STRUCTURAL ENGINEER

Study: Building model expand possibilities of wood as a structural material in mid- to high-rise buildings

April 2012 » Web Exclusive

By Michael Green; Eric Karsh

Wood has long been an attractive building material due to its competitive pricing, reduced environmental impact and versatility. However, structural engineers and architects designing with wood have historically been limited to low- to mid-rise structures. But there is an opportunity to expand the possibilities, specifically to introduce wood as an efficient solution for large-scale, tall buildings.

In the recently released "Case for Tall Buildings study," the authors of this article provided an in-depth look at new wood structural building systems that are the first significant challengers to concrete and steel since their introduction in skyscraper design more than a century ago. The introduction of this new building methodology is driven by the need to find safe, sustainable alternatives in the urban landscape. The proposed building model, dubbed FFTT (Finding the Forest Through the Trees), has significant potential to revolutionize the building industry through expanded use of wood as a core structural material in mid- to high-rise buildings.

The FFTT model

FFTT is a unique tilt-up system that effectively balloon-frames mass timber panels in a cost-effective and simple manner, allowing the construction of tall wood buildings, ranging from 10 to 30 stories. The FFTT system is a predominantly wood system with a solid-wood central elevator, stair core and wood floor slabs, with perimeter moment frames or interior shear walls for buildings exceeding 12 to 15 stories, depending on location.

The FFTT system is based on the strong column/weak beam structural concept, where "strong" columns consist of large solid engineered wood wall panel elements, linked together by "weak" but ductile structural steel beams embedded into the thickness of the wall panels. The link beam elements tie the wall panels together, providing the system with rigidity, while allowing control over the level of seismic forces during a severe seismic event. The system does this by providing plastic hinges and absorbing energy, much like a fuse limits the level of power that runs through an electrical system. Standard reinforced concrete is envisaged for the foundations and all below grade structures.

Mid- to high-rise buildings that use the FFTT structural concept can accommodate both office and residential uses.

FFTT is unique

Driven by the economic and practical realities of building in urban landscapes today, the FFTT system is adaptable to a variety of building types, scales and locations, and allows for the fast erection of simple and structurally sound buildings. The assembly concept of FFTT is intended to drive the cost of construction down and make wood solutions cost competitive with steel and concrete.

The successful implementation of the FFTT model is based on its simplicity. This design solution aims for a universal system of building that is easily understood and requires little training. In time, the design will increase the global market for wood products and result in an exportable building industry as the panels can be designed, engineered, pre-cut, pre-assembled and then flat packed to become an exportable building structural system.

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Dependable... affordable... easy to construct
The FFTT system has been engineered to address seismic requirements in high seismic zones such as Vancouver, B.C. The engineering has shown that in the case of a wood structure, wind loads often govern the design, rather than earthquake forces. This is notably due to the significantly lighter weight of a wood structure, compared to one made of concrete. An analysis of wind-induced vibrations will be required for the lighter timber towers.

Early tests also identified that solid wood panels perform very well in fire. When combined with modern fire suppression systems and compartmentalization, structures can be detailed to safely resist fire, eliminating the need for encapsulation and reducing building weight and cost, while showcasing the natural beauty of the exposed timber.

FFTT offers designers and architects options for using various mass timber products. By designing for a variety of options, we have worked to broaden the cost competitiveness of the marketplace. Each mass timber product has unique properties and may be ultimately chosen for architectural, as well as structural reasons.

In the construction of an FFTT building, timber elements are expected to be pre-fabricated to sizes designed to optimize speed and ease of construction. The header to panel connections will be simple and can be made on the ground to connect several panels together. These can then be "tilted up" several stories at a time.

Environmental impact
For more than a century, mid-rise and tall buildings around the globe have been built predominantly with concrete and steel. These two incumbent materials have been excellent choices and will continue to be important materials in future construction. The questions then arise: Why did we feel the need to introduce an alternative to concrete and steel and why now?

