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OFF-SITE MANUFACTURE FOR CONSTRUCTION:
BARRIERS TO UPTAKE

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WHAT IS OFF-SITE MANUFACTURE?

There is no clear and comprehensive definition of what off-site manufacture (**OSM**) is, as it encompasses many different systems and processes.

In its broadest sense, OSM for construction utilises technologies which enable a proportion of the construction to be completed under factory conditions and then transported onto a site.

Commonly used categories and processes include closed panel systems (where wood, steel or concrete panels arrive finished and plastered), pods (non-loadbearing units fitted with fixtures and finishes in the factory. e.g. bathroom pods) and design for manufacture and assembly (**DfMA**) (a design approach where interfaces are pre-considered as a whole and engineered at an earlier stage). It can also include full volumetric construction, where completed three-dimensional units are transported on the back of lorries to site.

OSM is an example of a modern method of construction (**MMC**). MMC utilises digital techniques and Building Information Modelling (**BIM**) – the digital description of every aspect of the built asset. These digital models can then be directly transferred to production lines.

Improvements in digital modelling techniques have the potential to transform OSM into viable alternatives to traditional on-site construction.

OSM has major benefits but constraints still exist

Benefits	Concerns/Constraints
· Generally faster build to a higher quality (fewer component defects) because you move from a construction approach to a manufacturing approach where production-line techniques are utilised. This allows builds to get onto site earlier and reduces the time and cost for resolving snagging issues compared with traditional methods of construction.	· OSM can require substantial up-front investment in order to develop the infrastructure/factories, demanding a very different cash-flow profile. There are further costs associated with maintaining factory output levels.
· Reduces labour input (both onsite and offsite), with fewer workers needed to manufacture, deliver and install components. Production lines can also be run continuously with multiple teams running day and night shifts.	· Doesn't have certainty of an order book (volatile pipeline) and capacity is currently limited. However, more contractors are beginning to build facilities for themselves.
· Standardisation of modules or components within buildings and infrastructure can improve the quality of those components through an iterative process of analysing performance data and making changes for future components.	· Historically, high costs and fluctuating demand for OSM builds.
· Digital techniques used in OSM improve the safety of the product as component assembly can be standardised and tracked.	· Defects need substantial redesign (also high abortive costs).
· BOPAS scheme introduced – provides Lloyds underwritten certainty to insurers and mortgage lenders about the quality of MMC construction.	· Concerns over whether OSM can beat the flexibility/efficiency of traditional construction methods.
· Traditional build costs in London are high. Here MMC should be competitive.	· OSM requires design to be finalised at a much earlier stage, reducing flexibility to amend design as a project progresses.
· Offers greater capacity for mass customisation of design.	· Faster build time counts for less as housebuilders still have to sell.
· If building apartments to rent, rent receipts can be received much earlier.	· Limited uptake partly due to perceptions about aesthetics of OSM buildings.
· Repetitive design allows for economies of scale.	· Some materials used in OSM are less resilient to fire, water and physical damage, robust regulation and design[1].
· Potential to improve working conditions and reduce work-related injuries for construction workers due to the controlled nature of the factory environment.	· Entrenched cultural practices in the sector. There is a reluctance to deviate from existing/established networks of contracting bodies.

[1] Written evidence from Zurich Insurance (OMC0054) and Written evidence from Concrete Centre (OMC0061) given to the House of Lords Science and Technology Committee

Why do we need it and why is it growing?

The stagnating private sale market makes the traditional housebuilding model appear less well adapted to current conditions. With a lack of availability of trade contractors, the supply construction chain is tied up. This, combined with the fact that traditional construction costs have risen over the past few years in the residential sector, provides fertile ground for OSM to take root.

In July 2018, the House of Lords Science and Technology Committee (the Committee) published a report[2] noting that the current labour shortage is only likely to worsen in the coming years and suggested that OSM could play a key role in helping the Government meet its target of delivering 300,000 homes per year by the mid-2020s.

This view was supported in 'The Farmer Review of the UK Construction Labour Model – Modernise or Die[3]' (the Farmer Review), which found that due to the age profile of the construction workforce, huge numbers are retiring and are not being replaced, creating what the review called a "burning platform".

The Farmer Review indicates that over the next 10 years there will be an estimated 20-25% decline in the available labour force. This decline is likely to have a significant impact on capacity within the sector, leading to skills shortages that are likely to encourage off-site construction. He goes on to suggest that the Government has a role to play by encouraging clients to change their behaviours (through fiscal or planning system incentives) and buy manufacturing-led construction rather than traditional.

As OSM requires fewer workers due to the fact that many of the manufacturing processes are digitised and completed by machines, moving to an OSM model may help to ameliorate the worsening labour shortage.

[2] Off-site manufacture for construction: Building for change
[3] The Farmer Review of the UK Construction Labour Model – Modernise or Die

Why do we need it and why is it growing?

