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INVESTIGATING THE IMPACT OF DEFECTS ON KEY STAKEHOLDERS IN THE UK NEW HOUSING SECTOR

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Abstract: The UK house building sector is facing dual pressures to expand supply, along with delivering against tougher Building Regulations' requirements, predominantly in the areas of sustainability. A review of current literature has highlighted that the pressures the UK house building industry is currently under may be having a negative impact on build quality, causing an increase in defects. A review and synthesis of the current defect literature with respect to new-build housing and the wider construction sector has found that the prevailing emphasis is limited to the classification, causes, pathology and statistical analysis of defects. There is thus a need to better understand the overall impact of individual defects on key stakeholders within the new-build housing defect detection and remediation process. As part of ongoing research to develop and verify a defect impact assessment rating system, this paper seeks to contribute to our understanding of the impact of individual defects from a key stakeholder perspective by undertaking the literature review and synthesis phase. The literature review identifies the three distinct, but interrelated, dominant impact factors: cost, disruption, and health and safety. By pulling the strands of defect literature together the theoretical lens and key stakeholder sampling strategy is formed as the basis for the subsequent impact weighting development phase.

1 INTRODUCTION

In the United Kingdom (UK) there is a substantial shortfall in the number of dwellings available (Wilcox & Perry 2013) amid claims that the UK requires an additional 240,000 homes per year to meet demand (e.g. Holmans 2013). In order to satisfy the demand the UK government has introduced a number of new-build focussed policies and incentives to increase the housing supply (HM Government 2011). For example, the Get Britain Building investment fund is designed to enable house builders to progress sites that have stalled, not started or are on hold (DCLG 2014a). The UK house building industry has responded to the increased demand and government incentives by significantly up-scaling supply, with a 23% increase in new housing starts for 2013 compared to 2012 volumes (DCLG 2014b). In addition to the pressure to increase housing supply, the UK house building industry is under a further pressure via the introduction of a target for all new houses to be 'zero carbon standard' (Zero Carbon Hub 2014) from 2016 (UK Government 2012). The zero carbon homes agenda has resulted in the introduction of tougher Building Regulations, for example, changes to part L 'Conservation of Fuel and Power' (DCLG 2013), which has resulted in the house building sector incorporating new technical solutions into new-build houses to achieve compliance (e.g. NHBC Foundation 2012).

A review of current literature has highlighted that the pressures the UK house building industry is currently under may be having a negative impact on build quality, causing an increase in defects (e.g. Hopkin *et al.* 2014). There is increasing evidence that the inclusion of new technologies can and does adversely impact new-home quality; both in the material sense of the home itself and in the well-being of occupants (e.g. Yao & Yu 2012, Gill *et al.* 2010). In much the same way, it has long been advocated that an increase in housing supply can reduce build quality. For example, tightened delivery dates cause materials and workforce capacity to become stretched, and site management becomes less stringent due to workload (e.g. Sommerville *et al.* 2004). This situation is worsening as the UK house building sector is currently reporting materials, skills and workforce shortages (e.g. HBS 2013, UKES 2012). Further evidence of the increase in the number of new housing defects is in the Home Builders Federation (HBF) survey results (HBF 2014), which show that in 2014, 92% of home owners reported defects within their new-build house, the first time there has been an increase since 2011.

This paper offers an insight to the impact of individual defects from a key stakeholder perspective by undertaking the literature review and synthesis phase from a wider project to develop and verify a defect impact assessment rating system.

2 DEFINITIONAL DEBATE ON DEFECTS

A synthesis of construction defect literature has highlighted a wealth of research into defects, ostensibly utilising a multitude of separate terms and categories to define defects, for example, defects (e.g. Atkinson 2002), snags (e.g. Craig 2007), faults (e.g. BRE 1990), failures (e.g. Porteous 1992) and non-compliance (e.g. Baiche *et al.* 2006).

A 'defect' is defined as a shortfall in performance occurring within the life of the product, element or dwelling (BRE 1988). More specifically, Watt (1999) defines a 'building defect' as a failure or inadequacy in the function, performance, legal or user requirements of a building, and can become apparent within the structure, fabric, services or other facilities of the building.

A 'failure' is defined as an unacceptable difference between expected and observed performance (Ahzahar *et al.* 2011). Porteous (1992) further defines a 'building failure' as a shortfall in the technical performance, to an extent that the user and impartial expert evaluator define the building as defective. Josephson and Hammarlund (1999) conclude a defect to be the failure to achieve intended usage requirements.

