Optimising Off-Site Manufactured Components in the UK House-Building Sector: Understanding the Legal and Contractual Issues

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1. Introduction

There is an emerging consensus that the United Kingdom (UK) is presently facing a housing crisis, the root cause of which is predominantly down to the lack of provision of affordable housing (Helm, 2017; Ferrari, 2015). Calls for a change in approach, to the way the government meets the housing needs of its citizens, have seldom been more audible (Harris, 2018). One potential solution proffered due to its perceived success in other countries as a solution to their own housing crises and also due the significant role it had in the UK after World War II (Vale, 2013), is the construction of pre-fabricated homes using off-site manufactured components (Miles and Whitehouse, 2013). There is therefore a perceived need to adopt innovative and new construction practices to accelerate the rate of construction (NHBC, 2016).

The various benefits to the adoption of these construction methods are well documented and include:

- **increased speed of construction** - because off-site components can be manufactured at the same time as the foundations of the building are being prepared to accept these components (Schoenborn, 2012);

- **improved construction quality** - Goodier and Gibb, (2005), due to the fact components can be manufactured offsite in a facility with specialist equipment and organisation (Warszawski, 2003);

- **environmental benefits** – Cleary, (2011), reduction in vehicle emissions from employing reduced on-site workforce and the re-capture of material wastage in factories producing the manufactured components (Smith, 2018);

- **efficiency savings** - research shows that investment into factories yield more valuable output than those invested to on-site construction;

- **greater predictability of cost** - compared to on-site construction (Whyte, 2014); reduced on-site disturbance (Smith, 2016);

- **increased levels of safety** - for workers (Smith, 2018); and

- **increased security** - for tools (as less portable tools are required on-site) (Smith, 2018).

Whilst the above benefits offer stakeholders significant opportunities, there are a number of legal and cultural barriers to the adoption of these construction methods in the UK (Pan *et al.*, 2007), including: a perception that these methods are more expensive than traditional on-site construction (Goodier and Gibb, 2005), interfacing problems (Pan *et al.*, 2008), long lead-times for the manufacture of the required components (Ruiz, 2005), delays in the planning process - inter alia the increased likelihood of such applications receiving objections from interested parties fearful of the resultant aesthetic of pre-fabricated homes (Knerr, 2004), and inadequate manufacturing capacity to meet the demand of larger-scale housing development projects (Wu *et al.*, 2016).

Several terminologies are frequently used to represent industrialisation, from prefabrication, through to offsite manufacturing, modern methods of construction and offsite production. Given these derivations, for the purposes of clarity, the emphasis placed in this chapter uses the term "off-site manufacturing" (OSM), where this is deemed to include construction processes and activities undertaken away from the actual building site, such as in a factory environment or production facility.

Extant literature highlights a number of barriers to OSM implementation in the housebuilding sector (Arif *et al.*, 2017; Larsson *et al.* 2011; Arif and Egbu 2010; Jaillon and Poon 2010; Taylor 2009; Pan *et al.* 2004; Pasquire and Gibb 2002). Moreover, is also evident that a number of legal issues prevail, particularly with legal uncertainty (Wilkinson, 2017). These legal obstacles are acting as additional barriers to the widespread adoption of OSM, particularly within the house-building sector. One reason for this may be the lack of knowledge on the diversity of legal and contractual issues that are relevant for the wider adoption of off-site manufacturing. This is a significant knowledge gap. Give the implications of this, this chapter explores the paucity of research on the legal issues affecting the use/adoption of OSM (within the context of UK house-building). In doing so, it investigates the core legal and contractual challenges affecting the use of OSM, including the potential risks posed by these 'modern methods of construction' - for those managing housing developments or administering building contracts. This is undertaken through four key foci: process, policy, culture and enforcement. A structured framework is presented for discussion, identifying the legal and contractual issues associated with the use of OSM within different jurisdictions as a basis for further research.

2. Research Methodology

Given the nature of this research, and acknowledging the paucity of literature on the legal and contractual issues associated with OSM, the research methodological approach undertaken for this chapter takes the form of an in-depth literature review supported by a case study analysis. This approach includes a set of search parameters using core databases, matched to textbooks, journal articles, case reports, legislation and government consultation papers.

Relevant facts, figures and arguments are extracted from these sources and categorised broadly into: i) data highlighting actual (empirical) or potential (theoretical / academic) legal and contractual issues arising from the growing use of OSM within UK house-building, ii) data revealing actual or potential legal challenges and barriers to the adoption of OSM in the sector, and iii) data providing insights into the legal reforms required to overcome those barriers.

3. Legal and Contractual Issues Affecting the Use of OSM in House Development Projects

3.1 Introduction

The legal and contractual issues affecting the use of OSM within housing development projects can be broadly categorised into four core areas, namely: Process, Policy, Enforcement and Culture – represented in Figure 1. These four areas highlight the potential legal and contractual issues affecting the use of OSM in housing development projects, along with concomitant categories and sub-categories. Whilst this list is not considered exhaustive, the classifications encompass the main challenges which directly or indirectly impinge on OSM.

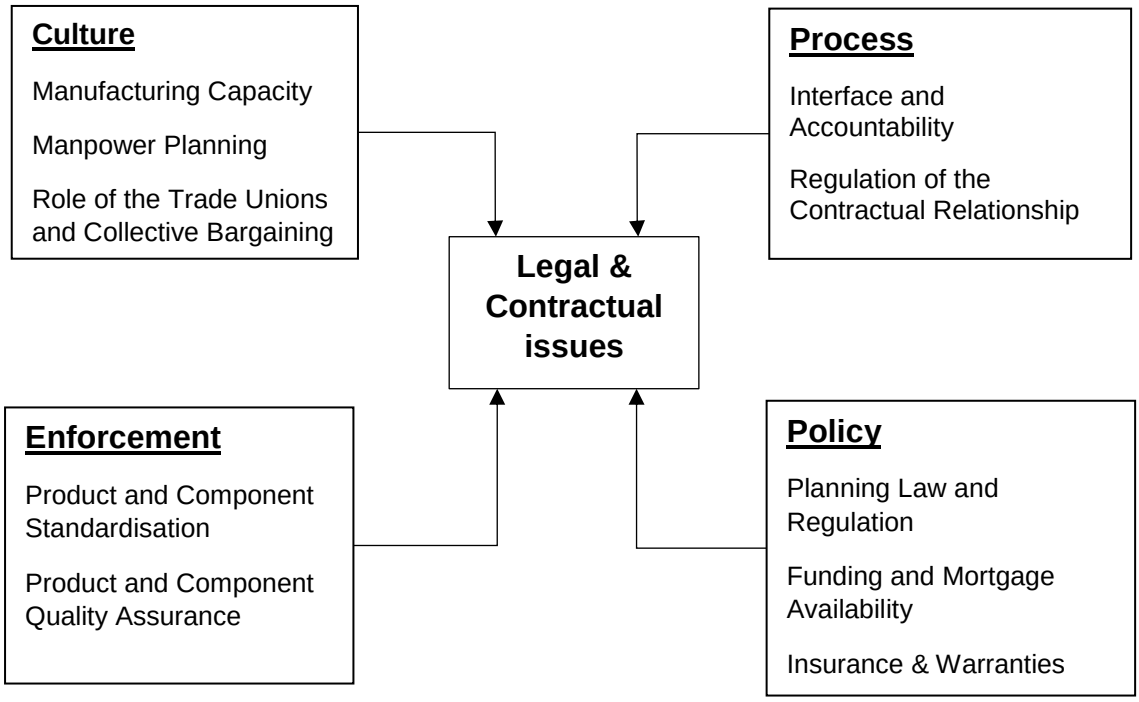

Figure 1: The potential legal and contractual issues affecting the use of OSM in the housing development projects

3.2 Process

Interfacing and Accountability

Ultimate responsibility for traditional construction methods generally fall on the main contractor, who is responsible for ensuring that all workers and sub-contractors deliver their respective contributions to the project in a timely manner and to a satisfactory quality. This is largely appropriate, as the main contractor retains control of the construction site, and is

therefore well-placed to supervise the delivery of all aspects of the works. With modern construction methods utilising off-site manufactured components, this paradigm for accountability may not be so straightforward.

