, it's not sampled. It's 100%
00:33:57	S1	Okay. 100%. Okay. In terms of quality compliance which was the last part of this conversation. Apart from the quality reports based on the checking sheets that you had been deploying and the software that you had mentioned...
00:34:22	S2	Yeah
00:34:23	S1	Well, it provides a quality report as well.
00:34:26	S2	Yeah
00:34:27	S1	Do you rely on any other sort of report in terms of content format or frequency?
00:34:34	S2	No, I have an activity schedule on the wall next door which basically gives us a running program of what's being checked, what's being signed off and where we're at on site.
00:34:45	S1	Okay.
00:34:45	S2	And that's about it really, because they don't report that back through the sort of programme. So, the other things which that helps with is my programme report where basically I'll link all the subcontractors to sign off dates and link that back to programme dates so I know who started on programme, who started after they should have started for no reason of their own. I've got durations for every task. So, anywhere I got red, they've overrun their duration. So, where they should have had two or three days in the other thing and they're eight or nine days so they've got a five-day deficit delay that they have caused on my unit so.
00:35:25	S1	Okay.
00:35:25	S2	Yeah. So, that's a good thing with the way we're doing it, I can link it directly back to programme and monitor every plot independently.

00:35:35	S1	The next thing is do you have a specific procedure to analyse the reports and defects records and how do you feedback your subcontractor team towards corrective measures and things like that?
00:35:56	S2	We called it subcontract maintenance. So, we've got the minutes here where we have a quality section on our weekly subcontract maintenance. So any defects get reported in with that and our defect report would go in as a part of the weekly subcontract maintenance minutes along with any programmes or anything else at all. And then it's just enrolment process of closing the defects. We're closing them out and not leaving any rolling on for too long.
00:36:26	S1	Do you have like a weekly basis meeting with your subcontractor to deal with this specifically?
00:36:36	S2	No, it's basically specific—it's wrapped up within the subcontract maintenance so we have a once a week sit down with the guys, formally, that'll recover the minutes. Daily, we'll have the "oh, that's not quite right, we need to sort that out" or weekly if there is any significant issues where it's not getting sorted out, as we call them formally and then those numbers are attached to the subcontract main minutes. We are in the process of implementing the performance board that we got for the subcontractors. So, we'll have a little table of who's got the most defects, who's got the least defects and... you know.
00:37:10	S1	Trying to keep the—
00:37:11	S2	Yeah, a bit of a competition.
00:37:12	S1	Alright. Okay. Well, it's healthy, the competition right?
00:37:15	S2	Yeah, yeah.
00:37:15	S1	Okay Chris, this is perfect. Well, I don't have anything else to ask you. So, I'm going to stop it here.
00:37:23	S2	Yeah—[RECORDING ENDS HERE]

[00.37.29]

[End of Audio]

Duration 37 minutes 29 seconds

Interview 5.a and 5.b– Transcript

Timecode	Speaker	Transcript
00:00:02	S1	Okay. Today is the 12th of September 1917...2017. Oh, my.... (Laughter)
00:00:11	S2	We have gone back in time.
00:00:13	S3	Time travelling.
00:00:17	S1	Just to make sure you have received upfront, the questionnaire and the information sheet and the consent as well?
00:00:23	S2	Yes.
00:00:23	S1	Yeah. And then we always start with the basic information which is your name please?
00:00:29	S2	It's Quality Officer*.
00:00:31	S1	Right. And your professional qualification?
00:00:34	S2	In a chartered quantity surveyor.
00:00:36	S1	Alright. Your number of professional experience, years?
00:00:41	S2	Wow. Now you're asking.
00:00:45	S1	It's a tricky one. (Laughter)
00:00:46	S2	Fifteen.
00:00:48	S1	Alright. And your role in this project?
00:00:53	S2	I'm the employer's agent acting on behalf of Housing Association*.
00:01:01	S1	What is the number of housing units in this project specifically, we usually have one project as the background, right?
00:01:16	S2	Yeah, these 40 housing units or 40 affordable housing units on the scheme.
00:01:20	S1	Okay. And the tenure of those housing units, I mean in terms of letting, shared ownership and open market, do you have this...?

00:01:32	S3	Um, 24 shared, 16 rent on that sheet there.
00:01:37	S1	Alright, okay. Alright. There are some questions that are more related to the contractor and house association such as if you have quality accreditation in your organisation or something like that.
00:01:55	S2	We do as a company but it's not specifically related to this site.
00:02:00	S1	Okay, alright. The project overall cost?
00:02:23	S2	Yeah, I can say it's five million, five million pounds.
00:02:29	S1	And the duration of the project?
00:02:33	S2	By the time it completes, October 2018, will be approximately two years from there.
00:02:44	S1	And when did you started out? When did you hit the ground?
00:02:48	S3	The contract says October 2016. I guess they would've, they started on site by then.
00:03:00	S1	So you're almost halfway.
00:03:01	S2	Yes, we are.
00:03:04	S1	And the project procurement route, do you guys know?
00:03:09	S3	Land and build.
00:03:11	S2	It's not a procurement route in terms of two stage design built, and the thing it's a bespoken procurement route applicable to an affordable housing scheme.
00:03:21	S1	Alright. Because we're talking about the other way around, instead of the housing association owning the land and then procuring contractors and other participants. Alright. In terms of requirements and objectives, does the project have a formal quality plan or it is, and is it specific for the project or is there standard used by the housing association?
00:03:49	S3	It's building regulations and then it meets added development standards, so it means code for sustainable homes level three. There's a (name of the housing association)'s specification which all units need to meet as well an agreed specification, contract specification.

00:04:11	S2	Yeah, it needs to obtain NHBC quality control certification and secured by the design part II accreditation which is the security aspect of the building.
00:04:24	S1	So by the way, NHBC is providing you the warranties or...?
00:04:28	S2	Yes, building control and warranty.
00:04:31	S1	Okay, both of them, alright.
00:04:33	S3	As I mentioned, there's two percent of the homes which need to be lifetime homes as well.
00:04:47	S1	Okay. It's basically mandatory, right? It's the proportion that you have to comply with in terms of regulation.
00:04:54	S3	That's in terms of section number six in terms of the lifetime homes and the mobility homes as well so yeah.
00:05:05	S1	Okay. What would be the requirements regarding to energy performance? Building regulations or do you have...?
00:05:12	S2	Yes they have to sort of achieve or exceed building regulations. And they have to comply with code for sustainable homes level 3.
00:05:22	S1	Level 3, alright.
00:05:25	S2	They are generally the driving performance criteria.
00:05:27	S1	Perfect, alright. And as a housing association, do you have specific requirements regarded to energy performance added to your strategic goals as a company or you do it by project per project?
00:05:46	S3	Yes, as per standards dictated, the building regulation standards on the (section) 106. Or yeah, local planning requirements. Now, we're going to strive to achieve a certain level but we'll obviously comply with the standards that they put.
00:06:02	S1	Just out of curiosity, do you guys have any passive house scheme for instance that you can remember or something like that?
00:06:10	S3	No we don't. We've, our most...well, I have to be honest, energy efficient homes, there was a scheme called (name of the project) which is in South Gloucestershire in Bristol. And it was going to be a code level six. That then got downgraded. But basically the intention was that to be carbon neutral.

00:06:40	S1	Alright, nearly zero energy building, yeah?
00:06:46	S3	Yeah. So they were, but what they would do was offset by planting trees and doing this and doing that. So yeah, originally, it's meant to be a lot higher. We, I think it's probably code four now. Or a bit more, really. And I think across (housing association) the highest one I could think of is code level four other than that one.
00:07:06	S1	Just a few, just a little thing here, I think it's alright for we to continue this interview with the three of us. It works pretty well. I have no problem with that. And just so, I would like you just introduce yourself and say about your role in the....
00:07:20	S3	My name is Project Manager*. I have no actual professional qualifications. You might need to know that. I would....
00:07:32	S3	I've been working with Housing Association* since 2002 so what's that? Thirteen years.
00:07:38	S2	Fifteen.
00:07:39	S3	Oh yeah, 15. (Laughter) My role in this is as a the project manager from Housing Association*'s point of view. So I kind of interface with the developer, the employer's agent and pass on all that information at the delivery of the unit. So I'm responsible for the budget and keeping everyone updated with the programme. The number of, number of assets on Housing Association* is over 50,000 and geography area it covers the whole of southwest. I think we've just may have one or two lands at Cornwall admin. We sold most of Cornwall, transferred this to ones in Devon. So that is probably where we sort of like, it happens as we go. Now with the ongoing projects, personally I probably got about eight schemes on site.
00:08:41	S1	Well, it's a huge company.
00:08:47	S3	Yeah, in terms of development, we're top five for this year just gone by. We're generally in the top 10 in terms of program. And I think in terms of numbers we're again in the top 10 I think of 55,000 homes. Definitely the biggest in the southwest. That I'm sure.
00:09:05	S1	A lot of background and experience in that. I mean it's brilliant. That's one thing that I'm trying to get at broad scope in terms of my case studies for a small housing associations up to the ones such as Housing Association* so it's quite interesting in the sense that we have broad scope of size and number of developments going on in this.

00:09:32	S3	I think we got over thousand employees as well. I'm not sure of the number, 12,000 or so. So it's a big organisation, yeah. So it's a lot of division of labour.
00:09:46	S1	Okay, alright. So you mentioned that in terms of the targets to be achieved in terms of energy performance are the ones regarded to Building Regulations part 1La. We can move forward now to risk assessment which is, so far as I could reach is where you anticipate issues or try to learn from the previous developments in what are the things that went wrong that you want to make it right from first time and the next one. Which are the stakeholder involve in the process of the defining the quality requirements regarding to energy performance and when does it happen is quite redundant for what we said.
00:10:58	S2	It kind of is, obviously the key stakeholders are the ones that produces section 106 and produce the plan information because they then hold the performance criteria. So in this instance it will be Swindon Borough Council that will produce those documents and state it as a standard everybody needs to achieve building regulations anyway. But they were there and obviously have that clause in that we just need to comply with code sustainable homes level 3. So from that instance, the stakeholder is the local authority.
00:11:31	S1	Okay, alright. Alright, okay. Going forward, do you guys see or do you have a process in place to assess the risks regarded to your managerial or workforce capabilities or technical issues, meaning the defects which can affect the achievement of the requirements regarding to thermal performance?
00:11:57	S3	From performance, in terms of code, achieving code, some developers are previously gone for more bolt-on to the actual property rather than just in the fabric and PVs. And we've had issues with some of those like the MVHRs, et cetera. So we kind of, as we're going through that process you know we put an offering, It's accepted, we start to define what the spec is, certain things like those bolt-on, we kind of push back because there have been issues in terms of maintenance. And also that's ongoing cost to Housing Association* as a whole. So kind of, that was a problem a few years ago. But now that's moved away and most people just do the fabric and put the PVs only if they need to.
00:12:46	S2	Because construction techniques have developed a lot since the whole solar array first came out. All the developments can now achieve code 3 through a fabric first construction through the insulation without a need for PV, solar thermal or water harvesting.

00:13:05	S1	And regarding to the installation of the building envelope for instance, do you guys have ways to identify issues from other projects that you would like to be done differently in this current project?
00:13:40	S2	In a scheme setup like this not so much, because it's developer led. The risk and the expectation is put on the developer. And obviously the warranty and building control inspectors would ensure that they comply with the standards. So we do also have, as an employer's agent also have clerk of works who will inspect frequently, be it weekly or fortnightly. And they will flag up with their experience in the area any issues that they see. We will then, if it needs, address that around the table or as I imagine maybe just dealing with that there and then. So whilst there's nothing necessarily that (housing association) can pull in because of the way the contract is setup from other sites, there are checks involved.
00:14:35	S1	And....
00:14:35	S3	We have site reports. I got copy of my site report. I'll send to you.
00:14:38	S1	Oh good, excellent. That would be great. And to your experience, do you understand, do you think that managerial team on site, I mean the site management and the workforce understand the impact of the defects on the energy performance of buildings? How aware do you think people are here?
00:15:02	S3	I think they generally build to what's on the drawings. I think that's their concern really. That is the drawing and I'm doing this. I'll do whatever is said on the drawing. If that answer the question, I think that would be my feeling.
00:15:32	S1	So you can say that they pretty much follow up what is in the drawing.
00:15:38	S2	I think that there's two sides in situations like this. I completely agree with Ralph. They are a big development company, they've got targets to meet. They'll have a design, a set of drawings and they will build to that. On the flip side, if it's a land led scheme that Housing Association* have and they tender, and the contractor is appointed, part of the tendering process may be for them to submit information on how to increase efficiency of a building or how to value engineer it or other a similar scenario. So from that side of things, I think from the site team and management perspective, there probably would be a bit of sort of added drive. Because if they succeed that will reflect well on them on Housing Association* which is likely to generate further business down the line.

00:16:28	S1	Sure, sure. Thinking about what you just said, can you tell me from the top of your head what is the proportion of schemes or developments that are housing association led or developer led?
00:16:45	S3	For Housing Association*, 80%, 85% of the homes we develop per year are developer led. And we develop about a thousand homes year.
00:17:37	S1	What is the reason for that?
00:18:03	S3	I think we Housing Association*, I think most big RPs (Registered Provider) see the benefit in size. And if you want to be larger then you will go with volume production which is through the Section 106. That's a positive flipside to that because they're cheaper as well. And it's had I think we've done that. I mean I think the government have, I think they appreciate that kind of volume. If you have house association who develops a thousand units of homes, a thousand units a year compared to one developing 50, the cost of the house will not be exactly the same. We think ourselves as a developing RP, we want to increase our size, our number we have done. We had a goal to get to 50,000 homes by 2015. We made it by 2016. So I think for us, and it's the dedication we are going. The area we cover, there’s a lot of development going on, you know, Swindon, Bristol, South Gloucestershire.
00:19:20	S1	Yeah, you would a have a huge structure to run all of those schemes on your own. I mean is that correct that I assume that this position is because you understand that your core business is on managing assets rather than building assets?
00:19:39	S3	Yeah, I guess so. I guess, we still class though we're not actually physically building them, we do feel that we have, that was input in there. But I think yeah primarily what we have to do is to increase the start and provide as many homes as possible for people. So yeah, why we could spend a whole year go through a scheme and develop 24 homes or we could develop 400 in that year. Then we’re housing 400 more people. I think that's kind of what we at Housing Association* have decided yeah.
00:20:17	S1	Alright, okay. What would be the challenges and obstacles when implementing those quality management procedures that you go on about in terms of...?
00:20:51	S2	I guess, well one of the challenges is just ensuring that they (developer/contract) achieve those goals in the first place. The contract is therefore setup on that basis. If they don't achieve NHBC building control and warranty sign off, there's no obligation to take the units. If they don't achieve code sustainable homes level three, there's no obligation to take the units.

