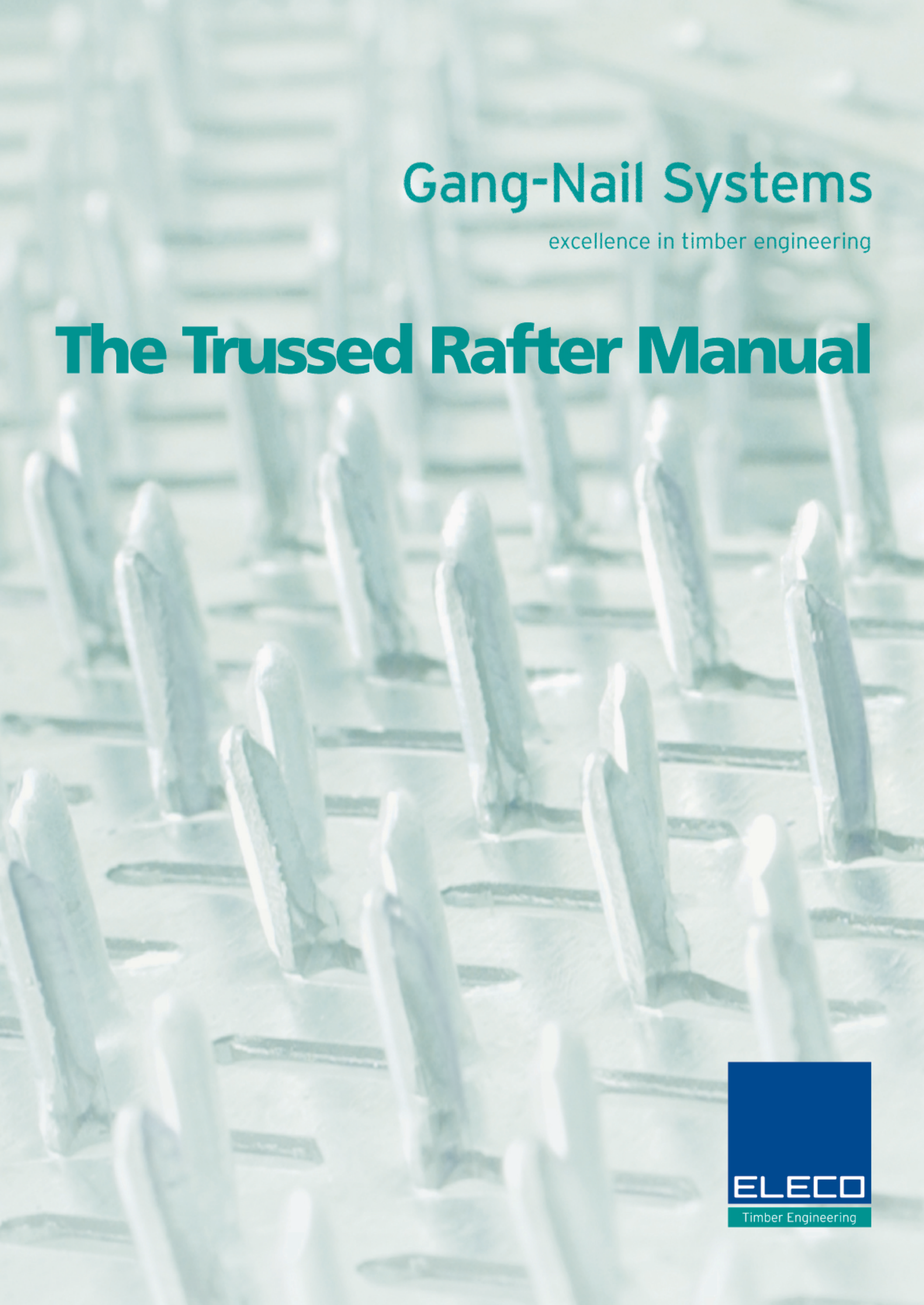


Gang-Nail Systems

excellence in timber engineering

The Trussed Rafter Manual

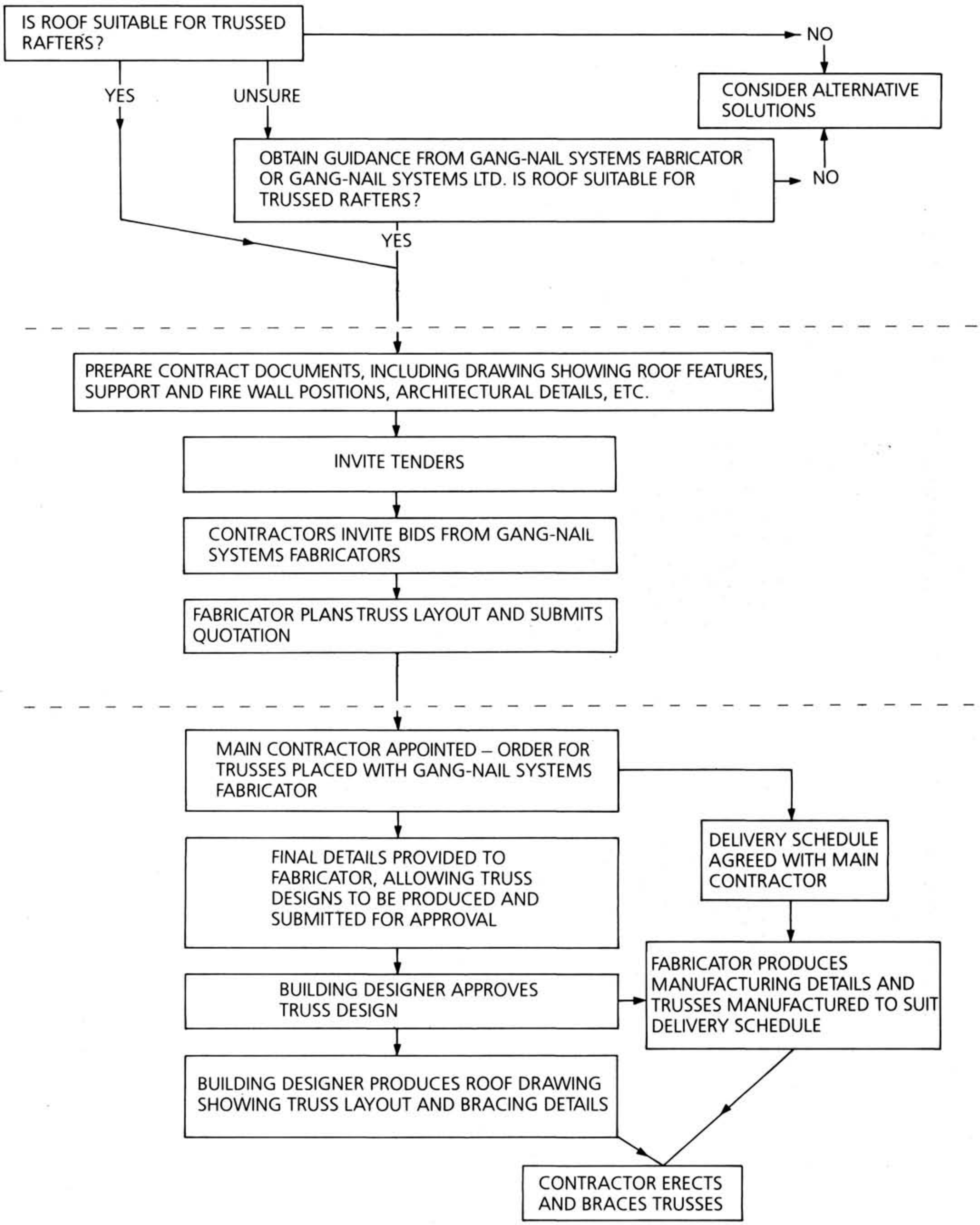
ELECO

Timber Engineering

THE TRUSSED RAFTER MANUAL

CONTENTS

ROUTE MAP



IS ROOF SUITABLE FOR TRUSSED RAFTERS?
NO
YES
UNSURE
CONSIDER ALTERNATIVE SOLUTIONS
OBTAIN GUIDANCE FROM GANG-NAIL SYSTEMS FABRICATOR OR GANG-NAIL SYSTEMS LTD. IS ROOF SUITABLE FOR TRUSSED RAFTERS?
NO
YES
PREPARE CONTRACT DOCUMENTS, INCLUDING DRAWING SHOWING ROOF FEATURES, SUPPORT AND FIRE WALL POSITIONS, ARCHITECTURAL DETAILS, ETC.
INVITE TENDERS
CONTRACTORS INVITE BIDS FROM GANG-NAIL SYSTEMS FABRICATORS
FABRICATOR PLANS TRUSS LAYOUT AND SUBMITS QUOTATION
MAIN CONTRACTOR APPOINTED – ORDER FOR TRUSSES PLACED WITH GANG-NAIL SYSTEMS FABRICATOR
DELIVERY SCHEDULE AGREED WITH MAIN CONTRACTOR
FINAL DETAILS PROVIDED TO FABRICATOR, ALLOWING TRUSS DESIGNS TO BE PRODUCED AND SUBMITTED FOR APPROVAL
BUILDING DESIGNER APPROVES TRUSS DESIGN
FABRICATOR PRODUCES MANUFACTURING DETAILS AND TRUSSES MANUFACTURED TO SUIT DELIVERY SCHEDULE
BUILDING DESIGNER PRODUCES ROOF DRAWING SHOWING TRUSS LAYOUT AND BRACING DETAILS
CONTRACTOR ERECTS AND BRACES TRUSSES

Comment

FEASIBILITY STAGE

- Section 2 gives some guidance on what can be achieved.
- When the required guidance is extensive, the fabricator may charge a fee. In this situation, the Client may consider nominating a supplier to work with the building team. This reduces the initial costs and allows problems to be solved at the pre-tender stage, resulting in better control at the construction stage, which often equates to a cost saving.

TENDER STAGE

- Avoid itemising trusses in a Bill of Quantities (see Section 10).
- On larger jobs, give an indication of how the contract will be phased.
- Provide the information listed in Section 10, thereby ensuring that the fabricator has enough detail to produce an accurate quotation.
- In addition to designing and manufacturing the trussed rafters, some fabricators will undertake the design and detailing of the complete structural roof including the stability bracing.

CONSTRUCTION STAGE

- Trussed rafters are designed and manufactured to suit each contract. Adequate time must therefore be allowed between placing the order and requiring the trusses on site. As a guide, it is recommended that orders are placed at least 4 weeks prior to required delivery. On larger jobs, this period may extend to several months.
- In addition to designing and manufacturing the trussed rafters, some fabricators will undertake the erection of the roof.

INTRODUCTION

The Trussed Rafter Manual is a comprehensive reference guide to trussed rafter roof design, specification and construction. It is specifically designed to meet the information needs of all the members of the project team, from feasibility planning, through the detail design stage, to erection and completion on site. Consequently, the Manual will be of use to a broad range of specifier groups, including architects, engineers, contractors, developers and also students.

Gang-Nail Systems Ltd, in conjunction with their UK and Eire network of fabricators, have been at the forefront of trussed rafter technology for 40 years. Their ongoing involvement in the development of British Standards and Eurocodes is a testament to this fact. The Manual not only draws upon this accumulated wealth of knowledge and experience, but also incorporates work carried out by the Building Research Establishment, Trussed Rafter Association and British Standards Institution.

Gang-Nail's role within the construction industry is to support a network of timber trussed rafter manufacturers, by manufacturing and supplying punched metal plate connectors, and developing the applications software necessary to design and supply prefabricated trussed rafters to the highest specification.

The extent to which primary product manufacture is combined with a sophisticated and highly developed range of support services for client fabricator companies is seldom realised. Parallel developments in both the design and client services offered by Gang-Nail Fabricators has meant the combined resources of the System Owner and Fabricator network can respond to the most demanding requirements from the roofing sector.

Since the establishment of Gang-Nail Systems Ltd the range and complexity of projects designed, supplied and erected under the System by fabricator companies has progressed rapidly. Housing applications are well known, with an estimated 95% of new build housing utilising prefabricated trusses. Less well known is the extent to which trussed rafter roof structures are now part of the non-domestic building scene. The aesthetic and architectural appeal of pitched roofs has spawned a rich variety of commercial and industrial applications, including offices, shopping centre, superstores, hospitals, schools, hotels and light industrial buildings. An estimated 45% of the annual output from the trussed rafter industry is presently directed towards these types of project.

Gang-Nail's preparation of The Trussed Rafter Manual has taken this continuing trend into account by approaching its subject not only in the context of domestic dwelling requirements, but also in terms of what can be achieved on larger scale developments.

It is important to recognise that The Trussed Rafter Manual sets out to inform and guide the project team and not to replace the Structural Engineer. It is essential that the Building Designer, who is assumed to have ultimate responsibility for all aspects of the project, considers and approves the information given in relation to the specific project under consideration. If used in this way the aim of the Manual will have been fulfilled, and its rightful position on the desk of all relevant parties will be assured.

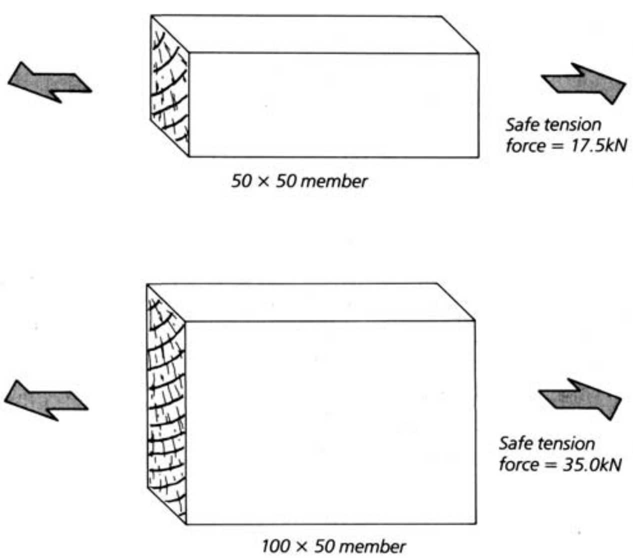
TRUSS MECHANICS, MATERIALS AND RESPONSIBILITIES

The modern trussed rafter roof has evolved in form over the past forty years. The speed with which it can be manufactured and erected, along with its efficiency of material use has meant that it is now used in the vast majority of domestic roofs and increasingly for commercial construction projects. Before providing detailed guidance on all aspects of trussed rafter roof design and construction, a brief description is provided in this section of the basic structural mechanics of trusses, the materials which are used, and the responsibilities of the various parties involved in their design. Roof trusses are primarily made up of tension and compression members; so what are tension and compression members and how do they behave?

Tension Members

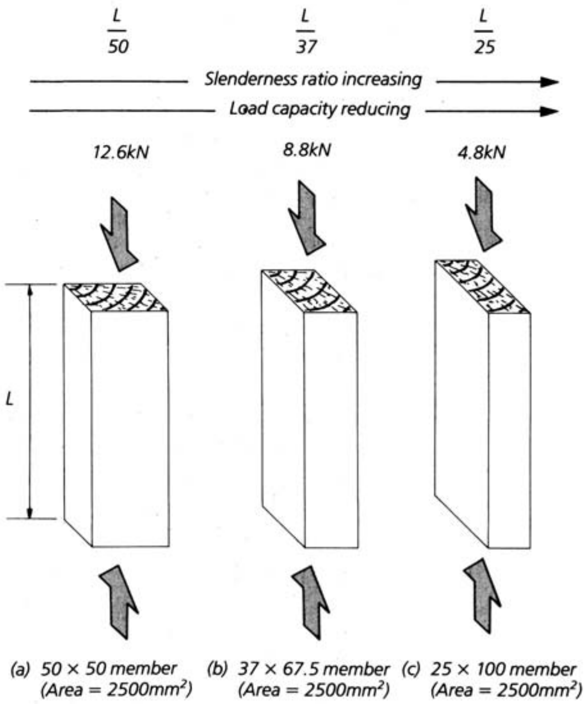
A member subject to a tension force is being pulled or stretched; it is said to be in tension. Common examples of a tension member are a car tow rope and the rope supporting a child's swing. The ability of a member to restrain tension forces depends on the raw material strength of the member and its cross-sectional area. Illustrated in Figure 1. 01 is the force a 50mm x 50mm member can withstand and a 100mm x 50mm member, which being twice the area carries twice the force.

FIGURE 1.01 *TENSION MEMBERS*



Compression Members

A member subject to a compression force is being pushed or compressed; it is said to be in compression. Common examples of compression members are columns or the leg of a table. Unlike the tension member the ability of a member to resist an applied compression force is not only dependent on raw material strength and cross-sectional area, but also member length and minimum breadth. A simple experiment will demonstrate this. Hold a 300mm scale rule vertically on the desk and push down on it. At a relatively small load it will buckle. Repeat the experiment with a 150mm long scale rule, it will take a much greater force before it buckles. If we were to take a 10mm length of the scale rule and subject that to compression, it would eventually crush at a relatively enormous load and be said to fail in compression as opposed to buckling. This experiment demonstrates the principle that as member length increases so load carrying capacity decreases. Similar experiments keeping length and cross-sectional area constant would show that load capacity decreases as the cross-section changes from a square to a long rectangle (Figure 1. 02).

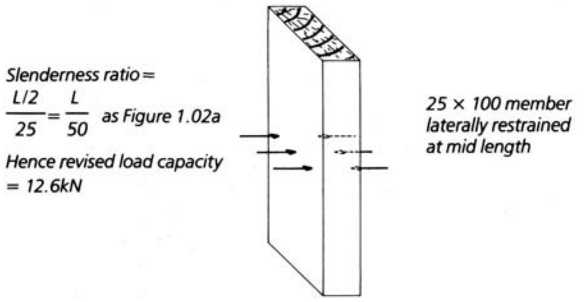


Combining these two findings indicates that load capacity is dependent upon the slenderness ratio; that is

$$\text{Slenderness Ratio} = \frac{\text{Member Length}}{\text{Minimum Cross-sectional Dimension}}$$

If we rigidly supported the 25mm x 100mm member laterally at mid-point in the 25mm direction, the length over which it can buckle is halved and hence its slenderness ratio would be equal to that for the 50mm x 50mm section and the allowable load would increase from 4.8kN to 12.6kN (Figure 1.03). This explains the importance of lateral bracing and demonstrates why, when requested by the Trussed Rafter Designer, lateral braces must be correctly installed.

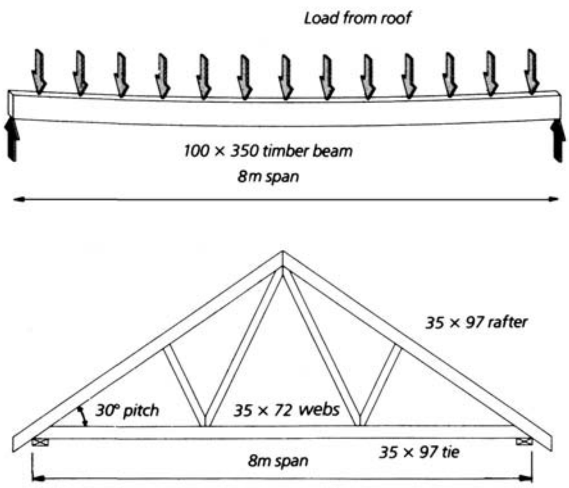
FIGURE 1.03 *LATERAL RESTRAINT*



Trussed Rafters

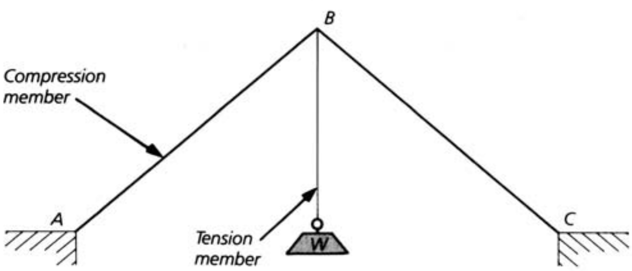
To support an 8m span roof with beams at 600mm centres requires 100mm x 350mm timber members. The equivalent trussed rafter, assuming a pitch of 30°, would use much smaller member sizes and only a quarter of the timber (Figure 1.04). How is this possible?

FIGURE 1.04 *TIMBER BEAM AND EQUIVALENT TRUSSED RAFTER*



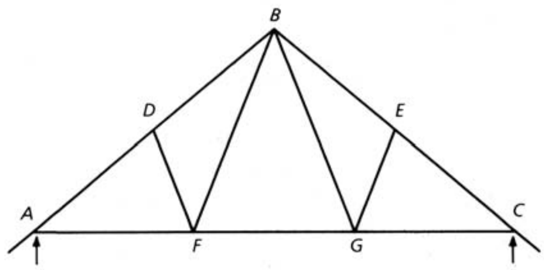
Consider two rafter members - AB and BC - in contact at B and restrained from moving at A and C (Figure 1.05). It is possible to suspend a weight W from node B, placing AB and BC in compression; the rope is in tension.

FIGURE 1.05 *BASIC FRAMEWORK*



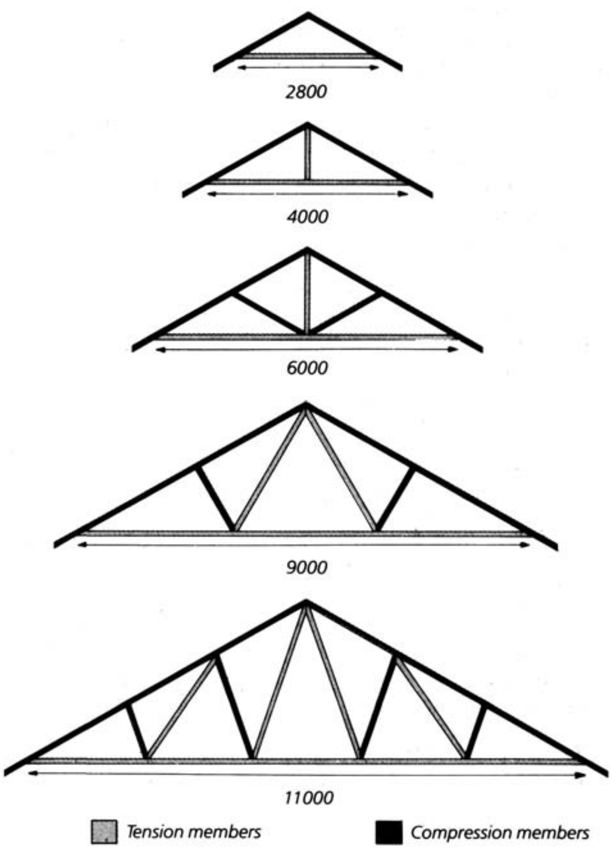
Relating this to a truss (Figure 1.06) points A and C are prevented from spreading by the bottom chord AC which is in tension and ties the rafters together. For this reason, bottom chord AC is often called the ceiling tie.

FIGURE 1.06 TRUSS ACTION



An 8m long, 35mm x 97mm ceiling tie would deflect and so it is supported at F and G by members BF and BG which hang from node B and are in tension. The length of members AB and BC would also result in excessive deflection so they are propped at D and E by members DF and EG which are in compression. In this way it is possible to increase the span range for a given timber size by simply adding more tension and compression webs, as shown in Figure 1.07, assuming chord members 35mm x 97mm throughout.

FIGURE 1.07 *MAXIMUM SPANS FOR 35 × 97 CHORD MEMBERS*



TRUSS MECHANICS, MATERIALS AND RESPONSIBILITIES

This example illustrates that the members in a truss are subjected to axial forces (i.e. tension or compression). Since members can resist axial forces more easily than they can bending forces, smaller timber sections can be used in a truss than an equivalent beam.

Combined Stress Index

In reality trussed rafter chords receive load along their entire length and they are therefore subject to bending forces. The same basic theory, however, still applies, except that instead of all the member strength being used for axial forces (tension or compression), some of it is required to resist the bending forces. The design calculation for the trussed rafter will state the Combined Stress Index (C.S.I.) for each member, which should not exceed 1.0. A value of 1.0 says the member is stressed to the maximum permitted value: in tension, compression, bending, or a combination of these. Some examples are as follows:

Rafter C.S.I.	= 0.81	81% of the strength of the rafter is being used to resist combined bending and compression forces
Ceiling Tie C.S.I.	= 0.49	49% of the strength of the tie is being used to resist combined bending and tension forces
Tension Web C.S.I.	= 0.73	73% of the strength of the web is being used to resist tension forces

Connector Plates

Gang-Nail punched metal plate fasteners are manufactured from galvanised mild steel. Rows of integral nails are pressed out to project at right angles to one face of the plate (Figure 1.08). The slots so formed define the length direction of the fastener. One nail is formed from each slot, with alternative rows of nails facing in opposite directions. The nails are formed with a slightly dished cross-section.

The use of Gang-Nail connector plates is covered by British Board of Agrement Certificates. The fasteners are stamped with the identification mark: GN20, GN14 or GN80X.

GN20

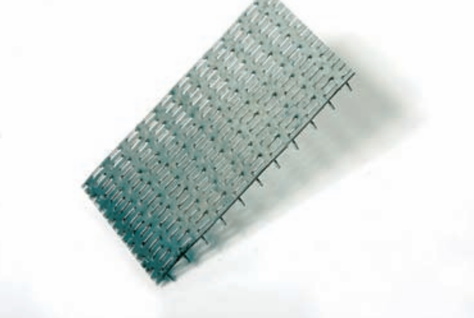
GN20 plates are available in widths of 50mm, 63mm, 76mm, 101mm, 127mm and 152mm and lengths from 71mm up to 1220mm, although the maximum length normally used is 401 mm.

The fasteners are manufactured from carbon steel of nominal 1mm finished thickness and protected against corrosion by hot-dip galvanising with a minimum zinc coating weight of 275 g/m2 The steel specification is in accordance with BS EN 10326.

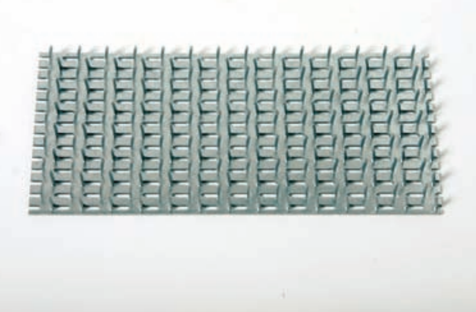
Some typical joints with their load carrying capacities are given in the diagrams shown as Figure 1.09.

FIGURE 1.08 THE GANG-NAIL CONNECTOR PLATE RANGE

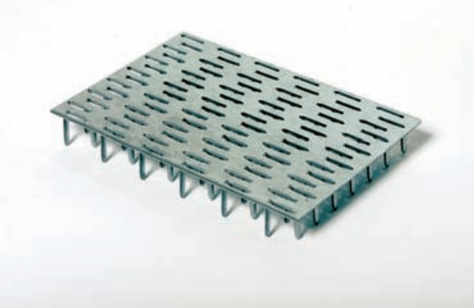
GN20



GN80X



GN14



Field Splice Plate

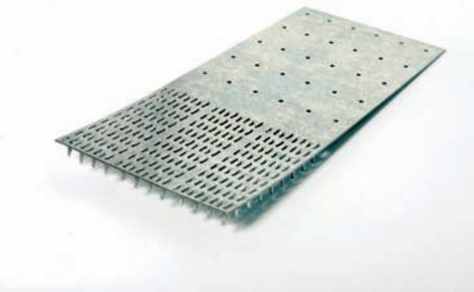
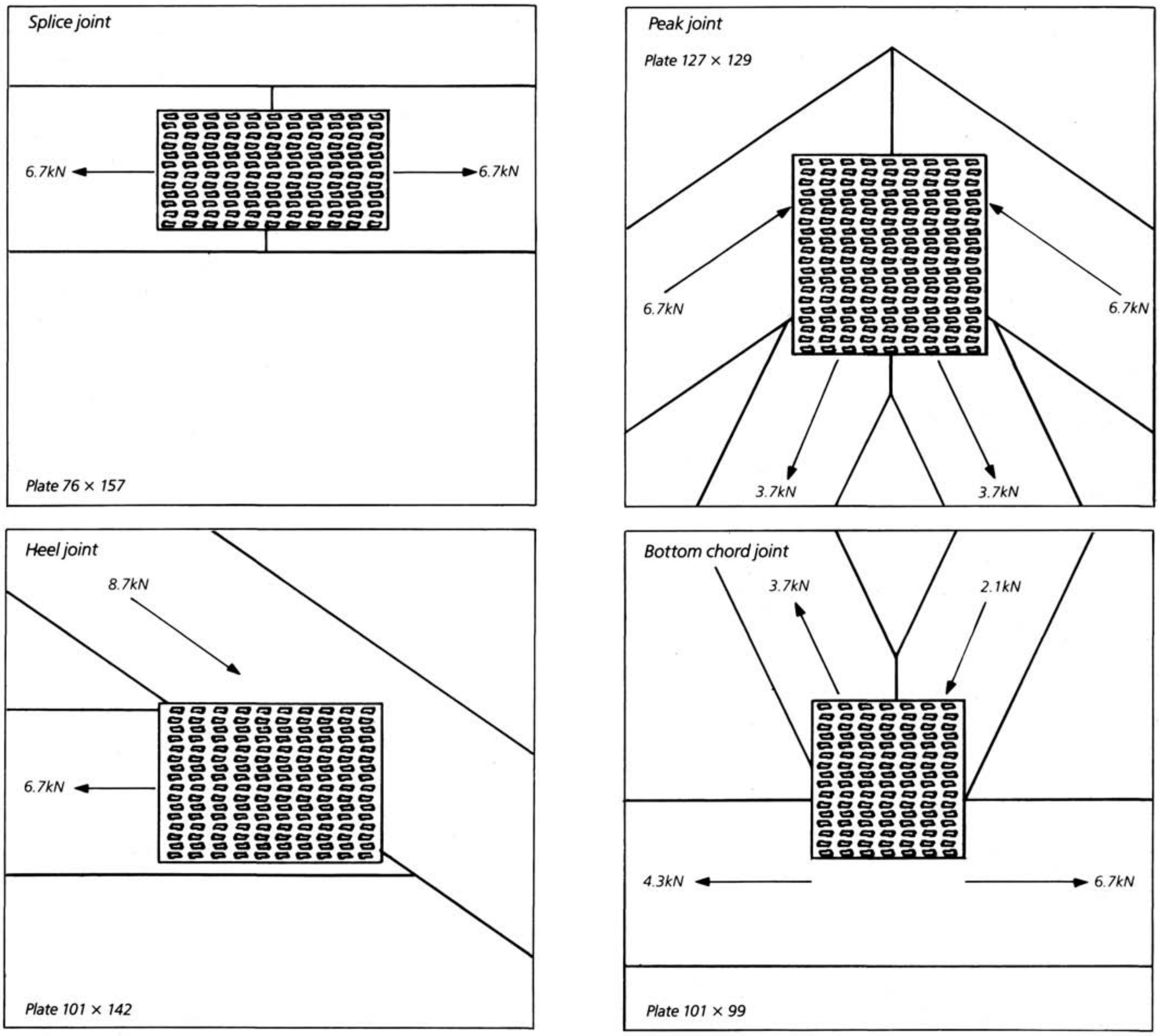


FIGURE 1.09 *TYPICAL JOINTS*

Note: Plate details are for a 30° pitch 8m span fink truss. Axial forces only shown.



