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Leading UK housebuilders' utilisation of offsite modern methods of construction

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Leading UK housebuilders' utilisation of offsite modern methods of construction

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Abstract

In recent years the industry has been exhorted to increase its utilisation of offsite technologies, or 'Modern Methods of Construction', in order to address the under-supply and poor build quality of housing. Despite the well-rehearsed benefits of such technologies, the take-up within the industry has been slow. This paper reports on research which examined housebuilders' practices and strategies regarding the use of offsite-Modern Methods of Construction (offsite-MMC). A questionnaire survey of the top 100 housebuilders in the UK and a series of interviews were used to reveal the extent to which such technologies are being utilised and the factors which impinge on their popularity. The findings suggest that current offsite-MMC usage in large housebuilders is low, but that the level is likely to increase, given the pressures to improve quality, time, cost, productivity and health and safety. The wider take-up of offsite-MMC is, however, inhibited by perceived higher capital costs, interfacing problems, long lead-in time, delayed planning process and current manufacturing capacity. Based on these findings, the paper provides a set of strategies for improving offsite-MMC practices amongst housebuilders. It is hoped that will help deliver an improvement of housing supply in the UK.

Keywords: Housebuilding, offsite-Modern Methods of Construction (offsite-MMC), practices, strategy.

The total number of words in the manuscript is 5,270. This excludes the abstract, references, tables and figures.

Introduction

The level of housing supply in the UK has declined markedly since the 1960s (ODPM, 2005). This trend, coupled with a large rise in the number of households (Barker, 2005; DETR, 2000; ODPM, 2005), has led to an acute need for new housing throughout the country, and especially in the South East. Concerns abound as to whether traditional construction methods are able to meet the growing housing demand and quality standards (see Barker, 2003; Housing Forum, 2002; ODPM, 2003). It is unsurprising, therefore, that there have been widespread calls for the adoption of offsite manufacturing. The recent Barker Review (2003) suggested that offsite technologies could both improve the quality of construction and offset the impact of skills shortages in the industry. Modern Methods of Construction (MMC) is the term used by the UK Government to describe a number of innovations in housebuilding, most of which are offsite technologies, moving work from the construction site to the factory (Gibb, 1999). Benefits from using such technologies have been widely studied (e.g. Gibb, 1999; Housing Forum, 2002; Parry *et al*., 2003; Sparksman *et al*., 1999; Venables *et al*., 2004) and they mainly include reductions in cost, time, defects, health and safety risks and environmental impact and a consequent increase in predictability, whole life performance and profits. However, despite the attractiveness of offsite technologies, both the nature and the scale of innovation in the UK housebuilding sector are conservative in comparison with other countries (Hooper, 1998). Developers have been slow to adopt innovative building technologies (Ball, 1999;

Barlow, 1999) and many industry stakeholders have concerns about its effectiveness in comparison to traditional methods (POST, 2003).

Various industry and research initiatives have examined the barriers to the use of offsite technologies and seek ways forward in housing supply. However, the extent to which offsite-MMC practices are currently being adopted by housebuilders has been overlooked. This paper contributes to the extant body of knowledge on offsite by reviewing leading housebuilders' current practices and strategies with regard to the use of offsite-MMC. It explores the nature and extent of current offsite practices amongst the top 100 housebuilders, discusses the drivers for and barriers against the use of offsite-MMC and critically examines the strategies adopted by these firms for utilising such technologies.

Offsite-MMC practices in the housebuilding industry

Offsite technologies have long been used in the UK construction industry and range from manufactured components to whole modular building (Gibb, 1999; Housing Forum, 2002). However, the extent of offsite-MMC usage has been seldom recorded, which contributes to the accumulation of uncertainties and prejudices of industry players over the use of offsite technologies. The lack of records and the consequent uncertainties and prejudices may be at least partially attributable to the apparent lack of a uniform definition for offsite technologies. Offsite production and onsite work co-exist in projects no matter what types of offsite technologies are used, and so demarcating what constitutes offsite practices

is problematic. Rather than adding to the debate over definitions, this paper adopts the generic term offsite-MMC to refer to categories of component and sub-assembly, non-volumetric pre-assembly, volumetric pre-assembly and modular building (see Gibb, 1999).

The historic development of offsite-MMC reveals a combination of various driving forces which have encouraged its use, including political, economic, social, technological and environmental factors (Bowley, 1960; Gann, 2000; Gibb, 1999, 2001; Groak, 1992; McCutcheon, 1989; White, 1965). A range of publications have explored the uptake of offsite-MMC from the perspectives of clients (Gibb and Isack, 2003), manufacturers and suppliers (Venables *et al*., 2004) and designers (Pan *et al*., 2004; Pasquire and Connolly, 2003). However, arguably one of the strongest advocates for the use of MMC is the UK Government in its push for its application to the housing sector. From 2004, the Housing Corporation started to require at least 25% of new social housing it funds to be built using MMC (Housing Corporation, 2003). However, government influence on private sector house building to use such methods has been limited, and they have not provided direct incentives for private sector MMC through planning policy or building regulations (POST, 2003). This is significant given the fact that private house builders build almost 90% of new UK homes (Barker, 2003). A few of the larger private housebuilders have invested in MMC factories to increase production (POST, 2003), but these are largely restricted to individual housebuilding firms and there are no established mechanisms for learning and information sharing amongst leading firms (Roy *et al*., 2005).

