



IN-SERVICE INSPECTION, MAINTENANCE AND REPAIR OF GLUED LAMINATED TIMBERS SUBJECT TO DECAY CONDITIONS

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PREFACE

Wood structures, when properly designed and constructed, have performed well for centuries. Proper design and construction techniques include protection of the wood from moisture or the use of pressure preservative treatments when protection from moisture is not possible [1,2]. The advent of glued laminated timbers brought new design opportunities for wood structures. Unfortunately, some of these structures were not constructed in accordance with these recognized principles of designing for permanence, and problems have occurred. This technical note was developed to address problems of decay found in such structures. It discusses inspection for and repair of decayed portions of the structure and provides guidelines for preventing reoccurrence of decay.

INSPECTION

All buildings should be inspected periodically to make sure that roofs, downspouts, etc., are functioning properly and members are not being inadvertently subjected to excessive moisture. Members which have been exposed to moisture due to roof leakage or drainage problems should be inspected carefully. Water from leakage or improper drainage can elevate the moisture content of laminated timbers, promoting decay. Decay may exist, even if it is not visible on the surfaces of the members.

Those structures which have laminated timbers exposed to the weather, which have not been pressure-treated, should also be inspected carefully. Although decay may not be detected in the inspection, consideration should be given to providing protection for these members against future decay. Additionally, those structures with untreated timbers used in humid environments where the equilibrium moisture content of the wood exceeds 20% should be inspected.

Several inspection methods are available for identifying and determining the extent of decay. Relatively simple methods can be used to identify members that are susceptible to decay and locate areas of surface decay. More complex methods are often used to identify and determine the extent of internal decay.

VISUAL INSPECTION

The simplest method used for detecting decay is visual inspection. It is a useful tool for identifying surface decay and locations that may be susceptible to decay. Problematic areas noted in a visual inspection should be investigated further with other inspection techniques to confirm the presence of decay and determine its extent.

Stains and Discolorations. Stained or discolored wood should be noted and investigated further. Water stains or rust from connections indicate that the wood has been or is wet and is susceptible to decay. Further inspection should be conducted to determine the existing moisture content of the wood and the source of the moisture.

Surface Irregularities. Roughened surfaces, swollen or sunken faces can reveal a history of high moisture conditions and potential decay below the surface. Pockets of decay near the surface of the member may be covered by a thin layer of intact wood that is sunken or depressed [5,6].

Fruiting Bodies. The presence of fruiting fungal bodies on the wood is a definite indicator of decay. Further inspection should be conducted to determine the extent of the decay. The presence of fruiting bodies typically indicates a serious problem.

Mold. Mold will grow on wood with high moisture content. While the presence of mold does not necessarily indicate a problem with decay, it does indicate a moisture problem that may lead to decay. Further investigation should be conducted to determine the moisture content of the wood and the source of moisture.

Insect Activity. Signs of insect activity in the wood should be further investigated. Most wood-destroying insects only attack water-softened wood, so insect activity may indicate high moisture content. In addition, holes caused by insects are potential points of water entry that will cause increased moisture content. Because of the increased levels of moisture, insect attack may be accompanied by decay.

Mechanical Damage. Any mechanical damage should be noted during the visual inspection. In addition to weakening the member, mechanical damage can also create pockets or expose end grain that will readily absorb and trap moisture.

Checks. As wood dries seasoning checks may occur. Typically, checks are not of structural concern. However, checks on wood surfaces that are exposed to weather (i.e. unprotected by a roof) can trap moisture, leading to decay. Checks on top surfaces of members exposed to weather are of particular concern.

Visible decay. Intermediate and advanced decay can often be identified visually. Typically, decayed wood in these stages has recognizable color differences from sound wood. Severely decayed wood is often characterized by cracks parallel and perpendicular to the grain, giving the wood surface an appearance similar to charred wood.

TESTS FOR DECAY

Locations of potential decay identified through visual inspection can be further investigated with a number of tests. These tests are useful in confirming the presence of decay and determining its extent.

Sounding. Striking wood with a hammer or similar object is a commonly used inspection technique to locate severe internal decay. A trained inspector can interpret dull or hollow sounds as possible indicators of decay. Sounding is not an effective method for detecting incipient or intermediate decay [5]. It is also not effective on thick timbers [6].

