High Performance

Wood

Wood

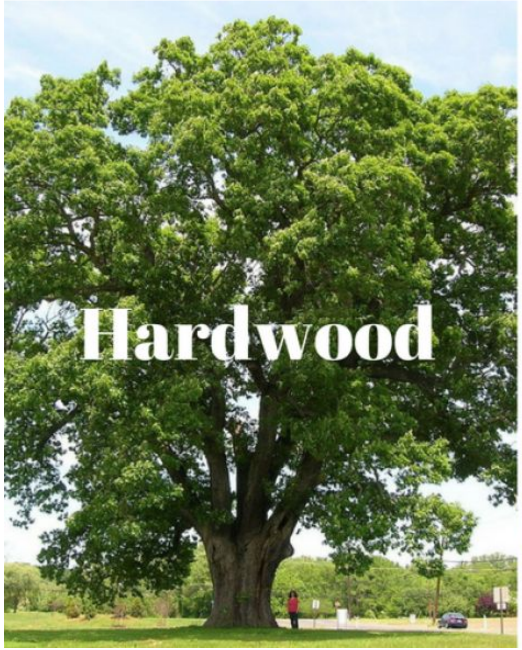
Tree Growth

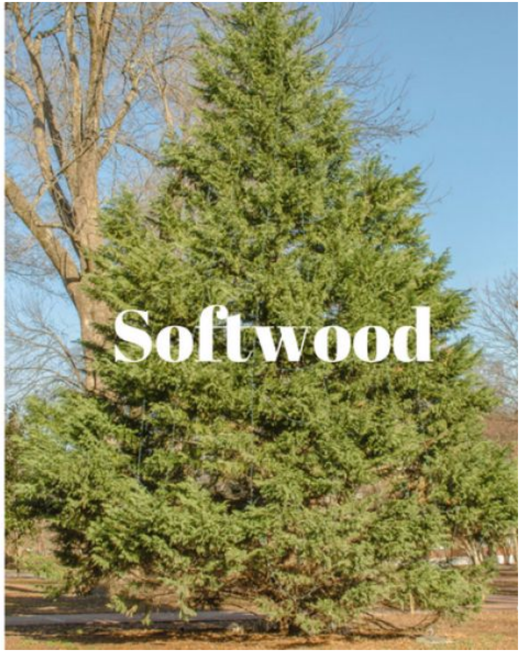
The trunk of a tree is covered with a protective layer of dead bark

The thick layer of living wood cells inside the cambium is the sapwood. In this zone of the tree, nutrients are stored and sap is pumped upward from the roots to the leaves and distributed laterally in the trunk. At the inner edge of this zone, sapwood dies progressively and becomes heartwood. In many species of trees, heartwood is easily distinguished from sapwood by its darker color. Heartwood no longer participates in the life processes of the tree but continues to contribute to its structural strength.

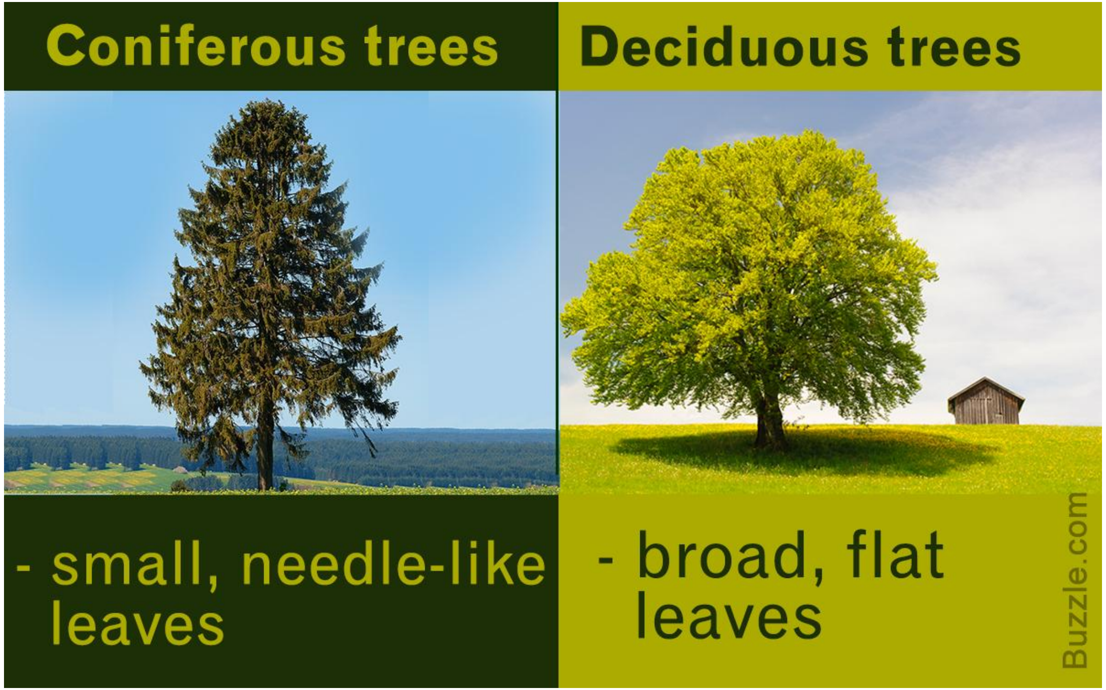
Softwoods and Hardwoods

Softwoods come from coniferous trees and hardwoods from deciduous trees.





Coniferous vs Deciduous Trees



SOFTWOODS	HARDWOODS
Used for Framing, Structural Panels	*Used for Trim, Paneling, Cabinetwork, Furniture*
Alpine fir	American beech
Balsam fir	American chestnut
Black spruce	Aspen
Douglas fir	Basswood
Eastern hemlock	Benge*
Eastern spruce	Birch
Eastern white pine	Black ash
Englemann spruce	Black cherry
Idaho white pine	Black walnut
Jack pine	Butternut
Larch	Elm
Loblolly pine	Hard maple
Lodgepole pine	Hickory
Longleaf pine	Lauan*
Mountain hemlock	Magnolia
Northern pine	Mahogany*
Pitch pine	Pecan
Ponderosa pine	Red alder
Red pine	Red oak
Red spruce	Rosewood*
Shortleaf pine	Sassafras
Sitka spruce	Soft maple
Slash pine	Sweetgum
Sugar pine	Teak*
Sycamore	Tupelo
Tamarack	White oak
True fir	White poplar
Virginia pine	Yellow poplar
Western hemlock	
Western larch	
Western white pine	
White spruce	

Wood - Benefits vs Challenge

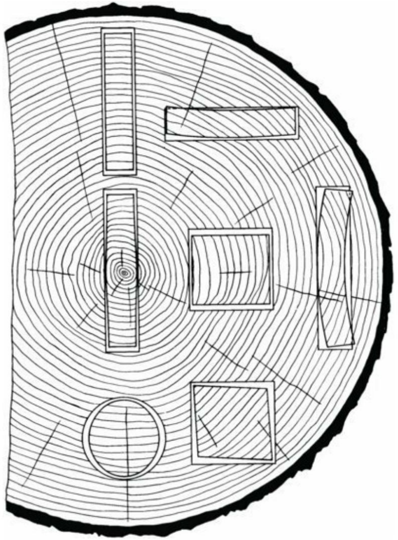
Transportation

Construction Process

Toxic air (composites)

