MODERN METHODS OF CONSTRUCTION

1. Introduction

'A construction process that can involve the use of new technology and composite and traditional materials and components (often with extensive off-site production of components) in combination with accelerated on-site assembly methods and to the exclusion of many of the construction industry's traditional wet trades'.

Modern Methods of Construction (MMC) is a generic term for both Off-Site Manufacturing and new site-based building techniques and materials. We have seen an increasing desire by many within the construction and property development industry to use these materials. Many of the current drivers for the use of MMC come from Government Policy, via the likes of Housing Organisations and Local Authority Partnerships, who need affordable, rapidly constructed housing. The UK's relative construction skills shortages can also be addressed by transferring more site work into the factory. The advantages of less site time and reduced workforce are also common to the commercial construction sector.

Revisions to the Building Regulations and environmental considerations are significant factors as well. New buildings now have to be more energy efficient in terms of their thermal and acoustic performance. Quality control and waste are easier to regulate in a factory setting, while works traffic, noise and dust pollution are also reduced.

A variety of new approaches are being adopted across the construction sector but two of the most common (and of most interest to Insurers) are: a) pre-formed timber panels (or cassettes) which are whole roof, floor or wall panels, which can be supplied with windows, insulation and external cladding; and b) volumetric or modular construction, where pods or modules, that could be anything from a bathroom to half a house, are supplied ready-made and assembled/stacked on site.

These new technologies are used in the construction of all manner of buildings from small blocks of flats to education, health, hotels and leisure centres, all the way up to the latest major construction projects in large cities.

Modern Methods of Construction are transforming the way homes and commercial properties are built. But while new building products and methods bring significant benefits, it's important to understand, select and manage the risks that these materials and construction methods present.

An alternative, sceptical, definition of MMC might be *'the reintroduction of combustible materials into a building where they have been previously designed out'*. From a fire safety and insurability perspective (including water damage potential) our primary concern with MMC is those systems where an enhanced fire load has been introduced into the structure or the vulnerability to fire or water damage has been increased. This guidance note therefore concentrates on two specific areas: Panel Systems and Modular (or Pod) Construction.

It is important to note that both panel and modular systems can incorporate non-combustible materials which do not introduce an enhanced fire load into the structure: as Insurers we are mostly concerned with systems of a complete or partial combustible nature.

There are also many examples of where conventional or new building materials and systems are being introduced or reintroduced into the new building stock, arguably without full consideration of the associated insurable risks. Whilst not strictly falling within the definition of MMC some of these have been highlighted in the appendix for useful guidance

The arguments in favour of increased off-site fabrication are sound but must be weighed against the risks of each specific project.

2. Modern Methods of Construction

2.1 Panel Systems: Lightweight Timber Frames

Timber frames have been around for hundreds of years; however, the concept is now being used to create some much larger and more innovative structures than have been seen previously with off-site manufacture of wall, floor and roof cassettes becoming ever more common. Pre-formed panels generally comprise the timber studwork and noggins, a plywood sheet (to provide lateral strength) and are often an internal layer of plasterboard. Holes for windows and doors are already formed. The fire load associated with these panels is variable depending on the composition. The space between the structural timbers is often filled with insulation: this could be mineral wool, rigid polyisocyanurate board or, at worst, polystyrene beads. As well as selecting non-combustible insulation, the combustible content can be reduced further by substituting the plywood sheet for a fire resistant board (e.g. calcium silicate). As well as insulating the space between the structural timbers a further layer of insulation board is often added to the wall make-up. It is important to know exactly what is within the structure and where.

Whilst it is possible to treat the timbers to improve their susceptibility to inception this is rarely done and adds very little. The fire resistance of the frame is wholly reliant on the applied fire protections which are installed by following trades. The arguments for off-site manufacture are sound and justified but once the frame is erected concerns around materials, detailing, workmanship and quality control applied in a construction environment come back to the fore. No matter the degree of off-site fabrication there will always be a fairly significant proportion of on-site fire protection works required.

2.2 Panel Systems: Cross Laminated Timber

Cross Laminated Timber (CLT) is an engineered timber product with good structural properties which normally forms the structural floor and wall elements of buildings, and has been used successfully to build up to nine storeys in the UK. CLT is formed of sheets of plywood or OSB bonded together with permanent adhesives. CLT differs from glulam in that it is formed into panels rather than beams, hence the layers of timber are bonded perpendicularly to one another. It is often argued that timber has a superior performance to steel in a fire situation due to the outer layer charring and protecting the essential structure below. However, the same argument cannot be applied to CLT, which is made up of thin layers glued together, as the outer layer has been shown to burn and fall away exposing the layer below to flames and refuelling the fire.

