DEFECTS OF NEW-BUILD DWELLINGS CONSTRUCTED TO BUILDING REGULATIONS AND TO THE 'CODE FOR SUSTAINABLE HOMES'

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Defect is an important aspect to address for enhancing quality of homes. However, there is little research into defects of new-build homes in the UK constructed to the 'Code for Sustainable Homes' which has been introduced to the UK building industry since 2007 as an environmental assessment tool. The aim of this paper is to contribute to knowledge of the defect profile of new homes regarding the defect number, type, location, severity and responsible trades. The research was carried out through analysing defect records for 327 homes in the UK constructed to the Code in comparison with to Building Regulations. In total 3209 defects were identified, with the mean average of 9.8 defects per home. Despite some extreme cases 91.4% of the dwellings studied were reported of 20 or less defects each. It is concluded that the defect profile of UK new-build homes since 2007 has improved in number, diversity and severity of defects. Nevertheless, kitchens and bathrooms remained as two most defective areas, with plumbers and painters/decorators being most often tasked for rectifications. With the evidence presented no clear relationship was observed between the defect profile of the homes and their performance standards or build methods adopted.

Keywords: building standard, defect, quality, sustainable home.

INTRODUCTION

Housing represents a significant part of our society. In the UK, public and private housing together contributes a total value of £3,923 billion or 56% of the nation's wealth (Office for National Statistics 2009). Previous research has estimated that defects cost between 2-6% of the overall build cost during construction (Ball 1987; Hammarlund 1990; van den Beukel 1989), and between 3-5% in post-completion maintenance (Josephson and Hammarlund 1999). Therefore, eliminating defects and maintaining good quality have an important cost benefit for the society. The Callcutt Review (2007:63) advocates that the high demand for housing must not be met with housing to a low standard, 'building to a low standard, where new housing incurs additional cost because defects in design or construction have to be expensively remedied after occupation, is a false economy'.

Although it may be inevitable that defects in a building occur through general wear and tear, defects due to human errors in the construction of a home should be

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mitigated. However, previous research (e.g. Assaf et al. 1996; Harrison 1993; Pheng and Wee 2001) has suggested that most defects identified of new-build homes are actually attributed to human errors in relation to design, specification, workmanship and management, which imposes an urgent need for attention of both research and practice. The UK government announced the ‘Code for Sustainable Homes’ (CSH) in 2006 to be ‘A mark of quality’ (DCLG 2006:5), which replaced ‘EcoHomes’ as the environmental assessment tool for new domestic buildings in the UK. The CSH has since April 2007 been adopted in the UK, as a voluntary scheme but often made required by planning authorities. In such cases, the adoption of the CSH imposes additional performance requirements to Building Regulations that represent a compulsory minimum level of performance standards, and therefore introduces an opportunity but also a challenge to quality control. The number of defects has been regarded as an important indicator of quality of homes (see e.g. Harrison 1993; Auchterlounie 2009). However, despite the previous studies on the types and locations of defects in domestic buildings, most such research was with buildings constructed to Building Regulations, while there is very little research into defects of homes built to the CSH. Also, it remains unclear if the adoption of the CSH has had any impact on the defect profile of new-build homes.

Therefore, the aim of this paper is to contribute to knowledge of defects in new-build dwellings constructed after the CSH was introduced to the UK building industry. Several questions guided this research: 1) What is the defect profile, e.g. number, type and location of defects, of new-build homes constructed to the CSH in comparison with those to Building Regulations only? 2) How severe are such defects? 3) What trades are responsible for rectifying such defects?

LITERATURE REVIEW

The concept of defect

Number of defects is a key indicator of quality that has been used in the house building industry (Auchterlounie 2009). Harrison (1993) reported that quality was directly related to the number of defects found in a property. However, there exist many terms similar to 'defect' in the literature of construction management, such as rework (Love 2002), quality deviation (Burati et al. 1992), nonconformance (Abdul-Rahman 1995), quality failure (Barber et al. 2000), non-compliance (Pan and Garmston 2012), fault (Bonshor and Harrison 1982) and snag (Love 2002; Sommerville et al. 2004).