Building life cycle

Wood - Lumber



Sawing

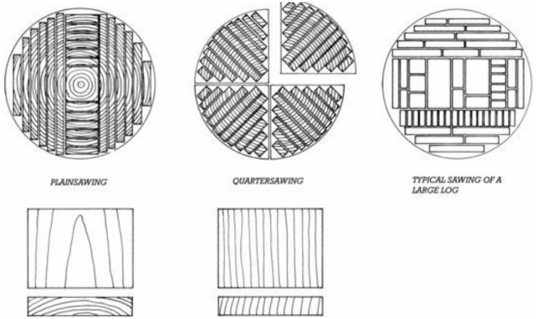
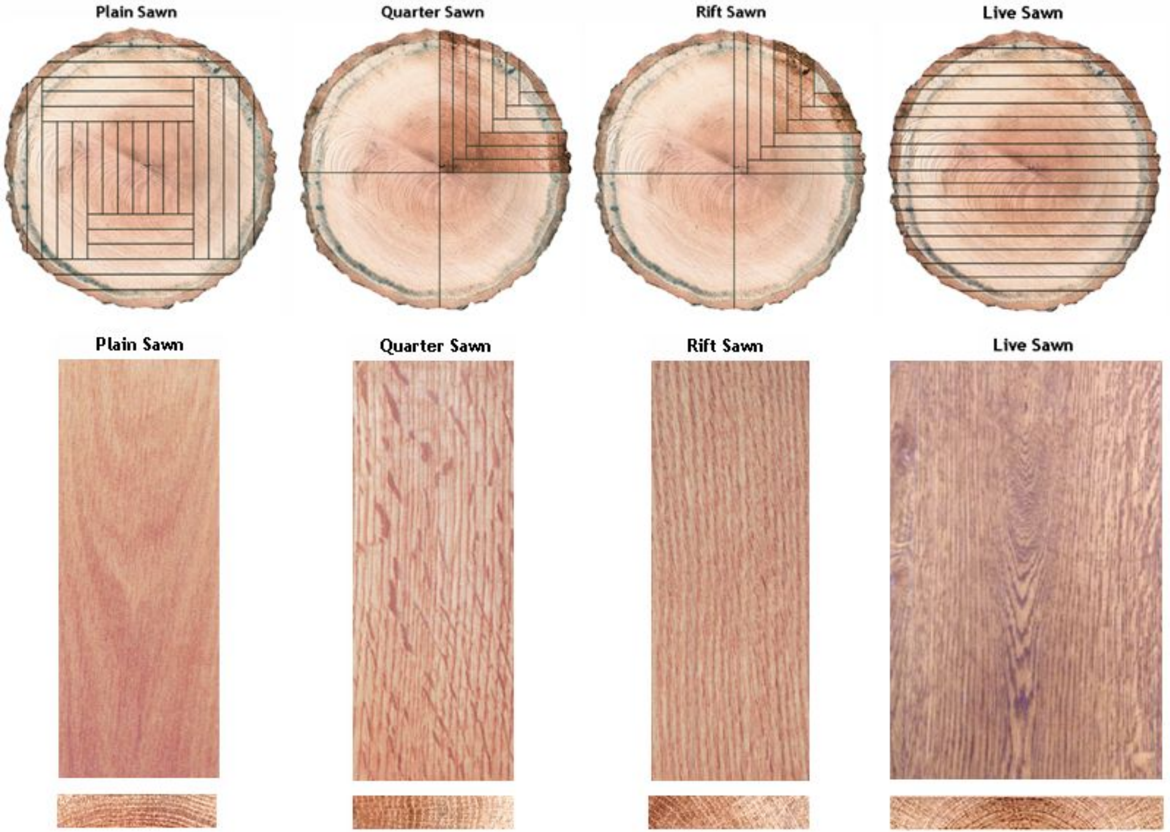


Figure 3.9 ***Left:*** Vertical-grain Douglas fir. Tightly spaced growth rings and quartersawing produce a distinctive, consistent grain pattern on the face of this piece of lumber. ***Right:*** Flat-sawn pine. More widely spaced growth rings and plainsawing produce a broader, more irregular grain figure. *(Photo by Joe Iano.)*

The shrinkage behavior of woods cannot be ignored in building design. For example, in constructing building frames of plainsawn lumber, a simple distinction is made between parallel-to-grain shrinkage, which is negligible, and perpendicular-to-grain shrinkage, which is considerable. The difference between radial and tangential shrinkage is not considered because the orientation of the annual rings in plainsawn lumber is random and unpredictable. As we will see in Chap-

Wood - Sawing pattern

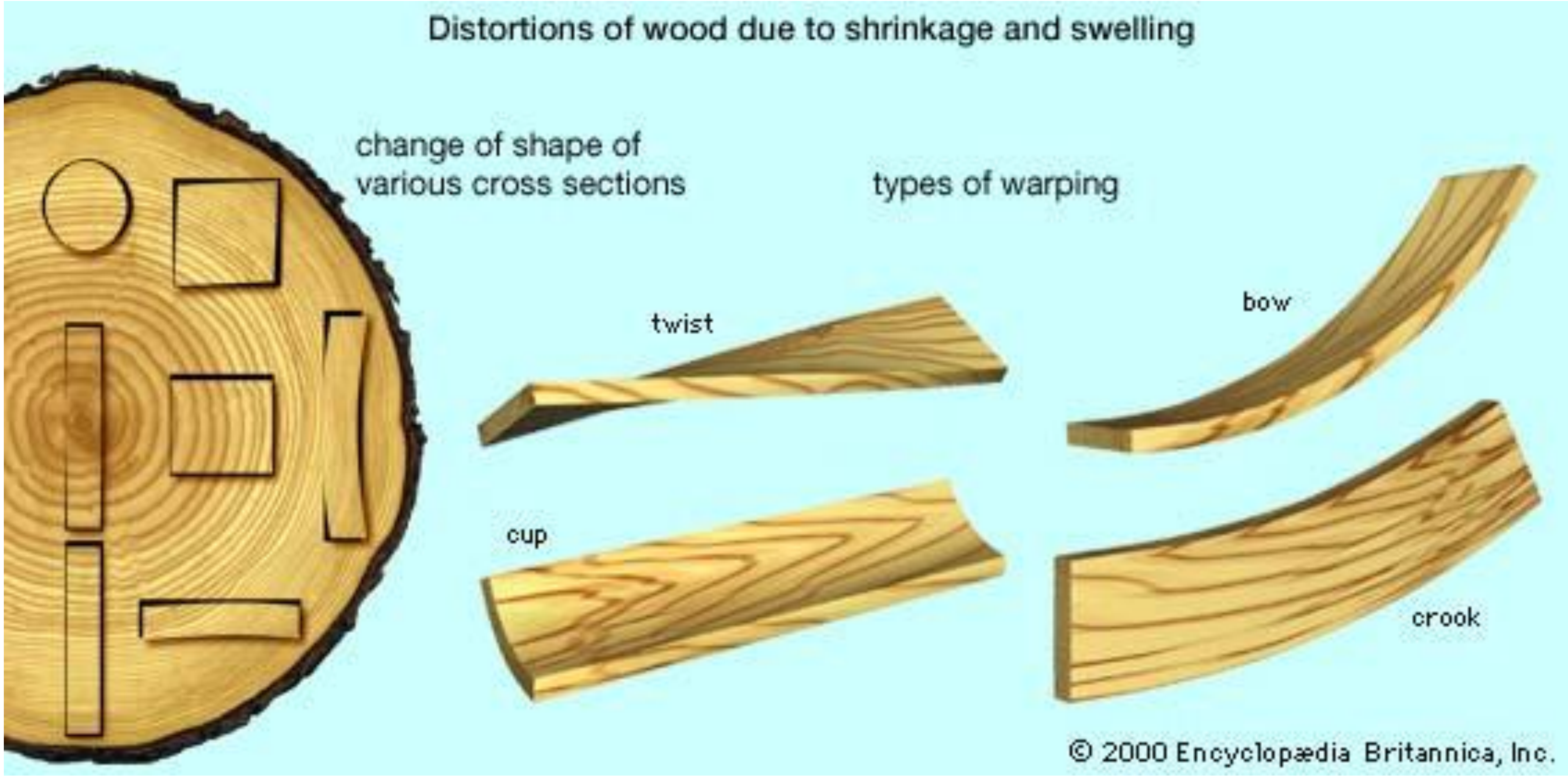


Wood - Seasoning

The amount of water present in wood is called its moisture content (MC) and is described as the weight of the water in the wood as a percentage of the weight of the dry wood. To determine moisture content, wood is first weighed in its wet state (Wwet). It is then placed in an oven, dried until all moisture in the wood has evaporated, and weighed again (Wdry). Moisture content can then be calculated as follows:

MC=(Wwet-Wdry)/WdryX100

Wood - 4 types of wood seasoning distortions



Wood - Lumber Dimensions

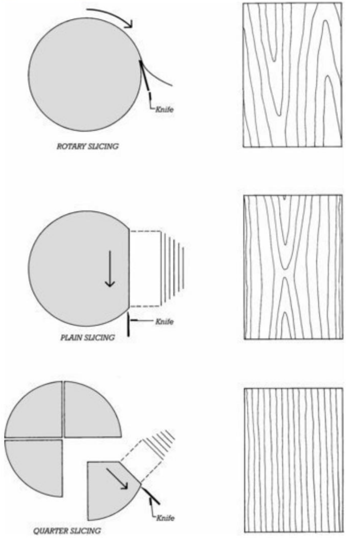
Lumber sizes in the United States are given as nominal dimensions in inches, such as 1 × 2 (“ one by two”), 2 × 10, and so on.

Softwood Dimensional Lumber Sizes	
Nominal Lumber Dimensions	Actual Dimensions
1 × 2	3⁄4 in × 1 1⁄2 in
1 × 3	3⁄4 in × 2 1⁄2 in
1 × 4	3⁄4 in × 3 1⁄2 in
1 × 6	3⁄4 in × 5 1⁄2 in
1 × 8	3⁄4 in × 7 1⁄4 in
1 × 10	3⁄4 in × 9 1⁄4 in
1 × 12	3⁄4 in × 11 1⁄4 in
2 × 2	1 1⁄2 in × 1 1⁄2 in
2 × 3	1 1⁄2 in × 2 1⁄2 in
2 × 4	1 1⁄2 in × 3 1⁄2 in
2 × 6	1 1⁄2 in × 5 1⁄2 in
2 × 8	1 1⁄2 in × 7 1⁄4 in
2 × 10	1 1⁄2 in × 9 1⁄4 in
2 × 12	1 1⁄2 in × 11 1⁄4 in
4 × 4	3 1⁄2 in × 3 1⁄2 in
4 × 6	3 1⁄2 in × 5 1⁄2 in
6 × 6	5 1⁄2 in × 5 1⁄2 in
8 × 8	7 1⁄4 in × 7 1⁄4 in

Wood - Veneer

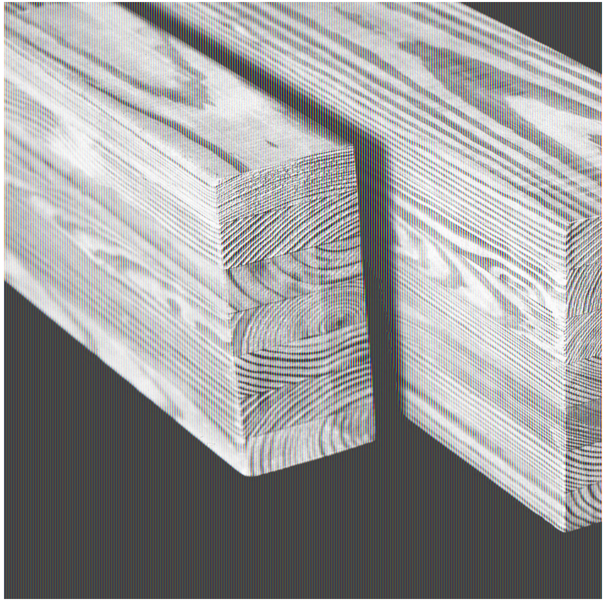
Wood produced in very thin sheets (about ⅛ inch or 3 mm in thickness or less) is called veneer.

Figure 3.25 Veneers for structural panels are rotary-sliced, which is the most economical method. For better control of grain figure in veneers destined for finish woodwork, logs may be ***plainsliced*** or ***quartersliced***. Though more expensive to produce, these veneers have more attractive grain figures than rotary-cut veneers.



Wood - Laminated wood

Glue- Laminated Wood - Joining many smaller strips of wood together with glue (glue-laminated wood or Glulam)



Wood - Laminated wood

Cross-Laminated Timber (CLT) - made up of an odd number of layers.

Wood - LVL

Laminated veneer lumber— made from thin wood veneer sheets.

Wood i-Joists

The top and bottom flanges of the members may be made from solid lumber, laminated veneer lumber, or laminated strand lumber. The thinner webs, which connect the top and bottom flanges, may be plywood or OSB

Wood - Plywood

Plywood is made of veneers selected to give the optimum combination of economy and performance for each application.

A-grade plywood: A-grade plywood is the highest quality and is the most expensive, as most sheets will be free of flaws.

B-grade plywood: B-grade plywood has a mostly smooth surface and a solid foundation. Some repairs might have been made on this plywood, but B-grade would have only minor flaws.

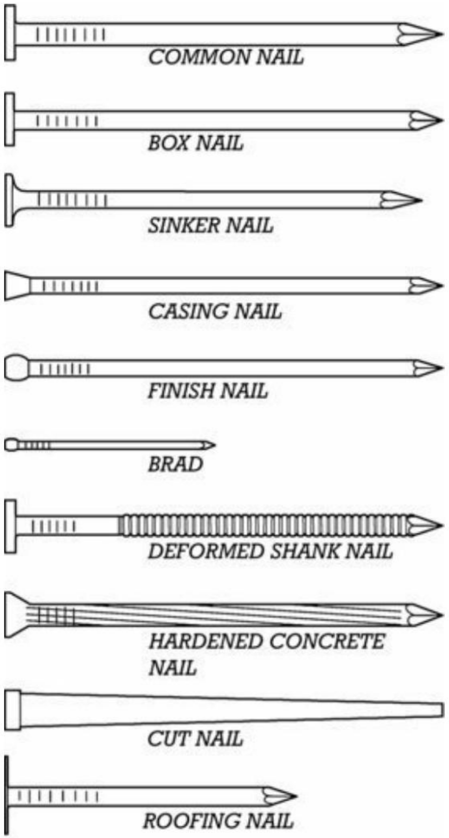
C-grade plywood: C-grade plywood has some knots throughout its sheets, up to 1.5 inches in diameter.

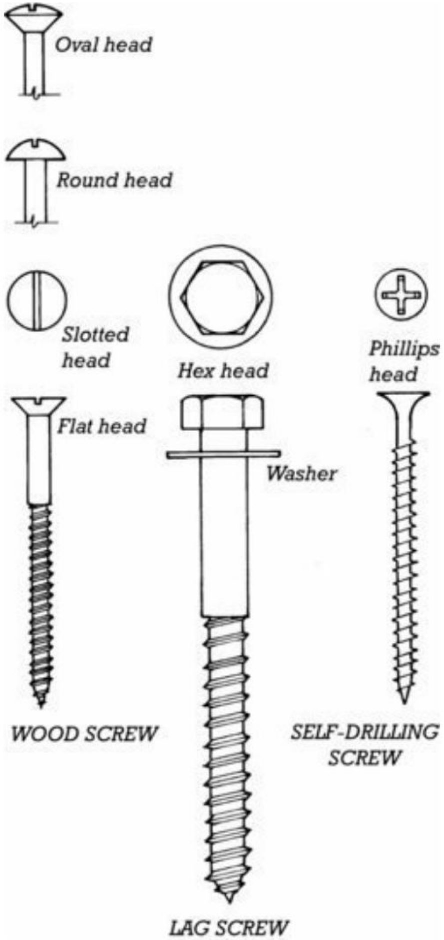
D-grade plywood: D-grade plywood sheets are the most inexpensive. They haven’t been repaired, and the flaws can be a little larger and more noticeable. This grade of plywood can feature knots up to 2.5 inches.

