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Modern Methods of Construction:

barriers and benefits for Irish housing

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Preface

Preface

Ireland faces challenges on several fronts. Some of these are domestic in nature, with domestic solutions, whereas others are more international in character. The Irish economy over the last number of decades is mostly a success story. It has managed to catch up with its Western European neighbours in terms of standard of living and, in many instances, has exceeded them. Granted, its success has been checkered by instability, but overall Ireland is no longer a country which, in aggregate, exports its young people. It is instead a country in which Irish and non-Irish alike want to, and do move to.

One of the main challenges Ireland faces – the most salient political issue of the last decade – is how to house its population. On some measures, particularly for homeowners, Irish housing is comparatively affordable. For those renting privately in urban areas, it is completely unaffordable. While transfers and other state supports can and do alleviate affordability, particularly for social tenants, they do not address the fundamental problem – a lack of supply. The result for this large and growing number of people falling between the cracks of renting and owning is homelessness.

Homelessness is an intolerable scourge for any modern, developed country. It affects the poorest in society. The large numbers of homeless are bad enough, but recent social tensions provide an extra layer of urgency to the matter. Failure to address the housing situation has already resulted in social unrest, and the situation now risks boiling over to uglier political developments.

The major challenge globally is undoubtedly climate change. Despite being a small country, and despite climate issues hitherto packing a relatively light electoral punch on these shores, Ireland has obligations to live up to, as outlined in the Climate Action and Low Carbon Development (Amendment) Act 2021. The record on living up to those obligations is, however, poor. As we detail in this report, the built environment plays an environmentally important role and, while progress has been made, will need to do more in the coming years to develop sustainable practices.

TASC and the CIOB are delighted to once again be working in partnership. TASC and the CIOB first partnered on a report launched in 2021 on job quality in the Irish construction sector. Among the challenges then was how to attract, grow, and retain the construction workforce in the context of ongoing supply shortages. These issues still loom large, and offsite construction has a role to play. It is well-known that construction work is among the most physically demanding. By moving some of that work from the site into the factory, it can be made safer and more attractive.

Indeed, Modern Methods of Construction (MMC) can be one of the solutions to Ireland's other, multifaceted challenges. Aside from more pleasant work, it offers a means of building housing that is both high quality and sustainable. By moving a large part of the building process to a factory setting, units can be completed more quickly by overlapping different stages of the construction process. It therefore has the potential to increase supply, a supply that has a lower level of embodied carbon.

As laid out in this report, there are a number of challenges and barriers if the MMC sector is to grow. Both the market sector, and the non-market or social housing sector have important roles to play. State agencies and local authorities will need to be nimble and show leadership. The policies suggested in this report follow on from the analysis. They are ambitious, but not unachievable.

1 Introduction

1 Introduction

What are Modern Methods of Construction?

Modern methods of construction (MMC) is a broad term that captures a diverse range of building processes and products. The term is generally used to describe construction which takes place in a factory setting as opposed to onsite. It includes the construction of full 3-D units or modules. They are 3-D in the sense of not being flat and include the construction of rooms offsite including bedrooms, bathrooms, and kitchens. As they take up 'volume' the construction of such units is also referred to as volumetric construction. They are transported to the site and integrated with the rest of the building, often by stacking modules on top of each other.

MMC also refers to the construction of flat, 2-D units or panels in a factory setting. Various types of materials are available to make 2-D panels and they are used to make walls, floors, and roofs. These are transported, assembled, and integrated with other parts of the building. A distinction is sometimes made between open panels, which are more common, and closed panels, which are more sophisticated. Open panels form the skeletal structure only, whereas closed panels include lining materials, insulation, electrical services, and other components. Materials used in 2-D panelised components include timber, light steel or light gauge steel frame, precast concrete, structurally insulated panels, insulated concrete formwork (ICF), and cross-laminated timber (CLT) (DHLGH, 2023a).[1]

The 'modern' part of MMC is therefore somewhat misleading. Precast concrete is widely used in Ireland and has been for some time. The same is true of timber-framed buildings. Similarly, the term offsite construction is used by many as interchangeable with MMC, but not by others. A recently published government guide lists seven categories of MMC. Category 1 is 3-D primary structural systems or volumetric MMC. Category 2 is 2-D panelised components. The remaining five categories contain mostly non-structural elements such as manufactured partition walls which are non-load bearing, but also include onsite developments such as robotics, drones, and other innovations (DHLGH, 2023a). The figures below illustrate various forms of offsite construction. In this report, we will use MMC and offsite construction interchangeably.

1 Structurally insulated panels are formed by inserting an insulation layer between two structural boards. Cross-laminated timber is formed by gluing together different layers of wood perpendicularly.



Figure 1: Module being hoisted onsite.



Figure 2: Modules stacked on a completed building.



Figure 3: 2-D panel being hoisted onsite.



Figure 4: 2-D precast concrete walls being assembled.



Figure 5: 2-D panel being built in a factory.



Figure 6: Timber frame building being erected.



Figure 7: Timber frame building completed.



Figure 8: Light gauge steel framed building.

Different MMC products can be combined in a myriad of ways and forms. Timber frame buildings can be combined with conventional construction in that they have concrete ground floors and timber intermediate floors. This has been how timber frame buildings in Ireland have historically been built. Alternatively, they can be combined with pre-fabricated panels made in factories. In Ireland, the cladding or external shell of timber framed buildings is usually made from bricks and blocks, though it need not be (GoI, 2000s). A timber frame house with bricks and blocks is shown in Figure 7.

Similarly, light gauge steel frame buildings can be used with a variety of different elements. They can be combined panelised elements which may themselves be made of steel, but they need not be combined with panels and the panels may not be made of steel. The cladding can come in a variety of forms including brickwork, metallic sheets, and timber (Yandzio et al., 2015). 3-D modules are usually constructed with steel, though timber is possible (DEHLG, 2003).

Benefits of Modern Methods of Construction

Greater use of MMC offers many potential benefits to those working within the sector and to society at large. It provides opportunities for a more sustainable built environment, better working conditions, and a more productive construction sector that can deliver high-quality homes more quickly than conventional, onsite construction.

Perhaps the main benefit of MMC is its potential environmental impact. Ireland has among the highest emissions per capita in the OECD and the EU. It is estimated that 37% of Ireland's carbon emissions come from the built environment. Of this, 14% is from the embodied carbon arising from the production and transport of building materials, as well as the maintenance, repair and disposal of buildings and infrastructure. The remaining 23% is from the heating, lighting, and cooling of buildings (Oireachtas, 2022).

As timber is a naturally occurring resource that absorbs CO_2 from the atmosphere, its greater use in construction can reduce the embodied carbon emitted by the sector. In contrast, concrete, the main material used in residential construction in Ireland, has a very high embodied carbon content. Though concrete can be precast in a factory setting, it is typically not. Timber frames can be constructed onsite, but they are typically constructed offsite. Structural steel has a comparable though somewhat larger global warming impact to timber (Morris et al., 2021). Factory construction also results in considerably less waste and deliveries to site, and more of the materials can be recycled (EY, 2021: 24). MMC or offsite construction can therefore reduce emissions from the sector significantly.

Construction work can be very onerous and working conditions are often precarious. Ireland's health and safety record in construction is very good relative to other European countries, though the sector is comparatively precarious (Sweeney, 2021). By working in a controlled factory setting, accidents and injuries are less likely. A factory setting also enables workers to escape from Ireland's climate, which can be harsh in winter months. MMC therefore provides opportunities for more pleasant working lives.

It is well-known that the construction sector suffers from low productivity growth. A variety of factors account for this including lack of standardisation. Each output or unit is built on a unique tract of land that could have its own site-specific challenges. Even if designs were standardised, and they are not,

construction may lack the repetition that enables efficiencies in many other sectors. Other causes of low productivity growth include high levels of cyclicality, informality, fragmentation, corruption, and poor risk-reward incentives in contracts.

By building in a factory setting, it is possible to overcome or at least mitigate the challenge of stagnant productivity using MMC. As we detail throughout this report, MMC allows for much greater standardisation of the product. This can yield considerable improvements in output through learning by doing and repetition. MMC also produces less waste than conventional construction methods and enables construction to be carried out more quickly. Estimates vary as to increased speed of delivery, but construction time can be reduced by between 4 to 6 weeks. This enables a total reduction in project time of up to 8 weeks (IBEC, 2021).[2]

The potential gains from offsite production are therefore numerous, however, a number of barriers exist to upscaling MMC in Ireland which we turn to shortly.

Outline and research in this report

This report examines the barriers to greater use of MMC in Ireland with a focus on the residential sector. It analyses both the private and the public sectors. This is to improve delivery in terms of speed, quality, and environmental impact. Better public delivery is desirable in and of itself, but is also of interest as public sector investment can be leveraged to encourage the private sector. The report is interested in both sectors and the impact that one has on the other.

Construction or development is a complex process and has grown more complicated over time. There are many different parts and processes that constitute a final product, and there are many different actors involved in and outside the 'onsite' construction sector. In terms of process, there is land acquisition, planning, financing, and construction to name a few. In traditional construction, the major actors are developers or clients who take the risk of purchasing and developing land and selling the final unit. There are funders which include banks and investment funds that finance construction, and institutional investors who purchase the final product. There are contractors, who construct or manage the actual building and there are subcontractors who carry out part of the building process. Contractors and clients hire a range of professionals such as architects, engineers, and quantity surveyors whereas contractors and sub-contractors hire a range of tradespeople. Then there is the state in its various forms which includes regulators such as building regulators and planners. The state also acts as a developer such as local authorities that procure contractors for social housing.

The stakeholders are largely the same with MMC except there are now manufacturers who do much of the construction offsite. Sometimes manufacturers only manufacture, though in other cases they perform multiple functions. Some manufacturers act as contractors in that they also manage the overall construction process on behalf of the client as well as performing construction offsite. Some of the major developers also have their own manufacturing facilities.

This report concerns itself with the whole of the construction supply chain. It examines the barriers to greater use of MMC across the sector whether that it is manufacturers, contractors, developers, end

2 Based on a visual measurement of a chart, which may not have been accurately scaled, the saving was 28%. An international McKinsey report estimates that modular construction can reduce project time by between 20 to 50% (Bertram et al., 2019).

users, or the state. As the supply chain and the process of housing supply is opaque with relatively little data available, this report relies on mostly qualitative interview data.

For the research, a two-hour roundtable discussion was first hosted. This comprised eight stakeholders from across the sector, five of whom worked in the private sector, and three of whom worked in either the public or third sector. The idea of a roundtable discussion was to provide a preliminary assessment of the barriers to MMC, and informed a subsequent series of in-depth interviews. 30 stakeholders were then interviewed over 28 interviews. 20 of the interviewees were from the private sector with the remaining ten taken from the public and third sector. From the private sector, most of the interviewees were contractors, manufacturers, and architects. A plurality of the remaining interviewees were stakeholders from local authorities.

There are multiple barriers to MMC in Ireland. The main barrier to its more widespread adoption is that it tends to be more expensive than conventional construction. As a result, contractors are uninclined to choose MMC. Because some of the products associated with MMC are new, stakeholders across the supply chain are wary about using it. This includes developers and consumers who are the end users. It also includes funders and insurers who do not fully understand the risks associated with it.

Many factors contribute to its greater expense relative to conventional construction. Demand for MMC is underdeveloped. Without assurance of a certain level of demand over a sustained period of time, manufacturers are unable to realise MMC's potential economies of scale. Lack of demand, of course, goes back to its greater expense and its perceived riskiness. Additionally, regulatory factors elevate costs as many of the products associated with MMC are untried and untested compared to conventional construction products.

Aside from being more expensive, there are a number of other hurdles which directly restrict MMC. Ireland's building regulations restrict the use of combustible materials, which limits the use of timber to four storeys. Banks are unwilling to provide mortgages for end users of modular homes, which restricts consumer demand. Insurers are unwilling to provide professional cover for products for which they cannot calculate risk based on historical data.

Planning was said to be a barrier by some but not by others. The procurement processes were reasonably well adapted to MMC in the private sector, though improvements still needed to be made especially in terms of greater involvement of contractors and delegation of design responsibility.

Public sector procurement was deemed to be less flexible, though improvements had been made. MMC is being used increasingly by local authorities in the building of social housing. However, there has not been a commitment at a level to facilitate the realisation of significant economies of scale in the sector. Most local authorities were small and for many social housing developments MMC made little sense.

