

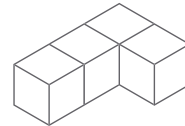


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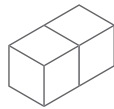
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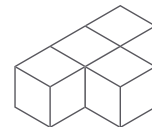
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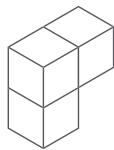
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Foreword

The construction industry is at a critical juncture. For years it has struggled with deeply ingrained structural flaws, giving rise to low margins and low productivity. To this can now be added the looming uncertainties of Brexit, which promise to exacerbate skills shortages, and to accelerate the threat of a demographic time bomb for the industry's labour force.

The silver lining is that hard times often provide the catalyst for real and lasting change. There is a growing perception that technological advances and new methods of construction are gaining traction, and have the potential to drive productivity gains and increase capacity, while still delivering on quality.

But the tipping point has not yet come, particularly when it comes to using advanced off-site manufacturing (OSM) techniques to deliver cutting-edge buildings. Despite several notable pioneers, traditional on-site construction remains the norm while the industry grapples with how best to embrace the opportunities – and mitigate the risks – that OSM presents.

That could be about to change. From next year the UK Government is committed to adopting a “presumption in favour of off-site construction” across several key departments, including transport, defence, health and education. In addition, the “Construction Sector Deal”¹ launched this summer with a view “to transform the sector's productivity through innovative technologies and a more highly skilled workforce”. It identified OSM as one of its key areas of focus, in the belief that it will “minimise the wastage, inefficiencies and delays that affect on-site construction, and enable production to happen in parallel with site preparation – speeding up construction and reducing disruption”.

Meeting those objectives will necessitate a paradigm shift in how projects are developed and implemented, requiring greater collaboration between clients, architects, contractors and suppliers, and further investment in R&D and production processes. Other innovations such as artificial intelligence (AI), robotics, 3D printing, and blockchain digital supply ledgers

could also increasingly play a role in finally bringing the industry into the 21st century.

To keep all this innovation on track, a robust legal framework will be essential, from contract terms for supply and installation to professional indemnity and product liability, and effective regulation of environmental, health and safety, and employment issues.

For many in the industry, however, off-site manufacturing and its implications remain uncharted territory – or at least a work in progress – which is why we are publishing this report. Using an exclusive survey of C-suite executives from the UK's top 50 contractors and in-depth interviews with a broad cross-section of industry players, we give an overview of some of the key technical, commercial, legal and regulatory implications that businesses need to consider.

Should you require any further information on this topic, or the findings contained in this report, please do not hesitate to contact us.

¹ <https://www.gov.uk/government/publications/construction-sector-deal/construction-sector-deal>



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Survey results

Our survey of the UK construction's C-suite provides a useful pulse check of the industry's current position with regards to OSM and the direction of travel for the next five years.

Investment

One of the first things we asked was why they would invest in OSM technology. To improve productivity was, unsurprisingly, the most popular answer. This was followed by the need to overcome new challenges in construction and tackle the skills shortage.

Over two thirds (68%) of survey respondents said that their organisations are very seriously considering the use of new and emerging construction-related technology, with the remaining 32% taking a 'somewhat serious' approach.

This serious approach is reflected in the percentage of revenue invested in OSM over the last five years, compared to the next five. Just over half (55%) of survey respondents spent only 0-2% of revenue on OSM in the last five years, while in five years' time just 6% expect to invest at this low level. The majority plan to invest much more.

Barriers

According to the survey respondents, the top two reasons hindering the implementation of OSM are capital costs and lack of relevant knowledge within their organisation. Based on our interviews, a lack of a clear project pipeline can also be considered a serious barrier.

Despite these hurdles, all respondents agree – to some extent - that OSM has the potential to fundamentally transform the construction industry.

Timescale for step-change

The construction industry is yet to reach a tipping point in which a large proportion of construction is carried out using OSM techniques. Currently four fifths (80%) of survey respondents' organisations use OSM for just 1-20% of the construction work they carry out.

However, in five years' time this is expected to increase, with 61% saying they expect to double the amount of construction work that they carry out using OSM, to up to 40% of the total.

The majority of the survey respondents (62%) believe it will take 5-10 years for OSM technology to have a material impact on their organisation's productivity.

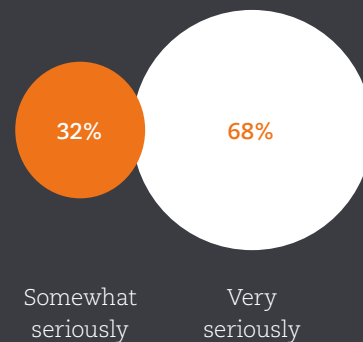
A survey of over
30 C-suite executives
from the UK's top 50
construction firms.

Investment

Why do you/would you invest in off-site manufacturing technology?



How seriously is your organisation considering the use of new and emerging construction-related technology?

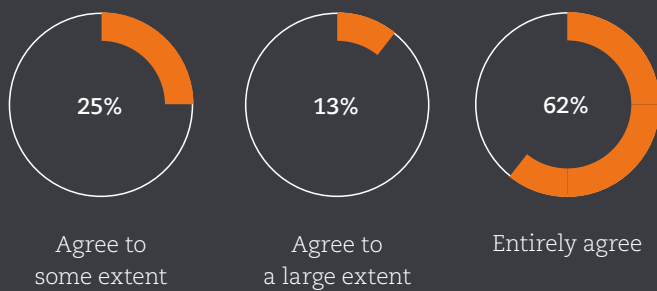


Percentage of revenue invested in off-site manufacturing over the last five years vs next five years:



Barriers holding back progress

Off-site manufacturing has the potential to fundamentally transform the construction industry.

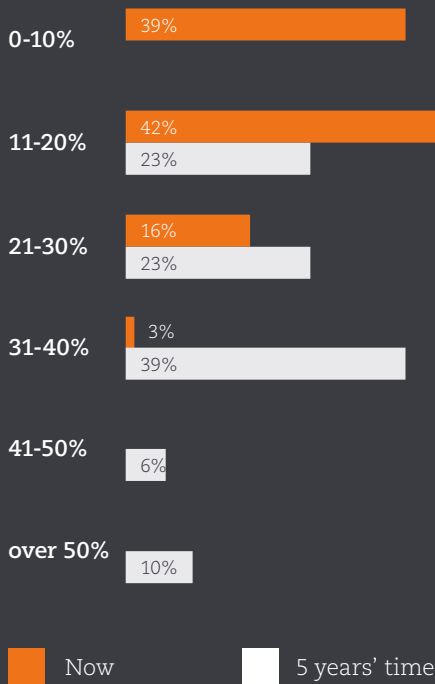


The key barriers stopping the development of off-site manufacturing in the construction sector:

- 1st**
Capital costs/investment costs
- 2nd**
Lack of relevant knowledge within the organisation
- 3rd**
Waiting for broader roll out across industry
- 4th**
Increased risk
- 5th**
Unavailable technology
- 6th**
Resistance from the board

Timescale for step-change

Current use of off-site manufacturing in construction vs next five years:



When do you expect off-site manufacturing technology to have a material impact on your organisation's productivity?

25%

said 1-2 years

62%

said 5-10 years

10%

said 10-15 years

3%

said more than 20 years

Disruption in construction: An industry perspective

In 2016, The Farmer Review of the UK Construction Labour Model warned that the construction industry must “modernise or die”.

How much do you expect off-site manufacturing to change how construction is carried out in your organisation over the next 5-10 years?

23%

said to some extent

74%

said to a large extent

3%

said entirely

Two years on from this influential report, what progress has the industry made in embracing its key recommendation to make greater use of off-site manufacturing techniques, and what barriers may still be holding it back? What does the future look like and how will we get there?

To find out, we interviewed a wide variety of industry participants covering a broad spectrum of perspectives, including: architects, designers, developers, contractors, housing associations, representative bodies and government organisations.

Their views on how off-site construction is impacting today's infrastructure and built environment - from innovative private housing schemes to student accommodation, from public sector buildings to transport and utilities - shine a fascinating spotlight onto current thinking in the industry (where opinions differ), and what are likely to be the drivers of real, long-lasting change.