A 'fault' is described as an unacceptable departure from good practice set out in Building Regulations and other authoritative publications (BRE 1990). Ilozor *et al.* (2004) argue that a defect and a fault are one in the same.

A 'non-compliance', also known as 'non-conformance' (Abdul-Rahman 1995), is described to be a deviation from the design specification (Assaf *et al.* 1995). Baiche *et al.* (2006) infer a non-compliance to be simply a 'failure' to adhere to Building Regulations, or approved standards; a term Sommerville and McCosh (2006) define as ‘regulatory defects’.

A 'snag' is argued by Sommerville and McCosh (2006) to be the same as 'errors' and 'defects' within a new house, whereas Atkinson (2002) argues 'errors' as a cause of 'defects'.

These terms appear to be used interchangeably to describe the same phenomenon, i.e. imperfections in buildings (defects), causing minimal difference in the approach or outcome, as discussed in section 3 below.

3 OUTPUT THEMES IN CURRENT CONSTRUCTION DEFECT RESEARCH

The extant literature, regardless of the chosen designation for defects, tends to adopt a similar position where it limits itself to the classification (e.g. Macarulla *et al.* 2013), causes (e.g. Josephson & Hammarlund 1999), pathology (e.g. Atkinson 2002), and statistical analysis (e.g. Sommerville & McCosh

2006) of defects. The construction defect literature can generally be grouped in to three different defect related output themes: those that produce general findings; those that differentiate between individual types of defects; and, those that introduce a level of importance to individual defects. Each theme is discussed below.

3.1 General findings

The defect scholarship tends to produce general findings in respect to the causes, pathology, and statistical factors of defects. For example, Sommerville and McCosh (2006) analyse the overall numbers of defects within new homes in the UK. Love *et al.* (1999) review the total remediation cost of defects as a percentage of the production cost of construction projects. Atkinson (2002) examines the responsibility for defects taking place on construction sites, in general. Josephson and Hammarlund (1999) explore the typical causes of defects in construction projects. Whilst the general findings can produce a useful insight in to the current status of defects within the construction industry, it can be prone to assuming all defects have the same characteristics, causes and level of importance. The literature can also be susceptible to providing generic recommendations in respect to defect reduction, including: training for trades and better management on site (e.g. Sommerville & McCosh 2006). By differentiating between individual defects, the literature could provide more relevant tailored guidance to reduce individual defect types.

3.2 Individual types of defects

There is literature available that identifies and classifies individual types of defects. However this identification tends to be through the frequency in which different defects are encountered over particular stages of a construction project. For example, Baiche *et al.* (2006) identify the most common Building Regulations contraventions taking place during construction, including radon protection, misplaced damp proof membranes and damp proof courses, and inadequate thermal insulation; Craig (2007) presents a list of prevalent 'snags' in UK new homes during the first two years post completion, including making good, paint, cleaning, plastering, mastic, fitting, doors, sealant, and grout; and, Mills *et al.* (2009) stress the most prominent sources of warranty claims in Australia including, slab foundations, strip foundations, roof leaks, shower base leaks, external water penetration, plumbing, shower cubicle leaks, drainage, pier and beam foundations, leaking windows. The defect classification literature provides valuable detail as to the most prevalent type of defects occurring within the construction industry. However it does not identify a level of priority with regards to approaching targeted defect reduction. Bringing a level of priority to defects will help to guide this decision (e.g. Sommerville 2007).

3.3 Priority of individual defects

A small subset of the defect classification literature has started to introduce a level of priority to defects, albeit in respect of the process for remediating defects identified on a building survey. This level of priority tends to be based upon the current physical condition of the individual building element. de Oliveira Pedro *et al.* (2008) proffer a condition survey to identify the severity of the defects identified within a number of building elements, giving individual building elements a weighting coefficient based upon their perceived level of importance. Che-Ani *et al.* (2011), influenced by the RICS HomeBuyer survey, extend this logic to establish a priority for repairing individual defects, based on two contrasting input parameters: condition and repair priority (ranging from (1) cosmetic to (5) health and safety risk). The survey develops an overall score based upon the product of the contrasting input parameters, with the repair priority being displayed in a traffic light format. Whilst the building condition survey has brought a level of priority to the defect remediation process, it appears to be based around the individual surveyor's perception of importance and urgency. Sommerville (2007) argues that an approach of being able to establish the impact of individual defects will further develop the ability to determine whether individual defects are significant or not, and guide what should be focussed upon. There is, however, a dearth of literature seeking to understand the overall impact of individual defects.

