

Historic buildings

Timber frames and roofs

This leaflet describes the character of historic timber frames and roofs and identifies some of the problems associated with them, and methods of repair.

There is a list of references and useful contacts on the last page.



Timber framed cottage

Introduction

Timber construction has been employed throughout the world for longer than any other building method, except earth.



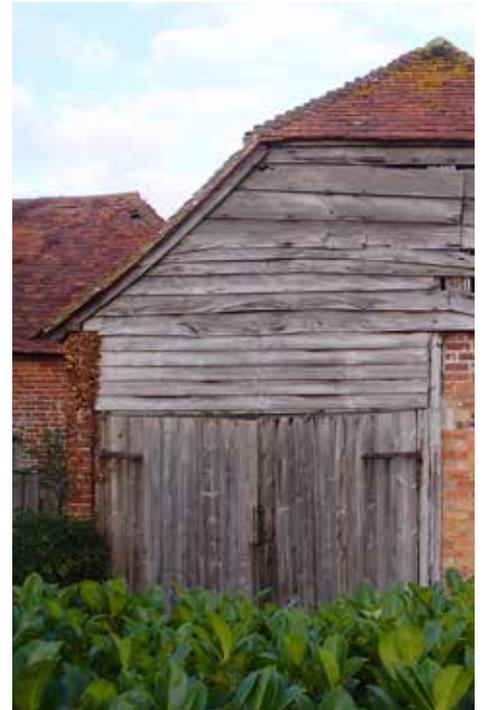
Example of timber frame with painted brick infill panels

History

In Britain, there has been timber wall construction since at least the Roman occupation and roofs of wood have existed for a lot longer than can be recorded. The oldest surviving type of timber building in Britain dates to the C13th.

The timber of choice in England was oak, but sometimes elm and sweet chestnut were used. From the mid C16th softwoods including fir were imported from Europe. From the C19th vast quantities of softwoods from America were also imported.

Timber framed buildings were prefabricated on the ground, and carpenters etched the timbers with various forms of marking, so that all the pieces fitted together correctly when being assembled. They were then hoisted into position and pegged into place. Framing patterns indicate the quality and age of many structures and for what sort of people they were built. In time, most forms of construction were used for all levels of society.



Timber cladding





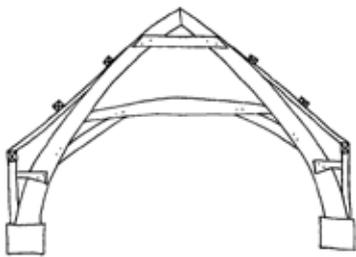
Post and truss cottage, Minstead



Cruck framed cottage, Ibsley

Description

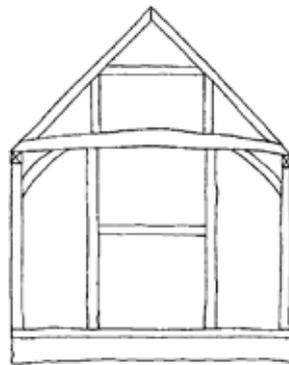
Timber framing members are jointed together and as such can resist structural forces acting on them. Most structures consist of 'cross frames', with either posts and trusses, crucks or aisles.



Cruck

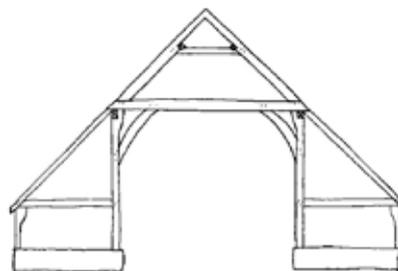
Crucks usually consist of a pair of timbers from a split tree trunk formed into an 'A' frame and jointed at the top. The rafters are set upon purlins, which are jointed to the crucks. Non-loadbearing wall framing is constructed on the ground, usually off the same plinth as the crucks, and infill panels fitted. It is believed that this form of construction developed at a high level in society and filtered down to the lower rungs over time.

The most common form of framing is post and truss. The main posts support the wallplates, which are jointed at the eaves by a tie beam. Roof trusses sit on this and support the purlins which carry the loading of the common rafters.