It's clear from our interviews that some sectors of the industry are further advanced than others in the use of OSM, having diverse priorities and

a range of different drivers. Benefits in terms of speed to build are being weighed up against concerns over quality, and for many, the cost benefits are yet to be fully realised. We consider these contrasting views in more detail in the following sections.

But first, how different does the picture look now to Mark Farmer compared to 2016, when he authored his report? Well, he is confident that the necessary changes are fathering real momentum, with Government maintaining its focus on OSM, private sector interest increasing, and a growing frustration with the limitations of traditional construction techniques. More clients are prepared to move up the risk chain by adopting innovative new techniques and there has been a shift towards true advanced manufacturing.

All of which means that the off-site market is beginning to believe that its time has come, although Mark predicts that the positive disruption that it brings is more likely to be an evolving process, rather than a "big bang". At present, the use of OSM still requires conscious buy-in by developers. The objective is to reach a position where its use represents "business as usual".



Driving demand

The primary drivers of off-site techniques and technologies are well-known - the skills shortage, the housing crisis and the productivity gap being chief among them. But at a more granular level, what are the factors at play in making OSM an attractive option for an industry traditionally resistant to change?



Where time is short and space at a premium, speed, increased capacity and lower cost of delivery are critical considerations. Many of those now embracing OSM are demonstrating how improvements in all three factors can be achieved, converting planners and the public alike to the benefits.

“

I think we are seeing a real tipping-point. We've seen many false starts before, but now there's real energy and visible delivery at scale around off-site construction.

- Philip Breese, Weston Williamson

In just one example, architects Weston Williamson and Partners were able to create a 50% uplift in the number of units achievable in a block of student flats in south London by converting to a modular design, without increasing the building's height or footprint. This switch meant that the development could also be delivered within a far shorter timeframe than would usually have been possible, with minimal impact on the local area and with scope to retain architectural “design quality”. This is exactly the type of outcome that both private developers and public authorities will be keen to see replicated.

Indeed, Homes England, the national housing and regeneration agency, sees a key role for OSM, as it seeks to achieve its policy objectives of facilitating an increase in housing supply and creating a more diverse housing market. One of its aims is to encourage and enable collaboration among industry players large and small, to meet the challenge of labour shortages via OSM, and it is funding several pilot schemes, specifically related to volumetric manufacture and focusing on the private rental sector.

“

Off-site manufacturing is seen as the way forward on all scales – national and international.

- Robbie Erbmman,
Transport for London

Which off-site manufacturing technology/developments will have the biggest impact on your organisation?

1st

Off-site modular construction

2nd

BIM

3rd

Off-site 3D printing of bespoke components

4th

Mobile off-site manufacturing factories

5th

Pre-furnished volumetric solutions

However, as our interviews have highlighted, there are many factors at play in making the case for OSM. Moving from site to factory can increase productivity by eliminating weather-related delays and by taking advantage of production-line efficiencies, and can encourage recruitment and retention by moving operations indoors.

Indeed, a precision-engineered design solution, manufactured in a controlled environment, could be off-site's USP in providing both assurance over quality and improved working conditions.

“

Off-site is not just about building things better, but building better things.

- Matt Gough, Mace

That may sound unlikely to critics, concerned over what they see as poorer build quality compared to traditional techniques, but proponents of OSM say that such negative perceptions are outdated, pointing out that the off-site techniques of today are vastly superior to the “pre-fabs” of the 20th century that gave pre-manufactured options such a bad reputation.

Some might argue that off-site production is at the expense of traditional craft skills and individual bespoke design, but the creation of

identikit boxes is an outcome that most OSM protagonist are keen to avoid. As Mark Farmer points out, there needs to be a focus on place-making, as well as technical build quality.

Indeed, the desire for individuality and a “sense of place” can be a positive factor in driving consumer/end-user demand for OSM. According to a number of our interviewees, homebuyers today - especially the younger generation - are less put off by the idea that houses have been built off-site than they are motivated by the desire to “put their own stamp” on their homes. Designing flexible platforms for “mass customisation” – where homebuyers can pick and choose the external look or internal layout and fittings of their new home to reflect their own individual style – will be vital in tapping into this desire for more bespoke options.

Don't get left behind!

Many interviewees were keen to point out that there are clear risks inherent in not embracing off-site. Those that don't could find themselves edged out of the market by established OSM players from around the globe, such as China or other parts of Europe, or by disruption from new entrants. As Steve Fozard of Costain put it: “We need to undertake a radical digital transformation or we could be wiped out when the Amazon, Google or Tesla of construction comes along.”

There was a strong feeling, however, that there is still time for the UK to position itself as a market-leader on the global stage, providing vital export opportunities and re-invigorating both manufacturing and construction. Although Germany and Scandinavia are seen as more advanced in the off-site space, it was felt that there were still significant opportunities for UK players to drive innovation and seize market share. “We need to start thinking about exportability rather than importability,” was the challenge laid down by Susan Hone-Brookes of the Manufacturing Technology Centre.

“

We've got so many highly repeatable elements in construction that we could productionise tomorrow – we just need to change how we think.

- Susan Hone-Brookes, MTC

Toby Uppington of AECOM believes that the time to act is now. “The huge disruptive change at the moment, because of the focus on technology, means that the OSM market is in a “sweet spot” which companies can capitalise on.” AECOM is a major proponent of OSM, and has a “presumption in favour of off-site”.

As Toby says: “it’s not what can be pre-fabricated off-site but what can’t” that should be the key question in each case.

In addition to creating export potential, the development of additional manufacturing capability also makes sense for UK-based construction, from a logistical and cost perspective, and allows closer scrutiny of quality and better risk mitigation.

Seizing this opportunity, however, may require the tackling of some of the structural barriers that have long held UK manufacturing back. For example, Robbie Erbmman, TFL’s Head of Housing Strategy, cites the difficulties of creating off-site facilities in and around London, due the high cost of land, lack of manual labour force and high wage costs. Steve Fozard believes that this is where the traditional manufacturing heartlands of the Midlands and the North have a competitive advantage, and that OSM could play a part in rebalancing the North-South divide in terms of skills and job opportunities.

Reconciling the need to invest with commercial realities

Though the drivers for moving towards an off-site manufacturing model, and the risks of not doing so, are becoming clearer, the hurdles also continue to loom large.

Clear, long term pipelines of projects are vital

Making the business case for investment in OSM is, perhaps, the biggest obstacle. Many of the commentators we spoke to were unequivocal in their view that a lack of a secure, visible, long-term pipeline of projects, on which off-site techniques can be used, is a major barrier to investment - both when it comes to R&D, and even more so in the context of developing new manufacturing facilities to deliver the economies of scale necessary to make off-site viable.

Though investment in innovation is certainly taking place, it's yet to crystallise in the kind of scalable way that could open the door for widespread adoption. Architect Bryden Wood is rising to this challenge by looking at how it can spearhead standardised manufactured solutions to create standard components - what it calls a "platform-based approach" - which can one day be commercialised and shared.

Other businesses are also pushing the envelope in their own ways. Whether it's the recent use by Mace of a 600-tonne on-site factory tent at its £180m development at East Village in the Olympic Park, in order to provide a covered, controlled environment, AECOM's strategy of investing in supply and fabrication, and assembling either on-site or in a nearby temporary facility, or Swan Housing's bespoke

production facility in Essex, from which it plans to deliver a 600-home development over the next five years.

The latter is a good example of the type of vertically integrated approach to procurement increasingly being taken, whereby businesses can retain control of the whole project life-cycle, turning the traditional model, underpinned by architect/main contractor/sub-contractor relationships, on its head.

“

There needs to be a lot more picking apart of the economic model for construction. A component-led approach is one way to do this so clients have more control.

- Colm Lacey, Brick by Brick

Lack of a visible secure pipeline is an issue which is particularly acute in the rail sector. Superficially, there does appear to be a clear investment route via Network Rail's Control Periods, which set out investment priorities over five-year timeframes. These are, however, at the mercy of available budgets, which tend to deplete towards the end of each period. As David Clarke of the Railway Industry Association (RIA) points out, although the rail sector has been using off-site fabrication for many years (particularly for track renewals), there is still scope to do far more.

