DrJ CERTIFICATION

#1131
ISO/IEC 17065
Product Certification Body

Master Plank® Laminated Veneer Lumber (LVL) **TER No. 0812-01**

Issue Date: December 31, 2008
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DIVISION: 06 00 00 – WOOD AND PLASTICS
Section: 06 17 00 – Prefabricated Structural Wood

1. **Product Line Evaluated:**
   - **1.1. Master Plank® laminated veneer lumber (LVL)**
     - **1.1.1.** Master Plank® Beams and Headers – 2900 Fb- 2.0 E
   - **1.2.** For the most recent version of this report, visit drjengineering.org.

2. **Applicable Codes and Standards:**[1]
   - **2.1.** *2000*, *2006* and *2009 International Building Code®* (*IBC*)
   - **2.2.** *2000*, *2006* and *2009 International Residential Code®* (*IRC*)
   - **2.3.** *2005 National Building Code of Canada®* (*NBC*)
   - **2.4.** *BOCA® National Building Code/1999* (*BNBC*)
   - **2.5.** *1997 Uniform Building Code™* (UBC)
   - **2.6.** *1999 Standard Building Code®* (SBC)

3. **Performance Evaluation:**
   - **3.1.** Master Plank® LVL was evaluated to determine its:
     - **3.1.1.** Structural performance with respect to the application of gravity, lateral buckling and uplift loading requirements.
       - **3.1.1.1.** Performance was assessed for each of the foregoing building codes in the context of the code-referenced *Standard Specification for Evaluation of Structural Composite Lumber Products*, *ASTM D5456*.

[1] Unless otherwise noted, code references are from the 2012 versions of the codes. This product is also approved for use with the 2000 and 2003 versions of the *IBC* and *IRC* and the standards referenced therein.

3.1.2. Use as an alternative material to that described in Chapter 23 of the *IBC*, *BNBC*, *SBC*, and *UBC*, as well as compliance with the requirements noted in Section 2303.1.9 of the *IBC*, Section 2301.2 of the *IBC* for allowable stress design, and Section 2303.4 of the *BNBC*.

3.1.3. Use as an alternative material and method of construction in compliance with Section 104.11 of the *IBC*, Section 106.4 of the *BNBC*, Section 103.7 of the *SBC* and Section 104.2.8 of the *UBC*.

3.1.4. Compliance with Section 2308 of the *IBC*, Section 2305 of the *BNBC* and Chapters 5, 6 and 8 of the *IRC* for conventional light frame construction applications.

4. Product Description and Materials:

4.1. Master Plank® LVL is manufactured by Finnforest Oy, of Finland and distributed by Finnforest-USA, Engineered Wood Division of Roseville, MI. The product is manufactured by laminating wood veneers with an Exterior Type adhesive in a continuous process with the grain of the wood oriented parallel to the length of the member in accordance with an ISO 9001 quality certification system.

4.2. The veneers used in Master Plank® LVL are between 0.122" and 0.133" (3.1 and 3.4 mm) thick.

4.3. Material Availability:

4.3.1. Thicknesses range from ¾" to 3½" (19 to 89 mm).

4.3.2. Nominal depths are 3½" to 24" (89 to 610 mm).

4.3.3. Lengths are available up to 60' feet (18 m).

4.3.4. Custom widths and lengths are available.

4.3.4.1. In these cases, special design will be performed to provide the appropriate design and application recommendations.

5. Applications:

5.1. Master Plank® LVL is an alternative to sawn lumber for floor, roof and wall structural members. Structural applications include use as beams, columns, headers, joists, rafters, rim boards and wall studs.

5.2. Master Plank® LVL may also be used for industrial applications such as scaffold plank, staging, bleacher seats, cross arms, ladder rails and other applications.

5.2.1. While the structural design values provided are the base design values to use, some applications may have special design requirements, such as the requirement for preservative treatment.

5.2.2. Custom design is available for the above-mentioned applications.

5.3. Master Plank® LVL shall be installed in accordance with the applicable code, the approved construction documents, this Testing and Engineering Report (TER) and the manufacturer's installation instructions.

5.3.1. If the manufacturer's installation instructions conflict with this TER, the TER instructions supersede and should be used.

5.4. Structural Design:

5.4.1. Design of Master Plank® LVL is governed by the applicable code and the *ANSI/AF&PA National Design Specification for Wood Construction* (*NDS*®).

5.4.2. Unless otherwise noted, adjustment of the design stresses for duration of load shall be in accordance with the applicable code.

5.4.3. The design provisions for wood construction noted in Chapter 23 of the *BNBC*, *SBC*, and *UBC*, Section 2301.2 of the *IBC* (for allowable stress design) and Section R301.1.3 of the *IRC*, apply to Master Plank® LVL for allowable stress design (ASD), unless otherwise noted in this report.

5.4.3.1. Allowable unit stresses for Master Plank® LVL for dry conditions of use are specified in Table 1a.

5.4.3.1.1. Allowable Stresses for Master Plank® LVL[2,3,4,5] (Allowable Stress Design)

[2] 1 psi = 0.00689 MPa or 1 MPa = 145 psi.

[3] The values in these tables are based on covered, dry conditions of use. See Section 8.3.4 of this report.

Bending Stress, F_b (psi)		Tensile Stress, F_t (psi)	Compressive Stress, F_c (psi)			Horizontal Shear Stress, F_v (psi)		Modulus of Elasticity,[6] E (psi)	
Beam[7,8]	Plank	Parallel-to-Grain[9]	Parallel-to-Grain	Perpendicular-to-Grain		Beam	Plank	Beam	Plank
				Beam	Plank				
2900	3200	2300	2700	870	435	320	320	$2.0x10^6$	$2.0x10^6$

Table 1a: Allowable Stresses for Master Plank® LVL (Allowable Stress Design)

5.4.4. Limit States Design using Master Plank® LVL shall be in accordance with *CAN/CSA-O86-01*.

5.4.4.1. The specified strengths for Master Plank® LVL for dry conditions of use should not exceed the values set forth in Table 1b.

5.4.4.1.1. Specified Strengths for Master Plank® LVL[10,11,12,13] (Limit States Design)

Bending, F_b (MPa)		Tension, F_t (MPa)	Compression, F_c (MPa)			Horizontal Shear, F_v (MPa)		Modulus of Elasticity,[14] E (MPa)	
Beam[15,16]	Plank	Parallel-to-Grain[17]	Parallel-to-Grain	Perpendicular-to-Grain		Beam	Plank	Beam	Plank
				Beam	Plank				
37.25	40.69	25.85	29.50	10.93	5.44	3.40	2.53	13,800	13,800

Table 1b: Specified Strengths for Master Plank® LVL (Limit States Design)

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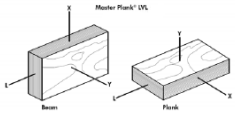
[4] The values provided in these tables are based on normal load duration. Loads of longer or shorter duration shall be adjusted in accordance with the applicable code. Duration of load adjustments shall not be applied to Fcperp and E.

[5] Orientation nomenclature for Master Plank® LVL.



[6] The Apparent E for both beams and planks is $1.9x10^6$ psi and can be used directly in traditional beam deflection formulas. The tabular values of $2.0x10^6$ psi represent the True E (i.e. shear-free) for both beams and planks. Using True E, deflection is calculated as follows for uniformly loaded simple span beams:

$\Delta = [270WL^4/Ebh^3] + [28.8WL^2/Ebh]$ where: Δ = deflection in inches
W = uniform load in plf,
L = span in feet
E = Modulus of elasticity in psi
b = width of beam in inches
h = depth of beam in inches

[7] The bending values in these tables are based on a referenced depth of 12" (305 mm). For other depths, the bending values shall be adjusted by a size factor adjustment of $(12/d)^{0.15}$. For depths less than 3½" (89 mm), use the value for 3½" (89 mm).

[8] When structural members qualify as repetitive members in accordance with the applicable code, a four percent increase is permitted.

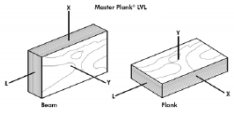
[9] The value for, Ft is based on a length of 55" (1397 mm). For lengths longer than 55" (1397 mm), adjust Ft by a factor of $(55/L)^{0.125}$. For lengths shorter than 55" (1397 mm), use an adjustment factor of 1.0.
(1397 mm) shall not be increased.

[10] 1 psi = 0.00689 MPa or 1 MPa = 145 psi.

[11] The values in these tables are based on covered, dry conditions of use. See Section 8.1.4 of this report.

[12] The values provided in these tables are based on normal load duration. Loads of longer or shorter duration shall be adjusted in accordance with the applicable code. Duration of load adjustments shall not be applied to Fcperp and E.

[13] Orientation nomenclature for Master Plank® LVL.



