FUNCTIONAL REQUIREMENTS

7.8 ROOF STRUCTURE

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.8.1 Statutory requirements

Roof structure and loading

Roof framing and rafter design must be in accordance with current Building Regulations.

The roof of the building shall be constructed so that the combined dead, imposed and wind loads are sustained and transmitted by it to the ground safely, and without causing such deflection or deformation of any part of the building, or such movement of the ground, as to impair the stability of any part of another building.

Section 2A of Approved Document A (England and Wales) gives basic requirements for the stability of low rise residential buildings. With respect to the roof, it requires that the structure should be of such construction that it has adequate interconnection with the walls, allowing it to act as a horizontal diaphragm capable of transferring the wind forces to buttressing elements of the building.

In this respect, it is acknowledged that a traditional cut roof, i.e. using rafters, purlins and ceiling joists, generally has sufficient built-in resistance to instability and wind forces, e.g. from either hipped ends, tiling battens, rigid sarking or the like. However, the need for diagonal rafter bracing equivalent to that recommended in BS EN 1995-1: 2004+A1, or Annex H of BS 8103-3 for trussed rafter roofs, should be considered, especially for single-hipped and non-hipped roofs of more than 40° for detached houses.

Section 2B of Approved Document A (England and Wales) contains advice on 'sizing of certain timber members in floors and roofs for dwellings', and refers the Designer to the following sources:

- Span tables for solid timber members in floors, ceilings and roofs (excluding trussed rafter roofs) for dwellings. Published by TRADA.
- BS 8103-3, Structure design of low rise buildings, Code of Practice for timber floors and roofs for dwellings.
- BS EN 1995-1: 2004+A1, Eurocode 5 design of timber structures. General. Common rules and rules for buildings.

Section 2C of Approved Document A

The design criteria set out is intended to be adequate for imposed roof loads of 1.00kN/m^2 for spans not exceeding 12m, and 1.50kN/m^2 for spans not exceeding 6m.

All structural timber used in a conventional cut roof, i.e. rafters, purlins, ceiling joists, binders and other timber elements, should be stress graded. All such timber must be stamped as either 'DRY' or 'KD' (Kiln Dry). The use of ungraded, or 'green', timber is not acceptable.

Allowances for wind loading

The need for a roof to withstand wind pressure and suction will be met if the proposed roof is braced effectively, as discussed elsewhere in this Manual, and secured to the structure, as detailed below, with walls adequately restrained.

The securing of roofs to the supporting structure roof timbers normally involves a timber wall plate or similar, which should be levelled using a spirit level so that loadings from the roof are directed perpendicularly down the supporting wall.

The wall plate may, as good practice, be fixed to ensure correct positioning when roof timbers or trusses are being installed by means of galvanised mild steel holding down straps (30mm x 5mm x 1,000mm long at maximum 2m centres) nailed to the wall plate and securely fixed to the inner surface of the wall with compatible fixings.

There is a need to ensure that holding down straps are provided in areas of severe wind exposure where required by the roof design.

7.8.2 Treatment of timber

Preservative treatment of roof timbers is normally unnecessary, except where specifically required under relevant standards and Codes of Practice, and in the following circumstances:

- Roof timbers should be preservative treated where the insulation and ceiling line follow the roof pitch.
- The Approved Document of Regulation 7 of the Building Regulations for England and Wales requires that in certain geographical areas, all softwood roof timbers should be treated against attack by the House Longhorn Beetle.

The areas at risk are:

- The District of Bracknell Forest
- The Borough of Elmbridge
- The Borough of Guildford (other than the area of the former Borough of Guildford)
- The District of Hart (other than the area of the former Urban District of Fleet)
- The District of Runnymede
- The Borough of Spelthorne
- The Borough of Surrey Heath
- In the Borough of Rushmoor, the area of the former district of Farnborough
- The District of Waverley (other than the parishes of Godalming and Haslemere)
- In the Royal Borough of Windsor and Maidenhead, the parishes of Old Windsor, Sunningdale and Sunninghill
- The Borough of Woking

The treatment should be impregnation with a preservative suitable for use in hazard Class 2, in accordance with BS 8417: 2003, or equivalent, for a 60 year anticipated service life. Cut ends must be liberally brushed or dipped with an end-grain preservative.

It is strongly recommended that, where punched, metal fasteners are proposed to roof trusses. Only micro-emulsion or organic solvent preservatives should be used for timber treatment, to limit the possibility of corrosion of the fasteners and so as not to adversely affect glued joints.

