Mass Plywood Panels: Designing with the Newest Mass Timber Structural Product

Presented by Austin Basl, Freres Lumber Co., Inc.

www.frereslumber.com

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Course Description

Mass plywood panels (MPP), a veneer-based engineered wood product, are a recent addition to the mass timber line-up of product options. This presentation will introduce MPPs with an outline of the manufacturing technologies, testing and certification that led to their development, followed by an in-depth look at the applications and requirements associated with their use. Topics will include methods of structural design, code compliance, product size options, and availability.

Learning Objectives

- Discuss the composition of mass plywood panels and the veneer-based manufacturing technology that led to their development.
- Highlight testing completed and certification received to date for mass plywood panels.
- Demonstrate options for the use of mass plywood panels in construction, including wall, floor and roof systems.
- Review methods of structural design available to designers to aid in mass plywood panel projects.

Distilled Learning Objectives

- What MPP is and how it is made
- The reliability and flexibility of MPP
- Designing with MPP
- MPP on sustainability

How MPP Became

Freres Lumber Co. started in 1922 as Lumber Mill

- 1959 – large log veneer plant
- 1963 – small log veneer plant
- 1989 – veneer drying facility
- 1998 – plywood plant
- 2007 – cogeneration facility
- 2017 – MPP facility

What is MPP and how it made?

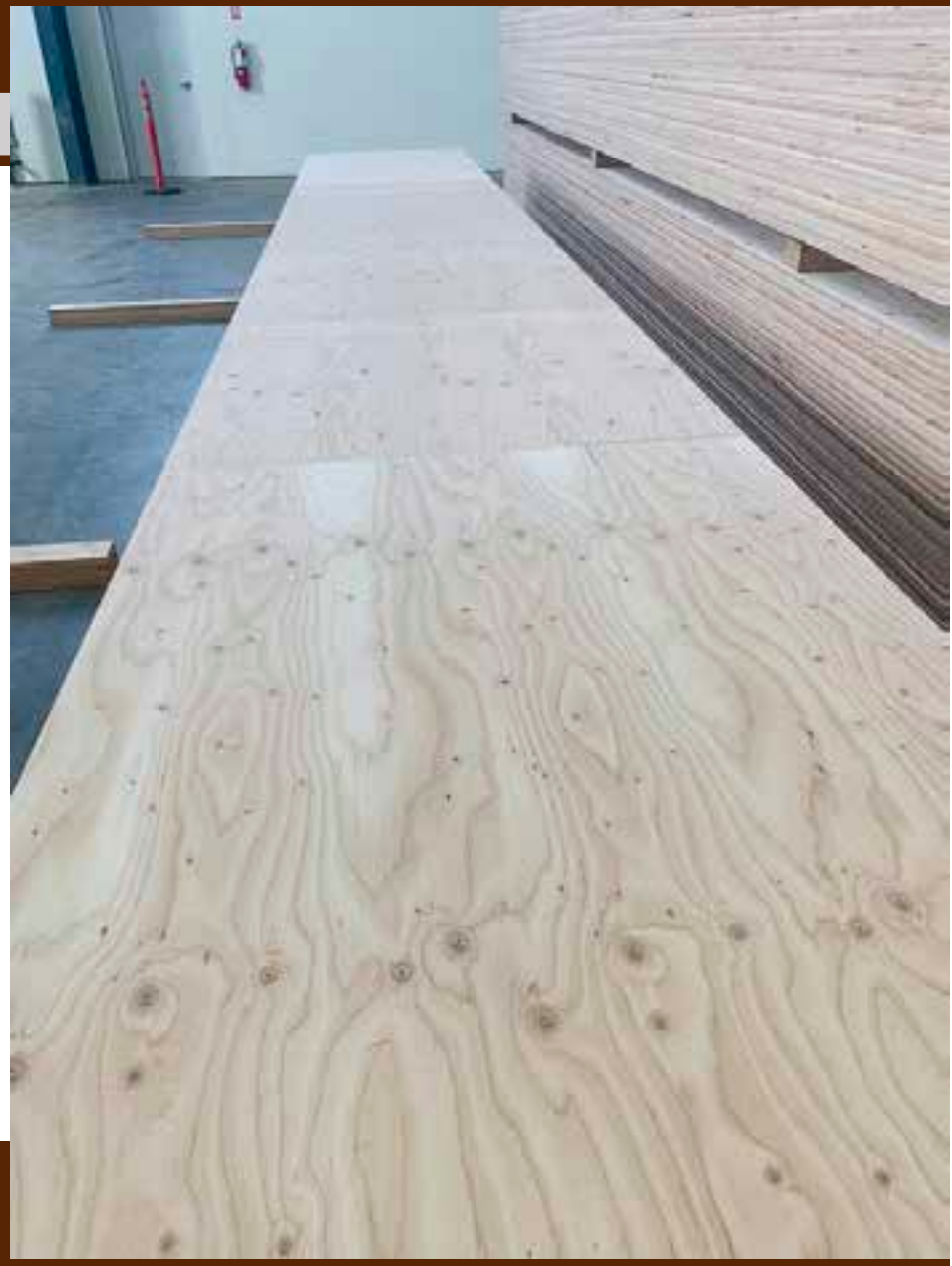
What is MPP?