[14] The Apparent E for beams is 12,901 MPa and for planks is 13,100 MPa and can be used directly in traditional beam deflection formulas. The tabular values of 13,800 MPa represent the True E (i.e. shear-free) for both beams and planks. Using True E, deflection is calculated as follows for uniformly loaded simple span beams:

$\Delta = [(156WL^4x10^6)/Ebh^3] + [2{,}400WL^2/Ebh]$ where: Δ = deflection in millimeters
W = specified uniform load in N/m,
L = span in meters
E = Modulus of elasticity in MPa
b = width of beam in millimeters
h = depth of beam in millimeters

[15] The bending values in these tables are based on a referenced depth of 304.8 mm. For other depths, the bending values shall be adjusted by a size factor adjustment of (304.8/d)0.15. For depths less than 89 mm, use the value for 89 mm.

[16] When structural members qualify as repetitive members in accordance with the applicable code, a four percent increase is permitted.

[17] The value for Ft is based on a length of 6096 mm. For other lengths, adjust Ft by a factor of (6096/L)0.125. For lengths shorter than 1397 mm, use the value for 1397 mm.

5.4.5. Lateral loads for nails, screws and bolts and withdrawal loads for nails installed in Master Plank® LVL shall be as prescribed in the applicable code for sawn lumber having a minimum specific gravity equal to that provided in Table 2.

5.4.6. Fastener spacing shall be as prescribed in the applicable code (for sawn lumber) unless specifically indicated in Table 2 or Table 3 or as prescribed in Section 2318.3 of the *UBC* and Part 11 of the *ANSI/AF&PA National Design Specification for Wood Construction* (*NDS*®).

5.4.7. Other nail spacings for specific applications, such as prefabricated steel components or hangers, may be used. Nail spacings for these applications should follow what is specified and detailed in the proprietary connector catalogues for the specific gravities as defined in Table 2.

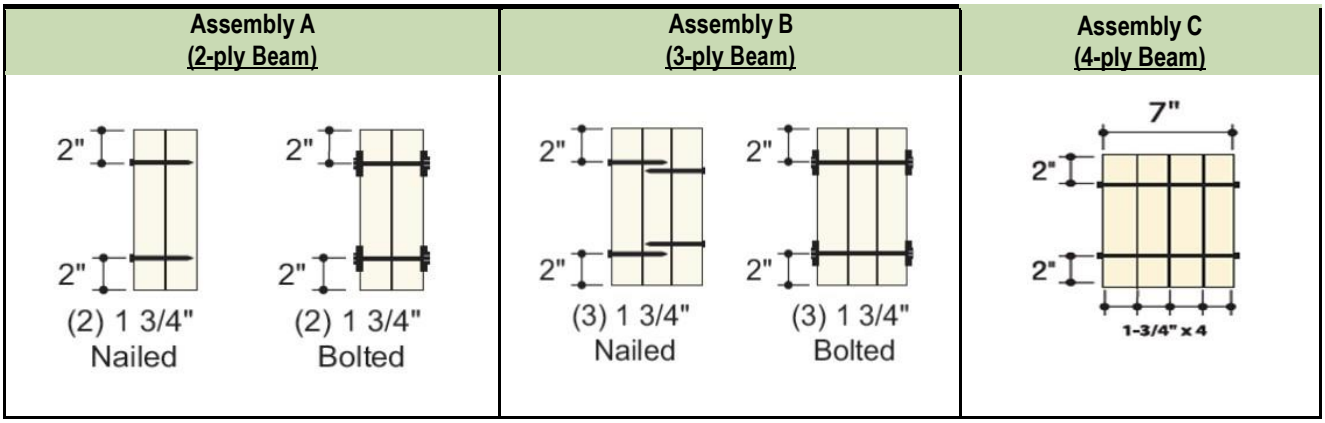
5.4.8. Allowable lateral loads for machine bolts installed perpendicular to the wide face of Master Plank® LVL (perpendicular to the glue lines), with loads applied parallel or perpendicular to the grain of the wood veneers, shall be as prescribed in the applicable code for sawn lumber with the minimum specific gravity at least equivalent to that defined in Table 2.

5.4.8.1. Equivalent Specific Gravities and Minimum Fastener Spacing for Design of Mechanical Connections[18]

Product	Fastener	Fastener Axis Orientation[19]	Load Direction	Equivalent Specific Gravity for Design Purposes	Minimum Spacing[20]
Master Plank® LVL	Nails & Screws	Y axis	Lateral	0.45	2" (51 mm) on-center[4]
		X axis	Lateral	0.44	
	Nails	X and Y axes	Withdrawal	0.48	
	Bolts	X and Y axes	Lateral	0.50	Per applicable code

Table 2: Equivalent Specific Gravities and Minimum Fastener Spacing for Design of Mechanical Connections

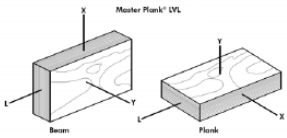
5.4.9. Connection requirements for multiple member side-loaded beams are defined in the following assembly details and have the maximum uniformly distributed load carrying capacity as defined in Table 3.



Figures 1-3: Connection Requirements for Multiple Member Side-Loaded Beams

[18] Connection design values are as provided in the *National Design Specification*® (*NDS*®) *for Wood Construction* and *Engineering Design in Wood*, *CAN/CSA-O86*, for sawn lumber having equivalent specific gravities as shown.

[19] Orientation nomenclature for structural composite lumber.



[20] Adjustment of the design stresses for duration of load shall be in accordance with the applicable code.

5.4.9.1. Connection Requirements for Multiple Member Side-Loaded Beams[21,22,23,24,25,26,27]

Assembly Detail (See Figures 1-3)	Maximum Uniformly Distributed Load (PLF) That Can Be Applied to Either Side Of the Beam				
	2 Rows of 16d (0.162x3½") Nails at 12" o.c.	3 Rows of 16d (0.162x3½") Nails at 12" o.c.	2 Rows of 16d (0.131x3½") Nails at 12" o.c. or	3 Rows of 16d (0.131x3½") Nails at 12" o.c. or	2 Rows of ½" Bolts at 12" o.c.[28,29]
A	510	760	350	530	1,015
B[30]	380	570	265	395	760
C					675

Table 3: Connection Requirements for Multiple Member Side-Loaded Beams

5.5. Fire-Resistance:

5.5.1. The provisions of *IBC* Section 721.6.3, dealing with the design of fire-resistant exposed wood members, apply to Master Plank® LVL.

5.5.2. The nominal char rate for Master Plank® LVL is 1.65 in/hr (0.70 mm/min).

6. Test and Engineering Substantiating Data:

6.1. VTT Building Technology, *Research Report*, dated February 9, 1995, signed by Tuija Vihavainen, Research Professor, and Mikael Fonselius, Research Scientist. The report includes test data regarding:

6.1.1. Sampling of the Master Plank® LVL to be used for material testing

6.1.2. Edgewise bending of Master Plank® LVL

6.1.3. Flatwise bending of Master Plank® LVL

6.1.4. Tension parallel to grain of Master Plank® LVL

6.1.5. Compression parallel to grain of Master Plank® LVL

6.1.6. Compression perpendicular to grain (beam) of Master Plank® LVL

6.1.7. Compression perpendicular to grain (plank) of Master Plank® LVL

6.1.8. Horizontal shear (beam) of Master Plank® LVL

6.1.9. Horizontal shear (plank) of Master Plank® LVL

6.2. Analysis and Report, dated September 16, 1998, signed and sealed by Kirk Grundahl, P.E.

6.3. Paper entitled, *Effect of size on the bending strength of laminated veneer lumber*, by Mikael Fonselius.

6.4. VTT Building Technology, *Research Report*, dated November 14, 1997, signed by Tuija Vihavainen, Research Professor and Mikael Fonselius, Research Scientist. This report includes test data regarding long-term creep of, and connections to, Master Plank® LVL.

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[21] Specific gravity for nailed or screwed connections is 0.45 and for bolted connections is 0.50.

[22] Multiply the appropriate table value by:

1. 1.5 for nails or bolts spaced at 8" o.c. per row
2. 2 for nails or bolts spaced at 6" o.c. per row
3. 3 for nails or bolts spaced at 4" o.c. per row
4. 0.5 for bolts spaced at 24" o.c. per row

[23] Determine the appropriate beam size required to support the load before determining the connection requirements.

[24] Screws can be used in place of bolts, provided the screw capacity is equal to or better than that of a ½" diameter bolt. Refer to the screw manufacturer's literature.

[25] Tabulated values assume adequate end distance, edge distance and spacing per Chapter 11 of the 2005 edition of the *National Design Specification® for Wood Construction* (*NDS®*).

[26] Tabulated values are for normal load duration. Values may be increased by 15 percent for snow load applications and by 25 percent for non-snow load roof applications as applicable.

[27] For beams greater than 7" wide, consult a registered design professional for the attachment requirements.

[28] A standard cut steel washer of minimum 0.118" thickness, with a minimum outside dimension of 1-⅜", is required between the wood and bolt head and nut.

[29] Bolted connections assume full diameter bolts with bending yield strength (Fyb) of 45,000 psi.

[30] Nailing is required from both sides for 3-ply beams.

6.5. Research Report entitled, *The Creep Properties of Kerto-Laminated-Veneer-Lumber,* prepared by Tomi Toratti, dated 1988, containing results of long-term creep testing of the Master Plank® LVL.