GN80X

An 18 gauge (1.2mm thick) plate manufactured from high strength steel and normally used for splices.

GN14

GN14 is a 14 gauge connector plate manufactured from steel nominally 2mm thick (Figure 1.08). GN14 plates are predominantly used for special applications where very large joint forces occur. The length of the nail is 20mm and hence the Agrement Certificate prohibits their use in timber less than 44mm thick. Available widths are 66mm, 76mm, 114mm, 133mm, 152mm, 190mm and 228mm in lengths from 100mm up to 1220mm.

Field Splice Plates

A plate with one half consisting of Gang Nails and the other holes to receive square twist nails. Used to fix a 2 part truss together on site e.g. top hat attic truss.

TRUSS MECHANICS, MATERIALS AND RESPONSIBILITIES

Timber
All timber used in the manufacture of trussed rafters must be stress graded. Some of the common species are given in Table 1.01, taken from BS5268:Part 3.

TABLE 1.01: 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

European redwood and whitewood are imported as a mixed parcel of timber, the majority of which is whitewood. These timbers form the bulk of all trussed rafters manufactured and it
is important that specifiers do not try to separate them.

The normal grades of European redwood/whitewood employed are TR26 and C16.

The most common widths of timber are 35mm or 47mm, and depths range from 72mm to 197mm for 35mm thickness and 72mm to 244mm for 47mm thick timbers. For webs, a depth of 60mm is permissible.

The timber is prepared on all faces, often to what the timber trade refers to as hit and miss planing. A fully planed finish, as with joinery timbers, may not be achieved, but the majority of the sawing marks are moved.

Moisture Contents
Trussed rafters are assumed to satisfy the 'Dry Exposure' conditions defined by BS5268:Part 2, whereby the moisture content of the timber must not exceed 18% for any significant period. BSEN 14250 does permit the moisture content to be 22% at the time of manufacture, recognising that the timber will dry tobelow the 18% value during the construction phase and before the majority of the design load is applied. Typical values recorded in occupied buildings range from 10% to 16%

The control of the moisture content of timber is important since it influences the properties of the timber. For example:

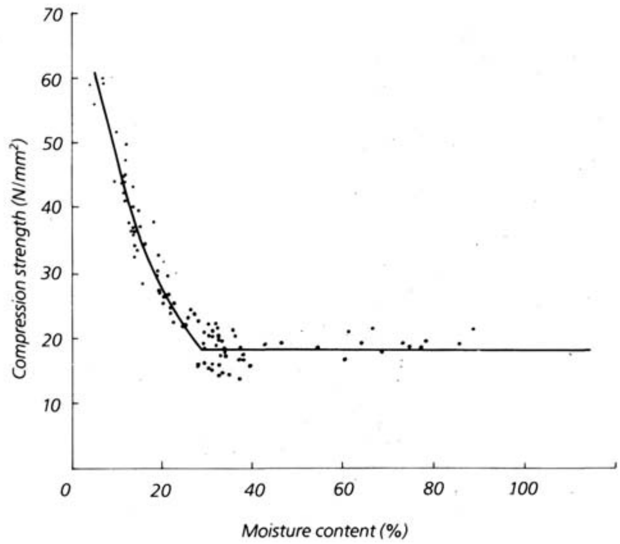
(1) Below a moisture content of 25% wood is less prone to decay and may be considered immune below 20%.

(2) In unseasoned timber, water is held partly in the cell walls and partly as free moisture within the cell cavities. As the timber dries, the free moisture is evaporated before the cell walls lose their water. Fibre saturation is defined as the condition when all the free water has been removed but the cells are still saturated.

Below the fibre saturation point, changes in moisture content are accompanied by shrinkage of the wood and an increase in most strength properties. To account for the shrinkage, timber sizes are normally related to a moisture content of 20%.

The relationship between moisture content and strength differs for each property but, as an indication, Figure 1.10 relates moisture content to compression strength.

FIGURE 1.10 *TYPICAL RELATIONSHIP BETWEEN TIMBER STRENGTH AND MOISTURE CONTENT*



Below the fibre saturation point, strength increases significantly with reducing moisture content. Having adopted 'dry stresses' for the design, the significance of ensuring the moisture content does not exceed 18% will be apparent.

Treatment of Timber
The risk of rot or insect attack in the timber of well ventilated pitched roofs is regarded by BS5268:Part 5 as low, except in those areas specified in the Building Regulations as subject to infestation by the house longhorn beetle (Hylotrupes bajulus L). The preservative treatment of trussed rafters, other than in these specified areas, may be regarded as unnecessary except as an insurance against the cost of possible repairs. Where preservative treatment is required, it should satisfy the requirements of the Building Regulations. The type of preservative used should neither increase the risk of corrosion of punched metal plate fasteners or nails. The recommendations of BS5268:Part 5 in this respect should be followed.

TRUSS MECHANICS, MATERIALS AND RESPONSIBILITIES

Where cross cutting is carried out after treatment, all sawn ends should be given the appropriate treatment required by the relevant preservative or treatment specification, before assembly.

Organic solvent type preservatives lend themselves to modern industrialised techniques for the fabrication of trussed rafters, since punched metal plate fasteners may be pressed into the timber shortly after treatment.

Copper/Chrome/Arsenic (CCA) preservative should not be used because of the possible risk of corrosion of punched metal plate fasteners and nails.

Galvanised punched metal plate fasteners and nails should not be used in timber which has been treated with a flame retardant.

Load Duration

The grade stresses and joint strengths given in BS5268: Part 2 are for long-term loading. Timber can however sustain greater loads for a period of a few minutes than for a period of several years and BS5268: Part 2 reflects this fact in quoting load duration factors by which the grade stresses can be modified. These factors are given in Table 1.02 and apply to all strength properties but not moduli of elasticity or shear moduli (see also Section 3).

TABLE 1.02: MODIFICATION FACTOR K3 FOR DURATION OF LOADING

Duration of loading	Value of K_3
Long term	1.00
Medium term (e.g. dead + snow, dead + temporary imposed)	1.25
Short term (e.g. dead + imposed + wind, dead + imposed + snow + wind)	1.50
Very short term (e.g. dead + imposed + wind)	1.75

British Standards and Codes of Practice

There is one major British Standard applicable to trussed rafters, namely BS5268:Part 3:A brief outline of this and relevant supplementary documents follows.

BS5268: Part 3: Code of Practice for trussed rafter roofs - regulates the materials and design methods used.
It encompasses information on the handling, storage and site erection of trusses. Comprehensive guidance is also given on stability bracing and overall roof bracing.

BS5268: Part 2: Code of Practice for permissible stress design, materials and workmanship - provides basic stress data for the structural timbers to be used in manfacturing the trusses.

BS EN 14250: Product requirements for trussed rafters - gives all the rules required to manufacture trusses with punched metal plates.

BS EN 519: Softwood grades for structural use-sets out the basic rules for stress grading timber, including an explanation of and limits for visual defects.

BS6399: Part 1: Code of Practice for dead and imposed loads - stipulates the intensity of load that structures should be designed for.

BS6399: Part 3: Code of Practice for imposed roof loads - colloquially referred to as the snow code, this document gives detailed guidance on the snow loads to be used in the design of a roof, in particular drift loads.

BS6399: Part 2: Wind Loads - provides data to enable an assessment of the wind loads on a structure.

BS648: Schedule of weights of building materials - gives typical recognised weights for materials.

The manufacture and design of trussed rafters is reliant upon computer software. The programs are complex and revisions take time to introduce. It is not always feasible, therefore, for revisions to be implemented on the day an amendment to a Code is issued.

Design Responsibilities

To avoid misunderstanding and confusion, it is essential that in contracts involving trussed rafters both the supplier and customer clearly understand the legal responsibilities of each party.

On every project, no matter how small, a person must be given the overall responsibility of Building Designer and clearly defined as such. As this person requires detailed knowledge of the design assumptions for the entire building it is generally impractical for the Trussed Rafter Designer or Roof Designer to assume this role. To assist in the clear understanding of the above functions, the definitions of the various parties involved is stated.

The Building Designer may be the owner of the building, his appointed architect, a structural engineer appointed by the owner or his architect or, in the case of small buildings, the actual builder. The Building Designer should ensure that the design of the roof as a whole, and its connection to, and compatibility with, the supporting structure and adjacent elements of the building are satisfactory with regard to the overall stability of the complete structure. The Building Designer should note also any stability requirements specified by the Trussed Rafter Designer and should ensure that these requirements are incorporated in the complete structure.

The design of the roof should be checked by the Building Designer to determine if an adequate margin of safety exists against uplift due to wind forces and, when required, adequate holding down fixings are specifiedfor both the trussed rafters and the wall plates or bearings. The Building Designer is responsible for detailing the bracing necessary to provide the restraintsrequired by the Trussed Rafter Designer.

TRUSS MECHANICS, MATERIALS AND RESPONSIBILITIES

The Trussed Rafter Designer designs and details the individual trussed rafters, clearly stating their size, loading and support conditions, stating the points of lateral restraint required to prevent buckling of compression and rafter members and, where necessary, internal members. The Trussed Rafter Designer should receive information from the client or his agent as listed in Clause 11.1 of BS5268:Part 3 and provide information in return as listed in Clause 11.2 (Further guidance is given in Section 8). The Trussed Rafter Designer is usually the truss fabricator and his supporting System Owner.

The Roof Designer may be appointed by the Building Designer to carry out that part of the Building Designer's duties which relate to the roof structure. The Roof Designer would normally liaise with the Trussed Rafter Designer to ensure that all structural aspects of the roof are considered. He would also require information from the Building Designer with regard to wind loading, location and size of shear or buttressing walls and deflection criteria.

It is recommended that the above terms of Building Designer, Trussed Rafter Designer and Roof Designer are used in contractual documents for the sake of clarity of meaning.

ROOF AND TRUSS FORMATIONS

Following an introduction to basic roof and truss shapes, common modifications are discussed along with factors which influence the choice of truss. Detailed guidance on forming the roof is given in Section 4, in particular hip systems and roof intersections.

Roof Shapes

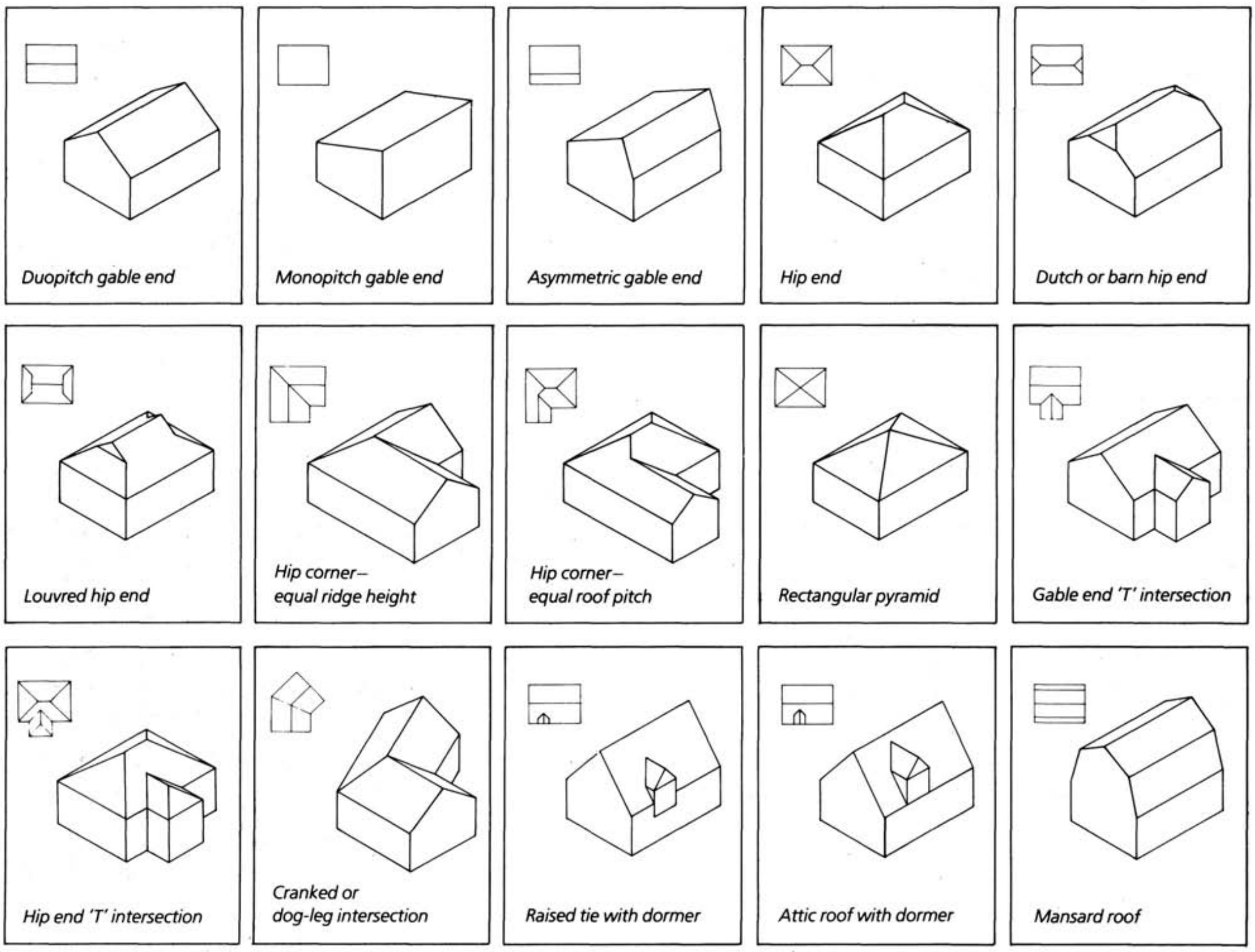
It is now fully accepted that trussed rafters provide an economic structural roof solution. With more emphasis being place on the appearance of buildings they also allow the architect virtually free expression when designing the roofscape.

Domestic Roofs - Roofs for housing and similar type buildings may be a variety of shapes. The shapes are dictated primarily by the floor plan, followed by architectural and engineering considerations. Illustrated in Figure 2.01 are some of the more common basic shapes which can occur in isolation or in combination with other shapes.

Commercial and Industrial Roofs - In principle, the variety of shapes and layouts depicted for domestic type roofing apply also to commercial and industrial buildings. Spans may, however, be larger and loads considerably higher, making it necessary to treat eac project on its merits.

Ideally the Gang-Nail fabricator should be consulted at the feasibility stage.

FIGURE 2.01 *BASIC ROOF SHAPES*

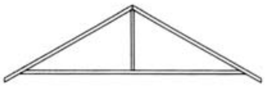


ROOF AND TRUSS FORMATIONS

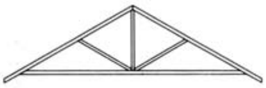
Truss Shapes and Spans

The selection of truss shape is dependent on span, loadings, rafter alignment (discussed later) and timber size limitations. It is therefore best left to the fabricator to decide on the profile to be used. As an indication, however, the most common truss profiles are shown in Figures 2.02 and 2.03. The normal economic span is shown, although greater spans can be achieved.

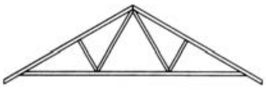
FIGURE 2.02 *DUOPITCH TRUSSED RAFTERS*



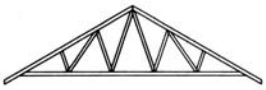
King Post Truss
Spans up to 4.5 metres.
Used primarily in house and garage construction.



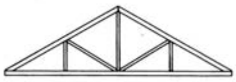
Queen Post Truss
Spans up to 6 metres.
Domestic type structures.



Fink Truss
Spans up to 11 metres.
The most commonly used truss shape. Easily accomodates a water tank.



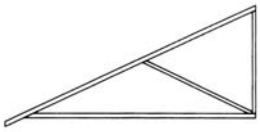
Double W
Spans up to 16 metres.
Used primarily in commercial buildings.



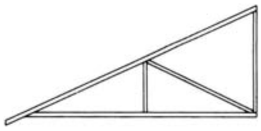
Howe Girder
Spans up to 8 metres.
Used as a girder to support other trusses or loose infill.

The names for monopitch trussed rafters are derived from the number of bays the top and bottom chords are divided into. For example, a 2 on 1 (or 2/1) will have 2 top chord bays and 1 bottom chord bay.

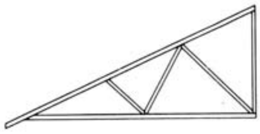
FIGURE 2.03 *MONOPITCH TRUSSED RAFTERS*



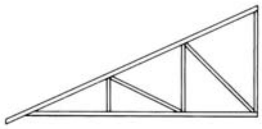
2/1 Mono
Spans up to 2.5 metres. Used on hip ends and lean to roofs.



2/2 Mono
Spans up to 4.5 metres. Used on large span hip ends and spanning onto fire walls.



3/2 Mono
Spans up to 6.0 metres.
Used back to back onto central corridor.



3/3 Mono
Spans up to 8.0 metres.
Used on monopitch roofs.

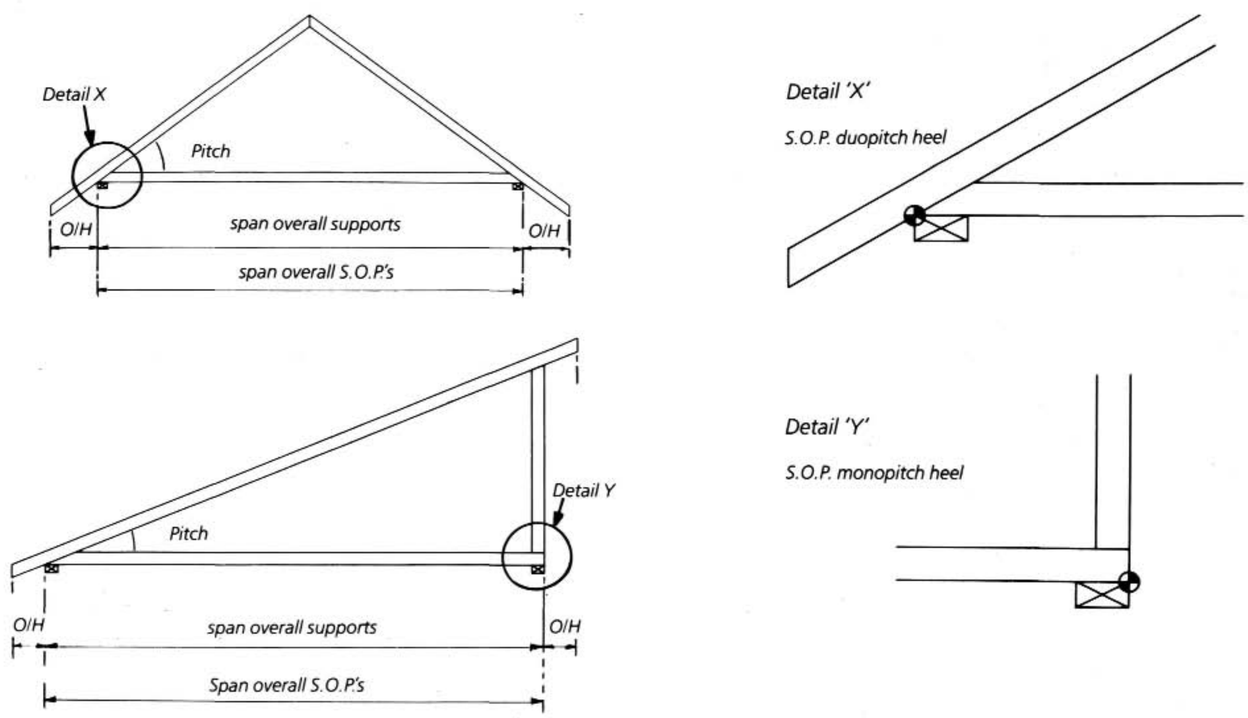
The required dimensions and reference points for duopitch and monopitch trussed rafters are shown in Figure 2.04. It is worth emphasising the following points:

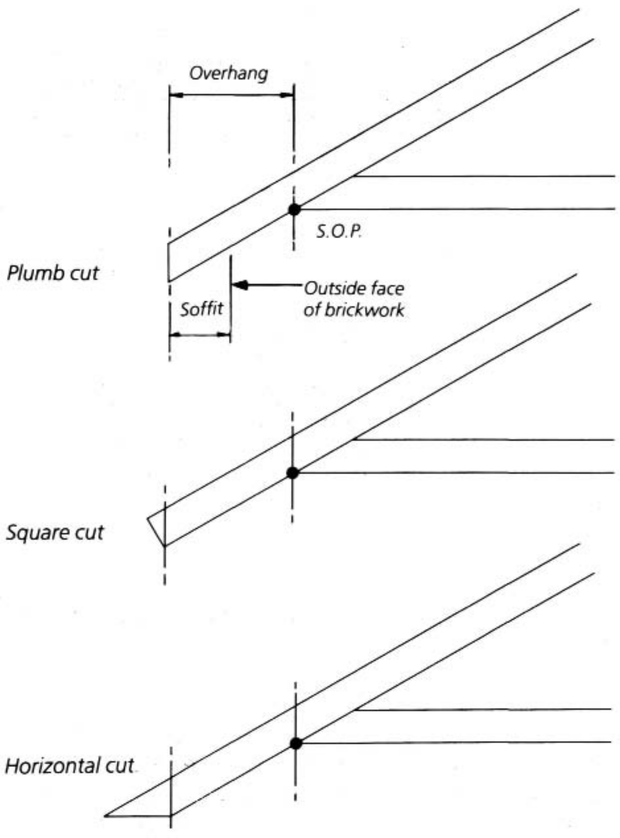
(1) The outside face of the wall plate is oftenlocated at the Setting Out Point (S.O.P.) and consequently span overall supports equals span overall S.O.P.'s. The two spans should however be thought of as being separate since in all modified trusses they will not be equal.

(2) The overhang and soffit width are not the same dimension. Both are measured to the back of the fascia, but the former is from the S.O.P. and the latter the outside face of the brickwork. For trussed rafters, the required overhang dimension and end cut should be given.

ROOF AND TRUSS FORMATIONS

FIGURE 2.04 *DIMENSIONING DUOPITCH AND MONOPITCH TRUSSED RAFTERS*





Common Truss Modifications

Increasingly, on domestic and on most commercial/industrial projects, standard trusses must be modified to suit architectural and structural requirements. Stubbed, cantilevered and extended chord trusses are by far the most common modifications required and these are discussed in detail.

Stubbed Trusses

Where a full profile truss is truncated, as in Figures 2.05 and 2.06, it is referred to as a stubbed truss. Since stubbed trusses usually occur with full profile trusses, they are normally derived from the geometry of the profile truss (e.g. Truss B in Figure 2.05). This is for several practical and economic reasons:

(1) Helps to maintain rafter alignment (see later).

(2) Minimises production 'downtime' in resetting the jig, since only a few adjustments are required.

(3) The majority of timber components are common to trusses A and B, which reduces cutting time.

(4) Alignment of webs helps detailing and installation of the stability bracing and services.

ROOF AND TRUSS FORMATIONS

FIGURE 2.05 *STUBBED TRUSSES AT RE-ENTRANT AREA*

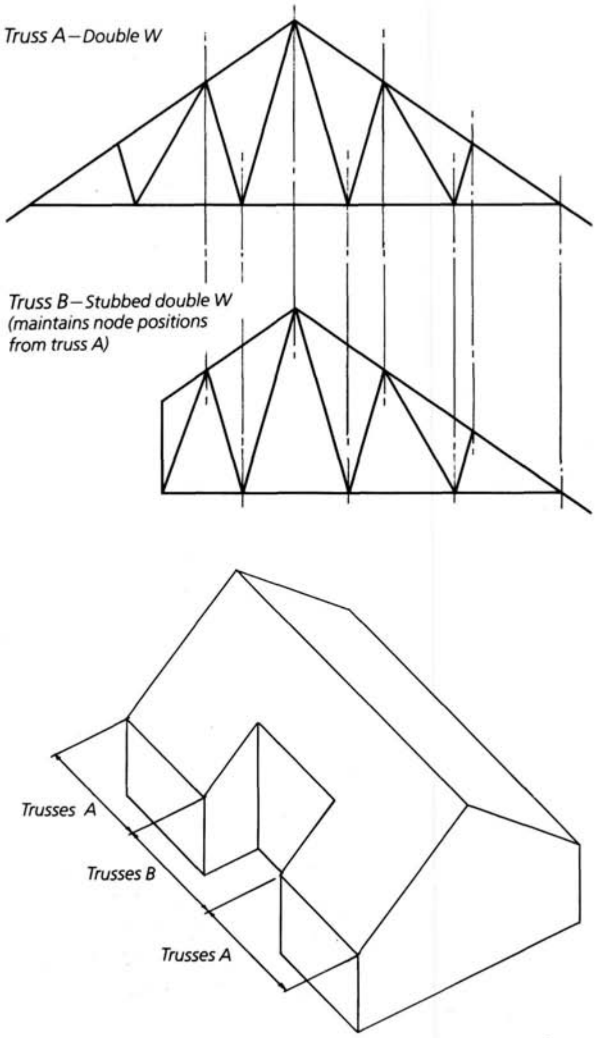
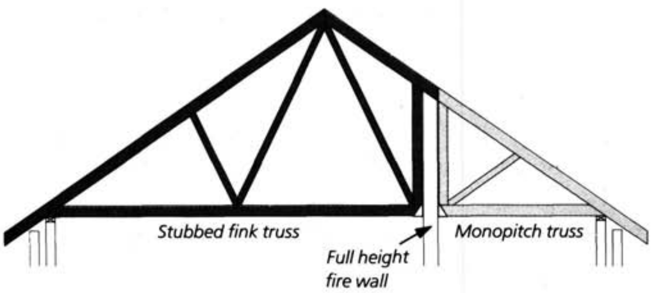


FIGURE 2.06 *STUBBED TRUSS AT FIRE WALL*



To be specific, stubbed trusses should be referred to as, for example, stubbed fink or stubbed 2 on 2 monopitch trusses, depending on the profile they are derived from.

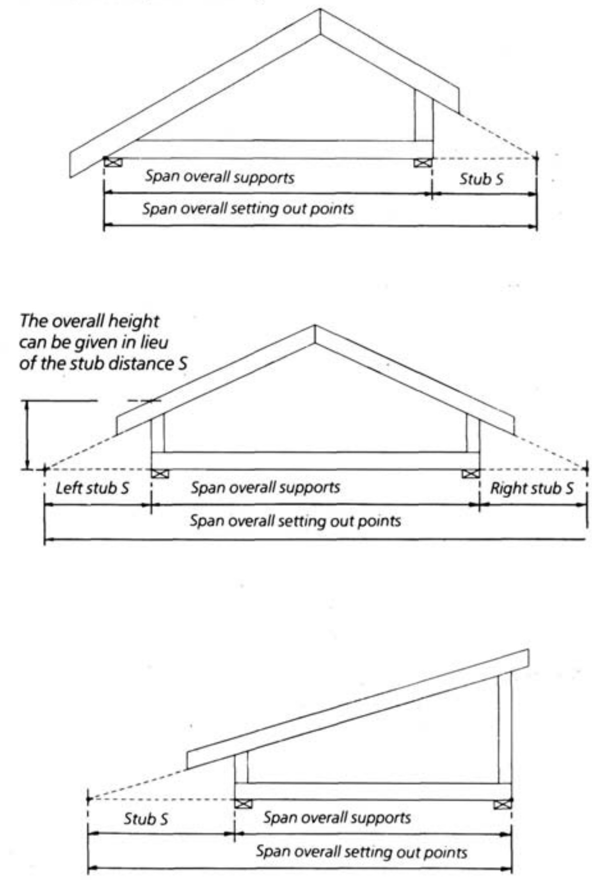
In the rare cases of stubbed trusses occurring in isolation, it may be advantageous to produce a special design with the nodes adjusted to balance the chordbay lengths.

