
Repair of Historic Timber Structures

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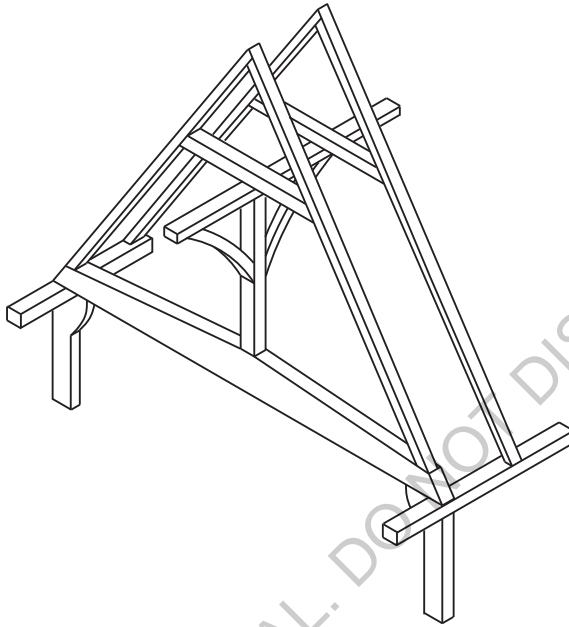
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Figure 2.7 Crown-post roof construction



under the collars and the post is braced to the plate to provide racking resistance.ⁱ The only example in a high, cathedral roof is at Exeter, where it has proved ineffective, with severe racking of the nave roof towards the west end.

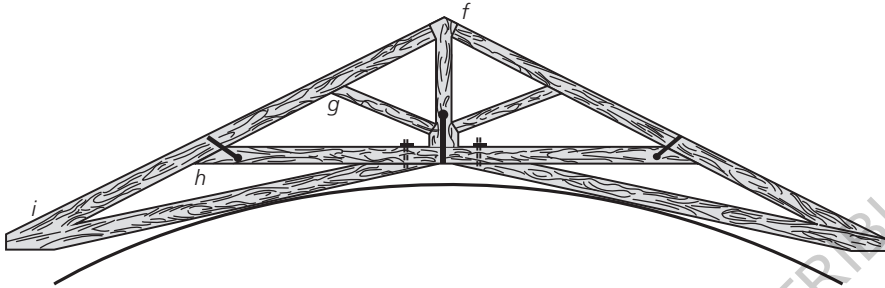
Longitudinal stability of purlin roofs was dealt with by having so-called wind braces between principal rafters and purlins. Note that all cruck buildings have purlins; the wind braces were essential to the framing process, providing a longitudinally stable frame as it was being erected.

With the roof open to the hall below, the structure was often treated as a decorative device. In common rafter roofs, the crown post might be decoratively treated. In purlin roofs, the most common architectural device was to have arch-braced principals, possibly combined with a collar and taking its most elaborate form in hammerbeam roofs. Such arch bracing presents a problem of containing outward thrusts, easily handled in masonry buildings where buttresses can be provided, but they are sometimes seen in completely timber-framed construction.

Like the whole of this chapter, this section can only be a brief introduction to the various roof types. Readers will find that there is a wealth of studies of this type of structure. A good introduction with a wide coverage can be found in John Walkers' *The English Medieval Roof* (2011), which is a collection of essays dealing with a wide geographical range.

ⁱ Note that I call this a collar plate rather than a collar purlin because it provides no support to the roof.

Figure 2.15 Trusses with raised tie beams to clear a vaulted ceiling



pushed this idea rather too far. The trussed roof also allowed raised tie beams to clear vaulted ceilings (Figure 2.15).

Timber

Timber grows outward from the pith and juvenile wood found at the centre of a log and during the growth process a distinction develops between the heartwood at the centre and the outer sapwood. This can be seen by a difference in colour. The growth rings are the result of different rates of growth and cell sizes between spring wood, put on early in the year to carry the rising sap, and summer wood, of smaller cells. Branches, which give rise to knots in the converted timber, grow from the pith.