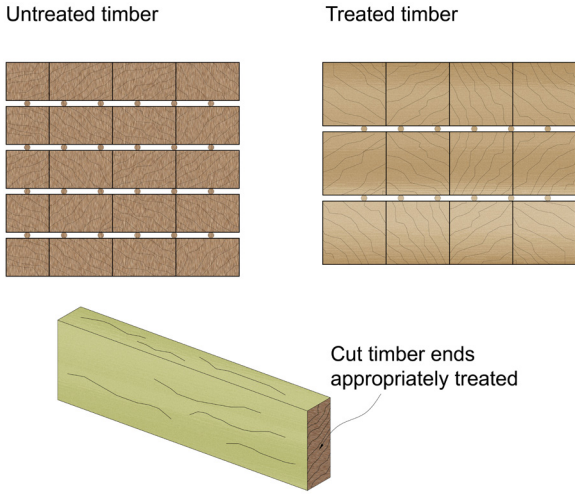


Figure 1: Timber treatment

7.8.3 Trussed rafter design

7.8.3.1 Design responsibility

The Building Designer is responsible for the 'framing' of any given roof as a whole. This means that he or she must take responsibility for the bracing together (framing) of the trussed rafter configuration, which then supports the roof covering and the tying together of the supporting walls.

Whilst it is the supplier of the rafters who generally has the knowledge and expertise required to achieve the best engineering solutions, the Designer must be certain that the loading calculations and resultant configuration is fit for purpose.

The following checklists, derived from BS EN 1995-1: 2004+A1, set out:

- Information required by the manufacturer from the Designer.
- Information that should be supplied by the manufacturer to the Designer.

Designer to truss manufacturer

- The height and location of the building, with reference to any unusual wind conditions.
- The profile of the trussed rafter, including camber if required.
- The span of the trussed rafter.
- The pitch or pitches of the roof.
- The method of support and position of supports.
- The type or weights of roof tiles or covering, including sarking, insulation and ceiling materials.
- The size and approximate position of any water tanks or other equipment to be supported on the trussed rafters.
- The overhang of the rafters at eaves, and other eaves details.
- The positions and dimensions of hatches, chimneys and other openings.
- The service use of the building, with reference to any unusual environmental conditions and the type of preservative treatment where required.
- The spacing of trussed rafters and special timber sizes where these are required to match existing construction.

Truss manufacturer to Designer

- Finished sizes, species, stress grades or strength classes of timber members.
- The type, sizes and positions of all jointing devices with tolerances, or the number of effective teeth or nails required in each member at each joint.
- The positions and sizes of all bearings.
- Loadings and other conditions for which the trussed rafters are designed.
- The spacing of trussed rafters.
- The positions, fixings and sizes of any lateral supports necessary to prevent buckling of compression members, such as rafters and struts. (Details of the permanent bracing necessary to ensure the overall stability of the complete roof structure and supporting walls should be provided by the Building Designer).
- The method of support for tanks and ancillary equipment, together with the capacity or magnitude of additional load assumed.
- The range of reactions to be accommodated at the support positions, including those required to resist wind uplift forces.
- The basis of the design.
- Details of any changes in spacing to accommodate chimneys or openings.
- Any special precautions for handling and erection, in addition to those covered by BS EN 1995-1: 2004+A1.

7.8.3.2 Spans

Maximum permissible spans for the most common building types and rafter configurations are given in BS EN 1995-1: 2004+A1 Section 9.

For designs that fall outside BS EN 1995-1: 2004+A1 conditions, the trussed rafter must demonstrate adequate jointing and structural integrity by calculation.

7.8.3.3 Loads

Trussed rafters and the framed roof must support the dead loads as specified in BS EN 1991-1 and BS EN 1991-1-7, the wind loads in BS EN 1991-1-4: 2005+A1 and the imposed loads in BS EN 1991-1-3. Loads acting on rafters are dead loads (tiles/slates, battens, underlay and rafter self-weight), imposed loads (snow load and maintenance) and the wind uplift load. Other dead loads that act on the ceiling ties (ceiling, insulation, water tanks and the tie self-weight) and imposed loads (loft access and weight of storage) will also have to be taken into account by the Designer.

BS EN 1991-1 and BS EN 1991-1-7 specify the following limits for imposed loads on the rafters uniformly distributed over the whole roof, measured on plan:

- Roofs pitched 10° to 30°: 0.75kN/m^2.
- Roofs pitched 31° to 75°: 0.75kN/m^2 – 0 kN/m^2 (reduced linearly).

