Mass Timber Connections
Presented by Greg Kingsley, PhD, PE

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.
Acknowledgements

WoodWorks – Wood Products Council (WPC)
- Karen Gesa – Technical Director, Project Resources & Solutions Division
- Scott Breneman – Senior Technical Director – Mass Timber

KL&A Engineers & Builders
- Greg Kingsley
- Chris Kendall
- Erin Kinder
- Brian Malone
- Craig Dixon
- Rachel Chaggaris

Swinerton Mass Timber
- Graham Montgomery
- Brendan Kelly
- Chris Evans

OZ Architecture
- Jacob Levy
- Joe Anastasi
Purpose

To understand the spectrum of available mass timber connections and aid in the selection of cost-optimal connections.
The Players

- Owner
- Architect
- General Contractor
- Mass Timber Supplier
- Structural Engineer
The Players

• Owner
• Architect
• General Contractor
• Mass Timber Supplier
• Structural Engineer
## Mass Timber Connections Index

Go to WoodWorks.org and click on “Design & Tools”


106 structural connections

<table>
<thead>
<tr>
<th>Connection Type</th>
<th>Image</th>
<th>Designer Notes</th>
<th>Class</th>
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<th>Cost</th>
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- Where screws are used instead of nails, Cost increases and Constructability is moderate.  
- Typical minimum plywood thickness is ½” nominal.  
- Coordinate spline and rout width and thickness with panel supplier. | 1     | low  | $    | easy  | easy    | rated |
### Table 2: Mass Timber Panel Support at Mass Timber Beam

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| **2-1. Panel Bears on Beam** | ![Diagram](image) | **Purpose**: Transfer of vertical loads from roof or floor panel to wood beam. Can also transfer shear along the length of the beam.  
**Description**: Roof or floor panel beam on top of wood beam. Positive attachment is made with partially-threaded screws.  
**Notes**:  
• Capacity of primary load path is controlled by perpendicular-to-grain bearing capacity of floor panel or beam.  
• Screws provide load path for in-plane loads. | 1 | High | $ | Easy | Easy | Level II |

| **2-2. Panel Bears on Beam at Notch** | ![Diagram](image) | **Purpose**: Transfer of vertical load from roof or floor panel to wood beam. Can also transfer shear along the length of the beam.  
**Description**: Roof or floor panel beam on notch in wood beam and is connected with partially-threaded screws.  
**Notes**:  
• Capacity of primary load path is controlled by perpendicular-to-grain bearing capacity of floor panel or notch.  
• Reasonable minimum notch bearing width is 1”.  
• Shop machined notch provides more reliable elevation control than applied bracket or ledger.  
• In panel design, consider that panel is not continuous across connection and multi-span conditions may not be achievable.  
• Beam must be designed for reduced net section. | 1 | Medium | $$ | Easy | Easy | Level I |
Design Considerations
Design Considerations

• Structural Basics
• Aesthetics
• Construction Tolerance
• Constructability
• Moisture
• Fire Rating
• Inspections
Structural Basics

- IBC
- ASCE-SEI 7
- AWC NDS
- AISC
- APA T300
- CLT Handbook
Wood Design Reminders

- Bearing is Better than Dowel-Type Fasteners
- Parallel is Better than Perpendicular to Grain
- No Screw Withdrawal from End Grain
- Edge Distances and Spacing are Important
- Notch with Care
Wood Design Reminders

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2018 AWC NDS, Section 12.2.2.3
Wood Design Reminders

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- 2018 AWC NDS, Section 12.5
- Manufacturer’s Literature
Wood Design Reminders

- Bearing is Better than Dowel-Type Fasteners
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- 2018 AWC NDS, Section 5.4.5
- APA – The Engineered Wood Association (EWS) T300 Glulam Connection Details Construction Guide
- MTC Solutions ASSY Screws as Tensile Reinforcement in Notched Beams

