STRUCTURLAM
MASS TIMBER CORPORATION

Intelligence In Wood

Mass Timber Technical Guide

for CrossLam® CLT and GlulamPLUS®

CANADIAN VERSION

UBC Brock Commons - Tallwood House, Vancouver, BC, Canada

Art Gallery of Ontario, Toronto, ON, Canada

There's a Revolution Happening.

And Structurlam Is Leading the Way.

North America and timber construction have histories that are inseparable. From our forestry practices and manufacturing infrastructure to our model building codes and standards, building with wood is more deeply rooted here in North America than anywhere else on the planet.

As our structures grew larger and taller, wood became limited to stick-built construction. Today, all of that is changing, as wood is now at the forefront of an exciting, new construction technology with mass timber construction.

With the power to lock away carbon through the life span of a building, timber provides a natural and innovative alternative to steel and concrete. Proven, cost-effective and renewable, it's no wonder mass timber construction is quickly becoming the platform of choice for owners, architects, engineers and builders.

Structurlam is uniquely positioned to help make this revolution a reality. With nearly 60 years of experience as the industry's leader in innovating with wood, we're here to guide you to this next generation of building design and construction.

So, no matter what your project—whether you're looking to make a statement of beauty, technical leadership, function or environmental responsibility—Structurlam's mass timber building products are the answer.

Mica Heli-Ski Lodge, Mica, BC, Canada

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Note: Glulam is referenced throughout this guide as GlulamPLUS®. CLT is referenced as CrossLam® CLT.

UBC Earth Systems Science Building, Vancouver, BC, Canada

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Mass Timber Construction Is:

Economically Viable and Competitive

Compared to traditional steel and concrete, mass timber construction compresses your project schedule by moving much of the on-site labour to the factory. Once on-site, it's more about simple assembly rather than construction.

NOTE: With a portion of the reallocated cost of labour reflected in the mass timber cost of materials, it is important to compare the costs of the two systems at an installed-complete/structure stage of the project.

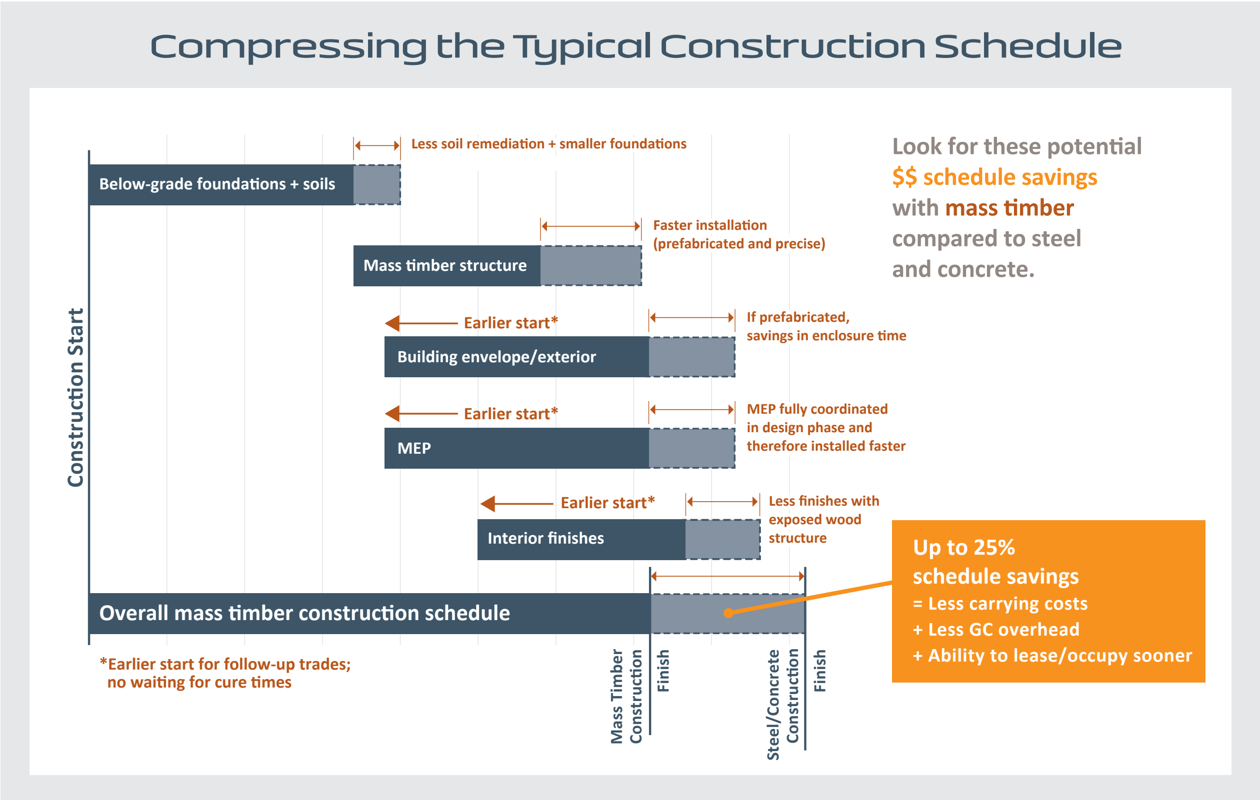
The cost benefits of mass timber construction can be summarized as follows:

REDUCED CONSTRUCTION CYCLE TIME

- As a fully integrated system supplier, Structurlam delivers your mass timber building system ready to assemble with all connecting hardware and accessories.
- When specified by the contractor, Structurlam components arrive on-site with all pick points identified, supporting a safe and efficient lift.
- When compared to traditional reinforced concrete construction practices where reinforcing steel is manually hand tied on-site, forms and falsework are constructed and concrete is poured and must be left to set to strengthen, mass timber solutions can accelerate production schedules by as much as 25%. (See graphic below.)
- As a part of the Structurlam Advantage (see pages 17–22), the construction schedule can be further compressed by coordinating the delivery schedule with the installation schedule.
- A compressed construction cycle also reduces the risk from delays that can occur through an extended cycle and the potential for resulting claims and back charges.

For a complete list of Structurlam Service Options, see page 22.

FIGURE 1: MASS TIMBER VS. STEEL/CONCRETE CONSTRUCTION SCHEDULE



Mass Timber Cost & Design Optimization Checklists, WoodWorks – Wood Products Council

REDUCTION IN SKILLED LABOUR REQUIRED

- With more skilled labourers retiring from construction trades than entering, availability of skilled labour is one of the biggest challenges in the industry today.
- Mass timber construction repositions a significant portion of the on-site skilled labour to permanent positions in manufacturing, significantly reducing the cost of labour on the project.

IMPROVED JOBSITE SAFETY PERFORMANCE

- Fewer jobsite labourers and a compressed cycle time both contribute to improvements in jobsite safety performance. This often results in lowered insurance rates and incurred costs due to claims and recordable incident investigations.

REDUCED FOUNDATION COSTS

- As a building material, mass timber components are up to 75% lighter than traditional reinforced concrete components required for the same project.

  With this reduction in the total building weight, mass timber construction systems require smaller and lighter foundations. This results in the following benefits:

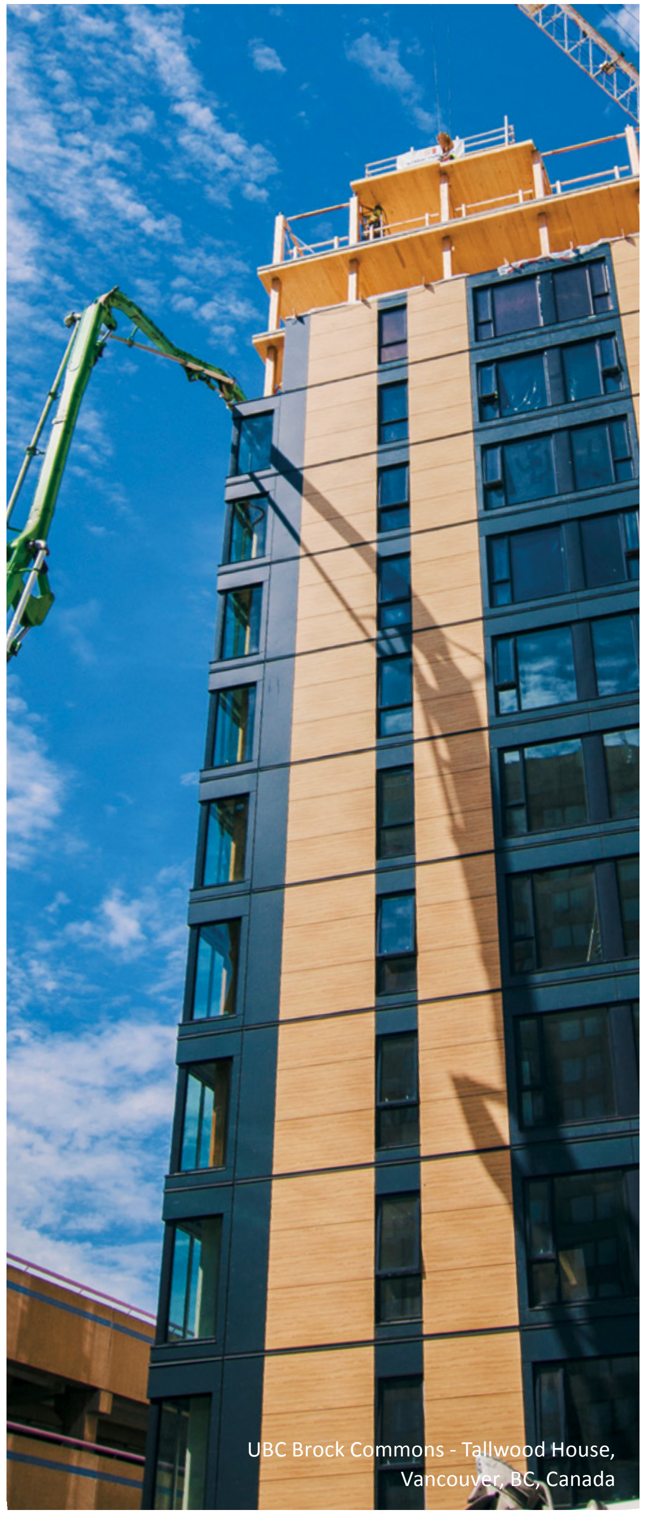
  › A cost savings to the project in reduced materials and labour required for footings and foundations

  › A solution for development in poor soil locations

  › More cost-effective seismic solutions

IMPROVED PROJECT ROI

- Cost of capital is materially reduced due to accelerated build schedule.



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Mass Timber Construction Is:

Code-Approved to North American Standards

The 2015 National Building Code of Canada (NBCC) permits cross laminated timber through CSA-O86 – Engineering Design in Wood when manufactured in accordance to the ANSI/APA PRG 320 Standard (for Performance Rated Cross Laminated Timber), and structural glued laminated timber (when manufactured in accordance to the CSA O122 – Structural Glued-Laminated Timber), along with mass timber construction building systems to be used in all buildings permitted to be of combustible construction.

Six storey buildings permitted to be of combustible construction (up from four storeys in the 2010 NBCC) were included into the 2015 NBCC for Group C (residential) and Group D (business and personal services) occupancies. See table 1 below.

TABLE 1: CANADIAN CODE REGULATIONS – UP TO 6 STOREYS

CODE	GROUP C – ARTICLE 3.2.2.50		GROUP D – ARTICLE 3.2.2.58	
BUILDING HEIGHT	No more than six storeys			
HEIGHT BETWEEN FIRST STOREY FLOOR AND UPPER-MOST FLOOR LEVEL	No more than 18 m (59')			
MAXIMUM BUILDING AREA PER BUILDING HEIGHT	STOREYS	BUILDING AREA	STOREYS	BUILDING AREA
	1	9,000 m²	1	8,000 m²
	2	4,500 m²	2	9,000 m²
	3	3,000 m²	3	6,000 m²
	4	2,250 m²	4	4,500 m²
	5	1,800 m²	5	3,600 m²
	6	1,500 m²	6	3,000 m²
FIRE RESISTANCE	- Floor assemblies: fire separations with no less than one-hour - Roof assemblies: no less than one-hour - Load bearing walls, columns and arches: rating not less than required for the supported assembly			

NOTE: Mixed uses, such as retail stores, shops and restaurants can be located on the first two storeys of these buildings.

TABLE 2: CANADIAN CODE REGULATIONS – UP TO 12 STOREYS

CODE	GROUP C	GROUP D
BUILDING HEIGHT	No more than 12 storeys	
HEIGHT BETWEEN FIRST STOREY FLOOR AND UPPER-MOST FLOOR LEVEL	No more than 42 m (138')	
MAXIMUM BUILDING AREA PER BUILDING HEIGHT	6,000 m²	7,200 m²
FIRE RESISTANCE	- Floor assemblies: fire separations with no less than two-hours - Load bearing walls, columns and arches: not less than required for the supported assembly	
EXPOSED MASS TIMBER WALLS AND CEILINGS	Limited area allowed	

NOTE: Mixed uses, such as retail stores, shops and restaurants can be located on the first through third storeys of these buildings.

A new construction type called **encapsulated mass timber construction (EMTC)** will be included in the upcoming 2020 NBCC, which will permit mass timber buildings up to 12 storeys for Group C and Group D occupancies. See table 2 above.

Manufacturers of mass timber components, cross laminated timber and glued laminated timber, certified in North America, adhere to the standards set forth as described above.

When considering product manufactured outside of North America, it should be noted that a limited number of offshore suppliers are certified to North American standards. As a result, it is imperative to consider more than the conversion of design stress properties. Key considerations that are upheld to the North American standards as referenced on pages 12 and 13.

DESIGN PROPERTY COMPATIBILITY

The design capacities published in ANSI/APA PRG 320-2019 and CSA O112:16 were derived analytically using the Canadian lumber properties published in CSA O86 – Engineering Design in Wood. Lumber from outside of North America has different characteristics, may not be recognized in CSA O86 and has published design values that are incompatible with those of North American lumber.

As a result, the design properties for mass timber products manufactured with foreign species lumber should be carefully examined for compatibility with the North American design standards.

Product Quality Assured

We are proud of our ongoing certification and adherence to the North American cross laminated timber and glued laminated timber standards referenced throughout this guide. GlulamPLUS® and CrossLam® CLT are certified to meet the requirements of Standard for Wood Products – Structural Glued Laminated Timber and Cross Laminated Timber (CLT) as described in CSA O122 and ANSI/APA PRG 320-2019.

These standards outline the quality control requirements required by CSA/ANSI and are verified by the APA – The Engineered Wood Association (www.apawood.org) through ongoing and monthly independent third-party inspection visits to Structurlam's manufacturing operations. For more information on destructive performance testing, see table 2 on page 65.

Further design considerations and local code approvals may be required when considering a foreign supply source, which can increase project timelines and cost. By adhering to these standards, Structurlam can assure a standard of quality to the professionals who specify our products. For more information, refer to pages 12 and 13.

Adhesives

STRUCTURLAM ADHESIVE SYSTEMS

The manufacturing of all code approved mass timber products to produce long length lamellas requires adhesives approved for face bond lamination and end to end finger jointing. Structurlam uses adhesives specific to our manufacturing processes that are certified to North American testing and manufacturing standards.

All adhesives must conform to CSA O122 and ASTM D7247 testing methods for fire, heat and moisture and must support ANSI manufacturing standards – see table 3 below.

The adhesive component is product thickness and depth dependent and comprises approximately 1% by weight of Structurlam's mass timber building products.

GLUE-BOND DURABILITY

The structural integrity of mass timber components depends upon the integrity of the glue-bond between the component lumber elements. This is true for the entire service life of these mass timber components. Conditions that can impact the glue-bond integrity are exposure to elevated heat (such as a fire event) and exposure to high moisture conditions for extended periods.

FIRE PERFORMANCE

The fire resistance of cross laminated timber and structural glued laminated timber is based on the certification requirements of the North American testing and manufacturing mass timber standards. These standards require rigorous adhesive heat durability testing to ensure mass timber product structural integrity under the most severe fire conditions.

EMISSIONS

Both Henkel and Hexion adhesives used by Structurlam for manufacturing our mass timber products are certified to UL GREENGUARD Gold. GREENGUARD Gold certified products are qualified to meet UL GREENGUARD standards for low chemical emissions into indoor air during product usage. These adhesives are formulated to meet or exceed all global emissions standards.

TABLE 3 : ADHESIVES FOR GLULAM AND CLT MASS TIMBER PRODUCTS

ADHESIVE APPLICATION	ADHESIVE BRAND	ADHESIVE TYPE	EMISSIONS CERTIFICATION	ADHESIVE PERFORMANCE TESTING		
				FULL SCALE FIRE TEST	HEAT DELAMINATION	MOISTURE DURABILITY
Finger Joints Crosslam CLT®/GlulamPLUS®	Hexion Cascomel™	Melamine Formaldehyde (MF)	UL GREENGUARD Gold	✓	✓	✓
Face Bond GlulamPLUS®	Hexion EcoBind™	Melamine Formaldehyde (MF)	UL GREENGUARD Gold	✓	✓	✓
Face Bond Crosslam CLT®	Henkel Loctite HB X PURBOND	Polyurethane (PUR)	UL GREENGUARD Gold	✓	✓	✓

North American Glulam Standards to be Met When Considering an Offshore Supplier

TABLE 4: GLULAM STANDARDS

SUMMARY OF DIFFERENCES IN FOREIGN GLULAM PROPERTIES, AFFECTED APPLICATIONS AND REQUIRED ACTIONS		
DIFFERENCES	**AFFECTED APPLICATIONS**	**ACTION NEEDED**
Design Value Compatibility	All glulam applications designed in accordance with a recognized standard	Glulam design properties must be derived in accordance with the North American building codes and design standards.
Volume Effect Adjustment	All glulam beam applications that exceed 130 mm (5-1/8") in width, 610 mm (24") in depth and 9.1 m (30') in length	Glulam bending strength must be adjusted for the volume effect required by the North American building codes and design standards.
Adhesives	All glulam applications that depend on glue-bond performance in elevated temperature events and high humidity	Glulam adhesives must meet CSA O112.9.
Fire Performance	All glulam applications that depend on glulam fire endurance	Glulam must be manufactured and certified to CSA O122 for fire performance.
Quality Assurance and Third-Party Certification	All glulam applications that depend on glulam quality	Glulam must be certified and inspected monthly by an accredited third-party certification or inspection agency.
Lower Bearing Capacity	All beam applications, such as: - End and intermediate reactions - Steel connections designed for Douglas fir or Southern Pine bearing	Engineer must reconfigure design of supporting structure with: - More bearing support area - Larger posts - Different connection details
Lower Shear Capacity	All shear-critical applications, such as: - Glulam supporting other beams on steel connections or point loads from the structure above - Cantilevered or continuous span beam over intermediate support - Very high load in a short span	Engineer must analyze shear-critical applications.
Lower Relative Density **Note: The relative density for European Spruce is 0.42 or less, while the specific gravity for Douglas fir is 0.49, respectively.**	When anything is connected to the beam, such as: - Floor and roof diaphragms with wood structural panels nailed directly to the beam - Steel connections designed for Douglas fir or Southern Pine beams - Lighting, sprinklers and HVAC	Engineer must consider: - Additional fasteners - Larger or custom steel connections - Reduced steel connection capacity - Redesigning all load-bearing connections—nails, bolts or screws—for reduced fastener capacity
Different Field Drilling and Notching Recommendations	All beam applications that require field drilling and notching for structural or non-structural (plumbing or electrical wiring) applications	Engineer must consider the applicability of the industry recommendations and their compatibility with other structural elements.

Reference: APA Form W500 - North American Structural Glued Laminated Timber vs. Imported Product, www.apawood.org

North American Cross Laminated Timber (CLT) Standards to be Met When Considering an Offshore Supplier

TABLE 5: CLT STANDARDS

SUMMARY OF DIFFERENCES IN FOREIGN CLT MANUFACTURING AND DESIGN PROPERTIES		
DIFFERENCES	**AFFECTED APPLICATIONS**	**ACTION NEEDED**
ANSI/APA PRG 320-2019 Requirements	All CLT panel and applications	CLT design properties must be derived in accordance with North American building codes and standards.
Design Properties	ALL CLT panels and applications designed in accordance to North American codes and standards	Lumber used in the manufacture of CLT panels may have different design characteristics. ANSI/APA PRG 320-2019 has derived capacities for typical North American species used in CLT production. Only wood species and grades recognized by the Canadian Lumber Standards Accreditation Board (CLSAB) can be used in manufacturing CLT under ANSI/APA PRG 320-2019. Foreign species will differ in certain aspects, including stiffness, bending and shear strength, bearing capacity and specific gravity.
Adhesives	All panel and CLT applications that depend on glue bond performance in elevated temperature events	All CLT panels produced in North America must be produced using adhesives that have passed CSA O112.9. In addition, CLT panels must be qualified with a full-scale compartment fire test per ANSI/APA PRG 320-2019 Annex B. Other adhesives may not provide adequate bonding in high-heat incidents, raising life safety issues.
Full-Scale CLT Qualification	All CLT panel grades and layup applications	ANSI/APA PRG 320-2019 requires full-scale bending and shear tests when qualifying CLT grades and layups to ensure the design values are justified. This is not required in any foreign countries.
Moisture Durability	All CLT panel applications designed to withstand moisture durability conditions	CLT panels must be evaluated for stringent moisture durability per ANSI/APA PRG 320-2019 including evaluation of vacuum-pressure soak tests.
Relative Density	Any lateral load analysis, bearing or connection design	Due to relative density differences between various wood species which can vary from 0.42 to 0.55, lateral load analysis must be evaluated in each specific case. This needs to occur whenever substituting alternate species for CLT panels to ensure the capacity of connectors and bearing capacity remains adequate for the structure in question. Lower relative density not only reduces connection properties, but can also significantly reduce the bearing capacity of the product. For these reasons, all of these evaluations must occur when considering alternate species.
Quality Assurance and Third-Party Certification	All CLT panels and applications that depend on quality CLT	ANSI/APA PRG 320-2019 requires regular inspection of manufacturing processes for CLT panels by an independent third-party inspection or product certification agency.

Reference: Form S500A - APA - North American CLT vs. Imported Product, www.apawood.org

Mass Timber Construction Is:

Architecturally Enabling

As humans, we have an inherent desire to be connected to nature and our environment. More and more, we're seeing projects embrace this connection to the natural world. This is especially true in corporate offices, where creating an appealing workspace is both a benefit and a competitive advantage. Mass timber is the perfect structural material for this biophilic approach to design. Mass timber construction delivers the warmth and beauty of wood while still lending itself to inviting designs such as soaring ceilings, organic shapes and open spaces. And whether the mass timber components are encapsulated, or you opt to highlight the natural allure of the wood, you create environments people want to be in and return to time and time again.

An Engineered Solution

Mass timber components, when manufactured in accordance with CSA O122 – Standard for Structural Glued-Laminated Timber and ANSI/APA PRG 320 Standard for Performance Rated Cross Laminated Timber, are recognized in CSA O86 as structurally rated components.

Design professionals employing mass timber construction can use the same engineering principles and standards with the same safety and code compliance recognition as are applied to materials such as steel and concrete. Mass timber embodies strength, resiliency and design ability expanse with the potential to reduce design time compared to other building selections.

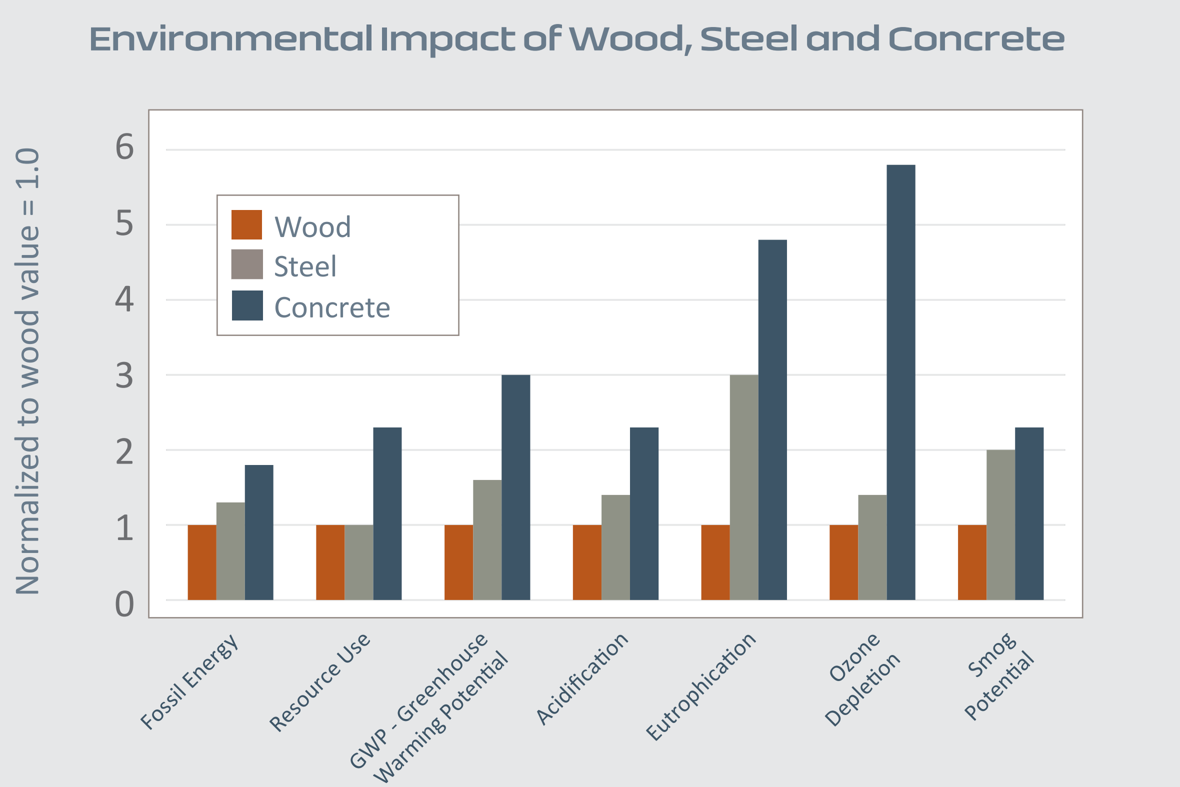
Shane Homes YMCA at Rocky Ridge, Calgary, AB, Canada

Environmentally Responsible

The United Nations states that two of the most compelling issues in the world today are shelter and climate change. Mass timber construction speaks to both.

- Wood as a building material is a renewable resource that can be regenerated through sustainable forestry practices. Structurlam uses only wood that is sustainably harvested, including FSC and SFI chain-of-custody certified.
- Harvested timber retains its carbon through the life of the building, while reforestation through replanting increases the carbon capture rate by as much as a factor of two times over the same acreage.
- Located within the timberlands it draws upon, Structurlam minimizes the transportation footprint required to produce mass timber components. This is most compelling when compared to importing competitive mass timber products or steel from offshore producers.
- Less energy is consumed in the production of mass timber components. By some estimates, wood conversion is as much as five times more efficient than cement for concrete and up to 20 times more energy efficient than the production of steel. (See graphic below.)
- As a choice, mass timber construction enables a virtuous cycle of capturing carbon from the atmosphere while supporting the forestry practices of responsible harvesting techniques and reforestation practices.

FIGURE 2:
NORMALIZED COMPARISON OF ENVIRONMENTAL IMPACTS OF WOOD, STEEL AND CONCRETE BUILDINGS



Three hypothetical buildings (wood, steel and concrete) of identical size and configuration are compared. In all cases, impacts are lower for the wood design.