The Committee's report also suggests that the OSM projects undertaken so far have seen increased productivity. The report quotes Laing O'Rourke explaining their "70:60:30" approach:

"70% of a project's construction [is] conducted off site, leading to a 60% improvement in productivity, and a 30% improvement in delivery schedule"

This is in line with G&T's estimate that a well programmed and developed off-site construction solution in the residential market has the potential to have a 20% shorter programme than traditional methods, with fully-fitted out modular volumetric construction times as much as 40% less.

The environment is also a significant factor. The environmental advantages of OSM range from waste reduction through using standard material sizes, to reduced travel to site due to fewer material deliveries and a smaller range of activities that need to be completed on site.

Because precision is one of the advantages of OSM, the end products are more likely to be energy efficient, reducing UK energy consumption and greenhouse gas emissions. There is also a lower impact on the local community as *"projects that are completed more quickly with less noise, less local air pollution and less traffic disruption, easing the concerns of local residents[4]".*

[4] Written evidence from WPI Economics (OMC0031) given to the House of Lords Science and Technology Committee

Laing O'Rourke

Laing O'Rourke and Caledonian Modular Ltd have completed work on Hinkley Point C's new **£50m campus**, providing en-suite accommodation and recreational facilities for **510 workers.**

Using the latest in off-site construction practices, the Laing O'Rourke construction team has delivered **15 modular accommodation blocks each with 34 bedrooms**, along with an amenity building comprising a reception, restaurant, retail, internet room, bars, TV rooms and gym facilities **within 14 months on-site. 350 car parking spaces and two 5-a-side football pitches** which can be used as multi-use games areas have also been delivered.

The units were **delivered 96% complete** and were then bolted together onsite before finishing wiring and plumbing. It took approximately **six weeks to complete each 34-bedroom block once delivered.**

Crest Nicholson

Crest Nicholson has announced that it intends to build approximately **15% of its homes using off-site manufacturing by 2020.** Over the course of the next 18 months, the company plans to scale up trials of the production technique, aiming to have **300 apartment units in production next year and 420 in 2020.** The company is making progress with core house type range, which will be delivered using a mixture of traditional and OSM techniques

L&G Homes

L&G Homes (a business within L&G capital) has created a **550,000 sq ft modular housing warehouse** in Sherburn-in-Elmet, Yorkshire, capable of turning out **3,500 homes a year**. The first homes produced by its modular factory are being designed for private and affordable rented schemes, with L&G claiming that it will have the capacity to produce 3,500 a year.

L&G has confirmed that the first homes for occupation are currently in production and were expected to be installed on site in September 2018. The company recently commented that the **'precision-engineered'** aspect of the process has **proved troublesome.** The factory's machines can cut materials and **build to tolerances of 0.1mm**, but initially L&G could not get CLT boards supplied to the same tolerance level.

Balfour Beatty

Balfour Beatty recently committed to reducing the amount of work undertaken on-site by **25% by 2025**[5]. Balfour Beatty believes that OSM uptake has been slow due to a fear of failure and suggests that the Government moves away from a risk transfer procurement model, which favours low-cost tendering, to a risk sharing model that will incentivise investment in OSM.

Their publication calls the Government, the industry's largest client, to action and suggests where changes can be made.

Balfour Beatty also provides examples of some of their projects that have adopted OSM, ranging from the installation of composite poles carrying cables from windfarms to substations by using air crane helicopters, to modular rail stations with switches and crossings.

With all stakeholders standing to benefit from OSM, **Balfour Beatty believes that the industry must collectively commit to the OSM agenda to overcome the barriers to wider adoption.**

[5] 25% by 2025 – Streamlines construction: Seven steps to offsite and modular building (August 2018)

Costs: The perception that OSM costs more

Whilst there is little widely available empirical evidence that proves the business case for OSM, it is widely accepted that due to the repetitive, factory-tailored nature of OSM, costs can be lower.

Labour cost savings are possible as OSM warehouses aren't reliant on trade-based workers with higher city centre wages, but on local task-trained operatives. Costs savings are also made by standardising design details which reduce overall design fees. There are also potential cost savings due to a lower risk of delays on site.

The shorter construction programme of OSM can also reduce the costs of site management and facilities costs, while producing a faster return on investment, with reduced financing costs.

However, these savings are not always achieved in practice. Whilst savings are being made in some areas such as student accommodation and budget hotels, in other areas, such as build-to-rent (BTR), capital costs remain higher than for traditional on-site contractor delivery[6]. NHBC's 2016 research report, 'Modern methods of construction – views from the industry[7]' found that one of the key issues preventing or restricting greater use of full volumetric construction was cost. There was concern that some companies *"had been unable to achieve significant site savings to counter the higher capital cost [of OSM], in preliminaries for example[8]"*

This obstacle is likely to be overcome once units can be delivered at scale and to a repeatable design. In theory, construction in a controlled factory environment will boost productivity as tasks can be automated and repeated, leading to faster delivery times, reduced cost and improved quality. However, you also have to factor in the impact of production downtime on overall cost.