This report is organised as follows. Section 2 outlines market-structural barriers to MMC. Section 3 examines finance and insurance-related issues. Section 4 discusses regulatory issues and building regulations. Section 5 looks at procurement, especially in the private sector. Section 6 covers planning-related matters. Section 7 examines public sector procurement and the supply of social housing. Section 8, the final section, offers some discussion and policy recommendations.

2 Market structural factors

2 Market structural factors

Context

Some categories of MMC are well-developed in an Irish context. Though estimates vary widely, between 24-48% of new build homes are timber-framed, where the main load-bearing structure is timber (Bermingham, 2023; Oireachtas, 2022; Thompson, 2023). The use of timber frames may not have grown much over time as 25% of residential homes in Ireland were built using timber frames according to a 2004 study (Gallagher, 2010). While it is possible to build timber frames onsite, most if not all are produced offsite (Bermingham, 2023).[3]

It is estimated that 70% of newly built homes internationally and around four fifths of new homes in Scotland use timber frames. The latter is telling given its similarity to Ireland in terms of climate, size, proximity, and socioeconomic development. Ireland imports the majority of timber used in construction from Scandinavia because of its superior strength and aesthetic features. Ireland has a lower forest cover than most EU countries and farmers are not always incentivised to plant trees (Oireachtas, 2022). At the same time, 80% of Irish timber is exported where it is mostly used to construct timber frame buildings. According to Timber Frame Ireland, a leading timber frame manufacturer, timber frame houses are more cost-effective over the long run because of their superior energy performance (TFI, 2023).

The use of pre-cast concrete is also well-established in Ireland. As with timber frame buildings, the precise extent of pre-cast concrete use in new builds is unknown. A survey of main contractors in the 2000s indicated that the vast majority of them have used MMC and that around half of that was pre-cast concrete making it the most common type of MMC (Gallagher, 2010).[4] This is confirmed in a more recent survey of large contractors where pre-cast concrete is named as the most commonly used form of MMC (EY, 2021).

Brick and block work is on the critical path in that if it is delayed, it will delay the entire project. Consequently, rising wages and industrial relations disputes between blocklayers and contractors led to its growth in popularity in the 2000s. Other factors include Irish weather conditions which can delay the conventional blockwork and costs associated with blockwork, such as scaffolding (ibid).

Referring to the more technologically novel forms of MMC, The Royal Institute of Architects of Ireland (RIAI, 2022) notes that MMC 'is at a very low level of maturity' and much of what is being produced is being exported. 2-D MMC makes up the vast majority of MMC and there are relatively few modular manufacturers in the country. Of the total number of new dwellings or residential units constructed in 2019, around 6% used volumetric/modular compared to an estimated 24% that used timber frame buildings (IBEC, 2021; CSO, 2023a). An inability to meet existing demand was cited as a problem within the industry pre-pandemic (Martin, 2021). An industry analysis focuses on certainty of demand as a key barrier as opposed to the level in any given year (IBEC, 2021). By providing a stable pipeline, manufacturers are incentivised to invest in facilities and skills. The Irish government has committed to building 700 modular homes to house Ukrainian refugees. Targets for 2023 are likely to have been missed due to difficulties accessing suitable sites.

3 An interviewee clarified that the building regulations strongly incentivise a timber frame building to be manufactured offsite.

4 Among the 'alternative methods' used, precast wall panels were 48%, composite wall panels 28%, and timber frames 6% (Gallagher, 2011: 74).

During the pandemic, the MMC sector was hit harder by rising materials costs than the traditional construction sector. This is because MMC requires most materials to be provided upfront for manufacturing in a factory setting. Traditional builders, in contrast, can build out what they have until new supplies arrive (Martin, 2021). The supply chain in MMC is also more fragmented as there is a limited number of suppliers (Reddy, 2020).

Integral to any manufacturing process, if the efficiency potential of the technology is to be realised, is standardisation. Standardisation can mean many things including repetition of manufacturing tasks and methods, but also standardisation of contracts, drawings, reports, and data collection within projects. It has been argued that a large number of different housing designs poses a barrier to realising MMC economies of scale in Ireland (IBEC, 2021). Reddy (2020) finds that the small-scale nature of many Irish construction projects and the consequent bespoke design renders MMC unsuitable or unviable. This is listed as the most important out of 22 barriers (ibid.)

Attitudes are often cited as an impediment to MMC both in Ireland and internationally (Payne and Serin, 2023). Despite the fact that all residences must conform to Irish building standards, the image of poorly built 'prefabs' appears to still linger in the public's mind (RIAI, 2022). A survey carried out in 2020 finds that the perception of offsite construction having limited durability and lifecycle to be around or slightly above the middle in a list of 22 barriers. Clients' perceptions that MMC offers monotonous design also ranked around middle whereas an inflexibility to adapt to new technologies is assigned greater importance (Reddy, 2020). Clients may be unwilling to take a risk on what they perceive to be a nascent technology (RIAI, 2022). The relative novelty of aspects of MMC has yet to gain full acceptance by stakeholders.

Finally, MMC requires a different set of skills from the construction industry and workforce at large. One study puts a lack of skills and knowledge as the main barrier to greater use of MMC in Ireland (GoI, 2022a). Offsite construction requires higher levels of skill in the installation workforce than traditional construction. Attitudes are once again important as there appears to be a bias toward traditional and masonry construction in terms of third-level training. Skills required in the construction sector for upscaling MMC, but which are not sufficiently in place, include understanding MMC as an integrated process, collaboration, quality assurance and control, knowledge of construction materials, and planning and scheduling skills. (ibid.). Increased investment in skills and changing the emphasis in current educational and training settings will be required in the coming years if we are to see a shift towards further use of MMC.

Interviews

Cost and pace of delivery

Most contractors we interviewed were of the view that MMC tends to be more expensive. Well-established forms of offsite construction such as timber frame housing and precast concrete were competitive with traditional construction, though still a little bit more expensive. 2-D panels and 2-D panels with light gauge steel also tend to be more expensive. Interviewees did not rank which forms were more expensive as it would depend on the overall design with the exception that with fully modular units the cost differential between MMC and traditional is greatest.

The rise in costs in recent years encouraged developers to revert to traditional construction to save money. MMC may still make sense if time or quality is of the essence in a project. Time could be a factor when building a school or student accommodation, which may need to be completed before the term begins. Similarly a hotel or nursing home, where the sooner rooms are rented out the more money is made; or when a company has agreed to vacate a building on a certain date. These units are also highly standardised which reduces costs.

Speed of delivery, while enabling rooms to be rented out more quickly, does not necessarily entail overall cost savings in dense, build-to-let residential developments. In the case of precast concrete used for constructing apartments, the logistical costs associated with moving concrete panels, particularly with a crane, can be considerable. Precast concrete may be selected based on speed of construction for other reasons. For instance, if a developer has work lined up after completion of the current project, or if market demand in an area is unstable and there is a desire to complete a development before conditions change. Precast concrete is less economical for housing developments due to the costs of moving concrete panels around a site as opposed to stacking them on top of one another in the case of apartments.[5]

Standardisation

Standardisation also makes apartments more amenable to MMC than housing, in both precast concrete and light gauge steel. With light gauge steel, installation of electrical, mechanical, and other services tends to be bespoke in a given development or is at least perceived to be given the relative immaturity of the technology. This leads to significant cost savings when work is repeated which is more likely to arise in apartment developments.

With housing, the most common form of MMC is timber frame housing. Timber frames with a block outer core for weather protection are much more common than timber frames with a brick slip or rendered external cladding. The latter, as will be discussed later, are unproven in terms of durability. One interviewee pushed back on the idea that timber frame building is more expensive. It was argued that the prevalence of timber frames in the construction of housing is evidence of its competitiveness compared to traditional construction. Timber frame housing is more likely to be used in large developments whereas one off housing and smaller developments are more likely to use traditional concrete. Timber frames are less commonly used in apartments, particularly modern, dense developments because of height restrictions. Some interviewees complained that architects are more inclined to put their own stamp on the product to build their brand with housing than with apartment, which again does not lend itself to standardisation and use of MMC.

Labour and skills

Avoiding industrial relations issues also makes MMC attractive, particularly in light of the increase in labour costs over the last number of years. It is difficult and expensive to acquire tradespeople, and work within the factory has been significantly deskilled. The actual assembling of modules

5 ICF, on the other hand, is suitable for housing. It uses lightweight polystyrene blocks which lock together and which are then filled with cement. Being a non-structural component of a building, it is typically not used in apartments. ICF offers the convenience of speed with greater flexibility compared to precast concrete. Using concrete and polystyrene, its embodied carbon is high, though its insulation qualities are excellent. Used in Ireland since the 1970s, it remains a niche product (Stanway, 2017).

is not particularly challenging. On the factory floor, there could be teams of four, perhaps led by a tradesperson such as a carpenter, though many of the team members may have been former tradespeople. These are the same people who then assemble the units onsite. Skilled workers such as plumbers and electricians are needed onsite to provide services to the building. Manufacturers may employ some in the factory to ensure the products do not leak or there are no electrical faults. A particular issue for the timber sector is that third level courses focus on concrete/masonry and provide little to no training in timber construction, despite its current prevalence and future potential.

Economics of MMC

As to why MMC tends to be more expensive, the small number of MMC suppliers also elevates cost. Related to that is the fact that the volume of construction done using MMC tends to be small in Ireland. Aside from labour, factories have high fixed costs from investment in machinery and facilities.

Certainty of demand was repeatedly spoken about as essential for the industry to grow. This needs to come from the public sector as it is only the public sector that can provide such a guarantee. Certainty of demand enables productivity improvements through learning by doing via repetition. As is, this is not facilitated by the large number of different types of public housing designs that are, in any event, not calibrated to the needs of MMC.

Demand certainty also enables manufacturers to invest resources in machinery and people that yield efficiencies. The difference between static and linear manufacturing was referenced. With static manufacturing, teams move from station to station to work on different parts of a module. Linear manufacturing is more akin to an automotive assembly line and provides greater scope for efficiency improvements. In this case, the teams remain in place and it is the module that is moved via rails or trolleys (Lawson et al., 2014: 225: 236). One interviewee gave a very clear insight into the importance of demand certainty who we quote at length:

'once we got awarded the Ukrainian project, during the design phase, we finished the factory filled it full of equipment. Our manpower here at the factory has gone from 25 people up to 110. Okay, and we have two factories running producing between six and eight houses per week. So that's what a pipeline can do… So the first houses we built here, the two-bed ones, the first ones took probably 60 days. Okay, we've got down to 40 days, we're now down to less than 20 days'

In relation to manufacturing capacity he explained:

'without having a clear pipeline of work in front of us, it's difficult to convince the owners of the company or the investors to put money to a business that can be sporadic. So like at the minute, we're all in on residential. This time last year, we were all in on pharma. This time next year, it's looking like we'll be back to bathroom pods and not doing any residential so we have to stay agile as a business in order to be able to shift from a pharma project to a residential back to bathroom pods, etc. So we can't set up rails or production line in our factory stuck to a particular module size. Because if we do, [in] six months time our order book changes, we have to reconfigure a factory. So [at] the minute we move the man rather than moving the material, rather than moving the product, you know, we don't have rails or the product moves down to the factory, we move all the men' (Interview 7).

Similar comments were made by a timber frame manufacturer when a large, repetitive development was compared to a one-off housing development:

'take a general good design we've gone through with Glenveagh, you're looking at a square footage of about 26 to 27 euros per square foot ..if I was to put a one-off into the factory, 35, 36 euros a square foot ..even at 36 euros a square foot, it wasn't enough' (Interview 22).

The same interviewee said that timber frame housing is over half of the overall housing market in Ireland, but only 3% of one-off housing. A number of reasons were put forward as to why such efficiency savings exist when building timber frame housing at scale. With one-off housing, walls may need to be made off the main manufacturing line. The roof and floor may be different in a one-off, whereas with mass production the manufacturer will be much more familiar with the output. Another interview emphasised not savings through repetition, but savings through lower per unit design costs. He emphasised that unlike in modular construction, linear manufacturing is already the norm in timber frame housing, so repetition is not where the savings come from.

Stability of demand has not always been forthcoming from the state. One manufacturer spoke of a case in which a government department had sought major changes in an agreement for a contract for a number of units post tender. This created major problems for the manufacturer as 'we ended up with an empty floor for eight weeks, because we had so many units placed in orders' (Interview 5). As we discuss later, interviewees also complained that there are too many different design types in local authorities which, aside from inhibiting standardisation, also prevent cost savings from bulk purchases of inputs.

