DEEP DIVE

Mass timber 101: Understanding the emerging building type

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Perkins+Will

Building tall with structural wood is the aim of many research-minded project teams these days. But the building type is largely outside the scope of current building codes in the U.S., meaning each project requires ample — and often costly — testing to prove it will perform equal to or better than it would if it were made of materials like concrete and steel.

Mass-timber is making headway across the country, though the push is stronger in Canada and throughout parts of Europe. Code is one factor challenging broader adoption in the U.S., as is ready access to the engineered wood products and the heavy timber members that form the structure of tall-wood buildings.

Andrew Tsay Jacobs

The handful of projects finished or in the works in the U.S. evidence that great heights will be one of the last things tall wood achieves. In the meantime, projects like T3, a seven-story office building in Minneapolis, and a new engineered-wood building at the University of Massachusetts at Amherst, are building traction for mass-timber by implementing wood structural systems at a smaller scale, within the scope of current code.

To learn more about how mass-timber construction will scale up, as well as to define what's currently included in the purview of mass-timber construction for low-, mid- and high-rise projects, we spoke with Andrew Tsay Jacobs, director of the Building Technology Lab at Perkins+Will and a member of the International Code Council's Ad Hoc Committee on Tall Wood Buildings, which has been tasked with developing a proposal that may increase the height and code area limits on mass-timber buildings.

This interview has been edited and condensed.

For starters, what defines a mass-timber project?

TSAY JACOBS: If the primary load-bearing structure is made of either solid or engineered wood, it's a mass-timber building. A building that uses mass timber as an accent and not a primary structural element isn't mass timber.

What's the difference between mass timber and heavy timber?

TSAY JACOBS: Heavy timber is associated with a type of construction, Type IV, so there's a little bit of a definition overlap between a type of construction and a material. Whereas mass timber is referring to these large wood products, which are typically panelized and engineered, it doesn't necessarily exclude solid-sawn heavy timber elements. Mass

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timber is a broader and more material-specific word, whereas heavy timber has the traditional and very historical meaning related to a construction type.

If you say something is mass-timber, people are thinking about what materials are composing the structure, and it's not by default going into any construction type. It's like saying "steel" or "concrete." So mass timber is the other thing that's not steel or concrete. It's kind of like: precast is to concrete as mass-timber is to wood.

Perkins+Will recently proposed the Chicago River Beech tower, a concept for an 80-story, mass-timber high-rise. What are some of the research objectives for that project?

TSAY JACOBS: The noncombustible wood [assembly] is a pretty interesting topic. There's a strong desire to have wood be the driving aesthetic, which is why the non-combustible assembly is important — whereas you could do an 80-story building and cover it up with gypsum board and find a way to prove that it's going to perform as good as the steel or concrete building in a fire event. [At River Beech], the desire is to expose the wood, and given the current code language, you'd have to have non-combustible wood to do that. The research behind the tower is to prove that you can develop a wood assembly that's not combustible.

The atrium at the Chicago River Beech concept tower.
Perkins+Will

As far as combustibility in mass-timber assemblies more generally, what are the major areas of focus today?

TSAY JACOBS: Two things: the structural performance during a fire (as in, does the building have enough wood to support itself after the fire) and fire-fighting ability within that space (the fire affects the structure but it also must be combated from without and from within). Testing it doesn't impact the definitions but it would, depending on how well it performs, affect how the height and area tables are constructed. If we're comfortable that it performs really well, you'll find that the [ICC's Ad Hod Committee on Tall Wood Buildings] becomes comfortable with a certain height and area limit on different assemblies.

What kinds of strategies are being used to help mass-timber be fire-resistant?

TSAY JACOBS: Early warning systems, more redundant fire sprinkler systems, gypsum wallboard and even concrete help to protect the wood, depending on the application. In exterior-wall construction, you can limit or eliminate combustibles because that may not be a load-bearing element in a high rise, and [in that case] you can use a traditional curtain wall construction.

The assumption is that you would let the wood char both in heavy timber buildings and in [mass-timber buildings]. What portion of the wood is expected to burn and how much of it is protected by non-combustible [material] is the part that takes a lot of interrogation. If you compare apples to apples, and you provide the same duration of non-combustible protection over a mass-timber assembly and a steel one, the mass timber would out-perform steel because by the time you get through that same amount of fire protection, the wood building's not going to heat up rapidly and fail, like steel. Instead, it's going to start burning slowly.

Is there a perception gap in the industry as far as understanding how mass-timber will perform in a fire?

TSAY JACOBS: Within the industry, people know that heavy timber chars and is slow burning and isn't going to fail rapidly because it's proven itself that way over time, and the building code doesn't require you to protect it. That implies that there is something inherent in heavy-timber construction that resists fire — the wood itself. That's well-known, but everyone also knows that light-frame construction is like kindling in a fire, it goes up really fast. That tends to drag down the perception of the performance of wood in a fire in general. If you hold up a matchstick to a tree, it's not going to suddenly burst into flames — even if you stuck a burning log up next to the tree, it's not going to burst into flames. There's a scale issue that people haven't really wrapped their minds around in the industry, but there's some sensibility that the larger elements of wood have inherent resistance to fire and are slow-burning.