4 THE IMPACT OF DEFECTS

A review of existing construction defect literature has identified a number of common aspects which have the potential to impact on a variety of stakeholders involved with construction projects, including: cost (e.g. Georgiou *et al.* 1999, Mills *et al.* 2009, Josephson & Hammarlund 1999, Love & Li 2000, Rosenfeld 2009), potential health and safety/regulatory non-compliance (e.g. Georgiou *et al.* 1999, Baiche *et al.* 2006, Ilozor *et al.* 2004, Love & Edwards 2004, Macarulla *et al.* 2013, Smith *et al.* 2013), and disruption (e.g. Davey *et al.* 2006, BEC 1991, Rosenfeld 2009, Sommerville *et al.* 2004). Each aspect is discussed below.

4.1 Cost implications

Existing research argues that defects in general have cost implications for the builder and warranty provider. For the builder defects are argued to reduce the amount of profit available from projects (e.g. Sommerville & McCosh 2006, Davey *et al.* 2006) while for the warranty provider defects are argued to cost vast sums of money to remedy (e.g. Mills *et al.* 2009). It is claimed that remediation of defects occurring during the construction stage and the defects liability period (first two years post completion) cost the builder on average between 2.3% and 9.4% of the production cost (e.g. Josephson & Hammarlund 1999, Love *et al.* 1999, Love & Li 2000). Outside of the construction and defects liability period, construction projects tend to be subject to warranty cover (e.g. Sommerville & McCosh 2006). The cost of defect remediation during the post completion warranty period in Australia (seven years post occupation) is argued to be circa 4% of the contract value (e.g. Mills *et al.* 2009). The generalised cost argument offers valuable insights and headline figures with regards to the overall cost of defects to both builders and warranty providers; however it can be disposed to assuming that all defects have the same cost characteristics. There are notable exceptions that acknowledge the diverse financial nature of defects. For example, Davey *et al.* (2006) point out that it costs a minimum of £50 for an operative to attend to a single defect. Mills *et al.* (2009) further identify that different defects cost varying sums to remedy; for instance, remediation of external water penetration is more costly than plumbing, on average. Rosenfeld (2009) drills down deeper to identify a number of specific costs associated with identifying and resolving individual defects. The costs identified include the cost of investigating the cause of the defect (either by internal staff or external specialists, or both), the cost of the repair (including materials, labour, and equipment), the costs of staff time in handling customer complaints (along with any legal fees and/or compensation paid during the complaint process), and the cost of warranty repairs. Along the same line of associated costs, Davey *et al.* (2006) argue that post completion defects also incur travelling costs during both the investigation and remediation processes. Finally, Georgiou *et al.* (1999) propose that individual defects with high associated costs should be seen as “major” defects.

4.2 Potential health & safety (H&S)/regulatory implications

It is argued that defects can have a negative impact on project safety (e.g. Love & Edwards 2004). The implication is that reducing defects has the potential to improve construction health and safety (H&S) in general (e.g. Macarulla *et al.* 2013). There is also a more specific H&S concern proffered within the literature, regulatory non-compliance. Sommerville and McCosh (2006) comment that the majority of construction defect research concentrates on defects that do not comply with the Building Regulations. Smith *et al.* (2013) further explain that this is because the Building Regulations are the minimum set of standards that a construction project is required to meet. Building Regulations compliance is to certify that reasonable standards of H&S are ensured for building users (e.g. Baiche *et al.* 2006). Regulatory defects have the potentiality to jeopardise the H&S of the occupants, with Smith *et al.* (2013) arguing the need to consider human safety once the building is occupied. During construction, a building inspector must take all reasonable steps to satisfy themselves that the requirements of the Building Regulations have been met; however the primary responsibility for achieving compliance remains with those who commission and undertake the work (e.g. LGO 2014). Under the Building Act (1984) if a person carrying out building work contravenes the Building Regulations, they may be taken to the magistrates' court and ordered to pay a fine for the contravention, and a further fee for each day the contravention continues post-conviction. In specific circumstances, under a new build warranty the warranty provider will provide cover for defects (that contravene Building Regulations) where they present a danger to the H&S of the occupants (e.g. NHBC 2012). This generalised approach provides a clear indication of the H&S implications associated with non-achievement of regulatory compliance, along with those affected. However it neglects to discuss in detail the varying H&S implications of individual defects. There is a small pool of literature that acknowledges the heterogeneous nature of defects and the accompanying H&S concerns they pose. Georgiou *et al.* (1999), for example, argue that individual defects with the potential to damage H&S should be deemed a “major” defect. It is also recommended that focus should be placed upon reducing individual defects in areas deemed detrimental to the H&S of the home occupants (e.g. Baiche *et al.* 2006). Ilozor *et al.* (2004) further argue that there is still a need to concentrate on defects that are low in number, if only to ensure safety. NHBC (2012) drill down deeper by highlighting ‘chimney and flue defects’ as types with the potential to present an imminent danger to the H&S of the home occupants.

