STRUCTURLAM
MASS TIMBER CORPORATION

Intelligence In Wood

Mass Timber Technical Guide

for CrossLam® CLT and GlulamPLUS®

U.S. VERSION

Duke University, Durham, NC, USA

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.

Carbon12, Portland, OR, USA

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

Structurlam Mass Timber Corporation - Operating in the United States under Structurlam Mass Timber U.S., Inc.


Shoreline Medical Center, Seattle, WA, USA

Benefits of Mass Timber Construction

Economically Viable and Competitive
Code Approved
Quality Assured
Adhesives
Architecturally Enabling
Engineered Solutions
Environmentally Superior

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 labor to the factory. Once on-site, it's more about simple assembly rather than construction.

NOTE: With a portion of the reallocated cost of labor 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.

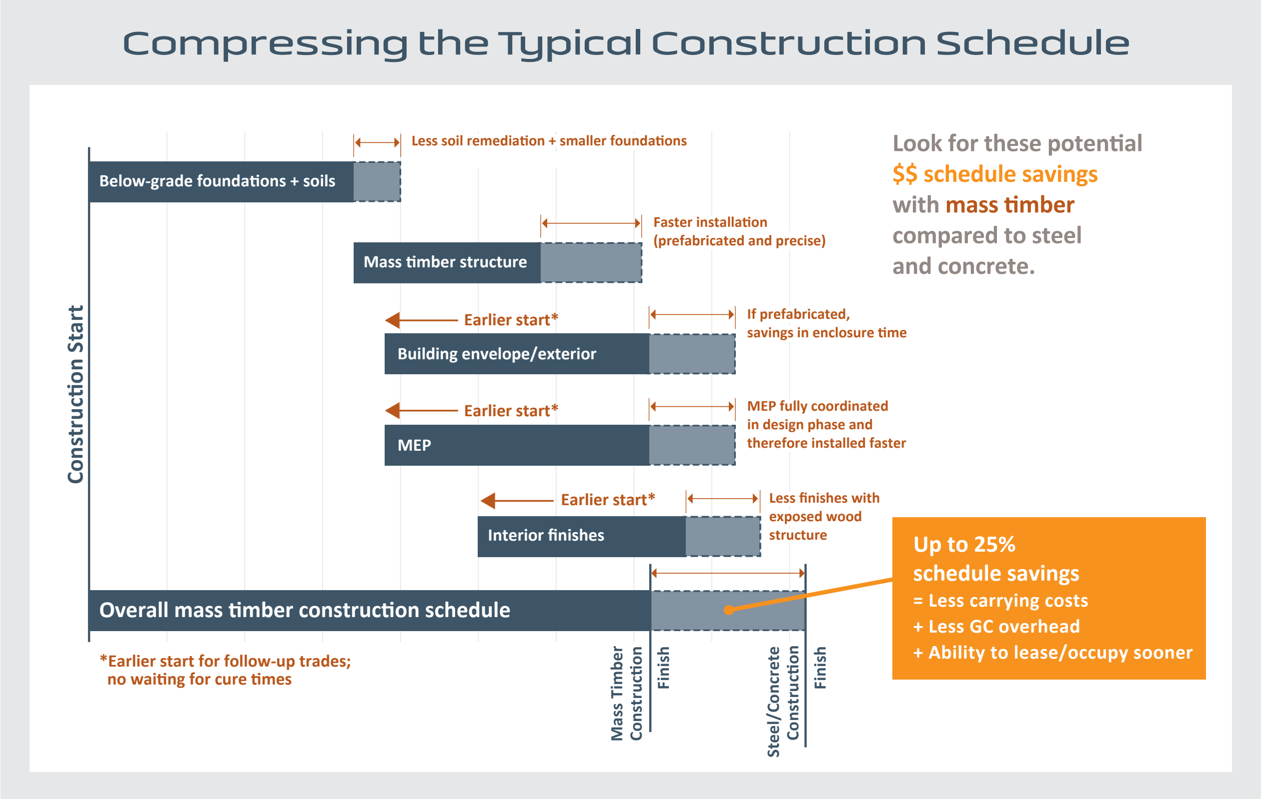
The cost benefits of mass timber construction can be summarized as follows:

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 practices where steel bar reinforcing 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 LABOR REQUIRED

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

IMPROVED JOBSITE SAFETY PERFORMANCE

- Fewer jobsite laborers 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

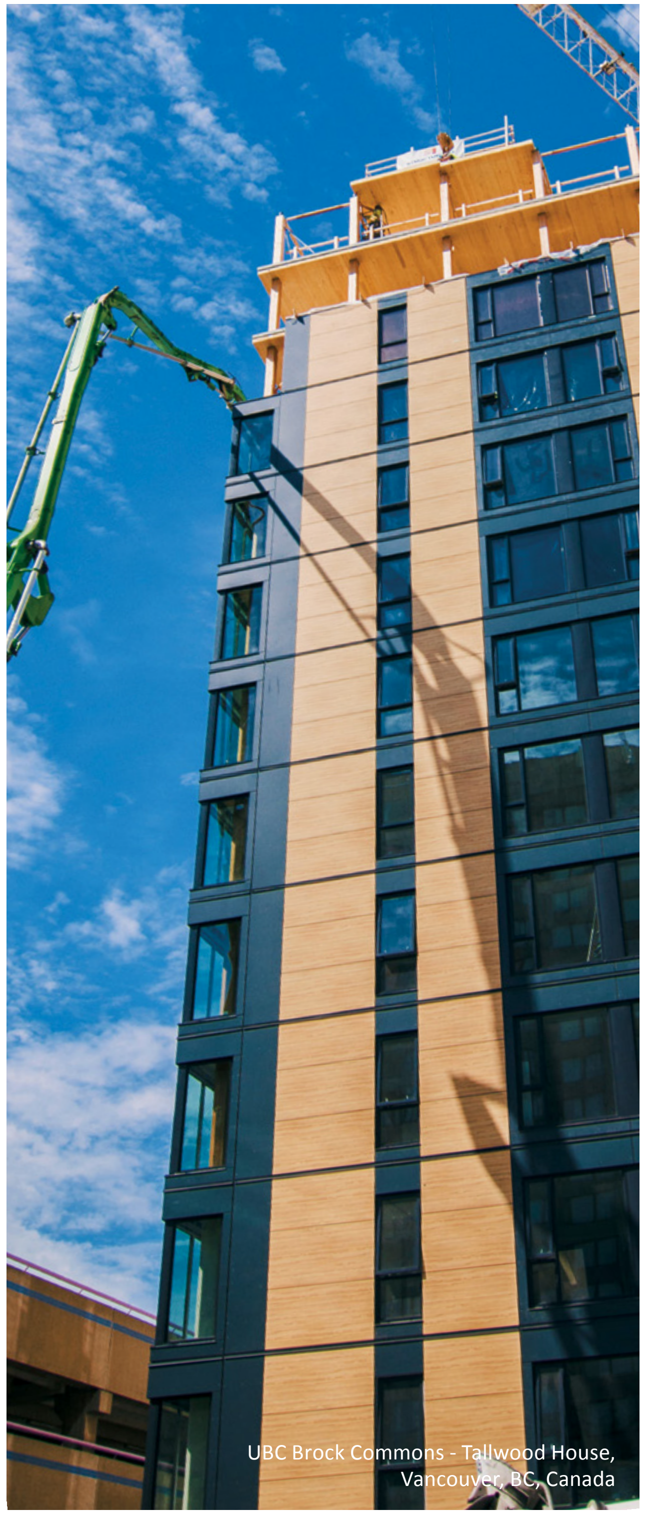
- As a building material, mass timber components are up to 75% lighter than traditional reinforced concrete components required for the same project.

  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 labor 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.



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

Mass Timber Construction Is:

Code-Approved to North American Standards

The International Building Code (IBC) recognizes cross laminated timber (when manufactured in accordance to the ANSI/APA PRG 320-2019 Standard (for Performance Rated Cross Laminated Timber), and structural glued laminated timber (when manufactured in accordance to the ANSI/APA A190.1 – 2017 Standard for Wood Construction Products – Structural Glued Laminated Timber), along with mass timber construction building systems for the following building typologies:

- Multifamily Residential up to six stories
- Conventional Non-Residential up to six stories (offices and banks, hotels and motels, dormitories and other health (excluding hospitals)
- Large Non-Residential up to six stories (warehouses, stores, public, recreation, schools, government)

In December 2018, the International Code Council (ICC) released voting results to adopt amendments to the 2021 IBC, including:

TYPE IV-A	Maximum 18 stories/270' Building Height with 972,000 SF Allowable Building Area. Noncombustible. Primary frame and vertical bearing structure require a three-hour fire resistance rating; most other structures require a two-hour fire resistance rating. All timber required to be protected with noncombustible materials.
TYPE IV-B	Maximum 12 stories/180' Building Height with 648,000 SF Allowable Building Area. Limited-area of exposed mass timber walls and ceilings allowed. Most structures require a two-hour fire resistance rating.
TYPE IV-C	Maximum 9 stories/85' Building Height with 405,000 SF Allowable Building Area. Most structures require a two-hour fire resistance rating, but nearly all timber can be exposed.

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 ANSI A190.1 were derived analytically using the lumber properties published in the National Design Specification (NDS) for Wood Construction. Lumber from outside of North America has different characteristics, may not be recognized in the NDS 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.

STRUCTURLAM ICC-ES REPORT ESR-3631

The Structurlam ICC-ES Report ESR-3631 affirms CrossLam® CLT for design stress properties for gravity loads as recognized in the standards listed on this page confirms in-plane shear properties for CrossLam® CLT.

This additional recognition allows CrossLam® CLT to be considered in applications where the component may be subjected to structural lateral loading as part of an engineered diaphragm component. These values effectively prove the stiffness of CrossLam® CLT and allow the engineer to design a diaphragm system where connections between panels govern in a rigid or semi-rigid diaphragm.

This is particularly useful for structures in earthquake zones or areas of high wind loads. Mass timber designs in these areas utilizing CLT without this added level of recognition will be required to provide a shear diaphragm solution, such as an outer layer of plywood in order to satisfy code.

For additional information on this topic, refer to Cross Laminated Timber Horizontal Diaphragm Design Example at https://www.structurlam.com/wp-content/uploads/2016/10/Structurlam-CrossLam-CLT-White-Paper-on-Diaphragms-SLP-Oct-2015.pdf.

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 ANSI A190.1-2017 and ANSI/APA PRG 320-2019.

These standards outline the quality control requirements required by 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 ASTM testing methods for fire, heat and moisture and must support ANSI manufacturing standards – see table 1 below. These test methods and manufacturing standards are approved in the U.S. by the International Building Code (IBC). The IBC is a model building code developed by the International Code Council (ICC) .

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.


Hutton Headquarters Office, Wichita, KS, USA

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	✓	✓	✓
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 2: 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 5-1/8" in width, 12" in depth and 21" 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 and high humidity	Glulam adhesives must meet ASTM D7247 and ANSI 405 in the U.S. and ASTM D7247 and CSA O122 in Canada.
Fire Performance	All glulam applications that depend on glulam fire endurance	Glulam must be manufactured and certified to ANSI A190.1 or 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 Specific Gravity **Note: The specific gravity for European Spruce is 0.42 or less, while the specific gravity for Douglas fir and Southern Pine is 0.50 and 0.55, 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 3: 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 American Lumber Standards Committee (ALSC) 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 ASTM D7247. 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.
Specific Gravity	Any lateral load analysis, bearing or connection design	Due to specific gravity 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 specific gravities not only reduce 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 ANSI/APA PRG 320-2019 Standard for Performance Rated Cross Laminated Timber and ANSI A190.1 Standard for Wood Products for Structural Glued Laminated Timber, are recognized in the National Design Specification (NDS) 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.

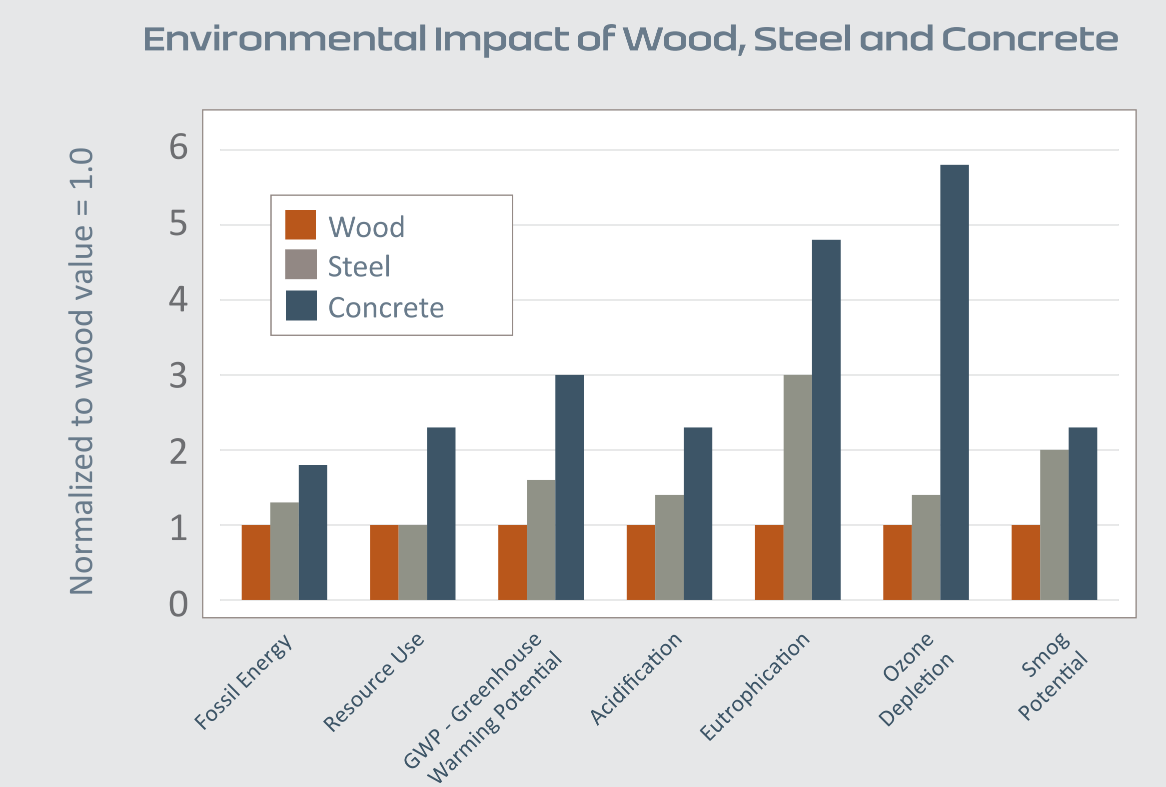
Shane Homes YMCA at Rocky Ridge, Calgary, AB, Canada

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*

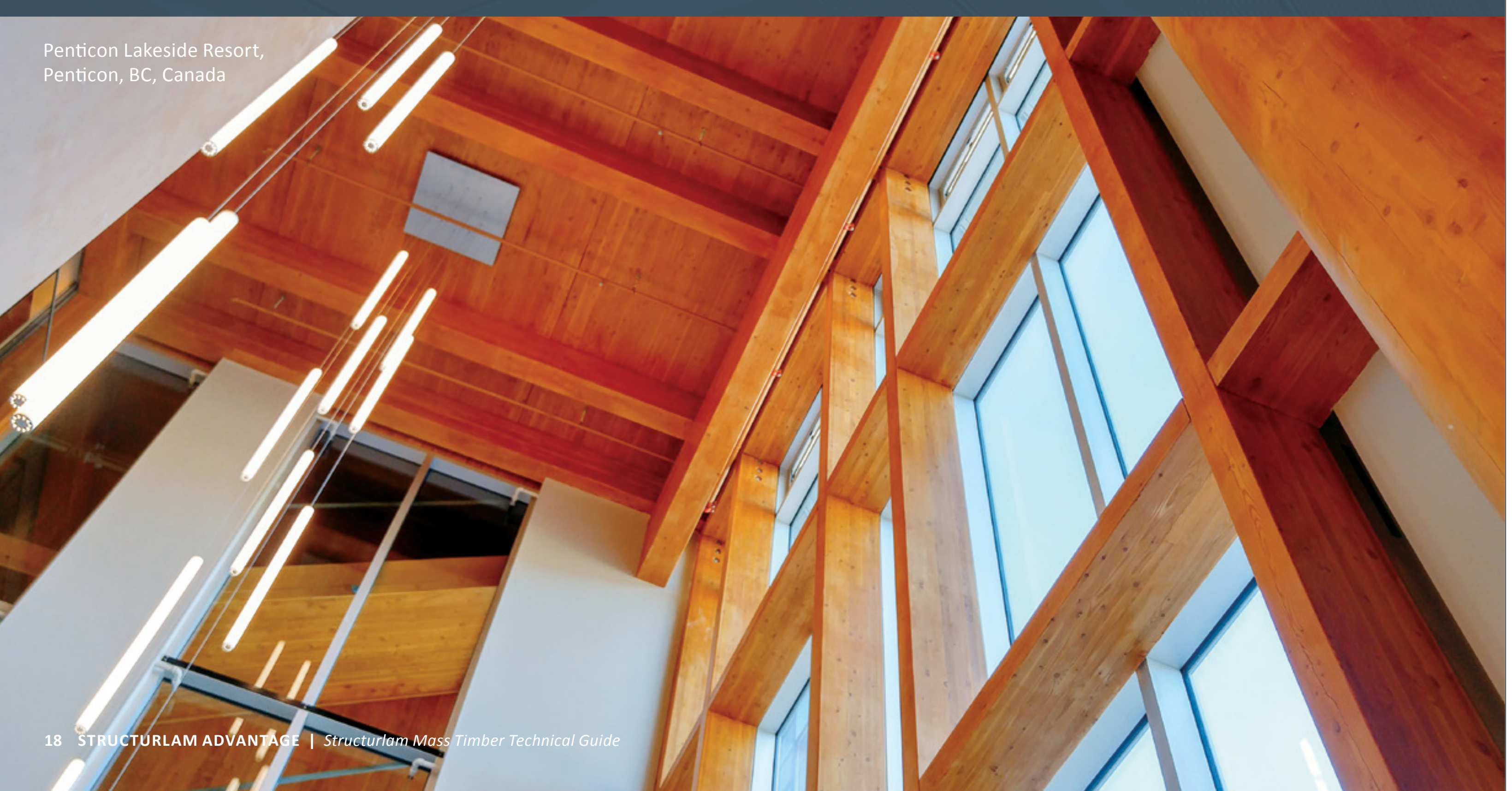
Telus Gardens, Vancouver, BC, Canada

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.


Penticon Lakeside Resort,
Penticon, 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 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 2018 International Building Code (IBC) and National Design Specification (NDS) for Cross Laminated and Glued Laminated Timber and are manufactured in accordance with ANSI/APA PRG 320-2019 Standard for Performance Rated Cross Laminated Timber and ANSI A190.1 Standard for Wood Products – 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 90 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 ANSI A190.1, section 9.3.

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.

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

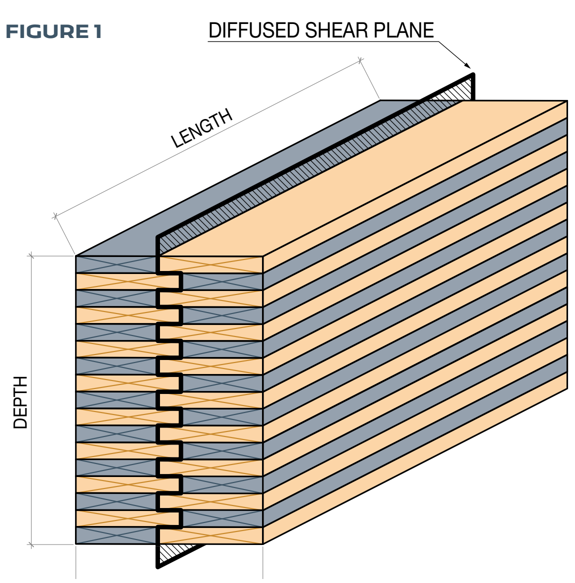
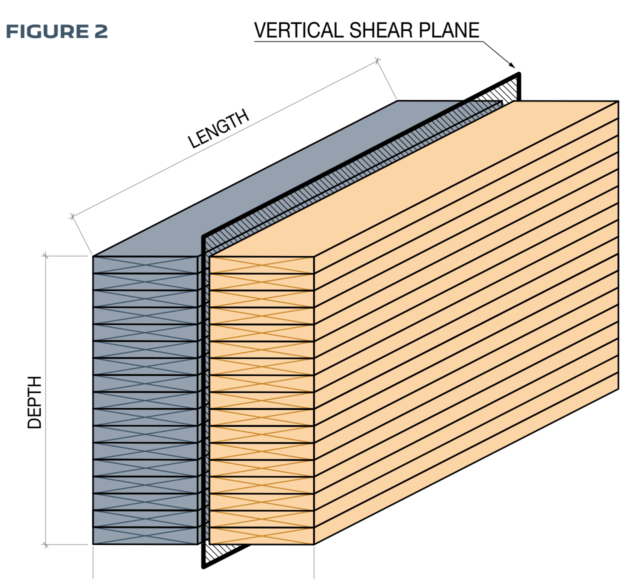


FIGURE 2



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 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 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.

