Glulam Design Properties and Layup Combinations

ENGINEERED WOOD SYSTEMS
APA EWS

Be Constructive WOOD

Wood is the right choice for a host of construction applications. It is the earth's natural, energy efficient and renewable building material.

Engineered wood is a better use of wood. It uses less wood to make more wood products. That's why using APA trademarked I-joists, glued laminated timbers, laminated veneer lumber, plywood and oriented strand board is constructive ... for the environment, for innovative design, and for strong, durable buildings.

A few facts about wood.

▪ ***We're not running out of trees.*** One-third of the United States land base – 731 million acres – is covered by forests. About two-thirds of that 731 million acres is suitable for repeated planting and harvesting of timber. But only about half of the land suitable for growing timber is open to logging. Most of that harvestable acreage also is open to other uses, such as camping, hiking, and hunting. Forests fully cover one-half of Canada's land mass. Of this forestland, nearly half is considered productive, or capable of producing timber on a sustained yield basis. Canada has the highest per capita accumulation of protected natural areas in the world – areas including national and provincial parks.

▪ ***We're growing more wood every day.*** American landowners plant more than two billion trees every year. In addition, millions of trees seed naturally. The forest products industry, which comprises about 15 percent of forestland ownership, is responsible for 41 percent of replanted forest acreage. That works out to more than one billion trees a year, or about three million trees planted every day. This high rate of replanting accounts for the fact that each year, 27 percent more timber is grown than is harvested. Canada's replanting record shows a fourfold increase in the number of trees planted between 1975 and 1990.

▪ ***Manufacturing wood is energy efficient.*** Wood products made up 47 percent of all industrial raw materials manufactured in the United States, yet consumed only 4 percent of the energy needed to manufacture all industrial raw materials, according to a 1987 study.

Material	Percent of Production	Percent of Energy Use
Wood	47	4
Steel	23	48
Aluminum	2	8

▪ ***Constructive news for a healthy planet.*** For every ton of wood grown, a young forest produces 1.07 tons of oxygen and absorbs 1.47 tons of carbon dioxide.

Wood. It's the constructive choice for the environment.

NOTICE:
The recommendations in this report apply only to glulam that bears the APA EWS trademark. Only glulam bearing the APA EWS trademark is subject to the Association's quality auditing program.

GLULAM DESIGN PROPERTIES AND LAYUP COMBINATIONS

Introduction

Glued laminated timbers (glulam) are manufactured by end joining individual pieces of dimension lumber or boards together with structural adhesives to create long length laminations. These long length laminations are then face bonded together with adhesives to create the desired glulam shape. Through the laminating process, a variety of shapes can be created ranging from straight rectangular cross-sections to complex curved shapes with varying cross-sections. Thus, glulam is one of the most versatile of the family of glued engineered wood products and is used in applications ranging from concealed beams and headers in residential construction to soaring domed stadiums.

Glulam Layup Principles

Bending Members

In addition to being able to produce virtually any size or shape of structural member, the laminating process also permits the manufacturer to optimize the use of the available wood fiber resource by selecting and positioning the lumber based on the stresses it will be subjected to in-service. For example, for members stressed primarily in bending, a graded layup of lumber is used throughout the depth of the beam with the highest quality laminations used in the outer zones of the beam where the bending stresses are highest with lower quality laminations being used in zones subjected to lower bending stresses. Layup combinations for members stressed primarily in bending are provided in Table 1. These members may range in cross-section from straight rectangular beams to pitched and tapered curved beams.

As indicated in Table 1, bending members can be further divided into balanced and unbalanced layups as shown in Figure 1. Unbalanced beams are asymmetrical in their layups with the highest quality laminations, referred to as tension laminations, used only on the bottom of the member. These are intended for use in simple span applications or short cantilevered conditions where only the bottom of the beam is subjected to maximum tension stresses. Results of a large number of full-scale beam tests conducted or sponsored by the glued laminated timber industry over the past 30 years have shown that the quality of the laminations used in the outer tension zone controls the overall bending strength of the member.

For a balanced beam, the grade of laminations used is symmetrical throughout the depth of the member. This type of member is typically used for cantilever or continuous span beams which may have either the top or bottom of the member stressed in tension.

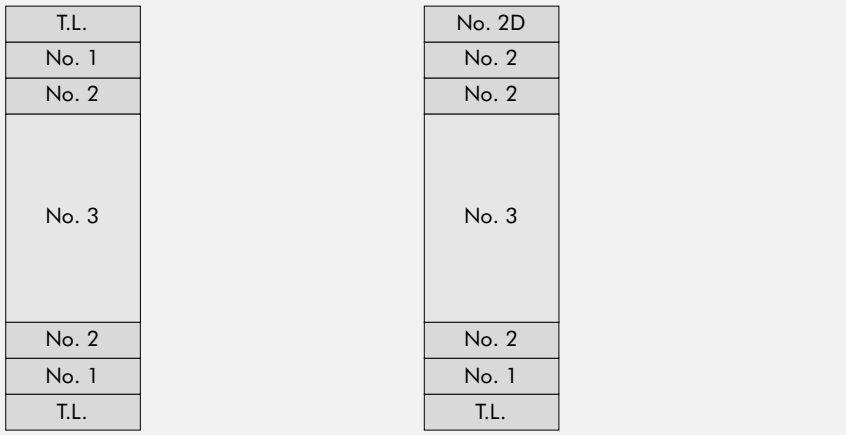
In addition to stamping the beam with the *APA EWS* trademark signifying that the member has been manufactured in accordance with the provisions of *ANSI Standard A190.1 for Structural Glued Laminated Timber,* unbalanced beams also have the word TOP prominently stamped on the top of the member as shown in Figure 2. This is provided as guidance to the contractor to ensure that the member is installed in the proper orientation. If members are inadvertently installed in an improper orientation, i.e., "upside down" the allowable F_b value for the compression zone stressed in tension is applicable. The controlling bending stress and the capacity of the beam in this orientation must be checked to determine if they are adequate to meet the design conditions.

Axially Loaded Members

For members stressed primarily in axial tension or axial compression where the stresses are uniform over the cross-section of the member, single grade lamination layups such as those given in Table 2 are recommended since there is no benefit to using a graded layup.

FIGURE 1

BALANCED VERSUS UNBALANCED LAYUP EXAMPLE



Combined Stress Members

If the member is going to be subjected to high bending stresses as well as axial stresses such as occur in arches or beam-columns, a bending member combination as tabulated in Table 1 is typically the most efficient. Tapered beams or pitched and tapered curved beams are special configurations that are also specified using Table 1 bending member combinations.

Development of Allowable Stresses

The laminating process used in the manufacture of glulam results in a random dispersal of naturally occurring lumber strength reducing characteristics throughout the glulam member resulting in mechanical properties for glulam having higher values and lower variability as compared to sawn lumber products. For example, the coefficient of variation for the modulus of elasticity (E) of glulam is published as 10% which is equal to or lower than any other wood product.

Since glulam is manufactured with kiln dried lumber having a maximum moisture content at the time of fabrication of 16%, this results in higher allowable design stresses as compared to dry (moisture content of 19% or less) or green lumber.

The use of kiln dried laminating lumber also means that the moisture content of a glulam is relatively uniform throughout the member unlike green sawn timbers which may have widely varying moisture contents within a given member. This use of uniformly dry lumber gives glulam excellent dimensional stability. Thus, a glulam member will not undergo the dimensional changes normally associated with larger solid sawn green timbers, and will remain straight and true in cross-section. A "dry" glulam is also less susceptible to the checking and splitting which is often associated with "green" timbers.

FIGURE 2

TOP IDENTIFICATION FOR AN UNBALANCED LAYUP

Allowable stresses for glulam are determined in accordance with the principles of ASTM D-3737, *Standard Practice for Establishing Stresses for Structural Glued Laminated Timber.* A key strength consideration accounted for in this standard is the random dispersal of strength reducing characteristics previously discussed. By randomly distributing the strength reducing characteristics found in dimension lumber, the effect of any given defect is greatly minimized. Other strength considerations accounted for in this standard are those associated with using dry lumber and characteristics unique to the glued laminated timber manufacturing process such as being able to vary the grade of lumber throughout the depth of the member.

Many different species of lumber can be used to produce glued laminated timber. In addition, a wide range of grades of both visually graded and mechanically graded lumber can be used in the manufacture of glulam. This wide variety of available species and grades results in numerous options for the producers to combine species and grades to create a wide array of glulam layup combinations.

For some layup combinations, the use of different species within the same member is permitted. This is done when it is desirable to use a lower strength species in the core of a glued laminated timber and a higher strength species in the outer zones. However, the specifier is cautioned that when mixed species are used, they may result in an appearance that may not be suitable for an exposed application as the species will typically have different coloration and visual characteristics.

Published Design Stresses for *APA EWS* Trademarked Glulam

Table 1 provides the allowable design stresses for layup combinations primarily intended for use as bending members as produced by members of Engineered Wood Systems (EWS), a related corporation of *APA – The Engineered Wood Association*. Table 1 tabulates the layup combinations based on species, whether the combination is for a balanced or

unbalanced layup and whether the lumber used is visually or mechanically graded as signified by a V (visual) or E (E-rated or mechanically graded).

Table 2 provides similar stresses for members primarily intended for use in axially loaded applications.

Published Grade Requirements for *APA EWS* Trademarked Glulams

Tables 3 and 4 provide the grade requirements for the laminations used in manufacturing the beams listed in Tables 1 and 2, respectively.

In addition to the layup combinations tabulated in Tables 1, 2, 3 and 4, EWS periodically evaluates the use of new layup combinations and stresses based on the use of a computer simulation model identified as GAP. The GAP simulation model is based on the provisions of ASTM D-3737 and has been verified by extensive laboratory testing of full-size glulam beams at the APA Research Center in Tacoma, Wash. and at other laboratories throughout North America. As these new special layups are evaluated and approved by EWS, they are added to National Evaluation Service Report *NER-486* as part of the periodic reexamination process. *NER-486* is subject to periodic reexamination, revisions and possible closing.

Specifying Glulam

Common Layup Combinations

While the use of a wide variety of species and grades results in optimizing the use of the lumber resource by the manufacturer, the multiplicity of layup combinations as tabulated in Tables 1 and 2 can be confusing to the design professional.

To simplify the selection process, the layup combinations typically available from members of EWS have been highlighted in the tables in this Data File. For bending members, these are 24F-V4 (unbalanced) and 24F-V8 (balanced) combinations for Douglas-fir, 24F-V3 (unbalanced) and 24F-V5 (balanced) combinations for southern pine, and the 24F-1.8E layup (unbalanced) which permits the use of several different species.

By selecting one of these highlighted combinations the specifier will be identifying glulam products that have sufficiently high design properties to satisfy virtually any design situation and which are typically available in most major market areas in the U.S. Other layup combinations are available on a regional basis and the designer should verify availability of any combination for a given geographic area by contacting local suppliers or the EWS glulam manufacturers (see EWS Source List of Glulam Manufacturers).

Specific End Use Layup Combinations

It is important to note that certain layup combinations in Tables 1 and 2 have been developed for specific end use applications. Several examples of these are as follows:

The **20F-V12** (unbalanced) and **20F-V13** (balanced) combinations use Alaska Yellow Cedar. These are intended for applications exposed to the elements or high humidity conditions where the use of the heartwood of a naturally durable species is preferred instead of using a pressure preservative treated glulam.

The **24F-1.8E** layup is a general purpose layup combination intended primarily for stock beams used in residential construction. This layup permits the use of a variety of species and is suitable for virtually any simple span beam application.

The **26F-E/DF1**, **26F-E/DF1M1**, **30F-E2M2**, and **30F-E2M3** combinations were developed for use in combination with prefabricated wood I-joists and are often referred to as I-joist depth compatible layups.

The **28F-E/SP1** and **30F-E/SP1** layups are southern pine combinations which are intended for applications where high bending stress and MOE properties are specified.

In many cases these high bending stresses and MOE characteristics may not actually be required for the end-use application and combinations with lower allowable stresses such as the 24F layups should be considered.

Specifying by Stresses

When the specifier or end user is uncertain as to the availability or applicability of a specific layup combination, the most efficient way to specify glulam is to provide the manufacturer or supplier with the required stresses to satisfy a given design. For example, assume a simple span beam design requires the following allowable stresses to carry the in-service design loads:

F_b = 2250 psi
F_v = 150 psi
F_{cperp} = 500 psi
MOE = 1.65 x 10^6 psi

If the designer provides the manufacturer or supplier with these required stresses, a number of layup combinations satisfying these stress requirements could then be supplied depending on availability. This will often result in the lowest cost option being supplied while still satisfying all design requirements.

TABLE 1

DESIGN VALUES FOR STRUCTURAL GLUED-LAMINATED TIMBER FOR NORMAL DURATION OF LOAD AND DRY CONDITIONS OF USE[1][2][3]

		Bending about X-X Axis						
		Loaded Perpendicular to Wide Faces of Laminations						
		Extreme Fiber in Bending F_{bx}		Compression Perpendicular to Grain $F_{c\perp x}$[9]				
Combination Symbol[4]	Species-Outer Lams/ Core Lams[5]	Tension Zone Stressed in Tension[6][7]	Compression Zone Stressed in Tension[8]	Tension Face	Compression Face	Shear Parallel to Grain F_{vx}		Modulus of Elasticity E_x
		psi	psi	psi	psi	psi		10^6 psi
1	2	3	4	5	6	7[19]	8[20]	9
Visually Graded Western Species								
The following combinations are **NOT BALANCED** and are intended primarily for simple-span applications.								
EWS 16F-V3	DF/DF	1,600	1,150	560[12][13]	560	240	190	1.5
EWS 20F-V4	DF/DF	2,000	1,450	590[12][13]	560[12]	240	190	1.6
EWS 20F-V12	AC/AC	2,000	1,400	560	560	240	190	1.5
EWS 24F-V4	DF/DF	2,400	1,850	650	650	240	190	1.8
EWS 24F-V5	DF/HF	2,400	1,600	650	650	195	155	1.7
EWS 24F-V5M1	DF/SPF	2,400	1,600	650	650	195	155	1.8
The following combination is **NOT BALANCED** and shall be applicable to members having a depth of 27 inches or less.								
EWS 24F-V5M2	DF/HF	2,400	1,600	650	650	195	155	1.8
The following combination is **NOT BALANCED** and shall be applicable to members having a depth of 24 inches or less.								
EWS 24F-V5M3	DF/HF	2,400	1,600	650	650	195	155	1.8
The following combinations are **NOT BALANCED** and are intended for straight or slightly cambered members for dry use and industrial appearance,[14] and shall be applicable to members having a depth of 9 to 20 laminations.								
EWS 24F-V4M1	DF/DF	2,400	1,850	650	650	240	190	1.8
EWS 24F-V4M2	DF/DF	2,400	1,850	650	650	200	160	1.8
The following combinations are **BALANCED** and are intended for members continuous or cantilevered over supports and provide equal capacity in both positive and negative bending.								
EWS 20F-V8	DF/DF	2,000	2,000	590[12][13]	590[12][13]	240	190	1.7
EWS 20F-V13	AC/AC	2,000	2,000	560	560	240	190	1.5
EWS 24F-V8	DF/DF	2,400	2,400	650	650	240	190	1.8
EWS 24F-V10	DF/HF	2,400	2,400	650	650	195	155	1.8
The following combinations are **BALANCED** and are intended for straight or slightly cambered members for dry use and industrial appearance,[14] and shall be applicable to members having a depth of 9 to 20 laminations.								
EWS 24F-V8M1	DF/DF	2,400	2,400	650	650	240	190	1.8
EWS 24F-V8M2	DF/DF	2,400	2,400	650	650	200	160	1.8
E-Rated Western Species								
The following combinations are **NOT BALANCED** and are intended primarily for simple-span applications.								
EWS 20F-E8	ES/ES	2,000	1,300	450	450	180	145	1.5
EWS 24F-E15M1	HF/HF	2,400	1,600	500	500	195	155	1.8
EWS 24F-E/CSP3	CSP[21]/CSP	2,400	1,550	560	650	195	160	1.6
EWS 24F-E/CSP4	CSP[21]/CSP	2,400	1,700	560	650	195	160	1.8
EWS 24F-E/ES1	ES/ES	2,400	1,700	560	560	180	145	1.7
EWS 24F-E/SPF3	SPF[21]/SPF	2,400	1,550	560	650	195	160	1.6
Wet-use factors[2]		0.8	0.8	0.53	0.53	0.875	0.875	0.833

