

Stains and Natural

Stain was undoubtedly the most common form of integral protection used on the buildings examined. Wood members that were subjected to the most intensive weathering, as well as members not touched by rain or sun, had stained surfaces. Emphasis will be placed on those buildings most clearly showing the influence of the three exposure groups.

Stain as a coating is essentially a "paint which has been greatly diluted by linseed oil, volatile thinner, and sometimes a preservative" (7, p. 365). Durability often varies with the type and amount of pigment used. Iron oxide pigments which are finely divided in linseed oil are among the most durable (6, p. 2). It is important to remember that paints and stains are not used primarily to prolong the life of the wood, but to emphasize grain or give color. To assure proper performance, they must be used with judgment. Although stains that include a water repellent reduce moisture movement and mechanical degradation, checking still may occur. Therefore, under maximum exposure conditions, durable, decay-resistant woods or competent maintenance should be employed where only stain is used.

Natural finishes allow the wood grain to show through them. They may be surface-coating finishes or penetrating finishes. The surface-coating finishes, which include varnishes and synthetic resins, form a usually glossy, continuous, resinous coating over the wood. Most of these finishes break down under ultraviolet light exposure and usually must be renewed annually. The penetrating finishes, including oils, sealers, and water repellents, do not form a coating, but instead soak into the surface. These, too, need frequent renewal unless they are protected from sunlight and rain, but have the advantage of being easier to maintain. The Forest Products Laboratory natural finish, also a penetrating stain, contains additional ingredients that increase durability under exposed conditions.

Maximum exposure.--One of the buildings studied, with exposed structural wood members on its west side, had been stained a dark color. Several situations encouraging weathering and decay, due to inadequate maintenance and lack of independent protection, were observed, as illustrated by sectional view in figure 21-24. The glulam beams supporting the main floor are fully exposed to rain and sun. Their ends may be further affected by the sun reflection and the heat radiating from the nearby aggregate paving. Because a portion of the beams is shielded by a sunscreen, but not shielded from rain, high moisture content persists in these exposed areas and green algae and moss have formed. The bench slats also entrap moisture on the beams, and where the slats abut against a metal post, more algae growth can be seen (possibly due to condensation on the metal surface, which eventually soaks into the end grain). After 9 years of service, the beams show heavy checking and decay in some areas.

How has stain affected this exposed structure? Since there was inadequate maintenance, the stain has been successful only in achieving a uniform color. (The stain was renewed only once, 3 years ago.) Had it been properly maintained, the stain would have helped to slow moisture movement, but additional protection was needed to combat the severe exposure. Although two coats of a water-repellent preservative were applied after the building was erected, this was not sufficient. Pressure treatment, prior to erection, would be the only alternative to reduce internal decay caused by deep checking.

Intermediate exposure.--Most of the buildings having stained structural members had no major weathering or decay problems. Some structural areas showed bare wood, especially on the summerwood surfaces of some Douglas-fir glulam beams which had been in service for 4 years, but proper maintenance would have eliminated this problem.