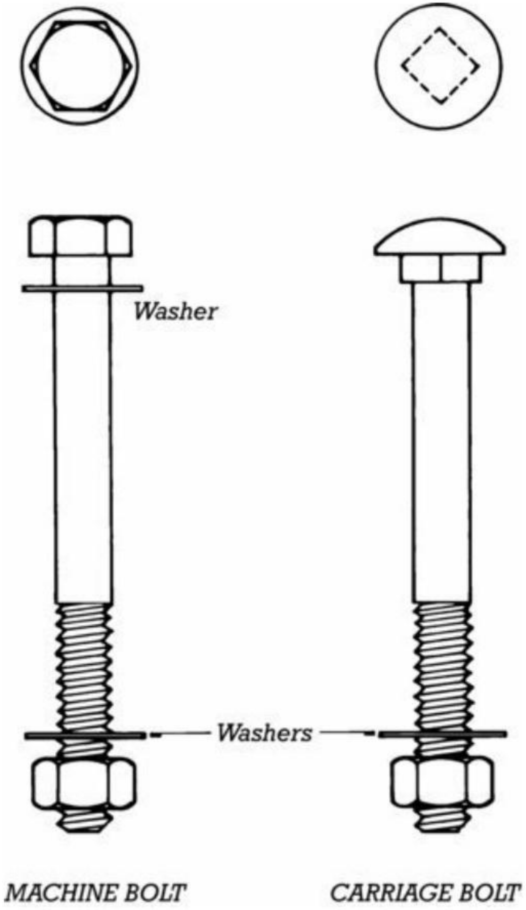
Wood - OSD

Oriented strand board is a type of engineered wood similar to particle board, formed by adding adhesives and then compressing layers of wood strands in specific orientations