6.6. Letter dated March 27, 1999, by Kirk Grundahl, P.E. of Qualtim Inc., containing results of nail-split testing performed by Qualtim on March 17, 1999.

6.7. Letter dated October 22, 2001, signed by Antti Jarvi and Mikael Fonselius of VTT, and Tero Nokelainen of Finnforest, containing an analysis resulting in revisions to the tension parallel to grain design value and the modulus of elasticity for plank applications.

6.8. Letter dated December 7, 2003, from Kirk Grundahl, P.E. of Qualtim Inc., containing an analysis resulting in connector, MOE and shear values.

6.9. VTT Building Technology, *Inspection Report*, dated March 4, 2003, signed by Liisa Rautiainen, Assessment Manager and Mikael Fonselius, Senior Research Scientist, containing results of density, MOR, MOE and tension testing.

6.10. VTT Building Technology, *Research Report*, dated July 24, 2001, signed by Heikki Kukko, Research Professor, and Ari Kevarinmaki, Senior Research Scientist, containing lateral load testing of nails for Master Plank® LVL.

6.11. VTT Building Technology, *Inspection Report*, dated March 4, 2003, signed by Liisa Rautiainen, Assessment Manager and Mikael Fonselius, Senior Research Scientist, containing results of shear testing on structural-size Master Plank® LVL.

6.12. VTT Building Technology, *Research Report*, dated July 24, 2001, signed by Matti Kokkala, Research Professor, and Ari Kevarinmaki, Senior Research Scientist, containing lateral load testing of bolts for Master Plank® LVL.

6.13. *Quality Control Manual for Master Plank*, signed by representatives of Finnforest Oy and the third-party inspection agency, VTT Building Technology, dated January 1, 2003.

6.14. NER-555 ICC Evaluation Service, Inc. *Legacy Report for Master Plank* reissued April 1, 2004.

6.15. Some information contained herein is the result of testing and/or data analysis by other sources, which DrJ relies on to be accurate as it undertakes its engineering analysis.

6.15.1. DrJ does not assume responsibility for the accuracy of data provided by testing facilities, but relies on each testing agency's accuracy and accepted engineering procedures, experience, and good technical judgment.

6.16. Where appropriate, DrJ relies on the derivation of design values, which have been codified into law through the codes and standards (e.g., *IRC*, *WFCM*, *IBC*, *SDPWS*, etc.), to undertake the review of test data that is comparative or shows equivalency to an intended end-use application.

6.16.1. DrJ does not assume responsibility for the accuracy of any code-adopted design values but relies upon their accuracy for engineering evaluation.

6.16.2. DrJ also relies on the fact that manufacturers of code-adopted products stand behind the legally established design values that have been created by the associations that publish code-defined design values for a given commodity product.

6.16.3. DrJ evaluates all equivalency testing and related analysis using this code-defined engineering foundation.

7. Conditions of Use:

7.1. Master Plank® LVL shall be installed in accordance with the applicable code, the approved construction documents, this TER and the manufacturer's installation instructions. If this TER and the manufacturer' instructions are not in agreement, this TER supersedes and should be followed.

7.2. The manufacturer's published installation instructions shall be available at the jobsite at all times during installation.

7.3. Master Plank® LVL complies with or is a suitable alternative to sawn lumber as allowed in the *2003*, *2006* and *2009 International Building Code®* (*IBC*) and *2003*, *2006* and *2009 International Residential Code®* (*IRC*) and the *2005 National Building Code of Canada* (*NBC*), subject to the following conditions:

7.3.1. Design calculations and details shall be furnished to the code official verifying that the material is used in compliance with this TER. The calculations must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

7.3.2. Master Plank® LVL shall be fabricated in the Finnforest Oy facilities, located in Finland, with quality control inspections by VTT Building Technology (AA-607).

7.3.3. The design values shall not exceed those set forth in this report and shall be adjusted with the applicable factors specified by the *2003*, *2006* and *2009 International Building Code®* (*IBC*), the *2003*, *2006* and *2009 International Residential Code®* (*IRC*) and the *2005 National Building Code of Canada* (*NBC*).

7.3.4. The service conditions for Master Plank® LVL are dry conditions of use. For dry conditions of use, the equilibrium moisture content of sawn lumber must be less than 16 percent.

7.3.5. The service conditions for Master Plank® LVL with fire-retardant or preservative chemical treatments are outside the scope of this report.

7.3.6. Fastener design values shall be as specified in Table 2 of this report.

7.3.7. Cutting and notching of Master Plank® LVL is beyond the scope of this report.

7.3.8. Minimum bearing length and anchorage of Master Plank® LVL shall meet the requirements of Chapter 23 of the 2003, 2006 and 2009 *International Building Code®* (*IBC*) or Division B, Article 9.23 of the 2005 *National Building Code of Canada* (*NBC*), as applicable, for sawn lumber.

7.4. Material Safety Data Sheet for Master Plank® LVL:

7.4.1. Product Identification and Company Information

Product Name: **Laminated Veneer Lumber**	Brand Name(s): **Master Plank® LVL**
Imported and Distributed in the USA by: **METSÄ WOOD** **800 Military Street, Suite 200** **Port Huron, MI 48060**	Emergency Telephone Number: **(800) 622 – 5850**
Manufacturer's Name: **Finnforest Oy** **Lohja, Finland** **Punkaharju, Finland**	Additional Information: **(800) 622 – 5850** www.metsagroup.com

7.4.2. Hazardous Ingredients/Identity Information

Hazardous Components:	**OSHA**	**ACGIH**	Other Limits Recommended: **NIOSH**	**%**
Wood	PEL-TWA 15 mg/m^3 Total Dust PEL-TWA 5 mg/m^3 Respirable Fraction	TLV-TWA 5 mg/m^3 TLV-STEL 10 mg/m^3	REL 1 mg/m3 Total Dust	90 – 98%
Formaldehyde	PEL-TWA 0.75 ppm PEL-STEL 2 ppm	TLV – Ceiling 0.3 ppm	REL 0.016 ppm REL – Ceiling ppm 15 minute exposure limit	< 1%

7.4.3. Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_2O = 1)	0.44 – 0.51
Vapor Pressure (mm Hg)	N/A	Melting Point:	N/A
Vapor Density (AIR = 1)	N/A	Evaporation Rate (Butyl Acetate = 1)	N/A
Solubility in Water: Insoluble			
Appearance and Odor: Light tan wood, slight aromatic odor			

7.4.4. Fire and Explosion Hazard Data

Flash Point (Method Used)	**Flammable Limits**	
N/A	LEL: 40 g/m^3 Airborne dust	UEL: N/A
Auto Ignition Temperature: Varies; 400 – 500 degrees F (204 – 260 degrees C)		
Extinguishing Media: Water, Carbon Dioxide, Sand		
Special Fire Fighting Procedures Use water to wet wood dust to reduce likelihood of airborne dust exploding and to avoid partially burned dust dispersing into the air. Remove burned or wet dust and other wood materials to an open area after fire is extinguished and avoid breathing dust and other burned wood products.		
Unusual Fire and Explosion Hazards Airborne wood dust is an explosion hazard in the presence of an ignition source and depending on the concentration of dust, moisture content and size of the particles.		

7.4.5. Reactivity Data

Stability	Unstable:		**Conditions to Avoid:**
	Stable:	☑	Ignition sources: heat, sparks, open flame
Incompatibility *(Materials to Avoid)* Oxidizing agents			
Hazardous Decomposition or Byproducts: Products of wood combustion: Potentially toxic fumes, aldehydes, carbon monoxide, hydrogen cyanide, organic acids			
Hazardous Polymerization	May Occur		**Conditions to Avoid:**
	Will Not Occur	☑	N/A

7.4.6. Health Hazard Data

Route(s) of Entry:			
Inhalation? Dust: Yes	Skin? Dust: Yes	Ingestion? Unlikely in normal use	Eyes? Dust: Yes
Signs and Symptoms of Exposure:			
Inhalation: Coughing, irritation, nasal dryness	Skin: Dust may cause skin irritation.	Ingestion: N/A	Eyes: Dust may cause eye irritation