For example, when it comes to track renewals, the RIA estimates that a 30% productivity gain could be achieved simply by smoothing out the pipeline, so that appropriate investment can be made in people and skills, as well as in measures such as increased pre-fabrication and standardised designs. And around two-thirds of the signalling network also needs replacing in the next 15 years, so there's huge potential to create the “digital railway” that has been on the horizon for so long.

So why the hold up? “At the moment we are between a rock and a hard place,” Clarke says. “The volume is just not there to meet the investment case, but neither is the confidence in the ability to deliver – which is essential for a guaranteed pipeline.”

A different note of caution was sounded by Stephen Barker of East West Railway Company who pointed out that, when it comes to building entirely new rail infrastructure, the rationale for off-site construction is very different to that for existing rail upgrades. New rail projects are often not subject to the same time, space and access constraints, as upgrades to existing infrastructure, as they don't involve work on “live” tracks. In these projects, he says: “If there's a premium to be paid for off-site, it may not be worth it. But if quality improvements can be delivered, that's likely to be more of a driver.”

“

There's huge potential out there, but more thought needs to be given to demonstrating the gains.

- Stephen Barker,
East West Railway Company

This reinforces the core message of many of our contributors – OSM needs to be about enhanced quality, not just reduced time and cost, if it is to achieve its true potential.

Where will the impetus come from?

Whether the Government truly has the political will or capital to deliver a secure, long-term pipeline – whether for homes, schools, hospitals, railways or other infrastructure – was a moot point for many of those we interviewed. All believed, however, that the Government's commitment to procuring off-site buildings where possible would be crucial in drawing major investment in OSM techniques and technologies.

Although, as argued by the recent House of Lords report “Offsite Manufacture for Construction: Building for Change”, Government could be doing more. Suggestions there included the adoption of key performance indicators and a “comply or explain” approach to reinforce its presumption in favour of OSM.

Despite this, some were sceptical that any government would be able to guarantee a pipeline for long enough (e.g. over a decade) in a constantly shifting political landscape to allow major investment decisions to be made. After all, building a factory is a major outlay for even a large industry player, and carries significant risks.

“If you set up a big beast, it’s got a big mouth that needs feeding,” observed Andy King of modular pioneers Wernick Group.

However, on the flip side Andy believes that traditional construction methods could themselves start to become comparatively expensive, particularly if Brexit exacerbates the lack of traditional skills in the industry. If and when this happens, the investment case for OSM may become easier to make, acting as a major driver towards greater use of off-site techniques.

Leveraging funding opportunities

Whether or not the Government can lead real change as a client may still be open to debate, but that said, it is at least taking steps to provide the right conditions for investment, and to

provide help in the form of financial support for industry innovation, and it believes that the construction sector could do more to take advantage of the opportunities available.

For example, Homes England sees the creation of an environment that encourages investment in OSM as one of its major challenges. Stephen Kinsella, its Director of Land, points out that the cyclical nature of the housing market can often deter investors. This is why it is seeking to diversify the market via a broader focus on private rented homes and affordable housing, in order to make it a more attractive prospect.

Innovate UK is a body set up to support collaborative investment in innovation. It holds competitions for organisations to win funding for original ideas from any sector of UK industry, typically within a GBP 5-20m budget range.

To date, many of its applications have come from developers of new products or “gadgets”, but Innovate UK is also keen to back process-driven innovations that enable businesses to “do things better”, and off-site technologies could be a clear example of this.

The Manufacturing Technology Centre (MTC) is another resource for companies with good ideas in the OSM space. Part of the High Value Manufacturing Catapults set up a decade or so ago to help turn academic research into economic opportunities, the MTC helps companies prove the viability of concepts in order to get investment for their commercialisation, and is one-third publicly funded.



What will change look like?

A variety of innovations are gaining momentum, from customisable homes where buyers can “click and select” features and add-ons, to component-led “platforms”, developed using Design for Manufacture and Assembly (DfMA) techniques.

It's the latter that Jaimie Johnston of Bryden Wood believes is the answer to making OSM a concept that the industry at large can adopt. This requires an understanding of the underlying DNA of different building types, so that a kit of standardised parts can be developed that works for every possible requirement and configuration, enabling constructors to “customise without compromise” in order to create unique buildings from standardised components.

Building or product?

Such standardisation would mean a further shift away from traditional construction methods towards a true manufacturing approach, where all the intelligence goes into the design of the “product”, so that assembly itself is relatively easy. Jaimie's view is that such a component-led approach would help to tackle the current

skills gap, dramatically altering the profile of the labour market, by enabling greater use of local, unskilled workers to put the parts together, while creating attractive modern career paths in other, more highly skilled areas. It could also address productivity issues, reduce costs, boost UK manufacturing and create scalability.....even delivering the export potential referred to earlier by Susan Hone-Brookes.

It's a concept that chimes with Andy King's view of the future. Wernick is heavily involved in its own innovations focussed on developing modular solutions, but Andy says that - to create a real step-change - generic, standardised solutions will one day need to be developed, and continuously refined, in the broader market.

Pioneering such a radical change may need someone with plenty of capital,

ambition and desire to do things differently, perhaps even coming from outside the industry – much like Tesla is doing for electric cars. In addition, the transferability of skills between manufacturing and construction – which is currently very rare – may need to improve, as the line between ‘building’ and ‘product’ blurs.

Indeed, Susan Hone-Brookes of the MTC foresees a future where factories could be flexible enough to have production lines feeding both construction clients and the automotive or engineering sectors, manufacturing for the former a broad range of off-site components on demand. “Volumetric, modular, standardised components – they all have their place. If manufacturing facilities could produce them all, they would have a well-diversified portfolio and be in a good position to withstand market fluctuations.”

“

We need different ways of thinking to drive out real efficiencies. There's much to compare between car manufacture and construction manufacture.

- Geoff Pearce, Swan Housing

Colm Lacey, from Croydon Council's development vehicle Brick by Brick, agrees that being able to rely on a component solution would help avoid some of the problems that the industry currently faces when it comes to off-site. He points to the risk of being tied to one process or supplier, which could leave businesses vulnerable to delays in delivering a specific product, or create problems at a later date if bespoke suppliers / installers become insolvent at a time when replacement products or repairs are needed. He thinks that the market needs greater choice: "We want to be in the right place at the right time with modular, but we are limited by what is available. At the moment, suppliers have their choice of schemes, rather than the other way around."

Open source or closed innovation?

For a component-led solution to achieve its full potential, however, many believe that it needs to be

underpinned by an "open-source" approach, where intellectual property (IP) is widely shared to create critical mass in the market, so that more businesses can then benefit from successful innovation.

“

Through an open-source, standardised approach, if we can share IP, we can create a bigger market.

- Jaimie Johnston, Bryden Wood

Jaimie Johnston cites the example of the inventor of the ISO shipping container, Malcolm McLean (founder of the McLean Trucking Company). He made the design of his containers widely available, together with patents for the locks that fit them together, recognising that such a move would "grow the market for containerisation and amplify the benefits² Vehicles, ports and other logistics could then be designed to accommodate this new standard, creating a more streamlined and efficient market, expanding individual companies' own capabilities and creating "a powerful network effect."

Under this model, the originator of the innovation may not end up with a monopoly of the market, but it does have a whole sea of opportunities to pursue, rather than simply being a big fish in a small pond.

It's this that Bryden Wood would like to see replicated in the context of OSM, but a fundamental shift in thinking may be required, to resist the pressure to prioritise short term objectives and outcomes. As Toby Uppington, of AECOM points out, companies tend to want to capitalise the benefit of their investments as soon as possible, so that they can provide a return for shareholders.

Off-site or on-site?

Another idea that many interviewees discussed was the validity or otherwise of a rigid distinction between off-site and on-site operations, and whether the real question is, the extent to which construction methods should give way to "production line" processes, wherever the actual location.

For some, change is "using traditional materials, but putting them together in a different place" – as Geoff Pearce of Swan Housing describes his organisation's investment in a bespoke factory to produce off-site homes.

Others, like David Pearce of the RIA say that "it's not so much off-site manufacturing as on-site manufacturing" – an idea that has its champions in the building sector too, as Mace's on-site production tents attest. Indeed, there's a sense that, while using a fixed-location factory is the right course of action for some, for others, a "floating" facility that can travel to site might be a better solution.