There are no limitations on the amount trusses can be stubbed but, to prevent large uplift forces occurring, an approximate 'rule of thumb' is to ensure the final span is not less than the height of the truss.

When specifying stubbed trusses, the dimensions given in Figure 2.07 should be stated. The span over setting out points allows a check to be made that the other dimensions are correct and no misunderstandings have occurred.

FIGURE 2.07 *DIMENSIONING STUBBED TRUSSED RAFTERS*

N.B. State also required overhang



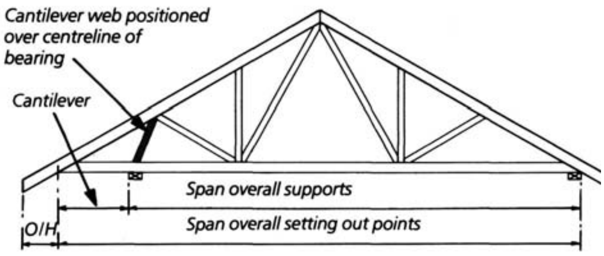
A range of support and end conditions are described in Section 5.

Cantilevered Trusses

A cantilevered truss occurs where the main body of the truss, not just the rafter overhang, projects outside the support, as shown in Figure 2.08. When referring to cantilevered trusses, the profile name should be used. For example, Figure 2.08 shows a cantilevered fan truss. All the standard profiles can be cantilevered at one or both ends.

ROOF AND TRUSS FORMATIONS

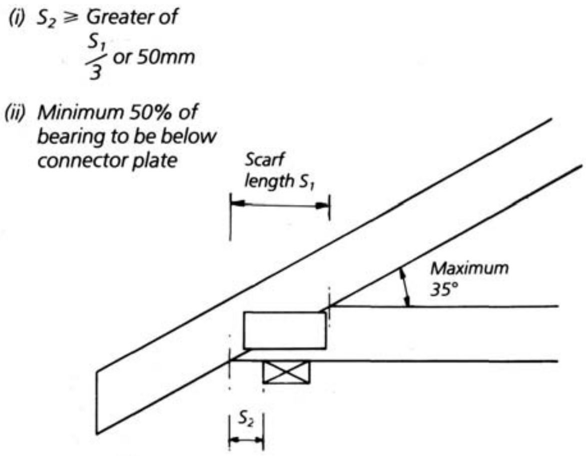
FIGURE 2.08 *CANTILEVERED TRUSSED RAFTER*



The structural treatment of cantilevered trusses varies with increasing cantilever distance:

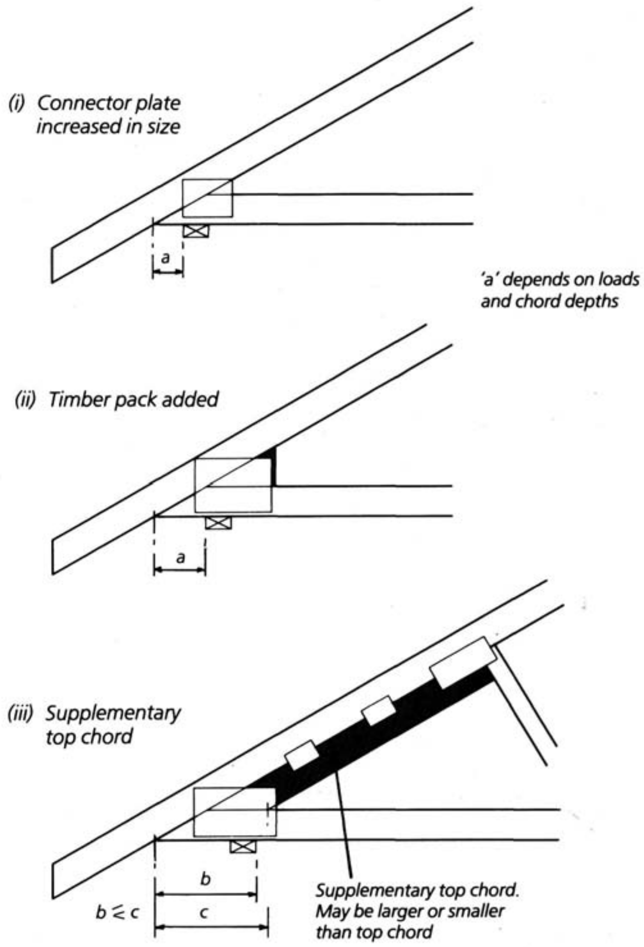
(1) Standard Heel
BS5268:Part 3: permits a small cantilever on normal heel joints without further modification, as shown in Figure 2.09.

FIGURE 2.09 *ALLOWABLE BEARING SHIFT*



(2) Modified Heel
In some instances, cantilevers greater than (1) can be accommodated by modifying the heel joint, as shown in Figure 2.10. Limitations depend on loads and timber sizes, but the support will always be local to the heel joint.

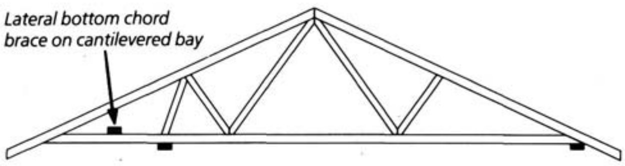
FIGURE 2.10 *HEEL DETAILS MODIFIED TO ACCOMMODATE CANTILEVER*



(3) Cantilever Web
Where the support occurs outside of (1) and (2), a cantilever web is added to strengthen the bottom chord, as shown in Figure 2.08. The maximum cantilever distance permitted is normally limited to the lesser of a quarter of the setting out points span, or the first internal node point.

In some instances a cantilever causes the outer bottom chord bay to be in compression and a lateral brace may be required, as shown in Figure 2.11. The Trussed Rafter Designer will advise when this is to be provided.

FIGURE 2.11 *BRACING TO CANTILEVERED BOTTOM CHORD BAY*



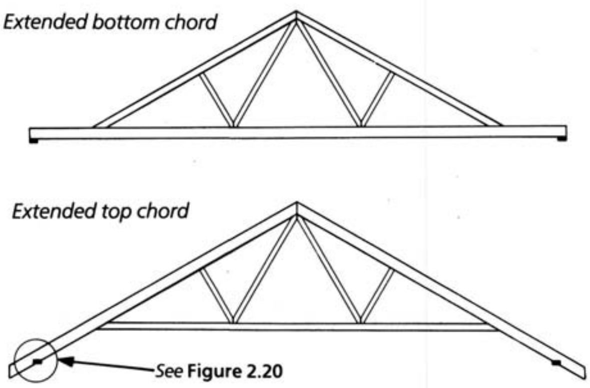
ROOF AND TRUSS FORMATIONS

When specifying cantilevered trusses, the dimensions given in Figure 2.08 should be provided. Since traditionally the cantilever distance has been measured to either the centreline or the outside face of the wall plate, all the dimensions shown should be provided to ensure no misunderstanding occurs.

Extended Chord Trusses

Extended chord trusses occur in two principal forms, either extended top chords or extended bottom chords, as shown in Figure 2.12. In both cases, the support occurs on the extended member. They are predominantly used in conjunction with the fink or queen post truss but, with the exception of scissor and flat trusses, can be applied to other truss families.

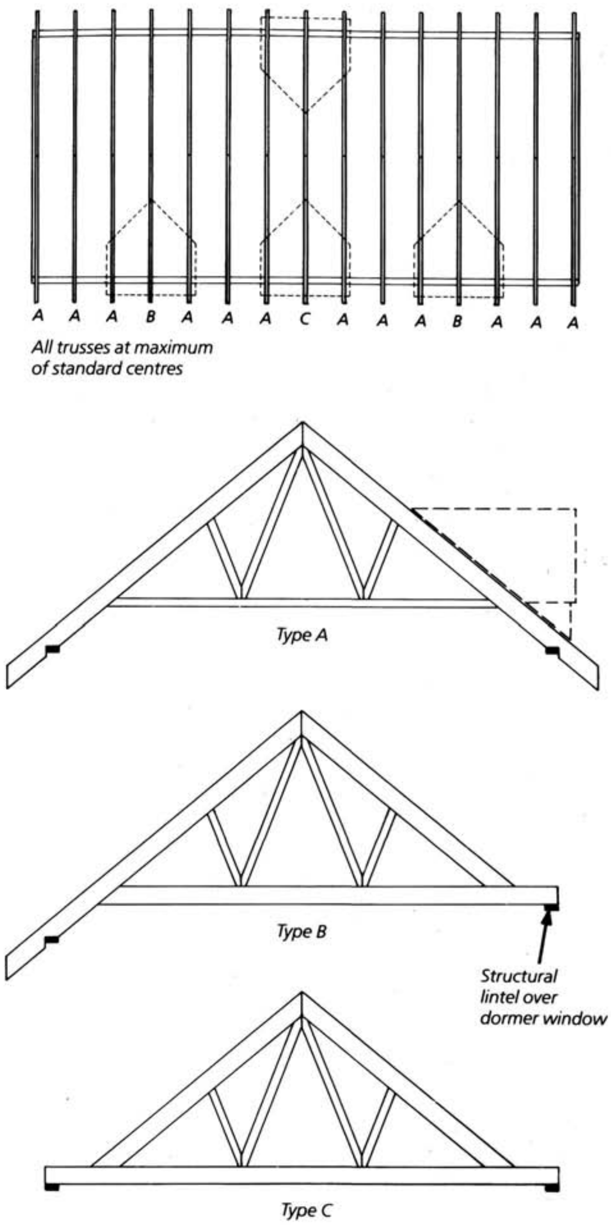
FIGURE 2.12 *EXTENDED CHORD TRUSSES*



Since the bottom chord, or tie member, does not occur at wall plate level but is raised, extended top chords are commonly referred to as raised tie trusses. The lower eaves height produces a cottage effect, allowing the new structure to blend in with period properties and, consequently, is attractive to some planning authorities. Other applications are to allow increased internal room height or as a design feature.

The extended bottom chord is normally used over dormer windows in raised tie roofs, as shown in Figure 2.13. It is also useful where the distance between the support wall varies. Designed for the maximum case, the extended leg can be cut back on site to take up the reducing span.

FIGURE 2.13 *APPLICATION OF EXTENDED CHORD TRUSSES*



ROOF AND TRUSS FORMATIONS

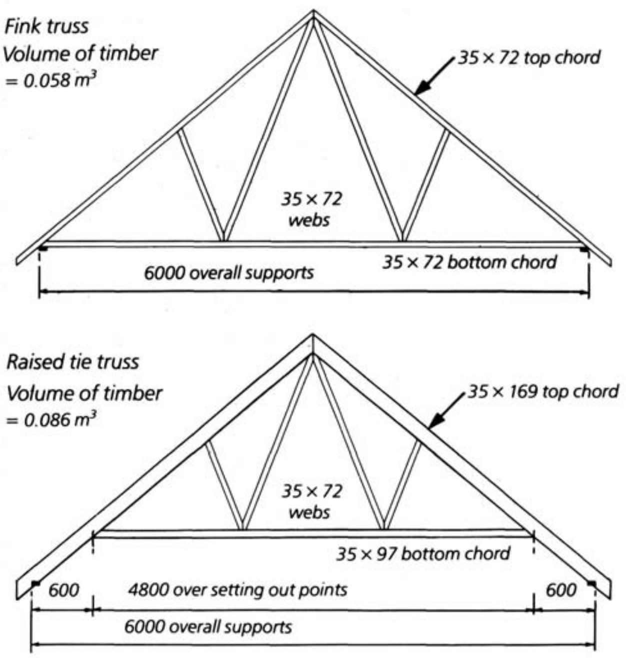
Hip end and roof intersections present specific problems and should be discussed with a Gang-Nail fabricator.

Structurally, the extended legs support the weight of the roof and resist the large bending forces imposed upon them. Additionally, the horizontal deflections that occur on raised tie trusses must be contained to a figure the supporting structure can accept. (For most structures it is recognised that 6mm can be tolerated at each support.) To achieve this, the extended legs must be strengthened using one of the following three methods:

(1) Increased Depth of Chord

The simplest solution is to increase the depth of the extended chord member. Figure 2.14 compares a standard fink and raised tie trussed rafter of equal span. It can be seen that the top chord has increased from 72mm to 169mm in depth.

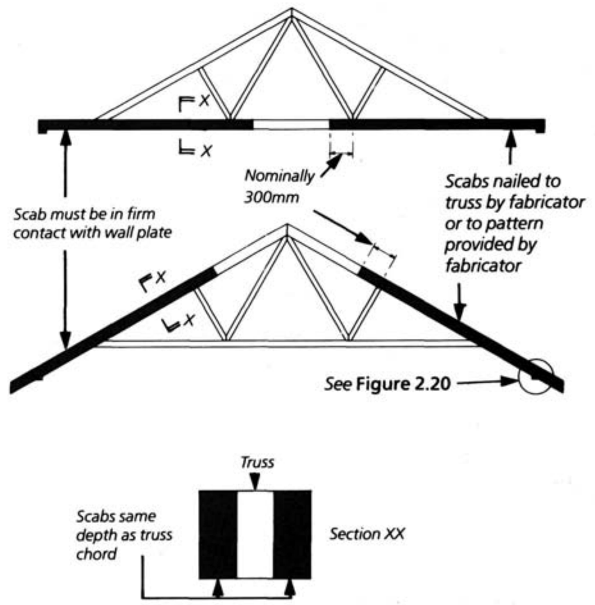
FIGURE 2.14 *COMPARABLE FINK AND RAISED TIE TRUSSED RAFTERS*



(2) Add Scabs

The extended chord can be reinforced by nailing or bolting additional members (scabs) to it, as shown in Figure 2.15. Repeating the above example results in a 145mm deep top chord with one scab or 120mm top chord with two scabs.

FIGURE 2.15 *REINFORCING 'SCAB' MEMBERS*



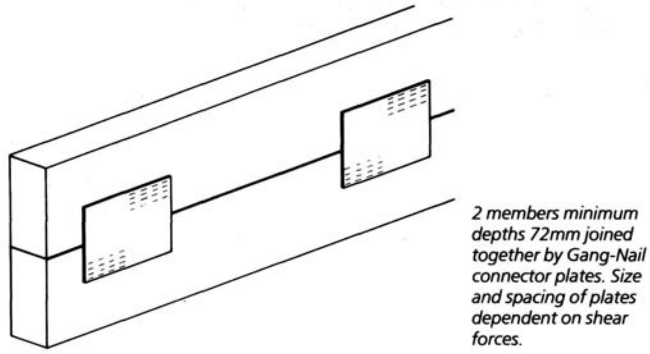
Preferably the scabs should be nailed to the truss by the fabricator, since they are a vital part of the structure and represent over 50% of the bending strength of the extended leg. Where they are to be site fixed, a nailing pattern must be obtained from the fabricator and strictly adhered to.

For some designs, bolts may be specified instead of nails. Bolts should be treated against corrosion and supplied complete with two plate washers to prevent the nut and bolt head from being drawn into the timber.

(3) Superchord

The term superchord describes deep chord structural members that are formed by stitching two smaller timber sections together using Gang-Nail connector plates, as illustrated in Figure 2.16. Whereas for solid timber the maximum sections available are 35mm x 197mm and 47mm x 244mm, superchords 35mm x 314mm and 47mm x 388mm can be produced from stock timber sizes.

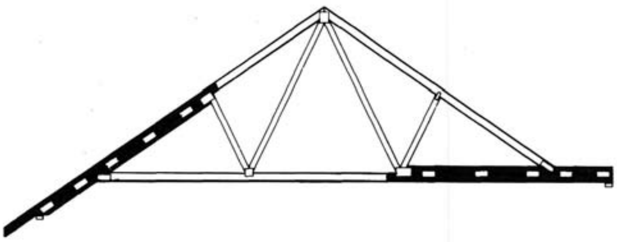
FIGURE 2.16 *SUPERCHORD*



ROOF AND TRUSS FORMATIONS

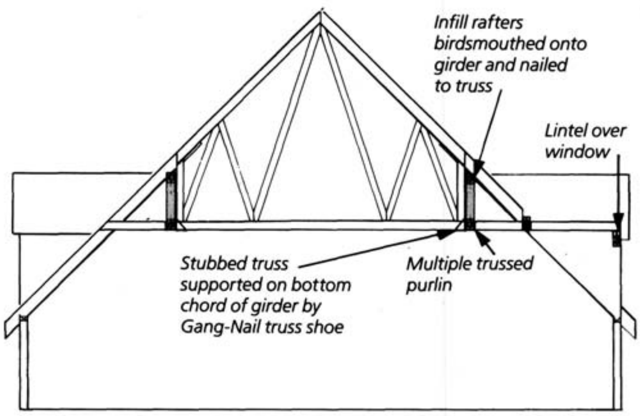
It is particularly suited to extended chord trussed rafters (Figure 2.17) offering not only significant economies in manufacture and delivery but also providing the architect with greater freedom in design.

FIGURE 2.17 *SUPERCHORD ON EXTENDED CHORD TRUSSED RAFTERS*



As an alternative to reinforcing the extended legs, it may be preferable to use cross wall construction, as shown in Figure 2.18. By supporting the body of the truss on the beams, the load is relieved from the extended leg allowing smaller timber sections to be used and longer rafter extensions.

FIGURE 2.18 *CROSS WALL CONSTRUCTION*



To specify extended chord trusses provide the dimensions, as illustrated in Figure 2.19. Try to avoid extended legs greater than 0.9m, unless alternative methods of support can be provided.

FIGURE 2.19 *DIMENSIONING EXTENDED CHORD TRUSSES*

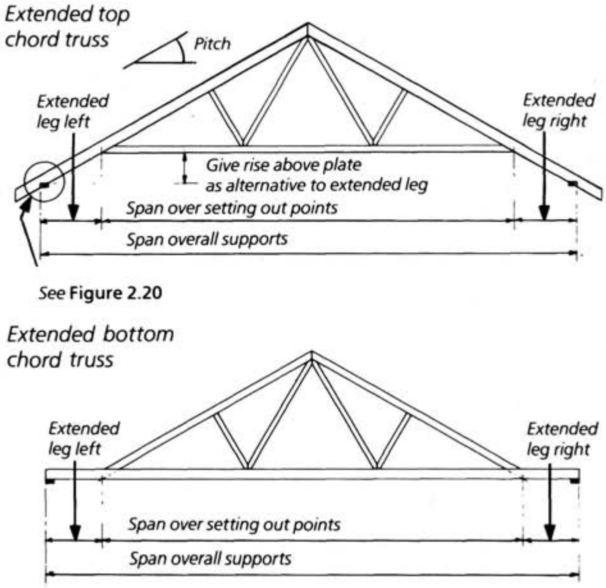
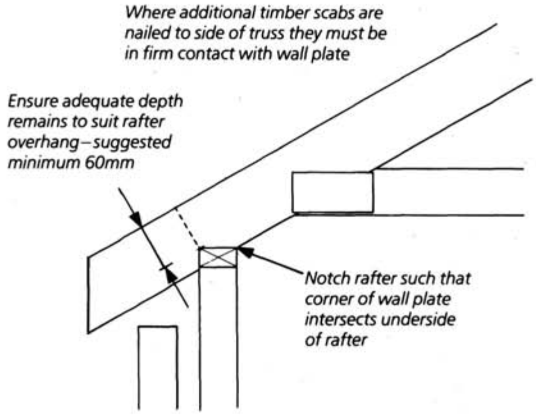


FIGURE 2.20 *RAISED TIE SUPPORT DETAIL*



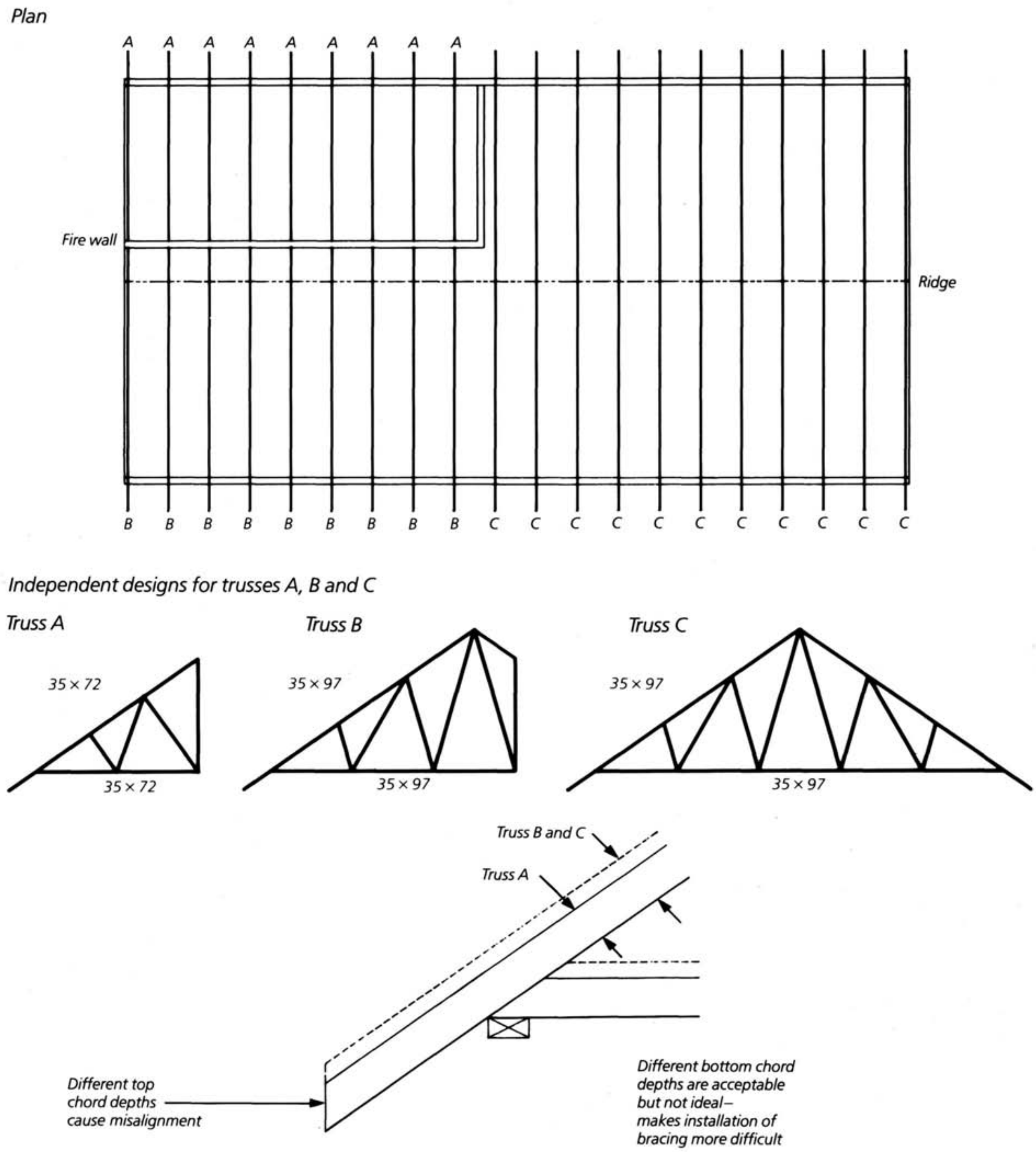
ROOF AND TRUSS FORMATIONS

Rafter Alignment

Where more than one design of trussed rafter is employed on a roof, the rafters for the various sections must align. This is referred to as line-up' and is illustrated in Figure 2.21. There are two ways to align rafters. The preferred solution, and by far the simplest, is to make the top chord depth on trusses A, B and C all the same.

The fabricator if provided with the correct information, would normally make this adjustment automatically. To compensate for the increased chord depth, truss A would be revised to a 2 on 2 monopitch profile, thereby saving a web member. The alternative solution is to cantilever truss A a sufficient distance to 'line-up' the rafter, but practical problems are such that this approach is rarely adopted.

FIGURE 2.21 *RAFTER ALIGNMENT*

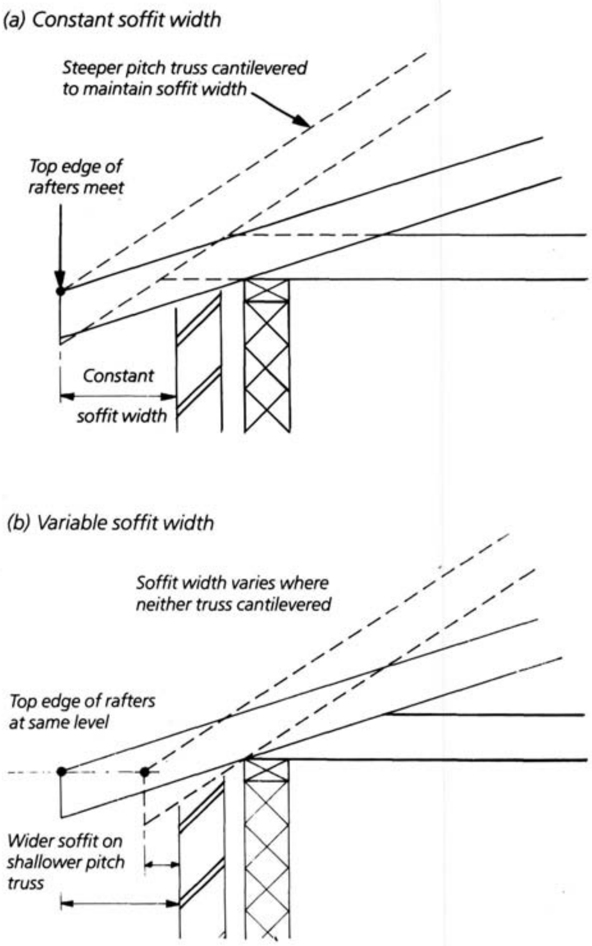


ROOF AND TRUSS FORMATIONS

Fascia Alignment

Fascia alignment on asymmetric roofs requires separate consideration. Where roofs of different pitch intersect,the fascia board is usually aligned. This can be achieved in two ways, as shown in Figure 2.22. It must be made clear to the fabricator which detail is required.

FIGURE 2.22 *FASCIA ALIGNMENT*



Timber Sections

To ensure the trussed rafter has sufficient robustness to withstand reasonable site handling, BS5268:Part3 requires that it should be a minimum of 35mm thick for spans up to 11m and 47mm thick for a 16m span.

Within and above this range of spans the minimum thickness should be obtained by linear interpolation or extrapolation. The trussed rafter may be manufactured to the required thickness as one unit or consist of two or more rafters, each not less than 35mm thick, permanently fastened together at the fabricator's works. The maximum bay and web lengths are also limited to those given in Tables 2.01 and 2.02.

TABLE 2.01: *MAXIMUM BAY LENGTH OF RAFTERS AND CEILING TIES*

Depth of member	Maximum length (measured on plan between node points)			
	35mm thick		47mm thick	
	Rafter	Ceiling tie	Rafter	Ceiling tie
mm	m	m	m	m
72	1.9	2.5	3.3	3.3
97	2.3	3.0	3.6	4.3
120	2.6	3.4	3.9	5.0
145	2.8	3.7	4.1	5.3

TABLE 2.02: *MAXIMUM LENGTH OF INTERNAL MEMBERS*

Depth of member	Maximum length (measured between node points)	
	35mm thick	47mm thick
mm	m	m
60	2.4	3.5
72	3.6	5.2
97	4.5	6.0

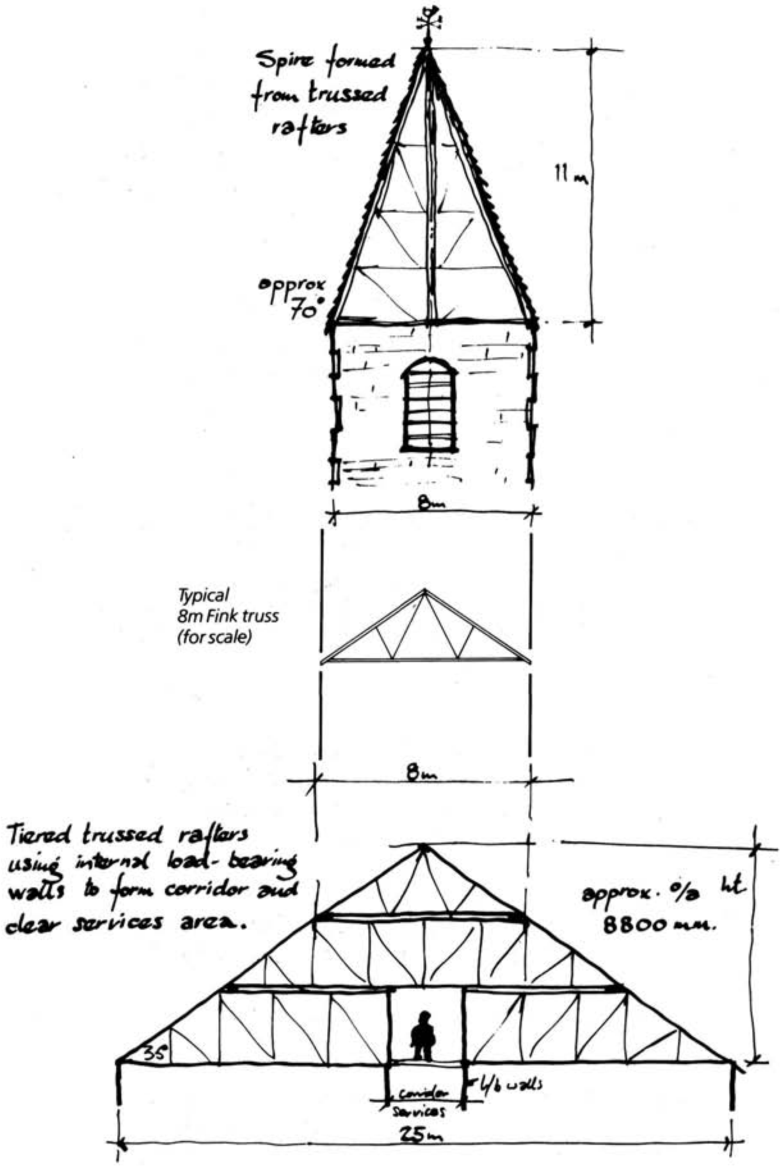
Manufacture and Delivery

To suit manufacturing and delivery requirements, the normal size range for trussed rafters in one piece is for spans up to 16 metres and heights up to 4 metres. Absolute limits depend upon available delivery routes and manufacturing equipment, and spans up to 20 metres and heights in excess of 5 metres have been achieved.

