MMC Material Definitions, Options and Methodology

1. Timber and Timber Composite

There are three options for structural timber components and systems:

a) Mass Engineered Timber (MET)
b) Milled Timber
c) Structural Insulated Panels (Composite)

Use of timber for the primary structure of a building is constrained by various factors including potential shrinkage and fire resistance. CLT and LVL are primarily used as MMC Category 2 panel systems however both mass engineered panels and milled timber are used in the fabrication of volumetric modules. (Refer to Part 4)

1.1. MET – there are three basic types:

a) Glued laminated timber (Glulam)
b) Cross Laminated Timber (CLT)
c) Laminate Veneered Lumber (LVL)

1.1.1. **Glulam** is an engineered wood product, manufactured from layers of parallel timber laminations - normally Spruce or Pine but occasionally more durable timber species such as Larch, Douglas Fir or even hardwoods such as Oak or Sweet Chestnut. Individual laminates can be finger-jointed to produce long lengths in accordance with the requirements of BS EN 385:20013. One of the greatest advantages of glulam is that it can be manufactured in a wide variety of shapes, sizes and configuration. Beams wider than normally available, can be manufactured by laying boards of different widths side by side and reversing each layer so that there is an overlap and no straight-through vertical joint.

In addition to straight prismatic sections, beams can also be single tapered, double tapered and bevelled. Curved profiles range from a simple curved beam to a pitched and tapered curved beam, to a complex arch configuration. Curved glulam is manufactured by bending laminates on formers before being bonded together with adhesive, clamped and cured.

With its high load bearing capabilities and high dimensional stability glulam can be manufactured up to 50 metres in length and 4.5 metres in width. A variety of different structural components can be formed including parallel beams, pre-cambered beams, sloped beams with a straight or arched bottom chord, curved beams, flitch beams, and trusses.

Large open areas can be created using glulam portal frames - arches and spans are only limited by the length and weight of the glulam components due to fabrication and transport restrictions, with site conditions occasionally being a further constraint.

CLT is a structural two-way spanning solid panel product that can be used to form walls, roof and floor panels as well as shear walls and lift shafts. It is produced by stacking a number of layers of timber, known as lamellas, at 90° to the layer below and subsequently glued to create panels of up to 24m in length and 2,950mm in width, which can encompass between three and seven layers

Cross laminated timber is used across all the construction sectors. The benefits are widely acknowledged for many, but the material has not been used extensively for residential developments in the UK. The advantages of CLT as a core structural solution truly come into play in medium rise residential developments.

The key is the strength to weight ratio – it has proven multi-storey capability, with residential buildings up to 10 storeys already constructed in the UK and a structural capacity beyond this with significantly taller CLT buildings in Norway and Canada. However, recent changes to the Building Regulations prohibit its use for exterior walls above 18m (roughly 6 storeys).

Construction benefits are numerous, from reduced loading on foundations and infrastructure services, to impressive thermal, acoustic and airtightness performance over more traditional materials. Most importantly, a CLT construction solution can achieve cost and programme certainty for the primary structure.

1.1.2. **LVL** is an engineered wood product that uses multiple layers of thin wood assembled with adhesives. It is typically used for headers, beams, rim-board, and edge-forming material. LVL offers several advantages over typical milled lumber: Made in a factory under controlled specifications, it is stronger, straighter, and more uniform. Due to its composite nature, it is much less likely than conventional lumber to warp, twist, bow, or shrink. It is an engineered product comparable to glulam but with a higher allowable stress.

1.2. Milled Timber

1.2.1. **Milled timber** is used in several ways to prefabricate structural and non-structural assemblies and components. Timber frame structures are a precision-engineered, strong and durable build method. They are lightweight compared with other frame materials consequently foundation loads are lower reducing foundation costs.

The construction of timber frame-based structures utilises factory manufactured wall panels, floor and roof panels. The systems used are classified as either open panel, insulated or closed panel. These panels can include the wall insulation pre-fitted and can include the pre-fitting of doors, windows and service zones for onsite installation of M&E works.