Attitudes to MMC

Attitudes were said to be an important barrier to greater use of MMC in Ireland. During the interviews, it was pointed out that unless a house is made from concrete, it may not be considered a proper home. There was therefore a consumer bias against modular homes in particular. Another interviewee with experience in the precast concrete space noted that clients, especially older clients, were less inclined to go for an offsite solution. They may be less educated on various forms of MMC, or they may not want to cede control as with MMC subsequent changes to design become more expensive:

'he can't come along and change and say I actually think we'll change the location of the socket in the 'C-type' house in the sitting room because the sockets and conduit are already cast into the wall.. that took that freedom away from him so he was reluctant to do that' (Interview 14).

Other developers may be cautious about using MMC, particularly modular, because they are reluctant to be the first to take the risk on a relatively unknown product.

3 Finance and insurance

3 Finance and insurance

Context

Upfront investment

Construction development entails significant risks. As each development is unique, so are the risks associated with any given project. The sector is highly cyclical and prone to insolvencies, projects are subject to delays, and the work is hazardous. The final product may not satisfy expectations or plans so disputes can arise. A means of managing these risks is therefore important, and this management takes on a new character with technological developments and different construction methods.

The cash flow or payments that accrue to contractors from the client are invariably scheduled based on completed works. This could be in the form of monthly payments based on whatever work is completed by the contractor within that month. Alternatively, payment could be tied to completed stages of the project, such as 25% of the total payment being due once the foundation is complete. It is illegal for main contractors to withhold payment to subcontractors on the basis of main contractors not having received their payment from the client, though late payments appear to be common in practice (Moore, 2023). Clients may be protected by the failure of a contractor to discharge its duty, such as through an insolvency, by performance and surety bonds.[6]

The financing model for MMC is different from traditional construction. Offsite manufacturers require large initial investments in plant and machinery. Returns accrue over the long-run so a stable flow of business is required to be able to finance those investments. The costs of running a factory can be 30% of the total value of a completed building (Lawson, 2011: 237). A downturn can push manufacturers into insolvency which has, indeed, happened to a number of UK modular manufacturers recently (Gerard, 2023). Traditional contractors, in contrast, are more likely to rent machinery on a project-by-project basis so do not have the same financial obligations as offsite firms.

As a large share of construction is carried out in a factory, a larger share of inputs must be assembled at an early stage compared to traditional construction. Factory personnel, materials, and overhead costs can comprise between 50 to 60% of the total value of a building built with MMC. Factory running costs and materials are similar whereas personnel costs are somewhat lower (ibid.). The upshot is that MMC manufacturers require a significant amount of funding upfront.

Insurance

Construction entails many potential liabilities which, in turn, require a functioning insurance market to protect against risks. There are many different insurable risks in conventional construction including liability for public and employee accidents, contractors' all risk covering liability against damage to plant and machinery, and more (see Clough et al., 2015). Professional indemnity insurance (PII) protects against issues arising from design flaws which the design team may be liable for. A recent

6 Under this scenario the client (surety bond) or contractor (performance bond) pays a premium to a financial institution to acquire a bond. In the event of 'default' whereby the contractor fails to fulfill its obligation, the financial institution makes good to the client through either financial compensation or by arranging for another contractor to complete the work.

report estimates that between 50 to 80% of apartments and duplexes built in Ireland between 1991 and 2013 suffer from defects. Fire defects are the most common followed by water ingress and structural defects (GoI, 2022b). Design issues are responsible for around a quarter of defects in Ireland (RIAI, 2022: 29). PII has become considerably more difficult and expensive to obtain over the last number of years due to the Grenfell fire and other events (OGP, 2022).

The relative newness and specifics of MMC pose difficulties for insurers. As we detail in the section on procurement, a greater amount of the design risk is delegated by the client to contractors. Compared to traditional procurement, there is greater need for cover against design liability (Lynch, 2017). Moreover, there is a lack of data and understanding regarding the reparability, maintenance, and modification of MMC products. As insurers rely on past data to calculate their exposure when underwriting, this cannot be done in an MMC context, at least not as accurately. This leads them to either increase the price or restrict the supply of insurance (Howden, 2022).

The problem is most acute for PII. Issues for insurers include the potential for repetitive failure given that many units are the same, repairing defective volumetric units may not be possible but may instead require rebuilding from scratch, and failures to abide by European Standards given many of the products may be new. Compared to traditional construction, the products and processes are less tried and tested. Insofar as underwriters are willing to provide cover, UK insurance costs are expected to be double to triple the rate compared to traditional construction (ibid.).

Interviews

Lending restrictions

Consumer access to mortgages was said to be a major barrier to volumetric building. Essentially, the major banks are unwilling to provide mortgages for volumetric or modular homes. Banks, apparently, would make a number of demands of modular manufacturers but still not agree to provide mortgages. One manufacturer recalled engaging with banks to allay their concerns about providing mortgage finance. He recalled that first they demanded a certificate of completion, the certificate from the local authority building control that says that building regulations have been abided by. After the completion certificates were furnished, banks then demanded the modular home be fixed to the foundation. After fixing the home to the ground, they then required a 60-year guarantees, which were then provided. Despite meeting all demands, banks were still unwilling to provide mortgage finance. It seems that banks were unsure about quality and modular units do not have a proven track record of longevity. They were also concerned that modular units can be moved, at least in principle. As a result, modular manufacturers residential work is highly reliant on non-market or social housing for demand. Interestingly, credit unions were often willing to provide mortgage finance.

The issue of durability was also an issue for timber frame houses with a brick slip or render finish. It was observed that even if a guarantee is given, whether it is for modular, timber frame, or other MMC products, one can only prove durability by showing its survival and quality over the timeframe in which it is claimed to last.

On the development finance side, banks have again been reluctant to lend. In traditional construction, investment funds and/or banks will provide finance for site acquisition. Once a site is acquired,

banks and investment funds then provide funding for construction. In the case of apartments an institutional investor will likely have agreed to purchase units prior to completion. In the case of housing developments, banks may provide each tranche of finance after each group of houses is completed, or the developer will finance the construction of the subsequent groups of housing after selling the first. Banks may release funds in stages, such as 25% after the first stage is completed. In the case of MMC and modular in particular, the client may need 60% of funding upfront to pay the manufacturer. This is because a large part of the building is done in the factory and it is, moreover, done much more quickly compared to traditional building. This is less of an issue for other MMC methods given less of the construction costs are borne offsite. In relation to modular:

'It's a huge initial cost. So basically you're looking at about 60% upfront. So the banks aren't used to giving out that much money initially. They like to stage 20 to 30%, another 20 to 30%, they'd be staged in drawdowns.. They aren't used to having a development done in a year ..it's usually okay with the first 20 houses you'd only get a payment, the next 20 houses.. [with modular building] you can get 20 houses done in a month. So it's definitely what they [the banks] don't understand quite yet how does it work that quickly' (Interview 2).

This is not to say banks do not lend. Another manufacturer said that developers can get finance upfront, and it is reflected in a higher cost of finance. However, for him, working with companies on industrial units is more straightforward from a funding perspective than private residential. An upfront payment of 40% of total was not necessarily a problem as he had worked with industrial clients on a number of occasions in the past so there was a level of trust. Banks were not an issue as many of the large companies had their own funds. Public sector contracts were more challenging as there was less flexibility. They are less willing to provide advance payments though it appears to be changing. Approved Housing Bodies (AHBs) were generally found to be more flexible in this regard.

Another manufacturer said that large upfront payments are rare, which seems plausible. An alternative mechanism to manage risk is through an advance payment bond, which is very similar to a performance bond. Here the client provides a certain amount of funding upfront to the manufacturer and the manufacturer agrees to pay a bank or financial institution a premium. In the event of a default by the contractor, the bank makes good to the client (Kearney and McAdam, 2022). The market for both performance and advance payment bonds is, however, thin in Ireland and has grown thinner in recent years.

Accelerated payment terms are another alternative and appear to be the most common risk management tool. Here the manufacturer may get paid every two weeks which will enable it to pay its suppliers who may be paid monthly. Generally, inspections will be made of the factory to ensure work is ongoing to ensure it is progressing as agreed. The manufacturer then makes a payment application by issuing a vesting certificate whereby the client becomes the owner of the materials. The manufacturer can then be paid on a regular basis by, for instance, the main contractor (depending on the type of contract).

We did not source interviewees working within the financial sector. One interviewee argued based on anecdotal knowledge that end funders of apartments such as institutional investors are disinclined to fund MMC projects. They are interested in a stable, long-term return and because MMC is a

relative unknown quantity, they will tend to favour financing traditional construction (Interview 11). Another interviewee observed that, in his experience, funds are less risk-averse than banks and so are more willing to fund the construction side of an MMC project (Interview 15).

Insurance

It was confirmed that insurance costs are very high for manufacturers. One interviewee complained that if he were a traditional builder his insurance costs would be one third of what they are for him as a modular manufacturer. Goods need to be insured against damage in the factory, and separate insurance is needed for modules in transport. In traditional construction if a block is broken the implications are small, but if a module or assembly is broken it can have very large cost implications. There was a lack of awareness, it was noted, among Irish insurers of the risks associated with MMC. One modular manufacturer observed that premia are charged based on a percentage of turnover, so that if the business grows their cost does so too whether or not the risk has grown as well. Homeowner insurance is also higher with MMC compared to traditional construction.

PII was found to be a major challenge. This was not necessarily a problem for manufacturers but rather for the design consultants they hire. It was confirmed that the cost of PII has increased rapidly over the last number of years. Availability was less of an issue, at least for large contractors. As with other types of construction insurance, there is a nervousness on the part of insurers to provide PII for MMC given the lack of knowledge of MMC. Particularly post-Grenfell and with problems with defects in Ireland, insurers have been requiring more and more information from designers about the buildings they have designed in terms of materials used and their heights and dimensions. More specific to MMC is insurers' growing interest in cladding, the outer, non-load bearing shell that serves numerous functions such as weather protection. It is used in most MMC projects, unlike traditional construction projects (Interview 1).

Another issue with the insurance market is that because most of the MMC products are new, they are not necessarily compliant with the building regulations. Effectively, certification is required for the product to be sold. One interviewee noted that in the UK there are specialist insurers who go into factories and are willing to provide cover. This enables firms to get up and running much more quickly:

'(certification) takes 18 months, you know? And then what are you going to do with the factory in that 18 months… you have to produce the product to get the certification, but you can't sell it until you get certification, which is at least 18 months, you know, whereas in the UK, you can get up and running in three and three months.' (Interview 6).

The issue of PII is related to the general problem of finance. Funders of a project, such as an investment fund or bank involved in financing development or an institutional investor involved in final purchase (in the case of apartments), may require a high level of PII, which may not be available. This may prevent them from funding a project.

4 Regulatory factors

4 Regulatory factors

Context

Regulatory factors have been repeatedly raised as posing a barrier to greater use of MMC in Ireland. This point has been made frequently by industry and consultancy studies, which have been echoed in a recently published government roadmap on MMC reform (DETE and DHLGH, 2023a). The point was also made in our workshop.

The Building Regulations set out the legal requirements for the construction of new units and works on existing ones. Eleven in all, they aim to ensure the wellbeing and safety of occupants. They are written 'in terms of functional requirements' in that they do not specify materials and processes that can or cannot be used (DETE and DHGLG, 2023: 23). Each regulation is accompanied by a set of Technical Guidance Documents (TGDs). These provide more proscriptive and detailed guidance to ensure compliance with the Building Regulations. When work is carried out in compliance with the TGDs, the work is considered prima facie compliant with the Building Regulations (ibid.).

Fire safety and materials

Part B of the regulations relates to fire safety. The accompanying TGD on implementation restricts the use of combustible materials in residential buildings greater than 10m in height, which effectively limits timber buildings to a maximum of four storeys (IBEC, 2021). Ireland is not unusual by international standards in limiting the height of timber buildings in buildings without sprinklers. It is for buildings with sprinklers where the limits become relatively strict. Among a sample of mostly European and developed countries, eight countries have similar or greater restrictiveness than Ireland, but 27 countries have regimes less restrictive. Its fire resistance requirement of 60 minutes for 3-4 storey buildings is the modal or most common time internationally, which is also around the average (Östman, 2021).[7]

A number of architects and commentators have cautioned that fire safety standards have deteriorated in Ireland in recent years. The removal of a requirement for a balcony, longer corridors, allowing unescapable windows, higher buildings, open plan kitchens, and other changes have been criticised on fire safety grounds (Hegarty, 2020; 2023; Clifford, 2020). Nevertheless, by effectively limiting timber buildings to four storeys, the form of MMC that offers the greatest environmental benefits is restricted. This, it is argued, impedes the growth of the sector (IBEC, 2021).