MPP is a Certified Mass Timber Panel.

- Its closet cousin is CLT in which it has cross lamination and can be used in identical applications
  - In fact, it is certified as a CLT panel per PRG 320
- It can be up to 11’10” wide and 48 feet long (60 feet next year)
- The primary difference is MPP is veneered based versus lumber based

MPP Building Blocks

- MPP is made of layers of 1-1/8” 4x8 sheets of of very strong plywood called lamellas.
  - 9 layers of 1/8” veneer.
  - It is actually qualified as a LVL (laminated veneer lumber)
- Each piece of veneer is machine density graded ensuring the strongest wood.
- Each layer of veneer is orientated in the long or cross direction.
  - The lamellas can have the cross plies built in.

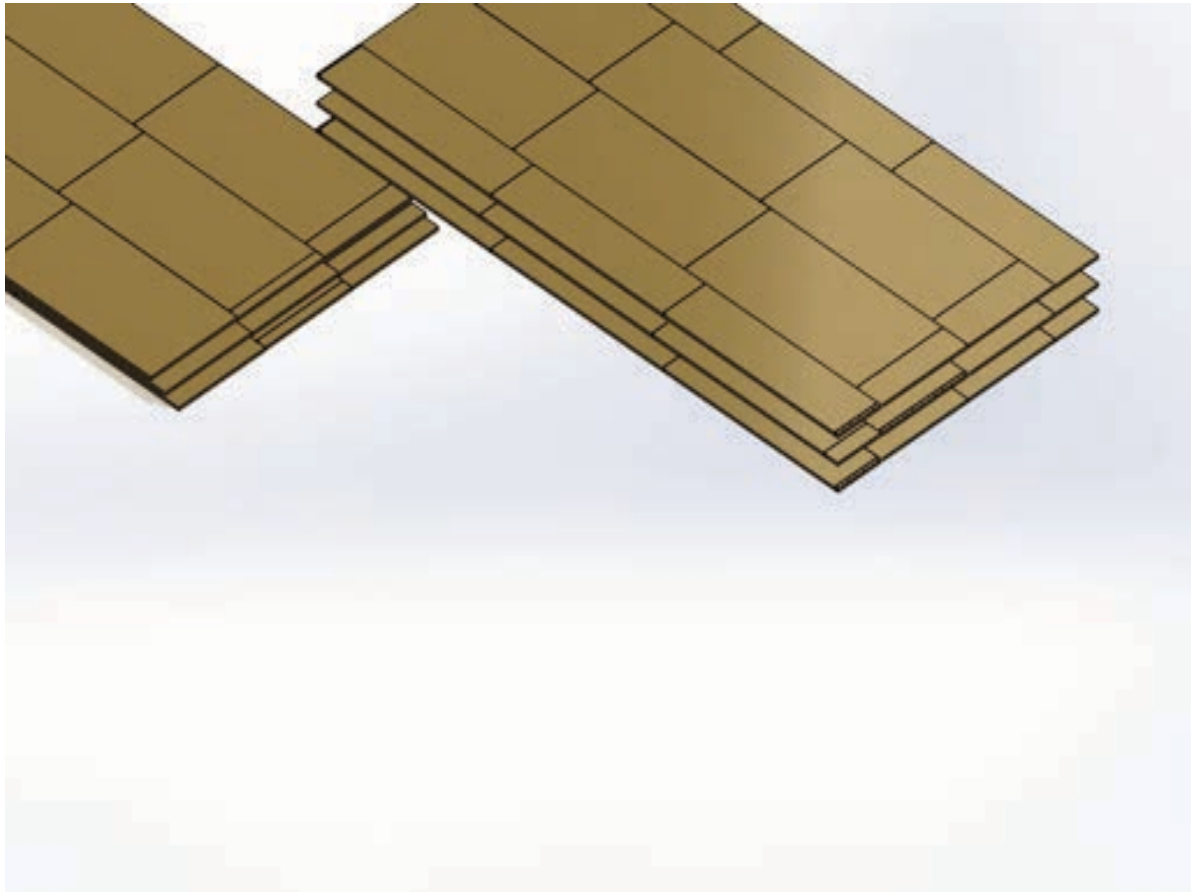


Long and Wide LVL

- The 4x8 lamellas are scarf jointed together to make one long panel for MPP
- 1 inch by 4 foot by 60 foot sheet of LVL.
  - LVL joist or rim board
- Long plywood with span capacity
  - What could you do with it?