Timber frame currently accounts for around a quarter of all new homes being built in the UK. This build method, which includes open and closed panels, is utilised by every sector of the construction industry including social housing providers, due to timber frame's superb environment credentials, as well as being quick and easy to construct.

Milled timber is also used as the primary structure for volumetric modules intended for single storey or low-rise buildings.

1.2.2. **Open-panels** are structurally engineered units used for load-bearing internal walls and the inner leaf of external walls, comprising studs, rails, sheathing on one face and a breather membrane. The open panel system is made from treated softwood timber framing, over which a structural sheet material of either plywood sheathing or oriented strand board (OSB) is fixed. U-values ranging from 0.26 down to 0.15 W/m^2K, can be achieved.

1.2.3. **Closed-panel** are load-bearing similar to open panels but with the addition of sheathings and/or linings on the both faces, insulation, a vapour barrier on the warm side of the insulation and a breather membrane on the outer face of the panel. Doors, windows and internal services/fixture battens can also be fitted in the factory. U-values can easily exceed regulatory requirements, delivering excellent thermal and airtightness properties.

1.3. Structural Insulated Panels (SIPs)

1.3.1. **SIPs** are a high-performance building system for residential and commercial construction consisting of an insulating foam core sandwiched between two structural facings, typically oriented strand board (OSB) from sustainable sources. They are manufactured in strip format 1220mm wide, a maximum 7.4m long and either 142mm or 172mm thick. The strips are cut to length and shape by computer in factory completed with door and window openings.

Two storey panels with a high strength to weight ration are a quick and efficient method of creating a weather proof shell. SIPs use less timber than CLT and structural timber frames and are one of the most economical and eco-friendly forms of construction, but limited in terms of maximum height

2. Steel

There are two options for structural steel systems and components:

a) Hot Rolled Steel (HRS)
b) Light Gauge Steel (LGS)

2.1. Hot Rolled Steel

2.1.1. **HRS** is formed using a rolling process at a temperature above its recrystallization temperature as it is easy to shape at this elevated temperature. Compared to LGS, which is cold rolled, hot rolled steel typically does not require any post-forming heat treatment.

Hot rolling is often the cheapest way to form steel because the additional steps that cold rolled steel requires, such as annealing, are avoided. It does not have the same tolerances as LGS due to the thermal expansion that occurs at the temperature required for hot rolling. It is available various x-section shapes including round bars, sheets, plates, I-beams/columns, channels, angles, circular and rectangular hollow sections.

2.1.2. HRS is one of the most commonly used materials for traditional construction structural frames. Beam and column assemblies can be prefabricated as elements of large structures. Examples are the frame for the Leadenhall Building in London, which was pre-fabricated in the East Midlands and the bridge deck units for the Queensferry Crossing, which were manufactured in Shanghai.

2.1.3. It is also used as a primary structure material for volumetric modules, prefabricated plant rooms, bathroom pods, service risers and other 3D assemblies required a frame to support the components. Most HRS cuboid assemblies have corner posts,

sometimes intermediate posts, and edge beams categorising them as point loaded structures.

2.2. Light Gauge Steel

2.2.1. **LGS** is formed from thin gauge galvanised strip material rolled and formed into a wide range of structural sections. The sections are also referred to as cold formed steel.

Profile shapes and section sizes vary, but most include lips at free edges to provide stiffness and avoid premature failure by local buckling. Thicknesses for load bearing products typically vary from 1.2 mm to 3.2 mm. The most notable benefits of using LGS are speed of construction, cost-effectiveness and safety. The product is popular as it is easy to handle both for fabrication and construction. Cold forming machines can be fitted into containers for use on-site.

2.2.2. LGS is used as a primary structure material in kit form (posts & rails) for site assembly or as closed and open panel systems. The load bearing characteristics of LGS are defined as line loadings, which spreads the deadload of a structure in a similar way to CLT and LVL.

2.2.3. It is also used as a primary structural material for volumetric modules and 3D assemblies where line loading is the preferred structural solution.