Latent defects in the components utilised may cause a building to fail, or contribute towards the failure of that building. In the event that a defect is discovered, it may not be straightforward to determine who is responsible, *factually*, for that defect: the main contractor who installed the relevant components, or the manufacturer who produced them. Where the main contractor selected the components to be utilised, then this issue is less problematic. However, it is often the case that the main contractor is not appointed early enough in the design process to have an input into the product selection process, which is usually managed by the appointed architect for the project (Fewings, 2013). If a defect in the product selected by an architect is responsible for the failure of a building, then the main contractor might attempt to resist liability on the basis that they did not enjoy responsibility over the design decisions for that building. Factually, it may be difficult to determine retrospectively, in some circumstances whether the failure was a result of the component itself, or the way that the component was installed or interfaced with other building materials or off-site manufactured components[1].

Regulation of the Contractual Relationship

While the above risks can be managed - if not equitably, at least with legal certainty - through a well-drafted contractual instrument, clearly those standard contract forms which have been developed by the Joint Contracts Tribunal (JCT) and International Federation of Consulting Engineers (FIDIC) for example, to regulate the relationships between parties to traditional building projects, may not be a good fit for projects which are heavily reliant on off-site manufactured components. For one thing, it is not entirely clear to what extent these components ought to be regarded as products as opposed to workmanship (Schneier, 1999). It is also not clear to what extent the discovery of a defect in an off-site manufactured component ought to be regarded as a design failure or a defect in workmanship (Knowles, 2012). An aggrieved claimant might look to exploit these uncertainties to mount a claim in tort, for product liability, to circumvent any contractual restrictions limiting liability or the claimant pool. Such claims could not be excluded by contract forms because the potential claimants are not in fact parties to the original construction contract, and would therefore not be subject to any applicable limitation clauses; which for example, excluded or limited liability in the tort of negligence for product liability (Rush and Ottley, 2006; Barendrecht *et al.*, 2006).

In any event, it is not always possible to exclude liability for death or personal injury, so such clauses would not protect a manufacturer of an off-site manufactured component, or indeed a main contractor, from claims arising after a public disaster such as the Grenfell Tower fire in 2017. These legal challenges are not unique to the construction sector. Aircraft manufacturers, for example, assemble their products using a number of complex off-site manufactured components; and when an aircraft fails, it can be a challenging process to determine whether it was the manufacturer of the component and/or the manufacturer of the aircraft that was responsible (and in what proportions?). In reality, when disaster strikes, what matters more than finding the party who is factually responsible, is finding at least one related party with deep enough pockets to assume legal responsibility and compensate those affected (Night, 1988).

[1] The Irish case of *Norta Wallpapers (Ireland) Ltd v. John Sisk & Sons (Dublin) Ltd* (1977) 14 BLR 49 is a good example of how a properly worded contract can help to manage these difficult situations. See also, J. R Knowles, *200 Contractual Problems and their Solutions* (Wiley, 2012) 59.

This is particularly important when the public at large put pressure on policy makers and prosecutors to take punitive action. For example, days after the Grenfell Tower disaster, protesters gathered in the streets calling for prosecution of those responsible (Bell, 2018), even though nobody knew at that stage who was, in fact, responsible for the latent defects, if any, which led to or exacerbated this disaster. In the United States (US), the *General Aviation Revitalization Act* 1994 was enacted to protect the airline manufacturing industry from this intrinsic legal uncertainty. This Act imposed a limitation on the amount of time in which a claim could be brought against the manufacturers of aircraft or their downstream suppliers of off-site manufactured aircraft components, 18 years from the date on which the products are delivered (Campbell and Woodley, 2005).

While this framework was introduced to protect the airline industry, ultimately it helped to promote legal certainty for all parties affected by this kind of product liability. In addition, product liability insurance premiums stabilised, which freed revenue for investment into research and development, leading to the manufacture of higher quality (and safer) aircraft (Christiansen, 2013). While such legislation limits legal redress for victims of such disasters, the time limits are considered 'fair', if a latent defect has not materialised within 18 years of its initial delivery; then it seems 'unfair' to hold a manufacturer liable on the basis that they did not identify that defect while designing and testing their product, unless of course there was evidence that they were factually aware of that defect. While the victims of such a disaster may be disappointed by the fact that their rights to redress are somewhat limited, the increased legal certainty might expedite their transition from the grief stage of the Kubler-Ross model, to the acceptance stage (Anfara and Mertz, 2014).

Anecdotally, it would be interesting to explore through further research, how a framework similar to the *General Aviation Revitalization Act* 1994 could be used to promote legal certainty in the construction sector, which is increasingly dependent upon the use of off-site manufactured components.

3.3 Policy

Planning Law and Regulation

The introduction of this chapter highlighted that it was traditionally more difficult to secure planning permission for pre-fabricated housing developments because of the negative perceptions associated with the kinds of houses which have historically been built using these methods. This issue is exacerbated in relation to houses which are constructed using off-site manufactured components *and* are designed to be 'affordable homes' because (in some cases), in order to be affordable, such homes may need to be constructed using lower quality components manufactured from cheaper and less visually appealing materials. In addition, in order to realise the benefits of economies of scale associated with OSM for larger affordable housing developments, it may be necessary for all of the homes within the development to utilise the same off-site manufactured components - which could have a major visual impact on an area.

In the UK government's recent White Paper entitled *Fixing our Broken Housing Market*, a case study of a development of 55 new, but individually designed homes in Saffron Walden, Essex, was cited, identifying how it was possible for larger multi-home developments to employ variations to reduce the visual impact of new developments on the locality (Department for Communities and Local Government, 2017). While such schemes are commendable, it is unlikely that such an approach could be adopted for developments aimed at low income

families, utilising off-site manufactured components, as the increased costs associated with using different components for different dwellings would substantially increase project costs. In addition, in order to be affordable, these properties may also need to be smaller than their equivalent-bedroomed non-affordable counter-parts; and potentially smaller than the minimum sizes which are currently recommended by the UK government in its own planning law frameworks. There is historic precedent for this concern: During the 1920s, the UK government constructed a number of small bungalows using offsite manufactured components, specifically for families on low incomes who would otherwise be unlikely to afford their own homes. However, the Town and Country Planning Act 1932 introduced, for the first time in the UK, minimum sizes for new residential homes – the remit of which put an end to the construction of this otherwise successful public housing project (Abbott, 2013).

While the present guidelines on minimum sizes for new homes are just that, i.e. guidelines, nevertheless, planning authorities generally refuse to grant planning consent for properties which are smaller than 37 square metres (Jones, 2018). These restrictions would likely prevent local authorities in the UK from being able to approve developments comprising small modular homes of the kind being built, for example, in Dublin to meet its own housing and homelessness crisis. Where, these homes are no bigger than the size of a shipping container, i.e. less than 30 square metres (Hughes, 2015). These minimum restrictions may give those local authorities who are already reluctant to encourage the construction of this kind of affordable housing within their respective jurisdictions, a legitimate ground for refusing planning consent for such proposals. The UK government has already acknowledged this potential barrier to building more affordable homes using off-site manufactured components and has suggested in a recent White Paper that the legislative ought to consider reforming planning law to lower or remove its 'one size fits all' recommendations on minimum sizes for new dwellings (Department for Communities OSM, critics might well argue that this reform proposal is at odds with the UK government's commitments to the objectives of the United Nation, one of which is to regulate upwards the minimum floor area per person for dwelling houses (Hughes, 2015). In any event, it is clear that delays in securing planning permission - while sites are selected and proposals debated, that these contentious issues represent a significant impediment to OSM uptake in the UK.