MPP Layup

- The lamellas that are not turned into products get used for MPP panels, beams, or columns
  - MPP width and thickness is built up with scarfed and bonded lamellas in a brick format.
  - Panels are built to desired thickness.
    - Currently offered at 1 inch thickness, from 2 to 12 inches



Mass Timber Panel Facility Operational December 2017

MPP Beams, and Columns

- From the MPP we have the ability to make Beams and Columns
- They will be processed on a dedicated processing line that will produce up to 24 inch thick beams on edge, 24 inch beams in plank orientation and columns up to 24 inches thick.
- It also be able to cut a taper in the beams or columns

The Reliability and Design Flexibility MPP can give You

Reliable Quality with MPP

Veneer Products have Very Stringent Quality Control

- MPP is certified through PRG 320.
- The lamellas had to be certified as LVL through ASTM-D5456
- LVL is made up of density graded veneer
  - G1, G2, G3, and even a Super G!
  - Ultrasonic Propagation Time

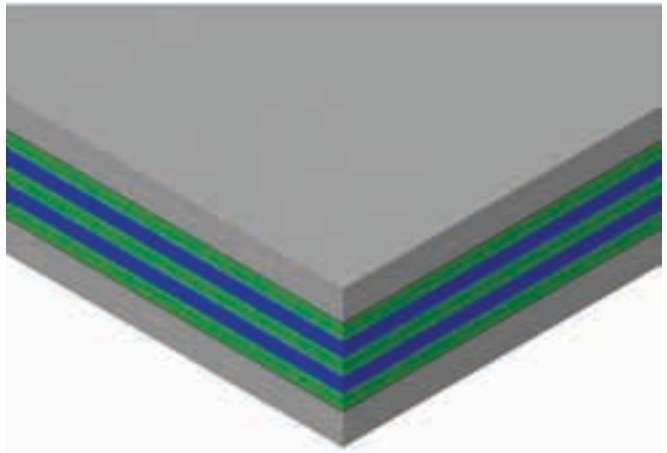
Quality Control

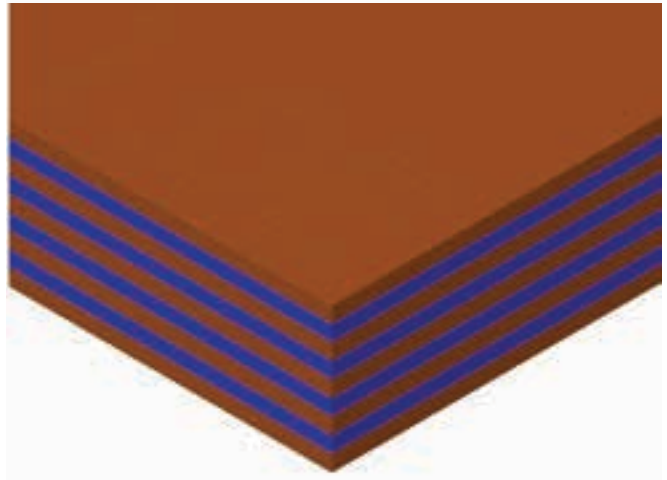
- At the LVL level there are many test such as 4-point bending, tension, and bond durability testing.
  - With and with out a scarf joint.
- Finally, MPP is tested per PRG320 with a secondary bond durability and block shear testing.