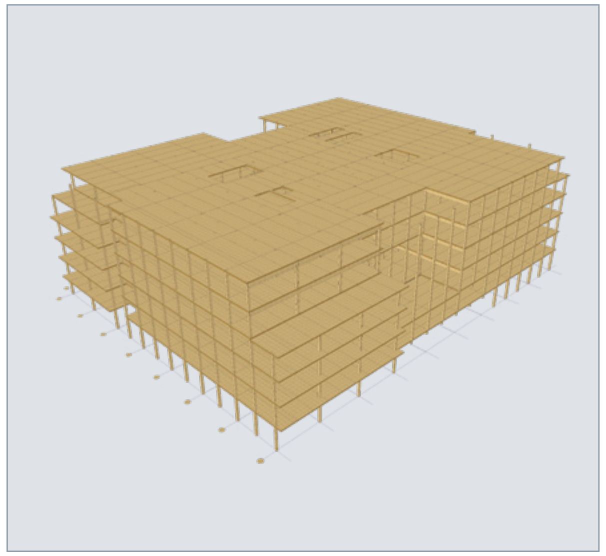
Mass Timber Design Process

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 77–89), 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

Post-Beam-Panel

Hybrid Light-Frame

Mass Timber System Selection Chart

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

UBC Brock Commons, Vancouver, BC, Canada

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

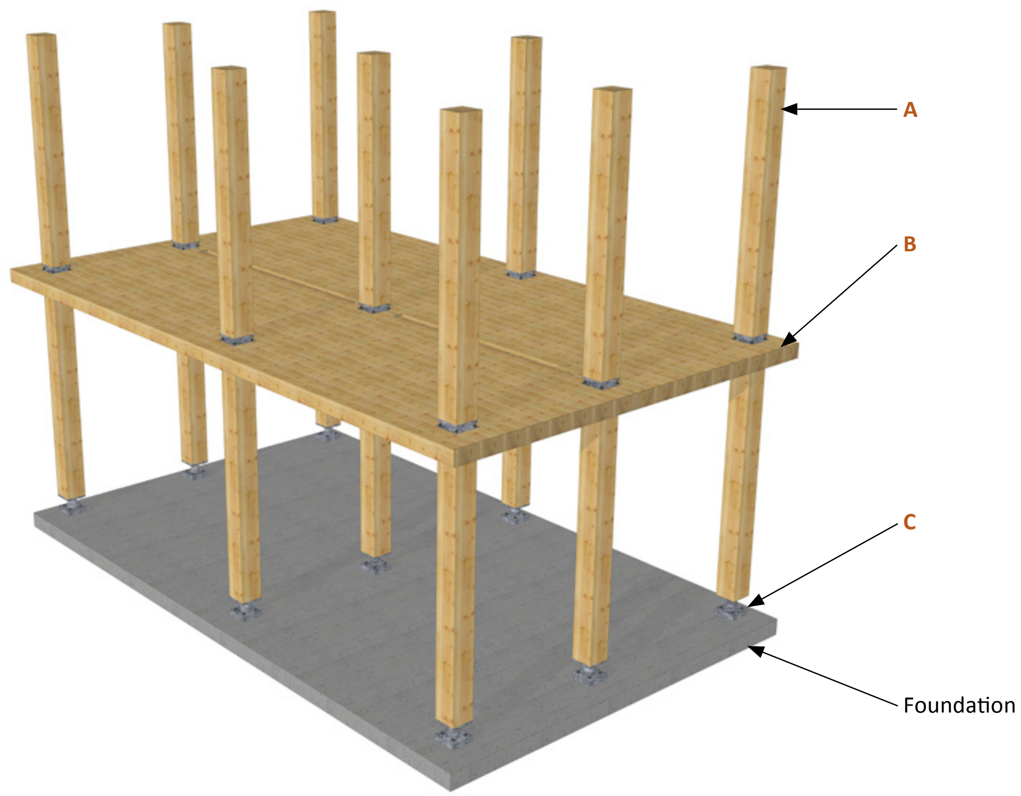
- The open and clear head heights of the Post and Panel System allow easy routing of mechanical, electrical and plumbing (MEP) systems.
- Connection design is typically less complex than other systems, making it ideal for fast, efficient and safe mass timber construction (see "Connections" on pages 42–53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

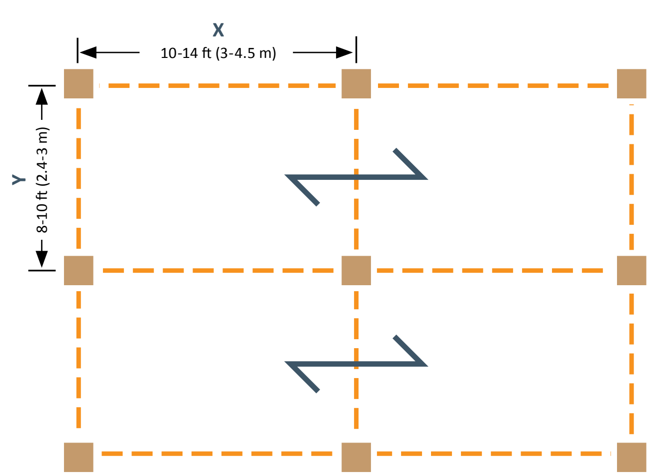
FIGURE 1: POST AND PANEL SYSTEM



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 7'-10.5" and 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 40' (12.19 m), and the maximum width that can be pressed is 7'-10.5" (2.4 m) and 9'-10.5" (3 m). 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

3935 Lakeshore Road, Kelowna, BC, Canada

Carbon12, Portland, OR, USA

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

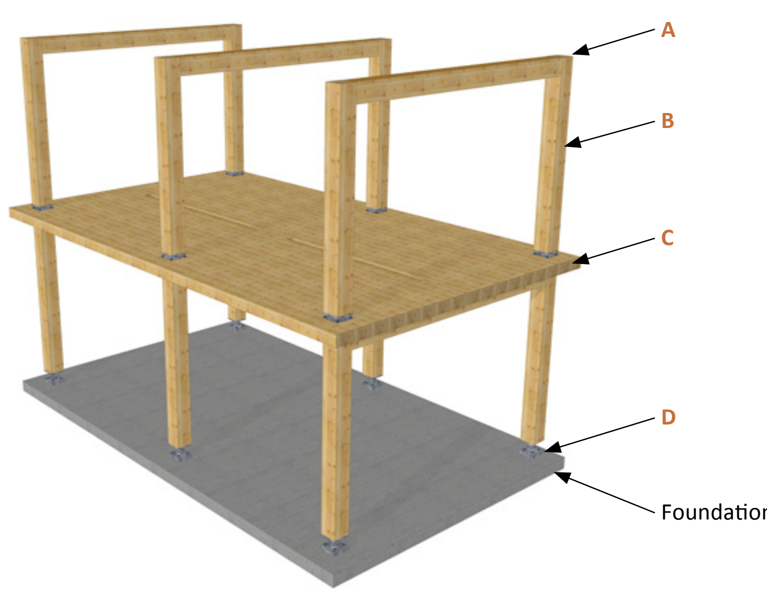
System Components

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



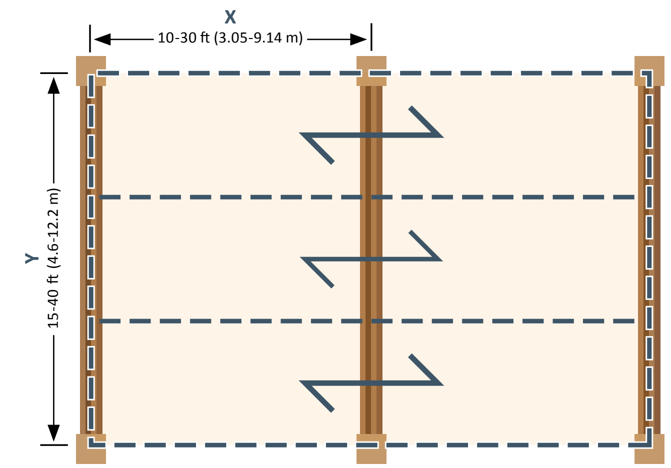
Grid Patterns

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 40' (12.19 m), and the maximum width that can be pressed is 7'-10.5" and 9'-10.5".

The use of augmented grids can create impressive structural efficiencies. An example would be a 30' (9.1 m) primary beam span in the Y direction and 15' (4.5 m) 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
Photo credit: Seagate Mass Timber, Inc.

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

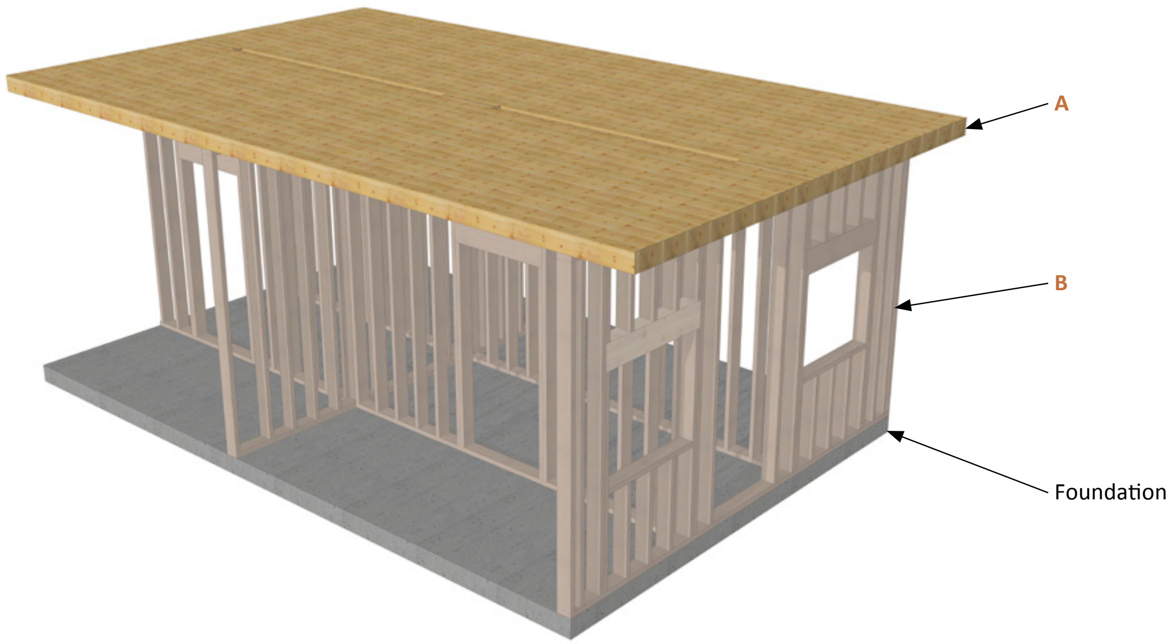
- The Hybrid Light-Frame System delivers improved construction cycle time over conventional light-frame systems.
- As a hybrid system, it's also a popular transitional system for builders more familiar with traditional building techniques.
- MEP infrastructure can be installed within the wall assembly.
- 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 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 stories (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 STORIES	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	8' (2.4 m)	14' (4.2 m)	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	12' (3.6 m)	20' (12.1 m)	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	8' (2.4 m)	16' (4.8 m)	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		13' (4 m) 16' (5 m)	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	8' (2.4 m)	20' (6 m)	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		20' (6 m)	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		20' (6 m)	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	8'-10' (2.44 m-3.05 m)	10'-14' (3.05 m-4.27 m)	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	10'-30' (3.05 m-9.14 m)	15'-40' (4.57 m-12.19 m)	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	20'-30' (6.10 m-9.14 m)	20'-30' (6.10 m-9.14 m)	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	10'-30' (3.05 m-9.14 m)	10'-15' (3.05 m-4.57 m)	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 labor markets
HYBRID STEEL FRAME CLT	30' (9.14 m)	30' (9.14 m)	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


Wesbrook Community Centre, Vancouver, BC, Canada

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

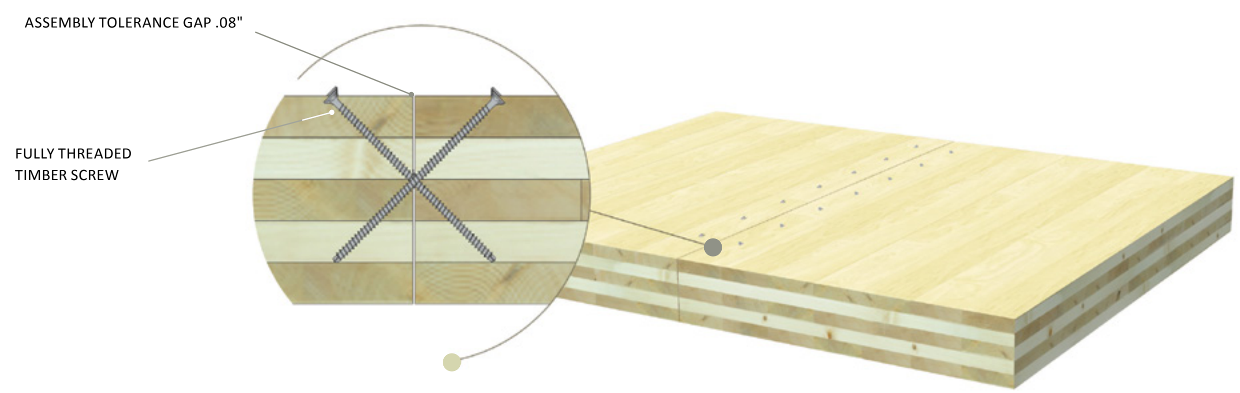


TABLE 1: REFERENCE LATERAL DESIGN VALUES FOR CLT BUTT JOINTS LOADED IN SHEAR

PANEL & JOINT CONFIGURATION				ASSY FASTENER OPTIONS	REFERENCE DESIGN VALUES (lbs)	MINIMUM SPACING IN A ROW
	LOADING		PANEL SERIES THICKNESS			
3-PLY	$Z_{//}$		4.13" 105 mm	VG Cyl 1/4" x 5-1/2"	123	1"
3-PLY	$Z_{\perp}$					
5-PLY	$Z_{//}$		6.89" 175 mm	VG CSK 5/16" x 8-5/8"	190	1-1/4"
				VG CSK 3/8" x 8-5/8"	251	1-1/2"
5-PLY	$Z_{\perp}$		6.89" 175 mm	VG CSK 5/16" x 8-5/8"	152	1-1/4"
				VG CSK 3/8" x 8-5/8"	201	1-1/2"

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 NDS.*
3. *The table contains reference lateral design values (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed reference design values are valid for dry service conditions only, where C_M=1.0.*
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. *Adjustment for narrow edge loading of CLT (C_{EG}) shall be considered, following NDS-2018 clause 12.5.2.*
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*

FIGURE 2: CLT SPLINE CONNECTION IN SHEAR

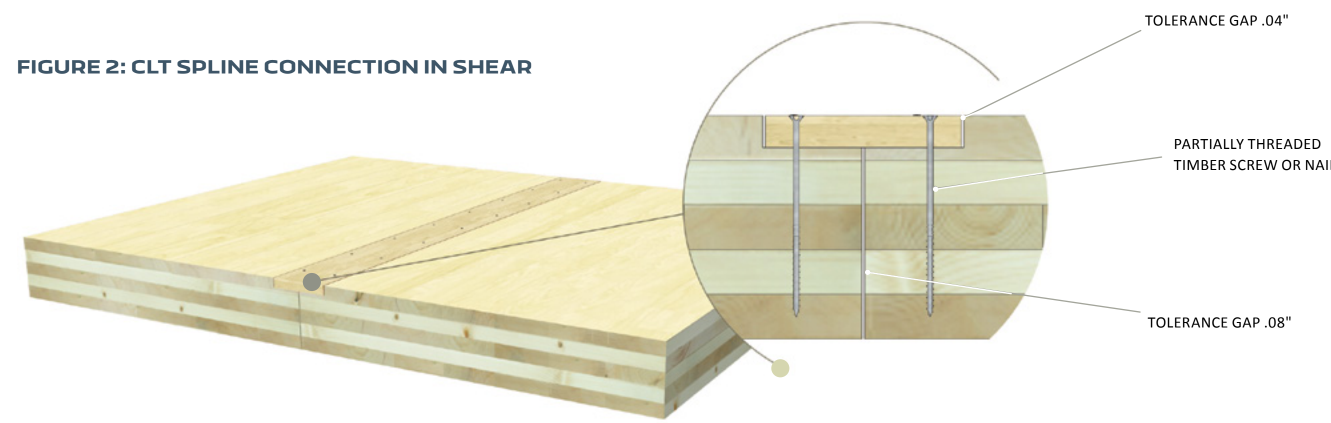


TABLE 2: REFERENCE LATERAL DESIGN VALUES FOR CLT SURFACE SPLINE JOINTS LOADED IN SHEAR

PANEL & JOINT CONFIGURATION					ASSY FASTENER OPTIONS	REFERENCE DESIGN VALUES (lbs)	MINIMUM SPACING IN A ROW
	LOADING		SPLINE THICKNESS	PANEL SERIES THICKNESS			
3-PLY	$Z_{//}$		3/4"	3.43" 87 mm	Eco 1/4" x 3-1/8"	134	1-3/4"
			3/4"	4.13" 105 mm	Eco 5/16" x 3-1/2"	172	2-1/4"
			1"	4.13" 105 mm	Eco 5/16" x 3-1/2"	178	2-1/4"
5-PLY	$Z_{//}$		1"	6.89" 175 mm	Eco 3/8" x 4-3/4"	269	2-5/8"

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 NDS.*
3. *The table contains reference lateral design values (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed reference design values are valid for dry service conditions only, where C_M=1.0.*
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. *Reference lateral design values 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

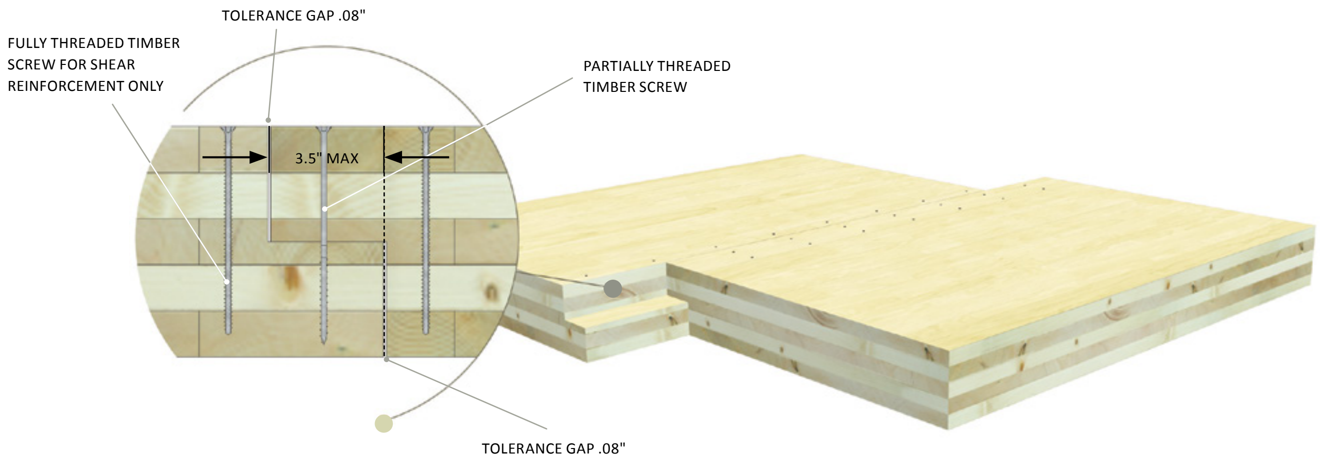


TABLE 3: REFERENCE LATERAL DESIGN VALUES FOR CLT LAP JOINTS LOADED IN SHEAR

PANEL & JOINT CONFIGURATION			ASSY FASTENER OPTIONS	REFERENCE DESIGN VALUES (lbs)	MINIMUM SPACING IN A ROW
	LOADING	PANEL SERIES THICKNESS			
3-PLY	$Z_{//}$	3.43" 87 mm	Eco 1/4" x 3-1/8"	151	1"
		4.13" 105 mm	Eco 1/4" x 3-1/2"	153	
		4.13" 105 mm	Eco 5/16" x 4"	209	1-1/4"
	$Z_{\perp}$	3.43" 87 mm	Eco 1/4" x 3-1/8"	151	1"
		4.13" 105 mm	Eco 1/4" x 3-1/2"	153	
		4.13" 105 mm	Eco 5/16" x 4"	167	1-1/4"
5-PLY	$Z_{//}$	5.5" 139 mm	Eco 1/4" x 4-3/4"	185	1"
		6.89" 175 mm	Eco 5/16" x 6-1/4"	243	1-1/4"
			Eco 3/8" x 6-1/4"	354	1-1/2"