For trussed rafters manufactured and delivered in two or more parts, only design parameters limit what can be achieved as illustrated by the following examples of past jobs.

ROOF AND TRUSS FORMATIONS

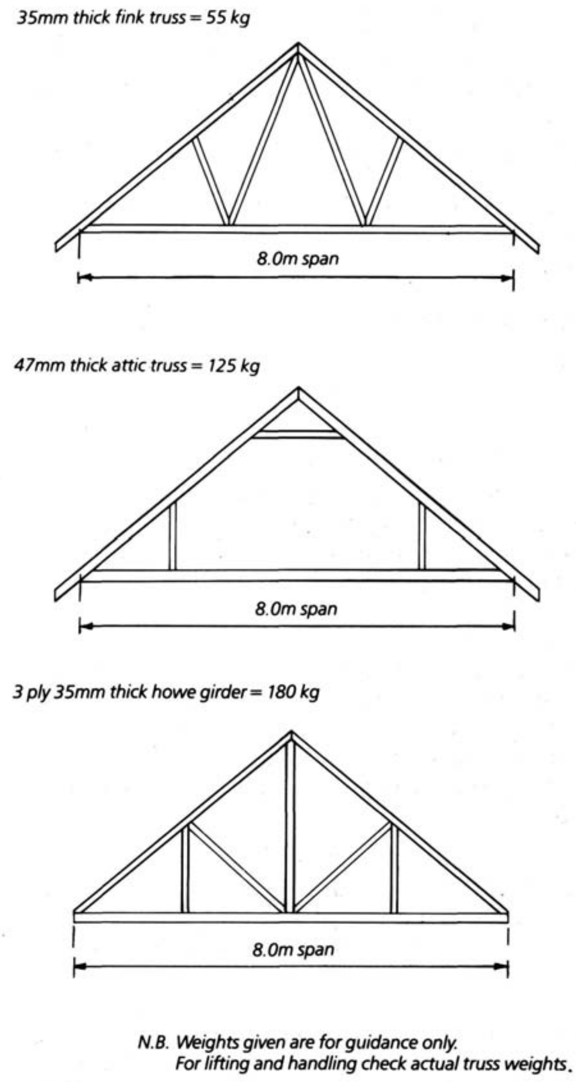
FIGURE 2.23 *EXAMPLES OF MULTIPART TRUSSED RAFTERS*



Handling and Site Access

Trussed rafters can be large, flexible, heavy units and it is important to consider the handling of them and site access at an early stage. Where cranes cannot be used, unit weight is important. Illustrated are the weights of three typical trussed rafters.

FIGURE 2.24 *TYPICAL TRUSS WEIGHTS*



DESIGN LOADS

Trussed rafters are precisely engineered structural components, the design of which is dependent on the loads adopted. The following serves to assist the specifier in understanding and evaluating design loads.

Dead Loads

Dead loads are the loads that make up the permanent structure. They include:

Roof Finishes

Roof finishes vary in weight from light aluminium sheetings which are less than 100N/m2, to natural slate tiles, such as York stone, which can exceed 2500N/m2. Manufacturers of roof tiles give 'laid weights'. BS5268:Part 3 suggests a value of 575N/m2 for common concrete interlocking tiles.
An additional allowance of 110N/m2 for felt, battens and the rafter is usually adequate. Thus, total dead load for concrete interlocking tiles is:

Laid Weight	= 575 N/m^2
Felt, Battens, Rafter	= 110 N/m^2
Total	685 N/m^2

Ceiling Finishes

A load of 250N/m2 will take account of 12mm plasterboard, skim coat, noggings, insulation and selfweight of the ceiling joist. Where suspended ceilings are proposed, laid weights should be obtained from the ceiling manufacturer.

Water Tanks

BS5268:Part 3 requires an allowance to be made for a water tank unless there is specific information to the contrary. To allow for 230 litre or 300 litre net capacity tanks, supported as described in. Section 6, a load of 900N per truss is applied as two node point loads of 450N.

In non-domestic properties where larger tanks are required, the location, size and weight of the tank must be given. For exceptionally large tanks, support independent of the trusses may be preferable.

Services

Except for special cases, such as communal heating and water systems, the loads from services on domestic structures can be ignored. On other types of building, such as hospitals, schools and offices, service loads can be significant and should be assessed.

Service layouts will be modified up to and even after installation. It is wrong therefore to specify discrete loads for which individual trusses must be designed, especially as it is difficult to ensure that the particular truss will be erected in the specified position on site. The only practical solution is to agree with the services engineer, at the outset, a uniformly distributed load to be used either over the whole roof or over specific areas. Typically a value of 250N/m2 to 500N/m2 is used. This involves a small element of overdesigning but the cost is fully recovered in the flexibility it allows the services contractor and by project time not being wasted designing remedial works to allow plant repositioning. Exceptions to a uniformly distributed load are main elements of plant, such as air handling units. For these, specific locations, weights and sizes must be given.

If a boarded walkway is to be provided in the roof void, allowing easier access for maintenance staff, the extent and detail of the walkway must be given. See Section 6 for information on support requirements.

Fittings

Where fittings are to be suspended from or supported by the trussed rafters, a description and unit weight is required. Typical examples are folding partitions, chandeliers, cupolas or clock towers.

Fire Barriers

To provide a horizontal fire barrier, additional or thicker layers of plasterboard may have to be nailed to the ceiling. Vertical barriers can be achieved by nailing two layers of plasterboard to the face of a truss. In both cases the fabricator must be informed so that the extra loads are included in the design.

Imposed Loads

Imposed loads are determined according to the intended occupancy or use of a building, including the weight of moveable partitions, furniture, people, stored materials and snow on the roof.

Snow Loads

The load to be applied is detailed in BS6399:Part 3.
It depends on the geographical location and altitude of the site, together with the roof geometry. This information must be provided by the specifier.

Bottom Chord Imposed Load

On the majority of roof structures a light storage load of 250N/m2 is allowed over the entire roof area. The specifier must inform the fabricator if a greater value is required. In addition, a 900N allowance for a man load must be considered, placed to give the maximum stresses. Where trusses are placed at maximum centres of 600mm and a plasterboard ceiling is applied, BS5268:Part 3 allows 25% of this load to be redistributed onto the adjacent trusses. In this event the man load allowance on any one truss becomes 675N.

Other Imposed Loads

Details of any item, from climbing ropes in schools to bath lifts in old peoples' homes, must be provided.

Wind Loads

Primarily, the effect of wind load on a roof is uplift. This is particularly true the shallower the pitch, for three reasons:
(i) Higher uplift forces occur.
(ii) Lighter forms of construction are used.

DESIGN LOADS

(iii) Reduced surface area and hence lower weight of roof structure.

The need to consider uplift was well illustrated in 'Gale damage to buildings in the UK - an illustrated review' by P.S.J. Buller, published in 1986 by the Building Research Establishment (BRE).

To enable a design check to be carried out, the specifier must give either specific wind data or the grid coordinates of the site.

It is normal practice when designing a trussed rafter to overstate the dead loads to allow for uncertainty, ultimately producing a safe structure. When carrying out a check on wind uplift this could lead to an unsafe structure, since it is the dead load that resists the uplift forces. The MINIMUM expected dead loads should therefore also be stated.

Attic Trussed Rafters-Special Loading Considerations

Attic trussed rafters support extra dead and imposed loads.

Dead Loads - Floor boarding will be required on the bottom chord and plasterboard to the walls and ceiling.

Imposed Loads - BS6399:Part 1 requires an imposed load of 1.5kN/m2 over the floor area for domestic buildings. Greater values will be required for other types of use and details should be provided by the specifier.

Loading Conditions

Timber members can, as explained in Section 1, sustain very much greater load for a period of a few minutes than for a period of several years. Where appropriate, a check is made on three periods of loading: long, medium, and short-term. These loading conditions comply with BS5268:Part 3 and are made up as follows:

Long-Term
Long-term loads comprise dead loads on the top chord and dead plus permanent imposed load on the bottom chord. The tank load, if applicable, is placed in the bay where the tank is to be situated.

Medium-Term
Long-term.loads, as above, plus the imposed top chord (snow) loading.

Short-Term
Medium-term loads, as above, plus the addition of a 900N man load modified in accordance with BS5268:Part3. The man load should be placed in any position so as to produce the maximum stress and reactions in the members.

Occasionally it is also necessary to consider wind gust forces that are very short-term. This load case therefore consists of long-term loads, as above, plus wind loads.

TABLE 3.01: SUMMARY OF LOADS AND LOAD CASES

Rafter Loads	Location	Duration
Dead		
For concrete interlocking tiles 685N/m≈ UDL (measured along the slope) or as specified	Full length	Long-term
Imposed		
Snow Load as BS6399: Part 3 (except drift loads)	Full length	Medium-term
Drift Loads	Full length	*
OR		
900N man load	Centre of Bay	Short-term
Wind		
Wind calculated according to BS6399:Part 2	Full length	Very short term

Ceiling Tie Loads

Dead	Location	Duration
250N/m≈ UDL		
PLUS	Full length	Long-term
2 x 450N concentrated loads for water tank or actual load if greater	At 2 nodes nearest water tank	
PLUS		Long-term
Service/fittings loads		
Imposed	As appropriate	Long-term
250N/m≈ UDL		
900N man load reduced where appropriate to 675N	Full length	Long-term
	Centre or either end of any bay	Short-term

* Drift loads are included in a special category of loading, termed Accidental. Accidental loads are subject to reduced factors of safety.

FORMING THE ROOFSCAPE

This section builds on the introduction to trussed rafters given in Section 2, 'Roof and Truss Formations' and provides more detailed guidance on forming the roofscape. Features, such as hips and roof intersections, are described along with trusses that require special consideration, such as the scissor and attic families.

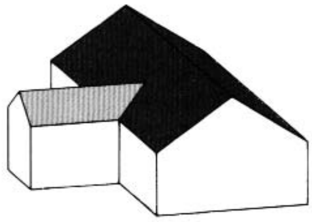
T Intersections and Valley Infill

Where two roofs intersect at 90°, a T intersection is formed. The oncoming ridge can be below, equal to, or above the main ridge, and spans and roof pitches can vary. (Figure 4.01).

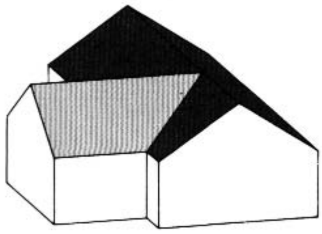
Case 1 is considered in Figure 4.02, but the principles remain the same for Cases 2 and 3. The intersection is formed by the use of diminishing valley frames, collectively referred to as a valley set.

The valley frames transfer the rafter loads down onto the underlying trusses in a uniform manner. To achieve this they require vertical webs at approximately 1200mm centres and must be erected in firm contact with each rafter they cross. Since the tile battens are omitted in the overlay roof area, supplementary members must be provided to laterally restrain the rafters of the supporting trusses. Typically, tile battens are nailed to the underside of the truss top chord, extending 1200mm beyond the valley line.

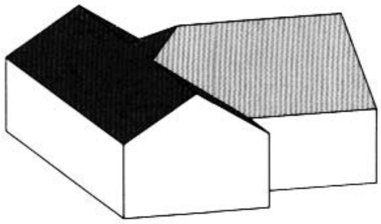
FIGURE 4.01 'T' *INTERSECTIONS*



Case 1, oncoming span below the main ridge

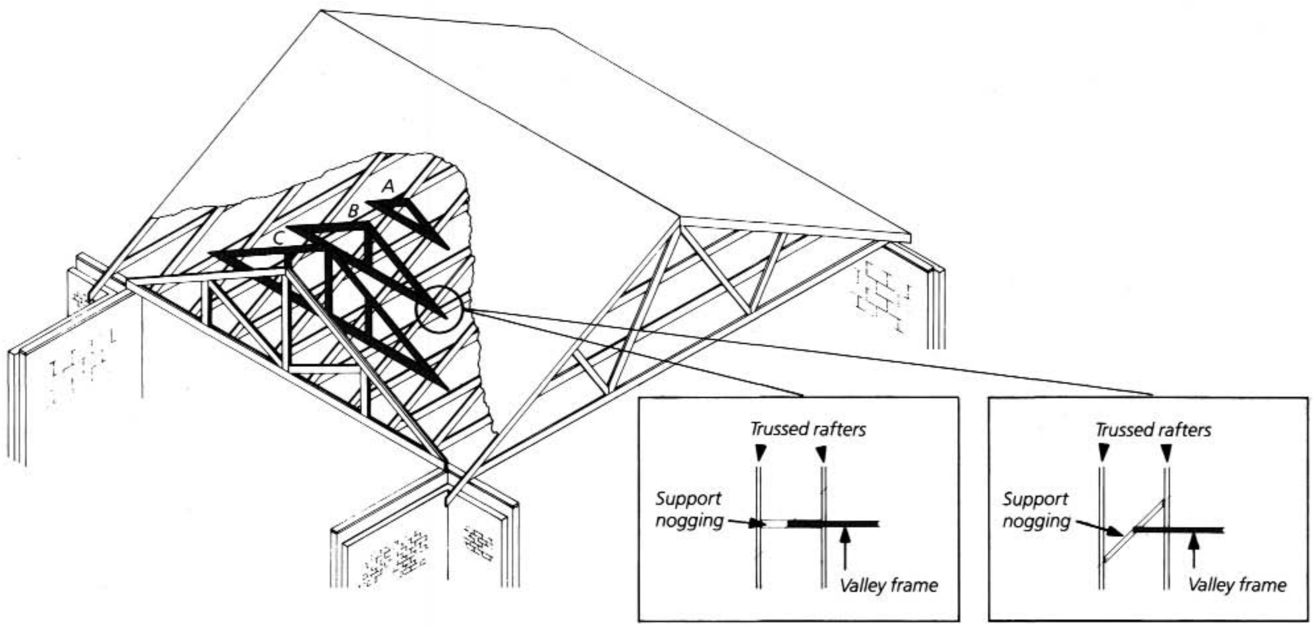


Case 2, equal ridge heights



Case 3, oncoming span above the main ridge

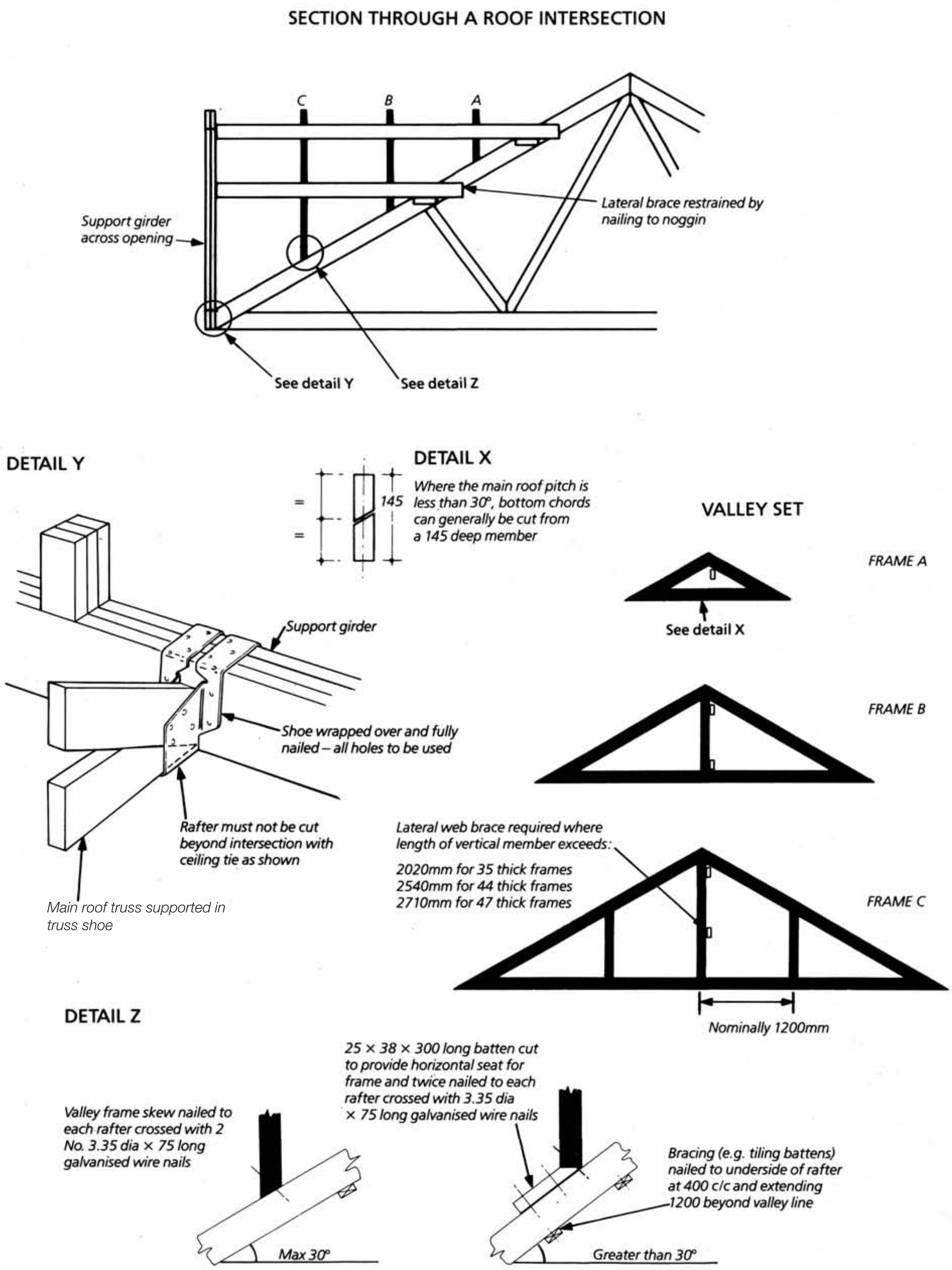
FIGURE 4.02 *ROOF INTERSECTION*



Additional support, if required, provided at ends of valley frames where these do not coincide with trussed rafters

FORMING THE ROOFSCAPE

FIGURE 4.02 *ROOF INTERSECTION*



FORMING THE ROOFSCAPE

Where there is no load bearing wall through the intersection, a girder truss will be required to carry the roof trusses over this opening, as shown in Figure 4.02. Due to the heavy loads being carried by these girders, a larger than normal bearing is often required. It is recommended that consideration be given to the desirability of using a concrete padstone for the girder support. Gang-Nail fabricators can supply information on minimum bearing areas and girder support loads for individual projects.

Valley frames are the most economic and structurally sound solution to T intersections, ensuring the load is transferred to the supporting trusses uniformly. Where the area is to be formed using site framing, it must contain a horizontal tie member and vertical posts similar to those used in the valley frame. Nailed joints are less efficient and require greater end/edge distances than Gang-Nail connector plates and consequently a 50% increase in timber depth will be required.

Hip Systems

Other than the basic gable end, the hipped roof is the most common feature being incorporated into roofs and one of the most attractive. Figure 4.03 illustrates the hip family.

General points to note are:
(1) A hip system is the collective name for a group of trussed rafters that form the hip.

(2) A hip end is a complex three dimensional framework which, for simplicity, is treated as a two dimensional problem. In design, the hip board is sized to satisfy an ultimate load criteria for safety reasons. In practice, it carries negligible load.

(3) Although hips above 12m span are common and spans of 20m have been achieved, special details may be required depending on roof pitch and the location of internal walls and consequently a Gang-Nail fabricator should be consulted at the planning stage.

(4) Generally the minimum preferred pitch is 22.5°, which allows adequate depth for the girders supporting the hip.

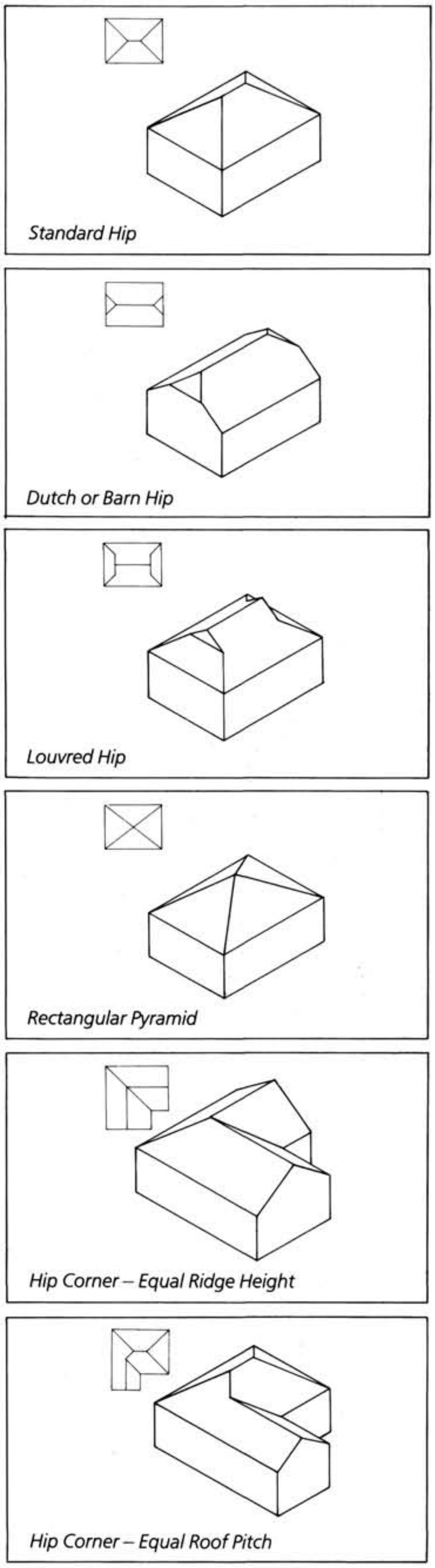
(5) Where the pitch on the end is different to that on the sides, the specifier has two options: either the steeper pitch truss must be cantilevered or the soffit width varied to maintain the eaves line (see Section 2, Figure 2.22).

(6) All normal roof finishes can be used and modifications, such as stubbed ends and small cantilevers, can be incorporated.

(7) Through discussion with the supplier, hip girders can be positioned at the design stage to avoid chimneys or to prevent large reactions occurring over windows, etc.

(8) In some instances, pre-made components can be provided to simplify and speed up the construction of the infill area.

FIGURE 4.03 *HIP FAMILY*

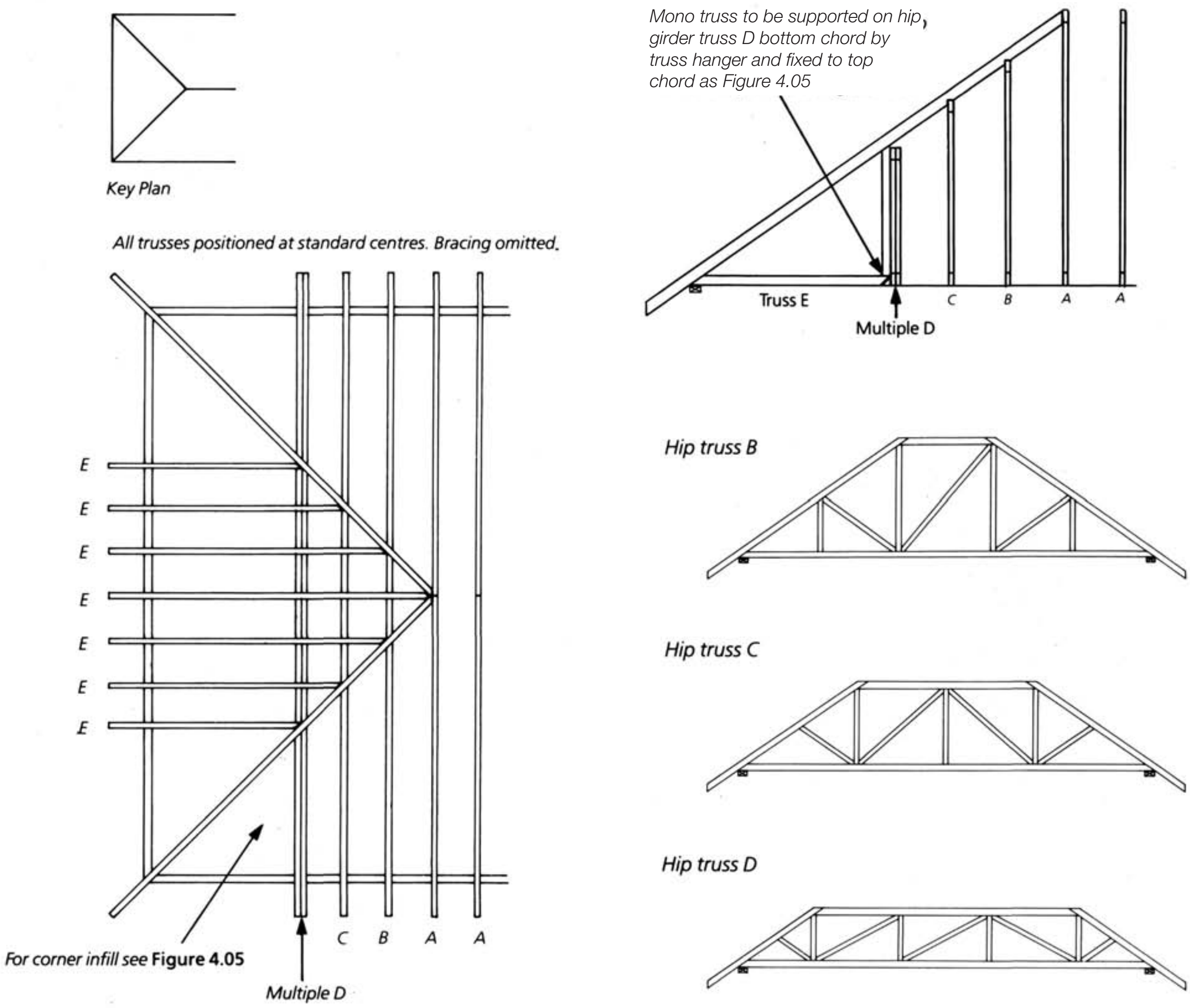


FORMING THE ROOFSCAPE

(9) Maximum economy will be achieved by allowing the fabricator to select the framing method that best suits his manufacturing process. With the exception of the site infill hip end, hip systems are all based around girder and intermediate trusses of the same profile using flying rafters. This is fully described for the standard centres hip (Figures 4.05 and 4.06). Brief details are also given for other hip systems.

The alternative to the 'flying rafter' method of constructing hips is the step-down hip. This is shown in Figure 4.04. Due to the increase in different truss profiles required, it is expensive to produce, time consuming to design, difficult to brace and therefore rarely if ever used.

FIGURE 4.04 *STEP-DOWN HIP SYSTEM*



Standard Hip End

There are five alternative methods of framing the standard hip end:

(1) Standard Centres Hip-most common up to 11m; girder position fixed.

(2) Standard Set Back Hip-similar to (1) with girder position flexible.

(3) Girder Based Hip - alternative to (1).

(4) Site Infill Hip - for small hips to 6m span.

(5) Two Stage Hip — for large hips in excess of 11 m span.