Or

- A concentrated load of 0.9kN, whichever produces the greater stress or deflection.

Experience shows that for most common tiled and slated roofs, the uniformly distributed load is more severe.

7.8.3.4 Bracing, support and typical roof openings (BS EN 1995-1-1:2004+A1)

As stated above, the Designer is responsible for framing the roof. The correct bracing configuration locks all timber supporting roof elements into a single structural, load-bearing unit. Standard bracing details are given in BS 5268-3.

Appendix A and further information can be found in BRE Defect Action Sheets 83 and 84.

Where recovering of existing roofs occurs: Approved Document A Section 4, , deals with the requirements for checking the structural integrity of the roof and supporting structure when considering the re-roofing of buildings.

For information and design criteria necessary for ordering: , BS 5268: 3, provides a comprehensive list of criteria that should be supplied by the Building Designer or Site Supervisor to the Trussed Rafter Designer/Fabricator to enable a design to be prepared.

This includes:

- Span of the trussed rafter, wall plate to wall plate plus the width of wall plate at each end.
- Pitch of the roof.
- Method of support.
- Position of support.
- Anticipated loading of the roof structure, i.e. The weight of the roof tiles and the exposure of the site should it attract excessive wind loads.

- Position and size of water tanks.
- Position and size of openings, i.e. Loft hatches, roof windows, chimneys.
- Due to the site locality, any particular preservative treatment necessary for the timber, e.g. to protect against House Longhorn Beetle.
- Eaves details, i.e. overhang required, etc.

In return, the Trussed Rafter Designer should supply the following details for site use:

- Position, bearing and spacing of trussed rafters.
- Position, fixings and sizes of lateral supports to prevent buckling of compression members such as rafters and struts.
- Deviations from standard spacings, etc. to accommodate openings.
- Support details for water tanks.
- Any special handling equipment.

7.8.3.5 Site storage

The delivery of trussed rafters should be planned so as to minimise the period of storage necessary on-site. When delivered, the trusses should, at all times, be kept clear of the ground and vegetation and be supported by level bearers sited under or adjacent to the points of support assumed by the design.

To prevent any distortion, there is a need to ensure that the trusses are stored in a vertical position, as in Figure 2.

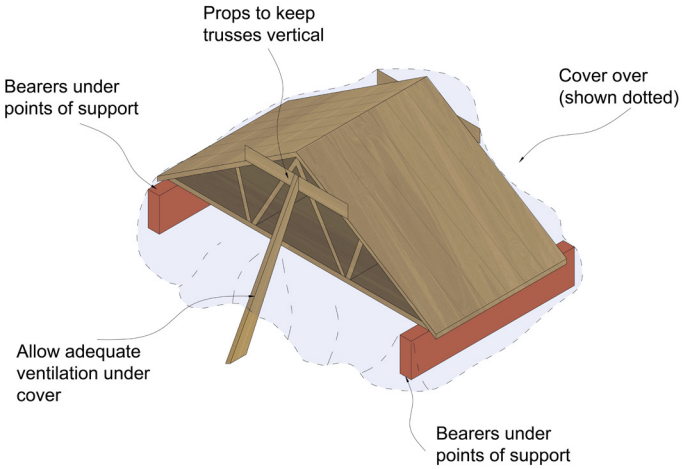


Figure 2: Onsite storage of trusses

Horizontal storage is sometimes possible, as in Figure 3. In both cases, stacks of trusses should be covered with a weather proof cover, whilst maintaining adequate ventilation to prevent the occurrence of condensation. Trusses should be checked visually upon arrival on the site for damage occurring during transportation, and again before site use for damage occurring during storage. Trusses with a moisture content exceeding 20% should not be installed.

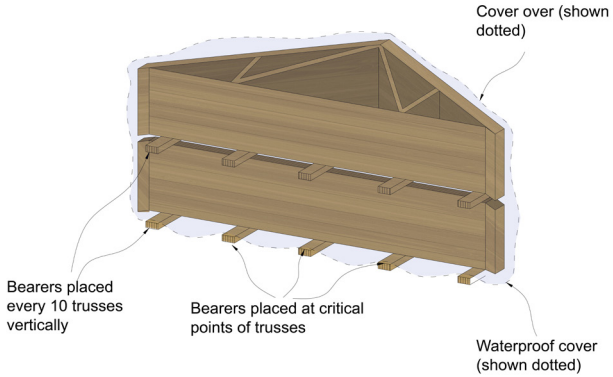


Figure 3: Horizontal storage of trusses

7.8.3.6 Handling and transportation

When transporting and handling trussed rafters, sagging and flexing should be avoided at all times. Whether handling is manual or by using mechanical equipment, trusses should be moved in a vertical position unless support can be provided to every joint.