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 NDS.*
3. *The table contains reference lateral design values (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed reference design values are valid for dry service conditions only, where C_M=1.0.*
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. *Reference lateral design values 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: REFERENCE LATERAL DESIGN VALUES FOR CLT PANEL TO BEAM CONNECTIONS IN SHEAR

CLT PANEL & BEAM CONFIGURATION				ASSY FASTENER OPTIONS	REFERENCE DESIGN VALUES (lbs)	MINIMUM SPACING IN A ROW
	BEAM TYPE	LOADING	PANEL SERIES THICKNESS			
3-PLY	Dfir (0.50)	$Z_{//}$	3.43" 87 mm	Eco 1/4" x 6-1/4"	198	2-5/8"
			4.13" 105 mm	Eco 1/4" x 7-7/8"	198	2-5/8"
				Eco 5/16" x 7-7/8"	259	3-3/8"
		$Z_{\perp}$	4.13" 105 mm	Eco 5/16" x 7-7/8"	207	3-3/8"
		$Z_{M,\perp}$				
		$Z_{S,\perp}$				
5-PLY	Dfir (0.50)	$Z_{//}$	6.89" 175 mm	Eco 3/8" x 11-7/8"	380	4"
		$Z_{M,\perp}$			282	4"

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 NDS.*
3. *The table contains reference lateral design values (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed reference design values are valid for dry service conditions only, where C_M=1.0.*
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

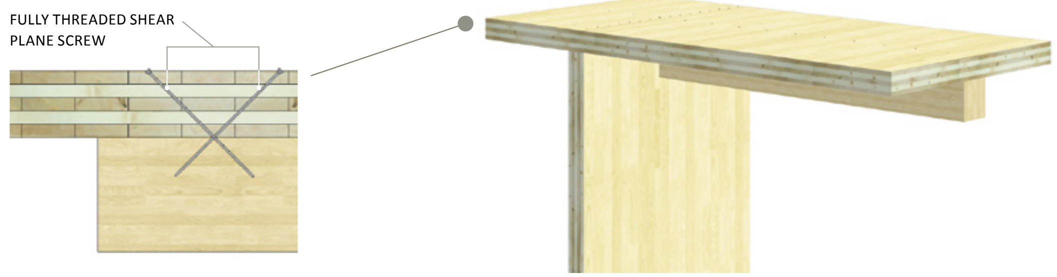


TABLE 5: REFERENCE DESIGN VALUES FOR CLT PANEL TO BEAM CONNECTION INCLINED SCREWS

CLT PANEL & BEAM CONFIGURATION				ASSY FASTENER OPTIONS WITH INCLINED SCREWS	REFERENCE DESIGN VALUES PER SCREW CROSS (lbs)	MINIMUM SPACING IN A ROW
	BEAM TYPE (sg)	LOADING	PANEL SERIES THICKNESS			
3-PLY	Dfir (0.50)	$Z_{x//}$	3.43" 87 mm	VG CSK 5/16" x 9-1/2"	1,283	4-3/4"
			4.13" 105 mm	VG CSK 5/16" x 11-7/8"	1,582	4-3/4"
				VG CSK 3/8" x 11-7/8"	1,769	5-5/8"
		$Z_{x\perp}$	3.43" 87 mm	VG CSK 5/16" x 9-1/2"	1,308	4-3/4"
			4.13" 105 mm	VG CSK 5/16" x 11-7/8"	1,666	4-3/4"
				VG CSK 3/8" x 11-7/8"	1,862	5-5/8"
5-PLY	Dfir (0.50)	$Z_{x//}$	6.89" 175 mm	VG CSK 3/8" x 19"	2,979	5-5/8"
		$Z_{x\perp}$	6.89" 175 mm	VG CSK 3/8" x 19"	3,021	5-5/8"

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 NDS.*
3. *The table contains reference lateral design values (Z) for 2 ASSY fasteners installed in a screw cross configuration conforming to the connection geometry and loading conditions described.*
4. *Listed reference design values are valid for dry service conditions only, where C_M=1.0.*
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. *Reference lateral design values only apply to parallel loading along the span direction of the glulam.*
8. *Z_{XII} Reference lateral design value per screw cross with CLT main member loaded along the major span direction.*

   Z_{XT} Reference lateral design value per screw cross with CLT main member loaded along the minor span direction.

Source: *MTC Solutions, mtcsolutions.com*

CLT Wall and Glulam Floor Beam Systems

FIGURE 6: PRE-ENGINEERED CONNECTORS

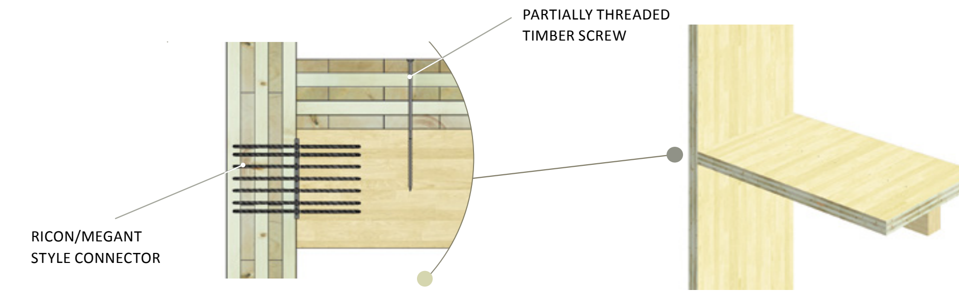


FIGURE 7: RICON S VS

Each product kit includes two matching connector plates.

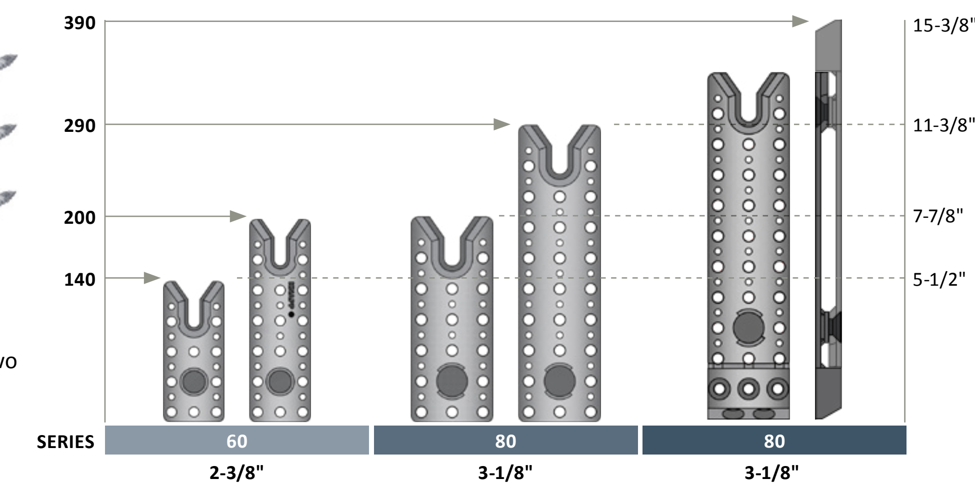


FIGURE 8: MEGANT

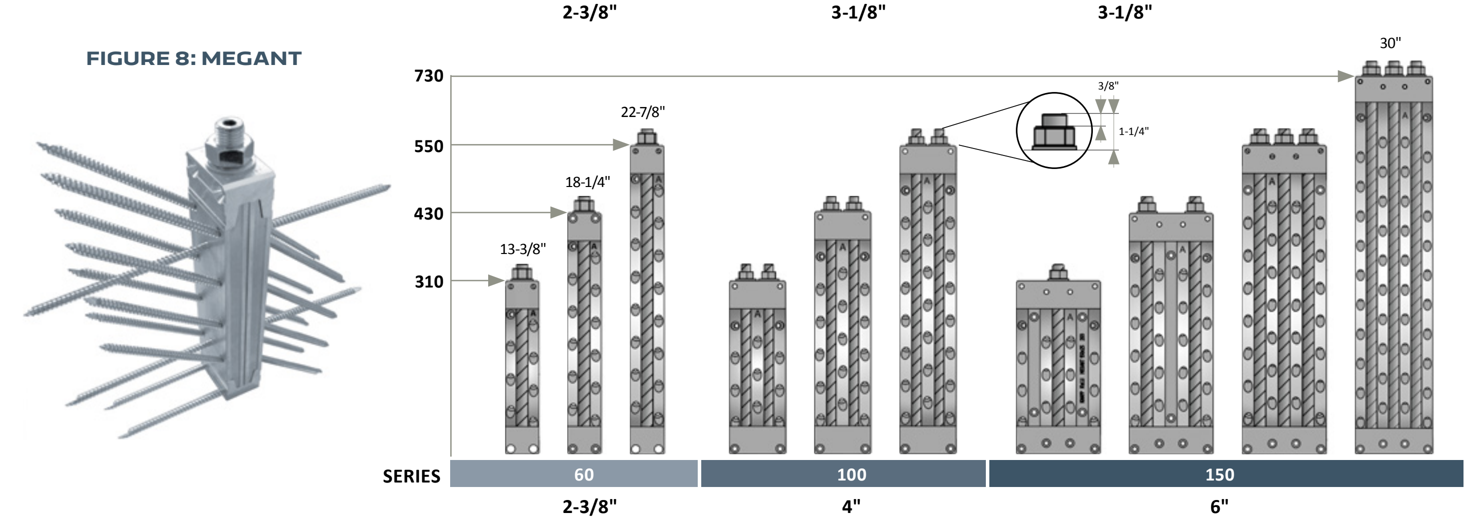


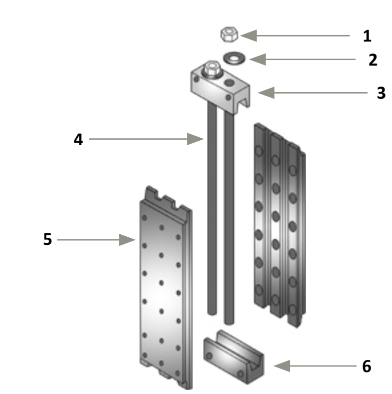
FIGURE 9: PRODUCT KIT DETAILS

Notes:

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

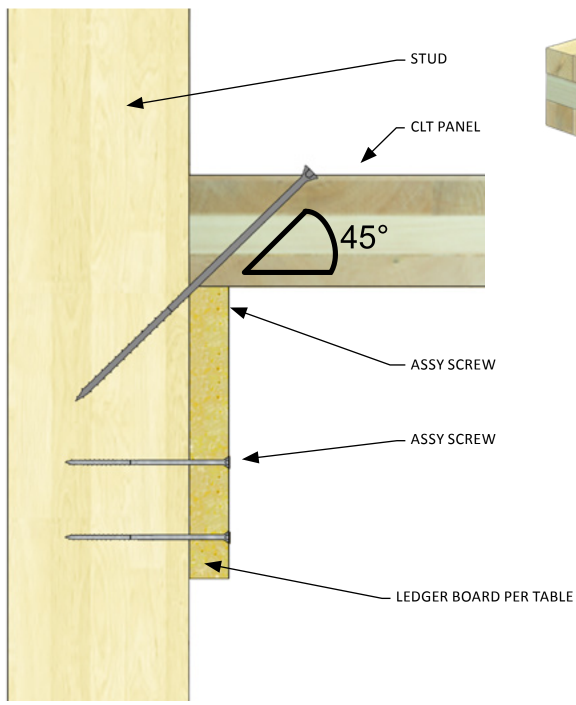
Source: *MTC Solutions, mtcsolutions.com*

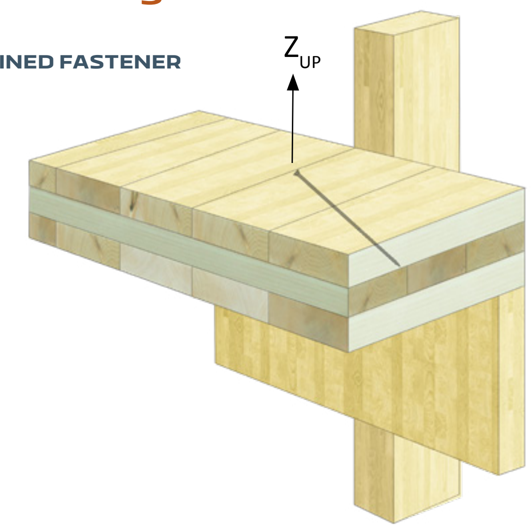
NUMBER	DESCRIPTION
1	Hex Nut
2	Washer
3	Top Clamping Jaws (without thread)
4	Threaded Rod
5	Connector Plate (x2)
6	Bottom Clamping Jaws (with thread)



CLT Floor to Ledger Connection System

FIGURE 10: CONNECTION SYSTEM WITH INCLINED FASTENER





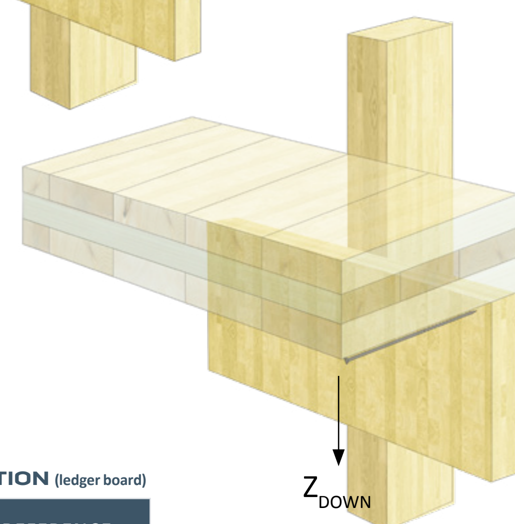


TABLE 6: REFERENCE DESIGN VALUES FOR WALL TO CLT FLOOR CONNECTION (ledger board)

PANEL & LEDGER CONFIGURATION					ASSY FASTENER OPTIONS	REFERENCE DESIGN VALUES (lbs)
LOADING		STUD TYPE	LEDGER THICKNESS	PANEL SERIES THICKNESS		
2" STUD	Z_{DOWN}	2" Lumber	1-1/2"	-	Eco 1/4" x 4-3/4"	199
					Eco 1/4" x 6-1/4"	
3-PLY	Z_{UP}	2" Lumber	1-1/2"	3.43" 87 mm	VG Cyl 1/4" x 7-7/8"	292

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 NDS.*
3. *The table contains reference design values for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed reference design values are valid for dry service conditions only, where C_M=1.0.*
5. *Uplift capacity (Z_{UP}) shall not exceed downward load capacity (Z_{DOWN}) for continuous load path.*
6. *Reference Lateral Design Values (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 ICC-ES Evaluation Report for the loading condition shown above.*

Source: *MTC Solutions, mtcsolutions.com*

CLT Panel to Steel Connecting System

FIGURE 11: CLT PANEL WITH STEEL SIDE PLATE IN SHEAR

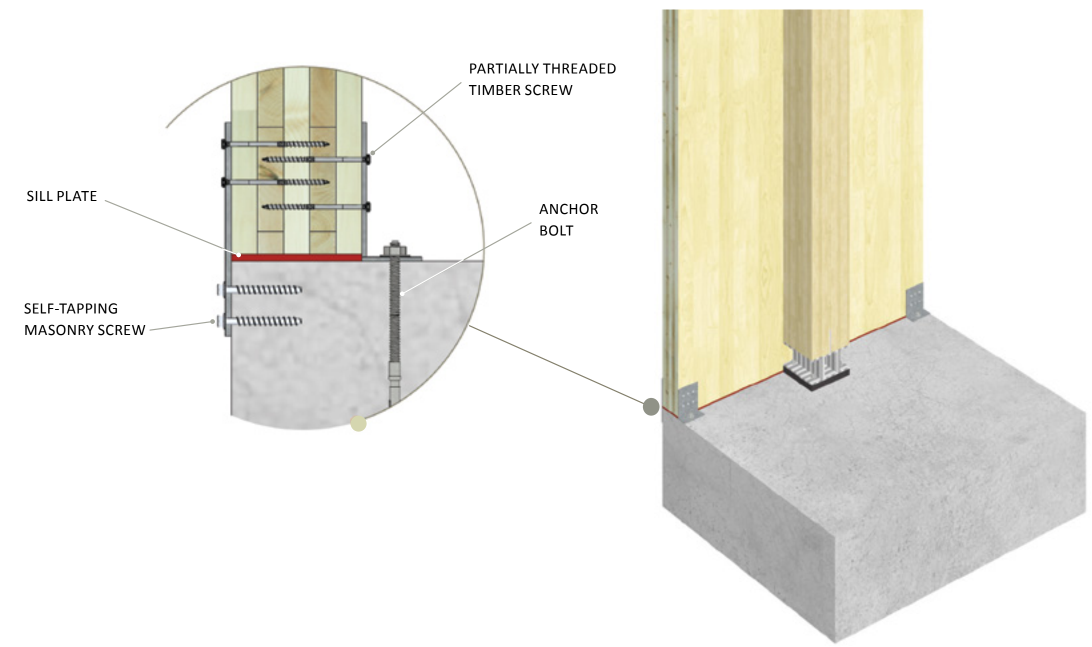


TABLE 7: REFERENCE LATERAL DESIGN VALUES FOR CLT STEEL SIDE PLATE CONNECTIONS IN SHEAR

PANEL & JOINT CONFIGURATION					ASSY FASTENER OPTIONS	REFERENCE DESIGN VALUES (lbs)	WITHDRAWAL DESIGN VALUES (lbs)
LOADING			PANEL SERIES THICKNESS	STEEL THICKNESS			
3-PLY	$Z_{//}$		3.43" to 4.13" 87 mm to 105 mm	3/16"	Kombi 5/16" x 3-1/8"	279	370
				1/4"	Kombi 5/16" x 3-1/8"	312	
				1/2"	Kombi 5/16" x 3-1/8"	323	
	$Z_{\perp}$		3.43" to 4.13" 87 mm to 105 mm	3/16"	Kombi 5/16" x 3-1/8"	223	
				1/4"	Kombi 5/16" x 3-1/8"	249	
				1/2"	Kombi 5/16" x 3-1/8"	258	

Notes:

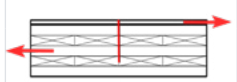
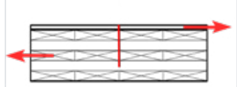
1. *For complete data, please refer to the **MTC Solutions' "Mass Timber Connections Design Guide,"** downloadable on **MTC Solutions' website**.*
2. *Connections must respect the minimum spacing, edge and end distance requirements for ASSY screws in CLT and meet all relevant requirements of the "Notes to the Designer" section, as specified in the **MTC Solutions' "Mass Timber Connections Design Guide"** and the NDS.*
3. *The table contains reference lateral design values (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.*
4. *Listed reference design values are valid for dry service conditions only, where C_M=1.0.*
5. *The side member is assumed as ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_E = 87,000 psi 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: REFERENCE LATERAL DESIGN VALUES FOR CLT STEEL SIDE PLATE CONNECTIONS IN SHEAR

PANEL & JOINT CONFIGURATION					ASSY FASTENER OPTIONS	REFERENCE DESIGN VALUES (lbs)	WITHDRAWAL DESIGN VALUES (lbs)
LOADING			PANEL SERIES THICKNESS	STEEL THICKNESS			
5-PLY	$Z_{//}$		5.47" to 7.52" 139 mm to 191 mm	3/16"	Kombi 5/16" x 3-1/8"	279	370
					Kombi 3/8" x 4-3/4"	394	616
					Kombi 1/2" x 4-3/4"	542	663
				1/4"	Kombi 5/16" x 3-1/8"	312	370
					Kombi 3/8" x 4-3/4"	430	616
					Kombi 1/2" x 4-3/4"	575	663
				1/2"	Kombi 3/8" x 4-3/4"	505	616
					Kombi 1/2" x 4-3/4"	713	663
					Kombi 1/2" x 5-1/2"	725	
	$Z_{\perp}$		5.47" to 7.52" 139 mm to 191 mm	3/16"	Kombi 5/16" x 3-1/8"	223	370
					Kombi 3/8" x 4-3/4"	267	616
					Kombi 1/2" x 4-3/4"	356	663
				1/4"	Kombi 5/16" x 3-1/8"	249	370
					Kombi 3/8" x 4-3/4"	292	616
					Kombi 1/2" x 4-3/4"	379	663
				1/2"	Kombi 3/8" x 4-3/4"	339	616
					Kombi 1/2" x 4-3/4"	471	663
					Kombi 1/2" x 5-1/2"		