Health Hazards *(Acute and Chronic)*			
Inhalation: Wood dust may cause: Respiratory irritation, coughing, sneezing, nasal dryness and sinusitis. Repeated or prolonged exposure to wood dust can result in respiratory sensitization. Prolonged exposure to wood dust has been associated with some forms of nasal cancer.	Skin: Formaldehyde and wood dust may cause Allergic contact dermatitis in sensitized individuals	Ingestion: N/A	Eyes: Wood dust may cause eye irritation
Medical Conditions Generally Aggravated by Exposure:			
Inhalation: Exposure to wood dust may aggravate pre-existing respiratory conditions Skin Contact: Exposure to wood dust or formaldehyde may aggravate allergies in some sensitive individuals.			
Emergency and First Aid Procedures:			
Inhalation: Remove to fresh air. If persistent irritation, severe coughing, or breathing difficulty occurs, get medical attention.	Skin: Wash with soap and water. If irritation persists get medical attention.	Ingestion: N/A	Eyes: Flush with plenty of water to remove dust. If irritation persists get medical attention.
Carcinogenicity:			
NTP? Yes	IARC Monographs? Yes	OSHA Regulated? Yes	
Additional Carcinogenicity Information: Wood Dust			
The NTP (National Toxicology Program) *Report on Carcinogens*, Eleventh Edition, Wood Dust, states: "Wood dust is *known to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in humans. An association between wood dust exposure and cancer of the nasal cavity has been observed in many case reports, cohort studies, and case-control studies that specifically addressed nasal cancer. Strong and consistent associations with cancer of the nasal cavities and paranasal sinuses were observed both in studies of people whose occupations are associated with wood dust exposure and in studies that directly estimated wood dust exposure." The WHO IARC Classifies Wood Dust as Group I, Carcinogenic to Humans based on their evaluation of increased risk of nasal cancer due to exposure to wood dust.			
Additional Carcinogenicity Information: Formaldehyde			
The NTP (National Toxicology Program) *Report on Carcinogens*, Eleventh Edition – Formaldehyde states: "Formaldehyde (gas) is *reasonably anticipated to be a human carcinogen* based on limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals (IARC 1982, 1987, 1995).			
Excess incidences of nasopharyngeal cancers in humans were observed in two of six cohort studies, three of four case-control studies, and in meta-analyses." The WHO IARC Classifies Formaldehyde as Group I, Carcinogenic to Humans based on studies that provided evidence that formaldehyde causes nasopharyngeal cancer in humans.			

7.4.7. Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled: Not applicable for products in purchased form. Vacuum or sweep wood dust for recovery or disposal. Avoid creating airborne dust conditions, if necessary use water to wet wood dust.
Waste Disposal Method: Incinerate or landfill in compliance with all local, state, and federal regulations
Precautions to Be taken in Handling and Storing: No special handling precautions are required for products in purchased form. Store in a dry, well ventilated place away from heat, flame and ignition sources. Avoid creating airborne dust conditions
Other Precautions: N/A

7.4.8. Control Measures

Ventilation:			
Local Exhaust: Yes	**Mechanical:** No	**Special:** Spark Suppression	**Other:** No
Respiratory Protection *(Specify Type)* Not applicable for products in purchased form. Use a NIOSH approved dust respirator when allowable dust limits may be exceeded			
Protective Gloves: Fabric or leather work gloves are recommended.			
Eye Protection: ANSI approved eye protection is recommended when sawing, sanding or machining wood products.			
Other Protective Clothing or Equipment: Protective equipment, such as gloves and outer garments, may be needed to avoid skin contact.			
Work/Hygienic Practices: Keep work areas clean and avoid accumulation of dust. Avoid direct contact with skin when handling wood products.			

8. Identification:

8.1. Master Plank® LVL is identified with a stamp noting the product manufacturer (Finnforest Oy), product distributor (Finnforest-USA, Engineered Wood Division), product name, grade, and quality control agency VTT Building Technology (AA-607). In addition to other information to confirm code compliance, the number of this TER is provided for field identification.

8.2. Additional technical information can be found at metsagroup.com.

Figures 4-5: Stamps Identifying Product

9. Review Schedule:

9.1. This TER is subject to periodic review and revision. For the most recent version of this TER, visit drjengineering.org.

9.2. For information on the current status of this TER, contact DrJ Engineering.

Scope of Responsibility / Work, Operations Policies, and Legal Responsibilities

- Mission and Scope of Responsibility
- Product Evaluation Operations Concepts and Policies
- Legal Aspects of Product Approval

Appendix A

2009 IBC

104.11 Alternative materials, design and methods of construction and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been *approved*. An alternative material, design or method of construction shall be *approved* where the *building official* finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, *fire resistance*, durability and safety.

104.11.1 Research reports. Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from *approved* sources.

104.11.2 Tests. Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the *building official* shall have the authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the *building official* shall approve the testing procedures. Tests shall be performed by an *approved agency*. Reports of such tests shall be retained by the *building official* for the period required for retention of public records.

2301.2 General design requirements. The design of structural elements or systems, constructed partially or wholly of wood or wood-based products, shall be in accordance with one of the following methods:

1. *Allowable stress design* in accordance with Sections 2304, 2305 and 2306.
2. *Load and resistance factor design* in accordance with Sections 2304, 2305 and 2307.
3. *Conventional light-frame construction* in accordance with Sections 2304 and 2308.

    Exception: Buildings designed in accordance with the provisions of the AF&PA WFCM shall be deemed to meet the requirements of the provisions of Section 2308.

4. The design and construction of log structures shall be in accordance with the provisions of ICC 400.

2303.1.9 Structural composite lumber. Structural capacities for structural composite lumber shall be established and monitored in accordance with ASTM D 5456.

721.6.3 Design of fire-resistant exposed wood members. The *fire-resistance rating*, in minutes, of timber beams and columns with a minimum nominal dimension of 6 inches (152 mm) is equal to:

Beams: $2.54Zb\ [4 - 2(b/d)]$ for beams which may be exposed to fire on four sides.

(Equation 7-18)

$2.54Zb\ [4 - (b/d)]$ for beams which may be exposed to fire on three sides.

(Equation 7-19)

Columns: $2.54Zd\ [3 - (d/b)]$ for columns which may be exposed to fire on four sides

(Equation 7-20)

$2.54Zd\ [3 - (d/2b)]$ for columns which may be exposed to fire on three sides.

(Equation 7-21)

where:

b = The breadth (width) of a beam or larger side of a column before exposure to fire (inches).

d = The depth of a beam or smaller side of a column before exposure to fire (inches).

Z = Load factor, based on Figure 721.6.3(1).

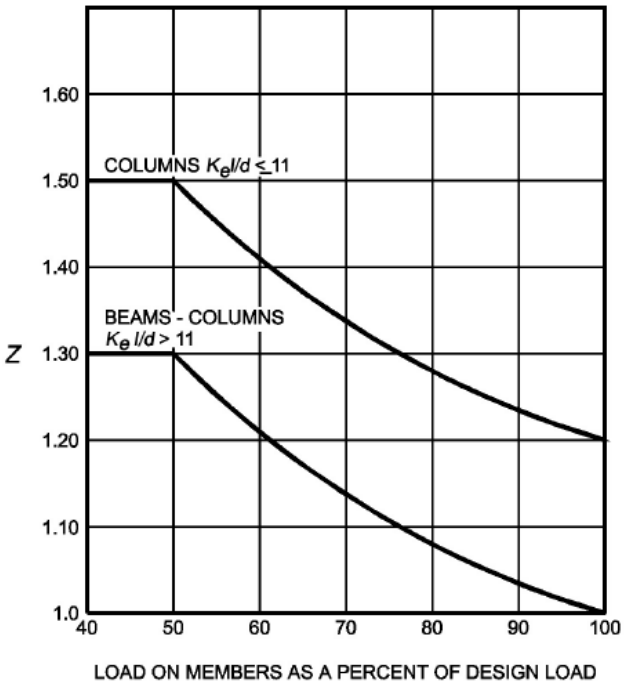


FIGURE 721.6.3(1)
LOAD FIGURE

K_e = The effective length factor as noted in Figure 721.6.3(2).

l = The unsupported length of columns (inches).

721.6.3.1 Equation 7-21. Equation 7-21 applies only where the unexposed face represents the smaller side of the column. If a column is recessed into a wall, its full dimension shall be used for the purpose of these calculations.

721.6.3.2 Allowable loads. Allowable loads on beams and columns are determined using design values given in AF&PA NDS.

721.6.3.3 Fastener protection. Where minimum 1-hour *fire resistance* is required, connectors and fasteners shall be protected from fire exposure by $1^1/_2$ inches (38 mm) of wood, or other *approved* covering or coating for a 1-hour rating. Typical details for commonly used fasteners and connectors are shown in AITC Technical Note 7.

721.6.3.4 Minimum size. Wood members are limited to dimensions of 6 inches (152 mm) nominal or greater. Glued-laminated timber beams utilize standard laminating combinations except that a core lamination is removed. The tension zone is moved inward and the equivalent of an extra nominal 2-inch-thick (51 mm) outer tension lamination is added.