		There will be break clauses in the contract as well. So that's how they're all, that's how all the contracts, developer led contracts are structured. So that in itself is sort of a quality assurance.
00:21:33	S1	So you just take over once all the obligations and the compliances are put on the table. And then you move forward towards that.
00:21:41	S2	Yeah we have as we just had, we will have monthly meetings where we will lead and review all of those areas. So we can review any issues that NHBC, because they regularly inspect any issues, RI’s that they flag up, we will query just to make sure that they, that there are some. If not, brilliant. But if there are some then we need to make sure that site management is dealing with those and getting those cleared. Otherwise, there is no chance of them achieving sign off and be able to build. So we will monitor those. Similarly, in code for sustainable homes, at the beginning of the scheme, there will be a pre-assessment done based on the limited design information that they have. We’ll make sure we get a copy of that. And then they go through various stages to design stage certificate which can be produced say half way through the scheme which will then anticipate based on whatever information s left that they will achieve the required standards. So we'll make sure that they're in place. And then at the time of taking possession of the plots, we’ll ensure that either there's a comfort letter from the assessor to say, “Yes, I've received all the information. They will achieve the standard.” Or if he's had that information a bit earlier, he will produce a fire certificate which will confirm that they are up to a determined level. So there are, there's an ongoing process from early inception all the way through to completion really.
00:23:18	S1	Okay. And those interim assessments that you just mentioned. I assume that they are provided by your clerk of works based on your structured checking sheets and flag up....
00:23:31	S2	No, in terms of the code for sustainable homes the developer will appoint the consultant, whose professional qualification it is to produce these assessments and to check the built basically and the design. So it's then, our contact with the developer. Developer then relies on providing that information to the assessor who then produce certificate.
00:23:56	S1	Okay, alright. And you in your role is to make sure that those assessments are going through and you have the results and the compliances that they need to provide.
00:24:08	S2	Yes, yeah, that's an essential part of A, what I do and B, what (housing association) requires through the contract.

00:24:15	S1	Okay, perfect. Alright. So it's quite comprehensive in the sense that you have specific consultant going through, getting code for sustainable homes compliance and then you have NHBC through the process of getting building regulations compliance as well. And then on top of that, you have your own team, your own clerk of works working on behalf of the housing association as well to try to flag up or try to anticipate any uncorrected defect or something like that.
00:24:52	S2	Exactly, yeah.
00:24:53	S1	So it's overlapping activities which provide a quite expensive approach, right?
00:25:00	S2	Yes.
00:25:01	S1	That's brilliant. I believe that construction sites are quite complex. And it's difficult to keep on top of everything every day and every unit, right?
00:25:25	S2	People are only human. As qualified as you maybe, there's always a chance that you're going to miss something and then there's someone else who's not necessarily qualified but knows something about that and spot it then (Overlapping Conversation).
00:25:37	S1	Yeah so it's complementary, right?
00:25:41	S2	Yeah.
00:25:40	S1	It's complementary.
00:25:44	S2	Yeah, they're going to complement each other.
00:25:51	S3	That's with humans, they do see it as someone checking their work and some people have issues with that. That's part of management, isn't it?
00:26:01	S1	The next question will be about resources. We pretty much talked about who is responsible for developing and implementing the quality management procedures. We just talked about that. I would just like to ask you, is there a place where you put all those information together?
00:26:20	S2	There's a final, as a final document those are quite in every contract. So we will basically ensure, again it's part of the requirement of the contract that the developer will have to put this together at the end of the scheme. That will include, or we have this information, piecemeals through the programme anyways, that there will a final summary of all the requirements under the contract. So it will include all building control, final certificates. It will include all NHBC guarantee whoever wants the documents, all the code for

		sustainable homes information from the pre-assessment all the way through the final certificates as well as other bits of information, like specification, the drawings and EPC's, energy performance certificates. So I guess that is how that is sort of controlled. Those were the final issue of those all in one place.
00:27:21	S1	Okay. And in terms of NHBC inspections, do you have those key stages where they come or they come random or...?
00:27:33	S2	There are key stages of build, yes.
00:27:46	S2	Off the top of my head, I can't remember all the stages. But the site team have a NHBC book. So when he (NHBC inspector) is expected to come, is to do that stage of inspection. It might be a pre-plaster or whatever. He will need to note the plot number in that book and sign to show this has been inspected. So there's, so that quality control but it's at stages. They may, if they're trying to inspect plot 52, at pre-plaster stage they may walk the site and spot something that they will pick up and note. Hence, as an RI or reportable item. We'll then check that and ask them if there any issues at all, because that will prevent them in clearing the next stage.
00:28:32	S1	So they come here on demand?
00:28:34	S2	Essentially, yes. So when the site team are approaching the next stage, they will contact the NHBC inspector and ask him to come down and visit.
00:28:42	S1	Is it fair enough for me to say that they are the ones who set the building elements or the key stages which will be assessed?
00:28:51	S2	Yes.
00:28:54	S1	The preset....
00:28:53	S2	Yeah, yeah.
00:28:54	S1	Okay. I'll just to try to read out if the ones we have in Plymouth, for instance, the key stages are the same?
00:29:00	S2	Oh yes.
00:29:05	S1	Yeah. Drainage, foundations up to DPC and then wall plates and then the roof and the final inspection.
00:29:14	S3	The site manager will know. When you speak to them, they'll know what it is.

00:29:18	S1	Alright, okay. And do you know if those guys work on the basis of sampling or they go on and about every housing unit?
00:29:27	S2	Every plot.
00:29:27	S1	Every plot, okay. Alright. The thing is that this is how they should, right? But I was talking to some people around Plymouth for instance. And there's, they're talking or they're using LABC. And they told me that they have, they're very short numbered. So the visits are quite quick and they are not able to visit all the units that they should. So sometimes....
00:29:57	S3	It's one of those things, isn't it? The person telling you this might have had a bad experience. And I think people off the record might be prepared to say, that information. But I think it's safe to say, the whole construction industry shows that. And everyone are stretched and the pressure is on them are greater. I think that's fair to say it for everyone really.
00:30:31	S1	So, we have already answered this question is there specific team in place to ensure the achievement of the quality requirements. So we said where you have at least three teams working on this behalf, on this, with this objective. Do you you have any specific procedure to create awareness in workforce in terms of the quality requirements?
00:31:07	S2	The developer generally will have toolbox talks. This site signed up for the considered constructor's as well, which was not directly related to the quality and efficiency of the building. It does relate to the site as a whole, provided facilities for people. And obviously we just scored, I think there's two of this per year. We will request that because they can also achieve additional points on the code for sustainable homes assessment. So that is, so they've been directly linked into a requirement they need to achieve. But yeah, I think other than that, the site team will probably be a bit better place to tell you anything over and above that they do.
00:32:00	S1	And as a housing association do you believe that the setup in place in this project fulfil the needs for achieving the quality standards?
00:32:21	S3	I mean we have, yeah. For us, obviously what says the Section 106 is what we get in the contract. The contract should link to what the the Section 106 requires. And that for us, that's sufficient. If it's not, if the units are not in this criteria then we are not taking them. And it's kind of as simple as that. And from Housing Association*'s point of view, I mean the more technically aware people are of the craft and works and everything else follows the process and procedure which is contractual lease or passed on, relied on the site and the

		employer's agent to make sure we're getting more then we expect. So yes we are.
00:33:07	S1	So you part upon the principle that the contractor has a vested interest to do everything he can to put up the thing in place because otherwise you wouldn't have a long term relationship, right?
00:33:16	S2	Absolutely. I think the contracts, project teams from the client, employer's agent, to the contractor, to the consultants, they're all in place or drive towards the same goal. So in theory that should be sufficient.
00:33:32	S3	What is agreed, isn't it? They want to sell usually if we're going to buy them at a price they're happy with. We then need to get some sort of legal agreement to make sure what we said is going to happen. We're both happy with that so we sign that. And then we have monthly meetings to make sure we are following those processes. And then you know, very simplistic but that's kind of the plan, isn't it? Do handover, shake the hands and then in a year's time and never see them.
00:34:01	S1	Alright, okay. That's really good. I think that's how you build long term relationships I suppose.
00:34:08	S3	Yeah, I think even with the site here you know there's been issues. But we kind of meet up monthly. We all want the same thing which is an easy life. (Overlapping Conversation). So the easier we can make that happen then perceive personalities, we get on with people you know. I think sometimes the main pressure is around timing and that's because there are shareholders and there are directors wanting the units as soon as possible. And I think that's the main conflict really not the quality, more about the actual time constraints of the program, yeah.
00:34:53	S2	That's the way of the world I think.
00:34:56	S1	Well, moving towards, moving forward towards quality control. Do we have, well the question is about which of the performance attributes are considered by the plan or the project? We talked about complying with building regulations and code for sustainable homes, so it's basically u-values and air permeability. Is there anything else that you...?
00:35:22	S2	Code for sustainable homes covers quite a large area. Obviously the efficiency of the building is a key element. There are other areas whilst I'm no expert, there are other areas down to site location and energy use of the site and people using the site. That all ties into that. So there are other factors into that assessment all be it at the end of the day as long as you get the

		required result then that's what everyone is after, finding the ways to get to it. But as long as it hits their target, it ticks the box.
00:36:11	S1	Alright, okay. More specifically towards your area or your work, what is, do you have a procedure for defect identification or collection in place?
00:36:30	S2	Well, obviously there's a checklist, I guess it's three stages. First is during construction where the clerk of works will attend weekly or fortnightly and highlight any key issues as he's going. So we generally have a report or we can ensure or (housing association) schemes' have their own clerk of works who will generate a report and serve that to the team. The second process is in the lead up to taking the possession of the property. So once you have CML (certificate from the Council of Mortgage Lenders) awarded by NHBC so the properties are compliable. And myself and the clerk of works will then undertake a snagging inspection so we'll go through the whole property.
00:37:19	S1	During the handover?
00:37:21	S2	Yes so identifying things that aren't quite complete or things that aren't quite right with defective issues. We'll just walk through the whole house and the externals. That process that generally takes two weeks so that we'll give a list to the developer. So yes, that approximately will generally take two weeks. We'll hand the developer the snagging sheets. They will then get their subcontractors to attend to the items. We'll return the following week, check off the items that are done. Invariably there are items that aren't done or have been missed. Then I have the second copy of the sheets. And in the following week, we'll do a final inspection with a view to hand in the property over to Housing Association* on the basis that they are suitable. So that's the second point. And the final point is then once the properties are handed over, then they enter the defects liability period.
00:38:32	S1	In a year?
00:38:32	S2	Yeah. So that will last for 12 months. Further inspection will be done once that's 12 months has elapsed or at the 12-month point just to see if there's any major issues with the property or mainly outstanding defects the residents have reported that haven't been resolved. So that will be the final check. That checklist is then issued again to the developer. They attend to, clear the items on that basis any potential money that are held will be released. So three-stage process really.
00:39:06	S1	Alright. Getting you a little bit more down perhaps into performance tests, for instance to air permeability or pressure tests, do you know if the contractor

		undertake them on the basis of the sampling suggested by the building regulations or they test 100% of the units?
00:39:32	S2	Generally, I find they air test all units.
00:39:34	S1	All units.
00:39:35	S2	Sound test, they generally don't but they will work to the robust detail standards up to the construction. We'll mitigate the need for sound testing. Some sites do sound test as well. But generally, air test wise, we generally have test for up to 90%, 95% of units.
00:39:57	S1	Alright, okay. And is it done once they're completed?
00:40:03	S2	Yes.
00:40:03	S1	Do you have interim testing or something like that?
00:40:04	S2	No, no, I think they will generally produce… so the consultants will produce their sort of design stage… so SAP assessments which will obviously generate the design detail. And they have experience enough and confidence in those to leave everything until a week before NHBC comes in, get the air test done. And in my experience, I haven't had any plots failing the air test. The construction and the quality is that good now that they far exceed what's required.
00:40:40	S1	Excellent. And may I also assume that your approach towards quality assurance is made over 100% of the units or you do sampling?
00:40:51	S2	No, it's very single plot.
00:40:51	S1	Okay, perfect. Well, to finish up because we talked a little bit about putting all the documentation together at the end of the project. It's about how do you report the quality compliance to the other participants of the project. Do you have like a final meeting or something like that where you get everybody together and discuss what went wrong and what have been done better?
00:41:15	S2	We should. We should. Generally, in my experience it's, you tend to have that type of thing. Again, going back to the land led schemes where the developer is leading the scheme. There's just so many, such a big turnover, you don't get the chance. You can take the lessons learned into the next so if we do another site with Contractor* and with Housing Association*, the same parties to the scheme, you can bring in lessons learned from previous schemes. However generally that doesn't always happen. So it would be a

		very good thing to do but with the time constraints and the amount of stuff going on.
00:41:57	S1	And of course it's quite interesting to have this scheme the other way around which is developer led because it gives me a different perspective.
00:42:18	S2	Yes, exactly.
00:42:18	S1	Okay, well thank you very much.
00:42:19	S2	No problem.

