PLACING DEFECTS AT THE HEART OF HIGH QUALITY NEW HOMES: THE LEARNING PERSPECTIVE

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The UK new-build housing sector is facing dual pressures to expand supply, whilst delivering against tougher planning and Building Regulation requirements; predominantly in the areas of sustainability. The sector is currently responding by significantly scaling up production and incorporating new technical solutions into new homes. This trajectory of up-scaling and technical innovation has been of research interest; but this research has primarily focus on the 'upstream' implications for house builders' business models and standardised design templates. There has been little attention, though, to the potential 'downstream' implications of the ramping up of supply and the introduction of new technologies for build quality and defects. This paper contributes to our understanding of the 'downstream' implications through a synthesis of the current UK defect literature with respect to new-build housing. It is found that the prevailing emphasis in the literature is limited to the responsibility, pathology and statistical analysis of defects (and failures). The literature does not extend to how house builders individually and collectively, in practice, collect and learn from defects information. The paper concludes by describing an ongoing collaborative research programme with the National House Building Council (NHBC) to: (a) understand house builders' localised defects analysis procedures, and their current knowledge feedback loops to inform risk management strategies; and, (b) building on this understanding, design and test action research interventions to develop new data capture, learning processes and systems to reduce targeted defects.

Keywords: action research, defects, house builders, new homes, risk management.

INTRODUCTION

In the United Kingdom (UK) there is a considerable shortfall in the number of dwellings required (Wilcox and Perry, 2013). It is claimed that an additional 240,000 homes a year will be required to meet demand and needs (Holmans, 2013), a housing output increase of over 70% when compared to 2012 levels (DCLG, 2014a). In order to satisfy the increased 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

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designed to enable house builders to progress housing development sites that have stalled, have not started or are classified as being on hold (DCLG, 2014b).

In addition to increasing housing supply, under the Climate Change Act (2008) the UK has set a 2050 target to achieve carbon emissions reductions of 80% compared to 1990 levels. One contributing factor to achieving these reductions is the target for all new houses to be 'zero carbon standard' (Zero Carbon Hub, 2014) from 2016 (UK Government, 2012). The zero carbon home agenda has resulted in the introduction of tougher planning and Building Regulations, including changes to part L 'Conservation of Fuel and Power' (DCLG, 2013).

The house building sector has responded to the dual pressures by significantly ramping up supply, with a 23% increase in new housing starts for 2013 compared to 2012 volumes (DCLG, 2014a). In addition to increasing supply, the house building sector is incorporating new technical solutions into new-build houses to meet the tougher regulatory requirements (NHBC Foundation, 2012). Whilst responding to these pressures, the sector is reporting materials, skills and workforce shortages following the 2008 economic downturn. The reported shortages are causing concerns within the industry over future housing quality (e.g. UKCES, 2012; HBS, 2013); however, there is scant rigorous empirical evidence to verify the reported concerns.

The paper offers an insight into the challenges facing the new-build housing sector: increasing the production of new houses, whilst developing new technical solutions to meet tougher low-carbon regulation requirements. A review of new-build housing sector literature finds authors concentrating on the 'upstream' implications for house builders of the new ramping up of production whilst delivering against a new set of regulations. The extant literature, though, gives scant consideration to potential 'downstream' implications, namely build quality and defects. The literature review distils a number of gaps within the literature, culminating in a proposed research agenda to address these gaps.

NEW HOUSE-BUILDING INDUSTRY PRESSURES

New technical solutions

In the UK new-build housing industry, the up-scaling of production, with the incorporation of new technical solutions to meet new regulatory requirements has been of research interest. The significant emphasis of research focuses on the new technical solutions (material artefact) itself: how it performs, the demands of the system when integrated and the micro-economics of the system (e.g. Bevan and Lu, 2012). The potentiality of the new technologies is of particular interest. Hinnells (2008), for example, identifies a number of potential new technologies (including fabric measures and micro-generation) to achieve reductions in energy demand. Sodagar *et al*. (2011), for instance, conclude that straw bale construction is a viable option to reduce carbon emissions.

Upstream implications for business model and standardised design template

A number of commentators have highlighted the upstream implications of new technical solutions for house builders' business models and standardised design templates (e.g. Lees and Sexton, 2014; Pan, 2010). Standardised design templates are defined as *"the design and production plans and practices which, through constant repetition from development to development, permit house builders to meet the various market and regulatory requirements as economically as possible"* (Lees and Sexton, 2014: 277). Lees and Sexton (2014) indicate that the rationale for the choices

of new technical solutions by house builders is to minimize the disruption to their standard design templates. Sodagar *et al*. (2011) highlight the lack of material availability and pressures on suppliers as part of the minimisation of disruption logic pursued by housing builders.