Arguably, the characteristics of housebuilders determine to a large extent their attitudes and practices of taking up offsite-MMC. There are currently around 18,000 housebuilders registered by the National House Building Council, but only a small proportion of these undertakes the full range of housebuilding activities from acquiring land to selling constructed homes (Barker, 2003). Further, the market is not well stratified, with under 200 firms producing more than 50 homes per year in the UK (Wellings, 2003). The larger housebuilders normally take the role of developing and building houses, some supported by in-house design teams and partnered with their manufacturers and suppliers. However, some developers have no construction capability and sub-contract the entire construction process (Venables *et al.*, 2004). This situation complicates what is a very fragmented sector with many strong regional players and national firms which are formed around a set of regional operations (Barker, 2003). The inevitable corollary of this is that there is little sharing of knowledge and good practice and hence the take up of offsite technologies has been inhibited within the sector. The business focus on eliciting profits from the development of land and the management of finance during this process rather than the actual construction process itself (Ball, 1996; Barlow *et al.*, 2003; Venables *et al.*, 2004) appears to be another factor inhibiting housebuilders' take-up of offsite-MMC.

Since offsite technologies was recommended as part of the solution to improving construction in the Egan Report (1998), various industry and research initiatives have attempted to investigate the industry's use of such technologies. However,

these have focused on examining the attitudes, perceived drivers and barriers, and recommendations for the use of such technologies (Goodier and Gibb, 2004; Parry *et al*., 2003; Venables *et al*., 2004). In terms of the practices and strategies used by housebuilders, an early market survey by Ross (2000) investigated the use of offsite manufacture (OSM) by around 200 social housing organisations and 100 builders/developers. Nearly half of responding firms claimed to have used OSM in the last 10 years but the usage within most firms was less than a quarter of their housing. The majority of firms used panellised construction but less than one fifth utilised volumetric approaches. More than 60% respondents intended to use OSM for their future projects but the level of usage was not identified. Although useful in helping to understand offsite-MMC practices of such firms, Ross' study did not explore strategies that housebuilders adopted or would recommend to other developers. This paper reports on survey and interview-based research which sought to take a more focused perspective in investigating the application of offsite-MMC to housebuilders. This paper examines the extent of offsite-MMC utilisation by large firms and their strategies with regard to their current and future use of the technologies.

Methodology

Given that the aim of the project was to investigate the extent and strategies towards offsite-MMC utilisation amongst large housebuilders, the methodology employed was to survey of the top 100 housebuilders in the UK measured by the number of unit completions (see Wellings 2003). According to the UK

Government statistics, the number of housing unit completions in 2001/02 (UK) was 175,000, out of which private housebuilders contributed 153,500 (or 87% of the total). Based on statistics provided in the Private Housebuilding Annual (Wellings, 2003), the top 100 housebuilders in 2003 contributed 113,882 (65%) to the total amount by the industry (Table 1). Data was collected via a combination of face-to-face interviews and completion of a postal questionnaire survey. All of the respondents were senior managers with responsibility for company policy level decisions on whether to use offsite-MMC within their developments. Together, this approach yielded an overall response rate of 36%, with the responding firms accounting for around 30% of all unit completions in the UK (Table 2). Whilst the sample size precludes the use of sophisticated statistical techniques, it does enable a broad picture of the utilisation of offsite-MMC methods, and strategies for their future development, to be discerned through descriptive statistics.

(Insert Table 1)

(Insert Table 2)

An initial survey instrument was developed following a comprehensive literature review of studies which had investigated the take up of offsite-MMC in the past (i.e. Edge *et al*., 2002; Goodier and Gibb, 2004; Lusby-Taylor *et al*., 2004; Venables *et al*., 2004). The instrument comprised a mix of qualitative and quantitative questions with a methodical use of Likert scales (see Oppenheim,

1992). Section 1 aimed to provide overall views of housebuilders on their current and future offsite-MMC applications. Section 2 sought to identify the drivers and barriers and their importance or significance to the future uptake of such technologies. Section 3 intended to examine the top 100 housebuilders' strategies with regard to their future take-up of offsite-MMC. The instrument was refined through discussions with leading researchers and industrial contacts. The data was analysed using a combination of Microsoft Excel and QSR NVivo, a computer aided qualitative data analysis package (see Blismas and Dainty, 2003).

Results

The related findings of the survey are presented as follows under headings derived from the research instrument.

Housebuilders' satisfaction with their own offsite-MMC applications

The majority of the responding organisations (61%) held a 'neutral' attitude towards their offsite-MMC applications. 15% were unsatisfied, with less than one quarter of the respondents (24%) stating that they were satisfied (Figure 1). None of the respondents were fully satisfied. The comparison between responses from the largest and smaller companies suggested that the smaller housebuilders appeared to be less satisfied with their offsite-MMC applications. An analysis of the housebuilders' comments with regard to their satisfaction both on the questionnaire and during the interviews revealed a differential understanding of offsite-MMC applications. This is partly due to the current lack of a unique

definition of offsite. A few respondents claimed that offsite-MMC never lives up to expectations or perhaps expectations are too high. The perceived higher first costs and lack of guidance on the site integration of offsite-MMC were clearly concerning the firms. Though the majority of the firms would like to see a lot more use of offsite-MMC, they presented a prudent attitude to taking-up such technologies.

(Insert Figure 1)

The nature and extent of offsite-MMC applications currently adopted by leading housebuilders

Housebuilders were asked to indicate their offsite-MMC usage in relation to key building elements for both flats/apartments and individual houses. A ratio scale was used to measure the magnitude of offsite-MMC usage in the firms from 'never' to 'always' (Figure 2). A weighted rating of the usage of offsite-produced building elements was obtained by duplicating the ratings from each responding firm to its housing completions divided by the sum of housing completions by all the firms. The computing showed very small changes of the final weighted ratings by using data input from the top 20 firms and that from the top 100. In this regard, the weighted ratings presented in this paper only took the data input from the top 20 firms.