4.3 Disruption implications

It has been argued that defects generally cause disruption to both home occupants and house builders (e.g. Davey *et al.* 2006). Rosenfeld (2009) identifies that defects occurring during the construction process can cause disruption to the builder through resource usage, for example, site management investigating their causes, and the deployment of labour and equipment to remedy the defects; instead of undertaking new work. Remediation of defects has the potential to cause delays in handover, and put builders at risk of complaints from the home occupants (e.g. Sommerville *et al.* 2004). Post completion defects are also argued to cause disruption by way of operatives having to return to, and be granted access to a previous job (by the home occupant) (e.g. Davey *et al.* 2006). The BEC (1991) suggests that home occupants are unlikely to welcome disruption that occurs due to work being carried out incorrectly. Rosenfeld (2009) identifies that handling post completion defects has the potential to cause disruption to a builder’s staff. Disruption to staff can include time spent travelling to investigate and remediate defects, and the process of having to arrange for trades to return to properties to undertake repairs (e.g. Davey *et al.* 2006). It is further argued that invaluable time of managers within a construction company is consumed dealing with issues of the past, when it could be better spent concentrating on the company’s current and future projects (Rosenfeld, 2009). Over prioritisation of current and future projects in place of resolving defects during the defects liability period (first two years post completion) often results in poor quality service, and breakdowns in communication between construction companies and clients (e.g. Davey *et al.* 2006). Existing research provides valuable evidence by identifying a number of defect related consequences with the potential to cause disruption. It however can be susceptible to discussing defects only in a universal context. Individual defects have differing potential disruption impacts on both house builders and home occupants, such as divergent levels of inspection, varying repair durations, fluctuating demand on labour and equipment, and the unstable levels of communication and service the combination of these aspects will invariably cause.

What has become apparent from the prevailing literature relating to the impact of defects in construction is how a number of the identified factors are closely interrelated and can involve a number of stakeholders. For example, a post completion defect that is a non-compliance with the Building Regulations has a number of related implications: first, cost implications for undertaking the repair, and/or any potential fines for the contravention; second, potential H&S implications due to Building Regulations compliance being to ensure that reasonable standards of health and safety for building users are achieved; and, finally, disruption implications by the way of operatives having to return to the property, and be granted access by the customer to rectify the situation. Sommerville (2007) has made a useful contribution to the debate by identifying that there are a lack of models available to quantify the overall impact of individual defects. Further, the same defect would likely include a number of stakeholders, including: the home buyer/occupier, builder and building inspector. The following section further examines the defect detection and remediation process, and the key stakeholders involved.

5 THE IDENTIFICATION OF KEY STAKEHOLDERS INVOLVED IN THE NEW HOUSING DEFECT DETECTION AND REMEDIATION PROCESS

Despite the limited research or models to identify the overall impact of individual defects on key stakeholders, the literature has established the defect detection and remediation process in house building along with the key stakeholders involved in the process. Figure 1 provides a simple overview of the process. Four key stakeholders are identified: the home buyer/occupier, house builder, warranty provider, and building inspector. These stakeholders and their involvement within the process are discussed below.