(APA T300)
Aesthetics
Aesthetics
<table>
<thead>
<tr>
<th>Solution</th>
<th>Gap between Mass Timber Beam and Concrete Wall</th>
<th>Grouting below Sill Plate at Mass Timber Panel to Concrete Wall</th>
<th>Adjustable Column Base at Mass Timber Column to Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection Example</td>
<td><img src="image1" alt="Beam Perpendicular to Wall Connected to Face of Wall" /></td>
<td><img src="image2" alt="Panel Bears at Top of Wall" /></td>
<td><img src="image3" alt="Column Bears on Concrete with Adjustable Standoff Base" /></td>
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**Beam Perpendicular to Wall Connected to Face of Wall**

**Panel Bears at Top of Wall**

**Column Bears on Concrete with Adjustable Standoff Base**
Moisture

SCREW HEAD ALIGNS WITH FACE OF MEMBER

COUNTERSINK SCREW
Moisture

Drying shrinkage through depth of 7-ply CLT floor:
**Fire Rating**

**TABLE 601**

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Primary structural frame (see Section 202)</td>
<td>3 1/2</td>
<td>2 1/2</td>
<td>1 1/2</td>
<td>1 1/2</td>
<td>3 1/2</td>
</tr>
<tr>
<td>Bearing walls, Exterior</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Nonbearing walls and partitions Exterior</td>
<td>3 1/2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Nonbearing walls and partitions Interior</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Floor construction and associated secondary members (see Section 202)</td>
<td>2</td>
<td>2</td>
<td>1 1/2</td>
<td>1</td>
<td></td>
</tr>
<tr>
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</tr>
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See Table 602

**Inventory of Fire Resistance-Tested Mass Timber Assemblies & Penetrations**

Following is a list of mass timber assemblies and penetration fire stopping systems in mass timber assemblies that have been tested for fire-resistance. Sources are noted at the end of this document. For free technical assistance on any questions related to the fire-resistance design of mass timber assemblies, or free technical assistance related to any aspect of the design, engineering, or construction of a commercial or multi-family wood building in the U.S., email help@woodworks.org, or contact the WoodWorks Regional Director nearest you.

**Contents**:
- Table 1: North American Fire Resistance Tests of Mass Timber Floor / Roof Assemblies
- Table 2: North American Fire Resistance Tests of CLT Wall Assemblies
- Table 3: North American Fire Tests of Penetrations and Fire Stops in CLT Assemblies
- Table 4: North American Fire Resistance Tests of Connections

**Sources**

**Disclaimer**

Inspections
Connection Index
Connection categories go from top to bottom of structure:

- Panel to Panel
- Panel Support
- Beam Support
- Supporting Other Framing Systems
- Wall Panel to Wall Panel
- Base Connections
Panel to Panel Connections

• Diaphragm loads

• Many fasteners required
  • Consider fastener type

• Multiple fire-rated options

Panel to Panel Connections
Panel to Panel Connections
Panel Support

Panels supported on …

• Beam
• Column
• Wall Panel
• Concrete or Masonry
• Light Frame
• Steel Beam
Panel Support at Mass Timber Beam

- Overall floor depth
- Panel continuity
- Fire rating
- Aesthetics
Panel Support at Walls

Panels Supported by Walls:

Gravity Support
- Mass Timber Wall
- Concrete
- Masonry
- Light Frame
Panel Support at Steel Beam

Hybrid Structural System

• Reasons
  • Structural Depth
  • MEP coordination
  • Aesthetics
• Fire protection
- Mass Timber Girder
- Mass Timber Column
- Mass Timber Wall Panel
- Concrete or Masonry
- Light Frame
- Steel Frame
Beam Support at Girder

• Largest Section

• Many connections applicable to other Beam Support Conditions
  • Column
  • Wall Panel
Beam Support at Girder
Beam Support at Column

- Many options
- Aesthetics
- Loads
- Ceiling height
Base Connections:
• Column at Concrete
• Wall Panel at Concrete
Connection Information
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  - Where screws are used instead of nails, Cost increases and Constructability is moderate.  
  - Typical minimum plywood thickness is $\frac{3}{8}$" nominal.  
  - Coordinate spline and rout width and thickness with panel supplier. | 1     | medium | $ | easy | easy | Level I |
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### Connection Information