Source: *Dovetail Partners using the Athena Eco-Calculator*

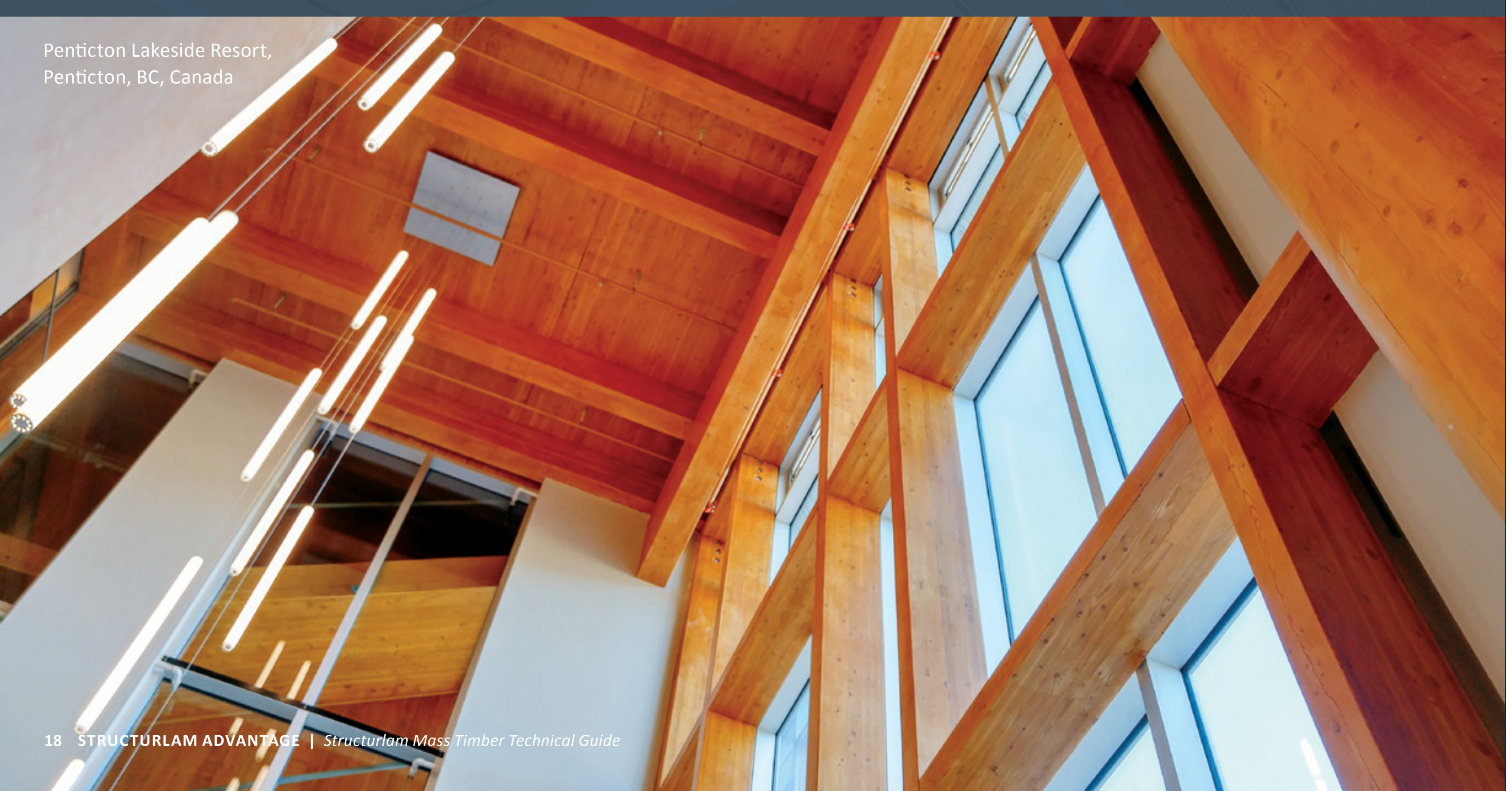
Telus Gardens, Vancouver, BC, Canada

The Structurlam Advantage

The Structurlam Brand Promise

When you choose Structurlam, you have the assurance you'll be working with:

- The North American **industry leader** in mass timber construction. Structurlam proudly supports and is certified to all North American building codes and manufacturing standards.
- **A partner in your design.** Structurlam utilizes 3D Building Information Modeling (BIM), including the design and specification of all related steel connections and hardware. We detail your vision down to the last screw, nut and bolt.
- **A partner with your project.** Structurlam plans the delivery of every component to maximize your construction schedule, right down to how each member is loaded on every truck.
- **A fully integrated supplier.** We supply CrossLam® cross laminated timber and GlulamPLUS® beams and columns mass timber building products, as well as custom steel connectors and related hardware.
- **A steward of the environment.** Structurlam uses wood that is sustainably harvested, including SFI and FSC chain-of-custody certified. Certificates for your project are available upon request.



Penticton Lakeside Resort,
Penticton, BC, Canada

The Structurlam Advantage

For nearly 60 years, our experience as a world-renowned fabricator of complex mass timber components has given us the deep knowledge and expertise to create beautifully designed systems of the highest quality. Our work process is designed to ensure 100% accountability through every step of your project, including:

Mass Timber Design Support
Our Mass Timber Specialists, supported by our internal customer and technical services teams, have amassed the experience of every project we have supplied. As a resource to your project design team, we will share our best practices with you to deliver the most cost-effective and creative solutions that meet or exceed the requirements of the U.S. building codes, as well as your own high expectations.

Budgeting
Our estimators and senior designers possess deep knowledge of mass timber design and engineering, including hardware and connections to provide you with accurate and timely SD-, DD- and CD-level budgets and quotations for your project.

Project Management
A dedicated project manager guides each Structurlam project through design, fabrication, delivery and installation, providing each customer with a single point of contact and the utmost in customer service.

Lumber Procurement
Through our strategic supply relationships, Structurlam has dedicated personnel to procure a wide range of commodity lumber and raw materials, as well as the related steel and system accessories, to protect against raw material price volatility. This mitigates the risk of price escalation for projects that have deferred production windows or prolonged production cycles.

Sustainability
Structurlam is a fully certified FSC manufacturer of mass timber building products and is committed to achieving the highest standards of sustainable construction requirements. Our mass timber building products can be supplied with SFI and FSC certification.

Fabrication Design and 3D Modeling
Following the building design process, our fabrication design team will create an exact 3D model of your project including all mass timber components with all steel and hardware connectors, right down to every nut, bolt and screw, including vital details such as holes, daps, slots, counter-bores and chamfers. This process allows us to envision potential construction issues long before arriving on the jobsite. Individual component shop drawings are then produced with exacting specifications as part of our quality control best practices.

Fabrication
From the 3D model, data is transferred electronically, directly to our state-of-the-art CNC fabrication machinery where components are reproduced to extreme precision (less than 3 mm (1/8")). No other manufacturer in North America can match our quality and precision on CLT and glulam building products.

Quality and Application Assurance
Structurlam maintains a rigorous Quality and Application Assurance program that meets or exceeds the standards set forth in the North American model building codes, throughout our process. Third-party inspected and verified, Structurlam delivers defect-free quality, the first time.

Codes and Standards Compliant
Structurlam CrossLam® CLT and GlulamPLUS® beams and columns meet the requirements set forth in the 2015 National Building Code of Canada (NBCC) and CSA O86:19 for Cross Laminated and Glued Laminated Timber and are manufactured in accordance with CSA O122 – Structural Glued-Laminated Timber.

Options – Adhesives, Finishes and Coatings
We offer a variety of options to enhance the aesthetic appeal of your GlulamPLUS® beams and columns, including two adhesives, three smooth finishes, three rustic finishes and a wide array of factory-applied coatings.

Packaging and Delivery
Secure arrival to the jobsite is the cornerstone of our delivery system. Depending on the job requirements, we factory install connectors and test-fit pieces to ensure smooth on-site assembly. GlulamPLUS® beams and columns are individually wrapped and sealed, corners are protected and additional packaging such as plywood sheathing is added when necessary. Please refer to page 92 for additional Care and Handling recommendations.

Coordinated Installation
Structurlam's experienced project management team will coordinate with the project installers to ensure safe and efficient on-site installation. The result is a building with optimized structural performance, rapid assembly and superior aesthetic appeal.

Our team takes pride in every project, from preliminary consultation and design through manufacturing, shipment and installation. We understand the many challenges of both design and construction and make it our primary goal to ensure that all processes run as smoothly as possible.

Superior Engineering for Superior Performance

STAGGERED MULTIPLE PIECE LAMINATION VS. BLOCK GLUED LAYUP METHODOLOGY

When manufacturing wide-section members, Structurlam utilizes a staggered multiple piece lamination technique as described in CSA O122, section 6.4.4.

In contrast, the block glued methodology, commonly used by foreign manufacturers, allows for narrower single-lamination components to be edge-glued along the face of the two beams to produce built-up wide-section components. These edge-laminated blocks create a continuous, vertical shear plane between the two edge-glued narrow beams and are not permitted in CSA O122.

The multiple piece layup where edge laminations are both staggered and face glued is a preferred methodology because it creates more diffused shear planes, better dimensional stability and increased homogenization of the lamstock in the glulam structural member.

Diffused Shear Planes: Foreign manufacturers commonly use a block glued methodology where narrower single-lam components are edge-glued to produce built-up wide components. This creates a continuous vertical shear plane between the two edge-glued components. In contrast, the multiple piece lamination technique creates noncontiguous vertical glue-line shear planes through the components.

Dimensional Stability: Based upon the same principle of an increased number of elements within the component, a staggered multiple piece lamination layup reduces the dimensional tendencies of any one element and can potentially increase the overall stability of the component. This can be most prominently realized in wider and deeper sections.

Increased Homogenization: Glulam beams and columns constructed through the staggered multiple piece lamination technique are composed of more individual elements than through a single lamination layup practice. This increased number of elements acts to further diffuse the impact of any one element on the resulting component and creates a more homogeneous construction.

STAGGERED MULTIPLE PIECE LAMINATION

- The staggered multiple piece lamination method creates a noncontiguous shear plane in the glulam member.
- This staggered layup does not rely on the glue line integrity to the same degree as the forces can be resisted by the overlapping laminations in shear.
- This staggered glulam composition method is implicitly safer, more robust and does not demand the same degree of quality control over the glue line integrity as the block glued lamination method.

BLOCK GLUED GLULAM

- The block glued glulam lamination method creates a contiguous vertical shear plane that relies on the glue-bond line integrity to transfer loads through the glulam member.
- In an asymmetric loading application, the load component must transfer across the glue line in shear to allow the glulam member to act as a compound unit.

FIGURE 1

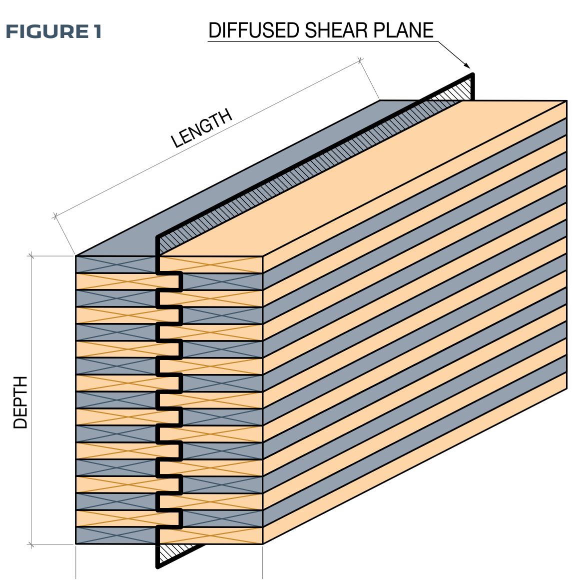
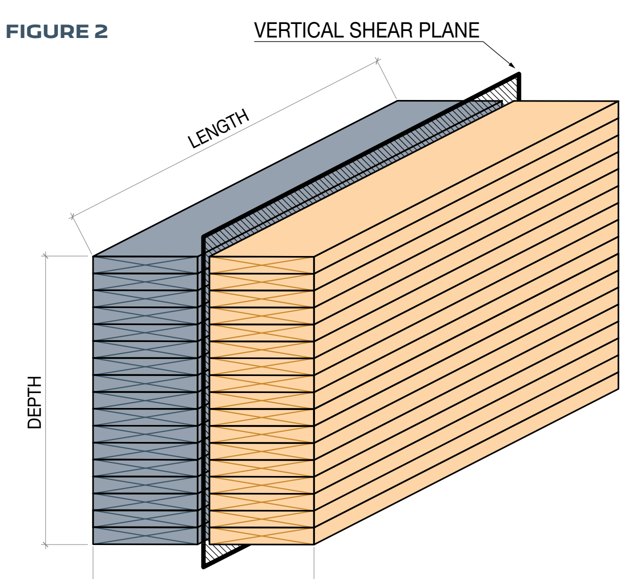


FIGURE 2



Nearly 60 years of North American Mass Timber Expertise

When you choose Structurlam, you'll be working with the North American industry leader in mass timber manufacturing and project delivery, a company at the forefront of the mass timber revolution. We proudly support and are certified to all North American building codes and manufacturing standards. Compared with the costs and logistics of working with overseas manufacturers, Structurlam is the right choice for simplified construction and sustainability.

We are also your partner in the process. We use 3D Building Information Modeling (BIM) to detail your vision down to the last screw, nut and bolt. Our sophisticated CNC machinery ensures extreme precision (less than 3.175 mm (1/8")) in all our fabrication. No other manufacturer in North America can match our quality and precision on CLT and glulam building products. We plan the delivery of every component to maximize your construction schedule, right down to how each member is loaded on every truck.

We work closely with you every step of the way. That's an advantage that overseas companies simply cannot achieve.

Get It Built to Order, Not Built to Ship

We don't live in a world of cookie-cutter buildings. Every project is unique, which may call for unique sizes of panels and unique shapes and lengths of beams. Working with Structurlam gives you tremendous control over the custom nature of your project.

Our advanced 3D modeling and precision machining create exactly the piece of engineered wood you need. Perhaps just as important is the fact that, because we're the local source for mass timber, we can deliver custom and oversized pieces much more readily than overseas manufacturers.

Foreign companies have to overcome the additional logistical burden of shipping large pieces overseas. This means that pieces need to fit in 2.44 m x 12.19 m (8' x 40') containers, compromising the scope of projects.

The cost of this shipping is obvious, but there are hidden costs as well. Chopping panels, beams and columns into sea container sizes often leads to increased installation costs. With Structurlam, we deliver products ready to install, loaded in order of assembly to speed things along.

It's one more way that makes local sourcing a smart choice.

Structurlam Manufacturing Facility, Okanagan Falls, BC, Canada

As a Manufacturer, Structurlam Delivers

Defect-free quality, the first time, every time. Structurlam utilizes state-of-the-art CNC robotics, along with a rigorous Quality and Product Application Assurance program throughout our process, from 3D modeling and inline lumber testing to test-fitting all component connections, ensuring what is delivered to the jobsite matches precisely with the 3D model created in our design center.

Our state-of-the-art scheduling system allows for your job to be delivered in full, on time and in spec. This will take place when milestone-based scheduling is adhered to, allowing for production to meet your expected deliveries.

Service Options

Structurlam offers a range of design and fabrication service levels, each incorporating various elements of the Structurlam Advantage. The service options range from complete structural engineering and project design to simple supply of your approved shop drawings, thus ensuring your needs, preferences and budgets are met. These service levels include:

ENGINEERING DESIGN AND SUPPLY

- Respect the architect's design intent
- Provide specialty engineering
- Complete detailing and drafting services of mass timber system components (including all steel connections and hardware)
- Supply of all mass timber system components (including all steel connections and hardware) per Structurlam shop drawings

DESIGN FOR MANUFACTURING AND ASSEMBLY (DfMA)

- Assist the EOR and architect with achieving cost optimization
- Complete detailing and drafting services (steel connections and hardware)
- Supply of mass timber components per Structurlam shop drawings

TRADITIONAL SUPPLY

- Complete detailing and drafting services (steel connections and hardware)
- Supply of all mass timber components per Structurlam shop drawings

FABRICATION ONLY

- Supply of mass timber components per single piece shop drawing or fully detailed 3D model

We believe that Structurlam is uniquely positioned to meet even the most challenging project requirements. We are confident that you will find our decades of North American experience and expertise worthy of further discussion.

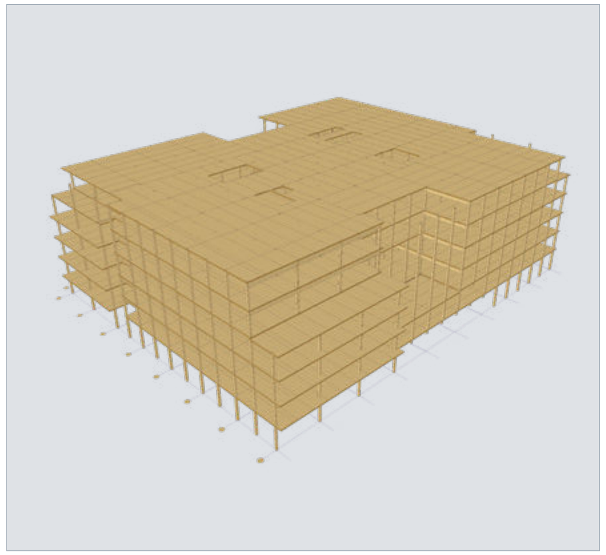
Mass Timber Design Process

Mass Timber Design Process

Once you've determined mass timber construction is your building approach and chosen Structurlam as your supply partner, we recommend the following series of steps and decisions to help guide your progression forward.

1	Determine standard grid pattern(s) for your design (recommended grid patterns for each mass timber system can be found on pages 28, 33 and 36 of this guide).
2	Select a mass timber building system for your project (see Mass Timber Building Systems starting on page 25 for a description of popular mass timber systems and recommendations for building typology).
3	Consider each design element (fire performance, acoustics and sound transmission, vibration control, etc.) through the Design Considerations section in the guide (pages 41–60) and the effect each consideration may have on member sizing.
4	Using the engineering design properties provided in the guide for CrossLam® CLT (see pages 61–76) and GlulamPLUS® beams and columns (see pages 77–91), determine preliminary member sizing for individual grid assemblies for the load and applicable code requirements of your project.
5	As you develop a working design solution, your Structurlam Mass Timber Specialist will work with you to complete your design, including grid layout and member sizing and positioning, as well as to develop a preliminary budget for your project. Feel free to contact your Structurlam Mass Timber Specialist at any time during the process.

As always, we're here to assist. Regardless of what level you ultimately work with us—whether Design, Supply, Fabrication Only or any stage in between—we recommend you engage one of our team of Mass Timber Specialists as early in the process as possible.



Mass Timber Building Systems

Post and Panel System

Post and Panel is a common type of mass timber structural system made up of CrossLam® CLT floor panels resting directly above GlulamPLUS® columns. This system does not use any beams or secondary supporting members for the CrossLam® CLT panels. The panels are designed to work in a full two-way span system point-supported on bearing columns.

This system is made up of a series of typical grids, allowing for the simple design of open concept living and workspaces. It's ideal for building types in which a regularly repeating grid pattern can be established throughout the structure. These structures include hotels, dormitories or micro apartments and can be used effectively in both hybrid material systems as well as full timber-based structures.

Benefits

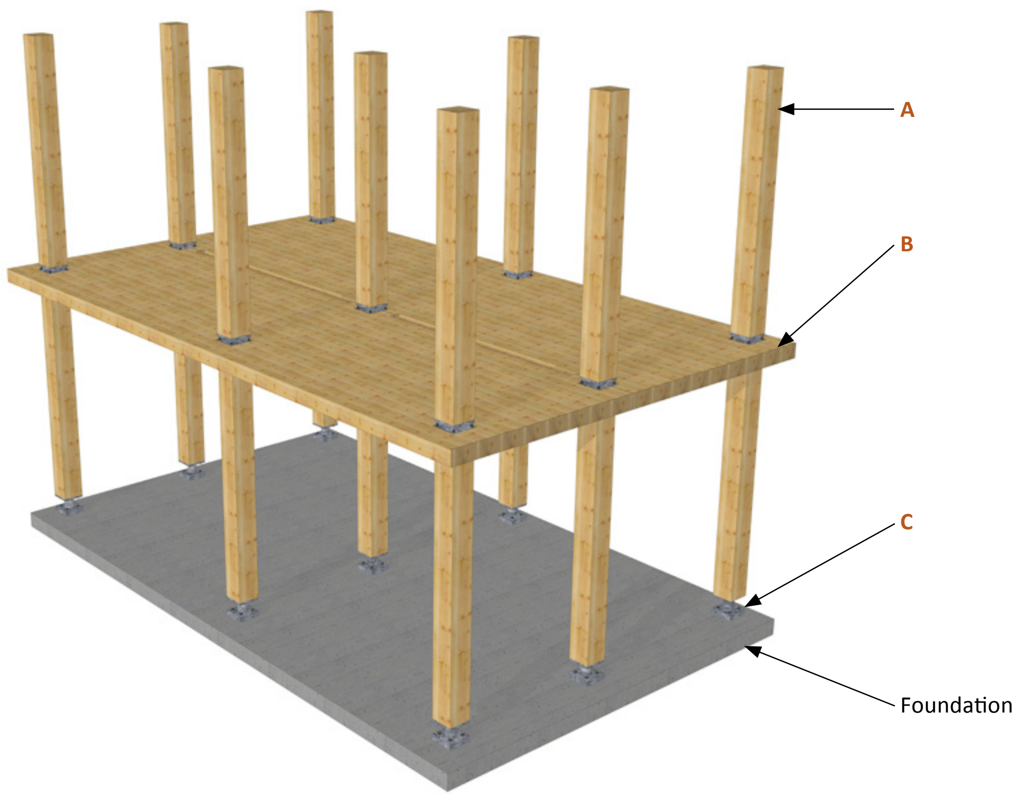
- The open and clear head heights of the Post and Panel System allow easy routing of mechanical, electrical and plumbing (MEP) systems.
- Connection design is typically less complex than other systems, making it ideal for fast, efficient and safe mass timber construction (see "Connections" on pages 42–53 under "Mass Timber Design Considerations" for additional information).

System Components

The Post and Panel System is made up of the following components:

A	GlulamPLUS® Columns
B	CrossLam® CLT Panels
C	Steel Connectors/Fasteners (screws, caps, etc.)

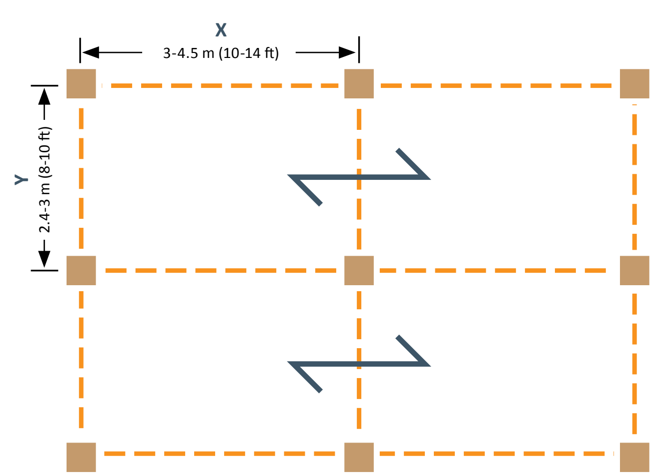
FIGURE 1: POST AND PANEL SYSTEM



Grid Patterns

The figure to the right shows the typical grid sizes used for Post and Panel mass timber building systems. The optimal grid sizes for this type of system are 2.4-3 m (7'-10.5"-9'-10.5") wide since this maximizes the utilization of CrossLam® CLT by reducing material costs and waste. Other sizes can be used; please consult with your Structurlam Mass Timber Specialist on efficiencies related to alternative patterns. Due to the nature of pressing CrossLam® CLT, the maximum length of panel that can be pressed is 12.19 m (40'), and the maximum width that can be pressed is 2.4 m (7'-10.5") and 3 m (9'-10.5"). This results in grid layouts that are ideal for hotels, multifamily and student- or senior-living housing and facilities.

FIGURE 2: TYPICAL POST AND PANEL SYSTEM GRIDS



MEP Routing

As a result of the open and clear head heights of the Post and Panel system, routing mechanical, electrical and plumbing (MEP) systems along ceiling lines is recommended. This is particularly convenient where drop ceilings will be incorporated in the design where MEP systems can be concealed above the finished ceiling.

Building Typology

IDEAL FOR

- Hotels
- Dormitories
- Multifamily Residential
- Senior Housing
- Industrial

UBC Brock Commons - Tallwood House, Vancouver, BC, Canada

Post-Beam-Panel System

The Post-Beam-Panel System is composed of CrossLam® CLT floor panels bearing on a system of GlulamPLUS® beams and columns. The beams and columns form the vertical load-bearing structure of the building. Connecting the CrossLam® CLT panels completes the structural system and creates the platform for subsequent floors. Its principles can be used in both hybrid material and full timber-based structures.

The Post-Beam-Panel System allows for more flexibility in the grid pattern of the design, making the system well suited for projects that feature open floor plans and work concepts, such as corporate offices, high-end residential, multifamily and commercial buildings, government and other public access structures.

Benefits

- Allows for open floor plans and design concepts.
- Left exposed, GlulamPLUS® beams and columns and CrossLam® CLT panels add high architectural appeal.
- No additional timber construction education required.

First Tech Credit Union, Hillsboro, OR, USA

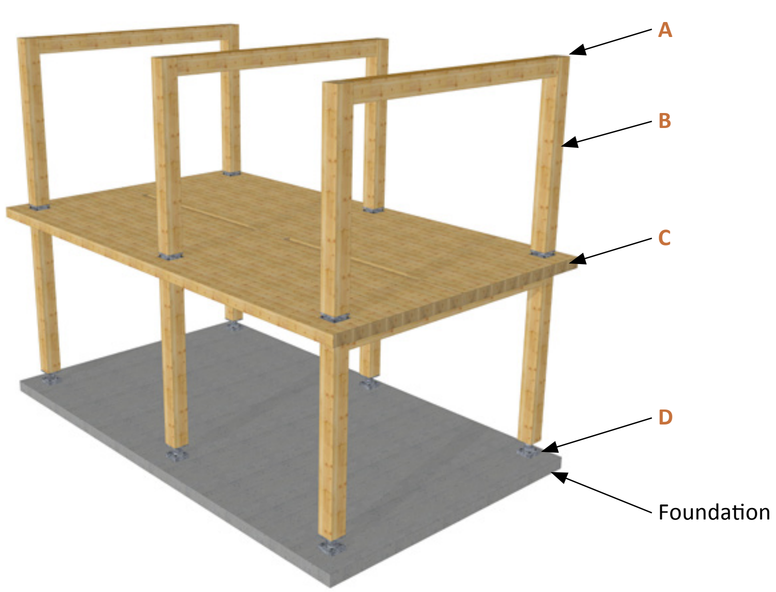
System Components

This system is made up of the following components:

A	GlulamPLUS® Beams
B	GlulamPLUS® Columns
C	CrossLam® CLT Panels
D	Steel Connectors/Fasteners (screws, caps, etc.)

All are prefabricated to provide the highest degree of accuracy and to simplify and accelerate construction on-site.

FIGURE 1: POST-BEAM-PANEL SYSTEM



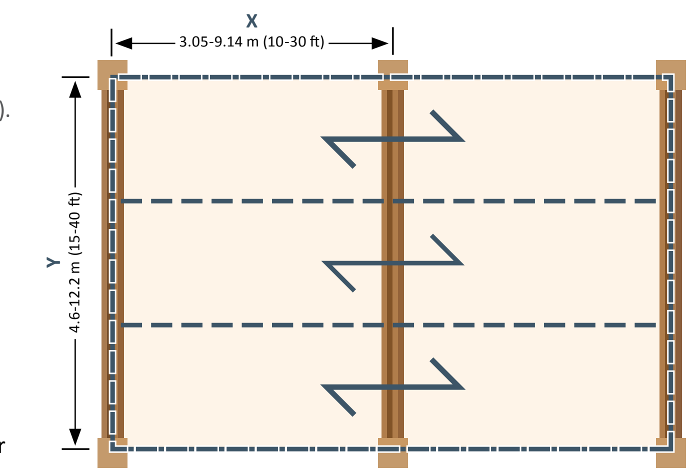
Grid Patterns

TYPICAL GRIDS

The figure to the right shows typical grid sizes used for Post-Beam-Panel mass timber building systems. Due to the nature of pressing CrossLam® CLT, the maximum length of panel that can be pressed is 12.19 m (40'), and the maximum width that can be pressed is 2.4 m (7'-10.5") and 3 m (9'-10.5").

The use of augmented grids can create impressive structural efficiencies. An example would be a 9.1 m (30') primary beam span in the Y direction and 4.5 m (15') bay spacing in the X direction. Located on exterior bays of the building, this produces large functional spaces.

FIGURE 2: TYPICAL POST-BEAM-PANEL SYSTEM GRIDS



MEP Routing

Depending on the degree of encapsulation of the mass timber components as required by code (often determined by fire performance considerations) or by architectural preference, routing for mechanical, electrical and plumbing (MEP) systems can be located within false ceilings, walls or floors; or in the case where the mass timber components will be left exposed for architectural effect, incorporated into the design as the designer best determines.

