

MAINTAINING OUR HERITAGE

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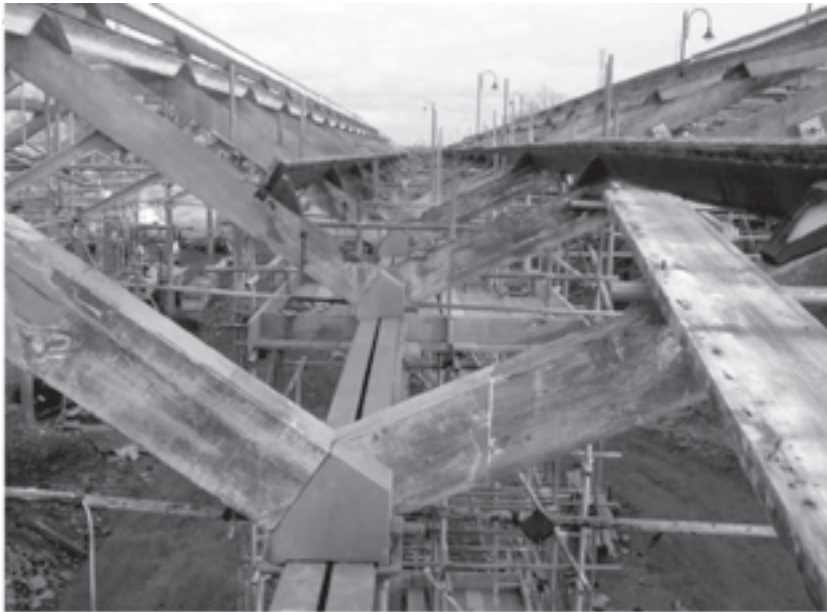


Figure 1. Series of repaired trusses

Michael Hall, Senior Surveyor, ProTen Services Ltd, explains how timber resin repair systems can be used to retain much of the original timber, and provide an aesthetically pleasing result.

When damaged or decaying timbers are found in a heritage building, the prospect of having to replace the historic beams can be devastating for the owners. It is difficult to pinpoint what gives a period property character, but one thing is certain: upset just one aspect and it is likely to affect the whole feel of the building. Insensitive repairs to historic timbers can be particularly noticeable, and not only spoil the visual effect of the architecture but devalue the property.

From an environmental perspective, timber is an extremely valuable resource, and it is recognised as important to conserve as much of the original material as possible. It is often only a small but structurally critical section of timber that has become rotten, infested or fractured, and so wherever possible, methods should be used that simply replace or repair the defective section and allow the majority of the timber to be retained.

The use of specially designed resins allows this to be achieved; not only can the repairs be carried out in an aesthetically pleasing manner, which in many cases are invisible to the untrained eye, but the structural capacity can also be maintained (and in the majority of cases significantly improved) whilst, of course, wastage of timber is kept to a minimum. The epoxy resins used have been developed over almost three decades, and are now suitable to act as both a replacement material to substitute the lost timber and as an adhesive to bond on re-claimed timber of a similar age and appearance.

Resin repair systems can be used to remediate a wide range of timber defects, including decayed truss or beam ends, structural cracks – either natural or induced, and the debonding of laminated beams. They can also be used in conjunction with imbedded steel or carbon fibre reinforcement to upgrade the

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Figure 2. Decayed timber



Figure 3. Injecting resin

loading capacity of beams. In the majority of repairs, the basic components used can be broadly categorised as the parent timber, the replacement timber, reinforcing or connecting materials and of course the epoxy resins. The role of the resin may be solely as an adhesive, or as a structural filler and adhesive, i.e. in the form of a three part 'grout' comprising of a base liquid, a hardener and a graded filler. A coupling agent or primer may be required to promote adhesion, and shuttering is sometimes necessary for retention purposes.

Epoxy resin grouts are used for both bulk filling purposes (i.e. for re-forming timber sections), or as an adhesive for securing reinforcement bars in the parent or introduced timber. They have a relatively low viscosity, and as such are self-levelling and free-flowing 'searching' substances, making them ideal for use in filling voids and providing a sufficient bond to the timber.

The cured properties of the three-part grouts include a compressive strength of $>50 \text{ N/mm}^2$, a tensile strength of 17 N/mm^2 , a flexural strength of 32 N/mm^2 and a specific gravity of 1.6. The initial cure occurs at 24 h (dependent on the ambient temperature) and full cure at 3-7 days, again dependant on temperature. The minimum application temperature is normally 5°C , but winter formulations are available for adverse conditions.

Their structural capability can therefore be seen to be more than comparable with timber and they maintain a consistent density throughout the crosssection.

Thixotropic resin adhesives are highly viscous prior to curing, and are commonly used for bonding reinforcing rods or ties within pre-drilled holes in the parent timber. Where the repair area is inaccessible or vertically orientated, this type of resin can also be used in the void-filling role. Again, typical cured properties include a compressive strength $>50 \text{ N/mm}^2$, a tensile strength of 18 N/mm^2 , Youngs modulus: 5000 N/mm^2 .

Repair of trusses

Where there is significant decay to a beam or truss bearing end, a new timber section can be bonded onto the original

parent timber. Known as a Timber Resin Splice (TRS), this method is the simplest way of creating a structural bond between the new bearing end and the existing beam or truss. It is used to avoid the considerable disruption and cost that would be experienced if the original timber were to be removed in its entirety, which would invariably involve significant disruption of existing floors, ceilings and partitions etc.