Pick test. One of the simplest methods for detecting surface decay, the pick test is conducted by driving a pointed tool, such as a pick, awl, or screwdriver, a short distance into the wood and prying out a sliver. A brush (abrupt) or crumbly break indicates decayed wood, whereas a splintered break indicates sound wood [5].

Penetration or Withdrawal Resistance. Because decayed wood is softer than sound wood, probing with a pointed tool can be used to locate surface decay. However, care should be taken to differentiate between water-softened wood and decay [5,6]. A specialized tool called a pilodyn can be used to measure the resistance of the wood to penetration. A hardened pin is driven by a spring into the wood. The distance of penetration can be used as a measure of decay [5]. The resistance to screw withdrawal can also be used as a quantitative measure of decay. This procedure is described in the *Wood and Timber Condition Assessment Manual* [6].

Drilling and Coring. Drilling and coring are both used to locate soft wood or voids in wood members and determine the thickness of the residual shell. Low resistance to drilling may be an indication of decay. A

trained inspector notes changes in drilling resistance and inspects the core or drill shavings for signs of decay. The core or drill shavings can be taken to a lab for further analysis [5,6]. Holes created by coring or drilling should be filled with treated wood plugs to prevent moisture entry. The structural effects of such holes must also be considered.

Resistance Drill Testing. Proprietary equipment has been developed to insert non-destructive, needle-sized drill bits into wood and plot a graph of drill penetration vs. drill torque. The measure of drill torque is an indicator of wood density. Zero resistance to drilling is an indication of a void or decay.

Moisture Measurements. Moisture meters can be used to determine the moisture content of the wood at locations of interest. Resistance-type meters with long, insulated needles are the most useful, because they can measure moisture content at various depths below the surface. Pockets of high moisture content indicate conditions suitable for decay. Moisture contents of cores or drill shavings removed from the member can be determined in the lab using the oven-dry method. To minimize drying in transport, the cores or shavings should be stored in individual sealed containers or plastic bags.

Stress wave timing. Based on the principle that a stress wave travels slower in decayed wood than it does in sound wood, sophisticated stress wave timing techniques have been developed to non-destructively locate decay in wood members. Both sides of a member must be accessible for this inspection technique. One side is struck with a hammer that is instrumented with an accelerometer starting the timer. A second accelerometer held in contact with the other side of the member senses the stress wave and stops the timer. Wave travel times will be greater for decayed wood than for sound wood. An increase in transmission time corresponds to a loss in strength [6]. Stress wave time is affected by moisture content and the presence of preservative treatment, so care should be given to interpreting results. Air gaps formed by checks or multiple-piece laminations, which are not edge glued can also increase wave travel times, so their effects should be considered. More information regarding stress wave timing is available in the *Wood and Timber Condition Assessment Manual* [6] and *Nondestructive Testing for Assessing Wood Members in Structure: A Review* [7].

REPAIR AND TREATMENT

The first step is to determine the amount of sound wood remaining in the member. A preliminary structural review should then be conducted to determine the scope of the problem and estimate the residual capacity of the members involved. This should be done by an engineer knowledgeable in timber design and experienced with the structural system involved.

NONSTRUCTURAL REPAIR

Members which do not need to be structurally repaired should have the decay cavities thoroughly cleaned and dried. The voids can then be filled by wood inserts or an epoxy-type filler. Wood inserts should be made of pressure-treated wood. Epoxy fillers should completely fill the void, level with the surface of the member. Where appearance is a factor, the filler can be sanded flush with the face of the member.

Commercially available epoxy resins intended for cavity filling in wood members can be used. A suitable resin will have good adhesion, low shrinkage upon curing, tolerance of fillers and good weather resistance. Some resins can be extended by mixing fine sawdust into them. This reduces the cost of the filler material and adds body so that it can be handled and molded like soft putty. Depending upon the size of the cavity, the epoxy-resin-sawdust mixture may need to be applied in multiple layers to prevent excessive heat buildup and foaming. The proper curing temperature must be maintained in accordance with the manufacturer's recommendations. AITC Technical Note 14 provides additional guidance on the use of epoxies.