Manual lifting

On long-span trusses, it may be necessary to employ additional labour at intermediate positions. If required, the truss may be inverted so that the apex hangs down. See-sawing the truss across walls and scaffolding must be avoided. Individual designs and site conditions may dictate different requirements in order to install trusses in their final position.

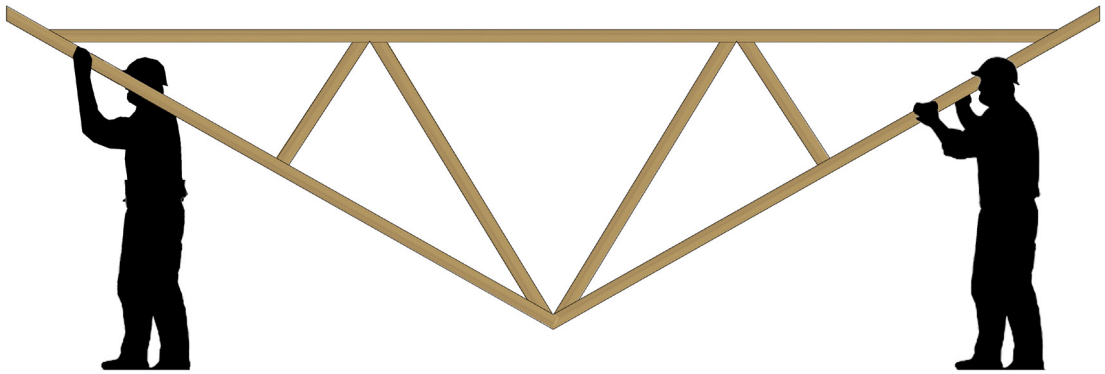


Figure 4: Suggested method of manual lifting

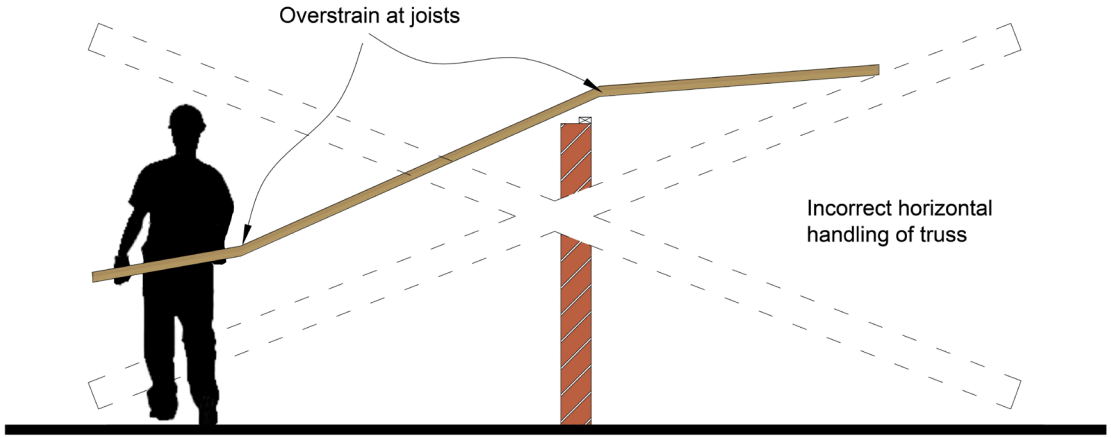


Figure 5: Avoid bending or see-sawing of trusses

Mechanical lifting

Ideally, when using mechanical lifting the trusses should be lifted in banded sets and lowered onto suitable supports. Lifting points should be rafter or ceiling intersections or node points. Lifting trusses singularly should be avoided, but where unavoidable a suitable spreader bar should be used to withstand the sling force.

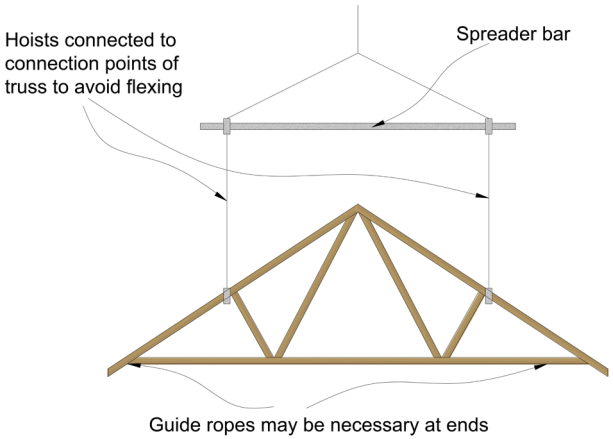


Figure 6: Mechanical lifting

7.8.3.7 Erection

It is essential when erecting a trussed rafter roof to ensure that the first trussed rafter is erected and braced rigidly in the correct vertical position so that it provides a base model against which all the other trusses can be set out.