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 NDS.
3. The table contains reference lateral design values (Z) for a single ASSY fastener conforming to the connection geometry and loading conditions described.
4. Listed reference design values are valid for dry service conditions only, where C_M=1.0.
5. The side member is assumed as ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi 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

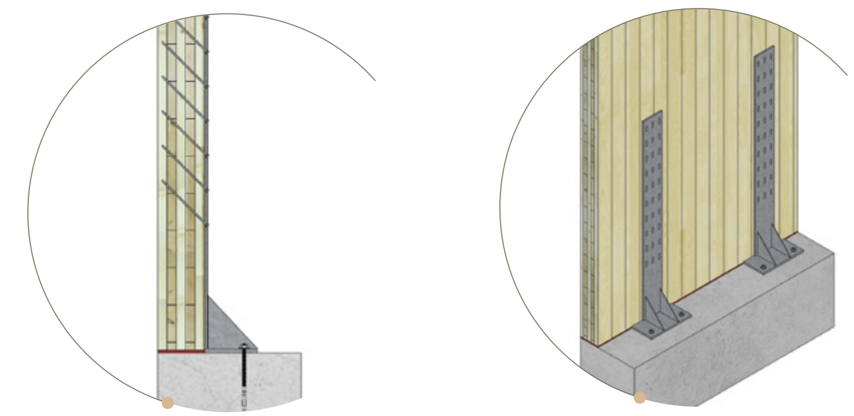
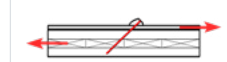
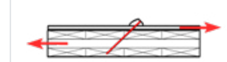
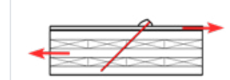
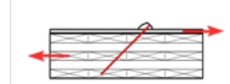


TABLE 9:
REFERENCE LATERAL DESIGN VALUES FOR CLT STEEL SIDE PLATE CONNECTIONS WITH INCLINED SCREWS

PANEL & JOINT CONFIGURATION					ASSY FASTENER OPTIONS WITH 45° WASHER	WITHDRAWAL DESIGN VALUES (lbs)
LOADING			PANEL SERIES THICKNESS	STEEL THICKNESS		
3-PLY	$Z_{//}$		3.43" 87 mm	5/32"-1/2"	VG CSK 5/16" x 5-1/2"	532
	$Z_{\perp}$				VG CSK 5/16" x 5-1/2"	576
5-PLY	$Z_{//}$		6.89" 175 mm	5/32"-1/2"	VG CSK 5/16" x 9-1/2"	1,109
				1/4"-3/4"	VG CSK 3/8" x 9-1/2"	1,137
	$Z_{\perp}$			5/32"-1/2"	VG CSK 5/16" x 9-1/2"	1,113
				1/4"-3/4"	VG CSK 3/8" x 9-1/2"	1,147

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 NDS.
3. The table contains reference design values for a single ASSY fastener conforming to the connection geometry and loading conditions described.
4. Listed reference design values are valid for dry service conditions only, where C_M=1.0.
5. The side member is assumed as ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi 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 design value 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. $Z_{//}$ Reference lateral design value per screw in tension with loading direction along major span direction of CLT panel.
    $Z_{\perp}$ Reference lateral design value 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 1/8" (3mm) to 3/16" (5mm).

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

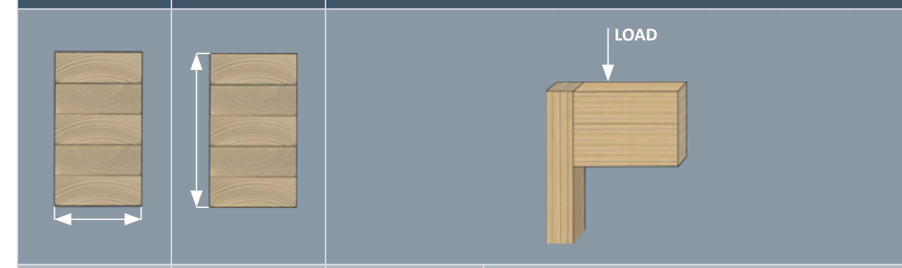
GlulamPLUS® Connections

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: REFERENCE DESIGN VALUES FOR WALL TO CLT FLOOR CONNECTION (ledger board)



MINIMUM BEAM WIDTH	MINIMUM BEAM DEPTH	ALLOWABLE LOAD		BEAM HANGER SYSTEM
INCH	INCH	KIPS	5 10 15 20 25 30	
4"	7"	3.7		Ricon S VS 140x60
	9-1/2"	5.2		Ricon S VS 200x60
	15-3/4"	8.2		Megant 310x60
	20-1/2"	12.8		Megant 430x60
	25-1/4"	12.8		Megant 550x60
4-3/4"	9-1/2"	7.5		Ricon S VS 200x80
	13"	9.1		Ricon S VS 290x80
	17"	17.1		Ricon XL 390x80
5-5/8"	15-3/4"	10.5		Megant 310x100
	20-7/8"	17.5		Megant 430x100
	25-5/8"	19.5		Megant 550x100
7-1/2"	15-3/4"	13.6		Megant 310x150
	20-1/2"	22.7		Megant 430x150
	25-1/4"	31.8		Megant 550x150
	33-1/8"	32.6		Megant 730x150

Notes:

1. *Allowable loads listed here are only valid for Allowable Stress Design in the USA.*
2. *This table is a pre-selection tool only. For complete design guidelines, please refer to the **MTC Solutions' Beam Hanger Design Guide**, downloadable at **mtcsolutions.com** and to the NDS for complete design guidelines.*
3. *Allowable loads listed here are only valid for use in Dfir in standard term loading (C_D =1.0). Please refer to each respective connector section for more values.*
4. *In the table:* ■ *Single connector allowable load.* ■ *Double connectors allowable load, minimum beam width is larger than 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.

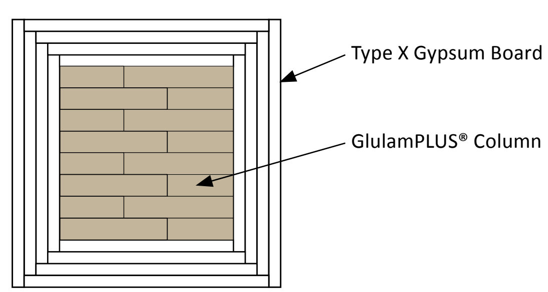
Fire resistance is the ability of a material to continue to provide structural strength and resistance to heat or vapor transfer during a fire event. A fire resistance rating (FRR) refers to the time that a building component can withstand fire or heat and integrity failure. It's important to note that 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 5/8" (16 mm) 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 1.5"/hr (0.65 mm/min). 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)

FRR performance is designed according to the local code and 2018 NDS. Extensive testing has been completed to allow a codified approach to cover a variety of use scenarios.

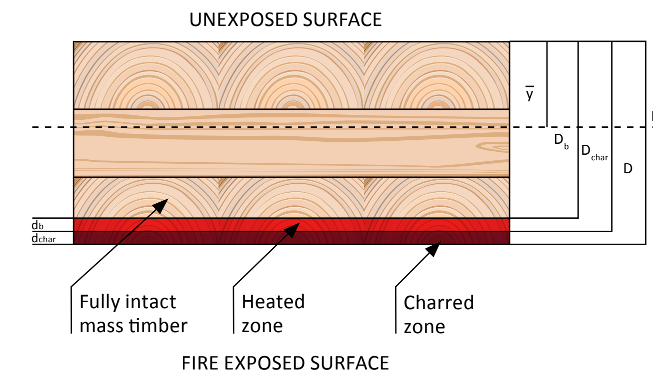
Type IV Heavy Timber Construction of the 2018 IBC Chapter 6: CLT is allowed in the IBC 2018 under Type IV Construction - 602.4 Type IV construction (Heavy Timber, HT). The hourly fire resistance rating requirements for walls, floors and roofs are found in Table 601 of the IBC.

Char calculation method of the 2015 and 2018 NDS: The NDS methodology uses wood-engineering-based mechanics to calculate the fire resistance of wood members and is referenced in Section 722.1 ILO 721.1 of the IBC. Effective charring rates calculated using the NDS methodology are also included in Section 722.1 ILO 721.1 of the IBC.

Execution of proprietary ASTM E-119 testing that is specific to the project assemblies: Standard Test Methods for Fire Tests of Building Construction Materials or UL 263, Standard for Fire 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

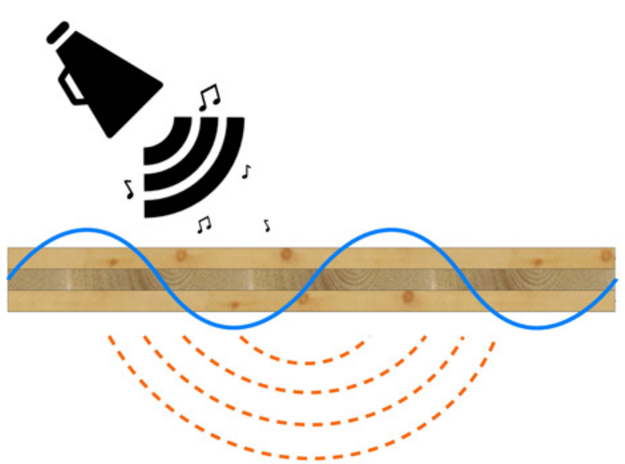
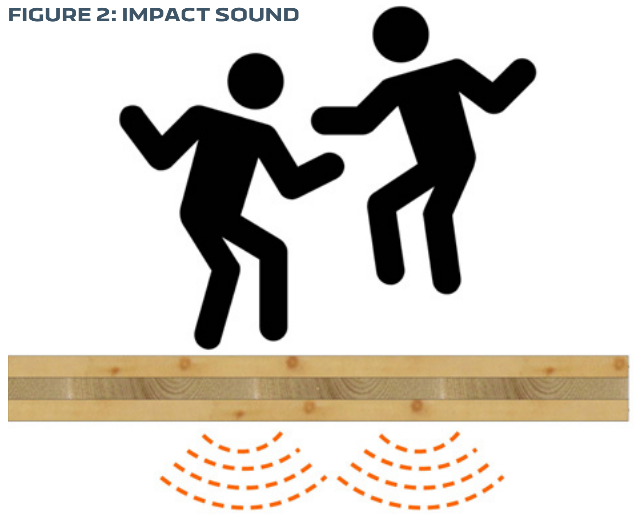


FIGURE 2: IMPACT SOUND



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.

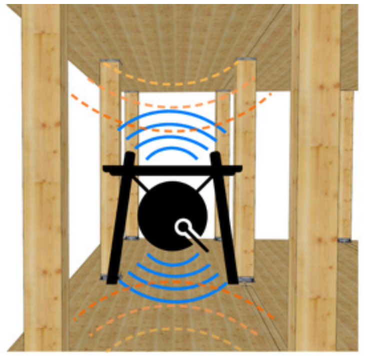
Impact Sound Mitigation:
To reduce the transmission of impact sound between building areas, install damping materials on the impact surface such as:

- 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.

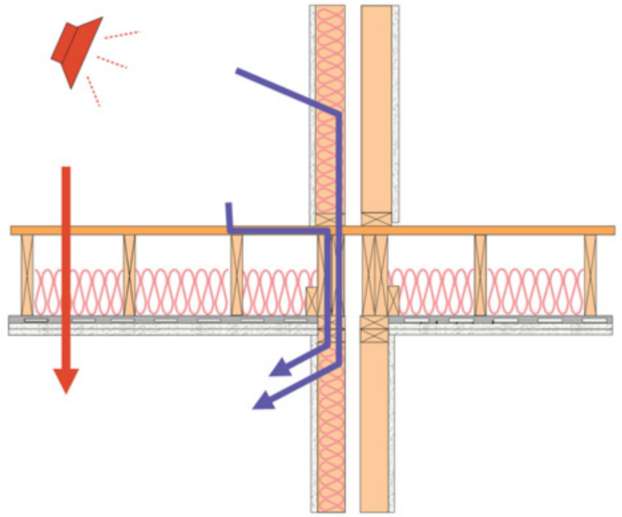
FLANKING SOUND MITIGATION

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 2013 U.S. 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: 6.89") SOUND TRANSMISSION CLASS (STC) IMPACT INSULATION CLASS (IIC)		BARE	GYPSUM BOARD CEILING 2 LAYERS 1/2" THICK TYPE X GYPSUM BOARD			
			DIRECTLY ATTACHED	1-1/2" WOOD FURRING @ 24" O.C.	HUNG CEILING ON METAL GRILLAGE 6" BELOW CLT SURFACE	DIRECTLY ATTACHED TO CLT AND ADDITIONAL ACOUSTIC HUNG CEILING WITH 5/8" THICK TYPE X ON METAL GRILLAGE 6" UNDERNEATH
BARE		41 (25)	42 (25)	50 (36)	68 (56)	67 (55)
FLOOR TOPPINGS	1-1/2" CONCRETE TOPPING ON 3/8" CLOSED-CELL FOAM	53 (36)	**53 (40)**	**59 (50)**	**76 (66)**	**74 (64)**
	1-1/2" CONCRETE TOPPING ON 1/2" WOOD FIBERBOARD	52 (35)	**53 (38)**	**59 (47)**	**76 (64)**	**73 (63)**
	1-1/2" CONCRETE TOPPING ON 3/4" RECYCLED FABRIC FELT	59 (42)	**59 (46)**	**63 (45)**	**77 (61)**	**75 (60)**
	1-1/2" CONCRETE TOPPING ON 1/2" RUBBER NUGGETS ON FOIL	53 (46)	**53 (44)**	**59 (49)**	**73 (65)**	**70 (63)**
	1-1/2" CONCRETE TOPPING ON 5/16" SHREDDED RUBBER MAT	52 (38)	**52 (38)**	**58 (48)**	**76 (66)**	**74 (64)**
	1-1/2" CONCRETE TOPPING ON 5/8" SHREDDED RUBBER MAT	54 (44)	**54 (43)**	**60 (51)**	**76 (67)**	**73 (65)**
	1-1/2" CONCRETE TOPPING NOT BONDED TO CLT	49 (28)	**49 (32)**	**56 (41)**	**75 (60)**	**74 (60)**
	2x12 mm CEMENT BOARD ON 1/2" WOOD FIBERBOARD	48 (46)	**48 (38)**	**54 (47)**	69 (63)	**68 (60)**
	1-1/2" GYPSUM CONCRETE ON 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 fiber batts (thickness 1-1/2" (38 mm) for furring and 5-1/2" (140 mm) 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:

2013 CLT Handbook - Chapter 9

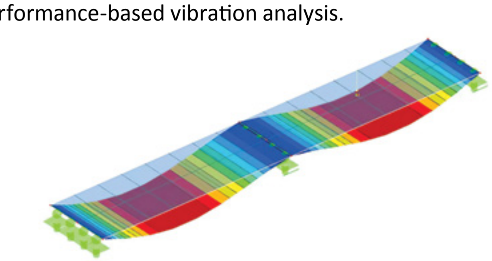
Thermal and Energy Performance

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 IBC Table 1604.3. Calculating deflection should conform to the U.S. CLT Handbook, 2013, Chapter 2. Creep is a critical factor that should be accounted for in any structural design. See the approach outlined in Chapter 6 of the U.S. CLT Handbook. The 2015 and 2018 NDS 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 stories. 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 Chapter 7 of the 2013 U.S. CLT Handbook. 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 NDS 2015 and the 2013 U.S. 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.

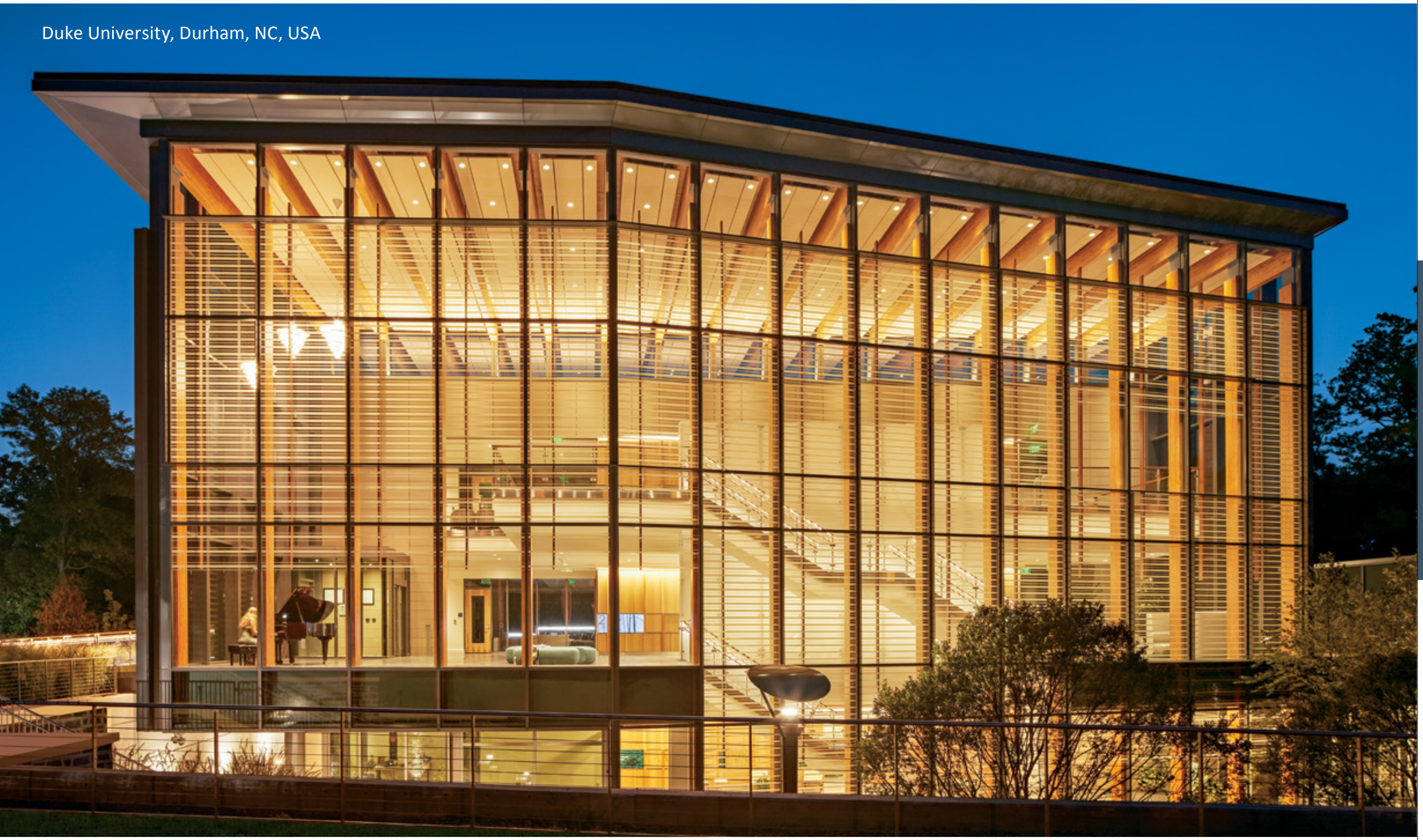
TABLE 2: CROSSLAM® CLT FLOOR VIBRATION PERFORMANCE

CROSSLAM® CLT SERIES	CLT PANEL (in)	CONCRETE SLAB (in)	VIBRATION CONTROLLED SPAN (ft)
87 V	3.43	5.31	10.5
105 V	4.14	5.91	12.1
139 V	5.48	7.48	14.8
175 V	6.90	8.46	16.7
191 V	7.53	9.25	18.4
243 V	9.58	10.24	21.0
245 V	9.66	10.83	21.6
315 V	12.42	12.40	24.9

50 psf live load plus self weight plus 21 psf miscellaneous dead load

☐ Indicates CrossLam® CLT thickness advantage

Duke University, Durham, NC, USA



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

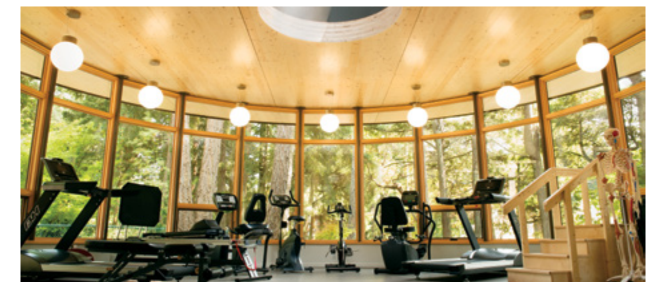
CROSSLAM® CLT ADVANTAGES:

- North American code approved
- Superior wood fiber 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 400 square feet per lift.