Design Flexibility with MPP

Current certified LVL for MPP

- 1.6E
  - 7 long ply layer and 2 cross plies.
    - A combination or G1, G2, and G3 veneer grades
    - The layup is 3 long – 1 cross – 1 long – 1 cross – 3 long
      - There are more plies in the long direction therefore it will perform better in the long direction
- 1.0E
  - 5 long ply layers and 4 cross ply layers all alternating and all G3s
    - Since there are more cross plies then the 1.6E it will have better minor for spanning capacity



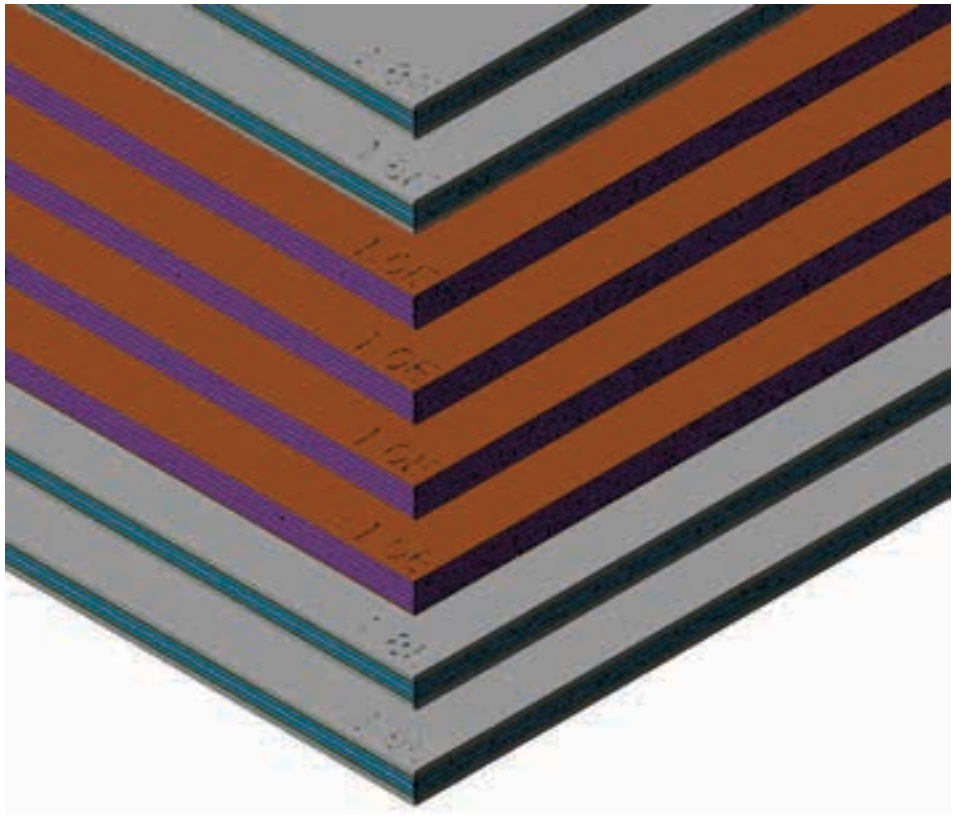


Future LVL Layups

- 2.0E which is like traditional LVL.
  - All long ply and all G1 veneers
- 2.2E is all long ply but all “super Gs”
- 8 long plies and 1 cross ply
- Place G1s at the cross ply for reduced rolling shear?
- Or…?

MPP Layup

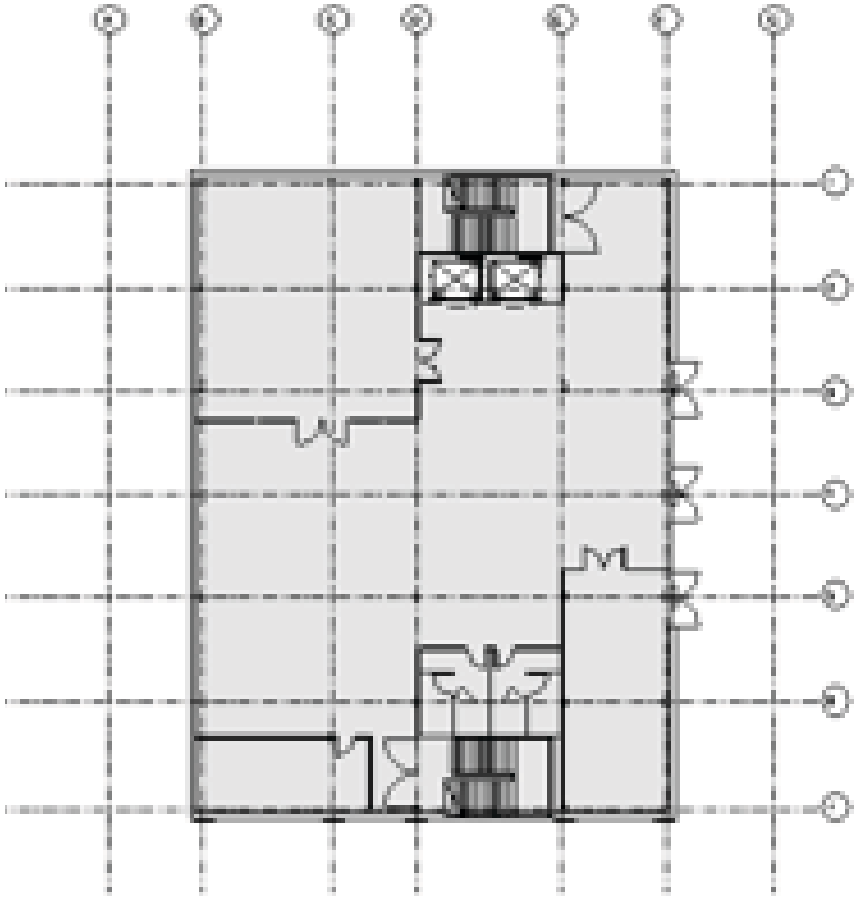
- Using the different LVL layups we can create different MPP layups
- We will start by putting lower grade material in the middle of the panel were it isn't structurally needed.
  - Similar spans at a lower cost
- However, a 2.0 or even a 2.2E on the outer ply we could get greater spans.
- Or eliminate beams and start optimizing a 2-way span slab
- Or maximize minor span direction
  - Cross ply the lamellas?