Bending about Y-Y Axis							Axially Loaded		
Loaded Parallel to Wide Faces of Laminations									
Extreme Fiber in Bending[10] F_{by}	Compression Perpendicular to Grain $F_{c\perp y}$[9]	Shear Parallel to Grain F_{vy}		Shear Parallel to Grain F_{vy} (For members with multiple piece lams which are not edge glued)[11]		Modulus of Elasticity E_y	Tension Parallel to Grain F_t	Compression Parallel to Grain F_c	Modulus of Elasticity E
psi	psi	psi		psi		10^6 psi	psi	psi	10^6 psi
10	11	12[19]	13[20]	14[19]	15[20]	16	17	18	19
1,450	560	210	165	105	85	1.5	950	1,550	1.5
1,450	560	210	165	105	85	1.6	1,000	1,550	1.6
1,200	470	210	165	105	85	1.4	900	1,500	1.4
1,500	560	210	165	105	85	1.6	1,100	1,650	1.6
1,350	375	180	140	90	70	1.5	1,100	1,450	1.5
1,350	375	180	140	90	70	1.5	1,050	1,450	1.5
1,350	375	180	140	90	70	1.5	1,100	1,450	1.5
1,350	375	180	140	90	70	1.5	1,100	1,450	1.5
1,500	560	210	165	105	85	1.6	1,100	1,650	1.6
1,500	560	210	165	105	85	1.6	1,100	1,650	1.6
1,450	560	210	165	105	85	1.6	1,000	1,600	1.6
1,250	470	210	165	105	85	1.5	925	1,550	1.5
1,450	560	210	165	105	85	1.6	1,100	1,650	1.6
1,400	375	180	140	90	70	1.6	1,150	1,600	1.6
1,450	560	210	165	105	85	1.6	1,100	1,650	1.6
1,450	560	210	165	105	85	1.6	1,100	1,650	1.6
1,400	300	160	125	80	65	1.4	800	1,000	1.4
1,300	375	170	135	85	70	1.5	950	1,200	1.5
1,200	470	175	140	90	70	1.5	900	1,750	1.5
1,400	470	180	145	90	75	1.6	1,150	1,900	1.6
1,100	300	160	125	80	65	1.5	1,050	1,150	1.5
1,200	470	175	140	90	70	1.5	900	1,750	1.5
0.8	0.53	0.875	0.875	0.875	0.875	0.833	0.8	0.73	0.833

Table 1 continued on page 8

TABLE 1 (Continued)

DESIGN VALUES FOR STRUCTURAL GLUED-LAMINATED TIMBER FOR NORMAL DURATION OF LOAD AND DRY CONDITIONS OF USE[1][2][3]

		Bending about X-X Axis						
		Loaded Perpendicular to Wide Faces of Laminations						
		Extreme Fiber in Bending F_{bx}		Compression Perpendicular to Grain $F_{c\perp x}$[9]				
Combination Symbol[4]	Species-Outer Lams/ Core Lams[5]	Tension Zone Stressed in Tension[6][7]	Compression Zone Stressed in Tension[8]	Tension Face	Compression Face	Shear Parallel to Grain F_{vx}		Modulus of Elasticity E_x
		psi	psi	psi	psi	psi		10^6 psi
1	2	3	4	5	6	7[19]	8[20]	9
E-Rated Western Species								
The following combination is **NOT BALANCED** and is intended primarily for simple-span applications.								
EWS 24F-E/SPF4	SPF[21]/SPF	2,400	1,700	560	650	195	160	1.8
The following combination is **NOT BALANCED** and shall be applicable to members having a depth of 9-1/2, 11-7/8, 14, and 16 inches.								
EWS 26F-E/DF1	DF/DF	2,600	1,950[16]	650	650	240	190	2.0
The following combinations are **BALANCED** and are intended for members continuous or cantilevered over supports and provide equal capacity in both positive and negative bending.								
EWS 20F-E8M1	ES/ES	2,000	2,000	450	450	180	145	1.5
EWS 24F-E/CSP1	CSP/CSP	2,400	2,400	560	560	195	160	1.6
EWS 24F-E/CSP2	CSP/CSP	2,400	2,400	560	560	195	160	1.8
EWS 24F-E/SPF1	SPF/SPF	2,400	2,400	560	560	195	160	1.6
EWS 24F-E/SPF2	SPF/SPF	2,400	2,400	560	560	195	160	1.8
The following combination is **BALANCED** and shall be applicable to members having a depth of 7-1/2, 9, 9-1/2, 11-7/8, and 14 inches, and a width of 1-1/2 through 3-1/2 inches.								
EWS 20F-E/SPF1	SPF/SPF	2,000	2,000	425	425	195	160	1.5
The following combination is **BALANCED** and shall be applicable to members having a depth of 9-1/2, 11-7/8, 14, and 16 inches.								
EWS 26F-E/DF1M1	DF/DF	2,600	2,600	650	650	240	190	2.0
Visually Graded/E-Rated Western Species or Southern Pine								
The following combination is **NOT BALANCED** and is intended primarily for simple-span header applications.								
EWS 24F-1.8E Glulam Header[18]	WS, SP/WS, SP	2,400	1,600	500	500	195	155	1.8
Visually Graded Southern Pine								
The following combinations are **NOT BALANCED** and are intended primarily for simple-span applications.								
EWS 24F-V1	SP/SP	2,400	1,750	740	650[12]	270	240	1.7
EWS 24F-V3	SP/SP	2,400	1,950	740	740	270	240	1.8
EWS 26F-V1	SP/SP	2,600	1,950	740	740	270	240	1.8
EWS 26F-V2	SP/SP	2,600	2,100	740	740	270	240	1.9
EWS 26F-V3	SP/SP	2,600	2,100	740	740	270	240	1.9
The following combinations are **NOT BALANCED** and are intended for straight or slightly cambered members for dry use and industrial appearance,[14] and shall be applicable to members having a depth of 9 to 20 laminations.								
EWS 24F-V3M1	SP/SP	2,400	1,950	740	740	270	240	1.8
EWS 24F-V3M2	SP/SP	2,400	1,950	740	740	225	200	1.8
EWS 26F-V3M1	SP/SP	2,600	2,100	740	740	270	240	1.9
EWS 26F-V3M2	SP/SP	2,600	2,100	740	740	225	200	1.9
Wet-use factors[2]		0.8	0.8	0.53	0.53	0.875	0.875	0.833

Bending about Y-Y Axis							Axially Loaded		
Loaded Parallel to Wide Faces of Laminations									
Extreme Fiber in Bending[10] F_{by}	Compression Perpendicular to Grain $F_{c\perp y}$[9]	Shear Parallel to Grain F_{vy}		Shear Parallel to Grain F_{vy} (For members with multiple piece lams which are not edge glued)[11]		Modulus of Elasticity E_y	Tension Parallel to Grain F_t	Compression Parallel to Grain F_c	Modulus of Elasticity E
psi	psi	psi		psi		10^6 psi	psi	psi	10^6 psi
10	11	12[20]	13[20]	14[19]	15[20]	16	17	18	19
1,400	470	180	145	90	75	1.6	1,150	1,900	1.6
1,850	560	210	165	105	85	1.8	1,400	1,800	1.8
1,400	300	160	125	80	65	1.4	800	1,000	1.4
1,150	470	170	140	85	70	1.5	900	1,800	1.5
1,500	470	170	140	85	70	1.6	1,150	2,000	1.6
1,150	470	170	140	85	70	1.5	900	1,800	1.5
1,500	470	170	140	85	70	1.6	1,150	2,000	1.6
875	425	170	140	85	70	1.4	425	1,100	1.4
1,850	560	210	165	105	85	1.8	1,400	1,800	1.8
1,300	375	180	140	90	70	1.5	950	1,200	1.5
1,500	650	235	210	120	105	1.5	1,100	1,350	1.5
1,600	650	235	210	120	105	1.6	1,150	1,700	1.6
1,900	650	235	210	120	105	1.6	1,150	1,600	1.6
2,200	740	235	210	120	105	1.8	1,200	1,650	1.8
2,100	650	235	210	120	105	1.8	1,150	1,600	1.8
1,600	650	235	210	120	105	1.6	1,150	1,700	1.6
1,600	650	235	210	120	105	1.6	1,150	1,700	1.6
2,100	650	235	210	120	105	1.8	1,150	1,600	1.8
2,100	650	235	210	120	105	1.8	1,150	1,600	1.8
0.8	0.53	0.875	0.875	0.875	0.875	0.833	0.8	0.73	0.833

Table 1 continued on page 10

TABLE 1 (Continued)

DESIGN VALUES FOR STRUCTURAL GLUED-LAMINATED TIMBER FOR NORMAL DURATION OF LOAD AND DRY CONDITIONS OF USE[1][2][3]

		Bending about X-X Axis						
		Loaded Perpendicular to Wide Faces of Laminations						
		Extreme Fiber in Bending F_{bx}		Compression Perpendicular to Grain $F_{c\perp x}$[9]				
Combination Symbol[4]	Species-Outer Lams/ Core Lams[5]	Tension Zone Stressed in Tension[6][7]	Compression Zone Stressed in Tension[8]	Tension Face	Compression Face	Shear Parallel to Grain F_{vx}		Modulus of Elasticity E_x
		psi	psi	psi	psi	psi		10^6 psi
1	2	3	4	5	6	7[19]	8[20]	9
Visually Graded Southern Pine								
The following combinations are **BALANCED** and are intended for members continuous or cantilevered over supports and provide equal capacity in both positive and negative bending.								
EWS 24F-V5	SP/SP	2,400	2,400	740	740	270	240	1.7
EWS 24F-V5M1	SP/SP	2,400	2,400	740	740	270	240	1.8
EWS 26F-V4	SP/SP	2,600	2,600	740	740	270	240	1.9
The following combinations are **BALANCED** and are intended for straight or slightly cambered members for dry use and industrial appearance,[14] and shall be applicable to members having a depth of 9 to 20 laminations.								
EWS 24F-V5M2	SP/SP	2,400	2,400	740	740	270	240	1.8
EWS 24F-V5M3	SP/SP	2,400	2,400	740	740	225	200	1.8
EWS 26F-V4M1	SP/SP	2,600	2,600	740	740	270	240	1.9
EWS 26F-V4M2	SP/SP	2,600	2,600	740	740	225	200	1.9
E-Rated Southern Pine								
The following combinations are **NOT BALANCED** and are intended primarily for simple-span applications.								
EWS 28F-E1	SP/SP	2,800	2,300	740	740	270	240	2.0
EWS 28F-E1M1	SP/SP	2,800	2,300	740	740	270	240	2.1
The following combinations are **BALANCED** and are intended for members continuous or cantilevered over supports and provide equal capacity in both positive and negative bending.								
EWS 28F-E2	SP/SP	2,800	2,800	740	740	270	240	2.0
EWS 28F-E2M1	SP/SP	2,800	2,800	740	740	270	240	2.1
The following combination is **NOT BALANCED** and shall be applicable to members having a nominal width of 6 inches or less.								
EWS 30F-E1	SP/SP	3,000	2,400	740	740	270	240	2.0
The following combination is not balanced and shall be applicable to members having a nominal width of 6 inches or less, and a depth of 18 inches or less.								
EWS 30F-E1M1	SP/SP	3,000	2,400	740	740	270	240	2.1
The following combination is **BALANCED** and shall be applicable to members having a nominal width of 6 inches or less.								
EWS 30F-E2	SP/SP	3,000	3,000	740	740	270	240	2.0
The following combination is **BALANCED** and shall be applicable to members having a nominal width of 6 inches or less, and a depth of 18 inches or less.								
EWS 30F-E2M1	SP/SP	3,000	3,000	740	740	270	240	2.1
The following combination is **BALANCED** and shall be applicable to members having a depth of 16 inches or less.								
EWS 30F-E2M2	DF/SP	3,000	3,000	650[22]	650[22]	270	240	2.1
The following combination is **BALANCED** and shall be applicable to members having a depth of 18 inches or less.								
EWS 30F-E2M3	DF/SP	3,000	3,000	510[22]	510[22]	270	240	2.1

Bending about Y-Y Axis							Axially Loaded		
Loaded Parallel to Wide Faces of Laminations									
Extreme Fiber in Bending[10] F_{by}	Compression Perpendicular to Grain $F_{c\perp y}$[9]	Shear Parallel to Grain F_{vy}		Shear Parallel to Grain F_{vy} (For members with multiple piece lams which are not edge glued)[11]		Modulus of Elasticity E_y	Tension Parallel to Grain F_t	Compression Parallel to Grain F_c	Modulus of Elasticity E
psi	psi	psi		psi		10^6 psi	psi	psi	10^6 psi
10	**11**	**12**[19]	**13**[20]	**14**[19]	**15**[20]	**16**	**17**	**18**	**19**
1,600	650	235	210	120	105	1.5	1,150	1,700	1.5
1,600	650	235	210	120	105	1.5	1,150	1,700	1.5
2,100	650	235	210	120	105	1.8	1,150	1,600	1.8
1,600	650	235	210	120	105	1.5	1,150	1,700	1.5
1,600	650	235	210	120	105	1.5	1,150	1,700	1.5
2,100	650	235	210	120	105	1.8	1,150	1,600	1.8
2,100	650	235	210	120	105	1.8	1,150	1,600	1.8
1,600	650	235	210	120	105	1.7	1,300	1,850	1.7
1,600	650	235	210	120	105	1.7	1,300	1,850	1.7
1,600	650	235	210	120	105	1.7	1,300	1,850	1.7
1,600	650	235	210	120	105	1.7	1,300	1,850	1.7
1,750	650	235	210	120	105	1.7	1,250	1,750	1.7
1,750	650	235	210	120	105	1.7	1,250	1,750	1.7
1,750	650	235	210	120	105	1.7	1,250	1,750	1.7
1,750	650	235	210	120	105	1.7	1,250	1,750	1.7
1,750	650	235	210	120	105	1.7	1,250	1,750	1.7
1,750	650	235	210	120	105	1.7	1,250	1,750	1.7

TABLE 1 (Continued)

DESIGN VALUES FOR STRUCTURAL GLUED-LAMINATED TIMBER FOR NORMAL DURATION OF LOAD AND DRY CONDITIONS OF USE[1][2][3]

		Bending about X-X Axis						
		Loaded Perpendicular to Wide Faces of Laminations						
		Extreme Fiber in Bending F_{bx}		Compression Perpendicular to Grain $F_{c\perp x}$[9]				
Combination Symbol[4]	Species-Outer Lams/ Core Lams[5]	Tension Zone Stressed in Tension[6][7]	Compression Zone Stressed in Tension[8]	Tension Face	Compression Face	Shear Parallel to Grain F_{vx}		Modulus of Elasticity E_x
		psi	psi	psi	psi	psi		10^6 psi
1	2	3	4	5	6	7[19]	8[20]	9
E-Rated Durango Pine								
The following combinations are **NOT BALANCED** and are intended primarily for simple-span applications.								
EWS 16F-E1[17]	DP/DP	1,600[15]	1,300[15]	650[12]	650[12]	270	240	1.6
EWS 20F-E1[17]	DP/DP	2,000[15]	1,550[15]	650[12]	650[12]	270	240	1.7
EWS 24F-E1[17]	DP/DP	2,400[15]	1,750[15]	740	650[12]	270	240	1.8
The following combinations are **BALANCED** and are intended for members continuous or cantilevered over supports and provide equal capacity in both positive and negative bending.								
EWS 16F-E3[17]	DP/DP	1,600[15]	1,600[15]	650[12]	650[12]	270	240	1.6
EWS 20F-E3[17]	DP/DP	2,000[15]	2,000[15]	650[12]	650[12]	270	240	1.7
EWS 24F-E4[17]	DP/DP	2,400[15]	2,400[15]	740	740	270	240	1.8
Wet-use factors[2]		0.8	0.8	0.53	0.53	0.875	0.875	0.833

(1) The combinations in this table are applicable to members consisting of 4 or more laminations and are intended primarily for members stressed in bending due to loads applied perpendicular to the wide faces of the laminations. Design values are tabulated, however, for loading both perpendicular and parallel to the wide faces of the laminations. For combinations and design values applicable to members loaded primarily axially or parallel to the wide faces of the laminations, see Table 2. For members of 2 or 3 laminations, see Table 2.

(2) The tabulated design values are for dry conditions of use. For wet conditions of use, multiply the tabulated values by the factors shown at the end of the table.

