Module 15: Roof structure (Part 2) – Roof timbers & fixing

Module Objectives

By the end of this session, participants will understand:

1. Factory built trusses and carpenter built roof structures
2. Rules for grading and treating of roof timbers
3. Bracing of roof trusses
4. Fixing of roof timbers

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Roof timbers & trusses

Before manufactured gang-nail roof trusses became common in South African homes, the roof was constructed on site by a skilled roofing carpenter, who was able to do mathematical calculations as regards angles and dimensions.

When inspecting older houses, the home inspector will still come across these carpenter-built roofs. One feature of such roofs was often the need for internal load-bearing walls. About 50 years ago prefabricated, multi-nailed (gang-nail) roof trusses became widely used. These factory produced trusses are now mostly used for simple cost effective roof designs. Assembling a roof with factory-made trusses does not require the same level of skill from the carpenter/roofer.

Each roof is designed from the drawings that the builder or owner provides. The complex calculations are done on proprietary computer programs. The roof structure must still be designed by a Competent Person, and this is sometimes done in-house by the truss manufacturer. Once the house walls have been partly built, the roof truss manufacturer will usually visit the site for final measurements and then produce custom measured trusses to fit that particular house.

Gang-nailed factory made trusses use lighter weight timber than traditional roofs, and get their strength from the fact that when assembled, all the small sections of timber gang-nailed together, become and act as one unit.

When roof trusses are used, only the perimeter walls need to be designed as load-bearing walls. Internal walls become simple partitions and can be arranged without the need to provide support for the roof structure.

Use of factory manufactured engineered trusses:
- Save money by making use of lighter timber.
- Save money – less skilled labour is needed to build the roof.
- Provide flexibility as regards the positioning of internal walls, and save money by reducing the need for foundation footings for the internal walls. Because these walls are non-loadbearing, they are often built with only the slab (or a thickened section of the slab) as support).
Trusses

Mono-pitched and double-pitched nailed and bolted trusses (i.e. constructed on site) must be of the Howe type with the number of bays, bolts at connections, timber sizes and SABS grades, roof pitches as specified by SANS 10400 (see also NHBRC Manuals 2:2 and 3:4.5).

Howe type truss – maximum span between supporting walls: 10m

Construction timber must be graded for strength and stiffness. Grading into different strength classes, allows the best possible use to be made of the various timber dimensions.

All timber used both for the trusses and the secondary timbers must meet the specifications for structural grades S5, S7 and S10. These are now the only legal grades that are used in South African house roofs.

Examples of SABS grading marks. The timber should be stamped with the designed structural grade value (e.g. S5) together with the certification authority logo, either SABS or SATAS and the initials of the timber mill of source.

A Competent Person must specify the nail plate requirements for each truss joint.
Treated timber

Softwood timber (pine) is usually used for roof structure construction in South Africa. In many areas of the country, roof timber must be treated with CCA (Copper Chrome Arsenate) or a similar approved preservative, to prevent rot, fungus and insect attack.

These areas are: Albany; Alexandria; Bathurst; Bellville; Bredasdorp; Caledon; Camperdown; Cape Town; Ceres; Clanwilliam; Durban; East London; Eshowe; George; Hankey; Heidelberg (Cape); Hermanus; Hopefield; Humansdorp; Ilanda; Ixopo; Joubertina; King Williams Town; Kirkwood; Knysna; Komga; Lions River; Lower Tugela; Lower Umfolozi; Malmesbury; Montagu; Mooi River; Mossel Bay; Mpumalanga; Mtonjaneni; Mtunzini; New Hanover; Paarl; Pietermaritzburg; Piketbert; Pinetown; Port Alfred; Port Elizabeth; Port Shepstone; Queensburg; Richmond (Natal); Riversdale; Robertson; Simons Town; Somerset West; Stellenbosch; Strand; Stutterheim; Swellendam; Tulbagh; Uitenhage; Umlazi; Umvoti; Umzinto; Vredenburg; Wellington; Worcester.

