Post-Frame

Construction Guide

Foreword

Throughout U.S. history, post-and-beam construction concepts and design have been used as the model for constructing rural buildings, previously referred to as pole barns. Since the turn of the century, the simplicity and durability of post-and-beam design, now called post-frame construction, have made it ideal for demanding applications such as dairy barns, riding arenas, animal housing, and other rural buildings.

Post-frame buildings are known for their reliable performance and ability to withstand severe weather conditions. Engineers have capitalized on these advantages by using modern technology to update the designs, which has extended the use of post-frame construction to commercial buildings. Common commercial applications include auto dealerships and repair shops, retail stores, office buildings, and churches.

Another good use of post-frame construction continues to be agricultural building designs, which include hog and chicken housing, dairy barns, and equestrian facilities. Because posts are spaced four or more feet apart, the wide openings allow for easy creation of stalls, wash racks, or holding areas. Other facilities such as furniture stores and auto dealerships also benefit from wider openings. Facilities like these can use the wide openings for showrooms and large open-glass displays.

The design concepts of post-frame construction are simple and offer flexibility, which make it popular among architects, engineers, and building designers. Post-frame buildings are economical, easy to construct, code-complying, and they offer excellent performance under high wind and seismic loading conditions.

CONTENTS

Wood Construction: An Environmental Asset

Wood products have so many cost and construction advantages over other building materials that it is easy to forget what an environmental asset it is to use wood.

We sometimes forget that wood is naturally reusable, recyclable and biodegradable. Or the best insulator of all structural building materials, thus conserving finite fossil fuels and coal by requiring less energy to heat and cool a building constructed with wood. Or that it takes far less energy to transform trees into wood products than it does to manufacture steel, aluminum, masonry or plastic products. And with less pollution of the air and water, too.

Wood is also renewable. Ores and petroleum used for manufacturing non-wood products, once used, are not renewable. They are gone forever.

A few more facts about wood:

- **We are 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 the land suitable for growing timber is open to logging. Most of that harvestable acreage is also open to other uses, such as camping, hiking, hunting, etc.
- **We are growing more wood every day.** American landowners plant more than two billion trees every year. In addition, millions of trees seed naturally every year. The forest products industry, which comprises about 15 percent of forestland ownership, is responsible for 41 percent of replanted forest acreage. That results in 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 harvested.
- **Manufacturing wood products 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

- **Good 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 right product for the environment.

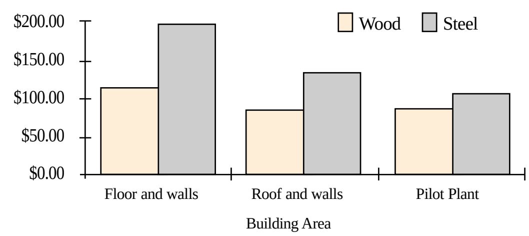
These facts should not be surprising. The forest products industry depends on the long-term renewability of forest resources for its survival. It's just common sense that it should not exhaust its resource lifeblood, but rather ensure its perpetuation.

Simply stated, wood framing is the most environmentally responsible material you can build with today. Refer to Tables 1 and 2 below.

TABLE 1

Cost of Energy Required to Manufacture Wood vs. Steel Structural Framework - Unit Cost Comparison [1]

Building Area	Sample Area, m^2	Wood $/$m^2$	Steel $/$m^2$
Office/Lab			
Floor and walls	950	112.10	199.10
Roof and walls	1010	85.20	131.40
Pilot Plant	1460	87.70	104.70

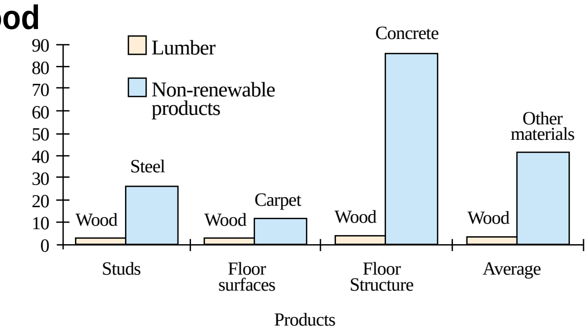


1 *Hanscomb Consultants, Inc., The Hulbert Group B.C., Ltd. James Kwong Hishi Consulting Engineers,* ***A Comparison of Wood vs. Steel Structural Costs*** *for the Forintek Western Research Facility.*

TABLE 2

Net Energy Required (in million BTU oil equivalent) per Ton of Lumber Product Compared to its Non-wood Equivalent [2]

Products	Lumber	Non-renewable Products
Studs (lumber vs. steel)	2.91	26.67
Floor surfaces (lumber vs. carpet)	2.91	12.27
Floor structure (joist vs. concrete)	4.14	86.31
Average	3.32	41.75
Penalty per ton of lumber replaced	38.43	

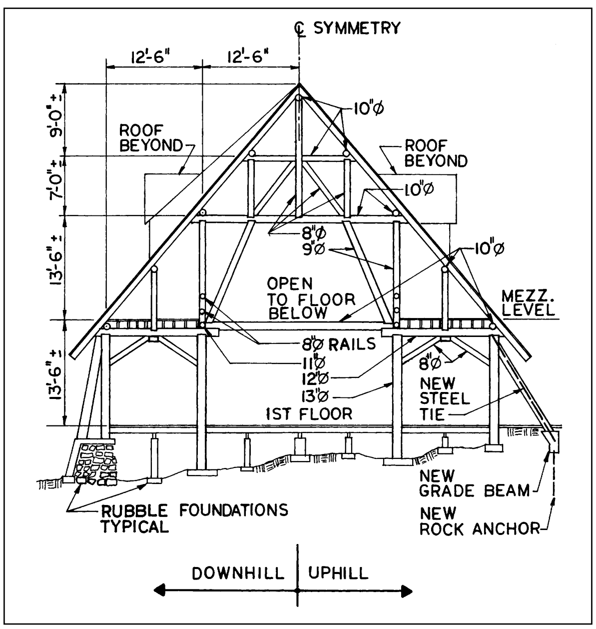


2 *Koch, Peter, "Wood Versus Non-Wood Materials in U.S. Residential Construction: Some Energy Related Global Implications,"* ***Forest Products Journal****, 42(5), pp. 31-42.*

Longevity of Wood Structures

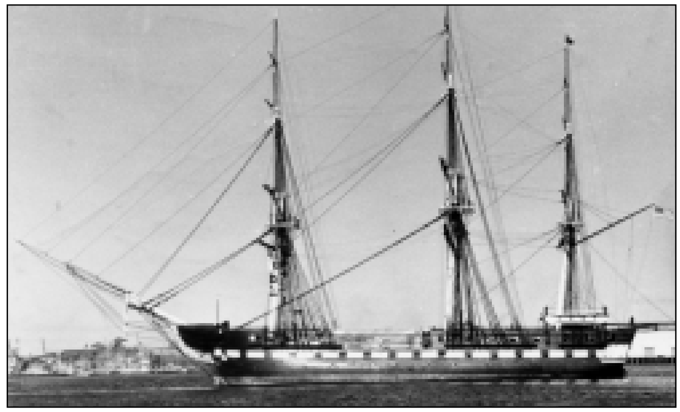
Historical review always aids in learning about the methods and serviceability of building construction. When reviewing wood structures, one finds a record of long duration and durable performance. Consider, for instance, the Stave Churches in Norway, some of which were constructed in the 10th Century; the all-wood U.S.S. Constitution launched in 1797; the Santa Cruz Municipal Wharf constructed in the early 1900's; the Bridgeport Covered Bridge, spanning 212 feet and built in 1862; and finally, a post-frame structure called Paradise Inn in Mount Rainier National Park, built in 1917. These examples show the longevity of wood structures when properly designed, detailed, constructed, and maintained.[1]

With today's knowledge of wood performance, post-frame structures can be even more durable than history has already proven. In fact, with modern technologies, wood is increasingly the structural material of choice.



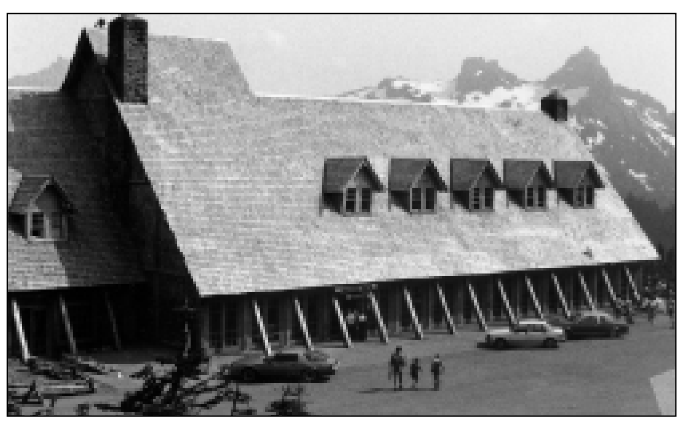
Plan view of Paradise Inn post-frame structure.

Norwegian Stave Church, built in the 10th century.



All-wood U.S.S. Constitution, launched in 1797.

Bridgeport, CA, 212-foot long covered bridge, built in 1862.



Mt. Rainier National Park's Paradise Inn, built in 1917.

1 ***Classic Wood Structures.*** *Prepared by a task committee of the Committee on Wood of the American Society of Civil Engineers (ASCE), New York, NY, 1989.*

Durability

As its name suggests, post-frame construction uses posts that are usually placed in direct contact with the ground. This is a severe exposure environment for all types of structural elements. To combat this exposure and achieve longevity, wood posts are pressure treated with preservatives approved by the Environmental Protection Agency (EPA).

Waterborne preservatives are the preferred method of treatment, although other approved treatments may be used. Waterborne preservative treatments are clean, odorless and paintable. Most importantly, when pressure treated in accordance with standards of the American Wood Preservers' Association (AWPA) and used following the guidelines of the EPA, preservative treated wood is safe to use and poses no threat to people or animals.

The minimum waterborne treatment retention for structural posts used in post-frame construction is 0.6 pounds of preservative per cubic food (pcf) of wood. Lumber for use in ground contact is required to have 0.4 pcf retention. Ground contact applications may include: bottom plates, skirt or sill boards, and any siding that may be in contact with the ground or concrete. Design properties for wood used in applications where the moisture content will exceed 19% for an extended period of time must incorporate the wet service factor, C_M. Wood closer than eight inches to exposed earth is also required to be treated and falls in the treatment category for above-ground applications. Preservative treatment types, products, examples, and retention requirements are shown in Table 3.

To be certain that treated wood products will provide the service life desired, it is important to use products that have been treated in accordance with AWPA standards and identified with a quality mark of an accredited inspection agency of the American Lumber Standard Committee (ALSC). This quality mark may be in the form of an ink stamp or end tag. Refer to Figure 1.

Southern Pine has long been a preferred species when pressure treatment with preservatives is required because of its ease of treatability. The unique cellular structure of Southern Pine permits deep, uniform penetration of preservatives, rendering the wood useless as a food source (e.g., for fungi, termites, and other micro-organisms).

The use of properly treated wood when required, regardless of species or product type, backed up by a reputable post-frame builder, will provide assurance that your post-frame building will last for the structure's useful life (e.g. typically greater than 40-50 years) and be an environmentally responsible place to work or live. For more information on treated wood products, refer to the publication *Pressure-Treated Southern Pine* published by the Southern Pine Council.

TABLE 3

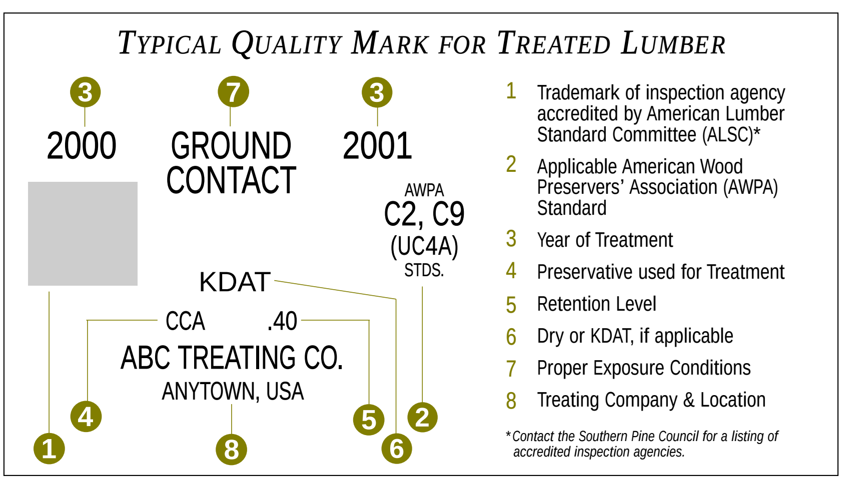
Minimum Preservative Retentions (in pcf) for Various Wood Products[1]

Product and service conditions	CCA	Penta
Sawn lumber and plywood		
Above ground	0.25	0.40
Ground contact	0.40	0.50
Structural poles	0.60	0.60
Glulam posts	0.60	0.60
Round poles	0.60	0.45
Sawn fence posts	0.40	0.50
Round foundation piles	0.80	0.60

1 Based on AWPA Commodity Standards or corresponding Use-Category Standards.

Treated nail-laminated post.

FIGURE 1



Advantages of Post-Frame Construction

Post-frame construction lends itself to a variety of architectural styles.

Large wall openings are possible with wide post spacings.

Large open areas are possible with long-span trusses.