(3) The tabulated design values are for normal duration of loading. For other durations of loading, see applicable building code.

(4) The combination symbols relate to a specific combination of grades and species in Table 3 that will provide the design values shown for the combination. The first two numbers in the combination symbol correspond to the design value in bending shown in Column 3. The letter in the combination symbol (either a "V" or an "E") indicates whether the combination is made from visually graded (V) or E-rated (E) lumber in the outer zones.

(5) The symbols used for species are DF = Douglas fir-larch, HF = Hem-fir, AC = Alaska cedar, ES = Eastern spruce, SPF = Spruce-pine-fir, CSP = Canadian spruce-pine, SP = Southern pine, and DP = Durango pine.

(6) The tabulated design values in bending, F_{bx}, are based on members 5-1/8 inches (130 mm) in width by 12 inches (305 mm) in depth by 21 feet (6,400 mm) in length. For members with a larger volume, F_{bx} shall be multiplied by a volume factor, C_v, determined in accordance with applicable building code.

(7) The design values in bending about the X-X axis, F_{bx} in this column for bending members shall be multiplied by 0.75 for depth > 15 inches or 0.85 for depth ≤ 15 inches when the member is manufactured without the required special tension lamination(s). See Column 3 in Table 3 for the special tension lamination(s) provisions.

(8) Design values in this column are for extreme fiber stress in bending when the member is loaded such that the compression zone laminations are subjected to tensile stresses.

(9) The compression perpendicular to grain design values in this table are not subject to the duration of load modifications.

(10) The values of F_{by} were calculated based on members 12 inches in depth (bending about Y-Y axis). When the depth is less than 12 inches, the values of F_{by} shall be permitted to be increased by multiplying by the following factors:

Beam Depth, inches

All Species	10-3/4 or 10-1/2	8-3/4 or 8-1/2	6-3/4	5-1/8 or 5	3-1/8 or 3
Factor	1.01	1.04	1.07	1.10	1.16

For members with depth greater than 12 inches, the value of F_{by} shall be reduced by applying the size factor, $(12/d)^{1/9}$, where d is the beam depth in inches.

Table 1 continued on page 12

Bending about Y-Y Axis							Axially Loaded		
Loaded Parallel to Wide Faces of Laminations									
Extreme Fiber in Bending[10] F_{by}	Compression Perpendicular to Grain $F_{c\perp y}$[9]	Shear Parallel to Grain F_{vy}		Shear Parallel to Grain F_{vy} (For members with multiple piece lams which are not edge glued)[11]		Modulus of Elasticity E_y	Tension Parallel to Grain F_t	Compression Parallel to Grain F_c	Modulus of Elasticity E
psi	psi	psi		psi		10^6 psi	psi	psi	10^6 psi
10	11	12[19]	13[20]	14[19]	15[20]	16	17	18	19
1,500	650	235	210	120	105	1.5	1,050	1,550	1.5
1,600	650	235	210	120	105	1.5	1,050	1,550	1.5
1,600	650	235	210	120	105	1.6	1,100	1,550	1.6
1,700	650	235	210	120	105	1.5	1,100	1,600	1.5
1,800	650	235	210	120	105	1.5	1,150	1,650	1.5
2,000	650	235	210	120	105	1.6	1,250	1,700	1.6
0.8	0.53	0.875	0.875	0.875	0.875	0.833	0.8	0.73	0.833

(11) These values for shear parallel to grain, F_{vy}, apply to members manufactured using multiple piece laminations with unbonded edge joints. For members manufactured using single piece laminations or using multiple piece laminations with bonded edge joints, the shear parallel to grain values in Columns 12 and 13 apply. The values in this column do not apply to members with 5, 7 or 9 laminations when unbonded edge joints occur in alternate laminations at mid-depth of the member with no edge joints in adjacent laminations and the outside lamination contains unbonded edge joints. The value in this column shall be reduced by 16 percent for members containing 5 laminations when unbonded edge joints occur in each lamination forming a staggered pattern in the member with no edge joint closer than 1 inch to the mid-depth of the member.

(12) Where specified by the designer, this value shall be permitted to be increased to 650 psi for Douglas fir-Larch, or 740 psi for southern pine or Durango pine by providing in the bearing area at least one dense 2-inch nominal thickness lamination of Douglas fir-larch for western species combinations, southern pine for southern pine combinations, or Durango pine for Durango pine combinations. These dense laminations shall be backed by a medium grain lamination of the same species.

(13) For bending members greater than 15 inches in depth, the design value for compression stress perpendicular to grain is 650 psi on the tension face.

(14) When containing wane, these combinations shall be used in dry conditions only. In this case, wet-use factors shall not be applied. Because of the wane, these combinations are assigned for an industrial appearance grade. If wane is omitted, these restrictions shall not apply.

(15) This tabulated design value shall be multiplied by a volume factor, C_v, based on the same volume factor applicable to southern pine structural glued laminated timber in accordance with Footnote No. 6 to this table.

(16) This tabulated value is permitted to be increased to 2,200 psi for beam depths less than 16 in.

(17) For connection design, use the specific gravity of 0.52 for Durango pine based on oven-dry weight and volume.

(18) This combination shall be manufactured from either EWS 24F-V4/WS, EWS 24F-V5M1/WS, EWS 24F-V5M2/WS, EWS 24F-V5M3/WS, EWS 24F-E15M1/WS, EWS 24F-E/SPF4, or EWS 24F-V3/SP, and is intended primarily for use in header applications. Design values given for this combination are based on the minimum values for all combinations mentioned above. For connection design, use the specific gravity of 0.42 for Spruce-pine-fir based on oven-dry weight and volume.

(19) These tabulated shear values are applicable to prismatic glulam members subjected to typical static and transient dead, live, snow, wind and earthquake loadings but excluding impact or cyclic loadings such as may occur in bridges or crane rail applications. These values allow for checking up to 10% of the glulam width in the shear critical zone.

(20) These tabulated shear values are applicable to non-prismatic glulam members subjected to typical static and transient loadings and all members subjected to impact or cyclic loads such as may occur in bridges or crane rail applications. These values allow for checking up to 10% of the glulam width in the shear critical zone.

(21) L2D/DF laminations are used in the outer compression zone.

(22) The allowable compressive stress perpendicular to grain of the beam shall be permitted to be increased to the published allowable compressive stress perpendicular to grain of the outermost laminated veneer lumber.

TABLE 2

DESIGN VALUES FOR STRUCTURAL GLUED-LAMINATED TIMBER FOR NORMAL DURATION OF LOAD AND DRY CONDITIONS OF USE[1][2][3]

					Axially Loaded		
					Tension Parallel to Grain F_t	Compression Parallel to Grain F_c	
Combination Symbol	Species[4]	Grade[5]	Modulus of Elasticity E	Compression Perpendicular to Grain $F_{c\perp}$[6]	2 or More Lams	4 or More Lams	2 or 3 Lams
			10^6	psi	psi	psi	psi
1	2	3	4	5	6	7	8
Western Species							
EWS 1	DF	L3	1.5	560[14]	900	1,550	1,200
EWS 2	DF	L2	1.7	560[14]	1,250	1,900	1,600
EWS 3	DF	L2D	1.8	650	1,450	2,300	1,850
EWS 5	DF	L1	2.0	650	1,600	2,400	2,100
EWS 22	WW	L3	1.0[15]	255	525	850	675
EWS 70	AC	L2	1.4	470	1,000	1,450	1,550
Southern Pine							
EWS 47	SP	N2M[17]	1.4	650[14]	1,200	1,900	1,150
EWS 48	SP	N2D[17]	1.7	740	1,400	2,200	1,350
EWS 49	SP	N1M[17]	1.7	650[14]	1,350	2,100	1,450
EWS 50	SP	N1D[17]	1.9	740	1,550	2,300	1,700
The following combination is intended for dry use and industrial appearance,[18] and shall be applicable to members having a depth of 9 to 20 laminations.							
EWS 49M1	SP	N1M[17]	1.7	650[14]	1,350	2,100	1,450
The following combination is intended for dry use and industrial appearance,[18] and shall be applicable to members having a depth of 4 to 20 laminations.							
EWS 49M2	SP	N1M[17]	1.7	650[14]	1,350	2,100	1,450
Wet-use factors[2]			0.833	0.53	0.8	0.73	0.73

(1) The combinations in this table are intended primarily for members loaded either axially or in bending with the loads acting parallel to the wide faces of the laminations. Design values for bending due to loading applied perpendicular to the wide faces of the laminations are also included, however, the combinations in Table 1 are usually better suited for this condition of loading. The design values for bending about the X-X axis (F_{bx}) shown in Column 20 are for members from 2 laminations to 15 inches deep without tension laminations. Design values approximately 15 percent higher for members with 4 or more laminations are shown in Column 21. These higher design values, however, require special tension lamination(s). See Columns 4 through 6 in Table 4 for the tension lamination(s) provisions.

(2) The tabulated design values are for dry conditions of use. For wet conditions of use, multiply the tabulated values by the factors shown at the end of the table.

(3) The tabulated design values are for normal duration of loading. For other durations of loading, see applicable building code.

(4) The symbols used for species are DF = Douglas fir-larch, WW = softwood species, and SP = southern pine.

(5) Grade designations are given in Footnote No. 8 of Table 3.

(6) The compression perpendicular to grain design values in this table are not subject to the duration of load modifications.

(7) Footnote No. 10 of Table 1 also applies.

(8) These values for shear parallel to grain, F_{vv}, apply to members manufactured using multiple piece laminations with unbonded edge joints. For members using single piece laminations or using multiple piece laminations with bonded edge joints, the shear parallel to grain values tabulated in Columns 14 though 19 apply. The values in Columns 12 and 13 do not apply to members with 5, 7 or 9 laminations when unbonded edge joints occur in alternate laminations at mid-depth of the member with no edge joints in adjacent laminations and the outside laminations contains unbonded edge joints. The values in Columns 12 and 13 shall be reduced

Bending about Y-Y Axis											Bending about X-X Axis			
Loaded Parallel to Wide Faces of Laminations											Loaded Perpendicular to Wide Faces of Laminations			
Extreme Fiber in Bending F_{by}[7]			Shear Parallel to Grain F_{vy}								Extreme Fiber in Bending F_{bx}[9]		Shear Parallel to Grain, F_{vx}[13]	
4 or More Lams	3 Lams	2 Lams	4 or More Lams (For members with multi-lams)[8]		4 or More Lams		3 Lams		2 Lams		2 Lams to 15 in. Deep [10]	4 or More Lams [1][2][11]	2 or More Lams	
psi	psi	psi	psi		psi		psi		psi					
9	10	11	12[19]	13[20]	14[19]	15[20]	16[19]	17[20]	18[19]	19[20]	20	21	22[19]	23[20]
1,450	1,250	1,000	105	85	210	165	200	160	180	145	1,250	1,500	240	190
1,800	1,600	1,300	105	85	210	165	200	160	180	145	1,700	2,000	240	190
2,100	1,850	1,550	105	85	210	165	200	160	180	145	2,000	2,300	240	190
2,400	2,100	1,800	105	85	210	165	200	160	180	145	2,200	2,400	240	190
800	700	550	80[16]	60[16]	155[16]	120[16]	145[16]	115[16]	130[16]	105[16]	725	850	175[16]	140[16]
1,250	1,100	925	105	85	210	165	200	160	180	145	1,350	1,550	240	190
1,750	1,550	1,300	120	105	235	210	225	200	205	180	1,400	1,600	270	240
2,000	1,800	1,500	120	105	235	210	225	200	205	180	1,600	1,900	270	240
1,950	1,750	1,500	120	105	235	210	225	200	205	180	1,800	2,100	270	240
2,300	2,100	1,750	120	105	235	210	225	200	205	180	2,100	2,400	270	240
1,950	1,750	1,500	120	105	235	210	225	200	205	180	1,800	2,100	270	240
1,950	1,750	1,500	120	105	235	210	225	200	205	180	1,800	2,100	225	200
0.8	0.8	0.8	0.875	0.875	0.875	0.875	0.875	0.875	0.875	0.875	0.8	0.8	0.875	0.875

by 16 percent for members containing 5 laminations when unbonded edge joints occur in each lamination forming a staggered pattern in the member with no edge joint closer than 1 inch to the mid-depth of the member.

(9) Footnote No. 6 of Table 1 also applies.

(10) These design values are for members of from 2 laminations to 15 inches in depth without tension laminations.

(11) These design values are for members of 4 or more laminations in depth and require special tension laminations. See Columns 4 through 6 in Table 4 for the tension lamination(s) provisions. When these values are used for the design and the member is specified by combination symbol, the designer shall also specify the required design value in bending.

(12) When special tension laminations are not used, the design values in bending about the X-X axis (F_{bx}) shall be multiplied by 0.75 for bending members over 15 inches deep. For bending members 15 inches and less in depth, use the design values in Column 20.

(13) Laminations shall not contain wane.

(14) When tension laminations are used to obtain the design value for F_{bx} shown in Column 21 (see Footnote No. 11), the compression perpendicular to grain value, $F_{c\perp}$, for the tension face is permitted to be increased to 650 psi for Douglas fir-larch and 740 psi for southern pine and Durango pine because the tension laminations are required to be dense.

(15) The modulus of elasticity (E) shall be 900,000 psi when the following softwood species (WW) are used: western cedars, western cedars (North), white woods (western woods) and California redwood – open grain.

(16) When the following softwood species (WW) are used, the shear value parallel to grain (F_{vy}) specified in Columns 12 and 13 shall be reduced 5 psi, the shear value parallel to grain (F_{vy}) specified in Columns 14 through 19 shall be reduced 10 psi, and the shear value parallel to grain (F_{vx}) specified in Columns 22 and 23 shall be reduced 10 psi: coast Sitka spruce, coast species, western white pine and eastern white pine.

Footnotes continue on page 16

(17) Combinations EWS 47, EWS 48, EWS 49 and EWS 50 have more restrictive slope of grain requirements than the basic slope of grain of the grades of lumber used in order to obtain higher tension parallel to grain values and design values in bending when loaded perpendicular to the wide faces of the laminations. All laminations shall not contain a slope of grain less restrictive than 1:14 for EWS 47, EWS 48, and EWS 50, and 1:16 for EWS 49. Where these slope of grain requirements are not met, the design values specified in the following table for the applicable slope of grain apply. The design bending values, F_{bx}, specified in Column 5 of the table are applicable to members with 2 or more laminations up to 15 inches in depth without tension laminations, and the values specified in Column 6 of the table are for members with 4 or more laminations with tension laminations.

		Tension Parallel to Grain, F_t	Comp. Parallel to Grain, F_c		Bending about the X-X Axis, F_{bx}		Bending about the Y-Y Axis, F_{by}		
Slope of Grain	Comb. No.	2 or More Lams psi	2 or 3 Lams psi	4 or More Lams psi	2 to 15 in. Lams psi	4 or More Lams psi	2 Lams psi	3 Lams psi	4 or More Lams psi
1		2	3	4	5	6	7	8	9
1:12	EWS 47	1,200	1,150	1,900	1,400	1,600	1,300	1,550	1,750
	EWS 48	1,400	1,350	2,200	1,600	1,900	1,500	1,800	2,000
	EWS 49	1,300	1,450	1,900	1,750	2,100	1,500	1,750	1,950
	EWS 50	1,550	1,700	2,200	2,100	2,400	1,750	2,100	2,300
1:10	EWS 47	1,150	1,450	1,700	1,550	1,850	1,500	1,750	1,850
	EWS 48	1,150	1,450	1,700	1,550	1,850	1,500	1,750	1,850
	EWS 49	1,150	1,450	1,700	1,550	1,850	1,500	1,750	1,850
	EWS 50	1,350	1,700	2,000	1,800	2,100	1,750	2,100	2,100
1:8	EWS 47	1,000	1,150	1,500	1,350	1,600	1,300	1,550	1,600
	EWS 48	1,150	1,350	1,750	1,600	1,850	1,500	1,800	1,850
	EWS 49	–	–	–	–	–	–	–	–
	EWS 50	–	–	–	–	–	–	–	–

(18) When containing wane, these combinations shall be used in dry conditions only. In this case, wet-use factors shall not be applied. Because of the wane, these combinations are assigned for an industrial appearance grade. If wane is omitted, these restrictions shall not apply.

(19) These tabulated shear values are applicable to prismatic glulam members subjected to typical static and transient dead, live, snow, wind and earthquake loadings but excluding impact or cyclic loadings such as may occur in bridges or crane rail applications. These values allow for checking up to 10% of the glulam width in the shear critical zone.