Wood - Fasteners

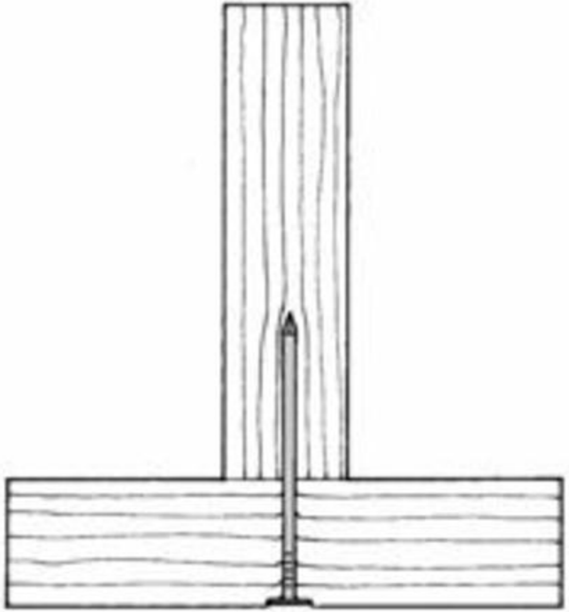




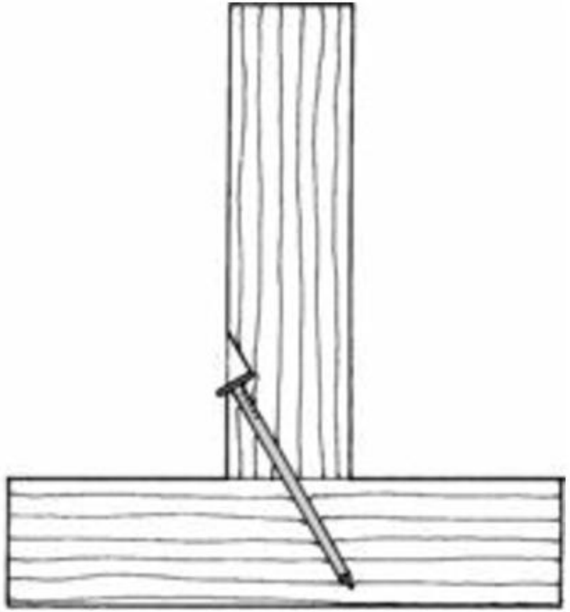


Wood - Fasteners

FACE NAIL

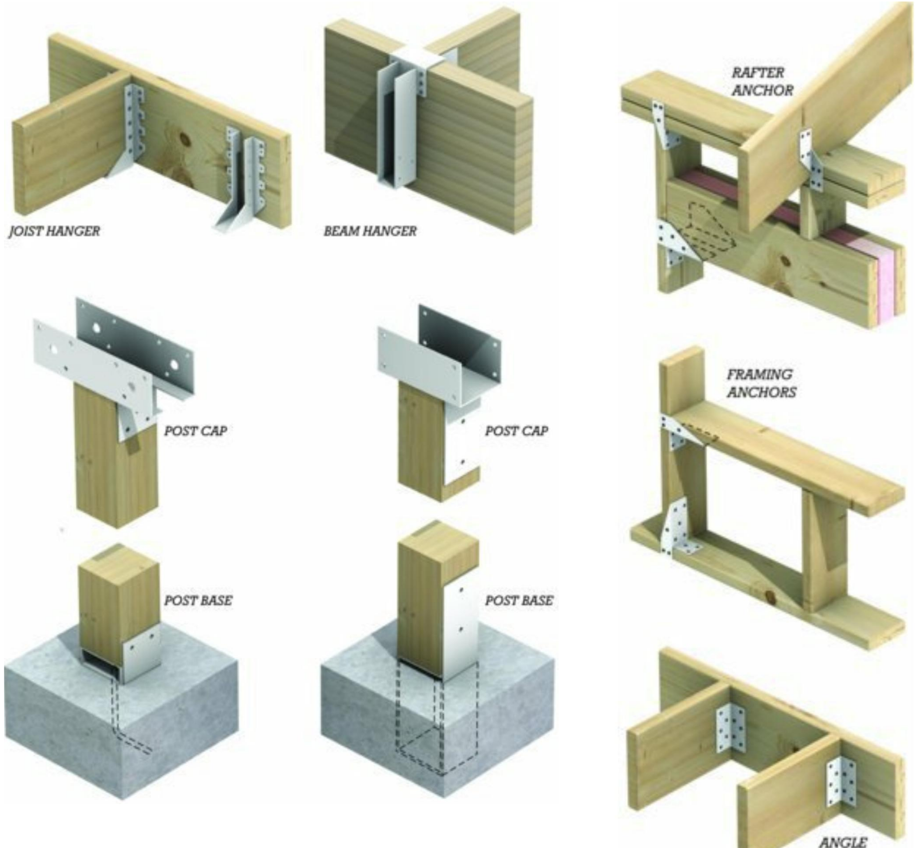


END NAIL

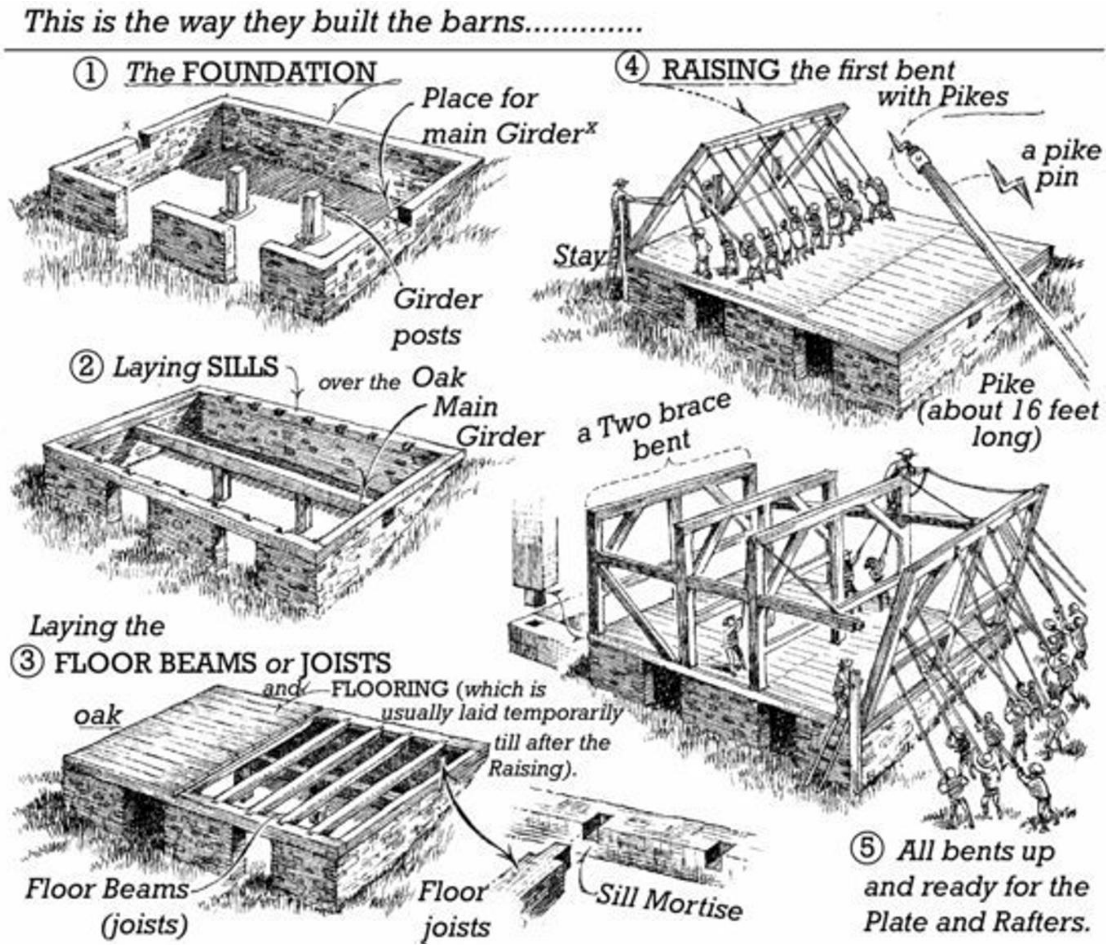


TOE NAIL

Wood - Sheet Metal and Metal Plate



Wood - Heavy Timber



Wood - Heavy Timber

FIRE-RESISTIVE HEAVY TIMBER CONSTRUCTION
Large timbers, because of their greater capacity to absorb heat, are much slower to catch fire and burn than smaller pieces of wood. When exposed to fire, a heavy timber beam, though deeply charred by gradual burning, will continue to support its load long after an unprotected steel beam exposed to the same conditions has collapsed. If the fire is not prolonged, a fire-damaged heavy timber beam or column can be sandblasted afterward to remove the surface char and continue in service.

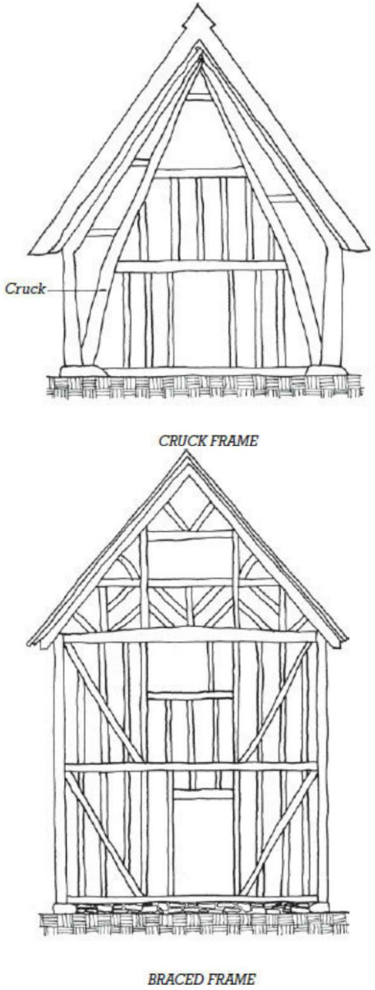
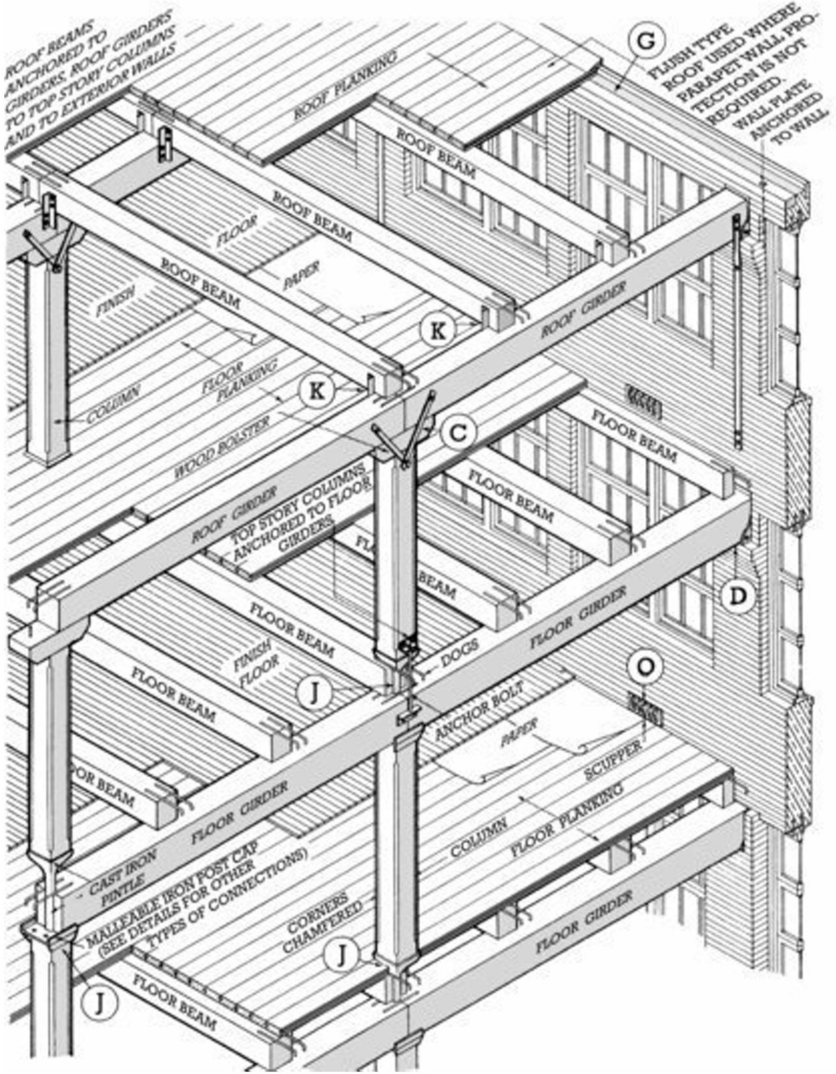


Figure 4.3 The European tradition of heavy timber framing was brought to North America by the