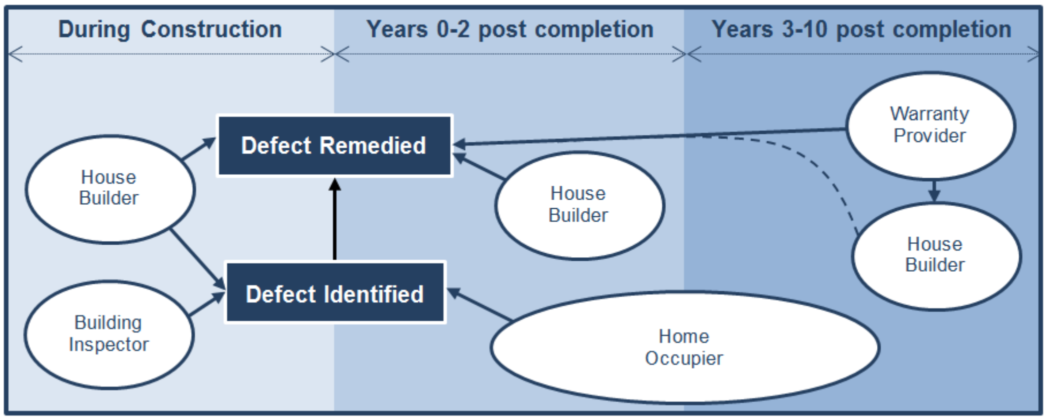

Figure 1: Typical defect detection and remediation process in the UK new house building

During the construction of a new home, an inspection procedure involving examination of work on site takes place to assess whether compliance with Building Regulations is achieved (e.g. Smith *et al.* 2013). The inspection procedure can be undertaken by either a building inspector from the local authority or an independent approved inspector (e.g. CIC 2014a). As shown in Figure 1 building inspectors frequently observe non-compliance (identify defects) during the construction process and produce checklists of faults that require correction (e.g. Baiche *et al.* 2006). The house builder typically accepts the inspector's decision and rectifies the defect (e.g. Smith *et al.* 2013). As work progresses on site employees of the house builder, typically either site or project management, will also undertake quality inspections of the building area. If defects are identified a tradesperson will then be required to rectify the defect for the builder to approve (e.g. Sommerville *et al.* 2004).

During the builder's liability period (first two years post completion), the UK house building industry utilises a snagging process which is heavily reliant on the home buyer/occupier (e.g. Sommerville *et al.* 2004). The home buyer/occupier is responsible for identifying and reporting any problems back to the builder's customer care department so that they can deploy trades to rectify them.

Outside of the first two years, most new homes are subject to warranty cover. Warranties are typically ten years in length. After the builder's liability period of two years, the warranty is used to cover building defects in years 3-10 (e.g. Premier Guarantee 2013). According to Construction Industry Council (CIC, 2014b), there are seven key players in the new home warranty market in the UK, each offering new home warranty products; they are Building LifePlans, Local Authority Building Control, Build Zone, Castle 10, CRL, Premier Guarantee, and National House Building Council (NHBC). If the home occupier notices a defect that requires attention, they are required to contact the warranty provider and notify them of the identified defect, and afford the warranty provider the opportunity to inspect the home. Upon acceptance of a valid claim, the warranty provider will make the necessary arrangements to have the defect remedied (e.g. NHBC 2012). Warranty providers will keep a record of claims history as part of their risk assessment procedures and for calculating the builder's renewal fees (e.g. Auchterlounie 2009). Mills *et al.* (2009) argue that the warranty provider spends large sums of money rectifying defects. However it is acknowledged that repairs are also undertaken directly by the original builder to protect their renewal fee from increase (e.g. NHBC 2011).

6 DISCUSSION

What has become clear from the review of literature relating to the impact of defects is that there is scant rigorous empirical evidence to identify the overall impact of individual defects on key stakeholders. There is only a small pool of literature that discusses, in isolation, some of the individual facets that contain the potential to impact on a variety of stakeholders, i.e. cost, disruption and health and safety/regulatory (e.g. Georgiou *et al.* 1999, Baiche *et al.* 2006, Ilozor *et al.* 2004). Furthermore, the scholarship has identified that the three aspects with impact potential are closely linked. This close link suggests that it would be difficult to consider one impact criterion without considering the others. Despite this close relationship the review has identified a lack of models available to quantify the overall impact of individual defects (e.g. Sommerville 2007). Such a model would develop the ability to establish the impact of individual defects and will further develop the ability to determine whether individual defects are significant or not, and guide what defects should be focussed upon for targeted defect reduction.

7 RESEARCH AIM AND OBJECTIVES

The aim of this research is to better understand the impact of defects on key stakeholders within the new-build housing defect detection and remediation process.

In order to achieve the above aim, the following objectives will need to be satisfied:
- Determine which of the identified aspects are more important to the relative stakeholders, and why.
- Develop and verify a defect impact assessment system for the purposes of defect analysis.

8 RESEARCH METHOD

To successfully achieve the aim and objectives set out in section 7, further research will be undertaken in three phases (see Figure 2): the development of impact weighting, testing of impact criteria, and validation of impact criteria.