Building Typology

IDEAL FOR

- Multi-story Residential
- Office Buildings
- Corporate Headquarters and Campuses
- Industrial Buildings
- Large Assembly Halls

Carbon12, Portland, OR, USA

Virtuoso - Westbrook Village, by Adera Development Corporation, Vancouver, BC, Canada

Virtuoso - Westbrook Village, by Adera Development Corporation, Vancouver, BC, Canada
Photo credit: Seagate Mass Timber, Inc.

Hybrid Light-Frame System

This system is a hybrid between typical light-frame (wood or steel) and mass timber construction. Commonly, only the shear walls and horizontal structure (floor and roof) are constructed using CrossLam® CLT, while the rest of the structure utilizes traditional light-frame construction principles.

This system is generally used for multifamily residential structures. When off-site prefabricated wall panel systems are used, benefits of an accelerated construction schedule can be realized. This system also allows for added flexibility in floor plan design and layout.

Benefits

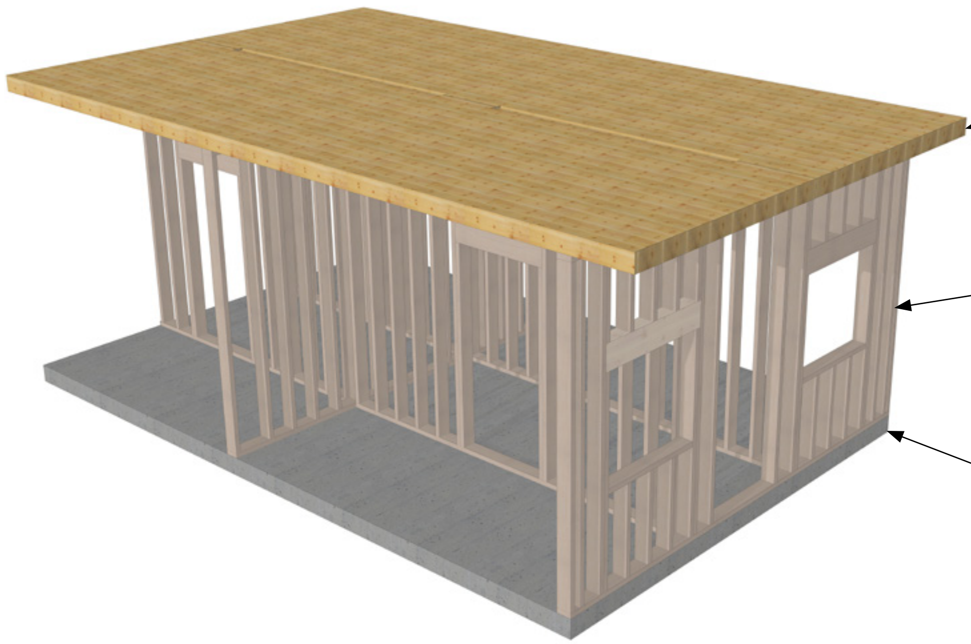
- The Hybrid Light-Frame System delivers improved construction cycle time over conventional light-frame systems.
- As a hybrid system, it's also a popular transitional system for builders more familiar with traditional building techniques.
- MEP infrastructure can be installed within the wall assembly.
- CrossLam® CLT horizontal panels improve lateral (seismic and wind) capacity and design performance as compared to traditional light-frame construction.
- Downstream trades for MEP can adhere directly to the underside of CLT, accelerating installation timelines.
- Solid CLT floor plates create a fire block between levels, enhancing fire safety from traditional light-frame systems.

System Components

The Hybrid Light-Frame System is made up of the following components:

A	CrossLam® CLT (floor, shaft walls or roof)
B	Light-frame walls (wood or steel)

FIGURE 1: HYBRID LIGHT-FRAME SYSTEM



Grid Patterns

While utilizing traditional light-framing materials for walls allows for greater flexibility in vertical load transfer, designers should still consider a CLT floor panel size that is optimal to the manufacturers' production capabilities. Standard hybrid light-frame projects vary in open spans from 3.0 m-4.3 m (10'-14'). Large spans often require a dropped beam to remain economically competitive with light-frame systems.

MEP Routing

With traditional light-framed walls, designers often choose to incorporate mechanical, electrical and plumbing (MEP) systems within walls. MEP can also be attached directly to the underside of the CLT panels, simplifying routing installation.

Building Typology

- Multifamily residential
- Conventional non-residential up to six storeys (offices, hotels, motels, dormitories)

Virtuoso - Westbrook Village, by Adera Development Corporation, Vancouver, BC, Canada
Photo credit: Seagate Mass Timber, Inc.

Mass Timber System Selection Chart

TABLE 1:
GLULAMPLUS® BEAMS AND COLUMNS
CROSSLAM® CLT PANELS

SYSTEM	DESCRIPTION	TYPICAL OCCUPANCIES	# OF BUILDING STOREYS	MIN SPAN CLT	MAX SPAN CLT	TYPICAL PANEL THICKNESSES mm (in)
POST AND PANEL	Supported CLT panel on glulam columns similar to a concrete slab building. Limited to CLT production sizes and panel strength limitations. Best used in encapsulated scenarios.	Hotel Dormitories Micro Apartments	6 to 18	2.4 m (8')	4.2 m (14')	175 (6.88) 245 (9.72)
POST-BEAM-PANEL	Most common and generic system similar to traditional timber frame construction augments with mass timber panel systems and modern connections for a smooth and reliable performance.	Office Residential	1 to 18	3.6 m (12')	12.1 m (20')	139 (5.5) 175 (6.88) 191 (7.58)
POST, BEAM, PURLIN, PANEL	Similar to a Post-Beam-Panel System; however, it includes an extra set of purlins to further break up the span. The system works well with large grid sizes or one-hour fire ratings and thin panels.	Office Residential	1 to 18	2.4 m (8')	4.8 m (16')	87 (3.43) 105 (4.13) 139 (5.5) 175 (6.88)
HYBRID LIGHT-FRAME CLT	Traditional light-frame wood walls are used with 2x4s, 2x6s or steel studs in the wall layout. CLT floor panels are placed on top of the wall stud systems in a platform framing approach. This yields significant installation time savings for the project. Downstream trades also realize a faster installation process with CLT floor plates as opposed to traditional methods.	Multifamily Residential Low Rise Small Office	1 to 6		4 m (13') 5 m (16')	87 (3.43) 105 (4.13) 139 (5.5) 175 (6.88)
HYBRID STEEL FRAME CLT	Structural steel gravity and lateral frames are covered with CLT decking solutions. Not only does this greatly reduce the project's carbon footprint, but it can also lead to beautiful aesthetic finishes and installation time savings on-site.	Office Public Buildings Post Disaster Status	1 to 18	2.4 m (8')	6 m (20')	87 (3.43) 105 (4.13) 139 (5.5) 175 (6.88) 191 (7.58) 245 (9.72)
CLT TILT-UP	These projects use CLT as a simple, quick kit of parts. CLT is used for gravity load, lateral and floor plate systems. By using a one-stop supplier, the project is quickly coordinated and installed for the perfect fit on-site. These projects can quickly be designed and delivered.	Industrial Tilt-Up Remote Location Post Disaster Status	1 to 4		6 m (20')	105 (4.13) 139 (5.5) 175 (6.88) 191 (7.58) 245 (9.72)
BOUTIQUE BUILDINGS	Unique structures with free-form systems and dynamic components. No two parts are the same, and the architecturally exposed mass timber often results in award-winning designs.	Public Buildings	1 to 4		6 m (20')	87 (3.43) 105 (4.13) 139 (5.5) 175 (6.88) 191 (7.58) 245 (9.72) 315 (12.5)

SYSTEM	RECOMMENDED GRID X (beams)	RECOMMENDED GRID Y (purlins/panel)	FIRE RESISTANCE	MEP	ACOUSTICS	VALUE PROPOSITION
POST AND PANEL	2.44 m-3.05 m (8'-10')	3.05 m-4.27 m (10'-14')	2 hr encapsulated	Surface Mounted MEP collides with nothing	Requires additional build floor system or dropped ceiling	Quick speed of installation and MEP simple layout fastening
POST-BEAM-PANEL	3.05 m-9.14 m (10'-30')	4.57 m-12.19 m (15'-40')	1-2 hr exposed 2+ hr encapsulated	Raised Access Floor Dropped Ceiling Surface Mounted MEP collides with beams in one direction only	Requires additional build floor system or dropped ceiling	Mass timber kits of parts, quick install, amazing performance and aesthetics, cost competitive
POST, BEAM, PURLIN, PANEL	6.1 m-9.14 m (20'-30')	6.1 m-9.14 m (20'-30')	1 hr exposed 2+ hr encapsulated	Raised Access Floor Dropped Ceiling Surface Mounted MEP collides with beams and purlins	Requires additional build floor system or dropped ceiling	Mass timber kits of parts, quick install, amazing performance and aesthetics, cost competitive
HYBRID LIGHT-FRAME CLT	3.05 m-9.14 m (10'-30')	3.05 m-4.57 m (10'-15')	1 hr exposed 2+ hr encapsulated	Surface Mounted MEP collides with nothing	Requires additional build floor system or dropped ceiling	Speed of installation of higher-quality performance product, can create overall cost savings in tight labour markets
HYBRID STEEL FRAME CLT	9.14 m (30')	9.14 m (30')	1-2 hr exposed 2+ hr encapsulated	Surface Mounted MEP collides with steel frame, or use raised access floor	Requires additional build floor system or dropped ceiling	Good for teams with low mass timber experience, green footprint, ease of install, ease of design
CLT TILT-UP	undefined	undefined	1-2 hr exposed 2+ hr encapsulated	Dependent on system design	Requires additional build floor system or dropped ceiling	Quick installation, single supplier, coordinated kit of parts easy for remote installation
BOUTIQUE BUILDINGS	undefined	undefined	1-2 hr exposed	Dependent on system design	Requires additional build floor system or dropped ceiling	Beautiful, customized, award-winning buildings

Mass Timber Design Considerations

Connections

Fire Performance

Acoustic Performance

Thermal and Energy Performance

Deflection

Design Layout

Vibration Control

Mass Timber Construction Connection Details

Structurlam can supply all connecting steel components and related hardware. All notches, slots, grooves, holes and connecting details are prefabricated by Structurlam. All members are either preassembled or test-fit prior to delivery to minimize erection issues in the field and maximize the efficiency gains from Structurlam mass timber systems.

The following sections show typical connection details used in mass timber construction systems for CrossLam® CLT and GlulamPLUS® beams and columns.

Cross Laminated Timber (CLT) Connections

CLT Panel to Panel Connecting System

FIGURE 1: CLT BUTT JOINT CONNECTION IN SHEAR

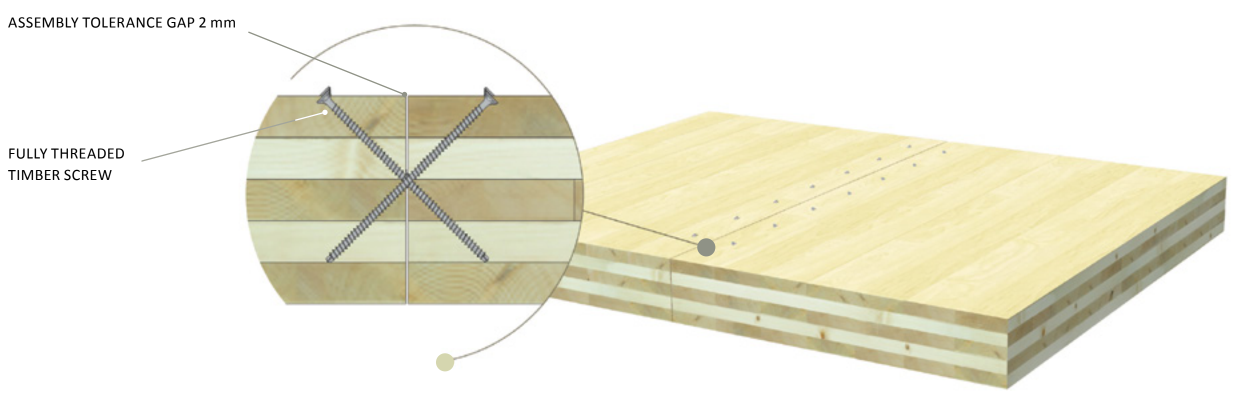
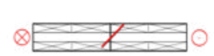
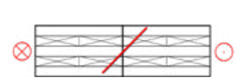
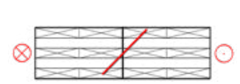


TABLE 1: FACTORED LATERAL RESISTANCES FOR CLT BUTT JOINTS LOADED IN SHEAR

PANEL & JOINT CONFIGURATION				ASSY FASTENER OPTIONS	FACTORED RESISTANCES (N)	MINIMUM SPACING IN A ROW (mm)
LOADING			PANEL SERIES THICKNESS (mm)			
3-PLY	$Z_{//}$		105	VG Cyl 6 x 140	660	25
	$Z_{\perp}$			VG Cyl 6 x 140	460	
5-PLY	$Z_{//}$		175	VG CSK 8 x 220	1,170	32
				VG CSK 10 x 220	1,720	40
	$Z_{\perp}$		175	VG CSK 8 x 220	820	32
				VG CSK 10 x 220	1,160	40

Notes:

1. *For complete data, please refer to the **MTC Solutions' "Mass Timber Connections Design Guide,"** downloadable on **MTC Solutions' website**.*
2. *Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the **MTC Solutions' "Mass Timber Connections Design Guide"** and the CSA O86:19.*
3. *The table contains factored lateral resistances (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed factored resistances are valid for dry service conditions only, where K_{sf}=1.*
5. *Fasteners are installed at a 45° angle intersecting the shear plane at half the panel thickness.*
6. *The angle between force and fastener axis is 90°.*
7. *$Z_{//}$ Angle between loading direction and wood grain in the shear plane Θ = 0°.*
   $Z_{\perp}$ Angle between loading direction and wood grain in the shear plane Θ = 90°.
8. *Adjustment for panel edge loading of CLT shall be considered, following CSA O86-19 clause 12.6.5.2.*

Source: *MTC Solutions, mtcsolutions.com*

FIGURE 2: CLT SPLINE CONNECTION IN SHEAR

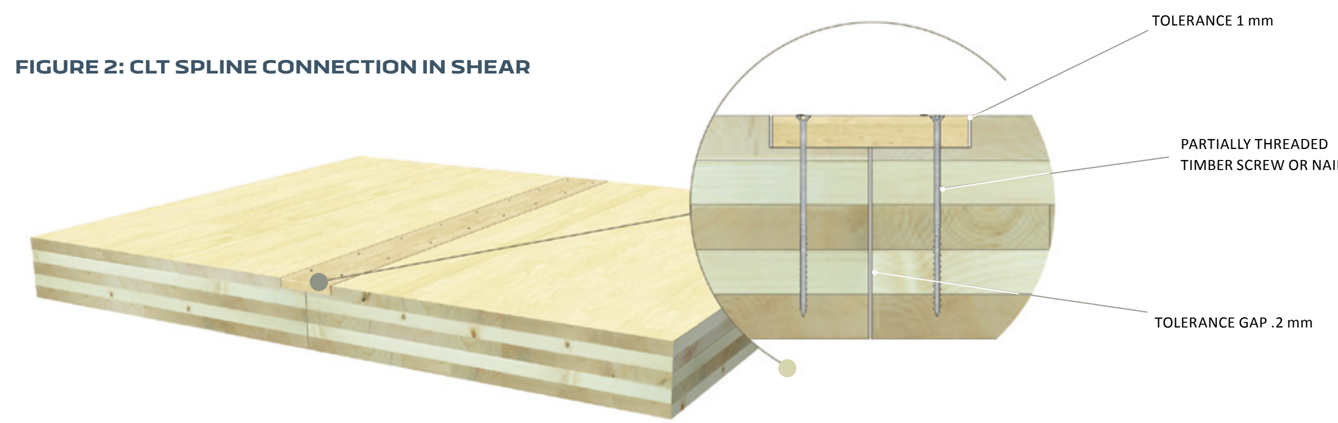
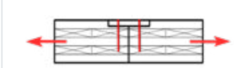
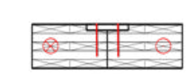


TABLE 2: FACTORED LATERAL RESISTANCES FOR CLT SURFACE SPLINE JOINTS LOADED IN SHEAR

PANEL & JOINT CONFIGURATION					ASSY FASTENER OPTIONS	FACTORED RESISTANCES (N)	MINIMUM SPACING IN A ROW (mm)
LOADING			SPLINE THICKNESS (mm)	PANEL SERIES THICKNESS (mm)			
3-PLY	$Z_{//}$	 	19.05	87	Eco 6 x 70	630	90
				105	Eco 8 x 90	1,040	120
			25.4	105	Eco 8 x 90	1,050	120
5-PLY	$Z_{//}$	 	25.4	175	Eco 10 x 120	1,610	150

Notes:

1. *For complete data, please refer to the **MTC Solutions' "Mass Timber Connections Design Guide,"** downloadable on **MTC Solutions' website**.*
2. *Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the **MTC Solutions' "Mass Timber Connections Design Guide"** and the CSA O86:19.*
3. *The table contains factored lateral resistances (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed factored resistances are valid for dry service conditions only, where K_{sf}=1.*
5. *Fasteners are installed at a 90° angle, intersecting the shear plane in the CLT panel at a depth equal to the spline thickness.*
6. *The angle between the force and the fastener axis is 90°.*
7. *Factored lateral resistances may be applied to parallel and perpendicular loading toward the panel joint considering grain directions and minimum end and edge distance requirements.*
8. *$Z_{//}$ Angle between loading direction and wood grain in the shear plane Θ = 0°.*

Source: *MTC Solutions, mtcsolutions.com*

CLT Lap Joint Connection System

FIGURE 3: CLT LAP JOINT CONNECTION IN SHEAR

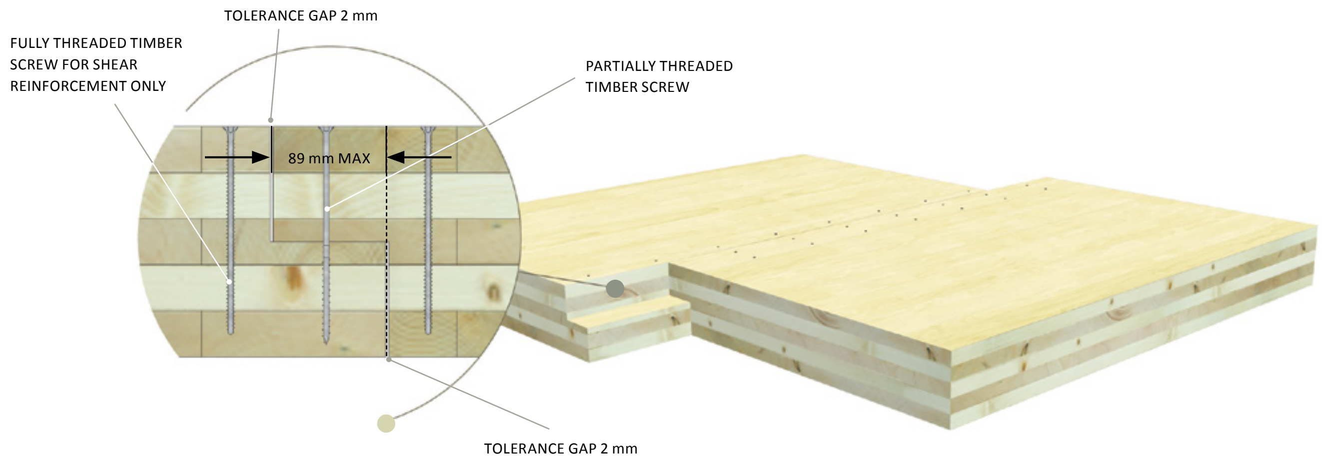


TABLE 3: FACTORED LATERAL RESISTANCES FOR CLT LAP JOINTS LOADED IN SHEAR

PANEL & JOINT CONFIGURATION			ASSY FASTENER OPTIONS	FACTORED RESISTANCES (N)	MINIMUM SPACING IN A ROW (mm)
	LOADING	PANEL SERIES THICKNESS (mm)			
3-PLY	$Z_{//}$	87	Eco 6 x 80	610	25
		105	Eco 6 x 90	670	
		105	Eco 8 x 100	970	32
	$Z_{\perp}$	87	Eco 6 x 80	300	25
		105	Eco 6 x 90	350	
		105	Eco 8 x 100	480	32
5-PLY	$Z_{//}$	139	Eco 6 x 120	870	25
		175	Eco 8 x 160	1,570	32
			Eco 10 x 160	2,100	40

Notes:

1. *For complete data, please refer to the* ***MTC Solutions' "Mass Timber Connections Design Guide,"*** *downloadable on* ***MTC Solutions' website****.*
2. *Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the* ***MTC Solutions' "Mass Timber Connections Design Guide"*** *and the CSA O86:19.*
3. *The table contains factored lateral resistances (Z) per ASSY fasteners conforming to the connection geometry and loading conditions described.*
4. *Listed factored resistances are valid for dry service conditions only, where K_{sf}=1.*
5. *Fasteners are installed at an angle intersecting the shear plane at half the panel thickness.*
6. *The angle between force and fastener axis is 90°.*
7. *Factored lateral resistances may be applied to parallel and perpendicular loading toward the panel joint considering grain directions and minimum end and edge distance requirements.*
8. $Z_{//}$ *Angle between loading direction and wood grain in the shear plane ϴ = 0°.*
   $Z_{\perp}$ *Angle between loading direction and wood grain in the shear plane ϴ = 90°.*

Source: *MTC Solutions, mtcsolutions.com*

CLT Panel to Beam Connecting System

FIGURE 4: CLT PANEL TO BEAM CONNECTION IN SHEAR

TABLE 4: FACTORED LATERAL RESISTANCES FOR CLT PANEL TO BEAM CONNECTIONS IN SHEAR

CLT PANEL & BEAM CONFIGURATION				ASSY FASTENER OPTIONS	FACTORED RESISTANCES (N)	MINIMUM SPACING IN A ROW (mm)
	BEAM TYPE	LOADING	PANEL SERIES THICKNESS (mm)			
3-PLY	Dfir (0.50)	$Z_{//}$	87	Eco 6 x 160	940	135
			105	Eco 6 x 200	940	135
				Eco 8 x 200	1,660	180
		$Z_{\perp}$	105	Eco 8 x 200	1,100	180
		$Z_{M,\perp}$			1,340	
		$Z_{S,\perp}$			1,190	
5-PLY	Dfir (0.50)	$Z_{//}$	175	Eco 10 x 300	2,450	225
		$Z_{M,\perp}$			1,970	225

Notes:

1. *For complete data, please refer to the* ***MTC Solutions' "Mass Timber Connections Design Guide,"*** *downloadable on* ***MTC Solutions' website****.*
2. *Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the* ***MTC Solutions' "Mass Timber Connections Design Guide"*** *and the CSA O86:19.*
3. *The table contains factored lateral resistances (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed factored resistances are valid for dry service conditions only, where K_{sf}=1.*
5. *Fasteners are installed at an angle intersecting the shear plane at the interface of the CLT panel and supporting beam.*
6. *The angle between force and fastener axis is 90°.*
7. $Z_{//}$ *Main member and side member loaded parallel to grain ϴ = 0°.*
   $Z_{M,\perp}$ *Main member loaded perpendicular to grain (ϴ = 90°); side member loaded parallel to grain (ϴ = 0°); ϴ = 90° with regards to K_{Θ}.*
   $Z_{S,\perp}$ *Main member loaded parallel to grain (ϴ = 0°); side member loaded perpendicular to grain (ϴ = 90°); ϴ = 90° with regards to K_{Θ}.*
   $Z_{\perp}$ *Main member and side member loaded perpendicular to grain ϴ = 90°.*

Source: *MTC Solutions, mtcsolutions.com*

CLT Panel to Beam Connecting System

FIGURE 5: CLT PANEL TO BEAM CONNECTION WITH INCLINED SCREWS

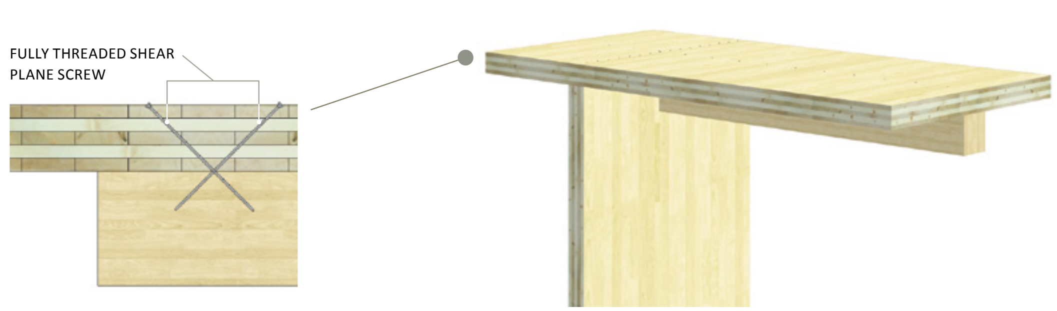
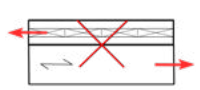
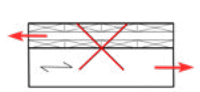
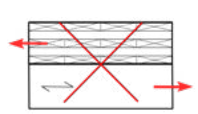


TABLE 5: FACTORED RESISTANCES FOR CLT PANEL TO BEAM CONNECTION INCLINED SCREWS

CLT PANEL & BEAM CONFIGURATION					ASSY FASTENER OPTIONS WITH INCLINED SCREWS	FACTORED RESISTANCES PER SCREW CROSS (N)	MINIMUM SPACING IN A ROW (mm)
	BEAM TYPE (sg)	LOADING		PANEL SERIES THICKNESS (mm)			
3-PLY	Dfir (0.50)	$Z_{x//}$		87	VG CSK 8 x 240	7,780	120
				105	VG CSK 8 x 300	9,710	120
					VG CSK 10 x 300	12,100	143
		$Z_{x\perp}$		87	VG CSK 8 x 240	8,650	120
				105	VG CSK 8 x 300	10,220	120
					VG CSK 10 x 300	12,740	143
5-PLY	Dfir (0.50)	$Z_{x//}$		175	VG CSK 10 x 480	20,380	143
		$Z_{x\perp}$		175	VG CSK 10 x 480	21,010	143

Notes:

1. *For complete data, please refer to the **MTC Solutions' "Mass Timber Connections Design Guide,"** downloadable on **MTC Solutions' website**.*
2. *Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the **MTC Solutions' "Mass Timber Connections Design Guide"** and the CSA O86:19.*
3. *The table contains factored lateral resistances (N_R) for 2 ASSY fasteners installed in a screw cross configuration conforming to the connection geometry and loading conditions described.*
4. *Listed factored resistances are valid for dry service conditions only, where K_{sf}=1.*
5. *Fasteners are installed at an angle intersecting the shear plane at the interface of the CLT panel and supporting beam.*
6. *The angle between force and fastener axis is 45°.*
7. *Factored lateral resistances only apply to parallel loading along the span direction of the glulam.*
8. *Z_{XII} Factored lateral resistances per screw cross with CLT main member loaded along the major span direction.*

   Z_{XT} Factored lateral resistances per screw cross with CLT main member loaded along the minor span direction.
9. *Adjustment for panel edge loading of CLT shall be considered, following CSA O86-19 clause 12.6.5.2.*

Source: *MTC Solutions, mtcsolutions.com*

CLT Wall and Glulam Floor Beam Systems

FIGURE 6: PRE-ENGINEERED CONNECTORS

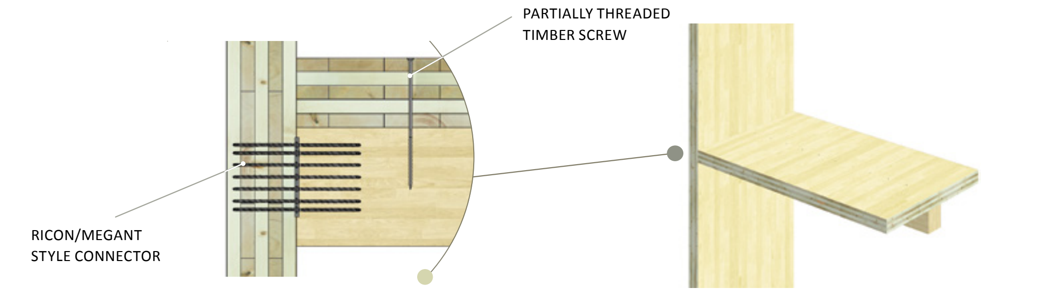


FIGURE 7: RICON S VS

Each product kit includes two matching connector plates.