² Bryden Wood "Platforms: Bridging the gap between construction and manufacturing"
<https://www.brydenwood.co.uk/filedownload.php?a=360-5aaf9367d5105>

Given that the threat of future, on-going disruption looms large - whether through external challenges like Brexit or through endemic structural weaknesses within the industry itself - investing in more flexible options may be more suitable for some business models, than making a large capital investment in a permanent factory site.

A changing skills environment.... and a digital future

In an OSM environment, skills requirements are likely to shift significantly. Weston Williamson's Philip Breese notes that the move towards off-site is going to require a whole new approach to training. Matt Gough of Mace sums it up like this: "The future does look more multi-skilled. Workers may need to manage new areas such as logistics or understand the design principles behind what they are working on."

This makes it imperative for the industry to train and recruit people with the right kind of skills. TFL's Robbie Erbmam points out that the Mayor of London's Construction Academy is an important step in the right direction. It will support training providers, employers and young people in developing the skills needed for London's future built environment – and that includes supporting "the development of training provision for the construction of precision-manufactured housing".³

Educating the supply chain is also important – which is why several tier one contractors, including Costain, Laing O'Rourke, Skanska, Wates and Balfour Beatty, have come together to set up the "Off-Site School" to update their supply chains free of charge about the benefits of off-site. Such a collaborative approach is, many believe, the key to driving real change in the industry.

For Mark Farmer, digital expertise will have a key role to play in the future skills environment, especially given the importance of DfMA. Digitally-enabled facilities and scalable platforms, underpinned by high-tech skills, will need to come to the fore to transform what is essentially an "analogue" process into a digital one. And this applies to on-site activities, as much as to OSM.

“

Digital is at the heart of how we change – both on- and off-site. Digital should not stop at the factory door.

- Mark Farmer, Cast

Costain's Steve Fozard agrees. He is already working on digital twins and workflows, underpinned by BIM, which give him the ability to meet clients and suppliers in virtual site models.

He also believes that a digital supply chain is essential to overcoming the skills gap, as well as creating traceable records for asset owners which will provide assurance over product standards and suitability of usage – one area where blockchain could come to the fore.

“

We need to undertake a radical digital transformation or we could be wiped out when the Amazon, Google or Tesla of construction comes along.

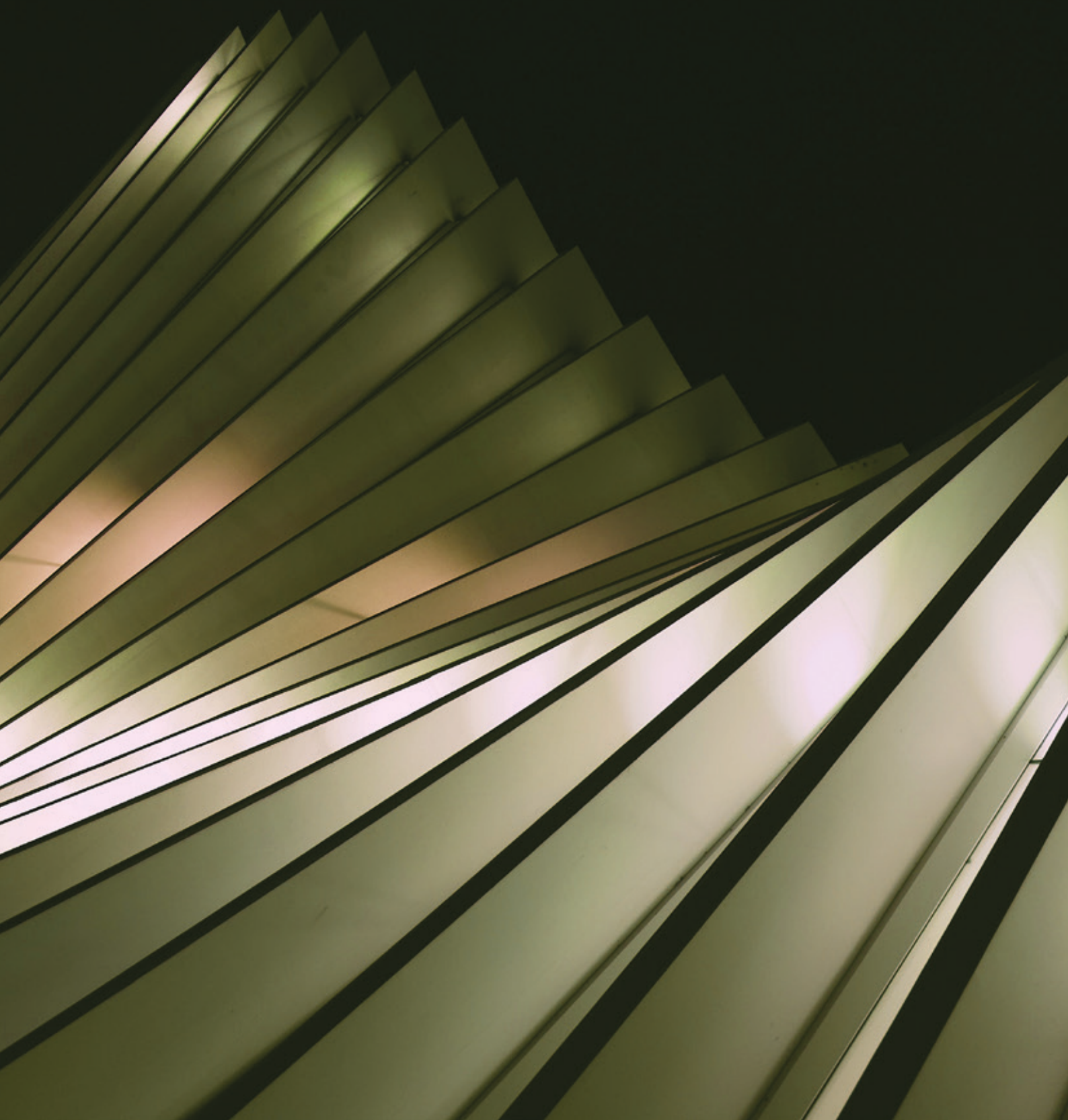
- Steve Fozard, Costain

“

You get the supply chain you deserve. It's vital to build long-term collaborative relationships where everyone benefits...

- David Clarke,
Rail Industry Association

³ https://www.london.gov.uk/sites/default/files/mayors_construction_academy_programme_april.pdf



Re-thinking legal frameworks and quality assurance to support innovation

Radical new ideas
and ways of working
are likely to require
established quality
assurance and legal
frameworks around
construction to
be re-evaluated.

QA for OSM

Issues such as mortgageability of new OSM homes were raised by a number of our interviewees. Many do not see a problem so long as housebuyers have access to warranty schemes similar to those that apply to other new homes. Whilst significant progress has been made in this respect - through, for example, the activities of the Buildoffsite Property Assurance Scheme (BOPAS) - one of the recommendations of the recent report on OSM by the House of Lords Science and Technology Select Committee was that “the Government explore options for the accreditation of housing built using off-site manufacture, to ensure that mortgages are available to those who wish to purchase them”.

Generally, there appears to be a widespread sense that some sort of industry standard “Kitemark”, or other quality assurance indicator, might be required for OSM products, along the lines of the FENSA accreditation for windows, in order to provide additional comfort to those encountering OSM for the first time. After all, it will not need many reported instances of poor quality for the “prefab” image to return with a vengeance.

The immediacy of this issue was demonstrated by the recent assertion of another parliamentary committee, in the midst of this year’s unusually hot summer: “Modular homes are not resilient to heatwaves, and the Committee is calling for

the Government to end public funding for them.”⁴

Needless to say, OSM proponents strongly disagreed, pointing out that heat mitigation is a matter of good design and appropriate materials, whether construction takes place on or off-site. The force of such arguments would clearly be enhanced, however, if backed up by a recognised industry accreditation.

Contracting for OSM

From a contractual and supply chain perspective, it was pointed out by some that the allocation of risks and liabilities may be very different for projects and developments constructed off-site compared to those built in a traditional manner. There was a strong feeling that a collaborative approach and shared risks and rewards, with incentives aligned between all parties, is critical to success.