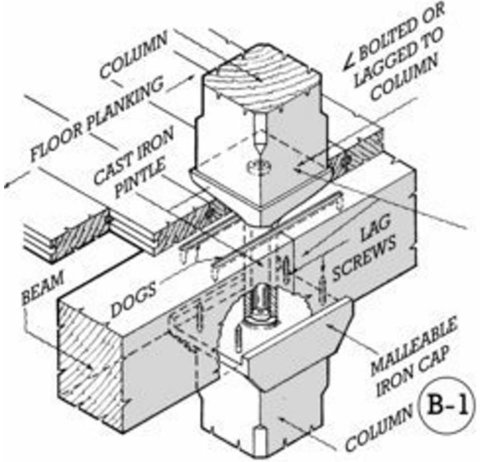
Wood - Heavy Timber

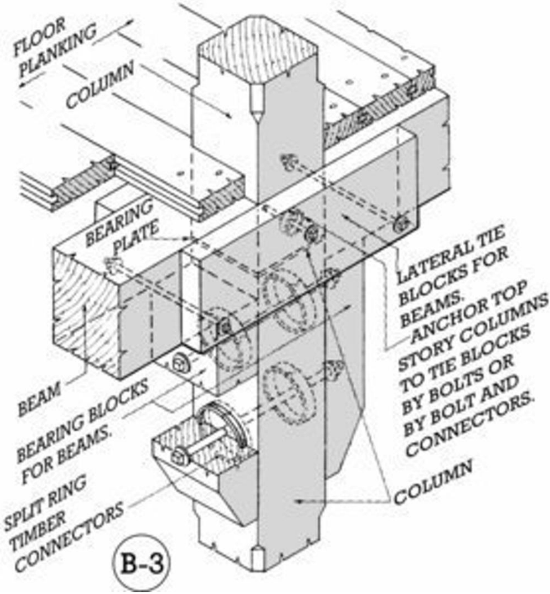
Heavy timber girder-column connections designed so that the large shrinkage typical of beams and girders does not affect the columns.



Wood - Heavy Timber

Details for the bearing of a beam on masonry in traditional Mill construction. In each case, the beam end is firecut (see Figure 4.13) and anchored to the wall by means of either lag screws or a lug on the iron bearing plate.





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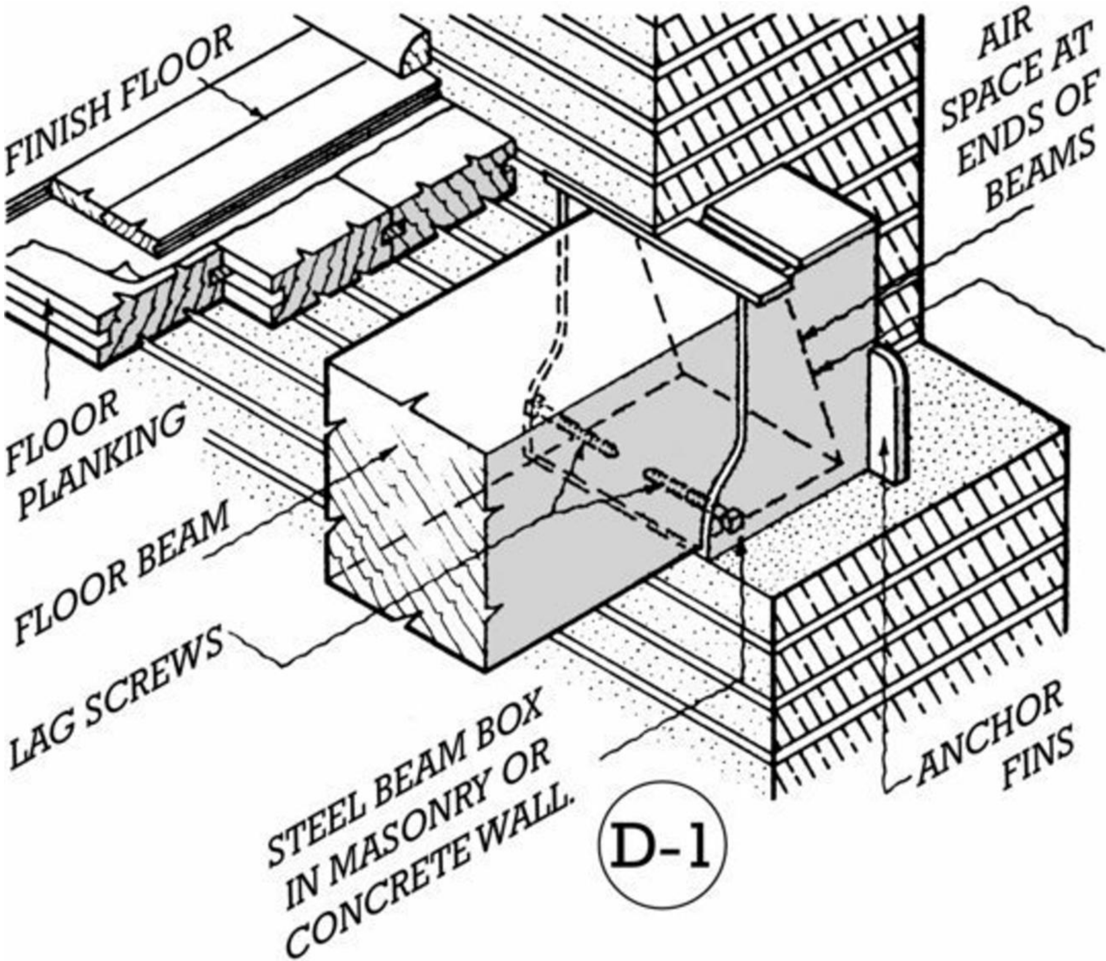