It has been acknowledged that there is need for greater backing for OSM and derivatives in local plans, as well as promotion of self and custom build; including the provision of a range of sites for small to medium enterprise (SME) builders - to provide more opportunities for modular housing (Irvine, 2018). In other words, local authority planning departments have a very important role to play here, through the adoption and implementation of local plans supporting developments utilising off-site manufactured components and the development of factories where these components can be manufactured. However, if local planners are willing to embrace these changes, they will inevitably face pressure from local councillors, with pre-established and entrenched ideas about the merits of prefabricated housing; and local communities, with their 'not in my back yard' objections, which will inevitably cause delays in the site selection and planning consent processes (Barry, 2016). In this context, the government's ability to galvanise local planners towards this common vision is somewhat limited, due to the decentralisation of competence that has occurred in this arena over the past few decades (Smith and Wistrich, 2016). Moreover, an agenda to which the government remains committed through a recent policy White Paper, where the government publicised its commitment, "To give people more control over the development of their local area [and give] communities the power to set the priorities for local development through neighbourhood planning (Ministry of Housing, Communities and Local Government, 2015)."

The reluctance of some local authorities in Greater London to actively promote the policy objectives of the London Mayor's *London Plan*, is an apt example of how little influence centralised government has over local authorities when it comes to planning matters. For example, despite the draft London Plan's commitment to supporting 'build to rent' developments, only a third of London boroughs have shown any support for this agenda within their own local plans (Geoghegan, 2018). In addition, various London Boroughs have publicly voiced their concerns about the merits of some aspects of this draft London Plan (Barker, 2018). In order to better understand this complex dynamic, a major London's premier planning consultancy, was approached for comment, noting "The only way that the government can force local planners to embrace prefabricated construction is through statutory reform to re-centralise local planning policies. Without statutory reform, the government's planning policies can only influence local authorities and cannot impose legal obligations on local planners to approve developments employing specific construction methods or techniques. However, the government is very unlikely to introduce such reforms in the near-future because to do so would be viewed as a retrograde step away from the localisation agenda which it has been so keen to promote.[2]". This anecdotal evidence supports the view that reforms to planning law could potentially help put pressure on local authorities to look more favourably on planning applications for developments employing prefabrication and OSM components, even where this is at the expense of the preservation of land within conservation areas or designated as 'green belt'. However, it seems clear that major reform in this area is unlikely, in light of the government's continuing commitment to the localism agenda.

Funding and Mortgage Availability

Another significant barrier to the increased uptake of OSM in the UK construction industry is the lack of available funding from traditional lenders for this kind of construction. As offsite manufactured components are usually bespoke, and also often utilise innovative materials or fabrication technologies (which are largely new to the construction industry), it is perceived difficult for financiers to evaluate the risk of lending against such homes. Historically-acquired pre-conceptions about the durability of prefabricated buildings have not helped in this regard. Lenders understand bricks and mortar and have now largely[3] come to terms with timber- and steel-frame construction methods. However, due to the lack of product standardisation and the relative infancy of these modern construction methods, lenders remain concerned over the longevity of prefabricated or semi-prefabricated homes (Giblin, 2018). While steel-frame construction faced similar challenges, the risks of this type of construction are quite limited - the major concern being corrosion of the steel itself (Chess and Broomfield, 2013). Lenders were able to manage these risks by sending surveyors to inspect the condition of the structural steel, removing bricks from the facia of these buildings where necessary, before agreeing to provide a mortgage (Smith, 2016). The risks of off-site manufactured components are not so readily discernible, as these components tend to be comprised of various materials each with their own and combined risk profiles; even materials which have a long history of reliability may interact with other materials to cause unforeseen deterioration (Sjostrom, 2014). While British Standard BS5750 and International Organization for Standardization ISO9000 schemes provide some assurances as to the consistency of manufacturing quality, they offer little assurance of the intrinsic quality or durability of the manufactured products themselves (Sjostrom, 2014). Where Sjostrom, (2014) observes "Without carrying out a detailed

[2] Transcript from telephone interview undertaken with xxxx on 21st March 2018.

[3] Not all lenders are willing to finance timber-frame dwelling houses; see V. Wallis, 'Will building societies lend on a timber-frame house?' (The Guardian, 3 July 2014) [Online] <https://www.theguardian.com/money/2014/jul/03/building-society-refuses-mortgage-timber-frame> accessed 21st March 2018.

assessment of the standards included within the manufacturers quality control systems, it was not possible to determine which manufacturers achieved a high level of consistency and reliability in the products delivered to the construction site". If lenders need to undertake individual assessments of the reliability of specific products manufactured for specific developments (in order to evaluate the risk of any given mortgage application), then this will inevitably invite time and cost implications for applicants. Moreover, those lenders willing to finance such developments tend to withhold mortgage funding until all off-site manufactured components have been fully assembled into immovable homes (Knerr, 2004). This means that developers utilising these approaches may need to pursue alternative more-expensive funding routes to finance the construction phase of their developments (until the homes are complete), where these loans can then be converted to traditional mortgages (Knerr, 2004).

Insurance and Warranty

While these issues are not *legal* barriers to the increased uptake of OSM *per se*, nevertheless there may be *legal* solutions to these issues. A review undertaken by the US Office of Technology Assessment during the 1980s recommended the introduction of legal reforms mandating extended and insurance-backed manufacturers' warranties for modular buildings, to alleviate lenders' concerns and facilitate the flow of project finance into this sector (US Office of Technology Assessment, 1986). Given this, further research would be needed to evaluate the viability of this reform proposal in the UK, as it seems that lenders are more concerned about the longer-term durability of these components, and therefore, extended warranties may only go so far towards reducing this barrier to funding. It is likely that would have significant cost-implications for developers, which would then need to be analysed through cost-benefit analyses (which traditionally underpin the business case for using these components and methods, in the first place).

Perhaps a more effective approach might be for the government to facilitate the standardisation of off-site manufactured components. This would help financiers develop guidelines and policies to manage the risks of lending against pre-fabricated homes, in much the same way that the barriers experienced by steel-frame construction were ultimately overcome. It is almost certainly the case that the lack of any dedicated framework providing minimum standards of quality and durability for these kinds of components is one of the reasons why lenders continue to view these kinds of homes as 'high risk'. The introduction of a 'Kitemark' style scheme, would be a good first step towards this objective. This reform has already been proposed by the Greater London Assembly in its recent report entitled *Signed, Sealed, Delivered*: "The Mayor should work towards defining and adopting a Manufactured Housing Design Code…'' The design code should be branded as a Mayoral 'kite mark', supported by suitable warranty providers to promote its use. It would drive a more standardised and aggregated demand profile which can be delivered by a range of technologies and systems and which is fully recognised by the funding and valuation sectors. The use of such a London design code should be incentivised by the full range of Mayoral strategies including land and planning'' (London Assembly, 2017).