Love (2002:19) defined rework as ‘the unnecessary effort of redoing a process or activity that was incorrectly implemented the first time’. Ashford (1992) defined rework as ‘the process by which an item is made to conform to the original requirement by completion or correction’. Snagging is referred to by the independent UK body Inspector Homes Ltd as the act of checking a new home for difficulties with the quality of finish and workmanship. Accordingly, Sommerville et al. (2004) regarded snags as the items identified near completion stage of a construction project which require remediation or action. The BRE study (Bonshor and Harrison 1982:1) defines a ‘fault’ as ‘a departure from good practice as established by criteria in the published requirements and recommendations of authoritative bodies. Additionally, for site faults only, a departure from a design requirement’.

With regard to the concept of defect, Josephson and Hammarlund (1999:683) used the definition ‘the non-fulfilment of intended usage requirements’. Barrett (2008) defined defect as ‘a lack or absence of something essential to completeness’. The BSI (2004:86) defined defect as ‘fault or deviation from the intended condition of a material, assembly or component’, where ‘fault’ is defined as ‘inability to function properly’ (p.86), and ‘deviation’ as ‘algebraic difference between a size and the corresponding required size’ (p.77).

The many terms outlined above are interrelated with each other but different in their scopes and definitions. None is universally accepted. The complexity of the concept of defect is further complicated by the value-laden nature of this concept and indeed also the concept of quality in a broader sense that people’s perceptions and expectations can be very diverse, dependant on their roles. In the context of housebuilding, such roles may include policy-makers, builders, occupants and end-users. Nevertheless, defects are commonly categorised as being either patent or latent; a defect is patent if observable, whether or not it is actually observed, while latent defects are hidden and not observable (Barrett 2008). The research reported in this present paper addressed defects in buildings which occupants encountered and reported to the builders and developers of concern.

Types and locations of defects of homes

Defects may be associated with any element of the building. Marshall et al. (2009) identified typical defects that can be found in poorly designed, built and/or managed domestic properties less than 10 years old. Such defects included: cracks in walls especially at natural lines of structural weakness, e.g. windows, doors junctions with extensions and bays; bulging/bowing of walls; rising dampness; uneven ground floor slabs; movement in upper floors; damp penetration of roof; cracking to render; loose/hollow render; condensation; faulty heating, plumbing and electrics; and blockages/leaks to drainage. Marshall et al.’s (2009) list is not exhaustive but provides a useful outline of commonly encountered defects in residential buildings. It has also been recorded that significantly disproportionate numbers of defects occur in the wet areas of buildings. Chew (2005) commented that wet areas account for 10% of a building’s gross area but contribute 30-50% of the building’s total maintenance cost. Defects associated with the wet areas are often attributed to the constant drying and wetting cycles experienced in rooms like bathrooms and kitchens. Chew (2005) recorded leaks as the most common type of defects in these areas, accounting for 53% of all the defects studied. Johnson and Meiling (2009) studied offsite prefabricated timber modules in Sweden, and recorded defects which included holes and mess on the walls caused by craftsmen, missing linings around doors and windows, and doors in need for adjustment owing to movements in the structure. In Johnson and Meiling’s study, 33% of all defects were related to walls and 52% to walls or openings.

Previous research on defects of new-build homes in the UK

Sommerville et al. (2004:256) collated data from over 600 new home inspection surveys and suggested that larger houses contained larger numbers of ‘snags’, and that in an extreme case, ‘A staggering 406 snags were found and recorded within a five-bedroom residential property after the building had been snagged by the builder’. Sommerville and McCosh (2006) further analysed the defects identified in 1696 new homes in the UK, and reported an average number of 59 defects per property. However, there was a considerable variation, with the number of defects per property ranged from 1 to 389 (with the standard deviation of 47) and five properties with over 300 defects reported. This study confirms the positive correlation between 'number of defects' and a number of factors including 'number of bedrooms' and 'size of property'.

However, despite these studies, little research exists into the defects of homes in the UK built after the CSH was adopted in 2007.