[00.42.31]

[End of Audio]

Duration 42 minutes and 31 seconds

Interview 5.b (continuation) – Transcript

Timecode	Speaker	Transcript
00:00:03	S1	Just to complement the last topic, which is about the quality compliance. And I'm particularly interested in the way you, from the housing association perspective, how do you assess the contractors and the developers that you work with? How do you assess in terms of quality? Do you have a procedure for that?
00:00:31	S2	It's one of those things which we've had and sort of dipped off and now is kind of in the way of coming back. Generally, how we assess the quality is through the number of defects, the number of issues we have. A lot of this anecdotally you know, and certain developers generally provide the units on time to a good standard. And then, oppose to that, some developers who are late and have bad standards. There's a lot of talk around the office about that. And I think on the sort of from…back from that, what we try to do is in terms of defects retentions, the retentions we have would be slightly varied dependent on the skills and quality of them. So, you kind of almost hold back more money if they're not performing in terms of contracts. Another way where we also do that is we have a defects reporting process. So, a resident phones to a particular number and advise us what the defects are. We would then, in the first 12 months, we go back to the developer, if it's an actual defect, for them to actually do the repairs. And then we monitor that they're dealt with within the actual contractual allotted time.
00:01:51	S1	Let me ask…
00:01:53	S2	In our system, it's a computer based system, and it will basically…we now have the ability to run reports, to see what the common defects are, who the developers are the most who have the most defects and what sites. So, we're able to run those sorts of reports.
00:02:12	S1	And so, this defect system, who provides you with those reports? (Overlapping Conversation)
00:02:18	S2	The residents.
00:02:18	S1	The residents. Who feeds in the system?
00:02:22	S2	Okay. It starts off, obviously, we go through the snag to see whether or not there's any issues before the handover. Ours employer's agent will do the snagging. They then come back one or two weeks later to do the de-snag or

		the back-snag to make sure those items were picked up. If there are still some outstanding items which are minor on the piece of practical completion of the edification, we'll have those outstanding snags identified there. And we may decide that some of those can wait until at 12 months' inspection. So, they're minor bits which can wait. Or it maybe we agree that some of those outstanding snags are picked up in the next week or the next couple of weeks. Those outstanding snags would be monitored through site meetings. So, the next site meeting, we're like, "Have you done this?" So, we will go through that process. Should we then, you know, say we take the units hand them over with outstanding snags or not, it doesn't matter. If then defects come out…So, when we're giving the residents the property, we say this, "This is your property. If anything goes wrong, give us a call on this free phone number." So, the resident will phone us up to say, "Oh, my toilet's not flushing properly," for example. It will be then us who then advise whether it is a defect or not. A very common one is like the boiler's not working. So, we check if there's a pilot light. We have set questions.
00:03:47	S1	All right.
00:03:48	S2	We have a call centre, dedicated call centre, 24-hour call centre, who takes the calls of the residents. And I think we took over 200,000 calls last year and yeah, I think that's the number.
00:04:01	S1	Considering, you have 55,000 units.
00:04:05	S2	Yeah. So, it's not too…it's busy, but it's not too bad. They'll take the calls, they'll go through the normal checklist to ask the obvious questions. If they're happy that is a defect, then, what they will do is send that defect onto the customer service team or the developer. They will then keep that information on the system, so that we could check to make sure they've dealt with that defect within mostly…Non-urgent ones are going to be 30 days. So, in 30 days, it's dealt with. So, we'll then send the chaser to see what has been done
00:04:42	S1	Right. So, you start with the snagging process, then through the liability period for the 12 months. So, if you get something there, you pass it over to the contractor or the developer.
00:04:55	S2	So, if…within that 12 months, any sort of defects, we report it to them. They should come out and deal with it. Some of them maybe decided or agreed that we'll wait until the 12 months inspection to get through. So, what will then happen, the 12-month inspection we'll go around, we'll make an appointment with the residents, it will be our employer's agent, our technical adviser, clerk of and a representative from the developer will all go to that meeting, to go to

		the site with the property with the resident, and the resident will walk them around and show them what, if any, issues they have. If they haven't got any issues, they sign the form to say there's no issues. If there are issues, then we will agree for when they are to be done and we'll chase them.
00:05:41	S1	So, before you finish the liability period, you go around every unit and check with the tenants whether they're okay with that.
00:05:48	S2	It's normally done on a phase by phase. So, you know, it will take four…like, for example we've got two units we'll take in at the end of this month and I think seven just a few days after. We'll probably put those nine together. And in 12 months down the line, we'll go around and look at all nine in a day. If one of them wasn't…he's happy, one isn't, we'd still retain them. And if they're all part of the same phase, you know, because we do like a phase release of money. Once they sign off the defects sheet, we released the retention, and then, any other issues that come, so, they phone saying my boiler's not working, for example. If it's a rented property, it will be (housing association)'s responsibility to sort the corrective work. So, you'd have to wait for the whole two years of the programme before you get your money. Yeah. But if one person doesn't sign it, then, we wouldn't release the money. And then, we ask the developers to do the work. It's one of those…that's the process. That's the intended process. If it's a shared ownership property, it will be their responsibility. Because they have the management maintenance property.
00:07:12	S1	All right. Well, that's pretty robust.
00:07:17	S2	Yeah. It's you know…there's still a few holes in that. But you're right. If you say it's a thousand homes we get new every year, you know, in terms of like viewing the schemes, which…Okay, we've got two offices, 500 each. The Bristol office where I'm from, out of the 500, we may have I'd say, three or four complaints, where things didn't quite happened how we wanted to…But at any given time, that's not you know…as a percentage, it's quite small. But you know, obviously it's a process. There are holes in the process.
00:08:00	S1	And can you recall what would be the kind of defect that stands out?
00:08:09	S2	Okay.
00:08:12	S1	What are the most recurrent ones?
00:08:15	S2	Okay. Defects or not…I'm not sure you'd call it defects, but gardens.
00:08:18	S1	All right.

00:08:19	S2	Gardens tend to be you know in terms of the maintenance. Because you put a new turf down, which is what we've decided to do. We don't have to. Private residents just get mud and…they pay actually for the turf. So, we put turf down and the residents need to water it to keep it up and going. And if they don't, it will die. So, that's kind of a common theme and one of the most contentious ones. Because the manager will say, "Well, it was good when we gave it to you." They'll say, "Well, look at it now." And sometimes, there's not enough top soil or if the ground's not been rotavated enough. So that's probably the most common and the most contentious is the garden. But in the house itself, leaks maybe. You know, maybe like bathroom, the connections with the radiator or connections in the bath. Maybe little minor leaks. We get shrinkage. A lot of the calls aren't actually defects as what we find. Doors, ironmongery, not properly closing. Yeah, that kind of things. So, minor things. From an energy performance… I've got a call from a rented tenants who wanted to use the feed-in tariff, get the benefit from feed-in tariff. The first protocol there is, whether or not the scheme's grant funded or not. If it's grant funded, then, they can't actually benefit from that because that's seen as double subsidy. So if it's not grant funded which section 106 does not apply, there's a possibility. But the owner…if the person who asks for the feed-in tariff needs to own the actual PVs or solar panel, if it's a shared owner, we can say they are owned by them. So, it's fine. If it's rented, it's owned by (housing association). So, a few years ago, what some of us was doing is we were getting the feed-in tariff because it was financially beneficial. But now, it's, I think is four pence per kilowatt now is what they get in terms of the feed-in tariff. So, in terms of the administration involved for (housing association), we decided it's not worth for going through the process. But I've had a resident who'd asked for ability to do that. It's quite complicated because we would have to then gift it to them. When they move out, what happens then? So, we need some sort of assurance that they would gift it to the next resident. And then, we need housing management to make sure they can police that. So, it's difficult. I've left that with housing management and our property service team to see what we could do. But…
00:11:04	S1	More than a liability than an asset.
00:11:06	S2	Yeah, and it's strange. The resident will still benefit, you know. They get free electric, 50 pence per kilowatt. They're getting free electric as and when they use it. But it's a bit of a shame that no one's getting the feed-in tariff. So, there's a few sort of like nuances about the way the system works, which the intentions…I suppose from an energy performance point of view, is beneficial. But it would be good if it was beneficial economically as well or more beneficial. And I think that's…a few things need to be tied up. I'm waiting to

		speak to housing manager today. And then, I'll get that sort of finalised, how (housing association) is doing things going forward.
00:11:51	S1	All right. That's great. Well, I should stop it here.
00:11:58	S2	Yeah.
00:11:57	S1	That's great. Thank you.
00:12:00	S2	No problem.

[00.12.00]

[End of Audio]

Duration 12 minutes 0 seconds

Interview 5.c – Transcript

Timecode	Speaker	Transcript
00:00:00	S1	Okay, just before we get started I have to make sure that you've got upfront the information sheet and the consent as well, all right?
00:00:09	S2	Yes.
00:00:10	S1	And then just basic information about you guys. So what are your names?
00:00:16	S2	All right, my name is Site Manager*.
00:00:19	S3	My name is Assistant Site Manager*.
00:00:20	S1	All right and what are your professional qualifications?
00:00:24	S2	My professional qualification, I have an IOB, Institute of Building, I also have HND, a national diploma and also an agency as well. Also MBQ4, that's enough.
00:00:43	S1	Yeah, sure.
00:00:46	S2	Assistant Site Manager's from a kind of a trade background and he's an assistant manager at the moment and don't necessarily need a professional qualification from that he's worked his way up through experience alone and I think a company might put people through MBQ4s again which is just an experience based qualifications, so.
00:01:10	S1	Okay. Number of years of professional experience in the construction industry?
00:01:19	S2	From 16 through college, so since 19 and I'm 46 now, I've been working with (contractor) for 17 years and 10 years with (another contractor) before that and so seven years of college and the university, so. Add it up. (laughter)
00:01:39	S1	All right. How about you Assistant Site Manager?
00:01:41	S2	Assistant Site Manager would be doing what 10?
00:01:42	S3	I've doing it for 13 years all at Contractor*.
00:01:48	S1	Okay, all right, great. Well, the name of the company is Contractor*, right?

00:01:56	S2	Contractor*, yeah, Southwest.
00:01:57	S1	All right, so you guys are developers and playing the role as a contractor as well?
00:02:02	S2	Yeah, we kind of work as almost a design and build company.
00:02:05	S1	Okay, all right, so well, this is one of the questions the procurement route you have here is the design and build?
00:02:14	S2	Yeah, it's a design and build, we design our houses and then they just get laid out in development, so we acquire… actually here, (contractor company)'s strategic projects where a company who actually buy land and sell off land, are under the Contractor* umbrella and then we normally take some of the land that CSP (Contractor* Strategic Projects) provide.
00:02:39	S1	Do you have your own design team or do you outsource?
00:02:43	S2	We use external consultants, so architects et cetera that there is hired architects to develop like a standard house type or they're going for standard or whatever they decide, but if you use external architects and external engineers et cetera and whatever job they're doing, it's external people used as an internal technical department and with technical managers on to a more commercial department or so with quantities of surveyors, planners and the planning department as well and a finance department.
00:03:21	S1	And if you agree, we would like to make the questions and we always have a specific project as a background, all right.
00:03:28	S2	Yeah.
00:03:28	S1	So we're talking about Case Study 5*, 4.13.
00:03:32	S2	4.1 stroke 3. It's kind of a one site split into two, so we call it 4.1 stroke 3.
00:03:42	S1	Okay and the number of housing units you have here?
00:03:45	S2	We have a hundred and on these sorts of split phases along, we have a 119. So, 119 on one phase and so, yeah, that is probably two phases, normally phases of about 50 houses.
00:04:04	S1	Okay, all right. And the project duration?
00:04:09	S2	You would want to build that in a couple of years, two to three years, depending on your build speed. You work out normally projected, you work

		out about one a week, we build one a week, four per month, sometimes four to six per month depending on the project duration so you would like to 50 plots out of a site per year, if with… we're probably one manager, one assistant, a couple of labourers and forklift driver but if you wanted more, then you would have to resource it.
00:04:52	S1	Well, going through the questions, what are your requirements in terms of energy performance for this project? Comply with building regs or…?
00:05:10	S2	Yeah, we need to comply with building regs and… John, what are we got for that? These are difficult question; you should be talking to our technical guys really because I find that we get on it. We do it from a site based level. We need to comply to… this is what our houses need to pass, we actually do an air test which then creates an energy performance certificate.
00:05:38	S1	Yeah, you could see, yeah.
00:05:39	S2	Which enables us to get NHBC which the National Highest Building Council which acts like building surveyors and they would then to give us a final certificate to enable a mortgage to go through.
00:05:51	S1	So NHBC is providing you the warrantees and the building control as well?
00:05:55	S2	Yes. So they act like building surveyors.
00:05:59	S1	Okay, so in terms of having a formal quality plan towards the energy performance, you have those guys from NHBC working as your building surveyors, checking on quality and the things related to energy performance?
00:06:12	S2	Yes, but we also got our own internal checks as we go along, so we have a quality manual, I think we got that quality manual.
00:06:23	S3	Absolutely.
00:06:24	S2	Absolutely. We got a quality manual which takes us through every single stage which we need to check.
00:06:32	S2	Yeah and we also got this tablet in which at each stage… So we used a tablet which we click into at certain stage we need to pass, sign and we tick off on the tablet and then that goes through all the departments, so everybody could see that that stage is passed and we could move forward, so we've got our name to it and that gives you all the stages required at that particular stage, so it could be all skirting is sealed for instance or gaps around windows being filled.