From a manufacturing perspective, the UK suffers from a shortage of bespoke OSM factories capable of manufacturing OSM components. However, if different regional kitemarks were adopted, then this may limit developers' access to factories from specific regions; which in light of supply chain issues, would almost certainly be preferable for this legal reform to take place at European level. Not only is the European Union well versed in regulating product standards, but European harmonisation of the standards for prefabricated building components would increase the supply pool for all Members States wishing to embrace the benefits of OSM

to meet their own national housing demands. This would also make the industry responsible for the manufacture of these components more competitive. For instance, it has been reported that one significant barrier to supply is the onerous contractual terms which manufacturers demand from local authorities and developers wishing to purchase off-site manufactured components. For example, one UK factory refused to supply a local authority in London unless it agreed to subscribe to a 15-year supply deal, which was not deemed viable by that authority. If more factories produced the same standard set of components, then the relative bargaining power of these suppliers would decrease, which in turn would improve the efficiency of the relevant supply chains. The threat of cheaper Chinese imports (Curry, 2016) would also help encourage European suppliers to be more flexible with their contractual terms. Additionally, reform at the European level might increase the number of lending institutions available to UK developers, as banking institutions within other jurisdictions would be more readily able to assess the risks of financing UK-based projects. A harmonised marketplace for these kinds of components might also help remove the barriers to parallel importation posed by intellectual property law[4].

The UK's imminent withdrawal from its membership of the European Union is likely to render less accessible the benefits of such reform. If the UK leaves the Customs Union, then fiscal barriers to the importation of off-site components manufactured overseas, in European Member States would make the importation of these components more expensive and, consequently, the supply issue – thereby, undermining mass market viability. That being said, opponents proffered that Brexit would improve the viability of off-site manufactured construction, because it would reduce the supply of skilled construction workers to the UK, making it more expensive to employ traditional construction methods (Reuters, 2017). Notwithstanding this debate, factories manufacturing off-site components generally employ unskilled or semi-skilled workers (Woo and Low, 2013), and these workers can be supplied from the national population, post-Brexit. Whether these reforms are introduced at the national or European levels, it is clear that product standardisation will help remove a significant barrier to the uptake of OSM in the UK. Over time, perhaps lenders would become more confident that building components manufactured in accordance with these standards represented no greater risk in terms of durability and longevity than traditional construction techniques; and that once there is a less restricted flow of capital into this sector, developers would be able to access the cost-benefits of these emerging construction techniques (London Assembly, 2017).

The Grenfell Tower disaster in 2017 brought into sharp focus the need for this kind of product standardisation. The *post mortem* of this disaster (which is still on-going), revealed that an off-site manufactured component (the cladding used to insulate the outside of the building) acted as an accelerant to the fire (Mairs, 2017). However, this was not the only operating cause; the Moore-Bick Inquiry identified the lack of fire safety systems as one explanation for why the Grenfell Tower fire led to substantially more damage than fires in other tower blocks in the UK and Australia which utilised this same exterior foam cladding (Bell, 2018). Nonetheless, the fact that the off-site manufactured components utilised to clad the outside of Grenfell Tower were only one cause of this fire, the repercussions are probably going to compound the negative image on public and lender perceptions on the risks of modern construction methods. It is therefore important that findings are published as soon as possible to restore certainty here. If this disaster can serve as a catalyst for the introduction of enhanced safety standards for off-

[4] *Terrapin v Terranova* [1976] ECR 1039; C. Barnard, *The Substantive Law of the EU: The Four Freedoms* (Oxford University Press, 2007) 159.

site manufactured components, then at least one positive thing can be said to have emerged from these tragic events.

The primary mandate of the Hackitt Inquiry is to devise a strategy of regulatory reform to prevent similar disasters from occurring again. Analysis of the regulatory reforms which have been introduced in other jurisdictions to enhance public safety in residential construction will undoubtedly inform this strategy. For example, in Australia, the Senate Economics References Committee into Non-Conforming Building Products and the Victorian Cladding Taskforce was appointed to investigate the causes of a cladding-fuelled fire at the Lacrosse apartments in Melbourne, which occurred in 2014 (Senate Economics References Committee, 2017). This taskforce made a number of recommendations for regulatory reform, including the need for greater clarity of 'CodeMark Certificates of Conformity' (Bell, 2018), a recommendation which was made previously by this author. Other recommendations included a proposed ban on the use of these particular exterior cladding panels in Australia; the introduction of a national register of approved suppliers for offsite manufactured components (which would *inter alia* mitigate some of the quality/ safety risks associated with the importation of lower-cost components from overseas); and, mandatory third-party certification for approved suppliers, to include evidence of robust product auditing systems. While these reform proposals are all worthy of exploration, they are only part of the picture. After all, the fire which occurred at the Lacrosse apartments in Melbourne in 2014 did not claim any lives because fire safety systems had been installed in those apartments and the emergency services reacted promptly, following a plan of action which had been specifically developed to deal with such incidents (Bell, 2018).

3.4 Culture Issues

Employment and Trade Union Law

Historically, trade unions and their members have enjoyed significant influence over the UK construction industry. It has been argued in extant literature that one of the reasons why the government routinely referred to prefabricated buildings as 'temporary' solutions after World War II, was to allay union concerns that these construction methods would play a permanent role in the UK's construction industry and reduce jobs for skilled construction workers (Vale, 2003). In other jurisdictions, it is certainly the case that construction worker unions are actively opposed to the increased uptake of these modern methods of construction (Li, 2016). However, the recent merger between the two main construction worker unions in the UK - the Union of Construction, Allied Trades and Technicians (UCATT) and Unite the Union (UNITE), is likely to strengthen considerably the bargaining and lobbying power of this combined super-union (Lea, 2016). To date, this union has remained silent on the issues relating to the effect of modern construction methods on the interests of their members.

Reforms are needed facilitate the increased uptake of OSM. Further research is needed to evaluate the extent to which the activities of relevant unions represents a significant barrier to the realisation of the objectives stated within the government's recent Housing White Paper, and also the role that these unions *could* play in helping to make these visions a reality. In some respects, the historic resistance of trade unions to these modern construction methods has exacerbated the problem, by excluding union members from the workforces of these factories (Gangbox, 2015). For example, in the US, very few manufacturers of modular components have been able to conclude deals with relevant employee unions (The San Francisco Building and Construction Trades Council, 2016). This means that they are 'forced' to employ non-union members, and are therefore not obliged to offer those employees union rates of pay. In the absence of pay obligations, there is some speculation that these manufacturers prioritise

cost-savings and firm competitiveness over employee welfare. Those manufacturers which are union signatories, such as ZETA in Sacramento (The San Francisco Building and Construction Trades Council, 2016), face a competitive disadvantage, as their costs of manufacture are consequently higher than their non-union counterparts. In order to overcome this problem, trade unions need to embrace this growing sector, and adopt a longer-term view. It may be necessary that (initially), lower rates of pay are agreed with these manufacturers to take into account their need to remain competitive, not only with their direct competitors, but also with traditional construction methods. Ultimately, it is proffered that this in the trade unions' best interests to enter into such agreements, as this will help create more job opportunities for their members and, over time, will allow them to exercise more control over the working conditions and rates of pay of these factory workers.

3.5 Enforcement

The legal issues related to the use of OSM are attributable to many factors, such as: uncertainties in the yet to be tested legal system, immature or incompatible commercial and industry practices, and fast advancing development of technology. Thus, in order to prevent and minimise legal and contractual complexities, it will be necessary for the OSM legal and contractual framework to cover the following three aspects: 'Self-Regulatory Industry Reform Strategies', 'Process Reform Strategies', and 'Legislative Reform Strategies' – see Figure 2.