- Post-frame construction techniques meet building code requirements.
- Like all buildings, they are permanent structures when properly maintained.
- Architectural designs that blend in with the local community are easily achieved.
- Excellent performance has been observed during high winds or hurricanes when compared to other construction methods.[1]
- Post-frame structures can be designed to perform well under seismic loading conditions.
- Site preparation is easy and post-frame structures are very adaptable to problem sites such as steep slopes and flood plains.
- State-of-the-art engineering is built into post-frame construction through the American Society of Agricultural Engineers (ASAE) standards, providing dependable performance.
- Building system cost savings are considerable. Savings can be realized in:
  - Materials.
  - Labor due to shorter construction time.
  - The use of more cost effective construction equipment.
  - Lower interest costs due to quicker erection.
  - Less building maintenance required.
  - Energy savings due to natural insulating properties of wood and its inherent ability to effectively insulate the wall and roof cavities.
  - When making cost comparisons, it is important to compare in-place systems costs and estimate the future maintenance and heating or cooling costs for all building types being considered.
- Embedding post foundations can be more easily performed during winter construction than pouring concrete foundations.
- There is greater design flexibility when using post-frame construction techniques. For example:
  - Long-span trusses create large building open areas without the need for interior load-bearing walls.
  - Wide post spacings create flexibility for large wall openings.
  - A variety of materials can be used for the structural elements, such as:
    - Trusses, solid-sawn lumber, or glued-laminated beams.
    - Solid-sawn, nail-laminated, glued-laminated, or structural composite lumber posts in the walls.
- Finally, wood post-frame buildings are easy to build because they can be constructed with readily available tools and equipment.

1 Harmon J.D., Grandle C.R., 1992, "Effects of Hurricane Hugo on Agricultural Structures," ***Applied Engineering in Agriculture****, 8(1), pp. 93-96.*

Post-Frame Construction Features

Today, post-frame construction is built upon thoroughly developed engineering principles, which means that the entire building is designed for optimum load-carrying performance. Post-frame structures begin with posts and end with wood or steel siding covering the structural framework. Each element of the structure is present for a specific purpose, providing the required strength to meet all applicable code requirements.

Sound design and quality manufacturing will create a building that meets or exceeds accepted standards for safety and performance. A review of post-frame structural elements follows:

Columns

Columns, or posts, are one of the most important elements in post-frame construction. The posts can be buried directly in the ground, buried in concrete, or anchored to a concrete foundation. See Figures 2 and 3.

Supporting columns are spaced further apart in post-frame buildings than in typical construction – 4 feet, 8 feet, or more, rather than the 16 or 24 inches on center typically used for conventional light-frame wood structures. See Figures 4 and 5.

There are five major categories of columns in use today: solid sawn; glued-laminated; structural composite lumber; unspliced, mechanically laminated; and spliced, mechanically laminated. Each column type has specific advantages, some of which follow:

Solid columns (e.g., square or round solid-sawn, glued-laminated, or structural composite lumber):

- The column is solid throughout providing continuity of strength.
- They have a history of excellent structural foundation performance.
- The columns are easily treated with preservatives for lasting performance. As an example, consider the durability of telephone poles.

Mechanically laminated columns (unspliced or spliced):

- Smaller pieces of lumber that can be put together to create large columns. (This also applies to glued-laminated columns.)
- Higher lumber grades can be used, creating stronger columns. (This also applies to glued-laminated columns.)
- Individual 2x laminations are easier to treat thoroughly.
- In spliced columns, only the portion of the column in ground contact needs to be treated, saving treatment costs.
- Corrosion-resistant fasteners are only needed in the treated wood portion of the column, resulting in cost savings.
- These columns can provide efficient truss/rafter connection details because the length of the different laminations can be varied, creating a slot for the truss/rafter to slide into.

Columns are the primary structural elements for framing side and end walls. Column design should be performed by professional engineers experienced in post-frame construction because they are such a critical structural element. These elements should be designed to meet the accepted analysis and design procedures in ASAE Engineering Practice (EP), No. 484.1. Column embedment should follow ASAE EP 486 for both lateral and vertical loading design.

Columns may be subjected to both compressive and bending forces. Evaluation of the combined conditions is addressed in both the *Allowable Stress Design (ASD) and Load* and *Resistance Factor Design (LRFD) Manuals for Engineered Wood Construction*, published by the American Forest and Paper Association (AF&PA). You can contact AF&PA at 202/463-2700 or visit www.awc.org.

Allowable uniform loads for glued-laminated posts/columns are provided in Table 4.

FIGURE 2

POST ANCHORAGE (post embedded)

Typical for Solid-Sawn Columns

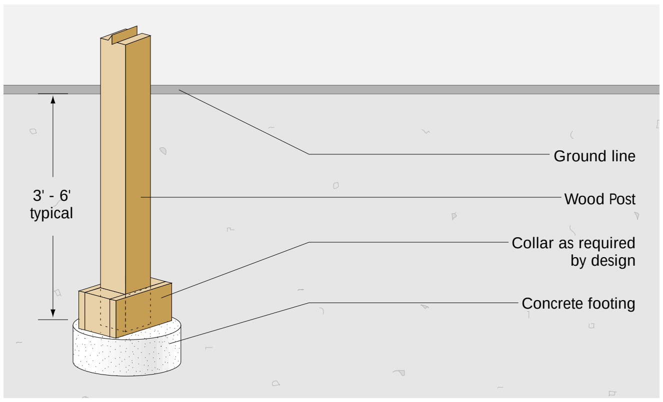
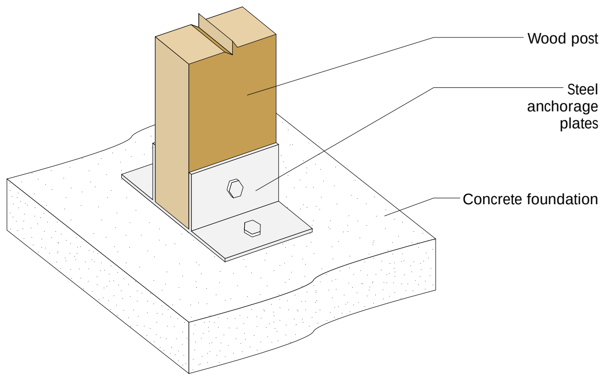


FIGURE 3

POST ANCHORAGE (post pinned)

Typical for Glued-Laminated Columns



Solid-sawn column.

Solid-sawn columns used to support glulam beams.

Nail-laminated column.

FIGURE 4

ROOF TRUSSES AT 8 FT. ON CENTER

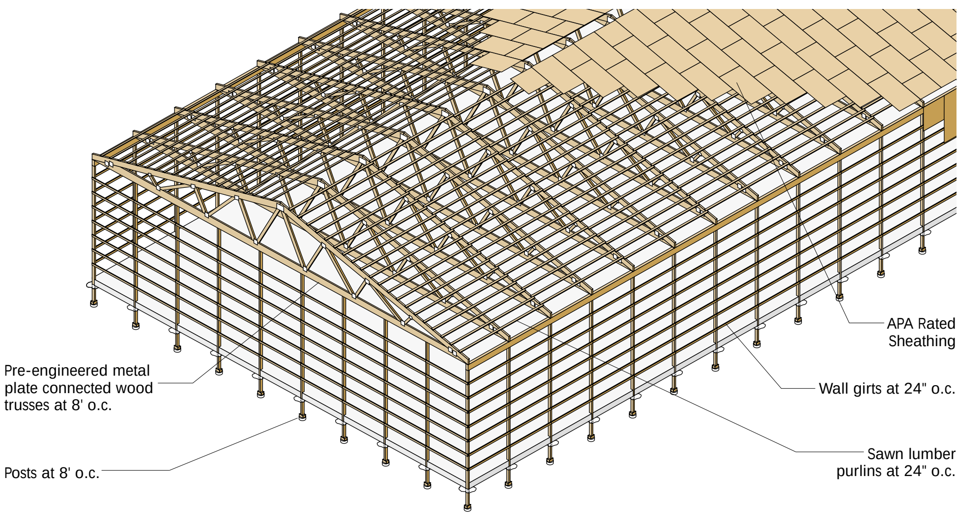


FIGURE 5

ROOF TRUSSES AT 4 FT. ON CENTER

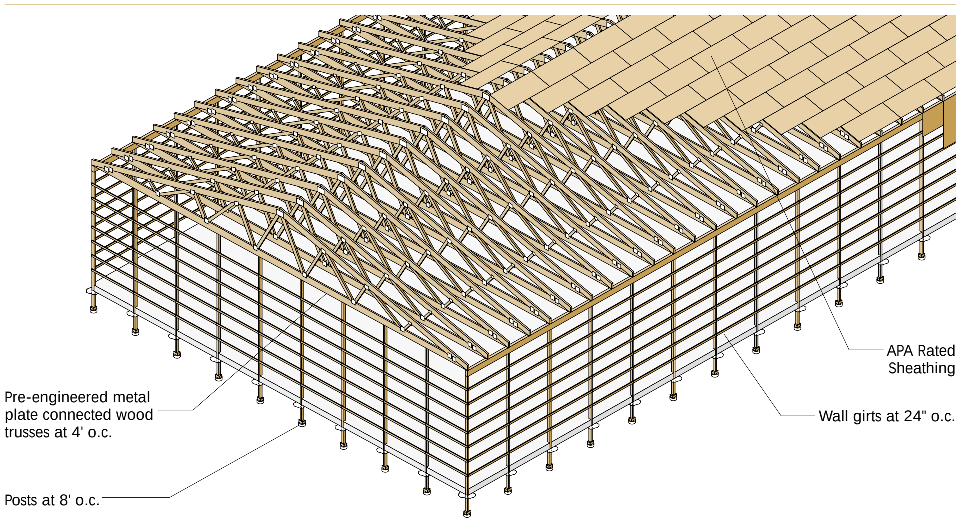
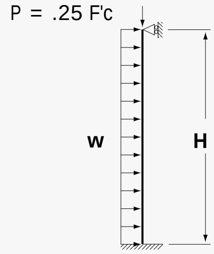
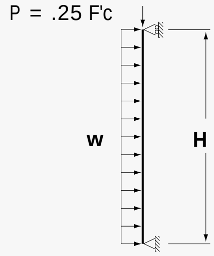
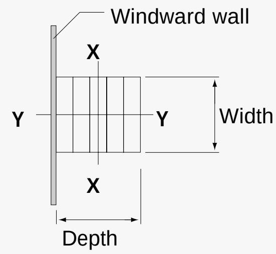


TABLE 4

GLUED-LAMINATED POST/COLUMN
Allowable uniform loads, w (plf), for Glued-Laminated Posts







Load Cases P-I (embedded) P-II (pinned) Post Orientation

	H = 12'		H = 14'		H = 16'		H = 18'		H = 20'	
	P-I	P-II	P-I	P-II	P-I	P-II	P-I	P-II	P-I	P-II
3-1/8 x 6	313	244	230	177	176	122	139	86	113	63
3-1/8 x 7-1/2	488	398	359	283	275	213	217	167	176	122
3-1/8 x 9	703	601	517	424	396	315	313	244	253	196
3-1/8 x 10-1/2	957	850	703	601	538	444	425	341	345	271
3-1/8 x 12	1250	1140	918	811	703	601	556	460	450	363
5-1/8 x 6	513	400	377	290	288	200	228	141	185	103
5-1/8 x 7-1/2	801	652	588	464	450	349	356	273	288	200
5-1/8 x 9	1153	986	847	695	649	516	513	400	415	321
5-1/8 x 10-1/2	1570	1393	1153	986	883	728	698	559	565	444
5-1/8 x 12	2050	1869	1506	1331	1153	986	911	755	738	596
6-3/4 x 7-1/2	1055	859	775	612	593	460	469	360	380	264
6-3/4 x 9	1519	1298	1116	916	854	680	675	527	547	422
6-3/4 x 10-1/2	2067	1835	1519	1298	1163	959	919	737	737	580
6-3/4 x 12	2700	2462	1984	1753	1518	1298	1186	982	950	767
8-3/4 x 9	1969	1683	1446	1187	1107	882	867	677	695	537
8-3/4 x 10-1/2	2680	2379	1969	1683	1488	1227	1162	932	931	733
8-3/4 x 12	3500	3191	2538	2243	1918	1639	1497	1240	1200	969
8-3/4 x 15-1/2	4389	4078	3175	2876	2399	2112	1873	1601	1501	1248
8-3/4 x 15	5361	5051	3879	3578	2930	2639	2288	2008	1834	1588

Notes:
(1) Load Duration Factor, C_D = 1.60; F_b = 2,400 psi; F_c = 2,400 psi; F_v = 190 psi; E = 2,000,000 psi
(2) Post must be positioned with the largest dimension perpendicular to walls (wide laminations parallel to wall).
(3) Maximum deflection = L/120 under wind load. Other deflection limits may apply.
(4) Tabular values assume dry-service condition. For wet-service condition, multiply tabular values by 0.8.
(5) Volume effect, C_V is included.
(6) Maximum beam shear is located at a distance from the supports equal to the depth of the beam.
(7) Green numbers limited by deflection; gray shaded numbers limited by bending strength.
(8) Final design should include a complete analysis, including lateral stability, eccentricity and bearing stresses.

Design Example
Given: Post Embedded, assume supported cantilever analog (Load Case P-I)
Wall Height = 16'
Post Size = 6-3/4" x 10-1/2"
Problem: Find maximum allowable uniform load
Other terms: S = Section modulus
F'_c = adjusted strength in compression parallel to grain (including buckling and load duration)
F_{cE} = Euler buckling strength
C_P = Column stability factor

Uniform load based on moment at groundline [based on eq. 3.9-3, 1997 NDS]:

$$w = 96\left(1 - \left(\frac{f_c}{F'_c}\right)^2\right)\left(\frac{F_b \times C_D \times C_V \times S}{H^2}\right)$$

$$w = 96\left(1 - (0.25)^2\right)\left(\frac{2{,}400 \times 1.6 \times 1.0 \times 124}{(16 \times 12)^2}\right)$$

w = 1,163 *plf*

Uniform load based on moment above groundline [based on eq. 3.9-3, 1997 NDS]:

$$w = 170.7\left(1 - \left(\frac{f_c}{F'_c}\right)^2\right)\left(1 - \left(\frac{0.25 \times F_c \times C_D \times C_P}{F_{cE}}\right)\right)\left(\frac{F_b \times C_D \times C_V \times S}{H^2}\right)$$

$$w = 170.7\left(1 - (0.25)^2\right)\left(1 - \left(\frac{0.25 \times 2{,}400 \times 1.6 \times 0.81}{4{,}445}\right)\right)\left(\frac{2{,}400 \times 1.6 \times 1.0 \times 124}{(16 \times 12)^2}\right)$$

w = 1,709 *plf*

(9) Tabular values assume a rigid roof diaphragm such as for wood structural panels.