ROOFS

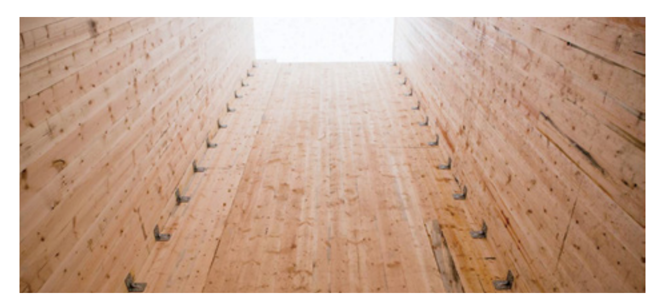
CrossLam® CLT panels provide overhanging eaves and span a variety of roof layouts. Their thermal properties contribute to a more efficient envelope assembly. Panels can be as thin as 3.43" and as thick as 12.42", resulting in a maximum roof span of 40' with appropriate loading. CrossLam® CLT roofs are 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 International Building Code (IBC) recognizes CLT as a structural system for wood construction when manufactured according to the ANSI/APA PRG 320-2019 Standard for Performance Rated Cross Laminated Timber.

The IBC approves the use of CLT in exterior/interior walls, floors and roofs for Type IV Construction specific to the use of CLT.

In December 2018, the International Code Council (ICC) released voting results to adopt amendments to the 2021 IBC, including:

TYPE IV-A	Maximum 18 stories/270' Building Height with 972,000 SF Allowable Building Area. Noncombustible. Primary frame and vertical bearing structure require a three-hour fire resistance rating; most other structures require a two-hour fire resistance rating. All timber required to be protected with noncombustible materials.
TYPE IV-B	Maximum 12 stories/180' Building Height with 648,000 SF Allowable Building Area. Limited area of exposed mass timber walls and ceilings allowed. Most structures require a two-hour fire resistance rating.
TYPE IV-C	Maximum 9 stories/85' Building Height with 405,000 SF Allowable Building Area. Most structures require a two-hour fire resistance rating, but nearly all timber can be exposed.

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
- Bearing Capacity
- Shear Capacity
- Diaphragm Capacity

DESIGN PROPERTY COMPATIBILITY

The design capacities published in ANSI/APA PRG 320-2019 were derived analytically using the North American lumber properties published in the National Design Specification (NDS) for Wood Construction. Lumber from outside of North America has different characteristics, may not be recognized in the NDS 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.

STRUCTURLAM ICC-ES REPORT ESR-3631

The Structurlam ICC-ES Report ESR-3631 affirms CrossLam® CLT for design stress properties for gravity loads as recognized in the standards listed on this page confirms in-plane shear properties for CrossLam® CLT.

This additional recognition allows CrossLam® CLT to be considered in applications where the component may be subjected to structural lateral loading as part of an engineered diaphragm component. These values effectively prove the stiffness of CrossLam® CLT and allow the engineer to design a diaphragm system where connections between panels govern in a rigid or semi-rigid diaphragm.

This is particularly useful for structures in earthquake zones or areas of high wind loads. Mass timber designs in these areas utilizing CLT without this added level of recognition will be required to provide a shear diaphragm solution, such as an outer layer of plywood in order to satisfy code.

For additional information on this topic, refer to Cross Laminated Timber Horizontal Diaphragm Design Example at https://www.structurlam.com/wp-content/uploads/2016/10/Structurlam-CrossLam-CLT-White-Paper-on-Diaphragms-SLP-Oct-2015.pdf.

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 ANSI A190.1-2017 and ANSI/APA PRG 320-2019.

These standards outline the quality control requirements required by 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 ASTM testing methods for fire, heat and moisture and must support ANSI manufacturing standards – see table 1 below. These test methods and manufacturing standards are approved in the U.S. by the International Building Code (IBC). The IBC is a model building code developed by the International Code Council (ICC) .

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.

Glue-Bond sample test blocks

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	9'-10.5" x 40' (3,000 mm x 12,192 mm)
MAXIMUM THICKNESS	12.42" (315 mm)
MINIMUM THICKNESS	3.43" (87 mm)
PRODUCTION WIDTHS	7'-10.5" and 9'-10.5" (2,400 mm and 3,000 mm)
MOISTURE CONTENT	12% (+/-3%) at time of manufacturing
FACE BOND GLUE TYPE	Henkel Loctite HB X PURBOND
FINGER JOINT GLUE TYPE	Hexion Cascomel®
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 and ICC-ES ESR-3631
DENSITY	30-31 lbs/ft^3
DIMENSIONAL STABILITY	Longitudinal and Transverse 0.01% per % Δ in MC. Thickness 0.2% per % Δ in MC
THERMAL CONDUCTIVITY	R value: 1.2 per inch (h·ft^2·°F /Btu)
CO_2 SEQUESTRATION	37.4 lbs/ft^3 (subject to local manufacturing and distances)
DIMENSIONAL TOLERANCES	
THICKNESS	1/16" +/- (2 mm) or 2% of CLT thickness, whichever is greater
WIDTH	1/8" +/- (3 mm) of the CLT width
LENGTH	1/4" +/- (6 mm) of the CLT length
SQUARENESS	Panel face diagonals shall not differ by more than 1/8" (3 mm)
STRAIGHTNESS	Deviation of edges from a straight line between adjacent panel corners shall not exceed 1/16" (2 mm)
MACHINED SURFACES	+/- 1/8" (3 mm) with all tooling units except the chainsaw, which is +/- 1/4" (6 mm)


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

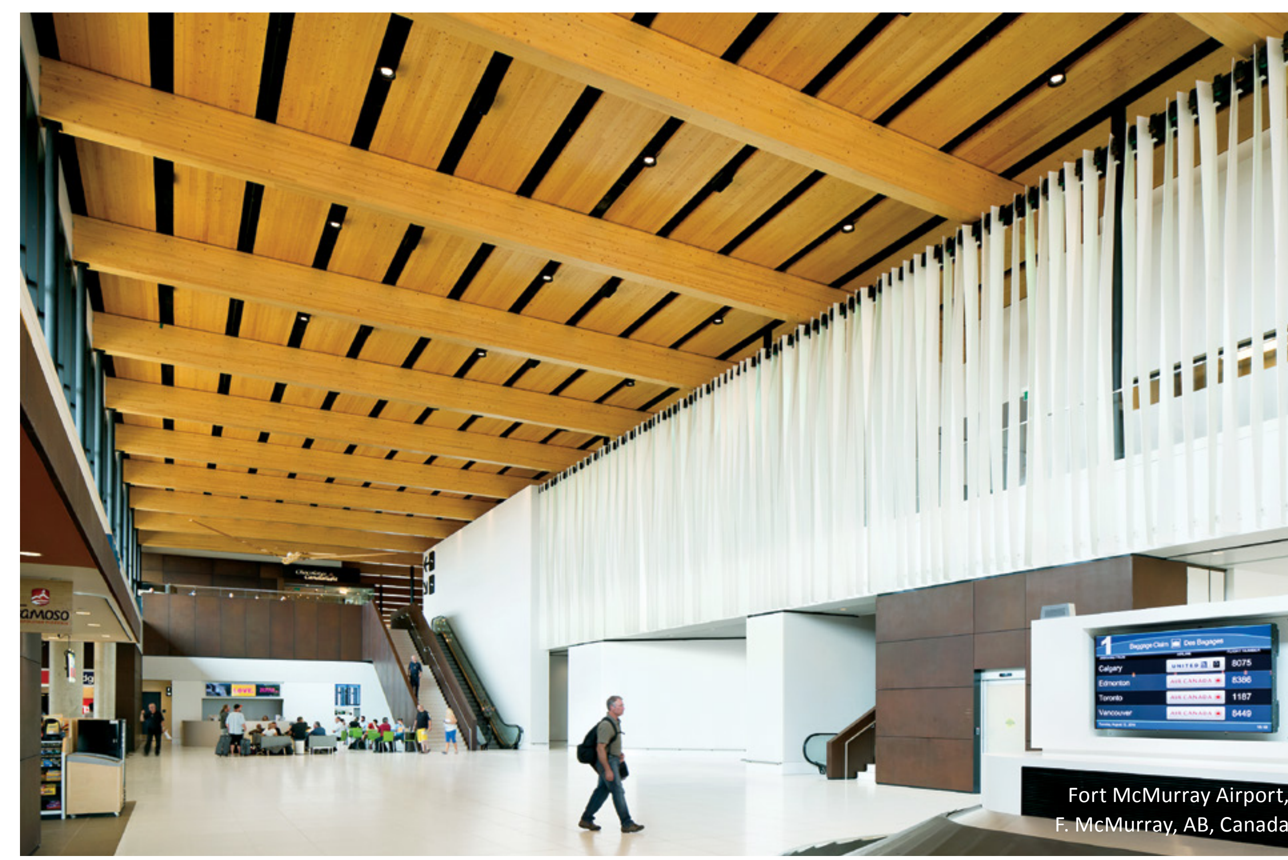
CrossLam® CLT Panel Layups

TABLE 4: LUMBER SPECIES AND THICKNESS FOR CLT PANEL LAYUPS

CROSSLAM® CLT SERIES	GRADE	FACE LAYERS	MAJOR LAYER (L)	MINOR LAYER (T)	LAYER THICKNESS (in)									PANEL DEPTH (in)
					L	T	L	T	L	T	L	T	L	
87 V	V2.1	SPF #2&Btr Appearance Grade Dfir #2SE	SPF #2&Btr	SPF #3&Btr	1.38	0.67	1.38							3.43
139 V					1.38	0.67	1.38	0.67	1.38					5.48
191 V					1.38	0.67	1.38	0.67	1.38	0.67	1.38			7.53
243 V					1.38	0.67	1.38	0.67	1.38	0.67	1.38	0.67	1.38	9.58
105 V	V2M1.1			SPF #2&Btr	1.38	1.38	1.38							4.14
175 V					1.38	1.38	1.38	1.38	1.38					6.90
245 V					1.38	1.38	1.38	1.38	1.38	1.38	1.38			9.66
315 V					1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	12.42
87 E	E1M4	MSR 2100 1.8E SPF	MSR 2100 1.8E SPF	SPF #3&Btr	1.38	0.67	1.38							3.43
139 E					1.38	0.67	1.38	0.67	1.38					5.48
191 E					1.38	0.67	1.38	0.67	1.38	0.67	1.38			7.53
243 E					1.38	0.67	1.38	0.67	1.38	0.67	1.38	0.67	1.38	9.58
105 E	E1M5			SPF #2&Btr	1.38	1.38	1.38							4.14
175 E					1.38	1.38	1.38	1.38	1.38					6.90
245 E					1.38	1.38	1.38	1.38	1.38	1.38	1.38			9.66
315 E					1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	12.42

L = Longitudinal Layer (Major Layer)
T = Tangential Layer (Minor Layer)

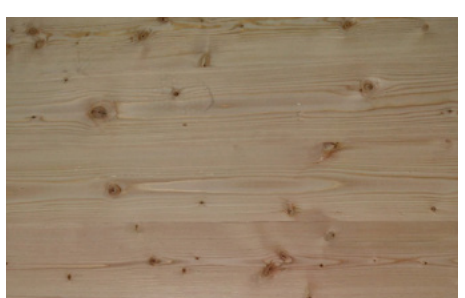
Spandrel panels cannot be produced in any layups with 0.67" thick lamellas.


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 FIBER CHARACTERISTICS	
SHAKE AND CHECKS	Several up to 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**

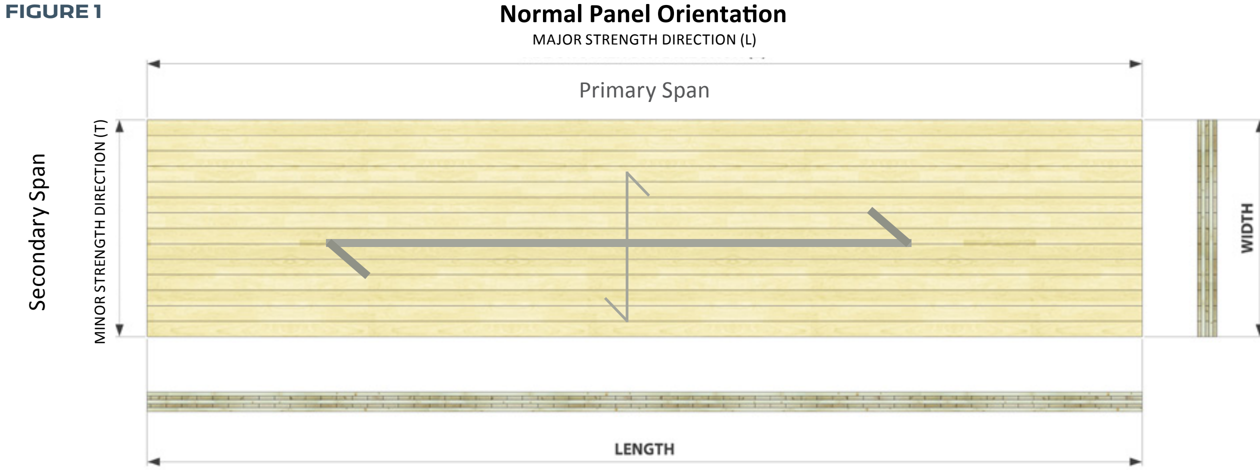
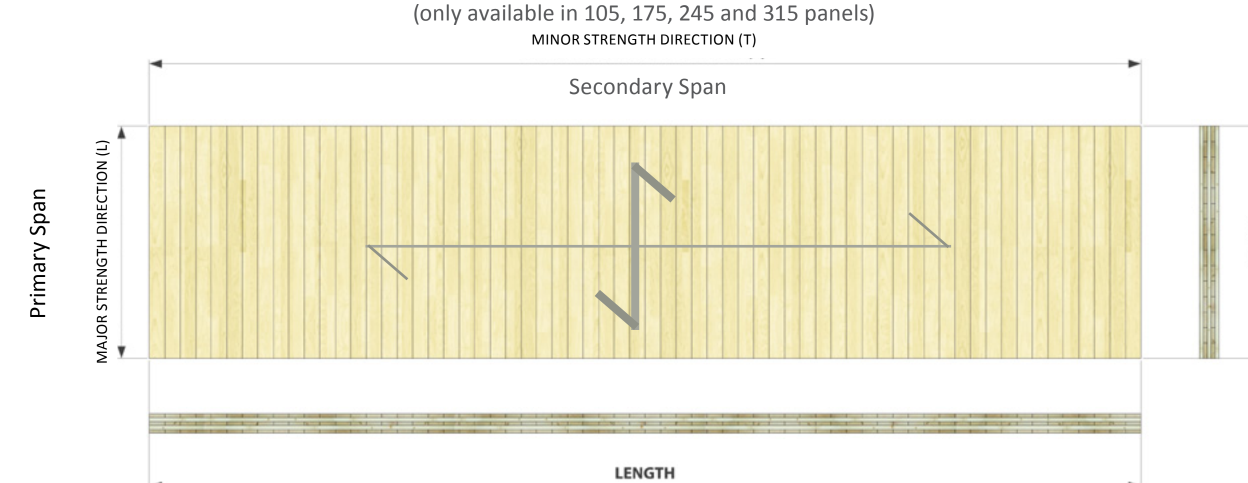


FIGURE 2 **Spandrel Panel Orientation**

(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: ALLOWABLE DESIGN CAPACITIES

CLT GRADE	MAJOR LAYER	WEIGHT lbs/ft²	MAJOR STRENGTH DIRECTION					MINOR STRENGTH DIRECTION				
			$F_bS_{EFF,0}$ (lbs-ft/ft)	$EI_{EFF,0}$ (10^6lbs-in²/ft)	$GA_{EFF,0}$ (10^6lbs/ft)	$M_{ALLOW,0}$ (lbs-ft/ft)	$V_{ALLOW,0}$ (lbs/ft)	$F_bS_{EFF,0}$ (lbs-ft/ft)	$EI_{EFF,90}$ (10^6lbs-in²/ft)	$GA_{EFF,90}$ (10^6lbs/ft)	$M_{ALLOW,90}$ (lbs-ft/ft)	$V_{ALLOW,90}$ (lbs/ft)
V2.1	87 V	7.5	1,444	56	0.5	1,444	1,220	37	0.4	0.30	32	240
	139 V	11.9	3,329	206	1.0	3,329	1,770	537	21	0.60	457	850
	191 V	16.3	5,917	503	1.4	5,917	2,290	1,216	83	0.91	1,034	1,080
	243 V	20.8	9,212	995	1.9	9,219	2,800	2,133	209	1.20	1,814	1,320
V2M1.1	105 V	9.0	2,042	96	0.5	2,042	1,440	277	3.7	0.53	235	495
	175 V	15.0	4,701	366	1.1	4,701	1,980	2,403	96	1.10	2,042	1,440
	245 V	21.0	8,315	906	1.6	8,315	2,500	5,531	366	1.60	4,701	1,970
	315 V	27.0	12,896	1,806	2.1	12,896	3,025	9,782	906	2.10	8,315	2,470
E1M4	87 E	8.2	3,465	72	0.5	3,465	1,220	37	0.4	0.38	32	240
	139 E	13.0	7,983	264	1.0	7,983	1,770	537	21	0.77	457	945
	191 E	17.8	14,183	645	1.5	14,183	2,280	1,216	83	1.10	1,034	1,200
	243 E	22.7	22,075	1,278	2.0	22,075	2,800	2,133	209	1.50	1,814	1,460
E1M5	105 E	9.7	4,900	123	0.5	4,901	1,430	277	3.7	0.66	235	495
	175 E	16.1	11,261	469	1.1	11,261	1,980	2,403	96	1.30	2,042	1,590
	245 E	22.5	19,897	1,161	1.6	19,897	2,500	5,531	366	2.00	4,701	2,180
	315 E	28.8	30,837	2,314	2.1	30,838	3,000	9,782	906	2.60	8,315	2,750

TABLE 7: ALLOWABLE DESIGN PROPERTIES FOR LAMINATIONS

CLT GRADE	MAJOR STRENGTH DIRECTION						MINOR STRENGTH DIRECTION					
	$F_{B,0}$ (psi)	$E_{,0}$ (10^6 psi)	$F_{T,0}$ (psi)	$F_{C,0}$ (psi)	$F_{V,0}$ (psi)	$F_{S,0}$ (psi)	$F_{B,90}$ (psi)	E_{90} (10^6psi)	$F_{T,90}$ (psi)	$F_{C,90}$ (psi)	$F_{V,90}$ (psi)	$F_{S,90}$ (psi)
V2.1	875	1.4	450	1,150	135	45	500	1.2	250	650	135	45
V2M1.1	875	1.4	450	1,150	135	45	875	1.4	450	1,150	135	45
E1M4	2,100	1.8	1,575	1,875	160	50	500	1.2	250	650	135	45
E1M5	2,100	1.8	1,575	1,875	160	50	875	1.4	450	1,150	135	45

Notes:

1. *Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS.*
2. *The CLT grades are developed based on APA Product Report PR-L314. Please refer to specific grade layups for complete panel information.*
3. *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 tables above).*
4. *Values are calculated per one-foot-wide section of panel.*
5. *The panel weight is based on SPF lumber values in the 2015 NDS.*

CrossLam® CLT Load Span Tables

TABLE 8: FLOOR PANEL LOADS
MAXIMUM SPAN (ft)

	CROSSLAM® CLT SERIES	FLOOR LIVE LOAD (psf)									
		40 RESIDENTIAL		50 OFFICE/CLASSROOM		75 MECHANICAL ROOM		100 ASSEMBLY/STORAGE		150 LIBRARY	
		VIBRATION	DEFLECTION L/240	VIBRATION	DEFLECTION L/240	VIBRATION	DEFLECTION L/240	VIBRATION	DEFLECTION L/240	VIBRATION	DEFLECTION L/240
SINGLE SPAN	87 V	**10.58**	12.33	**10.58**	11.95		**10.56**		**9.71[a]**		**8.18[a]**
	87 E	**11.37**	13.33	**11.37**	12.67	**11.37**	11.43		**10.55**		**9.33**
	105 V	**12.04**	14.58	**12.04**	13.86	**12.04**	12.51		**11.48[a]**		**9.69[a]**
	105 E	**12.93**	15.77	**12.93**	15.00	**12.93**	13.54		**12.51**		**11.07**
	139 V	**14.65**	18.68	**14.65**	17.81	**14.65**	16.15		**14.49[a]**		**12.27[a]**
	139 E	**15.75**	20.17	**15.75**	19.24	**15.75**	17.47	**15.75**	16.19		**14.41**
	175 V	**16.78**	22.24	**16.78**	21.23	**16.78**	18.93[a]	**16.78**	17.01[a]		**14.45[a]**
	175 E	**18.01**	24.01	**18.01**	22.93	**18.01**	20.88	**18.01**	19.38		**17.28**
	191 V	**18.30**	24.65	**18.30**	23.56	**18.30**	21.10[a]	**18.30**	18.99[a]		**16.16[a]**
	191 E	**19.65**	26.58	**19.65**	25.43	**19.65**	23.21	**19.65**	21.58		**19.29**
	245 V	**20.98**	29.30	**20.98**	27.81[a]	**20.98**	24.48[a]	**20.98**	22.12[a]		**18.91[a]**
	245 E	**22.50**	31.57	**22.50**	30.27	**22.50**	27.74	**22.50**	25.85	**22.50**	23.16
	243 V	**21.68**	30.34	**21.68**	29.08	**21.68**	25.79	**21.68**	23.30		**19.92**
	243 E	**22.91**	32.67	**22.91**	31.33	**22.91**	28.73	**22.91**	26.80	**22.91**	24.04
	315 V	**24.86**	35.47[a]	**24.86**	33.49[a]	**24.86**	29.69[a]	**24.86**	26.95[a]		**23.18[a]**
	315 E	**26.66**	38.72	**26.66**	37.23	**26.66**	34.29	**26.66**	32.07	**26.66**	28.86
DOUBLE SPAN	87 V	**10.58**	13.59[a]	**10.58**	12.62[a]	**10.58**	10.88[a]		**9.71[a]**		**8.18[a]**
	87 E	**11.37**	18.23	**11.37**	17.16	**11.37**	15.51	**11.37**	14.35	**11.37**	12.65[a]
	105 V	**12.04**	15.98[a]	**12.04**	14.86[a]	**12.04**	12.85[a]		**11.48**		**9.69**
	105 E	**12.93**		**12.93**		**12.93**	18.42	**12.93**	17.04	**12.93**	14.98[a]
	139 V	**14.65**	19.96[a]	**14.65**	18.61[a]	**14.65**	16.17[a]		**14.49[a]**		**12.27[a]**
	139 E	**15.75**		**15.75**		**15.75**		**15.75**		**15.75**	17.43[b]
	175 V						**18.93[a]**		**17.01[a]**		**14.45[a]**
	175 E										
	191 V								**18.99[a]**		**16.16[a]**
	191 E										
	245 V										**18.91[a]**
	245 E										
	243 V										
	243 E										
	315 V										
	315 E										

MAXIMUM VALUE IS 20'

Span is governed by maximum panel length of 40'

Use max value of 20' or design as simple span using table values above.