TGD relating to Part D of the building regulations concerns the appropriate use of materials. As will be discussed in the interview section, the procedures through which materials are deemed compliant have important implications for the viability of MMC. The TGD states that all works shall be carried out using 'proper materials' fit for their intended use. It includes materials which: a.) bear a Conformité Européenne (CE) marking in accordance with the provision of the Construction Product Regulation; b.) comply with an appropriate harmonised standard or European Technical Assessment per the Construction Products Regulation; or c.) comply with an appropriate Irish Standard or Irish

7 Some countries provide ranges but by taking midpoints we calculate the average to be 52 minutes. Fire resistance is the ability of a construction element to withstand fire in one or more ways such as resistance to collapse, resistance to fire penetration, and resistance to the transfer of excessive heat (DCC, 2023).

Agrément Certificate or with an alternative national technical specification of any State which is a contracting party to the Agreement on the European Economic Area (ECLG, 2013).

The CE marking indicates the manufacturer's declaration that the good conforms with relevant EU legislation on health, safety, and environmental standards. It is obligatory for most construction products and for all products covered under harmonised EU standards. When a product does not fall within the scope of a harmonised standard, it can obtain the right to sell the product in a member state with additional testing (European Commission, 2014). In that case, the 'non-harmonised' product needs to be assessed through a relevant European Technical Assessment (ETA).

All such products, whether harmonised or unharmonised, are automatically Irish standards. A product may also be compliant if it is covered by a relevant national standard, which can be found by referring to the TGDs of the building codes. Another route to national compliance is Agrément certification. Agrément certificates are designed for new building materials for which published national or European standards do not exist, which may include new materials and products used in offsite construction. In this case, the National Standards Authority of Ireland (NSAI) carries out the assessment and issues an NSAI Agrément certificate for eligible products or materials (NSAI, 2023).[8] As the interviews discuss, obtaining Agrement certification is a major issue and stumbling block to greater use of MMC.

In other words, anything that has a CE certificate or has been assessed through an ETA is deemed compliant with Irish building regulations. Similarly, a product covered by an Irish national standard, has an Irish Agrément certificate, or is compliant as a product that has been certified in any member state is deemed compliant in an Irish context. Builders and designers are required by law to make sure products are compliant, though the greatest burden is placed on the manufacturer. The interviews and further investigations revealed that there are additional nuances.

Building regulations

The 31 local Building Control Authorities (BCAs) have responsibility for ensuring that the building regulations are upheld and have the power to carry out inspections. When a building is being constructed, the owner assigns persons to ensure that works are being carried out in accordance with the building regulations. The assigned certifier acts as a single point of contact with the BCA and is responsible for lodging documentation, inspection plans, and statutory certificates (NBCO, 2020). Examples of documentation include fire safety and disability access certificates. The design certifier is responsible for ensuring the design of the building is in accordance with building regulations and may be the same person as the assigned certifier (SCSI and RICS, 2020). Previously, building regulations were presumed to be upheld by self-assessment involving builders and professionals. Due to a number of issues and scandals regarding construction quality and defects, the two roles – the assigned and design certifier – were introduced in 2014. The use of new methods of MMC is likely to require education and upskilling within BCAs and by the designated persons onsite (DETE and DHGLG, 2023).

8 The assessment may include lab testing, onsite testing, or inspection of a manufacturing process. EU CE marked product contains information about the performance of the product. Compared to traditional national Irish standards, European standards and assessments provide harmonised testing methods as opposed to prescriptive minimum performance and threshold levels. The NSAI has therefore produced additional 'guidance' on appropriate minimum performance standards for some products that are in compliance with European standards, both harmonised and non-harminised (ECLG, 2013: 6).

The regulatory landscape has evolved over a number of years, though not necessarily in response to emerging technological developments.

Interviews

There was wide agreement that the building regulations impede the growth of offsite construction. They also inhibit MMC being used to construct dense or high buildings. It was reiterated that the building regulations limit the height of timber buildings to three to four storeys. The TGDs state that no compartment wall (such as between two apartments) or no compartment floor can be built with combustible materials if the building is greater than 10m in height. The regulations also prevent timber frame buildings from being constructed on top of traditionally-built or concrete-based buildings. As a result, timber-frame buildings which offer the greatest advantages from a sustainability perspective, and perhaps the greatest prospect for growth as an MMC technique, is severely curtailed. Most interviewees that discussed the topic felt the idea that timber is unsafe is woefully antiquated.

Height restrictions and fire safety

One engineer was less persuaded that removing building height restrictions would be a game changer. As one builds higher, a larger and larger amount of timber needs to be used in the structure to prevent its disproportionate collapse under conditions of it being damaged. This made it uneconomical to go beyond six storeys. Removing the restrictions will only create more four-to-six-storey buildings. As to how other jurisdictions such as the UK have tall timber frame building, it was observed that regulations had subsequently been changed that would make this more difficult. It was pointed out that changes in the building code take a long time. Ireland will rarely deviate beyond what is permissible in the UK, so major changes are unlikely. A different engineer mostly disagreed. He argued that depending on the type of timber used this need not be the case and that the financial returns from building higher outweigh the cost of additional reinforcements.

Some Interviewees provided international comparisons that other countries such as the Nordic countries use timber-based buildings seemingly without issues. Timber can be more fire resistant by treating it chemically and by making frame members more substantive or chunkier. Allen and Iano (2019) observe that building codes recognise heavy timber framing and steel to be roughly equivalent in fire safety terms. Testing done in an Irish context revealed cross-laminated timber to be fire-safe (Yasir et al., 2023). It was argued in the focus group that manufacturing in a factory setting provides greater scope for high-quality, high-spec, and default-free products.

None of the interviews were able to provide international comparative evidence on Ireland's fire safety record – whether its relatively restrictive practices were accompanied by a strong safety record. A recent international comparison involving mostly developed and European countries provides mixed but, on balance, positive evidence. The study notes that international comparisons are difficult due to non-standardised data collection and measurement, and metrics such as per capita fire-related deaths and injuries are driven by a variety of factors outside the scope of buildings codes, with alcohol consumption being a major risk factor. Out of 32 countries, Ireland had the highest number of fires but the third lowest number of deaths for the latest year of data (Manes et al., 2023). The likelihood of a fatality given a fire is exceptionally low, though the likelihood of a fire is very high. Nordic countries were toward the high end in terms of fatalities and around the middle in terms

of number of fires. It is hypothesised that both climate and a high share of wood in buildings are factors (Geneva Association, 2014). It should be noted that the age profile of buildings in the Nordic countries is generally older than in Ireland so the comparison may not be like for like (BPIE, 2011: 36).

Towards the end of the project, these points on Ireland's performance internationally were put to an engineer working in the timber frame space who had considerable experience in fire safety. It was acknowledged that Ireland has and should have high standards given recent problems with quality. However, the emphasis on exceptionally high safety standards was questioned as the rest of the world was moving toward greater use of timber for environmental reasons:

'we have very strict regulations ..we've got two contrasting challenges, one of which is maintaining the same levels of safety we're used to. And we do need to have high standards. But I think in some cases where we impact progress as well, in terms of there's a balance to be drawn between accepting new materials that are widely accepted internationally, and have proven safety records versus being extremely risk averse and not allowing anything that isn't traditional' (Interview 28).

Certification and enforcement

Aside from the regulation on building height, parties such as the assigned certifier may be reluctant to sign off building products and components on fire safety grounds. This is a particular issue with offsite construction as new products and processes come on the market regularly, and is an issue with fire safety in particular:

'every building is unique, as there'll be always something that is unique to that building. And it will all be queried, you know, with either an assigned certifier or fire consultant, has this been tested specifically in this scenario? And invariably, it's no, you know, there are more and more things being tested all the time. But in parallel, there are newer materials coming online all the time.. like on the surface will seem perfectly acceptable. But in the sort of regulatory world that we're getting into hasn't been tested. And nobody is willing to sign off.' (Interview 1)

A wall using MMC components may have been tested and deemed fire resistant. But when additional sockets are added, certifiers may want additional testing despite what is deemed to be only a minor difference.

It was also noted that different local authorities have different standards when it comes to certifying the fire safety of a building. Although nominally the standards are uniform, in practice it depends on the interpretation of the fire safety officer involved in any given authority. Local authority building control officers may reject the assigned certifier's sign off and require additional testing. This makes building more expensive and was said to be a barrier to standardisation.

This raises the broader issue of building regulations. It was argued that with traditional construction using masonry and concrete there are building codes in place that define what the permissible building products and processes are. With MMC, those codes do not exist and so contractors and developers are reluctant to use them:

'if you're building using traditional methods of construction .. there's codes that tell you what to do. So it's very easy for you as a company to follow those codes. And no, you're not going to, you're not going to get sued, essentially, if you get it wrong.. but with panelized and volumetric modular, those codes don't exist.' (Interview 9).

As discussed, products can be certified through the NSAI, though some interviewees complained the process is time-consuming and expensive. There may be an insufficient number of testing facilities, or they may not be sufficiently resourced.

It was pointed out that if European CE marking was obtained or ETA testing was done, the product is, in principle, compliant though there were added nuances. An added nuance is that national annexes exist based on the context in a member state. For instance, Ireland has a different climate to other member states so some additional demands may be made for products to be usable in Ireland. For products that obtained approval through the ETA system in particular, national annexes do not exist. National standards, which refer to TGDs, may not exist either so an Agrément certificate may be necessary. It was emphasised by some that the TGDs should be updated to include MMC-related products.

There was also uncertainty surrounding whether a product needs certification if a certifier is willing to sign off on it. If the certifier signs off on the product, it can be compliant even without certification, however, the building control officer may or may not impose additional requirements. In practice, certifiers may be unwilling to sign off without Agrément or other types of certification as they may be liable to be sued in the event of something going wrong.

One regulator observed that the compliance process in Ireland is, indeed, strict. Echoing some of the above comments in relation fire safety and timber, Ireland's strictness is a consequence of the legacy of defects and the subsequent tightening of standards. Any reduction in standards would, it was argued, come with a reduction in quality. The interviewee further explained that it is not straightforward to speed up the approval process. Just as new medical and pharmaceutical products can take a protracted period before being deemed fit for use, it is similarly the case with construction materials and processes. Had the modular homes for Ukrainian refugees been subject to conventional quality standards, they likely would not have passed.

A related issue was that there is insufficient standardisation. This could come in the form of fewer model plans for social housing, as will be discussed. From a regulatory perspective, there could be greater standardisation of construction details. This could include details on what materials the panels are made of and how they are put together. TGDs could be amended to include products used in MMC and if they conformed to them, they would be automatically certified. This would mean less need for testing and calculations, either onsite or from an assessment authority.

It was pointed out that if building regulations were updated to include materials and products used in MMC, and if the government made a firm commitment to building social housing, then many of the concerns of funders and insurers would be allayed (Interview 7).

5 Procurement

5 Procurement

Context

A number of different procurement strategies are available to parties for the construction of market housing. Under the traditional procurement model, it is the client or developer who completes the design of the building. This does not necessarily mean that the client has permanently employed architects, engineers, and other design professionals at hand to perform the work. Rather, it refers to the fact that the client controls and originates the building design where a design team may be hired for that specific purpose. This process is separate from the construction undertaken by the builder/contractor who is hired by the client after a competitive tendering process. The contractor is responsible for sub-contractors and scheduling the works during the construction period. Traditional procurement is also known as design-bid-build or architect-led procurement.

Under the design and build model, the client employs the contractor who then has responsibility for both designing and constructing the building. The client may have a conceptual design but does not detail its form or how it will be constructed. The design-build organisation may undertake all of the design and building work itself, or it may contract out aspects of or all the design and building work. The important part is that the client has a single point of contact who is responsible for both the design and building. By vesting design and building authority to a single entity, and by overlapping design and construction, projects may be delivered more quickly.

Other types of procurement are possible. In construction management delivery, the client contracts separate entities to undertake design and undertake building as in design and build. Unlike design and build, the client may not deal directly with contractors but with a construction manager who oversees the contractor or contractors. This is known as 'construction management at risk', as the construction manager bears construction risk and responsibility. In a 'construction management at fee' model, the client may deal with the design team and the contractors, again similar to the design and build model. However, a construction manager is also brought in to provide early expertise in the design process and is answerable to the client. The construction manager, in this case, is not responsible for the contractors.