2.3 Panel Systems: Structurally Insulated Panels (SIPS)

These are similar in make-up to composite panels widely found as an external cladding in commercial buildings. Two sheets of plywood or OSB sandwich an insulating layer, usually comprising Expanded Polystyrene (EPS) but sometimes a rigid thermosetting foam board (such as PUR). These wall panels are manufactured off site often with openings already formed and are secured to (usually) a concrete base on site. Traditional (or engineered) joists form the floors but the roof slopes can also be constructed from SIPs. The structural stability and insulation properties of such panels are not in dispute but it would be hard to find a more combustible combination of materials making up the structure of a building.

2.4 Modular Construction

Often referred to as “Pods” these comprise factory produced three-dimensional units that are delivered to site structurally complete and usually fully finished internally. The frames will normally be lightweight steel, timber or concrete and can be supplied with some, or all, external and internal finishes (including services such as electrics and plumbing) in place. Services are then connected to the main distribution network by site operatives.

They range in size from bathroom pods, through complete hotel bedrooms to large sections of commercial buildings. Whilst these Pods and Units can significantly speed up the original construction of a building, they can be difficult to source, repair or replace if damaged.

Pods can be self-supporting i.e. just piled on top of each other, built around a steel/concrete core or even fully supported on a concrete / steel frame with floors and roofs already constructed. Hence they can make up the whole building or just parts (e.g. bathroom pods). The walls may comprise steel or concrete but commonly they will incorporate timber board, plasterboard or a fire resistant board and either loose fill or rigid board insulation. The composition and combination of these materials will determine the fire properties of the structure as will how they are assembled together and fire-stopped whilst in situ. There could be many different combinations of materials in such pods (as all systems are different) so to gain a full understanding of each system requires close scrutiny. The overall resilience of the structure is also reliant on high standards of quality control during assembly. Post-assembly this is very difficult to verify.

Very little large scale testing has been carried out on modular / volumetric / pod structures and so little is known of how they will react as a system when subjected to a real fire scenario

2.5 Lightweight Timber Frames

Whilst not strictly an MMC the type of construction described in 2.1 is also assembled on site from the basic constituent elements (lengths of timber, plasterboard, plywood and insulation). This would often be the case with more bespoke designs that do not benefit from the advantages of mass production of standard units. Whether produced in sections in a factory or from scratch on site many of the same concerns exist because much of the critical fire stopping and passive protection work will still need to done as the frame is assembled and issues with workmanship and quality control come to the fore.

3. What are the (Insurance) Concerns

In general the insurance industry consider MMC buildings as a much greater risk and typically the insurance premiums will be disproportionately high or, in extreme cases, buildings are considered to be uninsurable. The main problem facing Insurers is that it is often very difficult to tell that a building has been constructed using non-conventional methods of construction as quite often the underlying structure will be faced with a traditional brick outer skin or other familiar cladding. Some of the fundamental concerns with MMC are as follows:

3.1 Modular and panel constructions are very rarely fire tested as a complete system. They may be tested as individual pods or on an elemental basis (i.e. just a small section of wall or ceiling) but there will rarely be test data available reflecting how fire spreads in a completed building. If a fire enters the (myriad of) cavities that are an inevitable consequence of MMC, the resulting damage is likely to be severe. The same consideration applies to water entering a cavity – it is very difficult to detect and to remediate the consequent damage.

3.2 There are a large variety of modular build systems with infinite combinations of materials. In the absence of (full scale) fire test data for each system it is incredibly difficult for Insurers to make a valid assessment of acceptability and will consequently tend to err on the cautious.

3.3 The fire resistance of timber panel systems (and more traditionally site-constructed timber buildings) is reliant on applied fire protection: plasterboard; fire stopping; fire collars and the like. There is very little commonality of approach, a huge variance in Contractor experience and far too little on-site quality control. It is not unreasonable to assume that very few completed structures will provide more than a nominal resistance to fire.

3.4 With many systems being unique any chosen Contractor is likely to be lacking in experience and will be effectively learning new methods each time he is engaged on a project.

3.5 Individual pods, or panel-built rooms may be fire tested in their as-built state but once an occupant has damaged or made alterations to the walls or ceilings, any adjudged fire resistance will then have been compromised (or at worst negated completely).

3.6 In light of the above it could be argued that the more vulnerable building systems should be avoided when constructing certain classes of building. For example the risk of damage to applied fire protection in social housing is far greater than in a hotel. How the building is used (tenant hoarding for example) may compromise the design criteria. It is critical to have a full understanding of how the building works and what is important (maybe in the form of a User Manual). If it is not possible to manage tenants and occupants then certain types of construction may be best avoided.