The choice of timber for building must depend on both suitability for the task and availability. Until the seventeenth century, oak, readily available in most parts of the country, was the timber of choice for framing buildings in Britain, chosen both for its strength and durability. Oak was a suitable material because its heartwood is resistant to both beetle and fungal attack. Elm was used where oak was not available but is inferior in both properties. In spite of rumours to the contrary, there is no evidence that chestnut was ever used in Britain (Papworth, 1857) but it was used extensively on the Iberian Peninsula. In Portugal, for example, both oak and chestnut were used. Softwood was more commonly used in Germany but oak might have been used in districts where it was available. Timber supplies there were affected by the possibility of river transport. The great rivers, the Rhine, Elbe and Donau were used for transporting timber in log-rafts. Naturally, in northern and eastern Europe, where adequate supplies of hardwoods were not available, softwoods were the basic construction timber. Softwoods were imported into Britain in large quantities for structural timbers after the Great Fire of London because of competing demand by the Royal Navy for oak. These were mainly *Pinus sylvestris* (Scots pine), with sources from several Baltic countries. However, partly for strategic reasons and for fiscal policies, in the early nineteenth century, the government encouraged north-American trade by imposing differential import duties so that new softwood species began to arrive from that trade. Softwoods were also imported into the Netherlands from Baltic sources and were imported into the Iberian countries from their American colonies.

There is a distinction between the growing characteristics of hardwoods (deciduous trees) and softwoods (coniferous trees). The first is the effect of climate on growth rate. For softwoods,

Figure 6.5 Knot patterns as drawn in BS 5756

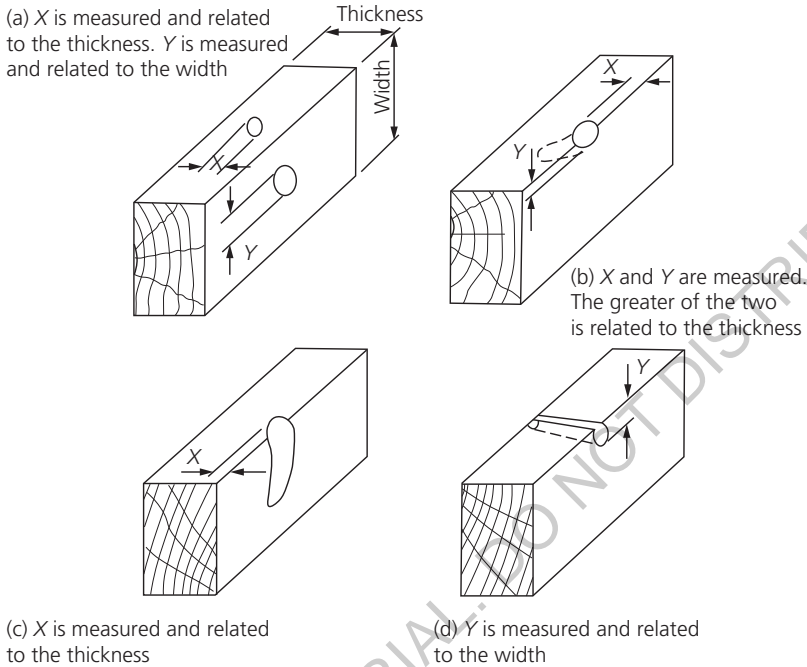
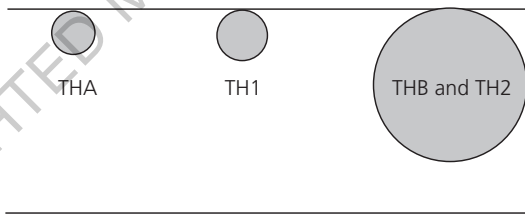
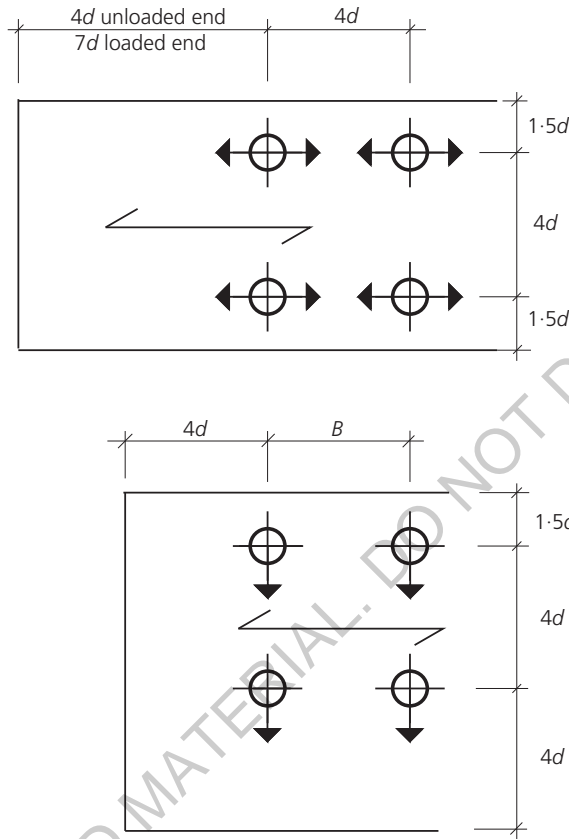