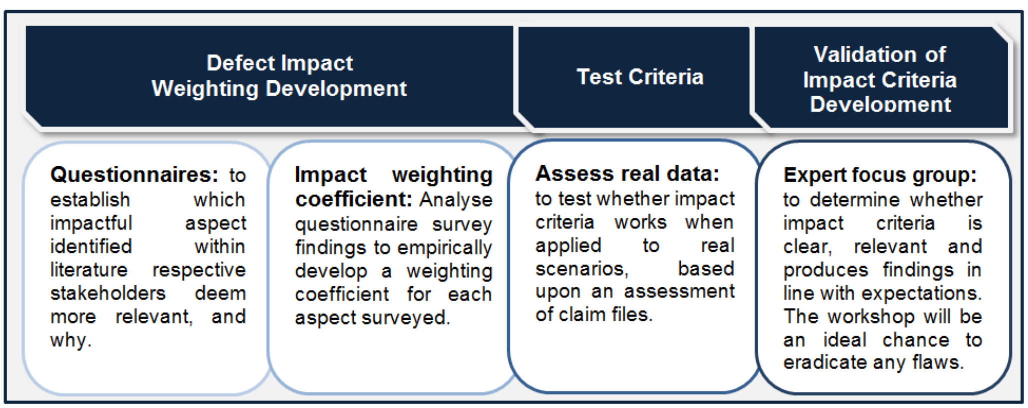

Figure 2: Defect impact assessment development method

8.1 Development of impact weighting

The literature review and synthesis undertaken in this paper has helped to form the initial defect weighting criteria and identify the key stakeholders in the new-build housing defect detection and remediation process. Questionnaires will be employed to establish the weighting coefficient for the identified aspects of defects with potential to impact upon stakeholders within construction projects. The questionnaire will establish which aspect is deemed to be the most important to the respective stakeholders, and why. As the defect scholarship takes a normative position of the identified aspects, the why question within the survey will seek to explore the stakeholders' perceptions of these terms and the underlying factors behind their selection. The questionnaire survey will be distributed to the four key stakeholders identified in section 5, home buyer/occupier, house builder, warranty provider, and building inspector. First, a list of home owners who have had a defect rectified under their warranty within the last year will be sourced from the UK's largest new home warranty provider. Second, members of the same warranty provider's staff will be identified. Third, building inspectors from the UK's largest independent building inspection service will be located. Fourth, active house builders held within the UK's leading warranty provider and independent building inspector's register will be identified. (Note: the UK's largest independent building inspection service is responsible for over 50% of the building control market, and the UK's largest warranty provider provides cover on circa 80% of new build houses, therefore making them a representative sample).

Developing a weighting coefficient for each of the individual components (e.g. de Oliveira Pedro *et al.* 2008) and multiplying them together (e.g. Che-Ani *et al.* 2011) will allow for the overall impact of the combined criteria of individual defects to be calculated. Primary data drawn from the questionnaire survey results will generate the capability to empirically develop a weighting for each of the predefined aspects, which will allow us to identify which of the elements should have the largest influence to the overall impact rating.

8.2 Testing of impact criteria

Upon completion of criteria development, the developed impact model will be tested through its application to defects extracted from the defect records of the UK's largest new home warranty provider's claims database. Claim files provide objective information with regards to the magnitude, cost and cause of defects, therefore making them an ideal source of data for research in to defects (e.g. Georgiou *et al.* 1999). Testing new systems on secondary data is a method frequently employed. For example, Georgiou *et al.* (1999) tested the suitability of their defects classification system by analysing defect records for Australian homes. The UK's largest warranty provider provides cover on circa 80% of new build houses, therefore making them a representative sample.

8.3 Validation of impact criteria

The impact criteria will finally be validated through exposing it to expert focus groups to establish whether the system is clear, relevant and produces findings in line with expert expectations, along with identifying any improvement opportunities. Georgiou (2013) argues that expert validation and achieving a level of consensus is necessary to prove that the author's objectivity is sufficient. The expert focus groups will consist of two comparative focus groups to validate findings (e.g. Adams & Cox 2008). The focus groups will consist of participants, including; Chartered Surveyors, Chartered Engineers and Chartered Building Engineers. Focus groups have been chosen as they offer rich amounts of data and different perspectives on a given topic, and serve as a useful tool for gaining insight in to different views and dynamics within a group context, for example, consensus and disagreement (e.g. Litosseliti 2003).