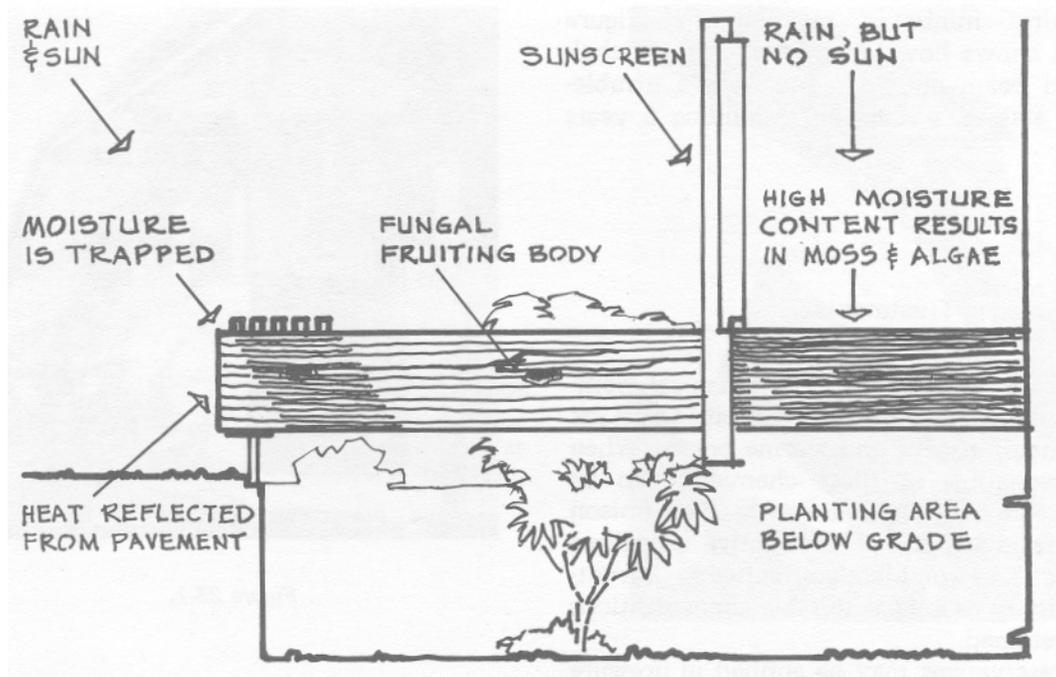


Figure 21-24.--Stain needs constant maintenance when *subjected to* maximum exposure.

Because of the natural finish used and the unusual independent protection involved, the Winkenwerder Forest Sciences Laboratory building at the University of Washington provided a good example of protection through coating (fig. 22-25). A natural finish, developed by the U.S. Forest Products Laboratory, was used as a protectant against fungal attack. This is basically boiled linseed oil with a preservative (pentachlorophenol) to prevent discoloration from lingering dampness plus wax for water repellency and iron oxide or other pigments for color. Unlike most natural finishes that need renewing after one or two years, this coating was still in good condition after 4 years of service. The tops of a few of the beams (where exposed to rain) show some bare summerwood but this is not extensive.

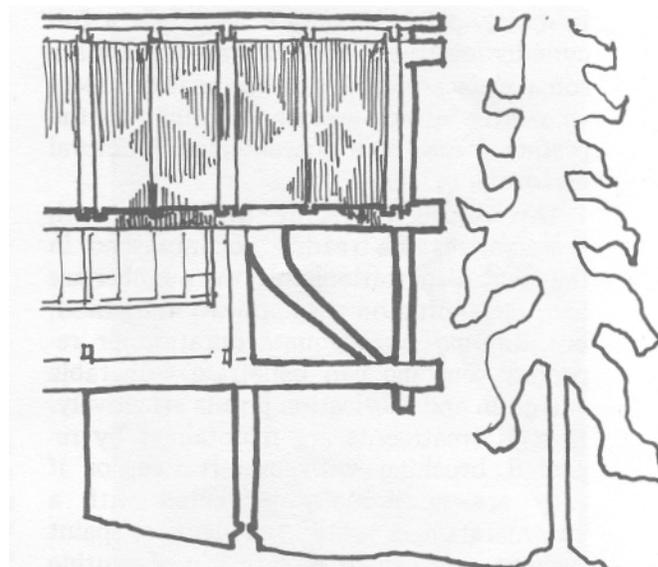


Figure 22-25.

Minimum exposure.--Stain performs very well under these protected conditions and

requires minimum maintenance. Figure 23-1 shows how large overhangs and sheltered beam ends can maintain a troublefree stained surface on a building 6 years old.

Preservative Treatments

Wood preservatives are chemical compounds that make wood resistant to attack by fungi, insects, and marine borers. When impregnation of these chemicals can be achieved to sufficient depth, they poison the food supply of destructive organisms and can be completely effective in preventing decay as long as suitable concentrations are retained.

Preservatives may be applied in pressure cylinders by processes which achieve excellent penetrations in most species. Glulam timbers can be treated in the form of thin laminations prior to gluing, resulting in more complete penetration of the section. Pressure-treated lumber usually must be ordered specially, and small quantities may be costly when they are less than a full cylinder or truck load. However, there are some applications of exterior heavy timbers where the use of pressure treatment is the preferred means of guaranteeing structural performance.

Dip, brush, or spray treatments with preservatives are readily accomplished in the field. Penetrations into the member are low, depending on the application method, but dipping of adequate duration or repeated brushing can penetrate vulnerable end-grain and fabrication points effectively. If such treatments are maintained by repeated brushing with preservative, or if they are additionally protected with a well-maintained water repellent or paint system, they can be effective in preventing decay.