We do not have data on the extent to which different procurement methods are used in Ireland. Greenhalgh and Squires (2011) note that in the UK, the vast majority of post-war private construction used traditional procurement. Design and build was used extensively for replenishing the public housing stock, after which it fell out of favour (ibid.: 133). As construction became more complex, greater need for coordination between the design and build teams arose. In terms of the number of contracts, traditional procurement represented an estimated 90% of construction in 1985 but in 2022 represented 56%. The corresponding figures for design and build are 3.6% in 1985 and 34% in 2022 (RICS, 2010: 8; Greenhalgh and Squires, 2011: 97, 136; RIBA, 2022).[9] These figures include all public and private construction excluding civil and heavy engineering works and so relate to residential and commercial construction (RICS, 2010; RIBA, 2022). Traditional procurement is more appropriate

9 On a value of contracts basis, latest figures go to 2010. Traditional procurement in the UK constituted 69.5% of construction in 1985 and 41.4% in 2010. The corresponding figures for design and build are 8% in 1985 and 39.2% in 2010 (Greenhalgh and Squires, 2011: 43; RICS, 2010: 8). Note that the design and build figures are higher on a value of contracts basis, underlying the fact that design and build is more appropriate for larger, more complicated developments.

for medium and small-scale projects where time is not at a premium. Design and build is more appropriate for high-value, complicated developments.

Once the procurement method is selected, the next step is to agree upon a tendering strategy. Tendering relates to the bidding process whereby a contract is won and the price is then set, and can be considered part of the procurement process. The most common type of tendering in the UK is single-stage tendering, which represents 72% of tenders (RIBA, 2022). An invitation is issued to a number of contractors to submit a bid for a project within a predetermined deadline. This is typically carried out at an advanced stage of the pre-construction process, when all the necessary information to construct the building has been prepared.[10] The bids are then analysed in terms of cost and quality and the winning bidder is then selected. This is commonly associated with the traditional, sequential procurement model (Greenhalgh and Squires, 2011: 94). However, single-stage tendering is also possible with design and build whereby the client invites submissions for both the design and building of a project. In that case, the design process would be less advanced before the tender.

Two-stage tendering has become more common in recent years and represents 37% of tenders in the UK (RIBA, 2022). In one version of two-stage tendering, the number of bidders is filtered or reduced on the basis of completing a pre-qualification questionnaire. These contractors are then invited to submit bids. In another version, contractors may be invited to submit preliminary proposals in the form of outline design and costs prior to, or as the building is being designed in detail. The successful bidder or contractor then works with the design team as a consultant to flesh out the design in detail. There is then a second tender for the construction of the project which will typically though not necessarily be won by the contractor involved in the first stage.[11] This type of tendering is more associated with non-traditional procurement such as design and build though, as above, single-stage tendering is also possible for design and build.

It is worth stating that while the latter process is described as two-stage tendering by RICS, its sister organisation, the Society of Chartered Surveyors Ireland (SCSI), describes the process as Early Contractor Involvement (ECI) (SCSI, 2020).[12] For RICS, ECI is distinct from two-stage tendering. To underline the confusion, ECI is sometimes described as a procurement strategy, as opposed to a form of tendering which, as above, is a component of the tendering process. In the context of MMC following civil engineering guidelines, Finnie et al. (2018) define ECI as a non-traditional construction process whereby a contractor's skills are introduced early into a project. Non-traditional procurement such as design and build or management contracting can be considered as forms of ECI, as can two-stage tendering.[13]

It is generally agreed that conventional procurement methods are ill-fitted for MMC. With traditional construction, an architect may be hired for high-level designs prior to planning permission being

10 Stage 4 (RIBA, 2020).

11 Negotiation with contractors may also be used instead of competitive tendering. This can be used as an alternative to one and two-stage tendering, or as a form of tendering in its own right (RIBA, 2022).

12 According to SCSI, ECI is 'where the client tenders an initial contract during the design stage of the project for a main contractor to provide expertise, principally in respect of buildability, programme and cost. This initial ECI contract is then followed by the main contract to construct the Works' (SCSI, 2020: 8).

13 'The term 'ECI' may be used as a concept to describe any procurement strategy that involves the contractor during the design phase, such as design and build (DB), management contracting (MC) or construction management (CM) …. This may be contrasted with the traditional single-stage tender model, where contractors are invited to bid after designs are fully developed.' (Finnie et al., 2018: 176).

secured. Once planning permission is granted, a design team is assembled to create more detailed designs, after which construction proceeds. In the case of traditional procurement, the design and building processes are strictly sequential, whereas in the case of design and build procurement, some overlap of design and build is facilitated. With MMC, a manufacturing method may not necessarily fit with a given design (Peck, 2021). So-called ECI forms of procurement whereby the manufacturer is consulted prior to, or during design are appropriate for MMC (Finnie et al., 2018).

Interviews

There was general agreement that procurement methods need to change to facilitate greater use of MMC in Ireland. In particular, it was recognised that greater ECI was needed, as was a move away from traditional procurement and towards design and build procurement. It was recognised that private sector procurement was more flexible and better equipped to use offsite solutions than the public sector, although there was a diversity of viewpoints on precisely how well-adapted procurement in the private sector is to MMC. It was pointed out that some of the largest housebuilders are developing manufacturing facilities themselves.

Some interviewees, working mostly but not exclusively in the architectural space, referred to the fact that there was an overemphasis on obtaining the lowest cost in construction procurement in Ireland. This is less suited to MMC as manufacturers need to work in partnership with clients at an early stage. At the same time, it was recognised that the small number of manufacturers can lead to an absence of competitive pressures, as discussed. So, while greater partnership is needed, so is a greater number of manufacturers to provide competitive tension (Interviewee, 15).

The procurement process for precast concrete is quite well-established, though some older clients may be more reluctant to use an offsite solution. In the case of traditional procurement, once planning permission is granted based on high-level drawings,[14] the client's design team then puts together more detailed, tender drawings that describe the building in detail, including its conformity with various building codes. These drawings are provided to bidders (contractors) and form the basis on which submissions are priced by contractors when the project is put out to tender. Before they submit the bid, the contractor may consult with a manufacturer regarding an offsite solution. The contractor will then submit a costed proposal and present both an offsite and conventional build option to the client. If the bid is successful, the contractor may then try to convince the client or the design team to go with an offsite method. In a minority of cases, the tender drawings will specify an offsite method should be used, so the issue of trying to convince the client does not arise.

In design and build procurement, the process is similar from the manufacturer's point of view. The manufacturer is again consulted by the contractor prior to the contractor making a submission. The difference is that it is the contractor who is the one detailing the design. The manufacturer may provide a rougher estimate of using an offsite solution in this case – in traditional procurement, the contractor is in possession of detailed tender drawings provided by the client prior to submitting a bid.

With traditional construction, industrial relations issues can arise. One is simply the cost of supervising block layers. Another issue is that as block layers are technically self-employed, they can be poached

14 The planning drawings specify the dimensions and external finish of the building.

by other contractors who offer higher wages during a project. With design and build, the contractor has control over the construction method and can decide to use an offsite method. In the case of traditional procurement, the contractor may not be successful in convincing the client to use offsite. Design and build therefore facilitates offsite methods compared to traditional procurement.

However, when moving towards more modern offsite methods, from light gauge steel to full modular, procurement processes are less well-established. Not all clients may be educated on how buildable a design is using, say, modular. A number of complications can arise if design is completed without an appreciation of the manufacturing processes involved. For instance, if the design requires modules that are too big or a certain shape, transportation can be a problem. Installation of services, such as electric cables, has a greater need to be localised in modules, whereas in traditional build they can be spread out. Such considerations require consultation with a manufacturer at an early stage:

'you can't modularise most traditional designs, but you can traditionalise most modular designs.. people go away and design something, then they want to do it modular and it ends up costing multiples more than what it should because it's too wide, it's too tall, they're not the right proportions, it's inefficient... there are very specific parameters around which modular needs to be designed to facilitate transport and lifting' (Interview, 6).

This is also true of high-level design, not just detailed design. One reason is that the floor-to-floor depth is greater in modular than in traditional, which needs to be incorporated into the design at an early stage. Indeed, it may be necessary to consult with a manufacturer pre-planning:

'(ideally) we're involved at a very early stage pre-planning, to work with the client to establish a basis of design, because the design is slightly different in terms of the wall thicknesses and the floor plate thicknesses, so often we'll get a client coming to us with a design that's already complete. And it's done in a traditional manner. And they say, can you make this modular? And 99% of the time, it's no, you can't because you'll go outside of your planning heights' (Interview 7).

Modular construction could be facilitated by a two-stage tendering process. Two-stage in the sense that a manufacturer is brought into the fray to assist with high-level design prior to applying for planning permission. The contract is then put out to tender, which may well be, but not necessarily will be won by the same manufacturer. The MMC market in Ireland is still immature so such early consultation is not the norm.

Most interviewees were of the view that design and build is a more appropriate form of procurement than traditional procurement. In some cases manufacturers were contracted directly by the client, in other cases they may work under a main contractor. Traditional procurement model is also possible where the client is already in possession of a detailed design before going out to tender. In that case, the client would need to be knowledgeable of manufacturing. This may happen if the client and the manufacturer had worked with each other in the past so that the process could be considered a partnership. Or it could arise in a two-stage procurement process.

Not all of the interviewees were sold on design and build being the best way to procure things compared to the importance of ECI. Some interviewees raised the possibility that the main contractor may try to extract value or negotiate too much with the manufacturer, which may ultimately result in quality problems. This could be overcome if the client nominated the subcontractor, that is the

manufacturer. When the contract is being put out to tender the client will inform the main contractor of the offsite supplier or manufacturer to be used.

Some felt that what is called design and build merely transfers risk to the contractor and does not really transfer control of design to the contractor. It was said that how design and build works in practice is that the client gets a design team to do high-level design. Once they get planning permission, they also do detailed design. Then they put the contract out to tender. After the tender is won by a contractor, the design team is novated or transferred to the contractor. The main difference between this and traditional procurement is that the design risk rests with the contractor, not the client. The contractor under the reality of design and build does have more influence to refine the design than under traditional procurement.[15] But it is not truly design and build:

'but that's not really proper design and build because the building essentially already has been designed. You're saying to the contractor, okay, here you go. Here's the design. We want you to build for us. But you take the design team, but you take all the risks that goes with that design.'[16]

The issue, then, is not whether it is design and build versus traditional procurement, but to what extent the procurement and tendering process uses ECI. Design and build as it is actually practiced can facilitate MMC if the client's design team has consulted manufacturers. However, it was argued this is not the optimal way to do things. Textbook design and build is better suited as by delegating not only risk but also real design responsibility, contractors can utilise their experience and expertise in terms of buildability and reducing costs.

15 It was pointed out that structural engineers may over-engineer the building foundations and superstructure. The contractor will use its expertise to refine the design and may also tweak the mechanical and electrical systems. The overall look and feel of the building is usually not changed by the contractor.

16 The system arose as some clients had poor experiences with 'true' design and build – when design responsibility was properly delegated to the contractor. Clients' expectations were not met partly due to poor tendering practices such as a limited design brief or inadequate planning drawings. Ultimately, the changes demanded by clients resulted in them incurring higher costs. A design and build model in which limited design responsibility is allocated to the contractor – sometimes called design and dump – emerged.

6 Planning

6 Planning

Context[17]

Given the involvement of the state in the regulation of land use, there is more known about the Irish planning system than there is procurement. The Irish planning system follows a hierarchical structure of plans. At the highest level, are national plans such as the National Planning Framework (NPF). Regional plans facilitate national plans and under the NPF, Ireland currently has three regions: the Eastern and Midland Region, the Southern Region, and the Northern and Western Region. Then come city and county development plans, which are informed by national and regional plans. Development plans are crafted by local authorities and set out, in detail, land use objectives for a six-year period. Importantly, they include maps showing various zoning designations within the county or city over the period. This includes land zoned for residential purposes, land designated for neighbourhood centres, and many more. Finally, the local area plan sets out in greater detail planning policies in an area where significant development and change is anticipated. A local area plan is required for any designated town or an area with a population in excess of 5000.