Roof Systems

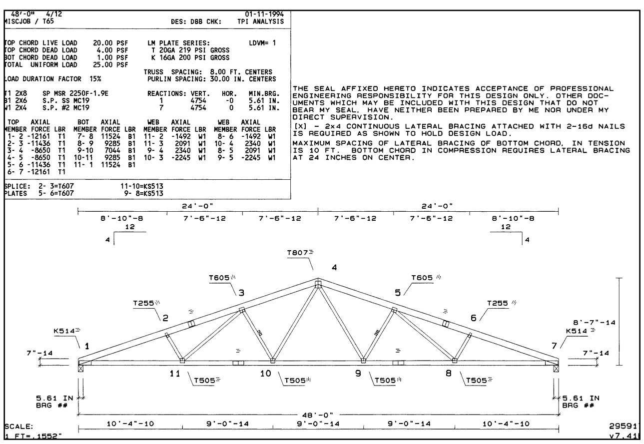
After columns, the next most critical element in post-frame construction is the roof system. The primary load-resisting elements of a post-frame roof are metal plate connected trusses and solid-sawn purlins, although other wood framing systems may also be used.

Metal Plate Connected Trusses

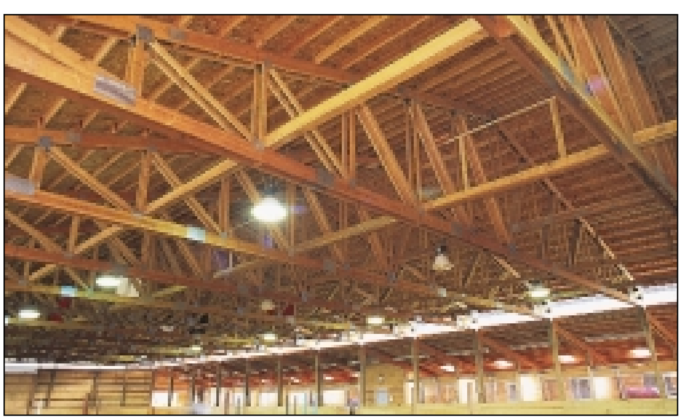
Metal plate connected (MPC) trusses are precisely engineered components that compliment post-frame technology very well. The advantages of MPC trusses include:

- Long, clear spans are possible (e.g., 80' or longer).
- Trusses can be designed for wide on-center spacing applications (typically 4', 8', 10').
- Trusses are built under controlled manufacturing conditions that provide precise assembly and high quality.
- Trusses are lightweight and can be installed with carpenter/contractor crews and normal construction equipment, resulting in faster erection.
- Design versatility means cost optimized trusses for the job at hand.
- Product application reliability is enhanced because a truss system is designed by professional engineers for each specific application. This process ensures that the appropriate roof structural element will be used to carry the loads (particularly snow and wind loads) at the job site. An example of a post-frame truss design drawing is shown in Figure 6.
- Design possibilities are limited only by one's imagination.

FIGURE 6



Typical truss design engineering.



Post-frame construction allows for an open 72-foot span in this equestrian facility.

Erecting and Bracing Trusses

Wood trusses are designed and fabricated based on exacting specifications. However, all this is at stake in the handling, erection, and, most importantly, bracing stages of construction. Trusses must be erected properly to ensure they perform as expected, and for job-site safety. Trusses may be erected manually, by fork lift, or by crane, depending on truss size, wall height, and job conditions. Trusses should always be hoisted vertically to avoid lateral bending that could damage truss members or joints. All trusses must be securely braced. Temporary bracing is used during erection to hold trusses in place until permanent bracing, purlins, sheathing, and ceilings (if used) are installed. Proper erection bracing will assure that trusses are installed properly, and create a safe working environment. Permanent bracing is used to make the truss component an integral part of the roof and building structure. Temporary and permanent bracing includes lateral, diagonal, and cross bracing.

Building designers are responsible for the proper design of permanent bracing. Erection contractors are responsible for the proper installation of temporary and permanent bracing.

For additional guidance on handling, erecting, and bracing wood trusses, contact the Truss Plate Institute (TPI) at 608/833-5900 or the Wood Truss Council of America (WTCA) at 608/274-4849, or visit www.woodtruss.com.

Erection of long span trusses.

A small commercial building using rafters.

Solid-Sawn Rafters

The advantages of solid-sawn lumber rafters in post-frame building applications include:

- Immediate availability from a lumber dealer for delivery to the job site.
- They can be cut to meet site installation requirements.
- High-strength Southern Pine rafters can span long distances.
- Rafters are affordable.
- Carpenters are familiar with installation.

Design values for dimensional lumber are based on results of the North American In-Grade Testing Program. More than 70,000 full-size, In-Grade pieces of lumber were tested to the breaking point. Southern Pine remains the strongest structural lumber species for engineered and framing applications.

Purlins placed flush with the top of trusses simplify installation of roof sheathing.

Purlins

Purlins are 2x4 or 2x6 dimensional lumber members that span between main roof members to provide framing for sheathing material attachment. Their functions are:

- Resisting gravity loads (e.g. sheathing dead load and snow loads).
- Resisting secondary wind uplift loads.
- Laterally bracing rafters or truss top chords.

Purlins can be placed flat-wise or on edge across roof framing members, or installed between them. See Figure 7 for typical roof purlin framing. It is important that purlin spacing be specified to the truss designer because purlins function as an integral part of the truss' permanent lateral bracing. Connection detailing is also very important for proper purlin installation. Purlins can be placed on a designed ledger or in hangers so the top of the purlin is flush with the top of the truss or rafter for easier sheathing installation.

Purlins are very easy to install because they are light framing members. This helps speed up the roof framing process.

Horizontal wall girts supporting sheathing.

Wall Girts

Girts are 2x4 or 2x6 members attached horizontally to post-frame columns to support the wall sheathing and to carry wind loads. They also provide lateral support for the columns to resist buckling. Wall girts speed construction due to their horizontal orientation, and eliminate the need for the top and bottom plates of standard stud walls.

Stud Walls

Post-frame construction can also incorporate stud-wall construction, depending on client needs. Stud walls provide excellent construction flexibility and economy. These construction elements can be manufactured on the job site or in a wall-panel plant. Sheathed stud walls can also provide excellent resistance to lateral loads.

FIGURE 7

TYPICAL ROOF PURLIN FRAMING

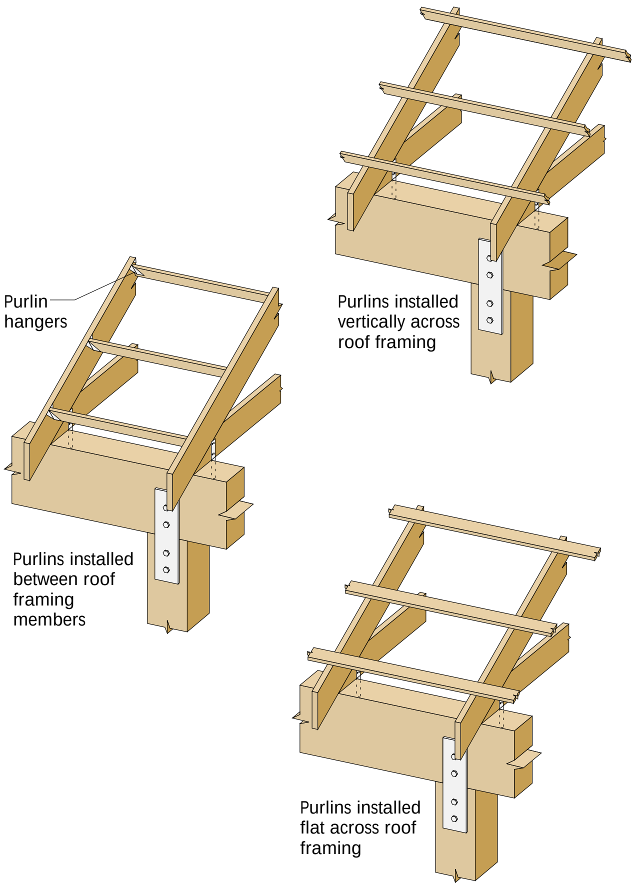
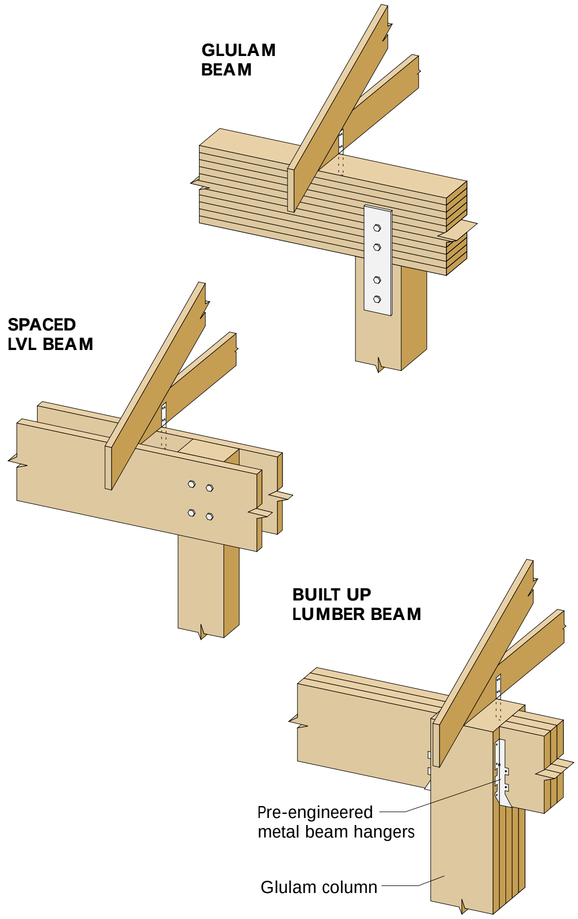


FIGURE 8

TYPICAL BEAM TO COLUMN CONNECTIONS



Structural Insulated Panels (SIPs)

Pre-engineered and prefabricated Structural Insulated Panels (SIPs) can also be used for roof and wall construction. SIPs are made with insulation sandwiched between two layers of wood structural panels. For roof construction, SIPs can be designed to span as far as 24 feet. Structural Insulated Panels offer an affordable alternative when relatively high insulation values are required.

Headers

Header beams may or may not be necessary, depending on post and truss spacing. When trusses are aligned with posts, header beams are not necessary because trusses are directly supported by the post.

When headers are used, they can be cut to fit between posts and can be attached to posts with metal hangers. Or, headers can be specified in longer lengths to span continuously across multiple posts.

Their design requires consideration of bending, shear and compression-perpendicular-to-grain stresses, and deflection (due to bending and shear) performance.

Allowable load tables are provided in Tables 5, 6, and 7 for Southern Pine glued-laminated beams, Douglas-Fir glued-laminated beams, and built-up Southern Pine lumber headers, respectively.

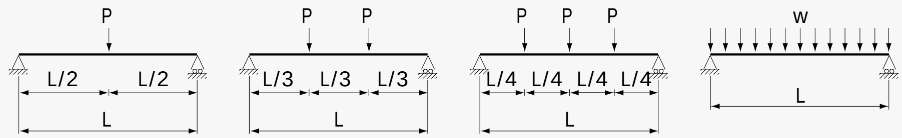
Header design must consider the connection of the header to the post and ensure that there is proper lateral bracing. The attachment of framing members into each header is also very important. Both gravity and uplift loads must be considered. See Figure 8 for typical header to post framing connections.

Headers can be made from a variety of materials, including: solid-sawn lumber, glued-laminated timber, structural composite lumber, or parallel chord trusses. Creative header use enhances the functionality and attractiveness of the exterior facade and interior spaces of post-frame design.