These challenges are discussed in the next section, alongside potential practical solutions under the following sub-headings:

- The Planning Process
- Procurement and Contractual Options
- Testing and Certification of Product Performance
- Quality Inspection Schemes
- Accreditation, Assurance and Insurance Schemes

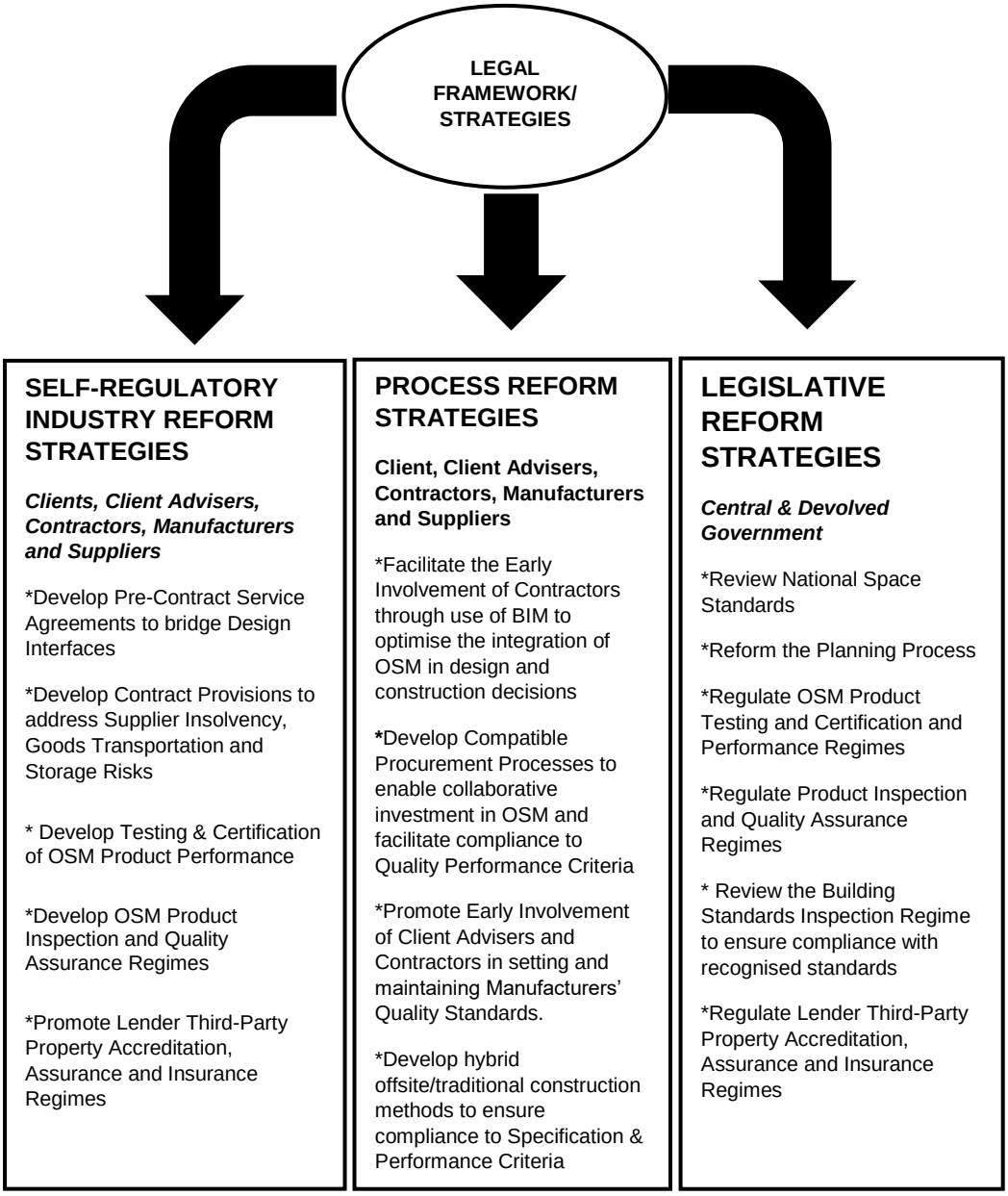

Figure 2: Strategies for an OSM Legal Framework

4. Discussion: Strategies for Mitigating Legal and Contractual Challenges

4.1 The Planning Process

Delays in the planning process have been cited as a significant barrier to the increase uptake of off-site manufacture (Pan *et al.* 2008). As previously discussed, a significant planning-related barrier is that OSM manufactured homes within some larger developments and certainly within the London context are often smaller than those units built using traditional methods. For example, the Town and Country Planning Act 1932 specifies the minimum size of homes that can be built within England and Wales. Currently, the smallest dwelling that can be built for

one person is 37 square metres (Jones 2017). The requirement could therefore pose a problem for Housing Associations intending to market units within London, for example, that are only 26 square metres (Collinson 2017). There is a clear conflict between current space standards to be upheld and the UK Government's target to build at least 66,000 homes per year. In fact, within the Governments recent White Paper published in 2017, it was suggested that the National Space Standards should be reviewed in order to ensure greater housing choice (MHCLG, 2017). Until this is actioned, developers will undoubtedly face considerable difficulty in achieving planning consent for developments that fall below the current threshold. The potential support that could be given by planning departments and Local Authorities is therefore seen as a critical element for encouraging further uptake of off-site manufacture (Irvine, 2018).

4.2 Procurement and Contractual Options

Most construction projects are traditionally procured using a standard form of contract that includes standardised, non-negotiated provisions, and drafted to accommodate traditional construction. Acknowledging these standard forms, it would be ill-advised to use an inappropriate standard form of contract without fully understanding how it could be adapted as a base document from which specific OSM issues could be satisfactorily addressed. The type of contract should recognise: the scope of commitment, the relationship with the client and the client's advisers - commensurate with time, cost and quality issues specific to off-site procurement. There are also notable cultural factors which parties should be sensitive to in proposing contractual terms. Inherent in contracting is the parties' experience of off-site procurement and their understanding of the basic needs forms such as: i) how much they can afford to complete the project, ii) the level of design required and, iii) the timeframes available to complete the works. Superimposed on these basic questions, is the client's desire to maintain control, or indeed delegation to a third party (such as a construction manager), or even wholly to the contractor (undertaking the work directly or managing trade packages - depending on the nature of the works), which will limit the procurement options and contractual structures available. These factors apply equally to off-site construction or traditional construction methods - but with a twist.

Consider the following example, a scenario where modular units are procured by the developer and involves a contractor used to the design and build approach. This may create apprehension, especially if they have not been involved in the selection of the off-site manufacturer/supplier. The concern is both qualitative (e.g. what is the delivered unit going to look like compared to what is specified?) as well as cost and time-driven (e.g. will the delivered item incorporate easily with the remainder of the works, or will there be time and costs incurred regarding adaption of what has been manufactured?). Many of these concerns can largely be overcome in OSM by entering into (before tender) a pre-construction phase, stand-alone contract with the contractor such as JCT's pre-contract services agreement. This could bridge the potential design interface issues which may arise between manufacture and physical incorporation of units on site where the contractor has early access to the component manufacturer for the proposed project. Whilst this may increase the initial cost in terms of additional consultancy/management fees, the potential subsequent savings could be sizeable as programme timings and the need for defect remediation would more often than not be reduced. The contractor's early engagement is often widely viewed as being essential in the final design process and preparations for the construction phase, including the programme, cost plans, buildability and specialist procurement. Building Information Modelling could facilitate this

approach, creating an opportunity for the contractor to inform design and construction optimisation decisions from the outset of a project through to completion. The integrated workflow would also allow designers, contractors, suppliers and manufacturers to understand the implications of their design and construction decisions. Site issues such as transportation, assembly and the commission of modular units could also to be considered and addressed early. However, given the significant planning involved, it is crucial that the modelling approach is flexible and able to be updated throughout the project to counter any unforeseen events.