Designing with MPP

Optimizing the Design

- Consider the mass timber panel manufacturer early in design!
  - No standard sizes
  - Earlier you decide the more economical the project
- You are working with fixed sizes
  - There is a lot of wood so the waste can add up fast!
- MPP minimum length is 32 feet and a maximum of 48 feet
- Optimizing for the CNC
  - Think saw cuts



Optimize Span

- MPP has 1 inch intervals, 2 inches to 12 inches
- From a 2 inch panel to a 3 inch.
  - 50% more wood!
- 6 inch MPP is a typical floor thickness.
  - Reduce span by a few feet and use a 5 inch MPP
    - Saves 20% over the 6 inch!

MPP Maximum Span Floor Table

Lay-Up ID	Thickness inches	Vibration Controlled Span (feet)	Load Controlled Spans Live Load				
			40 PSF	50 PSF	75 PSF	100 PSF	150 PSF
F16-2	2	7.80	8.28	7.73	6.74	6.10	5.31
F16-3	3	10.41	11.99	11.38	9.91	8.99	7.82
F16-4	4	12.95	15.78	15.06	13.26	12.02	10.46
F16-5	5	15.31	19.43	18.57	16.57	15.02	13.06
F16-6	6	17.55	22.95	21.98	19.86	18.00	15.66
F16-7	7	19.69	26.40	25.32	23.16	20.99	18.25
F16-8	8	21.76	29.77	28.60	26.30	23.99	20.86
F16-9	9	23.76	33.06	31.80	29.31	26.98	23.47
F16-10	10	25.56	36.15	34.81	32.14	29.83	25.89
F16-11	11	27.62	39.43	38.02	35.21	32.98	28.68
F16-12	12	29.47	42.52	41.05	38.09	35.81	31.29

NOTES:
1) Single Span, Uniform Load, Major Force Direction Only.
2) Total Loads include live load, MPP weight, 20 psf concrete topping weight, and 15 psf additional loading.
3) Live Load Deflection limit = Span (L)/360, Total Load Deflection Limit = L/240.
4) Vibration controlled spans calculated using concepts outlined in the MPP Handbook and assume a bare floor.
5) Deflection calculated following guidance from APA Technical Topics TT-123.
6) When designing for vibration, use the vibration span for any loading condition that does not produce a span shorter than the vibration span.

Structural Design Reports

- MPP is a certification reports
  - PR-L324 report per ASTM-D5456 (LVL)
  - PR-L325 report per PRG320 (MPP)
- PR-L324 report for our LVL.
  - 1 inch lamellas and is good for up to 3 inches thick
  - This will give you on edge bending values, plank orientation bending, dowel bearing values for fastener design, and our rim board design properties.