(Insert Figure 2)

The level of overall application of offsite-MMC of housebuilders is low. Generally, the extent of using offsite-MMC for multiple occupancy dwellings (flats/apartments) is slightly higher than for individual houses. Some highly documented offsite-MMC techniques are actually only applied to a very limited extent in housing, and these include complete modular building, bathroom and toilet pods and flat packs, kitchen pods and flat packs, offsite plant rooms and complete wall panels (both skins). One might argue that the results in this paper with regard to the offsite-MMC usage lack of quantitative statistics and have overlooked the part of smaller developers who may be specialising in offsite-MMC. However, this paper draws a qualitative overview of offsite-MMC usage in housing given that the top 20 firms contributed the majority of housing completions in the UK. The paper also provides relative measurements of the usage of the many building components and systems which are produced offsite.

The trend of offsite-MMC applications

Over half (58%) of the housebuilders were planning to increase their use of offsite-MMC (by volume) over the next three years, on average by around one fifth. The remaining firms indicated that they planned to maintain their current levels (Figure 3). Although the results show that the majority of the housebuilders were actually open to the increased take-up of offsite technologies, comments made suggest that there is still a risk-averse attitude to the use of offsite-MMC amongst a significant number of those responding. Some explained that the increase of offsite-MMC is subject to the performance of their trial projects. Most showed more confidence on somewhat established non-volumetric offsite

technologies rather than volumetric which has not been used extensively in housing.

(Insert Figure 3)

Kitchen and bathrooms were seen as the best opportunity for growth in offsite solutions (44%), with external walls (41%), timber frame structures (37%) and roofs (33%) also featuring strongly (Figure 4). However, the housebuilders did not generally see great potential for complete modular buildings. The analysis of comments revealed that housebuilders assessed the potential for offsite-MMC applications against a wide range of factors including technical requirements, cost, time, site integration and logistical concerns, customer choice options, sales impacts, mortgage issues and site constraints.

(Insert Figure 4)

Drivers for using offsite-MMC

The important drivers for using offsite-MMC measured on a five point Likert scale were identified as: 1) achieving high quality (4.3); 2) minimising on-site duration (4.2); 3) ensuring time certainty (4.0); 4) reducing health and safety risks (3.9) 5) addressing skills shortages (3.9); 6) ensuring cost certainty (3.8); and 7) revisions to the building regulations (3.5) (Figure 5). Other factors such as sustainability, restricted sites, government promotion, company strategy and clients' influences were considered to be of less importance.

(Insert Figure 5)

An analysis of housebuilders' comments made during the interviews reveals that the traditional drivers of time, cost, quality and productivity, coupled with increasing concerns with reducing health and safety risks, were the primary catalysts behind the decision to use offsite-MMC. Government promotion was considered much less relevant to the private housing sector than for social housing. Offsite-MMC was taken on board by some housebuilders. However, many did not integrate it into their company long-term strategy, but rather utilised offsite technologies on an *ad hoc* basis for their projects. The comparison between responses from larger and smaller firms suggests that larger housebuilders normally considered the factors on skills shortages, long-term strategy and clients' expectations more seriously than smaller firms did.

Barriers to the use of offsite-MMC

Significant barriers to the use of offsite-MMC in the top 100 housebuilders were identified as: 1) higher capital costs (4.4), whether perceived or real; 2) the difficulty to achieve economies of scale (4.2); 3) complex interfacing between systems (3.9); 4) the inability to freeze the design early on (3.8); 5) the nature of the UK planning system (3.5); and 6) manufacturing capacity (3.5) (Figure 6). Other factors such as the fragmented nature of the industry's structure, site specifics and logistics and the risk-averse culture were also highlighted, but were seen as having less significance. Skills shortages were also seen as a barrier to the

uptake of offsite-MMC although many consider this also to be a driver. Further research is being done currently to explore this aspect in more depth. Current organisation mechanisms and land acquisition processes in housebuilding business were also claimed as inhibiting issues to the use of offsite-MMC in some firms, but this influence appeared much less significant. A number of firms suggested that a lack of previous experience with using offsite is preventing them from a wider take-up of such technologies.

(Insert Figure 6)

Discussions with the interviewees reveal that other issues also contributed to the inhibition of current housebuilders' offsite-MMC practices. Concerns from the insurance industry and financial market over the use of non-traditional building methods were clearly hampering housebuilders to consider to use such technologies. Issues of purchasers' perceptions, extra costs for obtaining certificates for new systems, and lack of standardisation of housing types were also claimed negative to offsite practices.

All the driving forces and inhibiting factors identified above depict a complex case for housebuilders' practices of using offsite-MMC, which implies that an uplift of the take-up of offsite-MMC is not easy and requires appropriate strategies to help overcome the barriers. The following sections explore strategies which large housebuilders have developed during their offsite-MMC practices.

Strategies in use of housebuilders for using offsite-MMC

The results indicated that 71% of the respondents considered the incorporation of offsite-MMC into their basic house design (Figure 7). However, a considerable number of responding firms left the incorporation of offsite-MMC to fairly late stages, such as detailed planning application (23%) and pre-construction (6%). Several respondents ticked more than one box, explaining that they would consider different system types at different stages. Most respondents explained that the early incorporation of offsite-MMC into their basic house design mainly applied to volumetric systems, modular building and some more advanced panelised systems. However, offsite components, sub-assembly and some open panellised systems were often considered at later stages.