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  - Where screws are used instead of nails, Cost increases and Constructability is moderate.
  - Typical minimum plywood thickness is ¾" nominal.
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<td>medium</td>
<td>$</td>
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- **Load path:**
  - **Primary loads**
  - **Secondary loads**
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  - Where screws are used instead of nails, Cost increases and Constructability is moderate.  
  - Typical minimum plywood thickness is 3/4" nominal.  
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<td>Utilizes steel fabricated elements, with components such as angles and plates, and includes fasteners</td>
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<td>-------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Panels Connect with Single Surface Spline | ![Image](image) | **Purpose:** Transfer of in-plane shear along the panel to panel joint.  
**Description:** Adjacent floor panels with routed surfaces are butted together. A plywood spline is fastened to both panels using partially threaded screws or nails.  
**Notes:**  
- Capacity of connection is controlled by shear capacity of dowel-type fasteners.  
- Double Surface Spline or Steel Surface Spline can be used for increased capacity.  
- Spline may be fully above panels without routed surface where floor or roof coverings allow.  
- Where using nails, consider specifying nail gun nails instead of common wire nails for constructability, or collated screws instead of individual screws.  
- Where screws are used instead of nails, Cost increases and Constructability is moderate.  
- Typical minimum plywood thickness is 3/8” nominal.  
- Coordinate spline and rout width and thickness with panel supplier. | 1     | medium | $     | easy  | easy   | Level I |
<table>
<thead>
<tr>
<th>Connection Type</th>
<th>Image</th>
<th>Designer Notes</th>
<th>Class</th>
<th>Load</th>
<th>Cost</th>
<th>Const</th>
<th>Inspect</th>
<th>Fire</th>
</tr>
</thead>
</table>
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- Typical minimum plywood thickness is $\frac{3}{8}$" nominal.  
- Coordinate spline and rout width and thickness with panel supplier. | 1     | medium | $ | easy | easy | Level 1 |
Putting it all Together
### Table 2: Mass Timber Panel Support at Mass Timber Beam

<table>
<thead>
<tr>
<th>Connection Type</th>
<th>Image</th>
<th>Designer Notes</th>
<th>Class</th>
<th>Load</th>
<th>Cost</th>
<th>Const</th>
<th>Inspect</th>
<th>Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2-1. Panel Bears on Beam</strong></td>
<td><img src="image1" alt="Image" /></td>
<td><strong>Purpose</strong>: Transfer of vertical loads from roof or floor panel to wood beam. Can also transfer shear along the length of the beam. <strong>Description</strong>: Roof or floor panel bears on top of wood beam. Positive attachment is made with partially-threaded screws. <strong>Notes</strong>: - Capacity of primary load path is controlled by perpendicular-to-grain bearing capacity of floor panel or beam. - Screws provide load path for in-plane loads.</td>
<td>1</td>
<td>High</td>
<td>$</td>
<td>Easy</td>
<td>Easy</td>
<td>Level II</td>
</tr>
<tr>
<td><strong>2-2. Panel Bears on Beam at Notch</strong></td>
<td><img src="image2" alt="Image" /></td>
<td><strong>Purpose</strong>: Transfer of vertical load from roof or floor panel to wood beam. Can also transfer shear along the length of the beam. <strong>Description</strong>: Roof or floor panel bears on notch in wood beam and is connected with partially-threaded screws. <strong>Notes</strong>: - Capacity of primary load path is controlled by perpendicular-to-grain bearing capacity of floor panel or notch. - Reasonable minimum notch bearing width is 1”. - Shop machined notch provides more reliable elevation control than applied bracket or ledger. - In panel design, consider that panel is not continuous across connection and multi-span conditions may not be achievable. - Beam must be designed for reduced net section.</td>
<td>1</td>
<td>Medium</td>
<td>$5</td>
<td>Easy</td>
<td>Easy</td>
<td>Level I</td>
</tr>
</tbody>
</table>