Wood - Heavy Timber

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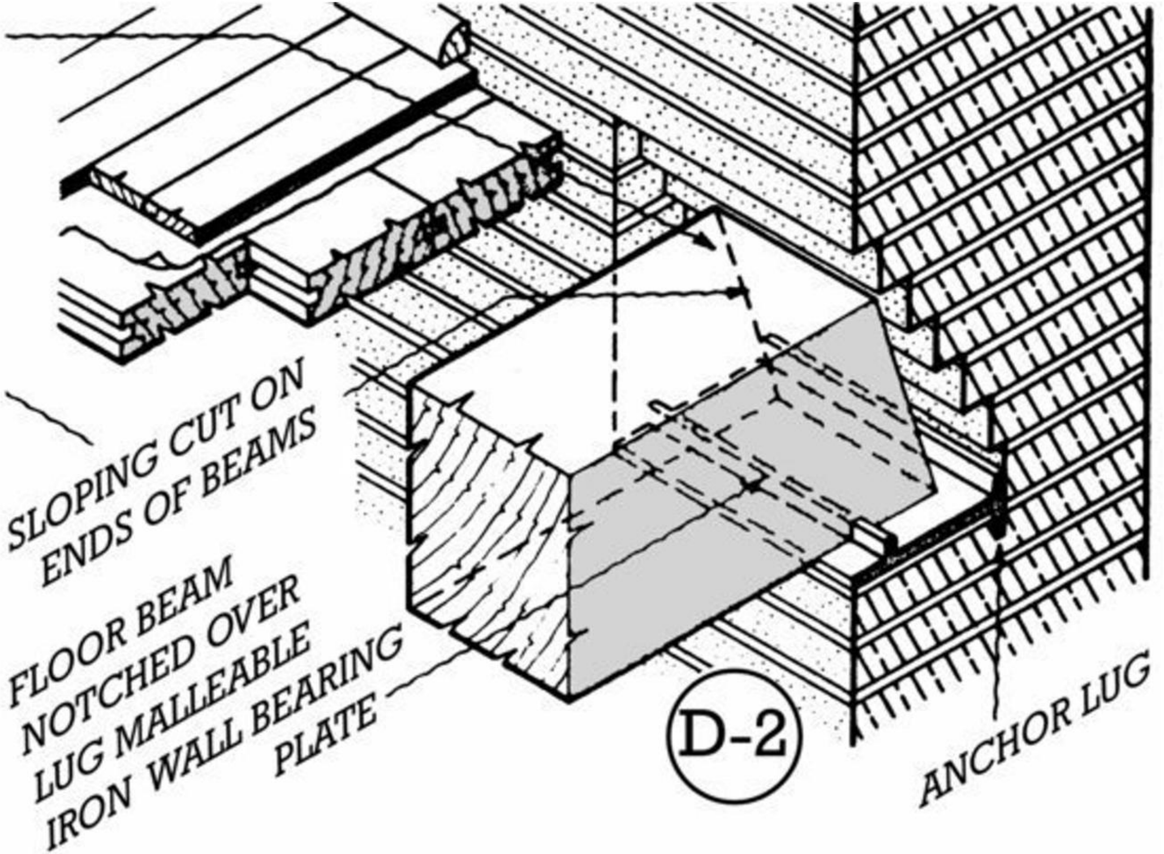
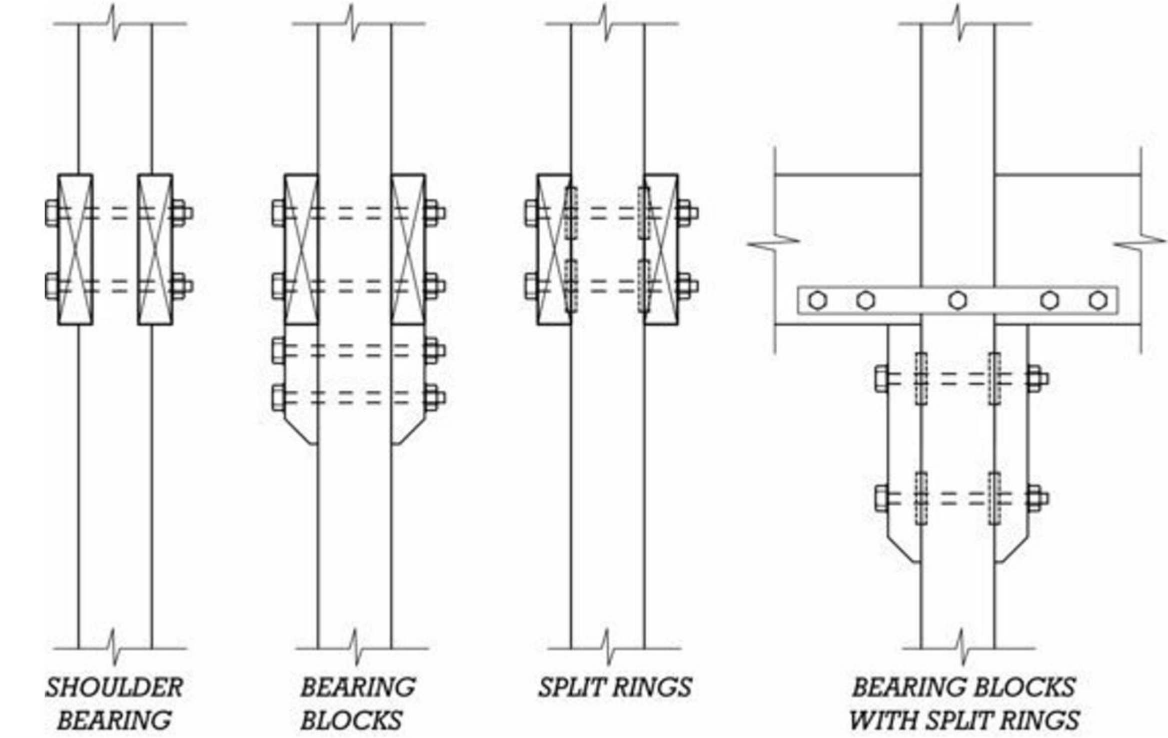


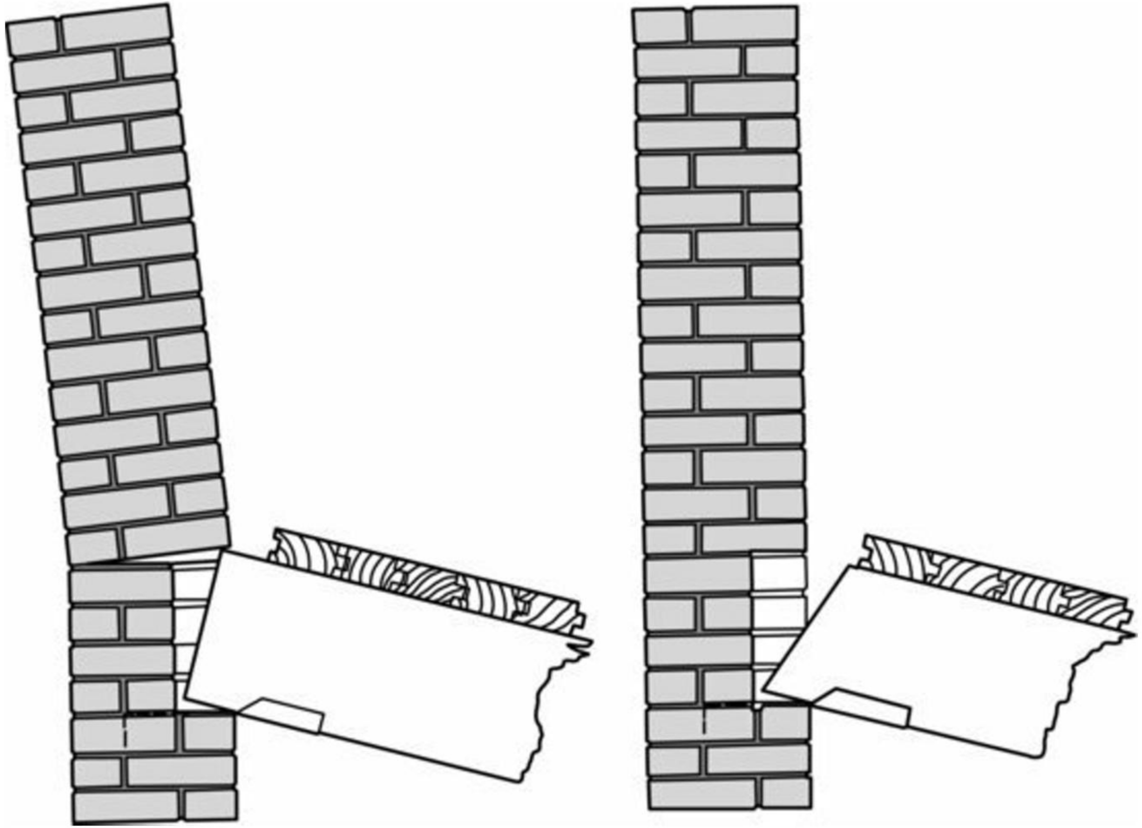
Wood - Heavy Timber

Connections for a glue-laminated wood frame. The tall column passes by the beam and remains unaffected by beam shrinkage. The cantilevered beam and hinge connector save wood by connecting the beams at points of zero bending moment rather than at the columns to take full advantage of continuous bending action in the beams.



Wood - Heavy Timber

A timber floor or roof structure that burns through in a prolonged fire might topple the portion of the wall above it (left) unless the beam ends are firecut (right) to allow the beams to rotate freely out of their wall pockets. In this illustration, the beam is anchored to the wall by a steel strap anchor.