Nail plates

There are three nail plate manufacturers which have been certified by the ITC: Alpine - Arrow shaped logo; International Truss Systems - Red striped plates with Tri-Plate printed on; Mitek - Blue ribbon plates with Mitek printed on.

Prior to the loading of the roof with the permanent cladding (tiles, sheeting etc), the roof must be inspected by the design engineer or one of his appointed I.T.C. registered roof inspectors, or by an engineer registered with the Engineering Council of S.A. who is qualified to inspect a timber roof structure, and who has access to all the necessary design and erection drawings.

The roof trusses must be erected and braced in accordance with relative details as specified in the ITC Vol. 1 and Vol. 2 Handbooks. This is in compliance with Regulation A19 of the National Building Regulations.
Bracing of roofs

Stability bracing of the top chords of trusses is required for gable end roofs in order to keep the trusses stable and upright. Hipped roofs provide their own inherent bracing via the hip structure.

Permanent bracing is distinct from the temporary bracing that the roof erector will employ to keep the trusses straight and vertically plumb during erection.

Tiled & slate gable roofs with a truss span of less than 6.6m, are normally braced underneath the top chords of the trusses, with a 38 X 76 mm diagonal bracing, nailed to the underside of the top chords, with three 75mm nails per intersection. The heel of the diagonal brace is nailed to the wall plate inside the last truss with three 100mm nails. For additional stability, a timber block is nailed to the wall plate (with six 75mm nails) hard against the opposite side of the last truss.
The brace must run upwards at approximately 45° and the "brace bay" number of trusses braced with a continuous brace, should approximately equal the length of the rafter (top chord).

Tiled gable roofs with a truss span over 6.6m and up to 9m have a similar diagonal brace (top chord stiffener) but of more robust timber (38X114mm). The fixing detail of the heel of this brace is different to that required for roofs of less than 6.6m. With roofs from 6.6m up to 9m, the heel of the brace is bolted (two 12mm bolts with square 36X4 washers on each side) to a shelf. This shelf is fixed between the last two end trusses and attached to the trusses with two hurricane clips on each side. If necessary the bracing member can be block spliced in the upper half (towards the apex). The block splice is to be nailed with six 75mm nails on each side.

Bracing of top chords of rafters for a tiled roof with a span of less than 6.6m. Note the different heel anchoring – detail below

Sheeted gable roofs are braced with herringbone bracing, nailed to the underside of the top chords between the purlins. This herringbone bracing is installed at intervals (normally only a few bays per roof are braced). The roof designer will indicate on the roof plan the required intervals for bracing.
Top chord bracing for sheeted roofs with spans up to 8m. Bracing (38X76mm) is nailed diagonally to the underside of the rafters, between the purlins (3X75mm nails per intersection). The maximum interval between bracing bays, calculated by formula (16.5m less 0.3 X span of the roof). The designer will indicate these intervals on the roof plan.
Hangers & build-in support

Alternatively, trusses, rafters and purlin beams can be supported on hangers, twice bolted to walls with masonry anchors, or built-in the masonry. Trusses must be fixed to the hangers either by being nailed in each hole with 32 mm long clout wire nails (fully nailed) or bolted with 12 mm diameter bolts in the holes provided.

Metal masonry anchors must be of the expanding type, be corrosion resistant and have a diameter and length of not less than 10 mm and 45 mm, respectively, and must be installed in accordance with the manufacturer’s instructions.
Roof fixing ironware

Here are some examples of roof fixing ironware commonly encountered in timber roof structures:

Truss hangers

Truss hangers in a variety of sizes and shapes for different applications. Truss hangers are used to anchor timber to walls or to other timber – for instance: anchoring jack trusses to a girder truss. Most truss hangers have provision for both bolts and for clout nails. Hangers are normally either fully nailed (in every hole) with 32mm clout nails, or bolted with 12mm bolts (or larger is specified).

Hurricane Clips

Hurricane clips are designed for general timber connections, where the members cross each other or meet at 90° angles. Common applications are purlins to trusses, truss rafters to wall plates, bracing, fixing and even light weight joist connections. Hurricane clips are fixed with 10 x 32mm galvanised clout nails (fully nailed though all holes). A temporary fixing “spike” is provided by some manufacturers to facilitate easy temporary installation (prior to nailing).