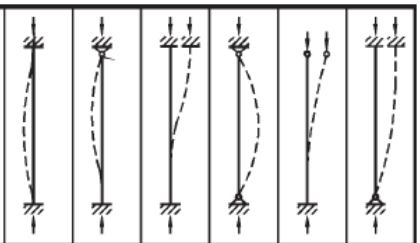
BUCKLING MODES						
THEORETICAL K_e VALUE	0.5	0.7	1.0	1.0	2.0	2.0
RECOMMENDED DESIGN K_e WHEN IDEAL CONDITIONS APPROXIMATED	0.65	0.80	1.2	1.0	2.10	2.4
END CONDITION CODE		ROTATION FIXED, TRANSLATION FIXED ROTATION FREE, TRANSLATION FIXED ROTATION FIXED, TRANSLATION FREE ROTATION FREE, TRANSLATION FREE				

FIGURE 721.6.3(2)
EFFECTIVE LENGTH FACTORS

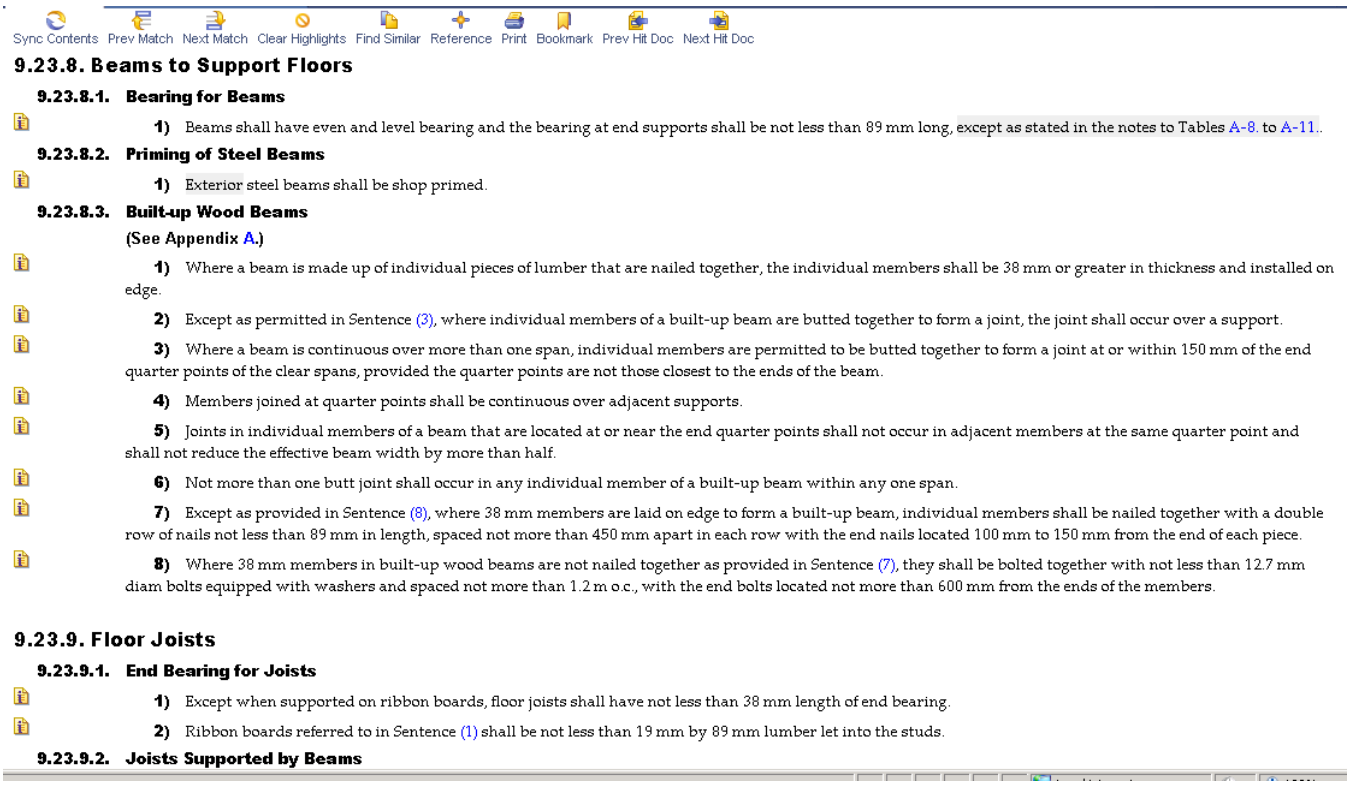
2009 IRC

R301.1.3 Engineered design. When a building of otherwise conventional construction contains structural elements exceeding the limits of Section R301 or otherwise not conforming to this code, these elements shall be designed in accordance with accepted engineering practice. The extent of such design need only demonstrate compliance of nonconventional elements with other applicable provisions and shall be compatible with the performance of the conventional framed system. Engineered design in accordance with the *International Building Code* is permitted for all buildings and structures, and parts thereof, included in the scope of this code.

1997 SBC

103.7 Alternate materials and methods. The provisions of the technical codes are not intended to prevent the use of any material or method of construction not specifically prescribed by them, provided any such alternate has been reviewed by the building official. The building official shall approve any such alternate, provided the building official finds that the alternate for the purpose intended is at least the equivalent of that prescribed in the technical codes, in quality, strength, effectiveness, fire resistance, durability and safety. The building official shall require that sufficient evidence or proof be submitted to substantiate any claim made regarding the alternate.

2005 CNBC



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9.23.8. Beams to Support Floors

9.23.8.1. Bearing for Beams

1) Beams shall have even and level bearing and the bearing at end supports shall be not less than 89 mm long, except as stated in the notes to Tables A-8. to A-11..

9.23.8.2. Priming of Steel Beams

1) Exterior steel beams shall be shop primed.

9.23.8.3. Built-up Wood Beams

(See Appendix A.)

1) Where a beam is made up of individual pieces of lumber that are nailed together, the individual members shall be 38 mm or greater in thickness and installed on edge.

2) Except as permitted in Sentence (3), where individual members of a built-up beam are butted together to form a joint, the joint shall occur over a support.

3) Where a beam is continuous over more than one span, individual members are permitted to be butted together to form a joint at or within 150 mm of the end quarter points of the clear spans, provided the quarter points are not those closest to the ends of the beam.

4) Members joined at quarter points shall be continuous over adjacent supports.

5) Joints in individual members of a beam that are located at or near the end quarter points shall not occur in adjacent members at the same quarter point and shall not reduce the effective beam width by more than half.

6) Not more than one butt joint shall occur in any individual member of a built-up beam within any one span.

7) Except as provided in Sentence (8), where 38 mm members are laid on edge to form a built-up beam, individual members shall be nailed together with a double row of nails not less than 89 mm in length, spaced not more than 450 mm apart in each row with the end nails located 100 mm to 150 mm from the end of each piece.

8) Where 38 mm members in built-up wood beams are not nailed together as provided in Sentence (7), they shall be bolted together with not less than 12.7 mm diam bolts equipped with washers and spaced not more than 1.2 m o.c., with the end bolts located not more than 600 mm from the ends of the members.

9.23.9. Floor Joists

9.23.9.1. End Bearing for Joists

1) Except when supported on ribbon boards, floor joists shall have not less than 38 mm length of end bearing.

2) Ribbon boards referred to in Sentence (1) shall be not less than 19 mm by 89 mm lumber let into the studs.

9.23.9.2. Joists Supported by Beams

1996 BNBC (BOCA)

106.4 Alternative materials and equipment: The provisions of this code are not intended to prevent the installation of any material or to prohibit any method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material or method of construction shall be approved when the code official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

2303.4 Combustibility: Wood used as structural elements or portions thereof shall be limited to combustible structural elements as required by this code.

Exceptions

1. Fireretardant-treated wood as permitted by Table 602, Note d, and which complies with Section 2310.0.
2. As specifically permitted by Section 602.4.1.

SECTION 2305.0 WOOD FRAME CONSTRUCTION

2305.1 Design and construction: Exterior walls, interior partitions, floors and roofs of wood construction shall be designed and constructed in accordance with this section, Section 2303.0 and Sections 2307.0 through 2312.0.

2305.2 Fastening: The quantity and size of fasteners connecting wood frame members together and sheathing materials to wood frame members shall not be less than that specified in Table 2305.2.

2305.3 Cutting and notching: A structural member shall not be cut, notched or pierced in excess of the limitations specified herein, unless a structural analysis is performed demonstrating that the load-carrying capacity of the member has not been reduced below the capacity required for the member in accordance with Chapter 16.

***BNBC* Section 2305 Continued on Next Page**

1997 UBC

104.2.8 Alternate materials, alternate design and methods of construction. The provisions of this code are not intended to prevent the use of any material, alternate design or method of construction not specifically prescribed by this code, provided any alternate has been approved and its use authorized by the building official.

The building official may approve any such alternate, provided the building official finds that the proposed design is satisfactory and complies with the provisions of this code and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in suitability, strength, effectiveness, fire resistance, durability, safety and sanitation.

The building official shall require that sufficient evidence or proof be submitted to substantiate any claims that may be made regarding its use. The details of any action granting approval of an alternate shall be recorded and entered in the files of the code enforcement agency.

2318.3 Nails and Spikes.

2318.3.1 Allowable lateral loads. Allowable lateral design values, *Z*, for common wire and box nails driven perpendicular to the grain of the wood, when used to fasten wood members together, shall be as set forth in Tables 23-III-C-1 and 23-III-C-2.

A wire nail driven parallel to the grain of the wood shall not be subjected to more than two thirds of the lateral load allowed when driven perpendicular to the grain. Toenails shall not be subjected to more than five sixths of the lateral load allowed for nails driven perpendicular to the grain.

