BRACING

If we are to learn from the past, it is clear that there is generally a lack of understanding of the purpose of roof bracing and who should be responsible for it. This has led to disputes, claims and, more importantly, inadequately braced structures.

As explained in Section 1, responsibility for the stability and wind bracing rests with the Building Designer, including any bracing necessary to provide restraint required by the Trussed Rafter Designer.

Bracing Function

Roof bracing serves three distinct functions:

Temporary Bracing - This is used to restrain the trusses during erection until it is possible to install permanent bracing. It is explained in detail in Section 11 and will not be considered here.

Stability Bracing - Permanent bracing which, throughout the life of the roof, holds the trussed rafters upright, in plane, and prevents any lateral buckling; that is, it 'stabilises' the trussed rafters.

Wind Bracing - The walls of a building are invariably subjected to wind loading and it is the responsibility of the Building Designer to determine whether walls are capable of resisting this loading. Where they are not capable of so doing (gable walls in particular may need support) then the Building Designer must provide bracing to the walls based on a careful consideration of the form of construction. The roof structure may be used to assist in wall bracing but, where the roof is used for this purpose, the Building Designer must provide bracing specifically for this function and wholly in addition to the stability bracing. This is referred to as 'wind bracing' and it can only be designed with careful consideration of the building construction as a whole, due regard being paid to the positions of buttressing and shear walls, the inherent strength of the walls and the degree of wind exposure.

Stability Bracing

The following details will enable the Building Designer to fully detail the stability bracing on a wide range of roofs.

For the majority of trussed rafters, spaced at 600mm or less, stability bracing will be adequate if:

(i) All bracing members are of the minimum size 22mm x 97mm, of a species listed in Table 7.01 and free from major strength reducing defects. Table 7.01 is taken from BS5268:Part 3.

(ii) Where bracing members are provided in two pieces, they are lap jointed over at least two trussed rafters and nailed as indicated in (iii).

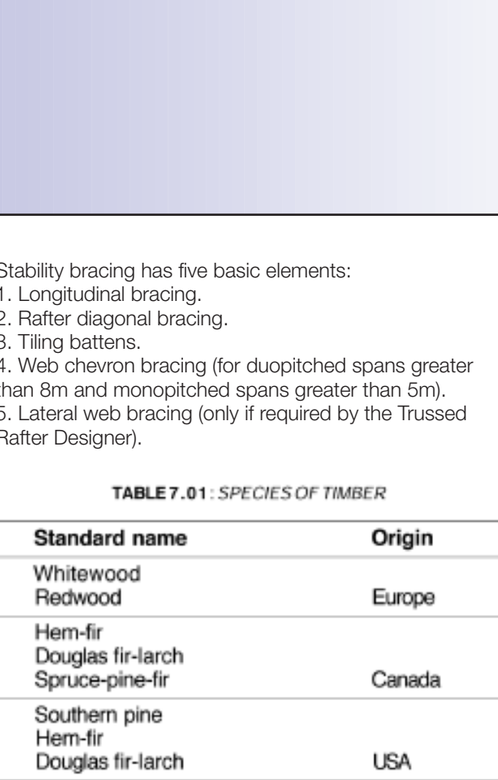
(iii) All bracing members are nailed to every trussed rafter they cross with two 3.35mm diameter x 65mm long galvanised round wire nails.

Stability bracing has five basic elements:
1. Longitudinal bracing.
2. Rafter diagonal bracing.
3. Tiling battens.
4. Web chevron bracing (for duopitched spans greater than 8m and monopitched spans greater than 5m).
5. Lateral web bracing (only if required by the Trussed Rafter Designer).

TABLE 7.01: *SPECIES OF TIMBER*

Standard name	Origin
Whitewood Redwood	Europe
Hem-fir Douglas fir-larch Spruce-pine-fir	Canada
Southern pine Hem-fir Douglas fir-larch	USA
Scots pine Corsican pine	Britain

FIGURE 7.01 *DIAGONAL BRACE*



BRACING

Before considering these in detail, it is important to understand the reason why diagonal bracing members are required in items 2 to 5. Figure 7.01 a shows a single rectangular framework which can be distorted with little effort. Even a multi-bay framework, as shown in Figure 7.01 b, offers negligible resistance. The addition of a diagonal member, as in Figure 7.01 c, rigidly braces the framework and holds it square, even when subjected to large forces. For the purposes of trussed rafter roofs, the brace will be equally effective if placedon either diagonal.