TABLE 5

GLUED-LAMINATED HEADER (SOUTHERN PINE)

Allowable concentrated loads (lbs, load cases I, II, III) and uniform loads (plf, load case IV) for Glued-Laminated Beams



Load Cases	H-I				H-II				H-III		H-IV	
	L = 8'				L = 10'				L = 12'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
3-1/8 x 5-1/2	1723	1259	861	429	1361	799	573	218	932	547	392	124
3-1/8 x 6-7/8	2697	2023	1349	674	2148	1571	1074	428	1781	1081	776	246
3-1/8 x 8-1/4	3889	2917	1944	972	3100	2325	1550	620	2572	1880	1286	427
3-1/8 x 9-5/8	5298	3973	2649	1324	4225	3169	2113	845	3508	2631	1754	585
3-1/8 x 11	6925	5193	3462	1731	5525	4144	2762	1105	4589	3442	2294	765
3-1/8 x 12-3/8	8768	6576	4384	2192	6998	5249	3499	1400	5815	4361	2907	969
3-1/8 x 13-3/4	10830	7549	5033	2649	8645	6484	4323	1729	7186	5389	3593	1198
3-1/8 x 15-1/8	13109	8304	5536	3036	10467	7850	5233	2093	8701	6526	4351	1450
3-1/8 x 16-1/2	15605	9059	6039	3457	12462	9046	6031	2492	10362	7772	5181	1727
3-1/8 x 17-7/8	18319	9813	6542	3917	14631	9800	6533	2797	12168	9126	6084	2028
3-1/8 x 19-1/4	21137	10568	7046	4421	16974	10554	7036	3115	14118	10539	7026	2353
3-1/8 x 20-5/8	22646	11323	7549	4975	19491	11308	7538	3454	16214	11292	7528	2644
3-1/8 x 22	24156	12078	8052	5588	22182	12062	8041	3818	18454	12045	8030	2898
5-1/8 x 8-1/4	6481	4861	3241	1620	5167	3875	2583	1033	4287	3133	2143	712
5-1/8 x 9-5/8	8830	6622	4415	2207	7042	5282	3521	1408	5847	4385	2923	974
5-1/8 x 11	11541	8656	5770	2885	9208	6906	4604	1842	7648	5736	3824	1275
5-1/8 x 12-3/8	14614	10961	7307	3654	11663	8748	5832	2333	9691	7268	4846	1615
5-1/8 x 13-3/4	18050	12581	8388	4415	14409	10807	7204	2882	11976	8982	5988	1996
5-1/8 x 15-1/8	21848	13839	9226	5060	17444	13083	8722	3489	14502	10877	7251	2417
5-1/8 x 16-1/2	26008	15098	10065	5762	20769	15077	10051	4154	17270	12953	8635	2878
5-1/8 x 17-7/8	30531	16356	10904	6528	24384	16333	10889	4662	20279	15210	10140	3380
5-1/8 x 19-1/4	35228	17614	11743	7368	28289	17590	11726	5191	23530	17566	11710	3922
5-1/8 x 20-5/8	37744	18872	12581	8292	32484	18846	12564	5757	27023	18820	12547	4406
5-1/8 x 22	40260	20130	13420	9314	36969	20103	13402	6364	30723	20075	13383	4830
5-1/8 x 23-3/8	42776	21388	14259	10450	41744	21359	14239	7017	34589	21330	14220	5278
5-1/8 x 24-3/4	45293	22646	15098	11721	45231	22615	15077	7721	38678	22584	15056	5752
5-1/8 x 26-1/8	47809	23904	15936	13152	47743	23872	15914	8482	42989	23839	15893	6254
5-1/8 x 27-1/2	50325	25163	16775	14775	50256	25128	16752	9307	47522	25094	16729	6788
5-1/8 x 28-7/8	52841	26421	17614	16632	52769	26385	17590	10206	52275	26348	17566	7356
5-1/8 x 30-1/4	55358	27679	18453	18777	55282	27641	18427	11188	55206	27603	18402	7961
6-3/4 x 11	15580	11685	7790	3895	12431	9323	6215	2486	10325	7744	5162	1721
6-3/4 x 12-3/8	19729	14797	9865	4932	15746	11809	7873	3149	13083	9812	6542	2181
6-3/4 x 13-3/4	24367	16985	11323	5960	19452	14589	9726	3890	16167	12126	8084	2695
6-3/4 x 15-1/8	29494	18683	12455	6831	23550	17662	11775	4710	19578	14683	9789	3263
6-3/4 x 16-1/2	35111	20382	13588	7779	28039	20354	13569	5608	23274	17456	11637	3879
6-3/4 x 17-7/8	41217	22080	14720	8813	32919	22050	14700	6294	27220	20415	13610	4537
6-3/4 x 19-1/4	47557	23779	15852	9947	38179	23746	15831	7008	31466	23600	15733	5244
6-3/4 x 20-5/8	50954	25477	16985	11194	43689	25442	16961	7772	36012	25407	16938	5949
6-3/4 x 22	54351	27176	18117	12574	49560	27138	18092	8592	40856	27101	18068	6521
6-3/4 x 23-3/8	57748	28874	19249	14108	55791	28835	19223	9473	45997	28795	19197	7125
6-3/4 x 24-3/4	61145	30572	20382	15824	61061	30531	20354	10423	51434	30489	20326	7765
6-3/4 x 26-1/8	64542	32271	21514	17756	64454	32227	21485	11450	57167	32183	21455	8443
6-3/4 x 27-1/2	67939	33969	22646	19947	67846	33923	22615	12565	63194	33877	22584	9164
6-3/4 x 28-7/8	71336	35668	23779	22453	71238	35619	23746	13778	69516	35570	23714	9930
6-3/4 x 30-1/4	74733	37366	24911	25349	74631	37315	24877	15103	74528	37264	24843	10748
6-3/4 x 31-5/8	78130	39065	26043	28731	78023	39011	26008	16558	77916	38958	25972	11621
6-3/4 x 33	81527	40763	27176	32733	81415	40708	27138	18160	81304	40652	27101	12555
6-3/4 x 34-3/8	84923	42462	28308	37474	84807	42404	28269	19935	84691	42346	28230	13559

Notes:

(1) Load Duration Factor = 1.15, F_b = 2,400 psi, F_v = 240 psi, E = 1,800,000 psi

(2) Maximum deflection = L/180 under total load. Other deflection limits may apply.

(3) Service condition = dry.

(4) Tabulated values represent total loads and have taken the dead weight of the beam (assumed 36 pcf) into account.

(5) Volume effect is included.

(6) Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

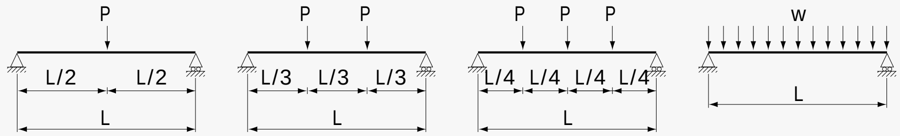
(7) White highlighted numbers limited by deflection
Gray shaded numbers limited by bending strength
Orange shaded numbers limited by shear strength.

(8) Beams having net widths of 3 in. and 5 in. may be substituted for 3-1/8 in. and 5-1/8 in. widths tabulated with the same depths.

(9) Final design should include a check for lateral stability and end bearing.

GLUED-LAMINATED HEADER (SOUTHERN PINE) – CONTINUED

Allowable concentrated loads (lbs, load cases I, II, III) and uniform loads (plf, load case IV) for Glued-Laminated Beams



Load Cases H-I H-II H-III H-IV

	L = 16'				L = 20'				L = 24'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
3-1/8 x 5-1/2	500	294	211	50	295	173	124	---	179	105	75	---
3-1/8 x 6-7/8	1006	591	424	101	613	360	258	---	393	231	165	---
3-1/8 x 8-1/4	1766	1037	744	177	1092	641	460	87	720	422	303	---
3-1/8 x 9-5/8	2606	1661	1192	283	1767	1037	744	141	1182	694	498	79
3-1/8 x 11	3413	2495	1706	425	2670	1567	1124	214	1802	1058	759	120
3-1/8 x 12-3/8	4329	3246	2164	541	3429	2249	1614	307	2603	1528	1096	174
3-1/8 x 13-3/4	5353	4015	2677	669	4245	3103	2123	423	3500	2117	1518	240
3-1/8 x 15-1/8	6486	4865	3243	811	5148	3861	2574	515	4249	2838	2036	322
3-1/8 x 16-1/2	7728	5796	3864	966	6138	4604	3069	614	5070	3706	2535	421
3-1/8 x 17-7/8	9079	6809	4539	1135	7215	5411	3607	721	5963	4472	2982	497
3-1/8 x 19-1/4	10538	7904	5269	1317	8379	6284	4189	838	6904	5178	3452	575
3-1/8 x 20-5/8	12106	9080	6053	1513	9629	7222	4815	963	7911	5933	3955	659
3-1/8 x 22	13783	10337	6892	1723	10955	8216	5477	1095	8984	6738	4492	749
5-1/8 x 8-1/4	2943	1728	1239	294	1821	1069	767	146	1199	704	505	80
5-1/8 x 9-5/8	4343	2769	1986	472	2946	1729	1240	236	1970	1156	829	131
5-1/8 x 11	5688	4158	2844	708	4450	2612	1874	356	3003	1763	1264	200
5-1/8 x 12-3/8	7214	5411	3607	902	5716	3749	2689	511	4338	2546	1826	289
5-1/8 x 13-3/4	8922	6691	4461	1115	7053	5172	3526	705	5760	3528	2531	401
5-1/8 x 15-1/8	10810	8108	5405	1351	8511	6383	4256	851	6958	4731	3394	537
5-1/8 x 16-1/2	12866	9650	6433	1608	10103	7577	5051	1010	8266	6176	4133	689
5-1/8 x 17-7/8	15054	11290	7527	1882	11827	8870	5914	1183	9683	7262	4841	807
5-1/8 x 19-1/4	17408	13056	8704	2176	13684	10263	6842	1368	11209	8407	5605	934
5-1/8 x 20-5/8	19929	14947	9964	2491	15672	11754	7836	1567	12845	9634	6422	1070
5-1/8 x 22	22616	16962	11308	2827	17791	13343	8895	1779	14588	10941	7294	1216
5-1/8 x 23-3/8	25467	19101	12734	3183	20041	15030	10020	2004	16440	12330	8220	1370
5-1/8 x 24-3/4	28484	21363	14242	3561	22421	16816	11210	2242	18399	13799	9199	1533
5-1/8 x 26-1/8	31665	23749	15832	3958	24931	18698	12465	2493	20465	15349	10233	1705
5-1/8 x 27-1/2	35010	25025	16683	4376	27571	20678	13785	2757	22638	16979	11319	1887
5-1/8 x 28-7/8	38518	26276	17518	4713	30340	22755	15170	3034	24919	18689	12459	2077
5-1/8 x 30-1/4	42189	27528	18352	5041	33238	24928	16619	3324	27305	20479	13653	2275
6-3/4 x 11	7679	5613	3839	956	6007	3526	2529	481	4054	2380	1707	270
6-3/4 x 12-3/8	9722	7292	4861	1215	7615	5061	3630	690	5856	3437	2466	390
6-3/4 x 13-3/4	11959	8969	5980	1495	9376	6982	4688	938	7656	4763	3417	541
6-3/4 x 15-1/8	14421	10816	7211	1803	11315	8486	5658	1132	9248	6386	4581	725
6-3/4 x 16-1/2	17107	12830	8554	2138	13432	10074	6716	1343	10987	8240	5494	916
6-3/4 x 17-7/8	20016	15012	10008	2502	15724	11793	7862	1572	12872	9654	6436	1073
6-3/4 x 19-1/4	23147	17360	11574	2893	18193	13645	9096	1819	14902	11176	7451	1242
6-3/4 x 20-5/8	26499	19874	13250	3312	20836	15627	10418	2084	17076	12807	8538	1423
6-3/4 x 22	30072	22554	15036	3759	23654	17741	11827	2365	19394	14546	9697	1616
6-3/4 x 23-3/8	33864	25398	16932	4233	26646	19985	13323	2665	21856	16392	10928	1821
6-3/4 x 24-3/4	37876	28407	18938	4734	29811	22358	14906	2981	24461	18346	12230	2038
6-3/4 x 26-1/8	42106	31579	21053	5263	33149	24862	16574	3315	27209	20406	13604	2267
6-3/4 x 27-1/2	46554	33784	22523	5819	36659	27494	18330	3666	30099	22574	15049	2508
6-3/4 x 28-7/8	51219	35473	23649	6362	40342	30256	20171	4034	33130	24848	16565	2761
6-3/4 x 30-1/4	56101	37162	24775	6806	44195	33146	22098	4420	36304	27228	18152	3025
6-3/4 x 31-5/8	61199	38851	25901	7268	48220	36165	24110	4822	39619	29714	19810	3302
6-3/4 x 33	66513	40541	27027	7751	52416	39312	26208	5242	43075	32306	21537	3590
6-3/4 x 34-3/8	72042	42230	28153	8256	56782	42114	28076	5678	46672	35004	23336	3889

Notes:

(1) Load Duration Factor = 1.15, F_b = 2,400 psi, F_v = 240 psi, E = 1,800,000 psi

(2) Maximum deflection = L/180 under total load. Other deflection limits may apply.

(3) Service condition = dry.

(4) Tabulated values represent total loads and have taken the dead weight of the beam (assumed 36 pcf) into account.

(5) Volume effect is included.

(6) Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

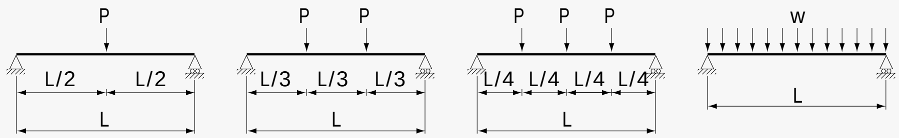
(7) White highlighted numbers limited by deflection
Gray shaded numbers limited by bending strength
Orange shaded numbers limited by shear strength.

(8) Beams having net widths of 3 in. and 5 in. may be substituted for 3-1/8 in. and 5-1/8 in. widths tabulated with the same depths.

(9) Final design should include a check for lateral stability and end bearing.