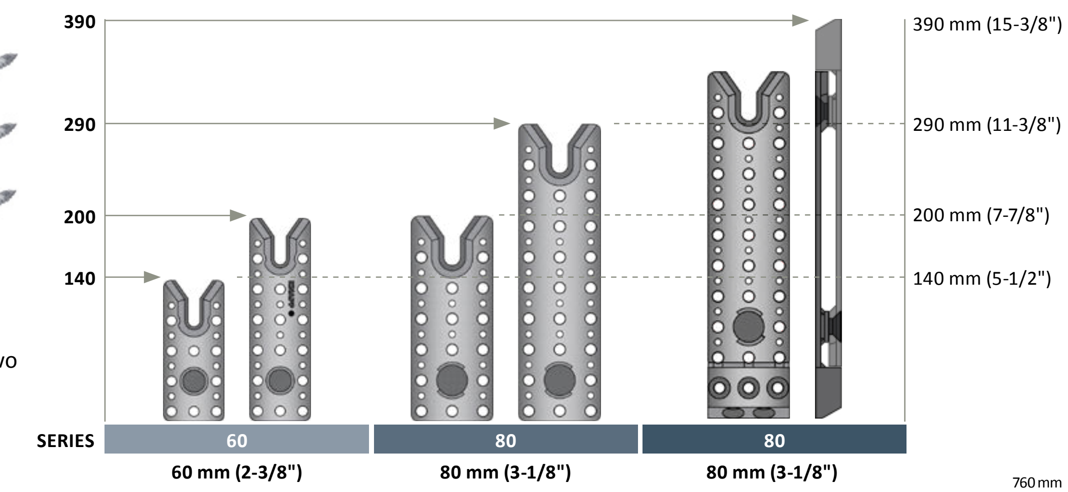
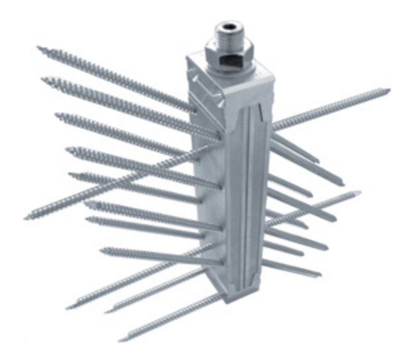


FIGURE 8: MEGANT



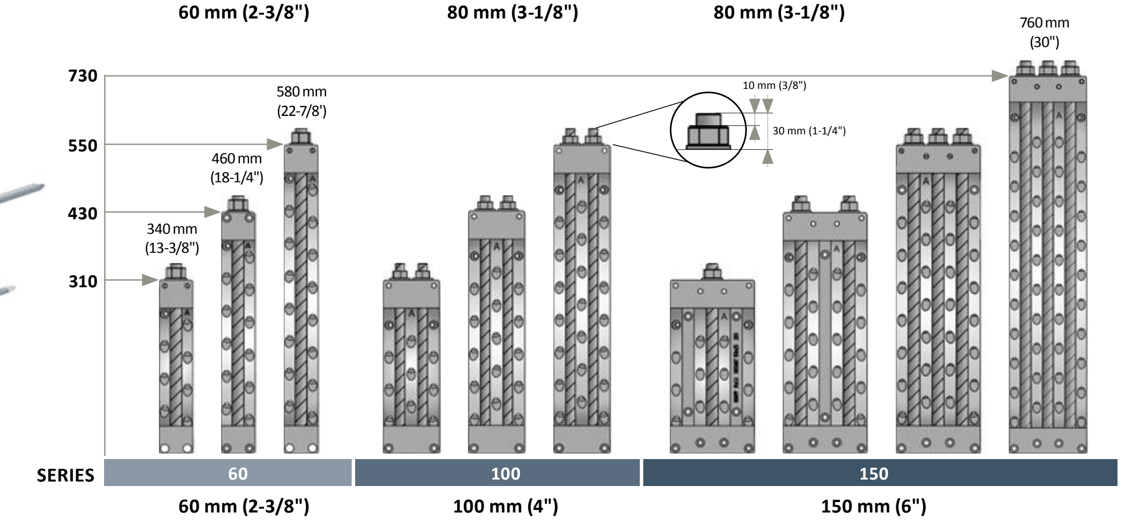


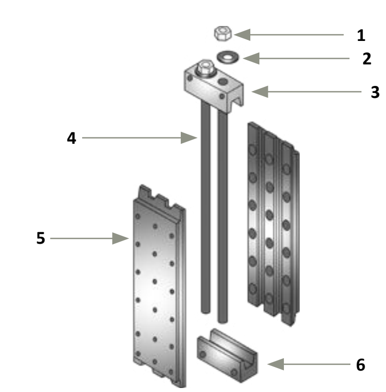
FIGURE 9: PRODUCT KIT DETAILS

Notes:

For complete data on each beam hanger system, please refer to the **MTC solutions' "Beam Hanger Design Guide,"** downloadable on **MTC solutions'** website.

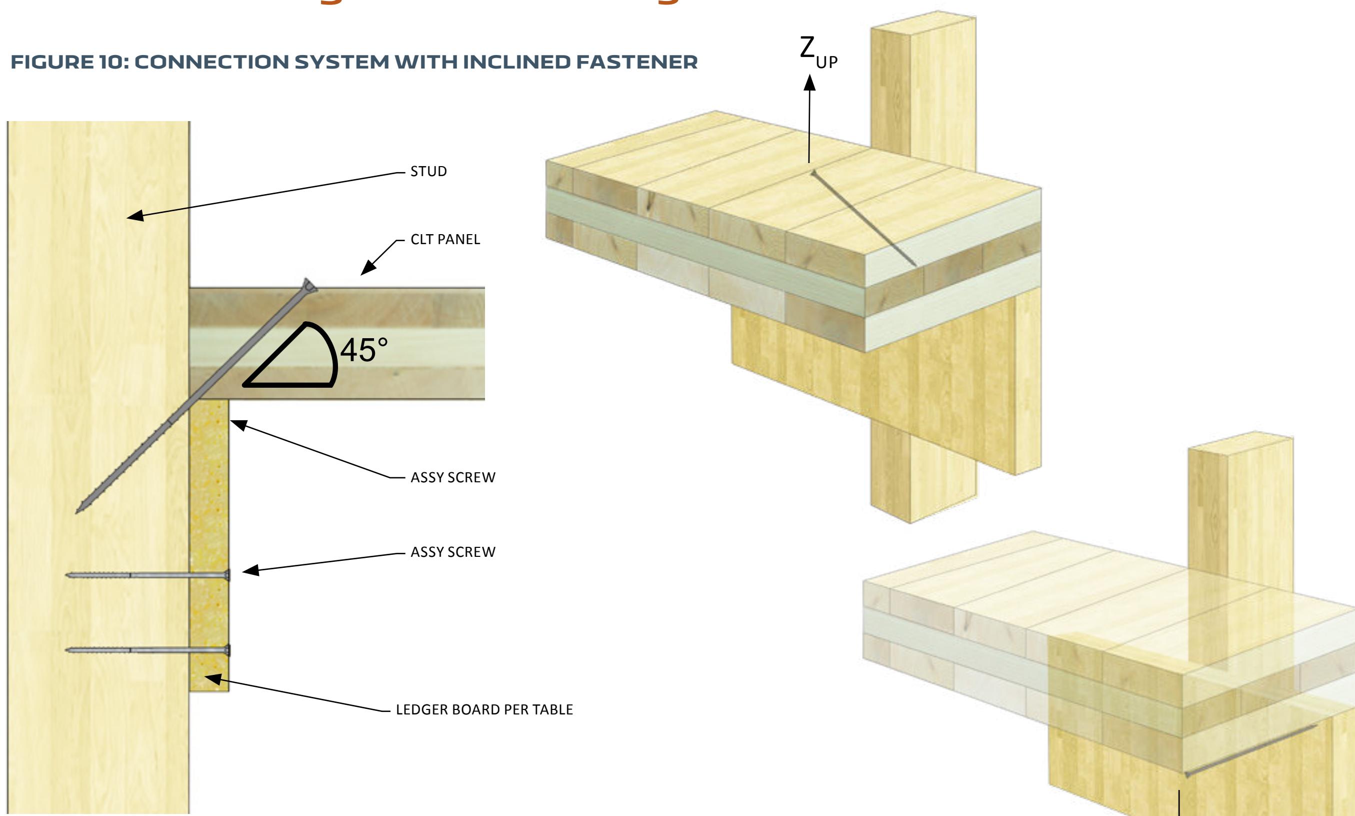
Source: *MTC Solutions, mtcsolutions.com*

NUMBER	DESCRIPTION
1	Hex Nut
2	Washer
3	Top Clamping Jaws (without thread)
4	Threaded Rod
5	Connector Plate (x2)
6	Bottom Clamping Jaws (with thread)



CLT Floor to Ledger Connection System

FIGURE 10: CONNECTION SYSTEM WITH INCLINED FASTENER



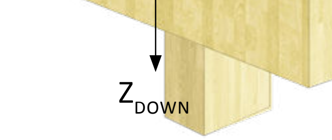


TABLE 6: FACTORED RESISTANCES FOR WALL TO CLT FLOOR CONNECTION (ledger board)

PANEL & LEDGER CONFIGURATION					ASSY FASTENER OPTIONS	FACTORED RESISTANCES (N)
LOADING		STUD TYPE	LEDGER THICKNESS (mm)	PANEL SERIES THICKNESS (mm)		
50 MM STUD	Z_{DOWN}	50 mm Lumber	38	-	Eco 6 x 120	599
					Eco 6 x 160	
3-PLY	Z_{UP}	50 mm Lumber	38	87	Eco 6 x 200	1,210

Notes:

1. *For complete data, please refer to the **MTC Solutions' "Mass Timber Connections Design Guide,"** downloadable on **MTC Solutions'** website.*
2. *Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the **MTC Solutions' "Mass Timber Connections Design Guide"** and the CSA O86:19.*
3. *The table contains factored resistances for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed factored resistances are valid for dry service conditions only, where K_{sf}=1.*
5. *Factored uplift resistances (Z_{UP}) shall not exceed factored downward resistances load capacity (Z_{DOWN}) for continuous load path.*
6. *Factored downward resistances (Z_{DOWN}) apply only to parallel (gravity shear) loading.*
7. *Engineered Wood Products must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective evaluation reports for the loading condition shown above.*
8. *Adjustment for panel edge loading of CLT shall be considered, following CSA O86-14 clause 12.6.6.3*

Source: *MTC Solutions, mtcsolutions.com*

CLT Panel to Steel Connecting System

FIGURE 11: CLT PANEL WITH STEEL SIDE PLATE IN SHEAR

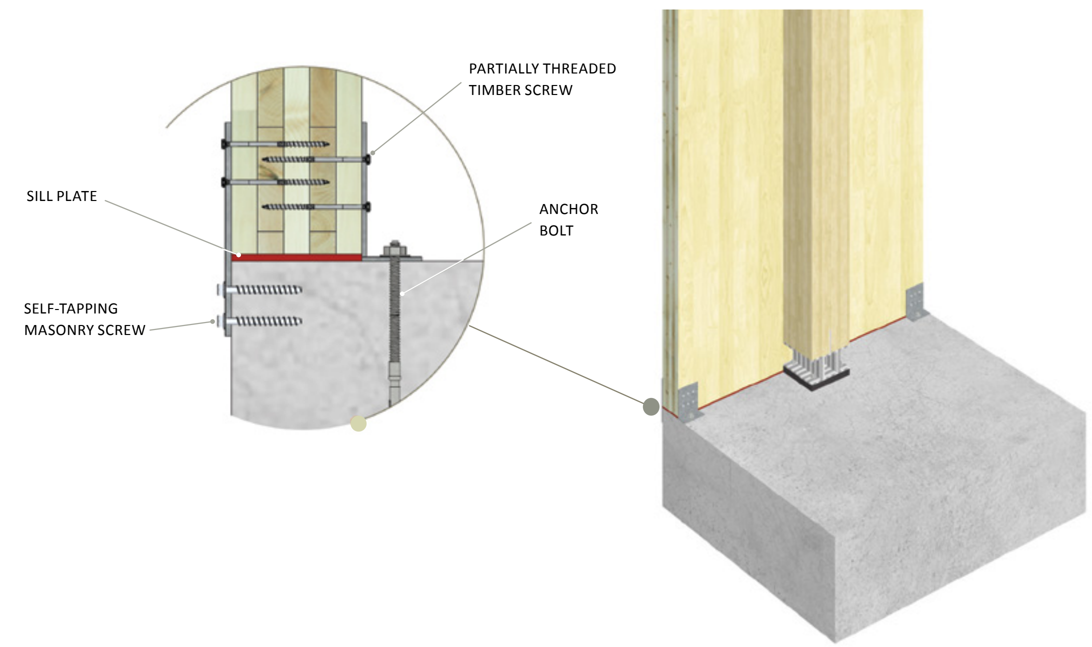


TABLE 7: FACTORED RESISTANCES FOR CLT STEEL SIDE PLATE CONNECTIONS IN SHEAR

PANEL & JOINT CONFIGURATION				ASSY FASTENER OPTIONS	FACTORED LATERAL RESISTANCES (N)	FACTORED WITHDRAWAL RESISTANCES (W)
LOADING		PANEL SERIES THICKNESS (mm)	STEEL THICKNESS (mm)			
3-PLY	$Z_{//}$	87 to 105	4.75	Kombi 8 x 80	2,203	3,100
			6.35	Kombi 8 x 80		
			12.7	Kombi 8 x 80		
	$Z_{\perp}$	87 to 105	4.76	Kombi 8 x 80	1,545	
			6.35	Kombi 8 x 80		
			12.7	Kombi 8 x 80		

Notes:

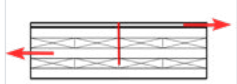
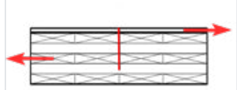
1. *For complete data, please refer to the **MTC Solutions' "Mass Timber Connections Design Guide,"** downloadable on **MTC Solutions' website**.*
2. *Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the **MTC Solutions' "Mass Timber Connections Design Guide"** and CSA O86:19.*
3. *The table contains factored lateral resistances (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed factored resistances are valid for dry service conditions only, where K_{sf}=1.*
5. *The side member is assumed as ASTM A36 grade steel or higher. In accordance with CSA O86:19, a dowel bearing strength of 400 MPa for steel is used in the yield limit equations.*
6. *Fasteners are installed at a 90° angle intersecting the shear plane at the interface of steel side member and CLT.*
7. *The angle between force and fastener axis is 90°.*
8. *ASSY Ecofast may be used in lieu of ASSY Kombi fasteners if proper head bearing is assured.*
9. *$Z_{//}$ Main member loaded parallel to grain (Θ = 0°)*
   $Z_{\perp}$ Main member loaded perpendicular to grain (Θ = 90°)
   W Steel plate loaded in withdrawal.

Source: *MTC Solutions, mtcsolutions.com*

CLT Panel to Steel Connecting System

CLT PANEL WITH STEEL SIDE PLATE IN SHEAR

TABLE 8: FACTORED RESISTANCES FOR CLT STEEL SIDE PLATE CONNECTIONS IN SHEAR

PANEL & JOINT CONFIGURATION					ASSY FASTENER OPTIONS	FACTORED LATERAL RESISTANCES (N)	FACTORED WITHDRAWAL RESISTANCES (W)
LOADING			PANEL SERIES THICKNESS (mm)	STEEL THICKNESS (mm)			
5-PLY	$Z_{//}$		139 to 191	4.75	Kombi 8 x 80	2,203	3,100
					Kombi 10 x 120	3,247	6,030
					Kombi 12 x 120	4,622	7,220
				6.35	Kombi 8 x 80	2,203	3,100
					Kombi 10 x 120	3,247	6,030
					Kombi 12 x 120	4,622	7,220
				12.7	Kombi 10 x 120	3,247	6,030
					Kombi 12 x 120	4,622	7,220
					Kombi 12 x 140		
	$Z_{\perp}$		139 to 191	4.75	Kombi 8 x 80	1,545	3,100
					Kombi 10 x 120	2,276	6,030
					Kombi 12 x 120	3,241	7,220
				6.35	Kombi 8 x 80	1,545	3,100
					Kombi 10 x 120	2,276	6,030
					Kombi 12 x 120	3,241	7,220
				12.7	Kombi 10 x 120	2,276	6,030
					Kombi 12 x 120	3,241	7,220
					Kombi 12 x 140		

Notes:

1. For complete data, please refer to the ***MTC Solutions' "Mass Timber Connections Design Guide,"*** downloadable on ***MTC Solutions' website***.
2. Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the ***MTC Solutions' "Mass Timber Connections Design Guide"*** and CSA O86:19.
3. The table contains factored lateral resistances (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.
4. Listed factored resistances are valid for dry service conditions only, where K_{sf}=1.
5. The side member is assumed as ASTM A36 grade steel or higher. In accordance with CSA O86:19, a dowel bearing strength of 400 MPa for steel is used in the yield limit equations.
6. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of steel side member and CLT.
7. The angle between force and fastener axis is 90°.
8. ASSY Ecofast may be used in lieu of ASSY Kombi fasteners if proper head bearing is assured.
9. $Z_{//}$ Main member loaded parallel to grain (ϴ = 0°).
   $Z_{\perp}$ Main member loaded perpendicular to grain (ϴ = 90°).
   W Steel plate loaded in withdrawal.

Source: MTC Solutions, mtcsolutions.com

FIGURE 12: CLT AND STEEL PLATE HOLD DOWN CONNECTORS WITH INCLINED SCREWS

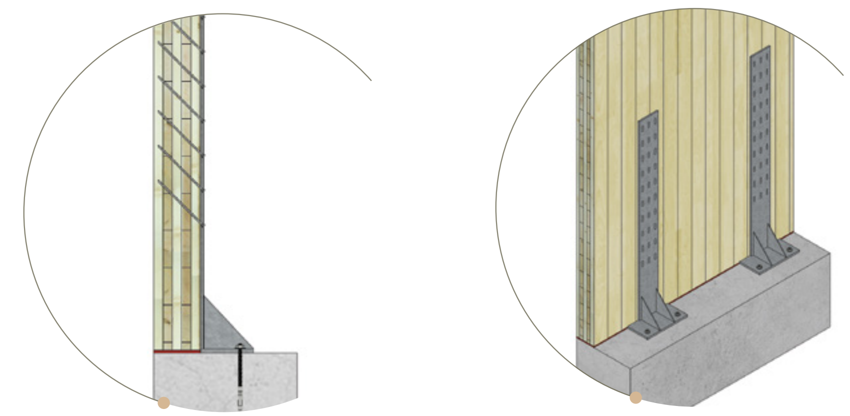
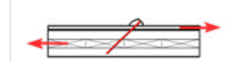
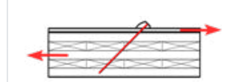


TABLE 9: FACTORED LATERAL RESISTANCES FOR CLT STEEL SIDE PLATE CONNECTIONS WITH INCLINED SCREWS

PANEL & JOINT CONFIGURATION					ASSY FASTENER OPTIONS WITH 45° WASHER	FACTORED RESISTANCES (N)
LOADING			PANEL SERIES THICKNESS (mm)	STEEL THICKNESS (mm)		
3-PLY	$Z_{//}$		87	4-15	VG CSK 8 x 140	4,069
	$Z_{\perp}$				VG CSK 8 x 140	4,152
5-PLY	$Z_{//}$		175	4-15	VG CSK 8 x 240	8,274
				6-20	VG CSK 10 x 240	9,140
	$Z_{\perp}$			4-15	VG CSK 8 x 240	7,759
				6-20	VG CSK 10 x 240	9,182

Notes:

1. For complete data, please refer to the ***MTC Solutions' "Mass Timber Connections Design Guide,"*** downloadable on ***MTC Solutions' website***.
2. Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the ***MTC Solutions' "Mass Timber Connections Design Guide"*** and CSA O86:19.
3. The table contains factored lateral resistances (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.
4. Listed factored resistances are valid for dry service conditions only, where K_{sf}=1.
5. The side member is assumed as ASTM A36 grade steel or higher. In accordance with CSA O86:19, a dowel bearing strength of 400 MPa for steel is used in the yield limit equations.
6. Fasteners are installed at a 45° angle intersecting the shear plane at the interface of steel side member and CLT.
7. The angle between force and fastener axis is 45°.
8. For ranges in steel plate thicknesses, a factored resistance is provided while assuring no through penetration of the fastener in the CLT panel with minimum steel plate thickness.
9. The designer must assure that all possible stress limits in the wood members and steel are not exceeded.
10. $Z_{//}$ Factored lateral resistances per screw in tension with loading direction along major span direction of CLT panel.
    $Z_{\perp}$ Factored lateral resistances per screw in tension with loading direction along minor span direction of CLT panel.

Source: MTC Solutions, mtcsolutions.com

GlulamPLUS® Connections

Mass timber projects typically feature multiple beam-to-beam and beam-to-column connections, with connections available from Structurlam in any of four main categories, as follows:

CUT-TO-LENGTH

Beams and columns are provided, square-cut to length for field assembly. For a precision fit, in some cases, beams and columns may need to be undersized by 3mm (1/8") to 5mm (3/16").

TRADITIONAL WOOD JOINERY

Traditional, wood-to-wood joinery of mortise and tenon, dovetail and rabbet connections are available and can be provided with tight-tolerance accuracy.

PRE-ENGINEERED CONNECTORS

Pre-engineered connectors are a preferred and typical connector system in mass timber projects. Straightforward to specify using available design values and tables, the connectors can be factory installed and test-fit prior to delivery, ensuring smooth, time-saving installation.

CUSTOM STEEL

In certain applications where pre-engineered connectors may not be feasible, typically as a result of irregular component shapes or geometries or where a particular aesthetic result is desired, custom steel connectors are typically used.

Custom steel connectors typically fall into one of two categories:

- Concealed: where the performance of steel connectors is desired with the visual appearance of a wood-to-wood connection
- Exposed: where the visual impact of large, heavy steel connectors is part of the architectural design

Consult with your Structurlam Mass Timber Specialist for more information and cost estimates for each. For more information on GlulamPLUS® connections refer to page 53.

Installation of beam using concealed pre-engineered beam connectors

Factory-installed custom steel connectors to be designed by engineer of record or specialty engineer

Concealed pre-engineered beam to column connectors

Custom steel connectors precision fit on-site

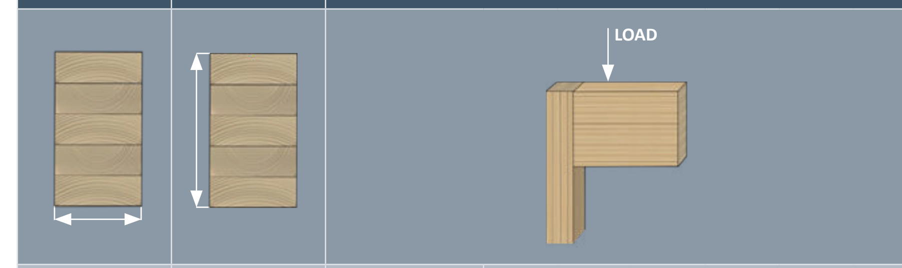
GlulamPLUS® Connections

SELECTION TOOL FOR BEAM HANGER SYSTEMS

The following pre-selection table helps the designer in choosing the right beam hanger system. The table lists the allowable loads for each system based on the minimum beam width and minimum beam depth.

More details on specific beam hanger systems can be found in the **MTC Solutions' "Beam Hanger Design Guide"** at **mtcsolutions.com**

TABLE 10: FACTORED RESISTANCES FOR WALL TO CLT FLOOR CONNECTION (ledger board)



MINIMUM BEAM WIDTH (mm)	MINIMUM BEAM DEPTH (mm)	FACTORED RESISTANCES (kN)	BEAM HANGER SYSTEM
100	180	26	Ricon S VS 140x60
	240	39	Ricon S VS 200x60
	400	60	Megant 310x60
	520	94	Megant 430x60
	640	125	Megant 550x60
120	240	58	Ricon S VS 200x80
	330	71	Ricon S VS 290x80
	430	131	Ricon XL 390x80
140	400	77	Megant 310x100
	530	128	Megant 430x100
	650	166	Megant 550x100
190	400	100	Megant 310x150
	520	166	Megant 430x150
	640	232	Megant 550x150
	830	318	Megant 730x150

Notes:

1. *Factored resistances listed are only valid for Limit State Design in Canada.*
2. *This table is a pre-selection tool. For complete design guidelines, please refer to the **MTC Solutions' Beam Hanger Design Guide**, downloadable at **mtcsolutions.com** and to the CSA O86:19.*
3. *Factored resistances listed here are only valid for use in Dfir in standard term loading (K_D =1.0). Please refer to each respective connector section for more values.*
4. *In the table:* ■ *Single connector factored resistance.* ■ *Double connectors factored resistance, the minimum beam width is larger than the listed value, refer to respective connector section.*
5. *Development of loads and design of connections are the responsibility of the design professional of record.*

Source: *MTC Solutions, mtcsolutions.com*

Fire Performance

Mass timber performs exceptionally well in fire events due to its slow-charring and self-insulating properties, providing effective fire protection.

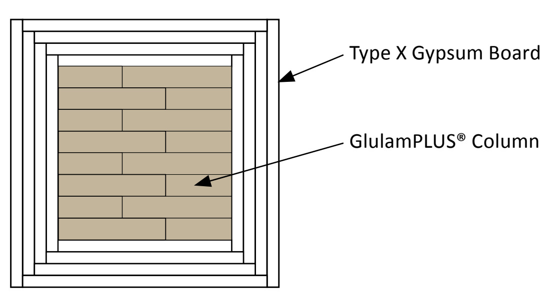
Fire resistance is the ability of a material to continue to provide structural strength and resistance to heat or vapor transfer during a fire event. A fire resistance rating (FRR) refers to the time that a building component can withstand fire or heat and integrity failure. It's important to note that requirements regarding fire safety vary depending on building occupancy type and location; therefore, the specific requirements must be confirmed when designing the system. Mass timber systems can be designed using various performance principles to meet the required criteria, including the following two methods:

THE ENCAPSULATION METHOD

This method encapsulates all structural mass timber components using Type X Gypsum Board and is the more conservative option between the two. Each additional board of 16 mm (5/8") gypsum board adds approximately 30 minutes of extra fire resistance to the timber components. This system maintains the integrity of the full load-bearing cross-section of the structural component.

Images Courtesy: Beam Craft

FIGURE 1: ENCAPSULATION METHOD



Encapsulation method with a two-hour fire rating.

THE CHAR METHOD

The char method allows mass timber to be directly exposed to fire. Since the timber is fully exposed, extra lumber is added during the design phase to meet the fire resistance rating (FRR). This system is designed by determining the approximate depth to which the fire would penetrate and the remaining structural strength of the member after a certain exposure time.

CrossLam® CLT and GlulamPLUS® behave as mass timber and have a predictable charring rate of approximately 0.65 mm/min (1.5"/hr). The char layer, which is formed during combustion, acts as an insulating layer for the inner layers, thus protecting the structural members from a further loss of strength. The FRR of CrossLam® CLT and GlulamPLUS® is dependent on several factors, including the member depth, span, applied loading and exposure. The most vulnerable components of this type of system tend to be the steel connectors due to the rapid reduction in steel's strength at high temperatures. To counteract this, it is required that all connectors be covered by a layer of timber or intumescent paint to protect the steel.

FIRE RESISTANCE RATING (FRR)

Fire Resistance Rating (FRR) performance can be designed either generically, according to the National Building Code of Canada (NBCC), or using an alternative method described in Annex B – Fire resistance of large-cross-section wood elements of CSA O86. Extensive testing has been completed to allow either the codified generic approach or the engineering approach in CSA O86 to cover a variety of use scenarios.

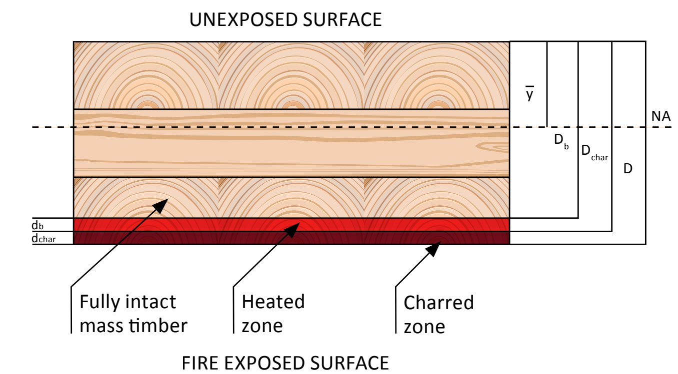
Glulam beams and columns can be designed using the current 2015 NBCC. For other mass timber elements (solid sawn, glulam, structural composite lumber and CLT), they can be designed using the methodology from Annex B within CSA O86.