Any temporary bracing should not be removed until permanent bracing has been installed.

Immediately prior to the fixing of permanent bracing, the trussed rafters should be checked again for alignment and verticality.

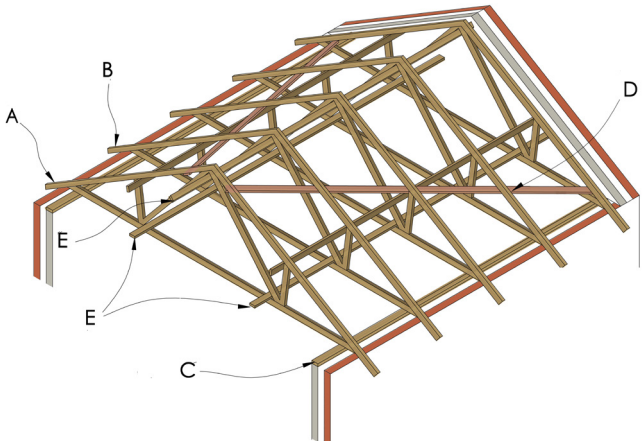


Figure 7: Trussed roof installation

Procedure for erection using Figure 7

- Before placing first truss, mark required position of trussed rafters on opposing wall plates.
- Erect and brace first trussed rafter (A) (only one shown but fix others as necessary).
- Erect next adjacent trussed rafter (B) and brace back to (A) using brace (C).
- Erect other trussed rafters as with (B).
- When the final accurate positioning of the trussed rafters has been confirmed, the rafter feet can be fixed into position.
- Fix permanent diagonal bracing (D) (only one brace shown for clarity).
- Fix longitudinal bracing (E) (only three shown for clarity).
- Fix all remaining bracing.
- Remove all temporary bracing.

The International Truss Plate Association Technical Handbook, available from trussed rafter suppliers, provides additional advice on trussed rafter erection.

7.8.3.8 Bracing to duo-pitched roofs

Fixing

To achieve a stable and wind-resistant roof and gable wall structure, the roof must be secured to the gable wall, if applicable, and fully braced by 100mm x 25mm timber, twice nailed to roof timbers using 65mm long x 3.35mm diameter galvanised wire nails. Where nail guns are used, 75mm long x 3.1mm diameter annular ring-shank nails are allowed. They do not need to be galvanised.

Types of bracing

There are three main types of wind bracing, which should be fixed:

- Diagonal rafter bracing
- Longitudinal bracing
- Chevron bracing (only necessary on trussed rafter spans over 8m)

Diagonal and longitudinal bracing are required in all trussed rafter roofs. Bracing for wind loads can also be enhanced by adequately fixed

tiling battens and/or sarking boards. The ceiling plasterboard (12.5mm thickness) or a similar rigid material will also contribute to the bracing process. Sarking boards, such as moisture-resistant plywood (minimum thickness 9mm) and moisture-resistant chipboard (minimum thickness 12mm), may provide adequate bracing without the need for additional wind bracing to the roof. Sarking boards should be laid with staggered joints and nailed at 200mm centres on every truss with 50mm long x 3mm diameter galvanised round wire nails.

Longitudinal bracing

Longitudinal bracing is shown in Figure 7; it should be positioned tightly to abut separating and gable walls. In timber frame construction, you should ensure that longitudinal braces are fixed to timber frame gables/separating walls to provide additional lateral restraint.

Chevron bracing

Chevron bracing is only required for roof spans exceeding 8m, and it can be identified as diagonal bracing to the web members of the roof truss.

For spans of between 8m and 11m, such bracing may only be required to a single web member on either side of the roof. For spans exceeding 11m, more extensive chevron bracing may be necessary.

Mono-pitched roof bracing

In mono-pitched trussed rafter roofs, the diagonal bracing pattern for narrow-fronted houses should be adopted. The requirement for longitudinal bracing is the same as for duo-pitched trussed rafter roofs.

Chevron bracing is required to the webs in roofs exceeding a 5m span, and also to upright members where inadequate lateral restraint is provided at the apex of the roof.