APA PRODUCT REPORT
www.apawood.org

FRERES Laminated Veneer Lumber **PR-L324**
Freres Lumber Co., Inc. Revised December 6, 2018

Product: Freres 1.6E, 1.55E, and 1.0E LVL
Freres Lumber Co., Inc., 14114th St., Lyons, Oregon 97358
(503) 859-2121
www.frereslumber.com

1. Basis of the product report:
   - 2018 and 2015 International Building Code (IBC): Sections 104.11 Alternative materials and 2303.1.10 Structural composite lumber
   - 2012 IBC: Sections 104.11 Alternative materials and 2303.1.9 Structural composite lumber
   - 2018 and 2015 International Residential Code (IRC): Sections R104.11 Alternative materials, and R502.1.5, R602.1.5, and R802.1.4 Structural composite lumber
   - 2012 IRC: Section R104.11 Alternative materials, and R502.1.7, R602.1.4, and R802.1.6 Structural composite lumber
   - 2018 and 2015 ANSI/AWC NDS, National Design Specification for Wood Construction
   - ASTM D5456-14b, D5456-13, and D5456-09 recognized by the 2018 IBC and IRC, 2015 IBC and IRC, and 2012 IBC and IRC, respectively
   - APA Reports T2018P-14, T2018P-15, T2018P-37, T2018P-38, and T2018P-40, and other qualification data

APA PRODUCT REPORT
www.apawood.org

FRERES Mass Panel Products **PR-L325**
Freres Lumber Co., Inc. Revised February 28, 2019

Products: Freres Mass Panel Products
Freres Lumber Co., Inc., 14114th St., Lyons, Oregon 97358
(503) 859-2121
www.frereslumber.com

1. Basis of the product report:
   - 2018, 2015, and 2012 International Building Code (IBC): Section 104.11 Alternative materials
   - 2018, 2015, and 2012 International Residential Code (IRC): Section R104.11 Alternative materials
   - ANSI/APA PRG 320-2018 Performance Rated Cross-Laminated Timber
   - ASTM D5456-14b, D5456-13, and D5456-09 recognized by the 2018 IBC and IRC, 2015 IBC and IRC, and 2012 IBC and IRC, respectively
   - APA Report T2018P-21 and other qualification data

MPP Design Report

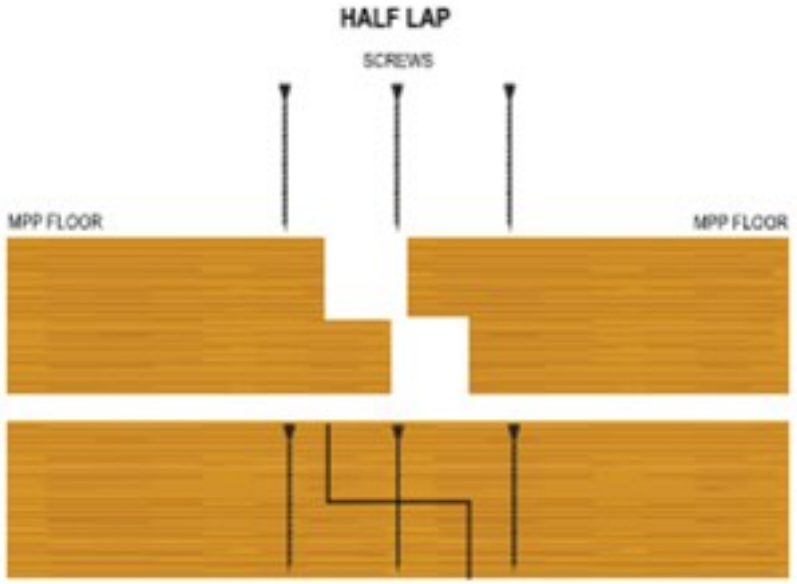
- PR-L325 for MPP
  - Bending and deflection values.
    - Reference the CLT Handbook for derivation
    - However, use PR-L324 for fastener, compression and in-plane shear values for the MPP
    - Edge joints must be considered in how it could effect your design