Reduced cross-section method of CSA O86: The Annex B methodology uses wood-engineering-based mechanics to calculate the fire resistance of wood members and will be referenced in Appendix D of the 2020 NBCC.

Execution of proprietary CAN/ULC-S101 testing that is specific to the project assemblies: Standard Methods of Fire Endurance Tests of Building Construction and Materials evaluate the duration for which CLT will contain a fire and maintain its structural integrity during exposure to fire.

For additional test documentation, visit https://www.structurlam.com/resources/testing/

FIGURE 2: CROSS-SECTION OF FIRE-EXPOSED CROSS LAMINATED TIMBER



FIRE STOPS AND SERVICE PENETRATIONS

A number of commercially available fire-rated joint systems for concrete can achieve the same fire test ratings when used in mass timber for up to two hours. Detailing and fire caulking need to be applied appropriately around the fire sleeve. This allows solid mass timber panels such as CrossLam® CLT to be a superior part of your fire protection system.

Wall assembly after testing showing the depth of charring on the exposed side. *NRC (2014) Fire Endurance of Cross Laminated Timber Floor and Wall Assemblies for Tall Wood Buildings.*

Protective "char layer" maintains structural integrity of interior section.

Acoustic Performance

When using CLT walls and floors, and in order to achieve the desired STC and IIC ratings for your building project, refer to table 1 on page 58. These assemblies contribute to the overall sound isolation and acoustic performance of your completed building.

Sound transmission is also affected by the components in wall and floor assemblies. Airtight construction and specifically engineered connections can help mitigate flanking sound transmission, further improving acoustic performance.

ACOUSTIC DESIGN PRINCIPLES

Sound and vibration control are directly associated with the comfort of building occupants. There are several different types of sound, including airborne sound, impact sound and flanking sound that must be minimized and optimized to provide maximum comfort and livability. Reverberation sound affects sound quality in a room but not rating values.

AIRBORNE SOUND (STC RATING)

Airborne sound is transmitted by various means, including speech, televisions and stereos. These airborne waves cause the structural components to vibrate and therefore transmit sound to adjacent spaces.

Airborne Sound Mitigation:
To mitigate the intensity of airborne sound from being transmitted into adjacent building spaces, architectural outfitting can be used. Fire, thermal and acoustic insulation can be combined where appropriate for walls, doors and windows. Techniques to reduce airborne sound often include the use of dense materials, which tend to attenuate sound waves effectively, for instance:

- Floor – using acoustic mat floor underlays or dropped ceilings
- Walls – using dense wall insulation, such as rock mineral wool

FIGURE 1: AIRBORNE SOUND

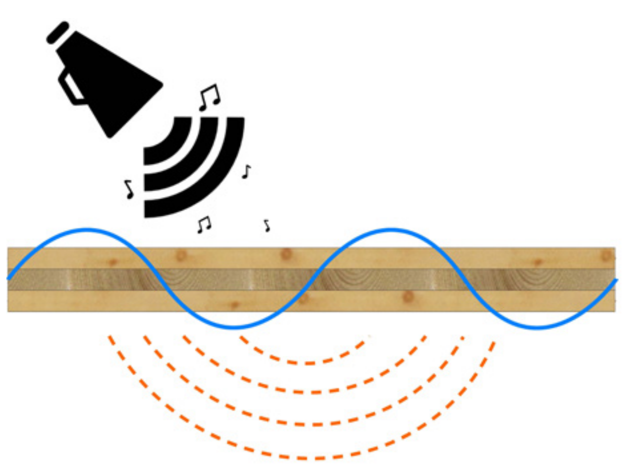
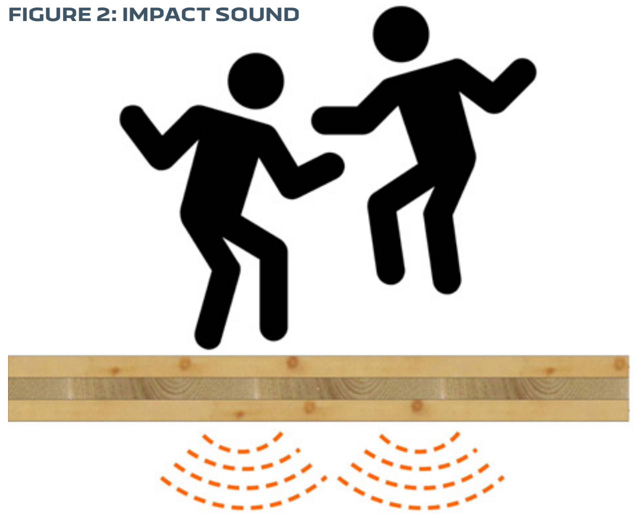


FIGURE 2: IMPACT SOUND



IMPACT SOUND (IIC RATING)

Impact sound is a structure-borne sound transmitted through a direct impact on solid elements such as through the walls and floors of a building. Examples of impact sound in a building include footsteps, falling objects and other sounds from your upstairs neighbors.

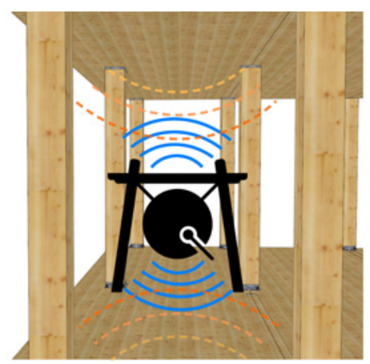
Impact Sound Mitigation:
To reduce the transmission of impact sound between building areas, install damping materials on the impact surface such as:

- Carpet flooring
- Resilient underlay beneath flooring surface
- Suspended ceiling or raised floors

SOUND REVERBERATION

Reverberation is a longer-lasting and degrading sound caused by the reflection from surfaces inside of a building. Varied surface shapes such as fluting or soft absorbing surfaces can help change the sound quality of a room and mitigate reverberation. This should not be confused with IIC (Impact) or STC (Sound Transmission) ratings.

FIGURE 3: SOUND REVERBERATION



First Tech Credit Union, Hillsboro, OR, USA

FLANKING SOUND (STC AND IIC RATING)

Flanking sound occurs due to the transmission of both airborne and impact sound or vibration through building components into other non-intended portions of the building via uninsulated and indirect sound paths. For example, flanking sound transmission paths include windows and doors, ducts and shared structural building components such as floor panels. Conventional flanking sound mitigation techniques commonly see a 2–5 dB increase in field STC/IIC ratings.

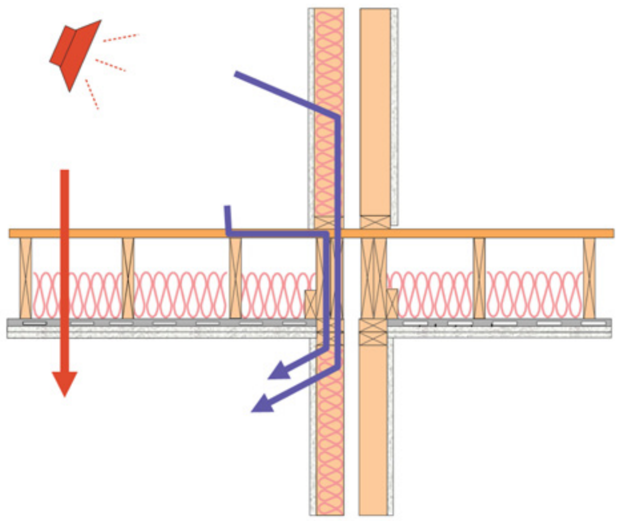
FLANKING SOUND MITIGATION

Flanking sound must be mitigated on a project-specific basis and is minimized using sound insulation techniques such as window placement and building component insulation developed during the design stage. A certain degree of flanking sound can typically not be avoided; however, it can be minimized through:

- Design of less direct (i.e., longer and more complex) sound transmission paths
- Prioritization of discontinuity between units and building elements (i.e., avoid using one panel for more than one living unit without adding acoustic barriers)
- The buildup of multiple layers in the structural component cross-section
- Sound encapsulation techniques to remove direct structural paths (i.e., dropped ceilings)

For more information on flanking sound transmission, refer to 2019 Canadian CLT Handbook - Chapter 9.

FIGURE 4: FLANKING SOUND MITIGATION



Direct Path (red arrow) vs. Flanking Path (blue arrows) on Floor Surface

Acoustic Ratings for Floor and Ceiling Assemblies

TABLE 1: ACOUSTIC RATINGS FOR FLOOR AND CEILING ASSEMBLIES

CLT FLOOR 5-PLY THICKNESS: 175 mm (6-7/8") SOUND TRANSMISSION CLASS (STC) IMPACT INSULATION CLASS (IIC)		BARE	GYPSUM BOARD CEILING 2 LAYERS 12.7 mm (1/2") THICK TYPE X GYPSUM BOARD			
			DIRECTLY ATTACHED	38 mm (1-1/2") WOOD FURRING @ 610 mm (24") O.C.	HUNG CEILING ON METAL GRILLAGE 152 mm (6") BELOW CLT SURFACE	DIRECTLY ATTACHED TO CLT AND ADDITIONAL ACOUSTIC HUNG CEILING WITH 16 mm (5/8") THICK TYPE X ON METAL GRILLAGE 152 mm (6") UNDERNEATH
BARE		41 (25)	42 (25)	50 (36)	68 (56)	67 (55)
FLOOR TOPPINGS	38 mm (1-1/2") CONCRETE TOPPING ON 9.5 mm (3/8") CLOSED-CELL FOAM	53 (36)	53 (40)	59 (50)	76 (66)	74 (64)
	38 mm (1-1/2") CONCRETE TOPPING ON 12.7 mm (1/2") WOOD FIBERBOARD	52 (35)	53 (38)	59 (47)	76 (64)	73 (63)
	38 mm (1-1/2") CONCRETE TOPPING ON 19 mm (3/4") RECYCLED FABRIC FELT	59 (42)	59 (46)	63 (45)	77 (61)	75 (60)
	38 mm (1-1/2") CONCRETE TOPPING ON 12.7 MM (1/2") RUBBER NUGGETS ON FOIL	53 (46)	53 (44)	59 (49)	73 (65)	70 (63)
	38 mm (1-1/2") CONCRETE TOPPING ON 8 MM SHREDDED RUBBER MAT	52 (38)	52 (38)	58 (48)	76 (66)	74 (64)
	38 mm (1-1/2") CONCRETE TOPPING ON 16 mm (5/8") SHREDDED RUBBER MAT	54 (44)	54 (43)	60 (51)	76 (67)	73 (65)
	38 mm (1-1/2") CONCRETE TOPPING NOT BONDED TO CLT	49 (28)	49 (32)	56 (41)	75 (60)	74 (60)
	2x12 mm CEMENT BOARD ON 12.7 mm (1/2") WOOD FIBERBOARD	48 (46)	48 (38)	54 (47)	69 (63)	68 (60)
	38 mm (1-1/2") GYPSUM CONCRETE ON 9.5 mm (3/8") CLOSED-CELL FOAM	50 (41)	50 (41)	58 (49)	72 (63)	73 (63)

Notes:

☐ *Measured ratings.*

☐ *Predicted ratings based on the measured ratings.*

Numbers in brackets are the IIC ratings.

For all gypsum board ceilings with cavities: The cavity between the furring ceiling was filled with glass fibre batts (thickness 38 mm (1-1/2") for furring and 140 mm (5-1/2") for hung ceiling).

Measured (white) and predicted (light blue) STC and IIC ratings (in brackets) of 5-ply CLT floors with and without floor toppings and gypsum board ceilings.

Final acoustic design is the responsibility of the architect/designer of record.

Reference:

CLT Handbook - Chapter 9, Canada, 2019.

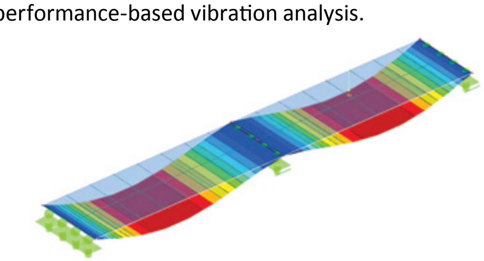
Thermal and Energy Performance

The material properties of mass timber help to manage the transfer of thermal energy through the building envelope by resisting air transfer, creating a highly insulated space. Due to the tight tolerances and precision of prefabrication in our state-of-the-art manufacturing facility, joints between panels and members tend to fit together tighter, resulting in the improved energy efficiency of your building. The mass in the mass timber also acts as a thermal battery, helping the structure better regulate internal environmental conditions.

For more information, refer to CLT panel properties on page 70.

Deflection

The deflection limits of CLT are specified in CSA 086:19 clause 5.4. Calculating deflection should conform to the CSA O86:19 clauses A.8.5.2. and A.8.4.3.2. Creep is a critical factor that should be accounted for in any structural design. See the approach outlined in CSA O86:19 clause A.8.5.2. CSA O86:19 clause A.8.5.4 contains design information on calculating deflection limits. Generally, the CLT floor plate will be governed by performance-based vibration analysis.



MEP Penetrations

Building penetrations for mechanical, electrical and plumbing (MEP) services are easier and more economical to install if their locations can be included in the design of the CLT panel. Penetrations can be cut in the factory, saving installation time and expense. MEP services not included before the manufacture of the panel can still be easily incorporated on-site using standard construction tools.

Design Layout

Multi-story mass timber buildings typically require that all loading paths are vertically and uniformly aligned throughout all storeys. Any walls and columns that remain aligned in the same vertical plane throughout the building can be used to brace the building. This is important to consider in all mass timber building systems described in this guide, including Post and Panel, Post-Beam-Panel and Hybrid Light-Frame. Structures with load paths that do not align will require transfer slabs and transfer beams. While possible, this approach is not cost-effective and can add complexity to the overall design. Base designs and concepts should avoid these types of design situations.

Vibration

Maximum floor vibrations for CLT slab elements must be carefully analyzed. Research in this area is ongoing. However, the proposed design method for controlling vibrations in CLT floors is outlined in CSA 086:19 clause A.8.5.3. Experience has shown that for panels supported on load-bearing walls, the method in the CLT Handbook generally produces well-behaving floors to typical walking excitations. Where floor panels are supported on long span beams, additional considerations should be given to the vibration performance of the whole framing system.

FLOOR VIBRATION CONTROL COMPARISON

Floor vibration performance depends on the application and the expectations of the user. Because of this, floor vibration should be designed accordingly. The preferred design method to controlling vibrations in CLT floors is found in CSA O86:19 - A.8.5.3 and the 2019 Canadian CLT Handbook. The chart below compares the thickness of CLT floors against concrete and at what level we are able to better control our vibration with CLT versus concrete. See table below for CrossLam® CLT floor vibration performance.

TABLE 2:
CROSSLAM® CLT FLOOR VIBRATION PERFORMANCE

CROSSLAM® CLT SERIES	CLT PANEL (mm)	CONCRETE SLAB (mm)	VIBRATION CONTROLLED SPAN (m)
87 V	87	135	3.2
105 V	105	150	3.69
139 V	139	190	4.5
175 V	175	215	5.09
191 V	191	235	5.61
243 V	243	260	6.4
245 V	245	275	6.58
315 V	315.5	315	7.59

2.4 kPa live load plus self weight plus 1 kPa miscellaneous dead load

☐ Indicates CrossLam® CLT thickness advantage

Mountain Equipment Co-op (MEC), Vancouver, BC, Canada

CrossLam® CLT

CrossLam® CLT

As a North American manufacturer with deep roots in wood construction, we understand building codes and the construction process. Our history is also what makes us uniquely suited to deliver solutions that serve the construction industry. So, we used our decades of heavy timber manufacturing experience to develop a revolutionary new CLT panel for the North American market.

The result of that work is CrossLam® CLT, our proprietary CLT panel built specifically for North America using native species softwood lumber, sourced from sustainably managed forests.

Significantly lighter, CrossLam® CLT is engineered to be a direct replacement for concrete and can be used for floors, walls, roofs, shear walls and diaphragms and cores and shafts. CrossLam® CLT spans in two directions with precision and accuracy, is carbon negative and opens the door to a new way to construct buildings in the 21st century.

The technical information in this guide is compiled to support you in developing designs that specify CrossLam® CLT panels. If you have questions and need help, let our qualified team of Mass Timber Specialists and technical support representatives help you specify the right solution for your project.

Earth Sciences Building, UBC, Vancouver, BC, Canada

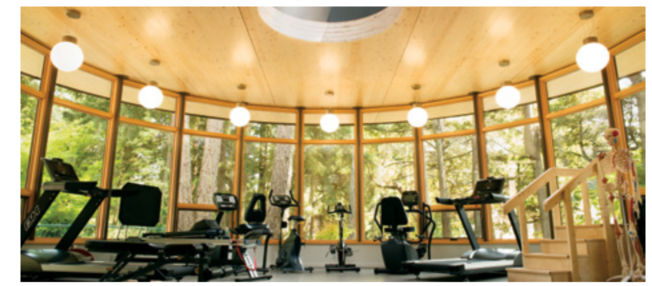
CROSSLAM® CLT ADVANTAGES:

- North American code approved
- Superior wood fibre and appearance
- CNC fabricated to exacting tolerances
- Delivered in coordinated sequence to installation schedule
- Steel and connecting hardware included
- All required holes, daps, slots, counterbores and chamfers included
- Rigorous quality control process
- BIM modeling options

CrossLam® CLT Product Applications

FLOORS

CrossLam® CLT panels are ideally suited for modern floor systems because they are two-way span capable and ship to site as ready-to-install components, greatly simplifying building construction and increasing jobsite productivity. CrossLam® CLT products help ensure an optimized structural solution that allows you to install up to 37.16 square metres (400 square feet) per lift.



ROOFS

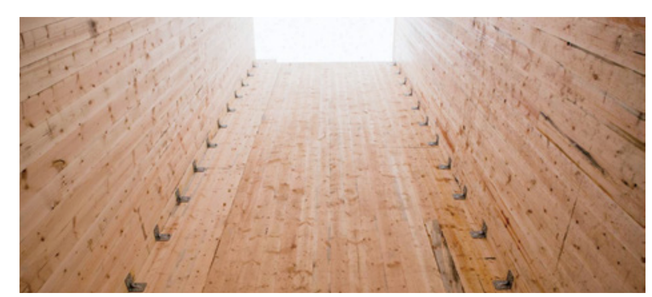
CrossLam® CLT panels provide overhanging eaves and span a variety of roof layouts. Their thermal properties contribute to a more efficient envelope assembly. Panels can be as thin as 87 mm (3.43") and as thick as 315 mm (12.42"), resulting in a maximum roof span of 12.19 m (40') with appropriate loading. CrossLam® CLT roofs are installed quickly, allowing projects to approach lockup and a watertight state in a short amount of time.

WALLS

CrossLam® CLT wall panels are a lighter, cost-competitive alternative to precast concrete systems. When used as a system, CrossLam® CLT wall and roof panels allow more flexibility and efficiency in building design. As vertical and horizontal load-bearing elements, CrossLam® CLT panels extend the design envelope for industrial projects and allow the use of one structural system for an entire project.

SHEAR WALLS AND DIAPHRAGMS

CrossLam® CLT panels may be used as lateral force-resisting systems for both wind and seismic loads. The Horizontal Diaphragm Design Example white paper provides a design method to determine the strength of CLT horizontal diaphragm and deflection due to lateral wind or seismic loads. See https://www.structurlam.com/wp-content/uploads/2016/10/White-paper-Rv12-June-2017.pdf.



CORES AND SHAFTS

CrossLam® CLT panel cores and shafts erect quicker and easier than comparable steel and concrete designs while still providing lateral bracing. Elevator and stair shafts can achieve two-hour fire resistance ratings.

Code-Approved to North American Standards

The National Building Code of Canada (NBCC) recognizes CLT as a structural system when manufactured according to the ANSI/APA PRG 320 Standard for Performance Rated Cross Laminated Timber.

In the 2015 NBCC, CLT can be used in exterior/interior walls, floors and roofs of buildings permitted to be on combustible construction. Buildings of combustible construction can be up to six storeys for Group C (residential) and Group D (business and personal services) occupancies. See table 1 below.

TABLE 1: CANADIAN CODE REGULATIONS – UP TO 6 STOREYS

CODE	GROUP C – ARTICLE 3.2.2.50		GROUP D – ARTICLE 3.2.2.58	
BUILDING HEIGHT	No more than six storeys			
HEIGHT BETWEEN FIRST STOREY FLOOR AND UPPER-MOST FLOOR LEVEL	No more than 18 m (59')			
MAXIMUM BUILDING AREA PER BUILDING HEIGHT	STOREYS	BUILDING AREA	STOREYS	BUILDING AREA
	1	9,000 m²	1	8,000 m²
	2	4,500 m²	2	9,000 m²
	3	3,000 m²	3	6,000 m²
	4	2,250 m²	4	4,500 m²
	5	1,800 m²	5	3,600 m²
	6	1,500 m²	6	3,000 m²
FIRE RESISTANCE	- Floor assemblies: fire separations with no less than one-hour - Roof assemblies: no less than one-hour - Load bearing walls, columns and arches: rating not less than required for the supported assembly			

NOTE: Mixed uses, such as retail stores, shops and restaurants can be located on the first two storeys of these buildings.

TABLE 2: CANADIAN CODE REGULATIONS – UP TO 12 STOREYS

CODE	GROUP C	GROUP D
BUILDING HEIGHT	No more than 12 storeys	
HEIGHT BETWEEN FIRST STOREY FLOOR AND UPPER-MOST FLOOR LEVEL	No more than 42 m (138')	
MAXIMUM BUILDING AREA PER BUILDING HEIGHT	6,000 m²	7,200 m²
FIRE RESISTANCE	- Floor assemblies: fire separations with no less than two-hours - Load bearing walls, columns and arches: not less than required for the supported assembly	
EXPOSED MASS TIMBER WALLS AND CEILINGS	Limited area allowed	

NOTE: Mixed uses, such as retail stores, shops and restaurants can be located on the first through third storeys of these buildings.

In the 2020 NBCC, CLT can be used in exterior/interior walls, floors and roofs of buildings permitted to be of combustible construction or new construction type called **encapsulated mass timber construction (EMTC)**. Buildings constructed of encapsulated mass timber will be permitted to be up to 12 storeys for Group C and Group D occupancies. See table 2 above.

Manufacturers of mass timber components of cross laminated timber, certified in North America, adhere to the standards set forth as described above.

When considering product manufactured outside of North America, all offshore manufacturers need to adhere to the North American Code Standards for cross laminated timber. It is imperative to consider more than the conversion of design stress properties. Key considerations that are upheld in the North American standards are noted below and further referenced on page 13.

- Design Properties
- Shear Capacity
- Bearing Capacity
- Diaphragm Capacity

DESIGN PROPERTY COMPATIBILITY

The design capacities published in ANSI/APA PRG 320-2019 were derived analytically using the Canadian lumber properties published in CSA O86 – Engineering Design in Wood. Lumber from outside of North America has different characteristics, may not be recognized in CSA O86 and has published design values that are incompatible with those of North American lumber.

As a result, the design properties for mass timber products manufactured with foreign species lumber should be carefully examined for compatibility with the North American design standards.

Product Quality Assured

We are proud of our ongoing certification and adherence to the North American cross laminated timber and glued laminated timber standards referenced throughout this guide. CrossLam® CLT is certified to meet the requirements of Standard for Wood Products – Structural Glued Laminated Timber and Cross Laminated Timber (CLT) as described in CSA O122 and ANSI/APA PRG 320-2019.

These standards outline the quality control requirements required by CSA/ANSI and are verified by the APA – The Engineered Wood Association (www.apawood.org) through ongoing and monthly independent third-party inspection visits to Structurlam's manufacturing operations. For more information on destructive performace testing, see table 2 below.

Further design considerations and local code approvals may be required when considering a foreign supply source, which can increase project timelines and cost. By adhering to these standards, Structurlam can assure a standard of quality to the professionals who specify our products. For more information, refer to pages 12 and 13.

Adhesives

STRUCTURLAM ADHESIVE SYSTEMS

The manufacturing of all code approved mass timber products to produce long length lamellas requires adhesives approved for face bond lamination and end to end finger jointing. Structurlam uses adhesives specific to our manufacturing processes that are certified to North American testing and manufacturing standards.

All adhesives must conform to CSA O122 and ASTM D7247 testing methods for fire, heat and moisture and must support ANSI manufacturing standards – see table 1 below.

The adhesive component is product thickness and depth dependent and comprises approximately 1% by weight of Structurlam's mass timber building products.

GLUE-BOND DURABILITY

The structural integrity of mass timber components depends upon the integrity of the glue-bond between the component lumber elements. This is true for the entire service life of these mass timber components. Conditions that can impact the glue-bond integrity are exposure to elevated heat (such as a fire event) and exposure to high moisture conditions for extended periods.

FIRE PERFORMANCE

The fire resistance of cross laminated timber and structural glued laminated timber is based on the certification requirements of the North American testing and manufacturing mass timber standards. These standards require rigorous adhesive heat durability testing to ensure mass timber product structural integrity under the most severe fire conditions.

EMISSIONS

Both Henkel and Hexion adhesives used by Structurlam for manufacturing our mass timber products are certified to UL GREENGUARD Gold. GREENGUARD Gold certified products are qualified to meet UL GREENGUARD standards for low chemical emissions into indoor air during product usage. These adhesives are formulated to meet or exceed all global emissions standards.

TABLE 1: ADHESIVES FOR GLULAM AND CLT MASS TIMBER PRODUCTS

ADHESIVE APPLICATION	ADHESIVE BRAND	ADHESIVE TYPE	EMISSIONS CERTIFICATION	ADHESIVE PERFORMANCE TESTING		
				FULL SCALE FIRE TEST	HEAT DELAMINATION	MOISTURE DURABILITY
Finger Joints Crosslam CLT®/GlulamPLUS®	Hexion Cascomel™	Melamine Formaldehyde (MF)	UL GREENGUARD Gold	✓	✓	✓
Face Bond Crosslam CLT®	Henkel Loctite HB X PURBOND	Polyurethane (PUR)	UL GREENGUARD Gold	✓	✓	✓

TABLE 2: DESTRUCTIVE PERFORMANCE TESTING

TYPE	METHODOLOGY
SHEAR TESTING	Test blocks are sampled where the glue-bond lines are mechanically loaded to withstand failure
CYCLIC – DELAMINATION TEST	Advanced wood aging process designed to simulate environmental trauma across 50 years of exterior service
END JOINT TENSION TESTING	Destructive lot-testing of manufactured finger joints to ensure that final products meet the prescribed strength ratings

NOTE: As a standard procedure each test result is documented and used to certify Structurlam products prior to shipment.

