

An Exploration of the Potential for Using Modular Housing Solutions to Address the UK's Housing Shortage

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Abstract

The UK construction industry is affected by a shortage of affordable housing exacerbated by a shortage of skilled labour. This paper explores opportunities to use modular homes to address the UK's housing shortage. In developing this paper, a questionnaire-based survey was undertaken following a literature review. The survey of industry professionals involved 70 structured questionnaires sent online. The study revealed that one of the most pressing issues within the housing industry is the lack of affordable new developments. Again, a lack of investment in apprenticeships has led to skilled trades shortages in the industry. The study found that modular homes would provide would produce homes quicker and cheaper. Other benefits of modular housing are the use of eco-friendlier materials, waste reduction and reduced CO2 emissions from construction processes and from reduced transportation. Reduced maintenance requirements also reduced life-cycle costs however traditional housing was seen as having a longer lifespan. Due to restrictions in place at the time relating to the COVID 19 pandemic, detailed confirmatory interviews could not be conducted. This could have provided some additional insights into the general trends arising from the survey. Further research could investigate the costs associated with contractors establishing their own manufacturing facilities as a means to reducing the time and costs for offsite manufacture of construction components. Future research could also explore the potential of increased integration of Value Engineering and Building Information Modelling (BIM) into modular house building and the evaluate the potential benefits.

Keywords

Modular, Housing, offsite-construction, skills shortage, construction

1.0 Introduction

The construction industry contributes to nearly £117 billion pounds to the UK's economy, 6% of the total revenue with the industry responsible for providing 2.4 million jobs in the UK making up 6.6% of all jobs (Rhodes 2019). Due to the ever-growing population across the UK and the rest of the world, there has been an increasing argument for the countries housing shortage and the unavailability of homes needed at an affordable price for first time buyers and young families. These current challenges are creating pressure on house builders to change the way in how builders develop (Zandari & Hashemi 2017).

In 2014, the UK house prices were valued at the second highest in the world when measured at a price per square meter (Hilber 2015). According to Marshall Recruitment (2019), statistics showed that the “price-to-income” multiplied by salary in the greater London area was around 8.5 times the average salary. Furthermore, the rest of the UK found that property prices had increased as much as 5 times the average income for a property. The UK house price growth over the past 40 years has increased faster than any other Organisation for Economic Co-operation and Development country (OECD) and has outgrown earnings. This has consequently produced a housing affordability crisis. As well as the increase in house prices throughout the UK, the housing unit sizes are a considerable amount smaller than in comparison to other European countries (Hilber 2015). Hilber (2015) provided statistics that the UK currently produce homes at around 38% smaller than Germany and a further 40% smaller than the Netherlands (Statistics Sweden 2005). Approximately the number of homes needed in England are up to 345,000 per year (Wilson & Barton 2020). Back in 2018/2019 the total amount of homes in England increased by around 241,000 homes providing a 9% productivity increase than the previous year although still lower than the estimated quantity needed. The current skills shortage is believed to be holding back efforts to resolve the housing crisis and the number of homes that are built. With around 87% of construction companies looking to expand producing around 100,000 vacancies, one in four (24%) of housebuilders explain that finding skilled trades are becoming the largest challenge (Owen, 2015). Furthermore, the UK workforce isn't getting any younger with the Office for National Statistics (ONS) revealing that 20% of construction workers are over fifty with 15% being over sixty (Marshall Recruitment 2019).

In this context, modular housing has been hailed with the government and the construction industry suggesting that, modular homes could be the answer in resolving the housing shortage and the skills shortage. Modular homes will provide a cheaper option also removing the need for as many skilled workers due to the units being constructed in quality-controlled factories off-site. This paper explores the opportunities to use modular construction solutions to address the housing deficit and the opportunities this will bring.

2.0 Literature Review

2.1 Modular Homes

Modular construction is a system that is pre-assembled and constructed in a factory consisting of a lightweight, load-bearing composite panels that are used to form the walls, ceilings and roofs of a structure (Glenn Low 1987). Lopez & Froese (2016) define modular housing as “*housing that is partially built in a plant, shipped to a development site, and placed on a foundation, where the roof structure and exterior finishes are completed*”. Modular homes are cost effective when comparing to conventional homes due to being built in a factory environment that provides ideal production conditions compared to site construction (Lindal 1982). Modular construction has established a

strong market in residential buildings due to the speed benefits, quality and cost savings that are achieved (Lawson 2010). This system of construction uses an inside out approach completing the interior surface, electrical, plumbing, mechanical fixings before completing the exterior. This differs from the traditional on-site assembly sequence constructing from the outside in (Ferver 1980).