Aside from marginal modifications to existing buildings, development projects generally require planning permission to be granted by the relevant local authority. The proposed development must first be advertised, and a sign erected at the site, after which the application is made. Once an application is submitted, the local authority assesses it, checking its consistency with the guidelines outlined in the development or local plan. Planning decisions may be appealed to An Bord Pleanála by both developers and members of the public. An exception is where the government deems an area to be of strategic importance and designates it a Strategic Development Zone (SDZ). In that case, no appeal to An Bord Pleanála is available.[18]

A similar direct application process to An Bord Pleanála was introduced for Strategic Housing Developments (SHDs), which were also permitted to overrule aspects of local development plans, such as height and density restrictions. Due to the high number of challenges with judicial reviews in the court system this system was abandoned and replaced. Under Large-scale Residential Developments schemes a two-stage process involving first application to the local authority and then a potential appeal to An Bord Pleanála was re-introduced. It retains critical aspects of SHDs such as decision timelines for planning authorities. Further reforms to the planning system are currently underway with the Draft Planning and Development Bill 2023 which, among other things, narrows the number of parties that can challenge decisions made by An Bord Pleanála in the court system through judicial reviews.

In an international context, Ireland's approach to planning has been characterised as belonging to the 'land use management' tradition (European Commission, 1997). Like the UK, regulation has been concerned with ensuring that development and growth are sustainable, and local authorities have undertaken much, if not most of the planning work. Plans do not precisely determine what gets built and there is a high degree of administrative discretion once planning applications are made. The

17 Part of this context is taken from Sweeney (2022).

18 Appeals may be lodged to An Bord Pleanála at the draft or public consultation phase, but once an area has been designated an SDZ, appeals cannot be lodged once planning permission is granted. The legality of a planning process can, however, be challenged through a judicial review.

major distinction between Ireland and the UK is that the UK does not have a zoning system and any citizen in Ireland can appeal planning permission granted by a local authority.

The UK and Irish approaches can be distinguished from European models wherein there is less discretion for decision making by the planning authority though, like Ireland, most have zoning systems. In France and Portugal there is a strong emphasis on the reduction of regional disparities whereas Mediterranean countries attach importance to urban design. Ireland is, however, moving closer to the 'comprehensive integrated' approach of Denmark, the Netherlands, Germany, and Austria. In such systems, there is less administrative discretion as zoning plans determine what does and does not get built to a much greater extent than in Ireland and the UK. The Netherlands has a strong tradition in detailed masterplans where, as in Germany, planning decisions are frontloaded into the initial plan. The discretionary nature of the Irish and UK systems, it is argued, makes the planning system much more difficult to navigate for development purposes (Breach, 2020; Bridgett, 2023). A benefit of discretionary systems is that it allows professional planners to use their judgement, including in situations where those making the planning rules would not have foreseen – it is more flexible (Bäing and Webb, 2020).

The Irish planning system is indeed comparatively democratic, but also cumbersome. The input of a wide variety of stakeholders such as environmental groups is particularly important in the context of ongoing biodiversity loss and climate breakdown. At the same time, the Irish planning system is highly adversarial, which elevates the risk of construction for developers. From 2012 to 2021 between 23% and 37.2% of residential planning applications were refused in the Greater Dublin Area, excluding Strategic Housing Developments (SHDs) (Reidy and Breen, 2022). Around one in five SHDs were subject to judicial review, and the majority of planning permissions were subsequently quashed (Parkins, 2022).[19]

In terms of offsite construction, MMC puts different demands on the planning system compared to conventional construction. Potentially the main rationale for using an offsite solution is speed of construction. Delays in construction due to the planning system may obviate that rationale. Pan et al. (2008) find that delays in the planning systems to be the fifth most important barrier out of eighteen barriers to greater use of MMC in the UK. One reason is that early engagement with a manufacturer becomes more difficult if there are delays in planning (Pan et al., 2012). We will see later that developers or contractors need to provide manufacturers certainty as to when the product is to be used for offsite construction to be economical. The UK National Audit Office notes that early planning approval facilitates greater speed as detailed design and manufacturing can start early, which run in parallel with other activities (NAO, 2005).

Another point worth noting in an Irish context is the extent of one-off housing. Just under 30% of the Irish housing stock is one-off housing (CSO, 2023b).[20] Around 40% of all homes construction between 2011-2016 were one-off, and 43% of all planning permissions granted for residential purposes between 2018-2022 were one-off (Daly, 2021; CSO, 2023c). Though planning approval is challenging in urban areas, there is more than a 90% chance of being granted permission for one-off housing (Daly, 2021). This is a major contributor to Ireland's high level of urban sprawl, which is very high by European standards (Ahrens and Lyons, 2019). From an MMC perspective, as we have seen, one-off housing makes it much more difficult to build offsite given the absence of economies of scale.

19 Some of the reasons were wide-ranging and include biodiversity considerations, overshadowing by tall buildings, and the development not adhering to SHD guidelines (Nagle and Sattin, 2021).

20 Defined as a detached house with an individual sewerage system.

Interviews

There were mixed views among interviewees in relation to the planning systems' role in offsite construction. There was wide agreement that the risk and delays in the planning system acted as barriers to construction generally. Uncertainty as to whether planning permission would be granted, and when it would be granted were noted. Aside from alterations to the planning application that gave rise to the delay, the cost of delays includes foregone income, rehiring costs, and potential changes in financial and construction costs once development resumes. Uncertainty in outcomes, whether in the final decision or timeline may lead developers to avoid projects with high planning risk. For instance, developers are reluctant to put in an application for high-density developments, given the difficulties of obtaining planning permission. However, not all respondents were of the view that the planning system discouraged offsite construction in particular.

Regarding uncertainty in the outcome of a planning application, this did not necessarily discriminate against offsite in favour of conventional construction. Among the riskiest developments from a planning perspective are, as above, high-density developments. As it is the building regulations that restrict MMC when it comes to density, at least with regard to timber frames, the planning system cannot be blamed for doing so.

In relation to delays, an important point is that construction does not start until planning permission has been granted. As such, when delays arise due to planning, this does not remove the benefit of speedy construction. As one interviewee put it:

'you don't start construction until you get planning. So, therefore, you've not laid any cost other than your professional fees for getting planning. You still would get the advantage of a speedy install' (Interviewee 11).

An exception may be developments that are highly delayed, such as those that take five or more years. In that case, noted one interviewee, saving six months with modular makes less of a difference (Interviewee 7).The main concern for planners was the suitability of the development for the overall surrounding, whether it conformed to planning guidelines in terms of sunlight, dual aspect, and so on. There was less concern as to the construction process or materials used:

'the planners don't care what it's made of, frankly, they care about it looks like where it's positioned, what its orientation is, is it serviced by public transport, can we get there with power and water and sewage?' (Interviewee 11).

An exception was an interviewee who observed that some urban local authorities insisted on certain aesthetic finishes to the building's external façade. Dublin City Council may insist on a brickwork finish and Galway City Council on a traditional stone finish, both of which may make an offsite solution more difficult or unviable. There are a limited number of approved materials that can create brick finishes using offsite construction. In that case, there would be little incentive to pursue an MMC method (Interviewee 13).[21]

21 This observation was made by a policymaker who may not have had a construction background. A reviewer of this report pointed out that many precast panels incorporate brick facades.

Other interviewees were firmer that the planning system does act as an impediment to offsite construction relative to conventional building. It was pointed out by several interviewees that a number of modular builders in the UK had gone bust. Serious delays in the planning system run the risk that the manufacturer who had agreed to build the unit for the developer may not be around for construction once planning permission is eventually granted. As it is not straightforward to switch to another manufacturer given their types of components or modules, the use of MMC is discouraged, particularly modular building.

The point was also raised that it is best, if possible, to begin manufacturing as early as feasible. This enables greater overlapping of elements of the construction process, improving the speed of construction. Given the nature of the Irish planning system as it currently exists, it appears not to overly affect the choice between conventional and offsite given construction begins after planning permission is obtained. If offsite construction is to be optimised, however, a more certain, well-resourced, and expeditious planning system would be required to overlap different elements of the construction process:

'the reality is considering the issues, we have a planning in this country, no one was going to manufacture on anything until you actually have a secure planning grant in your hand. And the problem with those is because there's no certainty in planning, you can't start early. So a lot of advantages you have with volumetric construction, you can start early in the factory.' (Interviewee 15).

Manufacturers need to plan in advance. They place orders with materials suppliers in advance of beginning the manufacturing process and allocate time and space in the factory to manufacture for specific projects. If manufacturing/construction began before planning permission was granted, delays in the planning system could result in components or modules being completed early. This would result in delivery onsite before the contractor is ready to install it with a consequent potential for damage. Or it may result in the manufacturer having to store the component or module, incurring storage costs that would need to be recouped from the client.

It seems that because the tendency in Ireland has been to begin the construction process after planning permission has been acquired, the decision is relatively unaffected by planning delays. An absence of delays, though, may change the timeframe around when construction commences. Certainty of planning would encourage construction to begin earlier, which would encourage offsite methods.

The importance of early decision-making and the cost of delays is true of using offsite light-gauge steel, timber frame, and full modular versus conventional construction, but less the case with offsite versus onsite concrete, which is the most established form of offsite construction method in Ireland. In the case of concrete, it is easier to decide later between conventional, in-situ concrete versus offsite precast, though the later the decision is made the greater the cost implications may be.

There was more agreement that delays to servicing land acted as a barrier to MMC. This came through very strongly in the roundtable discussion and interviewees, usually when prompted, agreed. It was observed that the Electricity Supply Board (ESB) and Irish water would sometimes take an inordinately long period of time to provide water and electrical connections to sites. This would discourage an MMC solution as it raised the possibility that a site may not be ready to receive

a component that has been built offsite. Clients and contractors are reluctant to leave manufactured components onsite due to possible weather and other types of damage.

Comparatively few of the interviewees brought up the role and prevalence of one-off housing as an impediment. It was discussed mostly by timber frame manufacturers, usually when prompted by questions surrounding economies of the scale. The section on structural-market factors shows that this clearly is an issue. The mostly likely explanation for the relative absence in the discussion is that most MMC manufacturers do not do one-off housing because it is so uneconomical to do so. As a result, it simply does not occur to them.

7 Social housing, public sector building, and public procurement

7 Social housing, public sector building, and public procurement

Context

The state is set to take a greater role in the supply of housing in the coming years. In recent years, non-market housing has constituted around one-quarter of new builds, a significant increase compared to previous periods (Sweeney, 2022). Under *Housing for All*, construction of privately owned and rented units is expected to comprise just under 60% of newly built units by 2030. The remainder will be a mixture of traditional social housing on the one hand, and affordable and cost rental units on the other (DHLGH, 2021).

There are a variety of delivery methods through which social and public housing is built. In terms of numbers, the most important delivery method has been turnkey build, comprising a little over half of new builds according to the most recent data (Farrell and O'Callaghan, 2020). Turnkey building is where an AHB or local authority agrees to purchase units from a private developer after design is complete and before, during, or shortly after construction. Part V, along with direct build, is the other major delivery mechanism. Part V is the process whereby private developers agree to allocate 20% of a private development for the purposes of social housing. The units or, in some cases land, are provided to the local authority at a discount.

In the context of offsite construction, direct build is the most relevant delivery mechanism. This is because under Turnkey development and Part V, the state has no direct influence over the design and construction process. Direct build, which has comprised a little under a quarter of new builds in recent years, is the process whereby builders are contracted by local authorities to build social and public housing on public land.[22] AHBs also engage in direct build whereby they purchase land from local authorities, often on favourable terms, who then build on it.

The construction of housing through direct build is, however, difficult. Local authorities must go through a four-stage approval process with the Department of Housing, Local Government and Heritage (the Department). The first stage entails making the case for building social housing in an area based on need. The second stage is pre-planning design which includes ensuring value for money and cross-checking with national guidelines on design. Stage 3 comprises the obtaining of planning permission and detailed designing of the unit. In the final stage, the local authority puts the contract out to tender, reviews the submission, and sends the submissions to the Department for review acceptance.

The process has been subject to considerable criticism, particularly Stages 3 and 4. This includes excessive intrusion by the Department over design details of developments in a given locale. There may be excessive negotiations on costs between a local authority and the Department prior to tender which, in any event, may be redundant as the tender price ends up being the final price. Local authorities also have to put each development out to tender as opposed to maintaining a shortlist of trusted contractors (Norris and Hayden, 2018; Sweeney, 2022; Burke-Kennedy, 2023).

22 One reviewer pointed to the fact that other jurisdictions do direct building on public land differently to Ireland. For instance, local authorities in other countries may have an in-house development team.

The advantage from the perspective of the state is the high degree of cost certainty it provides. Another advantage is that by vesting design control with the local authority, a better match can be made between those on the local authority waiting list and the type of social housing units that are built.