The use of preservatives is a practical alternate to the use of decay-resistant heartwood when design alone cannot assure permanence.



Figure 23-1.

Other Coatings

Two unusual types of coatings were examined in service: one, a polyester resin-fiber glass type and the other, a polysulfide polymer ("Thiokol").

The resin-fiber glass coating on the glulam arches in figure 24-9 forms a vapor barrier that both excludes and traps moisture. Blisters seen on another example during a warm summer day in August indicate that moisture may be trapped at the wood-resin interface. Because this coating was applied for decay protection after the arches were in service for 9 years, their moisture content probably was not sufficiently low before application. Moisture also could enter through the bottom of the arch or at the sealed joints around the steel plate of the buttress connection. In time, high moisture content at the wood-resin interface could cause decay. Complete encasement would not eliminate this situation because the coating could be punctured during erection of the structure or at any time while it was in service.

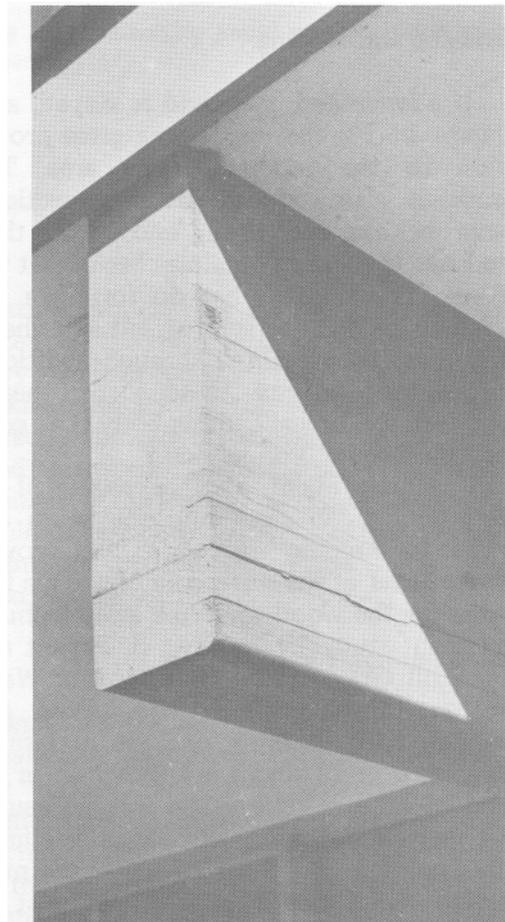
The polysulfide polymer was applied to glued laminated beam ends in the fabricating plant to reduce end checking by minimizing moisture exchange. Extremely

Figure 24-9.--A resin-fiber glass coating can trap, as well as exclude, moisture.



good adhesion is very important in such an end coating. Its efficiency is shown in figure 25-17; substantial surface checking has developed along the sides of a beam but only minor checking is visible across the end face. This demonstrates the severe dimensional change of the wood surface near the exposed beam ends.

Figure 25-17.--An elastic polysulfide polymer end coating minimizes moisture exchange and gives with the wood.



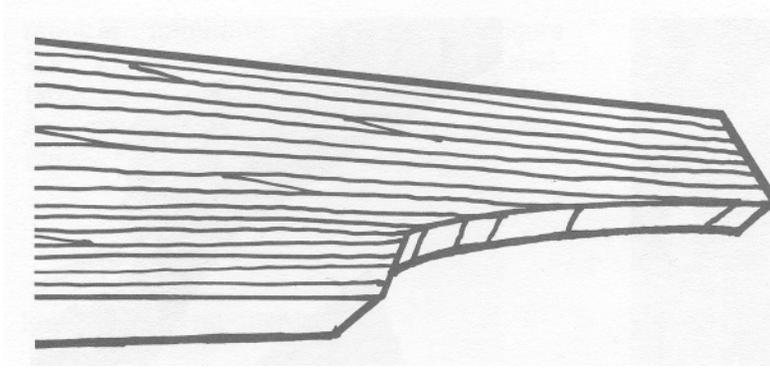


Figure 26-1 O.--Shaping beam ends can reduce checking but will not stop decay.