Manufactured construction, off-site construction, off-site manufacturing, industrialised building systems and modern methods of construction are all generic terms used interchangeably in extant literature to describe modular construction (Goulding *et al.* 2012). The underlying idea involved in all these concepts is that some activities relating to construction projects are moved away from the construction site into controlled factory environments within manufacturing establishments (Jaillon & Poon 2010). These are described in some literature as a panacea to the many problems associated with cost, time and quality associated with traditional construction processes (Goulding *et al.*, 2013).

2.2 UK's housing affordability crisis

The UK is currently in a housing crisis and despite the rapid increase in housebuilding, the UK house prices have grown by 160% since 1996 (Dmitracova 2019). Ferguson (2016) though states that the average house price has increased significantly more risen to an extraordinary 281% across the UK with statistics showing that London figures have increased a further 501% (Nationwide house price index). The reason behind the increase in property value is down to the lack of available homes therefore increasing the demand (Hall 2020). Hall (2020) goes on to explain that:

“When there is a high demand for a good or service, its price rises. If there is a large supply of a good or service but not enough demand for it, the price falls”.

In 2014, UK house prices were the second highest in the world, only topped by Monaco with house price growth increasing faster than any other OECD country (Hilber 2015). Since the late 1990's, the mortgage rates have tumbled with interest rates being fixed on a five-year-fixed-rate term. One of the many issues causing the housing crisis is the average earnings to house cost ratio. Currently, the UK house now costs almost eight times the average salary with banks and building societies typically lending people a maximum of four and a half times individuals income (Chu 2018). Because of this, the home ownership has slumped to 63% due to the soaring house prices relative to earnings (Independent 2018).

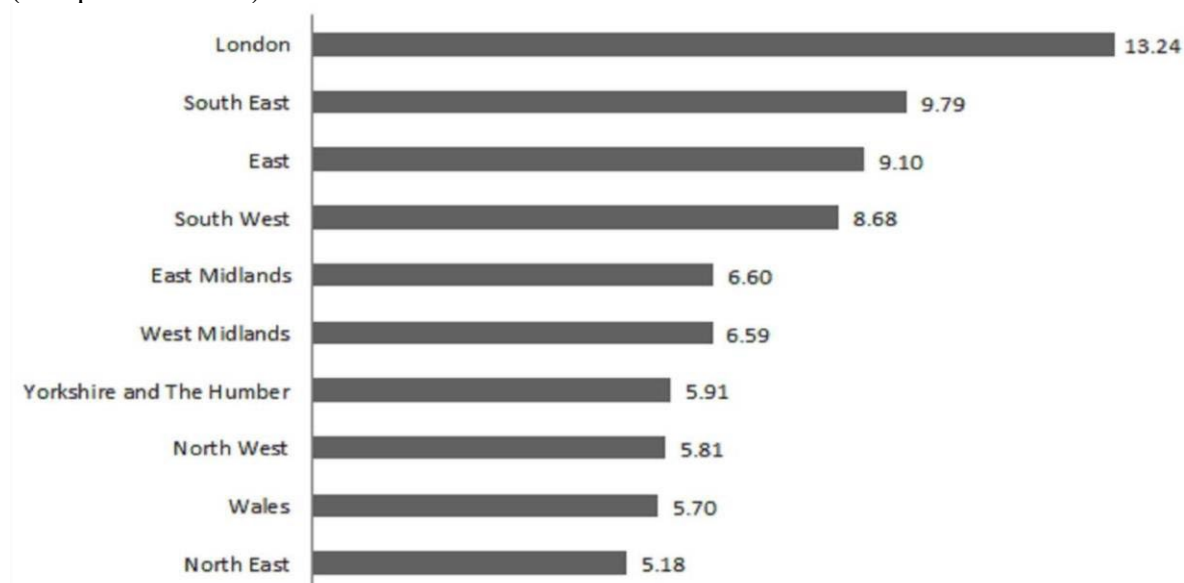


Figure 1 2017 House prices to earnings (Marshall Recruitment, 2019)

2.3 UK's Current skills shortage

Lloyds Banking Group believes that skills shortage and planning systems are preventing solutions for the housing crisis. A severe shortage of skilled workers in the housebuilding industry are hindering efforts to tackle the UK's housing crisis (Flockhart 2016). It has been reported that the current UK construction workforce is too small to meet with the UK Governments housing demands.