[6] Building magazine article – Construction methods: modular (23 July 2018)
[7] Modern methods of construction – views from the industry
[8] p.33 - Modern methods of construction – views from the industry

Costs: The perception that OSM costs more

Another variable that impacts cost is the particular off-site technique being used. Panel and frame systems (often pre-fitted with doors, windows and cladding) can be transported flat-pack onto site then erected cheaply and quickly. The more sophisticated option is the 'volumetric' system, e.g. modules pre-assembled in a factory. This option works well when building more than three storeys as pre-assembled modules have greater structural integrity than panels and frames. However, moving ready-made modules is expensive as you have to transport a lot of empty space.

In order to keep unit costs down, suppliers of volumetric modules require high utilisation. Having a consistent flow of work is tricky to achieve in a very cyclical industry like construction, with variable periods of high and low demand. Factories can produce modular units at lower costs only when its utilisation rate is high. However, with low levels of competition, manufacturers will not be incentivised to pass on cost savings to end-users, so despite costs coming down at higher utilisation rates, prices still remain high.

Cost savings are more likely to be seen when there are higher levels of competition in the OSM sector, forcing manufacturers to compete on margin. With limited suppliers, lower levels of competition enable greater profit maximisation, allowing manufacturers to keep prices similar to the next cheapest alternative – traditional on-site construction with some pre-fabricated elements.

The high cost of labour is another factor that may help tip the scales in favour of OSM. Skilled traditional labourers are becoming more scarce and the cost of employing such labour is increasing. If this trend continues, the attractiveness of OSM, which minimises the residual need for on-site traditional labour, will increase.

At the moment early adopters of modular construction are incentivised by the higher speeds. Driving down costs is perhaps seen as a lower priority in the current climate. However, as demand grows for off-site construction, market forces will push manufacturers to reduce their margins, resulting in lower unit costs for end users.

Why aren’t more companies doing it?

OSM in the UK is in its infancy. Providers are avoiding heavy investment into the automated fabrication systems so the sector is unlikely to be seeing the full benefit of the construction technique. To justify the substantial initial investment needed to set up a manufacturing facility, a company needs a strong, long-term pipeline of projects that they are likely to supply. In the current market conditions, unpredictable demand and fluctuations in the project pipeline don’t provide would-be OSM companies with the confidence to invest the requisite capital needed to establish such manufacturing facilities. Exchange rate volatility is also a challenge for would-be off-site manufacturers relying on raw material imports. The recent weakness of the pound has made the cost of imported raw materials more expensive, eating into any potential margin.

Closely related to this is financing and cash flow. Contractors are usually paid monthly, based on the work that has been completed in that period. With OSM, contractors are only likely to be paid when the modules/ units are erected on site. Consequently, OSM companies require a very different cash flow profile, with a sizeable up-front investment to fund their production cycle.

Entrenched cultural practices and the fragmented method of contractors working in silos has also hampered the progress of OSM in construction. OSM requires high levels of collaboration which is difficult to achieve in a sector where disputes are common and trust is low.

The processes involved in traditional construction are mostly sequential and isolated. With OSM, products are designed and created holistically, involving collaboration between multiple parties. The sector needs to adopt a more collaborative business model so that designers, contractors and suppliers are all involved in the fully integrated design approach at an early stage, which will increase the likelihood of success for off-site projects.

CONCLUSION

Whilst OSM for construction is not a 'one-size-fits-all' approach, it does have clear and tangible benefits which make a compelling case for its widespread use.

The Farmer Review provides several recommendations to promote the use of OSM in construction, ranging from government policy measures ('initiation') and planning breaks, to charges placed on business clients of the construction industry (e.g. 0.5% of construction value) which could be avoided if clients can demonstrate they are contributing stimulus to industry capacity by providing, for example, pre-manufacturing facilities.

In the Committee's report, 'Off-site manufacture for construction: Building for change', Andrew Wolstenholme explains that OSM ***"will not happen across the whole of the sector unless the public sector, which by a country mile is the largest construction client, understands the part it has to play".***

A consistent and coherent Government policy will assist in the mass take-up of OSM. In the November 2017 Budget, the Chancellor announced a ***"Presumption in favour"*** of OSM by 2019 across suitable capital programmes. The Committee, in its 'Off-site manufacture for construction: Building for change' report[9]' has since recommended that:

"…the Government develop and publish a series of Key Performance Indicators against which the success of the "presumption in favour" [of OSM] can be assessed" [10]

A presumption in favour would help give OSM companies confidence that there is a pipeline of repeatable projects and will therefore be more likely to make the necessary capital investments necessary for OSM.

The tangible benefits that OSM brings have led to the Government favouring the construction technique, committing to invest in OSM in the Construction Sector Deal. The Government believes that investment in OSM will help support the sector to develop the products and technologies necessary to fulfil market demand, incentivising further adoption of OSM techniques.

Needless to say, the widespread adoption of off-site techniques in the construction industry has several barriers to overcome. Perhaps the most substantial barriers are the structural and cultural shifts required.

If you have any questions regarding the content of this report, please contact Michael Urie.

[9] Science and Technology Select Committee: Off-site manufacture for construction: Building for change

[10] Chapter 6: Government actions to overcome barriers - Science and Technology Select Committee: Off-site manufacture for construction: Building for change