3.7 As these are built as systems a partial loss is more likely to result in the need for demolition and rebuild. It may also be difficult to obtain spare parts and components, especially for bespoke or limited-run systems. A relatively small degree of damage could therefore be disproportionately expensive and take infinitely longer to repair.

3.8 Using lightweight and combustible materials are likely to cause a greater degree of fire spread, leading to increased claims costs. Also rigid Insulation materials such as PIR are often used in MMC: these can be toxic in the event of a fire, and can greatly increase the intensity and spread of fire. Typically we would expect a timber framed or clad building to be completely destroyed in a fire.

3.9 Where MMC is to be used in favour of more traditional or better understood systems then the selection should be subject to a detailed risk assessment which should include, for example: the final occupancy of the building; the layout of the site (separation between blocks); proximity of neighbouring structures; the nature of the area (arson risk); proximity of Fire Service; adequacy of water supplies; and the risk to life both inside and outside. The choice of MMC is often determined on price alone which may result in the employment of less than optimum construction methods.

3.10 Third party / independent certification of all fire protection measures incorporated into a building is absolutely critical with bespoke or innovative building solutions. Building Control attendance on site may be limited to half a dozen site visits and the days of a clerk of works have long since passed. The third party certification may be undertaken by the Principal Contractor if he has the appropriate competence, though this is not always the case. Reliance cannot be placed upon Building Control for the certification of passive fire protection measures and Installers should not be allowed to self-certify.

Unless full and detailed records of the certification process are available post-build then it is incredibly difficult to have any confidence that the building will achieve what it has been designed to do.

3.11 In many cases it is not the suppliers of the MMC systems that are responsible for the fire resistance of the system but a number of following trades. A far higher degree of management oversight is therefore essential but not always achieved.

3.12 Even when a Flood Risk Assessment suggests that the flood risk is low, due to the typical MMC construction materials buildings are often highly susceptible to water damage (including Escape of Water losses), and damage could be difficult to trace, costly and will take a significant amount of time to reinstate.

3.13 The structure is at its most vulnerable to arson during construction when the insulation / structure is exposed and the building not yet weather-tight. At this time there is every opportunity, given the amount of ventilation in the open structure, for a small fire to spread rapidly. Several of the major fires that have occurred on MMC sites are thought to have resulted from arson, and thus the security of the site and the structure itself must be a critical aspect of the fire risk assessment. Also, the proximity of the structure to the site boundary and surrounding buildings should be an important element in the risk assessment.

4. What Protector would like to see

New developments

If a Protector client is proposing to construct a building using Modern Methods of Construction, introducing significant amounts of combustible materials or incorporating any of the design elements highlighted in the appendix, then it is essential that a Risk Engineer is fully involved as a member of the design team. Failure to disclose all relevant information and seek the counsel of the Insurer and your broker may result in a building that is either uninsurable or insurable only at increased cost and less favourable terms.

Beware of confusing approval standards and test data. We expect that the UK building materials testing regime will be reviewed and improved in the future. In the meantime as a minimum you should ensure that the test data being quoted is relevant for the intended use of a material or system. For example the Surface Spread of Flame test is not appropriate for external cladding materials.

Also consider the toxicity of building materials (including insulation) during a fire situation. Using an inappropriate material could render the building occupants incapacitated before they have chance to escape from a building.

Whilst the list is not exhaustive the following factors are important and material:

- A risk assessment to back up the suitability of a chosen construction method in light of the intended occupancy. Any Risk Assessment or Fire Safety Strategy, considering the fire protection/detection and design, should also be undertaken to include the Property Protection point of view, rather than simply life safety.
- The Automatic Fire Protection and Detection systems (such as Sprinkler installations)
- Fire breaks, fire stopping and compartmentation to limit internal fire spread.
- Fire test results and data to verify the appropriateness of the chosen system and materials
- The experience of the Contractor in other similar modular / panel build systems

- Details of the third party inspection and certification schemes for both products and installation
- Full design details of the composition of the pods and material specifications
- The Factory Quality Assurance procedures
- The extent and location of combustible elements within the structure and their potential susceptibility to an ignition source.
- Details of the site-applied fire stopping (materials, products and design)
- We recommend that the role and position of the Clerk of Works on site should be re-introduced as a means of ensuring on-site compliance during installation/construction.
- Avoid introducing any additional risks such as commercial catering facilities or Solar PV systems.