Figure 6.6 Knot areas with an impossible shape for THB and TH2 grades



the first difference being uncontentious. When grading a length of timber, the grader is concerned with the worst pattern of knots and must apply the grade that would result for the whole length of the piece. The grader does not know where the worst stresses will occur. In contrast, in an existing structure the engineer will know the stresses at any point along the length and can match the required strength to that stress. A knot towards the end of a beam in simple bending will be of less concern than the same size of knot in the centre of the span. In fact, ASTM D245 (ASTM, 2011) includes formal rules for adjusting allowable knot sizes along the length of the piece.

Figure 8.2 End and edge distances of bolts and screws



Screws

Screw technology has been changing in recent years, with the introduction of such devices as self-tapping screws for timber (see later). There is also a distinction between modern screws, in which the thread is larger than the shank, and earlier screws, in which the shank was the outside diameter of the screw with the thread cut into it. Manufacturers provide data for the capacity of their screws, while coach screws (lag screws in the USA) may be used where larger diameter fasteners are required. It is for the latter that Johansen’s equations might be used. Note that the load capacity of a group of fasteners needs to be reduced for close spacing, to avoid splitting of the timbers. Generally, the reduction applies if the screws are closer than ten diameters parallel to the grain or three diameters perpendicular to the grain (BS5268, clause 6.5.3 (BSI, 2002)). However, screws of 8 mm diameter or larger may be treated as bolts, with the spacing as close as four diameters parallel to the grain, as in Figure 8.2, before any reduction has to be applied.

Like bolts, coach screws are used with a washer under the head and require a larger pilot hole than ordinary screws. While BS5268 clause 6.5.1 (BSI, 2002) says that screws should

Figure 9.9 View of the back of the main gates at Trinity College, Cambridge

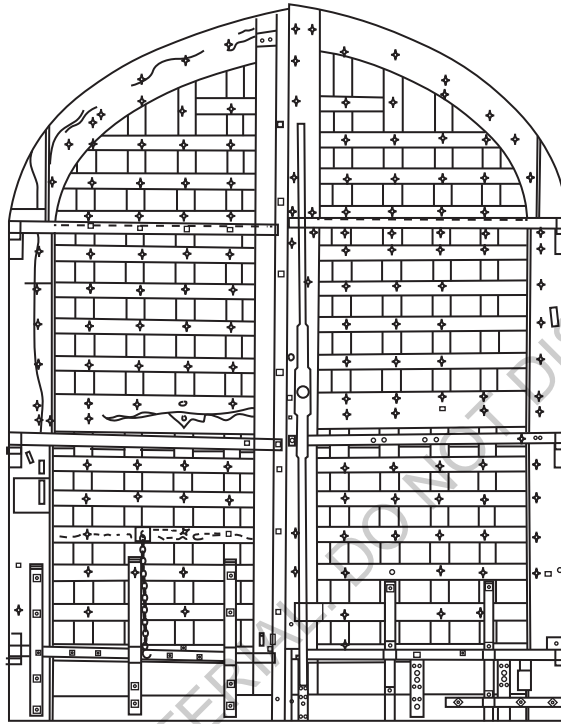
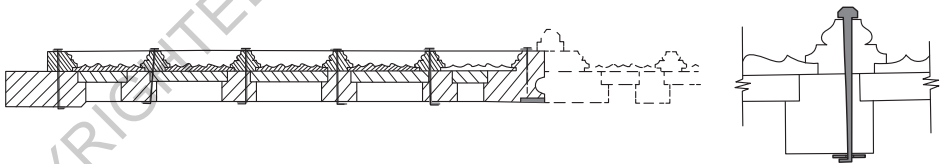


Figure 9.10 Section of the north gate with a detail showing the nail fixing



The decorative ribs were then nailed through the muntins and clenched over the ledges (see also Figure 9.9). The ledges crossed the muntins with halving joints. Racking could only be prevented by the resistance to rotation of the halving joints between muntins and ledges of this portcullis-like structure, which had proved inadequate. The toes of both leaves were dragging on the ground. Forces applied to the gate for daily opening and closing had in fact resulted in a fracture of the meeting stile of one of the leaves. Note how the gates interlock at the meeting stiles (Figure 9.10) so that both sides had to be closed together. Matters were brought to a head when one of the hinge pintels failed and it was then decided that a major programme of repair should be undertaken.