CrossLam® CLT Product Characteristics

TABLE 3: PRODUCT CHARACTERISTICS

MAXIMUM PANEL SIZE	3,000 mm x 12,192 mm (9'-10.5" x 40')
MAXIMUM THICKNESS	315 mm (12.42")
MINIMUM THICKNESS	87 mm (3.43")
PRODUCTION WIDTHS	2,400 mm and 3,000 mm (7'-10.5" and 9'-10.5")
MOISTURE CONTENT	12% (+/-3%) at time of manufacturing
FACE BOND GLUE SPECIFICATION	Henkel Loctite HB X PURBOND
FINGER JOINT GLUE SPECIFICATION	Hexion Cascomel® 4720 Resin with Wonderbond™ Hardener 5025A
SPECIES	SPF, Douglas fir
LUMBER GRADES	SPF #2&Btr, SPF MSR 2100, SPF #3, Dfir #2& Btr Square Edge
STRESS GRADES	V2M1.1, V2.1, E1M4, E1M5
MANUFACTURING CERTIFICATION	APA Product Report PR-L314
DENSITY	435 -544 kg/m³ (30-34 lbs/ft³)
DIMENSIONAL STABILITY	Longitudinal and Transverse 0.01% per % Δ in MC. Thickness 0.2% per % Δ in MC
THERMAL CONDUCTIVITY	RSI Value: 0.84 per 100 mm (K·m²/W) R Value: 1.2 per inch (h·ft²·°F /Btu)
CO_2 SEQUESTRATION	5.87 kN/m³ (37.4 lbs/cf) (subject to local manufacturing and distances)

DIMENSIONAL TOLERANCES	
THICKNESS	2 mm +/- (1/16") or 2% of CLT thickness, whichever is greater
WIDTH	3 mm +/- (1/8") of the CLT width
LENGTH	6 mm +/- (1/4") of the CLT length
SQUARENESS	Panel face diagonals shall not differ by more than 3 mm (1/8")
STRAIGHTNESS	Deviation of edges from a straight line between adjacent panel corners shall not exceed 2 mm (1/16")
MACHINED SURFACES	+/- 3 mm (1/8") with all tooling units except the chainsaw, which is +/- 6 mm (1/4")

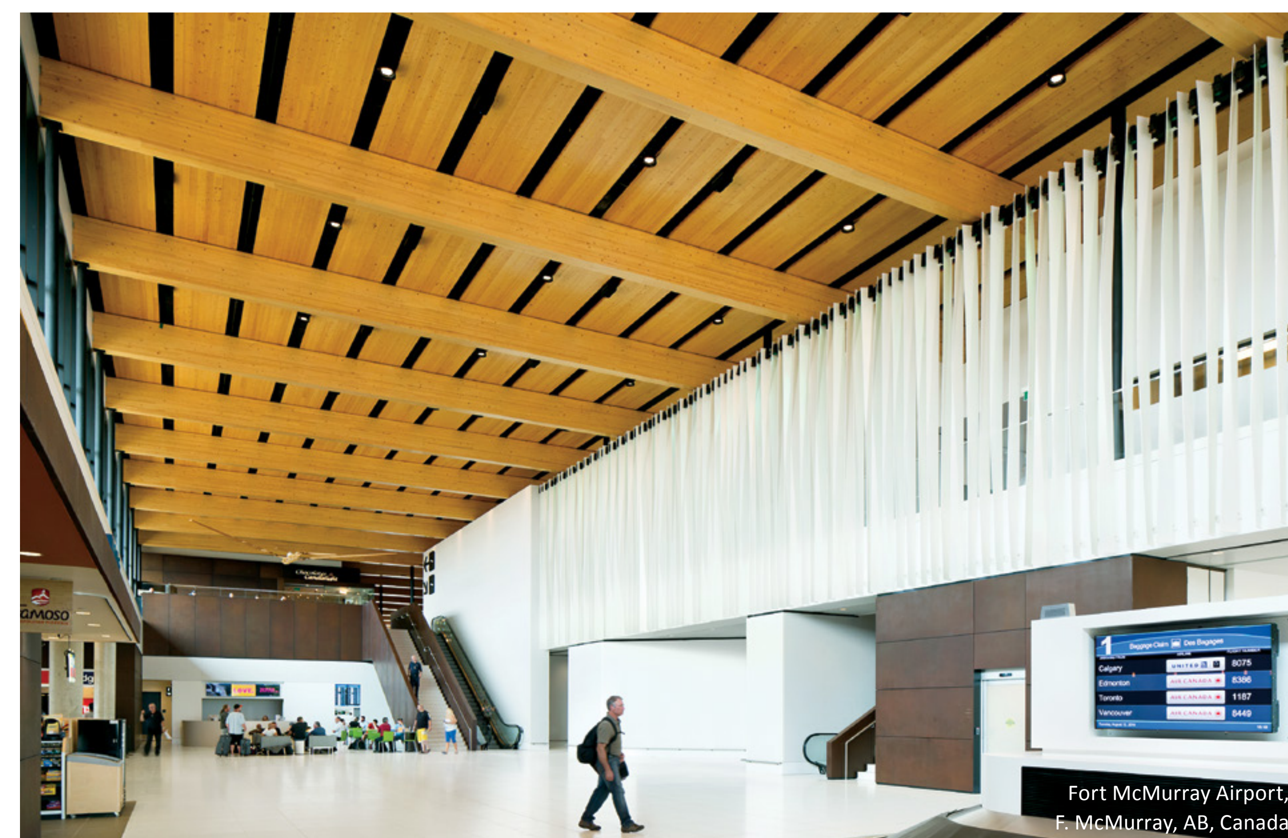

Virtuoso - Westbrook Village, by Adera Development Corporation, Vancouver, BC, Canada
Photo credit: Seagate Mass Timber, Inc.

CrossLam® CLT Panel Layups

TABLE 4: LUMBER SPECIES AND THICKNESS FOR CLT PANEL LAYUPS

CROSSLAM® CLT SERIES	GRADE	FACE LAYERS	MAJOR LAYER (L)	MINOR LAYER (T)	LAYER THICKNESS (mm)									PANEL DEPTH (mm)
					L	T	L	T	L	T	L	T	L	
87 V	V2.1	SPF #2&btr. DfirL3	SPF # 2& btr.	SPF # 3	35	17	35							87
139 V					35	17	35	17	35					139
191 V					35	17	35	17	35	17	35			191
243 V					35	17	35	17	35	17	35	17	35	243
105 V	V2M1.1			SPF # 2& btr.	35	35	35							105
175 V					35	35	35	35	35					175
245 V					35	35	35	35	35	35	35			245
315 V					35	35	35	35	35	35	35	35	35	315
87 E	E1M4	MSR 2100 1.8E SPF	MSR 2100 1.8E SPF	SPF # 3	35	17	35							87
139 E					35	17	35	17	35					139
191 E					35	17	35	17	35	17	35			191
243 E					35	17	35	17	35	17	35	17	35	243
105 E	E1M5			SPF # 2& btr.	35	35	35							105
175 E					35	35	35	35	35					175
245 E					35	35	35	35	35	35	35			245
315 E					35	35	35	35	35	35	35	35	35	315

L = Longitudinal Layer (Major Layer)
T = Tangential Layer (Minor Layer)
Spandrel panels cannot be produced in any layups with 17 mm thick lamellas.


Fort McMurray Airport,
F. McMurray, AB, Canada

CrossLam® CLT Finishes and Appearance Classification

TABLE 5: CROSSLAM® CLT FINISHES

	VISUAL	NON-VISUAL
INTENDED USE	Where one or both faces are left exposed	Where both faces are covered by another material
FACE LAYER - V SERIES	SPF #2&Btr Appearance Grade, Douglas fir, Appearance Grade	SPF #2&Btr
FACE LAYER - E SERIES	SPF MSR 2100 Square Edge	SPF MSR 2100
SANDED FACE	80 grit Note: Final finishing prep work must be completed on-site, including cleaning and touch-up of panels	N/A

	ALLOWABLE FIBRE CHARACTERISTICS	
SHAKE AND CHECKS	Several up to 610 mm (24") long, none through	As per NLGA #2, SPF #2&Btr
STAIN	Up to a max of 5% blue stain, heart stain allowed Note: E Series panels have no blue stain restrictions	Allowed, not limited
KNOTS	Firm & Tight (NLGA #2)	NLGA #2
PITCH STREAKS	Not limited	Not limited
WANE ON FACE	None	Allowed
SIDE PRESSURE	Yes	None
SURFACE QUALITY	 SPF APPEARANCE GRADE  DOUGLAS FIR	 SPF NON-VISUAL - EXAMPLE 1  SPF NON-VISUAL - EXAMPLE 2

The CrossLam® CLT Series

The V Series: Composed exclusively from #2 and BTR structural lumber.

The E Series: Contains MSR E-rated lumber for all major strength direction layers. The lumber for the E series panels does cost slightly more, but it allows a thinner panel to span further. This is more cost-effective in certain spans. However, it is important to note that E1 panels are not available with a visual grade or with a Dfir face layer. **This panel is recommended for non-visual uses only.**

CrossLam® CLT Name Convention

Panel Series / Panel Finish / Name / Position#

191 V J-1 RP 16

Panel Thickness in mm

Grade Indicator
V = V series : V2M1.1, V2.1
E = E series : E1M4, E1M5

J-1 : One Side SPF, Appearance Grade
D-1 : One Side Dfir Lumber, Appearance Grade
J-2 : Two Sides SPF, Appearance Grade
D-2 : Two Sides Dfir Lumber, Appearance Grade
No Label : Non-Appearance Industrial Panel

CrossLam® CLT Name Designations: EC - Elevator Core Panel RP - Roof Panel FP - Floor Panel WP - Wall Panel

FIGURE 1

Normal Panel Orientation

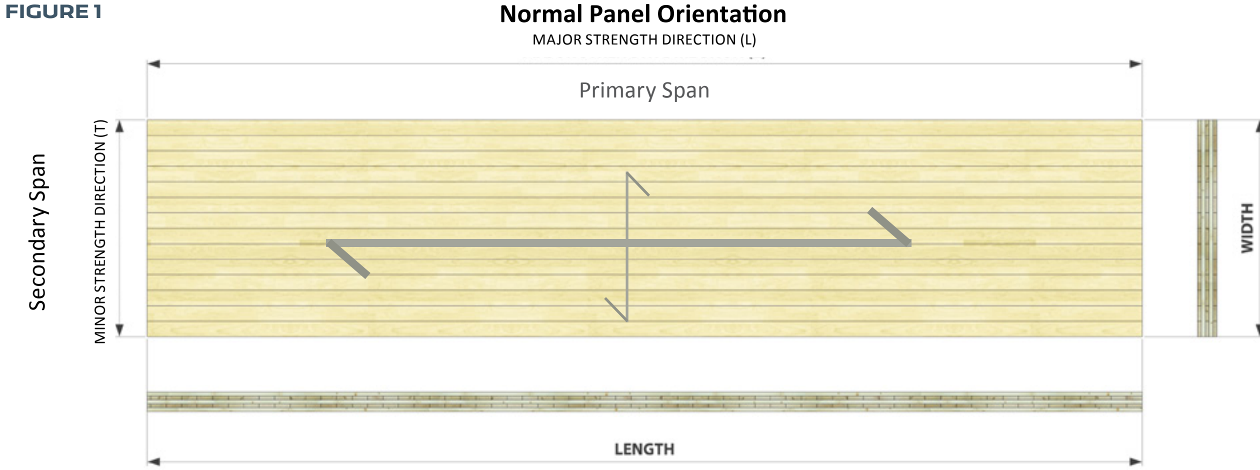
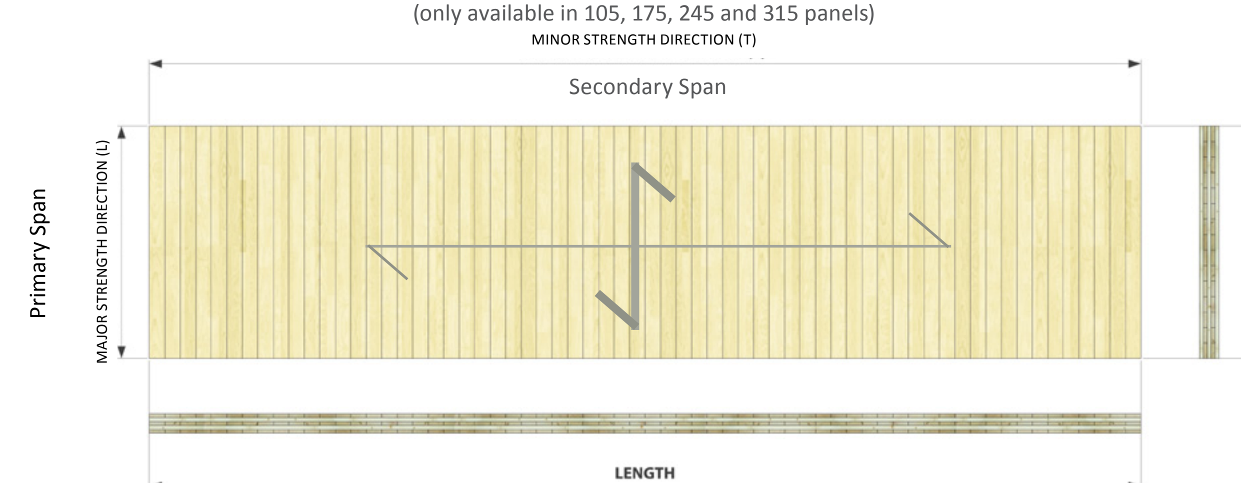


FIGURE 2

Spandrel Panel Orientation

(only available in 105, 175, 245 and 315 panels)



No side pressure available and visual application not recommended.

CrossLam® CLT Structural Panel Properties

TABLE 6: LIMIT STATE DESIGN (LSD) BENDING RESISTANCES

CLT GRADE	CLT SERIES	WEIGHT kg/m²	MAJOR STRENGTH DIRECTION					MINOR STRENGTH DIRECTION				
			$F_BS_{EFF,0}$ (10^6 N-mm/m)	$EI_{EFF,0}$ (10^9 N-mm²/m)	$GA_{EFF,0}$ (10^6 N/m)	$M_{R,0}$ (kNm/m)	$V_{R,0}$ (kN/m)	$F_BS_{EFF,90}$ (10^6 N-mm/m)	$EI_{EFF,90}$ (10^9 N-mm²/m)	$GA_{EFF,90}$ (10^6 N/m)	$M_{R,90}$ (kNm/m)	$V_{R,90}$ (kN/m)
V2.1	105 V	43.9	20.9	883	7.5	16.0	31.5	2.4	34	7.5	2.2	10.5
	175 V	73.2	48.1	3,390	15.0	36.8	52.5	20.9	884	15.0	18.8	31.5
	245 V	102.4	85.1	8,395	22.5	65.1	73.5	48.1	3,390	22.5	43.3	52.5
	315 V	131.7	132.0	16,741	30.0	101.0	94.5	85.1	8,395	30.0	76.6	73.5
V2M1.1	87 V	36.4	14.8	517	7.5	11.3	26.1	0.3	4	4.6	0.3	5.1
	139 V	58.1	34.1	1,907	14.9	26.1	41.7	4.9	215	8.7	4.4	20.7
	191 V	79.8	60.6	4,659	22.3	46.4	57.3	11.0	855	13.0	9.9	36.3
	243 V	101.6	94.4	9,230	29.8	72.2	72.9	19.3	2,147	17.3	17.4	51.9
E1M4	105 E	47.5	53.8	1,153	7.7	41.2	31.5	2.4	34	9.6	2.2	10.5
	175 E	78.6	123.7	4,416	15.3	94.7	52.5	20.9	884	19.2	18.8	31.5
	245 E	109.7	218.6	10,923	23.0	167.2	73.5	47.8	3,366	28.9	43.0	52.5
	315 E	140.8	338.8	21,766	30.7	259.2	94.5	85.5	8,428	38.5	76.9	73.5
E1M5	87 E	40.0	38.0	675	7.8	29.1	26.1	0.3	4	5.6	0.3	5.1
	139 E	63.6	87.7	2,487	15.5	67.1	41.7	4.9	216	11.3	4.4	20.7
	191 E	87.1	155.9	6,073	23.2	119.3	57.3	11.1	61	16.9	10.0	36.3
	243 E	110.7	242.7	12,026	31.0	185.6	72.9	19.5	2,166	28.6	17.5	51.9

Notes:

1. *Tabulated values are Limit State Design values and not permitted to be increased for the lumber size adjustment factor in accordance to CSA O86.*
2. *The CLT grades are developed based on CSA 086-14 and ANSI/APA PRG 320. Please refer to specific grade layups for complete panel information.*
3. *CrossLam® CLT is building code approved for dry service use applications only.*

TABLE 7: SPECIFIED STRENGTHS + MODULUS OF ELASTICITY

CLT GRADE	MAJOR STRENGTH DIRECTION						MINOR STRENGTH DIRECTION					
	$F_{B,0}$ (MPa)	E_0 (MPa)	$F_{T,0}$ (MPa)	$F_{C,0}$ (MPa)	$F_{CP,0}$ (MPa)	$F_{S,0}$ (MPa)	$F_{B,90}$ (MPa)	E_{90} (MPa)	$F_{T,90}$ (MPa)	$F_{C,90}$ (MPa)	$F_{CP,90}$ (MPa)	$F_{S,90}$ (MPa)
V2M1.1	11.8	9,500	5.5	11.5	5.3	0.5	11.8	9,500	5.5	11.5	5.3	0.5
V2.1	11.8	9,500	5.5	11.5	5.3	0.5	7	9,000	3.2	9	5.3	0.5
E1M5	30.4	12,400	17.7	19.9	5.3	0.5	11.8	9,500	5.5	11.5	5.3	0.5
E1M4	30.4	12,400	17.7	19.9	5.3	0.5	7	9,000	3.2	9	5.3	0.5

Notes:

1. *Tabulated values are Limit State Design values and not permitted to be increased for the lumber size adjustment factor in accordance to CSA O86.*
2. *The design values shall be used in conjunction with the section properties provided by the CLT manufacturer based on the actual layup used in manufacturing the CLT panel (see table 4: lumber species and thickness for CLT panel layups, pages 67.)*
3. *Values are calculated per one metre wide section of panel.*

CrossLam® CLT Load Span Tables

TABLE 8: FLOOR PANEL LOADS MAXIMUM SPAN (mm)

	CROSSLAM® CLT SERIES	FLOOR LIVE LOAD (kPa)									
		1.9 RESIDENTIAL		2.4 OFFICE/CLASSROOM		3.6 MECHANICAL ROOM		4.8 ASSEMBLY/STORAGE		7.2 LIBRARY	
		VIBRATION	DEFLECTION L/180	VIBRATION	DEFLECTION L/180	VIBRATION	DEFLECTION L/180	VIBRATION	DEFLECTION L/180	VIBRATION	DEFLECTION L/180
SINGLE SPAN	87 V	**3,250**	3,550	**3,250**	3,400	(shaded)	**3,150**	(shaded)	**2,950**	(shaded)	**2,650[a]**
	87 E	**3,460**	3,850	**3,460**	3,700	(shaded)	**3,450**	(shaded)	**3,250**	(shaded)	**2,950**
	105 V	**3,700**	4,150	**3,700**	4,000	**3,700**	3,750	(shaded)	**3,500**	(shaded)	**3,150[a]**
	105 E	**3,960**	4,500	**3,960**	4,350	**3,960**	4,050	(shaded)	**3,800**	(shaded)	**3,450**
	139 V	**4,480**	5,350	**4,480**	5,150	**4,480**	4,800	(shaded)	**4,550**	(shaded)	**4,000[a]**
	139 E	**4,780**	5,750	**4,780**	5,600	**4,780**	5,250	**4,780**	**4,950**	(shaded)	**4,500**
	175 V	**5,150**	6,300	**5,150**	6,100	**5,150**	5,750	**5,150**	**5,400**	(shaded)	**4,750[a]**
	175 E	**5,500**	6,850	**5,500**	6,600	**5,500**	6,200	**5,500**	**5,900**	(shaded)	**5,360**
	191 V	**5,600**	7,000	**5,600**	6,800	**5,600**	6,350	**5,600**	**6,050**	(shaded)	**5,300[a]**
	191 E	**5,970**	7,550	**5,970**	7,350	**5,970**	6,900	**5,970**	**6,550**	(shaded)	6,000
	245 V	**6,440**	8,250	**6,440**	8,050	**6,440**	7,550	**6,440**	**7,200**	(shaded)	**6,250[a]**
	245 E	**6,880**	8,950	**6,880**	8,700	**6,880**	8,200	**6,880**	**7,800**	(shaded)	7,150
	243 V	**6,630**	8,600	**6,630**	8,350	**6,630**	7,850	**6,630**	**7,450**	(shaded)	**6,550[a]**
	243 E	**7,070**	9,250	**7,070**	9,000	**7,070**	8,500	**7,070**	**8,100**	(shaded)	7,450
	315 V	**7,600**	10,100	**7,600**	9,850	**7,600**	9,300	**7,600**	**8,850**	(shaded)	7,650
	315 E	**8,160**	10,900	**8,160**	10,600	**8,160**	10,050	**8,160**	**9,600**	(shaded)	8,850
DOUBLE SPAN	87 V	**3,900**	4,450	**3,900**	4,100	3,900	**3,550[a]**	(shaded)	**3,150[a]**	(shaded)	**2,650[a]**
	87 E	**4,150**	5,100	**4,150**	4,950	**4,150**	4,600	**4,150**	4,300	(shaded)	**3,300[b]**
	105 V	**4,450**	5,200	**4,450**	4,850	4,450	**4,200[a]**	4,450	**3,750[a]**	(shaded)	**3,150[a]**
	105 E	**4,750**	6,000	**4,750**	5,800	**4,750**	5,400	**4,750**	5,050	(shaded)	**3,950[b]**
	139 V	**5,380**		**5,380**		**5,380**	**5,300[a]**	5,380	**4,750[a]**	(shaded)	**4,000[a]**
	139 E	**5,740**		**5,740**		**5,740**		**5,740**			**5,150[b]**
	175 V								**5,600[a]**		**4,750[a]**
	175 E										
	191 V										**5,300[a]**
	191 E										
	245 V										
	245 E										
	243 V										
	243 E										
	315 V										
	315 E										

Double span is governed by maximum panel length of 12.19 m --> Use max value of 6,095 or design as simple span using table values above.

[a] Represents governing value M_R.
[b] Represents governing value V_R.

Notes:

1. *For panel properties - see page 70. Span table assumes dry service conditions.*
2. *The following factors were used for calculations: $K_D = 1.0$; $K_S = 1.0$; $K_T = 1.0$; $K_H = 1.0$.*
3. *Spans shown represent distance between the centerlines of supports and are to be used for preliminary design only.*
4. *Span table above includes panel self weight, 1.2 kPa for concrete topping (where indicated), plus 1.0 kPa miscellaneous dead load.*
5. *Engineer to ensure that L/180 deflection limit is appropriate for intended use.*
6. *Spans are assumed to be equal for double span panels. Where two spans are not equal, use longer span for the design tables.*
7. *Total panel length is limited to 12.19 m due to fabrication process.*
8. *Values in **BOLD SHADING** correspond to a span governed by allowable bending stress, allowable shear stress or by vibration.*
9. *The non-structural flooring is assumed to provide an enhanced vibration effect on the double spans. Values include a 20% increase.*
10. *CLT is NOT an isotropic material. Therefore the presented values must only be used for bending of panels in the longitudinal (strong) axis.*
11. *For applications with deflection limits or loading different than what is included above, contact your Structurlam technical representative.*
12. (shaded) *Indicates panel is strength governed and vibration control should not be used as a governing factor.*

TABLE 9: FLOOR PANEL LOADS
50 mm CONCRETE TOPPING MAXIMUM SPAN (mm)

	CROSSLAM® CLT SERIES	FLOOR LIVE LOAD (kPa)									
		1.9 RESIDENTIAL		2.4 OFFICE/CLASSROOM		3.6 MECHANICAL ROOM		4.8 ASSEMBLY/STORAGE		7.2 LIBRARY	
		VIBRATION	L/180	VIBRATION	L/180	VIBRATION	L/180	VIBRATION	L/180	VIBRATION	L/180
SINGLE SPAN	87 V	**2,750**	3,050	**2,750**	2,950	**2,750**	2,800			2,750	**2,500**
	87 E	**2,930**	3,300	**2,930**	3,250	**2,930**	3,050	**2,930**		2,930	**2,700**
	105 V	**3,150**	3,600	**3,150**	3,500	**3,150**	3,350	**3,150**		3,150	**2,950**
	105 E	**3,400**	3,900	**3,400**	3,800	**3,400**	3,650	**3,400**		3,400	**3,200**
	139 V	**3,900**	4,650	**3,900**	4,550	**3,900**	4,350	**3,900**		3,900	**3,800**[a]
	139 E	**4,200**	5,050	**4,200**	4,950	**4,200**	4,700	**4,200**		**4,200**	
	175 V	**5,150**	5,500	**5,150**	5,400	**5,150**			**4,950**		**4,500**[a]
	175 E	**5,500**	6,000	**5,500**	5,900	**5,500**	5,600		**5,350**		**5,000**
	191 V	**5,600**	6,150	**5,600**	6,050	**5,600**	5,750		**5,500**		**5,000**[a]
	191 E	**5,970**	6,700	**5,970**	6,550	**5,970**	6,250	**5,970**	6,000		**5,600**
	245 V	**6,440**	7,350	**6,440**	7,200	**6,440**	6,850	**6,440**	6,600		**5,900**[a]
	245 E	**6,880**	7,950	**6,880**	7,800	**6,880**	7,450	**6,880**	7,150		**6,700**
	243 V	**6,630**	7,650	**6,630**	7,450	**6,630**	7,150	**6,630**	6,850		**6,200**[a]
	243 E	**7,070**	8,250	**7,070**	8,100	**7,070**	7,750	**7,070**	7,450		**6,950**
	315 V	**7,600**	9,050	**7,600**	8,850	**7,600**	8,500	**7,600**	8,200		**7,250**[a]
	315 E	**8,160**	9,800	**8,160**	9,600	**8,160**	9,200	**8,160**	8,850	**8,160**	8,300
DOUBLE SPAN	87 V	**3,300**	3,850	**3,300**	3,600		**3,200**[a]		**2,900**[a]		**2,500**[a]
	87 E	**3,510**	4,400	**3,510**	4,300	**3,510**	4,100	**3,510**	3,900		**2,950b**
	105 V	**3,800**	4,450	**3,800**	4,250	**3,800**			**3,450**[a]		**3,000**[a]
	105 E	**4,080**	5,200	**4,080**	5,050	**4,080**	4,800	**4,080**	4,600		**3,550b**
	139 V	**4,700**	5,750	**4,700**	5,400	**4,700**	4,850		**4,400**[a]		**3,800**[a]
	139 E	**5,040**		**5,040**		**5,040**		**5,040**	6,000		**4,650**[a]
	175 V						**5,700**[a]		**5,200**[a]		**4,750**[a]
	175 E										**5,750**[a]
	191 V								**5,800**[a]		**5,000**[a]
	191 E										
	245 V										**5,500**[a]
	245 E										
	243 V										
	243 E										
	315 V										
	315 E										

Double span is governed by maximum panel length of 12.19 m --> Use max value of 6,095 or design as simple span using table values above.

[a] Represents governing value M_R.
[b] Represents governing value V_R.

Notes:

1. *For panel properties - see page 70. Span table assumes dry service conditions.*
2. *The following factors were used for calculations: $K_D = 1.0$; $K_S = 1.0$; $K_T = 1.0$; $K_H = 1.0$.*
3. *Spans shown represent distance between the centerlines of supports and are to be used for preliminary design only.*
4. *Span table above includes panel self weight, 1.2 kPa for concrete topping (where indicated), plus 1.0 kPa miscellaneous dead load.*
5. *Engineer to ensure that L/180 deflection limit is appropriate for intended use.*
6. *Spans are assumed to be equal for double span panels. Where two spans are not equal, use longer span for the design tables.*
7. *Total panel length is limited to 12.19 m due to fabrication process.*
8. *Values in **BOLD SHADING** correspond to a span governed by allowable bending stress, allowable shear stress or by vibration.*
9. *The non-structural flooring is assumed to provide an enhanced vibration effect on the double spans. Values include a 20% increase.*
10. *CLT is NOT an isotropic material. Therefore the presented values must only be used for bending of panels in the longitudinal (strong) axis.*
11. *For applications with deflection limits or loading different than what is included above, contact your Structurlam technical representative.*
12. *(shaded box) Indicates panel is strength governed and vibration control should not be used as a governing factor.*

TABLE 10: ROOF PANEL LOAD TABLE
MAXIMUM SPAN (mm)

	CROSSLAM® CLT SERIES	ROOF SNOW LOAD (kPa)					
		1.1	1.6	2.2	2.9	3.3	8.5
SINGLE SPAN	87 V	4,250	4,000	3,800	3,600	3,500	2,550[a]
	87 E	4,600	4,350	4,100	3,900	3,800	3,000
	105 V	4,950	4,700	4,450	4,250	4,100	3,000[a]
	105 E	5,350	5,100	4,850	4,650	4,550	3,550
	139 V	6,250	6,000	5,700	5,450	5,300	3,800[a]
	139 E	6,750	6,450	6,150	5,900	5,750	4,600
	175 V	7,350	7,050	6,700	6,450	6,300	4,500[a]
	175 E	7,900	7,600	7,250	6,950	6,800	5,450
	191 V	8,100	7,750	7,450	7,100	7,000	5,050[a]
	191 E	8,700	8,350	8,000	7,700	7,550	6,100
	245 V	9,400	9,100	8,750	8,400	8,250	5,900[a]
	245 E	10,150	9,800	9,450	9,050	8,900	7,300
	243 V	9,800	9,450	9,100	8,700	8,550	6,250[a]
	243 E	10,500	10,150	9,750	9,400	9,250	7,550
	315 V	11,350	11,000	10,600	10,200	10,100	7,300[a]
	315 E	12,150	11,850	11,450	11,050	10,850	9,000
DOUBLE SPAN	87 V	5,650	5,050[a]	4,500[a]	4,050[a]	3,850[a]	2,550[a]
	87 E		5,800	5,500	5,200	5,100	3,000[b]
	105 V		5,900[a]	5,300[a]	4,700[a]	4,500[a]	3,000[a]
	105 E					6,000	3,600[b]
	139 V				6000[a]	5,750[a]	3,800[a]
	139 E						4,700[b]
	175 V						4,500[a]
	175 E						5,800[b]
	191 V						5,050[a]
	191 E						
	245 V						5900[a]
	245 E						
	243 V						
	243 E						
	315 V						
	315 E						

Double span is governed by maximum panel length of 12.19 m --> Use max value of 6,095 or design as simple span using table values above.