2318.3.2 Allowable withdrawal loads. Allowable withdrawal design values, *W*, for wire nails driven perpendicular to the grain of the wood shall be as set forth in Table 23-III-D.

Nails driven parallel to the grain of the wood shall not be allowed for resisting withdrawal forces.

2318.3.3 Spacing and penetration. Common wire nails shall have penetration into the piece receiving the point as set forth in Tables 23-III-C-1 and 23-III-C-2. Nails or spikes for which the gages or lengths are not set forth in Tables 23-III-C-1 and 23-III-C-2 shall have a required penetration of not less than 11 diameters, and allowable loads may be interpolated. Allowable loads shall not be increased when the penetration of nails into the member holding the point is larger than required by this section.

2318.4 Joist Hangers and Framing Anchors. Connections depending on joist hangers or framing anchors, ties and other mechanical fastenings not otherwise covered may be used where approved.

Table 2305.2
FASTENING SCHEDULE

Building element	Nail or staple size and type	Number and location
1. Floor construction		
Built-up girders and beams	20d common	32″ o.c. direct
Bridging to joists	8d common	2 each direct end
Floor joists to studs (No ceiling joists)	10d common	5 direct or
	10d common	3 direct
Floor joists to studs (With ceiling joists)	10d common	2 direct
Floor joists to sill or girder	8d common	3 toe nail
Ledger strip	16d common	3 each direct joist
1″ subflooring (6″ or less)	8d common	2 each direct joist
1″ subflooring (8″ or more)	8d common	3 each direct joist
2″ subflooring	16d common	2 each direct joist
Particleboard underlayment (1/4″-3/4″)	6d annular threaded	6″ o.c. direct edges and 12″ o.c. intermediate
Wood structural panel subflooring (1/2″ or less)	6d common *or* 6d annular or spiral thread	6″ o.c. direct edges and 12″ o.c. intermediate
(19/32″ - 3/4″)	8d common *or* 6d annular or spiral thread	6″ o.c. direct edges and 12″ o.c. intermediate
(7/8″ - 1 1/8″)	10d common *or* 8d ring shank *or* 8d annular or spiral thread	6″ o.c. direct edges and 6″ o.c. intermediate
(1/2″ or less)	16 gage galvanized wire staples	4″ o.c. edges and 7″ o.c. intermediate
(19/32″, 5/8″)	3/8″minimum crown, 1 5/8″ length	2 1/2″ o.c. edges and 4″ o.c. intermediate
2. Wall construction		
Stud to sole plate	8d common	4 toe nail or
	16d common	2 direct nail
Stud to cap plate	16d common	2 toe nail or 2 direct nail
Double studs	10d common	12″ o.c. direct
Corner studs	16d common	24″ o.c. direct
Sole plate to joist or blocking	16d common	16″ o.c.
Interior-braced wall sole plate to parallel joist	16d common	12″ o.c.
Double cap plate	10d common	16″ o.c. direct nail
Cap plate laps	10d common	2 direct nail
Ribbon strip, 6″ or less	10d common	2 each direct bearing
Ribbon strip, 6″ or more	10d common	3 each direct bearing
Diagonal brace (to stud and plate)	8d common	2 each direct bearing
Interior-braced wall top plate to joist or blocking	10d common	12″ o.c.
Tail beams to headers (where nailing is permitted)	20d common	1 each end 4 sq. ft. floor area
Header beams to trimmers (where nailing is permitted)	20d common	1 each end 8 sq. ft. floor area
Continuous header to stud	8d common	4 toe nail
Continuous header, two pieces	16d common	16″ o.c. direct
3. Roof and ceiling construction		
Ceiling joists to plate	16d common	3 toe nail
Ceiling joists (laps over partition)	10d common	3 direct nail
Ceiling joists (parallel to rafter)	10d common	3 direct nail
Collar beam	10d common	3 direct
Roof rafter to plate	8d common	3 toe nail
Roof rafter to ridge	16d common	2 toe nail or direct nail
Jack rafter to hip	10d common	3 toe nail or
	16d common	2 direct nail
1″ roof decking (6″ or less in width)	8d common	2 each direct rafter
1″ roof decking (over 6″ in width)	8d common	3 each direct rafter
4. Wall and roof sheathing		
1″ wall sheathing (8″ or less in width)	8d common	2 each direct stud
1″ wall sheathing (over 8″ in width)	8d common	3 each direct stud
Diagonal wall sheathing (seismic bracing)	See Table 2306.4.5	
1/2″ fiberboard sheathing	1 1/2″ galvanized roofing nail *or* 6d common nail *or* 16 gage staple, 1 1/8″ long with minimum crown of 7/16″	3″ o.c. exterior edge, 6″ o.c. intermediate
25/32″ fiberboard sheathing	1 3/4″ galvanized roofing nail *or* 8d common nail *or* 16 gage staple, 1 1/2″ long with minimum crown of 7/16″	3″ o.c. exterior edge, 6″ o.c. intermediate
Gypsum sheathing	12 gage 1 1/4″ large head, corrosion resistant	4″ o.c. on edge, 8″ o.c. intermediate

Table 2305.2 (cont'd.)
FASTENING SCHEDULE

Building element	Nail or staple size and type	Number and location
4. Wall and roof sheathing (cont'd.)		
Gypsum sheathing (seismic bracing)	11 gage 1¾″ long 7/16 inch head, diamond point, galvanized	4″ o.c. all bearing points
Particleboard wall sheathing		
(½″ or less)	6d common	6″ o.c. direct edges and 12″ o.c. intermediate
(⅝″ or less)	8d common	6″ o.c. direct edges and 12″ o.c. intermediate
Wood structural panel roof and wall sheathing		
(½″ or less)	6d common (walls); 8d common (roofs)[b,c]	6″ o.c. direct edges and 12″ o.c. intermediate
(19/32″ to 1″)	8d common[b,c]	6″ o.c. direct edges and 12″ o.c. intermediate[d]
(1″ or greater)	10d common[b,c]	6″ o.c. direct edges and 12″ o.c. intermediate
(½″ or less)	16 gage galvanized wire staples, ⅜″ minimum crown; length of 1″ plus panel thickness	4″ o.c. edges and 8″ o.c. intermediate
(19/32″, ⅝″)	Same as immediately above	2½″ o.c. edges and 5″ o.c. intermediate
Shingles, wood[a]	No. 14 B&S Gage corrosion resistant	2 each bearing
Weatherboarding	8d corrosion resistant	2 each bearing

Note a. Single nails shall penetrate not less than ¾ inch into nailing strips, sheathing or supporting construction except as otherwise provided for in Section 1507.0.
Note b. For regions having a basic wind speed of 90 miles per hour or greater where the mean roof height is less than 25 feet and for regions having basic wind speed of 80 miles per hour or less, nails which attach wood structural panel roof sheathing to gable end wall framing shall be spaced 6 inches on center. Where basic wind speed is greater than 80 miles per hour, nails which attach panel roof sheathing to intermediate supports shall be spaced 6 inches on center of a minimum of a 48-inch distance from ridges, eaves and gable end walls; and 4 inches on center to gable end wall framing.
Note c. For regions having a basic wind speed of 90 miles per hour or grater, 8d deformed shank nails shall be utilized to attach wood structural panel roof sheathing to framing within a minimum 48-inch distance from gable end walls provided the mean roof height is between 25 feet and 35 feet. For roof heights greater than 35 feet in a 90 miles per hour or greater wind region, attachment of wood structural panel roof sheathing shall be designed for the wind loads in Section 1609.0.
Note d. Nails shall be spaced 6 inches on center direct to panel edges and 6 inches on center to intermediate supports where panel spans are 48 inches on center or greater.
Note e. 1 inch = 25.4 mm, 1 foot = 304.8 mm.

2305.3.1 Solid lumber joists: Notches in solid lumber joists, rafters and beams shall not exceed one-sixth of the depth of the member, shall not be longer than one-third of the depth of the member and shall not be located in the middle one-third of the span. Notch depth at the ends of the member shall not exceed one-fourth of the depth of the member. Holes bored or cut into solid lumber joists, rafters or beams shall not be closer than 2 inches (51 mm) to the top or bottom of the joist, or to any other hole located in the member. Where the members are notched, the hole shall not be closer than 2 inches (51 mm) to the notch. The diameter of the hole in joists shall not exceed one-third of the depth of the member.

Exceptions

1. A notch over the support is permitted to extend the full width of the support.
2. Notches on cantilevered portions of the member are permitted to extend the full length of the cantilever if the strength and deflection of the cantilever is calculated based on the reduced member section.
3. The tension side of beams, joists and rafters, which are 4 inches or greater in nominal thickness, shall not be notched, except at ends of members.

2305.3.2 Engineered wood products: Cuts, notches and holes bored in trusses, laminated veneer lumber, glue-laminated members, or I-joists shall be based on research and investigation in accordance with Section 1703.2.

2305.3.3 Reinforcement: Where the stud is cut or bored in excess of one-third of its depth, the stud shall be reinforced to be equal in loadbearing capacity to a stud that is notched not more than one-third of its depth.

