



## Offsite Construction in the UK: Economic and Environmental Benefits

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### Abstract

In contrast to traditional piece meal onsite construction, offsite construction comprises the planning, designing, production, transporting, and assembly of building elements for speedy site assembly to a higher degree of completion. Offsite building utilises a wide range of materials, scales, and systems, as well as modern manufacturing and fabrication techniques and computer software. Offsite construction is utilised to create componentised, panelised, and modular elements that support structural, enclosure, service, and interior partition systems. Integrating these systems with the supply chain through research, design, testing, and prototyping is an off-site optimisation technique. Due of economic, health and safety, and environmental factors, major UK contractors have adopted offsite construction over the past decade. Large projects are requiring major contractors like Mace, Laing O' Rourke, and Balfour Beatty to invest in off-site manufacturing. Offsite construction is defined in detail in this paper, along with how it can help construction projects to succeed economically and environmentally. The impact of offsite construction was examined in this research using a narrative review of the existing literature, and the findings demonstrate that there are numerous advantages both economically and environmentally. Offsite construction is more environmentally friendly because it requires less energy and large machinery uses on site. Since it is simpler to anticipate the amount of material required and buy in bulk, the organisation may reduce waste and the number of vehicles required to transport the finished product to the site. Cost savings always result from transferring site processes to a production workshop setting. The cost of labour in mechanical and electrical installation is one of the highest costs in construction industry, therefore, as prefabricated solutions have been fully or partially completed before they arrive on-site, labour can be reduced with offsite construction.

**Keywords:** Offsite construction; Sustainability; Cost efficiency

### 1 Introduction

Construction is a relatively diversified industry that involves tasks such as building infrastructure and facilities, manufacturing and supplying goods, as well as maintaining, operating, and disposing. It also includes activities like mining, quarrying, and forestry. The UK's annual construction activities exceed £110 billion and accounts for around 6.5% of GDP. The public sector produces about 25% of construction activity, whilst the private sector produces 75% of the industry output (Reporting to HM Treasury and Cabinet Office Government Construction, 2016).

Offsite construction is the process of completing components or elements of a construction project at a site other than the one where they will be installed permanently. Planning, design, production, and assembly are frequently included in these processes in specially designed offsite facilities, then the finished product is delivered to the project location for final assembly processes. The UK's

housing shortage has forced a reconsideration of the country's building strategy. The Lyons Review (Lyons, 2014) and Off-site Housing Review Miles & Whitehouse (2013) of the Construction Industry Council both recommend utilising offsite construction technology to help improve the availability of affordable housing. In comparison to other developed countries, the UK is relatively cautious when it comes to home building innovation, despite the potential of offsite construction potential (Nadim & Goulding, 2010).

Offsite technique has been acknowledged as a key enabler of the industry's productivity in numerous government assessments into construction productivity and housing supply, including Barker 2004 and Farmer 2016. This is due to its many advantages. Meanwhile, the industry, which is renowned for its innovation bias and risk aversion, has been resistant to change (Sinesilassie *et al.*, 2017). The UK government's 2018 construction sector deal (HMG, 2018), which was released in response to its industrial strategy from a year earlier, outlined an ambition to change the industry by linking the construction, manufacturing, digital, and energy sectors (HMG, 2017). The plan aims to create new procedures and standards, including modular components for offsite building manufacturing that is being advanced through a variety of investments in a programme called "transforming construction" (through Innovate UK).

This paper has identified the benefits and pitfalls of offsite construction for the UK construction industry's social, economic, and environmental goals. Through the critical review of existing literature, this research has demonstrated that offsite building can be a better way to address the housing shortfall in the UK while having several advantages for the economy and environment.

## 2 Literature

Offsite construction is not anything new and it can be traced back to the Middle Ages when carpenters would often assemble the frames of buildings in the yards to ensure that all elements fitted together. The frames were then marked and dismantled to be transported to site and reassembled this system was known as quick frame in the 19th century. This technique developed into the familiar timber balloon and platform framing. In the 1830s John Manning a London carpenter and builder pioneered the Manning cottage a timber house that was standardised and designed to be transported overseas and assembled by unskilled workers, then during the Crimean war in the 1850s British engineer Isambard Kingdom Brunel designed the Renkioi hospital. The timber frame structure was manufactured in the UK flat packed shipped and assembled on site by unskilled workers in under six months (Deluxe Modular, 2019).

A consultation by the House of Lords in 2018 revealed that there is a real confusion in terms of terminology or terms such as modular, off-site, pre-fabrication, modern methods of construction volumetric and panelised all being used. Modern method of construction (MMC) includes older approaches that aim to optimise the construction process to obtain better products in less time. This can mean for example any building method that improves efficiency quality or environmental performance, in this way MMC include but are not limited to off-site construction instead off-site construction is a way to achieve MMC, off-site on the other hand is a construction method that adds substantial value to a product via the manufacture and pre-assembly of components, elements or modules in a factory before installation in the final location, so off-site is all about transferring some of the building works to a factory. There are four main categories of off-site construction: sub-assemblies and components, panelised systems, volumetric systems and hybrid systems. These can be in any material steel concrete timber or indeed a hybrid material (publications.parliament.uk, 2018).