9 CONCLUSION

This paper set out to contribute to our understanding of the impact of individual defects from a key stakeholder perspective by undertaking the literature review and synthesis phase from a wider project to develop and verify a defect impact assessment rating system. The synthesis of the current construction defect literature established a number of aspects with the potential to impact on stakeholders involved with the construction process. The literature review also identified a number of key stakeholder groups within the defect detection and remediation process in the new house building. This paper is concluded by offering the theoretical lens and key stakeholder sampling strategy as the basis for the subsequent impact weighting development phase, the findings of which to be presented at the upcoming conference.

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References

Abdul-Rahman, H. 1995. The cost of non-conformance during a highway project: a case study. *Construction Management and Economics*, **13**(1): 23-32.
Adams, A & Cox, A.L. 2008. Questionnaires, in-depth interviews and focus groups. *Cairns, P & Cox, A.L. eds. Research Methods for Human Computer Interaction.* Cambridge University Press, Cambridge, UK
Ahzahar, N., Karim, N., Hassan, S. & Eman, J. 2011. A Study of Contribution Factors to Building Failures and Defects in Construction Industry. *Procedia Engineering*, **20**: 249-255.
Assaf, S., Al-Hammad, A. & Al-Shihah, M. 1995. The effect of faulty construction on building maintenance. *Building Research & Information*, **23**(3): 175-181.
Atkinson, A. 2002. The pathology of building defects: a human error approach. *Engineering, Construction and Architectural Management*, **9**(1): 53-61.
Auchterlounie, T. 2009. Recurring quality issues in the UK private house building industry. *Structural Survey*, **27**(3): 241-251.
Baiche, B, Walliman, N & Ogden, R. 2006. Compliance with Building Regulations in England and Wales. *Structural Survey*, **24**(4): 279-299.
BEC. 1991. *Right first time, quality management for the smaller builder*, Building Employers Confederation, London, UK.
BRE: Building Research Establishment. 1988. *Common defects in low-rise traditional housing*. *BRE Digest 268.* BRE Press. Watford, UK
BRE: Building Research Establishment. 1990. *Rehabilitation - a review of quality in traditional housing*, BRE Press, Watford, UK.
Che-Ani, A.I., Tazilan, A.S., M. & Kosman, K.A. 2011. The development of a condition survey protocol matrix. *Structural Survey*, **29**(1): 35-45.
CIC: Construction Industry Council (2014a) Approved Inspectors Register [Online] http://cic.org.uk/ services/register.php [19 January 2015]
CIC: Construction Industry Council (2014b) Insurance and Warranties [Online] http://cic.org.uk/services/ insurance.php [24 September 14]
Craig, N. 2007. *The prevailing trends of defects and snagging in new homes in the UK, unpublished PhD thesis*, Glasgow Caledonian University, Glasgow, UK.
Davey, C, McDonald, J, Lowe, D, Duff, R, Powell, J A, and Powell, J E. 2006. Defects liability management by design. *Building Research and Information* **34**(2): 145-153.
DCLG: Department for Communities and Local Government. 2013. Planning Portal - *Approved Document L - Conservation of fuel and power,* UK.
DCLG: Department for Communities and Local Government. 2014a. Get Britain Building. [Online] https://www.gov.uk/government/policies/increasing-the-number-of-available-homes/supporting-pages/get-britain-building [28 April 2014]
DCLG: Department for Communities and Local Government. 2014b. Live tables on house building – Statistical data sets - [Online] https://www.gov.uk/government/uploads/system/uploads/attachment_data /file/282792/LiveTable209.xls [28 March 2014].
de Oliveira Pedro, J., de Paiva, J, and Vilhena, A. 2008. Portuguese method for building condition assessment. *Structural Survey*. **26**(4): 322-335.
Georgiou, J, Love, P & Smith, J. 1999. A comparison of defects in houses constructed by owners and registered builders in the Australian State of Victoria. *Structural Survey*, **17**(3): 160-169.
Georgiou J. 2013. Workmanship and defects in housing in the State of Victoria, Australia. *Association of Researchers in Construction Management*, ARCOM, Reading, UK, **29**: 1047-1056.
Gill, Z, Tierney, M, Pegg, I, & Allan, N. 2010. Low-energy dwellings: the contribution of behaviours to actual performance. *Building Research and Information*, **38**(5): 491-508.
HBF: Home Builders Federation. 2014. HBF 2014 Results. [Online] http://www.hbf.co.uk/ policy-activities /customer-satisfaction-survey/2014-results/ [25 April 2014].
HBS: Home Building Skills. 2013. *Preparing to deliver tomorrow's new homes. Home Building Skills Research Report 2013*, UK.
HM Government. 2011. *Laying the Foundations: A Housing Strategy for England*, Crown, London, UK.