MECHANICAL METHODS

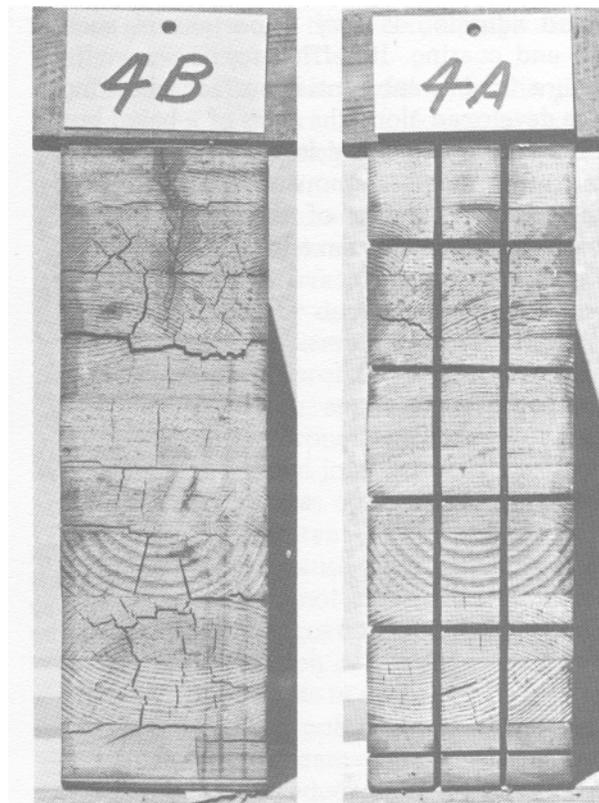
When a structural member is shaped or kerfed, its performance is improved, not by direct protection from critical exposure but by reducing the checking that will occur.

Shaping and Kerfing

If a laminated beam end is shaped, as in figure 26-10, the upper area gives protection to the undercut lower area. This cutback also reduces the cross-sectional area of exposed beam ends and, thus, reduces the size of possible checks that will form. The checks that do form are less obvious on the end surface, but side checking must be prevented through additional protection: one of these shaped beams supported a fungal fruiting body (i.e., conk or "mushroom") on its side.

Checking might also be regulated by introducing "checks" into the beam end prior to building erection. These provide stress relief at the surface by creating a free edge for the wood to shrink away from. In a recent study by Dr. Ben S. Bryant and Mr. Bill Gray of the University of Washington this hypothesis was tested and validated (4). A fairly uniform pattern of deep saw kerfs (about 1-1/2 inches) in the end of a beam relieves the stresses caused by uneven shrinking, and virtually eliminates random end checking under the most severe conditions (fig. 27). It must be

Figure 27.--1 Y2-inch-deep saw kerfs provide stress relief and reduce checking. 413 is the control.



remembered that checks are still present, even though uniform in size, which means additional protection against decay should be provided. Thorough treatment with a water-repellent preservative and yearly inspection would be one solution.

OTHER METHODS

Caulking has not been mentioned previously and needs to be considered along with specification and fabrication. These approaches to integral protection, especially the latter two, are essential to good performance in structural members.

Caulkin

Caulking has been used for centuries to prevent entry of undesired water into certain areas. In contemporary wood structures, many areas for undesirable water collection require caulking treatment. Besides acting as a joint sealer in exposed structural connections, a caulking bead could act as a dam to direct waterflow away from critical structural areas. In any case, a clean, even bead is essential for good appearance as well as for total success. Caulking should act in much the same way as flashing by providing a continuous protective cover over a joint but leaving a way out for possible entrapped moisture. Caulking could be used as shown in figure 28-25 to prevent water that falls on the horizontal members from running into vertical joints.

Specification and Fabrication

Structural wood members having a large cross-sectional area should have a moisture content in equilibrium with their environment in service, and allowances for dimensional change must always be made in structural and finishing details. In glulam members, all pieces should be at a uniform