00:07:09	S1	So, you have a structured checklist?
00:07:11	S2	Yes, a structured checklist for passing at certain stages of the plot normally and you also get the NHBC at certain stages, so the NHBC checks the plot at superstructure which could be a joist level or roof level and then he also checks it at pre-plastered which shows the stud work, whether metal or timber and looks at the work just before the plaster boarding starts. He also then checks it for a final which is ready for a CML which is going to give you the final certificate and he also does a draining test at that time and that gives you the final certificate and that's the three stages he does. He also checks foundations as well.
00:07:55	S1	Okay, so the key stages that they have set up…
00:07:58	S2	Yeah and that is their stages.
00:07:59	S1	…from all the sites that they have to go on.
00:08:01	S2	And we've got more key stages at different points to trigger our critical path on our programme to enable us to hit the milestones.
00:08:09	S1	Okay, that's good to have a structured thing because it's difficult to get everything on your mind at all times.
00:08:17	S2	Yes, it's a great system but sometimes, we actually physically check on things on site and then the computer almost becomes a hindrance because you go on and really done the work on site, looked at it, checked it and we need to actually report on it actually in the tablet and it almost becomes a hindrance because at the moment, you're working on site, doing, making people do and then you've got a report on the work you've just done to prove to others it's done but it takes our time, so it's not a realistic working tool for us yet. It's a new system, it could be improved.
00:09:05	S1	In what sense, Mark?
00:09:07	S2	This could be improved on, the way you can improve this is to improve the checklist to be true to the working… to the actual format or order of work, sometimes the list is not quite in sync in the order of work that you actually build in particular. It's like generic almost rather than bespoke for the thing that you do.
00:09:33	S1	So you have the same framework for different schemes?

00:09:39	S2	Yeah and then certain things are checked at different times, so it's not down to a fine science, it then becomes more hindrance than a tool. But it's a very good system that actually, it does cover all the items that you need to.
00:09:56	S1	Can I say that they substitute you're signing off checking sheets?
00:10:02	S2	Yeah, we still physically snag a plot ourselves at the end but we also have a customer care guy that comes in, so we snag a plot and we get a plot to a finish and we snag it and then we bring it up to our standards and then our customer care department and a guy that comes out, you do the customer care inspection and then that inspection can only happen once we've got a NHBC and then he checks it to prove that plot will be good enough for someone to move in, so it's an extra check by our customer care department, so when they take the plot over after the handover to the customer, it proves to them that they know that they've got a decent house plot.
00:10:56	S1	Okay, well, it's a minimum standard of quality, so to speak.
00:10:59	S2	Yeah, it is, yeah.
00:11:00	S1	And this person works for Contractor*?
00:11:02	S2	For Contractor*, so there's Contractor* department, an internal department who actually take the house after handover and then deal with all the customer care issues of that house if there is anything.
00:11:14	S1	Okay, so during the construction process, not talking about the snagging, it's a different process but during the construction process, the structure you have in place is this one, you have to comply with in terms of checking and signing off trades and things like that?
00:11:31	S2	Yes.
00:11:32	S1	Okay, great.
00:11:33	S2	So I'll just show you an example and you can see on there but so for instance if you go into plot one and you see forms and then you have different forms, your bill stage 11 would be finals, bill stage 9 is test and commission, so just before painting, bill stage 8 the second fix, 7 is plaster, 6 is first fix, stage 5 is when it's roofed and if you went into roofed and you've seen all the checks, you would check all of these items.
00:12:00	S1	All right.

00:12:01	S2	So these are all passed, all joists correctly fitted to hangers and all fixed and holes used, joists' blocks ends fitted, chip board floor level, flat and glued. So we have a thorough quality management, so it's quite an in depth quality check throughout at every stage and various forms at each steps.
00:12:25	S1	So you say that it would be better to have those ones bespoken for the specific construction?
00:12:30	S2	Yeah, they need to be ironed out to be almost bespoke for each site because slightly the order of play changes on how you build certain things depending on what you're using and what you're building.
00:12:43	S1	Okay, all right. Well, there's always room for improvement right?
00:12:46	S2	Yeah, I mean it is the first time we used this. Before we used the paper system in book format, okay, which we kind of did at the same stages and then just signed them off ourselves.
00:12:57	S1	Okay, well, the difference between these and the previous model is that this one is online and then you can share.
00:13:05	S2	And everybody can see instantly. So that's had a huge improvement and the guy in the office a thousand miles away can see that house has been checked today regarding the roof work just been finished.
00:13:19	S1	But the content and the items to be checked are pretty much the ones that you have previously on the paper based system?
00:13:25	S2	Yeah, pretty much, yeah.
00:13:26	S1	Okay, that's great. Do you see the energy performance part of those, being part of the strategic objective of Contractor*?
00:13:43	S2	Yeah, we know that our technical guys put a lot of effort into getting to the… from one of the big picture or the government strategy of this thing. I know we were kind of leading players in that a more technical people you need to speak to on that kind of thing.
00:14:03	S1	Yeah, no worries, I am interested in the site management side of things.
00:14:04	S2	But I know it is putting to us in construction way, we are obviously, we've got to comply with the materials we got to use in the system and the details are required but we go with the drawings that were given as… until we trust in

		those. Because we know it had been approved by the planning department, et cetera.
00:14:24	S1	And regarding to the design process you say that you have a consultants and architects working on your schemes, do you guys, as site managers, do you guys manage to contribute to the design process or feeding back or…?
00:14:43	S2	Yeah, we have feedback forms and there are many types of feedback forms, so for instance on the sites if you get an issue which a copy of this form, we get what we call the… an ongoing quality management talk, it' called an RFI and it's a form that can go back to not only technical or… and it filters out to architects or planners or whatever, it can be the QS, it can be a buyer, it can be anything, request for information and that could be a change request, that could be an issues with the drawing, a drawing contradicts, it could be many things and that is the kind of a universal form with a response needed, recommended action and an improvement for the future as well, so got all of those things.
00:15:35	S1	Okay, that's great. So you have a platform to feedback and to provide a…?
00:15:39	S2	Yeah, an ongoing platform as well to improve not only what you're doing now but obviously schemes in the future.
00:15:46	S1	All right. So just a quick question, so you have a building block here, a cavity, you have a….
00:15:53	S2	So we've got basically our detail is a traditional build, internal insulated block.
00:16:02	S1	All right, internal insulated? Okay.
00:16:04	S2	Yeah, a 100 mill cavity, a lot of these now, we're going one two five, a 125 millimetre of cavity, an external brick or block and sort of this brick is obviously left if its block will be rendered.
00:16:24	S1	Okay, so the cavity, you keep the cavity?
00:16:28	S2	No, we fill that with an eco bead which is a blown polystyrene bead which has got a glue format on it and it kind of holds it rigid and so we use that, it's called eco bead.
00:16:44	S1	All right and on top that you have internal insulation as well?
00:16:48	S2	Yeah, so you got an internal insulation block, so you've an internal block, eco bead cavity fill and 100 mill cavity brick external and then you've got a plaster board donned up on the inside but on party walls, we sometimes do an extra

		sign coat at either side of the party wall and there's different constructions for party walls, different tie structure and sometimes vents or insulation are used on party walls to clean and yeah, the party wall is an ever changing event on each side it changes a lot.
00:17:28	S1	All right, so the internal insulation is the rigid one I suppose because it's your plastering…?
00:17:33	S2	You don't have the internal.
00:17:35	S1	Oh you don't, just the cavity?
00:17:36	S2	Just the cavity, eco bead and an insulated block.
00:17:40	S1	Okay, so you parged the interiors as a…?
00:17:43	S2	Yeah you parge as a parge parties, party walls between dwellings.
00:17:49	S1	Okay. So of course you don't need the vapour barrier because you're…?
00:17:52	S2	It depends on the party wall detail, you know, sometimes it could be… and that depends on what our drawing system tells us because our drawing system we have on what we now call, I think is 4 Projects, John is it?
00:18:11	S3	4 Projects, yeah.
00:18:12	S2	So we've got a system on….
00:18:14	S1	A sharing platform right?
00:18:16	S2	Yes, a huge sharing platform which has been… so it's called Viewpoint 4 Projects which everybody's been going to and that brings up not only all the drawings and the latest revision because it instantly changes to the next revision, so whatever is on that system is true. So if we put a request for information and I've got changed in the next few days that would then… somebody would upload a drawing and that would get put on 4 Projects and then you'll be looking at the very current, the latest drawing, so it eradicates mistakes from a paper system or you revised a drawing and superseded it correctly.
00:18:52	S1	Okay, all right.
00:18:53	S2	A very good system planners, use it, it's got everything within….
00:18:57	S1	It's got the latest version, yes.

00:18:59	S2	The whole thing you always get the next version.
00:19:02	S1	Yeah, that's great.
00:19:03	S2	Fantastic really and the drawing is always true which is amazing for construction reasons.
00:19:11	S1	Okay, going a little bit back to the NHBC inspectors, in terms of complying with the building regs, do they come random or you request their…?
00:19:27	S2	We request a visit, so we must give them 24 hours notice for any type of a particular visit and the visit they do as we said was foundations, super structures, pre-plaster, final inspection, a drains test and they also do their own sporadic… what do they call them John, NHBC…?
00:19:55	S3	Health and safety?
00:19:56	S2	No, they do a visit every now and again just sporadically, what was it called? They call it a….
00:20:03	S3	Benchmark.
00:20:03	S2	No, they do a benchmark at the start but they do a frequency visit, it's called a frequency visit and they just… if they haven't been here for a couple of weeks, they will do a frequency visit because that site will show up on their computer system that… oh I haven't been there for two weeks, we need to do a frequency visit to check it out.
00:20:22	S1	Okay and do they have a sampling approach or do they have to visit a 100% of the housing units? How does this work in practical…?
00:20:33	S2	I don't know how they actually work themselves but if they missed something… it's not at all the case, if they miss it, they miss it.
00:20:44	S2	They've got KPIs themselves to actually physically hit themselves, so what did they miss? 1 out of 99 probably, so if you add 100 pre-plasters in the pack, you might miss one or two out of a 100, let's say.
00:21:01	S1	All right, so yeah, okay, drainage, foundations, superstructure and the pre-plastering or pre-boarding, right and then the roof.
00:21:12	S2	Yeah, so you get an NHBC book and yeah, they have diaries when they come out and also stage inspections, so stage inspections and there's a stage

		inspections. You've got foundations, drainage, superstructure, pre-plaster, pre-handover.
00:21:33	S1	Okay. Can I take a picture of that?
00:21:36	S2	You can take copies of these, pictures, anything you want.
00:21:39	S1	Okay, perfect. Excellent. So the next step here is about risk assessment, so which are the stakeholders that are involved in the process of defining the targets in terms of energy performance? I mean you're talking about complying with building regs, can we say that a 100% of your projects aim strictly for complying with building regs or you have other kinds of requirements in like passivhaus or code for sustainable homes?
00:22:20	S2	Yeah, you've got lifetime homes and things like this, you've got different ones because we've got housing association mixed in, normally about 33% or 30% of the site, so we've got a lifetime homes, we've got sustainable homes and sometimes you've got the disabled access homes, sometimes there's shared and various types and they all need different levels of efficiency, you know, but normally one site has got a level to get to, so let's say and air test gets done and that air test needs to be between three and six.
00:23:01	S1	Okay, so it is a bit different from what is required from…?
00:23:03	S2	Yeah, a different will need to be under eight, so if that….
00:23:08	S1	And since you talked about air pressure tests, so do you test 100% or the use sampling suggested by the building regulation?
00:23:16	S2	There is a schedule which is given to us at the start of the job. On this site is a 100%.
00:23:22	S1	Okay, so we can vary….
00:23:24	S2	Yeah, on a site before it was two of each house type**.**
00:23:28	S1	Okay, that is what is required by building regs...
00:23:29	S2	Yeah, and another site has been one for each housing type. It varies on the size I think, I don't know what the rules are on that honestly but this one is a 100%.
00:23:41	S1	Okay. And you test once the house unit id deemed completed?

00:23:45	S2	Normally, just as the house is… so it was painted, cleaned and mastic sealed and so it's finished and normally just before carpets go down and then you get, normally, a good result or the result that is supposed to be achieved.
00:24:08	S1	Do you have any process you placed to assess the possible risks related to managerial or a workforce capabilities or technical issues meaning defects that can affect the formal performance of the buildings?
00:24:23	S2	Well, only with the checks we have, if we follow the details and the drawings, finished or do the work on the tablet and check the tablet and check the tablet has been worked to, against the drawings, you do that on site physically, you still got to check it physically on site, I'll manage guys on site who are tradesman and that's the difficult thing.
00:24:50	S1	Okay, yeah, well the second question, to what extent do you think the work force or the managerial team understands the impact of defects on the energy performance of buildings, do you think the guys on site are aware of that?
00:25:05	S2	Yeah, general education across the whole culture of the industry needs to be improved without doubt.
00:25:13	S1	Yeah, I completely agree. Well, I can speak for my country and that's pretty much an issue.
00:25:26	S1	So do you have any kind of resource being deployed towards that like toolbox talks and things like that, you know, in order to create awareness?
00:25:36	S2	We have toolbox talks for various things like using…
00:26:05	S1	Let me ask you something, I think one of the issues now in the industry is that we work with loads of subcontractors, right? And they change a lot, so….
00:26:18	S1	Yeah, can you manage to work with the same groups over time or can you retain them to keep on working with you?
00:26:30	S2	We try. We try to set up a system, like we've got a system of, we do a kind of master programme, to kind of main master programme, so we get a PPP which is a Plot Planning Programme, which is generated from the budget and then that PPP is broken down by me into kind of a detailed short programme and then that detailed short programme is broken down into three programmes, to weekly to try and provide them with continuity at work to enable us to retain exactly the same staff if we can.
00:27:10	S3	Yeah, and build up your learning curve, right?