[a] Represents governing value M_R.
[b] Represents governing value V_R.

Notes:

1. *For panel properties - see page 70. Span table assumes dry service conditions.*
2. *The following factors were used for calculations: $K_D = 1.0$; $K_S = 1.0$; $K_T = 1.0$; $K_H = 1.0$.*
3. *Snow Load is based on BCBC 2012 with the following factors: $I_S = 1.0$ for ULS; $I_S = 0.9$ for SLS; $C_W = 1.0$; $C_S = 1.0$; $C_A = 1.0$.*
4. *Spans shown represent distance between the centerlines of supports and are to be used for preliminary design only.*
5. *Span table above includes panel self weight plus 0.5 kPa miscellaneous dead load.*
6. *Engineer to ensure that L/180 deflection limit is appropriate for intended use. Ponding or ceiling finishes may require higher deflection limits.*
7. *Spans are assumed to be equal for double span panels.*
8. *Total panel length is limited to 12.19 m due to fabrication process.*
9. *CLT is NOT an isotropic material. Therefore the presented values must only be used for bending of panels in the longitudinal (major) axis.*
10. *For applications with deflection limits or loading different than what is included above, contact your Structurlam technical representative.*

TABLE 11: WALL PANEL LOAD TABLE (AXIAL LOADING ONLY)

CROSSLAM® CLT SERIES																
PANEL D (mm)	87 V	87 E	105 V	105 E	139 V	139 E	175 V	175 E	191 V	191 E	245 V	245 E	243 V	243 E	315 V	315 E
L (m)	P_R (kN/m¹)															
2.0	394	662	450	767	702	1,203	712	1,227	949	1,636	933	1,612	1,172	2,025	1,140	1,972
2.5	307	508	388	655	633	1,079	670	1,150	894	1,536	895	1,544	1,121	1,934	1,101	1,902
3.0	233	381	326	544	561	947	625	1,069	836	1,431	858	1,478	1,071	1,843	1,065	1,839
3.5	175	283	268	443	487	816	578	983	775	1,319	821	1,410	1,019	1,749	1,032	1,779
4.0	132	212	218	356	417	692	528	894	711	1,203	782	1,340	965	1,650	998	1,718
4.5			176	286	354	582	478	804	646	1,086	741	1,266	909	1,547	964	1,656
5.0			142	229	297	486	429	717	581	972	699	1,189	850	1,441	929	1,592
5.5					250	405	382	634	520	863	656	1,111	791	1,334	892	1,525
6.0					209	338	339	558	462	762	612	1,032	731	1,227	854	1,456
6.5					176	283	299	490	409	670	569	954	673	1,123	816	1,386
7.0							263	429	361	589	526	878	616	1,023	776	1,314
7.5							231	375	318	516	484	805	562	929	736	1,242
8.0							203	329	280	453	445	735	512	842	696	1,171
8.5							179	288	247	398	407	671	465	761	657	1,100
9.0											372	611	421	688	618	1,031

Notes:

1. *For panel properties - see page 70.*
2. *Table assumes dry service conditions.*
3. *$Pr = \varphi F_c A_{eff} K_{zc} K_c$. Where the P_R values are not given, the slenderness ration exceeds 43 (maximum permitted by CSA O86-14).*
4. *The following factors were used for calculations: K_D=0.65; K_S=1.0; K_T=1.0; K_H=1.0; K_E=1.0*
5. *Table values are to be used for preliminary design only.*
6. *Eccentricity of axial load and wind loading has not been included.*
7. *Axial load table assumes outer laminations to be vertical.*
8. *For applications with loading different that what is included above, contact your Structurlam technical representative.*

TABLE 12: IN-PLANE SHEAR LOADING

CROSSLAM® CLT SERIES															
87 V	87 E	105 V	105 E	139 V	139 E	175 V	175 E	191 V	191 E	245 V	245 E	243 V	243 E	315 V	315 E
V_R (kN/m¹)															
54	54	95	95	108	108	190	190	163	163	285	285	217	217	380	380

Notes:

1. *For panel properties - see page 70.*
2. *Table assumes dry service conditions.*
3. *The following factors were used for calculations: K_{MOD} = 0.8; Y_M = 1.25.*
4. *Computed values based on "In-Plane Shear Capacity and Verification Methods" by Prof. G. Schickhofer, University of Graz.*
5. *Specified modulus of Strength: $F_{V,CLT,K}$ = 5.0 MPa; $F_{T,CLT,K}$ = 2.5 MPa, ref: "BSPhandbuch Holz-Massivbauweise in Brettsperrholz", Technical University of Graz.*
6. *Minimum width of wood used in lay-up is 89 mm.*
7. *Values are for CrossLam® panel only, not for shear connectors.*
8. *Table values are to be used for preliminary design only.*
9. *For applications with loading different that what is included above, contact your Structurlam technical representative.*

Carbon12, Portland, OR, USA

Mountain Equipment Co-op (MEC), Vancouver, BC, Canada

GlulamPLUS® Beams and Columns

Code Acceptance and Quality Assurance Standards
Adhesives
Product Characteristics
Appearance Classifications
Camber Standards
Allowable Design Stress Properties
Layups Patterns

GLULAMPLUS® Beams and Columns
BY STRUCTURLAM

Structurlam GlulamPLUS® is manufactured using the highest-quality, sustainably harvested lumber, produced to exacting standards and finished to create North America's most beautiful glulam beams and columns, allowing you to expose the structural elements of your building as a high-grade visual component.

Manufactured in a wide range of shapes, sizes and finish options to match the vision of your design, with options like factory-installed connections and factory-applied stain, GlulamPLUS® beams and columns stand above all others. When combined with CrossLam® CLT walls, floors and roof panels, GlulamPLUS® is a key component of beautiful, economically efficient structures.

The technical information in this guide is compiled to support you in developing designs that specify GlulamPLUS® beams and columns. If you have questions and need help, let our qualified team of Structurlam Mass Timber Specialists and technical support representatives help you specify the right solution for your project.

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GLULAMPLUS® ADVANTAGES:

- North American code approved
- Range of shapes and sizes
- Superior wood fibre and appearance
- Available in sanded, high-quality finish
- Prefabricated kit of parts, CNC-fabricated to tight tolerances
- Top-notch project delivery experience
- BIM modeling options
- Shop-assembled steel connections
- Rigorous quality control process

Code-Approved to North American Standards

The National Building Code of Canada (NBCC) recognizes structural glued laminated timber as a structural material for wood construction when manufactured in accordance with CSA O122-16 Standard for Wood Products – Structural Glued-Laminated Timber.

The NBCC permits the use of structural glued laminated timber as a structural member for combustible construction and the upcoming encapsulated mass timber construction and CSA O86 references design values, design equations and overall engineering design specification for structural glued laminated timber.

Manufacturers of glued laminated timber, certified in North America, adhere to the standards set forth as described above.

When considering product manufactured outside of North America, it should be noted few offshore suppliers adhere to North American standards. As a result, when considering product supplied from producers outside of North America, it is imperative to consider more than the conversion of design stress properties. See page 12 for key considerations that are upheld in the North American standards.

DESIGN PROPERTY COMPATIBILITY

The design capacities published in CSA O112:16 were derived analytically using the lumber properties published in CSA O86:19 – Engineering design in wood. Lumber from outside of North America has different characteristics, may not be recognized in CSA O86:19 and has published design values that are incompatible with those of North American lumber. As a result, the design properties for mass timber products manufactured with foreign species lumber should be carefully examined for compatibility with the North American design standards.

GlulamPLUS® Beams in Production

Glue-Bond Sample Test Blocks

GlulamPLUS® Face Bond Test Sample and Shear Test Guillotine

GlulamPLUS® Beams in Production

Product Quality Assured

We are proud of our ongoing certification and adherence to the North American cross laminated timber and glued laminated timber standards referenced throughout this guide. GlulamPLUS® and CrossLam® CLT are certified to meet the requirements of Standard for Wood Products – Structural Glued Laminated Timber and Cross Laminated Timber (CLT) as described in CSA O122 and ANSI/APA PRG 320-2019.

These standards outline the quality control requirements required by CSA and are verified by the APA – The Engineered Wood Association (www.apawood.org) through ongoing and monthly independent third-party inspection visits to Structurlam's manufacturing operations. For more information on destructive performance testing, see table 2 on page 65.

Further design considerations and local code approvals may be required when considering a foreign supply source, which can increase project timelines and cost. By adhering to these standards, Structurlam can assure a standard of quality to the professionals who specify our products. For more information, refer to pages 12 and 13.

Adhesives

STRUCTURLAM ADHESIVE SYSTEMS

The manufacturing of all code approved mass timber products to produce long length lamellas requires adhesives approved for face bond lamination and end to end finger jointing. Structurlam uses adhesives specific to our manufacturing processes that are certified to North American testing and manufacturing standards.

All adhesives must conform to CSA O122 and ASTM D7247 testing methods for fire, heat and moisture and must support ANSI manufacturing standards – see table 1 below.

The adhesive component is product thickness and depth dependent and comprises approximately 1% by weight of Structurlam's mass timber building products.

GLUE-BOND DURABILITY

The structural integrity of mass timber components depends upon the integrity of the glue-bond between the component lumber elements. This is true for the entire service life of these mass timber components. Conditions that can impact the glue-bond integrity are exposure to elevated heat (such as a fire event) and exposure to high moisture conditions for extended periods.

FIRE PERFORMANCE

The fire resistance of cross laminated timber and structural glued laminated timber is based on the certification requirements of the North American testing and manufacturing mass timber standards. These standards require rigorous adhesive heat durability testing to ensure mass timber product structural integrity under the most severe fire conditions.

EMISSIONS

Both Henkel and Hexion adhesives used by Structurlam for manufacturing our mass timber products are certified to UL GREENGUARD Gold. GREENGUARD Gold certified products are qualified to meet UL GREENGUARD standards for low chemical emissions into indoor air during product usage. These adhesives are formulated to meet or exceed all global emissions standards.

TABLE 1: ADHESIVES FOR GLULAM AND CLT MASS TIMBER PRODUCTS

ADHESIVE APPLICATION	ADHESIVE BRAND	ADHESIVE TYPE	EMISSIONS CERTIFICATION	ADHESIVE PERFORMANCE TESTING		
				FULL SCALE FIRE TEST	HEAT DELAMINATION	MOISTURE DURABILITY
Finger Joints Crosslam CLT®/GlulamPLUS®	Hexion Cascomel™	Melamine Formaldehyde (MF)	UL GREENGUARD Gold	✓	✓	✓
Face Bond GlulamPLUS®	Hexion EcoBind™	Melamine Formaldehyde (MF)	UL GREENGUARD Gold	✓	✓	✓

Shoreline Medical Center, Seattle, WA, USA

GlulamPLUS® Product Characteristics

TABLE 2: GLULAMPLUS® PRODUCT CHARACTERISTICS

MANUFACTURING/FIBRE		
FIBER	Interior Douglas fir (Pseudotsuga menziesii var. glauca). Other species available upon request.	
FACE BOND GLUE SPECIFICATION	Hexion Ecobind™, 6500, Hardner M 650Y	
FINGER JOINT GLUE SPECIFICATION	Hexion Cascomel™ 4720 Resin with Wonderbond™ Hardener 5025A	
SFI/FSC CERTIFICATION	Available upon request	
MOISTURE CONTENT	12% (+/-3%) at time of manufacturing	
DENSITY	560 kg/m³ (34 lbs/ft³)	
CERTIFICATIONS	CSA O122 and CSA O177	
DIMENSIONAL TOLERANCES		
WIDTH	+/- 2 mm (1/16")	
DEPTH	+3 mm (1/8") per 305 mm (1') of depth. -5 mm (3/16") or 2 mm (1/16") per 305 mm (1') of depth, whichever is larger.	
LENGTH	Up to 6.1 m (20'), +/- 2 mm (1/16"). Over 6.1 m (20'), +/- 2 mm (1/16") per 6.1 m (20') of length or fraction thereof.	
CAMBER OR STRAIGHTNESS	Tolerances for camber are applicable at the time of manufacture without allowance for dead load deflection. Up to 6.1 m (20'), the tolerance is +/- 6 mm (1/4"). Over 6.1 m (20'), the tolerance shall increase 3 mm (1/8") per each additional 6.1 m (20') or fraction thereof, but not to exceed 19 mm (3/4").	
SQUARENESS OF CROSS SECTION	The tolerance for squareness shall be within +/- 3 mm (1/8") per 305 mm (1') of specified depth unless a specialty shaped section is specified.	
MACHINED SURFACES	+/- 3 mm (1/8") with all tooling units except the chainsaw, which is +/- 6 mm (1/4")	
MIN MAX WIDTH	See page 84.	
AVAILABLE SIZES	**METRIC**	**IMPERIAL**
MAX LENGTH STANDARD	18.3 m	60'
MAX LENGTH SPECIALTY	33.5 m	110'
MAX DEPTH STANDARD	1,219 mm	48"
MAX DEPTH SPECIALTY	2,438 mm	96"
MINIMUM DEPTH	114 mm	4.5"


Shane Homes YMCA at Rocky Ridge, Calgary, AB, Canada

Glulam Appearance Classifications

Listed below are the CSA O122 appearance grades that glulam products must meet. At Structurlam, GlulamPLUS® exceeds visual standards set by CSA O122 (see table below). Lower-grade appearances are available by request.

INDUSTRIAL

COMMERCIAL

QUALITY

APPEARANCE GRADE REQUIREMENTS PER CSA O122	APPEARANCE GRADE		
	INDUSTRIAL	COMMERCIAL	QUALITY
Laminations may contain natural growth characteristics in specified grades of laminating stock.	Yes	Yes	Yes
Tight knots and stain may be present on exposed surfaces.	Yes	Yes	Yes
Sides should be surfaced true to specified dimensions.	Yes	Yes	Yes
Planer misses along individual laminations should be patched with replacement stock. Exposed surfaces should be sanded smooth and free of adhesive.	No	Yes	Yes
Loose knots, knot holes, and voids greater than 19 mm in diameter on exposed surfaces shall be replaced by wood inserts or non-shrinking, waterproof filling material.	No	Yes	Yes
Wane, pitch pockets, loose knots, knot holes, and voids on exposed surfaces shall be replaced by wood inserts or non-shrinking, waterproof filling material.	No	No	Yes
Slightly broken knots, slivers, torn grain, and checks shall be filled.	No	No	Yes

ADDITIONAL FEATURES FOR GLULAMPLUS® BEAMS AND COLUMNS INCLUDE:
1. GlulamPLUS® beams and columns exposed faces surfaces are sanded smooth to 80 grit.
2. Structurlam uses epoxy putty for correcting larger voids to assure adhesion.
3. For a staggered multi piece lamination layup, a full length wood spline insert is applied on the visible face to cover gaps of the adjacent boards.
4. GlulamPLUS® beams and columns are coated with a factory-applied temporary light-bodied sealer that provides some protection to the finished surface during shipping and through the construction phase.
5. For additional information on appearance classifications, refer to CSA O122.

FINISHES

Wood finishes are a necessary component of preserving your products. Bare wood products highlight the natural beauty of wood but may check, swell and change color over time. GlulamPLUS® beams and columns are coated with a sealer which, in addition to proper efforts for storage and handling during construction, can help to account for these factors. For more on GlulamPLUS® finishes, refer to page 92.

GLULAMPLUS® STANDARD WIDTH SECTIONAL DIAGRAMS

FIGURE 1: SINGLE LAMINATION BEAMS

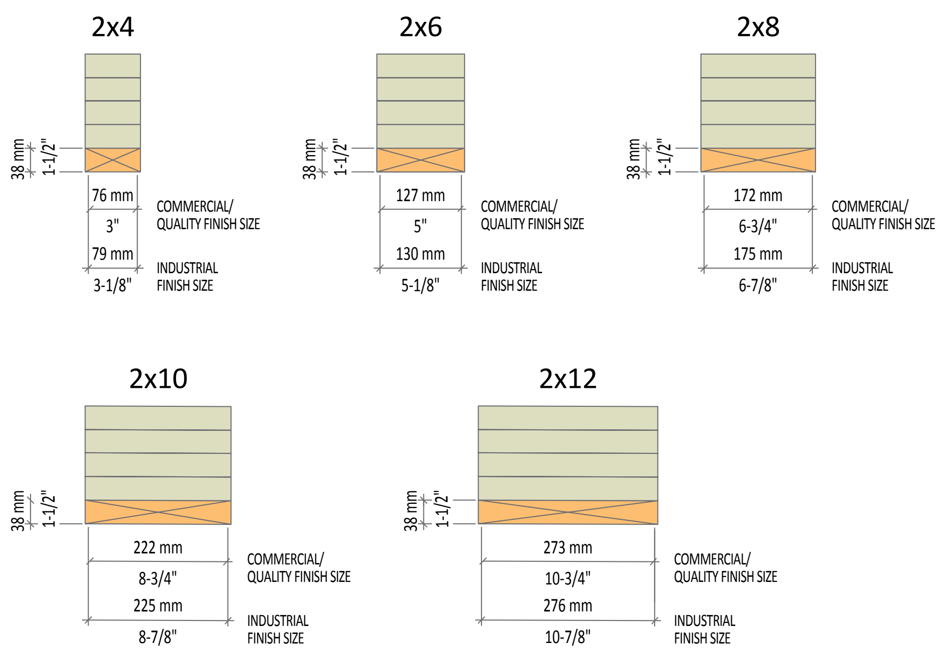
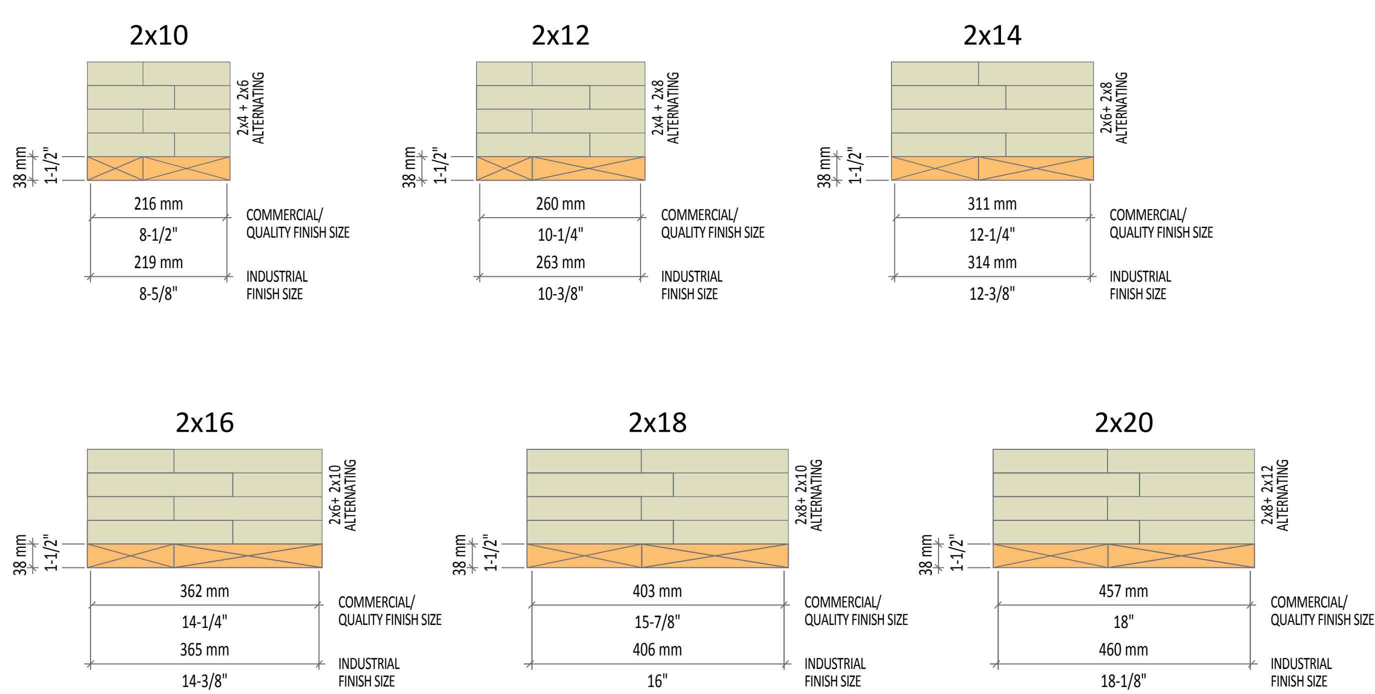


FIGURE 2: STAGGERED MULTIPLE PIECE LAMINATION



NOTE: All quality finished beams used for either appearance grade or with tight tolerance connections are additional undersized by 6 mm (1/4") in depth from full lamination roundings (38 mm x # of lams, - 6 mm).

TABLE 3: FINISHED WIDTHS OF GLULAMPLUS® BEAMS

NOMINAL SIZE	FINISHED WIDTHS*					
	INDUSTRIAL FINISH WIDTH		COMMERCIAL FINISH WIDTH		QUALITY FINISH WIDTH	
	METRIC (mm)	IMPERIAL (in)	METRIC (mm)	IMPERIAL (in)	METRIC (mm)	IMPERIAL (in)
2x4	79	3-1/8	76	3	76	3
2x6	130	5-1/8	127	5	127	5
2x8	175	6-7/8	172	6-3/4	172	6-3/4
2x10	219	8-5/8	216	8-1/2	216	8-1/2
2x12	263	10-3/8	260	10-1/4	260	10-1/4
2x14	314	12-3/8	311	12-1/4	311	12-1/4
2x16	365	14-3/8	362	14-1/4	362	14-1/4
2x18	406	16	403	15-7/8	403	15-7/8
2x20	460	18-1/8	457	18	457	18

*Other widths available from Structurlam

Staggered Multiple Piece Lamination: Structurlam utilizes a staggered multiple piece lamination layup technique as described in CSA O122, in the manufacture of wide-section members for GlulamPLUS® beams and columns. Structurlam analysis concludes staggered multiple piece lamination layup as a preferred methodology as follows:

Increased Homogenization: GlulamPLUS® beams and columns constructed through the staggered multiple piece lamination technique are composed of more individual elements than through a single lamination layup practice. This increased number of elements acts to further diffuse the impact of any one element on the resulting component and creates a more homogeneous construction.

Dimensional Stability: Based upon the same principle of an increased number of elements within the component, a staggered multiple piece lamination layup reduces the dimensional tendencies of any one element and can potentially increase the overall stability of the component. This can be most prominently realized in wider, deeper sections.

Diffused Shear Planes: In contrast to the block glulam layup methodology, commonly used by foreign manufacturers where narrower single-lam components are edge-glued to produce built-up wide components, the staggered multiple piece lamination technique creates noncontiguous vertical glue-line shear planes through the components. In contrast, the block laminating technique creates a continuous vertical shear plane between the two edge-glued components.

STAGGERED MULTIPLE PIECE LAMINATION

- The staggered multiple piece lamination method creates a noncontiguous shear plane in the glulam member.
- This staggered layup does not rely on the glue line integrity to the same degree as the forces can be resisted by the overlapping laminations in shear.
- This staggered glulam composition method is implicitly safer, more robust and does not demand the same degree of quality control over the glue line integrity as the block glued lamination method.

BLOCK GLUED GLULAM

- The block glued glulam lamination method creates a contiguous vertical shear plane that relies on the glue-bond line integrity to transfer loads through the glulam member.
- In an asymmetric loading application, the load component must transfer across the glue line in shear to allow the glulam member to act as a compound unit.

FIGURE 3

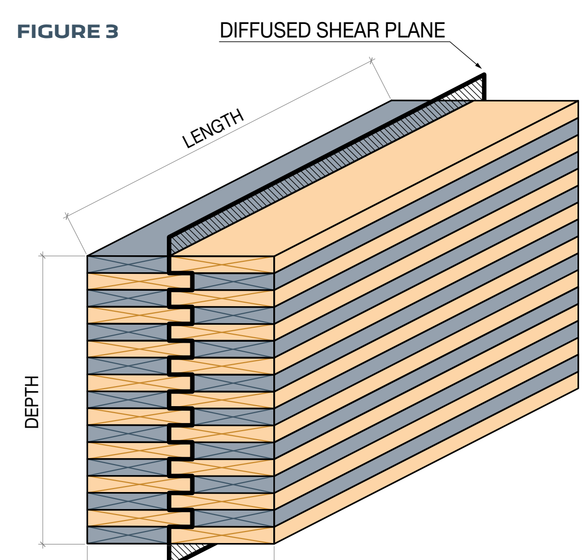


FIGURE 4

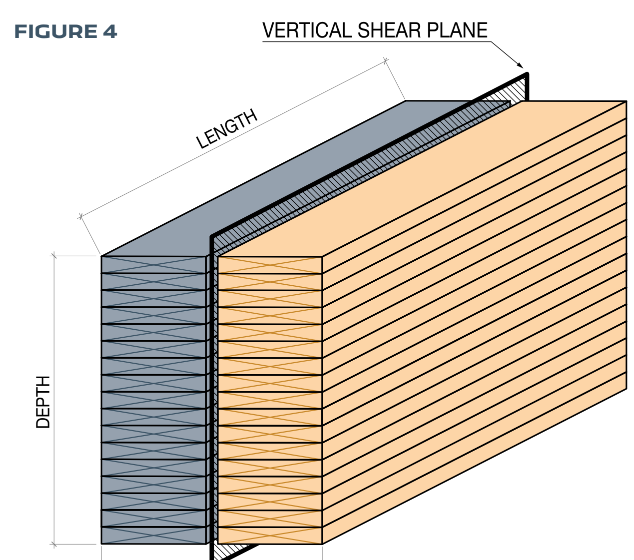


TABLE 4: GLULAMPLUS® CAMBER STANDARDS

Four standard levels of camber are available. Camber falling outside these standards is custom processed and will carry additional fabrication costs as arches. Standard camber carry no additional costs. Camber cannot be used with complex multi-point connections or pre-engineered tight tolerance connections. Camber should only be used when simple bucket or knife plate connections are used on each end of the beam.

	CAMBER VALUES PER BEAM LENGTH						Radius
CAMBER	6.1 m (20')	9.14 m (30')	12.2 m (40')	15.24 m (50')	18.3 m (60')	21.4 m (70')	
1	11.7 mm (0.46")	26.16 mm (1.03")	46.5 mm (1.83")	72.65 mm (2.86")	104.6 mm (4.12")	142.5 mm (5.61")	399.3 m (1,310')
2	8.4 mm (0.33")	18.8 mm (0.74")	33.3 mm (1.31")	52.1 mm (2.05")	74.9 mm (2.95")	101.85 mm (4.01")	558.7 m (1,833')
3	5.8 mm (0.23")	13.2 mm (0.52")	23.4 mm (.92")	36.3 mm (1.45")	52.3 mm (2.06")	71.4 mm (2.81")	798.6 m (2,620')
4	4.6 mm (0.18")	10.4 mm (0.41")	18.5 mm (0.73")	41.9 mm (1.15")	41.9 mm (1.65")	57.15 mm (2.25")	998 m (3,274')

Recommended Camber = 1.5 times dead load deflection for roof applications
1 time dead load deflection for floor applications

Camber is NOT recommended when using tight-tolerance pre-engineered connections.

They are also not recommended when using beam systems with multiple interconnections as installation becomes difficult and deflection loads can cause dynamic stresses on connections.

Continuous span beam applications will not have camber applied.