(Insert Figure 7)

In terms of the procurement methods used for project delivery, the top 100 housebuilders appeared to prefer fixed price/lump sum (41%) and in-house management (38%). The usage of strategic partnering alliances (9%), project partnering (7%) and design and build (5%), though highly publicly promoted recently, were fairly rare amongst the top housebuilders. Detailed analysis concentrating on offsite-MMC elements alone showed that more than half (57%) of the respondents preferred to use a fixed price/lump sum method, rather than strategic partnering alliance, project partnering or design and build for offsite elements.

The significant adhesion to traditional procurement methods amongst large housebuilders seems to be inconsistent with their awareness of incorporating offsite-MMC into early design stages. This inconsistency suggests that most housebuilders were aware of the principle of integrating offsite-MMC early on but, in practice, adhered to conventional procurement methods. The continuous use of conventional procurement methods for offsite would tend to preclude this approach, or at least make its potential benefits harder to achieve.

The responding housebuilders' strategies for using offsite-MMC were explored via open questions from which the following points were derived. In total, 54 strategies were identified and they were clustered in nature to four approaches towards *process, procurement, learning & benchmarking and training* (Table 3). Factors of market-focusing, peoples' preconception, planning and building regulations and finance were also identified, but less frequently.

(Insert Table 3)

Nearly three quarters (74%) of the responding firms considered offsite-MMC differently for individual houses and flats, from the aspects of applicability, finance, speed, business model, peoples' preconception, volume and flexibility. They claimed that offsite-MMC was more applicable to certain particular building types and special project circumstances. However, interviews with large firms revealed an apparent lack of understanding on how to select appropriate types of offsite technologies for particular schemes. Most companies were still making

their decisions on financial criteria or on the heuristic decisions of a few key personnel. Although decision-making tools like cost estimate workbooks and best practice scoring sheets had been used in some firms, more transparent robust methods were recognised as critical by all interviewees.

Some of the respondents highlighted the importance of considering the impact of 'the speed of build' on 'the rate of sales' as a potential benefit of offsite-MMC methods. The issue of 'mass customisation' (see e.g. Barlow, 1999) was acknowledged for utilising offsite technologies by some respondents. However, most participants regarded a faster build as more critical given the current undersupply of housing in the UK. A good command of time certainty for housebuilding was advocated by many responding firms. It is worth noting that this belief conflicts with one of the fundamental considerations 'speed of construction' of using offsite-MMC in the social housing sector. Though some firms had tried to take on board offsite-MMC early on and involve manufacturers and suppliers from the conceptual design stages, their efforts seemed to have been hampered by a lack of guidance and cooperation with their supply chain.

A few housebuilders had already put offsite-MMC on the agenda of their organisational strategic management to realise the full potential benefits from offsite production. Benchmarking exercises and training on offsite-MMC had been adopted in some firms to improve performance and customer satisfaction. However, the strategies of learning, benchmarking and training had been largely restricted within the housebuilding firms themselves. Some firms were promoting

sharing of information with their long-term partners but there were few mechanisms for diffusing good practices across the industry, for private housebuilders in particular.

Discussion

The survey results have revealed that housebuilders are less satisfied with their current offsite-MMC utilisation than other industry players, for example in the building services sector, as shown by a recent BSRIA study (Parry *et al*., 2003) with around 72% satisfaction. However, this finding does not necessarily suggest that housebuilders do not believe that there is considerable potential from offsite-MMC. The low level of satisfaction of housebuilders with their current offsite-MMC utilisation may be attributed to a current low level of offsite-MMC usage and the fact that considerable real and perceived barriers co-exist in the industry. This supports the general innovation literature that the adoption and diffusion of innovations are related to the extent of their usage and the availability of empirical evidence (see Nelson *et al*., 2004). This finding should also be read in the context that significant dissatisfaction with efficiency and quality performance of traditional housing construction prevails in the industry (Egan, 1998).

In practice, there is less overall use of offsite-MMC in the housing sector than is publicly perceived. This finding however reflects a recent *buildoffsite* market value study which states that the value of the UK offsite market in 2004 accounts for just 2.1% only of the total value of the construction sector (all construction

including refurbishment) (Goodier and Gibb, 2005). The majority of housebuilders (58%) planned to increase their use of offsite-MMC, which supports some recent studies. Parry *et al*. (2003) predicted a growth in the offsite fabrication market of 9.7% per annum (by value) up to 2010. AMA (2002) indicated that the market value of prefabricated buildings at manufacturers selling price will grow at an average rate 8% per year between 2001 and 2006. The increasing trend of offsite practices has also been reflected from the supply side. Goodier and Gibb (2004) found that nearly three quarters of the suppliers surveyed thought that the take-up of offsite by the industry was increasing in their sector. This positive trend in the growth of offsite applications is likely to be supported by current government support for offsite-MMC and the 25% MMC target (see Housing Corporation, 2003). However, despite the positive trend, the planned increased amount of offsite usage in housebuilders remains low. Moreover, a considerable number of responding firms were going to maintain their current level of offsite usage. Some argued that housebuilders are reluctant to use innovative building technologies (Ball, 1996) but this is not unusual given the slow take-up of innovation in the overall construction (Cripps, 2003) and the existing barriers identified earlier in this paper.