RESEARCH METHODS

The research reported in this paper employed an analytical case study approach to analysing the profile of defects of new-build homes. All data were collected from archived maintenance records of defects of new-build homes. The use of this data collection method enabled the collation of a large amount of detailed data and information in an accurate and time-efficient manner. The same method was used in previous studies of defects (e.g. Chew 2005; Chong and Low 2006; Sommerville and McCosh 2006). Maintenance records of defects of new-build homes may be archived in various types of organisations, including housing associations, housebuilders, responsive and planned maintenance contractors, and new-build contractors. However, many organisations consider their records of defects to be highly confidential, and therefore are reluctant to release the data for research. The data reported in this paper were collected from a national housebuilder in the UK, which operated in both social and private housing markets and supported research and development. The researcher was placed in this organisation for a year, and the good rapport built between the researcher and the organisation facilitated the obtainment of the effective access to data and information for this study.

In total eight projects of the case organisation were selected for the research. The selection of the projects took into account the following considerations in order to address the research questions and to ensure data consistency: 1) full records of defects were available for the project; 2) two types of projects were included, i.e. built and certified to the CSH and to Building Regulations 2006 to allow comparison. The selected projects together consisted of 327 separate dwellings, of which 169 (52%) were designed, constructed and certified to Building Regulations 2006 and 158 (48%) to the CSH Level 3. These dwellings were built using traditional masonry methods (166 dwellings; 51%) and timber frame methods (161 dwellings; 49%) (Table 1).

Table 1 Research sample of dwellings by number, build method and performance standard

Project	No. of homes	Build method		Performance standard	
		Timber Frame	Masonry	Part L 2006	CSH Level 3
1	61	61	0	0	61
2	44	44	0	0	44
3	37	0	37	0	37
4	16	0	16	0	16
5	53	16	37	53	0
6	40	40	0	40	0
7	36	0	36	36	0
8	40	0	40	40	0
Total	327 (100%)	161 (49%)	166 (51%)	169 (52%)	158 (48%)

Masonry denotes traditional masonry method used in the UK, with insulated cavity walls.

These features enabled the achievement of a like-for-like comparison of the profiles of defects of dwelling groups by ‘performance standard’ and by ‘build method’. The mean total floor area of the dwellings was 87m2 with the smallest 47m2 and the largest 169 m2. The dwellings studied were built in South Wales (198; 57.7%) and

Southwest England (145; 42.3%) which are associated with an essentially maritime climate, characterised by weather that is often cloudy, wet and windy but mild (Met Office 2011). The dwellings studied consisted of 261 houses (80%) and 66 flats (20%), which align well with the general 80/20 split between houses and flats of new-build homes in England and Wales (see Goodier and Pan 2010).

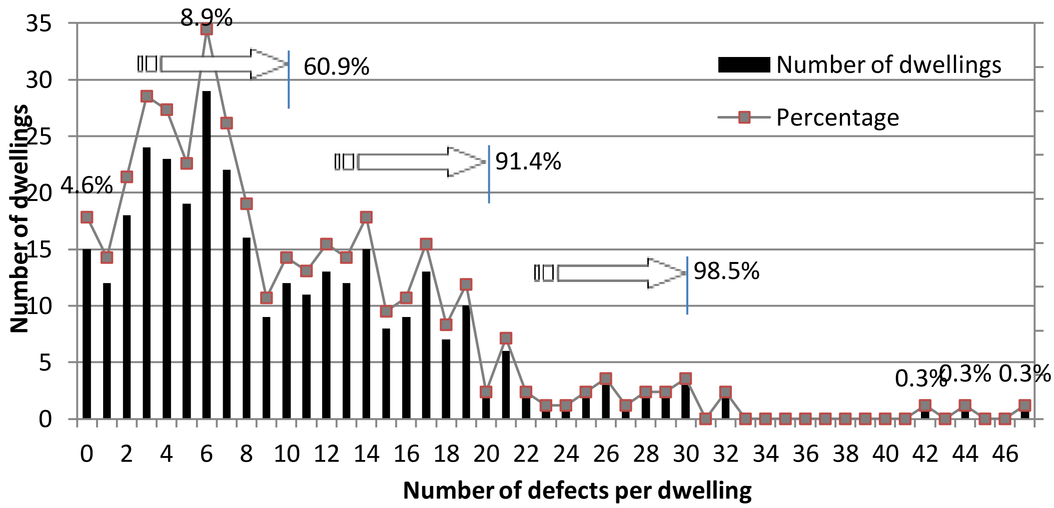
Data were collated using the defects registers kept at the case organisation, and then stored and analysed using Excel Spreadsheet and the IBM SPSS Software. The data analysis reported in this paper was mainly descriptive in nature to provide an overview of the defect profile. All defect descriptions recorded in the defect registers were analysed in order to identify and group the areas and types of defects in the dwellings thoroughly and effectively.