BC Passive House Factory, Pemberton, BC, Canada

TABLE 5: GLULAMPLUS® BEAM LIMIT STATE DESIGN STRENGTH PROPERTIES

ALL UNITS (MPa)											
COMBINATION	f_{BP}	f_{BN}	f_{Y}	f_{C}	f_{CB}	f_{CP}	f_{TN}	f_{TG}	f_{TP}	E	SPECIFIC GRAVITY
24f-E	30.6	23	2	30.2	30.2	7	20.4	15.3	0.83	12,800	0.50
24f-EX	30.6	30.6	2	30.2	30.2	7	20.4	15.3	0.83	12,800	0.50

NAME CONVENTION

24 f - E X

- X: Flexural members subjected to stress reversals
- E: Laminations are machine tested for stiffness
- f: Primary member usage (f - flexural, t - tension, c - compression)
- 24: Allowable stress in Imperial units, x 100 - i.e. 2,400 psi

FIGURE 5: BALANCED LAYUP

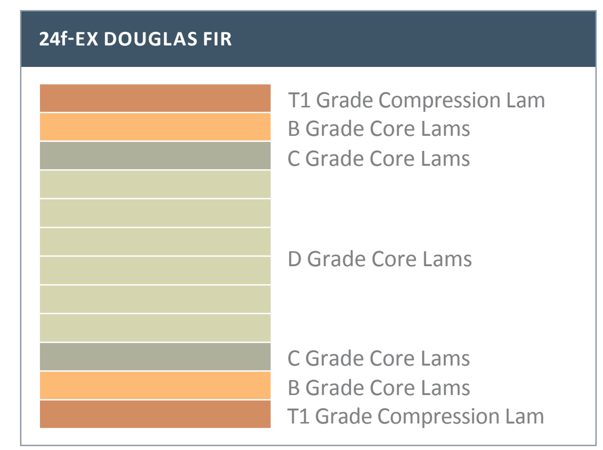


FIGURE 6: UNBALANCED LAYUP

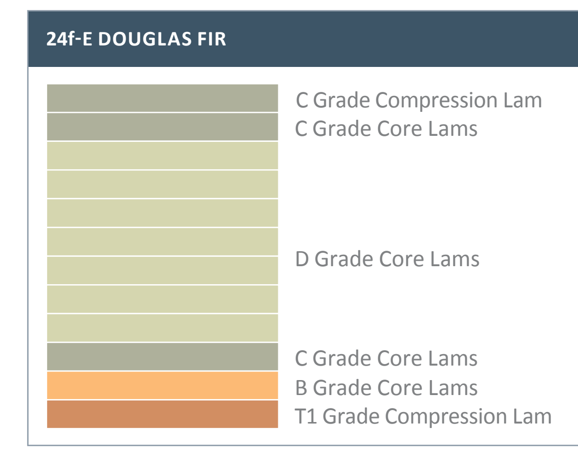


TABLE 6: GLULAMPLUS® COLUMN LIMIT STATE DESIGN PROPERTIES FOR GLULAMPLUS® COLUMNS

ALL UNITS (MPa)											
	f_{BP}	f_{BN}	f_V	f_C	f_{CB}	f_{CP}	f_{TN}	f_{TG}	f_{TP}	E	RELATIVE DENSITY
16c-E	14	14	2	30.2	30.2	7	20.4	15.3	0.83	12,400	0.50

The values listed in table 4 and table 5 on pages 86 and 87 are based on dry-service condition and standard-term load conditions.

Adjustment factors to be considered include:

K_D	Load Duration Factor
K_S	Service Condition Factor
K_H	System Factor
K_T	Treatment Factor
K_X	Curvature Factor
K_Z	Volume Factor
K_L	Lateral Stability Factor
K_C	Slenderness Factor
K_E	Effective Length Factor

Not all factors need be applied in all applications or for all design values. See the CSA O86:19, table 5.3.1 for a listing of which adjustment factors are required for specific situations.

TABLE 7A: GLULAMPLUS® COLUMN MAX AXIAL LOAD BASED ON LOADING ECCENTRICITY

MAX AXIAL LOAD $P_{F,MAX}$ (KN)												
COLUMN DIMENSIONS (mm) (W)X(D)	3.048 m (10 ft)		3.658 m (12 ft)		4.267 m (14 ft)		4.877 m (16 ft)		5.486 m (18 ft)		6.096 m (20 ft)	
	e=1/6 D or W	e=1/2 D	e=1/6 D or W	e=1/2 D	e=1/6 D or W	e=1/2 D	e=1/6 D or W	e=1/2 D	e=1/6 D or W	e=1/2 D	e=1/6 D or W	e=1/2 D
216 X 222	394	178	360	170	326	162	293	154	262	145	233	135
260 X 260	557	256	522	248	485	239	448	230	411	220	375	209
311 X 349	913	421	872	413	827	405	780	396	732	386	684	375
362 X 374	1,090	526	1,060	518	1,020	509	975	498	931	487	885	475
403 X 413	1,350	649	1,310	640	1,270	631	1,230	620	1,180	608	1,130	596
457 X 489	1,700	874	1,660	865	1,620	855	1,580	845	1,530	830	1,490	811

TABLE 7B: GLULAMPLUS® COLUMN MAX AXIAL RESISTANCE BASED ON CONCENTRIC LOADING

AXIAL RESISTANCE FOR CONCENTRICALLY LOADED COLUMNS (e=0, KN)												
COLUMN DIMENSIONS (mm) (W)X(D)	3.048 m (10 ft)		3.658 m (12 ft)		4.267 m (14 ft)		4.877 m (16 ft)		5.486 m (18 ft)		6.096 m (20 ft)	
	P_{RX}	P_{RY}	P_{RX}	P_{RY}	P_{RX}	P_{RY}	P_{RX}	P_{RY}	P_{RX}	P_{RY}	P_{RX}	P_{RY}
216 X 222	857	846	757	742	657	639	561	542	474	455	398	380
260 X 260	1,230	1,230	1,130	1,130	1,020	1,020	907	907	799	799	698	698
311 X 349	1,980	1,940	1,880	1,830	1,780	1,710	1,670	1,580	1,560	1,450	1,440	1,310
362 X 374	2,420	2,410	2,310	2,300	2,200	2,180	2,080	2,060	1,960	1,930	1,840	1,800
403 X 413	2,920	2,910	2,800	2,800	2,690	2,680	2,570	2,560	2,450	2,430	2,320	2,300
457 X 489	3,810	3,790	3,680	3,660	3,560	3,540	3,450	3,410	3,330	3,280	3,200	3,140

Assumptions and Notes:

1. *Dfir 16c-E glulam.*
2. *Column capacity under combined bending and axial load is only checked for bending moments due to eccentric loading. Additional bending introduced in the column, such as from wind loading or bracing, must be checked separately for its impact and will reduce the axial capacity of the column.*
3. *Assumed modification factors:*
   - *standard term load duration ($K_D = 1$)*
   - *dry service condition ($K_S = 1$)*
   - *no preservative treatment ($K_T = 1$)*
   - *straight members ($K_X = 1$)*
   - *no system factor ($K_H = 1$) except for M_{RY} calculation ($K_H = 1.1$)*
   - *effective length factor $K_E = 1$ (effectively pinned-pinned)*
4. *1/6 D or W eccentricities are listed as the worst case for bending about the x-x or y-y axis.*
5. *1/2 D eccentricities are provided for eccentricities resulting in strong axis (x-x) bending only.*
6. *Lateral support to be provided at column ends to prevent lateral displacement and rotation.*
7. *Tabulated values for e=0 (table 7B) should not be used directly for column sizing, but are intended to be used in conjunction with CSA O86:19 Cl. 7.5.12 for combined bending and axial load scenarios not covered by table 7A.*
8. *Column load capacities calculated are factored and calculated in accordance with CSA O86:19 and NBCC 2015.*
9. *These tables do not account for charring fire protection. Fire protection should be provided by encapsulation with a fire rating material as required by the applicable Building Code. Alternatively, Annex B can be used to calculate effective charring to provide fire protection.*

FIGURE 7: AXIAL LOAD ECCENTRICITY DIAGRAM FOR GLULAM COLUMNS

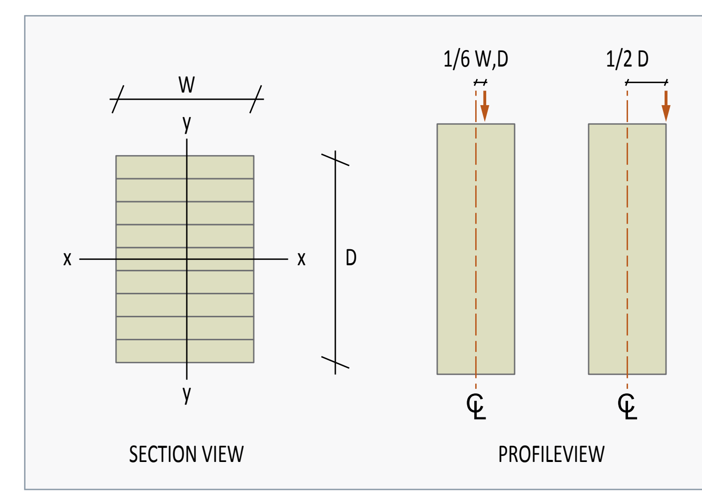


TABLE 8: GLULAMPLUS® BEAM ENGINEERING PROPERTIES

80 mm BEAM WIDTH													
DEPTH (mm) - nominal	228	266	304	342	380	418	456	494	532	570	608	646	684
WEIGHT (kg/m)	10.1	11.8	13.5	15.2	16.9	18.5	20.2	21.9	23.6	25.3	27.0	28.7	30.3
AREA (mm^2)	16,900	19,800	22,700	25,600	28,500	31,400	34,300	37,200	40,100	43,000	45,800	48,700	51,600
S ($x10^3$ mm^3)	626	859	1,130	1,430	1,780	2,160	2,570	3,030	3,520	4,050	4,610	5,210	5,850
I ($x10^6$ mm^4)	70	112	168	241	333	445	580	740	927	1,140	1,390	1,670	1,990
EI ($x10^9$ Nmm^2)	890	1,430	2,160	3,090	4,260	5,700	7,430	9,480	11,900	14,600	17,800	21,400	25,400
MAX UNSUPPORTED LENGTH L_U (mm)	1350	1160	1010	894	803	729	667	615	571	532	499	469	443
MOMENT CAPACITY M_R (kNm)	17.2	23.6	31.1	39.5	49.0	59.4	70.9	83.4	96.9	111	127	143	161
SHEAR CAPACITY V_R (kN)	20.3	23.7	27.2	30.7	34.2	37.6	41.1	44.6	48.1	51.5	55.0	58.5	62.0
SHEAR CAPACITY $W_{R\perp}^{0.18}$ (kN)	112	128	143	158	172	186	200	214	228	241	255	268	281

130 mm BEAM WIDTH													
DEPTH (mm) - nominal	304	342	380	418	456	494	532	570	608	646	684	722	760
WEIGHT (kg/m)	22.2	25.0	27.7	30.5	33.3	36.1	38.8	41.6	44.4	47.2	49.9	52.7	55.5
AREA (mm^2)	37,900	42,700	47,600	52,400	57,300	62,100	66,900	71,800	76,600	81,500	86,300	91,100	96,000
S ($x10^3$ mm^3)	1,890	2,400	2,970	3,610	4,300	5,060	5,880	6,760	7,700	8,710	9,770	10,900	12,100
I ($x10^6$ mm^4)	281	403	557	744	970	1,240	1,550	1,910	2,320	2,790	3,320	3,910	4,570
EI ($x10^9$ Nmm^2)	3,600	5,160	7,120	9,530	12,400	15,800	19,800	24,500	29,700	35,700	42,500	50,000	58,500
MAX UNSUPPORTED LENGTH L_U (mm)	2,810	2,500	2,240	2,040	1,860	1,720	1,590	1,490	1,390	1,310	1,240	1,170	1,110
MOMENT CAPACITY M_R (kNm)	51.9	66.0	81.8	99.3	118	139	162	186	209	234	259	286	314
SHEAR CAPACITY V_R (kN)	45.5	51.3	57.1	62.9	68.7	74.5	80.3	86.1	91.9	97.7	103.5	109.4	115.2
SHEAR CAPACITY $W_{R\perp}^{0.18}$ (kN)	218	240	262	284	305	326	347	368	388	408	428	447	467

175 mm BEAM WIDTH													
DEPTH (mm) - nominal	456	494	532	570	608	646	684	722	760	798	836	874	912
WEIGHT (kg/m)	44.8	48.5	52.3	56.0	59.7	63.5	67.2	70.9	74.7	78.4	82.1	85.9	89.6
AREA (mm^2)	76,600	83,100	89,600	96,100	103,000	109,000	116,000	122,000	128,000	135,000	141,000	148,000	154,000
S ($x10^3$ mm^3)	5,760	6,770	7,870	9,050	10,300	11,700	13,100	14,600	16,200	17,900	19,600	21,400	23,400
I ($x10^6$ mm^4)	1,300	1,660	2,070	2,560	3,110	3,740	4,440	5,230	6,110	7,080	8,150	9,330	10,600
EI ($x10^9$ Nmm^2)	16,600	21,200	26,500	32,700	39,800	47,800	56,900	67,000	78,200	90,700	104,000	119,000	136,000
MAX UNSUPPORTED LENGTH L_U (mm)	3,340	3,080	2,860	2,660	2,500	2,350	2,220	2,100	1,990	1,900	1,810	1,730	1,660
MOMENT CAPACITY M_R (kNm)	159	186	213	242	272	304	337	372	408	446	485	526	568
SHEAR CAPACITY V_R (kN)	92.0	99.7	108	115	123	131	139	146	154	162	170	177	185
SHEAR CAPACITY $W_{R\perp}^{0.18}$ (kN)	388	415	441	467	493	518	543	568	593	617	641	665	689

215 mm BEAM WIDTH													
DEPTH (mm) - nominal	608	646	684	722	760	798	836	874	912	950	988	1,026	1,064
WEIGHT (kg/m)	74.8	79.4	84.1	88.8	93.5	98.1	103	107	112	117	121	126	131
AREA (mm^2)	130,000	139,000	147,000	155,000	163,000	171,000	180,000	188,000	196,000	204,000	213,000	221,000	229,000
S ($x10^3$ mm^3)	13,100	14,800	16,600	18,500	20,600	22,700	24,900	27,200	29,700	32,200	34,900	37,600	40,500
I ($x10^6$ mm^4)	3,950	4,750	5,650	6,650	7,770	9,000	10,400	11,900	13,500	15,200	17,200	19,200	21,500
EI ($x10^9$ Nmm^2)	50,600	60,800	72,300	85,100	99,400	115,000	133,000	152,000	173,000	195,000	220,000	246,000	275,000
MAX UNSUPPORTED LENGTH L_U (mm)	4,030	3,790	3,580	3,390	3,220	3,060	2,920	2,790	2,680	2,570	2,470	2,380	2,290
MOMENT CAPACITY M_R (kNm)	354	395	438	484	531	580	631	684	739	796	854	915	977
SHEAR CAPACITY V_R (kN)	156	166	176	186	196	206	216	225	235	245	255	265	275
SHEAR CAPACITY $W_{R\perp}^{0.18}$ (kN)	600	630	661	691	721	751	780	809	838	867	896	924	952

Assumptions and notes:

1. *Dfir24f-EX glulam.*
2. *Uniformly distributed loading.*
3. *Nominal depths are based on the CWC Wood Design Manual tables; actual depths are unrounded nominal depths (38 mm - # lams) minus 6.35 mm (1/4").*
4. *Beam properties calculated based on actual depths and "Quality" finish widths.*
5. *Beam weight is based on density of 560 kg/m³ and "Industrial" finish widths.*
6. *Beam span for bending moment calculations assumed to be 18x actual depth.*
7. *Assumed modification factors:*
   - *standard term load duration ($K_D = 1$)*
   - *dry service condition ($K_S = 1$)*
   - *no preservative treatment ($K_T = 1$)*
   - *no system factor ($K_H = 1$)*
8. *For lateral stability, moment capacity is based on the structure providing continuous lateral support to the compression edge of the beam or lateral support provided by purlins or bracing at a spacing not exceeding L_U.*
9. *Shear capacity V_R is applicable for beams less than 2.0 m³ in volume; if beam volume is greater than 2.0 m³ the alternative shear capacity calculation $W_R L^{0.18}$ must be used per CSA O86.*
10. *Beam engineering properties are calculated in accordance with CSA O86-14 and NBCC 2015.*
11. *These tables do not account for charring fire protection. Fire protection should be provided by encapsulation with a fire rating material as required by the applicable Building Code. Alternatively, Annex B can be used to calculate effective charring to provide fire protection.*

TABLE 9: GLULAMPLUS® BEAM ENGINEERING PROPERTIES

265 mm BEAM WIDTH													
DEPTH (mm) - nominal	684	722	760	798	836	874	912	950	988	1,026	1,064	1,102	1,140
WEIGHT (kg/m)	101	107	112	118	123	129	135	140	146	152	157	163	168
AREA (mm^2)	177,000	187,000	196,000	206,000	216,000	226,000	236,000	246,000	256,000	266,000	276,000	286,000	296,000
S ($x10^3$ mm^3)	20,000	22,300	24,700	27,300	30,000	32,800	35,700	38,800	42,000	45,300	48,700	52,300	56,000
I ($x10^6$ mm^4)	6,800	8,000	9,350	10,800	12,500	14,300	16,200	18,400	20,700	23,200	25,800	28,700	31,800
EI ($x10^9$ Nmm^2)	87,000	102,000	120,000	139,000	160,000	183,000	208,000	235,000	264,000	296,000	331,000	368,000	407,000
MAX UNSUPPORTED LENGTH L_U (mm)	5,180	4,910	4,660	4,440	4,230	4,050	3,880	3,720	3,580	3,440	3,320	3,200	3,100
MOMENT CAPACITY M_R (kNm)	513	566	621	679	738	800	864	931	999	1,070	1,140	1,220	1,300
SHEAR CAPACITY V_R (kN)	212	224	236	248	260	271	283	295	307	319	331	343	355
SHEAR CAPACITY $W_{R\perp}^{0.18}$ (kN)	769	805	840	874	908	942	976	1,010	1,040	1,080	1,110	1,140	1,170

315 mm BEAM WIDTH													
DEPTH (mm) - nominal	760	798	836	874	912	950	988	1,026	1,064	1,102	1,140	1,178	1,216
WEIGHT (kg/m)	134	141	147	154	161	167	174	181	188	194	201	208	214
AREA (mm^2)	235,000	247,000	259,000	271,000	282,000	294,000	306,000	318,000	330,000	342,000	353,000	365,000	377,000
S ($x10^3$ mm^3)	29,600	32,700	35,900	39,200	42,700	46,400	50,200	54,200	58,300	62,600	67,000	71,500	76,200
I ($x10^6$ mm^4)	11,200	13,000	14,900	17,100	19,400	22,000	24,700	27,700	30,900	34,400	38,100	42,000	46,200
EI ($x10^9$ Nmm^2)	143,000	166,000	191,000	218,000	248,000	281,000	316,000	354,000	396,000	440,000	487,000	538,000	592,000
MAX UNSUPPORTED LENGTH L_U (mm)	6,670	6,350	6,060	5,790	5,550	5,320	5,120	4,930	4,750	4,590	4,430	4,290	4,150
MOMENT CAPACITY M_R (kNm)	743	812	883	957	1,030	1,110	1,200	1,280	1,370	1,460	1,550	1,640	1,740
SHEAR CAPACITY V_R (kN)	282	296	310	325	339	353	367	382	396	410	424	438	453
SHEAR CAPACITY $W_{R\perp}^{0.18}$ (kN)	972	1,010	1,050	1,090	1,130	1,170	1,210	1,250	1,280	1,320	1,360	1,400	1,430

365 mm BEAM WIDTH													
DEPTH (mm) - nominal	836	874	912	950	988	1,026	1,064	1,102	1,140	1,178	1,216	1,254	1,292
WEIGHT (kg/m)	171	179	187	195	202	210	218	226	234	241	249	257	265
AREA (mm^2)	301,000	315,000	329,000	343,000	356,000	370,000	384,000	398,000	411,000	425,000	439,000	453,000	467,000
S ($x10^3$ mm^3)	41,700	45,700	49,700	54,000	58,400	63,100	67,800	72,800	77,900	83,300	88,800	94,400	100,000
I ($x10^6$ mm^4)	17,400	19,900	22,600	25,600	28,800	32,200	36,000	40,000	44,300	48,900	53,800	59,100	64,600
EI ($x10^9$ Nmm^2)	222,000	254,000	289,000	327,000	368,000	413,000	460,000	512,000	567,000	626,000	689,000	756,000	827,000
MAX UNSUPPORTED LENGTH L_U (mm)	8,200	7,850	7,520	7,210	6,930	6,680	6,440	6,210	6,000	5,810	5,630	5,460	5,290
MOMENT CAPACITY M_R (kNm)	1,000	1,090	1,170	1,260	1,360	1,450	1,550	1,650	1,760	1,870	1,980	2,090	2,200
SHEAR CAPACITY V_R (kN)	361	378	394	411	428	444	461	477	494	510	527	543	560
SHEAR CAPACITY $W_{R\perp}^{0.18}$ (kN)	1,190	1,240	1,280	1,320	1,370	1,410	1,450	1,500	1,540	1,580	1,620	1,670	1,710

406 mm BEAM WIDTH													
DEPTH (mm) - nominal	988	1,026	1,064	1,102	1,140	1,178	1,216	1,254	1,292	1,330	1,368	1,406	1,444
WEIGHT (kg/m)	225	234	243	251	260	269	277	286	295	303	312	321	329
AREA (mm^2)	397,000	412,000	427,000	443,000	458,000	473,000	489,000	504,000	519,000	535,000	550,000	566,000	581,000
S ($x10^3$ mm^3)	65,100	70,200	75,500	81,100	86,800	92,700	98,800	105,000	112,000	118,000	125,000	132,000	140,000
I ($x10^6$ mm^4)	32,000	35,900	40,000	44,500	49,300	54,400	59,900	65,700	71,900	78,500	85,500	92,800	101,000
EI ($x10^9$ Nmm^2)	410,000	459,000	513,000	570,000	631,000	697,000	767,000	841,000	921,000	1,000,000	1,090,000	1,190,000	1,290,000
MAX UNSUPPORTED LENGTH L_U (mm)	8,590	8,270	7,980	7,700	7,440	7,200	6,970	6,760	6,560	6,370	6,200	6,030	5,870
MOMENT CAPACITY M_R (kNm)	1,510	1,620	1,730	1,840	1,960	2,080	2,200	2,330	2,450	2,590	2,720	2,860	3,000
SHEAR CAPACITY V_R (kN)	476	494	513	531	550	568	587	605	623	642	660	679	697
SHEAR CAPACITY $W_{R\perp}^{0.18}$ (kN)	1,490	1,570	1,620	1,670	1,710	1,760	1,810	1,850	1,900	1,950	1,990	2,040	2,080

460 mm BEAM WIDTH													
DEPTH (mm) - nominal	988	1,026	1,064	1,102	1,140	1,178	1,216	1,254	1,292	1,330	1,368	1,406	1,444
WEIGHT (kg/m)	255	265	275	285	294	304	314	324	334	344	353	363	373
AREA (mm^2)	450,000	467,000	485,000	502,000	519,000	537,000	554,000	572,000	589,000	607,000	624,000	641,000	659,000
S ($x10^3$ mm^3)	73,800	79,600	85,700	91,900	98,400	105,000	112,000	119,000	127,000	134,000	142,000	150,000	158,000
I ($x10^6$ mm^4)	36,300	40,700	45,400	50,500	55,900	61,700	67,900	74,600	81,600	89,000	96,900	105,000	114,000
EI ($x10^9$ Nmm^2)	465,000	521,000	581,000	646,000	716,000	790,000	870,000	954,000	1,040,000	1,140,000	1,240,000	1,350,000	1,460,000
MAX UNSUPPORTED LENGTH L_U (mm)	11,100	10,600	10,300	9,900	9,600	9,300	9,000	8,700	8,400	8,200	8,000	7,800	7,500
MOMENT CAPACITY M_R (kNm)	1,680	1,800	1,920	2,050	2,180	2,310	2,440	2,580	2,730	2,870	3,030	3,180	3,340
SHEAR CAPACITY V_R (kN)	540	561	582	602	623	644	665	686	707	728	749	770	790
SHEAR CAPACITY $W_{R\perp}^{0.18}$ (kN)	1,660	1,710	1,760	1,810	1,860	1,910	1,970	2,020	2,070	2,120	2,170	2,210	2,260

Notes:

See page 88 for notes.

CrossLam® and GlulamPLUS® Care, Handling, Rigging and Installation

PACKAGING

All CrossLam® CLT and GlulamPLUS® beams and columns are wrapped and protected at the factory to ensure arrival on-site in the best possible condition.

DELIVERY SEQUENCING

As part of the Structurlam Advantage to maximize economic efficiency gains with mass timber construction, Structurlam will work with the project construction team to coordinate the delivery and construction schedules. In the event temporary site storage is required, please see "Storage" for recommendations.

HANDLING

Use care and caution when lifting, ensuring consideration of weights and following all appropriate site safety procedures. Do not drag, dump or drop mass timber building components to unload from truck.

Always use wide nylon or fabric straps or slings with corner protectors when lifting CrossLam® CLT and GlulamPLUS® beams and columns to prevent surface damage or crushing of edges. Do not walk across panels or handle product with soiled or oily hands, tools or connecting hardware.

RIGGING

Prior to installation, CrossLam® CLT panels and GlulamPLUS® columns and beams need to be prepared for proper lifting and hoisting. All lifting equipment, rigging and hoisting devices are to be designed by the installer's erection engineer.

STORAGE

Store CrossLam® CLT and GlulamPLUS® beams and columns on a flat surface, raised off ground contact by 152 mm-305 mm (6"-12") using clean, wooden blocking spaced to ensure no product deflection. Separate courses with additional blocking, ensuring blocking is vertically aligned.

Cover product with good-quality, clean tarpaulin to protect from adverse weather conditions and UV exposure. Water will stain product. Prolonged exposure to sunlight will cause "tanning" and will discolor product.

For long-term storage, cut slits in the bottom of the wrapping to allow ventilation and drainage of any entrapped moisture.

Structurlam recommends retaining factory-applied wrapping on product until fully installed and building is enclosed to best protect finished surfaces.

FINISHING

Final finish coating of visually exposed CrossLam® CLT and GlulamPLUS® beams and columns is recommended and should be applied prior to introducing heat in the building. Finish sanding with 80 grit sandpaper in the direction of the wood grain is recommended prior to application of finishing product to exposed surfaces.

For GlulamPLUS® beams and columns, this includes a factory-applied light-bodied temporary sealer, providing some protection to the finished surface during shipping and through the construction phase. Structurlam recommends a final finish be applied to all CrossLam® CLT and GlulamPLUS® beams and columns.

Follow all application directions of finishing product. Finishing a small, concealed test area to ensure satisfactory end-results is always recommended.

CONDITIONING

In order to minimize adverse checking and/or dimensional movement in CrossLam® CLT and GlulamPLUS® beams and columns, it is critical that product is allowed to gradually adjust to final ambient moisture and temperature conditions over a period of several weeks.

Upon building closure, adjust building temperature and relative humidity slowly, over a series of weeks, allowing mass timber components equilibrium to adjust more naturally. (Remember, room temperatures near ceilings can be several degrees warmer than at floor level.) Do not expose CrossLam® CLT and GlulamPLUS® beams and columns directly to forced air during this period.

Mass Timber Systems Installation

Detailed pre-construction planning can help to ensure installation of our mass timber systems is easy, safe and efficient. Depending on the project site, we recommend that sufficient space be available to:

- Prepare panels for installation
- Re-sort panels according to the install sequence
- Apply treatments if required
- Install on-site hardware if required

TRUCKLOAD SEQUENCING

Truckload sequencing is a standard feature of Structurlam mass timber packages. The exact sequencing is established during the shop drawing process. To the extent possible, CrossLam® CLT panels are sequenced for delivery to be erected in place, directly from the delivering truck. In order to maintain safe shipment, some panels may be delivered out of sequence in order to properly balance the load. Please contact Structurlam to learn more about truckload sequencing.

ASSEMBLY DRAWINGS

Assembly drawings are produced using our 3D modeling software to provide instruction for fast and efficient site installation.

REFERENCES

CLT Handbook - Chapter 12, Canada, 2019.

STRUCTURLAM
MASS TIMBER CORPORATION
Intelligence In Wood

Penticton Lakeside Resort, Penticton, BC, Canada

Structurlam's Family of Mass Timber Building Products

CrossLam® CLT: Cross laminated timber panels used in floor, wall and roof structures

GlulamPLUS®: Glued laminated timber beam and column systems

3D BIM Models

Steel Connections

Project Management

Logistics Management

Contact us to learn more.

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