In 2017 the government had pledged to develop 300,000 new homes a year by 2020. A massive concern to this is that RICS have confirmed that a shortfall in skilled construction workers in the UK is currently at its highest point since 2007 (RICS 2019). According to the (CIOB) the industry must employ over 150,000 new workers by 2021 in order to keep up with the demands from the Government. Light (2017) disagrees by suggesting that Britain actually need a considerable amount more estimating that around 400,000 people each year must be recruited providing an equivalent statistic of one person every 77 seconds.

Approximately 87% of construction companies plan to increase their companies yet while all these vacancies are becoming available, 24% of housebuilders have confirmed that finding the candidates with the appropriate skills are becoming "the biggest challenge" (Owen 2015). It is evident that the lack of skilled trades is causing huge disruptions to the housing shortage and that moving forwards, the Government must invest into training schemes and apprenticeships to offset the reduced number of skilled professionals in the industry.

2.4 Affordability of Modular housing

In recent years due to the industry unsuccessfully supplying enough homes to keep up with the increase in population, a growing interest in the modular construction industry from both investors and developers have been the main topic (Lopez & Froese 2016). Modular homes are offering several benefits over traditional. Some of the advantages are a reduction in construction time due to the units being constructed in a factory, high quality as the factories are quality controlled and cheaper costs providing financial saving for suppliers and buyers reducing property prices.

Modular construction has long been developed and used in the construction industry within residential as a means of a quicker production supply and a quicker turn around (Velamati 2012). Mass production could allow new homes and apartments to be radically cheaper due to the design behind modular construction (Barnett 2018). Some experts believe factory-built properties could resolve the housing crisis due to mass production opportunities and better quality control provided by factory conditions.

2.5 Modular Construction impacts on skills shortage and productivity

Modular housing can address the skills shortage and tackle the domestic sector (Sean et al. 2015). The UK have an ageing workforce with 12% of construction workers under the age of 24. With the lack of skilled workers in the industry and the lack of skilled trades coming through the apprenticeship scheme, the means for modular housing will help solve the UK's skills shortage. The Government in 2015 expressed concerns about the lack of training stating that, "*structure of industry training is not sufficient to deliver the skilled workforce required to build enough adequate housing*" (Wilson & Barton 2020).

Modular construction will reduce the need for large amounts of skilled trades and will provide a lower skill demand due to houses being factory built. Traditional methods of construction will demand a high number of onsite skills that the industry lack although by transferring to modular methods of construction, 90% of activities will be completed prior to site delivery. Off-site manufacturing can attract and develop non-skilled resources throughout the industry without relying on limited skilled resources (KPMG 2016). In addition, modular construction will address the skills shortage and allow the government and developers to continue developing the despite the increase in the skills shortage. Off-site construction will offer the opportunity to speed up the delivery of new homes and will allow projects to be delivered on time or earlier by around 50% (Construction news 2016). There is evidence to suggest that schedules can be saved by almost 60% when comparing to traditional methods of construction.

Banks *et al.* (2018) presents a 40-storey mixed-use development in central London, UK which successfully employed the principles of DfMA across all engineering disciplines for the project. In this project, the delivery team developed effective off-site construction solutions across the entire project including the superstructure, facades, bathrooms and mechanical and electrical services. These were all designed, coordinated and facilitated using DfMA through advanced digital engineering and building information modelling techniques. According to Banks *et al.* (2018), the project was delivered with reduced programme and cost with an improved safety record, higher quality and reliability in a more sustainable way through reduced vehicle movements and a greater efficiency in the management of site logistics.

2.6 Limitations of Modular Construction

Modular homes are designed, manufactured and preassembled off-site before being transported to its final location (Warszawski 1999). Although modular construction comes with many benefits there are also limitations and disadvantages. Taylor (2010) explains that modular homes are limited when creating the floor plan because of transportation from the factory to site. Modular homes have a width of no more than 14 to 16 feet although can be 60 to 70 feet in length (Warszawski 1999). Taylor (2010) goes on to suggest that it's not feasible to deliver the modular homes very far due to the road size restrictions. Due to delivery playing a key role into transporting the modular home to its final location, contractors must consider transport limitations. These limitations can be time delays, permits needed due to oversize vehicles, and dimensional limitations.