Downstream implication for build quality and defects

The importance of potential 'downstream' implications of the ramping up of supply and the introduction of new technologies for build quality and defects is less prominent in the literature, but strands are to be found and are growing in volume and influence. 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. Yao and Yu (2012), for example, raise concerns of the risk of overheating in zero carbon homes with high thermal performance and airtightness characteristics. While Osmani and O'Rielly (2009) report builders' concerns about micro-renewables bolted on to properties, following several instances where damage has occurred after installation. Gill *et al*. (2010) drill further down on the types of defects in the low-energy homes they surveyed. These defects include numerous leaks to rainwater harvesting systems and the failure of a biomass district heating system.

There has been even less focus on the potential effects of ramping up housing supply will have on the new build housing sector in general. The house building industry is said to be particularly prone to the cyclical cycle of boom and bust (Eurostat, 2010). It is often argued that in periods of housing market boom, build quality is reduced as delivery dates tighten and materials/workforce capacity becomes stretched (e.g. Sommerville *et al*., 2004). The quality question is especially salient and raises a potential pressure for site management. In addition to quality being neglected, other pressures exist at the site management level and beyond, evidenced by the house building sector currently reporting materials, skills and workforce shortages (e.g. HBS, 2013; UKES, 2012).

When the issues of skills, materials and workforce shortages caused by the rapid increase in production are coupled with the additional requirement to introduce new technical solutions into new homes to conform to tougher regulations, a number of potential downstream implications for suppliers, site management, trades, and general build quality may arise. The Home Builders Federation (HBF) survey results (HBF, 2014) 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. The results provide early indications that the current new-build housing pressures may be eroding build quality.

UK NEW-BUILD HOUSING DEFECTS

Research into new-build housing defects in the UK is comparatively limited. There are two potential problems of this lack of explicit research into UK new-build housing defects. First, a large number of publications tend to focus on work within the wider construction sector (e.g. Porteous, 1992; Latham, 1994; Josephson and Hammarlund, 1999; Love and Li, 2000) or non-new-build housing (e.g. Page and Murray, 1996; Olubodun, 2000). Second, new-build housing defect research is largely non-UK based and tends to focus in, Australia (e.g. Georgiou et al., 1999; Ilozor *et al*., 2004; Mills *et al*., 2009) and Spain (e.g. Macarulla *et al.*, 2013).

The UK new housing defects are researched under a number of categories, including: defects (e.g. Atkinson, 2002), snags (e.g. Sommerville and McCosh, 2006), faults (e.g. BRE, 1990) and non-compliance (e.g. Baiche *et al*., 2006). These terms appear to be used interchangeably to describe similar research into the area of imperfections in buildings.

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 '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'.

A 'fault' is described as an unacceptable departure from good practice set out in Building Regulations and other authoritative publications (BRE, 1990), while Baiche *et al*. (2006) infer a 'non-compliance' to be a failure to adhere to Building Regulations, or approved standards.

Due to the differing categories, Sommerville (2007) argues the need for a standard lexicon, suggesting a lack of consistency in terminology as a factor that constrains research into defects. Despite the non-standard terminology within the literature, the authors often produce similar causes of the occurrence of defects. These causes include, for example, poor site management, supervision and inadequate quality inspections (e.g. Auchterlounie, 2009; Atkinson, 2002); and, lack of trade/operative skills and knowledge (e.g. Baiche *et al*., 2006; Somerville and McCosh, 2006). Based on common findings, authors tend to advocate similar recommendations to reduce defect prevalence. The consistency in findings and recommendations within the UK new-build housing defect literature suggests that standardising terminology is not a key factor in enhancing future research and reducing defects. As the UK defect scholarship utilises differing terminology and categorisation for defects, this begs the question as to whether individual house builders have differing interpretations for what constitutes a defect.

Despite the differing terminology within the literature, research into new housing defects can be generally grouped into three aspects: (a) the stage in which the housing project is studied; (b) the level of analysis; and, (c) the findings, and how the findings are used. Each aspect is discussed below.

(a) The stage in which the housing project is studied

The defect literature tends to focus on a particular stage of a house building project, without a whole project perspective being considered. The stages typically studied include the construction stage (e.g. Atkinson, 2002), and the post completion stage (in particular, the first two years post completion) (e.g. Sommerville and McCosh, 2006). In addition to focussing on a particular stage, prevailing literature draws upon small sample sizes. For example, Atkinson (2002) observes a single housing site while Baiche *et al*. (2006) investigate eleven local housing developments. These studies provide valuable detail in depth but are limited in the representativeness of the results.