**Fig. 1:** Offsite Construction

In order to increase the overall value of a project, off-site construction typically incorporates sizable amounts of production in a factory setting. Prefabrication, manufacturing, modularization, standardisation, pre-assembly of components and modules are some of the several components that this technique encompasses (Constructing Excellence, 2015).

Offsite construction has several advantages in the housing industry, including the ability to produce higher quality in less timing and at a lower cost, as well as potential to better control expenses. Additionally, efficiency is increased, waste is decreased, the impact of bad weather is decreased, labour and material requirements are decreased, and the total environmental impacts are decreased with less inconvenience to locals (Building Societies Association, 2017).

The focus on the specific offsite construction techniques is not usually prominent, even though much has been written on the possible advantages that offsite construction and the associated procedures offer however, many authors and practitioners, including Goh & Goh (2019), suggest that using prefabricated components rather than on-site fabrication will result in higher-quality products. This is because of improved monitoring and the corresponding quality assurance standard in a production setting (Smith, 2011). Prefabrication, according to Blismas & Wakefield (2009), improved accuracy, quality, and component life while lowering whole-life costs and faults. This is accomplished by using highly specialised equipment under controlled circumstances and quality assurance in a regulated industrial environment.

### **3 Research Method**

This research required several constructs to understand offsite construction method and its economic and environmental benefits in construction. In publications like peer-reviewed studies, construction manuals and reports, as well as rules and regulations, many of these constructs were discovered. These publications mostly concentrated on the benefits of applying offsite construction techniques in the construction sector. The accuracy of this study claim cannot be based on one, well-defined hypothesis. In practice, there were other realities to be understood, both from offsite construction as a developing innovative tool and other sustainable measures applied in the building sector. Due to the exploratory and interpretive nature of this topic, the analysis of data was essentially guided by an inductive theory building approach performed through a narrative literature review, from which the collection and examination of data informed the compilation of this research discussion and findings (Gray, 2013).

In continuing education, narrative literature reviews are frequently used to impart the most recent information about a particular subject or theme (Creswell, 2013; Denzin & Lincoln, 2005). This narrative review was conducted to present new and developing theories on the application of offsite construction methods in the building industry. The narrative review employed in this context,

however, was not carried out to describe the methodology that would allow data reproduction across the publications examined or to respond to specific quantitative research questions. In order to provide a realistic understanding of offsite construction's contribution during construction phases, the evaluation enabled the investigation of innovative strategies employed to enhance sustainability in the construction sector. The purpose of this project was to re-examine and critically analyse the existing data on off-site construction's potential to enhance both the economic and environmental aspects of the UK construction industry. The literature review carried out for this study established the link between the increased environmental and financial measures brought about by the employment of offsite construction techniques in the construction industry.

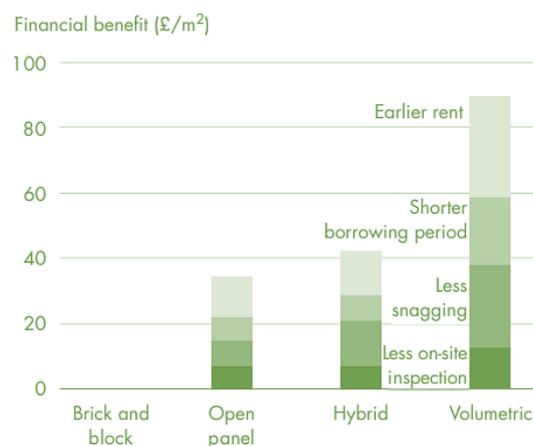
#### 4 Research Results

The result from the analysis of existing literature shows that there is a strong relationship between implementing offsite construction techniques and the economic and environmental impact in construction industry.

The UK is facing a housing crisis, and only half of the 300,000 homes required to meet demand are being created each year. The potential of offsite construction for residential housing has been highlighted as a modern method of construction (MMC) that harnesses digital techniques, such as building Information Modelling (BIM), have been supported as answers to the industry difficulties which could be up to \$22 billion in annual savings in Europe and the US (Cast Consultancy, 2019).

According to research released in, 2019 by the consulting firm McKinsey & Company, compared to traditional construction methods, offsite construction reduces the time required to provide housing, improves building quality, decreases waste, and requires fewer trades on-site (Mckinsey, 2019). Due to manufacturing precision, offsite construction can also result in greater insulation efficiency, which reduces home energy needs and improves occupant comfort. Offsite construction also contributes to the sustainable growth of urban areas by enhancing waste management, minimising onsite activity, and minimising interruptions to local communities.

The UK National Audit Office (NAO) states that offsite construction has financial gains result from quicker construction and less on-site work.