GLUED-LAMINATED HEADER (DOUGLAS-FIR)

Allowable concentrated loads (lbs, load cases I, II, III) and uniform loads (plf, load case IV) for Glued Laminated Beams



Load Cases H-I H-II H-III H-IV

	L = 8'				L = 10'				L = 12'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
3-1/8 x 6	2138	1604	1069	535	1702	1084	777	295	1268	744	534	169
3-1/8 x 7-1/2	3346	2510	1673	837	2667	2000	1333	533	2212	1468	1053	333
3-1/8 x 9	4824	3618	2412	1206	3847	2885	1924	769	3193	2395	1597	532
3-1/8 x 10-1/2	6572	4748	3165	1522	5243	3932	2621	1049	4354	3266	2177	726
3-1/8 x 12	8589	5426	3617	1812	6854	5141	3427	1357	5695	4271	2848	949
3-1/8 x 13-1/2	10875	6104	4070	2127	8682	6094	4063	1576	7216	5412	3608	1203
3-1/8 x 15	13431	6783	4522	2472	10724	6771	4514	1809	8916	6687	4458	1426
3-1/8 x 16-1/2	14922	7461	4974	2849	12983	7448	4966	2059	10796	7436	4957	1611
3-1/8 x 18	16278	8139	5426	3264	15457	8125	5417	2327	12855	8112	5408	1807
3-1/8 x 19-1/2	17635	8817	5878	3723	17605	8803	5868	2615	15095	8788	5858	2014
3-1/8 x 21	18991	9496	6330	4233	18959	9480	6320	2925	17514	9464	6309	2233
3-1/8 x 22-1/2	20348	10174	6783	4803	20313	10157	6771	3260	20112	10140	6760	2466
5-1/8 x 7-1/2	5488	4116	2744	1372	4374	3280	2187	875	3628	2407	1727	547
5-1/8 x 9	7912	5934	3956	1978	6309	4732	3155	1262	5237	3928	2619	873
5-1/8 x 10-1/2	10777	7786	5191	2495	8598	6449	4299	1720	7141	5356	3571	1190
5-1/8 x 12	14085	8899	5932	2971	11241	8431	5621	2225	9340	7005	4670	1557
5-1/8 x 13-1/2	17835	10011	6674	3489	14238	9994	6663	2584	11834	8875	5917	1972
5-1/8 x 15	22027	11123	7416	4053	17588	11105	7403	2967	14622	10967	7311	2339
5-1/8 x 16-1/2	24471	12236	8157	4672	21292	12215	8143	3377	17705	12195	8130	2643
5-1/8 x 18	26696	13348	8899	5353	25349	13326	8884	3817	21083	13303	8869	2964
5-1/8 x 19-1/2	28921	14460	9640	6105	28872	14436	9624	4289	24755	14412	9608	3303
5-1/8 x 21	31145	15573	10382	6942	31093	15547	10364	4798	28722	15520	10347	3663
5-1/8 x 22-1/2	33370	16685	11123	7877	33314	16657	11105	5347	32756	16629	11086	4044
5-1/8 x 24	35595	17797	11865	8929	35535	17768	11845	5942	35475	17738	11825	4449
5-1/8 x 25-1/2	37820	18910	12607	10121	37756	18878	12585	6590	37692	18846	12564	4881
5-1/8 x 27	40044	20022	13348	11484	39977	19988	13326	7296	39910	19955	13303	5341
5-1/8 x 28-1/2	42269	21134	14090	13058	42198	21099	14066	8070	42127	21063	14042	5834
5-1/8 x 30	44494	22247	14831	14893	44419	22209	14806	8921	44344	22172	14781	6362
6-3/4 x 10-1/2	14195	10255	6837	3286	11325	8494	5662	2265	9406	7054	4703	1568
6-3/4 x 12	18551	11720	7814	3913	14806	11104	7403	2930	12302	9226	6151	2050
6-3/4 x 13-1/2	23490	13185	8790	4595	18752	13163	8775	3403	15586	11690	7793	2598
6-3/4 x 15	29011	14650	9767	5339	23164	14626	9750	3908	19259	14444	9629	3080
6-3/4 x 16-1/2	32231	16115	10744	6153	28043	16088	10726	4448	23239	16061	10707	3481
6-3/4 x 18	35161	17580	11720	7050	33386	17551	11701	5027	27431	17521	11681	3903
6-3/4 x 19-1/2	38091	19045	12697	8041	38027	19013	12676	5649	31951	18981	12654	4350
6-3/4 x 21	41021	20510	13674	9143	40952	20476	13651	6319	36796	20442	13628	4824
6-3/4 x 22-1/2	43951	21975	14650	10374	43877	21939	14626	7042	41964	21902	14601	5326
6-3/4 x 24	46881	23441	15627	11760	46802	23401	15601	7827	46724	23362	15575	5860
6-3/4 x 25-1/2	49811	24906	16604	13330	49727	24864	16576	8679	49644	24822	16548	6429
6-3/4 x 27	52741	26371	17580	15126	52653	26326	17551	9609	52564	26282	17521	7035
6-3/4 x 28-1/2	55671	27836	18557	17198	55578	27789	18526	10629	55484	27742	18495	7684
6-3/4 x 30	58601	29301	19534	19616	58503	29251	19501	11750	58404	29202	19468	8379
6-3/4 x 31-1/2	61531	30766	20510	22474	61428	30714	20476	12989	61325	30662	20442	9125
6-3/4 x 33	64461	32231	21487	25904	64353	32177	21451	14367	64245	32122	21415	9930
6-3/4 x 34-1/2	67391	33696	22464	30096	67278	33639	22426	15907	67165	33583	22388	10798

Notes:

(1) Load Duration Factor = 1.15, F_b = 2,400 psi, F_v = 190 psi, E = 1,800,000 psi

(2) Maximum deflection = L/180 under total load. Other deflection limits may apply.

(3) Service condition = dry.

(4) Tabulated values represent total loads and have taken the dead weight of the beam (assumed 35 pcf) into account.

(5) Volume effect is included.

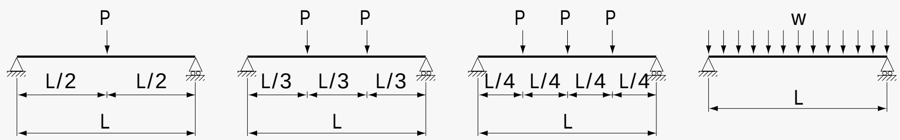
(6) Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

(7) White highlighted numbers limited by deflection
Gray shaded numbers limited by bending strength
Orange shaded numbers limited by shear strength.

(8) Final design should include a check for lateral stability and end bearing.

GLUED-LAMINATED HEADER (DOUGLAS-FIR) – CONTINUED

Allowable concentrated loads (lbs, load cases I, II, III) and uniform loads (plf, load case IV) for Glued-Laminated Beams



Load Cases H-I H-II H-III H-IV

	L = 16'				L = 20'				L = 24'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
3-1/8 x 6	687	403	289	69	412	242	173	---	257	151	108	---
3-1/8 x 7-1/2	1374	806	578	137	844	496	356	68	550	323	232	---
3-1/8 x 9	2371	1411	1012	240	1497	878	630	120	996	585	419	66
3-1/8 x 10-1/2	3238	2257	1619	385	2413	1416	1016	193	1625	954	684	108
3-1/8 x 12	4240	3180	2120	530	3359	2134	1531	291	2467	1448	1039	164
3-1/8 x 13-1/2	5376	4032	2688	672	4264	3059	2132	417	3516	2086	1496	237
3-1/8 x 15	6647	4985	3324	831	5277	3958	2638	528	4355	2885	2070	328
3-1/8 x 16-1/2	8053	6040	4027	1007	6397	4798	3199	640	5285	3863	2643	439
3-1/8 x 18	9594	7195	4797	1199	7626	5719	3813	763	6276	4707	3138	523
3-1/8 x 19-1/2	11269	8452	5635	1378	8962	6722	4481	896	7320	5490	3660	610
3-1/8 x 21	13079	9432	6288	1514	10389	7792	5195	1039	8440	6330	4220	703
3-1/8 x 22-1/2	15024	10105	6737	1655	11855	8891	5928	1186	9636	7227	4818	803
5-1/8 x 7-1/2	2253	1322	948	225	1385	813	583	111	903	530	380	60
5-1/8 x 9	3889	2314	1660	394	2454	1441	1033	196	1634	959	688	109
5-1/8 x 10-1/2	5310	3702	2655	631	3957	2322	1666	317	2665	1564	1122	178
5-1/8 x 12	6953	5215	3476	869	5509	3500	2511	477	4047	2375	1704	270
5-1/8 x 13-1/2	8817	6612	4408	1102	6944	5016	3472	684	5618	3421	2454	389
5-1/8 x 15	10901	8176	5451	1363	8501	6376	4250	850	6885	4732	3394	537
5-1/8 x 16-1/2	13145	9859	6572	1643	10207	7655	5104	1021	8274	6205	4137	689
5-1/8 x 18	15523	11642	7761	1940	12060	9045	6030	1206	9783	7337	4892	815
5-1/8 x 19-1/2	18087	13565	9043	2259	14059	10544	7030	1406	11412	8559	5706	951
5-1/8 x 21	20836	15468	10312	2482	16203	12152	8102	1620	13159	9869	6579	1097
5-1/8 x 22-1/2	23769	16573	11049	2714	18491	13868	9245	1849	15023	11268	7512	1252
5-1/8 x 24	26884	17678	11785	2956	20921	15691	10460	2092	17005	12754	8502	1417
5-1/8 x 25-1/2	30180	18783	12522	3209	23493	17619	11746	2349	19102	14327	9551	1592
5-1/8 x 27	33657	19888	13258	3472	26205	19654	13103	2567	21315	15986	10657	1776
5-1/8 x 28-1/2	37312	20992	13995	3747	29058	20921	13948	2755	23642	17732	11821	1970
5-1/8 x 30	41146	22097	14732	4035	32050	22023	14682	2949	26083	19563	13042	2174
6-3/4 x 10-1/2	6994	4876	3497	831	5211	3059	2194	417	3510	2060	1478	234
6-3/4 x 12	9154	6866	4577	1144	7088	4610	3307	628	5330	3128	2244	355
6-3/4 x 13-1/2	11470	8603	5735	1434	8891	6607	4445	889	7190	4506	3232	512
6-3/4 x 15	14032	10524	7016	1754	10886	8164	5443	1089	8813	6232	4407	708
6-3/4 x 16-1/2	16837	12628	8418	2105	13071	9803	6535	1307	10592	7944	5296	883
6-3/4 x 18	19883	14912	9941	2485	15445	11584	7722	1544	12525	9394	6263	1044
6-3/4 x 19-1/2	23168	17376	11584	2896	18005	13504	9003	1801	14611	10958	7306	1218
6-3/4 x 21	26690	20017	13345	3269	20752	15564	10376	2075	16849	12637	8425	1404
6-3/4 x 22-1/2	30447	21828	14552	3575	23682	17761	11841	2368	19237	14428	9619	1603
6-3/4 x 24	34438	23283	15522	3894	26795	20096	13397	2679	21775	16332	10888	1815
6-3/4 x 25-1/2	38661	24738	16492	4226	30090	22567	15045	3009	24462	18346	12231	2038
6-3/4 x 27	43115	26193	17462	4573	33565	25174	16782	3356	27296	20472	13648	2275
6-3/4 x 28-1/2	47798	27649	18432	4935	37219	27555	18370	3628	30277	22708	15139	2523
6-3/4 x 30	52709	29104	19403	5314	41053	29005	19337	3884	33405	25053	16702	2784
6-3/4 x 31-1/2	57848	30559	20373	5711	45063	30456	20304	4148	36677	27508	18339	3056
6-3/4 x 33	63212	32014	21343	6126	49251	31906	21271	4421	40094	30071	20047	3341
6-3/4 x 34-1/2	66939	33469	22313	6562	53614	33356	22237	4704	43655	32742	21828	3638

Notes:

(1) Load Duration Factor = 1.15, F_b = 2,400 psi, F_v = 190 psi, E = 1,800,000 psi

(2) Maximum deflection = L/180 under total load. Other deflection limits may apply.

(3) Service condition = dry.

(4) Tabulated values represent total loads and have taken the dead weight of the beam (assumed 35 pcf) into account.

(5) Volume effect is included.

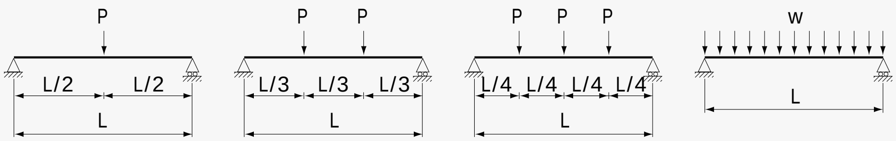
(6) Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

(7) White highlighted numbers limited by deflection
Gray shaded numbers limited by bending strength
Orange shaded numbers limited by shear strength.

(8) Final design should include a check for lateral stability and end bearing.

TABLE 7A

BUILT-UP LUMBER HEADER (NO. 1 SOUTHERN PINE)
Allowable concentrated loads (lbs, load cases I, II, III) and uniform loads (plf, load case IV) for No. 1 Southern Pine Lumber



Load Cases — **H-I**, **H-II**, **H-III**, **H-IV**

Nominal Dimensions	L = 4'				L = 6'				L = 8'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
2x6	1130	565	377	367	779	563	375	222	576	432	291	147
2x8	1490	745	497	535	1226	742	495	311	905	679	458	218
2x10	1901	951	634	776	1725	947	632	426	1272	944	629	293
2x12	2312	1156	771	1092	2304	1152	768	560	1792	1148	765	376
(2) 2x6	2261	1130	754	734	1577	1126	751	444	1174	881	588	295
(2) 2x8	2980	1490	993	1070	2493	1485	990	621	1858	1393	930	437
(2) 2x10	3803	1901	1268	1551	3517	1895	1263	852	2622	1888	1259	586
(2) 2x12	4625	2312	1542	2184	4608	2304	1536	1121	3730	2296	1531	752
(3) 2x6	3391	1696	1130	1102	2728	1690	1126	666	2034	1526	1018	476
(3) 2x8	4471	2235	1490	1605	4312	2227	1485	932	3218	2219	1480	655
(3) 2x10	5704	2852	1901	2327	5684	2842	1895	1278	4543	2832	1888	879
(3) 2x12	6937	3469	2312	3275	6912	3456	2304	1681	6466	3444	2296	1128
(4) 2x6	4522	2261	1507	1469	3640	2253	1502	888	2715	2036	1358	635
(4) 2x8	5961	2980	1987	2140	5755	2970	1980	1242	4296	2959	1973	873
(4) 2x10	7605	3803	2535	3102	7578	3789	2526	1704	6065	3776	2517	1172
(4) 2x12	9249	4625	3083	4367	9217	4608	3072	2242	8635	4592	3061	1504

Nominal Dimensions	L = 10'				L = 12'				L = 14'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
2x6	453	339	230	94	369	258	185	—	308	186	133	—
2x8	710	532	362	148	576	432	297	102	477	357	249	74
2x10	994	745	509	210	804	602	417	145	661	495	350	105
2x12	1391	1042	720	283	1111	832	588	206	899	672	492	151
(2) 2x6	931	698	466	187	768	516	370	—	633	372	267	—
(2) 2x8	1474	1106	739	297	1217	913	610	205	1031	773	518	149
(2) 2x10	2082	1561	1044	420	1719	1289	862	289	1458	1093	732	211
(2) 2x12	2963	2222	1486	565	2448	1836	1229	413	2078	1558	1044	301
(3) 2x6	1616	1131	809	308	1319	774	555	—	949	557	400	—
(3) 2x8	2558	1919	1281	504	2116	1587	1059	354	1797	1307	900	254
(3) 2x10	3613	2710	1809	669	2990	2242	1497	501	2542	1906	1273	365
(3) 2x12	5146	3432	2288	848	4261	3196	2135	678	3626	2719	1817	521
(4) 2x6	2157	1508	1079	411	1759	1032	740	—	1266	743	533	—
(4) 2x8	3416	2562	1709	672	2827	2120	1414	472	2402	1742	1202	339
(4) 2x10	4826	3619	2415	892	3995	2996	1999	668	3398	2548	1701	487
(4) 2x12	6875	4575	3050	1130	5696	4272	2851	904	4850	3637	2428	695

Table continues on page 16.
See notes, page 17.