2305.4 Loadbearing walls: Posts and studs in loadbearing walls and partitions shall be designed as columns, with due allowance for lateral support furnished by sheathing, intermediate bracing, horizontal bridging, wall coverings and the floor and roof assemblies. The walls shall be fabricated in such a manner as to provide adequate support for the materials that enclose the building and to provide for transfer of all lateral *loads* to the foundation in accordance with Section 1710.4.

2305.4.1 Wall framing: Studs shall be placed with the wide dimension perpendicular to the wall. Not less than three studs shall be installed at each corner of an exterior wall.

Exception: At corners, a third stud is not required where wood spacers or backup cleats of ⅜-inch-thick wood structural panel, ⅜-inch Grade M-S and M-2 "Exterior Glue" particleboard, 1-inch-thick lumber or other approved devices which serve as an adequate backing for the attachment of facing materials are used. Where fireresistance ratings or shear *loads* apply, wood spacers, backup cleats or other devices shall not be installed unless specifically approved.

2305.4.2 Double top plates: Stud walls shall be capped with double top plates installed to provide overlapping corners and wall intersections. Top plate joints shall be offset not less than 48 inches (1219 mm).

Exception: Buildings or structures located in seismic map areas having a peak velocity-related acceleration (A_v) less than 0.05, in accordance with Section 1610.1, detached *one-* and *two-family dwellings* located in seismic map areas having an A_v less than 0.15, and agricultural storage buildings that are intended only for incidental human

occupancy are permitted to have a single top plate, provided that the plate is adequately tied at joints, corners and intersecting walls by at least the equivalent of galvanized steel that is 3 inches (76 mm) by 6 inches (152 mm) by 0.036 inches thick and nailed to each wall or segment of wall by three 8d nails or the equivalent, and the rafters, joists or trusses are centered over the studs with a tolerance of not more than 1 inch (25 mm).

2305.4.3 Bottom plates: Studs shall have full support by a plate or sill. The sill shall have not less than a 2-inch nominal thickness and a width at least equal to the width of the studs.

2305.4.4 Notching and boring: Notches in solid lumber studs shall not exceed 25 percent of the stud depth. Bored holes shall not exceed 40 percent of the stud depth and the edge of the hole shall not be closer than $\frac{5}{8}$ inches (15 mm) to the edge of the stud. Notches and holes shall not occur in the same cross-section.

Exception: Bored holes shall not exceed 60 percent of the stud depth where studs are doubled.

2305.5 Nonloadbearing walls: Studs in nonloadbearing walls and partitions shall not be spaced more than 48 inches (1219 mm) o.c., and are permitted to be erected with the long dimension parallel to the wall, unless otherwise approved as an integrated assembly by testing. A single top plate shall be prohibited except where such plate is installed in accordance with Section 2305.4.2.

2305.5.1 Notching and boring: Notches in studs shall not exceed 40 percent of the stud depth. Bored holes shall not exceed 60 percent of the stud depth and shall not be closer than $\frac{5}{8}$ inches (15 mm) to the edge. Notches and holes shall not occur in the same cross-section.

2305.6 Support and anchorage: Support and anchorage of members on girders, walls and beams shall conform to Sections 2305.6.1 through 2305.6.4.

2305.6.1 Support and anchorage on girders: All members framing into girders shall be anchored or tied to secure continuity. The ends of all wood beams that rest on girders shall bear not less than 4 inches (102 mm) or shall be supported in approved metal stirrups, hangers or on wood clips or ribbon strips. Beams framing from opposite sides shall either lap at least 6 inches (152 mm) and be bolted or spiked together or, where framed end-to-end, the beams shall be secured together by approved ties, straps, dogs, plates or sheathing.

2305.6.2 Support and anchorage on walls or beams: Except where supported on a 1×4 ribbon strip and nailed to the adjoining stud, joists shall bear on walls or beams of wood or steel not less than $1\frac{1}{2}$ inches (38 mm) or shall be supported by metal stirrups, hangers or a nominal 2-inch wood ledger strip. The minimum concrete or masonry support shall be 3 inches (76 mm). Joists framing over beams from opposite sides shall either lap at least 3 inches (76 mm) and be securely fastened together or, where framed end-to-end, the joists shall be secured together by approved ties, straps, dogs, plates or sheathing.

2305.6.3 Girder supports: Wall plate boxes of the self-releasing type, or approved hangers, shall be provided where beams and girders are supported by concrete or masonry. An air space of $\frac{1}{2}$ inch (13 mm) shall be provided at the top, end and sides of the member unless approved naturally durable or *preservative-treated* wood in accordance with Section 2311.0 is installed. Wood beams and girders supported by walls required to have a fireresistance rating of 2 hours or more shall have not less than 4 inches (102 mm) of solid concrete or solid masonry between their ends and the outside face of the wall and between adjacent beams.

2305.6.4 Fire cuts: Wood and other combustible floor, roof and other structural members framing into concrete or masonry walls shall be cut to a bevel of 3 inches (76 mm) in depth and shall project not more than 4 inches (102 mm) into the wall.

2305.7 Wind bracing: Structural members and connections that resist wind pressures shall be designed for the wind loads specified in Section 1609.0. In buildings more than one story in *height* and where necessary for strength in one-story buildings, the corner posts shall be the equivalent of not less than two pieces of 2-inch by 4-inch studs. Bracing elements shall be continuous diagonal wood members which are let into the wall studs, diagonal wood board sheathing, wood structural panels, particleboard or other sheathing specified in Section 2305.13. Bracing sheathing shall be applied with all edges supported. Other sheathing materials shall be permitted when tested in accordance with ASTM E72 listed in Chapter 35.

The lateral *load* resistance shall be established by the lesser of: the values determined by dividing the maximum load reported in the test by 2.5; or the load at which the deflection reported in the test exceeds $h/480$, where h is the height of the test assembly.

2305.8 Seismic bracing: Where structural analysis of the seismic force-resisting system is not provided, buildings shall meet the provisions of this section and shall have roof and exterior wall *dead loads* less than or equal to 15 psf (718 Pa) and floor *dead loads* less than or equal to 10 psf (479 Pa).

Exceptions

1. Detached *one-* and *two-family dwellings* located in seismic map areas having an effective peak velocity-related acceleration (A_v) value less than 0.15.
2. The exterior wall weight limitation shall not apply to masonry veneer attached to one-story Seismic Performance Category B buildings.

2305.8.1 Wall bracing required: All exterior walls and required interior-braced walls shall be braced by one of the types of sheathing prescribed in Table 2305.8.1 for each 25 lineal feet (7620 mm) of exterior wall or required interior-braced wall line. The required length of sheathing shall be distributed along the length of the braced wall with sheathing placed at each end of the exterior wall or interior-braced wall. A minimum 4-foot (1219 mm) length of sheathing shall be located at the end of each braced wall. The construction of braced walls shall comply with the requirements of Section 2305.9.

2305.8.2 Double-sheathed walls: Where braced walls are sheathed on both sides with identical sheathing, the required length of sheathing in Table 2305.8.1 is permitted to be taken as one-half the tabular length. Where different sheathing

Table 2305.8.1
MINIMUM SEISMIC WALL BRACING PER 25 LINEAL FEET OF INTERIOR AND EXTERIOR WALL LENGTH[a, g]

Story location	Sheathing[b]	$0.05 \le A_v < 0.10$	$0.10 \le A_v < 0.15$	$0.15 \le A_v < 0.20$	$0.20 \le A_v < 0.30$	$0.30 \le A_v < 0.40$
Top or only story	GP	5′ 0″[c]	7′ 0″	9′ 0″	14′ 0″	18′ 0″[e]
	W/SP	4′ 0″	4′ 0″	5′ 0″	8′ 0″	10′ 0″[e]
First of two stories or second of three stories	GP	9′ 0″[d]	13′ 0″	17′ 0″[e]	25′ 0″[e]	32′ 0″[e]
	W/SP	5′ 0″	7′ 0″	10′ 0″[e]	14′ 0″[e]	18′ 0″[e]
First of three stories	GP	13′ 0″	Note f			
	W/SP	7′ 0″				

Note a. Interpolation of the tabular values is permitted where the length of wall between exterior walls or interior-braced walls is less than 25 feet.
Note b. GP = Gypsum or particleboard sheathing; W/SP = Diagonal wood boards or wood structural panels.
Note c. Fiberboard, installed in accordance with Table 2309.8, is permitted as bracing at 10 feet per 25 feet of wall length.
Note d. Fiberboard, installed in accordance with Table 2309.8, is permitted as bracing at 18 feet per 25 feet of wall length.
Note e. Applies to detached one- and two-family dwellings only.
Note f. Analysis of the seismic force-resisting system required.
Note g. 1 foot = 304.8 mm.

materials are used on either side of a wall, the required length of sheathing in Table 2305.8.1 is permitted to be taken as one-half of the tabular length for the material requiring the greater length. Double-sheathed walls shall have a minimum length of 4 feet (1219 mm).