Existing Buildings

If it has been possible to identify that non-conventional construction methods have been employed but we have been unable to gather the relevant detailed above, a cautious approach will be taken. Site inspection will never reveal the true nature of the risk but there may be favourable factors that steer it towards acceptability. It is very important to note that no matter how much information is available we will never be able to fully assess the resilience; repairability and durability of the building in question. Whilst this is, to some degree, true of all buildings it is even more so for new and untested methods of construction.

Factors that may be taken into account:

- The condition of the structure: external and internal walls intact; no exposed insulation
- Provisions in place for routine condition inspections
- Whether the nature of the building is suitably reflected in the Fire Risk Assessment
- Rights and responsibilities for entry and maintenance
- Budgeting and regimes for planned and reactive maintenance
- Measures in place for controlling Contractors, in particular where hot works are proposed in proximity to the structure
- Standards of security, fire protection and fire detection in conjunction with a robust emergency response
- Housekeeping and management of external waste storage
- Measures for the detection and isolation of escaping water

Timber frame cassette being craned into place

Pods being constructed under factory conditions

SIPs panels used in the structural walls

Concrete “pod” being delivered to site

PROTECTOR insurance

Appendix: Other Construction Features

A1 ETICS (External Thermally Insulated Cladding Systems)

Also known under many other names such as Sto Render and EWI (External Wall Insulation) this refers to an externally applied insulation covered in (usually) a layer of render. The insulation can be applied to concrete block or supported on a lightweight metal frame and boarding. The concern arises when the insulation is Expanded Polystyrene EPS (and it invariably is) as this is a thermoplastic material, is easily ignited and will self-propagate. A rendered finish is common to many wall finishes and does not necessarily indicate the presence of EPS below so such systems are difficult to identify. In addition mineral wool is sometimes used in place of EPS. EPS provides a continuous path for the passage of fire and whilst there are often requirements for fire breaks it is not possible to tell if these are in place. If fire cannot get to the insulation then it remains fairly innocuous. However if the edges are not well sealed (e.g. at the base of the wall or around windows) or the render is damaged exposing the EPS then the building becomes far more vulnerable. See separate Protector Guide *Rendered and Insulated EWI buildings.*

External insulation being applied

Glulam Beams

A2 Green Roofs

Green roofs are becoming a frequent addition to new building developments and unfortunately these can present a significant fire risk due to the volume of combustible vegetation present (if it is allowed to dry out). It should be noted that typically the vegetation, roof insulation, membranes and geotextiles are made from combustible materials. Further information is available at https://www.gov.uk/government/publications/fire-performance-of-green-roofs-and-walls The risk associated with such features can be managed by: preventing the system from drying out; avoiding smoking and BBQ's from these areas; creating effective fire breaks by limiting the size of the green roof into several sections and providing non-combustible materials in between; reducing the organic content of the growing medium; and increasing the non-combustible content of the growing medium.

A3 Solar Photovoltaic (PV) Systems

PV arrays (or solar panels) introduce additional hazards onto new structures or existing buildings when retrofitted. If installed and maintained correctly Photovoltaic panels are not themselves a significant fire risk; however, there is an increased risk to consider if the building itself catches fire. See separate Protector Guidance entitled *PV Solar Installations* and RISC Authority Guidance Note *RC62: Recommendations for fire safety with photovoltaic panel installations.*

A4 Rain screen

These are weatherproof external coverings that are easily fixed to factory produced framework attached to the building and can be made from metals, ceramics, granite, terracotta, vitreous enamel, laminates and timber. Insulation material may be present behind the cladding and may comprise combustible materials. There is also usually a cavity which greatly increases the risk of vertical fire spread if the insulation or cladding itself is combustible.

A5 Timber Cladding

Although a traditional building material, the use of timber cladding has become increasingly common in recent years driven by the desire for increased use of sustainable building materials. For new commercial buildings it is commonly used in combination with other cladding systems, although it can form the majority of the external area of the building. The use of timber cladding systems should ideally be avoided or at least subject to a detailed risk assessment (see 3.9).

A6 Engineered Timber

Timber is being used in many more innovative ways, often to reduce cost or weight but also to allow for more expansive and innovative building designs. To allow greater spans the central section of timber joists are often replaced with a steel web or thin plywood flange. These types of joists have far less resistance to fire than their solid counterparts.

A7 Glulam Beams

To facilitate greater spans, and for aesthetic reasons, thin layers of timber are shaped and glued together to form deep beams. Such beams provide a reasonable degree of resistance to fire and are often used to span large sterile areas such as sports halls or assembly areas where they do not cause Insurers a great degree of concern. Where a significant fire load is located directly below they will ultimately suffer the same fate as CLT though it should also be noted that they will fare no worse (and maybe even better) than unprotected steel beams.