RESULTS AND ANALYSIS

Overview of the defects

In total 3209 defects were identified in the defect records for the 327 dwellings studied, with the mean average of 9.8 reported defects per dwelling and the mode average of 6 reported defects per dwelling (8.9%). Fifteen dwellings (4.6%) were reported of no defect, while 3 dwellings were reported of significantly larger numbers of up to 47 defects per dwelling. Almost all (98.5%) dwellings were reported of 30 or less defects each, 91.4% of 20 or less, and 60.9% of 10 or less (Figure 1).

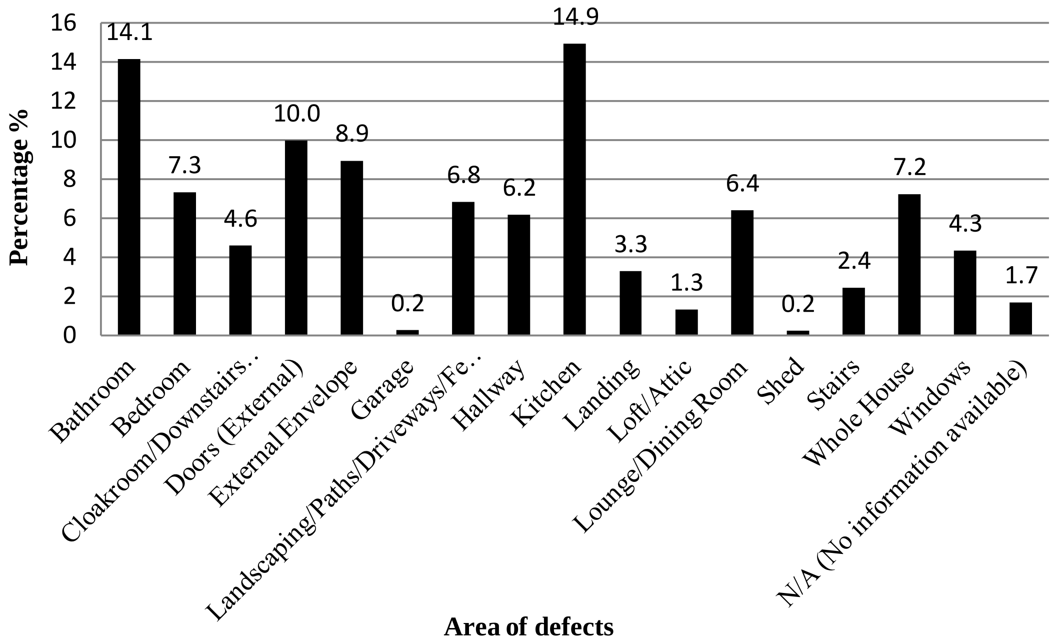
Figure 1 The overall profile of defects (n=3209)



Area of defects

In total 16 areas of defects were identified, which were: bathroom(s), bedroom(s), cloakroom (downstairs W/C), external doors, external building envelope, garage, garden (landscaping, fencing and driveways/pathways), hallway, kitchen, landing, loft/attic, lounge/dining room, shed/external stores, stairs, whole house (multiple room defects), and windows. All the 3209 defects recorded were distributed unevenly throughout these areas. The two areas with the largest numbers of defects were 'kitchens' (479 defects; 14.9%) and 'bathrooms' (454 defects; 14.1%), followed by 'external doors' (320; 10%), 'building envelope' (287; 8.9%) and 'bedroom' (235; 7.3%). The areas associated with the smallest numbers of defects were 'garages' (8; 0.2%), 'sheds' (7; 0.2%), and 'loft' (42; 1.3%) (Figure 2). A caveat for the areas with the smallest numbers of defects was that not all dwellings were designed with a shed or garage, and that where a shed and/or garage were included, the basic finishes to these areas reduced the likelihood of defects occurring. The lower level of defects recorded of the loft area might also be attributed to the low level of activity in this area so defects might often go unnoticed for a long period of time.