A mass-timber building isn't 100% wood. What's the role of non-wood material in such a building?

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TSAY JACOBS: I'll preface this by saying that the right material should be used for the right application. Steel is very ductile and wood is not. Concrete is ductile if it has the right proportion of steel it in. For things that need ductility, like failure mechanisms in a lateral force resisting system, for example, you'd want a lot of ductility, which is where steel plays a big role. Eventually, we will see more all-wood lateral systems, but for now we don't even have an R-value, so it requires a lot of engineering judgment, and that makes it hard for people to go down the route of using mass timber as a lateral system. Concrete is great as a stiffener, and toppings over cross-laminated timber, nail laminated timber and dowel laminated timber floors limit deflection and help with fire protection. At minimum, a 1-inch concrete topping is useful for increasing the mass of the floor structure to limit sound transmission and impact noise through the floor.

Steel connections aren't just wood-to-wood but also wood-to-concrete. If you have a concrete core, for example, surrounded by a wood vertical load-bearing system, slabs and columns and beams, we use steel to bridge the gap between those two materials, which have different construction tolerances. The steel is strong enough to compensate for the slight misalignment due to the construction process. With concrete foundation and masonry, too, you'll still see all of those playing the roles that they traditionally have in heavy timber construction.

Where will we see wood taking more share?

TSAY JACOBS: Where you'll see that, I think, is in the exterior wall. Normally it would have been masonry or concrete or even an aluminum and glass curtain wall, but you'll start to see the exterior wall made of mass-timber. Then there's going to be connection details for wood-to-wood, like dowel laminated timber, for example, where even the nails or screws that would normally hold 2-by elements can be replaced with dowels. This technology has been around for a long time, but you'll start seeing a little more of it replacing screws.

Why is that?

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TSAY JACOBS: There is an interest to work with one material. With nail laminated timber, when you're milling it, the nail placement is a pretty big deal because you don't want to be milling with a metal bit through metal nails. There are ways to do dowel laminated timber that are very efficient in the fabrication process — instead of screwing or nailing board after board, you just put all the boards up together, put them in a press, drill a hole all the way through and set a dowel through.

What are some of the top priorities of the ICC Tall Wood Buildings ad hoc committee today?

TSAY JACOBS: I don't speak for the committee, but it has several working groups looking at topics including structural, fire, definitions, heights and areas [to develop a code-change proposal that could change code and height allowances for some mass timber buildings]. We're checking right now what aspects of the code would require revision if a proposal to raise the heights and area limitations on wood construction came through. There are a number of changes in all four of those categories that would be required, so we're going through and finding out how different heights and areas and different exterior walls and shaft and stair cores being wood would impact the code or would require changes. [May 23] was the first day of fire testing of a two-story structure [under close observation by the committee]. There are going to be five tests that inform the code-writing process [for the 2021 International Building Code published in the fall of 2020]. Depending on how well the building performs in those five tests, the code will be developed to reflect the science and data that those tests gather.

T3 in Minneapolis
Michael Green Architecture

Code acceptance, supply availability and general interest in using mass-timber are all factors in the construction type's adoption. What's the likely order or priority of these factors to mainstream use of mass timber?

TSAY JACOBS: The code route is [the strongest driver]. People will start to ramp up right before it comes out [likely in 2021], and then there will be solid uptake within five years. After that, it'll be very obvious that the code allows us [to build tall wood buildings] and it is cost and schedule competitive and advantaged in some places. Within 10 years, production will greatly increase.

In the nearer term, the example of T3 is probably the best one I can point to. It's a large mass-timber building, but it's not a tall one. Right now, that is the best case because even though it may not have been cheaper to build than steel or concrete, the developer believed it could get a premium for the [wood] aesthetic when it leased out the space. The business case there is the way to get uptake in the current code climate or with the authority having jurisdiction, where there's a lot of aversion [to mass-timber] and there's a lot of testing required to prove a tall building. They could have made T3 out of light-frame, which would have been the cheapest thing to build, or steel or concrete, but they made it out of mass-timber because they knew they could get a premium. [Mass-timber] won out basically on aesthetics.

It takes a pretty big footprint, and maxing out the height limit of five to six stories, to see those gains. It also takes the right lot and zoning, etc., to even allow a building like that. In Minneapolis, the stars aligned. I think we'll see more of that.

If low-rise buildings are the opportunity for mass timber to build momentum now, what's the timeline for getting to taller mass-timber buildings?

TSAY JACOBS: The testing authorities want to see test reports demonstrating that the assemblies and the design are going to perform as well as Type I-A or Type I-B construction. There's a 12-story project in Portland, OR, that's going to be completed in a year or two, and that's the only tall one I know of [in the U.S.] that's going all the way. The only avenue at the moment is testing.

As soon as the code changes to allow tall wood buildings prescriptively, you won't have to get performance-based tests to do these buildings. You'll still see people testing listed assemblies here and there, but even a lot of that will be addressed prescriptively. The idea is that the code changes would be prescriptive in the way that would alleviate the need for lots of testing, which is why I don't think we will have to wait 40 years for 1,000 tests to have gone by. As soon as the code changes, you'll see that tall wood buildings are very easy to do without any testing if you're willing to not go crazy with your design.

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