

# AIA/GBCA JOINT COMMITTEE WHITE PAPER

## MASS TIMBER 101

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### INTRODUCTION

Mass Timber is gaining traction in the AEC industry. The qualities of biophilia and timber's innate workability are touted by its champions and industry advocates. Higher profile projects are beginning to feature the use of Mass Timber as a design element, such as Seattle's Bullitt Center. Why has the use of wood had a resurgence in popularity and how is it being positioned for use in larger construction projects? We will investigate the design implications of using Mass Timber in order to shed some light on this emerging material system.

### PROBLEM STATEMENT

Wood has traditionally been restricted in construction due to its combustible nature. Often limited to low rise construction and the residential market, Mass Timber is beginning to bring wood to ever greater heights and into larger commercial structures. While factories and commercial buildings have been framed out of traditional heavy timber using solid sawn columns and beams, the market for this is fading due to early tree harvesting. Trees are being cut down prior to reaching the mature growth needed to achieve heavy timber dimensions.

Filling this void is the emerging world of Mass Timber, but what constitutes the term 'Mass Timber'? Which design provisions are required in order to use wood in place of more common structural systems such as steel and concrete? How can timber meet the desired structural loads, fire resistance criteria, aesthetics, code requirements, and other demands necessary for a successful work of architecture and construction?

### BACKGROUND

#### Recent Popularity

The rise of Mass timber recently is undeniable. While advocacy groups such as the American Wood Council (AWC) are playing their part, the recently popularity of Mass Timber stems in part from its inherent sustainability construction benefits, and aesthetic preference. Wood is a more sustainable material than either construction or steel, leading to a smaller carbon footprint. Mass Timber weighs less than concrete and can lead to a lighter structure and subsequently lighter foundations. The wood used in Mass Timber sequesters carbon while growing, in contrast to concrete which is responsible for up to 8% of global greenhouse gas emissions.

Aside from sustainability is the element of efficiency and tolerance. If a mistake is made in concrete, it is quite literally set in stone. Mass Timber can be worked with traditional hand-held tools if necessary. A Mass Timber building is typically 25% faster to construct than a concrete

project and involves 90% less traffic on and around the site due to fewer concrete pours. In lieu of fire proofing which may be needed in a steel structure, the Mass Timber is inherently fire resistant through the natural char that builds up on its exterior when exposed to a fire.

Another often pointed to element is that of biophilia, or humans' innate desire to be around and connected to nature. The exposed wood present in Mass Timber requires more planning for the design and construction teams, but produces a desirable aesthetic that may be sought out by clients. The aesthetic of an exposed Mass Timber interior is very photogenic, which makes it inherently 'shareable' on social media and in magazines, propagating its rise in popularity further yet.

### Code Changes

While the Post and beam system for solid sawn heavy timber has been around for centuries, the IBC has only recently recognized laminated systems of heavy timber. Deemed 'structural composite lumber' (SCL) and 'cross laminated timber' (CLT), these revisions were first introduced in section 602.4 of the 2015 edition of the International Building Code, expanding the definition of type IV Heavy Timber construction. IBC 2018 further documents these new elements of Mass Timber and it is expected that the 2021 edition will include new provisions for tall buildings constructed of heavy timber: IV-A, IV-B, & IV-C.

### Types of Mass Timber

Mass Timber consists of two types of systems, trabeated (or post and beam) and panelized.

#### Post and Beam

1. Traditional Heavy Timber:
  - a. Large sawn 'single piece' lumber
  - b. More rare because of early age tree harvesting
2. Glue Laminated Timber:
  - a. Multiple layers of lumber glued together
  - b. Typically used for columns and beams
  - c. Multiple grades available for specification

#### Panels

3. Cross Laminated Timber
  - a. Multiple layers of smaller lumber glued together to form a panel
  - b. Strength is derived from the lay-up pattern, each of which are proprietary
  - c. Typically used for walls and floors
4. Nail Laminated Timber
  - a. Consists of nominal 2x lumber nailed together to form a panel
  - b. One of the oldest forms of mass timber
  - c. Labor intensive, and as a result use is decreasing
5. Dowel Laminated Timber
  - a. Consists of nominal 2x lumber that is drilled, then a dowel is friction fit into place.
  - b. All components are wood; no nails, no glue.
  - c. Reliefs can be cut or specified on the bottom to form patterns.
6. Glue Laminated timber
  - a. Similar to glulam beams, but smaller and laid flat to form panels
  - b. Gaining in popularity