Holmans, A E. 2013. *New Estimates of Housing Demand and Need in England, 2011 to 2031. Town and Country Planning Tomorrow Series Paper 16*. RAP Spiderweb, London, UK

Hopkin, T, Lu, S, Rogers, P & Sexton, M. 2014. Placing defects at the heart of high quality new homes: the learning perspective. *Association of Researchers in Construction Management*, ARCOM, Portsmouth, UK, **30**: 1153-1162.

Ilozor, B, Okoroh, M, Egbu, C & Archicentre. 2004. Understanding residential house defects in Australia from the State of Victoria. *Building and Environment*, **39**(3): 327-337.

Josephson, P & Hammarlund, Y. 1999. The causes and costs of defects in construction: A study of seven building projects. *Automation in Construction*, **8**(6):681–687.

LGO: Local Government Ombudsman. 2014. Complaints about building control [Online] http: //www.lgo.org.uk/publications/fact-sheets/complaints-about-building-control/ [9 January 2015]

Litosseliti, L. 2003. *Using focus groups in research*. Continuum, London,UK.

Love, P., Mandal, P. & Li, H. 1999. Determining the causal structure of rework influences in construction. *Construction Management and Economics*, **17**(4): 505-517.

Love, P & Li, H. 2000. Quantifying the causes and costs of rework in construction. *Construction Management and Economics*, **18**(4): 479-490.

Love, P.E.D & Edwards, D. 2004. Determinants of rework in building construction projects, *Engineering, Construction and Architectural Management*, **11**(4): 259–274.

Macarulla, M, Forcada, N, Casals, M, Gangolells, M, Fuertes, A & Roca, X. 2013. Standardizing Housing Defects: Classification, Validation, and Benefits. *Journal of Construction Engineering and Management*, **139**: 968-976.

Mills, A, Love, P & Williams, P. 2009. Defect Costs in Residential Construction. *Journal of Construction Engineering and Management*, **135**(1): 12-16.

NHBC: National House Building Council. 2011. *Tech. Extra, Feb. 2011.01*, NHBC, Milton Keynes, UK.

NHBC: National House Building Council. 2012. *Buildmark*, Milton Keynes, UK.

NHBC Foundation. 2012. *A survey of low and zero carbon technologies in new housing. NF42*, NHBC Foundation. Milton Keynes, UK

Porteous, W. 1992. Classifying building failure by cause. *Building Research & Information* **20**(6): 350- 356.

Premier Guarantee. 2013. *New home Warranty*, Premier, UK.

Rosenfeld, Y. 2009. Cost of quality versus cost of non-quality in construction: the crucial balance, *Construction Management and Economics*, **27**(2): 107-117.

Smith, J., Smith, B. & Mitchell, G. 2013 Review and analysis of the residential building certification process in south east Queensland, *Structural Survey*, **31**(1): 21-34.

Sommerville, J. 2007. Defects and rework in new build: an analysis of the phenomenon and drivers. *Structural Survey*, **25**(5): 391-407.

Sommerville, J, Craig, N & Bowden, S. 2004. The standardisation of construction snagging. *Structural Survey*, **22**(5): 251-258.

Sommerville, J & McCosh, J. 2006. Defects in new homes: an analysis of data on 1,696 new UK houses. *Structural Survey*, **24**(1): 6-21.

UK Government. 2012. Government takes next step on zero carbon homes - Announcements. [Online] https://www.gov.uk/government/news/government-takes-next-step-on-zero-carbon-homes--2 [5 February 2014].

UKCES: UK Commission for Employment and Skills. 2012. *Sector Skills Insights: Construction. Evidence Report, 50*. UK.

Watt, D. 1999. *Building pathology: Principles and Practice,* Blackwell Science, Oxford, UK.

Wilcox, S & Perry, J. 2013. *UK Housing Review 2013 Briefing Paper*, Chartered Institute of Housing, Coventry, UK.

Yao, R & Yu, C.W.F. 2012. Towards 'Zero-carbon homes' – issues of thermal comfort. *Indoor and Built Environment,* **21**(4): 483-485.

Zero Carbon Hub. 2014. *Cost Analysis: Meeting the Zero Carbon Standard*, Zero Carbon Hub, London, UK.