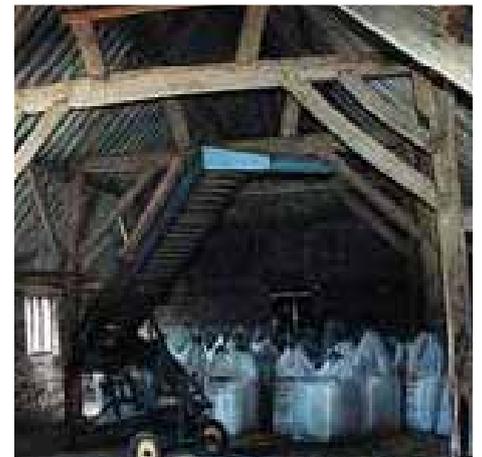
Post and truss

Aisled buildings were built when greater spans were required. These consist of a central space with side aisles. Very few dwellings survive, but there are still plenty of barns of this design, located in southern England, East Anglia and Yorkshire.

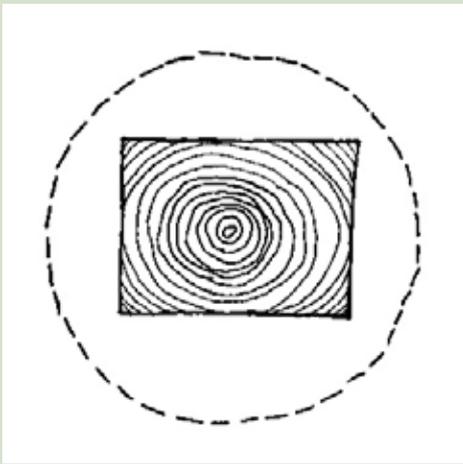


Aisles

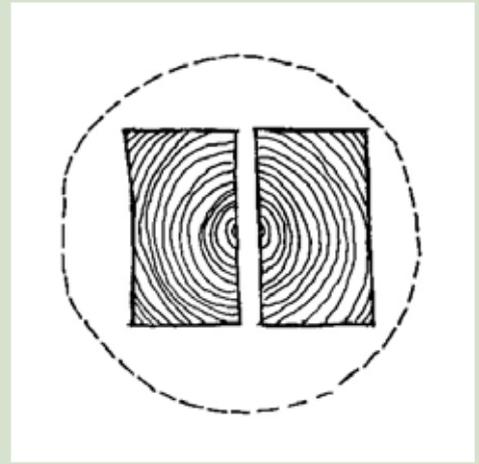
In the New Forest there are examples of both post and truss and aisled buildings. There are also some cruck framed buildings, which are generally rare in the South and South-East of England.



Aisled barn, Beaulieu



◀ Timber taken from the round. Also known as boxed heart and used for major structural members such as spine beams

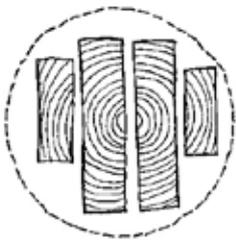


▶ Timber halved and used for framing members such as wall studs

Most joints are based on the mortice and tenon. Another joint regularly used is the lap joint, particularly in jointing wallplates and studs, where complete contact between both sections of timber is required to evenly spread the loading.

When timber was sawn, it was either taken 'from the round', or planked, or quartered, depending upon its intended use. Main beams were usually whole tree trunks, cleaned and squared off. Posts and studs were slabbed and floor boards were cut 'through and through'.

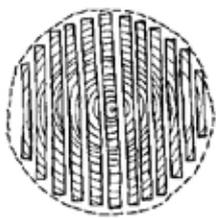
Ordinary brick facing also took place. Other infill materials include: brick; oak laths butted together and plastered; and stone slabs. This variation was due in part to the availability of materials. Only during the early part of the C19th when the railways came, did the boundaries of long established local building tradition blur.



Slabbed timber, used for common rafters

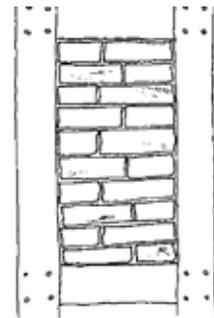
Most timber framed buildings were designed to be infilled and wattle and daub panelling was common. Oak staves were slotted vertically into the framing members and cleft oak or hazel woven between the staves. A clay and straw mixture was then 'daubed' onto both sides of the panel, before being limewashed.