Indeed, several of our interviewees questioned whether current JCT or NEC standard form contracts are fit for purpose for off-site projects. The potential need for new contracts to be developed specifically for an OSM context was seen as important for the development of the market – particularly, where the relevant procurement model is seeking to wrap the entire project lifecycle – planning, design, production, fabrication - but with necessary flexibility for the project client to withdraw at one or more of these stages.

Payment issues were also flagged up for particular attention. Traditional payment terms requiring payment after materials get onto site can be problematic for OSM, especially where full volumetric modules are essentially completed off-site weeks or months before actual delivery.

We address some of these issues and more in the next section.

⁴House of Commons Environmental Audit Select Committee <https://www.parliament.uk/business/committees/committees-a-z/commons-select/environmental-audit-committee/news-parliament-2017/heatwaves-report-publication-17-19/>

OSM – the legal perspective and key considerations

Here, we discuss many of the key legal issues raised by the increasing use of off-site manufacturing (OSM) and provide insight into some of the most important considerations parties involved will need to take into account.





Procurement and contracting

Legal areas of focus include:

- Procurement and contracting
 - Advance payments and insolvency risk
 - Professional indemnity
 - Product liability
 - Dispute resolution
 - Blockchain and smart contracts
 - Employment
 - Health & safety
-

OSM gives rise to a number of potential 'disruptors' to the traditional approach to contracting and procurement in construction.

Allocating contractual risk where there is high pre-manufactured value

Pre-manufactured value (PMV) is a term used in the Farmer Review to denote that element of a project's expenditure that relates to OSM. Where there is a high PMV as a proportion of overall project cost, much of the activity and risk in the construction process has been transferred away from the site of the development itself. This leaves a truncated period of on-site operations concentrating on enabling works, and subsequent assembly of the pre-manufactured components.

Such a shift sits uneasily with a traditional design and build (D&B) approach, where a contractor provides a single point of responsibility to its client and charges a premium for co-ordinating and managing what is primarily a site-based process. It is questionable why a developer should pay such a premium when most activity and risk resides instead in the PMV, and is outside the control and expertise of a traditional contractor. Why a contractor would wish to assume full contractual responsibility for a risk that it is not well-equipped to manage and mitigate is also debateable.

This does not mean that single point responsibility is always inappropriate in an OSM context. If all or most PMV lies with one manufacturer/supplier (for example, if a solution is fully modular), then that entity may be able to offer to wrap the on-site preparation and assembly as well, and thereby assume a turnkey-type responsibility to the developer.

Even where the PMV is spread across a range of manufacturers, there is no reason why, in principle, delivery and quality risk for all components could not be wrapped by one entity, provided that it has the expertise and confidence to manage the commercial and logistical processes involved.

Such an entity would probably have more in common with the Project 13⁵ concept of an “integrator”, rather than a traditional tier one contractor. An integrator is envisaged as any organisation that actively engages all tiers of the market, and integrates the core activities of modern construction – i.e. engineering and planning, the supply of components and resources, and on-site production.

If such an integrated approach carries too much risk to be offered on a turnkey basis, then some variant of construction management, or management contracting, is likely to be the favoured route.

A construction management approach would involve the developer contracting directly with the manufacturing supply chain but being assisted in the management of those contracts by an experienced consultant/contractor. A management contracting approach would see a consultant/contractor entering into the supply chain contracts itself and being responsible to the developer for the delivery of the pre-manufactured components, but only to the extent that it is able to recover from the suppliers any liability on its part for failures in delivery. In other words, the developer would retain the risk of supply chain insolvency.

Whichever route is chosen, however, the unifying theme is that it may no longer be appropriate for the lion's share of contractual risk to be absorbed by an organisation that is primarily site-focused.

Allowing for early design freeze

An efficient use of OSM will almost certainly require a project's design to be developed and finalised at a relatively early stage, prior to commencement of off-site production – particularly where that design has a specific impact on the form and characteristics of the components being manufactured.

Subsequent client-led variations to developed design have always been one of the primary causes of delay and additional cost in construction projects. The consequences are likely to be even more serious in an OSM context – especially if production lines need to be re-configured or manufactured components discarded. In such circumstances, subsequent variations could become an existential risk for the commercial viability of a development.

To avoid this, a robust two stage approach to procurement may be required to ensure early design ‘freeze’. Early supply chain involvement in the first stage of design development (implemented on DfMA principles), would lead to a definitive brief. This would then form the basis of the second stage procurement of the required off-site products and on-site resources, with minimum scope for subsequent variations.

This approach may also require a cultural shift by developers and their design teams, whereby they come to see construction as the disciplined procurement of a pre-determined product – albeit a highly-engineered one – rather than an evolving and essentially bespoke process.

⁵ Project 13 is a new business model proposed by ICE. It is based on enterprise rather than transactional principles, and is designed to boost certainty and productivity in delivery, improve whole life outcomes, and support a more sustainable, innovative, and skilled industry.]

Standardisation and collaboration

As is emphasised by the 2017 report on Delivery Platforms for Government Assets⁶, one of the key potential benefits of OSM is the scope for achieving both reductions in time and cost, and enhancements in quality and reliability, by the use of standard, repeatable processes and designs. To achieve this without compromising flexibility and functionality, the report recommends an iterative process, compromising:

- the rationalisation of design options, so as to remove unnecessary variation;
- the standardisation of common solutions, so as to facilitate production and installation;
- the ongoing optimisation of standardised components, so as to reflect refinements in light of repeated use.

From a procurement perspective, this iterative process will naturally work best in the context of long term project pipelines and frameworks - most readily achieved by public procurement in housing, health, education, prisons and other social infrastructure, or in the regulated transport or utilities sectors.

Whilst the use of OSM cannot itself drive the political and economic decisions required to procure such projects, its promised efficiencies in time, cost and quality could help to build the business case for them – particularly, in the context of demonstrating value for money for the taxpayer / billpayer.

The creation of long term project pipelines should, in turn, create the necessary incentives for the supply chain to invest in OSM and in other forms of innovation - leading to even greater efficiencies and value for money in procurement.

The implementation of such a virtuous cycle will, of course, require political leadership, and this is one of the reasons why the Government's stated intent to use its purchasing power to encourage OSM is particularly important.

From the more fragmented perspective of private sector procurement, however, it may be less easy to move the dial as quickly. Having said this, the potential benefits of long term investment in a robust, diverse and flexible marketplace for OSM are yet another reason to move away from a short term, adversarial and price-obsessed approach in favour of a

longer-term, more collaborative and strategic focus.

The case for alliancing, partnering, multi-project frameworks, joint ventures, and other forms of collaboration should therefore be bolstered by (and encourage) greater use of OSM. Innovation in this area will be accelerated by the type of open source approach to intellectual property and knowledge sharing that will only be viable in an environment of trust and co-operation.

A need for new contract forms?

Having considered these three ways in which OSM has the potential to disrupt traditional methods of procurement, the question arises as to whether they create a pressing need for a new approach to its standard form contracts?

While JCT, NEC, PPC and the other UK standards all have options within their respective stables that go some way to addressing the issues flagged above, none are yet sufficiently geared towards addressing a procurement structure that is likely to have all of the following characteristics:

- a long-term collaborative relationship between clients and a more diverse supply chain;

⁶ Produced by Bryden Wood, with input from the Manufacturing Technology Centre, the Ministry of Justice, the Education & Skills Funding Agency, and the Infrastructure and Projects Authority

- no intermediary in the form of a tier one contractor (unless it clearly adds value, due to the scale and complexity of the project);
- a primary focus on product delivery, rather than on-site activity;
- a highly-engineered digital design, with minimal subsequent variation; and
- incentivised innovation across successive projects, and across the supply chain itself, on an open source basis.

Client demand and market sentiment will dictate whether this represents a genuine gap in the market for contract forms, but we do believe that advisers will increasingly be called upon to provide more flexible and multi-dimensional solutions for OSM. As with OSM itself, success in this regard will require fresh and innovative thinking, rather than a simple extension of the traditional boundaries of risk to smother a reconfigured supply chain.

Advance payments and insolvency risk

One of the major considerations for the construction industry as a result of an increase in the use of OSM will be the issues associated with a shift away from the established payment regimes which are most commonly linked to work done on-site.



Cashflow and payment are major issues [for modular]. Traditional contract terms where payment is due 90 days after arrival on site just don't work in a set-up where entire buildings are being built off-site.