The findings of this study with regard to drivers and barriers to the use of offsite-MMC support those of a number of previous studies. Time and quality drivers identified in this paper have also been highlighted in the studies of Gibb and Isack (2003), Goodier and Gibb (2004), Parry *et al*. (2003) and Venables *et al*. (2004). In terms of ensuring cost certainty, Lusby-Taylor *et al*. (2004) showed that costs

should be less volatile than in traditional construction although they argued that it was unlikely at present that costs would be reduced by the use of MMC. Although offsite production addresses skills shortages (Barker, 2003; ODPM, 2003), a skilled workforce is still needed for offsite technologies and better broader training must be taken on board (Clarke, 2002; Goodier and Gibb, 2004; Palmer *et al*., 2003). This argument explains why the issue of skills shortages was identified as both an important driver and a significant barrier in the survey. The barriers to housebuilders' offsite practices identified in this paper are also supported by recent studies like Goodier and Gibb (2004) and Venables *et al*. (2004). The lower level of usage of complete modular buildings, volumetric pre-assembly and closed panel systems is partly due to current limited cost data which also concerns designers (Lusby-Taylor *et al*., 2004). Delays to the planning process has been recognised in a number of recent government policy documents (Barker, 2003; ODPM, 2005). Housebuilders claimed that current manufacturing capacity was inhibiting their offsite take-up, which appears to conflict with suppliers' optimism with their production capacity (Venables *et al.*, 2004). This should be read in connection with a current low level of partnering between housebuilders and manufacturers and suppliers. Taken together, the findings suggest a problematic context for a step-change increase in the uptake of offsite-MMC in the near future.

Housebuilders have developed various strategies on using offsite-MMC which are clustered to four approaches towards process, procurement, learning & benchmarking and training. Housebuilders' process strategies for using offsite-MMC embodied the approach of mixing the use of off- and on-site technologies.

This approach favours incremental, rather than radical, approach to technological innovation. This is not surprising given the benefit-driven nature of the housebuilding business and the risk profile resulting from current co-existent real and perceived barriers to offsite. Responding firms also showed a strong desire to increase design standardisation. This supports the study carried out by Hooper and Nicol (2000) which identified that a quarter of the leading housebuilders are making attempts to rationalise their house type portfolios significantly to a small core of designs to increase cost certainty but reduce volatility. Guidance on integrating offsite production into the housebuilding business process was clearly expected by most responding firms. Techniques of stakeholder analysis (Newcombe, 2003) and stakeholder mapping (Johnson *et al*., 2005) and existing work like Process Protocol should help develop process knowledge in the housing sector.

The learning and benchmarking strategies used by housebuilders appear to support the general literature on innovation. Offsite-MMC, as a concept, is new to the housebuilding sector though some offsite technologies have been used for decades. The current low level of usage of offsite-MMC in housebuilding has made significant contributions to attitudinal barriers to taking up such technologies. As argued by Nelson *et al*. (2004), unclear or varied evidence of an innovation can leave room for argument about which benefits and costs matter most or about how the innovation ought to be implemented to be most effective. Also, there exists debate on whether innovations are efficiency enhancing and improve technical or economic performance where there are no agreed criteria to

count (ibid). A historical cost-driven approach predominates the performance measurement of offsite technologies, whilst benefits of other aspects such as time, quality, health & safety and sustainability are hidden and not fully realised by the industry (Blismas *et al*., 2006). The learning & benchmarking strategy should help increase the empirical evidence for using offsite-MMC across the industry, and will also facilitate the establishment of widely agreed criteria for measuring its benefits and performance. This echoes the evidence presented by Nelson *et al*. (2004) that the innovation in question was improved over time in a way directly related to its growing use and feedback from that use. Though innovation leads to improved competitive advantage and greater profitability, it is risky, requires significant investment and is often resisted within the firm (Seaden *et al*., 2003). Therefore, housebuilders must develop their organisational learning which is claimed by Van De Ven (1986) as at the heart of managing innovation. Taking all these together, the finding of housebuilders' learning & benchmarking strategy is consistent with the general literature on innovation.

The construction industry has had a poor record of investing properly and consistently in education and training (Ball, 1996; Housing Forum, 2001). A strong reliance on subcontracting in UK construction (Dainty *et al*., 2001) adds problems to innovation and training (Ball, 1996). Though pre-assembly delivers improvements to the industry, it is a fundamental error to believe that prefabrication can compensate for the lack of skills. On the contrary, prefabrication is likely to require levels of techniques and precision that will only be derived from high-level training (Housing Forum, 2001). Housebuilders in this

survey highlighted the importance of training in seeking long-term benefit and maintaining a low work turnover. In order to transform the housebuilding process, as Clarke and Herrmann (2004) argue, investment in skills to enhance engineering and stable employment relation offers a clear alternative to tinkering with contract relations and cost reductions.

Finally, in relation to housebuilders' strategies for increasing their use of offsite-MMC, it is worth noting that the main strategy used by housebuilders was to involve those directly involved in project delivery process (e.g. designers, manufacturers and suppliers). However, stakeholders who are indirectly involved (e.g. the public, mortgage lenders, insurers, planning authorities, building control) were seldom mentioned. This suggests that housebuilders had developed substantial strategies within their direct supply chain, but neglected the great potential in the wider context of housing supply for using offsite-MMC. This situation must be improved since the vast majority of innovation problems stem from a mismatch between technological possibilities and market demands (Tushman and Moore, 1988). An organisation's strategy should be driven by an assessment of external opportunities and threats, and involve mediation between external forces for change and internal forces for stability (ibid). However, such assessment and mediation are left for further debate given that this paper is focused on housebuilders' practices and internal strategies for utilising offsite technologies.

Conclusions and future research

This paper has revealed leading housebuilders' offsite-MMC practices and strategies in use within the context of current housing under-supply and the slow take-up in offsite technologies. The findings have shown that the usage of offsite-MMC in large housebuilders is currently low, but the level is likely to increase in the future years. This positive trend appears to be evident with recent government MMC targets and efforts in releasing land supply and speeding planning process. Housebuilders are mainly driven to use offsite-MMC by a combination of factors such as quality, time, cost, productivity and health and safety. However, a wider take-up of such technologies is largely being inhibited by higher capital costs, interfacing problems, longer lead-in time, delayed planning process and current manufacturing capacity.