Some buildings constructed in the C17th and C18th were weather boarded. The New Forest has fine examples of both timber framed buildings with infill panels and timber clad barns.



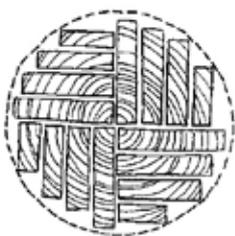
Planked timber used for flooring boards - this sometimes warped

Occasionally, during the Georgian period, when residents decided to modernise their timber framed buildings, they were clad in a tile that had the appearance of a brick when in place.

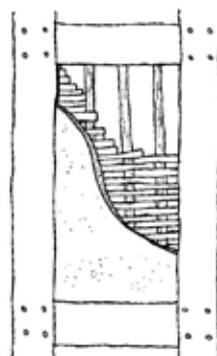


Brick infill panel

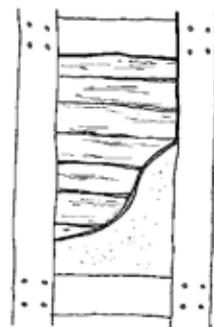
These 'mathematical' tiles were hung off battens fixed horizontally to the timber frame members and pointed in lime mortar once in position.



Quartered timber avoided the warping or 'cupping' action that planked timber experienced when dried



Wattle panel showing oak staves, woven hazel and a lime render finish



Oak lath infill with rendered finish



◀ Cutting a doorway through the collar of this roof is not recommended as it could seriously weaken the structure of this timber framed cottage and leads to loss of original historic fabric

▶ In many cases small repairs can be made successfully by replacing missing timbers



Problems and repair

Alterations to the original structure

Alterations to original structures are many, and can be the cause of the greatest damage, e.g. by removing part of a purlin to construct a dormer window, or by forming a doorway through one bay to another, and in so doing cutting a tie beam. Such actions can seriously weaken the structure of the building as a whole.

Repair

In essence, an understanding and appreciation of the frame as a whole must be gained. The failure of a single member can create undue stress on other members and this assessment can help pinpoint why a problem has occurred. In many cases a repair of limited scope (and cost) can be made successfully by replacing missing timbers, or by adding members to strengthen the frame using traditional timber repairs, or by using metalwork.

Inherent Defects

Inherent timber defects such as loose knots or deep shakes can allow ingress of water, causing dampness and decay. Additionally, deep cracks may house beetles and their eggs.

Repair

Knot holes and shakes on internal timbers can be left unfilled. However, those on timbers exposed to the elements should be filled with timber inserts, if possible. Irregularly shaped crevices can be packed with lime hair plaster and lime washed over. In the case of severe defects alternative repairs which involve traditional timber repairs or steel to reinforce areas of the frame may be considered.



These structural timbers have started to rot as a result of a leaking roof



Irregular shaped crevices can be packed with lime hair plaster and lime washed over



◀ Insect attack to roof timbers



▶ Rot to window

Rot

One of the major problems in timber construction is rot. The appearance of both wet and dry rot is similar, with tubes or threads, spores and sometimes fruiting bodies visible, depending upon the severity of infestation. The threads (hyphae) spread and eat holes into the wood cell walls. They produce enzymes that break down the fibrous material.

Wet rot can affect both hardwood and softwood. Cracking both along and across the grain is shallow. The fruiting bodies are rarely seen.

Dry rot usually only affects softwood, but occasionally hardwood can be damaged.

Cracking along and across the grain is very deep and the fruiting bodies are generally large and colourful.

These rots change the colour and density of wood and the strength is sometimes wholly removed.

Repair

Over-reaction to all forms of decay is still commonplace, and can destroy much historic fabric unnecessarily. There are standard procedures that should be adopted to combat the spread of the rot.

- Thoroughly ventilate and stop any ingress of water.
- Expose, as far as possible, timber in the affected area, but try to retain any adjoining sound historic fabric, such as cladding and plasterwork.
- Carefully investigate the extent of any damage. Non-destructive methods of testing, such as ultrasonics or sensor monitoring, can be used.
- Decide upon the most appropriate method of repair. This may involve traditional timber repairs or the use of steel to reform or strengthen junctions between structural members.