Longitudinal Bracing (or Binders)

Longitudinal bracing assists in restraining the trussed rafters and holding them in their correct position, particularly during tiling and fixing of plasterboard. When correctly fitted, longitudinal bracing adds to the overall roof stability. It runs at right angles to the trusses and should extend the whole length of the roof, finishing tight against a party or gable wall.

Longitudinal bracing should be installed at every unsupported node point. Adjacent to the rafters the brace should be fixed to the web, allowing the diagonal rafter brace to pass through as shown (Figure 7.02).

Where the truss configuration changes along a roof section, the nodes may not align. To overcome this problem, it is recommended that longitudinal binders from each roof section continue over two trusses and that both binders are located at the side of the node to minimise the distance between them (Figure 7.03).

FIGURE 7.03 *LONGITUDINAL BRACE – VARYING NODE POSITIONS*

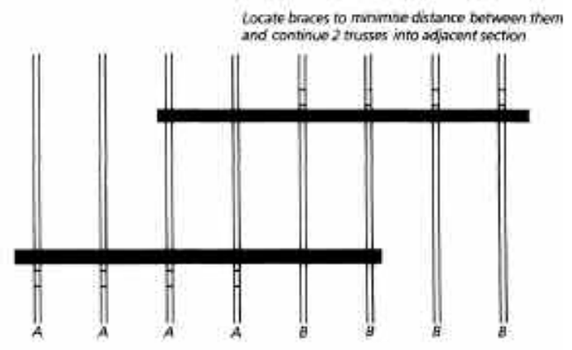
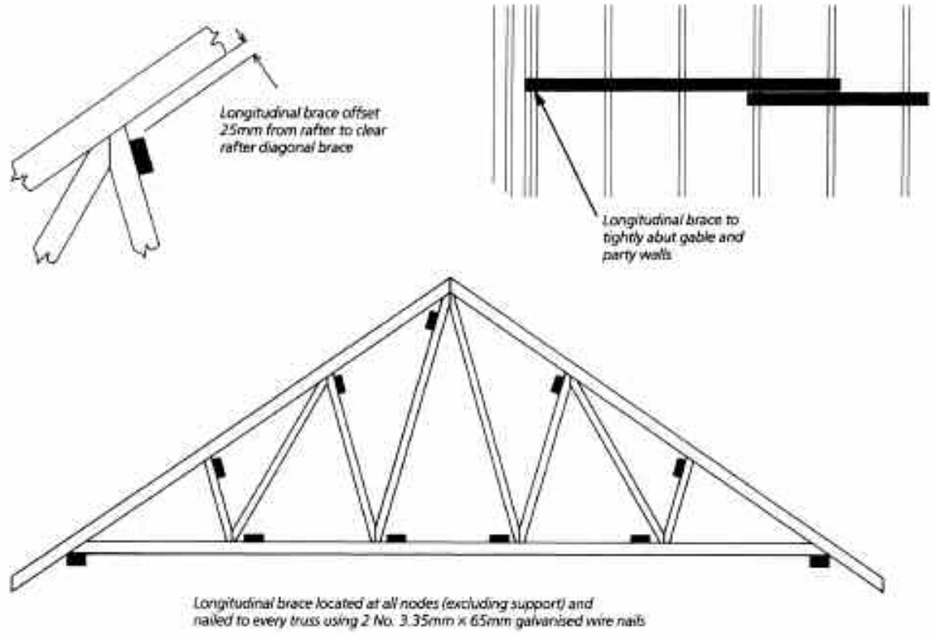


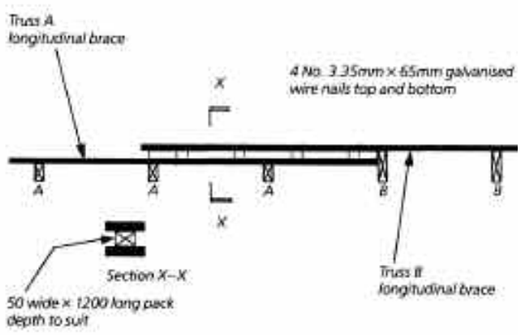
FIGURE 7.02 *LONGITUDINAL BRACING*

N.B. Other bracing omitted.



Where the depth of the chord varies between sections, packs may be required to maintain continuity (Figure 7.04).

FIGURE 7.04 *LONGITUDINAL BRACE – VARYING CHORD DEPTH*



Rafter Diagonal Bracing and Tiling Battens

The rafter diagonal brace provides the bracing restraint to prevent the rafters from buckling sideways (lateral buckling). Tiling battens distribute this bracing effect into every rafter ensuring all rafters are restrained at tile batten centres (top chord restraint distance), producing a laterally stiff component.

