An introduction to timber connections

The following extract comes from BM TRADA's newest publication series with guidance for engineers.

Timber has been used as a construction material for generations. From the early Japanese 'Tateana Dwellings' to the architecture of the Victorian era of England, the ingenious use of timber as a construction material is evident, through techniques developed independent of country or continental boundaries.

Local abundance of the material and the ease of conversion with the most basic of tools meant that solutions to some of the fundamental problems of construction seemed to have been found with relative ease in timber. The forming of a rudimentary curved notch on the underside of a round log to form a gravity fit in early cabin constructions, for example, is still used today, albeit with modern tools that allow this joint to be made more precise.

Studying the evolution of timber roofs from ancient times to the modern trussed rafter constructions, one can clearly see how our understanding of the modern 'triangulated' structures has been heavily influenced by the ingenuity of early timber constructions.

Royal Academy Music Recital Room. Photo: Adam Scott

Understanding timber

Being a natural material with varying properties and limitations in available sizes, designing with timber warrants a specialist understanding of the product. Strength and stiffness properties of timber are dependent on the species of wood and the geographical region of growth, as well as on the humidity and the temperature of the environment to which the structure is exposed. Duration of loading also has an effect. All these should be considered when designing structures with timber.

Optimising the use of available sizes of the material makes designing connections an integral part of any timber engineering project, with anisotropy and the variability of the material adding greater complexity to the problem.

Resolving connections

Most complex timber engineering projects require the connections to be resolved first, or at least in parallel with the sizing of the members, as the member sizes are most likely to be governed by the requirements of the connections. Intensity of the loads to be transferred between timber members across a joint, and the geometry of the group of fasteners forming the connection, will determine the stress levels generated within the timber surrounding each fastener.

When such stresses are managed through proper calculations and appropriate detailing, localised failures within members, which could ultimately lead to the failure of the connection and the structure as a whole, can be easily prevented.

At the most basic level, timber connections can be classified as:

- all-timber (carpentry) connections
- connections involving metal fasteners or connectors
- glued connections.

Combinations of these three types are also possible and are widely used.

Metal fasteners or connectors

Connections involving metal fasteners or connectors can be further divided into two main groups based on the mechanism of force transfer between the fastener and the timber members being connected. The first group involves dowel-type fasteners, such as nails, staples, bolts, dowels and screws, where the loads being transferred across the joint generate bending and tensile stresses in the fasteners, as well as embedment and shear stresses within the timber along the shank of the fastener. These are the most frequently used fasteners in contemporary connections.

The second group also involving metal fasteners are the surface or partial penetration fastener types such as punched metal plate fasteners, nailing plates, toothed metal plate fasteners, split and shear ring fasteners, where the load transfer is related to the surface area of the timber members and associated metalwork.

Dowel-type connections

Dowel-type connections involve the most common metallic fastener types in use, which includes nails, staples, bolts, dowels and screws. In discussing these connections, it is vital to understand the characteristics of these fasteners, their specifications and the load-carrying mechanisms involved.

Modern design methods for connections, such as the European Yield Model based calculations presented in Eurocode 5, require the designers to establish the capacity of an individual fastener in a given joint, before looking at combining them in a group to form the joint.

The sequence of steps shown in *Figure 1* should be followed to calculate the capacity of dowel-type connections, for which the dimensions of the materials to be connected are assumed. Some of these dimensions may need modification later to suit the calculations, or a different connection specified if the member sizes should remain unaltered. ■

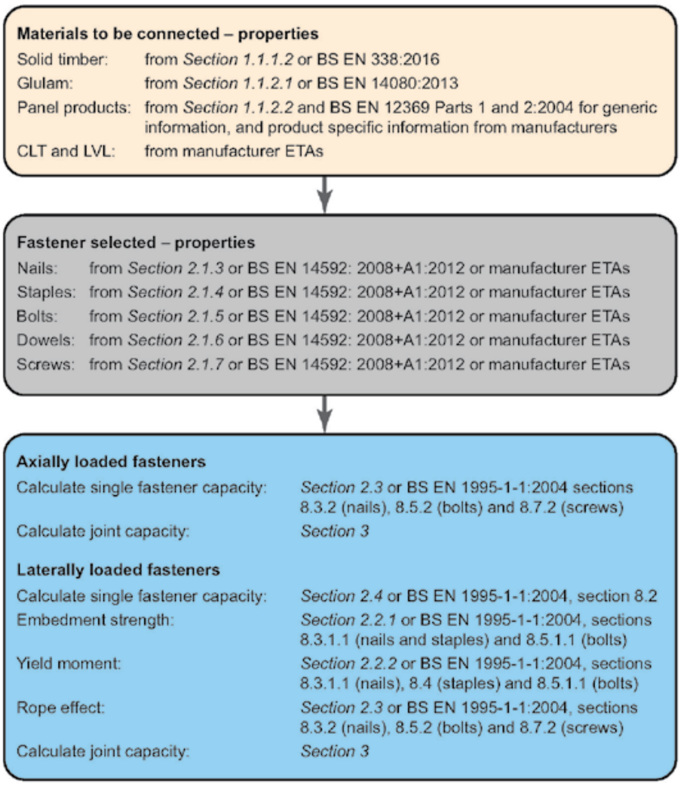

Figure 1: Connections design flow diagram

Further information

Timber connections: a guide for engineers. Part 1 – Theory is available to buy from bookshop.trada.co.uk

- *Part 1 – Theory* aims to explain the theoretical principles of timber connections, primarily the dowel-type connections.
- Part 2 will supplement Part 1, containing advanced topics such as fire resistance, brittle failure and durability.
- Part 3 will contain worked examples highlighting some of the principles discussed in the first two parts.
- Part 4 will look at recent connection exemplars, with the focus on engineering aspects.
- Part 5 will complete the series by looking at proprietary connectors commonly available on the market.

Further reading

- Ross, P., Hislop, P., Mansfield-Williams, H., Young, A., *Concise illustrated guide to timber connections,* ISBN 978-1-90510-851, BM TRADA, 2012
- *WIS 2/3-36 Design of structural timber connections,* BM TRADA, 2017