Insect Attack

Deathwatch beetle is often found in old houses where a lot of oak or elm was used in construction. This beetle attacks hardwood and occasionally softwood, particularly in damp buildings, because the grubs require moisture to survive. After changing to pupae and then into adults, they create their flight holes and exit the wood, often up to as much as six years after entering. It is only at this stage that one becomes aware of their existence in the wood. The damage created can be extreme in bearing ends of timbers. The centre of beams may be entirely hollowed out.

Furniture beetle attacks the sapwood of hardwood and softwood as well as plywood. Up to two years after being deposited in the wood in egg form, they create their flight holes and leave. This beetle very rarely damages timber sufficiently to render it structurally unsound.

Repair

Treatment usually involves organic solvents or pastes. These can be effectively applied by pressure injection or gravity feed.

If significant damage has been caused by insect attack, the most appropriate method of repair will need to be determined, which may involve traditional timber repairs or the use of metalwork.



◀ Timber framed and clad barn, before restoration



▶ After restoration

Distortion and Movement

Usually roofs were built in 'green' or newly felled timber, which was full of moisture and sap. In time the drying process caused warping. Later in its life parts of a roof might have rotted and moved again. It is essential to analyse why movement has occurred and if necessary to take action to prevent it continuing. However, rectifying this distortion should not be attempted, as undue stresses could be placed upon the frame, possibly creating further problems. These distortions add to the character of old buildings and may not be a problem.

Repair

Attempts to correct movement should not necessarily be undertaken. Forcing a frame back into its position can result in significant damage, since members and joints may have settled in their distorted positions and may also have been repaired in those positions.

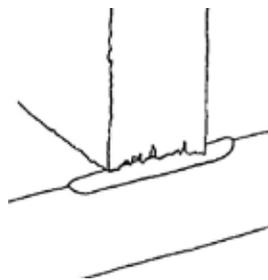
Junctions with Infill Panels

The joints between timber frames and infill panels can sometimes open up. This is usually due to the different rates of expansion of adjacent materials. If inappropriate fillers have been used in the past to stop the problem, including cement mortar, moisture can become trapped behind the surface and cause dampness.

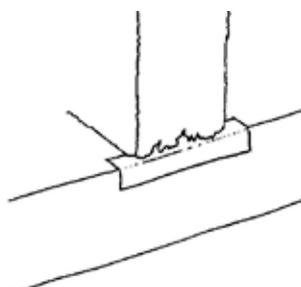
Repair

Loose filler can be removed and replaced with a flexible mastic set back in the joint and faced with a lime putty mortar of sufficient depth to ensure a key.

Weathered finish



Lead weather strip



Weathering

Exposed timber can suffer from weathering. The main problem tends to be on the horizontal surface of ledges, sole plates and window and door heads and sills, where standing water can be driven into the grain.

Repair

These external ledges can, if required, be given a 'weathering,' a slight chamfer which assists in draining excess water from the surface of the timber. This should only be done if the grain is close enough to resist drawing moisture into it. An open grain might exacerbate the problem. If this technique is not practical, a code 4 lead weather strip may be applied and tucked up under or into the infill material above.

This technique may be more effective where a vertical stud member is pegged into a horizontal sole plate, or where a window cill is fixed to a stud.

Typical scarf joints and mortice and tenons can be used equally effectively on roof timbers as on walling timbers.



◀ This timber roof is failing and repairs are needed to maintain the integrity of the structure

▶ Repairs to the timber frame with new timber to match the existing



Traditional Timber Repairs

The loss of original material should always be avoided wherever possible. The framing members, particularly in the roof, are often the original timbers, and can date a building accurately. The style of framing, the method of finishing the timber and the joints used are all important aspects of the members and the structure, and should be retained.

Understanding Timber Frames and Roofs

Structural members within timber frames and roofs act in different ways; some act in compression, some in tension. The joints of repairs must function properly in order to maintain the integrity of the structure.

Timbers in compression include vertical wall framing members. In this instance the grain of the inserted piece should match closely that of each end of the original member. An accurate and close fit must be made, to ensure a complete spread of the load.

Hardwood pegs may be used to locate the timbers when jointing, but they must not transmit any loading as this might create undue stress on the joint. The joint which already exists should usually be copied.