(20) These tabulated shear values are applicable to non-prismatic glulam members subjected to typical static and transient loadings and all members subjected to impact or cyclic loads such as may occur in bridges or crane rail applications. These values allow for checking up to 10% of the glulam width in the shear critical zone.

TABLE 3

GRADE REQUIREMENTS FOR MEMBERS STRESSED PRINCIPALLY IN BENDING AND LOADED PERPENDICULAR TO THE WIDE FACES OF LAMINATIONS[1,2]

			Minimum Grade of Laminations[4,5,6,7]									
			Percent/Grade/Species Each Zone[8]					Percent/Slope of Grain[9]				
Combination Symbol	Depth of Member	Tension Lam[3]	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone
1	2	3	4	5	6	7	8	9	10	11	12	13
VISUALLY GRADED WESTERN SPECIES (WS)												
The following combinations are NOT BALANCED and are intended primarily for simple-span applications.												
EWS	<12 in.	—	10%L2D/DF	—	L3/DF	—	L3/DF[10]	—	—	—	—	—
16F-V3/WS	12 to 15 in.	—	10%L2D/DF	—	L3/DF	—	L3/DF[10]	—	—	—	—	—
	<12 in.	302-20	10%L2/DF[10,11]	—	L3/DF	—	L3/DF[10]	—	—	—	—	—
	12 to 15 in.	302-20	10%L2/DF[10,11]	—	L3/DF	—	L3/DF[10]	—	—	—	—	—
	>15 in.	302-20	L3/DF[10,11]	—	L3/DF	—	L3/DF[10,11]	—	—	—	—	—
EWS	<12 in.	—	15%L1CL/DF[10]	15%L2/DF	L3/DF	5%L2/DF	10%L2/DF[10]	10% 1:14	—	—	—	—
20F-V4/WS	12 to 15 in.	—	20%L1CL/DF[10]	25%L2/DF	L3/DF	10%L2/DF	10%L2D/DF	10% 1:14	—	—	—	—
	<12 in.	302-20	10%L1CL/DF[10]	—	L3/DF	—	10%L2/DF[10]	—	—	—	—	—
	12 to 15 in.	302-20	10%L1CL/DF[10]	—	L3/DF	—	10%L2/DF[10]	—	—	—	—	—
	>15 in.	302-22	5%L1CL/DF[10,11]	10%L2/DF	L3/DF	—	5%L2/DF[10]	5% 1:14	—	—	—	—
EWS	<12 in.	302-20	15%L1D/AC	10%L2/AC	L3/AC	15%L2/AC	10%L1D/AC	—	—	—	—	—
20F-V12/WS	12 to 15 in.	302-22	15%L1D/AC	10%L2/AC	L3/AC	15%L2/AC	10%L1D/AC	—	—	—	—	—
	>15 in.	302-24	10%L1S/AC	10%L1D/AC	L3/AC	10%L2/AC	10%L1D/AC	5% 1:16	—	—	—	—
EWS	<12 in.	302-20	15%L1/DF	15%L2/DF	L3/DF	10%L2/DF	10%L2D/DF	—	—	—	—	—
24F-V4/WS	12 to 15 in.	302-22	15%L1/DF	15%L2/DF	L3/DF	10%L2/DF	10%L2D/DF	—	—	—	—	—
	>15 in.	302-24	10%L1/DF	10%L2/DF	L3/DF	10%L2/DF	10%L2D/DF	5% 1:16	—	—	—	—
	<12 in.	302-20	15%L1/DF	15%L2/DF	L3/DF	10%L2/DF	10%L1/DF	—	—	—	—	—
	12 to 15 in.	302-22	15%L1/DF	15%L2/DF	L3/DF	10%L2/DF	10%L1/DF	—	—	—	—	—
	>15 in.	302-24	10%L1/DF	10%L2/DF	L3/DF	10%L2/DF	10%L1/DF	5% 1:16	—	—	—	—
EWS	<12 in.	302-20	20%L1/DF	20%L1/HF	L3/HF	20%L2/HF	20%L2D/DF	—	—	—	—	—
24F-V5/WS	12 to 15 in.	302-22	20%L1/DF	20%L1/HF	L3/HF	20%L2/HF	20%L2D/DF	—	—	—	—	—
	>15 in.	302-24	15%L1/DF	20%L1/HF	L3/HF	10%L2/HF	10%L2D/DF	5% 1:16	—	—	—	—
EWS	4 lams	302-20	30%L1/DF	—	1.4E/SPF	—	10%L2D/DF	5% 1:16	—	—	—	—
24F-V5M1	5 lams to <12 in.	302-20	10%L1/DF	10%1.8E/SPF	1.4E/SPF	10%1.8E/SPF	10%L2D/DF	5% 1:16	—	—	—	—
1.8E 1050Ft				or 10%L2/DF		or 10%L2/DF						
/WS	12 to 15 in.	302-22	15%L1/DF	10%1.8E/SPF	1.4E/SPF	10%1.8E/SPF	10%L2D/DF	5% 1:16	—	—	—	—
				or 10%L2/DF		or 10%L2/DF						
	>15 in.	302-24	15%L1/DF	10%1.8E/SPF	1.4E/SPF	10%1.8E/SPF	10%L2D/DF	5% 1:16	—	—	—	—
				or 10%L2/DF		or 10%L2/DF						
The following combination is NOT BALANCED and shall be applicable to members having a depth of 27 inches or less.												
EWS	<12 in.	302-20	20%L1/DF	20%L1/HF	L3/HF	20%L2/HF	20%L2D/DF	5% 1:14	—	—	—	—
24F-V5M2	12 to 15 in.	302-22	20%L1/DF	20%L1/HF	L3/HF	20%L2/HF	20%L2D/DF	5% 1:16	—	—	—	—
1.8E/WS	>15 to 27 in.	302-24	15%L1/DF	20%L1/HF	L3/HF	10%L2/HF	10%L2D/DF	5% 1:16	—	—	—	—
The following combination is NOT BALANCED and shall be applicable to members having a depth of 24 inches or less.												
EWS	<12 in.	302-20	15%L1/DF	20%L2/HF	L3/HF	20%L2/HF	10%L2D/DF	5% 1:16	—	—	—	—
24F-V5M3	12 to 15 in.	302-22	15%L1/DF	20%L2/HF	L3/HF	20%L2/HF	15%L2D/DF	5% 1:16	—	—	—	—
1.8E/WS	15 to 24 in.	302-24	15%L1/DF	20%L2/HF	L3/HF	20%L2/HF	10%L2D/DF	5% 1:16	—	—	—	—

TABLE 3 (Continued)

GRADE REQUIREMENTS FOR MEMBERS STRESSED PRINCIPALLY IN BENDING AND LOADED PERPENDICULAR TO THE WIDE FACES OF LAMINATIONS[1,2]

			Minimum Grade of Laminations[4,5,6,7]									
			Percent/Grade/Species Each Zone[8]					Percent/Slope of Grain[9]				
Combination Symbol	Depth of Member	Tension Lam[3]	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone
1	2	3	4	5	6	7	8	9	10	11	12	13
VISUALLY GRADED WESTERN SPECIES (WS)												
The following combinations are NOT BALANCED and are intended for straight or slightly cambered members for dry use and industrial appearance, and shall be applicable to members having a depth of 9 to 20 laminations.												
EWS 24F-V4M1[15] /WS	9 lams to ≤ 15 in.	302-22	15%L1/DF	15%L2/DF	L3/DF	10%L2/DF	10%L2D/DF or 10%L1/DF	—	—	—	—	—
	>15 in. to 20 lams	302-24	10%L1/DF	10%L2/DF	L3/DF	10%L2/DF	10%L2D/DF or 10%L1/DF	5% 1:16	—	—	—	—
EWS 24F-V4M2[16] 200Fvx/WS	9 lams to ≤ 15 in.	302-22	15%L1/DF	15%L2/DF	L3/DF	10%L2/DF	10%L2D/DF or 10%L1/DF	—	—	—	—	—
	>15 in. to 20 lams	302-24	10%L1/DF	10%L2/DF	L3/DF	10%L2/DF	10%L2D/DF or 10%L1/DF	5% 1:16	—	—	—	—
The following combinations are BALANCED and are intended for members continuous or cantilevered over supports and provide equal capacity in both positive and negative bending (Footnote No. 3 applies both top and bottom of bending members).												
EWS 20F-V8/WS	<12 in.	—	15%L1CL/DF[10]	20%L2/DF	L3/DF	20%L2/DF	15%L1CL/DF[10]	10% 1:14	—	—	—	10% 1:14
	12 to 15 in.	—	15%L1CL/DF[10]	20%L2/DF	L3/DF	20%L2/DF	15%L1CL/DF[10]	10% 1:14	—	—	—	10% 1:14
	<12 in.	302-20	10%L1CL/DF[10]	—	L3/DF	—	10%L1CL/DF[10]	—	—	—	—	—
	12 to 15 in.	302-20	10%L1CL/DF[10]	—	L3/DF	—	10%L1CL/DF[10]	—	—	—	—	—
	>15 in.	302-22	5%L1CL/DF[10,11]	5%L2/DF	L3/DF	5%L2/DF	5%L1CL/DF[10,11]	—	—	—	—	—
EWS 20F-V13/WS	<12 in.	302-20	15%LID/AC	10%L2/AC	L3/AC	10%L2/AC	15%LID/AC	—	—	—	—	
	12 to 15 on.	302-22	15%LID/AC	10%L2/AC	L3/AC	10%L2/AC	15%LID/AC	—	—	—	—	
	>15 in.	302-24	10%LIS/AC	10%LID/AC	L3/AC	10%LID/AC	10%LIS/AC	5% 1:16	—	—	—	5% 1:16
EWS 24F-V8/WS	<12 in.	302-20	10%L1/DF	10%L2/DF	L3/DF	10%L2/DF	10%L1/DF	—	—	—	—	—
	12 to 15 in.	302-22	10%L1/DF	10%L2D/DF	L3/DF	10%L2D/DF	10%L1/DF	—	—	—	—	—
	>15 in.	302-24	10%L1/DF	5%L2/DF	L3/DF	5%L2/DF	10%L1/DF	5% 1:16	—	—	—	5% 1:16
EWS 24F-V10/WS	<12 in.	302-20	20%L1/DF	10%L2/HF	L3/HF	10%L2/HF	20%L1/DF	—	—	—	—	—
	12 to 15 in.	302-22	20%L1/DF	10%L2/HF	L3/HF	10%L2/HF	20%L1/DF	—	—	—	—	—
	>15 in.	302-24	15%L1/DF	15%L2/HF	L3/HF	15%L2/HF	15%L1/DF	5% 1:16	—	—	—	5% 1:16
The following combinations are BALANCED and are intended for straight or slightly cambered members for dry use and industrial appearance, and shall be applicable to members having a depth of 9 to 20 laminations.												
EWS 24F-V8M1[15] /WS	9 lams to ≤ 15 in.	302-22	10%L1/DF	10%L2D/DF	L3/DF	10%L2D/DF	10%L1/DF	—	—	—	—	—
	>15 in. to 20 lams	302-24	10%L1/DF	5%L2/DF	L3/DF	5%L2/DF	10%L1/DF	5% 1:16	—	—	—	5% 1:16
EWS 24F-V8 M2[16] 200Fvx /WS	9 lams to ≤ 15 in.	302-22	10%L1/DF	10%L2D/DF	L3/DF	10%L2D/DF	10%L1/DF	—	—	—	—	—
	>15 in. to 20 lams	302-24	10%L1/DF	5%L2/DF	L3/DF	5%L2/DF	10%L1/DF	5% 1:16	—	—	—	5% 1:16
E-RATED WESTERN SPECIES (WS)												
The following combinations are NOT BALANCED and are intended primarily for simple-span applications.												
EWS 20F-E8/WS	<12 in.	302-20	10%B/ES	15%C4/ES	D/ES	15%D4/ES	10%C6/ES	—	—	—	—	—
	12 to 13-1/2 in.	302-22	10%B/ES	15%C4/ES	D/ES	15%D4/ES	10%C6/ES	—	—	—	—	—
	>13-1/2 to 19-1/2 in.	302-22	20%B/ES	10%C4/ES	D/ES	10%D4/ES	15%C6/ES	—	—	—	—	—
	>19-1/2 to 24 in.	302-24	15%B/ES	10%C4/ES	D/ES	15%D4/ES	10%C6/ES	—	—	—	—	—
	>24 in.	302-24	15%B/ES	10%C4/ES	D/ES	10%D4/ES	15%C6/ES	—	—	—	—	—
EWS 24F-E15M1 /WS	<12 in.	302-20[17]	10%2.1E/HF	10%1.9E/HF	L3/HF	10%1.9E/HF	10%2.0E/HF	1/6	1/2	1/2	1/2	1/3
	12 to 15 in.	302-22[17]	10%2.1E/HF	10%1.9E/HF	L3/HF	10%1.9E/HF	10%2.0E/HF	1/6	1/2	1/2	1/2	1/3
	>15 in.	302-24	10%2.1E/HF	10%1.9E/HF	L3/HF	10%1.9E/HF	10%2.0E/HF	1/6	1/2	1/2	1/2	1/3

TABLE 3 (Continued)

GRADE REQUIREMENTS FOR MEMBERS STRESSED PRINCIPALLY IN BENDING AND LOADED PERPENDICULAR TO THE WIDE FACES OF LAMINATIONS[1,2]