Wood - Heavy Timber

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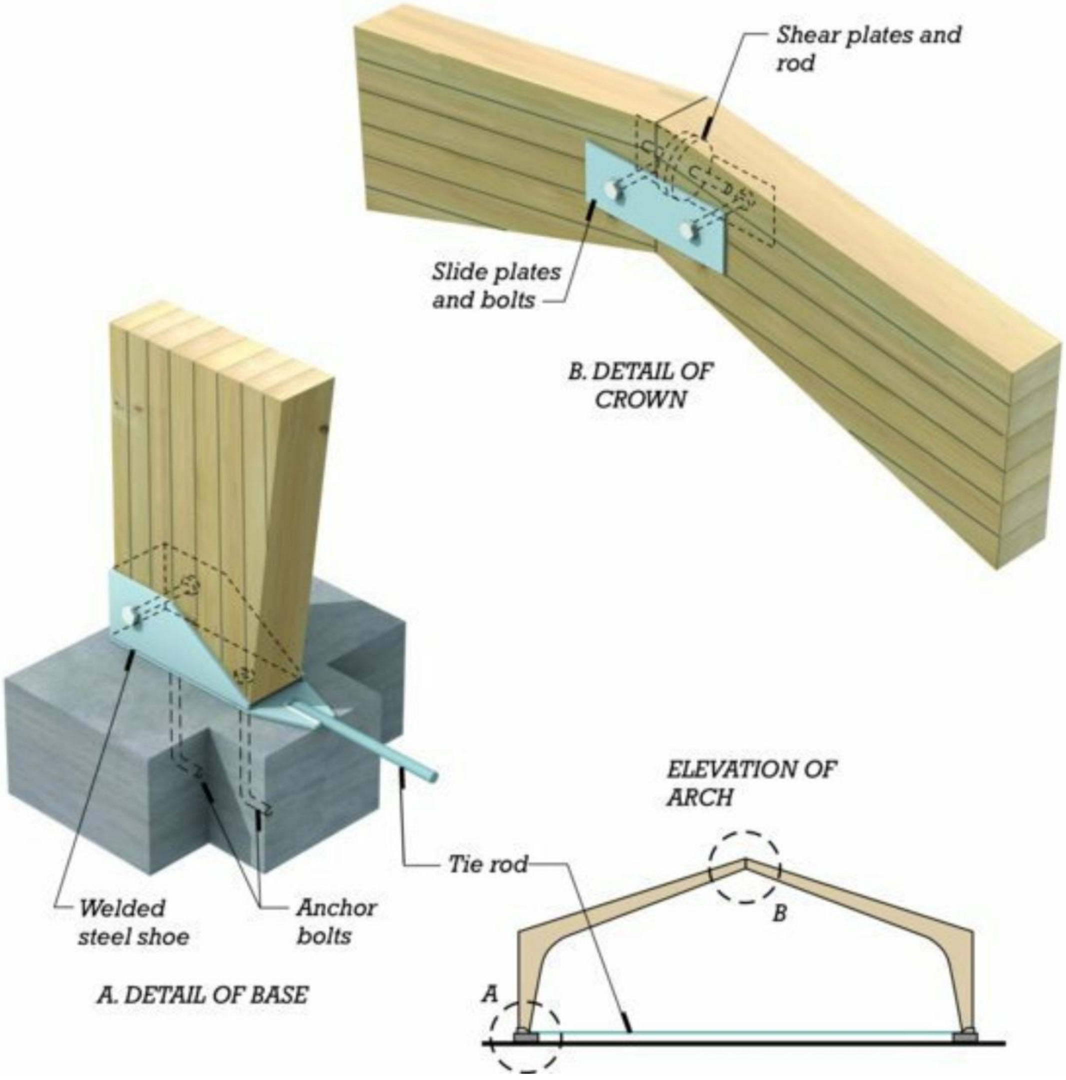
Wood - Heavy Timber

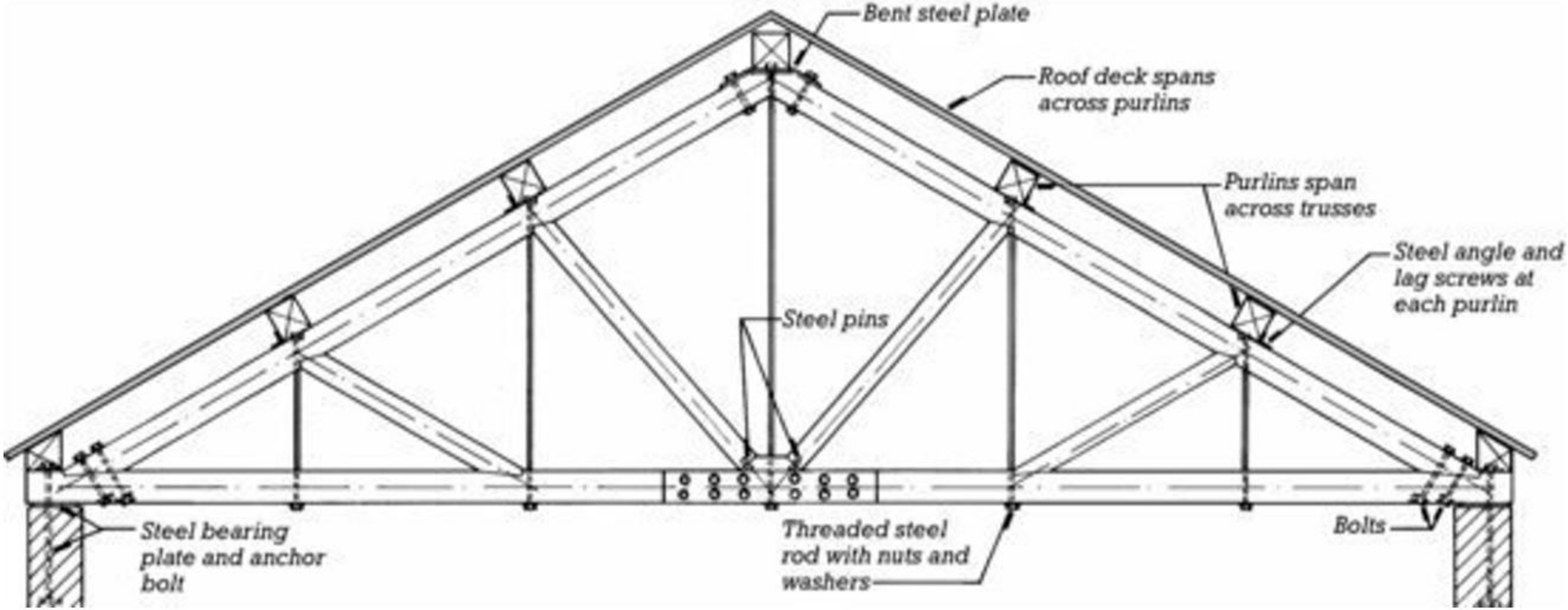
Glue-laminated beams support proprietary long-span trusses made of wood with steel tube diagonals. The glulams are hinged in the manner illustrated in Figure 4.12. The trusses, roof joists, and plywood roof deck are prefabricated into panels on the ground and then lifted into final position to reduce installation time.

Wood - Trusses

The majority of wood trusses built each year are light roof trusses of nominal 2-inch (38-mm) lumber joined by toothed plates (see Figures 3.48, 3.51, 5.65, and 5.66). For larger buildings, however, heavy timber trusses may be used. Their joints are made with steel bolts and welded steel plate connectors, split-ring connectors, or other proprietary connection hardware.



Wood - Heavy Timber



Wood - Heavy Timber

A contemporary heavy timber truss made from solid wood members. At the truss peak, connections rely on knife plates and through-bolts. At the foot of the truss, a steel shoe anchors the truss to the supporting beam.

Wood - Arches and Domes

A contemporary heavy timber truss made from solid wood members. At the truss peak, connections rely on knife plates and through-bolts. At the foot of the truss, a steel shoe anchors the truss to the supporting beam.