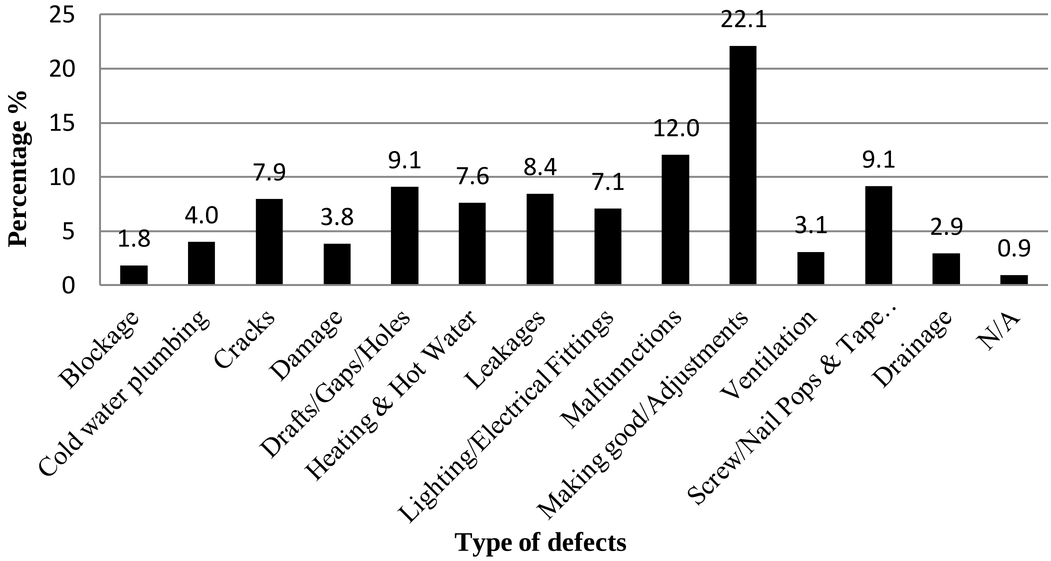
Figure 2 The profile of defects by area (n=3209)



Type of defects

In total 13 types of defects were identified, which were: blockage(s), cold water system, cracks, damage, draught(s)/gap(s), heating and hot water system, leakage(s), electrical systems, malfunctions (materials and components), making good/minor adjustments, ventilation system, screw/nail pops and tape blows, and drainage. All the 3209 defects recorded were distributed unevenly throughout these types, with the most significant defect type being ‘making good or adjustments to the finished dwelling’ (709 defects; 22.1%), followed by ‘malfunctions’ (386; 12%), ‘screw / nail pops and tape blows’ (293; 9.1%), ‘drafts/gaps/holes’ (291; 9.1%), ‘leakages’ (271; 8.4%), ‘cracks’ (255; 7.9%), etc. (Figure 3).

Figure 3 The profile of defects by type (n=3209)