			Minimum Grade of Laminations[4,5,6,7]									
			Percent/Grade/Species Each Zone[8]					Percent/Slope of Grain[9]				
Combination Symbol	Depth of Member	Tension Lam[3]	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone
1	2	3	4	5	6	7	8	9	10	11	12	13
E-Rated Western Species (WS)												
The following combinations are NOT BALANCED and are intended primarily for simple-span applications.												
EWS 24F-E	≤ 10-1/2 in.	Special	20%2.0E/CSP	5%1.8E/CSP	1.4E/CSP	5%1.8E/CSP	20%L2D/DF	1/6	1/3	1/2	1/3	—
/CSP3	>10-1/2 in.	rules[14]	5%2.0E/CSP	10%1.8E/CSP	1.4E/CSP	10%1.8E/CSP	5%L2D/DF	1/6	1/3	1/2	1/3	—
EWS 24F-E	≤ 12 in.	Special	20%2.0E/CSP	10%1.8E/CSP	1.4E/CSP	10%1.8E/CSP	20%L2D/DF	1/6	1/3	1/2	1/3	—
/CSP4	<12 in.	rules[14]	20%2.0E/CSP	10%1.8E/CSP	1.4E/CSP	10%1.8E/CSP	20%L2D/DF	1/6	1/3	1/2	1/3	—
EWS 24F-E	4 lams	302-20	5%1.9E/ES	—	B/ES	—	5%1.9E/ES	1/6	—	—	—	1/6
/ES1	5 lams to 10-1/2 in.	302-20	25%1.9E/ES	10%C4/ES	D/ES	10%C4/ES	15%B/ES	1/6	—	—	—	—
	12 to 15 in.	302-22	25%1.9E/ES	10%C4/ES	D/ES	10%C4/ES	20%B/ES	1/6	—	—	—	—
	>15 in.	302-24	25%1.9E/ES	10%C4/ES	D/ES	10%C4/ES	20%B/ES	1/6	—	—	—	—
EWS 24F-E	≤ 10-1/2 in.	Special	20%2.0E/SPF	5%1.8E/SPF	1.4E/SPF	5%1.8E/SPF	20%L2D/DF	1/6	1/3	1/2	1/3	—
/SPF3	>10-1/2 in.	rules[14]	5%2.0E/SPF	10%1.8E/SPF	1.4E/SPF	10%1.8E/SPF	5%L2D/DF	1/6	1/3	1/2	1/3	—
EWS 24F-E	≤ 12 in.	Special	20%2.0E/SPF	10%1.8E/SPF	1.4E/SPF	10%1.8E/SPF	20%L2D/DF	1/6	1/3	1/2	1/3	—
/SPF4	>12 in.	rules[14]	20%2.0E/SPF	10%1.8E/SPF	1.4E/SPF	10%1.8E/SPF	20%L2D/DF	1/6	1/3	1/2	1/3	—
The following combination is not BALANCED and shall be applicable to members having a depth of 9-1/2, 11-7/8, 14, and 16 inches.												
EWS 26F-E	9-1/2 in.	302-22	1-2.3E/DF	1-L2/DF	1-L3/DF	1-L2/DF	2-L1/DF	1/6	—	—	—	—
/DF1			+ 1-L1/DF									
	11-7/8 in.	302-24	2-2.3E/DF	1-L2/DF	1-L3/DF	1-L2/DF	2-L1/DF	1/6	—	—	—	—
			+ 1-L1/DF									
	14 in.	302-24	2-2.3E/DF	1-L2/DF	3-L3/DF	1-L2/DF	2-L1/DF	1/6	—	—	—	—
			+ 1- L1/DF									
	16 in.	302-26	3-2.3E/DF	1-L2/DF	3-L3/DF	1-L2/DF	2-L1/DF	1/6	—	—	—	—
			+ 1- L1/DF									
The following combinations are BALANCED and are intended for members continuous or cantilevered over supports and provide equal capacity in both positive and negative bending (Footnote No. 3 applies both top and bottom of bending members).												
EWS	<12 in.	302-20	10%B/ES	15%C4/ES	D/ES	15%C4/ES	10%B/ES	—	—	—	—	—
20F-E8M1	12 to 13-1/2 in.	302-22	10%B/ES	15%C4/ES	D/ES	15%C4/ES	10%B/ES	—	—	—	—	—
/WS	>13-1/2 to 19-1/2 in.	302-22	20%B/ES	10%C4/ES	D/ES	10%C4/ES	20%B/ES	—	—	—	—	—
	>19-1/2 to 24 in.	302-24	15%B/ES	10%C4/ES	D/ES	10%C4/ES	15%B/ES	—	—	—	—	—
	>24 in.	302-24	15%B/ES	10%C4/ES	D/ES	10%C4/ES	15%B/ES	—	—	—	—	—
EWS 24F-E	≤ 10-1/2 in.	Special	20%2.0E/CSP	5%1.8E/CSP	1.4E/CSP	5%1.8E/CSP	20%2.0E/CSP	1/6	1/3	1/2	1/3	1/6
/CSP1	≤ 10-1/2 in.	rules[14]	5%2.0E/CSP	10%1.8E/CSP	1.4E/CSP	10%1.8E/CSP	5%2.0E/CSP	1/6	1/3	1/2	1/3	1/6
EWS 24F-E	≤ 12 in.	Special	20%2.0E/CSP	10%1.8E/CSP	1.4E/CSP	10%1.8E/CSP	20%2.0E/CSP	1/6	1/3	1/2	1/3	1/6
/CSP2	>12 in.	rules[14]	20%2.0E/CSP	10%1.8E/CSP	1.4E/CSP	10%1.8E/CSP	20%2.0E/CSP	1/6	1/3	1/2	1/3	1/6
EWS 24F-E	≤ 10-1/2 in.	Special	20%2.0E/SPF	5%1.8E/SPF	1.4E/SPF	5%1.8E/SPF	20%2.0E/SPF	1/6	1/3	1/2	1/3	1/6
/SPF1	> 10-1/2 in.	rules[14]	5%2.0E/SPF	10%1.8E/SPF	1.4E/SPF	10%1.8E/SPF	5%2.0E/SPF	1/6	1/3	1/2	1/3	1/6
EWS 24F-E	≤ 2 in.	Special	20%2.0E/SPF	10%1.8E/SPF	1.4E/SPF	10%1.8E/SPF	20%2.0E/SPF	1/6	1/3	1/2	1/3	1/6
/SPF2	>12 in.	rules[14]	20%2.0E/SPF	10%1.8E/SPF	1.4E/SPF	10%1.8E/SPF	20%2.0E/SPF	1/6	1/3	1/2	1/3	1/6

TABLE 3 (Continued)

GRADE REQUIREMENTS FOR MEMBERS STRESSED PRINCIPALLY IN BENDING AND LOADED PERPENDICULAR TO THE WIDE FACES OF LAMINATIONS[1,2]

			Minimum Grade of Laminations[4,5,6,7]									
			Percent/Grade/Species Each Zone[8]					Percent/Slope of Grain[9]				
Combination Symbol	Depth of Member	Tension Lam[3]	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone
1	2	3	4	5	6	7	8	9	10	11	12	13
E-RATED WESTERN SPECIES (WS)												
The following combination is BALANCED and shall be applicable to members having a depth of 7-1/2, 9, 9-1/2, 11-7/8, and 14 inches, and a width of 1-1/2 through 3-1/2 inches.												
EWS 20F-E[19] /SPF1	7-1/2 in.	—	1-B/SPF	1-C4/SPF	6-D/SPF	1-C4/SPF	1-B/SPF	—	—	—	—	—
	9 in.	—	1-B/SPF	1-C4/SPF	8-D/SPF	1-C4/SPF	1-B/SPF	—	—	—	—	—
	9-1/2 in.	—	2-B/SPF	1-C4/SPF	7-D/SPF	1-C4/SPF	2-B/SPF	—	—	—	—	—
	11-7/8 in.	—	2-B/SPF	2-C4/SPF	8-D/SPF	2-C4/SPF	2-B/SPF	—	—	—	—	—
	14 in.	—	3-B/SPF	2-C4/SPF	9-D/SPF	2-C4/SPF	3-B/SPF	—	—	—	—	—
The following combination is BALANCED and shall be applicable to members having a depth of 9-1/2, 11-7/8, 14, and 16 inches.												
EWS 26F-E /DF1M1	9-1/2 in.	302-22	1-2.3E/DF + 1-L1/DF	1-L2/DF	1-L3/DF	1-L2/DF	1-2.3E/DF + 1-L1/DF	1/6	—	—	—	1/6
	11-7/8 in.	302-24	2-2.3E/DF + 1-L1/DF	—	2-L2/DF	—	2-2.3E/DF + 1-L1/DF	1/6	—	—	—	1/6
	14 in.	302-24	2-2.3E/DF + 1-L1/DF	1-L2/DF	2-L3/DF	1-L2/DF	2-2.3E/DF + 1-L1/DF	1/6	—	—	—	1/6
	16 in.	302-26	3-2.3E/DF + 1-L1/DF	1-L2/DF	1-L3/DF	1-L2/DF	3-2.3E/DF + 1-L1/DF	1/6	—	—	—	1/6
VISUALLY GRADED SOUTHERN PINE (SP)												
The following combinations are NOT BALANCED and are intended primarily for simple-span applications.												
EWS 24F-V1/SP	<12 in.	302-20[13]	10%N1D/SP	10%N2D/SP	N3M/SP	10%N2D/SP	10%N1D/SP	10% 1:14	10% 1:8	1:8	10% 1:8	10% 1:10
	12 to 15 in.	302-22	15%N1D/SP	15%N2M/SP	N3M/SP	15%N2M/SP	15%N1M /SP[10]	5% 1:14 + 10% 1:10	15% 1:8	1:8	15% 1:8	5% 1:12 + 10% 1:10
	>15 in.	302-24	15%N1D/SP	15%N2M/SP	N3M/SP	15%N2M/SP	15%N1M /SP[10]	5% 1:16 + 5% 1:12 + 5% 1:10	15% 1:8	1:8	15% 1:8	5% 1:14 + 5% 1:12 + 5% 1:10
EWS 24F-V3/SP	<12 in.	302-20[13]	10%N1D/SP	15%N2D/SP	N2M/SP	10%N2D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	12 to 15 in.	302-22	10%N1D/SP	15%N2D/SP	N2M/SP	10%N2D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:12
	>15 in.	302-24	10%N1D/SP	15%N2D/SP	N2M/SP	10%N2D/SP	10%N1D/SP	5% 1:14 + 5% 1:12	15% 1:8	1:8	10% 1:8	5% 1:12 + 5% 1:10
EWS 26F-V1/SP	7 lams to <12 in.	302-22	10%N1D/SP	15%N1D/SP	N1M/SP	10%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	12 to 15 in.	302-24	10%N1D/SP	15%N1D/SP	N2D/SP	10%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	>15 in.	302-26	10%N1D/SP	15%N2D/SP	N2M/SP	10%N2D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:12
EWS 26F-V2/SP	7 lams to <12 in.	302-22	10%N1D/SP	15%N1D/SP	N2D/SP	10%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	12 to 15 in.	302-24	10%N1D/SP	15%N1D/SP	N2D/SP	10%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	>15 in.	302-26	10%N1D/SP	15%N1D/SP	N2D/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:12
EWS 26F-V3/SP	7 lams to <12 in.	302-22	10%N1D/SP	15%N1D/SP	N1M/SP	10%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	12 to 15 in.	302-24	10%N1D/SP	15%N1D/SP	N1M/SP	10%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	>15 in.	302-26	10%N1D/SP	15%N1D/SP	N1M/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:12

TABLE 3 (Continued)

GRADE REQUIREMENTS FOR MEMBERS STRESSED PRINCIPALLY IN BENDING AND LOADED PERPENDICULAR TO THE WIDE FACES OF LAMINATIONS[1,2]

			Minimum Grade of Laminations[4,5,6,7]									
			Percent/Grade/Species Each Zone[8]					Percent/Slope of Grain[9]				
Combination Symbol	Depth of Member	Tension Lam[3]	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone
1	2	3	4	5	6	7	8	9	10	11	12	13
VISUALLY GRADED SOUTHERN PINE (SP)												
The following combinations are NOT BALANCED and are intended for straight or slightly cambered members for dry use and industrial appearance, and shall be applicable to members having a depth of 9 to 20 laminations.												
EWS 24F-V3M1[15] /SP	9 lams to ≤ 15 in.	302-22	10%N1D/SP	15%N2D/SP	N2M/SP	10%N2D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:12
	>15 in. to 20 lams	302-24	10%N1D/SP	15%N2D/SP	N2M/SP	10%N2D/SP	10%N1D/SP	5% 1:14 + 5% 1:12	15% 1:8	1:8	10% 1:8	5% 1:12 + 5% 1:10
EWS 24F-V3M2[16] 225Fvx/SP	9 lams to ≤ 15 in.	302-20[13]	10%N1D/SP	15%N2D/SP	N2M/SP	10%N2D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	>15 in. to 20 lams	302-24	10%N1D/SP	15%N2D/SP	N2M/SP	10%N2D/SP	10%N1D/SP	5% 1:14 + 5% 1:12	15% 1:8	1:8	10% 1:8	5% 1:12 + 5% 1:10
EWS 26F-V3M1[15] /SP	9 lams to ≤ 15 in.	302-24	10%N1D/SP	15%N1D/SP	N1M/SP	10%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	>15 in. to 20 lams	302-26	10%N1D/SP	15%N1D/SP	N1M/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:12
EWS 26F-V3M2[16] 225Fvx/SP	9 lams to ≤ 15 in.	302-24	10%N1D/SP	15%N1D/SP	N1M/SP	10%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	10% 1:8	10% 1:10
	>15 in. to 20 lams	302-26	10%N1D/SP	15%N1D/SP	N1M/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:12
The following combinations are BALANCED and are intended for members continuous or cantilevered over supports and provide equal capacity in both positive and negative bending (Footnote No. 3 applies both top and bottom of bending members).												
EWS 24F-V5/SP	<12 in.	302-20[13]	10%N1D/SP	5%N2D/SP	N2M/SP	5%N2D/SP	10%N1D/SP	10% 1:14	5% 1:8	1:8	5% 1:8	10% 1:14
	12 to 15 in.	302-22	10%N1D/SP	5%N2D/SP	N2M/SP	5%N2D/SP	10%N1D/SP	10% 1:15	5% 1:10	1:8	5% 1:10	10% 1:15
	>15 in.	302-24	10%N1D/SP	5%N2D/SP	N2M/SP	5%N2D/SP	10%N1D/SP	5% 1:16 + 5% 1:12	5% 1:10	1:8	5% 1:10	5% 1:16 + 5% 1:12
EWS 24F-V5M1 1.8E/SP	<12 in.	302-20	10%N1D/SP	15%N2D/SP	N2M/SP	15%N2D/SP	10%N1D/SP	5% 1:14 + 5% 1:10	15% 1:8	1:8	15% 1:8	5% 1:14 + 5% 1:10
	12 to 15 in.	302-22	10%N1D/SP	15%N2D/SP	N2M/SP	15%N2D/SP	10%N1D/SP	5% 1:16 + 5% 1:10	15% 1:8	1:8	15% 1:8	5% 1:16 + 5% 1:10
	>15 in.	302-24	10%N1D/SP	15%N2D/SP	N2M/SP	15%N2D/SP	10%N1D/SP	5% 1:16 + 5% 1:12	15% 1:8	1:8	15% 1:8	5% 1:16 + 5% 1:12
EWS 26F-V4/SP	7 lams to <12 in.	302-22	10%N1D/SP	15%N1D/SP	N1M or N2D/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:14
	12 to 15 in.	302-24	10%N1D/SP	15%N1D/SP	N1M or N2D/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:14
	>15 in.	302-26	10%N1D/SP	15%N1D/SP	N1M or N2D/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:14
The following combinations are BALANCED and are intended for straight or slightly cambered members for dry use and industrial appearance, and shall be applicable to members having a depth of 9 to 20 laminations.												
EWS 24F-V5M2[15] 1.8E/SP	9 lams to ≤ 15 in.	302-22	10%N1D/SP	15%N2D/SP	N2M/SP	15%N2D/SP	10%N1D/SP	5% 1:16 + 5% 1:10	15% 1:8	1:8	15% 1:8	5% 1:16 + 5% 1:10
	>15 in. to 20 lams	302-24	10%N1D/SP	15%N2D/SP	N2M/SP	15%N2D/SP	10%N1D/SP	5% 1:16 + 5% 1:12	15% 1:8	1:8	15% 1:8	5% 1:16 + 5% 1:12
EWS 24F-V5M3[16] 1.8E 225Fvx /SP	9 lams to ≤ 15 in.	302-22	10%N1D/SP	15%N2D/SP	N2M/SP	15%N2D/SP	10%N1D/SP	5% 1:16 + 5% 1:10	15% 1:8	1:8	15% 1:8	5% 1:16 + 5% 1:10
	>15 in. to 20 lams	302-24	10%N1D/SP	15%N2D/SP	N2M/SP	15%N2D/SP	10%N1D/SP	5% 1:16 + 5% 1:12	15% 1:8	1:8	15% 1:8	5% 1:16 + 5% 1:12

TABLE 3 (Continued)

GRADE REQUIREMENTS FOR MEMBERS STRESSED PRINCIPALLY IN BENDING AND LOADED PERPENDICULAR TO THE WIDE FACES OF LAMINATIONS[1,2]