The Building Designer must ensure that the top chord restraint distance assumed in design by the Trussed Rafter Designer, is not exceeded on site. One particular area requiring special attention is beneath overlay roofs, considered in Figure 4.02.

The rafter diagonal brace is nailed to the underside of rafters, is fixed at the wall plate and runs up to the ridge at an angle of approximately 45° to the rafters (Figure 7.05 on following page). The bracing should extend over the whole length of the roof, with a minimum of four braces being provided. It may be omitted from no more than two trussed rafters between bracing sets and single trussed rafters adjacent to the face of gable and party walls.

The diagonal bracing should continue from the apex to the wall plates. To achieve this, additional bracing to that fixed to the rafters will sometimes be required. For monopitch and stubbed trusses, where the end vertical web is not laterally restrained at its top by connection to a masonry wall or by being clad in plywood or a similar rigid sheet material, additional diagonal bracing is required: this is fixed to the inside face of the end vertical (Figures 7.06 and 7.07).

FIGURE 7.06 *DIAGONAL BRACING ON MONOPITCH TRUSSED RAFTERS*

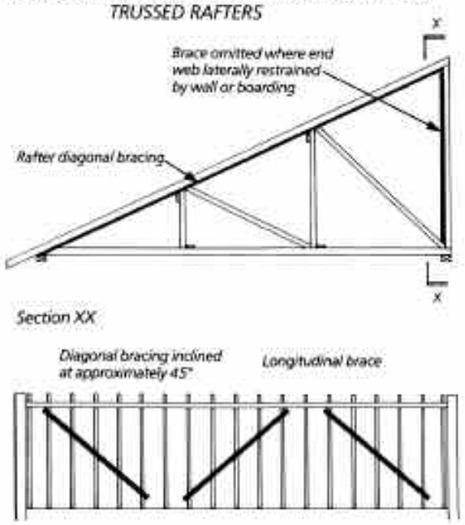


FIGURE 7.07 *DIAGONAL BRACING ON STUBBED TRUSSED RAFTERS*

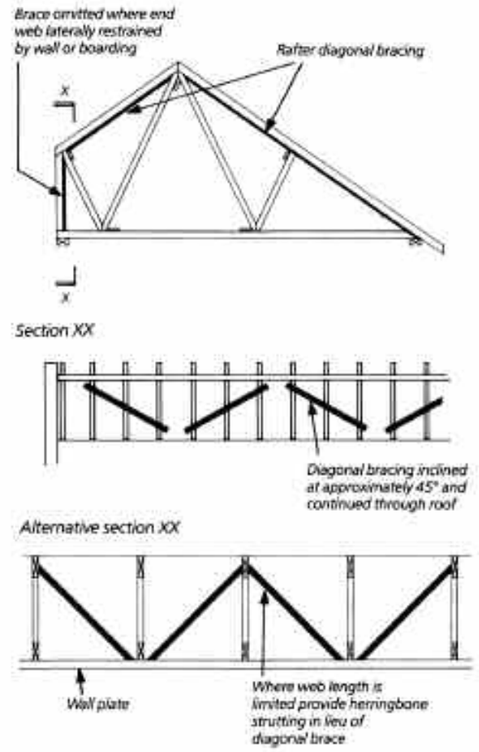
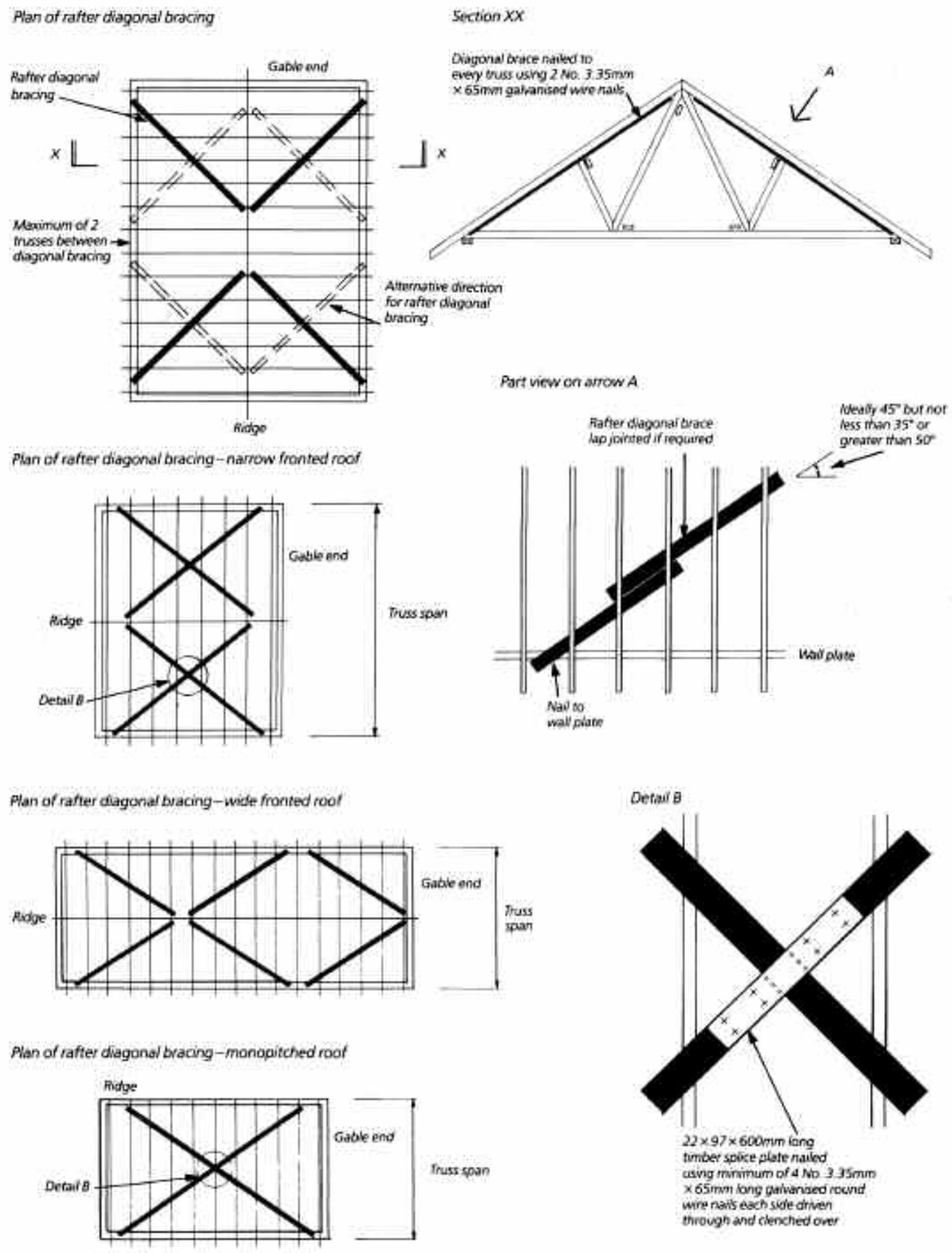