00:27:13	S2	To bring the learning curve up all those things, so it's very difficult because sometimes particularly at year ends with companies, with budgets, it's an all or nothing scenario rather than a steady progression of work.
00:27:31	S1	Okay, all right. So the next question would be about if you have a structured way to collect defects and quality issues and you just mentioned you had this platform and your own experience and the experience of everybody who works in the site…?
00:27:53	S2	Yeah, experience is huge, using the same guys on site is huge but feedback system is the best ones we use, the RFIs for…more so feeding back mistakes that have been seen at design level or initial design stages, turns it around quickly, defect issues, we still use the snagging tool of checking stuff and physically telling people if something's wrong but it's the education using the same trades over and over again in the same plots that eradicates defects.
00:28:28	S1	They know what you need and know what you expect from them.
00:28:30	S2	Yeah.
00:28:31	S1	Yeah, well that's the point of keep on working with this thing….
00:28:33	S2	It's man management daily that's still eradicates most mistakes, John, won't you say?
00:28:39	S1	Yeah, keeping people on their toes and yeah it's pretty much all over right?
00:28:44	S2	It's difficult and we're building x sites in an ever changing environment and the constantly changes, so if one guy fails, it makes the next six or seven to stop, affecting the programme.
00:28:58	S1	Bringing the psychological aspect it's much tougher than the technical one.
00:29:03	S2	Yeah, it's difficult.
00:29:08	S1	About compliance, do you have meetings with the subcontractors from time to time to discuss defects or things that you maybe were able to flag up?
00:29:25	S2	We haven't got a rigid system of meetings but as a company we have a monthly project review which we review lots of those items, like for instance feedback programme, et cetera, health and safety. We also have various health and safety check by NHBC, so we have an external health and safety check, we also have an internal health and safety department and then check

		wise, there are lots of… I've lost the question but what was the main bit of the question?
00:30:02	S1	Feeding back the workforce when things went differently from expected.
00:30:08	S2	So meetings with the subcontractors…we had a meeting today, we had a meeting regarding, we've had very demanding two weekly programmes which are very detailed programmes that we've put out, so we've got them in today to go through as much as we can to see if they're going to hit and meet those demands but also the issues that might affect the demands of that programme, so if there are or aren't any mistakes or the constantly recurring stuff that if we can eradicate those it will make things move faster and smoother and maybe hit out targets.
00:30:43	S1	Okay. So that's how we feedback to different participants, do you have a final project review once you're done and close to handover?
00:30:53	S2	Yes, we steadily collaborate a health and safety file which has all the details in that… and I can go back to archive which is all the main drawings and a robust detail file and everything. So you've got a full health and safety folder which gives you the design feedback required by law and also for future products, projects and that's the main feedback we do. There's always time as an issue at the end of the project, you're going on to the next one, the time is just fully spent. Having a full feedback meeting would go down very well but I get to do one in the last 10 years.
00:31:37	S1	Okay, all right.
00:31:39	S2	So the time between the end of the project and the start of a new one would be good to feedback and maybe eradicate lots of design issues, lots of construction issues to take into the next project.
00:31:50	S1	That's good, we'll see it… and that learning in the….
00:31:52	S2	That cushion in between jobs if someone could spend time or someone takes time in eradicating those issues of that company.
00:32:00	S1	And I understand that everybody's pressured regarding time, so do you have this luxury or do you just jump from one to the other?
00:32:09	S2	We kind of finish one job and then we move into the next and they almost lap over.

00:32:16	S1	Yeah, so it's difficult to have this extra time to reflect on the things that went wrong and right.
00:32:22	S2	Our construction managers levels, you almost don't get the chance to feedback your information unless you're doing it constantly throughout the job and the best things for that and that then depends if your company does it at the other end, the technical ways, the technical managers are feeding this back through to the architects, is the architect taken in, is the construction engineer taken all of this in? It almost warrants a one man department on its own feeding back on it, say, lets eradicate on all the jobs we've got and feeding it to all the internal departments of the company throughout the country.
00:32:55	S1	And speaking more in terms of the company, in terms of Contractor*, do you have like a specific area where this feedback goes to across different job sites, into one area or if somebody…?
00:33:09	S2	Into one vault, is it?
00:33:11	S1	Yeah.
00:33:11	S2	Yeah. I don't know but it could do with that but I don't think so. But all of these things, the health and safety will fed back and these things, you know, does…if I change a drawing on a particular house type today, does it get changed on every single region, on every single drawing, I don't know, but it should.
00:33:33	S1	Okay, all right. Well, that's pretty much what I had to ask you and it's really… I'm really thankful for your time and the information. Thanks.

[00.33.43]

[End of Audio]

Duration 33 minutes and 43 seconds

B.3: Observations form

Observation data collection form

BUILDING PERFORMANCE ANALYSIS WITH PLYMOUTH UNIVERSITY

Case study:

Date:

Type of observation:

Participants:

Areas of interest

1. Definition of quality requirements
2. Quality risk assessment
3. Quality resources assessment
4. Definition of quality metrics and control
5. Quality compliance procedures

B.4: Sample of observation data

Observation data collection form

BUILDING PERFORMANCE ANALYSIS WITH PLYMOUTH UNIVERSITY

4.d

Case study: 4
Date: 16/03/16
Type of observation: Meeting at [redacted]
Participants: [redacted]

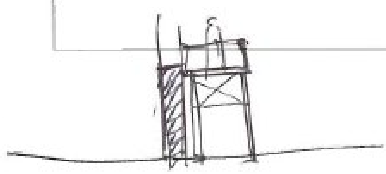
Areas of interest

1. Definition of quality requirements
2. Quality risk assessment
3. Quality resources assessment
4. Definition of quality metrics and control
5. Quality compliance procedures

Air pressure tests:
↳ consultant asked for additional test to
2 be undertaken after first-fix but before
3 boarding. want to check services penetrations
sealing.

vapour control layer
↳ it was decided to use parge coat instead
2 of membrane. concerns were raised by
contractor and consultant about damages
on the membrane during the construction
process

Balconies
it was decided that the balconies should
2 have their own independent galvanized metal
structure ~~s~~ to avoid thermal bridging.



B.5: Construction defects survey form and taxonomy

Case study:
Date:
Plot:

BUILDING PERFORMANCE ANALYSIS WITH PLYMOUTH UNIVERSITY

Type / Building element	Ground floor	Ground floor/external wall	External wall	External wall/openings	Openings (doors and windows)	Internal walls	External wall/upper floors	Upper floors	External walls/eaves	External walls/roof	Ceiling	Other
Discontinuity of insulation layer												
Missing insulation												
Damaged insluation (e.g. crushed, soiled, wet)												
Air pockets between insulation and wall face												
Inadequate insulation around service penetration												
Missing insulation in pipes and ducts												
Missing vapour/air barrier												
Gaps and ruptures in the vapour/air barrier												
Inadequate installation of the vapour/air barrier												
Inadequate sealing around services												
Missing/inadequate cavity closer												
Residual material in wall cavities												
Gaps between walls and openings (doors and windows)												
Inadequalte sealing - 2nd fix												
Others												

Description

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

	Heat loss mechanism	Defect/Key problem	Source	Origin	Type	Building element/Areas	Trade	Paper/Report
1	Thermal Bridging	Balcony steel structure penetrating through the insulation and	Design	Lack of information	Inadequate solution	Intermediate floor/external wall j	Designer	20
2	Thermal Bridging	Excessive φ-value (linear thermal transmittance) in door hand	Materials	Lack of information	Inadequate solution	Door	Door and wind	14
3	Air Leakage	Gaps around built-in joists in masonry	Workmanship	Error	Incorrect installation	Intermediate floor/external wall j	Structures	20, 22
4	Air Leakage	Gaps between external doors/window jambs and sill and exte	Workmanship	Error	Incorrect installation	External doors and windows/ext	Door and wind	9, 10, 14, 20, 22, 23
5	Thermal Bridging	Gaps between timber frame wall panels and slab due to exce	Workmanship	Error	Flatness / levelness	Ground floor/external wall junctio	Structures	10, 14, 20, 22
7	Air Leakage	Gaps between timber frame wall panels and slab due to exce	Workmanship	Error	Flatness / levelness	Ground floor/wall junctions	Structures	10, 14, 20, 22
8	Thermal Bridging	Gaps in insulation around air supply and heating grilles	Workmanship	Error	Incorrect installation	Exterior wall	Services	14
	Thermal Bridging	Gaps in insulation around air supply and heating grilles	Workmanship	Error	Incorrect installation	Interior wall	Services	14
9	Heat loss through insulation layer	Gaps in insulation around rooflight	Workmanship	Error	Incorrect installation	Roof junction	Insulations	20
10	Heat loss through insulation layer	Gaps in insulation between rafter and gable wall	Workmanship	Error	Incorrect installation	Roof junction	Insulations	20
11	Air Leakage	Gaps in the external door thresholds	Workmanship	Error	Incorrect installation	Door	Door and wind	10, 14
12	Thermal Bridging	Gaps in the insulation layer around services (pipes, cables e	Workmanship	Omission	Missing	External wall	Services	9, 14, 20, 22
	Thermal Bridging	Gaps in the insulation layer around services (pipes, cables e	Workmanship	Omission	Missing	Intermediate floor	Services	20
	Thermal Bridging	Gaps in the insulation layer around services (pipes, cables e	Workmanship	Omission	Missing	Internal wall	Services	9, 14, 20
13	Air Leakage	Gaps in the internal walls/ceiling junctions	Workmanship	Error	Incorrect installation	Internal walls/ceiling junctions	Partitions and	14, 22, 23
14	Air Leakage	Gaps in the rooflight/ceilings junction	Workmanship	Error	Incorrect installation	Roof junction	Roofs	20
15	Air Leakage	Gaps in the vapour control layer around services (pipes, cab	Workmanship	Omission	Missing	External wall	Services	9, 14, 20, 22
	Air Leakage	Gaps in the vapour control layer around services (pipes, cab	Workmanship	Omission	Missing	Intermediate floor	Services	20
	Air Leakage	Gaps in the vapour control layer around services (pipes, cab	Workmanship	Omission	Missing	Internal wall	Services	9, 14, 20
16	Air Leakage	Gaps in the vapour control layer between rafter and gable wa	Workmanship	Error	Incorrect installation	External wall/roof junction	Insulations	20
17	Air Leakage	Gaps in the vapour control layer in external wall/eaves junctio	Workmanship	Error	Incorrect installation	External walls/eaves junction	Insulations	20, 22
18	Air Leakage	Gaps in the windows mitred joints	Materials	Error	Tolerance error	Window	Suppliers	14
19	Air Leakage	Gaps or hole in the plasterboard in order to accommodate fi	Workmanship	Error	Incorrect installation	External walls	Services	20
	Air Leakage	Gaps or hole in the plasterboard in order to accommodate fi	Workmanship	Error	Incorrect installation	Internal walls	Services	20
20	Thermal Bridging	High timber concentration	Design	Lack of information	Inadequate solution	External doors and windows/ext	Designer	20
	Thermal Bridging	High timber concentration	Workmanship	Error	Incorrect installation	External doors and windows/ext	Insulations	20
21	Heat loss through insulation layer	Inadequate cavity filling around the openings - Gaps and lac	Workmanship	Error	Incorrect installation	External doors and windows/ext	Insulations	9, 10, 14, 20, 22, 23
22	Heat loss through insulation layer	Lack of continuity of insulation - gaps between insulation boa	Workmanship	Error	Incorrect installation	Ceiling	Insulations	9,, 20, 22
	Heat loss through insulation layer	Lack of continuity of insulation - gaps between insulation boa	Workmanship	Error	Incorrect installation	Exterior wall	Insulations	9, 20, 22
	Heat loss through insulation layer	Lack of continuity of insulation - gaps between insulation boa	Workmanship	Error	Incorrect installation	Roof	Insulations	9, 20, 22
23	Heat loss through insulation layer	Lack of continuity of insulation due to DPC/cavity tray	Workmanship	Error	Incorrect installation	Intermediate floor/external wall j	Insulations	20
24	Heat loss through insulation layer	Lack of continuity of insulation due to lintel/cavity tray	Workmanship	Error	Incorrect installation	Intermediate floor/external wall j	Insulations	14, 20
25	Heat loss through insulation layer	Lack of continuity of insulation layer between rafters	Workmanship	Error	Incorrect installation	External wall/eaves junction	Insulations	20
	Heat loss through insulation layer	Lack of continuity of insulation layer between rafters	Workmanship	Error	Incorrect installation	Roof	Insulations	20
26	Heat loss through insulation layer	Lack of continuity of insulation layer due to misalignment of th	Workmanship	Error	Misalignment	Ground floor/external wall junctio	Structures	20
27	Heat loss through insulation layer	Lack of continuity of insulation layer in the dormers	Workmanship	Omission	Missing	Roof	Insulations	20
28	Air Leakage	Lack of continuity of plaster adhesive in order to seal the plas	Workmanship	Error	Incorrect installation	External walls	Partitions and	20
29	Heat loss through insulation layer	Lack of insulation in external wall/eaves junction	Workmanship	Omission	Missing	External wall/eaves junction	Insulations	14, 20, 22
30	Thermal Bridging	Lack of insulation in steel purlins	Design	Omission	Missing	Roof	Insulations	20
	Thermal Bridging	Lack of insulation in steel purlins	Workmanship	Omission	Missing	Roof	Insulations	20
31	Air Leakage	Lack of taping of joints of insulation boards	Workmanship	Omission	Missing	External walls	Insulations	20
32	Air Leakage	Lack of taping of joints of vapour control layer	Workmanship	Omission	Missing	External walls	Insulations	20
	Air Leakage	Lack of taping of joints of vapour control layer	Workmanship	Omission	Missing	Internal walls	Insulations	20
	Air Leakage	Lack of taping of joints of vapour control layer	Workmanship	Omission	Missing	Roof	Insulations	20
33	Air Leakage	Lack of taping the insulation joints of ventiltated rafter void ro	Workmanship	Omission	Missing	Roof	Insulations	20
34	Thermal Bridging	Lack of use of lightweight block bellow the edge of the slab	Design	Omission	Missing	Ground floor/external wall junctio	Designer	20
	Thermal Bridging	Lack of use of lightweight block bellow the edge of the slab	Workmanship	Error	Incorrect installation	Ground floor/external wall junctio	Foundations	20
35	Air Leakage	Lack of vapour control layer	Workmanship	Omission	Missing	External walls	Services	20
	Air Leakage	Lack of vapour control layer	Workmanship	Omission	Missing	Internal walls	Services	20
	Air Leakage	Lack of vapour control layer	Workmanship	Omission	Missing	Roof	Services	20