Table 2305.8
WALL SPACING AND HEIGHT LIMITATIONS FOR WOOD FRAME CONSTRUCTION

Seismic Performance Category	Maximum distance between interior-braced walls (feet)[c]	Maximum stories (height) permitted[c]
A	See Section 1610.1, Exception #3	
B	35	3 (40 feet)
C	25	2 (30 feet)
D[a]	25	1 (20 feet)[b]
E	Engineering analysis required, see Section 2306.0	

Note a. Applies only to Seismic Hazard Exposure Group I; engineering analysis required for Seismic Hazard Exposure Group II.
Note b. Detached one- and two-family dwellings shall not exceed two stories or 30 feet in height.
Note c. 1 foot = 304.8 mm.

2305.8.3 Stud walls: Stud walls that are less than the full height of the story shall be braced as required for exterior walls or interior-braced walls and shall be considered an additional story.

2305.8.4 Sheathing installation: Sheathing shall be installed in accordance with the provisions of Table 2305.13 where acting as wall bracing. To be considered effective as bracing, the sheathing shall be at least 48 inches in width covering three 16-inch stud spaces or two 24-inch stud spaces and be fastened to the wall studs in accordance with Table 2305.2. Sheathing shall be fastened to the wall studs, sole plate and top plate in accordance with Table 2305.2. All vertical joints of panel sheathing shall occur over studs and all horizontal joints shall occur over blocking at least equal in size to the studs. All framing in connection with sheathing used for bracing shall not be less than 2 inches nominal in thickness.

2305.9 Braced wall: All exterior walls and interior-braced walls required by Table 2305.8, shall be constructed to transfer forces from roofs and floors to braced walls and from the braced walls in upper stories to the braced walls in the story below. Braced wall lines from the story above to the story below are permitted to be offset a maximum of 24 inches (610 mm). Blocking, where required by this section, need only be provided for the length of the wall specified in Table 2305.8.1.

2305.9.1 Roof to braced wall connections: Roof to interior-braced wall connections for buildings with maximum dimensions not over 50 feet (15240 mm) are permitted to be made at the intersection of exterior walls. Double top plates shall be lapped at the intersection and nailed in accordance with Table 2305.2. For buildings with maximum dimensions greater than 50 feet (15240 mm), the interior-braced walls shall be fastened directly to the ceiling joist in accordance with Section 2305.9.2 or 2305.9.3.

2305.9.2 Parallel floor joist and braced wall connections: Where the floor framing is parallel to the braced wall line, joists shall be doubled directly beneath the braced wall line and nailed in accordance with Table 2305.2.

Where the upper and lower braced walls are offset, the joist spaces between the offset braced walls shall be blocked with a minimum blocking size of 2 inches by 6 inches, spaced at 32 inches (813 mm) on center, within the joist cavity under the braced wall, and positioned in the upper portion of the cavity. The upper braced wall is permitted to be nailed to the blocking with two 16d nails at each piece of blocking. The lower braced wall shall be toe nailed, in accordance with Table 2305.2, to a joist located directly above the top plates.

2305.9.3 Perpendicular floor joist and braced wall connections: Where the floor framing is perpendicular to the braced wall line, solid blocking for the full depth of the floor joist shall be provided for the length of bracing required. The interior-braced wall shall be nailed to the blocking in accordance with Table 2305.2.

Where the upper and lower braced walls are offset, a minimum of 2-inch by 6-inch blocking shall be located in the upper portion of the joist space, directly beneath the upper braced wall and in the lower portion of the joist space, directly above the lower braced wall.

2305.10 Multiple stories: Where the frame is more than one story in *height* and studs and posts are not continuous from sill

to roof, the members shall be secured together with approved clips, splices or other connections to ensure a continuous, well-integrated structure. Sheet metal clamps, ties or clips shall be formed of galvanized steel or other approved corrosion-resistant material equivalent to 0.040-inch nominal thickness steel sheets for 2-inch framing members and not less than 0.052-inch nominal thickness steel sheets for 3-inch structural members. For 4-inch and larger members, column splices and beam and girder supports shall comply with Section 2304.1.

2305.11 Framing over openings: Headers, double joists, trusses or other approved assemblies which are of adequate size to transfer all superimposed *loads* to the vertical members shall be provided over all window and door openings in loadbearing walls and partitions.

2305.12 Framing around flues and chimneys: Combustible framing shall be a minimum of 2 inches (51 mm), but shall not be less than the distance specified in Section 2113.0 and the mechanical code listed in Chapter 35, from all flues, chimneys and fireplaces, and 6 inches (152 mm) away from flue openings.

2305.13 Wall sheathing: Except as provided for in Section 1405.3 for weatherboarding or where stucco construction that complies with Section 2506.0 is installed, all enclosed buildings shall be sheathed with one of the materials of the nominal thickness specified in Table 2305.13 or any other approved material of equivalent strength and durability.

Table 2305.13
MINIMUM THICKNESS OF WALL SHEATHING

Sheathing type	Minimum thickness	Maximum shear wall stud spacing[a]
Wood boards	5/8 inch	24 inches on center
Fiberboard	7/16 inch	16 inches on center
Wood structural panel	In accordance with Table 2307.3.5	
M-S and M-2 "Exterior Glue" Particleboard	In accordance with Table 2308.5(2)	
Gypsum sheathing	1/2 inch	16 inches on center
Gypsum wallboard	1/2 inch	24 inches on center
Reinforced cement mortar	1 inch	24 inches on center

Note a. 1 inch = 25.4 mm.

2305.13.1 Wood structural panel wall bracing: In buildings assigned to Seismic Performance Category D or E, where wood structural panel sheathing is installed structurally as covering on the exterior of outside walls, such sheathing shall be of the exterior type. Where used elsewhere structurally, wood structural panel sheathing shall be bonded by intermediate or exterior glue.

2305.13.2 Paper-backed lath sheathing: In occupancies in Use Group R-3 and one-story commercial buildings with brick or similar veneers, the sheathing shall conform to Section 2305.13 or shall consist of a layer of paper-backed lath complying with Section 2505.0 and a 1-inch (25 mm) intermediate space which shall be mortar filled as each course of veneering is applied.

2305.14 Flooring: The flooring of wood frame construction shall be of adequate strength and stiffness to support required *loads* and, where necessary for strength and for lateral support of the building, subflooring shall be provided.

2305.14.1 Floor spans: Design stresses of floor joists shall be determined in accordance with AFPA NDS listed in Chapter 35 and shall be braced in accordance with Section 2305.16. Metal-plate-connected floor trusses shall be designed in accordance with TPI 1 and AFPA NDS listed in Chapter 35.

2305.15 Roof spans: Design stresses of rafters shall be determined in accordance with AFPA NDS listed in Chapter 35 and shall be braced in accordance with Section 2305.16. Metal-plate-connected roof trusses shall be designed in accordance with TPI 1 and AFPA NDS listed in Chapter 35, and shall be braced to prevent rotation and provide lateral stability.

2305.15.1 Roof decking and sheathing: Roof deck sheathing shall consist of not less than 5/8-inch boards, wood structural panel of the thickness specified in Section 2307.3, or other approved materials of equivalent strength and rigidity. Where open deck sheathing is used on pitched roofs, such sheathing shall consist of not less than 1-inch by 4-inch roofers spaced not more than 6 inches (152 mm) on center, or of material of equivalent strength and rigidity.

2305.16 Bridging: All floor, attic and roof framing with a nominal depth-to-thickness ratio greater than or equal to 5:1, shall have one edge braced for the entire span. Where the nominal depth-to-thickness ratio of the framing member exceeds 6:1, there shall be one line of bridging for each 8 feet (2438 mm) of span. The bridging shall consist of not less than 1-inch by 3-inch lumber, double nailed at each end, or of equivalent metal bracing of equal rigidity. A line of bridging shall also be required at supports where equivalent lateral support is not otherwise provided.

2305.17 Foundation anchorage: Wall sill plates, minimum of 2-inch by 4-inch members, shall be sized and anchored to foundation walls or piers and at intermediate intervals as required to resist wind uplift. Foundation anchorage shall be provided by the installation of anchor bolts or other approved anchoring method. Anchor bolts shall be of a minimum diameter of 1/2 inch. The bolts shall be embedded in poured-in-place concrete or grouted unit masonry or solid masonry foundations to a depth of not less than 7 inches (178 mm). There shall be a minimum of two anchor bolts per section of plate and anchor bolts shall be placed 12 inches (305 mm) from the end of each section of plate, with intermediate bolts spaced a maximum of 6 feet (1829 mm) on center for one- and two-story buildings and not more than 4 feet (1219 mm) on center for buildings over two stories in height.

Exception: All buildings or structures located in seismic map areas having a peak velocity-related acceleration (A_v) equal to or less than 0.05 in accordance with Section 1610.1, and detached *one-* and *two-family dwellings* located in seismic map areas having a peak velocity-related acceleration (A_v) less than 0.15, and agricultural storage buildings which are intended only for incidental human occupancy, are permitted to

have maximum intermediate bolt spacings of 8 feet (2438 mm).

2305.18 Fire cuts: Wood structural members which frame into concrete or masonry walls shall conform to Section 2305.6.4.