In terms of how housebuilders are looking strategically to integrate more offsite-MMC into their house design and construction, most have developed various strategies centred on process, procurement, learning & benchmarking and training. However, the implementation of these strategies appears to be restricted within the wider supply chain and more attention should be paid to dealing with stakeholders who are not directly involved in project delivery. To improve housebuilders' offsite-MMC practices, transparent, robust decision-making coupled with performance measurement aimed at benchmarking both internal and external are crucial. However, working out how to realise these strategies is clearly challenging firms. A pan-industry mechanism to disseminate good practice

is crucial to the increased uptake of offsite-MMC in the future. It is only then that it is likely to grow to the extent that it makes a meaningful and significant difference to the supply of housing in the UK.

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Tables (in the order referred to in the text)

Table 1 Housing unit completions in 2001/02 (UK)

	All dwellings	Private enterprises		Registered Social Landlords	Local authorities
		All	The top 100 *		
Unit completion	175,600	153,500	113,882	21,900	200
Percentage of all	100%	87%	65%	13%	-

Source: Office of the Deputy Prime Minister; National Assembly for Wales; Scottish Executive; Department of the Environment, Northern Ireland. * Statistics of the top 100 are from the Private Housebuilders Annual 2003.

Table 2 Summary of responding housebuilders to the survey

Housebuilders	Unit completions	Turnover (£m)	Whether they were interviewed or responded to the questionnaire	
A1	13480	2062		Quest
A2	6238	1184		Quest
A3	6044	773	Int	Quest
A4	4164	827	Int	Quest
A5	3812	560	Int	Quest
A6	2691	461	Int	Quest
A7	1901	224	Int	Quest
A8	1854	456	Int	Quest
A9	1387	203		Quest
A10 *	1307	231	Int	Quest
B1	1085	233	Int	Quest
B2	1075	102		Quest
B3	877	145.6		Quest
B4	775	82.4	Int	Quest
B5 *	694	88.7	Int	Quest
B6	621	82.7	Int	Quest
B7	582	39.5		Quest
B8	504	101.6		Quest
B9	478	51.3		Quest
C1	445	46.5		Quest
C2	331	42.4		Quest
C3	257	24.7		Quest
C4	240	64.7		Quest
C5	204	23.2		Quest
C6	174	24.7		Quest
C7	173	17.6		Quest
C8	150	50.3		Quest
C9	150	18.8		Quest
C10	150	51.1		Quest
C11	149	24.9		Quest
C12	124	12.1		Quest
By responding firms	52,116 +	8308.8 +	11	31 (+5)
By the industry as a whole	175,600			
Response rate	30% +		11%	36%

Sources: ODPM and the Private Housebuilding Annual 2003 (Wellings, 2003).
Notes: 1) 'A' stands for housebuilders from the group of the top 20; 'B' from the top 21-40; and 'C' from the top 41-100. 2) The housebuilders with * have been acquired by others. 3) '+' means that some respondent firms are anonymous and thus their details are not included in this table.

Table 3 Housebuilders' strategies in use for offsite-MMC applications

Category	Representative examples of strategies
Process	• Involve manufacturers and suppliers early on • Adopt an approach of taking advantages of both offsite production and on-site work • Increase design standardisation to achieve economies of scale • Assess project sites at the pre-planning stage • Build up offsite-MMC database with comparison analysis of different systems • Plan and schedule deliveries of offsite-MMC elements
Procurement	• Set supply chain partnering and improve relationship with suppliers • Set partnering with offsite-MMC advising organisations • Manage risks by reducing dependence on supply • Improve the communication with the supply chain
Learning & benchmarking	• Adopt internal benchmarking to encourage learning from projects • Promote a learning culture • Keep reviewing offsite-MMC technologies • Encourage research and facilitate understanding • Promote innovative exploration of trials to assess benefits and barriers
Training	• Educate and train staff and organise internal seminars on using offsite-MMC • Train own labour to seek long-term benefit and maintain a low work turnover

Figures (in the order referred to in the text)

Figure 1 The top 100 housebuilders' satisfaction with their offsite-MMC applications