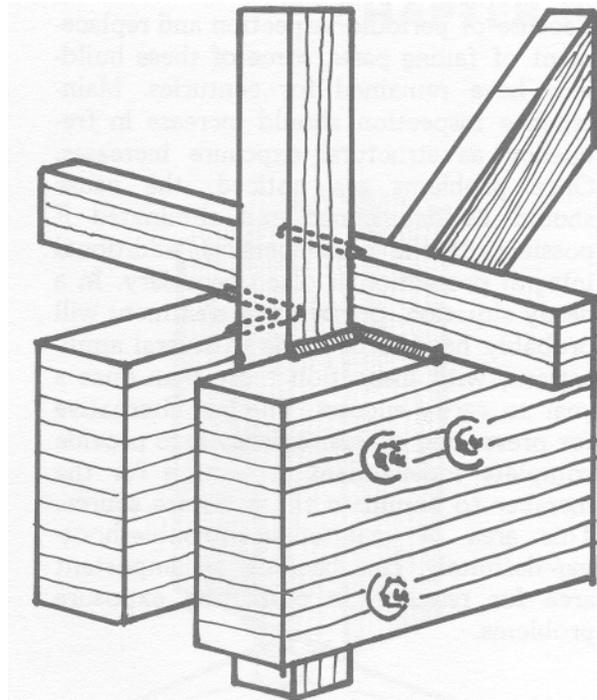


Figure 28-25.--Caulking could prevent water entrapment.

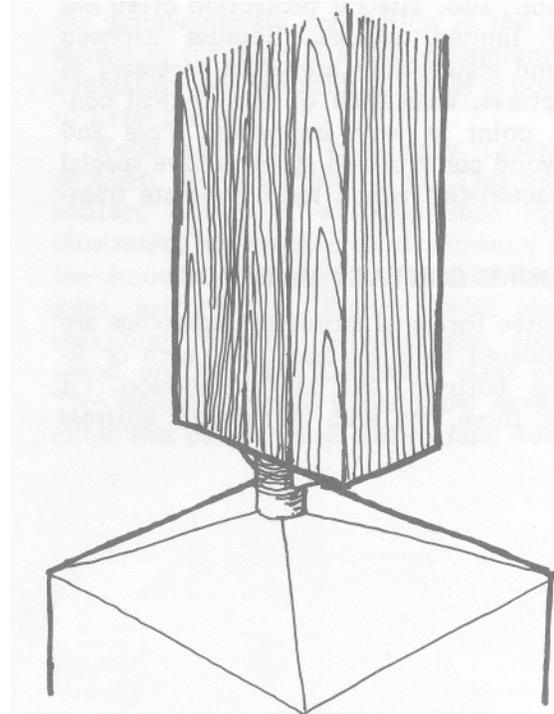
moisture content near the average moisture content of the member in service (1). Since heavy timbers greater than 3 inches in thickness cannot be thoroughly seasoned, shrinkage should be allowed for in solid wood members. Checking in large solid members is difficult to avoid, and twisting problems cannot be anticipated; hence, the advantages of glulams, made from dry wood, can be seen.

Maintenance Requirements

Since finishes and coatings do not permanently protect structural members, periodic surface renewal is necessary. Such maintenance is also necessary on steel and concrete surfaces. Note should be taken of the thorough maintenance programs of the Japanese for their temples and shrines.

Because of periodic inspection and replacement of failing parts, some of these buildings have remained for centuries. Maintenance inspection should increase in frequency as structural exposure increases. Once problems are noticed, the cause should be determined and eliminated if possible. If the cause persists, additional integral protection is often necessary. In a decay situation, preservative treatment will probably have to be made in several applications, with inspection more than once a year to verify success. The last alternative for preventing excessive decay is to provide complete independent protection for the member to eliminate the moisture source. This area of maintenance--troubleshooting--definitely can become an important area for research in correcting exposure problems.

CHAPTER IV



GROUND CONTACT AND SPECIAL SYSTEMS

**GROUND CONTACT
METHODS
PROBLEMS ENCOUNTERED
POLE CONSTRUCTION
PLYWOOD CONSTRUCTION**

Ground support for wood structural systems is the most important protection problem to be solved. The ground contact zone usually gets maximum exposure and yet very seldom receives independent protection; also, integral protection often has only limited success. Because exposed ground connections are often necessary in structures, discussion of this critical contact point is very important. Pole and plywood construction systems have special characteristics which merit separate treatment.

GROUND CONTACT METHODS

Three forms of structural anchorage are considered here: column foot, arch or A-frame buttress, and sill foundation. Of these three, the arch or A-frame buttress

has the most serious performance problems.

Column-foot and buttress connections observed in this study are designed in four basic ways: steel shoe, steel plate, steel bars, and concrete base. These four types will be analyzed.

The steel shoe connection is used to support the majority of wood structures. Fabricated steel pieces either enclose the base of the wood member (fig. 29-22) or are inserted into a slot in that member, as seen in figure 30-14. Otherwise, the wood column rests directly on a concrete foundation block, on a flat steel plate with foundation support, or on a steel post which provides the support. In one unusual application, shown in figure 31-8, vertical steel bars act as anchors to a tied arch.