7.8.3.9 Diminishing trusses

The Truss Roof Designer should provide details of fixings for the diminishing truss to the main roof truss.

- Where the diminishing truss has a splayed bottom chord that matches the pitch of the main truss (usually where the roof pitch is less than 30º), the truss can be skew-nailed to the main truss with two no 3.35mm diameter x 75mm galvanised wire nails.
- Where the diminishing truss has a square bottom chord, the truss can be skew-nailed to the main truss and supported on a continuous binder also fixed to the main truss. The top of the binder should be splayed to suit the bottom chord and; 2 no. 3.35mm diameter x 75mm. Galvanised wire nails should be used for the fixing.

7.8.3.10 Mono-pitch and girder trusses on trussed rafter hipped-end roofs

Mono-pitch trussed rafters can be used in conjunction with girder trusses on trussed rafter hipped roofs.

Mono-pitched trusses are fixed to girder trusses using metal shoes. The bearing of mono-pitched trusses onto the mild steel proprietary girder shoe should be confirmed with the Roof Designer before site installation is attempted.

Girder trusses are strengthened trusses designed to support loads in another plane (such as mono-pitched trusses).

7.8.3.11 Multiple-trussed rafters

Multiple-trussed rafters may be specified for a particular purpose, and may be delivered to site already fastened together. Alternatively, fixing together on-site of multiple rafters may be necessary, in which case it will be necessary to get full details of the fixing specification from the Roof Designer.

7.8.3.12 Provision for openings, i.e., loft hatches, chimneys, etc.

Wherever possible, a trussed rafter roof should be designed to accommodate necessary openings within the trussed rafter spacing, e.g. a loft hatch. If this is not possible, the spacing of trussed rafters may be extended to accommodate an opening. The Roof Designer should provide all necessary details.

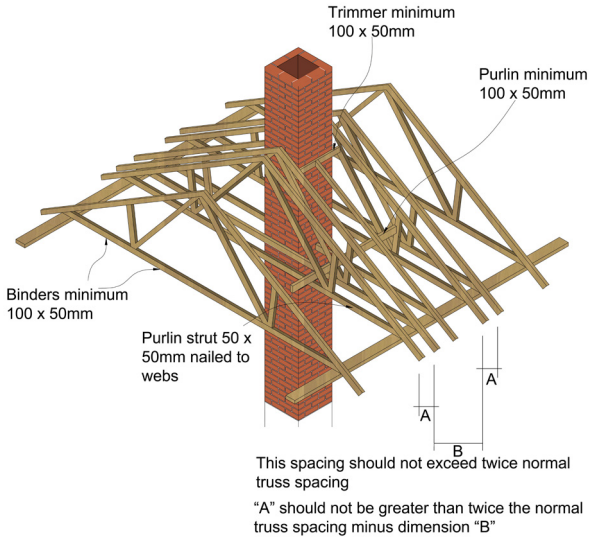


Figure 8: Roof trusses trimming around a chimney

7.8.3.13 Tank stands

Confirmation should be obtained from the Roof Designer that a trussed rafter roof design is capable of supporting water storage tanks. Tanks should be supported by bearer beams, on the ceiling ties portion of the truss. Bearers should be skew-nailed to supports as appropriate. Alternatively, proprietary joist hangers can be used. Tank bearers should be situated as close as possible to the node or intersection points of the trussed rafter. The dimensions of the bearers depend upon the size of the supported tank and the span of the trussed rafters.

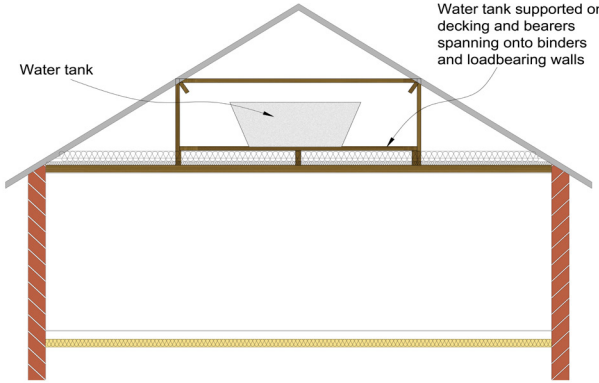


Figure 9: Tank stand configuration

7.8.3.14 Modifications to trussed rafters

Trussed rafters should never be cut, altered or repaired for use without the full agreement of the Trussed Rafter Designer. Remedies for defects to erected trusses can be found in BS 5268: 3, but the Roof Designer's advice should be sought prior to repairs being carried out.