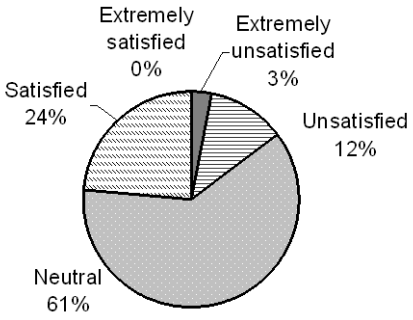
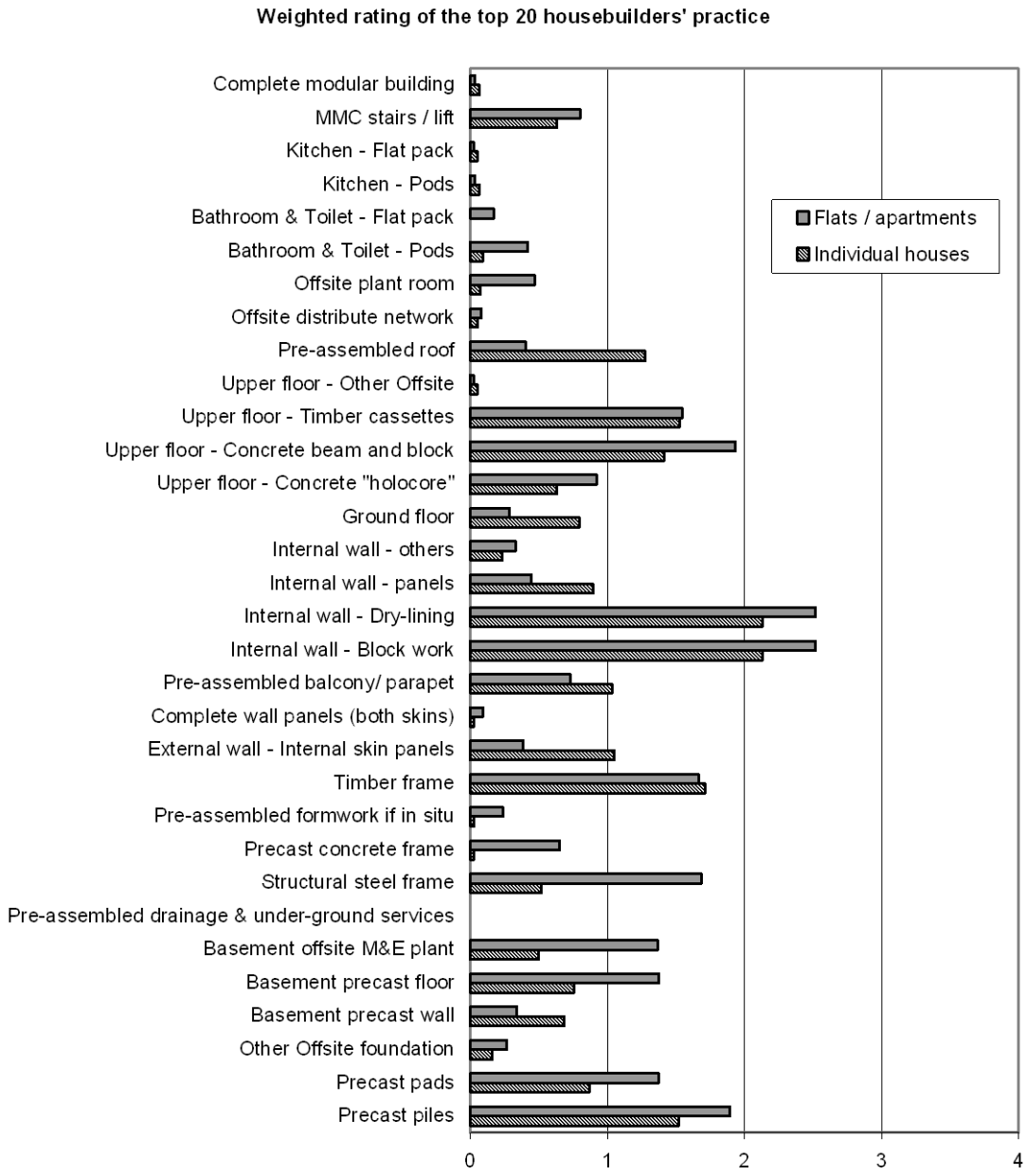


Figure 2 The nature and extent of offsite-MMC applications of housebuilders



Note: 0 = 'Never', 1 = 'Rarely' 2 = ' Sometimes' 3 = 'Mostly' 4 = 'Always'.

Figure 3 The trend of using offsite-MMC in the top 100 housebuilders (by volume)