The answer, very simply, is climate change. The large carbon footprint and excessive energy consumption required for the production of current industry-standard materials have made a significant negative impact on the environment through greenhouse gas emissions. Unlike other building materials that deplete the earth's resources, wood is the only major building material that grows naturally and is renewable. Wood products are better for the environment than steel or concrete. They need less energy across their life cycle, are responsible for less air and water pollution, and have a smaller carbon footprint. The FFTT Mass Timber building system offers an exciting and innovative solution with possible long term benefits to the building sector, the timber industry and the fight against climate change.

The full "Case for Tall Buildings" report can be accessed here.

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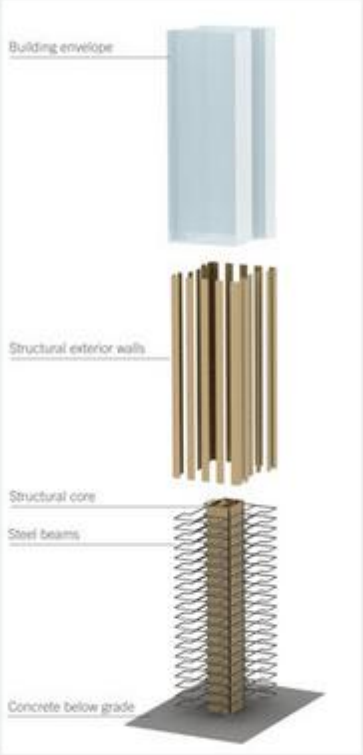
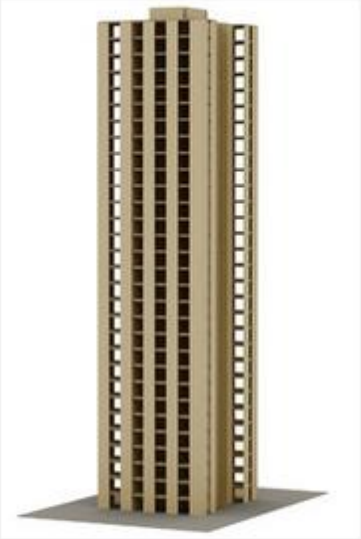
Option 1 - Up to 12 Storeys

Option 2 - Up to 20 Storeys

Option 3 - Up to 20 Storeys



Option 3 - Up to 20 Storeys



Option 4 - Up to 30 Storeys

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About the study's authors

Michael Green is a founding principal at Michael Green Architecture (MGA) in Vancouver. Recognized for his award winning buildings, public art, interiors, landscapes and urban environments, Green's reputation has led him to develop a wide range of projects from international airports and skyscrapers to Vancouver's Ronald McDonald House and modest but unique retail spaces and homes. His work extends around the globe including a current project for the Aga Khan Trust for Culture designing a sustainable community in the mountains of Central Asia. Green is dedicated to bringing attention to several of the challenges present in architecture today. The first is climate change and how the built environment is an enormous contributor to the factors damaging the very environment designers and architects are seeking to improve. The second is the reality that over the next 20 years, 3 billion people will need a new affordable home. In short, solving the world's massive shelter shortage with today's building approaches will ironically trigger further environmental turmoil. Green believes in championing the shift to new ways of building that will complement the intersection of man's greatest building challenges. MGA is a 14 person Architecture + Interior Design firm working on large and small projects in North America and around the world. Prior to MGA, Michael was a founding principal at McFarlane Green Biggar Architecture + Design (mgb) in Vancouver.

Originally from Québec, *Eric Karsh* began his consulting career in Ottawa in 1987 with Adjeleian Allen Rubeli Ltd, designers of the Toronto Skydome. Karsh has extensive experience in all common building materials, but since his arrival in British Columbia in 1993, has developed a unique expertise in timber engineering and construction. In 1998, Karsh co-founded the firm of Equilibrium Consulting Inc., which is now recognized internationally as a leader in the field of timber engineering, for work on projects such as the roof of the Raleigh-Durham Airport Expansion and the Art Gallery of Ontario Galleria Italia by Architect Frank Gehry. Over the last five years, Karsh has been actively involved in promoting solid wood construction as a viable, sustainable alternative to concrete construction. Karsh has engineered numerous innovative projects using various forms of solid wood construction, including Dowling Residence, the first all CLT building engineered in North America, and UBC's Earth System Sciences Building.

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