

# Structural Design with Wood

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Wood as a building material is often misunderstood even by persons who use it a great deal. Designers at any level with extensive experience in design with wood are hard to find. Poor design practices are often believed to be acceptable procedure by many practitioners.

Water is the major source of trouble in exterior wood structures. Most of the design practices suggested in this guide deal directly or indirectly with wood-moisture relationships. Wood also is a material containing randomly placed defects (knots, etc.) as well as certain structural strength characteristics related to the orientation of the wood grain. These features should be considered in design to get the best use of the wood and ultimately the best completed structure.

## Preservatives

When wood is to be used in contact with the soil or under moist high hazard conditions (decay or termites) the wood should be thoroughly treated with a wood preservative. For best results commercially treated material should be used. Most untreated construction lumber will decay rapidly under moist conditions—possibly within two to three years.

Wood members not in contact with the soil but within 18 inches of the ground line should be treated. Subterranean termites are abundant in Missouri and measures should be taken to counter the threat of attack. This measure is probably more effective and less costly than metal termite shields—certainly less subject to deterioration.

## Seasoning

For best results wood should be dried (seasoned) to an average moisture content of 15 to 19 per cent before being used to build a structure. Wetter wood will shrink and check in the structure. This *may* create problems such as nail popping and warpage. Many good structures have been built with “green” lumber, but the builder should be alert to the above problems. In Missouri 15 to 17 per cent moisture content is an average equilibrium condition. That is, wood exposed to the weather (not in contact with the soil) will dry to this level and substantially remain at this moisture content over the years.

## Moisture Barrier

Place a moisture barrier between untreated wood and concrete whenever the two materials join. The moisture barrier can consist of galvanized metal, sheet copper, building paper, polyethylene film, etc.

## Exposure

Design so that exposure of the end grain of wood in a horizontal plane is eliminated whenever possible. Where end grain exposure cannot be avoided (example: fence posts), provide for rapid moisture runoff of the exposed surface. This can be done by tapering the cut and brush coating the end with a wood preservative. In some applications, flashing or capping is appropriate.

Place the bark side of each board “up,” or to the weather, whenever possible (Figure 1). This is particularly important on deck surfaces, because the bark surface does not splinter or roughen as much as the so-called “pith” side. If lumber has wane (a patch of bark along an edge) it will be on the bark side, and possibly the builder will be forced to place the pith side up on some pieces for the sake of appearance and utility.

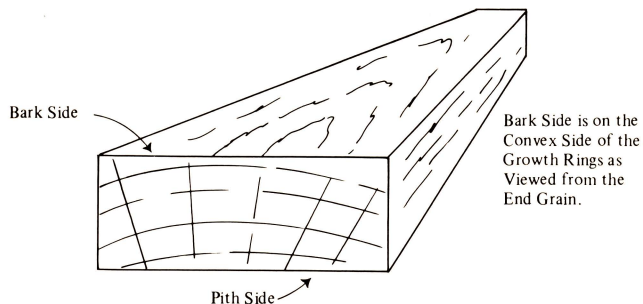


Figure 1.

Assemble joints or areas in which two wood pieces lap or form a common plane (butt or lap joints) in such a way that the area between the boards is not a moisture trap. In some instances it is best to keep the joints “open” (Figure 2) so water can readily drain through the joint. When treated lumber is not used, flood (brush) joint areas with a wood preservative about every two or three years.