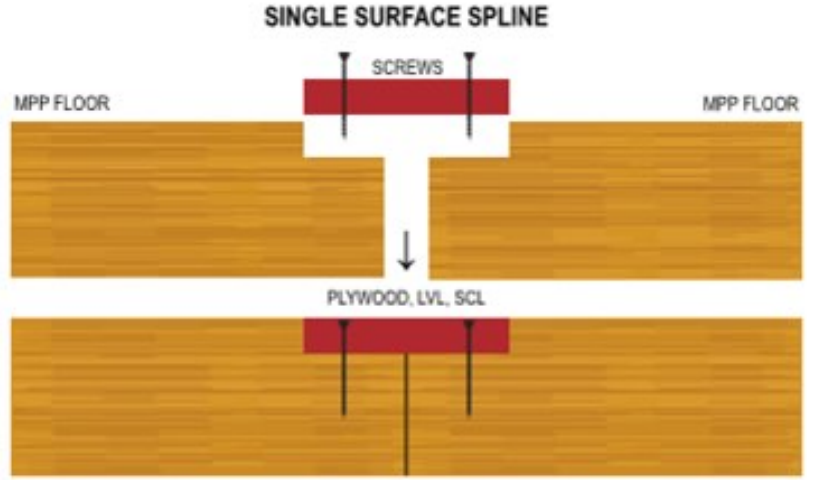
MPP In-plane Shear

- In-plane Shear Design
  - Working with Oregon State
  - However our PR-L324 report has in-plane shear capacity for our 1 inch lamellas
    - For now use number from report but factor in edge joints.
      - Even number lamellas –shear stress/2
      - Odd number lamellas – shear stress * ((thickness - 1) / 2) / thickness

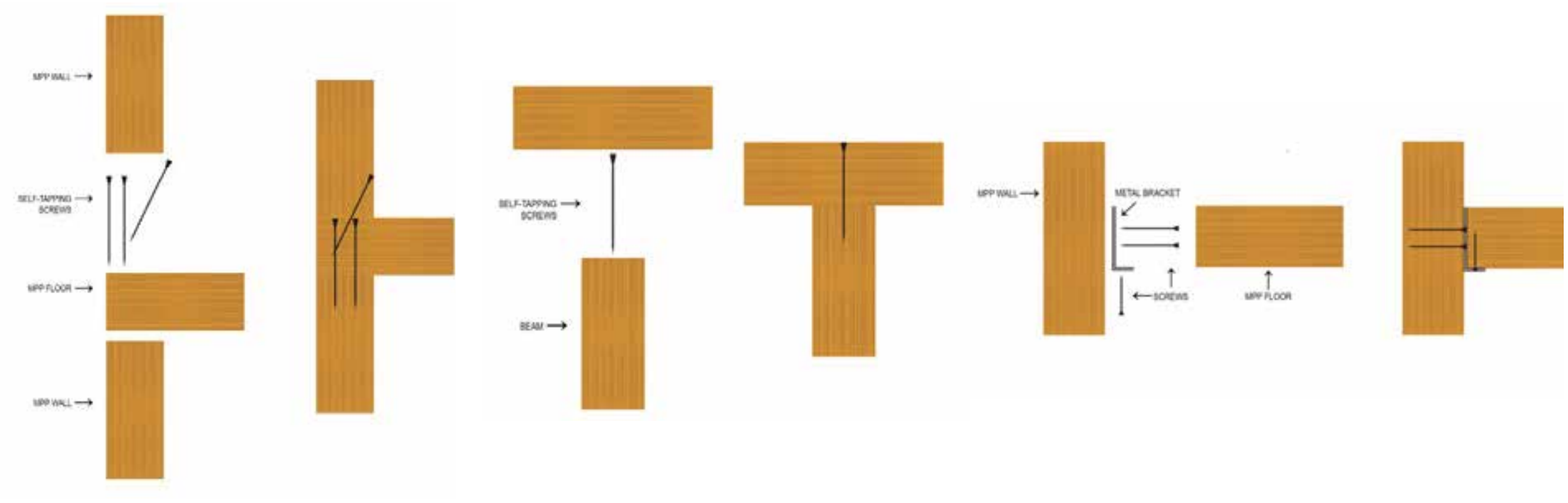
Thickness (inches)	F-16			
	In-Plane Shear Stress[2,3]		In-Plane Shear Capacity	
	$F_{v,e,0}$ (psi)	$F_{v,e,90}$ (psi)	$F_{v,e,0}$ T_p (lbs/ft of width)	$F_{v,e,90}$ T_p (lbs/ft of width)
2	128	128	3060	3060
3	85	85	3060	3060
4	128	128	6120	6120
5	102	102	6120	6120
6	128	128	9180	9180
7	109	109	9180	9180
8	128	128	12240	12240
9	113	113	12240	12240
10	128	128	15300	15300
11	116	116	15300	15300
12	128	128	18360	18360

Diaphragm Connections





Floor Connections



Structural Design with MPP

- MPP can be designed the same as CLT with a few exceptions.
  - You can't use the PRG320 model to calculate the panels properties.
  - Use the PR-L324 report when calculating compression and beams on edge (limited to 3" thickness).
  - The CLT Handbook, NDS, IBC and Woodworks are all really good resources.
    - And us at Freres Lumber.