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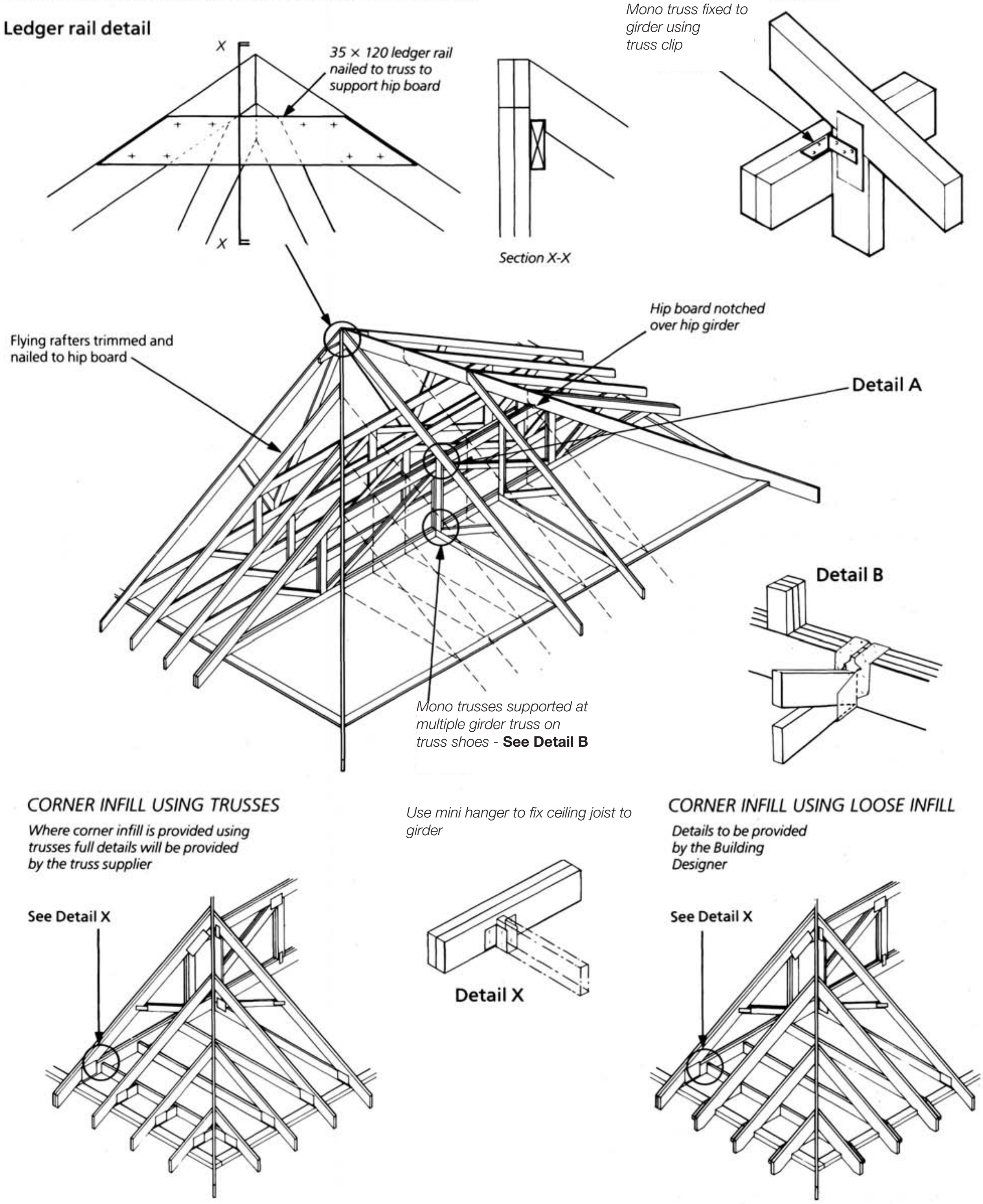
Standard Centres Hip

The most common form of construction for a hip end is the standard centres hip system. This comprises a number of identical flat top hip trusses, spaced at the same centre as the main trusses, and a multiple girder of the same profile supporting monopitch trusses off the bottom chord (Figures 4.05 and 4.06). The flying rafters on the hip and monopitch trusses are usually supplied full length and cut back on site to ensure that they meet the hip board.

FIGURE 4.05 *ISOMETRIC VIEW OF STANDARD CENTRES HIP*

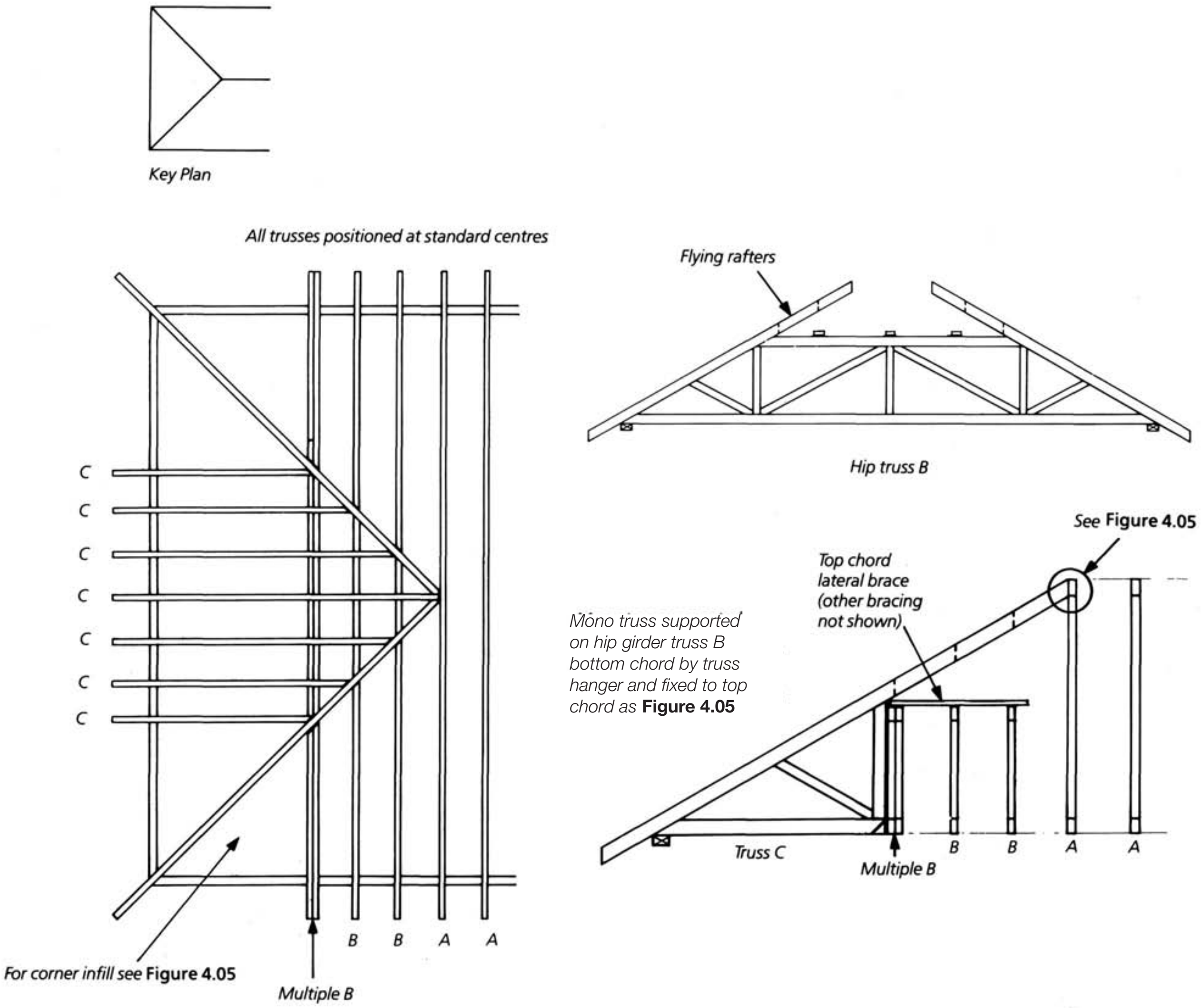


FORMING THE ROOFSCAPE

The hip board is notched over the hip girder to provide a support and taken to the apex of the hip, where it is supported on a ledger fixed to the last full profile truss.

The corner areas of the hip are completed by using site cut rafters onto the hip board and infill ceiling joists spanning onto the hip girder. The horizontal top chords of the hip trusses require lateral bracing back to the hip girder.

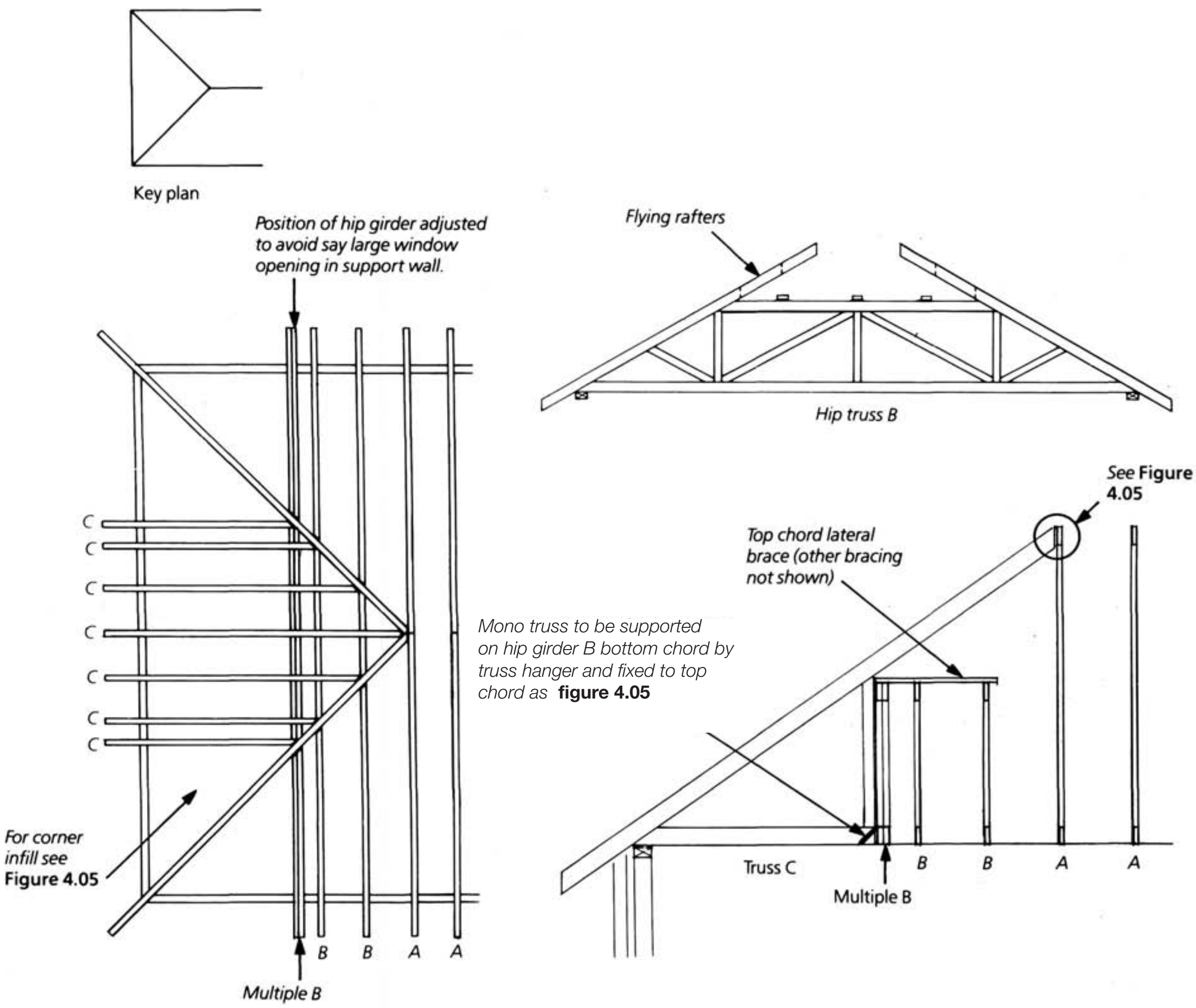
FIGURE 4.06 *STANDARD CENTRES HIP SYSTEM*



Standard Set Back Hip

The standard set back hip is virtually identical to the standard centres hip, except that the position of the hip girder can be chosen to avoid obstructions, such as chimneys, or to ensure the girder is not supported on a lightweight lintel.

FIGURE 4.07 *STANDARD SET BACK HIP SYSTEM*

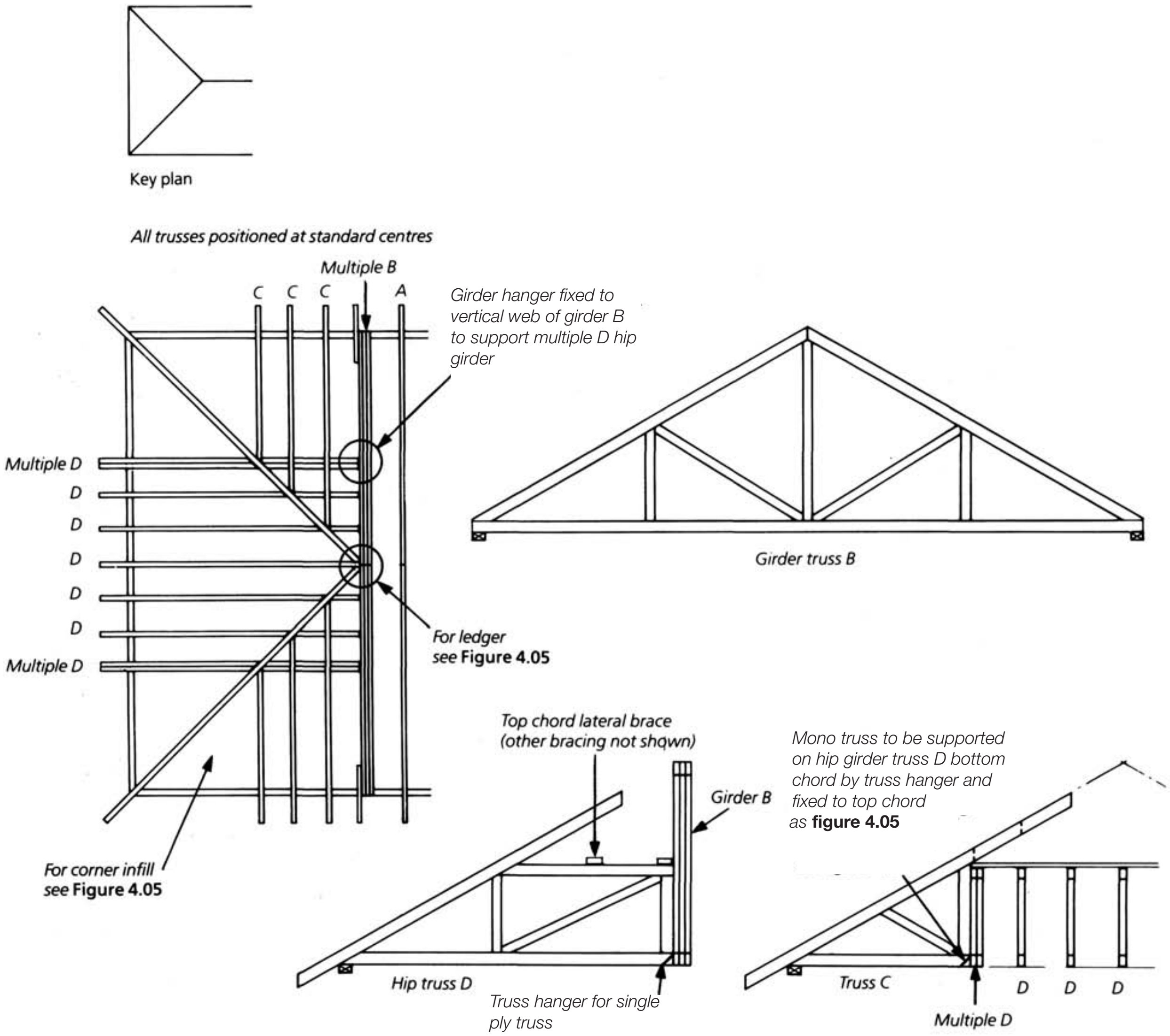


FORMING THE ROOFSCAPE

Girder Based Hip

The girder based hip is supported by a Howe girder at the apex. This, in turn, supports flat top trusses spanning from the end wall. To reduce the amount of site infill timbering, mono trusses can be used, spanning from the side walls onto a multiple flat top truss.

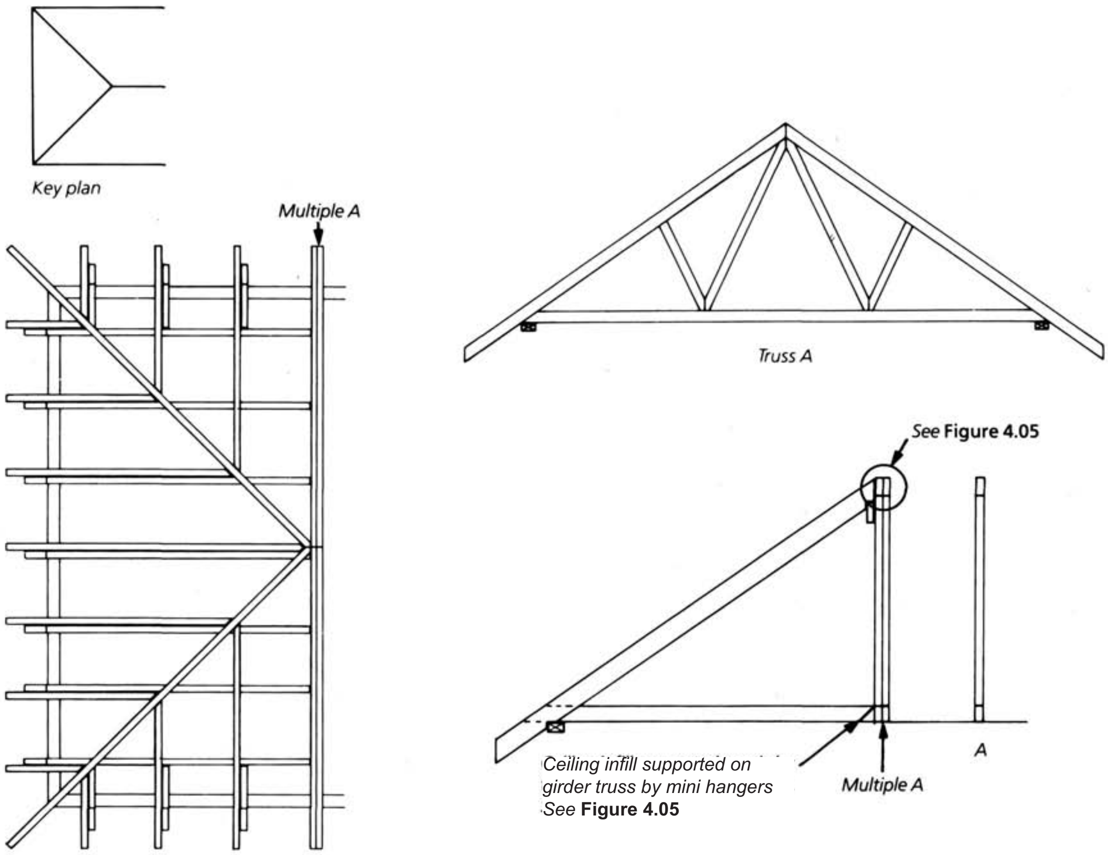
FIGURE 4.08 *GIRDER BASED HIP SYSTEM*



Site Infill Hip

The site infill hip is the basic form of hip end construction, consisting of a multiple girder at the apex position supporting the hip boards and loose ceiling joists. Site cut rafters span from the wall plate onto the hip board to form the roof slopes. No trusses are used in the hip end area. This form of construction is limited to a maximum span of 6 metres.

FIGURE 4.09 *SITE INFILL HIP END*

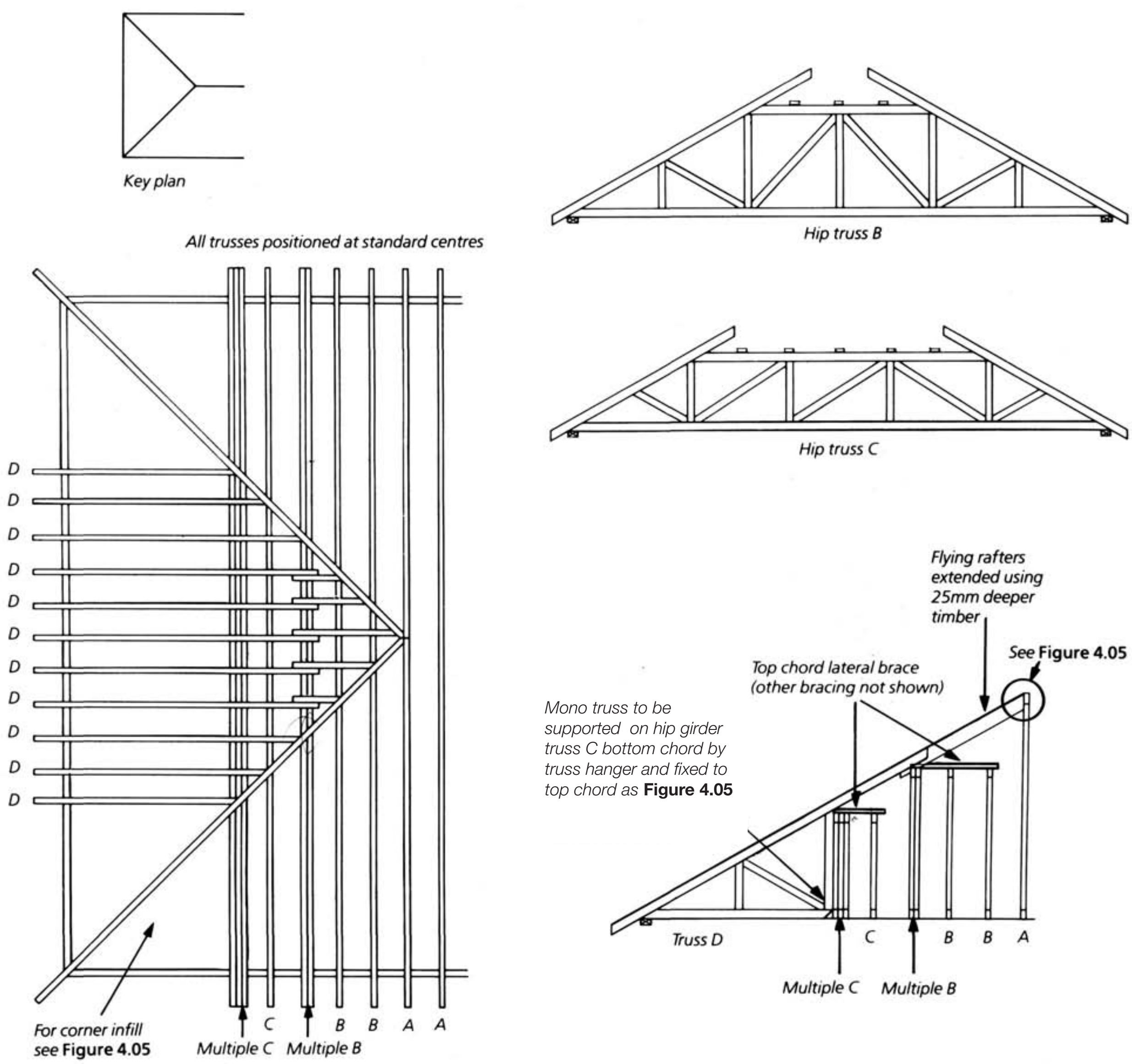


FORMING THE ROOFSCAPE

Two Stage Hip System

For spans greater than 11 m, the load on the hip girder is excessive and/or the corner infill area is too large. The two girder hip system solves both of these problems. From the framing plan it can be seen that a shallow girder is used to support the monopitch trusses and a deeper girder carries load from the flying rafters, with intermediate trusses of each profile being used.

FIGURE 4.10 *TWO STAGE HIP SYSTEM*



Dutch or Barn Hip

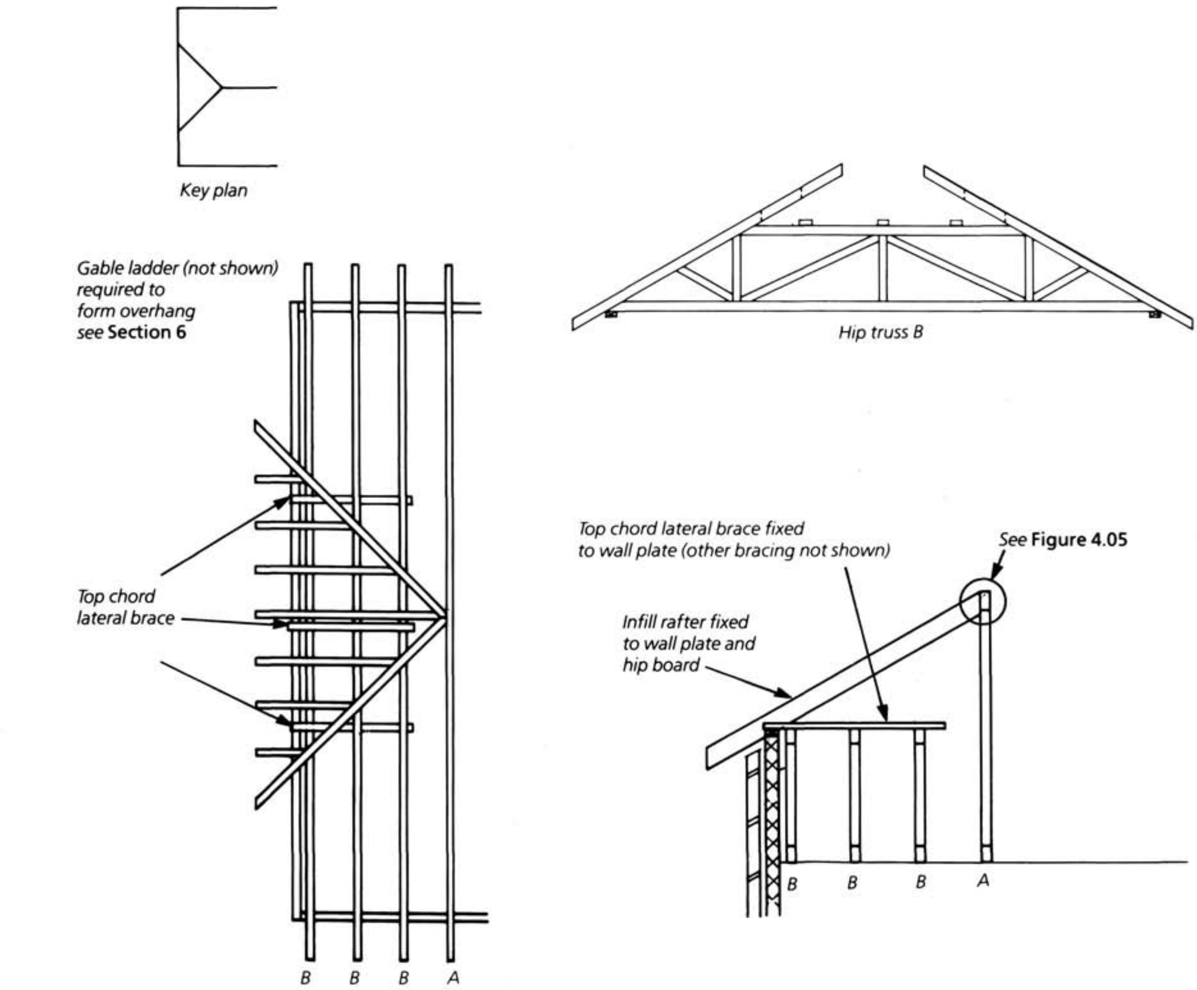
This form of hip end takes its name from the traditional Dutch barn roof. The gable wall is built up above the ceiling line and a truncated hip end formed. The result is an attractive roof line, relatively simple to achieve and falling between the gable end and hip end in terms of cost.

The trusses used in the hip section are a flat top hip truss with flying rafters cut back on site to meet the hip board.

Generally the set back (see Figure 4.11) is less than a quarter of the main span and a girder is not required; all trusses being spaced at standard centres.

The depth of the hip truss is dictated by the height above ceiling level of the gable wall. The return slope is constructed from site cut rafters, spanning from the gable wall up to the hip board. To provide lateral restraint to the top chords of the hip trusses, it is important to brace them back to the gable wall.