### Design Criteria

Though Mass Timber is still in its early stages of development, there are several resources which should be consulted for design criteria. One of the challenges in specifying Mass Timber is that each manufacturer uses proprietary, and thus different, lay-ups, grading, panel lengths, thicknesses, etc. If a manufacturer is not brought on board in the beginning of the project, or if it is competitively bid, a manufacturer may not be able to meet all of the specified performance criteria, or may have different lay-up or detail which will need to be implemented. If the project opts for one of the many Mass Timber manufacturers in Europe, the units will not translate into typical US dimensions and adjustments may need to be made to the design.

The AWC publishes the NDS 2018 which has a section on Cross Laminated Timber and helps shed light on fire resistance requirements. The code, and the NDS, reference the ANSI/APA PRG-320 which provides standard design criteria for lay-ups and grading.

### **Fire Resistance Criteria**

As a result of challenges to the 2012 IBC, fire resistance tests have been performed for CLT and structural composite lumber. Structural engineers are more involved in these tests and UL ratings have been devised for CLT floor assemblies as a result. For the purposes of simplification, the char rate of Mass Timber is nominally 1.5" per hour. The char formed on the outside of the timber is not considered for use in the structure and thus the wood is slightly oversized in order to account for this. One factor to consider is that the connections must also be protected if they are exposed.

### **Connections**

The connections between Mass Timber elements are nearly infinite. Standard connections involve splines, steel connecting plates, prefabricated hangers, dowels, through bolts, and carpentry connections such as notches and dados. Connections can be either concealed or exposed, and can be custom designed as needed. Custom connections are often delegated, with the design team specifying the performance criteria to be met.

### **Design Challenges**

Mass Timber can be used for most common building typologies, however, like every other system it comes with its own challenges. Some of the key challenges the design and construction teams must overcome are MEP systems, acoustics, enlarged structural members and more complex lateral force resistance.

### **Systems**

MEP systems must be planned for and coordinated far beyond what is typically done.

Systems can be routed out of walls in order to be recessed or hung below CLT floors above. If the CLT floor is to be exposed, a higher level of craftsmanship may be needed to fabricate the exposed ducts and utilities to maintain a clean aesthetic result. Underfloor access systems can also be used to provide concealment of systems as well as acoustical benefits.

### **Acoustics**

Because the exposed wood finish is one of the pluses to using Mass Timber, it is not likely that the design team or the client will want to conceal it in the end. This can result in echoing and acoustically poor spaces. The design team should take into account areas which may need to be concealed in order to provide more pleasant acoustics in the final space. Floor finishes may require an acoustic underlayment or topping slab followed by a finished floor in lieu of exposed CLT. Conversely, a ceiling or acoustic panels, such as tectum or fiber wrapped acoustic board can be used on the underside of a CLT deck to help mitigate the problem.

### **Structure**

When working with Mass timber, structural live load should be kept to a code minimum where possible. Columns will be more frequent than with other construction systems and will also be larger. This may be counteracted by not wrapping them in gypsum board and studs as would typically be done in a steel or concrete building. Beam spacings of between 12'-20' and depths of between 24" and 42" are common in Mass Timber construction. This additional depth can cause the building to be taller than needed if not carefully vetted by the design team.

Mass Timber is currently not a code compliant method for resisting lateral forces without receiving a code exception. Because of this, more traditional elements such as steel and concrete must be used to resist lateral forces. There are some states, such as Oregon, which have exceptions to this rule, potentially indicating that it may change in future editions of the code.

## CONCLUSION

The use of Mass Timber provides the AEC industry a sustainable avenue to create structures that are both efficient and aesthetically pleasing. Additionally, due to the rising popularity and media prevalence of Mass Timber, the industry should familiarize itself with these systems as there is a potential to receive requests from clients to use wood in lieu of traditional steel and concrete systems. The continued adoption and expansion of definitions indicated by sequential changes in the IBC indicate increased use and adoption of Mass Timber and begin to set a roadmap for it to be used more frequently in lieu of traditional construction methods. By familiarizing ourselves with the required design challenges and criteria outlined above, architects and contractors alike can share in the benefits produced by the use of Mass Timber.

## REFERENCES

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