FIGURE 7.05 *RAFTER DIAGONAL BRACING*



BRACING

For cantilevered trusses, the additional brace should be provided on the cantilever web as illustrated in Figure 7.08. Where small cantilevers require heel modifications only (see Section 2) the normal rafter diagonal brace will suffice, except that a detail similar to that in Figure 7.04 will be required where supplementary chords occur.

For raised tie and attic trussed rafters, the diagonal brace on the underside of the rafter protrudes into the room area. This is easily overcome by packing out the rafters using 22mm thick timber (Figure 7.09).

FIGURE 7.08 *DIAGONAL BRACING ON CANTILEVERED TRUSSED RAFTERS*

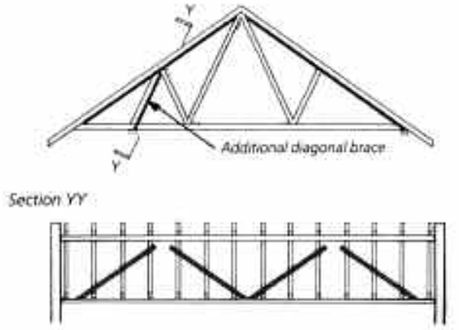
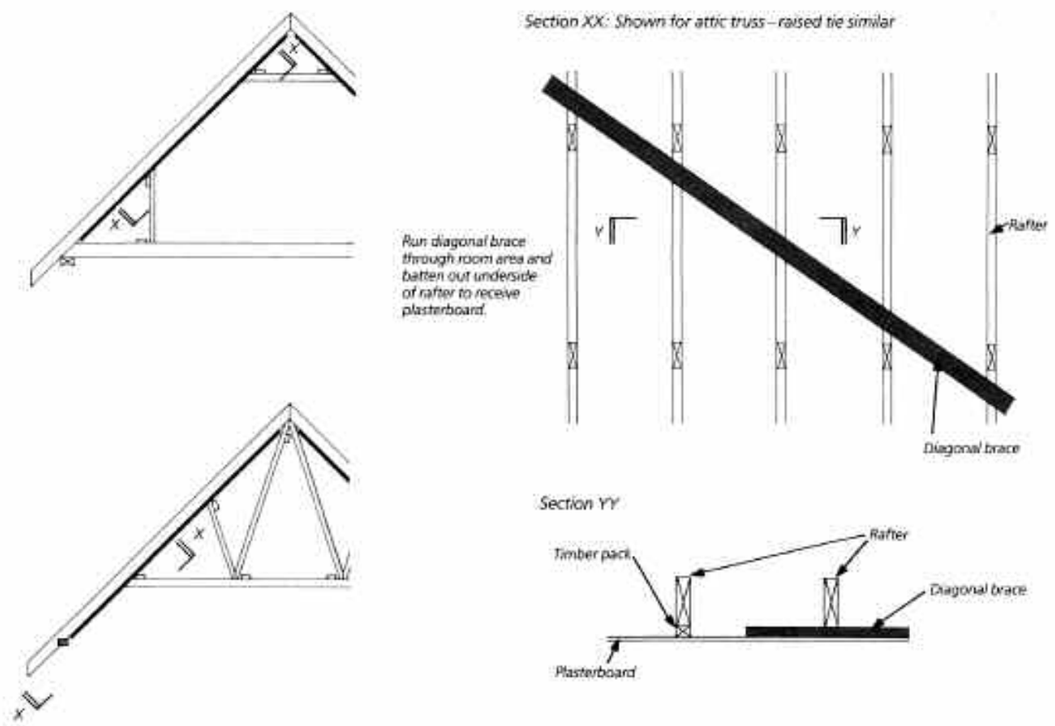