Research that does investigate large sample sizes (covering a wide range of house builders and geographical areas) focuses on defects occurring within the first two years of a property's life (e.g. Sommerville and McCosh, 2006). The investigation of

defects that occur within the first two years tends to produce results that indicate that the majority of problems are related to aesthetics e.g. the general finish of the property (e.g. Auchterlounie, 2009; Sommerville, 2007; Craig, 2007).

The occurrence of defects within new-build houses is however not limited solely to the first two years post completion. Outside of the first two year period, new-build houses are subject to a further eight year warranty period (Sommerville and McCosh, 2006), where the warranty provider will keep a record of claims as part of their risk assessment procedures (Auchterlounie, 2009).

According to the National House Building Council (NHBC, 2013), defects occurring during years 3-10 of the NHBC warranty include foundations, substructure and ground floors, superstructure, roofs, services, fixtures and finishes, and ancillary buildings and external works (see Figure 1 below). The results indicate a different defect trend from the 'aesthetic' issues reported in the first two years. It also confirms new-build properties are not defect free the moment they move outside of the defects liability period (two years). (Note: The National House Building Council (NHBC, 2014) is the UK's largest new-build warranty provider, providing cover on circa 80% of all new homes built within the UK.)

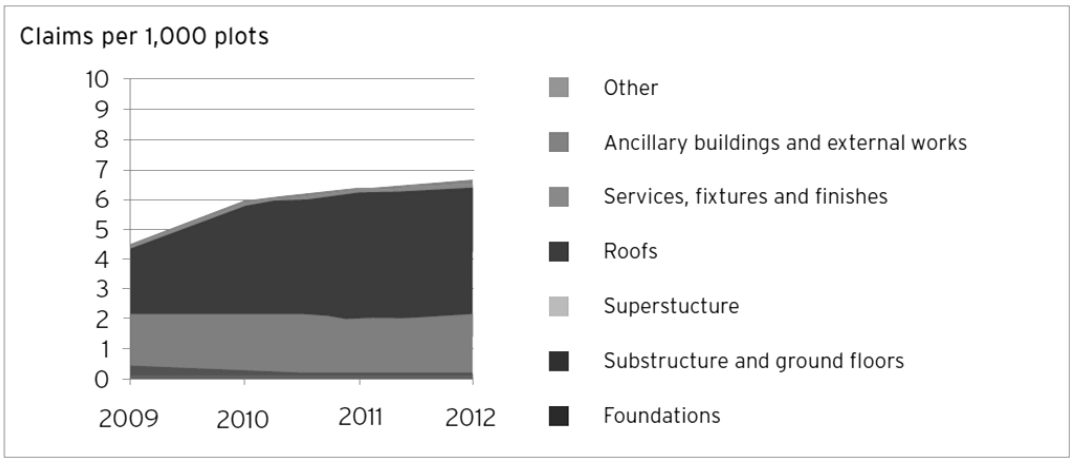

Figure 1 - Defects occurring during years 3-10 of the NHBC warranty (NHBC, 2013)

(b) The level of analysis

Generally, the UK new home defect literature focuses on industry level analysis as opposed to individual house builders. The industry level analyses can provide useful aggregated insights (e.g. Atkinson, 2002; Barker, 2004; Callcutt, 2007; Auchterlounie, 2009), but can be prone to assuming that all house builders have the same characteristics and associated performance. There are notable exceptions that do acknowledge the heterogeneous nature of the new-build housing sector. Sommerville *et al*. (2004), for example, highlight the multitude of methods that individual house builders use when recording and undertaking the snagging process. Similarly, Sommerville and McCosh (2006) argue that there is a clear difference in quality from one house builder to the next. Of the publications that differentiate between organisations and their respective processes (excluding Davey *et al*., 2006), the majority prescribe a *"standard"* solution for all house builders (e.g**.** Egan, 1998; Roy *et al*., 2003; Sommerville *et al*., 2004). The appropriateness of a 'standard solution', given the varied nature of house builder types and practices is an empirical question which has not been adequately investigated.

(c) The findings and how they are used
The research findings within the UK new-build housing defect literature are generally centred around: numerical occurrences of defects (e.g. Sommerville and McCosh, 2006), responsibility for defects taking place (e.g. Atkinson, 2002), the type of defects occurring (e.g. Baiche, *et al*., 2006), and the links between defects and home owner satisfaction (e.g. Auchterlounie, 2009). The existing research findings suggest that generally authors are able to establish the number, types, cause, and home owner satisfaction relationship of defects. However, a common feature running through the majority of the UK new-build housing defect literature is how findings and recommendations are seldom actively reported back to the house builder to assist with their feedback and learning processes (e.g. Sommerville and McCosh, 2006; Auchterlounie, 2009).