			Minimum Grade of Laminations[4,5,6,7]									
			Percent/Grade/Species Each Zone[8]					Percent/Slope of Grain[9]				
Combination Symbol	Depth of Member	Tension Lam[3]	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone
1	2	3	4	5	6	7	8	9	10	11	12	13
VISUALLY GRADED SOUTHERN PINE (SP)												
The following combinations are BALANCED and are intended for straight or slightly cambered members for dry use and industrial appearance, and shall be applicable to members having a depth of 9 to 20 laminations.												
EWS 26F-V4M1[15] /SP	9 lams to ≤ 15 in.	302-24	10%N1D/SP	15%N1D/SP	N1M or N2D/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:14
	>15 in. to 20 lams	302-26	10%N1D/SP	15%N1D/SP	N1M or N2D/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:14
EWS 26F-V4M2[16] 225Fvx/SP	9 lams to ≤ 15 in.	302-24	10%N1D/SP	15%N1D/SP	N1M or N2D/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:14
	>15 in. to 20 lams	302-26	10%N1D/SP	15%N1D/SP	N1M or N2D/SP	15%N1D/SP	10%N1D/SP	10% 1:14	15% 1:8	1:8	15% 1:8	10% 1:14
E-RATED SOUTHERN PINE (SP)												
The following combinations are NOT BALANCED and are intended primarily for simple-span applications.												
EWS 28F-E1[12]/SP	≤ 13-3/4 in.	302-24[12]	10%2.3E[12] + 10% N1D 2.3E[12]/SP	10%N1D[12] /SP	N2M/SP	10%N1D[12] /SP	10%N1D 2.3E[12]/SP	1/3 & 10% 1:12 + 10% 1:12	10% 1:12	1:8	10% 1:12	10% 1:12
	>13-3/4 in.	302-24[12]	5%2.3E[12] + 5% N1D 2.3E[12]/SP	15%N1D[12] /SP	N2M/SP	15%N1D[12] /SP	10%N1D 2.3E[12]/SP	1/5 & 5% 1:16 + 5% 1:12	15% 1:12	1:8	15% 1:12	10% 1:12
EWS 28F-E1M1[12]/SP	≤ 13-3/4 in.	302-24[12]	10%2.3E[12] + 10% N1D 2.3E/SP	10%N1D[12] /SP	N2M/SP	15%N1D[12] /SP	10%N1D 2.3E[12]/SP	1/3 & 10% 1:12 + 10% 1:12	10% 1:12	1:8	15% 1:12	10% 1:12
	>13-3/4 in.	302-24[12]	5%2.3E[12] + 5% N1D 2.3E[12]/SP	15%N1D[12] /SP	N2M/SP	15%N1D[12] /SP	15%N1D 2.3E[12]/SP	1/5 & 5% 1:16 + 5% 1:12	15% 1:12	1:8	15% 1:12	15% 1:12
The following combinations are BALANCED and are intended for members continuous or cantilevered over supports and provides equal capacity in both positive and negative bending (Footnote No. 3 applies both top and bottom of bending members).												
EWS 28F-E2[12]/SP	≤ 13-3/4 in.	302-24[12]	10%2.3E[12] + 10% N1D 2.3E[12]/SP	10%N1D[12] /SP	N2M/SP	10%N1D[12] /SP	10%2.3E[12] + 10% N1D 2.3E[12]/SP	1/3 & 10% 1:12 + 10% 1:12	10% 1:12	1:8	10% 1:12	1/3 &10% 1:12 + 10% 1:12
	>13-3/4 in.	302-24[12]	5%2.3E[12] + 5% N1D 2.3E[12]/SP	15%N1D[12] /SP	N2M/SP	15%N1D[12] /SP	5%2.3E[12] + 5% N1D 2.3E[12]/SP	1/5 & 5% 1:16 + 5% 1:12	15% 1:12	1:8	15% 1:12	1/5 & 5% 1:16 + 5% 1:12
EWS 28F-E2M1[12]/SP	≤ 13-3/4 in.	302-24[12]	10%2.3E[12] + 10% N1D 2.3E/SP	10%N1D[12] /SP	N2M/SP	10%N1D[12] /SP	10%2.3E[12] + 10% N1D 2.3E/SP	1/3 & 10% 1:12 + 10% 1:12	10% 1:12	1:8	10% 1:12	1/3 &10% 1:12 + 10% 1:12
	>13-3/4 in.	302-24[12]	5%2.3E[12] + 10% N1D 2.3E/SP	15%N1D[12] /SP	N2M/SP	15%N1D[12] /SP	5%2.3E[12] + 10% N1D 2.3E/SP	1/5 & 5% 1:16 + 10% 1:12	15% 1:12	1:8	15% 1:12	1/5 & 5% 1:16 + 10% 1:12

TABLE 3 (Continued)

GRADE REQUIREMENTS FOR MEMBERS STRESSED PRINCIPALLY IN BENDING AND LOADED PERPENDICULAR TO THE WIDE FACES OF LAMINATIONS[1,2]

			Minimum Grade of Laminations[4,5,6,7]									
			Percent/Grade/Species Each Zone[8]					Percent/Slope of Grain[9]				
Combination Symbol	Depth of Member	Tension Lam[3]	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone
1	2	3	4	5	6	7	8	9	10	11	12	13
E-RATED SOUTHERN PINE (SP)												
The following combination is NOT BALANCED and shall be applicable to members having a nominal width of 6 inches or less.												
EWS 30F-E1[12]/SP	≤ 13-3/4 in.	302-24[12]	10%2.3E[12] + 10% N1D 2.3E[12]/SP	10%N1D[12] /SP	N2M/SP	20%N1D[12] /SP	10%N1D 2.3E[12]/SP	1/3 & 10% 1:12 + 10% 1:12	10% 1:12	1:8	20% 1:12	10% 1:12
	>13-3/4 in.	302-24[12]	5%2.3E[12] + 5% N1D 2.3E[12]/SP	15%N1D[12] /SP	N2M/SP	15%N1D[12] /SP	15%N1D 2.3E[12]/SP	1/5 & 5% 1:16 + 5% 1:12	15% 1:12	1:8	15% 1:12	15% 1:12
The following combination is NOT BALANCED and shall be applicable to members having a nominal width of 6 inches or less, and a depth of 18 inches or less.												
EWS 30F-E1M1[12]/SP	≤ 13-3/4 in.	302-24[12]	10%2.3E[12] + 10% N1D 2.3E[12]/SP	10%N1D[12] /SP	N2M/SP	20%N1D[12] /SP	10%N1D 2.3E[12]/SP	1/3 & 10% 1:12 + 10% 1:12	10% 1:12	1:8	20% 1:12	10% 1:12
	>13-3/4 in. to 18 in.	302-24[12]	5%2.3E[12] + 5% N1D 2.3E[12]/SP	15%N1D[12] /SP	N2M/SP	15%N1D[12] /SP	15%N1D 2.3E[12]/SP	1/5 & 5% 1:16 + 5% 1:12	15% 1:12	1:8	15% 1:12	15% 1:12
The following combination is BALANCED and shall be applicable to members having a nominal width of 6 inches or less.												
EWS 30F-E2[12]/SP	≤ 13-3/4 in.	302-24[12]	10%2.3E[12] + 10% N1D 2.3E[12]/SP	10%N1D[12] /SP	N2M/SP	10%N1D[12] /SP	10%2.3E[12] + 10% N1D 2.3E[12]/SP	1/3 & 10% 1:12 + 10% 1:12	10% 1:12	1:8	10% 1:12	1/3 & 10% 1:12 + 10% 1:12
	>13-3/4 in.	302-24[12]	5%2.3E[12] + 5%N1D 2.3E[12]/SP	15%N1D[12] /SP	N2M/SP	15%N1D[12] /SP	5%2.3E[12] + 5% N1D 2.3E[12]/SP	1/5 & 5% 1:16 + 5% 1:12	15% 1:12	1:8	15% 1:12	1/5 & 5% 1:16 + 5% 1:12
The following combination is BALANCED and shall be applicable to members having a nominal width of 6 inches or less, and a depth of 18 inches or less.												
EWS 30F-E2M1[12]/SP	≤ 13-3/4 in.	302-24[12]	10%2.3E[12] + 10% N1D 2.3E[12]/SP	10%N1D[12] /SP	N2M/SP	10%N1D[12] /SP	10%2.3E[12] + 10% N1D 2.3E[12]/SP	1/3 & 10% 1:12 + 10% 1:12	10% 1:12	1:8	10% 1:12	1/3 & 10% 1:12 + 10% 1:12
	>13-3/4 in. to 18 in.	302-24[12]	5%2.3E[12] + 10% N1D 2.3E[12]/SP	15%N1D[12] /SP	N2M/SP	15%N1D[12] /SP	5%2.3E[12] + 10% N1D 2.3E[12]/SP	1/5 & 5% 1:16 + 10% 1:12	15% 1:12	1:8	15% 1:12	1/5 & 5% 1:16 + 10% 1:12
The following combination is BALANCED and shall be applicable to members having a depth of 16 inches or less.												
EWS 30F-E2M2	9-1/2 in.	—	1-1.50 in. 2.4E LVL[20]	1-1.30 in. N1D2.3E/SP	3-1.30 in. N2M/SP	1-1.30 in. N1D2.3E/SP	1-1.50 in. 2.4E LVL[20]	—	1:12	1:8	1:12	—
2.1E 650F$_{cp}$/SP	11-7/8 in.	—	1-1.75 in. 2.4E LVL[20]	1-1.40 in. N1D2.3E/SP	4-1.40 in. N2M/SP	1-1.40 in. N1D2.3E/SP	1-1.75 in. 2.4E LVL[20]	—	1:12	1:8	1:12	—
	14 in.	—	1-1.50 in. 2.4E LVL[20]	1-1.50 in. N1D2.3E/SP[21]	6-1.34 in. N2M/SP	1-1.50 in. N1D2.3E/SP[21]	1-1.50 in. 2.4E LVL[20]	—	1:12	1:8	1:12	—
	16 in.	—	1-1.75 in. 2.4E LVL[20]	1-1.50 in. N1D2.3E/SP[21]	7-1.36 in. N2M/SP	1-1.50 in. N1D2.3E/SP[21]	1-1.75 in. 2.4E LVL[20]	—	1:12	1:8	1:12	—
The following combination is BALANCED and shall be applicable to members having a depth of 18 inches or less.												
EWS 30F-E2M3	9-1/2 in.	—	1-1.375 in. 2.4E LVL[22]	1-1.35 in. N1D2.3E/SP	3-1.35 in. N2M/SP	1-1.35 in. N1D2.3E/SP	1-1.375 in. 2.4E LVL[22]	—	1:12	1:8	1:12	—
2.1E 510F$_{cp}$/SP	11-7/8 in.	—	1-1.75 in. 2.4E LVL[22]	1-1.40 in. N1D2.3E/SP	4-1.40 in. N2M/SP	1-1.40 in. N1D2.3E/SP	1-1.75 in. 2.4E LVL[22]	—	1:12	1:8	1:12	—
	14 in.	—	1-1.75 in. 2.4E LVL[22]	1-1.31 in. N1D2.3E/SP	6-1.31 in. N2M/SP	1-1.31 in. N1D2.3E/SP	1-1.75 in. 2.4E LVL[22]	—	1:12	1:8	1:12	—
	16 in.	—	1-1.75 in. 2.4E LVL[21]	1-1.50 in. N1D2.3E/SP	7-1.36 in. N2M/SP	1-1.50 in. N1D2.3E/SP	1-1.75 in. 2.4E LVL[22]	—	1:12	1:8	1:12	—
	18 in.	—	1-1.75 in. 2.4E LVL[22]	2-1.32 in. N1D2.3E/SP	7-1.32 in. N2M/SP	2-1.32 in. N1D2.3E/SP	1-1.75 in. 2.4E LVL[22]	—	1:12	1:8	1:12	—

TABLE 3 (Continued)

GRADE REQUIREMENTS FOR MEMBERS STRESSED PRINCIPALLY IN BENDING AND LOADED PERPENDICULAR TO THE WIDE FACES OF LAMINATIONS[1,2]

			Minimum Grade of Laminations[4,5,6,7]									
			Percent/Grade/Species Each Zone[8]					Percent/Slope of Grain[9]				
Combination Symbol	Depth of Member	Tension Lam[3]	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone	Outer Tension Zone	Inner Tension Zone	Core	Inner Comp. Zone	Outer Comp. Zone
1	2	3	4	5	6	7	8	9	10	11	12	13
E-RATED DURANGO PINE (DP)												
The following combinations are NOT BALANCED and are intended primarily for simple-span applications.												
EWS	<12 in.	—	10%2.1E/DP	—	N2M/DP	—	10%1.9E/DP[18]	1/6	—	—	—	1/2
16F-E1/DP	12 to 15 in.	—	10%2.1E/DP	—	N2M/DP	—	10%1.9E/DP[18]	1/6	—	—	—	1/2
	<12 in.	302-20	10%1.9E/DP[18]	—	N2M/DP	—	10%1.9E/DP[18]	1/6	—	—	—	1/2
	12 to 15 in.	302-20	10%1.9E/DP[18]	—	N2M/DP	—	10%1.9E/DP[18]	1/6	—	—	—	1/2
	>15 in.	302-20	10%1.9E/DP[18]	—	N2M/DP	—	5%1.9E/DP[18]	1/6	—	—	—	1/2
EWS	<12 in.	—	20%2.1E/DP	—	N2M/DP	—	10%2.1E/DP	1/6	—	—	—	1/2
20F-E1/DP	12 to 15 in.	—	15%2.1E/DP	15%1.9E/DP	N2M/DP	—	10%2.1E/DP	1/6	1/6	—	—	1/2
	<12 in.	302-20	10%2.1E/DP	—	N2M/DP	—	10%1.9E/DP[18]	1/6	—	—	—	1/2
	12 to 15 in.	302-20	10%2.1E/DP	10%1.9E/DP	N2M/DP	—	10%1.9E/DP[18]	1/6	1/6	—	—	1/2
	>15 in. to 19-1/2 in.	302-20	5%2.1E/DP	5%1.9E/DP	N2M/DP	—	5%1.9E/DP[18]	1/6	1/6	—	—	1/2
	>19-1/2 in.	302-22	15%1.9E/DP[18]	—	N2M/DP	—	15%1.9E/DP[18]	1/6	—	—	—	1/2
EWS	<12 in.	302-20	10%2.1E/DP	20%1.9E/DP	N2M/DP	—	10%2.1E/DP	1/6	1/6	—	—	1/2
24F-E1/DP	12 to 15 in.	302-22	10%2.1E/DP	20%1.9E/DP	N2M/DP	—	10%2.1E/DP	1/6	1/6	—	—	1/2
	>15 in.	302-24	10%2.1E/DP	10%1.9E/DP	N2M/DP	10%1.9E/DP	10%1.9E/DP[18]	1/6	1/6	—	1/2	1/2
The following combinations are BALANCED and are intended for members continuous or cantilevered over supports and provide equal capacity in both positive and negative bending (Footnote No. 3 applies both top and bottom of bending members).												
EWS	<12 in.	—	10%1.9E/DP[18]	—	N2M/DP	—	10%1.9E/DP[18]	1/6	—	—	—	1/6
16F-E3/DP	12 to 15 in.	—	10%1.9E/DP[18]	—	N2M/DP	—	10%1.9E/DP[18]	1/6	—	—	—	1/6
	>15 in.	302-20	10%1.9E/DP[18]	—	N2M/DP	—	10%1.9E/DP[18]	1/6	—	—	—	1/6
EWS	<12 in.	—	10%2.1E/DP	10%1.9E/DP	N2M/DP	10%1.9E/DP	10%2.1E/DP	1/6	1/6	—	1/6	1/6
20F-E3/DP	12 to 15 in.	—	10%2.1E/DP	10%1.9E/DP	N2M/DP	10%1.9E/DP	10%2.1E/DP	1/6	1/6	—	1/6	1/6
	<12 in.	302-20	10%1.9E/DP[18]	10%1.9E/DP	N2M/DP	10%1.9E/DP	10%1.9E/DP[18]	1/6	1/6	—	1/6	1/6
	12 to 15 in.	302-20	10%1.9E/DP[18]	10%1.9E/DP	N2M/DP	10%1.9E/DP	10%1.9E/DP[18]	1/6	1/6	—	1/6	1/6
	>15 in. to 19-1/2 in.	302-20	5%2.1E/DP	5%1.9E/DP	N2M/DP	5%1.9E/DP	5%2.1E/DP	1/6	1/6	—	1/6	1/6
	>19-1/2 in.	302-22	10%1.9E/DP[18]	5%1.9E/DP	N2M/DP	5%1.9E/DP	10%1.9E/DP[18]	1/6	1/6	—	1/6	1/6
EWS	<12 in.	302-20	10%2.1E/DP	20%1.9E/DP	N2M/DP	20%1.9E/DP	10%2.1E/DP	1/6	1/6	—	1/6	1/6
24F-E4/DP	12 to 15 in.	302-22	10%2.1E/DP	20%1.9E/DP	N2M/DP	20%1.9E/DP	10%2.1E/DP	1/6	1/6	—	1/6	1/6
	>15 in.	302-24	10%2.1E/DP	10%1.9E/DP	N2M/DP	10%1.9E/DP	10%2.1E/DP	1/6	1/6	—	1/6	1/6

(1) The combinations in this table are primarily applicable to members stressed in bending due to a load applied perpendicular to the wide faces of the laminations.

(2) The combinations are applicable to arches, compression members, tension members and bending members. For bending members, Footnote No. 3 applies. All combinations are applicable to members with four or more laminations. The tension lamination requirements in Footnote No. 3 do not apply to arches, compression members or tension members.

(3) In addition to the grade requirements tabulated for the outer tension zone, the grading restrictions as contained in AITC 302-24, 302-22 and 302-20 tension lamination requirements are applicable to the outer 5 percent of the total depth of bending members. These tension lamination requirements are shown in Column 3. E-rated tension laminations conforming to C1.3, C2.3 or C3.3 of Annex C in AITC 117—Manufacturing are permitted to be used with visually graded combinations provided Douglas fir-larch and southern pine laminations have a 2.0E and hem-fir laminations have a 1.8E. For EWS 20F-V4 and EWS 20F-V8 WS from 4 lams to 15 inches in depth, the required 302-20 tension laminations used with L1/DF outer tension zone laminations need not be upgraded to 1:14 slope of grain. Where 302-20 tension laminations are used in conjunction with L2, L2D or L3 outer tension zone laminations, the required slope of grain is 1:12. The 302-tension lamination required for some bending members is permitted to be omitted provided Footnote No. 7 to Table 1 applies. This reduction does not apply to arches which do not require special tension laminations.