- Andy King, Wernick Group

Due to the nature of OSM, suppliers are much more likely to require increased use of what is currently referred to as “advance payments” - i.e. any payment

made to a contractor relating to works that are yet to be carried out or at least yet to be carried out on-site.

One of the key issues here is the heightened risks associated with the potential insolvency of a primary member of the supply chain. This could be due to the developer losing any up-front payments, (for example, that may be needed to secure orders); and/or the costs and losses associated with recovering pre-manufactured materials that have yet to be delivered to site and may get caught up in the insolvency process.

Insolvency risk is also likely to be further raised by the concentration of work in one or two sub-contractors

due to the cost benefits associated with increased orders, particularly if the supplier is based overseas where unfamiliar insolvency processes could hamper recovery efforts even more.

Of course, the construction industry has dealt with insolvency and advance payment risks before (mainly relating to payment for goods and materials purchased and stored off-site) and these various protection options can also be considered in the context of OSM. However, the nature of OSM makes it likely that these options will be employed much more regularly than has traditionally been the case.

Possible protections

While it is impossible to fully cover off the potential cost and programme implications of a supply chain insolvency, the following steps can be taken to reduce the impact:

1. Carrying out proper financial due diligence on the relevant members of the supply chain (particularly if they are based overseas). Though this may be an obvious step, it is arguably the most important: other options will only reduce the impact of any supply chain insolvency.
2. Storage requirements and vesting certificates – if manufactured elements are to be manufactured and stored off-site, the paying party should ensure it has the right to regularly inspect and enforce strict controls on how they are stored (such as the items being clearly marked as the property of that party and being kept separate). In addition, it can require vesting certificates so that it has documentary evidence that it is the owner of the goods.
3. Defined schedules should be drawn up for delivery and revised payment structures so that manufactured elements are stored for minimal time (if the programme allows) and the amount of developer's capital exposed is reduced. The insolvency risk associated with a particular supplier will reduce the shorter

the amount of time that supplier holds any materials. This approach will also reduce storage costs.

4. Developers can require suppliers to obtain advance payment / listed item bonds from a bank, insurance company or specialist bondsman to cover not only insolvency but any failure to deliver the manufactured elements associated with the advance payment. These bonds are on-demand and will allow the client to immediately recover any lost sums up to the pre-agreed value of the bond (that reduces throughout the course of the contract). This will be required in addition to the developer's usual performance security which is very rarely on-demand (at least in the UK market).
5. Manufacture yourself - developers and large contractors have the option to develop the necessary capability to be able to carry out any OSM themselves, although in reality this is only open to the biggest players in the market.

Ownership and risk

Another key legal consideration is the transfer of ownership and risk in the manufactured elements. Again, this is an issue that the construction industry has been dealing with for some time in relation to on-site goods and materials. However, it is worth emphasising its importance in the OSM context.

Each construction contract will need

to clearly set out the agreed conditions and timings for transfer of ownership in manufactured elements. This is likely to be on payment (except where parts of an individual element need to be separately considered). This again relates back to insolvency risk – it will be imperative that ownership in any previously paid for manufactured elements being stored by a supplier have passed to the developer in the event of the insolvency of that supplier.

This is the approach taken in the JCT suite of contracts for off-site goods and materials (together with specific payment conditions such as the contractor putting in place the requisite insurance and providing a bond). In drafting these provisions, the parties will also need to consider whether they can deal simply with wholly completed manufactured elements or whether complications may arise due to a need for payments to be made for incomplete and/or parts of those elements.

The contract will also need to distinguish between the transfer of ownership and risk of any loss of or damage to the manufactured elements. While ownership may have transferred to the paying party, it is commonly the case that risk remains with the supplier who is storing them, together with specific obligations in relation to maintaining the proper types of insurance.

Professional indemnity (PI)

While OSM is seen by many as a potential solution to the skills shortage, it is inevitable that with the increase of OSM the proliferation of skilled trades people will decrease as requirements change.

In the short terms at least, this may result in further skills shortages, notwithstanding the automation of certain aspect of the build process, creating liability issues if workmanship is poor, which will not be covered by PI policies. For low volume, complex architectural requirements including innovative solutions to resolve planning or ground conditions, OSM is unlikely to be a suitable solution, and so skilled tradespeople will always be required.

As noted previously in this report, OSM requires a detailed design at an earlier stage in the construction/manufacturing process than is currently common, and therefore a significant front-loading of the cost of the design process will need to be incurred before funding has been secured. However, front loading designs in this way places an additional burden on the coordination of the designers, which presents opportunity for risk and error. Unlike traditional construction methods, if there is a design error in OSM there is limited flexibility for design changes without significant cost being incurred. The same principle applies to responding to unknown or unforeseen issues.

Off-site manufacture affords an opportunity for greater levels of uniformity and quality control. However, if this is not exercised appropriately then the consequences are likely to be more severe when contrasted to traditional construction processes, where the burden is spread over a number of contracting parties, each exercising their own quality control.

The OSM process does not lend itself well to targeted remedial solutions. Where a structure has been constructed in modular fashion where an issue is identified with one aspect of the structure (repeated many times over) fixing the problem is often complicated by the fact that each section interconnects. It may not be possible to resolve the issue without replacing the particular module, something that is incredibly expensive if the structure has been finished and occupied. It may be necessary to deconstruct many aspects of the structure that followed the module with the flaw in it. Similar considerations are relevant to when a module reaches the end of its design life or if a particular module reaches the end of its design life well in advance of the other parts of the structure.

Given the common exclusion in PI policies relating to workmanship and defective materials and productions techniques, the greater reliance placed on one contracting party in OSM places a greater importance on the suitability of the contractual terms as outlined above.

There is also the question of whether the ultimate occupier or those who have an interest in the constructed property (such as funders) will be able to obtain a warranty from the OSM manufacturer in the way that they presently can from consultants and sub-contractors? It's one they will want answered if OSM is to be embraced by clients.

Product liability

To date, there has been less focus on the product liability implications of off-site manufacturing processes in the construction industry.



Few commentators have explicitly considered the possible increased reliance on product liability insurance and/or product warranties in an OSM process which supplies the majority of the building.

The NEC4 Contracts Approach - Option X25

The problem that parties are likely to face with the increase in off-site manufacturing is reconciling risk allocation between manufacturer and contractor. In the first instance, manufacturers will want to contract with all of their customers on their pre-approved standard terms and conditions of supply. This allows manufacturers to assume the same risks across all of their products. Contractors, however, will want to establish a contract between the contractor and manufacturer that provides for the back-to-back flow down of the risks present in the contract between the employer and contractor. From a contractor's point of view, they will favour the standardisation of manufacturers' warranties (so far as multiple manufacturers are involved in one project) which will mean rejecting each individual manufacturer's terms and conditions of supply in favour of a standardised list of warranties set by the contractor.

The NEC suite of contracts does provide for a possible approach to dealing with this implicit tension in

trying to align manufacturers' terms & conditions and contractors' building contract obligations in its options clauses of the NEC4 Supply Contract and NEC4 Supply Short Contract.

In light of this tension, we may find the construction industry increasingly reliant on something akin to the mechanism in the NEC4 Supply Contract and the Supply Short Contract. These contracts are designed to be used for commoditised products capable of batch supply, making them attractive for certain OSM processes. More specifically, while a limitation date is required for the limitation of liability under Option X25, this Option seems to reflect the ability to specify and clarify the liabilities and guarantees provided by the manufacturer.

Option X25 states that: "The Supplier gives the Purchaser warranties for the amounts stated in the Contract Data and in the form set out in the Scope. A warranty is given to the Purchaser before Delivery."

Therefore Option X25 would allow the inclusion of warranties in relation to, for example, the programme of deliveries, undertaking factory tests, allowing inspection of the off-site plant; all of which are unlikely to appear in a manufacturer's standard terms and conditions of supply.

This approach essentially provides for a more standardised form of

contract between manufacturer and contractor that would be based on a form acceptable to a manufacturer but that specifically provides for certain product warranties that will allow the contractor an adequate extent of flow down of obligations from its building contract.

Separately, NEC4 Part 4, "Quality Management", allows for the parties to agree a predetermined programme of test and inspections of the off-site product.