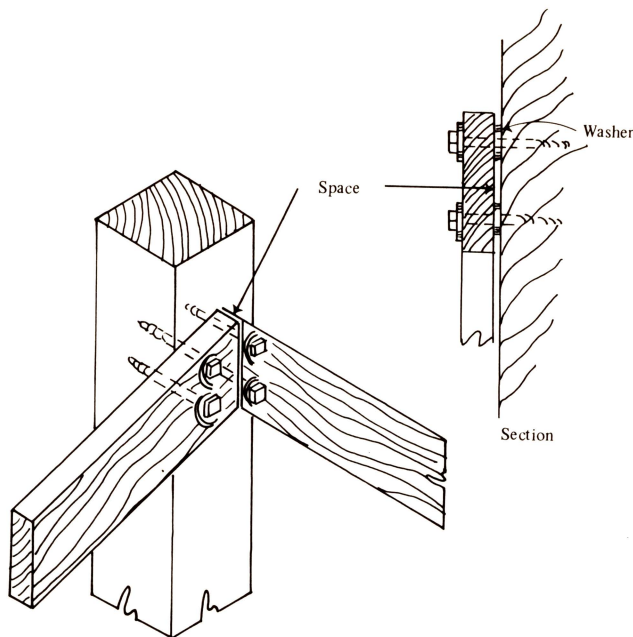


Figure 2.

## Lumber Selection

Select lumber by species and grade to best match your application. When lumber is used in high decay hazard situations it has become custom for many retailers, builders and homeowners to specify redwood or cedar for exterior work without further consideration. Actually, commercially treated pine has at least four distinct advantages:

- Currently, treated pine costs 30 to 40 per cent less than a comparable grade of heart redwood and cedar (sapwood not permitted).
- Pine (especially southern yellow) is much stronger than redwood or cedar. This means that one can build a structure of pine with less wood (greater spacing and smaller boards) and still retain the minimum required strength.
- Properly treated pine has much greater durability than heart redwood or cedar, especially second-growth wood. For example, if redwood will resist deterioration under high decay hazard conditions for 10 to 15 years, commercially treated pine will render service for 30 or more years.
- The color of treated pine varies with the preservative used in the treatment. Wood treated with an oil solution of "penta" is colored various shades of brown and in most instances furnishes a desirable, rustic appearance. Woods treated with CCA (chrome copper arsenate) are a light green to yellowish cast and also impart a pleasant appearance. In any case the "grain" in pine is more pronounced than in redwood or cedar. If a builder or buyer insists on using redwood or cedar, it is recommended that treated pine be used for posts of any member in contact with the soil. CCA treated pine can be stained to match the redwood or cedar.

## Imbedding

Treated wood posts and poles do not have to be imbedded in concrete for good results. In the case of fencing, tightly pack the hole with soil to the ground line level. The same procedure can be used for a wood column that is designed to support a compression load (in a porch, for example)

by adding a large *flat* rock at the bottom of the hole. Wood members imbedded in the ground should be inserted to a depth of  $\frac{1}{3}$  to  $\frac{2}{5}$  of the above-ground line height. Imbedding wood in concrete does *not* protect the wood against decay.

## Joists

Before each horizontal structural member (joist) is fitted, sight along the edge of the board. Few wood framing members are perfectly straight. It is easy to see the edgewise warpage, sometimes called "crook." Make a habit of placing the crown edge up (Figure 3). If this is done with each piece, the floor will be stronger in resisting deflection, and it will help prevent "squeaking."

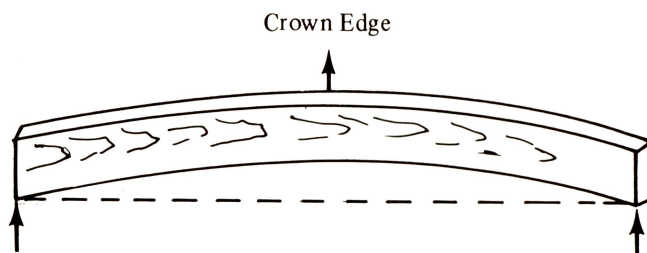


Figure 3.

Another criterion for best orientation of horizontal structure boards (joists) is the position of defects in the board. If large knots appear on or near the edge of the board, place the knot edge up (Figure 4). This simple procedure adds strength to a structure at no added cost. Knots are effective when subjected to compression (top side of joist) but have little or no strength where tensile strength is concerned (bottom edge of joist). This rule is particularly important when the defect occurs in the center third of a board.