FIGURE 4.11 *DUTCH OR BARN HIP SYSTEM*

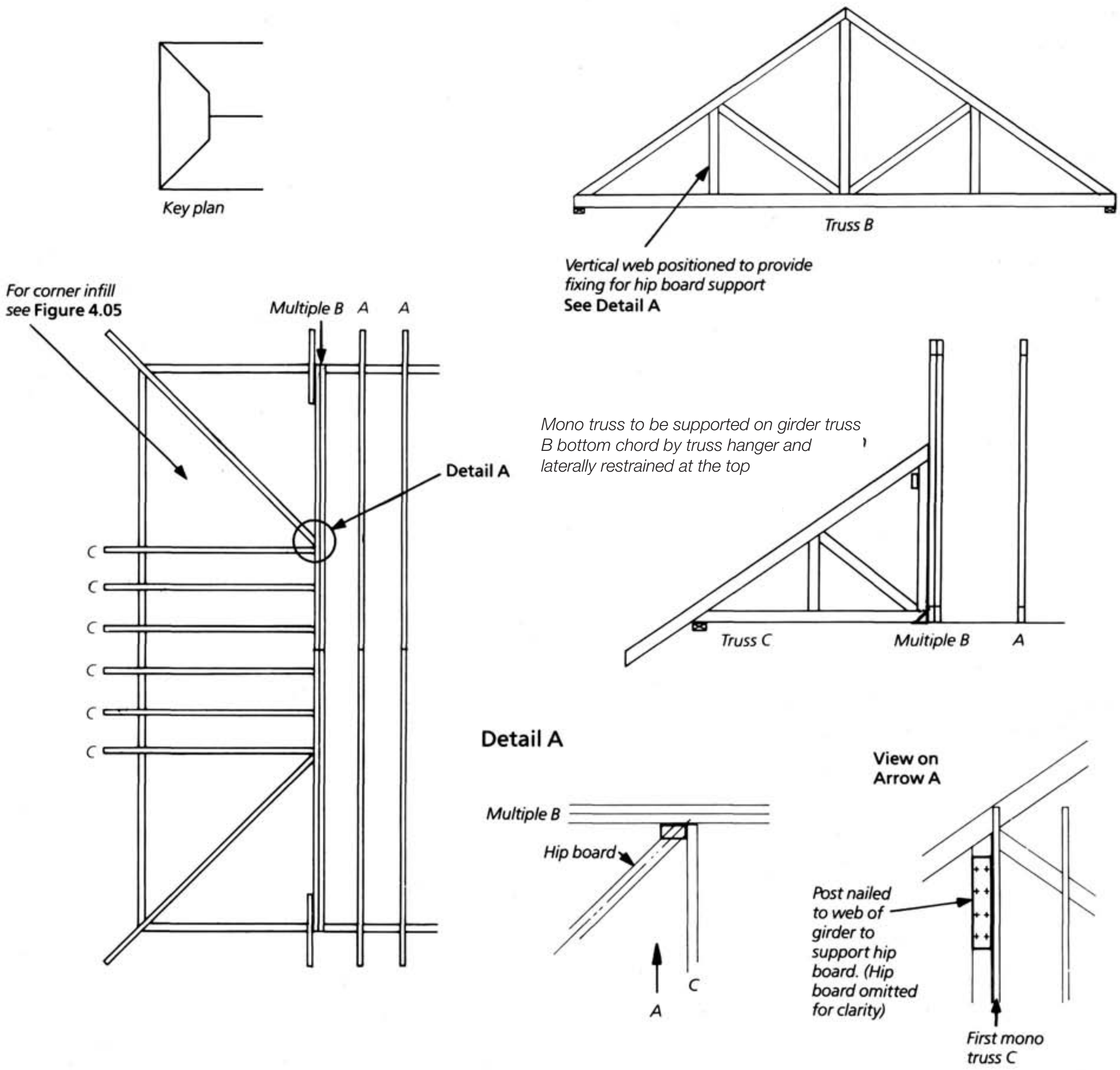


FORMING THE ROOFSCAPE

Louvred Hip

The louvred hip end is made up of the lower part of a hip end, terminated at the ridge with a vertical face. The construction is straightforward, using a girder truss at the vertical face which supports the hip monopitch trusses off the bottom chord. A vertical web is provided to support the hip board, with corner framing as for a standard hip.
The minimum span for the monopitch truss is span/4.

FIGURE 4.12 *LOUVRED HIP SYSTEM*

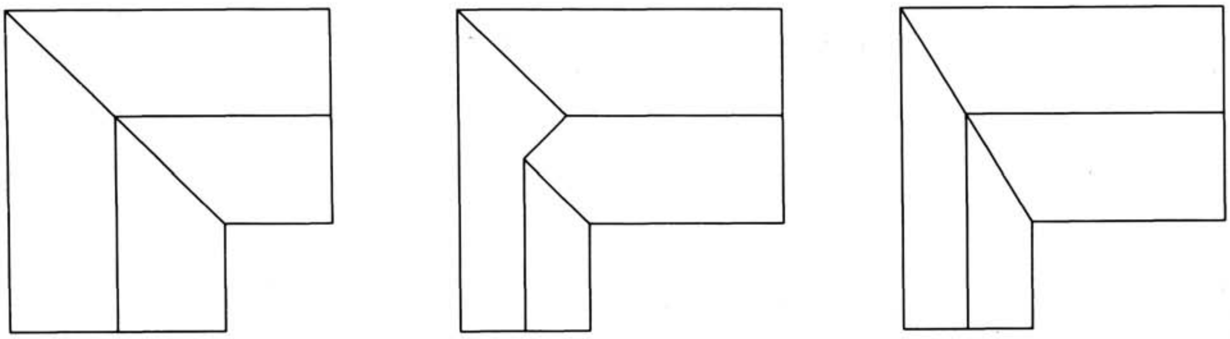


FORMING THE ROOFSCAPE

Hip Corners

A hip corner is formed when two roofs meet at right angles to each other. Common variations are shown in Figure 4.13.

FIGURE 4.13 *HIP CORNER – COMMON VARIATIONS*



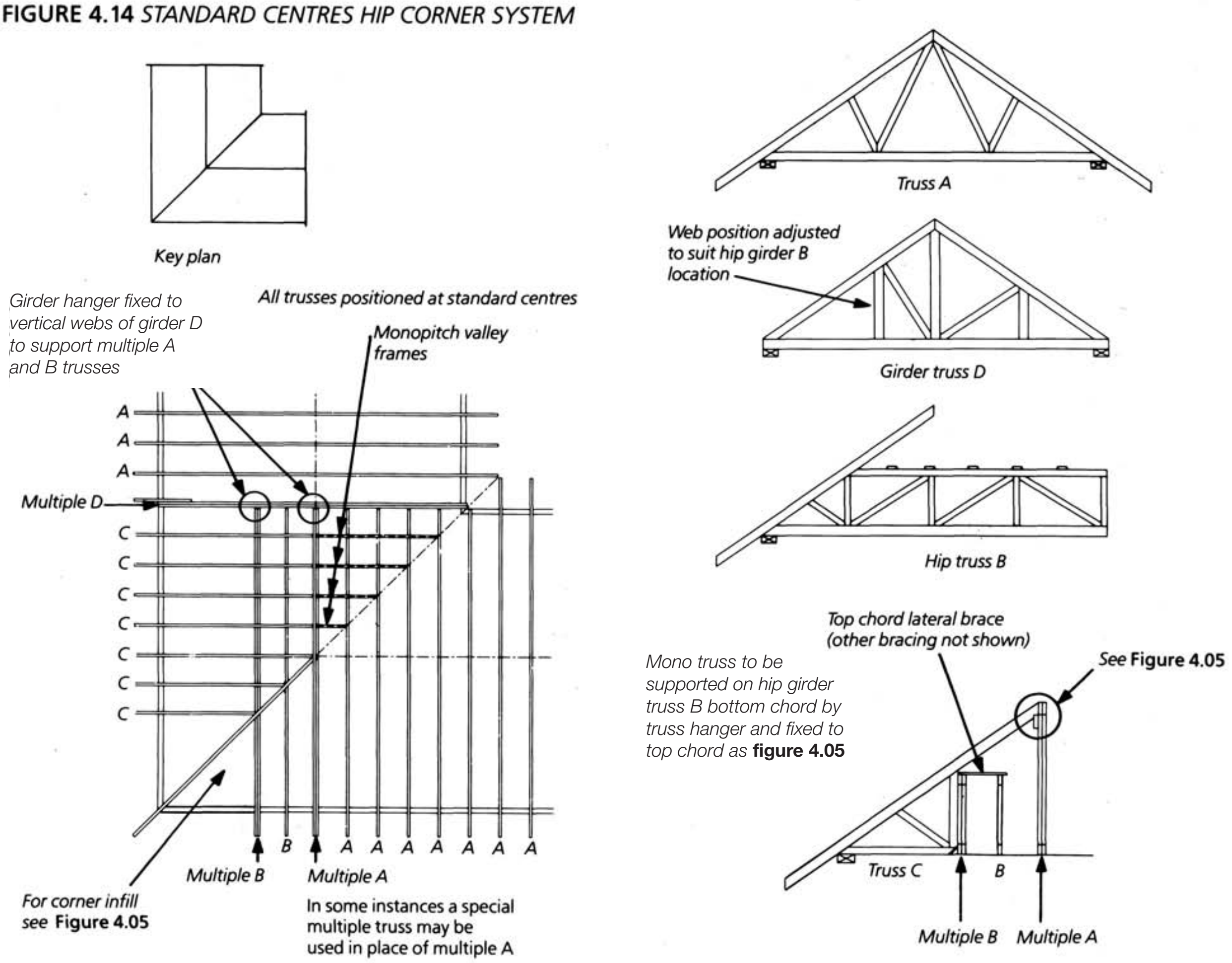
(a) Equal span and roof pitch   *(b) Unequal spans with equal roof pitch*   *(c) Unequal spans with matching ridge heights*

There are two common framing systems:

(1) Standard Centres Hip Corner.
(2) Standard Set Back Hip Corner.

As for hip ends, these two systems are very similar and only the former is illustrated in Figure 4.14 for a corner with equal spans and equal pitch.

FIGURE 4.14 *STANDARD CENTRES HIP CORNER SYSTEM*



FORMING THE ROOFSCAPE

Cranked or Dogleg Intersection

A cranked or dogleg intersection occurs when two roofs meet at an angle between 90° and 180°. Normally the intersecting roofs have the same span and pitch, but some variation can be accommodated so long as the ridge heights match.

FIGURE 4.15 *CRANKED OR DOGLEG INTERSECTION*

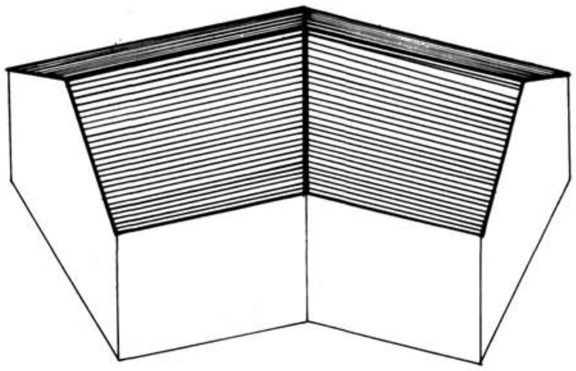
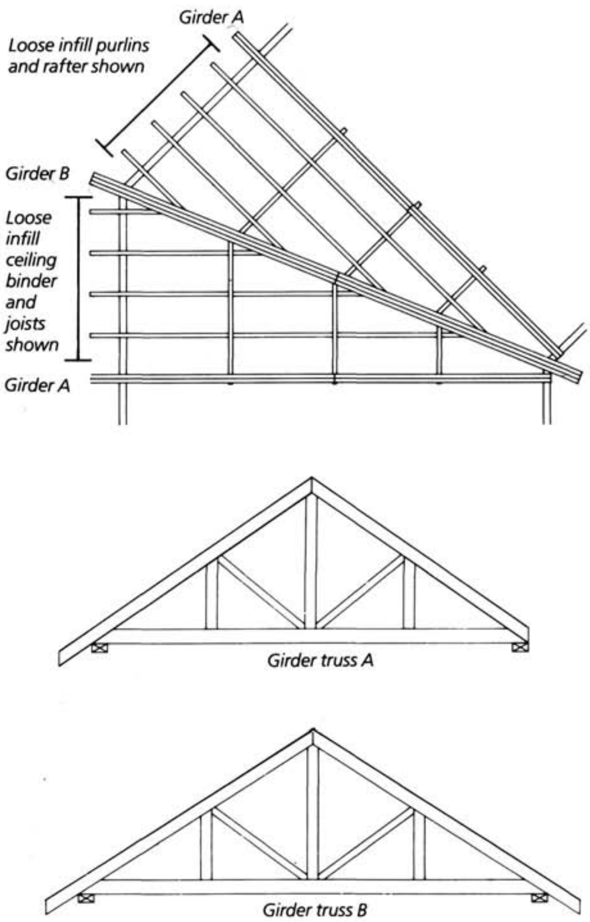


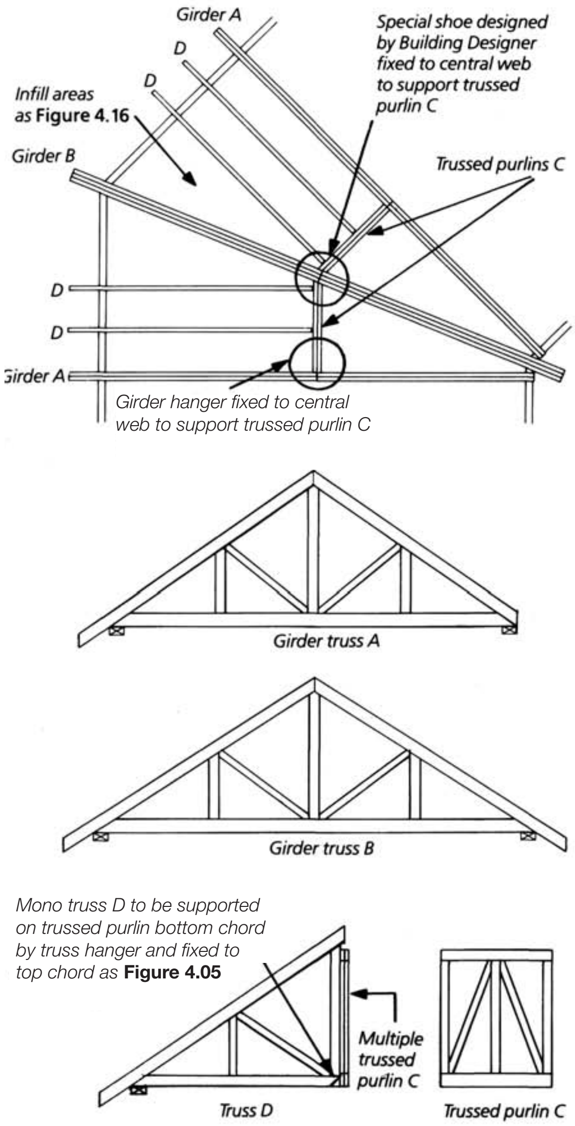
FIGURE 4.16 *FRAMING A CRANKED OR DOGLEG INTERSECTION*



The framing plan (Figure 4.16) shows the typical arrangement whereby girders are positioned on the intersection line and at the end of each leg, these being used to support loose infill. For small spans, girders A and B may be formed using two or three of the standard profile trusses nailed together. However, for larger spans, and to simplify erection, all three girders should have vertical webs and matching profiles. For further guidance on the choice of girder and the infill timbers, reference should be made to Section 6. Although detailed for a duopitch roof, monopitch and asymmetric roofs can be treated in a similar manner.

Except in situations where there are several identical dogleg turns, using stubbed trusses as a replacement for site infill would be too costly. Where this is proposed, special fixings will be required to support the stubbed trusses on the diagonal girders.

FIGURE 4.17 *DOGLEG INTERSECTION INCORPORATING TRUSSED PURLINS*



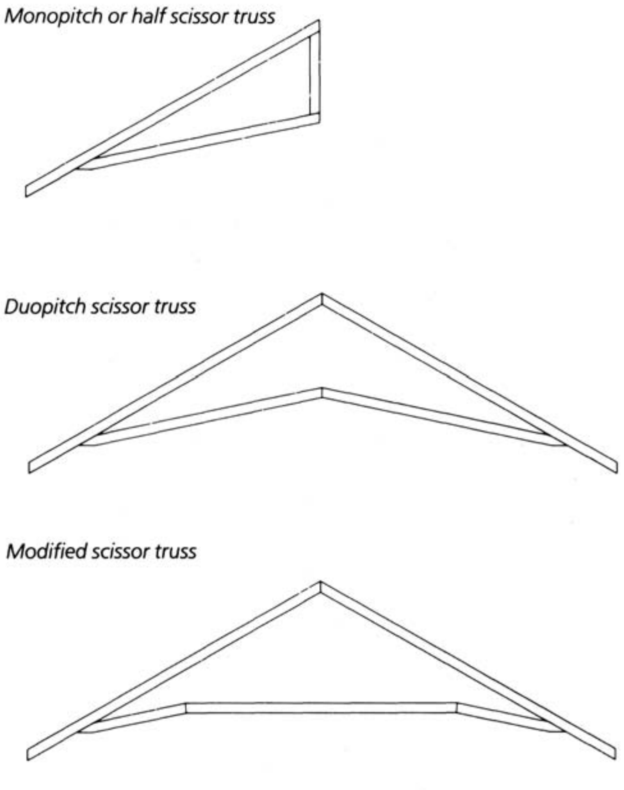
FORMING THE ROOFSCAPE

As spans increase and the design of purlins in solid timber becomes more difficult, it may be necessary to introduce trussed purlins at the ridge to support monopitch trusses (Figure 4.17). This increases the prefabricated area and reduces the site framed area.

Scissor Trusses

The term scissor truss is used to describe a truss with a sloping bottom chord. The three recognised variations are shown in Figure 4.18. These trusses are used either to increase internal headroom without raising the eaves or as a feature in, for example, a church building.

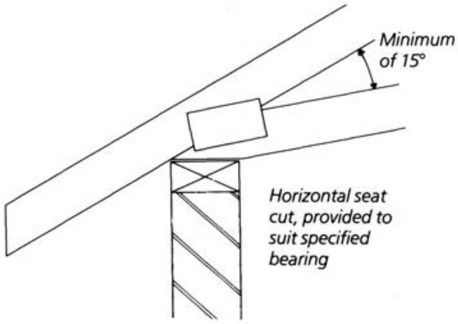
FIGURE 4.18 *SCISSOR TRUSSED RAFTERS*



Generally, the difference in pitch between the rafter and bottom chord should not be less than 15°. For larger spans, this minimum value may have to be increased. Under load, the structural action of scissor trusses results in a spread of the supports. This spread is often limited to a maximum of 12mm, which most buildings can accommodate without detriment to the finishes. By adopting these parameters, spans of 12m have been achieved.

The Gang-Nail scissor truss will be provided with a horizontal seat, cut to match the specified bearing width, as shown in Figure 4.19. The inclusion of water tanks, hip ends or roof intersections should be discussed with your Gang-Nail fabricator.

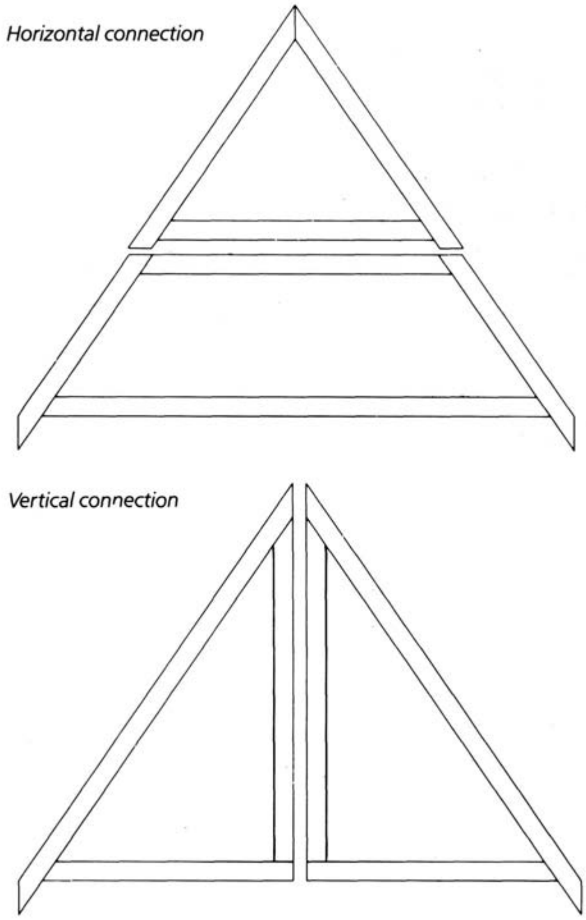
FIGURE 4.19 *HEEL SUPPORT DETAIL*



Multipart Trusses

In some cases the dimensions of a truss exceed those that can be manufactured, delivered or erected as one unit (see Section 2). To overcome this problem, it is possible to produce and deliver trusses in two or more parts and erect the required profile on site. Connections can either be in the horizontal or vertical plane.

FIGURE 4.20 *MULTIPART TRUSSED RAFTERS BASIC FORMS*



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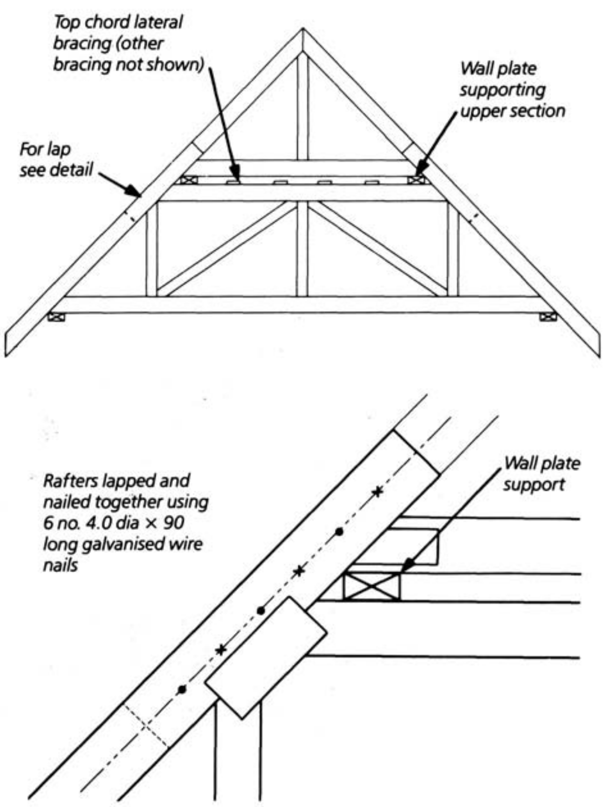
Vertical connections are used in the two extreme cases of small span trusses with steep pitches or very large span trusses. Since these truss types are seldom required, they are not considered further.

Horizontal connections occur in two forms:

Structural - The two parts are connected structurally to act as one unit. Attic trusses are frequently produced using this method, as discussed later.

Non-structural - The units are designed to work independently and only nominally connected. Since one truss sits on top of the other, they are often referred to as 'Top Hat' trussed rafters.

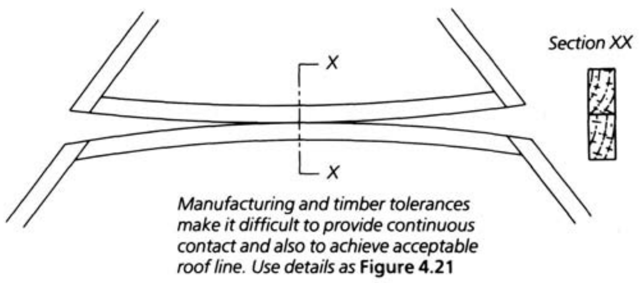
FIGURE 4.21 *TOP HAT TRUSSED RAFTERS*



The structural action of the top hat truss is one whereby the lower section supports itself plus the loads transmitted from the upper or top hat section. The profile will normally be taken from the hip family with a height generally between 2m and 3m. The upper section is often a Queen Post or fink profile.

To simplify erection and fixing, the top hat section laps alongside the lower section and bears on a 50mm x 100mm wall plate. These details should not be revised so as to allow the two sections to be in continuous contact along the adjoining chords. Small allowable tolerances in the timber and the manufacturing process will make it very difficult to achieve an acceptable roof line and the truss would not reflect the design assumptions (Figure 4.22).

FIGURE 4.22 *CONTINUOUSLY SUPPORTED TRUSS*



Most truss profiles can be supplied as multipart trusses. Standard modifications are also applicable.

Attic Trussed Rafters

The attic or room-in-the-roof trussed rafter is a simple means of providing the structural roof and floor in the same component (Figure 4.23b). This offers considerable advantages over loose timber construction:

(1) There are no restrictions on ground floor layout since the trusses span onto external walls.

(2) Attic trusses are computer designed and factory assembled units, resulting in increased quality assurance.

(3) Complex, labour intensive site joints are not required.

(4) Attic trusses can be erected quickly, offering cost savings and providing a weathertight shell earlier.

(5) Freedom to plan the first floor room layout.

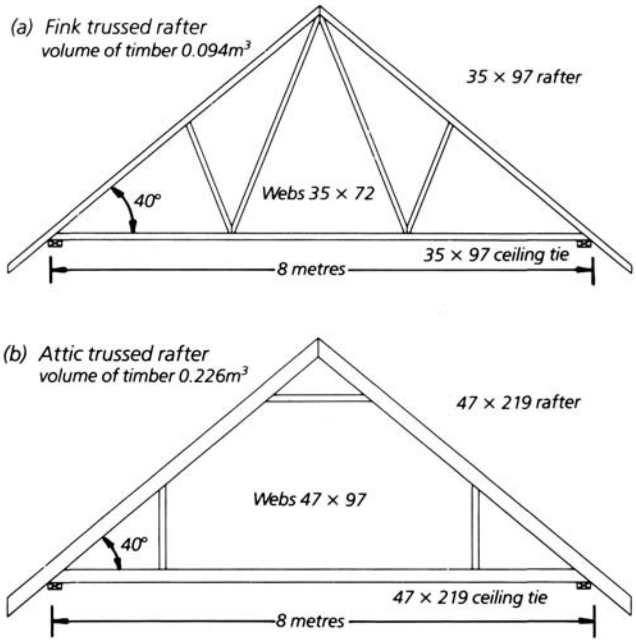
(6) A complete structure is provided, ready to receive roof finishes, plasterboard and floorboarding. If we compare an 8m fink truss (Figure 4.23a) with an equivalent 8m attic truss (Figure 4.23b), it can be seen that the chord timbers have increased in width and depth.

There are two reasons for this:
(1) The attic truss supports approximately 60% more load than a fink truss of the same span and pitch. This difference in load is made up of plasterboard ceilings and wall construction, full superimposed floor loading and floor boarding.

(2) The lack of triangulation in an attic truss will result in increased timber sizes. Predominantly 44mm or 47mm thick timber is used, with depths ranging from 145mm to 245mm.

FORMING THE ROOFSCAPE

FIGURE 4.23 *EQUIVALENT FINK AND ATTIC TRUSSED RAFTERS*



Where only two supports are available for attic trussed rafters, the bottom chord tends to hang off the rafters and the vertical webs are in tension. A central support adds considerably to the stiffness of the bottom chord, such that it often props the rafter and places the vertical webs in compression.

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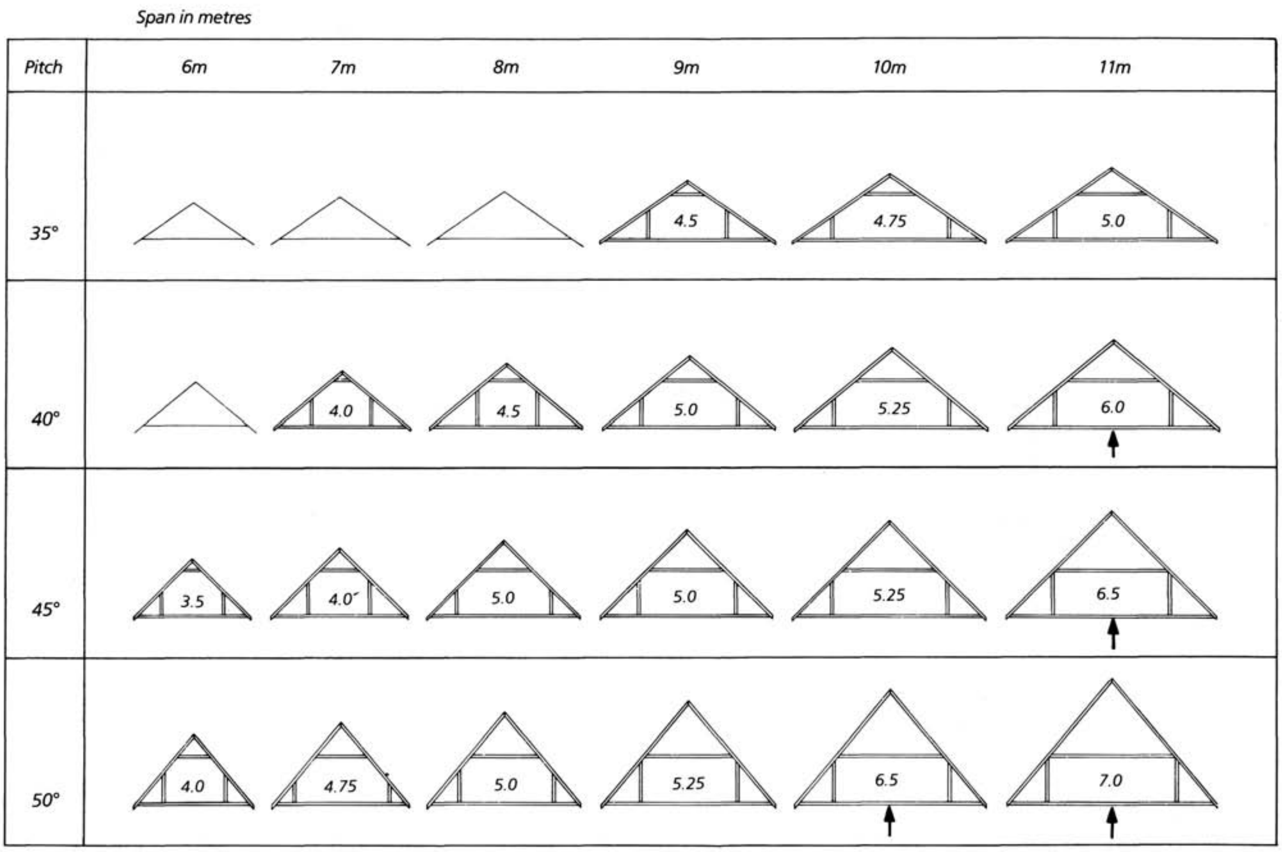
An indication of span, pitch and room widths which would result in comfortable designs are given in Figure 4.25. All cases outside of these should be discussed with your Gang-Nail fabricator.