Other relevant points

It is likely that the shift to OSM will require a clear distinction between manufacturing, delivery, assembly and installation. This is because a manufacturer will want to limit its liability/warranties to only losses caused by the defective manufacture of the product, as opposed to incorrect assembly or installation (where this is not part of their scope). Accordingly, parties must be clear who is responsible for each of these stages and if a defect arises, have processes in place that as far as possible allows them to establish the cause of the defect i.e. manufacture or assembly.

Any increase in the use of OSM processes in the construction industry will also see an increase in disputes between manufacturers and contractor/sub-contractor as they look to pass defect liability issues down the chain. As discussed

in more detail in the next section, such disputes will require bring the terms of the contracts between the parties into sharp focus (particularly any discrepancies between building contract and supply contracts).

Insurance

If a client/employer requires product liability cover (which is more likely to be the case in the event of an OSM project) it should be careful as to how it specifies the required product insurances for its off-site manufacturers. It should also clarify with the manufacturer whether there are any implications for the validity of that insurance if the manufacturer ceases to be involved beyond delivery of the product (i.e. whether it is involved in the installation/maintenance).

As noted above, an insurance product designed specifically for OSM manufacturers [or warranty for OSM-built buildings] would be a welcome addition to the suite of products available to the construction industry. In this, the work of Mark Farmer leading a cross-industry working group including lenders, valuers and insurers [through BOPAS (the Buildoffsite Property Assurance Scheme)] has made significant progress, although as Mark himself makes clear, further development is still needed⁷.

⁷<https://www.buildoffsite.com/content/uploads/2018/08/Buildoffsite-Newsletter-August-2018-Digital-Edition.pdf>

Dispute resolution

Off-site manufacturing and the HGCRA

In terms of disputes, a key issue to consider is the extent to which OSM activities fall within the Housing Grants, Construction and Regeneration Act 1996 (HGCRA). This is important, since the HGCRA imposes mandatory statutory obligations relating to payment and the referral of disputes to adjudication. For example, payees have the right to request payments by instalments and “pay when paid” clauses are prohibited. Parties also have the right to refer disputes to adjudication, which has short timeframes for deciding disputes.

The definition of “construction operations” which are subject to the HGCRA is broad and is likely cover many OSM activities, such as pre-fabrication of individual units to be installed into a building. However, it does not include the pure manufacture and delivery of products or materials to site.

A particular grey area concerns “hybrid contracts”. It is questionable whether the HGCRA applies to contracts where a contractor / manufacturer is engaged both to manufacture and supply products or materials (which would not be subject to the HGCRA) and also to carry out construction works or installations (which would be). It may be that the HGCRA only applies to a part of the contract – creating fertile ground for confusion and disputes.

Design claims

Another key issue for OSM concerns the design of the product being manufactured off-site.

As previously mentioned, a detailed design is often required at an early stage of the project to make OSM feasible. However, this may reduce flexibility in the design and inhibit the designer's ability to influence or alter the design at a later stage in the project, for instance due to unforeseen circumstances or if a design fault becomes apparent.

Faults in the design for a product manufactured off site may lead to significant re-design and re-construction costs, with potentially a knock-on effect across other elements of the project, which could spawn claims for additional costs and delay.

Delays and supply chain claims

Risk of delay to a project is potentially greater with an off-site manufacturing approach, because there is likely to be a multi-tiered supply chain, which may involve non-UK based suppliers. This may result in the flow of claims, including delay claims and claims for storage charges and/or additional transportation costs, up and down the supply chain.

The involvement of numerous parties in supply chains may also give rise to disputes as a result of differences between the contractual terms involved.

For example: suppliers may wish to limit their obligations to reasonable skill and care duties, and to avoid fitness for purpose responsibilities, whereas those higher up in the supply chain will be seeking fitness for purpose obligations, which may not be insurable. And in a series of contracts in a contractual chain, obligations relating to rectifying defects and defects liability periods may differ, resulting in different potential exposures for the parties in the chain.

The ability to pursue claims up and down the contractual chain will have to be carefully considered. In particular, if members of the chain are non-UK based suppliers then provisions regarding the choice of law for the relevant contracts and the jurisdictions for disputes will have to be carefully determined, as will the need for performance securities.

The blockchain revolution: how smart contracts could transform the supply chain

What other emerging technologies will have the biggest impact on our organisation?

- 1st
Smart sensors
- 2nd
Smart contracts
- 3rd
Blockchain
- 4th
Drones
- 5th
Driverless vehicles

The blockchain revolution:
how smart contracts could
transform the supply chain

Blockchain based smart contracts have the potential to revolutionise the construction industry's supply chain. By using burgeoning blockchain technology, which creates a shared and immutable ledger, the industry could create traceable records for asset owners to provide assurance over product standards and suitability of usage. Such checks are essential in the construction process, as underlined by the recent Grenfell disaster.

More significant benefits can be achieved when the underlying blockchain technology is overlaid with automated agreements – so-called smart contracts. Smart contracts are essentially self-executing digital contracts - a piece of computer code that is capable of monitoring, executing and enforcing an agreement.

In the context of OSM, smart contracts could help to reduce payment delays by automating the process. For example, when a supplier delivers building materials to a contractor or

manufacturer it could, in theory, ask the purchaser to scan a bar code once the goods arrive, which would trigger the smart contract to immediately release funds to the supplier. The benefits of such contract automation are clear and could be felt throughout the entire supply chain, a large majority of which faces problems with payment delays. If built on a blockchain platform, each party to the smart contract would have transparent access to the same information at the same time.

Clyde & Co launched its own smart contracts consultancy in September 2017, Clyde Code. It provides clients with legal and technical advice and services to help them realise the growing potential of smart contracts. The services provided by Clyde Code include: smart contract creation; existing contract enhancement; contract verification (to ensure that contracts will work as intended legally and technically); contract enforcement and dispute resolution; and forensic investigations in relation to smart contract failures.

Employment

The need to address the skills shortage and increase productivity while reducing costs are key factors in moving towards an OSM approach. As processes become increasingly mechanised and automated, there is likely to be a knock-on effect on employment.

Redundancy, relocation and outsourcing

A shift towards OSM could result in the need to make workplace redundancies, as traditional job roles change or companies restructure. Businesses must therefore factor in the cost of those redundancies into their planning and build in time for proper consultation. This is especially important where the collective consultation rules apply (i.e. if 20 or more employees are made redundant from one establishment in the UK within a 90 day period).

If employees are being re-located then it's vital to check whether employment contracts permit an employer to do that, and to consider whether staff will want to relocate.

In both cases, as well as considering the cost of redundancy or relocations, businesses could also expose themselves to liability if they get the process wrong. Mis-handled redundancies could see tribunal claims for unfair dismissal. Getting relocations wrong could trigger breach of contract claims and potentially constructive unfair dismissal claims as well.

Employers should beware that the employment tribunal system is such that an employee can claim anything at all and quite often the tribunals are reluctant to strike claims out early without having first heard evidence. Therefore, employees could for bona fide or tactical reasons also claim

discrimination/ whistleblowing to apply additional pressure, even if such claims have no merit.

If services are being outsourced, TUPE (Transfer of Undertakings Protection of Employment) rules will apply to employees being transferred to a new employer and terms and conditions of employment will be preserved. There are several information and consultation considerations here, for both the transferor employer and transferee employer, and it's vital that enough time is allowed for this process to occur.

For example, the transferor must provide the transferee with information about any transferring employees – such as contracts of employment, details of any disciplinarys or claims etc - 28 days ahead of the transfer. Failure to do so could result in a claim from the transferee employer.

The transferor must also provide representatives of the employees with information about the transfer itself. The penalty for getting this obligation wrong is 13 weeks actual pay per employee - so potentially very onerous.

Insurance

New materials and innovative construction techniques are creating greater uncertainty about the health and safety risks posed and the performance of buildings in the long run. Some of these are dealt with in the specific H&S and product liability

sections of this report, however they merit attention in an employment context too.

For example, new methods such as modular construction are affecting the way underwriters assess risk to establish whether materials used off-site pose greater fire risk. This means contractors' insurance, including employers' liability insurance, premiums for sites using off-site techniques will be more expensive with more exclusion clauses. Insurers are also demanding more onerous surveys and higher levels of risk management.