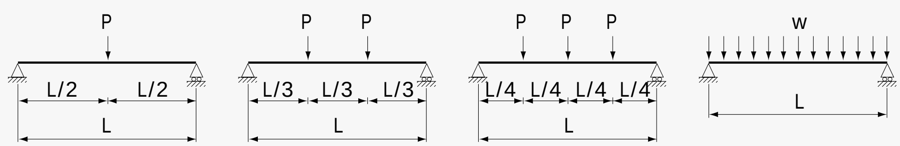
TABLE 7A (CONTINUED)

Nominal Dimensions	L = 16'				L = 18'				L = 20'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
2x6	236	138	99	—	180	105	76	—	139	81	58	—
2x8	400	299	213	—	337	252	182	—	284	201	144	—
2x10	549	410	299	80	457	341	258	—	380	283	223	—
2x12	731	546	417	114	597	445	356	89	489	364	305	72
(2) 2x6	471	277	198	—	359	211	151	—	277	163	117	—
(2) 2x8	891	657	447	—	780	508	365	—	684	401	288	—
(2) 2x10	1260	945	633	160	1105	829	556	—	979	734	493	—
(2) 2x12	1798	1348	905	229	1578	1183	795	179	1400	1050	707	143
(3) 2x6	707	415	298	—	539	316	227	—	416	244	175	—
(3) 2x8	1557	985	707	—	1299	763	547	—	1026	602	432	—
(3) 2x10	2203	1652	1104	277	1938	1453	971	—	1723	1292	864	—
(3) 2x12	3146	2360	1577	396	2770	2078	1389	311	2467	1850	1238	249
(4) 2x6	943	553	397	—	718	421	302	—	554	325	233	—
(4) 2x8	2081	1313	942	—	1732	1017	729	—	1367	803	576	—
(4) 2x10	2946	2210	1475	370	2592	1944	1298	—	2306	1729	1155	—
(4) 2x12	4210	3158	2108	528	3709	2782	1858	414	3305	2479	1656	332

See notes, page 17.

TABLE 7B

BUILT-UP LUMBER HEADER (NO. 2 SOUTHERN PINE)
Allowable concentrated loads (lbs, load cases I, II, III) and uniform loads (plf, load case IV) for No. 2 Southern Pine Lumber



Load Cases H-I H-II H-III H-IV

Nominal Dimensions	L = 4'				L = 6'				L = 8'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
2x6	895	565	377	367	591	443	297	199	437	328	220	111
2x8	1490	745	497	535	983	737	495	311	727	545	367	186
2x10	1901	951	634	776	1398	947	632	426	1033	774	522	266
2x12	2312	1156	771	1092	1915	1152	768	560	1412	1058	716	365
(2) 2x6	1801	1130	754	734	1193	895	597	399	887	665	444	222
(2) 2x8	2980	1490	993	1070	1992	1485	990	621	1483	1112	743	373
(2) 2x10	3803	1901	1268	1551	2839	1895	1263	852	2114	1586	1059	531
(2) 2x12	4625	2312	1542	2184	3900	2304	1536	1121	2906	2180	1456	731
(3) 2x6	3111	1696	1130	1102	2063	1547	1032	666	1536	1152	768	385
(3) 2x8	4471	2235	1490	1605	3446	2227	1485	932	2569	1927	1286	644
(3) 2x10	5704	2852	1901	2327	4911	2842	1895	1278	3663	2747	1833	879
(3) 2x12	6937	3469	2312	3275	6748	3456	2304	1681	5036	3444	2296	1128
(4) 2x6	4149	2261	1507	1469	2752	2064	1376	888	2050	1537	1025	513
(4) 2x8	5961	2980	1987	2140	4598	2970	1980	1242	3429	2572	1715	858
(4) 2x10	7605	3803	2535	3102	6553	3789	2526	1704	4890	3667	2446	1172
(4) 2x12	9249	4625	3083	4367	9007	4608	3072	2242	6723	4592	3061	1504

Table continues on page 17.

TABLE 7B (CONTINUED)

Nominal Dimensions	L = 10'				L = 12'				L = 14'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
2x6	344	258	174	70	281	210	142	—	235	174	119	—
2x8	571	428	290	118	465	349	238	81	388	291	200	59
2x10	810	607	412	169	658	493	338	116	547	409	284	84
2x12	1105	828	565	232	894	669	463	160	737	551	388	117
(2) 2x6	701	526	351	141	577	432	289	—	486	348	244	—
(2) 2x8	1175	882	589	237	969	726	485	163	819	614	411	118
(2) 2x10	1677	1258	840	338	1383	1037	693	232	1171	878	587	169
(2) 2x12	2306	1730	1156	465	1903	1427	955	320	1613	1210	810	233
(3) 2x6	1217	913	609	244	1003	727	502	—	848	523	375	—
(3) 2x8	2040	1530	1021	409	1684	1263	843	282	1428	1071	715	205
(3) 2x10	2910	2183	1457	584	2405	1804	1204	402	2041	1531	1022	293
(3) 2x12	4004	3003	2004	804	3311	2483	1658	554	2813	2110	1409	404
(4) 2x6	1625	1219	813	325	1339	969	670	—	1132	697	500	—
(4) 2x8	2723	2042	1362	546	2249	1687	1125	376	1908	1431	955	273
(4) 2x10	3886	2915	1944	779	3213	2409	1607	537	2727	2046	1365	391
(4) 2x12	5347	4010	2675	1072	4424	3318	2214	739	3760	2820	1882	539

Nominal Dimensions	L = 16'				L = 18'				L = 20'			
	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV	H-I	H-II	H-III	H-IV
2x6	199	130	93	—	168	98	71	—	129	76	54	—
2x8	328	245	171	—	279	209	148	—	238	178	129	—
2x10	459	344	243	64	388	290	210	—	328	245	183	—
2x12	613	458	331	88	511	382	286	69	427	318	248	55
(2) 2x6	417	259	186	—	335	197	141	—	258	151	109	—
(2) 2x8	706	529	354	—	616	462	310	—	544	375	269	—
(2) 2x10	1010	757	507	128	883	662	444	—	781	585	393	—
(2) 2x12	1393	1045	700	177	1220	915	614	138	1080	810	544	110
(3) 2x6	662	389	279	—	503	295	212	—	387	227	163	—
(3) 2x8	1234	924	618	—	1081	715	513	—	957	563	404	—
(3) 2x10	1766	1324	884	222	1549	1162	776	—	1374	1030	689	—
(3) 2x12	2436	1827	1221	306	2140	1605	1073	240	1901	1426	953	192
(4) 2x6	883	518	372	—	671	394	282	—	516	303	217	—
(4) 2x8	1649	1232	825	—	1445	953	684	—	1279	751	539	—
(4) 2x10	2360	1770	1181	296	2072	1554	1037	—	1838	1379	920	—
(4) 2x12	3258	2443	1631	409	2863	2147	1433	319	2545	1908	1274	256

NOTES:

(1) Load Duration Factor = 1.15, see 1997 National Design Specification Supplement for Design Values.

(2) Maximum deflection = L/180 under total load. Other deflection limits may apply.

(3) Service condition = dry.

(4) Tabulated values represent total loads and have taken the dead weight of the beam (assumed 35 pcf) into account.

(5) Depth effect is included.

(6) Repetitive member factor included where appropriate.

(7) Lateral stability was considered. The headers were assumed to be laterally braced at the point loads, fully braced for the uniform load.

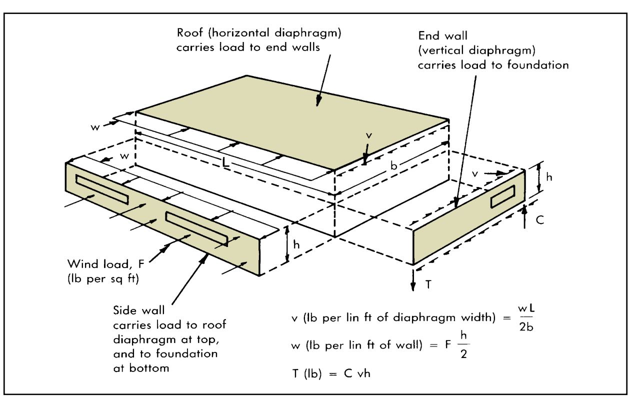
(8) Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

(9) White highlighted numbers limited by deflection.
Gray shaded numbers limited by bending strength.
Orange shaded numbers limited by shear strength.

Post-frame designs incorporating diaphragms and shear walls reduce post size and embedment requirements.

T-111 plywood-sided commercial building.

These viewing stands used diaphragms and shear walls to transfer lateral loads.



Lateral load distribution in buildings.

Diaphragms

When designing a building for lateral loads, such as those generated by wind or earthquakes, designers have several alternatives, including braced or rigid frames, diagonal rods, ‘X’ bracing, etc. Buildings can also resist extreme lateral loads through the application of a principal called “diaphragm design.”

A diaphragm is a flat structural unit acting like a deep, narrow beam. The term “diaphragm” is usually applied to roofs and floors. A “shear wall”, however, is just a vertical diaphragm. Shear walls provide support for the roof and floor diaphragms and transmit forces into the foundation.

A diaphragm structure results when a series of diaphragms are properly tied together to form a unit. When diaphragms and shear walls are used in the lateral design of a building, the structure is termed “a box system.”

An accurate method for engineering diaphragms (see ASAE EP 484.1 and *APA Design/Construction Guide: Diaphragms)* has evolved from extensive testing to allow the design of a building resistant to wind or earthquakes at very little cost.

With good common construction practice, most sheathed elements in a building add considerable strength to the structure. Exceptions include standing seam metal roofs, corrugated asphalt paper roofs, and other low-stiffness sheathing materials. Thus, if the walls and roofs are sheathed, adequately tied together and attached firmly to the foundation, many of the requirements of a diaphragm structure are already met. This fact explains the excellent performance of sheathed buildings in hurricane and earthquake conditions, even when they were not engineered as diaphragms.[1]

Utilizing the principle of diaphragm structure action results in reduced post size and embedment (foundation) requirements consistent with actual building performance. This makes post-frame construction more economical and competitive with other construction alternatives in code-enforced construction. In quantitative terms, the post size for a typical post-frame building can be reduced by more than one nominal size if the diaphragm contribution of roof cladding is considered. For example, the post reduces from a 6x10 solid-sawn (or 3-ply, 2x10 nail-laminated) column when no diaphragm action is used, to a 6x6 solid-sawn (or 3-ply, 2x6 nail-laminated) column when diaphragm action is considered for a 40’ wide x 80’ long building with a 16’ eave height.

When principles of diaphragm action are not used, the total lateral wind load must be resisted solely by the wall columns. Each side-wall post then behaves like a cantilever beam, resulting in a higher post bending moment at the groundline which requires a greater embedment depth.

1 APA Design/Construction Guide: Diaphragms.

Diaphragms (continued)

Diaphragm action also requires that all pieces of the structure work together, so connecting these pieces together is very important. This includes the correct size, type and spacing of fasteners. Once properly connected, post-frame construction technology creates a highly optimized structure.

Diaphragm sheathing materials are typically a structural wood panel, such as plywood or oriented strand board (OSB), or architectural steel. Structural wood panels have the following features:

- They are used where a traditional roof or wall appearance is desired.
- Diaphragm tables are referenced in the codes, allowing for easy design and application.
- Exterior adhesives are used in their manufacture to resist the effects of moisture during job-site construction and maintain an attractive appearance.
- They can easily be painted or shingled.
- Wood diaphragms have a large capacity to absorb impact loads, resulting in excellent performance under high-wind or earthquake loads.

Table 8 provides recommended design values for wood structural panel diaphragms based on specific fastener requirements.

For more information about structural wood panels, contact APA-The Engineered Wood Association at 253/565-6600, or visit www.apawood.org.

Architectural steel has the following features:

- It has high strength.
- It is lightweight, making it easy and quick to install.
- It is painted with weather-resistant paint to maintain its color and integrity for many years.
- All steel sheathing and fasteners are galvanized to prevent rusting due to weathering and to provide a long-lasting architectural finish.

To illustrate the effects of diaphragm action, Dr. Kifle G. Gebremedhin conducted the following series of tests:

1. Building framework only (no sheathing diaphragms).
2. Sheathing attached to end walls only.
3. Sheathing attached to all four walls.
4. Sheathing attached to all walls and one side of the roof.
5. Sheathing attached completely (full diaphragm in place).

Shown below (Figure 9) are the results of this testing which illustrate the building's increasing stiffness as more sheathing was put in place.