37	Heat loss through insulation layer	Loose insulation layer in partial cavity fill	Workmanship	Error	Incorrect installation	External walls	Insulations	20
38	Thermal Bridging	Misalignment between window/external door and insulation la	Design	Lack of information	Inadequate solution	External doors and windows/ext	Designer	20
	Thermal Bridging	Misalignment between window/external door and insulation la	Workmanship	Error	Misalignment	External doors and windows/ext	Insulations	9, 14, 20, 22
39	Heat loss through insulation layer	Missing insulation in the dormers	Workmanship	Omission	Missing	Roof	Insulations	20
40	Thermal Bridging	Missing insulation at MVHR ducts	Workmanship	Omission	Missing	Ceiling	Insulations	10
	Thermal Bridging	Missing insulation at MVHR ducts	Workmanship	Omission	Missing	Internal wall	Insulations	10
41	Thermal Bridging	Missing insulation at the ceiling	Workmanship	Omission	Missing	Ceiling	Insulations	10, 20
42	Heat loss through insulation layer	Missing insulation at the intermediate floor level perimeter	Workmanship	Omission	Missing	Intermediate floor/external wall j	Insulations	9, 20
	Heat loss through insulation layer	Missing insulation at the intermediate floor level perimeter	Design	Lack of information	Missing	Intermediate floor/external wall j	Designer	9, 20, 22
43	Thermal Bridging	Missing insulation at the slab perimeter	Workmanship	Omission	Missing	Ground floor/external wall junctio	Insulations	20
44	Thermal Bridging	Missing insulation in steel lintel flanges	Design	Lack of information	Inadequate solution	External doors and windows/ext	Designer	20, 22
45	Heat loss through insulation layer	Missing insulation in timber frame panels	Workmanship	Omission	Missing	Exterior wall	Insulations	10
46	Heat loss through insulation layer	Reduced insulation layer thickness due to joist ends protrusio	Workmanship	Error	Incorrect installation	Intermediate floor/external wall j	Structures	20
47	Thermal Bridging	Residual mortar droppings in partial cavity fill/cavity tray	Workmanship	Error	Carelessness	External walls	Brickwork	20
48	Air Leakage	Ruptures and displacements in the vapour control layer	Workmanship	Damage	Carelessness	External walls	Services	20
	Air Leakage	Ruptures and displacements in the vapour control layer	Workmanship	Damage	Carelessness	Internal walls	Services	
	Air Leakage	Ruptures and displacements in the vapour control layer	Workmanship	Damage	Carelessness	Roof	Services	20
49	Thermal Bridging	Use of uninsulated cavity closer around the openings	Design	Lack of information	Inadequate solution	External doors and windows/ext	Designer	20
	Thermal Bridging	Use of uninsulated cavity closer around the openings	Workmanship	Error	Incorrect installation	External doors and windows/ext	Insulations	9, 10, 14, 20, 22, 23
50	Thermal Bridging	Wrong thickness of insulation layer	Workmanship	Error	Incorrect installation	Ceiling	Insulations	9
	Thermal Bridging	Wrong thickness of insulation layer	Workmanship	Error	Incorrect installation	External walls	Insulations	9
	Thermal Bridging	Wrong thickness of insulation layer	Workmanship	Error	Incorrect installation	Roof	Insulations	9, 20
51	Thermal Bridging	Wrong type of insulation layer	Workmanship	Error	Incorrect installation	Ceiling	Insulations	9
	Thermal Bridging	Wrong type of insulation layer	Workmanship	Error	Incorrect installation	External walls	Insulations	9
	Thermal Bridging	Wrong type of insulation layer	Workmanship	Error	Incorrect installation	Roof		9, 20

B.6: Sample of construction defects survey

Case study: 1
Date: 27/04/16
Plot: 12

BUILDING PERFORMANCE ANALYSIS WITH PLYMOUTH UNIVERSITY

Type / Building element	Ground floor	Ground floor/external wall	External wall	External wall/openings	Openings (doors and windows)	Internal walls	External wall/upper floors	Upper floors	External walls/eaves	External walls/roof	Ceiling	Other
Discontinuity of insulation layer	~~1~~	1										
Missing insulation		2										
Damaged insluation (e.g. crushed, soiled, wet)		1										
Air pockets between insulation and wall face		1										
Inadequate insulation around service penetration												
Missing insulation in pipes and ducts												
Missing vapour/air barrier												
Gaps and ruptures in the vapour/air barrier			3									
Inadequate installation of the vapour/air barrier			~~[illegible]~~			4						
Inadequate sealing around services												
Missing/inadequate cavity closer												
Residual material in wall cavities												
Gaps between walls and openings (doors and windows)												
Inadequalte sealing - 2nd fix												
Others												

Description

1	Ill fitted insulation boards between slab perimeter and ext. wall.
2	insulation between slab perimeter and ext. wall partially missing.
3	Ruptures in vapour control layer.
4	Vapour barrier in party wall poorly installed.
5	
6	
7	
8	
9	
10	
11	
12	

B.7: Focus groups questionnaires

Focus group questionnaire

Thank you for taking part in this Focus Group. This activity aims to verify and validate the key findings of this research regarded to challenges found in social housing projects in the development and implementation of Project Quality Plans (PQP). Please bear in mind that this research has a special focus on the role of PQP on the prevention and correction of quality issues affecting the thermal performance of dwellings.

For this purpose, the focus group activity will take place in two sections. Firstly, the identified challenges will be presented and discussed. Hence, you will be asked to answer two questions for each of the challenges. At that stage you will be also asked to contribute with additional challenges posed to the process of developing and implementing PQP with focus on thermal performance that you are aware or have experienced. In the second section, an open discussion will take place to discuss the core findings of this research, where you and the other participants are invited to share your own experiences and concerns regarded to this topic.

Participant information:

Name:

Profession:

Job title:

Experience in construction industry (years):

Work location:

Type of projects (e.g. residential, social housing, commercial):

Scale of projects (e.g. number of housing units, area or project contract value):

Challenges questions

For each of the challenges overleaf please answer the following questions:

1. How do you rate on a scale of 1-10 the likelihood for this challenge to happen?*

Not likely — Very Likely

1	2	3	4	5	6	7	8	9	10

2. How do you rate on a scale of 1-10 the impact this challenge poses to the successful development and implementation of PQP with focus on the thermal performance of dwellings?*

Low impact — High impact

1	2	3	4	5	6	7	8	9	10

* Please rate 0 if you have never experienced or have any knowledge about the posed challenge.

CATEGORIES	CONCEPTS	CHALLENGES	Likelihood	Impact
Definition of quality requirements	Quality objectives and compliance	1. Lack of definition of quality compliance procedures among with the quality objectives, other than those defined and implemented by building control bodies.		
	Formal procedures	2. Lack of control of the ultimate compliance process and associated quality control, due to this process being assigned to third parties (i.e. building control bodies).		
Quality risk assessment	Stakeholders' participation	3. Lack of participation of important project stakeholders (e.g. housing association and contractor), limiting the input of relevant information and collaboration in the process of risk assessment.		
	Sources of information	4. Housing associations' defect records used for the project risk assessment mostly contained defects reported at the post-occupation stages by the dwellings' tenants.		
		5. Lack of use of previous defect records to inform and influence the risk assessment process.		
	Technical and managerial issues	6. Difficulties in sustaining a consistent communication process, impacting on the levels of quality objectives and specific defects awareness.		
		7. Operatives general level of education and technical capabilities.		
		8. Difficulty of retaining technical information and awareness with subcontractors due to high level of staff turnover and discontinuity of projects' sequence.		
		9. Tight programme and budget potentially compromising the administration of quality control procedures and quality of workmanship.		
Quality resources assessment	Process approach	10. Due to the approach adopted for quality compliance, the project quality plan implemented lacked of specific focus concerning quality issues related to thermal performance.		
	Provision of resources	11. Lack of appropriate resources (time and staff) allocated by the contractor and building control bodies for quality control procedures.		
		12. Lack of specific training and upskilling activities with the purpose of increasing awareness of the quality objectives and potential risks, as well as technical capabilities.		
Definition of quality metrics and control	Quality attributes and criteria	13. Lack of objectivity in translating quality acceptance criteria of performance attributes (e.g. thermal transmissivity of buildings fabric) into quality control tools.		
	Quality control procedures	14. Quality checking hold points overly distant to each other, affecting the identification of defects in certain building elements due to accumulated construction stages.		
		15. Definition of lengthy working packages which concentrate an overwhelming amount of construction aspects to be checked at a time, compromising the efficacy of the quality control activities.		

		16. Lack of use of quality checklist to support and structure quality control activities undertaken by quality officers on behalf of housing associations and building control bodies.		
		17. Lack of consistency of quality checklists due to being not site specific and generic in terms of construction method and sequencing.		
		18. Quality checklists deployed did not encompassed at least the most recurrent quality issues affecting the thermal performance of the dwellings' fabric.		
		19. Lack of consistency on the application of quality control procedures.		
Quality compliance procedures	Quality results	20. Quality reports lacking of focus on reporting quality issues related to the thermal performance of buildings as they are mostly developed upon checklists and site visit report templates.		
	Result analysis and actions	21. Defects affecting the thermal performance, which posed no apparent threat to programme and were not spotted by building control bodies, were not discussed in the managerial meetings.		
		22. Ultimate compliance procedure assigned to building control bodies.		
	Continuous improvements	23. Lack of structure to feedback defects occurrences identified during the construction stage which could be used as a source in the risk assessment stages of future projects.		

Additional challenges:

References

ABDUL-RAHMAN, H., WANG, C., WOOD, L. C. & KHOO, Y. M. 2014. Defects in Affordable Housing Projects in Klang Valley, Malaysia. *Journal of Performance of Constructed Facilities,* 28**,** 272-285.

AECOM. 2012. CEW1005 The Performance Gap - Non Domestic Building - Final Report.

AHZAHAR, N., KARIM, N. A., HASSAN, S. H. & EMAN, J. 2011. A Study of Contribution Factors to Building Failures and Defects in Construction Industry. *Procedia Engineering,* 20**,** 249-255.

AÏSSANI, A., CHATEAUNEUF, A., FONTAINE, J. P. & AUDEBERT, P. 2016. Quantification of workmanship insulation defects and their impact on the thermal performance of building facades. *Applied Energy,* 165**,** 272-284.

AIYETAN, A. 2013. Causes of rework on building construction projects in Nigeria. *Interim: Interdisciplinary Journal,* 12**,** 1-15.

ALENCASTRO, J., FUERTES, A. & DE WILDE, P. 2018. The relationship between quality defects and the thermal performance of buildings. *Renewable and Sustainable Energy Reviews,* 81**,** 883-894.

ALENCASTRO, J., FUERTES, A. & WILDE, P. D. 2016. Delivering energy-efficient social housing: implications of the procurement process. *Procedia Engineering, 182, pp. 10-17*.

ALJASSMI, H., HAN, S. & DAVIS, S. 2014. Project Pathogens Network: New Approach to Analyzing Construction-Defects-Generation Mechanisms. *Journal of Construction Engineering and Management,* 140**,** 04013028.

ANDERSON, B., CHAPMAN, P., CUTLAND, N., DICKSON, C., HENDERSON, G., HENDERSON, J., ILES, P., KOSMINA, L. & SHORROCK, L. 2001. *BREDEM-12 Model description 2001 update*, Building Research Establishment.

ANTONELLA, R. 2017. Global Warming and Its Health Impact. *The International Journal of Occupational and Environmental Medicine,* 8**,** 7-20.

ATKINSON, A. R. 2002. The pathology of building defects; a human error approach. *Engineering Construction & Architectural Management (Wiley-Blackwell),* 9**,** 53-61.

AUCHTERLOUNIE, T. 2009. Recurring quality issues in the UK private house building industry. *Structural Survey,* 27**,** 241-251.

BARBER, P., GRAVES, A., HALL, M., SHEATH, D. & TOMKINS, C. 2000. Quality failure costs in civil engineering projects. *International Journal of Quality & Reliability Management,* 17**,** 479-492.

BATTIKHA, M. G. 2008. Reasoning mechanism for construction nonconformance root-cause analysis. *Journal of Construction Engineering and Management-Asce,* 134**,** 280-288.

BBC. 2018. *Grenfell Tower: What happened* [Online]. https://www.bbc.co.uk/news/uk-40301289. [Accessed 12/07/2018].

BELL, M., WINGFIELD, J., MILES-SHENTON, D. & SEAVERS, J. 2010. LowCarbon Housing: Lessons from Elm Tree Mews. Joseph Rowntree Foundation, York.

BELL, M., SMITH, M. & MILES-SHENTON, D. 2005. Condensation Risk – Impact of Improvements to Part L And Robust Details On Part C – Interim Report Number 7: Final Report on Project Fieldwork, Report to the ODPM Building Regulations Division under the Building Operational Performance Framework – Project Reference Number CI 71/6/16 (BD2414). Leeds Metropolitan University, Leeds, UK.

BONSHOR, R. B. & HARRISON, H. W. 1982. *Traditional housing: A BRE study of quality*, Building Research Establishment Watford, UK.

BORDASS, B., COHEN, R., STANDEVEN, M. & LEAMAN, A. 2001. Assessing building performance in use 2: technical performance of the Probe buildings. *Building Research and Information,* 29**,** 103-113.