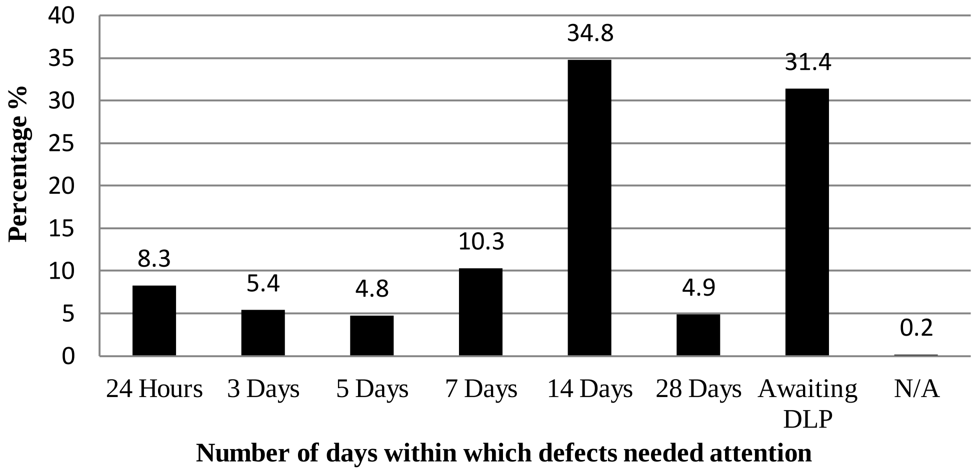


Severity of defects

In total seven different levels of severity of defects (which denote the levels of urgency measured by the number of days in which the defects needed attention) were identified, namely, 1 day, 3 days, 5 days, 7 days, 14 days, 28 days, and awaiting Defects Liability Period (DLP). The defects that required soonest attention, e.g. within 3 days, represented the most severe ones. The non-critical cosmetic and decorative defects were given longer periods before attention was needed. Awaiting the DLP denotes that a defect needed to be rectified before the end of the DLP. The DLP refers to the period in which the housebuilder was responsible for any defect occurring, and this period normally lasts for 12 months after the housebuilder's handover of the dwelling to the occupant in the UK contracting practice. Towards the end of the DLP a final inspection was conducted and any remaining defects were highlighted and needed to be addressed by the housebuilder before the responsibility for addressing any future defects was fully handed over to and absorbed by the housing association of concern.

Over a third (1116; 34.8%) of the defects studied required attention within '14 days', and nearly a third (1007; 31.4%) fell into the DLP category and were not deemed critical by the occupant, client or customer care team. These two categories were followed by around a tenth (331; 10.3%) of the defects requiring attention within '7 days'. Only 8.3% (266) of the defects studied were deemed most critical requiring attention within 24 hours (Figure 4).

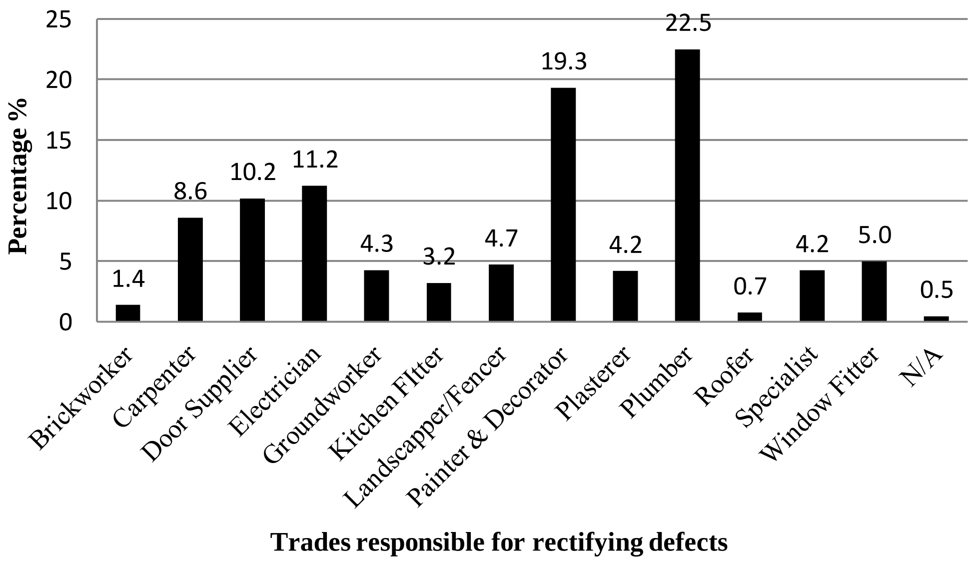
Figure 4 The profile of defects by severity (n=3209)



Responsibility for rectifying the defects

In total 14 trades and sub-contractors were deemed responsible for rectifying the defects, which were: brickworkers, carpenters, door suppliers, electricians, groundworkers, kitchen fitters, landscapers/fencers, painters & decorators, plasterers, plumbers, roofers, specialists (e.g. ventilation), and window fitters. Over a fifth of all the defects (722; 22.5%) were associated with 'plumbers' (which also included heating engineers), followed by 19.3% (620) of the defects associated with 'painters and decorators' (Figure 5).