FIGURE 9

Research Results of Diaphragm Action

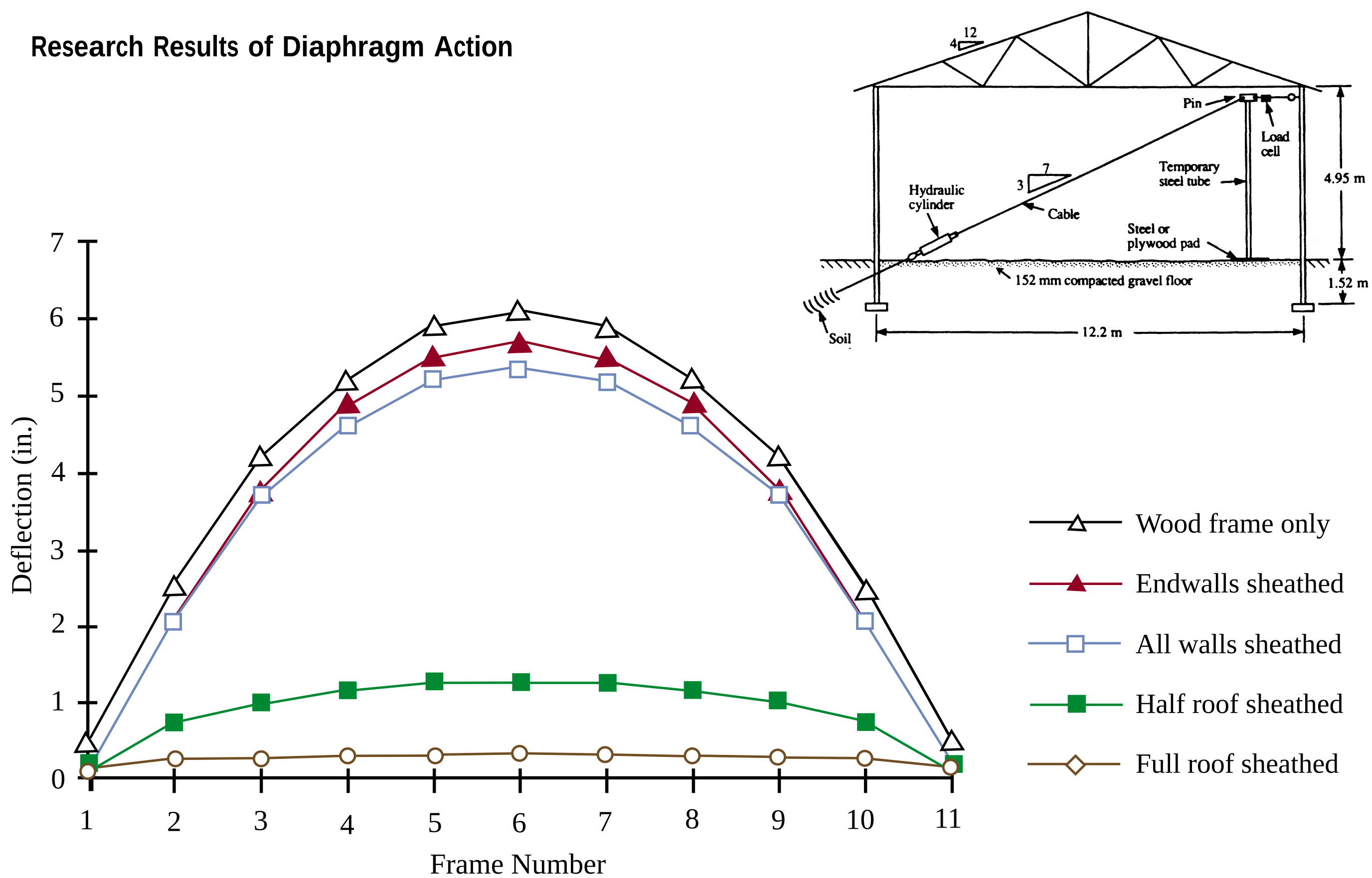


TABLE 8

RECOMMENDED SHEAR (POUNDS PER FOOT) FOR HORIZONTAL APA PANEL DIAPHRAGMS WITH FRAMING OF DOUGLAS-FIR, LARCH OR SOUTHERN PINE[(a)] FOR WIND OR SEISMIC LOADING

Panel Grade	Common Nail Size	Minimum Nail Penetration in Framing (inches)	Minimum Nominal Panel Thickness (inch)	Minimum Nominal Width of Framing Member (inches)	Blocked Diaphragms: Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)[(b)]: 6 / Nail Spacing (in.) at other panel edges (Cases 1, 2, 3 & 4): 6	4 / 6	2-1/2[(c)] / 4	2[(c)] / 3	Unblocked Diaphragms: Nails Spaced 6" max. at Supported Edges[(b)]: Case 1 (No unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 & 6)
APA STRUCTURAL I grades	6d[(e)]	1-1/4	5/16	2	185	250	375	420	165	125
				3	210	280	420	475	185	140
	8d	1-1/2	3/8	2	270	360	530	600	240	180
				3	300	400	600	675	265	200
	10d[(d)]	1-5/8	15/32	2	320	425	640	730	285	215
				3	360	480	720	820	320	240
APA RATED SHEATHING, APA RATED STURD-I-FLOOR and other APA grades except Species Group 5	6d[(e)]	1-1/4	5/16	2	170	225	335	380	150	110
				3	190	250	380	430	170	125
			3/8	2	185	250	375	420	165	125
				3	210	280	420	475	185	140
	8d	1-1/2	3/8	2	240	320	480	545	215	160
				3	270	360	540	610	240	180
			7/16	2	255	340	505	575	230	170
				3	285	380	570	645	255	190
			15/32	2	270	360	530	600	240	180
				3	300	400	600	675	265	200
	10d[(d)]	1-5/8	15/32	2	290	385	575	655	255	190
				3	325	430	650	735	290	215
			19/32	2	320	425	640	730	285	215
				3	360	480	720	820	320	240

(a) For framing of other species: (1) Find specific gravity for species of lumber in AF&PA National Design Specification®. (2) Find shear value from table above for nail size for Structural I panels (regardless of actual grade). (3) Multiply value by 0.82 for species with specific gravity of 0.42 or greater, or 0.65 for all other species.

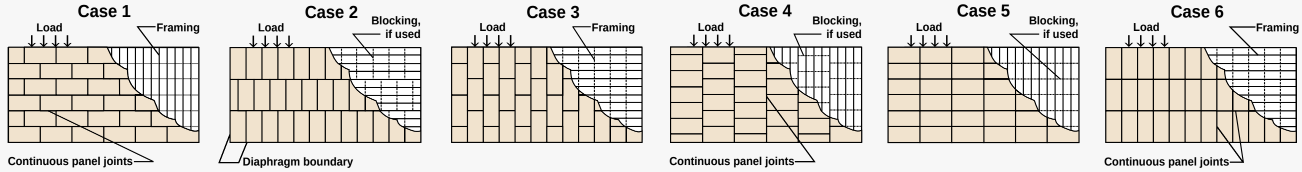
(b) Space nails maximum 12 in. o.c. along intermediate framing members (6 in. o.c. when supports are spaced 48 in. o.c.).

(c) Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c. or 2-1/2 inches o.c.

(d) Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 inches are spaced 3 inches o.c.

(e) 8d is recommended minimum for roofs due to negative pressures of high winds.

Notes: Design for diaphragm stresses depends on direction of continuous panel joints with reference to load, not on direction of long dimension of sheet. Continuous framing may be in either direction for blocked diaphragms.



Shear Walls

Installing wood structural panels to create shear walls is the best-known way to strengthen wood-frame buildings. A shear wall is more than the sum of its parts. It is a system – a single unit that ties together the floor, roof, walls and foundation to give a building greater resistance to lateral loads.

The top of a shear wall is fastened to the second floor or roof framing and the bottom is fastened to the sill plate. The sill plate is, in turn, fastened to the foundation at regular intervals as required by local codes. In some cases, a hold-down anchor may be required to resist high overturning movements.

Either Rated Sheathing or Rated Siding can be used in shear wall design. Table 9 provides maximum allowable shears for walls with Rated Sheathing; walls with Rated Siding; and walls with panels applied over gypsum sheathing, which is a system commonly used when the building must be fire rated.

To design a shear wall, follow these steps:

1. Determine the unit shear transferred by the roof diaphragm to the wall.
2. Determine the required panel grade and thickness, and nailing schedule from Table 9. In typical light-frame wood construction, the anchor bolts in the sill plate should be checked for shear. In post-frame construction, the shear is resisted by the post-to-ground connection, so check the selected connection system and hardware.
3. Check wall framing on each end of shear wall.

TABLE 9

RECOMMENDED SHEAR (POUNDS PER FOOT) FOR APA PANEL SHEAR WALLS WITH FRAMING OF DOUGLAS-FIR, LARCH, OR SOUTHERN PINE[a] FOR WIND OR SEISMIC LOADING[b]

Panel Grade	Minimum Nominal Panel Thickness (in.)	Minimum Nail Penetration in Framing (in.)	Panels Applied Direct to Framing: Nail Size (common or galvanized box)	Nail Spacing at Panel Edges (in.): 6	4	3	2[e]	Panels Applied Over 1/2" or 5/8" Gypsum Sheathing: Nail Size (common or galvanized box)	Nail Spacing at Panel Edges (in.): 6	4	3	2[e]
APA STRUCTURAL I grades	5/16	1-1/4	6d	200	300	390	510	8d	200	300	390	510
	3/8	1-1/2	8d	230[d]	360[d]	460[d]	610[d]	10d[f]	280	430	550	730
	7/16			255[d]	395[d]	505[d]	670[d]					
	15/32			280	430	550	730					
	15/32	1-5/8	10d[f]	340	510	665	870	—	—	—	—	—
APA RATED SHEATHING; APA RATED SIDING[g] and other APA grades except species Group 5	5/16 or 1/4[c]	1-1/4	6d	180	270	350	450	8d	180	270	350	450
	3/8			200	300	390	510		200	300	390	510
	3/8	1-1/2	8d	220[d]	320[d]	410[d]	530[d]	10d[f]	260	380	490	640
	7/16			240[d]	350[d]	450[d]	585[d]					
	15/32			260	380	490	640					
	15/32	1-5/8	10d[f]	310	460	600	770	—	—	—	—	—
	19/32			340	510	665	870	—	—	—	—	—
APA RATED SIDING 303[g] and other APA grades except species Group 5			Nail Size (galvanized casing)					Nail Size (galvanized casing)				
	5/16[c]	1-1/4	6d	140	210	275	360	8d	140	210	275	360
	3/8	1-1/2	8d	160	240	310	410	10d[f]	160	240	310	410

(a) For framing of other species: (1) Find specific gravity for species of lumber in the AF&PA National Design Specification®. (2)(a) For common or galvanized box nails, find shear value from table above for nail size for STRUCTURAL I panels (regardless of actual grade). (b) For galvanized casing nails, take shear value directly from table above. (3) Multiply this value by 0.82 for species with specific gravity of 0.42 or greater, or 0.65 for all other species.

(b) All panel edges backed with 2-inch nominal or wider framing. Install panels either horizontally or vertically. Space nails maximum 6 inches o.c. along intermediate framing members for 3/8-inch and 7/16-inch panels installed on studs spaced 24 inches o.c. For other conditions and panel thicknesses, space nails maximum 12 inches o.c. on intermediate supports.

(c) 3/8-inch or APA RATED SIDING 16 o.c. is minimum recommended when applied direct to framing as exterior siding.

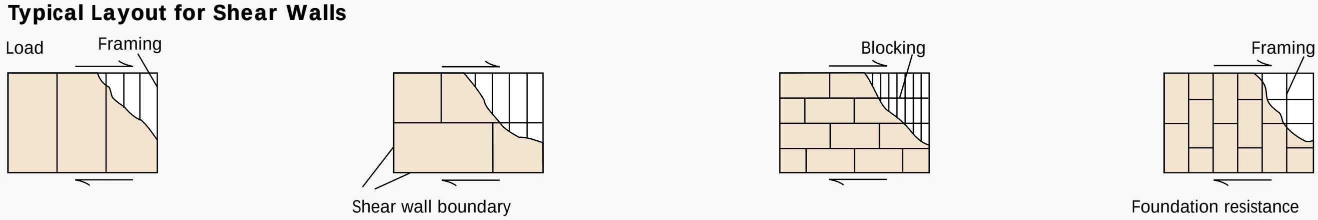
(d) Shears may be increased to values shown for 15/32-inch sheathing with same nailing provided (1) studs are spaced a maximum of 16 inches o.c., or (2) if panels are applied with long dimension across studs.

(e) Framing at adjoining panel edges shall be 3-inch nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c.

(f) Framing at adjoining panel edges shall be 3-inch nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 inches are spaced 3 inches o.c.

(g) Values apply to all-veneer plywood APA RATED SIDING panels only. Other APA RATED SIDING panels may also qualify on a proprietary basis. APA RATED SIDING 16 o.c. plywood may be 11/32 inch, 3/8 inch or thicker. Thickness at point of nailing on panel edges governs shear values.

Typical Layout for Shear Walls



Connections

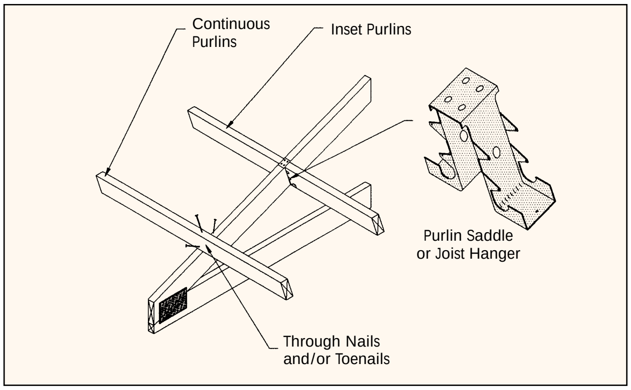
The key to the performance of any structure is directly related to how well the individual components are connected together. This is also true for post-frame construction. All connections must be engineered and detailed to transfer imposed loads from one structural member to another and then to the foundation. Connection designs include the use of nails, screws, bolts, specialty hangers, and metal connector plates for trusses. Some common post-frame connections are illustrated on this page. Figures 2, 3, 6 and 7 shown previously also illustrate some common post-frame connections. Connection design information can be obtained from the *Allowable Stress Design* and *Load and Resistance Factor Design Manuals* published by AF&PA. The structural design, effect of moisture cycling and aesthetic features are important considerations when designing and specifying connection details.

Each connection must meet structural design requirements by transferring loads from member to member without causing overloads and subsequent failure at the connection. Connection detailing becomes particularly important in a structure's resistance to lateral forces, such as those induced during a high wind or seismic event. Damage is greatly reduced when all framing elements are solidly tied together and then firmly anchored to the foundation.