Golawski (2018) points out that there are no design limitation preventing modular methods although BONE (2016) argues this by suggesting that modular methods will only provide a limited number of materials and layouts because of the factories mass production. Gassett (2015) agrees by confirming that modular homes lack customisation, and that design is limited. Project planning is another key factor producing yet another limitation. Sites in Japan, USA and Sweden have come across problems where clients would like to apply a variation in the scope of works and unlike traditional, modular construction has proven to be much more difficult when alterations are need (Kamali & Hewage 2016). Kamali & Hewage (2016) argue that modular homes provide a high initial cost and that although this method of construction is cheaper, a considerable amount of capital is initially needed when purchasing these products. The reason behind this is that modular homes are built and completed in a factory before transported to its final destination therefore supplies demand an upfront cost before purchase. Lynn (2017) opines that pre-manufactured homes provide a financial economical solution to the housing crisis. This is because of the reduction in labour costs and materials. The ready-built factory units reduce the need for the skilled trades and the materials wastage is heavily reduced due to machines producing the sufficient amount of material needed.

3.0 Research Methodology

This paper is based on a detailed review, critique and analysis of contemporary extant literature on the subject. Following the review, a questionnaire-based survey was used to collate views of industry stakeholders in relation to modular construction. This Literature review was based on of industry books, academic journals and scholarly reports that provided the secondary data (Naoum 2013) which provided also provided a basis for the development of the survey instrument. The survey provided the perspectives of respondents and helped to better understand their perceptions of how the UK can implement this method of construction and it potential to help resolve the current housing crisis that affects the UK

Owing to the prevailing restrictions on movement at the time of the survey, questionnaires were administered online using a survey tool called Sogosurvey. This online platform allowed the dissemination of questionnaires to respondents and their collation once completed. Once all the data was collected, Microsoft excel was used creating table and charts showing the results identifying.

4.0 Findings and Discussion

Evidence from the review of literature confirmed that the many acknowledged benefits of modular construction would enhance the application of modular approaches in housing developments. Amongst the many benefits included speed of construction, reduced costs, quality of construction and reduced life-cycle costs. Despite the proven benefits, there were limitations associated with their use such as higher initial costs, industry aversion to the technology negative perceptions associated with the technology.

A total of 70 questionnaires were sent out with 56 responses providing an 80% feedback response. All the data was collected and assessed analysed using simple statistical analysis of the respective percentages and averages. Respondents in the survey consisted of 7% Architects, 21% Surveyors, 7% Designers, 9% Project Managers, 5% Company Directors, 2% Planners, 5% Estimators, 13% Site Managers, 7% Contract Managers, 20% Contractors and 4% Clerk of Works. The results provided show that the most common sector that undertook the questionnaire were individuals that worked within commercial with a percentage of 46%. The data received also indicated that the majority worked for main contractors with a figure showing of 54%.

Of the respondents, 5% had a master's degree, with a further 9% achieving a professional qualification. 37% achieved a bachelor's degree, 21% gained an HND/HNC, 7% achieving A-levels and 19% completing a City and Guilds. Generally, therefore, the respondents comprised of a high proportion of professional level industry stakeholders with a good level of professional and technical knowledge of construction.

The results showed that 45% "strongly agreed" or "agreed" with modular construction having a good potential to become an alternative to conventional building methods with 30% disagreeing whilst 25% were unsure. This shows that whilst a majority see the potential of modular housing solutions, the proportion of stakeholders in the industry who are yet to be convinced is still significant.

On the potential benefits of modular solutions in the housing sector, 29% of respondents suggested that the overall speed of constructing the homes would increase providing better production levels. A further 25% believed that the materials provided for the modular homes would be eco-friendlier with another 20% stating that waste reduction levels would be significantly reduced as the pods are built in controlled environments. 16% explained that transportation emissions would be reduced due to

majority of materials used being from one factory. The remaining 10% of respondents highlighted the thermal insulation benefits that modular would bring to the industry. The small relative percentages who advocated these benefits may explain the hesitancy that exists in the industry in relation to the uptake of offsite techniques. This demonstrates that additional sensitisation and education for industry stakeholders on the potential benefits of modular techniques would help. On the prospects of modular housing becoming the mainstream method of construction in the housing sector in the future, 50% of respondents agreed with the prospect with 18% disagreeing as shown in figure 2. This shows that whilst a larger overall percentage of respondents see the potential imminent increase in the adoption of in modular solutions in housing, this is not necessarily backed up by an awareness of potential or proven benefits.