Timbers in tension include tie beams, joists and purlins. In repairing these members, sections of problem timber should be removed and new sections inserted. Each end should be mortice and tenoned into existing timber.

Rafters in a roof act in bending. They are usually supported at their top end by a ridge board and at their lower end by a wall plate. Sometimes, they are supported on struts or purlins in between.

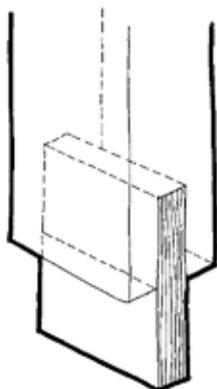
Scarf Joints

There are various sorts of commonly used scarf joints, but in all cases these joints should be about three times the depth of the member being repaired. Simple half lap scarfs can be used in jointing cill plates, but are not suitable for repairing members that are subject to bending, such as rafters. This is because the bolt connectors impart the strength to the timber, rather than the sort of joint used.

Joints that are suitable for members in bending include splayed scarfs. The most commonly used joint for tie beams is the stepped splayed scarf with folding wedges, which can resist bending and sideways twisting.

Mortice and Tenons

If the tenons have failed on a member, false tenons can be used. Timber of the same species is preferable. It should be laid with the grain following the line of the original.



False tenon



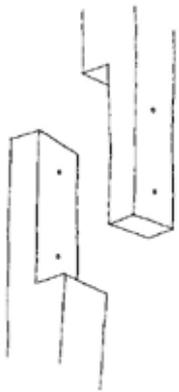
Localised repairs and the use of hardwood pegs



Repairs to the sole plate

Posts and Studs

The major problem that affects these members involves rotting bases. These vertical members should be repaired using either simple half laps or the more complex and efficient scissor scarfs, which resist bending and sideways twisting. In compression members it is essential that all faces of the joint make full contact with each other in order to spread loading effectively.