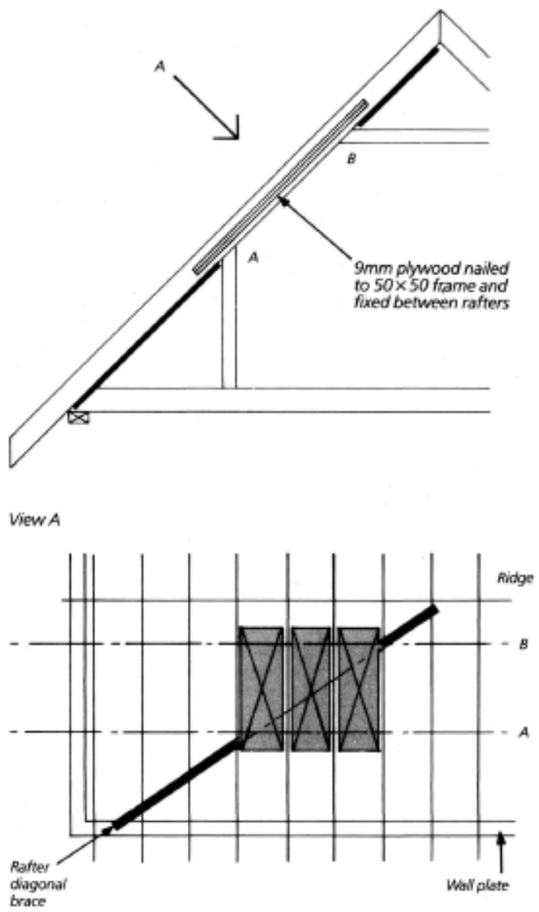
FIGURE 7.09 *RAFTER DIAGONAL BRACE – ATTIC AND RAISED TIE TRUSSED RAFTERS*



BRACING

An alternative sometimes used on attic trusses is to fix plywood diaphragms between the rafters over the room area (Figure 7.10). A simple 'rule of thumb' is to add sufficient diaphragm to allow the line of action of the brace to be continuous.

FIGURE 7.10 *PLYWOOD DIAPHRAGMS*



Tiling battens and boarding should be in accordance with the recommendations of BS5534: Particular reference should be made to the strength and stiffness of battens or boarding in relation to their primary function of supporting dead, imposed and wind loads. When necessary, advice may be sought from the tile manufacturer.

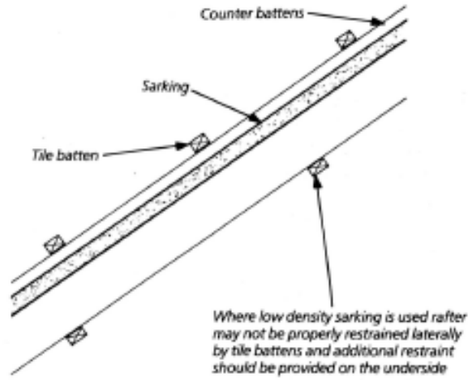
Battens should not be less than 1.2m in length and be continuous over at least two spans. They should be fixed to every rafter member which they cross, or on which they are jointed, with nails of the appropriate size and type specified by BS5534.