Other contractual issues that could arise from the use of OSM as opposed to traditional construction methods, include: i) legal ownership of goods prior to delivery and ii) risk of goods either in transit or whilst in storage (Wilkinson 2017). It would be incumbent on the developer to ensure that there are provisions within the contract that: incorporate up-front payment of goods to guarantee delivery of products and/or components and avoid any undue complications that may arise if the supplier becomes insolvent. A Retention of Title Clause would address such as situation within the JCT Standard Building Contract (2016) for example (King 2018). In the Australian context, such supply contracts would be governed by the provisions and application of the *Personal Property Securities Act 2009* (Cth) (PPSA). Supply contracts often contain security interests such as leases that meet certain threshold time periods and retention of title arrangements. Security interests would need to be perfected, which is best done by registration in order to preserve priority under the PPSA. Recent Australian Case Law demonstrated the importance of knowing and understanding the PPSA regime. In particular, the importance of registering security interests, and the consequences of not following the approach[5].

With respect to potential damage of goods, it would be important to have a provision for ongoing liability of the supplier whilst the goods are either in transit or in storage (and that there was sufficient insurance provision within the contract to cover such scenarios). It would also be advisable for both parties to agree a delivery schedule; identifying items for delivery, particularly in situations where storage on site is inadequate or inappropriate (Wilkinson 2017). In case of off-shore procurement the risk could be managed by staggering the volume of each shipment. Moreover, the risk and care of goods are normally within the remit of the supplier until "completion" or a similar concept under the contract. Alternatively, the transfer of risk in goods can accompany the transfer of ownership. These issues can have significant impact upon the responsibility for care of the works and reinstatement of damage. It would also be prudent to contract out of the Vienna Sales Convention to avoid its application which may alter the terms of the supply contract.

4.3 Testing and Certification of Product Performance

Most component manufacturers benefit from large test and development programmes to optimise performance. Typically, such testing regimes form part of trade associations' support in the market for the use of particular construction materials. Third-party certification by an

[5] See, for e.g., Maiden Civil (P&E) Pty Ltd; Richard Albarran and Blair Alexander Pleash as receivers and managers of Maiden Civil (P&E) Pty Ltd & Ors v Queensland Excavation Services Pty Ltd & Ors [2013] NSWSC 852 where the Supreme Court held that a registered security interest prevailed over unregistered legal title under the PPSA in an equipment hire arrangement.

accredited test authority is commonly available and should be sought for unusual details or designs unique to a manufacturer. This could involve a testing and certification process comparable to the provision for thermal, acoustic insulation, air-tightness and fire separation. It is also critical that a decision on the most appropriate form of offsite supply be made to meet the specification and performance criteria early in the design process. In particular, height and span in multi-storey configurations may suit different structural materials in order to be cost effective. Similarly, off-site products can generally be clad and roofed in any of the common facing materials. There may be opportunities to integrate cladding units with the offsite supply to avoid the costs and risks of scaffolding and working at height; and, as offsite products are usually dispatched from the factory in a weatherproof state, they are also protected from transportation and site damage.

4.4 Quality Inspection Schemes

Most manufacturers operate under recognised quality standards which require formal inspection and sign-off at each stage (as products progress through the factory environment and onto site). To gain a nationally recognised third-party quality assurance endorsement, this process is a prerequisite. The regime could be readily incorporated into the controlled environment such as manufacturing. This is usually more difficult to achieve on open building sites with itinerant trades and subcontractors. Many manufacturers encourage the early involvement of the client's representatives in the setting and maintaining of appropriate product quality. Where on larger projects, a prototype (or first manufactured unit) is used as a control to set mutually agreed standards. The comprehensive third-party Quality Assurance schemes require and provide inspection regimes as projects progress. Similarly, the Building Regulations (in the UK) require inspection of those aspects covered by the regulations to ensure compliance. It could be possible to include OSM as a category within a section of these regulations to cover Sustainability and Building standards, for example.

4.5 Accreditation, Assurance and Insurance Schemes

OSM can provide meaningful input to support the UK's house-building capacity and performance. However, lenders' willingness to offer mortgages on non-traditional homes will be a key factor for determining its uptake within the private sector. The Council of Mortgage Lenders notes state that they have no preference for any particular type of construction, provided the property is able meet certain standards of quality and hold its value over the mortgage term (Wilkinson, 2017). Since the post World War II prefabrication programme, offsite construction has made considerable progress in quality, performance, robustness and design of offsite manufactured methods of supply. Intrinsically, this means that today's modular homes have little in common with the past. Furthermore, the sector has taken a proactive approach in demonstrating compliance with high technical standards and lender requirements by establishing the Buildoffsite Property Assurance Scheme (BOPAS). BOPAS provides assurance, insurance and a traceable database to the financial markets that offsite properties are designed, manufactured and installed by accredited organisations and will deliver performance for in excess of 60 years (Santo 2017). In addition, the National House Building Council (NHBC) maintains a separate review for modular dwellings to ensure compliance with the NHBC Technical Standards. It also offers cover to successful projects supported by third party verification (although this covers structural elements only), alongside other similar warrantee suppliers such as Local Authority Building Control (LABC) and Premier Building Guarantees. Clients would therefore be strongly advised to seek independent

assurance and certification to recognised standards for their projects in order to avoid potential issues relating to the availability of warranties and loan finance options. Clearly, assurance schemes are a step in the right direction; but, there is much to be done in terms of instilling greater confidence amongst Lenders. Given this, the house building sector needs to become more familiar with the products available, and to accept that with the rapid advancement of technology, there has been a noticeable improvement in Product Quality (Giblin, 2018). The recent introduction of the Building Research Establishment (BRE) Building Product Standard (BPS 7014) should go some way to allay the concerns among manufacturers, developers, planners, mortgage lenders and insurers about the quality in offsite construction in the UK (CIOB, 2018).

4.6 Reflection and Further Research

This chapter explored the core legal and contractual challenges affecting the use of OSM in the UK building sector, along with the potential risks posed by these 'modern methods of construction' for those managing housing developments or administering building contracts. In doing so, it the particular foci adopted concentrated specifically on: process, policy and enforcement and culture.

Whilst these findings predominantly rest within the UK context, a number of important parallels can be drawn. Moreover, given the importance and gravity of this subject matter, it is advocated that there is an intrinsic need to undertake additional research in the following areas:

- To explore how a framework similar to the US General Aviation Revitalization Act 1994 could be used to promote legal certainty in the construction sector - which is increasingly dependent upon the use of off-site manufactured components:

- To explore the viability of introducing legal reforms mandating extended and insurance-backed manufacturers' warranties for modular buildings reform proposals;

- To investigate the extent to which active trade union opposition to the increased uptake of modern methods of construction represents a significant barrier to the realisation of the objectives stated within the UK Government's recent Housing White Paper, and the role that unions *could* play in helping to make these visions a reality;

- To evaluate the legal and contractual challenges that affect the use of OSM in housing development within different jurisdictions.

5. Conclusion

This chapter revealed numerous legal and contractual issues affecting the use of OSM in the housing development in the UK. Organisations such as the JCT and FIDIC can help facilitate the uptake of modern construction methods by ensuring their standard form contract suites incorporate OSM issues. The introduction of framework which standardises the quality of off-site manufactured components *used* to build houses in the UK would help encourage the flow of project finance into the UK's modular construction sector. In addition, the development of some form of 'national register' for approved suppliers, including bespoke quality assurance

schemes such as ‘CodeMark’ in Australia or the UK Kitemark scheme would not only help mandate third-party certification evidence, but also increase owner/stakeholder confidence.