STRUCTURAL REPAIR

In some instances, structural replacement of portions of a member may be necessary. The removal of the decayed portion of a structural member to a distance of several feet beyond the visible area of decay may be the best solution. This portion can then be replaced by a new section of glued laminated timber of

similar cross section connected to the remaining structural element by means of a steel connection, wood side members, or other structural means designed to carry the applicable loads. Obviously, such a repair procedure requires knowledge of structural design and extreme care to support the structure while the decayed portion is removed. **Repairs of any kind should be undertaken only under competent engineering supervision.** The replacement wood section should be pressure-treated with an appropriate wood preservative, unless steps are taken to ensure that moisture intrusion will not reoccur.

ELIMINATION OF CONDITIONS THAT PROMOTE DECAY

Once repairs have been made, steps should be taken to prevent the reoccurrence of decay. The most practical method of preventing future decay is to protect timber members from further contact with water and allow them to dry. When a member is dried below 20% moisture content, the decay fungi will become dormant. Decay will not spread if the wood is kept dry.

To prevent moisture entrapment, the repaired wood member should not be sealed in any way. It should not be painted, wrapped with fiberglass, or covered with metal or wood fastened directly to the member. These retard moisture in the wood from escaping, enhancing the conditions that promote decay.

Arches or beams projecting past the roofline can often be protected by extending the roofline to cover them. In some cases, beams projecting beyond the roofline can be simply cut off with the type of detailing shown in Figure 1.

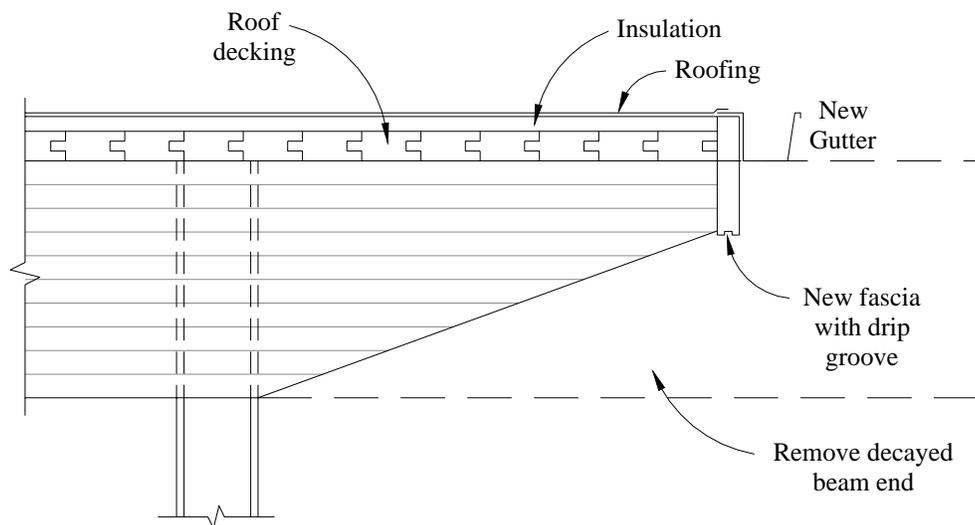


Figure 1. *Removal of decayed beam end.*

If extending the roofline to provide cover is impractical, carefully designed covers can be used to protect laminated timber members from direct exposure to the elements. An air space with at least one-half inch of clearance around the member should be provided to permit air circulation around the member. The bottom should be left open for ventilation. The bottom of the members and the air spaces between the member and the cover should be protected with metal insect screen to prevent infestation by termites or other wood destroying insects. The cover should be well constructed and flashing should be used to prevent infiltration of water at the roofline or side of the building. Figure 2 shows a metal cover protecting a laminated beam. Painting the surfaces of the wood will not keep the wood dry or provide protection against decay.