(4) Percent values are based on the total depth of the member. All fractional numbers of laminations shall be rounded upward to the next whole number. For the inner tension and compression zones, the resulting excess of percentage resulting from rounding upward of the outer zone is permitted to be subtracted from the inner zone requirements. The actual depth of the member shall be used to determine the tension lamination requirements from Column 3. In no case shall the tension lamination requirements in Footnote No. 3 be less than 5 percent of the total depth of the member in inches.

(5) The following substitutions of E-Rated Douglas fir-larch lumber are permitted for EWS 24F-V4 and EWS 24F-V8 WS with at least 7 laminations in depth:

Douglas Fir-Larch Visual Grade	Member Location	Douglas Fir-Larch E-Rated Substitution Grades
L1	Tension Side	2.2E-2 (2.2E-3 in outer tension zone)
	Comp. Side	2.2E-2, 2.0E-3
L2D	Tension Side	2.2E-2 (2.2E-3 in outer tension zone), 2.0E-3
	Comp. Side	1.9E-2*
L2	Tension Side	1.9E-6, 2.0E-3
	Comp. Side	1.9E-2

*7- and 8-lam beams shall be 1.9E-6. The substitution of 1.9E-2 for an L2D does not apply to the outermost compression lam.

(6) The combinations in this table have been established based on procedures given in ASTM D 3737 as modified by subsequent research.

(7) Where specified to have an extreme fiber in bending stress on the compression side which results in tension on the compression (top) side greater than the value given in Column 4, Table 1 (except for balanced combinations but not exceeding 200 psi higher than the value in Column 4) tension zone end joint spacing restrictions shall be applied to both the tension and compression zones.

(8) Grade designations are as follows:

Visually Graded – Western Species

L1 is L1 laminating grade (dense for Douglas fir-larch and Douglas fir south)

L1D is L1 dense laminating grade for hem-fir and Alaska cedar

L1S is a special grade of Alaska cedar

L1CL is L1 close grain laminating grade

L2D is L2 dense laminating grade (dense)

L2 is L2 laminating grade (medium grade)

L3 is L3 laminating grade (medium grade for Douglas fir-larch, Douglas fir south and hem-fir)

Visually Graded – Southern Pine or Durango Pine

N1D is No. 1 dense structural joists and planks or structural light framing grade or No. 1 boards both graded as dense

N2D is No. 2 dense structural joists and planks or structural light framing grade or No. 2 boards both graded as dense

N1M is No. 1 structural joists and planks or structural light framing grade or No. 1 boards both with medium grain rate of growth

N2M is No. 2 structural joists and planks or structural light framing grade or No. 2 boards with a medium grain rate of growth

N3M is No. 3 structural joists and planks or structural light framing grade or No. 3 boards both with a medium grain rate of growth

E-Rated Grades – All Species (examples)

2.0E-6 has 2.0E with 1/6 edge characteristic

1.8E-3 has 1.8E with 1/3 edge characteristic

1.4E-2 has 1.4E with 1/2 edge characteristic

E-Rated Grades – Eastern Spruce

B/ES has a minimum long-span E of 1.55 x 10^6 psi

C6/ES has a minimum long-span E of 1.6 x 10^6 psi

C4/ES has a minimum long-span E of 1.4 x 10^6 psi

D4/ES has a minimum long-span E of 1.4 x 10^6 psi

D/ES has no minimum long-span E requirement

These Eastern Spruce referenced herein shall apply to the following species grown in the United States or Canada: White spruce, Black spruce, and Red spruce. In addition to the minimum long-span E given above, these laminating lumber shall be graded in accordance with the requirements in CSA Standard O122.

(9) Where slope of grain is not tabulated, it shall be the slope of grain required for the grade. Slope of grain is not specified for E-rated lumber except for tension laminations, but slope near the ends of the piece shall not be steeper than slopes of grain in the remainder of the piece.

(10) When required to have 650 psi compression perpendicular to grain design value for Douglas fir-larch or 740 psi for southern pine, at least one 2-inch nominal thickness lamination of dense Douglas fir-larch for western species, or dense southern pine for southern pine species, shall be used in place of the tabulated lamination in the bearing area, provided the next inner lamination is medium grain Douglas fir-larch or southern pine.

(11) For Western species combinations EWS 16F-V3, EWS 20F-V4, and EWS 20F-V8, the next inner 5 percent of the outermost tension laminations are required to be L2D/DF for the same conditions indicated by Footnote No. 3. The excess of percentage of the outer 5 percent required by Footnote No. 3 resulting from rounding upward is permitted to be subtracted from the next inner 5 percent required by this footnote.

(12) For the manufacture of 28F and 30F (limited to a nominal beam width of 6" or less) southern pine members, quality control procedures for daily QC monitoring of the average and minimum MOE of the E-rated grades shall be established. End joints for the tension laminations shall be qualified at 1.67 x 3,000 = 5,010 psi. Following initial qualification, daily QC shall be maintained through the use of a statistical process control methodology. The visually-graded and E-rated laminations shall meet the following requirements:

Grade	Grade Requirements
2.3E-5&16 Tension Lam	Must meet all requirements for 302-24 tension lam; Average MOE ≥ 2.3 x 10^6 psi with no piece less than 1.96 x 10^6 psi; Edge characteristics ≤ 20%; Centerline characteristics ≤ 25%; Slope of grain ≤ 1/16; Both ends shall be dense.
2.3E-3&12 Tension Lam	Must meet all requirements for 302-24 tension lam; Average MOE ≥ 2.3 x 10^6 psi with no piece less than 1.96 x 10^6 psi; Edge characteristics ≤ 33%; Centerline characteristics ≤ 33%; Slope of grain ≤ 1/12; Both ends shall be dense.
N1D 2.3E	Average MOE ≥ 2.3 x 10^6 psi with no piece less than 1.96 x 10^6 psi; Slope of grain ≤ 1/12.
N1D	Average MOE ≥ 2.0 x 10^6 psi with no piece less than 1.67 x 10^6 psi; Slope of grain ≤ 1/12.

(13) The 302 grade tension laminations are included in C1, C2, and C3 of AITC 117—Manufacturing. When used in the indicated depth range with this combination, the laminating lumber shall have a slope of grain not steeper than that shown in Column 9 for the outer tension zone. This footnote applies to the 302-20 requirement of EWS 24F-V1, EWS 24F-V3, and EWS 24F-V5 southern pine.

(14) In addition, the 2.0E lam material shall be visually graded in accordance with provisions of Section C14.2, AITC 117-Manufacturing (alternate provisions for 302 tension lam) with the exception that general slope of grain restrictions are not applicable.

(15) This combination contains wane. Therefore, it shall be used in dry conditions only and the wet-use factors shall not be applied. Wane lumber is allowed for use with the following restrictions: (a) Maximum wane is 1/6 of the finished member width; (b) No wane is allowed for the outer top and bottom lams; (c) No wane is allowed for the 302 tension lams; (d) No wane is allowed in the central 40% of the member depth; (e) Maximum wane is 1/2 the lam thickness for No. 1 or L1 and 2/3 the thickness for No. 2 or L2; (f) Wane is allowed only on one side of the finished member; and (g) The first interior lam from the top or bottom shall have the wane located away from the outside lam.

(16) This combination contains wane. Therefore, it shall be used in dry conditions only and the wet-use factors shall not be applied. Wane lumber is allowed for use with the following restrictions: (a) Maximum wane is 1/6 of the finished member width; (b) No wane is allowed for the outer top and bottom lams; (c) No wane is allowed for the 302 tension lams; (d) Maximum wane is 1/2 the lam thickness for No. 1 or L1 and 2/3 the thickness for No. 2 or L2; (e) Wane is allowed only on one side of the finished member; and (f) The first interior lam from the top or bottom shall have the wane located away from the outside lam.

(17) The outer 5% tension lamination(s) shall have a slope of grain not steeper than 1:16.

(18) Where specified to have 650 psi compression perpendicular to grain design value for Douglas fir-Larch, or 740 psi for southern pine or Durango pine, at least one 2-inch nominal thickness lamination of Douglas fir-larch for western species combinations, southern pine for southern pine combinations, and Durango pine for Durango pine combinations having a modulus of elasticity *(E)* value 200,000 psi higher than the specified E values shall be used in the bearing area provided the next inner lamination is at least 1.9E modulus of elasticity.

(19) The layup requires the use of 1x laminations with a maximum nominal width of 4 inches. Only one ripping is permitted to achieve the specific beam width without varying the basic grade requirements of the full-width laminating lumber.

(20) 2.4E LVL used in this layup combination is laminated veneer lumber with a minimum average long-span E (flatwise) of 2.4 x 10^6 psi and a characteristic tensile strength (fifth percentile with 75% confidence) of 5,400 psi. The allowable compressive stress perpendicular to grain of the LVL shall not be less than 650 psi.

(21) The N1D2.3E/SP is permitted to be replaced by L1D2.3E/DF in this layup combination, which shall meet all requirements for dense L1/DF. In addition, the L1D2.3E/DF shall have a minimum average long-span E of 23 x 10^6 psi with no piece less than 1.96 x 10^6 psi. The slope of grain shall be no steeper than 1:14.

(22) 2.4E LVL used in this layup is laminated veneer lumber with a minimum average long-span E (flatwise) of 2.4 x 10^6 psi and a characteristic tensile strength (fifth percentile with 75% confidence) of 6,400 psi. The allowable compressive stress perpendicular to grain of the LVL shall not be less than 510 psi.

TABLE 4

GRADE REQUIREMENTS FOR MEMBERS WITH TWO OR MORE LAMINATIONS STRESSED PRINCIPALLY IN BENDING PARALLEL TO THE WIDE FACES OF THE LAMINATIONS[1,2,3,4]

Combination Number	Minimum Grade of Laminations[5]	Species	Tension Laminations Required[6]			Slope of Grain
			4 lams to <12 in. deep	12 in. to 15 in. deep	>15 in. deep	
1	2	3	4	5	6	7
VISUALLY GRADED WESTERN SPECIES (WS)						
EWS 1	L3	DF	302-20	302-20	302-20	1:8
EWS 2	L2	DF	302-20	302-20	302-20	1:12
EWS 3	L2D	DF	302-20	302-22	302-24	1:12
EWS 5	L1	DF	302-20	302-22	302-24	1:14
EWS 22[7]	L3	WW	302-20	302-20	302-20	1:8
EWS 70	L2	AC	302-20	302-20	302-20	1:12
VISUALLY GRADED SOUTHERN PINE (SP)						
EWS 47	N2M	SP	302-20	302-20	302-20	1:14[8]
EWS 48	N2D	SP	302-20	302-20	302-20	1:14[8]
EWS 49	N1M	SP	302-20	302-20	302-22	1:16[8]
EWS 50	N1D	SP	302-20	302-22	302-24	1:14[8]
The following combination is intended for dry use and industrial appearance[9], and shall be applicable to members having a depth of 9 to 20 laminations.						
EWS 49M1[10]	N1M[10]	SP	Not permitted	302-20	302-22	1:16[8]
The following combination is intended for dry use and industrial appearance[9], and shall be applicable to members having a depth of 4 to 20 laminations.						
EWS 49M2[11] 225Fvx/SP	N1M[11]	SP	302-20	302-20	302-22	1:16[8]

(1) The tension laminations required by this table are to be used only when the design values for bending about the x-x axis (F_{bx}) exceed those listed in Column 16 of Table 2, but are not greater than those listed in Column 17. These tension laminations are permitted to be omitted for bending members over 15 inches deep provided the design value in Column 17 is multiplied by 0.75. This reduction does not apply to arches which do not require special tension laminations.

(2) The tabulated combinations in this table are primarily intended for members loaded axially or in bending with the loads acting parallel to the wide faces of the laminations. The combinations are also permitted to be used as bending members loaded perpendicular to the wide faces of the laminations; however, combinations in Table 3 for four or more laminations are usually better suited for this condition of loading.

(3) It is not intended that these combinations be used for deep bending members which are loaded perpendicular to the wide faces of the laminations. If higher design values in bending about the x-x axis are specified for these combinations than those contained in Table 2, Column 16, see Footnote No. 1.

(4) The allowable wane permitted in some grades in Table 3 is not allowed for combinations in this table.

(5) Grade designations are the same as Footnote No. 8 to Table 3.

(6) The outer 5 percent of laminations on the tension side of bending members shall be replaced with the tension lamination shown in this table. Percent values are based on the total depth of members. Laminations of different thicknesses shall be permitted to be used in the same member provided that the total thickness of tension lamination(s) equals or exceeds 5 percent of the depth.

(7) The following species or species groups shall be permitted to be used for softwood species (WW) provided the design values in modulus of elasticity (E) in Column 4 of Table 2 are reduced by 100,000 psi: Western cedars, Western cedars (North), White woods (Western woods) and California redwood - open grain.

The following species or species groups shall be permitted to be used for softwood species (WW) provided the design values in shear parallel to grain in Columns 13, 14, and 15 (F_{vy}), and Column 18 (F_{vx}) of Table 2 are reduced by 10 psi and the design values in shear parallel to grain in Column 12 (F_{vy}) of Table 2 are reduced by 5 psi: coast Sitka spruce, coast species, western white pine, and eastern white pine (north).

(8) When the designer uses the reduced stresses as indicated in Footnote No. 1 to Table 2 and so specifies or else specifies only a given stress and the manufacturer selects the combination to use, the slope of grain for the combination shall be permitted to be as follows, depending on the design value specified (see Table 2):

Combination	Slope of Grain
EWS 47 and 48	1:8, 1:10 or 1:12
EWS 49, 50, 50M1, and 50M2	1:10 or 1:12

(9) Footnote No. 14 to Table 1 applies.

(10) Footnote No. 15 to Table 3 applies.

(11) Footnote No. 16 to Table 3 applies.

Member Sizes

In addition to specifying the allowable design stresses, it is also necessary to specify the size of member required. While glulam can be manufactured in virtually any cross-sectional size and length required, it is important to understand that since glulam is manufactured using dimension lumber, certain widths and depths become de facto standards which should be specified whenever possible. Table 5 provides typical net finished widths for glulam.

The depths of glulam are typically specified in multiples of 1-1/2" for Western species and 1-3/8" for southern pine. Thus, a 10 lamination member using Western species will have a net depth of 15" while a 10 lamination southern pine member will have a net depth of 13-3/4". Other thicknesses of laminations may be specified but these will require a custom order. An example would be the use of 3/4" thick laminations to produce members with a tight radius of curvature such as occurs in most arch members.

When used in conjunction with I-joists, glulam may be supplied in I-joist compatible (IJC) depths. For residential construction, these are 9-1/2", 11-7/8", 14" and 16". Section properties for these depths are shown in Tables 6 and 7 for 3-1/2" and 5-1/2" net widths.

TABLE 5

TYPICAL NET FINISHED GLULAM WIDTHS

Nominal Width	3	4*	6*	8	10	12
Western species	2-1/2	3-1/8	5-1/8	6-3/4	8-3/4	10-3/4
Southern pine	2-1/2	3	5	6-3/4	8-1/2	10-1/2

* For the 4 inch and 6 inch nominal widths, glulam may also be available in 3-1/2" and 5-1/2" widths respectively. These "full-width" members correspond to the dimensions of 2x4 and 2x6 framing lumber and are supplied with "hit or miss" surfacing which is only acceptable for concealed applications. For additional information on the appearance characteristics of glulam, see EWS Technical Note Y110, *Glued Laminated Timber Appearance Classifications for Construction Applications*.

Section Properties

Tables 6 and 7 provide net section properties for both Western species and southern pine glulam. Other sizes are also available.

Further Information

In addition to properly specifying the member size and allowable design properties, other considerations associated with the proper design of glulam include providing proper bearing support, assuring adequate lateral bracing and detailing connections to account for all in-service loads and environmental considerations.

APA, in conjunction with Eagle Point Software, has developed a comprehensive beam and column design sizing software program called WOODCAD.

For further information on WOODCAD or any other aspect of specifying or using glued laminated timber, contact APA's Engineered Wood Systems at the address listed on the back page.