The ends of battens should be sawn square and butt jointed centrally on a rafter member. Thus, adequate bearing and nailing can be provided for each end of each batten. Butt joints in battens should be arranged so that not more than one batten in four is jointed on any one rafter member. Cantilevering or splicing of battens between rafters should not be permitted.

Battens on boarded roofs must be supported on counter battens running in the opposite direction. This increases ventilation under the tiles and allows free drainage, thereby preventing rainwater from reaching the underlay. Counter battens must be fixed through to the rafters and not to the boarding alone.

Where rigid insulation is installed on top of the rafters, the tiling batten fixings can no longer be assumed to provide the necessary lateral restraint. In this case, additional battens are required on the undersides of the rafters to perform the lateral restraint function (Figure 7.11).

FIGURE 7.11 *COUNTER BATTENS ON BOARDED ROOF*

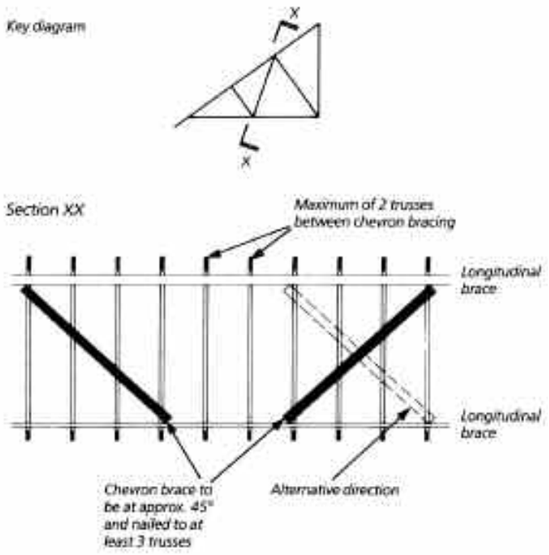


Web Chevron Bracing

Web chevron bracing provides additional lateral stability to the trussed rafters and is required on duopitch spans above 8m and monopitch spans above 5m.

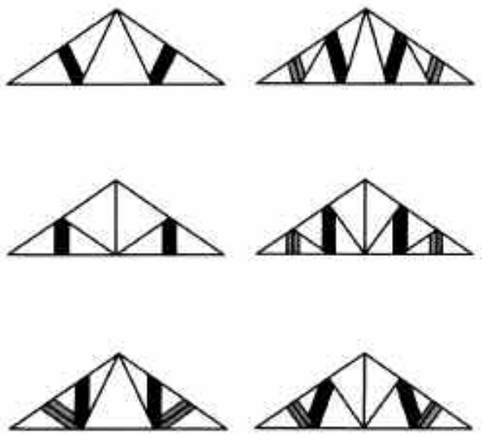
Where required by the Building Designer, chevron bracing should be nailed to the web members, inclined at an angle of approximately 45° and extended over at least three trusses (Figure 7.12). It must be continued over the complete roof and may be omitted from no more than two trussed rafters between sets of bracing and single trussed rafters adjacent to gable or party walls.

FIGURE 7.12 *CHEVRON BRACING*



To help communications between the Trussed Rafter Designer, Building Designer, fabricator and builder the TRA have standardised on the position of the chevron bracing for the more common truss types (Figures 7.13 and 7.14).

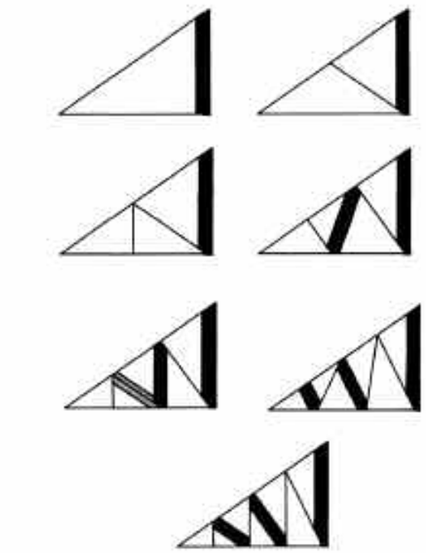
FIGURE 7.13 *CHEVRON BRACING FOR DUOPITCH TRUSSED RAFTERS*



Position of chevron bracing for spans over 8 metres.

Position of chevron bracing strongly recommended for spans over 11 metres.

FIGURE 7.14 *CHEVRON BRACING FOR MONOPITCH TRUSSED RAFTERS*



Position of chevron bracing for spans over 5 metres.

Position of extra chevron bracing required for spans over 8 metres.

Add extra bracing here if end of truss is not restrained by wall or cladding.