DISCUSSION

What has become clear from the review of literature surrounding the challenges facing the UK new-build housing sector (i.e. increase of supply, and regulatory change) is a primary focus on the potential upstream implications this has for the house builder. The literature regarding the new-build sector's challenges has not focused on the potential downstream implications of the ramping up of supply and the introduction of new technologies for build quality and defects.

The synthesis of UK new-build housing defect scholarship highlights a multitude of differing terms and categories to define defects. These differing terms raise the question as to how house builders interpret and classify defects. The extant literature, whilst using differing terminology for defects, adopts a similar approach, undertaking research into defects occurring at either the construction stage, or within the first two years post completion. The new-build defect literature lacks a broad approach (Sommerville, 2007), that utilises UK wide data of defects being discovered in both the defects liability period (first two years), and later on within the property's life (the additional eight year warranty period). Such data would provide a new research opportunity to understand the types of defects occurring within the first ten years of a large number of UK new-build houses, as well as allowing researchers to differentiate between separate house builders.

One reason for differentiating between separate house builders is that the defects literature generally either present house builders as being uniform, focussing on industry level analysis, or authors assume that a one fits all 'standard' solution to a given problem is appropriate for all house builders. One drawback of UK new build housing defect research reporting on an industry level is a lack of a feedback loop. In other words, the research findings and proposals are rarely actively reported back to the house builder**.** Egan (1998) suggested that house builders should in general methodically assess completed projects, in order to feed the knowledge gained back into future development processes as a form of continuous learning, with Callcutt (2007) arguing the need for a consistent assessment of quality. One way of introducing the missing feedback loop to the UK new-build housing defect research could be to adopt a 'post occupancy evaluation' (POE) approach. Within the field of building performance POEs are utilised (e.g. BRE, 2003). The POE is concerned with providing feedback relating to factors for achieving success in the design, construction, and use of buildings, with an aim of learning from this active feedback in order to make improvements in future projects (e.g. Cohen *et al*., 2001).

Introducing a feedback loop to new-build housing defects (as opposed to simply analysing post completion defects), may provide house builders the opportunity to learn from active feedback, to enable them to make informed small changes to their respective processes, and subsequently improve future 'repeat projects', the *"learning perspective"*. Whilst the 'learning perspective' has been suggested as a means of continuous improvement within the house building sector in general (e.g. Egan, 1998; NAO, 2007) the extant new-build housing defect literature is silent on how house builders actually learn and make improvements based upon past experience, if at all.

To summarise, a number of gaps within the literature have been highlighted: a) the lack of research into downstream aspects of the UK housing industry dual pressures, namely build quality and defects; b) the need to understand house builder's categorisation and interpretation of defects; c) the requirement for a broad research approach utilising data from both the first two years, and the following eight year warranty period to give an understanding of defects occurring later within a property's life, larger regional coverage, and the ability to differentiate between separate builders; d) the call for studying individual organisations and their differing processes in order to understand their respective processes regarding post completion defects, and learn from the better performing organisations; and finally, e) building upon this gained knowledge, develop the 'learning perspective' by utilising a POE approach to new-build housing defects, to introduce small changes (in line with their current processes) achieved by providing feedback to the house builders, with an aim of the organisations learning from this active feedback in order to make improvements in future 'repeat' projects, and reducing defects.

FUTURE WORK

As part of an ongoing collaborative research programme with the National House Building Council (NHBC) the authors propose to investigate the gaps identified in the previous section. First, develop an understanding of house builders' localised defect interpretations, data capture, and analysis procedures. In addition to comprehending how these procedures inform the builders' subsequent risk and quality management procedures. Finally, building upon this understanding and by drawing upon NHBC warranty data and builder repair records; test action research interventions to develop new defect assessment tools and post occupation evaluation (POE) learning systems that can fit in to the individual organisation's existing business models and processes in order to reduce future occurrences of prevalent defects.

CONCLUSION

This paper set out to establish the challenges facing the new-build housing sector, finding research to be favouring studies in to 'upstream' implications for house builders; whereas the scholarship gave scant consideration to potential 'downstream' implications, namely build quality and defects. A synthesis of the current UK new-build housing defect literature established a number of research gaps**,** especially how house builders actually learn and make improvements in order to reduce defect prevalence via knowledge gained past experience**.** The end result of the paper is a collaborative research project with the NHBC to address the gaps in literature. Research to understand how organisations both individually and collectively in practice; record, analyse and learn from their defect experiences, concluding in the development of defect assessment tools and learning systems to reduce prevalent defects.

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