**Fig. 2:** Offsite Economic Benefits

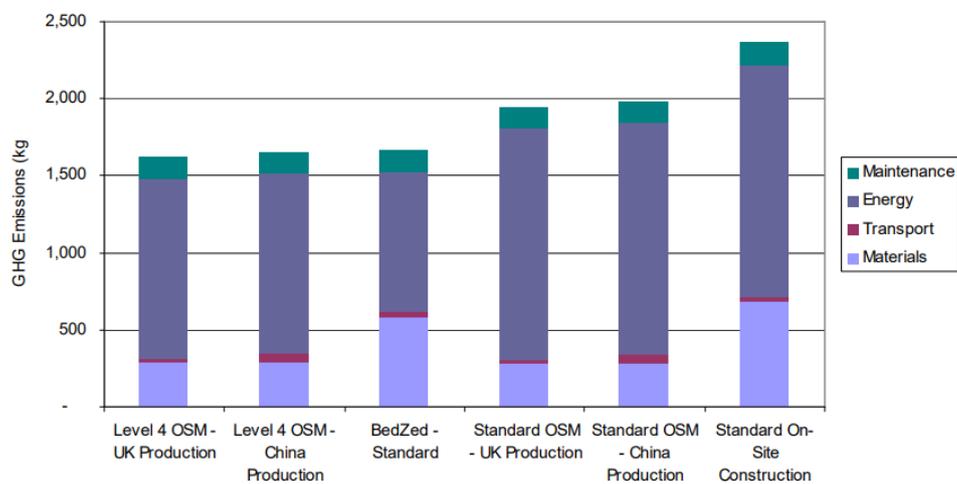
In addition to the financial advantages of off-site construction, MMC simplifies the process to reuse and recycle materials at the end of a building's existence by implementing design for deconstruction methodologies. This might be an effective technique to manage construction and demolition waste

in an integrated way that promotes circular construction (Ghaffar, Burman & Braimah, 2020).

Offsite construction has been recognised as one of the most innovative methods for improving quality, efficiency, and environmental performance in the housing construction industry. Results of studies back up these claims, including one from Hong Kong that demonstrates a 52% reduction in waste generation across all building types when adopting offsite construction techniques (Jaillon, Poon & Chiang, 2009). Similar results were discovered in a comprehensive review of high-rise residential projects in the UK, where MMC resulted to an average cost reduction of 30% while reducing waste by 70% and overall construction time by 50% (Lawson, Ogden & Bergin, 2012).

By moving onsite operations to the facility, material waste can be cut by up to 90%. Additionally, because fewer deliveries are needed during the construction phase, the energy consumed to move traffic around the site can be decreased by up to 70%. Nevertheless, it may be argued that their most important result is the 20% reduction in building lifespan energy consumption. Significant improvements are made possible by better insulation and a more tightly sealed building shell. Off-site techniques can, therefore, provide significant environmental advantages over time considering that in the UK, building life-cycle energy use is regarded as an important concern (Miles & Whitehouse, 2013).

Apart from reduction of solid waste, offsite construction generates less green house. Construction equipment can't help but release a variety of pollutants into the atmosphere. Although, air pollution cannot be eliminated, it can at least be reduced. Greenhouse gases like carbon dioxide are a more global issue that is already having a substantial impact on the global climate; however, offsite construction would reduce greenhouse gas emissions by 17% to 30% compared to on-site building (Barrat & Wiedmann, 2007).



**Fig. 3:** Greenhouse Gas Comparison between Onsite and Offsite

The benefits of off-site construction are well backed by research, but we must also consider the barriers to off-site construction adoption, including cost, standardisation, skill needs, customer and industry perception, and others.

## 5 Conclusion

According to a literature analysis, adopting offsite construction methods in the construction sector has several advantages, including those related to social, environmental, and economic factors. Offsite construction improved health and safety as well as working conditions since conventional

construction is a risky activity and that many tasks involve taking risks, operatives are still required to work at heights, in all weather conditions, outdoors, near heavy machinery and at other risks that are not present in other industries, even though site safety has greatly improved over the past 20 years. Offsite construction has various advantages for the environment, including reducing road traffic movement which offer substantial improvements regarding environmental pollution and traffic disruption over the conventional approach. Another benefit of offsite construction is reduced energy use on site and in operation. The usage of energy on site is decreased by offsite construction, which is associated to a variety of activities such transportation, section staff accommodation and services, Lighting, and Equipment. Since the finished buildings typically meet higher standards, off-site construction methods have the potential to use less energy overall. Final environmental benefit is reduced material wastes due to controlled production environment during the construction phase as well as reusing of the some building elements after decommissioning. Offsite construction has several benefits when it comes to economic and financial considerations, but the most visible and commonly mentioned benefit is speed of construction. The time needed to build and commission an offsite building is often cut in half or by 60% compared to conventional methods, which is widely regarded to be a significant improvement. The building developer has a significant financial benefit from speedy construction in the form of lower financing costs and a quick return.

In summary, Offsite construction has a wide variety of sustainability advantages, some of which are also highly advantageous financially. The faster pace of construction results in a shorter construction schedule, which lowers financing costs and has positive effects on the environment which are the biggest financial benefits. Furthermore, early completion and the resulting early sale or rental income offer major cash-flow advantages. Although various studies demonstrate the advantages of offsite construction, a comprehensive analysis of the market and sector barriers to offsite construction is still required.

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