Pre-cast Concrete

The main options for pre-cast concrete are.

a) Cross Wall Panel Systems
a) Components

2.3. Precast concrete in General

2.3.1. **Pre-cast concrete** is widely used in low and mid-rise apartment buildings, hotels and nursing homes. Concrete provides superior fire resistance and sound control for the individual units and reduces fire insurance rates.

It is also a popular material for constructing office buildings and prison cell blocks. The walls of a building can be manufactured while the on-site foundations are being built, providing significant time savings, resulting in early occupancy.

The speed and ease with which precast structures can be built has helped make precast a popular building material for parking structures. Precast concrete allows efficient, economical construction in all weather conditions and provides the long clear spans and open spaces needed.

For sports stadiums and arenas, seating units and concrete steps can be mass produced providing fast installation and long-lasting service. In addition, pedestrian ramps, concession stands, and dressing room areas can all be framed and constructed with precast concrete.

The smooth surface finish and the ability of precast, prestressed concrete to span long distances makes it suitable for use in manufacturing and storage structures.

Additional applications piles and decks for rail tracks and highway bridges, railway sleepers, educational institutions, commercial buildings such as shopping centres and public buildings including hospitals, libraries, and airport terminals.

2.3.2. Cross Wall Panel Systems

High quality smooth faced panels are pre-cast in re-usable steel moulds as the internal walls and floor components of a cross wall system. The outer walls are either cast as single skin using the same moulds or fabricated as composite sandwich panels complete with insulation and exterior finish. Paint can be applied directly to the surface of panels cast in the steel moulds. The main advantages of this method of construction are speed of construction without the need for scaffolding. However, this method of construction is only suitable for buildings with a regular internal layout, that are unlikely to be reconfigured in future.

2.3.3. Pre-cast Components

Standard pre-cast components include beams, columns, deck slabs, wall sections, railway sleepers and motorway retaining structures all shaped in one way and used repeatedly.

Bespoke pre-cast components are designed especially for the building, bridge, or structure where they are to be used. In addition to items listed above they include façade panels, decorative features and twin wall structures. A key benefit of precast concrete is that the product can be cast to a very high quality in ideal manufacturing conditions.

A good example of the component system is the residential tower at Two-Fifty-One Southwark by Laing O'Rourke.

2.4. Volumetric modules

Are essentially the same expect for the primary structure as described in the previous sections. The variations are:

a) Mass Engineered Timber (line loaded modules)
b) Milled Timber (line loaded modules)
c) Hot rolled steel with LGS infill (point loaded modules)
d) Hot rolled steel with milled timber infill (point loaded modules)
e) Light gauge steel with LGS infill (line loaded modules
f) Concrete (line loaded modules)

2.5. Accommodation Modules

3D modules are large building elements that can single fitted out units, or sections that can be linked together to form complete buildings without the need for additional superstructure.

By assembling modules in a factory environment, production line and lean construction techniques can be used to speed up delivery, achieve consistent quality, reduce waste and dramatically improve construction productivity.

Where practicable, single modules can be finished internally and fully fitted out with windows, doors, fixtures, fittings and building services. The last of these can

be commissioned and tested in the factory. The exterior cladding and roof structure/finishes are usually completed on site, but in some case the exterior wall finish is applied in the factory.

Typically, a single module is large enough for two hotel rooms or a one-bed apartment. Larger residential units are created by combing two or more modules with careful consideration and pre-planning of the interfaces. Long open plan spaces are formed using open sided modules, which are weather protected whilst in transit. Module dimensions and construction are constrained by weight and the logistics of transportation via the UK national roads.

The tallest modular residential building in the world at 130m is Clement Canopy in Singapore, which was built using pre-cast concrete modules type approved by the Singapore Building and Construction Authority.

The record will be taken by a UK building once the 40 storey 140m George Street, Croydon development is completed. Construction comprises LGS modules tied back to two slip-cast concrete towers provide lateral restraint.

2.6. Other Modular Assemblies

The same fabrication materials and methods listed at 4.1 and 4.2 are used for the assembly of bathroom and kitchen pods, utility cupboards, plant rooms, horizontal and vertical building services assemblies. Bathroom pods are also built using fibre-glass and composite panels.