Half Lap for post and stud

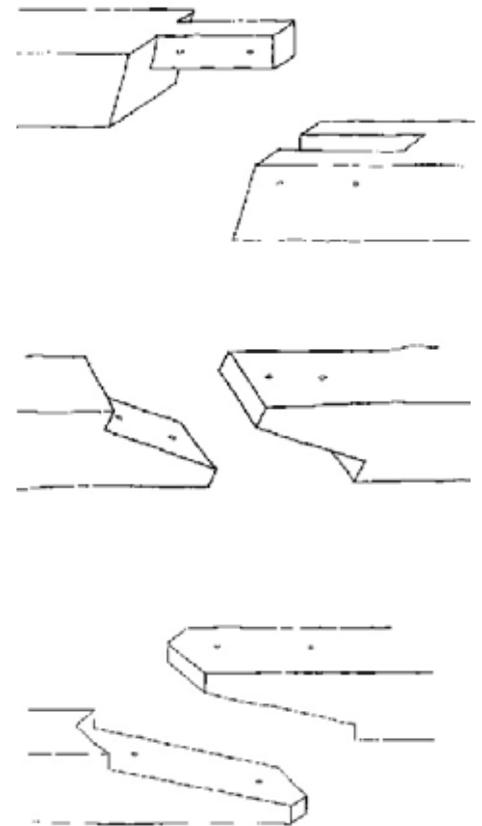


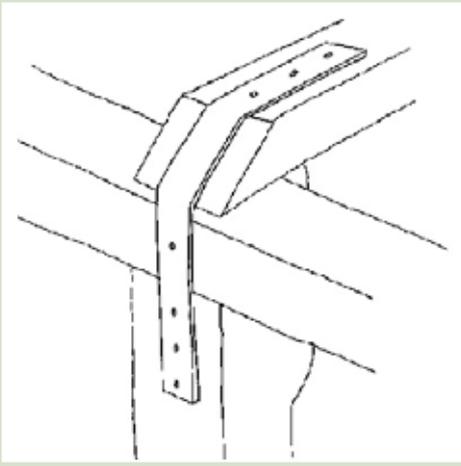
Scissor Scarf for post and stud

Sole Plates

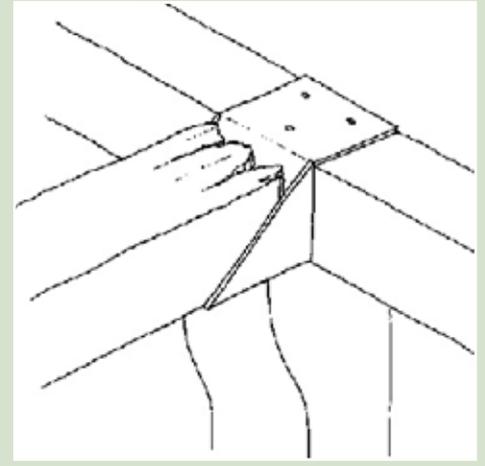
These elements of a timber frame often decay due to rising damp. If the plinth also has to be renewed it is quite straightforward to prop the frame and place a new sole plate and then rebuild the plinth. However, if the plinth is structurally sound, it is a more complex matter. The plate should be made from two sections of timber cut lengthwise and offered up separately into position. If it is merely a section that requires replacement, it should be jointed using one of the half laps traditionally used, or it should accurately reflect any previous historic repair to that member.

Three alternative joints for sole plates





◀ Tailor-made steel angle



▶ Tailor-made steel shoe

Choice of Timber

‘Green’ or unseasoned oak is acceptable for most repairs to frames and roofs. It may distort once in place, but the frame can usually absorb that movement without cracking.

If the frame or roof is particularly fine or complex, the timber should be fully seasoned with a moisture content of no more than 15%. The grain should accurately reflect that of the existing timber.

Secondhand timber should be avoided. It is difficult to work as it is dense, it may contain lots of old nails and it can be archaeologically misleading. This means that it might prove difficult to ascertain the age of the structure because of the use of timbers from different periods.

Pegs

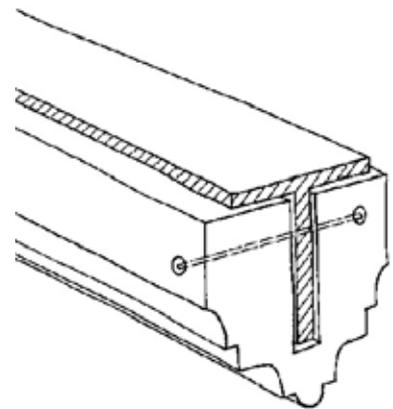
Pegs should be made from oak and kiln dried so that they do not shrink once in place. They should have a rounded entry end and be left square at the projecting end. If, however, the pegs are to be finished flush, they should be rounded for neatness. Secondhand pegs should not be used as they are not usually of the same age as the other pieces of timber, and therefore are archaeologically misleading. Also, they may be unsound or rotting.

Use of Metal in Repair Work

Timber repair is the traditional method of strengthening or stabilising timber framed buildings or roofs. However, steel can sometimes be used, in order to preserve more of the original frame, or important mouldings and plasterwork. This is done by using straps or braces to join members together.

Sometimes joist hangers or other standard fixings can be used, but on other occasions tailor-made steel fixings will be required to address particular situations. Where two members are separating, such as the spreading of a rafter foot and a wallplate, a simple galvanised steel angle can be screwed to both members. This repair is simple, effective and can be used for joining any two members. It prevents the loss of excessive historic timber and shows in a clear fashion the evolution of the structure.

Fitch plates can be used successfully on roof members such as tie beams. If beams have deflected under their own weight, this bend must be acknowledged when fitting a steel plate. The fixing bolts through the beam and plate must be located into sound timber and at least 2’ away from any edge.



Fitch plate in beam

These fixings must be designed so that the forces they carry are uniformly transferred to the frame and they must not be able to pull out or twist in situ. Nuts and bolts that pass through both the steel and the timber should be used rather than coach screws, which can tear out if movement occurs.

The steel should be galvanised or fully coated in red oxide paint, to avoid the damaging effects of tannic acid, which is found in oak. Fixings should ideally be stainless steel. If they are made of mild steel, they should be separated from the other steelwork with nylon washers, so that if the timber becomes damp, electrolytic action does not occur.

Historic buildings Timber frames and roofs Further information

Click on the website
address for link



References

Wood, Glass and Resins
by **Gower, Ashurst, J & N**
English Heritage, 1988

**Technical note 12: The Repair
of Timber Frames and Roofs**
by **Boutwood, J.** SPAB

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