Due to the delivery mechanism being so slow, local authorities may be disinclined to use direct build. It has been estimated that direct build by local authorities is between 28-42% more expensive, and AHB direct build is between 17-20% more expensive than Part V delivery (Lyons and O'Riordain, 2022). While this finding has been contested – one of the workshop participants with expertise in public procurement of social housing emphasised the small sample size and lack of like-for-like comparison[23] – a fast track delivery process is available. Under this delivery, Stage 3 becomes optional provided certain conditions are met. The conditions are that the total budget is below €20m, the project has advanced to Stage 3 within six months of Stage 2 approval, and the pre-tender estimated cost is contained with certain limits. A one-stage process is available for projects below €6m, but it appears that the expedited processes are not being used (DHLGH, 2022a).

Given that substantial completion of design is completed by the local authority, direct building would appear to necessitate a traditional procurement model. Detailed design by the local authority and limited ability by the contractor to engage the design team effectively crystallises the construction method prior to tender. However, it has been recognised for at least two decades that the traditional procurement model is ill-suited to capitalise on the opportunities that offsite construction offers, and that greater design responsibility needs to be allocated to contractors and manufacturers (DEHLG, 2003).

A standardised form of design and build contract for public construction has been available since 2007, but has been little used as traditional procurement is more tried and trusted (Housing Agency, 2023). Insofar as social housing has used design and build for offsite construction, it has been for 2-D panelised systems (DETE and DHLGH, 2023a). For the four-stage process to accommodate design and build, it appears the design team's role is to do high-level design, and after planning permission is granted, it then prepares the documents necessary for procuring a design and build contractor. Step 3 no longer involves detailed design but rather sets detailed minimum performance standards for the building (OGP, 2021). This could include details on the thermal, ventilation, and other aspects of building performance, but the contractor decides how those standards are to be met.

The Irish government is encouraging local authorities to use MMC for the purposes of building social housing. During the housing bubble years shortly before the crash, local authorities acquired large amounts of land. After the crash, they were left with land for which there was little demand, and some are still carrying the legacy debt. In December 2022, funding was made available to local authorities to relieve them of that debt contingent on using MMC to build social housing.

The Land Development Agency (LDA) is set to be the single largest builder of social and affordable housing in the public sector, most of which will be cost rental units. With new funding set to be allocated to it, it has targets of up to 2000 homes per year over the next three years which, if met, could make it the largest builder in either the public or private sector (Beesley, 2023). Distinct from

23 Farrell and O'Callaghan (2020) find that direct build is more cost effective than turnkey, suggesting direct build is efficient. This finding has been criticised by the construction sector as the analysis failed to incorporate implicit subsidies received by local authorities, such as fee and tax waivers (IIP, 2020).

most local authority delivery, the LDA primarily builds on lands in its possession and therefore can affect the design and construction process. As a commercial state-owned entity, it has greater autonomy than a local authority so is not required to go through a four-stage process. As with local authorities and other state agencies such as DFHERIS[24], it is tasked with using or considering MMC for its construction programmes (Housing Agency, 2023).

Another issue is the lack of standardised form of design. The DHLGH has a design manual which local authorities and AHBs are expected to refer to in their direct social housing projects (DHLGH, 2022b).[25] It contains a number of internal layout designs which differ according to whether it is an apartment, house, duplex, number of bedrooms, and other features. There are 58 different dwelling or unit types in total. It notes that MMC is encouraged and should be proposed as part of the tender documents. This could entail a deviation from the standard layouts, though not necessarily.

Private sector views on public building

It was acknowledged that MMC has been used effectively in the public sector. The education sector has been an important driver of this as the number of schools struggled to keep up with population growth in the 2000s. MMC forms included precast concrete panels, light gauge steel frames, and to a lesser extent timber frames. Hospitals have also been built using MMC such as by using light gauge steel. However, in these cases, offsite work comprises only a relatively small component of the overall cost, and because concrete has high levels of embedded carbon, it was felt that the benefits of MMC had not been optimised by the state.

Another complaint was that public projects have been very much designed by the client, at least historically. While this could accommodate the more established forms of MMC such as precast concrete, it does not facilitate the more recent innovations such as modular construction. As discussed in the previous section, early contractor involvement is necessary in that case. More recently, public projects are delegating more design responsibility to the contractor.

In some cases, contractors had been given responsibility for planning permission, in which case they would have a high level of control over design. Due to difficulties and delays in getting planning permission, such a level of risk transfer to the contractor led to disputes with the client and was ultimately deemed inappropriate. One interviewee complained that there was too much use of open tendering in Ireland compared to the UK. While closed tendering is sometimes used, in the open system there could be ten other contractors competing, which disincentivises contractors from competing for jobs. In the UK, there is a procurement framework specific to modular building. Under the Crown Commercial Service modular framework, a panel of contractors is selected for a period of four years. From the panel, contractors may win jobs by competing with the selected group, or by individual negotiation for a job with the client. This makes the procurement process quicker and less onerous for the contractor.

Aside from the allocation of design responsibility, there are other ways that public procurement does not facilitate MMC. As discussed in the section on finance and insurance, one of the complaints was that the public sector was less flexible in terms of providing upfront funding, though this was

24 Department of Further and Higher Education, Research, and Innovation and Science.

25 In relation to Turnkey build, 'mandating the use of this manual would not be appropriate where it would be inconsistent with the principle of not influencing the design' (DHLGH, 2022b: iv).

changing. AHBs were seen to be more flexible than local authorities in this regard. Upfront funding is less of an issue for 2-D panelised systems as in those cases offsite costs comprise a small share of total construction costs.

Another common complaint from the private sector was the lack of standardised design in social housing. Not only are there too many different types of design, but there is also discretion for local authorities to alter design according to local context. Design guidelines are just that, only guidelines. This makes it very difficult to yield the economies of scale that go with mass production. What is needed, it was argued, are frameworks or agreements between manufacturers and local authorities where there is a commitment to provide a number of houses over a stable period according to a limited number of designs:

'there was a meeting.. with the Department of Housing, where they said, right, they launched these designs, standardised designs, here you go, these can all be rolled out to all the various local authorities, etc. And we can set up frameworks and get all of this moving. So people in the audience ask, well, okay, what does that framework look like? They said, well, the local authority can take these designs, and implement them, or they can tweak them or change them to suit themselves, or they can go about their own design. So that's not a framework.' (Interview 7).

The experience of manufacturers dealing with the public sector was contrasted with how the private sector delivers houses, especially the two large PLCs. Because of standardisation of design, PLCs can obtain better prices through bulk purchases, while manufacturers are able to realise economies of scale through repetition. Again, we quote at length:

'Because there's no consistency in it we can't, as a modular manufacturer, we can't get efficiencies in it.. because everything has been redesigned and redesigned, redesigned, on a project specific basis. So, if you take an example of one of the big one of the big self-delivery developers sort of take Glenveagh or Cairn Homes. What they do and they're very, very good at doing it is they're very, very efficient in their design. So they create their own design document, and they give that to the architects and say, this is our design requirements, you do not move outside of this design. Our bathroom is this size by this size. Okay, and we have a Grade A or grade B... So, each architect they go to is not redesigning, redesigning, redesigning their procurement team isn't going back out, ordering off multiple different suppliers, and they can get efficiency in their design and their pricing and then the supply chain that are feeding them know I can order 2000 of these WCs (wash closets), because I'm going to use them working for Cairn homes. So I can hammer this manufacturer on the prices and get down to, you know, a really good number. Whereas if I'm ordering 60 of one type 80 of another type, 200 of another type, 300 of another type, know that the wastage that comes with that in terms of time and effort, and everything else, there's nothing standardised in it. And that's what the government they're doing. So if the government adopted a similar approach to what the private entities like, like Glenveagh, and like Cairn homes do in really locking in design standards and not budging from them, and saying, right here's our modular house, we have two styles, and we have two grades, Grade A and Grade B. Now modular manufacturers, there's three years worth of it in front of you, man up, invest and start delivering.' (Interview 7).

The guidelines that do exist are only a high-level architectural design. Namely, they include the basic dimensions and layout of the house, such as what would be submitted at the planning stage. They do not include a detailed structural design of how a house is to be built and how a house's

components carry its loads to keep the building upright. The design guidelines are not sufficiently detailed to hand over to a manufacturer to build. Each manufacturer would have to add its own detailing about structural and other elements of a building such that a different product is being built by each. Again, this elevates cost through impeding standardisation.

Some architects lamented that government procurement systems are geared toward minimising costs. There was insufficient attention being paid to quality and sustainability issues. One interviewee pointed out that quality is weighted 70% and costs 30% in evaluating tenders in the UK, unlike in Ireland where cost considerations were paramount. A whole system analysis was not being taken that can drive the offsite industry forward.

Social housing

From a local authority perspective, there may be a diversity of social housing needs in their area. For instance, some local authorities may require a mixture of one-bed, two-bed, and three-bedroom units. Added to that, there may be a need for units that can accommodate disabled and older people. With such a variety, MMC may not be the most appropriate type of building process.

A related issue is that most local authorities are quite small and therefore developments are likely to be small. Large local authorities, on the other hand, may have multiple sites. They may be able to concentrate different unit types in different sites which allows them to yield the benefits of MMC:

'we have two schemes that we're going to use MMC on. One is on the acceleration program and another one is a large 75-unit scheme. We still have four house types in it, which is not ideal for MMC at all. I need that mix. And in seeing large local authorities, they have such demands, and they have multiple sites that they can say, well, I'm going to do two and three and four beds here, and ones and twos here. It lends itself much better to MMC.' (Interview 17).

Even for large local authorities, not all projects will necessarily be large developments. Some may be infill development where building takes place in underutilised land within existing developments, especially urban developments. In that case, the number of units being built may be quite small.

One local authority member was not convinced that MMC sped up delivery. Some contractors that local authorities had used had had difficulty sourcing timber frames to build the units. A related issue was that without planning permission in place on the part of local authorities, contractors were uninclined to put in place the capacity to build using MMC. So, delays in the planning process were impeding not just delivery generally, but the use of MMC in particular. Recent reforms to the planning system which curtail elected representatives' input into social house developments were expected to help in this regard (see O'Connor and Cassidy, 2023).

The incentive for a local authority to use MMC is that it can be done more quickly and local authorities are under pressure from the Department to clear their waiting lists. One local authority member said that they have recently put MMC as a requirement into their tender documents. Another said they do not but there was an expectation that MMC would be used in light of the prioritisation given to speed of delivery. The rapid build target of 1,500 units under Rebuilding Ireland was viewed as important in

this regard, as is a similar commitment under Housing for All.[26] However, one interviewee observed that these targets were allocated over a number of years and were not sufficient to maximise economies of scale. It was confirmed that the four-stage process in a design and build context differs in regard to Stage 3. Rather than doing detailed design, local authorities choose detailed performance criteria before putting the documents out to tender.

One local authority representative raised the point that the government has issued a framework document for direct build of social housing using design and build procurement. It was discussed that there is little difference between this document and the framework document used for traditional procurement. In both documents, there is a timeframe or range of delivery times for completion of project (for instance 40-60 weeks). A tender that proposes to complete the project at an early point in the time range will be evaluated favourably. The problem is that the design and build document did not broaden that range to encourage earlier completion (for instance 20-60 weeks), a move that would incentivise MMC.

'if we let's say we were doing 52 houses, and we might say right, the earliest, in our opinion, based on what we noticed out there, and you say it's only light gauge steel frame and timber frame, the earliest someone could complete, that might be 60 weeks, and the latest would be 80 weeks. And they get marks for as close as they can get to 60 weeks, but they can't go over 80 weeks. So whoever provides a program that is showing it closer down to 60 weeks, they will get marks under a quality criteria. But there's no incentive there for someone who can say, well, hang on, I can do a lot of this offsite, I can deliver fully modular units to site and I could do this in 30 weeks, you know, like that. So, the contract just doesn't allow any of that to happen' (Interview 19).

Some local authority representatives had not heard complaints from contractors that there are too many design types of social housing for used in MMC. This could be because the above complaints about insufficient standardisation have come from modular manufacturers whereas insofar as MMC is used, it is 2-D light gauge steel and timber frame houses. It was observed that, as in the private sector, architects may overdesign units to build their brand. This can impede MMC and needs to be monitored by local authorities, though some if not most do not have the resources to do so.

The large number of different designs in the design manual may have been based on the existing units that local authorities have built up to now. One of the local authorities defended using their own design. A design based on the manual may not fit well with the existing development in that area.