[a] Represents governing value Mr and [b] represents governing value Vr.

Notes:

1. *For structural panel properties - see page 70. Span table assumes dry service conditions.*
2. *CLT is NOT an isotropic material. Presented values must only be used for bending of panels in the major strength axis.*
3. *Spans shown represent distance between the center lines of supports and are to be used for preliminary design only.*
4. *Span table above includes panel self weight, plus 15 psf miscellaneous dead load.*
5. *Engineer to ensure that L/240 deflection limit is appropriate for intended use.*
6. *Spans are assumed to be equal for double span panels.*
7. *Total panel length is limited to 40 ft 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. *Table values are to be used for preliminary design only.*
10. *Values for double spans include a 20% increase based on CSA O86-14.*
11. *Deflection L/240 is considered for total load.*
12. *[shaded cell] Indicates panel is strength governed and vibration control should not be used as a governing factor.*

TABLE 9: FLOOR PANEL LOADS
2" CONCRETE TOPPING MAXIMUM SPAN (ft)

	CROSSLAM® CLT SERIES	100% FLOOR LIVE LOAD (psf)									
		40 RESIDENTIAL		50 OFFICE/CLASSROOM		75 MECHANICAL ROOM		100 ASSEMBLY/STORAGE		150 LIBRARY	
		VIBRATION	DEFLECTION L/240	VIBRATION	DEFLECTION L/240	VIBRATION	DEFLECTION L/240	VIBRATION	DEFLECTION L/240	VIBRATION	DEFLECTION L/240
SINGLE SPAN	87 V	**8.79**	11.19	**8.79**	10.75	**8.79**	9.88	**8.79**	9.00[a]		**7.75[a]**
	87 E	**9.44**	12.11	**9.44**	11.64	**9.44**	10.71	**9.44**	10.00		**8.97**
	105 V	**10.17**	13.26	**10.17**	12.74	**10.17**	11.72	**10.17**	10.65[a]		**9.18[a]**
	105 E	**10.91**	14.35	**10.91**	13.79	**10.91**	12.69	**10.91**	11.86		**10.64**
	139 V	**14.65**	17.06	**14.65**	16.43	**14.65**	14.78[a]		**13.46[a]**		**11.63[a]**
	139 E	**15.75**	18.45	**15.75**	17.77	**15.75**	16.42		**15.38**		**13.87**
	175 V	**16.78**	20.38	**16.78**	19.39[a]	**16.78**	17.35[a]		**15.83[a]**		**13.71[a]**
	175 E	**18.01**	22.02	**18.01**	21.24	**18.01**	19.65	**18.01**	18.43		**16.64**
	191 V	**18.30**	22.64	**18.30**	21.62[a]	**18.30**	19.36[a]		**17.69[a]**		**15.33[a]**
	191 E	**19.65**	24.44	**19.65**	23.59	**19.65**	21.87	**19.65**	20.55		**18.59**
	245 V	**20.98**	26.32[a]	**20.98**	25.05[a]	**20.98**	22.53[a]		**20.65[a]**		**17.97[a]**
	245 E	**22.50**	29.16	**22.50**	28.18	**22.50**	26.19	**22.50**	24.64		**22.34**
	243 V	**21.68**	27.74[a]	**21.68**	26.39[a]	**21.68**	23.74[a]	**21.68**	21.75[a]		**18.92[a]**
	243 E	**23.28**	30.19	**23.28**	29.19	**23.28**	27.14	**23.28**	25.56		**23.19**
	315 V	**24.86**	31.80[a]	**24.86**	30.35[a]	**24.86**	27.44[a]	**24.86**	25.24[a]		**22.06[a]**
	315 E	**26.66**	35.95	**26.66**	34.81	**26.66**	32.48	**26.66**	30.64	**26.66**	27.87
DOUBLE SPAN	87 V	**10.55**	11.83[a]	**10.55**	11.17[a]	10.55	**9.91[a]**		**9.00[a]**		**7.75[a]**
	87 E	**11.33**	16.42	**11.33**	15.80	**11.33**	14.55	**11.33**	13.41[a]	**11.33**	11.54[a]
	105 V	**12.20**	13.95[a]	**12.20**	13.18[a]	12.20	**11.72[a]**		**10.65[a]**		**9.18[a]**
	105 E	**13.09**	19.48	**13.09**	18.75	**13.09**	17.29	**13.09**	15.86[a]	**13.09**	13.67[a]
	139 V	17.58	**17.51[a]**	**17.58**	**16.58[a]**	17.58	**14.78[a]**		**13.46[a]**		**11.63[a]**
	139 E	**18.90**		**18.90**		**18.90**		**18.90**			**15.67[b]**
	175 V				**19.39[a]**		**17.35[a]**		**15.83[a]**		**13.71[a]**
	175 E										
	191 V						**19.36[a]**		**17.69[a]**		**15.33[a]**
	191 E										
	245 V										**17.97[a]**
	245 E										
	243 V										**18.92[a]**
	243 E										
	315 V										
	315 E										

MAXIMUM VALUE IS 20'
Span is governed by maximum panel length of 40'.
Use max value of 20' or design as simple span using table values above.

[a] Represents governing value Mr and [b] represents governing value Vr.

Notes:

1. *For structural panel properties - see page 70. Span table assumes dry service conditions.*
2. *CLT is NOT an isotropic material. Presented values must only be used for bending panels in the major strength axis.*
3. *Spans shown represent distance between the center lines of supports and are to be used for preliminary design only.*
4. *Span table above includes panel self weight, 20 psf for concrete topping, plus 15 psf miscellaneous dead load.*
5. *Engineer to ensure that L/240 deflection limit is appropriate for intended use.*
6. *Spans are assumed to be equal for double span panels.*
7. *Total panel length is limited to 40 ft 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. *Table values are to be used for preliminary design only.*
10. *The non-structural flooring is assumed to provide an enhanced vibration effect on double spans. Values include a 20% increase.*
11. *Deflection L/240 is considered for total load.*
12. *For floors with concrete topping, where the concrete is applied directly to the CLT panel, weight of concrete is ignored in the calculation of vibration-controlled span limit, provided the area density of the topping is not greater than twice the bare CLT floor area density.*
13. *Indicates panel is strength governed and vibration control should not be used as a governing factor.*

TABLE 10: ROOF PANEL LOADS
MAXIMUM SPAN (ft)

	CROSSLAM® CLT SERIES	115% ROOF SNOW LOAD (psf, unfactored)										125% NON-SNOW LOAD	
		20		30		40		55		100		20	
		L/180	L/240	L/180	L/240	L/180	L/240	L/180	L/240	L/180	L/240	L/180	L/240
SINGLE SPAN	87 V	16.21	14.69	14.95	13.55	14.01	12.68	12.62[a]	11.70	9.91[a]	9.88	16.21	14.69
	87 E	17.51	15.87	16.17	14.65	15.15	13.72	14.00	12.67	11.85	10.70	17.51	15.87
	105 V	19.10	17.31	17.66	16.00	16.57	15.00	14.86[a]	13.86	11.72[a]	11.72	19.10	17.31
	105 E	20.62	18.68	19.09	17.29	17.92	16.22	16.58	15.00	14.06	12.69	20.62	18.68
	139 V	24.18	21.92	22.48	20.38	20.74[a]	19.18	18.61[a]	17.80	14.78[a]	14.78[a]	24.18	21.92
	139 E	26.04	23.61	24.25	21.98	22.86	20.71	21.24	19.24	18.15	16.42	26.04	23.61
	175 V	28.56	25.89	26.15[a]	24.16	24.05[a]	22.81	21.68[a]	21.23	17.35[a]	17.35[a]	28.56	25.89
	175 E	30.76	27.87	28.76	26.05	27.19	24.62	25.34	22.93	21.74	19.65	30.76	27.87
	191 V	31.51	28.57	29.00[a]	26.73	26.72[a]	25.27	24.13[a]	23.56	19.36[a]	19.36[a]	31.51	28.57
	191 E	33.86	30.70	31.74	28.77	30.06	27.24	28.07	25.43	24.17	21.87	33.86	30.70
	245 V	36.12[a]	33.60	33.02[a]	31.60	30.61[a]	30.00	27.81[a]	27.81[a]	22.53[a]	22.53[a]	37.07	33.60
	245 E	39.84	36.11	37.54	34.01	35.67	32.31	33.44	30.27	28.96	26.19	39.84	36.11
	243 V	38.09[a]	34.79	34.81[a]	32.72	32.26[a]	31.06	29.31[a]	29.07	23.74[a]	23.74[a]	38.36	34.79
	243 E		37.32	38.79	35.16	36.88	33.42	34.59	31.33	30.00	27.14		37.32
	315 V			39.24[a]	38.55	36.60[a]	36.60[a]	33.49[a]	33.49[a]	27.44[a]	27.44[a]		
	315 E						39.55		37.23	35.91	32.48		
DOUBLE SPAN	87 V	17.55[a]	17.55[a]	15.59[a]	15.59[a]	14.17[a]	14.17[a]	12.62[a]	12.62[a]	9.91[a]	9.91[a]	18.30[a]	18.30[a]
	87 E				19.79		18.56	18.93	17.16	15.31[a]	14.57		
	105 V			18.26[a]	18.26[a]	16.64[a]	16.64[a]	14.86[a]	14.86[a]	11.72[a]	11.72[a]		
	105 E									18.10[a]	17.29		
	139 V							18.61[a]	18.61[a]	14.78[a]	14.78[a]		
	139 E												
	175 V									17.35[a]	17.35[a]		
	175 E												
	191 V									19.36[a]	19.36[a]		
	191 E												
	245 V												
	245 E												
	243 V												
	243 E												
	315 V												
	315 E												

MAXIMUM VALUE IS 20'
Span is governed by maximum panel length of 40'.
Use max value of 20' or design as simple span using table values above.

[a] Represents governing value Mr and [b] represents governing value Vr.

Notes:

1. *For structural panel properties - see page 70. Span table assumes dry service conditions.*
2. *CLT is NOT an isotropic material. Presented values must only be used for bending panels in the major strength axis.*
3. *Spans shown represent distance between the center lines of supports and are to be used for preliminary design only.*
4. *Span table above considers panel self weight and 10 psf for miscellaneous dead load. [Ref: International Building Code 2012 - art.1607.5.]*
5. *Ponding or ceiling finishes may require higher deflection limits.*
6. *Engineer to ensure that deflection limit is appropriate for intended use.*
7. *Spans are assumed to be equal for double span panels.*
8. *Total panel length is limited to 40 ft due to the fabrication process.*
9. *Table values are to be used for preliminary design only.*
10. *L/180 is total load deflection limit; L/240 is snow load deflection limit.*
11. *For applications with deflection limits or loading different than what is indicated above, contact your Structurlam technical representative.*

TABLE 11: WALL PANEL LOADS
AXIAL LOADING ONLY (KIPS & POUNDS X 1,000)

PR (kips)		L (ft)														
PANEL NAME	PANEL SIZE (in)	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
87 V	3.43	36.80	35.13	30.69	23.28	16.77	12.32	9.34								
87 E	3.43	58.64	54.15	43.26	30.61	21.62	15.81	11.97								
105 V	4.14	37.07	36.24	34.36	30.52	24.81	19.31	15.06	11.95							
105 E	4.14	59.35	57.21	52.11	42.94	32.92	25.04	19.38	15.33							
139 V	5.48	55.94	55.17	53.58	50.51	45.09	37.78	30.63	24.79	20.26	16.79	14.10				
139 E	5.48	90.04	88.15	83.99	75.83	63.41	50.55	40.04	32.08	26.11	21.59	18.11				
175 V	6.90	56.13	55.73	54.98	53.72	51.65	48.36	43.64	38.03	32.52	27.69	23.66	20.35	17.64	15.41	
175 E	6.90	90.52	89.56	87.69	84.39	78.84	70.53	60.57	50.93	42.69	35.96	30.56	26.20	22.68	19.79	
191 V	7.53	74.88	74.36	73.40	71.80	69.18	65.02	59.00	51.69	44.37	37.86	32.39	27.88	24.18	21.13	18.60
191 E	7.53	120.83	119.61	117.24	113.09	106.11	95.53	82.51	69.64	58.48	49.33	41.94	35.98	31.14	27.18	23.91
245 V	9.66	75.05	74.78	74.30	73.56	72.47	70.90	68.66	65.50	61.27	56.13	50.54	45.06	40.02	35.57	31.69
245 E	9.66	121.26	120.62	119.48	117.65	114.87	110.73	104.73	96.66	87.07	77.11	67.74	59.43	52.26	46.15	40.96
243 V	9.58	93.76	93.37	92.68	91.59	89.96	87.55	84.05	79.12	72.72	65.41	58.01	51.16	45.10	39.86	35.38
243 E	9.58	151.48	150.57	148.90	146.19	142.00	135.62	126.42	114.50	101.28	88.42	76.91	67.02	58.66	51.62	45.69
315 V	12.42	93.93	93.73	93.37	92.84	92.10	91.09	89.75	87.95	85.57	82.46	78.50	73.73	68.39	62.82	51.62
315 E	12.42	151.90	151.42	150.58	149.31	147.49	144.95	141.45	136.69	130.35	122.36	113.06	103.14	93.34	84.16	75.84

Notes:

1. *For structural panel properties - see page 70.*
2. *Table assumes dry service conditions.*
3. $P_R = F_C A_{//} C_D C_M C_t C_P$, *where the* P_R *values are not given, the slenderness ratio exceeds 50.*
4. *The following factors were used for calculations:* C_D*=1.0,* C_M*=1.0,* C_T*=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 than what is indicated above, contact your Structurlam technical representative.*

TABLE 12: IN-PLANE SHEAR LOADING (APA PR-L314)

CLT LAYUP	LAYUP ID	THICKNESS, T_P (in)	IN-PLANE SHEAR STRESS		IN-PLANE SHEAR CAPACITY (b)	
			$F_{V,E,O}$ (psi)	$F_{V,E,90}$ (psi)	$F_{V,E,O}\,T_P$ (lbs/ft of width)	$F_{V,E,90}\,T_P$ (lbs/ft of width)
V2.1	87 V	3.43	175	235	7,200	9,700
	139 V	5.47	175[f]	235[f]	11,500[f]	15,400[f]
	191 V	7.52	175[f]	235[f]	15,800[f]	21,200[f]
	243 V	9.57	175[f]	235[f]	20,100[f]	27,000[f]
V2M1.1	105 V	4.14	195	290	9,700	14,400[d]
	175 V	6.90	270	290[d]	22,400	24,000[d]
	245 V	9.66	270[c]	290[d]	31,300[c]	33,600[d]
	315 V	12.42	270[c]	235[d]	40,200[c]	43,200[d]
V2M2.1	175 V XL	6.90	175[f]	235[f]	14,500[f]	19,500[f]
	245 V XL	9.66	175[f]	235[f]	20,300[f]	27,200[f]
	315 V XL	12.42	175[f]	235[f]	26,100[f]	35,000[f]
E1M4	87 E	3.43	175[f]	235[f]	7,200[f]	9,700[f]
	139 E	5.47	175[f]	235[f]	11,500[f]	15,400[f]
	191 E	7.52	175[f]	235[f]	15,800[f]	21,200[f]
	243 E	9.57	175[f]	235[f]	20,100[f]	27,000[f]
E1M5	105 E	4.14	195[e]	290[e]	9,700[e]	14,400[f]
	175 E	6.90	270[e]	290[e]	22,400[e]	24,000[f]
	245 E	9.66	270[e]	290[e]	31,300[e]	33,600[f]
	315 E	12.42	270[e]	290[e]	40,200[e]	43,200[f]
E1M7	175 E XL	6.90	175[f]	235[f]	14,500[f]	19,500[f]
	245 E XL	9.66	175[f]	235[f]	20,300[f]	27,200[f]
	315 E XL	12.42	175[f]	235[f]	26,100[f]	35,000[f]

Notes:

(a) The tabulated values are allowable design values.

(b) The tabulated values are for the full thickness (T_P*) of the CLT. The values shall be reduced when the CLT panel thickness is less than the full thickness.*

(c) Based on test results from 175 V of V2M1.1.

(d) Based on test results from 105 V of V2M1.1.

(e) Based on test results from V2M1.1.

(f) Based on test results from 87 V of V2.1.

Wood Innovation Design Center, Prince George, BC, Canada

GlulamPLUS® Beams and Columns

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.

Ballard Library, Seattle, WA, USA

GLULAMPLUS® ADVANTAGES:

- North American code approved
- Range of shapes and sizes
- Superior wood fiber 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 2015 and 2018 International Building Code (IBC) recognize structural glued laminated timber as a structural material for wood construction when manufactured in accordance with ANSI A190.1 Standard for Wood Products – Structural Glued Laminated Timber.

The IBC approves the use of structural glued laminated timber as a structural member for Type IV Construction and Chapter 5 of the NDS 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 ANSI A190.1 were derived analytically using the lumber properties published in the National Design Specification (NDS) for Wood Construction. Lumber from outside of North America has different characteristics, may not be recognized in the NDS and has published design values that are incompatible with those of North America 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® is certified to meet the requirements of Standard for Wood Products – Structural Glued Laminated Timber and Cross Laminated Timber (CLT) as described in ANSI A190.1-2017 and ANSI/APA PRG 320-2019.

These standards outline the quality control requirements required by 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 ASTM testing methods for fire, heat and moisture and must support ANSI manufacturing standards – see table 1 below. These test methods and manufacturing standards are approved in the U.S. by the International Building Code (IBC). The IBC is a model building code developed by the International Code Council (ICC) .

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.