The process involves cutting off the decayed timber so that only structurally sound timber is retained. The new section of timber is then cut to size, usually formed from reclaimed timber of a similar age and species, and slots or holes are formed to receive the reinforcing bars in both the existing and new timber. The length and configuration of the reinforcement required is calculated for each individual repair to both optimise the quantity of material used whilst achieving the structural capacity required, but the bars will normally extend to a minimum of 500 mm into each timber. Before the selected resins are poured in or injected it is essential that the slots or holes are cleaned to remove any shavings or dust to ensure proper adhesion. The bars are then placed in the slots, separated with spacers, and the resin poured or injected to encase the reinforcement.

The repair can be configured to suit limitations in access, i.e. slots can be formed in the top, side or underside of the beam or truss. This can be of particular importance if the beam is supporting a feature that is to be retained, such as a lime mortar floor.

A period of time is required following the repair to allow the resin to cure and to achieve its structural integrity, which is usually within 7 days. During the curing period the resin will soak into the surrounding timber to achieve the desired bond, and will also search out and fill adjacent cracks/voids to the extent that monitoring is required in the period immediately following the pouring of the resin to check for and to plug any leaks.

The repair can be designed to look like a traditional scarf joint, and where required special moulding mortars can be used to mimic graining and even woodworm or Deathwatch beetle flight

holes. Particular resins can also be stained to match the original timber, so that with a bit of care and the use of the most suitable resin even the property owners have difficulty identifying the repaired sections.

Repair of laminated beams

The use of laminated beams became increasingly common throughout the 20th Century as a cost-effective method of forming large section or curved beams. However, years of water ingress and general deterioration with age has in many cases led to the breakdown of the adhesive used in the construction of such beams. Where beams are displaying de-lamination, the laminates can be re-bonded by the injection of a two part low viscosity resin adhesive between the laminates. Should further stability be required, stainless steel or fibre rods can be inserted, through the vertical axis of the beam and held in place with the same or similar resin.

Repair of fissures

In many cases, small cracks and imperfections in beams add to the cosmetic appearance, and are desirable. If, however, the crack (either natural or induced) has structural implications, it

becomes necessary to carry out remedial works. This can be achieved either purely by injecting a low viscosity two part epoxy resin into the crack, or by providing supplementary measures involving the provision of steel or fibre ties at regular intervals across the crack, the ties being set in a similar resin.

Upgrading of timbers

One of the most effective uses of timber resin repair in heritage buildings becomes evident when a change of its use is proposed. Recent years have seen many heritage properties converted into luxury hotels, conference centres or venues for lavish private functions. The structural capacity of the existing beams is often not sufficient to bear the extra loading; however, with this technique the beams can be upgraded with minimal visual impact.

The process in effect requires the formation of a slot along the length of the beam to approximately three-quarters of the depth of the timber into which the required number of reinforcing bars are placed and encased in resin. The combination of the reinforcing bars and resin can increase the load bearing capacity of an original timber beam by two or three fold with little aesthetic alteration. This method is not only less disruptive,



Figure 4. Pouring resin



Figure 5. Repaired truss

but also more cost effective than the use of bulky external fitch plates or wholesale floor replacement.

To determine the exact repair specification needed to meet the proposed required loadings, structural calculations are of course required, and on completion loads are induced to monitor any deflection.

These techniques provide a much-needed solution to the quandary of damaged historic timbers – their stability can be restored without harming their original character and beauty. Further benefits of these methods compared to alternatives, such as the use of steel plates, is the minimal disruption that is caused to the building and the maximum retention of valuable timber.

ProTen Services Ltd has been involved in timber preservation for 80 years, and have witnessed the evolution of various resins since the 1980s. Whilst early resin systems were met with scepticism from some heritage bodies, today's resins and TRS systems have many beneficial properties, including: high versatility, long shelf-life, low fire risk, low odour, wide useable temperature range, low cure shrinkage, excellent adhesion and toughness.

Experimental data that is extensible to historic timber and emerging data from old epoxy repairs has abated the concerns once raised regarding the durability of resin repairs, and the method is now widely accepted as a viable means of timber preservation.

Our experience has been gained in carrying out timber resin repairs in a variety of locations and situations, including the Royal Train Shed at Wolverton and numerous historic and heritage buildings throughout the UK. In each case, whether it be a repair or an upgrade of a timber beam, the company is proud to have saved some of the country's heritage, and maybe to have convinced a few sceptics along the way.

- Further information or technical advice: ProTen Services are a national property preservation and environmental services company in the United Kingdom. With their Head Office situated in the UNESCO World Heritage Centre, Bath, ProTen Services have 80 years experience in the field of timber preservation. Please see www.protenservices.co.uk for full details of the Company's range of services.

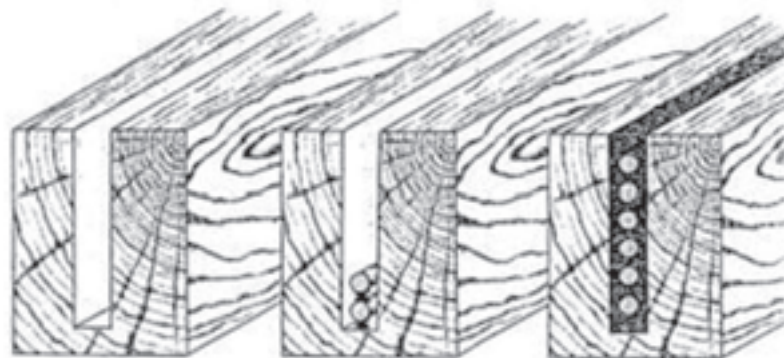


Figure 6. Upgrading a beam



Figure 7. TRS repair stages