BPIE (Buildings Performance Institute Europe). 2011. *Europe's Buildings under the microscope: A country-by-country review of the energy performance of buildings*, Buildings Performance Institute Europe (BPIE).

BRE (Building Research Establishment). 2016. *The Passivhaus Standard* [Online]. Available: http://www.bre.co.uk/page.jsp?id=2856 [Accessed 04/04/2016 2016].

BRE (Building Research Establishment). 2013. The Government's Standard Assessment Procedure for Energy Rating of Dwellings. *In:* ESTABLISHMENT, B. R. (ed.).

BRESNEN, M., HASLAM, C., BEARDSWORTH, A., BRYMAN, A. & KEIL, E. 1990. *Performance on site and the building client*, The Chartered Institute of Building.

BRISCOE, G. H., DAINTY, A. R. J., MILLETT, S. J. & NEALE, R. H. 2004. Client-led strategies for construction supply chain improvement. *Construction Management and Economics,* 22**,** 193-201.

BROOKS, T. & SPILLANE, J. 2016. Does inappropriate quality control demotivate workers? A critical review. 32nd Annual ARCOM conference, 2016 Manchester, UK.

BRYMAN, A. 2012. *Social research methods,* Oxford ; New York, Oxford ; New York : Oxford University Press.

BSI (British Standards Institution). 2015. BS EN ISO 9001:2015. *Quality management systems Requirements.* British Standards Institution.

BSI (British Standards Institution). 2011. BS 8534:2011 Construction procurement policies, strategies and procedures – Code of practice.

BSRIA (Building Services Research & Information Association). 2012. The Soft Landings Core Principles.

BURATI, J. L., FARRINGTON, J. J. & LEDBETTER, W. B. 1992. CAUSES OF QUALITY DEVIATIONS IN DESIGN AND CONSTRUCTION. *Journal of Construction Engineering and Management-Asce,* 118**,** 34-49.

CARBON TRUST. 2011. Closing the Gap: Lessons Learned on Realising the Potential of Low Carbon Building Design. Carbon Trust, London.

CHAN, A. P., SCOTT, D. & CHAN, A. P. 2004. Factors affecting the success of a construction project. *Journal of construction engineering and management,* 130**,** 153-155.

CHAN, A. P. C., SCOTT, D. & LAM, E. W. M. 2002. Framework of success criteria for design/build projects. *Journal of Management in Engineering,* 18**,** 120.

CHARMAZ, K. 2006. *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis (Introducing Qualitative Methods series)*, Sage Publications Ltd.

CHONG, W. & LOW, S. 2006. Latent Building Defects: Causes and Design Strategies to Prevent Them. *Journal of Performance of Constructed Facilities,* 20**,** 213-221.

CHONG, W. & LOW, S. 2005. Assessment of Defects at Construction and Occupancy Stages. *Journal of Performance of Constructed Facilities,* 19**,** 283–289.

COOPER, D. R. 2014. *Business research methods,* New York, New York : McGraw-Hill/Irwin.

CORBIN, J. M. & STRAUSS, A. L. 2008. *Basics of qualitative research : techniques and procedures for developing grounded theory,* Thousand Oaks, CA : London, Thousand Oaks, CA : London : SAGE Publications.

CRESWELL, J. W. 2013. *Research design: Qualitative, quantitative, and mixed methods approaches*, Sage publications.

CROSBY, P. B. 1996. *Quality is still free : making quality certain in uncertain times*, McGraw-Hill.

DAVIS, R., WILEN, A., CRANE, T., BRYER, L., WARD, D., POTTIER, F., CAVIN, L., BLOFELD, S. & BLACKWELL, M. 2015. UK Industry Performance Report - 2015. *Construction Industry Key Performance Indicators.*

DAVIS, K., LEDBETTER, W. B. & BURATI JR, J. L. 1989. Measuring design and construction quality costs. *Journal of Construction Engineering and Management,* 115**,** 385-400.

DBEIS (Department for Business, Energy and Industrial Strategy). 2018a. Energy consumption in the UK (ECUK) 2018. *In:* DEPARTMENT FOR BUSINESS, E. I. S. (ed.).

DBEIS (Department for Business, Energy and Industrial Strategy). 2018b. Energy Consumption in the UK (ECUK) 2018 Data Tables. *In:* DEPARTMENT FOR BUSINESS, E. I. S. (ed.).

DE WILDE, P. 2014. The gap between predicted and measured energy performance of buildings: A framework for investigation. *Automation in Construction,* 41**,** 40-49.

DEMING, W. E. 2000. *Out of the crisis,* Cambridge, Mass. ; London, Cambridge, Mass. ; London : MIT Press.

DUKES (Digest of UK Energy Statistics). 2017. Digest Of United Kingdom Energy Statistics. *In:* DEPARTMENT FOR BUSINESS, E. A. I. S. (ed.).

EASTERBY-SMITH, M. 2002. *Management research : an introduction*, Sage.

EGAN, J. 1998. The Egan Report-Rethinking Construction. *Report of the Construction Industry Task Force to the Deputy Prime Minister. London*.

ENERGY SAVING TRUST 2009. Enhanced Construction Details: Thermal bridging and airtightness - CE302.

FAYEK, A. R., DISSANAYAKE, M. & CAMPERO, O. 2004. Developing a standard methodology for measuring and classifying construction field rework. *Canadian Journal of Civil Engineering,* 31**,** 1077-1089.

FEIGENBAUM, A. V. 1991. *Total quality control*. *New York: McGraw-Hill, 1991, 3rd ed./rev. 40th anniversary ed.*

FELLOWS, R. & LIU, A. 2015. *Research methods for construction*.

FIELDING, N. G., LEE, N. F. R. M. & LEE, R. M. 1998. *Computer analysis and qualitative research*, Sage.

FORCADA, N., SERRAT, C., RODRÍGUEZ, S. & BORTOLINI, R. 2017. Communication key performance indicators for selecting construction project bidders. *Journal of Management in Engineering,* 33**,** 04017033.

FORCADA, N., MACARULLA, M., GANGOLELLS, M. & CASALS, M. 2015. Handover defects: comparison of construction and post-handover housing defects. *Building Research & Information*, 1-10.

FORCADA, N., MACARULLA, M., GANGOLELLS, M. & CASALS, M. 2014. Assessment of construction defects in residential buildings in Spain. *Building Research and Information,* 42, 629-640.

FORCADA, N., MACARULLA, M., FUERTES, A., CASALS, M., GANGOLELLS, M. & ROCA, X. 2013a. Posthandover Housing Defects: Sources and Origins. *Journal of performance of constructed facilities,* 27, 756-762.

FORCADA, N., MACARULLA, M. & LOVE, P. E. D. 2013b. Assessment of Residential Defects at Post-Handover. *Journal of Construction Engineering and Management-Asce,* 139, 372-378.

FORCADA, N., MACARULLA, M., FUERTES, A., CASALS, M., GANGOLELLS, M. & ROCA, X. 2012. Influence of Building Type on Post-Handover Defects in Housing. *Journal of Performance of Constructed Facilities,* 26, 433-440.

FOX, M., COLEY, D., GOODHEW, S. & DE WILDE, P. 2014. Thermography methodologies for detecting energy related building defects. *Renewable and Sustainable Energy Reviews,* 40, 296-310.

GAMBIN, L., HOGARTH, T., ATFIELD, G., LI, Y. & OWEN, D. 2012. Sector Skills Insights: Construction *In:* SKILLS, U. C. F. E. A. (ed.). https://www.gov.uk/government/publications/construction-sector-skills-insights.

GEORGIOU, J. 2010. Verification of a building defect classification system for housing. *Structural Survey,* 28, 370-383.

GEORGIOU, J., LOVE, P. E. D. & SMITH, J. 1999. A comparison of defects in houses constructed by owners and registered builders in the Australian State of Victoria. *Structural Survey,* 17, 160-169.

GIBBS, G. R. 2008. *Analysing Qualitative Data*, SAGE Publications.

GLASER, B. G. & STRAUSS, A. L. 1967. *The discovery of grounded theory : strategies for qualitative research,* Chicago, Ill, Chicago, Ill : Aldine Publishing Co.

GORSE, C., STAFFORD, A., SHENTON, D. M., JOHNSTON, D., SUTTON, R., FARMER, D. & SMITH, S. 2012.Thermal performance of buildings and the management process. Procs28th annual ARCOM conference, 3-5.

GREENWOOD, D., CONGREVE, A. & KING, M. 2017. Streamlining or watering down? Assessing the 'smartness' of policy and standards for the promotion of low and zero carbon homes in England 2010–15. *Energy Policy,* 110, 490-499.

GRIFFITH, A. & WATSON, P. 2003. *Construction management: Principles and practice*, Macmillan International Higher Education.

GUMMESSON, E. 1991. *Qualitative methods in management research*, Sage Publications.

HACKITT, D. J. 2018. Building a Safer Future Independent Review of Building Regulations and Fire Safety: Final Report. *In:* STATE FOR HOUSING, C. A. L. G. (ed.). www.gov.uk/government/publications.

HANSFORD, P. 2015. SOLID WALL INSULATION - Unlocking Demand and Driving Up Standards. Green Construction Board and HM Government.

HARRIS, F., MCCAFFER, R. & EDUM-FOTWE, F. 2013. *Modern construction management,* Chichester, Chichester : Wiley-Blackwell.

HARRISON, H. 1993. *Quality in new-build housing*, Building Research Establishment Watford, UK.

HM GOVERNMENT. 2018. Data Protection Act. http://www.legislation.gov.uk/ukpga/2018/12/pdfs/ukpga_20180012_en.pdf.

HM GOVERNMENT. 2013. Part L1A - Conservation of fuel and power.

HM GOVERNMENT. 2008. Climate Change Act 2008: Elizabeth II. *In:* OFFICE, T. S. (ed.). London.

HM TREASURY, H. M. 2015. Summer Budget 2015. https://www.gov.uk/government/publications/summer-budget-2015.

HOLMANS, A. 2013. New estimates of housing demand and need in England, 2011 to 2031. *Town & Country Planning Tomorrow Series Paper,* 16.

HOLT, G. D., LOVE, P. E. D. & NESAN, L. J. 2000. Employee empowerment in construction: an implementation model for process improvement. *Team Performance Management: An International Journal,* 6, 47-51.

HOME BUILDERS FEDERATION 2018. National New Home Customer Satisfaction Survey. *Home Builders Federation, London*, 1-4.

HOONAKKER, P., CARAYON, P. & LOUSHINE, T. 2010. Barriers and benefits of quality management in the construction industry: An empirical study. *Total Quality Management & Business Excellence,* 21, 953-969.

HOPKIN, T., LU, S.-L., ROGERS, P. & SEXTON, M. 2016. Detecting defects in the UK new-build housing sector: a learning perspective. *Construction Management and Economics,* 34**,** 35-45.

HOPPER, J., LITTLEWOOD, J. R., TAYLOR, T., COUNSELL, J. A. M., THOMAS, A. M., KARANI, G., GEENS, A. & EVANS, N. I. 2012. Assessing retrofitted external wall insulation using infrared thermography. *Structural Survey,* 30**,** 245-266.

HWANG, B.-G., ZHAO, X. & GOH, K. J. 2014. Investigating the client-related rework in building projects: The case of Singapore. *International Journal of Project Management,* 32**,** 698-708.

HWANG, B. G., THOMAS, S. R., HAAS, C. T. & CALDAS, C. H. 2009. Measuring the Impact of Rework on Construction Cost Performance. *Journal of Construction Engineering and Management-Asce,* 135**,** 187-198.

IEA (International Energy Agency). 2016. *FAQs: Energy Efficiency. ⟨http://www.iea.org/aboutus/faqs/energyefficiency/⟩ (accessed 10.07.16.*

ILOZOR, B. D., OKOROH, M. I., EGBU, C. E. & ARCHICENTRE. 2004. Understanding residential house defects in Australia from the State of Victoria. *Building and Environment,* 39**,** 327-337.

IPCC (Intergovernmental Panel on Climate Change). 2014. *Climate Change 2013: The Physical Science Basis.* , Cambridge University Press, Cambridge, UK, and New York, USA.

ISO (International Organization for Standardization). 2005. *ISO 9000:2005 - Quality Management Principles,* Geneva, Switzerland.

JAFARI, A. & LOVE, P. E. D. 2013. Quality Costs in Construction: Case of Qom Monorail Project in Iran. *Journal of Construction Engineering and Management,* 139**,** 1244-1249.

JEFFERYS, P., LLOYD, T., ARGYLE, A., SARLING, J., CROSBY, J. & BIBBY, J. 2014. Building the homes we need: A programme for the 2015 government. *Last accessed,* 1.

JOHNSTON, D., MILES-SHENTON, D. & FARMER, D. 2015. Quantifying the domestic building fabric 'performance gap'. *Building Services Engineering Research and Technology*.

JOHNSTON, D., FARMER, D., BROOKE-PEAT, M. & MILES-SHENTON, D. 2014. Bridging the domestic building fabric performance gap. *Building Research & Information*, 1-14.

JONES, R. V., FUERTES, A., GOODHEW, S. & DE WILDE, P. 2017. The Actual Performance of Aspiring Low Energy Social Houses in the United Kingdom. *Energy Procedia,* 105**,** 2181-2186.

JOSEPHSON, P. E., LARSSON, B. & LI, H. 2002. Illustrative benchmarking rework and rework costs in Swedish construction industry. *Journal of Management in Engineering,* 18**,** 76-83.

JOSEPHSON, P. E. & HAMMARLUND, Y. 1999. The causes and costs of defects in construction: A study of seven building projects. *Automation in Construction,* 8**,** 681-687.

JRAISAT, L., JREISAT, L. & HATTAR, C. 2016. Quality in construction management: an exploratory study. *International Journal of Quality & Reliability Management,* 33**,** 920-941.

JURAN, J. M. 1993. *Quality Planning and Analysis*, McGraw.