Figure 29-22.--Steel shoe connection. End grain and horizontal joints are exposed.

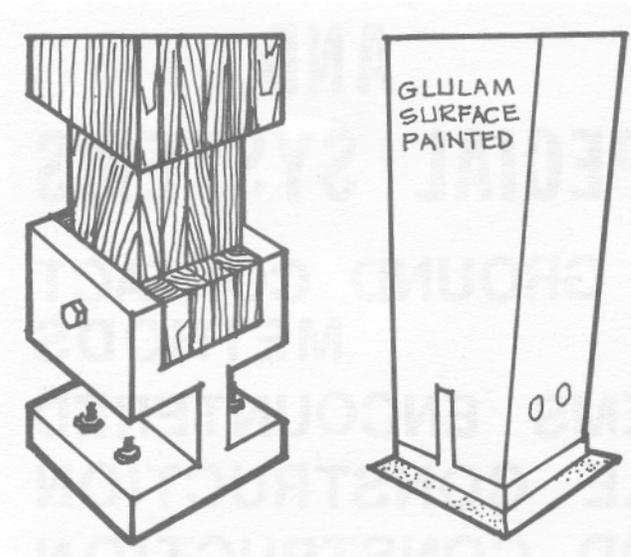


Figure 30-14.--Steel tongue connection. Exposed steel is minimized.

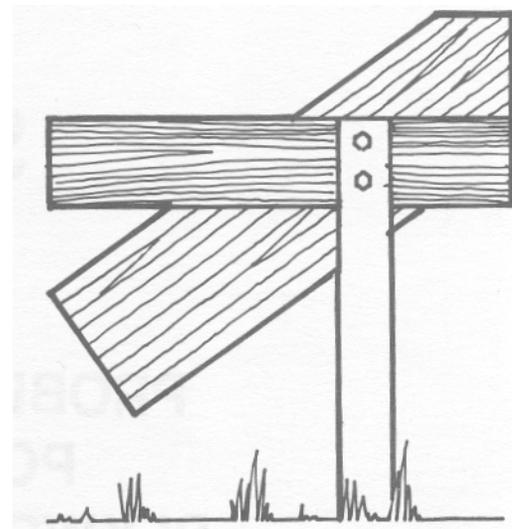


Figure 31-8.--Steel bars anchor a tied glulam arch to ground.

PROBLEMS ENCOUNTERED

Water entrapment is the major cause of performance problems in exposed wood joints. Exposing the end grain to water is a critical factor of the joint shown in figure 29-22. Water that runs down the column can accumulate on the end-grain surface, where it easily soaks into the wood fibers. Excessive checking may occur when the swollen wood dries. The arch buttress in figure 32-20 partially protects the joint from water runoff with metal flashing, but some water can still penetrate around the edges of the flashing and enter between the end of the arch and the steel shoe. Once water has entered any of these very narrow places by capillary action, it will not easily evaporate and may remain for a long time.

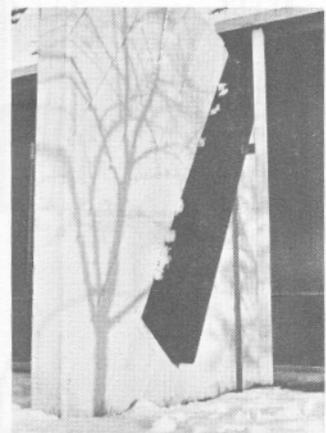
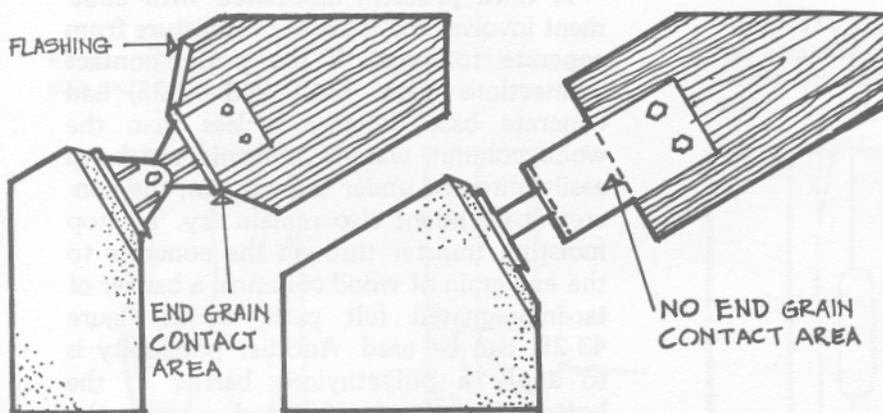
A solution to the problem is seen in figure 33-4 where the design separates end grain of the arch from the steel shoe to prevent retention of moisture. The steep angle of the wood-concrete connection in the arch shown in figure 34-5 allows maximum air circulation and reduced end-grain exposure to water runoff.