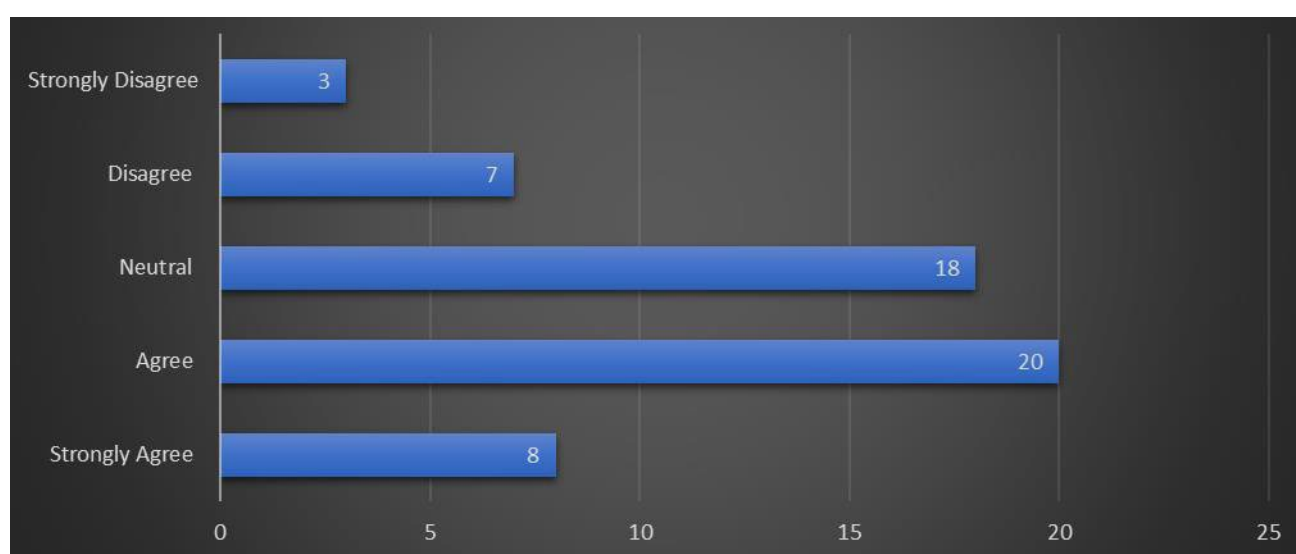


Figure 2 Potential of Modular Housing as Main Approach to Housing Development

5.0 Conclusions and Further Research

This study revealed that the current issues within the housing industry is the lack of new developments that are being built and the affordability for current dwellings. The housing crisis has affected an estimated 8.4 million people living in England. Another factor that this study revealed is that the population has outgrown the construction industry with around 3.6 million people living in an overcrowded home. Furthermore, due to the lack of investment in apprenticeships over the last 20 years contractors are now struggling massively to employ skilled trades to complete the jobs. All these factors have caused the current outcome with the objectives and learning outcomes being supported with the data gained from the questionnaire and interviews that had been completed.

The paper identified benefits of modular housing to include speed of construction, eco-friendlier materials, waste reduction and reduced CO2 emissions from construction processes and from reduced transportation. The overall proportions of the respondents who identify with these benefits are generally low, which suggests overall low levels of awareness of the potential benefits that offsite solutions present.

The study also identified modular homes as having the potential to provide cheaper housing options. Reduced maintenance requirements also reduced life-cycle costs however traditional housing was seen as having a longer lifespan.

Despite the acknowledged benefits and the opportunities presented by modular housing solutions, the numbers of respondents who demonstrate an awareness of the potential and the benefits of modular solutions in housing are relatively low. This points to a low level of awareness of the potential benefits that modular solutions offer and a weak understanding of the associated benefits. Industry-wide educational efforts in this regard will be beneficial.

Further research could investigate the costs associated with contractors establishing their own manufacturing facilities as a means to reducing the time and costs for offsite manufacture of construction components. Research could also explore the potential of increased integration of Value Engineering and Building Information Modelling (BIM) into modular house building and the evaluate the potential benefits.

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