Training and qualifications

OSM requires specific skills and training that differ from traditional construction. For example, on-site management and installation are likely to require the workforce to have logistical and materials handling skills rather than [or as well as] the traditional skill set.

Businesses and professionals must therefore ensure that employees and supervisors have the correct training and should not assume that the training already given for traditional construction is sufficient. This may not always be easy, given that suitable training may not be readily available on a nationwide basis or for specific products manufactured off-site.

However, without this, businesses may not be health and safety compliant. That could lead to greater risk of

personal injury off-site and employee claims against employer for personal injury and/or constructive dismissal which could pose a financial risk to the business. Insurance premiums may also rise as a result.

OSM and the regulatory framework

Employers should be aware that the current regulatory framework poses issues for the increased use of OSM in the construction process, due to the way the Construction (Design and Management) Regulations 2015 (CDM rules) are drafted.

The CDM rules, which manage health, safety and welfare of construction projects and define responsibilities according to particular roles, apply equally to off-site and on-site work – but they were clearly drafted for on-site work. However, in off-site work there is a risk that the responsibilities between the role of the principal designer and principal contractor may not be clear, creating uncertainty as to who is legally responsible for what.

Failure to comply with CDM regulations can result in work being shut down by the Health and Safety Executive (HSE) and in the most serious cases can lead to prosecution. Therefore, it is important to clearly define the roles and responsibilities of employees prior to OSM commencing. An equivalent to CDM specifically aimed at off-site work is clearly needed here.

Health & Safety

Historically the construction sector has seen one of the highest accident rates in the UK.

Latest figures from The Health and Safety Executive (HSE) show that in the construction sector there were 30 fatal accidents in 2016/2017 - the highest figure for a main industry - plus some 64,000 non-fatal injuries.

Falls from height

Some of the traditional construction site workplace risks, for example working at height, which accounted for just below 50% of the fatal injuries in the construction sector between 2012 and 2017, would not be completely removed by changing the method of the construction of buildings to an off-site internal manufacturing setting.

Importantly though, it is likely that the fall from height risk would be easier to manage in a modular building process, undertaken in a warehouse setting, where collective fall prevention and individual fall protection methods can more easily be adopted. In addition, in a modular system, workers are most likely to be only constructing single storey units to be connected together once they reach site. This would limit the maximum height from which a worker would be liable to fall during the initial construction phase and arguably the amount of time at which the working at height risk would exist would also be reduced.

Easier supervision?

A further potential benefit to the off-site building system is that the control and co-ordination of workers, including any necessary sub-contractor labour, may well be easier to supervise within an internal warehouse location, when compared to a large open construction site.

Nevertheless, the use of OSM methods will still involve a number of risks that are common on traditional construction sites, including workplace transport and heavy lifting activities.

Key risks: transport and heavy lifting

Indeed, it is arguable that these two broad areas of risk will in fact be far greater in the OSM process of buildings. For example, within the confines of a warehouse workplace, transport will need to be properly managed and carefully supervised to ensure proper segregation between plant and pedestrians.

Further, the modular building process will involve multiple lifting exercises to transport and deliver the prefabricated units from the warehouse to its ultimate destination at site, which will also necessitate transport via the public highways. These lifting activities are potentially high risk and will

require those involved to be properly trained. They will also require clear designated loading areas to be created within the warehouse.

Any potential innovation which has the prospect of improving worker safety should be given careful consideration. As long as construction businesses properly risk assess their activities and put suitable systems in place to manage those identified risks, then OSM of buildings may prove to be a safer approach to construction work in the future.

Regional perspectives



The Middle East perspective on OSM

Much like the rest of the world, OSM has potential to change the way construction is carried out in the Middle East. However, there are many factors in play in the region that are likely to limit the immediate benefits of OSM and therefore delay investment from the industry.

Before we get to the barriers, let's recap some of OSM's potential benefits. One clear advantage, regardless of geography, is OSM's ability to provide quality control assurance. As this report has touched on already, by creating the majority of components on the factory floor, it is far easier to standardise and test them before they are introduced to the built environment.

Eventually, producing standardised components would also likely lead to cost-savings for contractors due to greater efficiency and less time required for construction which benefits the projects and the industry more generally.

There is the potential to use BIM to link in with modular design and OSM. The benefits of BIM are well documented but in short it could allow the construction industry a much more holistic view of a building and the potential to digitally map all of its components.

Finally, the Dubai government are likely to back any OSM initiatives. For example, it currently supports 3D printing modular buildings, which are of course a form of OSM.

However, despite its many benefits, there are factors in the construction industry in the Middle East that may impact or delay any investment in OSM.

The low cost of labour in the Middle East compared to Western countries means that OSM will not achieve the same level of cost savings. It is unlikely to therefore drive productivity or efficiencies in contracts, which is one of the main attractions of OSM in Western countries.

Project Sponsors in the Middle East have a history for implementing design changes during a throughout the project. Given the number of variations and changes the costs in replacing off-site modules could actually lead to an overall increase costs.

BIM is not used as widely in the Middle East as in other countries, so potential benefits in this regard are currently limited.

The up-front cost of investing in an OSM factory may be less attractive in economic environments that are influenced by external factors such as the price of oil. The cost of investment could quickly change and so too could the viability of the factory.

It is also worth highlighting the scale of the region. Contractors tend to work all over the Middle East so questions marks remain over the cost of shipping components from a locally based factory and whether this would really save money.

While OSM has the potential to transform the construction industry, it only works if it achieves costs or time savings for the contractor or project.

While it is a good idea in principle it may take some time to be adopted in the Middle East. It is highly probable that contractors will implement the systems in their home jurisdictions (i.e. UK, US, Australia) and then potentially bring similar technology and processes to the region - once perfected and proven.

Having said that, some contractors are bucking the trend. For example, Liang O'Rourke are one of the front-runners in the region with regards to use of OSM, having recently worked on several major projects that relied on OSM techniques.

The Australian outlook on OSM

In many respects the Australian construction sector is ahead of the global curve with its approach to and uptake of off-site manufacturing (OSM). There are a number of established tier one contractors who have been using OSM for a significant proportion of the projects they work on for several years.

Australia's position at the forefront of OSM is largely down to Government stimulus and industry crisis. A few years ago, the former Prime Minister Malcolm Turnbull made a concerted effort to encourage the construction sector to innovate. At the time the industry was languishing, having benefitted in the boom times.

Fortunately, this combination of industry downturn and encouragement and financial stimulus from the government, backing the innovation agenda, forced a change.

At the same time the renewable energy industry was taking off. Major investments were made to build the required infrastructure and a large proportion of this was delivered through OSM techniques.

It was something of a perfect storm, as the renewables sector experienced exponential growth major contractors continued to invest in OSM and use it across other projects. With some contractors benefiting from increased productivity and reduced cost it was a fairly easy choice for the rest of the industry to follow suit.

The next phase of the OSM revolution appears to be moving the huge productivity and efficiency gains made from off-site and installing these on-site. One of the current drawbacks of OSM are the unavoidable transport costs of moving manufactured components from the factory floor to the construction site. By removing the transport requirements further cost-savings could be made.

3D-printing is one potential solution for moving the factory floor to the construction site. Many of the major players in the region are already investing in such technology with a view to bringing it to market as soon as it is commercially viable. Of course, an entirely on-site manufactured approach is unlikely but combined with OSM there are still efficiencies to be gained.

Three of the market leaders in this space are Laing O'Rourke, China Construction Bank and John Holland. They have all made great strides with their use of OSM and many in the market expect them to be the first to bring 3D-printing to the Australian construction sector.

With such a positive outlook there is of course a cloud on the horizon. The current 'threat' to the Australian OSM market is the advantage China has with cheaper labour and production costs. In recent years we have seen an influx of Chinese made OSM buildings constructed. One clear example, is in Western Australia where the natural resources sector continues to flourish. With thousands of temporary homes needed for the workers in a short space of time, OSM provided a very simple solution. But despite the Australian construction industry's prowess in OSM, it was the Chinese contractors that were able to deliver OSM built homes to the scale required.

As the Australian industry considers bringing off-site techniques on-site, it must also be aware of the global competition that has the technology and scale to compete for projects.



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