FIGURE 4.25 *STRUCTURAL FEASIBILITY GUIDE TO ATTIC TRUSSED RAFTERS*

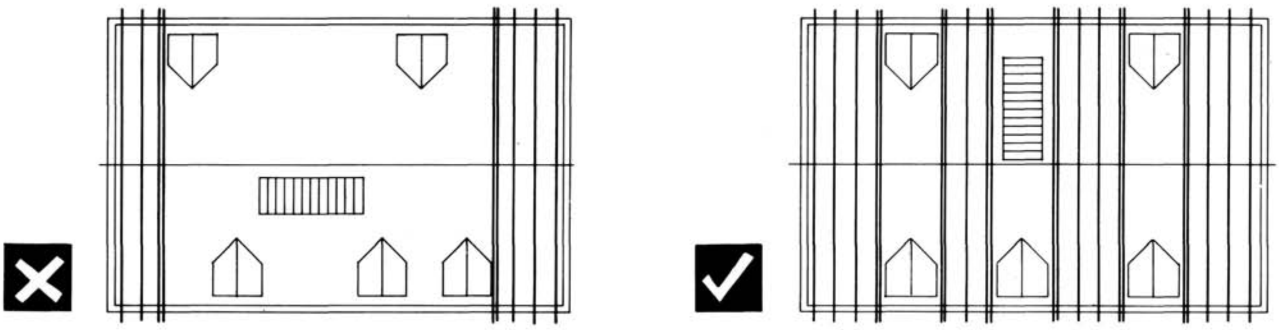


Attics - Good Practice

The application of a few basic principles at the concept stage of a project can result in substantial cost savings by maximising the use of prefabricated components and minimising loose infill areas.

(1) Dormer windows and stairwell openings are formed by placing multiple girders each side of the openings (see Figure 4.26) and loose framing in between. Place stairwells parallel to the trusses and position windows opposite each other.

FIGURE 4.26 *BUILDING LAYOUT TO SUIT ATTIC TRUSSED RAFTERS*



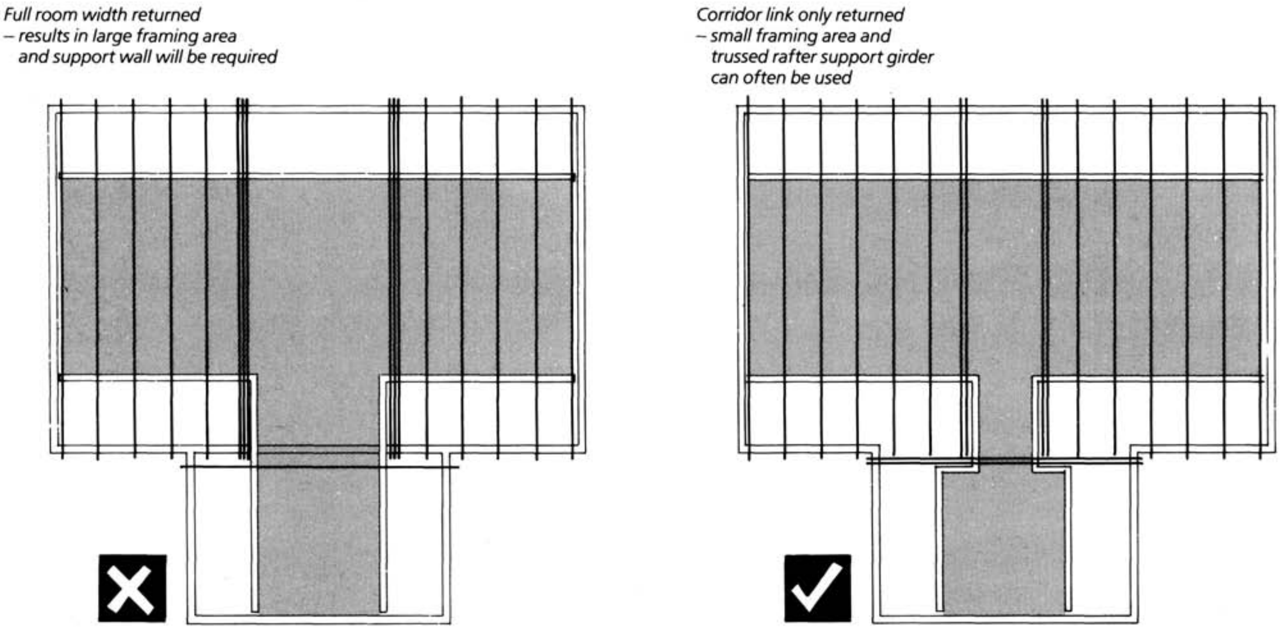
Unsuitable layout – Impossible to provide attics to support this roof since windows and stairs all overlap.

Suitable layout – Staircase parallel to trusses – Windows opposite each other – Site frame small widths

FORMING THE ROOFSCAPE

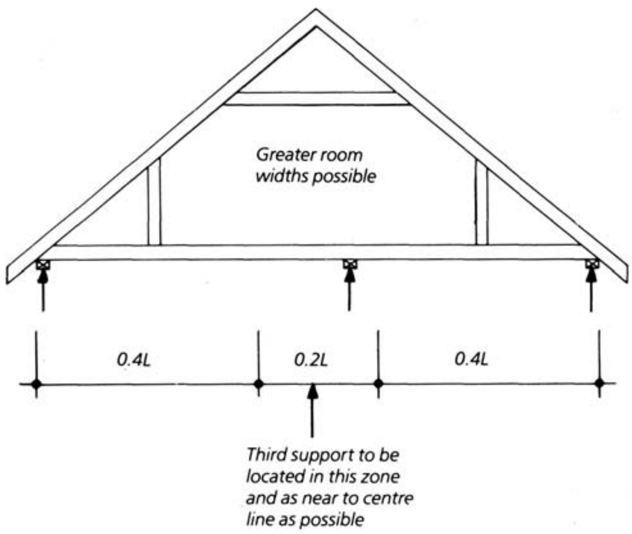
(2) For T intersections, detail a corridor link between the room areas. This will reduce the site framing required and also allow the use of a girder truss in some cases where a loadbearing wall is not provided (Figure 4.27). In the non-preferred arrangement a loadbearing wall is essential.

FIGURE 4.27 *ATTIC 'T' INTERSECTIONS*



(3) Make use of loadbearing ground floor walls to add extra support to the attic trusses. To be effective they should occur within the centre fifth of the span and will have most influence when placed near mid-span (Figure 4.28).

FIGURE 4.28 *THREE BEARING ATTIC TRUSSED RAFTERS*



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(4) It is easier to construct attic roofs with gable ends as opposed to hip ends. Nevertheless, hip ends can be used, although the number of supports available influences the ease with which this can be achieved.

(i) Two Supports. Minimum site framing is achieved by stopping the room at the apex of the hip (Figure 4.29a). Alternatively, a multiple attic truss can be provided at the hip to support site framing spanning onto a normal hip girder. In this case, the room extends into the hip area and dormer windows can be provided in the end elevation (Figure 4.29b).

(ii) Three supports. Where a central support is provided, the rooms can be easily extended into the hip area (Figure 4.30a). It is possible to go beyond but this would involve multiple girders with framing between them (Figure 4.30b).

FIGURE 4.29 *HIP END TO ATTIC ROOFS – 2 SUPPORT CASE*

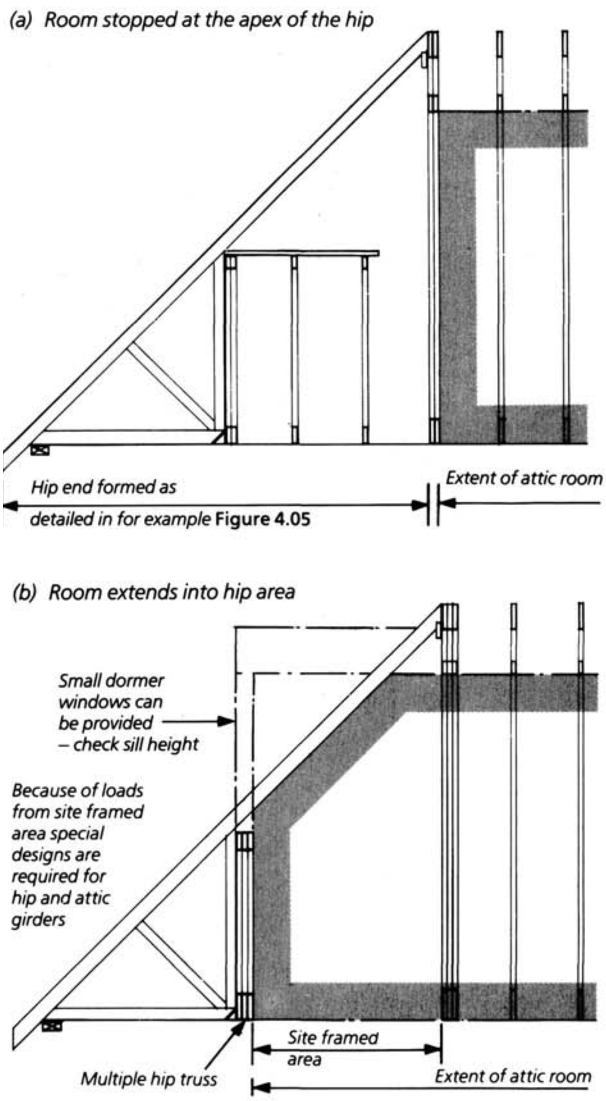
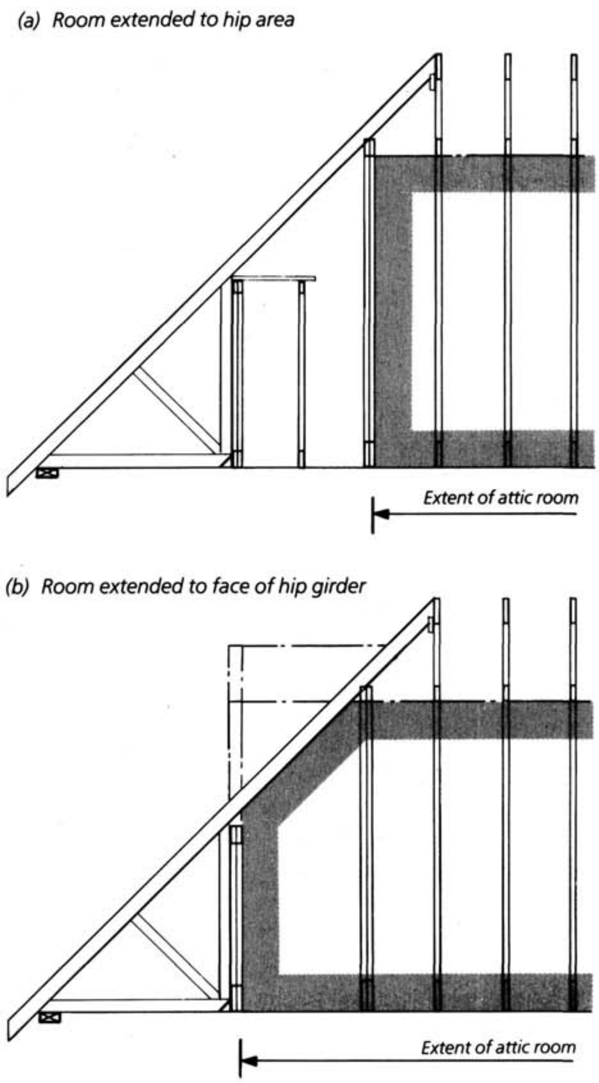


FIGURE 4.30 *HIP END TO ATTIC ROOFS — 3 SUPPORT CASE*

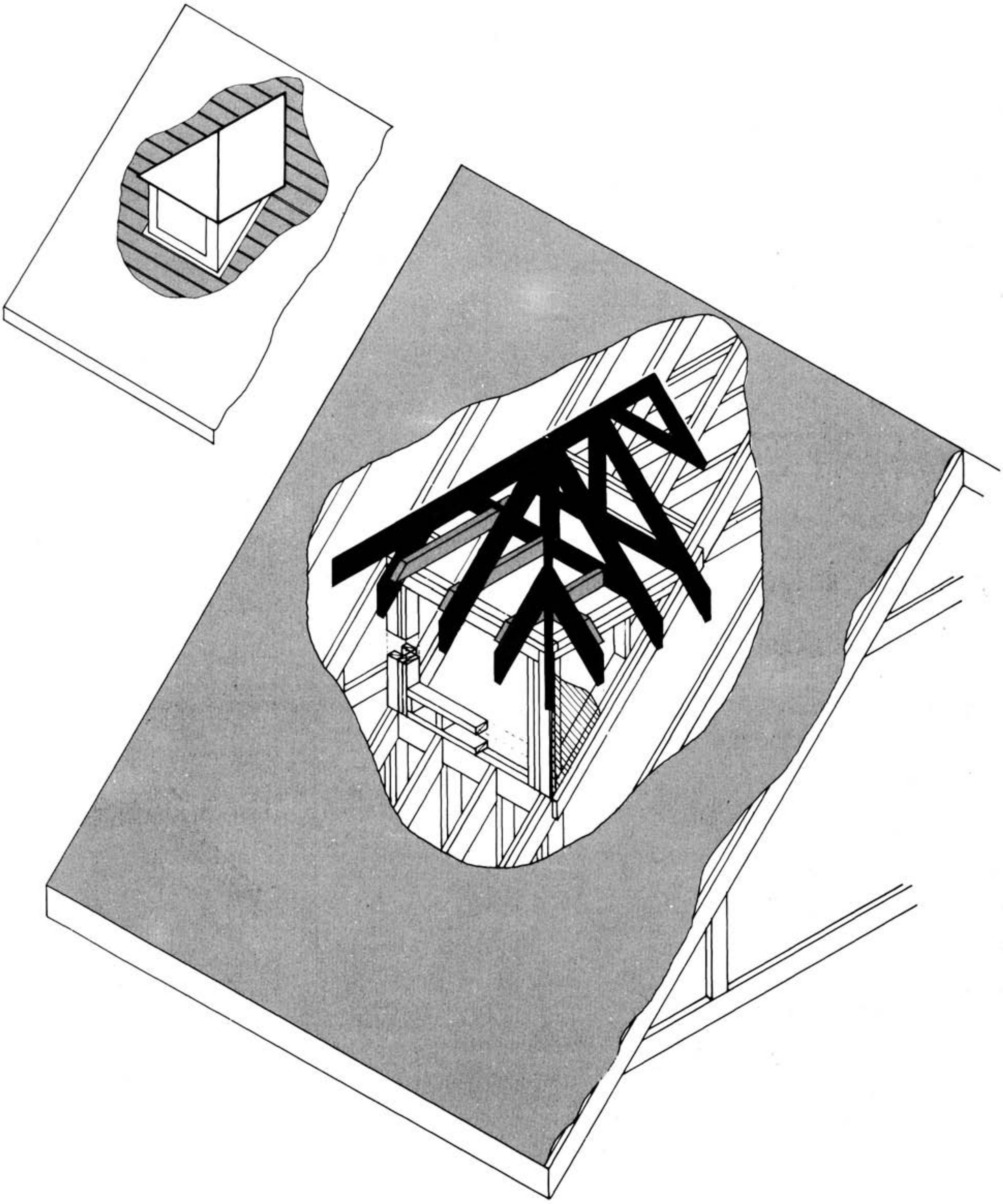


FORMING THE ROOFSCAPE

(5) Gable windows are easier to construct and usually cheaper than dormer windows. Small rooflights can be accommodated within the standard truss spacing.

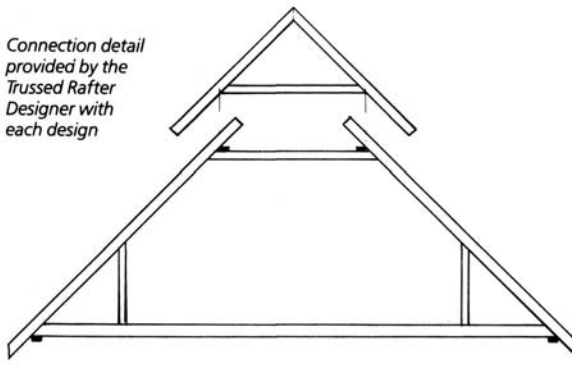
A typical dormer window and framing details are shown in Figure 4.31. Multiple trusses must be located each side of the opening which, ideally, should not be wider than 1200mm. Larger openings are possible but they require larger infill areas at additional cost.

FIGURE 4.31 *DORMER WINDOW DETAIL*



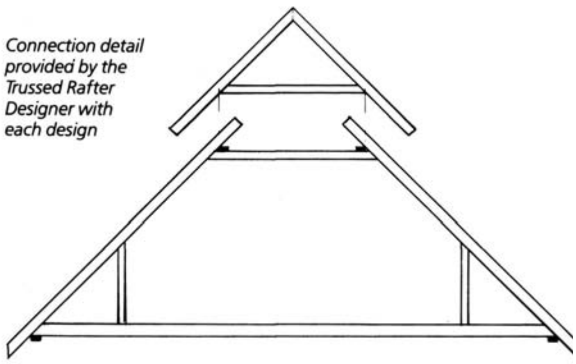
6) Where possible, keep the overall height below the transportable limit. Local conditions may influence this but, generally 4m is an accepted value. Above this height the unit is made in two parts. Unlike the two-part trusses described earlier, these units must be structurally connected on site to act as one (Figure 4.32). Details of the required connection will be provided by the truss supplier.

FIGURE 4.32 *TWO PART ATTIC TRUSSED RAFTERS*



(7) Try to locate openings on a 600mm grid to match the truss spacing. This can often reduce the number of trusses required (Figure 4.33).

FIGURE 4.32 *TWO PART ATTIC TRUSSED RAFTERS*



Attic Bracing

The principles of bracing are described in detail in Section 7. These apply to attic roofs, although it is worth emphasising the treatment of the diagonal brace (see Figures 7.09 and 7.10).

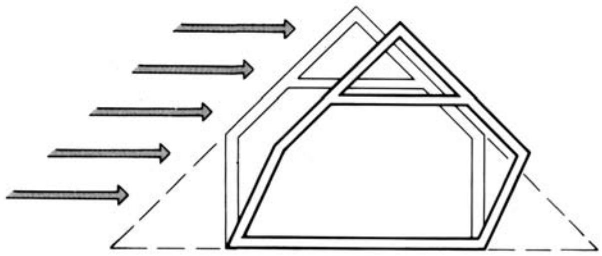
Attic Truss Modifications

The lack of triangulation in attic trusses requires that modifications, such as stubbed ends and cantilevers, are treated with care. The rules given in Section 2 do not apply.

(1) Stubbed Ends. To maintain stability the modifiedattic truss relies on its outer triangles. If these are removed the truss will collapse (Figure 4.34). The amount the attic truss can be stubbed depends on span, pitch, room width and local wind pressures. No simple rules can be given and each case must be treated individually.

(2) Cantilevering. Small cantilevers of less than 600mm can often be accommodated, but it is prudent to check with the Gang-Nail fabricator.

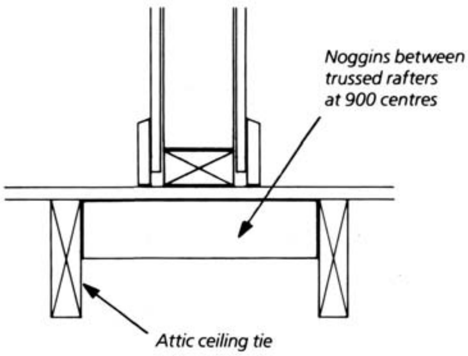
FIGURE 4.34 *SUSCEPTIBILITY OF STUBBED ATTIC TRUSSES TO WIND SWAY*



Attic Partitions

All internal partitions should be constructed using timber studs and plasterboard or some other lightweight partitioning material. Blockwork should not be used. Normally an allowance for the weight of the partitions is included in the design of the truss. It is therefore unnecessary to provide additional strength under walls as is the case with loose floor joists. To provide support to partitions running parallel to trusses, noggings should be used as shown in Figure 4.35.

FIGURE 4.35 *SUPPORT DETAIL FOR PARTITIONS PARALLEL TO ATTIC TRUSSED RAFTERS*



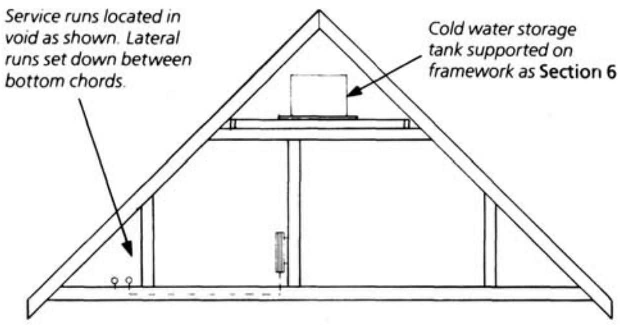
FORMING THE ROOFSCAPE

Attic Services

The lower void area is an ideal place to locate service runs, allowing lateral runs to be positioned between the bottom chords (Figure 4.36). In some instances, access for maintenance is provided into this area via a small fire resistant hatch in the wall.

The structural action of an attic trussed rafter is entirely different to that of a floor joist. The accepted practice of notching floor joists is totally unacceptable for an attic trussed rafter. This could easily halve the strength of the member.
DO NOT NOTCH OR DRILL ANY MEMBER.

FIGURE 4.36 *LOCATION OF SERVICE RUNS*



DO NOT CUT, NOTCH OR DRILL THE TRUSSED RAFTERS

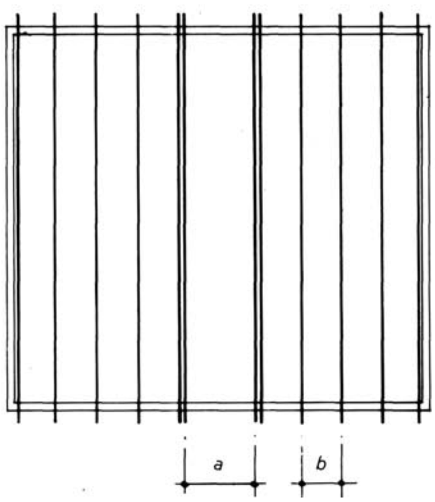
Girder Trusses and Site Infill

To minimise manufacturing costs and to avoid confusion on site, it is common practice to use standard trusses nailed together to form girders rather than produce separate girder designs.
The number of trusses required to form the girder is dictated by the width of roof that the girder supports, i.e.

$$\text{Number of trusses to form girder} = \frac{\text{Width of supported roof}}{\text{standard truss centres}}$$

To illustrate this, consider the following example (Figure 4.37):

FIGURE 4.37 *FRAMING AROUND OPENINGS*



$$\text{Width of supported roof} = \frac{a}{2} + \frac{b}{2}$$
$$= 550 + 300$$
$$= 850$$
$$\text{Number of trusses to form girder} = \frac{850}{600}$$
$$= 1.4$$

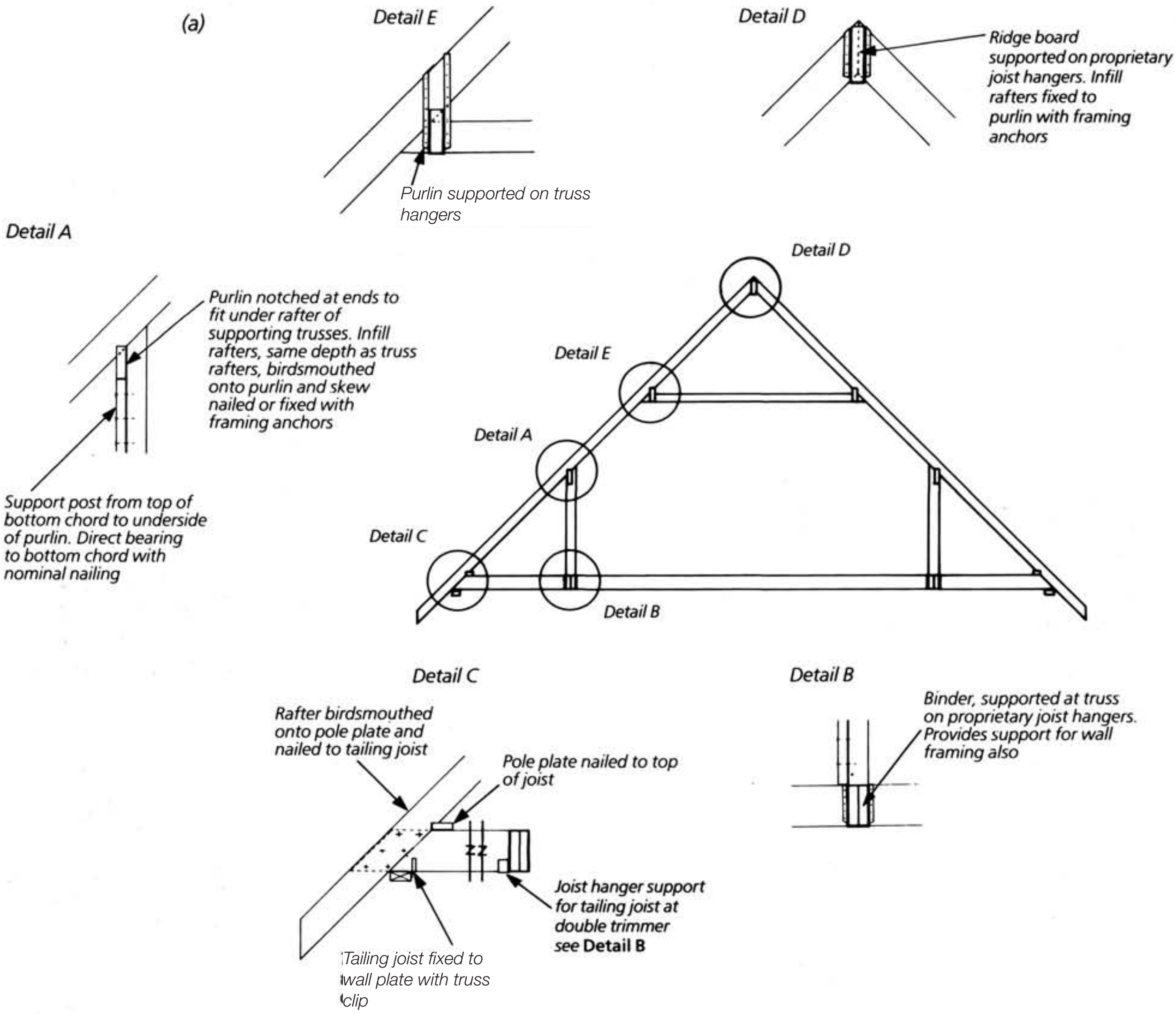
The result, in this case 1.4, must always be rounded up. In our example, therefore 2-ply girders are required. This approach is only valid where the maximum width supported by any girder does not exceed three times the standard truss spacing. Where specific designs for the girder are provided, larger openings can be accommodated. Infill must be supported at every node point by purlins and binders (Figure 4.38a) or by infill joists located at uniform centres along the bottom chord (Figure 4.38b).

Where this cannot be achieved, advice should be obtained from the Trussed Rafter Designer. For example, the stairwell in Figure 4.39 prevents a binder being located at node A, hence the staircase and floor may impose an unacceptable point load at X.