Web Lateral Brace

Web lateral braces are a function of the design of the trussed rafter and should be requested by the Trussed Rafter Designer. They are required on compression members to prevent lateral buckling resulting from the compression force and/or the length of the member.

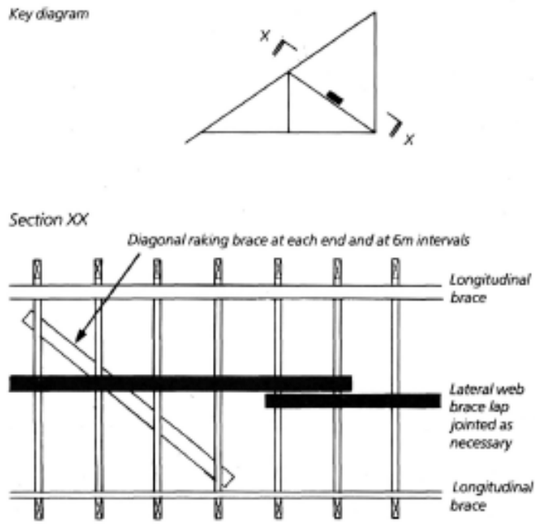
Web lateral braces must continue along a complete section of roof and be equally spaced along the web in instances where more than one brace is required. The longitudinal member is the 'distributor' of the bracing restraint into every trussed rafter. The bracing effort is provided by raking braces fixed at either end and repeated at 6m intervals (Figure 7.15).

SECTION 7

BRACING

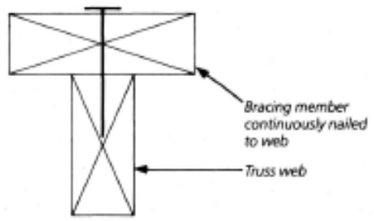
FIGURE 7.15 *WEB BRACE*

N.B. Raking brace can be omitted where chevron brace is fixed to web.



In some situations it may be preferable to laterally restrain the compression web by nailing an additional member along its length to form a 'T' section (Figure 7.16). This is particularly useful for trusses spaced at large centres or isolated trusses not easily braced in the conventional manner.

FIGURE 7.16 *'T' WEB BRACE*



Sarking

Where certain sarking materials are directly fixed to the top face of the rafter members, rafter diagonal bracing, chevron bracing and longitudinal bracing at rafter level may be omitted. This is allowable if the sarking material is moisture resistant, made from plywood (minimum thickness, 9mm) or chipboard (minimum thickness, 12mm). The boards should be laid with staggered joints and nailed at no less than 200mm centres to every truss they cover with 3mm diameter x 50mm long galvanised round wire nails. It is also acceptable if the sarking material comprises timber boarding of minimum thickness 16mm, nailed to each truss with two 3mm diameter x 50mm long galvanised wire nails. The boarding must be tightly abutted at its edges and no more than one board in four may be jointed to any one rafter member.

Cantilevering or splicing of boarding or sheet materials between rafters should not occur, except where adequate noggings are provided to support the free edge.

Extra care will need to be exercised during erection to ensure that stability, vertically and straightness are maintained until the sarking has been fixed.

Hip Ends

BS5268: Part 3 Appendix A accepts that in certain circumstances hip ends provide a satisfactory alternative to stability bracing in the hip end area. Where the length of roof between hip ends exceeds 1.8 metres however,this section should be braced

Wind Bracing

As fully described in Appendix A of BS5268: Part 3, experience has shown that, for a wide range of domestic structures, standard stability bracing used in conjunction with a plasterboard ceiling will provide sufficient wind bracing to the structure. This section therefore considers wind bracing for structures outside of the parameters of Appendix A. The need to seek advice from an experienced timber engineer is emphasised, although the following general guidance can be given. The options available are:

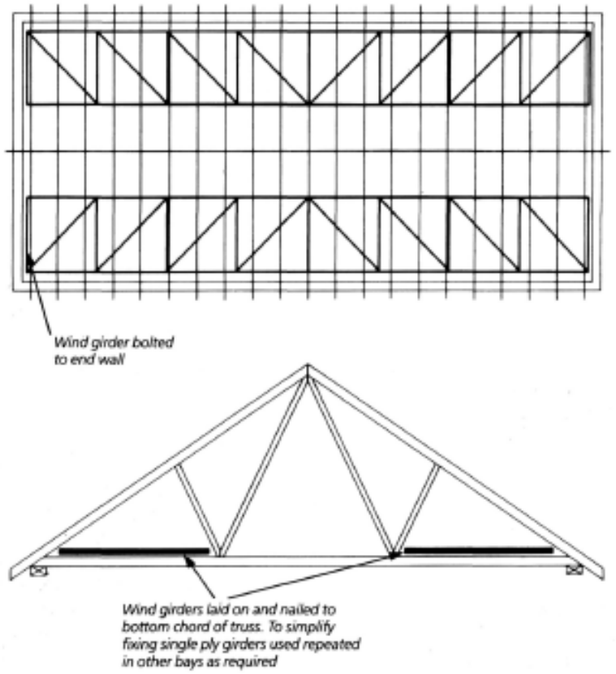
(i) Designed bracing.
(ii) Plywood diaphragms.
(iii) Wind girders.
(iv) Reinforced supporting structure.