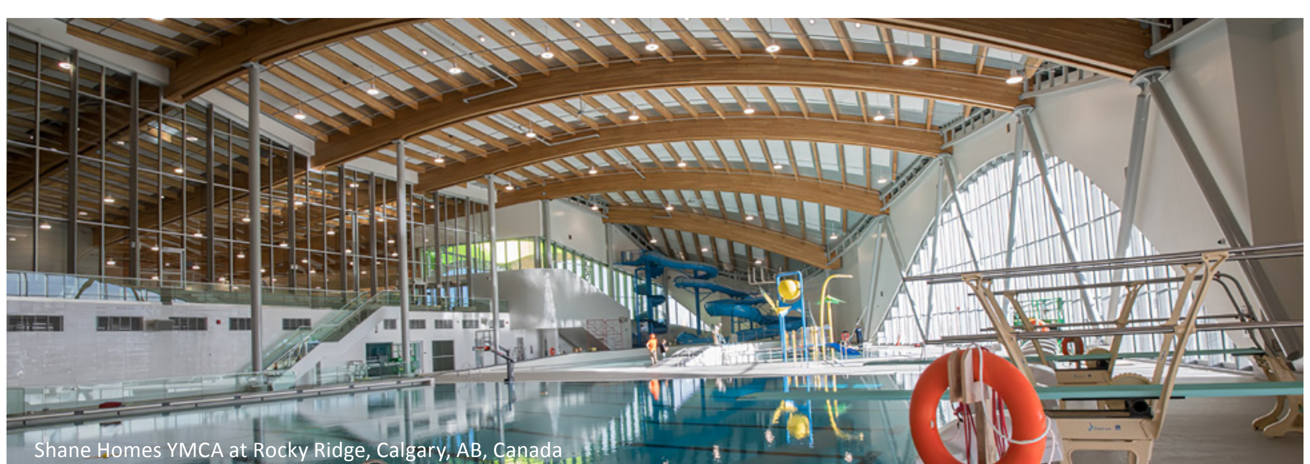
TABLE 1: ADHESIVES FOR GLULAM AND CLT MASS TIMBER PRODUCTS

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	✓	✓	✓

GlulamPLUS® Product Characteristics

TABLE 2: GLULAMPLUS® PRODUCT CHARACTERISTICS

PRODUCT CHARACTERISTICS		
WOOD SPECIES	Interior Douglas fir (Pseudotsuga menziesii var. glauca). Other species available upon request.	
FACE BOND GLUE TYPE	Hexion EcoBind™	
FINGER JOINT GLUE TYPE	Hexion Cascomel®	
SFI/FSC CERTIFICATION	Available upon request	
MOISTURE CONTENT	12% (+/-3%) at time of manufacturing	
DENSITY	34 lbs/ft^3	
CERTIFICATIONS	ANSI A190.1, ANSI 117, CSA O122 and CSA O177	
DIMENSIONAL TOLERANCES		
WIDTH	+/- 1/16" (2 mm)	
DEPTH	+1/8" (3 mm) per foot (305 mm) of depth. -3/16" (5 mm) or 1/16" (2 mm) per foot of depth, whichever is larger.	
LENGTH	Up to 20' (6.1 m), +/- 1/16" (2 mm). Over 20' (6.1 m), +/- 1/16" (2 mm) per 20' (6.1 m) 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 20' (6.1 m), the tolerance is +/- 1/4" (6 mm). Over 20' (6.1 m), the tolerance shall increase 1/8" (3 mm) per each additional 20' (6.1 m) or fraction thereof, but not to exceed 3/4" (19 mm). The tolerances are intended for use with straight or slightly cambered members and are not applicable to curved members such as arches.	
SQUARENESS OF CROSS SECTION	The tolerance for squareness shall be within +/- 1/8" (3 mm) per foot (305 mm) of specified depth unless a specially shaped section is specified. Squareness shall be measured by placing one leg of a square across a top and/or bottom face and measuring the offset from the other leg of the square to the member at the opposite face of the beam.	
MACHINED SURFACES	+/- 1/8" (3 mm) with all tooling units except the chainsaw, which is +/- 1/4" (6 mm)	
MIN MAX WIDTH	See page 82.	
AVAILABLE SIZES	**IMPERIAL**	**METRIC**
MAX LENGTH STANDARD	60'	18.3 m
MAX LENGTH SPECIALTY	110'	33.5 m
MAX DEPTH STANDARD	48"	1,219 mm
MAX DEPTH SPECIALTY	96"	2,438 mm
MINIMUM DEPTH	4.5"	114 mm



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

Glulam Appearance Classifications

Listed below are the ANSI A190.1 appearance classifications that glulam products must meet. At Structurlam, GlulamPLUS® exceeds visual standards set by ANSI A190.1. (see table below). Lower-grade appearances are available by request. For more on GlulamPLUS® finishes, refer to page 90.

INDUSTRIAL

- Glulam laminations may possess the natural growth characteristics of the lumber grade.
- No voids or low laminations are filled.
- Sides are planed true to specified dimensions.
- Occasional planing misses are permitted.
- No sanding.
- Members have a "hit and miss" (more miss) appearance.
- Wood inserts and filling are not required.
- Glue smear is allowed.

ARCHITECTURAL

- The wide face of laminations that are exposed should be free of loose knots. Otherwise, Glulam laminations may possess the natural growth characteristics of the lumber grade.
- Exposed corners should be eased.
- In exposed surfaces, voids measuring over 3/4" (19 mm) long should be filled.
- Open knot holes on the wide face that are exposed should be filled.
- All occurrences of pencil wane should be repaired with filler up to a maximum of 8" (203 mm). For pencil wane longer than 8" (203 mm), wood inserts should be used.
- Voids greater than 1/16" (2 mm) wide in edge joints on the wide exposed face should be filled with wood tone color filler.
- Exposed faces should be surfaced smooth planed.
- No sanding.
- Misses, wane and low laminations should not be permitted. Occasional repaired pencil wane should be permitted subject to Section 11.3.2.1.
- Corners of the member exposed should be eased with a minimum radius of 1/8" (3 mm).

PREMIUM

- Laminations should be selected to minimize loose knots, knot holes, pencil wane, bark inclusions and visible voids after final member surfacing.
- Knots should be limited to 20% of the net face of the lamination and not over two maximum sized knots should occur in a 6' (1.83 m) length. Otherwise, laminations are permitted to possess their natural growth characteristics.
- In exposed surfaces, voids measuring over 3/4" (19 mm) should be filled, or with clear wood inserts to match wood tone and grain color. A void not repaired is permitted to be longer than 3/4" (19 mm) if its areas do not exceed 1/2" squared (3.23 cm2).
- Repair requirements as noted above will apply when occasional voids occur due to loose knots, unsound knots or knotholes.
- All occurrences of pencil wane should be repaired with filler up to a maximum of 8" (203 mm). For pencil wane longer than 8" (203 mm), wood inserts should be used.
- Voids greater than 1/16" (2 mm) wide in edge joints on the wide exposed face should be filled with wood tone color filler
- Exposed faces should be surfaced smooth planed.
- No sanding.
- Misses, wane and low laminations should not be permitted. Occasional repaired pencil wane should be permitted subject to Section 11.4.2.1.
- Corners of the member exposed should be eased with a minimum radius of 1/8" (3 mm).

GLULAMPLUS® ADDITIONAL APPEARANCE STANDARD FEATURES

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 ANSI A190.1.

GLULAMPLUS® STANDARD WIDTH SECTIONAL DIAGRAMS

FIGURE 1: SINGLE LAMINATION BEAMS

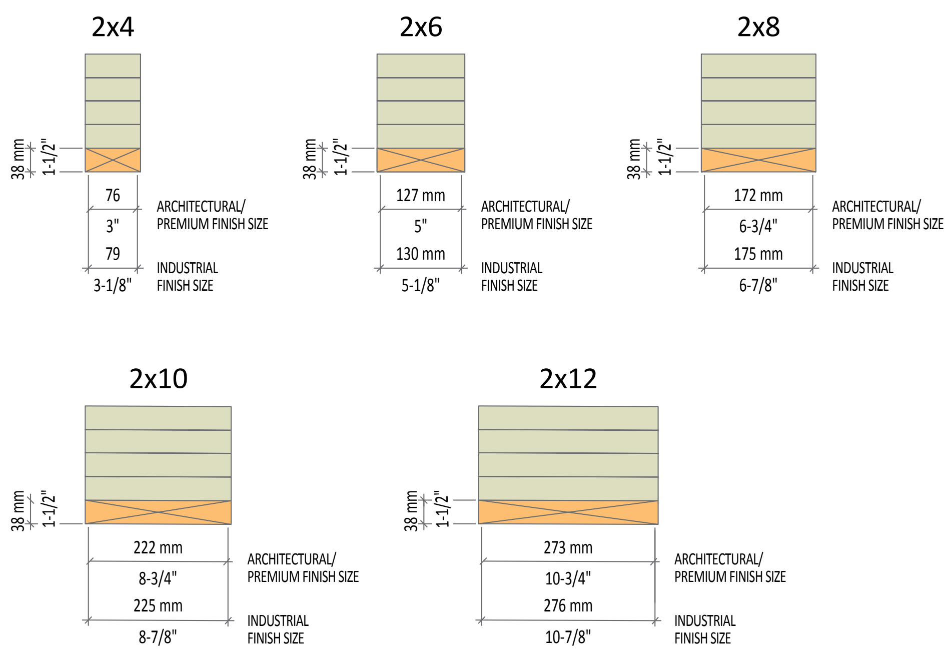
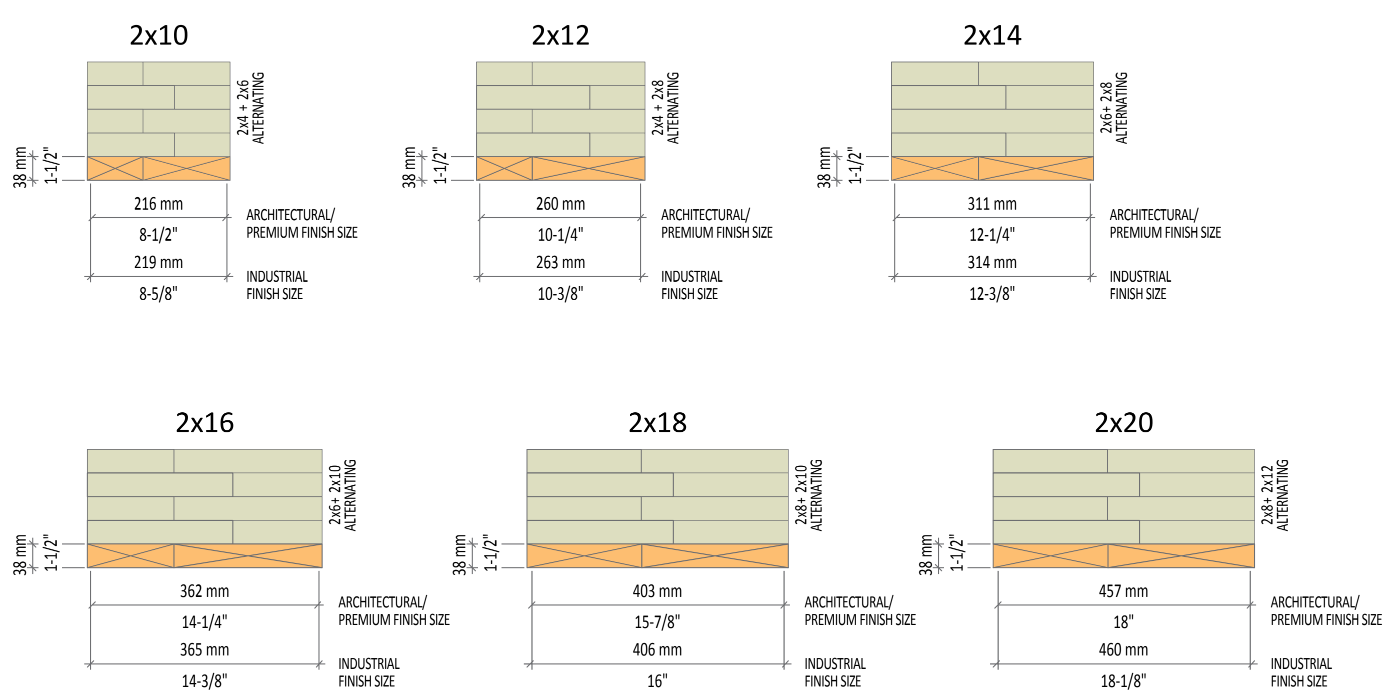


FIGURE 2: STAGGERED MULTIPLE PIECE LAMINATION



NOTE: All premium finished beams used for either appearance grade or with tight tolerance connections are additional undersized by 1/4" (6 mm) in depth from full lamination roundings 1-1/2" (38 mm) x # of lams, -1/4" (6 mm).

TABLE 3: FINISHED WIDTHS OF GLULAMPLUS® FINISHED BEAMS

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

*Other widths available from Structurlam

Staggered Multiple Piece Lamination: Structurlam utilizes a staggered multiple piece lamination layup technique as described in ANSI A190.1, section 9.3, 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

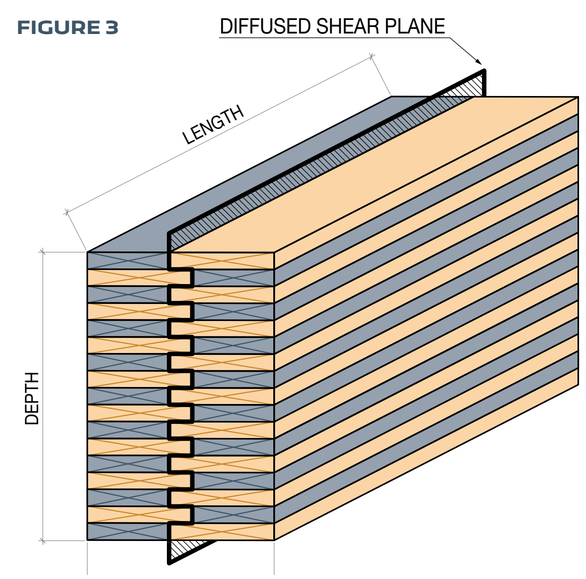
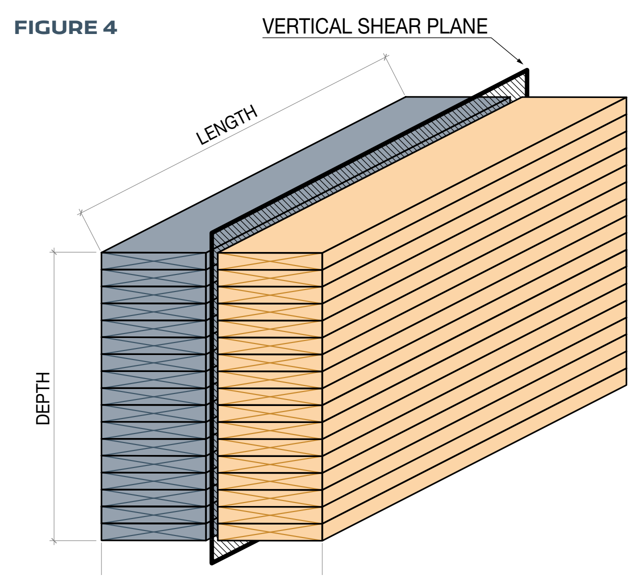


FIGURE 4



CAMBER

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.

TABLE 4: GLULAMPLUS® CAMBER STANDARDS

CAMBER	BEAM SPAN (ft)						RADIUS (ft)
	20'	30'	40'	50'	60'	70'	
1	0.46"	1.03"	1.83"	2.86"	4.12"	5.61"	1,310'
2	0.33"	0.74"	1.31"	2.05"	2.95"	4.01"	1,833'
3	0.23"	0.52"	0.92"	1.43"	2.06"	2.81"	2,620'
4	0.18"	0.41"	0.73"	1.15"	1.65"	2.25"	3,274'

Camber shown in inches.

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® ALLOWABLE DESIGN STRESS PROPERTIES

BEAM LAYUP DESIGNATIONS AND DESIGN STRESS PROPERTIES (pounds per square inch – psi)														
	BENDING ABOUT THE X-X AXIS						BENDING ABOUT THE Y-Y AXIS					AXIAL LOADED		
COMBINATION	F_{B+}	F_{B-}	COMP PERP (psi)	SHEAR FBX (psi)	E APP (x 10^6 PSI)	EMIN (x10^6 PSI)	F_{BY}	F_C PERP	F_V	E APP	E MIN	COMP PARALLEL	TENSION PARALLEL	SPECIFIC GRAVITY
2,400 - V4 DF	2,400	1,850	650	265	1,800,000	0.95	1,450	560	230	1.6	0.85	1,650	1,100	0.5
2,400 - V8 DF	2,400	2,400	650	265	1,800,000	0.95	1,550	560	230	1.6	0.85	1,650	1,100	0.5

NAME CONVENTION

EWS 24F V4 / DF

- Species designation from ANSI 117
- Balanced vs. Unbalanced Layup (see table below)
- Rated Bending Stress in psi x 100
- Engineered Wood System

GLULAMPLUS® BEAM LAYUP PATTERNS

V4 – Unbalanced Beam Layup
Use a V4 layup or short cantilever for most economical solution to simple span application.

V8 – Balanced Beam Layup
When dealing with a beam that is supported by multiple bearings or a beam that is cantilevered over a support, then a V8 balanced layup is typically required.

FIGURE 5: BALANCED LAYUP

24 F-V4 Douglas fir (12 Lamination Example)

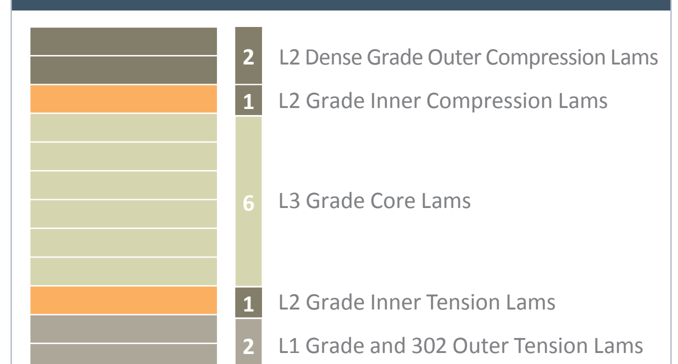


FIGURE 6: UNBALANCED LAYUP

24 F-V8 Douglas fir (12 Lamination Example)

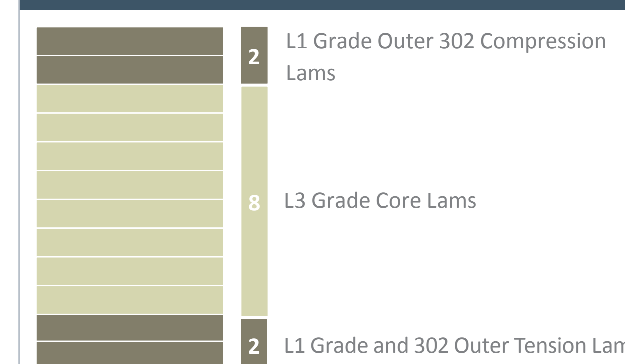


TABLE 6: GLULAMPLUS® COLUMN LAYUP DESIGNATIONS AND DESIGN STRESS PROPERTIES FOR GLULAMPLUS® COLUMNS

COLUMN LAYUP DESIGNATIONS AND DESIGN STRESSES[1] (pounds per square inch – psi)										
	E AXIAL X 10^6	E MIN X10^6	COMPRESSION PERP	F_T[2]	F_C AXIAL[3]	F_{BX}[4]	F_{VX}	F_{BY}	F_{VY}	SPECIFIC GRAVITY
L2 - DF	1.7	0.85	560	1,250	1,950	1,700	265	1,800	230	0.5

1. *Allowables shown for prismatic beams and columns with loads applied along the specified axis.*
2. *F_T shown for two or more laminations.*
3. *F_C shown for four or more laminations only.*
4. *F_{BX} shown for two laminations and up to 15" deep. For depths greater than 15" the F_{BX} factor is to be multiplied by 0.88.*

Allowables to be modified according to the 2018 National Design Specification for Wood Construction.

The values listed for GlulamPLUS® beams and columns are baseline properties that require modification depending on the size of the member, the type of loads applied and the environmental conditions.

Adjustment factors to be considered include:

C_D	Duration of load. (.9 dead loads, 1.0 normal loads, 1.15 snow loads, 1.25 construction loads and 1.6 wind and earthquake loads)
C_M	Moisture (wet service)
C_T	Temperature
C_L	Beam stability
C_V	Volume effect (5.125/b)^0.1*(12/d)^0.1*(21/L)^0.1
C_{FU}	Flat use factor
C_C	Curvature factor
C_F	Form factor
C_P	Column stability factor
C_B	Bearing factor

Not all factors need be applied in all applications or for all design values. See the National Design Specification for Wood Construction – 2015, table 5.3.1 for a listing of which adjustment factors are required for specific situations.