7.8.3.15 Combined trussed rafter and traditionally framed roofs

Extra care is necessary where the two principal timber pitched roof types are used in conjunction. The trussed rafters should be specifically designed to accept any additional loadings imposed by an adjacent traditional roof. Similarly, account should be taken of any loadings imposed by trusses on traditional roofs where only nominal loadings have been allowed for. If in doubt, consult the Roof Designer.

7.8.4 Traditional pitched roofs

7.8.4.1 General

Traditionally framed roof

The moisture content of structural timber should not exceed 20% at the time of stress grading and at the time of erection. All structural timber for use within the building fabric should be stress graded and marked 'KD' (Kiln Dry) or 'DRY'.

The purlins/binders should be adequately supported to contribute fully to the roof structure. For example, they could be built into the inner leaf of a gable end wall and supported by struts onto the load-bearing structure at centres specified in the design.

Always ensure that the correct strength class of timber is both ordered and used. Structural timbers are allocated a strength class by BS 5268: 2. The most common strength classes used are C16 and C24.

- The timber supplier will require the following information before supplying timber:type and strength class of timber required.
- Required sizes of timber.
- Any treatment required.

7.8.4.2 Definitions

Couple roof

This is the simplest method of producing a pitched roof, consisting of pairs, or couples, of rafters pitched against each other at their heads, with feet bearing on opposite walls. It is economical, but structurally limited, as heavy supporting walls are required to resist outward spread. When a steep pitch is combined with low eaves, the resulting clear roof space can be used to advantage. Where such roofs are designed, full structural calculations prepared by a Chartered Structural Engineer should be provided to demonstrate how eaves spread will be prevented.

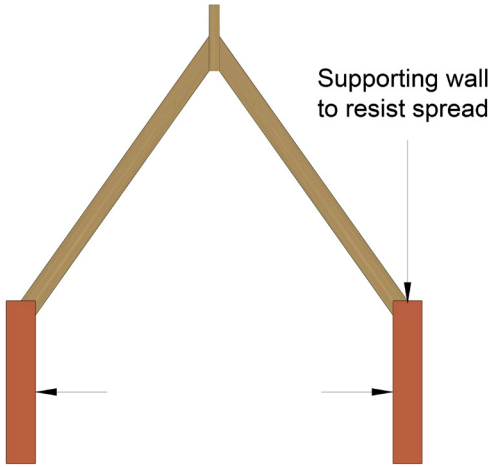


Figure 10: Couple roof

Close couple

Pairs of rafter feet are joined together with ties, often doubling up as ceiling joists, to form triangulation. The tie resists the outward thrust, and load is transferred vertically to supporting walls. The connection of ceiling joists or ties with a binder, supported from the ridge by hangers, allows a smaller timber section to be used. Rafter and ceiling joist dimensions for typical spans are given in the TRADA document, Span Tables for Solid Timber Members in Floors, Ceilings and Roofs for Dwellings.

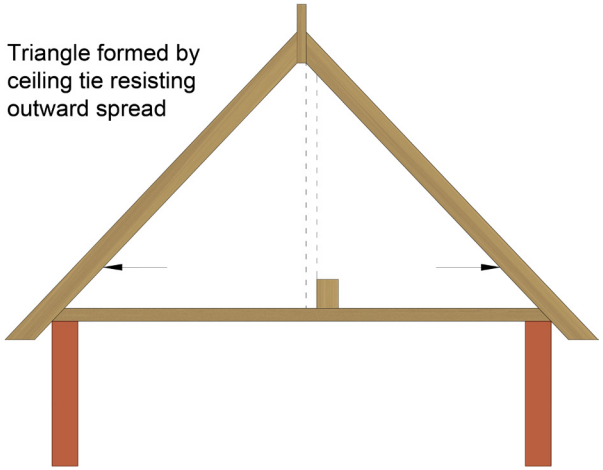


Figure 11: Close couple roof

Raised collar roof

When ties are introduced at a higher level than the rafter feet, they are termed ‘collars’. The higher the collar, the less influence on rafter spread and the larger the rafter section required to resist the bending moment. The height of supporting walls may be reduced, as the roof is effectively lowered so that the rafters and collars support the ceiling. To resist eaves spread, the height of the collar should be no higher than a third of the vertical height between the wall plate and ridge. Rafters supporting collar ties should be designed by a Chartered Structural Engineer, taking into account the additional point load imposed by the collar. The collar should be fixed to the rafters using 10mm bolts and incorporating large washers to prevent the bolt from being pulled through the timber.