Water also very commonly causes a problem where surfaces abut. This direct contact occurs in all steel shoe joints illustrated, but conditions of exposure and the amount of contact cause variability in joint performance. Figure 29-22 shows maximum contact between the glulam wood column and the heavy steel shoe. Two vertical exposed joints allow water to enter this contact area and remain, due to

Figure 32-20.--Flashing helps to protect end grain.

Figure 33-4.--Water entrapment eliminated for endgrain protection.

Figure 34-5.--End grain protected by its sheltered position.



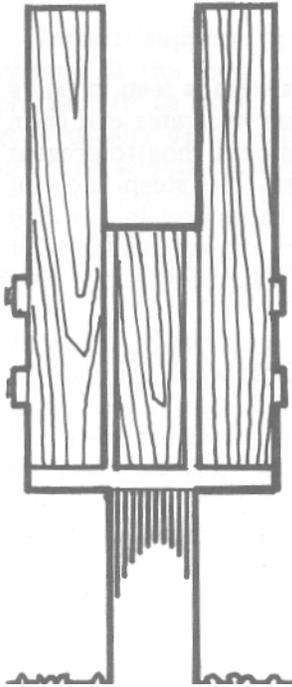


Figure 35-10.--Steel shoe does not trap much water: side-grain protection is provided.

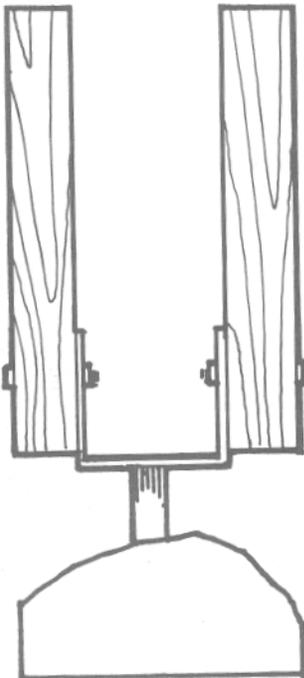


Figure 36-6.--Ground connection minimizes steel-wood contact. Both end grain and side grain are free from trapped water.

lack of air circulation which retards eventual drying. The building has been in service 5 years. The double column connections pictured in figures 35-10 and 36-6 shelter vertical exposed joints, and the latter example provides minimum contact of surfaces and maximum airflow. Where stresses do not require bearing plates, the use of steel tongues (figs. 30-14 and 39-19) also eliminates exposed vertical joints, but horizontal joints entrap moisture by the flush edges of the steel base plates. The buildings are 8 and 5 years old respectively.

Another problem involving abutment is the rusty stain that appears next to the steel boot on the surface of the 11-year-old laminated member in figure 37-15. This stain could result from slow iron-oxidation reactions, but the basic cause is moisture trapped between adjoining surfaces. An inset base plate (fig. 40-25) is probably the best column solution examined. No joints are exposed and no water can be trapped. Other steel plate connections (fig. 41-11) and concrete bases (figs. 42-21 and 43-25) can trap water running down the column. A rare example of total independent protection of an arch-buttress support, as shown in figure 38-2, should again be recalled. This extended overhang totally prevents any problems related to moisture.

A third problem associated with abutment involves the transfer of moisture from concrete to wood. If the ground-contact connections (figs. 42-21 and 43-25) had concrete base dimensions less than the wood column, waterflow would not be as easily directed under the column; the concrete base might also remain dry. To stop moisture transfer through the concrete to the end grain of wood columns, a barrier of tar-impregnated felt pads, as in figure 43-25, can be used. Another possibility is to apply a polyethylene barrier to the bottom surface of a felt pad, saturate the pad in water-repellent preservative, and place it between the concrete and wood surfaces. To minimize water entrapment on concrete surfaces of buttress connections,