

# AITC TECHNICAL NOTE 14

## USE OF EPOXIES IN REPAIR OF STRUCTURAL GLUED LAMINATED TIMBER

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Epoxy resins have been used in specific cases to repair timber that has deteriorated from decay or insect attack. They have also been used to repair certain structural deficiencies in existing construction. This Technical Note discusses the use of epoxies and their limitations in the repair of structural glued laminated timber.

The compressive strength and filling capabilities of epoxies can aid in repairing glued laminated timber. The tensile, shear, and bond strength of epoxies as structural wood adhesives are, however, limited and are further subject to variability due to conditions of use. Mechanical reinforcement should be used in conjunction with epoxies for repairs intended to develop shear capacity.

The use of epoxy for structural glued laminated timber repair should only be undertaken following a careful evaluation of the strength required by the design and the determination that epoxy can meet the existing design requirements. If used as an adhesive in repairs, epoxies in structural glued laminated timber should be adequate for wet-use and gap-filling applications. The strength properties of some epoxy formulations may be adversely affected by in-service temperatures in excess of 150°F.

All repair methods related to the use of epoxies should be developed, approved, and supervised by a professional engineer experienced in the design and repair of structural glued laminated timber and its fastenings. The use of any epoxy should be according to the epoxy manufacturer's recommendations.

Prior to making epoxy repairs, the wood member should be dried and the cause of any moisture problems should be corrected. Care should also be taken to avoid sealing the surfaces of the member with epoxies, which may trap moisture in the member.

#### COMPRESSION REPAIRS

Deterioration caused by decay or insect attack can be repaired with epoxy by removing the damaged wood and filling the void with an epoxy or epoxy/wood fiber mixture, thus restoring strength sufficient for the particular design. Because the curing of epoxies is typically an exothermic reaction, it is recommended that larger voids be filled with wood prior to epoxy injection to minimize the amount of epoxy used.

Shrinkage and swelling properties and modulus of elasticity of wood and epoxy differ, and these differences must be considered in large volume epoxy fillings. Consideration should be given to the suitability of compression area epoxy repairs if there will be exposure to alternating wetting and drying cycles. Some epoxy formulations can provide adequate bearing in areas of compression at bolts and shear connectors and can be used to repair such areas.

#### TENSION REPAIRS

The use of epoxies is not recommended for the repair of wood stressed in tension parallel to grain, whether occurring on the tension side of bending members or for wood stressed in axial tension. Radial reinforcement repairs for curved bending members can be accomplished by placing steel rods or re-bars

in oversize holes filled with epoxy. In this type of repair, the steel acts as the reinforcing element, and the radial stresses are transmitted through the epoxy in shear.

## **SHEAR REPAIRS**

If longitudinal checks or splits in the wood or delaminations at the glue line occur that require re-establishment of the horizontal shear strength of bending members, it is possible to use steel reinforcement in conjunction with epoxy for this purpose in a similar fashion as described for radial tension repair. For horizontal shear reinforcement, the steel reinforcing elements in epoxy-filled holes act to transmit longitudinal shear forces between adjacent beam sections. In all cases involving the use of mechanical reinforcement in combination with epoxy, the net section remaining after the required holes for the steel are drilled should be used when checking for resulting bending stresses.

### *Splits*

Splits are openings which travel from one side of the timber to the opposite side or from one side and through to the adjacent side. Seasoning checks can develop into splits under certain conditions. Splits can also be caused by shrinkage of the wood in connection details with widely spaced bolts in tight-fitting holes. Radial tension in curved members or notches or tapered cuts on the tension side of bending members may also cause splits.

Prior to repairing a split, structural analysis should be conducted to determine if a repair is necessary. (AITC Technical Note 18) The conditions causing the split should also be determined and remedied. This may require re-design of connection details, providing protection to keep the wood dry, or designing appropriate radial reinforcement. Tight-fitting mechanical fasteners, such as fully-threaded lag screws or epoxy-bonded steel bars, should be used in conjunction with epoxies in repairing splits, especially for long splits. Epoxies without mechanical reinforcement are not recommended for repairing splits.

### *Checks*

Seasoning checks are not typically of structural concern (AITC Technical Notes 11 and 18), and generally should not be repaired with epoxies. Cosmetic repair of checks with epoxy injection is also not recommended. A rigid epoxy will act as a wedge and prevent checks from closing during moisture cycles. The stresses created by this epoxy wedge may increase the size of the check and subsequently cause the check to develop into a split. The appearance of the completed epoxy repair may also be less desirable than appearance of the seasoning checks, because the color of epoxies do not generally match the color of the wood.

### *Delamination*

Delamination is the failure of an adhesive bond between laminations. It is characterized by smooth surfaces on the contact surfaces of laminations, without torn wood fibers. Delamination may be caused by improper lumber moisture content at the time of manufacture, incorrect adhesive mix, too great a lumber surfacing tolerance, or inadequate curing of the adhesive. Exposure to moisture of older timbers that were manufactured with dry-use adhesives can also result in delamination. Because of stringent quality control requirements placed on the manufacture of structural glued laminated timbers according to ANSI/AITC A190.1, delamination in modern timbers is rare.

The cause of any delamination should be investigated thoroughly in conjunction with the manufacturer of the laminated timber. The extent of the problem (whether it involves the entire lot of beams or is limited to a single occurrence) should be determined. An epoxy should be considered for delamination repair only after it is determined that it is necessary and will provide an adequate repair for the member. Tight-fitting mechanical fasteners should be used in conjunction with epoxies for delamination repairs. Epoxies without mechanical reinforcement are not recommended for this type of repair.

## **APPEARANCE OF EPOXY REPAIRS**

Epoxy resin repairs will typically cure with a hard and shiny surface that will accept finishes and stains differently from the wood itself. Epoxy manufacturers may recommend painting an epoxy repaired surface but a painted surface may not provide the desired finished appearance. A possible option is to add tinting to the epoxy resin to approximately match the finished color of the glued laminated timber. The epoxy manufacturer should be contacted in this case to assure that the material used to achieve the tinting will not affect the cured performance of the epoxy resin.