KALAMEES, T. 2007. Air tightness and air leakages of new lightweight single-family detached houses in Estonia. *Building and Environment,* 42**,** 2369-2377.

KANJI, G. K. & WONG, A. 1998. Quality culture in the construction industry. *Total quality management,* 9**,** 133-140.

KANJI, G. K. 1996. *100 methods for total quality management*, Sage.

KARIM, K., MAROSSZEKY, M. & KUMARASWAMY, M. 2005. Organizational effectiveness model for quality management systems in the Australian construction industry. *Total Quality Management & Business Excellence,* 16**,** 793-806.

LAI, K.-H., WEERAKOON, T. S. & CHENG, T. 2002. The state of quality management implementation: a cross-sectional study of quality-oriented companies in Hong Kong. *Total Quality Management,* 13**,** 29-38.

LANDIN, A. 2000. ISO 9001 within the Swedish construction sector. *Construction Management and Economics,* 18**,** 509-518.

LESTER, A. 2014. *Project management, planning and control : managing engineering, construction, and manufacturing projects to PMI, APM, and BSI standards*.

LOOSEMORE, M., LINGARD, H. & DAINTY, A. 2003. *Human resource management in construction projects: strategic and operational approaches*, Routledge.

LOVE, P. E., EDWARDS, D. J. & SMITH, J. 2016. Rework causation: Emergent theoretical insights and implications for research. *Journal of Construction Engineering and Management,* 142**,** 04016010.

LOVE, P. E. D. & EDWARDS, D. J. 2012. Curbing rework in offshore projects: systemic classification of risks with dialogue and narratives. *Structure and Infrastructure Engineering,* 9, 1118-1135.

LOVE, P. E., IRANI, Z. & EDWARDS, D. J. 2004. A rework reduction model for construction projects. *IEEE Transactions on Engineering Management,* 51, 426-440.

LOVE, P. E. & EDWARDS, D. J. 2004a. Determinants of rework in building construction projects. *Engineering, Construction and Architectural Management,* 11, 259-274.

LOVE, P. E. D. & EDWARDS, D. J. 2004b. Forensic project management: The underlying causes of rework in construction projects. *Civil Engineering and Environmental Systems,* 21, 207-228.

LOVE, P. E. D. 2002. Influence of project type and costs in building procurement method on rework construction projects. *Journal of Construction Engineering and Management-Asce,* 128, 18-29.

LOVE, P. E. D. & LI, H. 2000. Quantifying the causes and costs of rework in construction. *Construction Management & Economics,* 18, 479-490.

LOWE, R. J., WINGFIELD, J., BELL, M. & BELL, J. M. 2007. Evidence for heat losses via party wall cavities in masonry construction. *Building Services Engineering Research & Technology,* 28, 161-181.

MACARULLA, M., FORCADA, N., CASALS, M., GANGOLELLS, M., FUERTES, A. & ROCA, X. 2013. Standardizing Housing Defects: Classification, Validation, and Benefits. *Journal of Construction Engineering & Management,* 139, 968-976.

MCINTYRE, C. & KIRSCHENMAN, M. 2000. Survey of TQM in construction industry in upper Midwest. *Journal of Management in Engineering,* 16, 67-70.

MCMANUS, A., GATERELL, M. & COATES, L. 2010. The potential of the Code for Sustainable Homes to deliver genuine 'sustainable energy'in the UK social housing sector. *Energy Policy,* 38, 2013-2019.

MENEZES, A. C., CRIPPS, A., BOUCHLAGHEM, D. & BUSWELL, R. 2012. Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reduce the performance gap. *Applied Energy,* 97, 355-364.

MHLG (Ministry of Housing and Local Government). 2018. English Housing Survey headline report 2016 to 2017. *In:* MINISTRY OF HOUSING, C. L. G. (ed.).

MILLS, A., LOVE, P. E. D. & WILLIAMS, P. 2009. Defect Costs in Residential Construction. *Journal of Construction Engineering and Management-Asce,* 135, 12-16.

MILES, M. B. & HUBERMAN, A. M. 1994. *Qualitative data analysis : an expanded sourcebook*, Sage.

MILES, M. B. 1979. Qualitative Data as an Attractive Nuisance: The Problem of Analysis. *Administrative Science Quarterly,* 24, 590-601.

MINISTRY OF HOUSING, C. L. G. 2018. *Live tables on house building: new build dwellings* [Online]. https://www.gov.uk/government/statistical-data-sets/live-tables-on-house-building. [Accessed 21/05/2018 2018].

MOATAZED-KEANI, R., GHANBARI-PARSA, S., ALI & KAGAYA, S. 1999. ISO 9000 standards: perceptions and experiences in the UK construction industry. *Construction Management & Economics,* 17, 107-119.

MOGENDORFF, K. 2016. The building or enactment of expertise in context: what the performative turn in the social sciences may add to expertise research in construction management. *Construction Management and Economics,* 34, 484-491.

NA, R., LIN, S. M., GU, L. X., GROSSKOPF, K. & SHEN, Z. G. 2013. *IMPACT OF AIR LEAKAGE THROUGH RECESSED LIGHTING FIXTURES ON THE ENERGY PERFORMANCE OF RESIDENTIAL BUILDINGS - A CASE STUDY*.

NATIONAL STATISTICS. 2018. Overview of the UK population: November 2018.

NEF (National Energy Foundation). 2016. Insights from Social Housing Projects - Building Performance Evaluation Meta-Analysis. *Executive Report Innovate UK.* National Energy Foundation.

OGC (Office of Government Commerce). 2007. Procurement and contract strategies. *In:* COMMERCE, T. U. O. O. G. (ed.). http://webarchive.nationalarchives.gov.uk/20100503135839/http://www.ogc.gov.uk/documents/CP0066AEGuide6.pdf.

OYEWOBI, L., OKE, A., GANIYU, B., SHITTU, A., ISA, R. & NWOKOBIA, L. 2011. The effect of project types on the occurrence of rework in expanding economy. *Journal of Civil Engineering and Construction Technology,* 2, 119-124.

PALANEESWARAN, E., RAMANATHAN, M. & TAM, C. 2007. Rework in projects: Learning from errors. *Surveying and Built Environment,* 18, 47-58.

PALMER, J., GODOY-SHIMIZU, D., TILLSON, A. & MAWDITT, I. 2016. Building Performance Evaluation Programme: Findings from domestic projects - Making reality match design. Innovate UK.

PAN, W. & THOMAS, R. 2015. Defects and Their Influencing Factors of Posthandover New-Build Homes. *Journal of Performance of Constructed Facilities,* 29, 04014119.

PARTINGTON, D. 2000. Building Grounded Theories of Management Action. *British Journal of Management,* 11, 91-102.

PATTON, M. Q. 2015. *Qualitative research & evaluation methods : integrating theory and practice*.

PRETLOVE, S. & KADE, S. 2016. Post occupancy evaluation of social housing designed and built to Code for Sustainable Homes levels 3, 4 and 5. *Energy and Buildings,* 110, 120-134.

PROJECT MANAGEMENT INSTITUTE 2001. *Project Management Body of Knowledge (PMBOK® GUIDE)*.

QUAZI, H. A., HONG CHANG, W. & MENG CHAN, T. 2002. Impact of ISO 9000 certification on quality management practices: a comparative study. *Total Quality Management,* 13, 53.

REMENYI, D. 1998. *Doing research in business and management : an introduction to process and method,* London, London : SAGE.

ROBSON, C. 2011. Real world research: a resource for users of social research methods in applied settings.

RUPARATHNA, R. & HEWAGE, K. 2015. Review of contemporary construction procurement practices.(Author abstract). *Journal of Management in Engineering,* 31, 4014038.

SAAD, G. H. & SIHA, S. 2000. Managing quality: critical links and a contingency model. *International Journal of Operations & Production Management,* 20, 1146-1164.

SAMENI, S. M. T., GATERELL, M., MONTAZAMI, A. & AHMED, A. 2015. Overheating investigation in UK social housing flats built to the Passivhaus standard. *Building and Environment,* 92, 222-235.

SEKARAN, U. 2013. *Research methods for business : a skill-building approach,* Chichester, Chichester : John Wiley & Sons.

SILVESTRE, J. D. & DE BRITO, J. 2011. Ceramic tiling in building façades: Inspection and pathological characterization using an expert system. *Construction and Building Materials,* 25, 1560-1571.

SODAGAR, B. & FIELDSON, R. 2008. Towards a low carbon construction practice. *Construction information quarterly,* 10, 101-108.

SODAGAR, B. & STARKEY, D. 2016. The monitored performance of four social houses certified to the Code for Sustainable Homes Level 5. *Energy and Buildings,* 110, 245-256.

SOMMERVILLE, J. 2007. Defects and rework in new build: an analysis of the phenomenon and drivers. *Structural Survey,* 25**,** 391-407.

SOMMERVILLE, J. & MCCOSH, J. 2006. Defects in new homes: an analysis of data on 1,696 new UK houses. *Structural Survey,* 24**,** 6-21.

SOMMERVILLE, J., CRAIG, N. & BOWDEN, S. 2004. The standardisation of construction snagging. *Structural Survey,* 22**,** 251-258.

STALL-MEADOWS, C. & HYLE, A. 2010. Procedural methodology for a grounded meta-analysis of qualitative case studies. *International Journal of Consumer Studies,* 34**,** 412-418.

STERN, N., PETERS, S., BAKHSHI, V., BOWEN, A., CAMERON, C., CATOVSKY, S., CRANE, D., CRUICKSHANK, S., DIETZ, S. & EDMONSON, N. 2006. *Stern Review: The economics of climate change*, HM treasury London.

STRAUSS, A. & CORBIN, J. 1990. *Basics of qualitative research: Grounded theory procedures and techniques*, Sage.

TAN, H. C., CARRILLO, P., ANUMBA, C., KAMARA, J. M., BOUCHLAGHEM, D. & UDEAJA, C. 2006. Live capture and reuse of project knowledge in construction organisations. *Knowledge Management Research & Practice,* 4**,** 149-161.

TAYLOR, T., COUNSELL, J. & GILL, S. 2014. Combining thermography and computer simulation to identify and assess insulation defects in the construction of building façades. *Energy and Buildings,* 76**,** 130-142.

TAYLOR, T., COUNSELL, J. & GILL, S. 2013a. Energy efficiency is more than skin deep: Improving construction quality control in new-build housing using thermography. *Energy and Buildings,* 66**,** 222-231.

TAYLOR, T., COUNSELL, J., GILL, S. & OAKLEY, G. 2013b. Assessing the severity of workmanship defects using thermography and 2-D and 3-D heat transfer models. SB13 Graz Sustainable Building Conference, Graz, Austria. Verlag der Technischen Universität Graz.

THORPE, B. 2004. *Quality management in construction,* Aldershot, Aldershot : Gower.

TOFIELD, B. 2012. Delivering a Low-Energy Building: Making Quality Common Place. (Build with CaRe report). University of East Anglia, Norwich.

TRACY, S. 2013. *Qualitative Research Methods: Collecting Evidence, Crafting Analysis* John Wiley & Sons.

TULACZ, G. J. 2001. STAFF TURNOVER PLAGUES CONTRACTORS DESPITE REMEDIES. *ENR: Engineering News-Record,* 247**,** 14.

TUOHY, P. G. & MURPHY, G. B. 2015. Closing the gap in building performance: learning from BIM benchmark industries. *Architectural Science Review,* 58**,** 47-56.

VÄHÄ, P., HEIKKILÄ, T., KILPELÄINEN, P., JÄRVILUOMA, M. & GAMBAO, E. 2013. Extending automation of building construction — Survey on potential sensor technologies and robotic applications. *Automation in Construction,* 36**,** 168-178.

VAN DRONKELAAR, C., DOWSON, M., SPATARU, C. & MUMOVIC, D. 2016. A Review of the Regulatory Energy Performance Gap and Its Underlying Causes in Non- domestic Buildings. *Front. Mech. Eng.,* 1.

WANBERG, J., HARPER, C., HALLOWELL, M. R. & RAJENDRAN, S. 2013. Relationship between Construction Safety and Quality Performance. *Journal of Construction Engineering and Management,* 139**,** 04013003.

WANG, Q., AUGENBROE, G. & SUN, Y. 2014.The role of construction detailing and workmanship in achieving energy efficient buildings. Construction Research Congress, Atlanta, May, 19-24.

WATT, D. 2007. *Building pathology : principles and practice,* Oxford, Oxford : Blackwell.

WAY, M. & BORDASS, B. 2005. Making feedback and post-occupancy evaluation routine 2: Soft landings–involving design and building teams in improving performance. *Building Research & Information,* 33**,** 353-360.

WINGFIELD, J., BELL, M., MILES-SHENTON, D., SOUTH, T. & LOWE, R. 2011. Evaluating the impact of an enhanced energy performance standard on load-bearing masonry domestic construction - Understanding the gap between designed and real performance: lessons from Stamford Brook.

YIN, R. K. 2009. *Case study research : design and methods,* Los Angeles, Los Angeles : Sage Publications.

ZERO CARBON HUB 2016. Thermal Bridging Guide. www.zerocarbonhub.org.

ZERO CARBON HUB 2015. Builders' Book - An illustrated guide to building energy efficient homes. www.zerocarbonhub.org.

ZERO CARBON HUB 2014a. Closing the Gap Between Design and As-Built Performance - Evidence Review Report.

ZERO CARBON HUB 2014b. Closing the gap between design and as-built performance, End of term report.

ZERO CARBON HUB 2010. Carbon Compliance for Tomorrow's New Homes, A Review of the Modelling Tool and Assumptions, Topic 4, Closing the Gap Between Designed and Built Performance.

ZHENG, X., LE, Y., CHAN, A. P. C., HU, Y. & LI, Y. 2016. Review of the application of social network analysis (SNA) in construction project management research. *International Journal of Project Management,* 34**,** 1214-1225.