The NHBRC Manual 3: 4.9.6 (Figure CT26) recommends that purlins should be connected to rafters either with:

- One 100mm nail and tied with double strand 2.5mm galvanised wire, or

- Two fully nailed hurricane clips fixed to opposite faces.
The NHBRC Manual is out of date in this respect. The most recent edition (2005) of the National Building Regulations for roofs (SANS 10400 –L – 2005) allows for one hurricane clip per intersection. More clarity on the issue of the number of hurricane clips required is provided by the ITC Manuals – which is the guide book used by roofing engineers. As regards the number of hurricane clips needed to secure purlins, an A19 certificate for the roof structure will be issued as long as the requirements of the ITC SA Erector’s Manual (Vol. 2, Page 8) have been satisfied.

The ITC requires **two fully nailed hurricane clips per intersection** at all eaves, overhang purlins, ridge purlins and gable ends – in other words at all perimeter connections. The ITC Manual allows that all other areas of the roof structure may have only **one fully nailed hurricane clip per intersection**. The positioning of these clips is to be staggered. All hurricane clips must be fully nailed with either five 32mm dclout nails, or four serrated nails into each member (i.e. into both the truss and the purlin).
Swing clips

Swing clips are designed for fixing 38 x 76/50 x 76/76 x 76 purlins in an upright or sideways position to beams or trusses. These clips provide positive anchorage against uplift and lateral loads. The recommended application is a minimum of one swing clip and one 125mm wire nail driven vertically at each purlin/rafter connection. In addition, two swing clips and one 125mm nail must be used in braced bays. In overhang areas, two pairs of swing clips are recommended due to higher wind uplift forces.
The swing clips offer substantial time and labour saving over similar devices. The spikes on the clips are simply hammered home using a conventional claw hammer.

**Batten & purlin splice**

These provide sound structural connections for battens and purlins, and are SABS approved – but only in a factory environment where the splice can be either pressed home using hydraulic presses, or mechanically rolled in after temporary placing with a claw hammer. They are designed for use in converting “shorts” to “longs” and for the recovery of waste and offcuts in a factory environment.

**Fixing & splicing of battens & purlins**

SANS 10400-L: 2005 states that battens and purlins must be continuous over at least three rafters (i.e. two rafter spacing’s) and shall be fixed to every rafter that they cross. 38 mm x 38 mm battens shall be nailed to rafters with 75 mm wire nails and 38 mm x 50 mm battens set on edge with 90 mm wire nails. Purlins shall be fixed to rafters in accordance with the provisions of the illustration above.

Purlins must be spliced by double nailing purlin ends cut with a 45° miter – together with a 600mm connector, nailed across the splice with six 90mm nails. Splices must be located in close proximity to rafters and staggered so that there is not more than one splice in three
consecutive purlins. Purlins and rafter splices shall not be located within 1.5 m from the gable ends.

**Speed brace**

Speed Brace is a pre-punched shallow V profile, galvanised metal tension bracing strip, designed to brace top chords, bottom chords and webs. The bracing and connecting details are designed to provide equivalent bracing and stiffening properties to timber bracing.

**Metal straps**

These are pre-punched galvanised coil strips which are used in a variety of holding down, tying and bracing applications. The most common applications for metal strapping are:

- Holding down strap either built in, or bolted to walls and beams at truss heel/wall plate intersections.
- Truss to girder, or girder to girder, web tie connections.
- Attic and truss bracing where conventional timber bracing interferes in the roof space.
- Cross bracing of timber frame housing, roofs and garage doors.
- Rafter and gum pole structure bracing and ties.
Cleats

Cleats of different shapes and sizes have various support applications as timber connectors in roofs.

Roof ventilation

Adequate roof ventilation is becoming increasingly important as the drive towards energy efficiency in South African homes gains momentum. See “Home Insulation” Module.

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