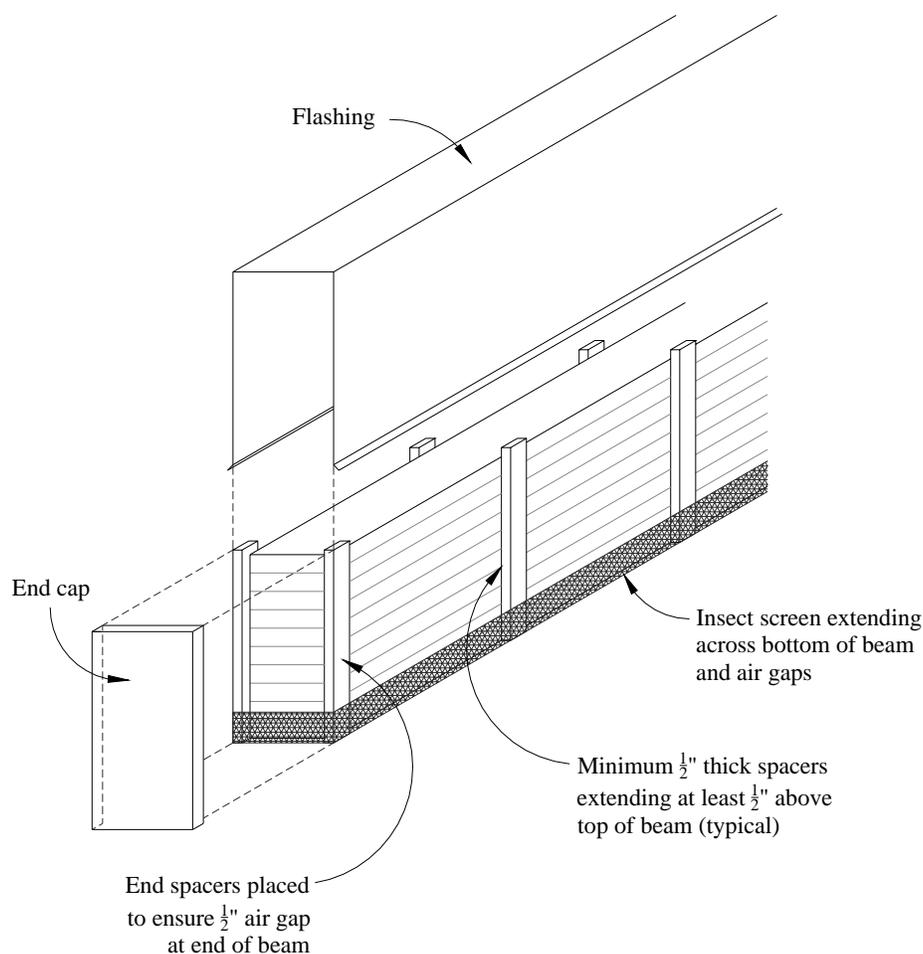


Figure 2. *Metal cover protection for glued laminated beam.*

PRESERVATIVE TREATMENT IN-PLACE

In some cases where drying of the member is slow, the member should be treated in-place with a wood preservative and also covered. In-place preservative treatment is usually not as effective as pressure preservative treatment meeting AWPA standards. However, when properly applied, treatment in place offers greater protection than untreated or painted surfaces.

Preservatives for in-place treatment are similar to those used in the pressure impregnation method of wood in retorts and usually require a licensed applicator to handle them. Different solvents are often used to facilitate dispersion of the chemical or chemicals used. The selection of the type depends on the use of the member and availability of the treatments.

SURFACE TREATMENTS

Surface treatments can be applied to protect newly exposed, untreated wood from decay. They are commonly applied to checks, mechanical damage, and field-fabricated areas to act as a barrier against the entry of decay organisms. However, the penetration of surface treatments is very shallow and, therefore, ineffective against established internal decay [5].

INJECTION OF PRESERVATIVE

Researchers at the University of Washington have reported using a specially modified lag screw with a grease gun to inject preservative chemicals [3]. Other methods of in-place treatment have also been used successfully. Some applicators have special equipment for injecting the preservatives under

pressure. Typical treatment methods require injection of preservative into holes drilled fairly close in order to increase the retention of the preservatives. Usually this is done in small areas more subject to decay than the remainder of the piece. In all cases, the drilled holes should be filled with pressure-treated wood plugs inserted tightly in the hole with a drive fit. The reduction in capacity due to the holes must be evaluated in all cases.

FUMIGANTS

Fumigants are specialized preservative chemicals that volatilize into toxic gases that migrate through the wood, killing decay fungi [5]. They can diffuse for several feet from the point of application along the wood grain [5,8]. Fumigants in both solid and liquid form have been used successfully as in-place treatments for wood subject to decay conditions [4,5], however, they should not be used if the member extends into an occupied enclosed or un-vented space because of the possibility that toxic fumes might accumulate there. Because fumigants dissipate with time, fumigant-treated members exposed to weather or moisture should be reinspected and retreated at regular intervals based on the exposure. 5 to 10 year intervals have been recommended for bridge applications [5]. The fumigant method is ideally suited for those situations where a member is to be treated and later covered and kept dry. Applicators are generally required to be licensed prior to using fumigants.

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