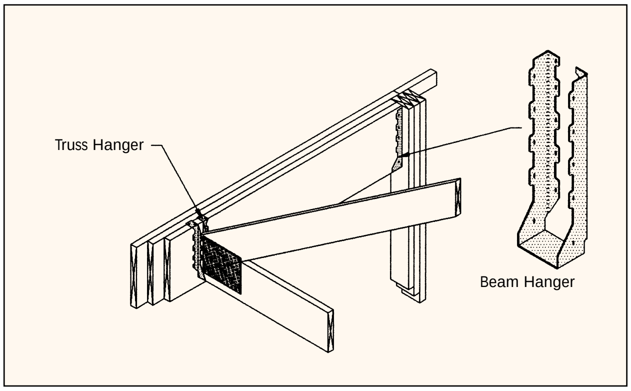
Notching can negatively affect connection strength and should be avoided. Whenever possible, it is important not to cut notches or holes near a connection. This could reduce the performance of the structural member, especially in header and beam applications. Notches may be used, however, in specific post-frame construction details. For example, the top portion of a post-frame post or column may be notched to form a flush seat for a metal plate connection truss. In this case, forces will be parallel-to-grain and splitting potential will be minimized.

Expansion and contraction at connections must be considered when detailing connections for wood framing. Most connections occur at the ends of members where wood end grain is exposed and susceptible to moisture movement. Such connections can be designed to prevent moisture effects by detailing drain holes or slots in box-type connections and by maintaining a gap of at least 1/2 inch between untreated wood and concrete or masonry construction.

In any type of wood construction, it is important to maintain the desired appearance. Almost all post-frame construction uses exposed metal fasteners for connections because it is less complicated and less expensive to leave them exposed. Most builders also believe that the exposed connections add a feeling of added visible strength to the design.



Purlin to truss connection.



Truss to header to column connection.

Truss to laminated column connection.

Closer view of a truss to laminated column connection.

Fire Performance

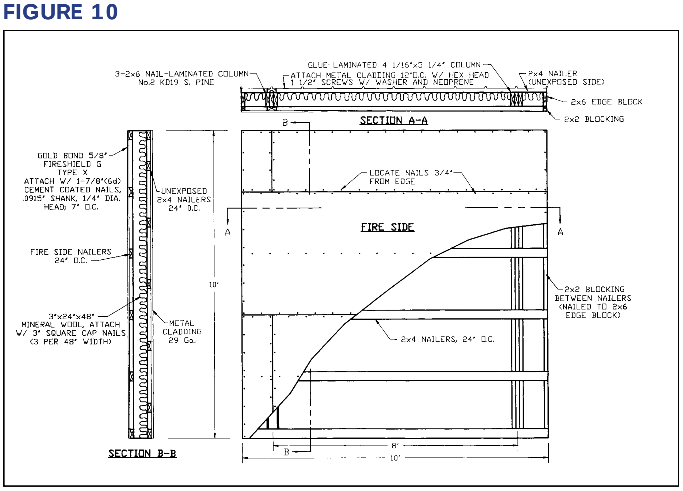
The construction of commercial/industrial buildings often requires that fire performance be considered in the design process. Properly designing a building for fire safety means faithfully executing building code regulations. This means breaking up a building into fire resistant compartments. With compartments and an efficient protection system, such as sprinklers, fires can be localized and more easily suppressed.

Dimension lumber, metal plate connected trusses, glued-laminated timbers and other structural wood products have a long history of solid fire endurance performance.

Standard fire tests measure the fire endurance performance of a variety of wall and floor/roof structural assemblies and boundary conditions that make up compartments. In North America, ASTM Standard E119 sets forth the conditions of the test and the interpretation of the results. Test results are measured in terms of the assembly's ability to withstand a severe fire for a period of time. Performance times are measured in hours: 1-hour rated, 2-hour rated, etc. The codes reference these hourly requirements for various building construction types and occupancies.

The three major source documents for dimension lumber and truss fire endurance assemblies are: the *Fire Resistance Design Manual* published by the Gypsum Association; the *Fire Resistance Directory* published by the Underwriters Laboratories, Inc. (ULI); and the *Uniform Building Code Table 43-C.* The assemblies in these documents range in performance from 1 hour to 2 hours, providing flexibility for any project need.

FIGURE 10



This load bearing, unsymmetrical exterior post-frame wall assembly passed a 1-hour fire test conducted by a nationally recognized testing laboratory, Warnock Hersey International [WH-651-0319], and is accepted nationally.

Proprietary fire endurance assemblies also exist. For more information on these, contact TPI or WTCA. The National Frame Builders Association (NFBA) has a fire endurance tested post-frame wall assembly suitable for 1-hour rated installations (see Figure 10). For more information contact NFBA.

Post-frame commercial occupancy.

Sprinklers

Sprinklers are one of the most proactive fire protection measures available. Statistics from the Federal Emergency Management Agency (FEMA) show the dollar loss to a sprinklered building is less than 50% of the dollar loss to a similar building without sprinklers. The National Fire Protection Association (NFPA) states that loss of life is rare in fully sprinklered structures, and that multiple deaths have only occurred where explosions have take place. Therefore, the use of sprinklers saves lives and property.

Sprinklers also allow more design flexibility because the codes allow building areas to increase 200% for one- and two-story buildings, and 100% for three-story buildings. The building height may also increase by one story.

The primary sprinkler installation standard used for commercial/industrial buildings is *Installation of Sprinkler Systems,* NFPA 13, which is also adopted by the model building codes. For more detailed information on sprinklers and their installation, contact NFPA at 617/770-3000, the National Fire Sprinkler Association at 914/878-4200, or a local sprinkler installation contractor.

Sound Transmission

Sound transmission ratings are closely aligned with fire endurance ratings for assemblies. This is because flame and sound penetrations follow similar paths of least resistance. Control of sound transmission is particularly important in post-frame buildings used for commercial construction, such as offices or churches.

Sound striking a wall or ceiling surface is transmitted through the air in the wall or ceiling cavity. It then strikes the opposite wall surface, causing it to vibrate and transmit the sound into the adjoining room. Sound is also transmitted through any openings into the room, such as air ducts, electrical outlets, window openings, and doors. This is airborne sound transmission.

The Sound Transmission Class (STC) method of rating airborne sound evaluates the comfort level of a particular living space. The higher the STC, the better the airborne noise control performance of the structure. An STC of 50 or above is generally considered a good airborne noise control rating.

Table 10 describes the privacy afforded by each STC rating:

TABLE 10

Sound Transmission Classes

STC Rating	Privacy Afforded
25	Normal speech easily understood
30	Normal speech audible but not intelligible
35	Loud speech audible and fairly understandable
40	Loud speech barely audible but not intelligible
45	Loud speech barely audible
50	Shouting barely audible
55	Shouting not audible

Impact sound transmission occurs when a structural element is vibrated by direct impact, for example, by someone walking. The vibrating surface generates sound waves on both sides of the element. The Impact Insulation Class (IIC) rates the impact sound transmission performance of an assembly. Higher IIC values indicate better performance, with an IIC of 55 required for good impact noise control.

Insurance Considerations

The cost of insuring a building is another major construction consideration, particularly in commercial buildings. The insurance industry uses the following criteria to evaluate the loss potential of buildings:

1. Occupancy load (type of business)
2. Exposure (possible risk of loss)
3. Construction type (wood, steel, or concrete)
4. Special hazards
5. Protection (sprinklers, fire alarms)

Occupancy loads and exposure are the two primary decision factors for insurance companies because they will most influence the risk of loss. The construction type (e.g. post-frame, steel-frame, etc.) portion of the rate does not typically vary by more than 5% from the most combustible to the least combustible designation for larger commercial/industrial buildings, based on research performed in the Midwest.[1] (See Table 11).

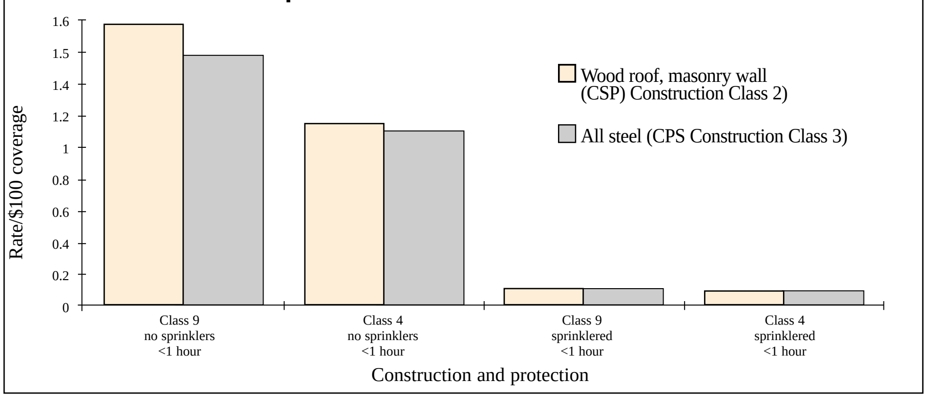
In addition, buildings of three stories or less are often underwritten using a global or class rate system which does not even differentiate by construction type. Increased building protection from sprinklers, periodic security checks, fire alarms connected to the fire department, etc., can dramatically lower insurance rates because of the reduced possibility of large fire losses.

Insurance ratings are often building-specific and are based primarily on the statistical loss experience and loss severity that insurance companies have found for the building type being constructed in a specific geographic region. In some cases, insurance companies use the global Insurance Services Office (ISO) loss statistics. In other cases, they use their own loss experience. Both influence the ultimate insurance rate quoted.

All of this means the cost of insuring a post-frame building should be comparable to the cost of insuring a steel-frame building. The key to getting the best insurance rate is to get several bids from different insurance brokers using different insurance companies. It is also helpful to add fire detection and protection systems to get the lowest possible rates.

TABLE 11

Content Rate Comparisons for an Ohio Warehouse



1 Bert Cohn Associates, Inc., 1992, "Insurance Rate Comparison for Selected States, Tentatives and Lost Cost Basis Rates." Prepared from Specific Commercial Property Evaluations Schedule, July 1990 Edition, by ISO Commercial Risk Services, Inc. Compilation and graphics by Bert Cohn Associates.

Additional Information

Consult the following publications for more detailed design and construction assistance. Refer to the back cover for contact and ordering details.

From the Southern Pine Council

Southern Pine Use Guide
24 pages: grade descriptions; design values; product specifications

Southern Pine Maximum Spans for Joists and Rafters
36 pages: span tables; design criteria

Pressure-Treated Southern Pine
16 pages: retentions; standards; proper use and handling

Southern Pine Headers and Beams
36 pages: size selection and allowable load tables

Southern Pine Floor Trusses
4 pages: design flexibility; span comparisons

Nonresidential Case Studies
Series of brief case studies featuring innovative uses of Southern Pine engineered wood systems

From the National Frame Builders Association

Recommended Practices for the Design and Construction of Agricultural and Commercial Post-Frame Buildings
Three-ring binder: complete reference guide in one convenient package; seventeen separate documents plus information to tie them all together

Post-Frame Building Design
An updated book providing a complete reference on post-frame design

Post-Frame Code Conforming Construction for Commercial Industrial and Institutional Applications
10-minute video: demonstrates that post-frame construction conforms to codes *and* is the answer to an endless variety of building needs

Better Building Brochure
8 pages, full color: details features, advantages and benefits of today's state-of-the-art post-frame buildings

From APA - The Engineered Wood Association

Diaphragm Design and Construction Guide, Form L350
Contains design and construction recommendations for engineered diaphragm systems in floor, shear wall, and roof systems

Residential and Commercial Design and Construction Guide, Form E30
Comprehensive guide to panel construction systems for both residential and commercial/industrial buildings

Glulam Product and Application Guide, Form EWS X440
Includes a detailed description of glulam properties and design and specification considerations

Introduction to Lateral Design, Form X305A
Provides a basic primer on how lateral loads are distributed to, and resisted by, wood-frame construction

Structural Insulated Panels, Form W605
Describes the composition and features of structural insulated panels and provides examples of the types of construction where they can be used

Oriented Strand Board, Form W410
Describes OSB composition, properties, code acceptances, and applications

Post-Frame

Construction Guide

Southern Pine Council (SPC)

SPC is a joint promotional body coordinated and supported by producing members of the Southern Forest Products Association (SFPA) and the Southeastern Lumber Manufacturers Association (SLMA). Collectively, SPC member companies produce 75 percent of the nation's Southern Pine lumber.

A comprehensive promotional program is supported with literature, video programs, and field services of marketing managers. Activities are targeted to residential, nonresidential, industrial and international markets. For more information, contact:

Southern Forest Products Association

Southeastern Lumber Manufacturers Association
P.O. Box 641700
Kenner, LA 70064-1700
Phone: 504/443-4464
Fax: 504/443-6612
www.southernpine.com

SFPA #203 20M-02/00

National Frame Builders Association (NFBA)

NFBA is a nationwide organization of building professionals... builders dedicated to providing only the highest quality structures at the lowest possible cost by utilizing post-frame construction technology. As a member of NFBA, not only are we completely familiar with the exceptional versatility and adaptability of post-frame construction, but we are qualified to design and erect a post-frame building to your most exacting functional, structural and architectural requirements. For more information, contact:

National Frame Builders Association
4840 W. 15th St., Ste. 1000,
Lawrence, KS 66049
Phone: 785/843-2444
Fax: 785/843-7555
www.postframe.org

APA – The Engineered Wood Association

APA is a nonprofit trade association whose member mills produce approximately 70 percent of the structural wood panel products manufactured in North America. The Association's trademark appears only on products manufactured by member mills and is the manufacturer's assurance that the product conforms to the standard shown on the trademark.

Always insist on panels bearing the "mark of quality" – the APA trademark. Your APA panel purchase is not only your highest possible assurance of product quality, but an investment in the many trade services that APA provides on your behalf. For more information contact:

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Form No. A475
Issued February 2000/0200