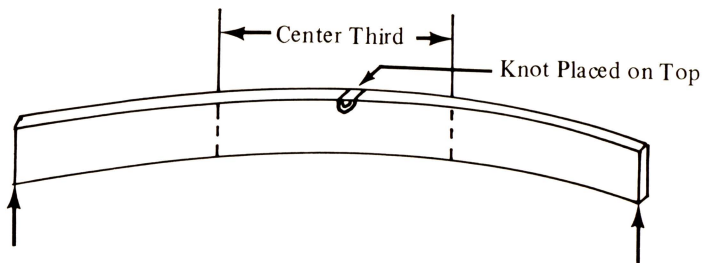
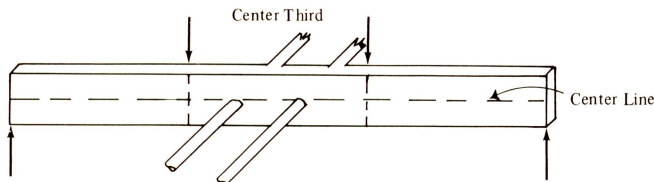


Figure 4.

Plumbers and electricians drill and cut through joist members in the process of wiring and installing piping in a house. This weakens boards that are cut, but to varying degrees. If a joist is "notched" along the bottom edge, the whole structural member is reduced in strength proportionate to the depth of the notch. For example, if a 2x8 is notched 2 inches deep, the strength of the 2x8 is reduced to that of a 2x6.

Whenever possible, "drill" through the joist with the smallest drill necessary to allow passage of the pipe or wire. Confine the drilling to the center line of the center third of the board (Figure 5). Thus, the strength of the member is not altered for practical purposes. If plumbers and electricians would use this rule whenever possible, the strength character of structures would be improved at little or no added cost.



Confine Drilling of Joists for Pipes & Wiring to the Center Third of the Center Line.

Figure 5.

## Exterior Treating

It is not necessary to use commercially treated wood parts for all components of an exterior structure. It is, however, recommended that a builder brush or dip coat the end grain and all "joint" areas with 5% pentachlorophenol oil solution. These areas should be brush coated every two or three years after construction.

## Storage

Well manufactured wood materials (lumber, plywood, particleboard, etc.) are frequently damaged or destroyed in storage. If wood materials are received at a building site in doubtful condition, the builder should reject the products at the time they are delivered. It is difficult to legitimately return materials that have been at the building site one or more days.

It has been the trend in recent years to simply "dump" wood materials at the building site. Wood materials in any form should not rest directly on the ground. They should be stored six or more inches off the ground. The pile of material should also be protected with a rain-proof covering of plastic, canvas or similar material. Sun, as well as rain and dew, will warp pieces in the upper part of a pile of wood materials.

A lot can be said about the quality of structures of a builder by the way he stores materials at a building site.

## Painting

Paint is applied to wood primarily for *appearance* purposes and not for *protection*. Wood exposed to the elements deteriorates at the rate of about  $\frac{1}{4}$ " every 100 years. If one is interested in the natural beauty of wood, the weathering and minor "wearing away" actually enhances the grain and texture of the wood. Contrary to popular belief, painting does not stop the passage of moisture into wood. It does act as a dampening agent which reduces the *rate* at which the moisture can enter or leave the wood. This property is used to advantage in some applications, such as the painting of windows and other millwork.

If color is desired, builders and owners can eliminate many of the continuing problems associated with paint (a coating "on" the wood) by selecting a good wood stain (a coating "in" the wood).

## Fasteners

Fastening or joining structural members has always been the weak link in the structural chain, regardless of the material used. This is particularly true with wood. Deterioration and breakage almost always occur at the joints.

Fastening wood parts usually means nailing wood parts together. Certainly, nailing is the most common method of joining. Stronger but less common methods of fastening include wood screws, log screws, bolts, framing anchors, and adhesives.

When one designs with wood, the weaknesses in a structure are probably not in the wood parts, but in the joints or fastening devices.

## More Information

For other good structural design ideas with wood, you may order "Construction Guide for Exposed Wood Decks," U.S. Department of Agriculture Handbook 432, or "Principles for Protecting Wood Buildings From Decay," U.S. Department of Agriculture Forest Service Research Paper FPL 190. These publications are available from the U.S. Government Printing Office, Washington D.C.

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