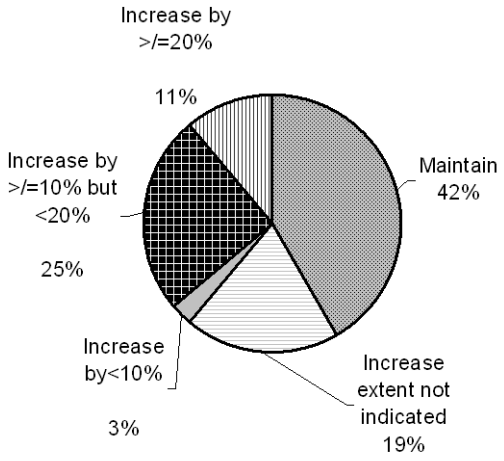


Figure 4 Elements which offer greatest potential for offsite-MMC

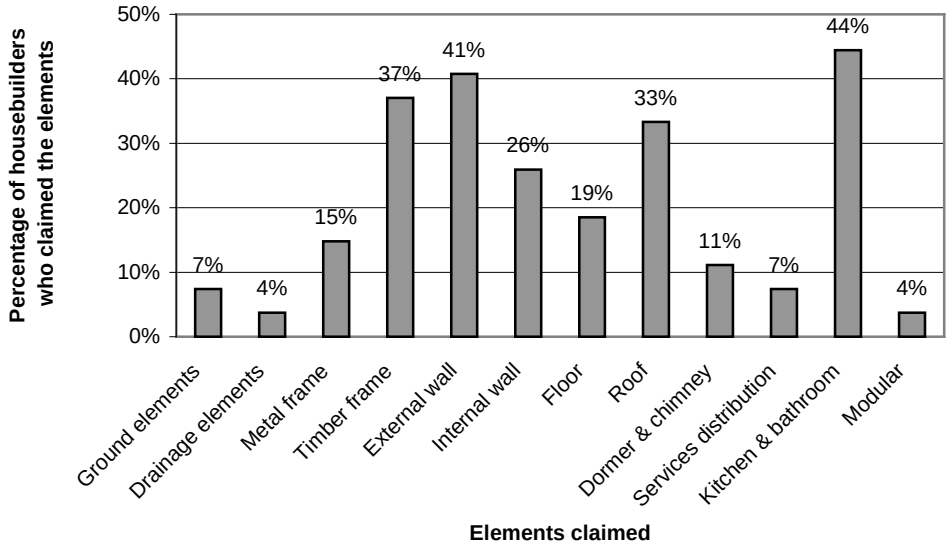
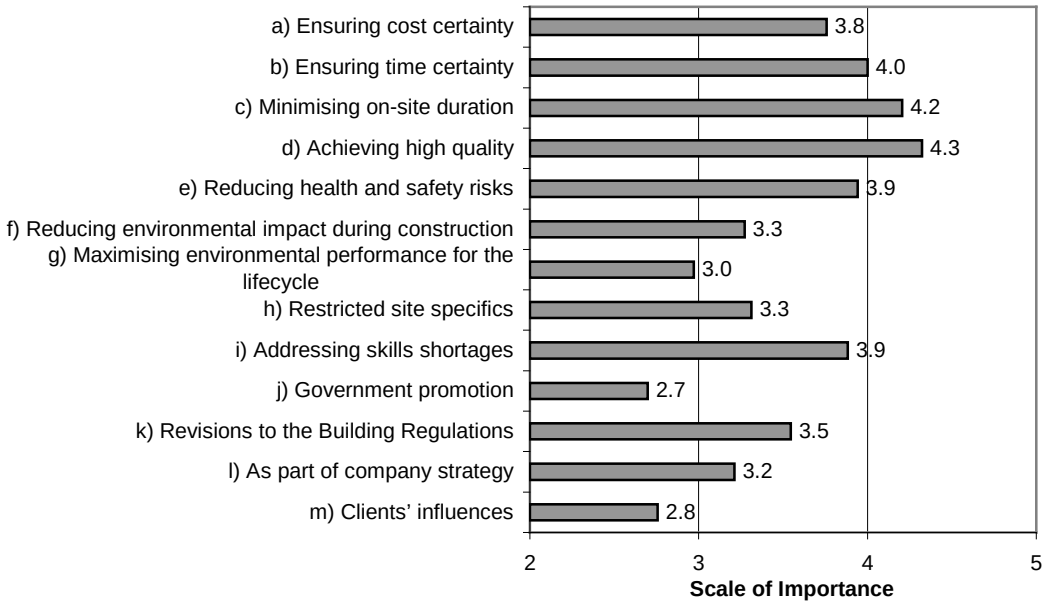
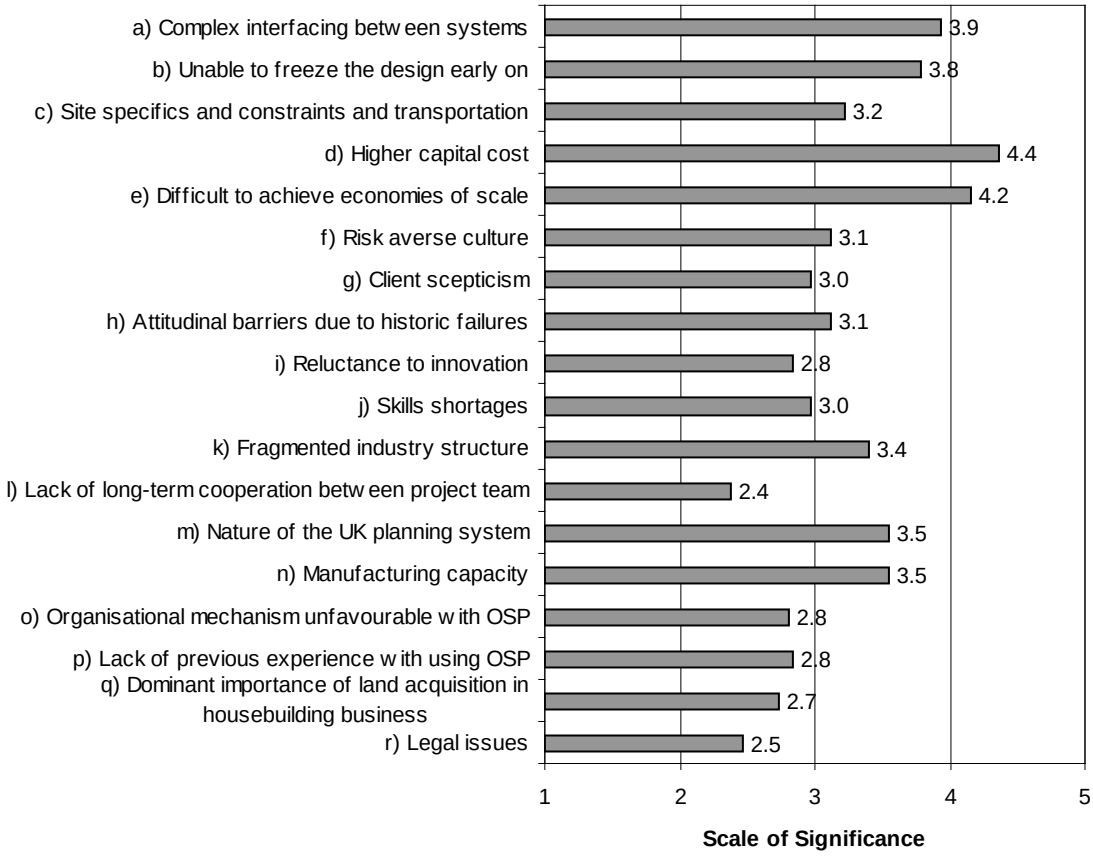


Figure 5 Drivers for using Offsite-MMC in the top 100 housebuilders – average score



Note: 1 = 'not relevant' 2 = 'somewhat important' 3 = 'fairly important' 4 = 'important' 5 = 'very important'

Figure 6 Barriers to the use of offsite-MMC in the top 100 housebuilders – average score



Note: 1 = 'not relevant' 2 = 'somewhat significant' 3 = 'fairly significant' 4 = 'significant' 5 = 'very significant'

Figure 7 Stages at which Offsite-MMC is taken into consideration by the top 100 housebuilders