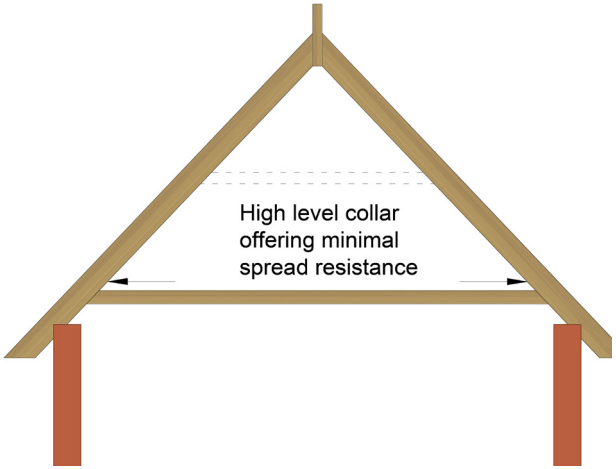


Figure 12: Raised collar roof

7.8.5 Fire stopping

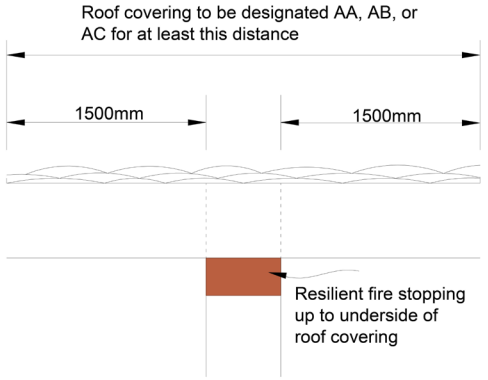
Compartmentation

The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire-resisting construction. The roof void, like most spaces within a building, can provide a route for the spread of fire and smoke. As an often-concealed space, it is particularly vital that fire-resistant cavity barriers are provided at the following points:

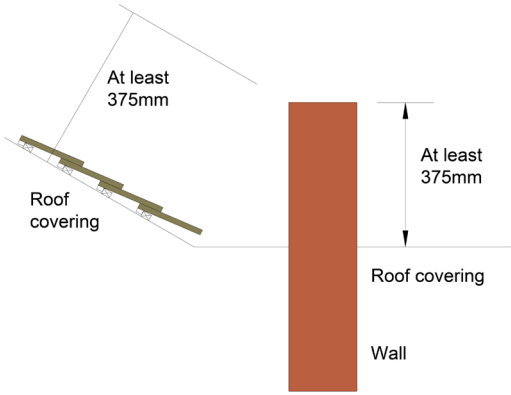
- At junctions of separating wall and external cavity wall.
- At junctions of compartment wall and compartment floor (not illustrated).
- At junctions of separating wall with roof, under roof tiles.
- Within boxed eaves at separating wall position.

Junctions of compartment walls with roof

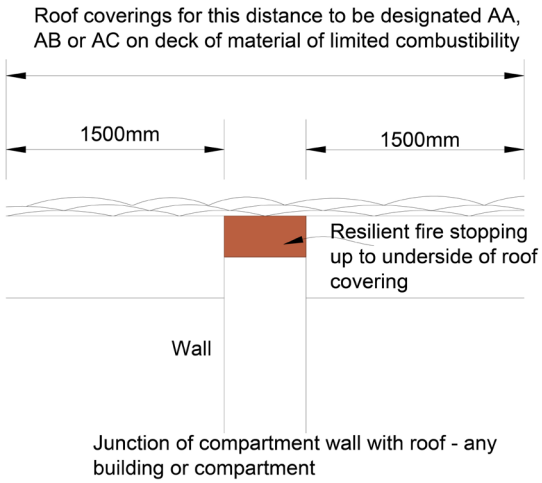
A compartment wall should be taken up to meet the underside of the roof covering or deck, with fire stopping, where necessary, at the wall/roof junction to maintain the continuity of fire resistance. The compartment wall should also be continued across any eaves cavity. If a fire penetrates a roof near a compartment wall, there is a risk that it will spread over the roof to the adjoining compartment. To reduce this risk, a roof zone 1,500mm wide on either side of the wall should have a covering of designation AA, AB or AC on a substrate or deck of a material of limited combustibility.



Junction of compartment wall with roof - dwelling house and building or compartment in residential (non institutional), office or assembly use and not more than 15m high.



Junction of compartment wall with roof - any building or compartment



Junction of compartment wall with roof - any building or compartment

Figure 13: Typical fire stopping details