In conclusion, it is evident that the main barriers to the increased use and uptake of OSM in construction are not in fact legal or contractual. That being said, some of main barriers highlighted in this chapter can be mitigated through legal reform.

Key Learning Points

- Standard form contracts cannot exclude product liability in tort for disasters which cause death or personal injury, or where the claimants are not parties to the original construction contract. A Framework similar to the General Aviation Revitalization Act 1994 might be an option worth exploring to mitigate this uncertainty;

- The nature and engagement of construction worker unions needs to be revisited in terms of their adoption of future OSM necessary reforms. Trade union engagement could have a significant positive (or negative) role to play;

- A standardised legal assessment approach is needed for OSM, particularly covering the legal and contractual issues within housing development projects. This should include: Process, Policy, Enforcement and Culture.

References

Abbott, L. (2013) *Political Barriers to Housebuilding in Britain: A Critical Case Study of Protectionism and its Industrial-commercial Effects*. ISR.

Anfara, V., A., and N. T. Mertz (2014) *Theoretical Frameworks in Qualitative Research*. SAGE.

Arif, M., Killian, P., Goulding, J., Wood, G. and Kaushik, A., 2017. Barriers and challenges for offsite construction in UK housing sector. *IRC 2017*, 854.

Arif, M., Goulding, J., and Rahimian, F. P. (2012). Promoting offsite construction: Future challenges and opportunities. Journal of Architectural Engineering, Vol 18, No. 2, 75-78.

Arif, M., and Egbu, C., (2010), Making a case for offsite construction in China, Engineering, Construction and Architectural Management, Vol. 17, No. 6, 536-548

Barendrecht, M., C. Jansen, M. Loos, A. Pinna, R. Cascao and S. van Gulijk (2006) *Service Contracts*. Walter de Gruyter.

Barker, N., (2018) 'Boroughs raise concerns over London Plan' (Inside Housing Magazine, 14th March [Online] <https://www.insidehousing.co.uk/news/news/boroughs-raise-concerns-over-london-plan-55233> accessed 21st March 2018.

Barnard, C. (2007) *The Substantive Law of the EU: The Four Freedoms*. Oxford University Press

Barry, S (2016) 'Turn nimbys into pimbys and we can solve the UK housing shortage crisis says L&G boss Nigel Wilson'. Wales Online, 3rd May [Online] <https://www.walesonline.co.uk/business/business-news/turn-nimbys-pimbys-can-solve-11276555> accessed 21st March 2018.

Bell, M (2018) 'How is that even possible?' Raising construction regulation from the ashes of Grenfell Tower'. March [Online] <https://www.scl.org.uk/papers/raising-construction-regulation-grenfell> accessed 30 April 2018.

Blismas, N.G, Pendlebury, M., Gibb, A., and Pasquire, C., (2005), Constraints to the Use of Off-site Production on Construction Projects, Architectural Engineering and Design Management, Vol. 1, No. 3, 153-162

Blismas, N.G, Pasquire, C., and Gibb, A., (2006), Benefit evaluation for off site production in construction, Construction Management and Economics, Vol. 24, No. 2, 121-130

Bowie, D (2017) *Radical Solutions to the Housing Supply Crisis*. Policy Press.

BuildoffSite (2012) *Buildoffsite Review 2012: The business case for offsite*, Buildoffsite, London.

Campbell, D., and S. Woodley (2005) *Liability for Products in a Global Economy*. CILS.

Chess, P., M., and J. P. Broomfield (2013) *Cathodic Protection of Steel in Concrete and Masonry*. CRC Press.

Christiansen, B (2013) *Transcultural Marketing for Incremental and Radical Innovation*. IGI Global.

Cleary, M (2011) *21st Century Sustainable Homes*. Images Publishing

Curry, R (2016) 'Chinese state-owned construction firm signs £2.5bn deal to build modular homes with UK housing association'. The Telegraph, 19 December [Online] <https://www.telegraph.co.uk/business/2016/12/19/chinese-state-owned-construction-firm-signs-25bn-deal-build/> accessed 22nd March 2018.

Department for Communities and Local Government (2017) 'Fixing our broken housing market'. HMSO [Online] <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/590464

/Fixing_our_broken_housing_market_-_print_ready_version.pdf> accessed 20th March 2018.

Ferrari, E., 2015. The social value of housing in straitened times: The view from England. *Housing Studies*, Vol 30, No. 4, 514-534.

Fewings, P (2013) *Construction Project Management: An Integrated Approach* (2nd ed., Routledge.

Gangbox News (2015) 'LEGOLAND – modular construction, deskilling and deunioniziation in the NYC building trades' [Online] <http://gangboxnews.blogspot.co.uk/2015/05/legoland-modular-construction.html> accessed 30 April 2018.

Geoghegan, J (2018) 'Only a third of London boroughs support build to rent, study finds'. Planning Resource, 14th February. [Online] <https://www.planningresource.co.uk/article/1457157/third-london-boroughs-support-build-rent-study-finds> accessed 21st March 2018.

Giblin, R (2018) 'Modular building: overcoming the funding and valuation challenges' (Social Housing, 10th January [Online] <https://www.socialhousing.co.uk/comment/comment/modular-building-overcoming-the-funding-and-valuation-challenges-53881> accessed 21st March 2018.

Goodier, C., and A. G. F. Gibb (2005) 'Barriers and opportunities for offsite in the UK' In A. S. Kazi (ed), *Systematic Innovation in the Management of Project and Processes*. Helsinki International Joint Symposium 148-158.

Goulding, J.S., and Arif, M., (2013), Research Road Map Report: Offsite Production and Manufacturing, Publication 372, International Council for Research and Innovation in Building and Construction, ISBN 97890-6363-076-8

Harris, J (2018) 'We can solve the UK's housing crisis – with a little imagination' (The Guardian, 22 January [Online] <https://www.theguardian.com/commentisfree/2018/jan/22/solve-uk-housing-crisis-new-houses> accessed 20th March 2018.

Helm, T (2017) 'Housing crisis threatens a million families with eviction by 2020' (The Guardian, 24 June) [Online] <https://www.theguardian.com/society/2017/jun/24/social-housing-poverty-homeless-shelter-rent> accessed 20th March 2018; McKinsey Global Institute, 'The global affordable housing challenge' (2015) [Online] <http://www.mckinsey.com/urbanization/tackling_the_affordable_housing_challenge> accessed 20th March 2018.

Hughes, J (2015) 'Are prefab villages really the future of housing?' (Irish Journal, 14th October) [Online] <http://www.thejournal.ie/readme/prefab-housing-2386705-Oct2015/> accessed 20th March 2018.

Irvine, S (2018) 'What planners need to know about modular housing' (Turley) [Online] <https://www.turley.co.uk/intelligence/what-planners-need-know-about-modular-housing> accessed 21st March 2018.

Jaillon, L., and Poon, C. S. (2009). The evolution of prefabricated residential building systems in Hong Kong: A review of the public and the private sector. *Automation in Construction*, Vol. 18, No. 3, 239-248. doi:https://doi.org/10.1016/j.autcon.2008.09.002

Jones, R (2017) 'Welcome to rabbit-hutch Britain, land of the ever-shrinking home' (The Guardian, 11th February) [Online] < https://www.theguardian.com/money/2017/feb/11/welcome-rabbit-hutch-britain-land-ever-shrinking-home> accessed 20th March 2018.

Knerr, D (2004) Suburban Steel: The Magnificent Failure of the Lustron Corporation, 1945-1951. Ohio State University Press.