Fire Rated

- Undergone E119 and E84 testing
  - Meets a 2 hour floor and a 1.5 hour wall with out 6 inch panel
  - Floor char rate at 1.55 in/hr per E119 testing
    - Versus 2.0 in/hr per NDS
  - Secondary flash over or delamination have not been observed
  - Fine tune fire design with 1 inch increments

Testing

- Oregon State University has completed a rocking wall and shear wall test
  - These can be used to validate your design
- Currently we are testing for deep beams on edge
  - Up to 12 inch wide and 6 feet deep.
- We are working with some suppliers for acoustical testing.
- 24 inch beams in plank and 24 inch columns
- Different LVL layups
- Different MPP layups

MPP Appearance Options

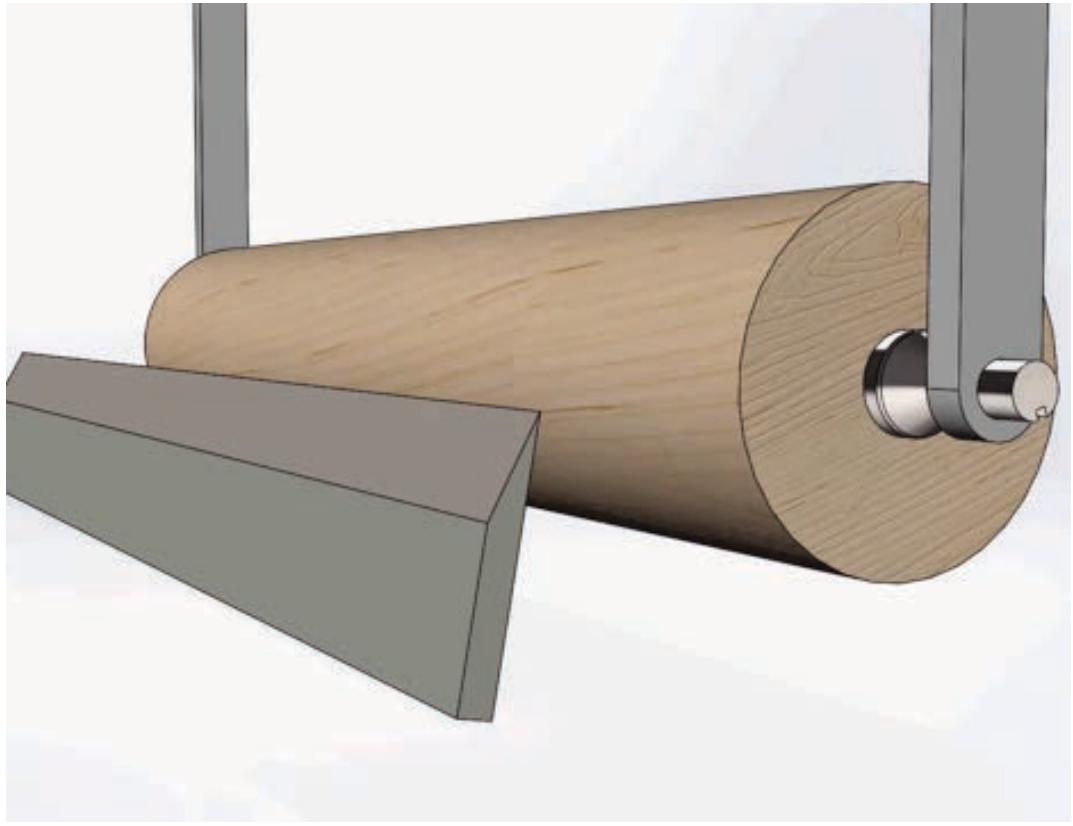
- 2 different structural appearance options
  - Industrial Finish (top image)
    - The veneers only needs to meet the stress rated requirements
  - Architectural (lower image)
    - The veneers meet stress rated requirements plus a knot requirement of being a dime size or smaller.
    - All open knots are puttied
    - This helps even out the color variation giving it a more even color

MPP Appearance Options

- Non-structural appearance
  - Any 4x8 or 4x10 panel can easily be worked into the manufacturing process.
    - Lap joints in panels prevent the potential for resin squeeze out.

MPP on Sustainability

- A sustainable product that stores carbon
- The log is processed by peeling it
  - Thin sheet of green veneer that takes little energy to dry.
- Smaller diameter logs
  - We can get multiple sheets of veneer from a 6 inch log
    - Prefer smaller trees found in a 2nd growth suppressed understory
      - Ideal for low impact thinning operations
      - Reduce forest fire fuel load



MPP

- Veneer based mass timber panel
- Reliable and safe
- Flexible to meet your specific needs
- A sustainable building product for the future

➢ QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

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