TABLE 7: GLULAMPLUS® COLUMN LOAD CAPACITY

L2 DF column design allowables - Eccentricity = 1/6 D or W

COLUMN DIMENSIONS (in) (W)x(D)	LOAD DURATION FACTORS	COLUMN LENGTH IN FEET					
		10	12	14	16	18	20
8.5 x 8.75	1	67,200	60,800	53,900	47,300	41,200	38,400
	1.15	74,700	66,400	58,100	50,300	43,300	37,500
	1.25	79,400	69,900	60,500	51,900	44,500	35,900
10.25 x 10.25	1	101,000	93,900	85,500	76,900	68,600	61,100
	1.15	113,400	104,200	93,600	83,100	73,300	64,700
	1.25	121,200	110,600	98,500	86,800	76,100	66,900
12.25 x 13.75	1	171,900	163,700	154,900	145,600	134,200	122,700
	1.15	195,000	184,500	173,500	159,900	145,700	131,800
	1.25	210,000	198,000	185,100	168,500	152,200	137,000
14.25 x 14.75	1	214,600	205,400	195,600	185,300	174,600	163,600
	1.15	243,800	232,300	219,800	206,800	193,200	179,500
	1.25	263,200	249,500	235,200	220,200	204,700	189,100
15.875 x 16.25	1	246,300	237,100	227,400	217,500	207,000	196,300
	1.15	280,500	269,100	256,700	244,100	230,900	217,500
	1.25	303,100	289,600	275,800	261,200	246,000	230,700
18 x 19.25	1	331,100	321,400	311,100	300,600	289,700	278,400
	1.15	378,200	365,900	353,300	339,800	326,200	311,900
	1.25	409,300	395,000	380,400	365,300	349,300	333,300

L2 DF column design allowables - Eccentricity = 1/2 D or W - load applied to face of column

COLUMN DIMENSIONS (in) (W)x(D)	LOAD DURATION FACTORS	COLUMN LENGTH IN FEET					
		10	12	14	16	18	20
8.5 x 8.75	1	33,600	31,600	29,400	27,100	24,800	22,600
	1.15	37,900	35,300	32,500	29,700	27,000	24,400
	1.25	40,600	37,600	34,400	31,300	28,300	25,500
10.25 x 10.25	1	49,400	47,200	44,300	41,300	38,400	35,600
	1.15	55,900	53,100	49,500	45,800	42,200	38,800
	1.25	60,200	56,800	52,700	48,600	44,600	40,800
12.25 x 13.75	1	81,300	78,100	74,800	71,600	68,400	65,200
	1.15	92,700	88,700	84,700	80,700	76,700	72,600
	1.25	100,200	95,600	91,100	86,500	81,900	77,300
14.25 x 14.75	1	100,400	96,700	93,100	89,500	85,900	82,300
	1.15	114,600	110,100	105,600	101,000	96,600	92,100
	1.25	124,000	118,800	113,700	108,600	103,400	98,300
15.875 x 16.25	1	109,500	106,000	102,600	99,300	96,000	92,700
	1.15	125,200	120,900	116,800	112,700	108,600	104,500
	1.25	135,600	130,800	126,000	121,400	116,700	112,100
18 x 19.25	1	144,900	140,900	137,100	133,500	129,900	126,400
	1.15	166,000	161,200	156,600	152,100	147,700	143,400
	1.25	180,000	174,500	169,400	164,200	159,300	154,300

The values in the tables above are for preliminary sizing only. Final design should include a complete analysis of loads, eccentricities, connections and bearing capacity supporting the column.

Notes:

1. *Loads shown are allowable axial loads (ASD) in pounds.*
2. *Eccentricity assumed to be 1/6 in either the x-x or y-y direction, whichever is worse.*
3. *Calculations per 2018 NDS and 2015 ANSI 117.*
4. *E (axial) = 1,7000,000 psi   Emin = 850,000 psi.*
5. *F_{BY} = 1,800. Size factor = (12/^{d})^(1/9).*
6. *F_{BX} = 1,700 psi. Volume factor per NDS. F_{BX} reduced by factor of .88 for Depths > 15".*
7. *F_C =1,950 psi.*

TABLE 8: GLULAMPLUS® BEAM ENGINEERING PROPERTIES

3.125" BEAM WIDTH													
DEPTH (in)	**9.00**	**10.50**	**12.00**	**13.50**	**15.00**	**16.50**	**18.00**	**19.50**	**21.00**	**22.50**	**24.00**	**25.50**	**27.00**
WEIGHT (#/ft)	6.6	7.8	8.9	10.1	11.2	12.3	13.5	14.6	15.8	16.9	18.0	19.2	20.3
AREA (in^2)	27.3	32.0	36.7	41.4	46.1	50.8	55.5	60.2	64.8	69.5	74.2	78.9	83.6
S (in^3)	39.9	54.7	71.9	91.4	113.3	137.5	164.1	193.0	224.3	257.8	293.8	332.1	372.7
I (in^4)	174.5	280.4	422.5	605.8	835.7	1,117.5	1,456.3	1,857.6	2,326.6	2,868.5	3,488.7	4,192.3	4,984.7
EI x 10^6 (psi)	314	505	760	1,090	1,504	2,011	2,621	3,344	4,188	5,163	6,280	7,546	8,972.5
MOMENT CAPACITY (ft #)	7,975	10,944	14,382	18,288	22,663	27,507	32,291	37,376	42,789	48,525	54,579	60,948	67,626.8
SHEAR CAPACITY (#)	4,831	5,659	6,487	7,315	8,143	8,971	9,799	10,628	11,456	12,284	13,112	13,940	14,768.2

5.125" BEAM WIDTH													
DEPTH (in)	**12.00**	**13.50**	**15.00**	**16.50**	**18.00**	**19.50**	**21.00**	**22.50**	**24.00**	**25.50**	**27.00**	**28.50**	**30.00**
WEIGHT (#/ft)	14.6	16.5	18.4	20.2	22.1	24.0	25.8	27.7	29.6	31.5	33.3	35.2	37.1
AREA (in^2)	60.2	67.9	75.6	83.3	91.0	98.7	106.3	114.0	121.7	129.4	137.1	144.8	152.5
S (in^3)	117.9	150.0	185.8	225.6	269.1	316.5	367.8	422.9	481.8	544.6	611.2	681.7	756.0
I (in^4)	692.8	993.5	1,370.5	1,832.6	2,388.4	3,046.5	3,815.6	4,704.4	5,721.4	6,875.4	8,174.9	9,628.7	11,245.4
EI x 10^6 (psi)	1,247	1,788	2,467	3,299	4,299	5,484	6,868	8,468	10,299	12,376	14,715	17,332	20,241.7
MOMENT CAPACITY (ft #)	23,586	29,860	36,218	43,116	50,543	58,490	66,948	75,910	85,369	95,318	105,751	116,664	128,050.1
SHEAR CAPACITY (#)	10,639	11,997	13,355	14,713	16,071	17,429	18,787	20,146	21,504	22,862	24,220	25,578	26,936.1

6.75" BEAM WIDTH													
DEPTH (in)	**18.00**	**19.50**	**21.00**	**22.50**	**24.00**	**25.50**	**27.00**	**28.50**	**30.00**	**31.50**	**33.00**	**34.50**	**36.00**
WEIGHT (#/ft)	29.1	31.6	34.0	36.5	39.0	41.4	43.9	46.3	48.8	51.3	53.7	56.2	58.7
AREA (in^2)	119.8	129.9	140.1	150.2	160.3	170.4	180.6	190.7	200.8	210.9	221.1	231.2	241.3
S (in^3)	354.4	416.9	484.4	556.9	634.6	717.3	805.0	897.8	995.7	1,098.6	1,206.6	1,319.7	1,437.8
I (in^4)	3,145.7	4,012.5	5,025.5	6,196.0	7,535.5	9,055.4	10,767.0	12,681.7	14,811.0	17,166.1	19,758.6	22,599.8	25,701.0
EI x 10^6 (psi)	5,662	7,222	9,046	11,153	13,564	16,300	19,381	22,827	26,660	30,899	35,566	40,680	46,261.9
MOMENT CAPACITY (ft #)	64,760	74,942	85,780	97,263	109,382	122,130	135,499	149,481	164,070	179,260	195,044	211,418	228,375.4
SHEAR CAPACITY (#)	21,167	22,956	24,744	26,533	28,322	30,111	31,899	33,688	35,477	37,266	39,054	40,843	42,631.9

8.5" BEAM WIDTH													
DEPTH (in)	**24.00**	**25.50**	**27.00**	**28.50**	**30.00**	**31.50**	**33.00**	**34.50**	**36.00**	**37.50**	**39.00**	**40.50**	**42.00**
WEIGHT (#/ft)	49.1	52.2	55.3	58.4	61.5	64.6	67.7	70.8	73.9	77.0	80.1	83.2	86.3
AREA (in^2)	201.9	214.6	227.4	240.1	252.9	265.6	278.4	291.1	303.9	316.6	329.4	342.1	354.9
S (in^3)	799.1	903.2	1,013.7	1,130.6	1,253.8	1,383.5	1,519.5	1,661.8	1,810.6	1,965.7	2,127.2	2,295.1	2,469.3
I (in^4)	9,489.2	11,403.1	13,558.4	15,969.6	18,650.8	21,616.6	24,881.2	28,459.0	32,364.3	36,611.4	41,214.8	46,188.7	51,547.4
EI x 10^6 (psi)	17,080.5	20,525.5	24,405.2	28,745.2	33,571.5	38,909.9	44,786.2	51,226.2	58,255.7	65,900.5	74,186.6	83,139.6	92,785.4
MOMENT CAPACITY (ft #)	134,601.7	150,288.8	166,739.7	183,945.6	201,898.3	220,590.2	240,013.9	260,162.8	281,030.2	302,610.1	324,896.6	347,884.2	371,567.5
SHEAR CAPACITY (#)	35,664.6	37,917.1	40,169.6	42,422.1	44,674.6	46,927.1	49,179.6	51,432.1	53,684.6	55,937.1	58,189.6	60,442.1	62,694.6

10.25" BEAM WIDTH													
DEPTH (in)	**27.0**	**28.5**	**30.0**	**31.5**	**33.0**	**34.5**	**36.0**	**37.5**	**39.0**	**40.5**	**42.0**	**43.5**	**45.0**
WEIGHT (#/ft)	66.6	70.4	74.1	77.9	81.6	85.3	89.1	92.8	96.5	100.3	104.0	107.7	111.5
AREA (in^2)	274.2	289.6	304.9	320.3	335.7	351.1	366.4	381.8	397.2	412.6	427.9	443.3	458.7
S (in^3)	1,222.4	1,363.4	1,512.0	1,668.3	1,832.3	2,004.0	2,183.4	2,370.4	2,565.2	2,767.6	2,977.7	3,195.5	3,421.0
I (in^4)	16,349.9	19,257.4	22,490.7	26,067.1	30,003.8	34,318.2	39,027.5	44,149.1	49,700.2	55,698.1	62,160.2	69,103.6	76,545.9
EI x 10^6 (psi)	29,429.7	34,663.3	40,483.3	46,920.8	54,006.9	61,772.7	70,249.5	79,468.3	89,460.3	100,256.6	111,888.3	124,386.6	137,782.6
MOMENT CAPACITY (ft #)	197,339.2	217,702.7	238,950.0	261,072.2	284,060.5	307,907.0	332,604.0	358,144.1	384,520.6	411,726.8	439,756.4	468,603.5	498,262.3
SHEAR CAPACITY (#)	48,439.8	51,156.0	53,872.3	56,588.5	59,304.8	62,021.0	64,737.3	67,453.5	70,169.8	72,886.0	75,602.3	78,318.5	81,034.8

Notes:

1. *Beam weight based on density of 35 pcf.*
2. *Properties based on 2,400 F_B Douglas fir layup.*
3. *Moment capacity shown is adjusted for volume effect. For effective length, span is assumed to be 18 times depth (i.e., for a 21" deep beam span is assumed to be 31'-6").*
4. *Moment and shear capacity shown is based on a normal 10-year duration of load (DOL = 1.0) and may be adjusted for DOL as per applicable building code.*
5. *Nominal depths are shown. For custom beams, actual beam depth will be 1/4" smaller to allow for clean up of beam. (Charts properties based on custom sizes.)*
6. *F_{BX} = 1,700 psi. Volume factor per NDS. F_{BX} reduced by factor of .88 for Depths > 15".*
7. *F_C =1,950 psi.*

TABLE 9: GLULAMPLUS® BEAM ENGINEERING PROPERTIES

12.25" BEAM WIDTH													
DEPTH (in)	**30.00**	**31.50**	**33.00**	**34.50**	**36.00**	**37.50**	**39.00**	**40.50**	**42.00**	**43.50**	**45.00**	**46.50**	**48.00**
WEIGHT (#/ft)	88.6	93.0	97.5	102.0	106.4	110.9	115.4	119.8	124.3	128.8	133.2	137.7	142.2
AREA (in^2)	364.4	382.8	401.2	419.6	437.9	456.3	474.7	493.1	511.4	529.8	548.2	566.6	584.9
S (in^3)	1,807.0	1,993.8	2,189.8	2,395.0	2,609.4	2,832.9	3,065.7	3,307.6	3,558.8	3,819.1	4,088.6	4,367.3	4,655.1
I (in^4)	26,879.2	31,153.4	35,858.2	41,014.4	46,642.6	52,763.5	59,397.7	66,566.0	74,289.0	82,587.3	91,481.6	100,992.7	111,141.2
EI x 10^6 (psi)	48,382.5	56,076.0	64,544.8	73,826.0	83,956.7	94,974.3	106,915.9	119,818.8	133,720.1	148,657.1	164,667.0	181,786.9	200,054.1
MOMENT CAPACITY (ft #)	280,529.2	306,500.8	333,489.3	361,485.2	390,479.7	420,464.0	451,430.2	483,370.5	516,277.5	550,144.2	584,963.8	620,729.9	657,436.2
SHEAR CAPACITY (#)	64,384.0	67,630.2	70,876.5	74,122.7	77,369.0	80,615.2	83,861.5	87,107.7	90,354.0	93,600.2	96,846.5	100,092.7	103,339.0

14.25" BEAM WIDTH													
DEPTH (in)	**33**	**34.5**	**36**	**37.5**	**39**	**40.5**	**42**	**43.5**	**45**	**46.5**	**48**	**49.5**	**51**
WEIGHT (#/ft)	113.4	118.6	123.8	129.0	134.2	139.4	144.6	149.8	155.0	160.2	165.4	170.6	175.8
AREA (in^2)	466.7	488.1	509.4	530.8	552.2	573.6	594.9	616.3	637.7	659.1	680.4	701.8	723.2
S (in^3)	2,547.3	2,786.0	3,035.4	3,295.5	3,566.2	3,847.6	4,139.8	4,442.6	4,756.1	5,080.3	5,415.1	5,760.7	6,117.0
I (in^4)	41,712.6	47,710.7	54,257.7	61,378.0	69,095.3	77,433.9	86,417.8	96,070.9	106,417.4	117,481.3	129,286.7	141,857.5	155,217.9
EI x 10^6 (psi)	75,083	85,879	97,664	110,480	124,372	139,381	155,552	172,928	191,551	211,466	232,716	255,344	279,392
MOMENT CAPACITY (ft #)	382,114	414,192	447,414	481,770	517,251	553,849	591,554	630,358	670,255	711,236	753,294	796,423	840,615
SHEAR CAPACITY (#)	82,448	86,224	90,001	93,777	97,553	101,329	105,106	108,882	112,658	116,434	120,211	123,987	127,763

16" BEAM WIDTH													
DEPTH (in)	**39**	**40.5**	**42**	**43.5**	**45**	**46.5**	**48**	**49.5**	**51**	**52.5**	**54**	**55.5**	**57**
WEIGHT (#/ft)	150.7	156.5	162.4	168.2	174.0	179.9	185.7	191.5	197.4	203.2	209.0	214.9	220.7
AREA (in^2)	620.0	644.0	668.0	692.0	716.0	740.0	764.0	788.0	812.0	836.0	860.0	884.0	908.0
S (in^3)	4,004.2	4,320.2	4,648.2	4,988.2	5,340.2	5,704.2	6,080.2	6,468.2	6,868.2	7,280.2	7,704.2	8,140.2	8,588.2
I (in^4)	77,580.7	86,943.4	97,030.5	107,869.1	119,486.2	131,908.9	145,164.0	159,278.6	174,279.7	190,194.4	207,049.5	224,872.1	243,689.2
EI x 10^6 (psi)	139,645	156,498	174,655	194,164	215,075	237,436	261,295	286,701	313,704	342,350	372,689	404,770	438,641
MOMENT CAPACITY (ft #)	574,085	614,703	656,551	699,620	743,900	789,384	836,063	883,931	932,979	983,201	1,034,590	1,087,139	1,140,842
SHEAR CAPACITY (#)	109,533	113,773	118,013	122,253	126,493	130,733	134,973	139,213	143,453	147,693	151,933	156,173	160,413

18" BEAM WIDTH													
DEPTH (in)	**39**	**40.5**	**42**	**43.5**	**45**	**46.5**	**48**	**49.5**	**51**	**52.5**	**54**	**55.5**	**57**
WEIGHT (#/ft)	169.5	176.1	182.7	189.2	195.8	202.3	208.9	215.5	222.0	228.6	235.2	241.7	248.3
AREA (in^2)	697.5	724.5	751.5	778.5	805.5	832.5	859.5	886.5	913.5	940.5	967.5	994.5	1,021.5
S (in^3)	4,504.7	4,860.2	5,229.2	5,611.7	6,007.7	6,417.2	6,840.2	7,276.7	7,726.7	8,190.2	8,667.2	9,157.7	9,661.7
I (in^4)	87,278	97,811	109,159	121,353	134,422	148,397	163,309	179,188	196,065	213,969	232,931	252,981	274,150
EI x 10^6 (psi)	157,101	176,060	196,487	218,435	241,960	267,115	293,957	322,539	352,916	385,144	419,275	455,366	493,471
MOMENT CAPACITY (ft #)	638,283	683,444	729,972	777,856	827,088	877,658	929,558	982,778	1,037,312	1,093,150	1,150,285	1,208,711	1,268,419
SHEAR CAPACITY (#)	123,225	127,995	132,765	137,535	142,305	147,075	151,845	156,615	161,385	166,155	170,925	175,695	180,465

20" BEAM WIDTH													
DEPTH (in)	**39**	**40.5**	**42**	**43.5**	**45**	**46.5**	**48**	**49.5**	**51**	**52.5**	**54**	**55.5**	**57**
WEIGHT (#/ft)	188.4	195.7	203.0	210.2	217.5	224.8	227.3	239.4	246.7	254.0	261.3	268.6	275.9
AREA (in^2)	775.0	805.0	835.0	865.0	895.0	925.0	935.0	985.0	1,015.0	1,045.0	1,075.0	1,105.0	1,135.0
S (in^3)	5,005	5,400	5,810	6,235	6,675	7,130	7,285	8,085	8,585	9,100	9,630	10,175	10,735
I (in^4)	96,976	108,679	121,288	134,836	149,358	164,886	170,292	199,098	217,850	237,743	258,812	281,090	304,612
EI x 10^6 (psi)	174,557	195,623	218,319	242,705	268,844	296,795	306,525	358,377	392,129	427,937	465,861	505,962	548,301
MOMENT CAPACITY (ft #)	701,771	751,423	802,579	855,226	909,355	964,955	983,814	1,080,531	1,140,489	1,201,881	1,264,699	1,328,936	1,394,584
SHEAR CAPACITY (#)	136,917	142,217	147,517	152,817	158,117	163,417	165,183	174,017	179,317	184,617	189,917	195,217	200,517

Notes:

1. *Beam weight based on density of 35 pcf.*
2. *Properties based on 2,400 F_B Douglas fir layup.*
3. *Moment capacity shown is adjusted for volume effect. For effective length, span is assumed to be 18 times depth (i.e., for a 21" deep beam span is assumed to be 31'-6").*
4. *Moment and shear capacity shown is based on a normal 10-year duration of load (DOL = 1.0) and may be adjusted for DOL as per applicable building code.*
5. *Nominal depths are shown. For custom beams, actual beam depth will be 1/4" smaller to allow for clean up of beam. (Charts properties based on custom sizes.)*
6. *F_{bx} = 1,700 psi Volume factor per NDS. Fbx reduced by factor of .88 for Depths > 15".*
7. *F_c = 1,950 psi.*

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 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

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.

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.
CLT Handbook - Chapter 12, U.S., 2013.

STRUCTURLAM
MASS TIMBER CORPORATION
Intelligence In Wood

Carbon12, Portland, OR, USA

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.

structurlam.com

HEAD OFFICE
Structurlam Mass Timber Corporation
2176 Government St.
Penticton, BC
Canada V2A 8B5
t: 250 492 8912
sales@structurlam.com

USA
Kris Spickler
4120 Douglas Blvd., #306-502
Granite Bay, CA 95746
t: 916 759 9320
kspickler@structurlam.com

PACIFIC NORTHWEST
Alese Ashuckian
1355 NW Everett St., #100
Portland, OR 97209
t: 503 597 9825
aashuckian@structurlam.com

CENTRAL DIVISION/ SOUTHERN CALIFORNIA
Cory Scrivner
Dallas, TX
t: 512 539 7881
cscrivner@structurlam.com

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