Knowles, J (2012) *200 Contractual Problems and their Solutions*. Wiley, 2012.
Kolarevic, B., and K. Klinger (2013) Manufacturing Material Effects: Rethinking Design and Making in Architecture. Routledge.
Larsson, J., Eriksson, P., Olofsson, T. and Simonsson, P. (2011) *Industrialised Construction in the Swedish Infrastructure Sector: Core elements and barriers*, Journal of Construction Management and Economics, Vol 32, No. 1-2, 83-96.
Lea, R (2016) 'Construction workers unite in Britain's biggest super-union' (The Times, 19 May) [Online] <https://www.thetimes.co.uk/article/construction-workers-unite-in-britains-biggest-super-union-bxdgkswdv> accessed 22nd March 2018.
Li, R (2016) 'Housing development's latest enemy: Bay Area construction unions' (San Fran. Business Times, 1 November) [Online] <https://www.bizjournals.com/sanfrancisco/blog/2016/10/housing-development-bay-area-oakland-labor-unions.html> accessed 22nd March 2018.
London Assembly (2017) 'Designed, sealed, delivered - The contribution of offsite manufactured homes to solving London's housing crisis' (HMSO, August) 47 [Online] <https://www.london.gov.uk/moderngov/documents/s67697/07b%20-%20Appendix%201%20-%20Rapporteur%20Report.pdf> accessed 22nd March 2018.
Mairs, J (2017) 'Grenfell Tower cladding identified as cheaper and more flammable option' (DeZeen, 19 June) [Online] <https://www.dezeen.com/2017/06/19/grenfell-tower-cladding-identified-cheaper-more-flammable-option-architecture-news/> accessed 22nd March 2018.
Miles, J., and N. Whitehouse (2013) *Offsite Housing Review*. Construction Industry Council.
Ministry of Housing, Communities and Local Government (2015) '2010 to 2015 government policy: planning reform' (HMSO, 8 May) [Online] <https://www.gov.uk/government/publications/2010-to-2015-government-policy-planning-reform/2010-to-2015-government-policy-planning-reform> accessed 21st March 2018.
Nadim and J. Goulding (2010) Offsite production in the UK: the way forward? A UK construction industry perspective. *Construction Innovation* Vol 2, 181-202.
National Audit Office (2005) 'Using Modern Methods of Construction to Build Homes more quickly and efficiently' (HMSO) [Online] <https://www.nao.org.uk/wp-content/uploads/2005/11/mmc.pdf> accessed 20th March 2018.
Night, S., G (1988) 'Products Liability: Component Part Manufacturer's Liability for Design and Warning Defects'.54 *Journal of Air Law and Commerce* Vol 9, 215-47.
Pan, W., A. G. F. Gibb and A. R. J. Dainty (2008) 'Leading UK housebuilders' utilization of offsite construction methods'. 36 *Building Research & Information* Vol 1, 56-67.
Pan, W., Gibb, A. G., and Dainty, A. R (2007) 'Perspectives of UK house builders on the use of offsite modern methods of construction'. 25 *Construction Management and Economics* Vol 2, 183-194.
Pasquire, C. and Gibb, A. (2002) *Considerations for Assessing the Benefits of Standardisation and Pre-assembly*, Journal of Financial Management of Property and Construction, Vol 7, No. 3, 151-61.
Rahimian, F.P., Goulding, J.S., Akintoye, A. and Kolo, S.J., 2017. Motivations, success factors, and barriers to the adoption of offsite manufacturing in Nigeria. *IRC 2017*, p.685.
Reuters (2017) 'Builders turn to bolt-together homes in Brexit Britain' (Reuters, 9 March) [Online] < https://uk.reuters.com/article/uk-britain-eu-construction-insight/builders-turn-to-bolt-together-homes-in-brexit-britain-idUKKBN16G1DC> accessed 22nd March 2018.

Ruiz, F (2005) *Building an Affordable House: Trade Secrets to High-value, Low-cost Construction*. Taunton.

Rush, J., and M. Ottley (2006) *Business Law*. Centage.

San Francisco Building & Construction Trades Council (2016) 'The Challenges of Modular Construction' (4th April) [Online] <https://www.sfbuildingtradescouncil.org/news/building-the-trades/560-the-challenges-of-modular-construction> accessed 30 April 2018.

Schneier, M (1999) *Construction Accident Law: A Comprehensive Guide to Legal Liability and Insurance Claims*. American Bar Association.

Schoenborn, J., M (2012) 'A Case Study Approach to Identifying the Constraints and Barriers to Design Innovation for Modular Construction' (Virginia Poly) 5 [Online] <https://vtechworks.lib.vt.edu/bitstream/handle/10919/32397/Schoenborn_JM_T_2012.pdf?sequence=1> accessed 20th March 2018.

Senate Economics References Committee into Non-Conforming Building Products and the Victorian Cladding Taskforce (2017), 'Interim report: aluminium composite cladding' (September) [Online] < https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Economics/Non-conforming45th/~/media/Committees/economics_ctte/Non-conforming45th/Interim_report_cladding/report.pdf> accessed 30 April 2018.

Sjostrom, C (2014)., *Durability of Building Materials and Components 7: Proceedings of the Seventh International Conference*. Routledge.

Smith, D., M., and E. Wistrich (2016) *Devolution and Localism in England.* Routledge.

Smith, P (2016) *Structural Design of Buildings*. Wiley.

Smith, R (2016) 'Off-Site and Modular Construction Explained' (NIBS) [Online] <http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/OSCC/OSMC_Explained.pdf > accessed 20th March 2018.

Taylor, S. (2009) *Offsite Production in the UK Construction Industry: A brief overview*. Buildoffsite by HSE, June, 2009, London.

Taylor, M.D. (2010) *A Definition and Evaluation of the UK Off-Site Construction Sector*. Construction Management in Economics, Vol 28, 885-896.

United Nations (n.d.) 'Floor Area Per Person' (United Nations) [Online] <http://www.un.org/esa/population/pubsarchive/chart/14.pdf> accessed 20th March 2018.

US Office of Technology Assessment (1986), *Technology, trade, and the U.S residential construction industry.* DIANE Publishing. 82.

Vale, B (2013) *Prefabs: The History of the UK Temporary Housing Programme*. Routledge.

Wallis, V (2014) 'Will building societies lend on a timber-frame house?' (The Guardian, 3 July) [Online] <https://www.theguardian.com/money/2014/jul/03/building-society-refuses-mortgage-timber-frame> accessed 21st March 2018.

Warszawski, A (2003) *Industrialized and Automated Building Systems: A Managerial Approach*. Routledge.

Whyte, A (2014) *Integrated Design and Cost Management for Civil Engineers*. CRC Press.

Woo, P., and S. P. *Low (2013) Lean and Cleaner Production: Applications in Prefabrication to Reduce Carbon Emissions*. Springer.

Wu, Y., S. Zheng, J. Luo, W. Wang, Z. Mo and L. Shan (2016) *Proceedings of the 20th International Symposium on Advancement of Construction Management and Real Estate*. Springer.

Zhang, L., Rahimian, F.P., Agapiou, A. and Goulding, J., 2017. Offsite construction: an opportunity for improving risk management. *IRC 2017*, p.908.

Case Law

General Aviation Revitalization Act 1994.
Town and Country Planning Act 1932 (as amended).
Unfair Contract Terms Act 1977 (as amended).
Terrapin v Terranova [1976] ECR 1039.
Norta Wallpapers (Ireland) Ltd v. John Sisk & Sons (Dublin) Ltd (1977) 14 BLR 49.