Designed Bracing - Applying standard engineering principles, a bracing system can be designed using timber members and site connections. This often presents detailing problems in transferring forces between members and is not often used.

Plywood Diaphragms - A very rigid structure can be achieved by nailing plywood, to a staggered pattern, continuously over the rafters or to the underside of the ceiling tie member. In Scotland, where boarded sarking is usually provided on the roof, this method is particularly suitable, since the additional costs would be small.

Wind Girders -Probably the most common method, employing flat chord trusses placed horizontally on the bottom chords of the main roof trussed rafters (Figure 7.17). These 'wind girders' span between the cross walls and absorb the wind forces on the sides of the building. Installation of the wind girders is simplified where a suspended ceiling is provided, since the girders can be nailed directly to the undersides of the trussed rafters.

FIGURE 7.17 *WIND GIRDER*



For hip ends or where the cross walls also require bracing, special details are required. To design the wind girders, the Trussed Rafter Designer needs to be given the load per metre and the amount the walls are permitted to deflect laterally, since it is often deflection rather than stress that controls the design. The typical lateral deflection permitted by Building Designers for a 4m high wall is 12mm.

Reinforced Support Structure- For reinforced concrete or steel frame buildings, the simplest solution may be to allow the structural frame to provide the lateral wind resistance.

Multipart Trusses

As noted in Section 9, the erection of a two-part truss, where no structural continuity is assumed, must be done in two stages. The first stage is to erect and fully brace the lower section, treating it as an independent roof, as illustrated by the example given in Figure 7.18.

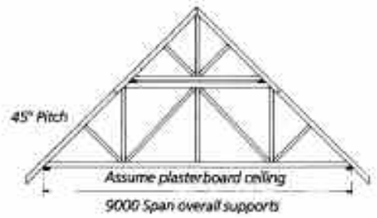
Erection of the lower section fully braced will result in a very rigid structure on which the upper section can be constructed. The bracing of the upper section follows standard principles with the addition that since the bottom chord is not plasterboarded, diagonal ceiling bracing should be provided on all but the very small spans.

SECTION 7

BRACING

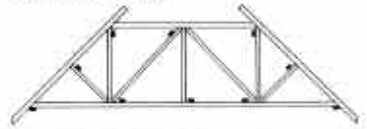
FIGURE 7.18 *TWO PART TRUSS STABILITY BRACING*

EXAMPLE



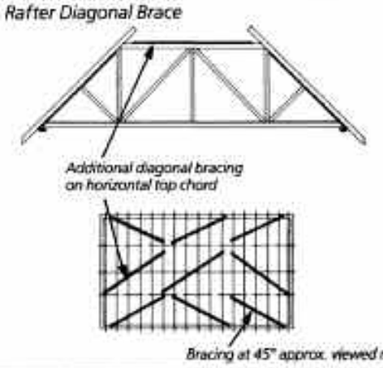
LONGITUDINAL BRACING

Longitudinal Bracing



RAFTER DIAGONAL BRACING

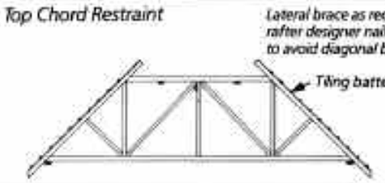
Rafter Diagonal Brace



TILING BATTENS

The sloping top chord will be restrained laterally by the tiling battens. For the horizontal top chord the trussed rafter designer must state the restraint assumptions. Restraint at mid bay and node points has been assumed.

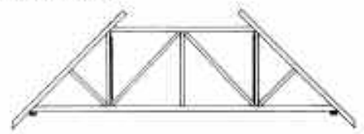
Top Chord Restraint



CHEVRON BRACING

The span is greater than 8m so chevron bracing will be required.

Chevron Bracing



WEB BRACING

The trussed rafter designer will state the webs requiring lateral bracing, but for length reasons alone diagonal compression webs will normally be braced.

Lateral Web Brace