TABLE 6

DOUGLAS-FIR GLUED LAMINATED BEAM SECTION PROPERTIES AND CAPACITIES

F_b = 2,400 PSI, E = 1,800,000 PSI, F_v = 240 PSI

3-1/8-INCH WIDTH

Depth (in.)	6	7-1/2	9	10-1/2	12	13-1/2	15	16-1/2	18	19-1/2	21	22-1/2	24	25-1/2	27
Beam Weight (lb/ft)	4.6	5.7	6.8	8.0	9.1	10.3	11.4	12.5	13.7	14.8	16.0	17.1	18.2	19.4	20.5
A (in.^{2})	18.8	23.4	28.1	32.8	37.5	42.2	46.9	51.6	56.3	60.9	65.6	70.3	75.0	79.7	84.4
S (in.^{3})	19	29	42	57	75	95	117	142	169	198	230	264	300	339	380
I (in.^{4})	56	110	190	301	450	641	879	1170	1519	1931	2412	2966	3600	4318	5126
EI (106 lb-in.^{2})	101	198	342	543	810	1153	1582	2106	2734	3476	4341	5339	6480	7773	9226
Moment Capacity (lb-ft)	3750	5859	8438	11484	15000	18984	23438	28359	33750	39609	45938	52734	60000	67734	75938
Shear Capacity (lb)	3000	3750	4500	5250	6000	6750	7500	8250	9000	9750	10500	11250	12000	12750	13500

3-1/2-INCH WIDTH

Depth (in.)	6	7-1/2	9	10-1/2	12	13-1/2	14	15	16	16-1/2	18	19-1/2	21	22-1/2	24
Beam Weight (lb/ft)	5.1	6.4	7.7	8.9	10.2	11.5	11.9	12.8	136	14.0	15.3	16.6	17.9	19.1	20.4
A (in.^{2})	21.0	26.3	31.5	36.8	42.0	47.3	49.0	52.5	560	57.8	63.0	68.3	73.5	78.8	84.0
S (in.^{3})	21	33	47	64	84	106	114	131	149	159	189	222	257	295	336
I (in.^{4})	63	123	213	338	504	718	800	984	1195	1310	1701	2163	2701	3322	4032
EI (106 lb-in.^{2})	113	221	383	608	907	1292	1441	1772	2150	2358	3062	3893	4862	5980	7258
Moment Capacity (lb-ft)	4200	6563	9450	12863	16800	21263	22867	26250	29867	31763	37800	44363	51450	59063	67200
Shear Capacity (lb)	3360	4200	5040	5880	6720	7560	7840	8400	8960	9240	10080	10920	11760	12600	13440

5-1/8-INCH WIDTH

Depth (in.)	12	13-1/2	15	16-1/2	18	19-1/2	21	22-1/2	24	25-1/2	27	28-1/2	30	31-1/2	33
Beam Weight (lb/ft)	14.9	16.8	18.7	20.6	22.4	24.3	26.2	28.0	29.9	31.8	33.6	35.5	37.4	39.2	41.1
A (in.^{2})	61.5	69.2	76.9	84.6	92.3	99.9	107.6	115.3	123.0	130.7	138.4	146.1	153.8	161.4	169.1
S (in.^{3})	123	156	192	233	277	325	377	432	492	555	623	694	769	848	930
I (in.^{4})	738	1051	1441	1919	2491	3167	3955	4865	5904	7082	8406	9887	11531	13349	15348
EI (106 lb-in.^{2})	1328	1891	2595	3453	4483	5700	7119	8757	10627	12747	15131	17796	20756	24028	27627
Moment Capacity (lb-ft)	24600	31134	38438	46509	55350	64959	75338	86484	98400	111084	124538	138759	153750	169509	186038
Shear Capacity (lb)	9840	11070	12300	13530	14760	15990	17220	18450	19680	20910	22140	23370	24600	25830	27060

5-1/2-INCH WIDTH

Depth (in.)	12	13-1/2	14	15	16	16-1/2	18	19-1/2	21	22-1/2	24	25-1/2	27	28-1/2	30
Beam Weight (lb/ft)	16.0	18.0	18.7	20.1	21.4	22.1	24.1	26.1	28.1	30.1	32.1	34.1	36.1	38.1	40.1
A (in.^{2})	66.0	74.3	77.0	82.5	88.0	90.8	99.0	107.3	115.5	123.8	132.0	140.3	148.5	156.8	165.0
S (in.^{3})	132	167	180	206	235	250	297	349	404	464	528	596	668	745	825
I (in.^{4})	792	1128	1258	1547	1877	2059	2673	3398	4245	5221	6336	7600	9021	10610	12375
EI (106 lb-in.^{2})	1426	2030	2264	2784	3379	3706	4811	6117	7640	9397	11405	13680	16238	19098	22275
Moment Capacity (lb-ft)	26400	33413	35933	41250	46933	49913	59400	69713	80850	92813	105600	119213	133650	148913	165000
Shear Capacity (lb)	10560	11880	12320	13200	14080	14520	15840	17160	18480	19800	21120	22440	23760	25080	26400

6-3/4-INCH WIDTH

Depth (in.)	18	19-1/2	21	22-1/2	24	25-1/2	27	28-1/2	30	31-1/2	33	34-1/2	36	37-1/2	39
Beam Weight (lb/ft)	29.5	32.0	34.5	36.9	39.4	41.8	44.3	46.8	49.2	51.7	54.1	56.6	59.1	61.5	64.0
A (in.^{2})	121.5	131.6	141.8	151.9	162.0	172.1	182.3	192.4	202.5	212.6	222.8	232.9	243.0	253.1	263.3
S (in.^{3})	365	428	496	570	648	732	820	914	1013	1116	1225	1339	1458	1582	1711
I (in.^{4})	3281	4171	5209	6407	7776	9327	11072	13021	15188	17581	20215	23098	26244	29663	33367
EI (106 lb-in.^{2})	5905	7508	9377	11533	13997	16789	19929	23438	27338	31647	36386	41577	47239	53394	60060
Moment Capacity (lb-ft)	72900	85556	99225	113906	129600	146306	164025	182756	202500	223256	245025	267806	291600	316406	342225
Shear Capacity (lb)	19440	21060	22680	24300	25920	27540	29160	30780	32400	34020	35640	37260	38880	40500	42120

8-3/4-INCH WIDTH

Depth (in.)	24	25-1/2	27	28-1/2	30	31-1/2	33	34-1/2	36	37-1/2	39	40-1/2	42	43-1/2	45
Beam Weight (lb/ft)	51.0	54.2	57.4	60.6	63.8	67.0	70.2	73.4	76.6	79.8	82.9	86.1	89.3	92.5	95.7
A (in.^{2})	210.0	223.1	236.3	249.4	262.5	275.6	288.8	301.9	315.0	328.1	341.3	354.4	367.5	380.6	393.8
S (in.^{3})	840	948	1063	1185	1313	1447	1588	1736	1890	2051	2218	2392	2573	2760	2953
I (in.^{4})	10080	12091	14352	16880	19688	22791	26204	29942	34020	38452	43253	48439	54023	60020	66445
EI (106 lb-in.^{2})	18144	21763	25834	30383	35438	41023	47167	53896	61236	69214	77856	87190	97241	108036	119602
Moment Capacity (lb-ft)	168000	189656	212625	236906	262500	289406	317625	347156	378000	410156	443625	478406	514500	551906	590625
Shear Capacity (lb)	33600	35700	37800	39900	42000	44100	46200	48300	50400	52500	54600	56700	58800	60900	63000

Notes:

(1) Beam weight is based on density of 35 pcf.

(2) Moment capacity must be adjusted for volume effect: $C_v = \left(\frac{12}{d}\right)^{1/10} \times \left(\frac{5.125}{b}\right)^{1/10} \times \left(\frac{21}{L}\right)^{1/10} \leq 1.0$, where d = beam depth (in.), b = beam width (in.), and L = beam length (ft).

(3) Moment and shear capacities are based on a normal (10 years) duration of load and should be adjusted for the design duration of load per the applicable building code.

TABLE 7

SOUTHERN PINE GLUED LAMINATED BEAM SECTION PROPERTIES AND CAPACITIES

F_b = 2,400 psi, E = 1,800,000 psi, F_v = 270 psi

3-INCH WIDTH

Depth (in.)	6-7/8	8-1/4	9-5/8	11	12-3/8	13-3/4	15-1/8	16-1/2	17-7/8	19-1/4	20-5/8	22	23-3/8	24-3/4	26-1/8
Beam Weight (lb/ft)	5.2	6.2	7.2	8.3	9.3	10.3	11.3	12.4	13.4	14.4	15.5	16.5	17.5	18.6	19.6
A (in.^{2})	20.6	24.8	28.9	33.0	37.1	41.3	45.4	49.5	53.6	57.8	61.9	66.0	70.1	74.3	78.4
S (in.^{3})	24	34	46	61	77	95	114	136	160	185	213	242	273	306	341
I (in.^{4})	81	140	223	333	474	650	865	1123	1428	1783	2193	2662	3193	3790	4458
EI (106 lb-in.^{2})	146	253	401	599	853	1170	1557	2021	2570	3210	3948	4792	5747	6822	8024
Moment Capacity (lb-ft)	4727	6806	9264	12100	15314	18906	22877	27225	31952	37056	42539	48400	54639	61256	68252
Shear Capacity (lb)	3713	4455	5198	5940	6683	7425	8168	8910	9653	10395	11138	11880	12623	13365	14108

3-1/2-INCH WIDTH

Depth (in.)	6-7/8	8-1/4	9-5/8	11	12-3/8	13-3/4	14	15-1/8	16	16-1/2	17-7/8	19-1/4	20-5/8	22	23-3/8
Beam Weight (lb/ft)	6.0	7.2	8.4	9.6	10.8	12.0	12.3	13.2	14.0	14.4	15.6	16.8	18.0	19.3	20.5
A (in.^{2})	24.1	28.9	33.7	38.5	43.3	48.1	49.0	52.9	56.0	57.8	62.6	67.4	72.2	77.0	81.8
S (in.^{3})	28	40	54	71	89	110	114	133	149	159	186	216	248	282	319
I (in.^{4})	95	164	260	388	553	758	800	1009	1195	1310	1666	2081	2559	3106	3725
EI (106 lb-in.^{2})	171	295	468	699	995	1365	1441	1817	2150	2358	2998	3745	4606	5590	6705
Moment Capacity (lb-ft)	5514	7941	10808	14117	17866	22057	22867	26689	29867	31763	37277	43232	49629	56467	63746
Shear Capacity (lb)	4331	5198	6064	6930	7796	8663	8820	9529	10080	10395	11261	12128	12994	13860	14726

5-INCH WIDTH

Depth (in.)	12-3/8	13-3/4	15-1/8	16-1/2	17-7/8	19-1/4	20-5/8	22	23-3/8	24-3/4	26-1/8	27-1/2	28-7/8	30-1/4	31-5/8
Beam Weight (lb/ft)	15.5	17.2	18.9	20.6	22.3	24.1	25.8	27.5	29.2	30.9	32.7	34.4	36.1	37.8	39.5
A (in.^{2})	61.9	68.8	75.6	82.5	89.4	96.3	103.1	110.0	116.9	123.8	130.6	137.5	144.4	151.3	158.1
S (in.^{3})	128	158	191	227	266	309	354	403	455	510	569	630	695	763	833
I (in.^{4})	790	1083	1442	1872	2380	2972	3656	4437	5322	6317	7429	8665	10031	11534	13179
EI (106 lb-in.^{2})	1421	1950	2595	3369	4284	5350	6580	7986	9579	11371	13373	15598	18056	20760	23722
Moment Capacity (lb-ft)	25523	31510	38128	45375	53253	61760	70898	80667	91065	102094	113753	126042	138961	152510	166690
Shear Capacity (lb)	11138	12375	13613	14850	16088	17325	18563	19800	21038	22275	23513	24750	25988	27225	28463

5-1/2-INCH WIDTH

Depth (in.)	12-3/8	13-3/4	14	15-1/8	16	16-1/2	17-7/8	19-1/4	20-5/8	22	23-3/8	24-3/4	26-1/8	27-1/2	28-7/8
Beam Weight (lb/ft)	17.0	18.9	19.3	20.8	22.0	22.7	24.6	26.5	28.4	30.3	32.1	34.0	35.9	37.8	39.7
A (in.^{2})	68.1	75.6	77.0	83.2	88.0	90.8	98.3	105.9	113.4	121.0	128.6	136.1	143.7	151.3	158.8
S (in.^{3})	140	173	180	210	235	250	293	340	390	444	501	562	626	693	764
I (in.^{4})	869	1191	1258	1586	1877	2059	2618	3269	4021	4880	5854	6949	8172	9532	11034
EI (106 lb-in.^{2})	1563	2145	2264	2855	3379	3706	4712	5885	7238	8785	10537	12508	14710	17157	19862
Moment Capacity (lb-ft)	28076	34661	35933	41940	46933	49913	58578	67936	77988	88733	100172	112303	125128	138646	152857
Shear Capacity (lb)	12251	13613	13860	14974	15840	16335	17696	19058	20419	21780	23141	24503	25864	27225	28586

6-3/4-INCH WIDTH

Depth (in.)	17-7/8	19-1/4	20-5/8	22	23-3/8	24-3/4	26-1/8	27-1/2	28-7/8	30-1/4	31-5/8	33	34-3/8	35-3/4	37-1/8
Beam Weight (lb/ft)	30.2	32.5	34.8	37.1	39.4	41.8	44.1	46.4	48.7	51.0	53.4	55.7	58.0	60.3	62.6
A (in.^{2})	120.7	129.9	139.2	148.5	157.8	167.1	176.3	185.6	194.9	204.2	213.5	222.8	232.0	241.3	250.6
S (in.^{3})	359	417	479	545	615	689	768	851	938	1029	1125	1225	1329	1438	1551
I (in.^{4})	3213	4012	4935	5990	7184	8528	10030	11698	13542	15570	17792	20215	22848	25701	28782
EI (106 lb-in.^{2})	5783	7222	8883	10781	12932	15350	18054	21057	24376	28027	32025	36386	41127	46262	51808
Moment Capacity (lb-ft)	71891	83377	95713	108900	122938	137827	153566	170156	187597	205889	225032	245025	265869	287564	310110
Shear Capacity (lb)	21718	23389	25059	26730	28401	30071	31742	33413	35083	36754	38424	40095	41766	43436	45107

8-1/2-INCH WIDTH

Depth (in.)	24-3/4	26-1/8	27-1/2	28-7/8	30-1/4	31-5/8	33	34-3/8	35-3/4	37-1/8	38-1/2	39-7/8	41-1/4	42-5/8	44
Beam Weight (lb/ft)	52.6	55.5	58.4	61.4	64.3	67.2	70.1	73.0	76.0	78.9	81.8	84.7	87.7	90.6	93.5
A (in.^{2})	210.4	222.1	233.8	245.4	257.1	268.8	280.5	292.2	303.9	315.6	327.3	338.9	350.6	362.3	374.0
S (in.^{3})	868	967	1071	1181	1296	1417	1543	1674	1811	1953	2100	2253	2411	2574	2743
I (in.^{4})	10739	12630	14731	17053	19607	22404	25455	28772	32364	36244	40422	44910	49718	54857	60339
EI (106 lb-in.^{2})	19330	22734	26516	30696	35293	40328	45820	51789	58256	65239	72760	80837	89492	98742	108610
Moment Capacity (lb-ft)	173559	193379	214271	236234	259268	283373	308550	334798	362118	390509	419971	450504	482109	514786	548533
Shear Capacity (lb)	37868	39971	42075	44179	46283	48386	50490	52594	54698	56801	58905	61009	63113	65216	67320

Notes:

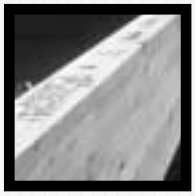
(1) Beam weight is based on density of 36 pcf.

(2) Moment capacity must be adjusted for volume effect: $C_v = \left(\frac{12}{d}\right)^{1/20} \times \left(\frac{5.125}{b}\right)^{1/20} \times \left(\frac{21}{L}\right)^{1/20} \leq 1.0$, where d = beam depth (in.), b = beam width (in.), and L = beam length (ft).

(3) Moment and shear capacities are based on a normal (10 years) duration of load and should be adjusted for the design duration of load per the applicable building code.

Glulam ridge beams complement the spacious, open designs common in modern residential construction. In this home, an overhead glulam beam between the dining and living rooms meets another beam in the corner to support the entire roof structure.

The Disney ICE rink in Anaheim, California features glulam arches curved to a 75-foot radius to form the ice center's roof system.



Glulam Design Properties and Layup Combinations

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