Other interviewees concurred with the views of private sector organisations that there were far too many design types for public and social housing. With 50+ different housing types, and with local authorities complementing these with their own designs, there was little possibility for efficiency savings through repetition and economies of scale. It was also noted that AHBs and the LDA also use their own designs, which differ from the national guidelines. A number of interviews remarked or agreed that the LDA has the capacity to drive standardisation. As a large national organisation, if it were to procure a limited number of different house types, manufacturers would become cost efficient at producing them. This would then encourage other entities to build according to these

26 In December 2022, the government committed to alleviating legacy debt incurred by local authorities during the bubble years contingent on the local authorities building 1,500 social housing units using MMC (DETE and DHLGH, 2023: 15). It is unclear to what extent this programme is separate from or additional to commitments to build 700 units to house Ukrainian refugees (DHLGH, 2023b: 10).

designs. As it is, not only does the LDA have its own designs, but it apparently delegates the decision about whether to use an offsite solution to the contractor. This is different to local authorities which actively encourage its use.

One AHB raised concerns about the risk of using MMC. There are a limited number of manufacturers in Ireland and a number of them have gone bust recently in the UK. There was therefore that concern in Ireland as well. Again, the size of the development and potential for economies of scale were also important determinants of whether MMC would be used. As with the LDA, it seems that the greater autonomy of AHBs with respect to the state has resulted in them being less influenced by government drive to use offsite construction more.

Local authorities did not see the need for high upfront payments as a problem in using MMC. They are willing to provide them when vesting certificates are issued. It is noteworthy that local authority housing uses either timber frame or 2-D light gauge steel so that the need for upfront payments is lower compared to modular manufacturing.

Modular manufacturing in direct build is more challenging. One reason is that it tends to be more expensive, so contractors are unlikely to choose it. Another reason is that modular has the greatest need for early contractor involvement. However, each modular manufacturer produces a slightly different product. There is then a risk that a local authority that engaged with a manufacturer prior to tendering may produce tender documents that cannot be built by most manufacturers. The process would run afoul of the need for a competitive tendering process.

8 Discussion and policy

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Discussion

It is clear that there are multiple barriers to greater use of MMC in the Irish market. Barriers cut across multiple areas of the industry supply chain and multiple areas of policymaking. Barriers differ somewhat depending on which aspect of MMC is being discussed. While common challenges exist, especially in terms of scale, the obstacles differ somewhat by building process and product.

For a contractor, the major problem is that MMC tends to be more expensive. Precisely how expensive is difficult to say a priori as it will depend on how MMC is designed and integrated into the overall structure. Speed of delivery, sustainability, quality, and industrial relation concerns are among the incentives to use MMC. While some developers have trepidation about using what they believe to be an unknown quantity, it is noteworthy that one interviewee stated that if it were cheaper the market would quickly adjust – demand would quickly increase. Being more tried and tested, consumer and developer attitudes would surely adjust too.

As to what accounts for the higher costs again the answer is multifaceted. With a large share of construction carried out in a factory, MMC has the potential for significant productivity improvements and hence significant reductions in cost. Learning by doing, or repetition is the most important avenue here, though other factors such as bulk purchasing play a part. Learning by doing requires a large and stable demand for MMC products. But if those products are more costly, such demand is unlikely to emanate from the market. Stable demand begets efficiencies, and efficiencies through cost improvements beget demand. The state, it seems, is needed to step in to set the process in motion.

Regulatory factors play a central role both in terms of affecting competitiveness and in directly limiting the use of MMC products. Manufacturers commonly complained about the compliance costs associated with MMC. Due to their newness in the market, many products are untested in terms of fire and other aspects of performance. This is in contrast to products used in traditional construction which are tried and tested and for which the building regulations provide assurance that what is being used is compliant. Though few can reasonably complain about testing for fire and other aspects of performance, it was felt that what were considered to be minor adjustments to products needed to be retested. The testing process was, moreover, time-consuming, expensive, and clogged.

While compliance issues may affect the speed and cost of delivery, ultimately products can be tested. A major limitation to greater use of timber in particular is the limitation on construction buildings greater than 10m using combustible materials. This prevents the widespread adoption of timber in dense developments, such as apartments. As reviewed in Section 4, there is a consensus that timber can be made as fire resistant as steel. Yet, the fire safety record of regions that use timber widely is inferior to Ireland's, though the age profile of their building stock needs to be factored in.

Given the relative newness of some of the technologies, the financing and insurance mechanisms that serve traditional construction processes are not yet in place in an MMC context. The issue of upfront payments from the client to the manufacturer is seemingly not a major stumbling block as it

can be addressed using vesting certificates. Funders of the development process are still to be fully convinced, however. For modular construction, the unwillingness of banks to provide mortgages, despite the willingness of some credit unions to do so constitutes a significant market failure. The cost, and in some cases the unavailability of professional indemnity insurance speaks to a related problem – many of these technologies are new and the risks associated with them are difficult to quantify. It is worth reiterating that barriers to MMC are related – one interviewee felt that if the building regulations were updated to include MMC products then the concerns of funders and insurers would be quickly allayed.

There is less agreement within the construction sector about whether the planning system discourages the use of offsite construction in particular. The practice is that the construction process begins after planning permission is granted. Planning delays, according to this view, do not remove the benefit of MMC. At the same time, others pointed out that if there was less uncertainty in terms of speed and outcome of a planning application, the manufacturing process could begin sooner. MMC uniquely allows for the potential overlapping of different stages of the construction process, but under a highly uncertain planning system, few developers would take such a risk. The prevalence of one-off housing is, however, an impediment. Delays in servicing land also disincentivise MMC.

There was consensus that procurement practices need to change if MMC is to be optimised. The key consideration is early contractor involvement. If a building is designed in detail without knowledge of offsite manufacturing, it can be very expensive or technically impossible to change it subsequently. As developers may not be knowledgeable or otherwise uninclined to use MMC for the various reasons that have been discussed, ECI has not always been forthcoming. ECI may even be necessary at the pre-planning stage, particularly for modular manufacturing. Greater use of design and build procurement should in theory facilitate MMC as it is the contractor that decides the design. Indeed, many had felt that design and build had facilitated greater use of offsite solutions. However, to the extent design and build is merely the transfer of risk and not design responsibility to the contractor, the full potential of MMC is unlikely to be realised.

The need for the state to step in has already been discussed, in this report and elsewhere. One of the main avenues for doing so is through state direct building of public housing. A number of issues have been raised in this context. One is the large number of different housing types used by local authorities and other agencies which, moreover, have the discretion to deviate from the large number of design types suggested under national guidelines. For local authorities, the pressure to deliver quickly is and has been an incentive to use MMC, though the targets for MMC builds do not appear to be at a level that would yield significant economies of scale. An added complication is that MMC is not necessarily appropriate for smaller local authorities and that changes to public procurement of housing, while welcome, do not fully incentivise offsite manufacturing.

Recommendations

Review height restrictions on timber with international comparative evidence

The height restriction on combustible materials is a major hurdle to the more widespread use of timber frames in residential buildings in Ireland. There is a need for greater density in Ireland for both liveability and environmental reasons, and the National Planning Framework (GoI, 2018) has made a commitment that 40% of new residential developments are to be in existing urban areas. This requires building higher.

Needless to say, fire safety is a legitimate reason to curtail the use of combustible materials. Most other jurisdictions do not have such strict limits on timber and there appears to be a consensus that timber is as fire-safe as other materials commonly used in construction, such as steel. At the same time, other jurisdictions that use timber have inferior fire safety records to Ireland. Though timber has been implicated as a reason, it is unclear whether these results are skewed by the older building stock in those countries where the timber used to construct it may not have been as fire-resistant as the types of timber used in construction today. A review of the height restrictions should not limit itself to Ireland but draw on international comparative evidence.

The Construction Safety Partnership Advisory Committee is due to give guidance on timber frame buildings in Ireland. Its focus has, to date, been on occupational health and safety concerns. Its remit could be broadened to continually review the safety of buildings along the lines of the UK Building Advisory Committee.

Broaden Technical Guidance Documents to include materials used in offsite construction

Manufacturers and other stakeholders have complained that the testing process for products to obtain certification to comply with the building code is onerous. It is slow, expensive, and the system is currently clogged. If the building regulations were broadened to include products used in MMC – if the TGDs were updated – there would be less need for manufacturers to repeatedly test. This would bring costs down and make MMC a more attractive option for clients and contractors. The sanctioning of products and materials by the state would provide assurance to those further up and down the supply chain who have concerns about MMC products and processes. This includes not only clients, but funders and insurers.

Consider taxation of concrete and other materials according to its embodied carbon content

As part of Budget 2023, a levy was introduced on cement. This was introduced to fund a redress scheme for homeowners adversely affected by defective products used in building their homes. Another justification for the levy is that cement is highly carbon intensive. However, the rate of the levy at 5% its open market value makes no reference to its embodied carbon content. The embodiedcarbon of concrete varies over a wide range (Purnell, 2013). Concrete blocks could be allocated into bands according to embodied carbon content and a levy could then be applied. If it is deemed appropriate to revise height restrictions on timber, fiscal incentives such as a reduction in VAT could be used to incentivise its use. An important consideration is the sourcing of the material as timber sourced from a region subject to deforestation is not sustainable compared to one sourced from a stable or growing forest.

Increase rapid delivery of social housing through direct build

It is widely agreed that the current housing targets under *Housing for All* need to be revised upwards. As part of that revision direct building of social housing should be increased. Though direct building is slow and expensive, it has the advantage that the state exerts control over the design and construction process. This can be used to drive MMC both to improve the delivery of social housing and also drive the sector forward. A stable pipeline of delivery enables manufacturers to plan for the future, invest in the relevant plant and machinery, and optimises the use of MMC.

An assessment of social housing need is periodically carried out by local authorities, which in recent years has been annual. The Department should audit local authorities to estimate the number and type of units that would be appropriately built using MMC over the coming periods, such as a three-year period. Further reductions in local authorities' outstanding debt or other fiscal incentives could be used to incentivise authorities to build social housing according to a narrower range of design types than is currently offered by the design manual. This may necessitate further guidance on design by the Department. This should be done in partnership or dialogue with the LDA so that they too are building according to a limited number of designs. Increasing output and standardisation would help drive economies of scale.

Procure and plan to use MMC

Greater use of design and build, and greater ECI are needed to further MMC in Ireland. The extent to which the state can influence private sector procurement is, in practice, limited. What it can do is influence its own procurement models, which may then be taken up by actors across the industry. To encourage greater take up of MMC in state building projects, the timeframe for project delivery in the design and build framework document could be broadened. This way tenders could propose to finish a project earlier than they are currently able to propose which, if evaluated favourably, would encourage the use of offsite methods.

In regard to planning, a number of issues arise. The length and difficulty of obtaining planning permission in urban areas can somewhat be mitigated by greater use of master planning. This way, public consultation takes place primarily at the masterplan stage, with limited scope for objections once a plan is in place, and once a proposed development is in accordance with that plan. Active land management whereby the state, be it a large local authority or the LDA, acquires land, furnishes it with infrastructure, and then either uses it, sells it, or leases it, would similarly be helpful. Waiting for the relevant infrastructure to be in place discourages offsite construction.

The extent of one-off housing is another barrier to MMC as it impedes standardisation. Upholding the desire of many to live outside cities is a legitimate goal of spatial planning, though should not be done at the expense of the environment, congestion, and housing delivery. According to Daly (2021), the main beneficiaries of one-off housing are not farmers but managerial and technical workers who commute to urban centres via private cars. Currently, one-off housing is allowed for agricultural workers, for people who grew up in the area in question, and for people who have been living there for fifteen years or more. In keeping with the principles of sustainable development, ideally one-off housing would only be permitted in situations where a household has an economic need for proximity to a given piece of land, typically for agricultural work. Otherwise, housing needs should be met within existing villages and towns. This is particularly important in Ireland, where many towns and villages have been in decline over the last 30 years.

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The Irish construction sector has played a central role in Ireland's political and economic landscape for several decades. While supply has increased in recent years, the level of output is still insufficient to meet Ireland's housing needs. The quality of housing has also improved dramatically, though the legacy of defects remains a bone of contention. The sector is both a major source of jobs and a major source of emissions.

Modern methods of construction, or offsite construction, offer the potential to address many of Ireland's housing problems simultaneously. Offsite methods can be delivered more quickly, more sustainably, and with improved working conditions. Ireland has, however, been slow to move. This report examines why, what the barriers are, and what can be done.



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