Figure 5 The profile of defects by responsibility for rectification (n=3209)



Defects and performance standards and build methods

By performance standard, 51% of the 3209 reported defects were associated with the homes designed, built and certified to Building Regulations 2006 (accounting for 52% of the sample dwellings), and 49% of the defects were associated with the homes designed, built and certified to the CSH Level 3 (accounting for the other 48%) (Table 2). The almost same profiles of defects and homes by performance standard suggest a general unclear relationship between the number of defects and the performance standard adopted for the dwellings studied as a whole. By build method, 51% of the 3209 reported defects studied were associated with the masonry homes (accounting for 51% of the sample dwellings), and 49% of the defects were associated with the timber framed homes (accounting for the other 49%) (Table 2). The same profiles of defects and homes by build method suggest a general unclear relationship between the number of defects and the build method adopted for the dwellings studied as a whole.

Table 2 The profile of defects by performance standard and build method

	Timber frame	Masonry	Total
Built to Building Regulations	695 (42%)	947 (58%)	1642 (100%)
	(44%)	(58%)	(51%)
Built to CSH Level 3	876 (56%)	691 (44%)	1567 (100%)
	(56%)	(42%)	(49%)
Total	1571 (49%)	1638 (51%)	3209 (100%)
	(100%)	(100%)	(100%)

DISCUSSION AND CONCLUSIONS

Previous research has examined the types and locations of defects in domestic buildings. However, much such research in the UK was with the buildings constructed to Building Regulations, while there is little research into defects of homes built to the CSH which has been introduced to the UK building industry since 2007. Also, it remains unclear if the adoption of the CSH has had any impact on the defect profile of new-build homes. In addressing the gaps in knowledge, this paper has examined the profile of defects in new-build dwellings in relation to the defect number, type, location, severity and responsible trades.

The mean average of reported defects per dwelling examined in this paper was 9.8, which was significantly lower than those previously reported, e.g. 59 defects per dwelling reported by Sommerville and Craig (2006). Despite a small number of extreme cases with up to 47 defects per home, 91.4% of the dwellings studied were reported of 20 or less defects each, indicating a much less variety than those reported in the UK building industry in previous years, e.g. 406 recorded defects in one property as reported by Sommerville et al. (2004). Nevertheless, kitchens and bathrooms were found to remain as two most defective areas, in terms of number of defects, of the new-build homes studied. This finding is in line with the result reported by Chew (2005). These areas are subject to the most extreme conditions in a home because they are normally humid, wet and hot and go through prolonged wetting and drying cycles. Also, this finding applied to homes built to Building Regulations as well as to the CSH, which suggests that the raised performance standard had no clear impact on the defect profile of the wet areas.

Plumbers and painters/decorators were identified as the two trades most often tasked for rectifying the reported defects. The finding on plumbers supports the results that most significant areas of defects were identified as the wet areas like kitchens and bathrooms. Many rectification activities for the defects associated with 'painters and decorators' actually resulted from 'making good' following other remedial works, which suggests a significant quality control problem towards the end of the construction period where finishes were applied to the dwelling. Nevertheless, it is worth noting that although these trades and subcontractors were responsible for rectifying the defects, they were not necessarily the parties who caused the defects.

This point of argument is also debated in the literature. For example, Pheng and Wee (2001) pointed to human error as the main cause of defects, while Low and Chong (2004) suggested that defects were more of a design based problem. Atkinson (2003) revealed that 82% of the defects studied were attributed to management, and therefore argued that defects were a management based problem. However, the results suggest no clear relationship between the number of defects and the performance standards adopted, i.e. the CSH Level 3 and Building Regulations 2006, or between the number of defects and the build methods utilised, i.e. timber frame and masonry. Nevertheless, only less than one tenth of the defects studied required attention within 24 hours, the vast majority being much less critical.

Drawing on the discussion together the paper concludes that the defect profile of new-build homes in the UK in recent years has improved from reported in the history, in number, diversity and severity of defects. However, critical defective areas remain as bathrooms and kitchens. From the evidence presented it is unclear if the adoption of the CSH has had any significant impact on the defect profile of new-build homes. Future research could cross analyse the multiple factors that influence building defects, results of which should help achieve an alternative insight into the defect profile of new-build dwellings.

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