FORMING THE ROOFSCAPE

FIGURE 4.38 *ATTIC INFILL*

(a)



(b)

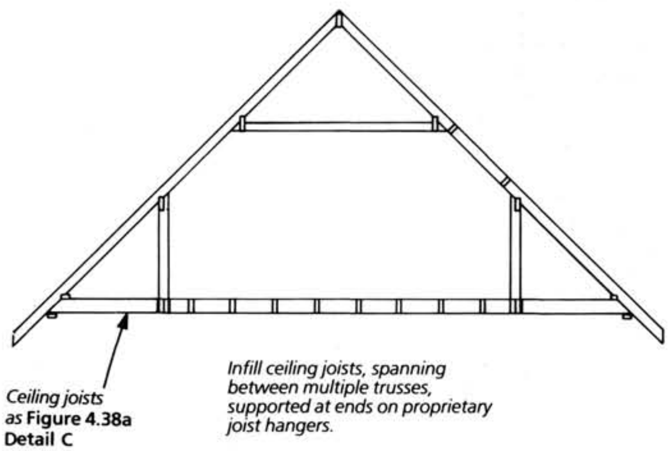
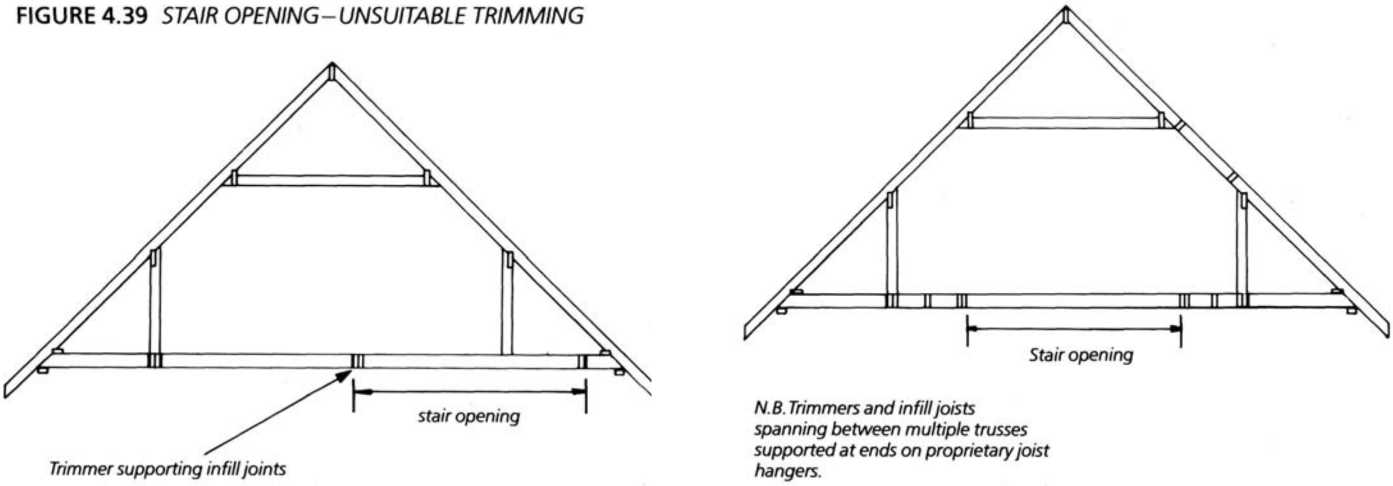


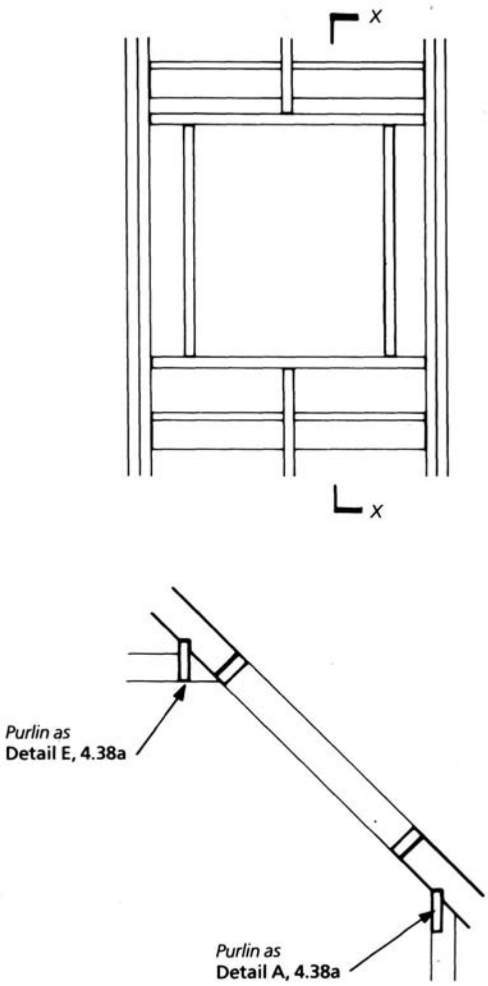
FIGURE 4.39 *STAIR OPENING – UNSUITABLE TRIMMING*



Figures 4.40 and 4.41 show acceptable methods for framing around windows and stairwells and give recommended connections and support details.

FIGURE 4.40 *ROOF LIGHT TRIMMING*

All joints are to be securely fastened

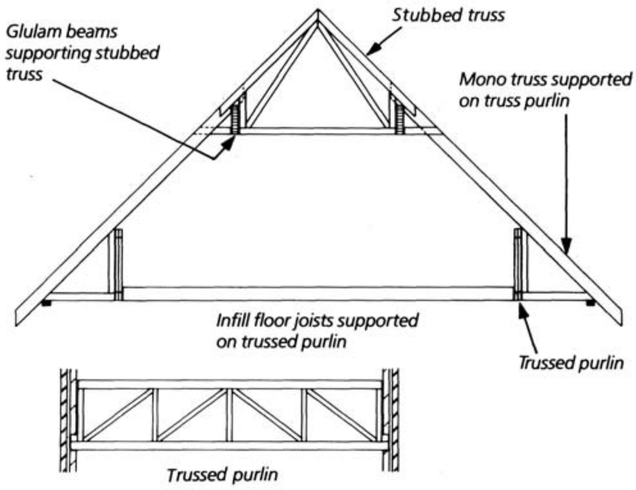


Alternative Forms of Attic Construction

Cross Wall Construction

Cross wall construction, as shown in Figure 4.42, is particularly suited to floor plans with large dormer windows or where the layout of the staircase and windows prohibit economic use of attic trusses. (see Figure 4.26).

FIGURE 4.42 *CROSS WALL CONSTRUCTION*



Attic Frame Construction

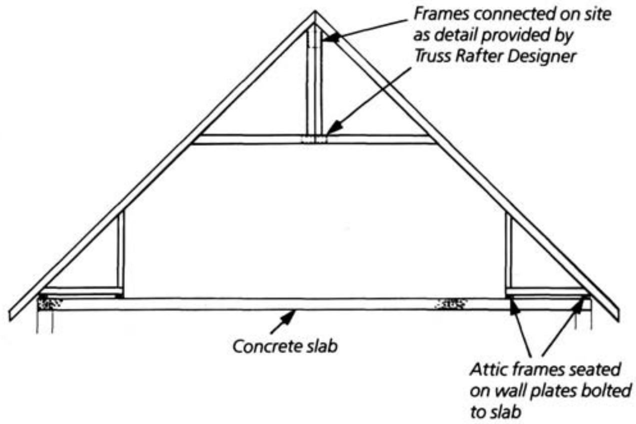
This form of construction is illustrated in Figure 4.43. It is particularly suitable where a concrete floor slab is provided and large room widths are required. It is not recommended for most domestic attic roofs for three main reasons:

(1) The saving in the cost of the frames compared to a full attic truss, is outweighed by increased erection costs.

(2) The design of the frames is dependent upon the support conditions and the stiffness of the floor joists provided by others.

(3) The horizontal thrust from the frames must be transmitted into the floor joists and through the splice joint in the joists. These connections will be structurally significant, since they would be required to transmit in excess of 6kN.

FIGURE 4.43 *ATTIC FRAME CONSTRUCTION*



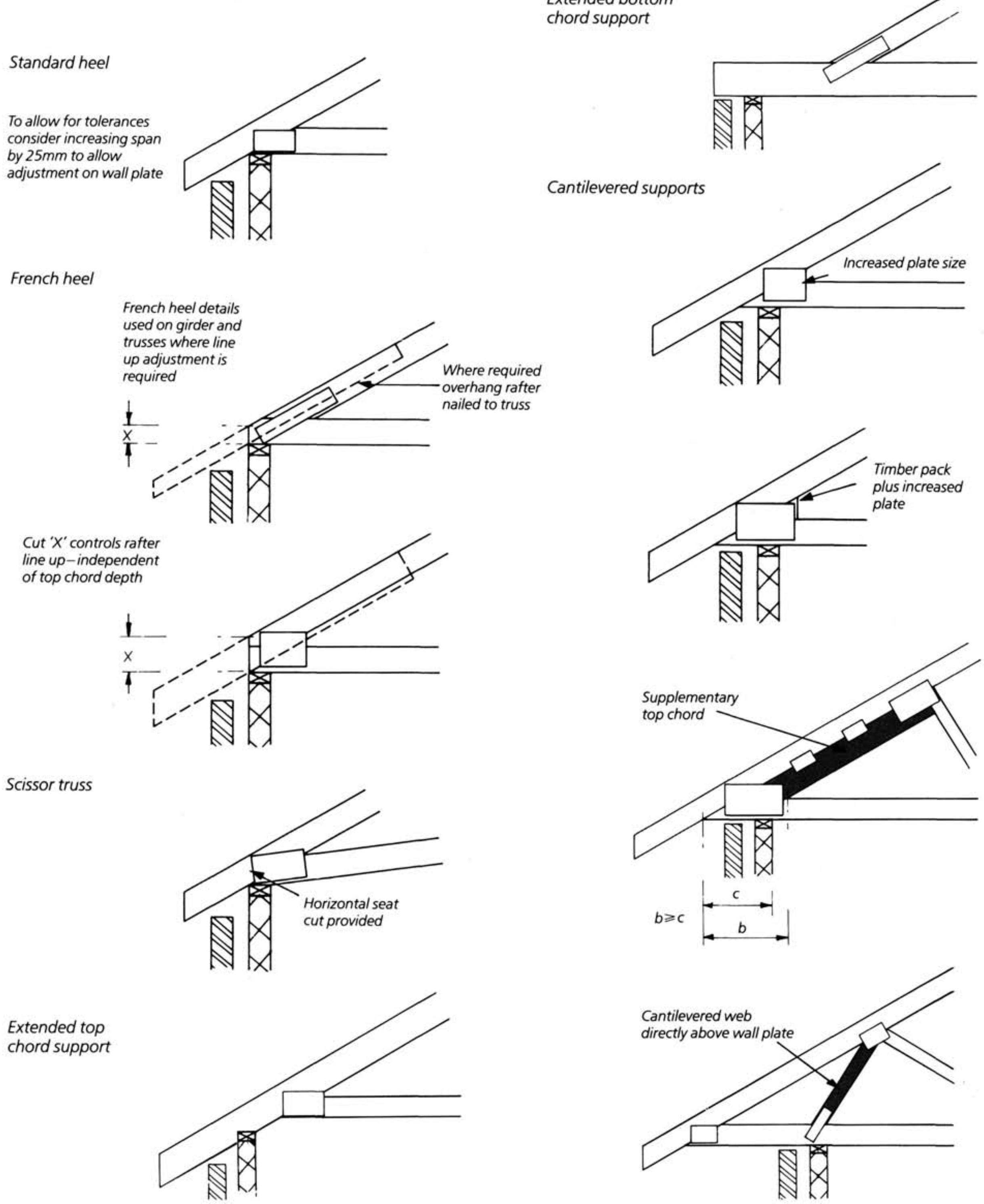
SUPPORT CONDITIONS

Satisfactory performance from trussed rafters is dependent upon the provision of proper bearings to support and restrain them without causing damage. All too often this detail is neglected, yet it is neither difficult to understand nor expensive to provide. This section will assist the specifier in ensuring that good practice is followed.

Eaves and Support Details

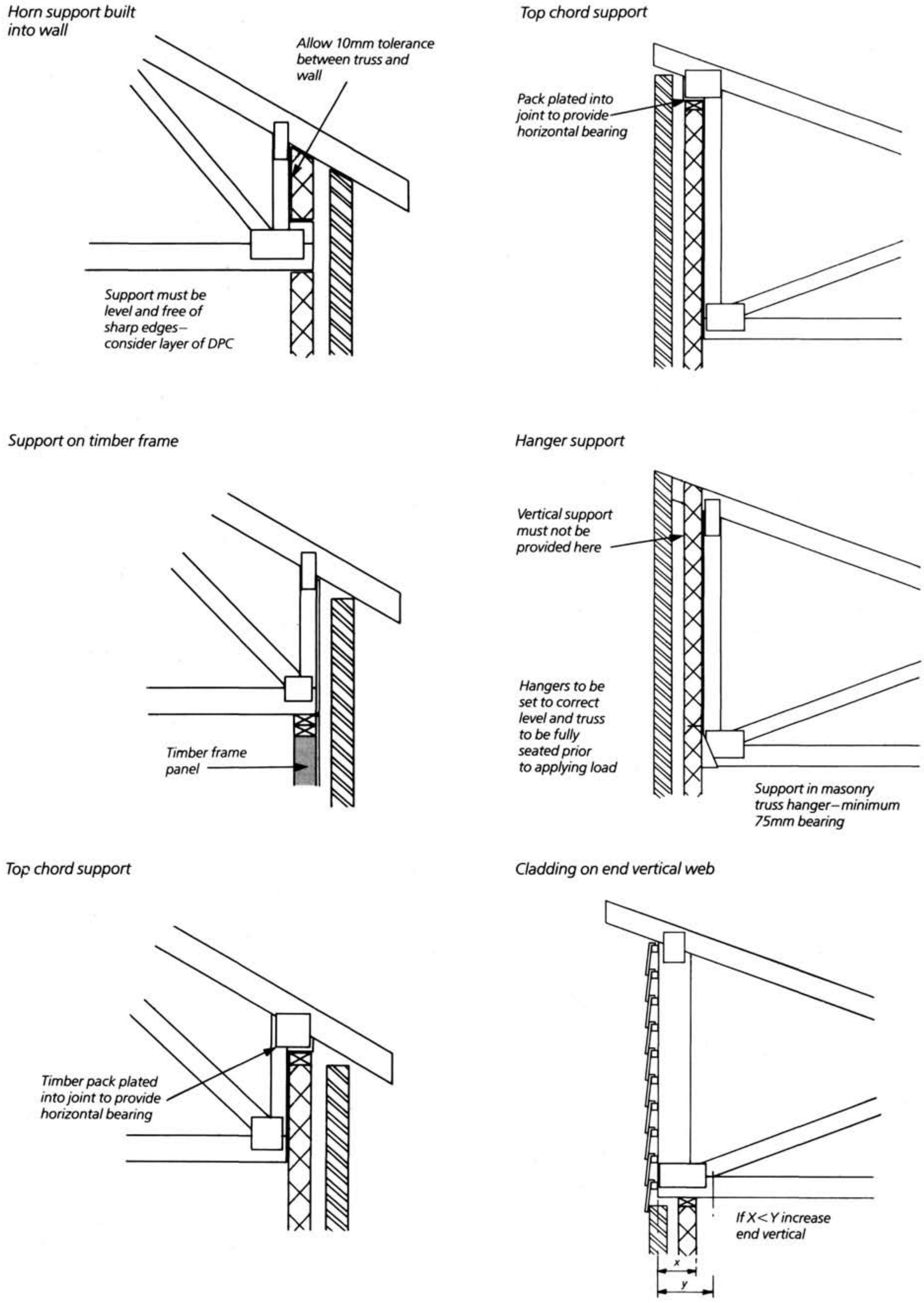
Figure 5.01 provides illustrations of a range of standard eaves and support details.

FIGURE 5.01a *EAVES DETAILS*



SUPPORT CONDITIONS

FIGURE 5.01b *MONOPITCH AND STUBBED END DETAILS*



SUPPORT CONDITIONS

FIGURE 5.01c *MULTI SUPPORTS*

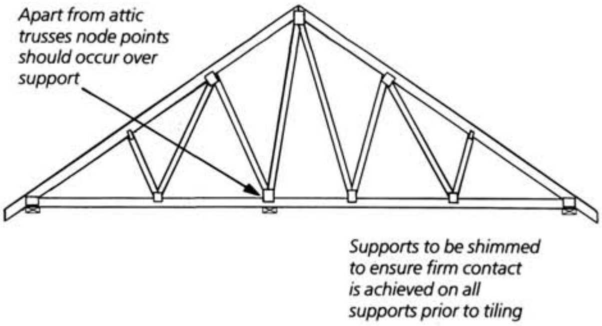
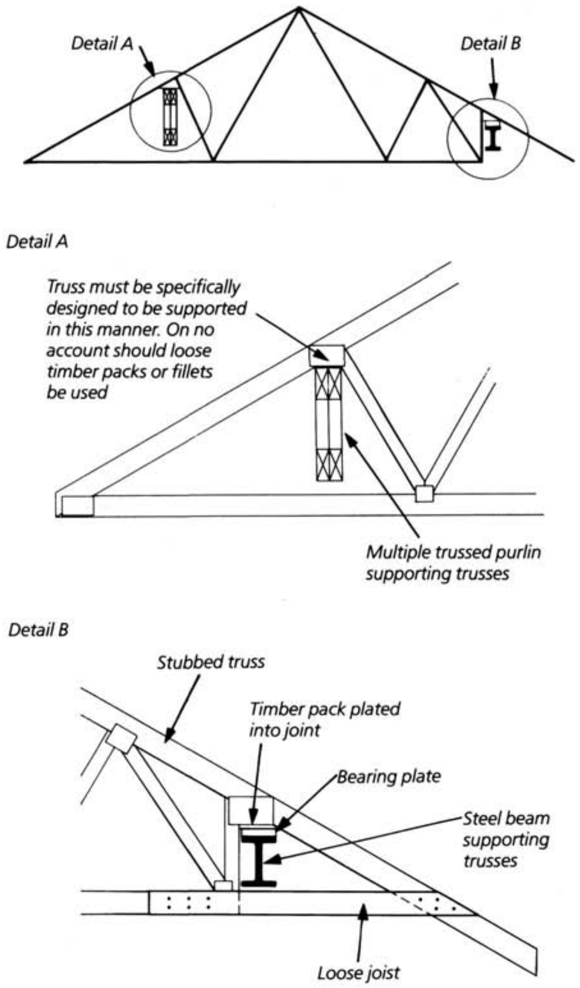


FIGURE 5.01d *INTERNAL SUPPORTS*

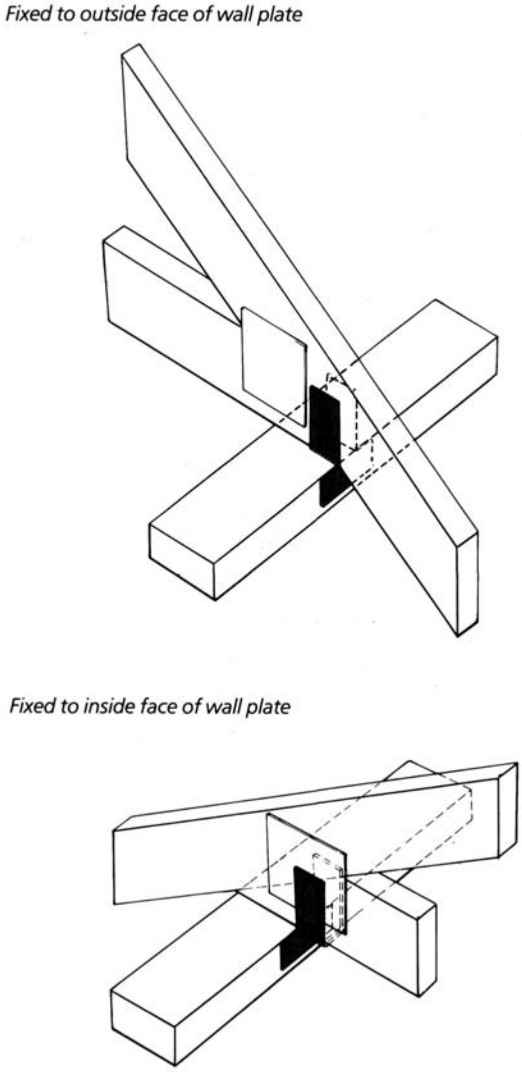


Truss Fixing Details

Gang-Nail trussed rafters are precision engineered computer designed components, manufactured under quality controlled factory conditions. The same care should be taken on site when fixing the trusses and it is strongly recommended that truss clips are used to secure the trussed rafters to the wall plates or bearing. (Figure 5.02).

FIGURE 5.02 *TRUSS CLIPS*

N.B. All nail holes must be used



Skew nailing should only be considered where the workmanship on site is of a sufficiently high standard to ensure that the fasteners, joints, timber members and bearings will not be damaged by careless positioning or overdriving of the nails. The minimum fixing at each bearing position should consist of two 4.5mm diameter x 100mm long galvanised round wire nails, which are skew nailed from each side of the trussed rafter into the wall plate or bearing. Where nailing through the punched metal plate cannot be avoided, the nails

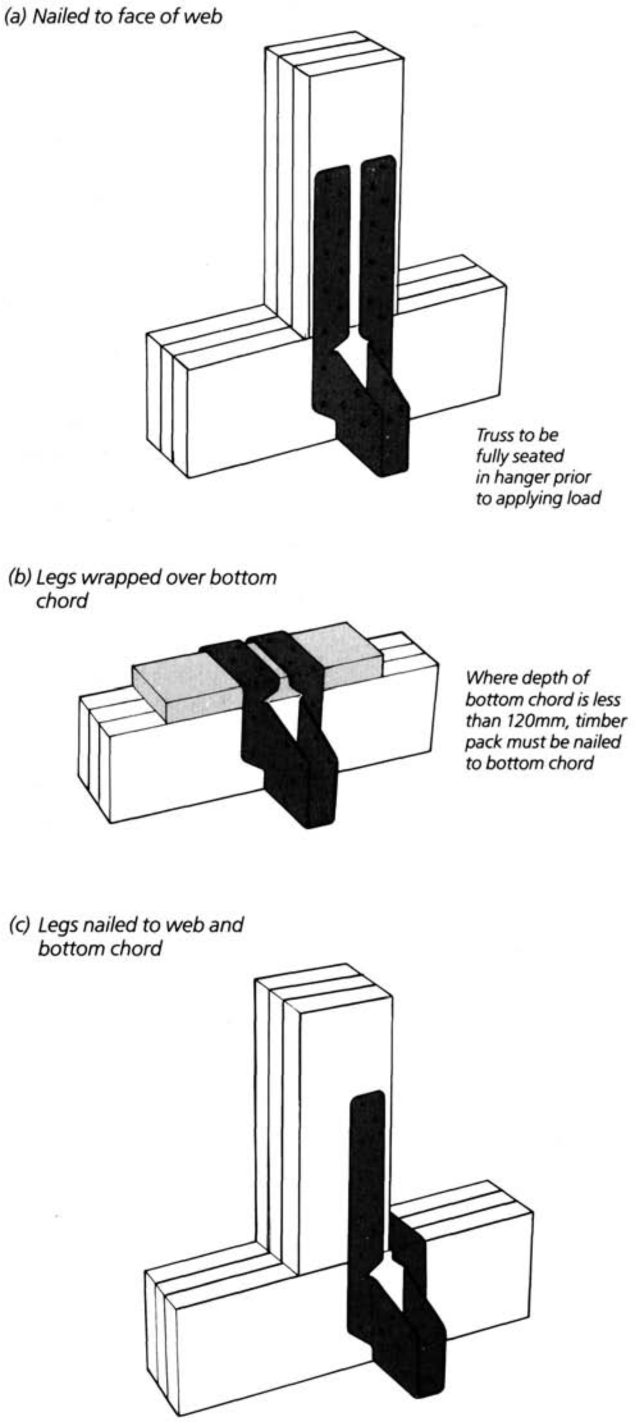
SUPPORT CONDITIONS

Should be driven through the holes in the fasteners.

Where a truss is to be supported by a trussed rafter girder, a truss hanger should be used. The hanger legs should be wrapped over the bottom chord of the girder or nailed to the web members, as shown in Figure 5.03. All nail holes should be used.

FIGURE 5.03 *TRUSS HANGER SUPPORT*

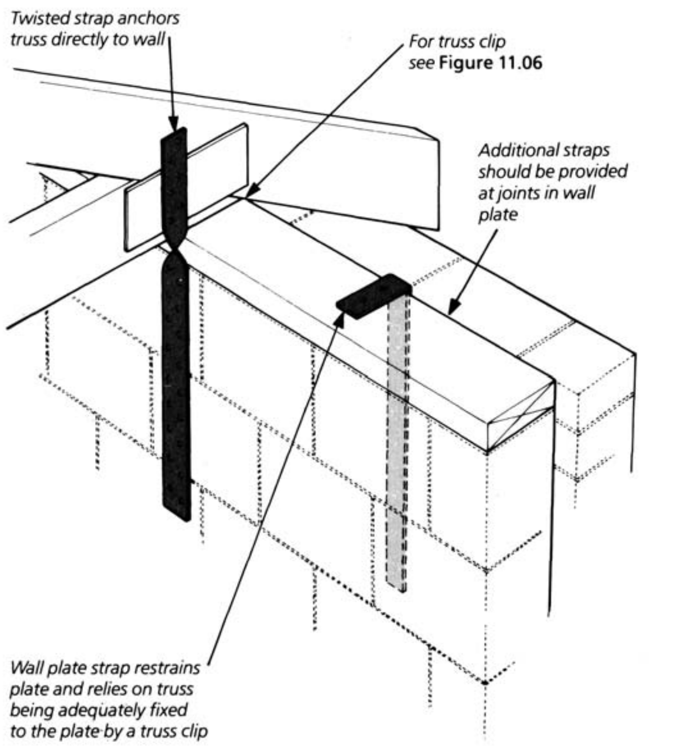
N.B. All nail holes to be used



In situations where trussed rafters are subjected to wind uplift positive fixing to the supporting structure is required. The fixing must mobilise sufficient dead weight to counteract the uplift force. Figure 5.04 shows two possible methods. The twisted strap ties the truss directly to the support wall.

The wall plate restraint strap relies on the truss being fixed to the wall plate using a truss clip. In both cases, the length of the strap required depends upon the uplift force and the weight of the supporting structure. Where lightweight structures are employed, e.g. timber frame construction, it may be necessary for the restraint to be taken down to the foundations.

FIGURE 5.04 *RESTRAINT AGAINST UPLIFT*



Trussed rafters should be supported only at the designed bearing points. It is advisable, therefore, to erect internal non-loadbearing walls after the roof tiling has been completed. This allows deflection to take place under dead load and reduces the risk of cracks appearing in ceiling finishes. Alternatively, if partitions are of brick or block, the final course can be omitted until the tiling has been completed.

Where non-loadbearing partitions are pre-made or site assembled, they should be an easy fit and must not be forced against the underside of the trussed rafter. (See also Section 9 'Site Practice'.)

Multiple Trussed Rafters

The eaves details shown earlier in this section also apply to multiple trussed rafters, but the extra thickness and loads associated with these units frequently necessitate alternative fixing details.

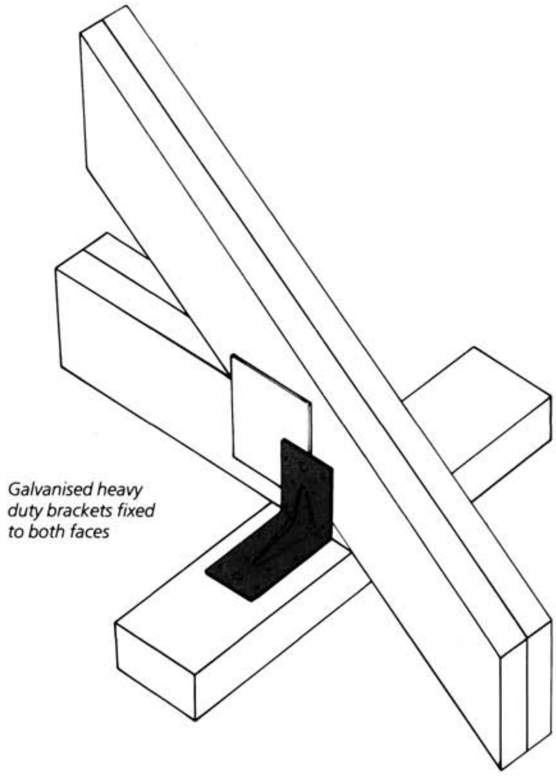
SUPPORT CONDITIONS

Fixing to Wall Plate

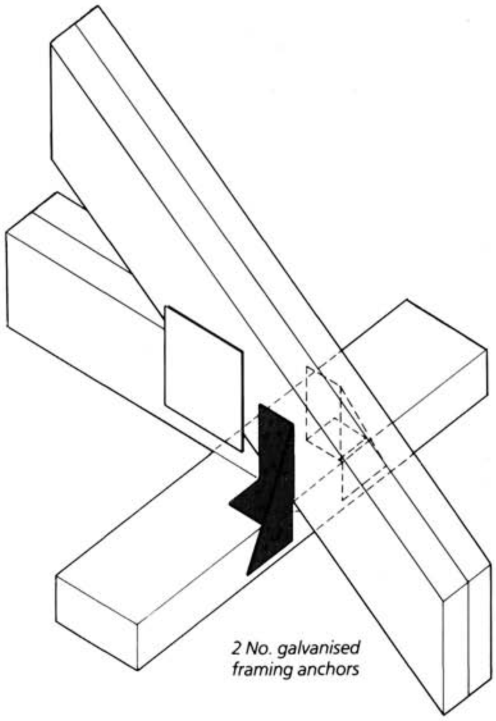
Truss clips for multiple units are not available. The preferred fixing method uses framing anchors or heavy duty angle brackets (Figure 5.05). Where wind uplift must be resisted, twisted straps are also required.

FIGURE 5.05 *GIRDER FIXING TO WALL PLATE*

(a) Heavy duty angle bracket



(b) Framing anchors



Girder Support

In general, where a multiple truss is supported by a trussed rafter girder, a metal hanger should be used. This should satisfy the following criteria:

(1) Adequate safe working load.

(2) Sufficient bearing length to support the oncoming truss.

(3) Correct width of hanger to suit the oncoming truss.
A hanger which is too wide should never be used with packs, as this will result in flexing of the bearing surface and lead to cracks in the ceiling finishes.

(4) The hanger fixing must be in accordance with the manufacturers' requirements and the Trussed Rafter Designer should approve the fixing proposed.

A range of medium and heavy duty girder hangers are shown in Figures 5.06 and 5.07. They provide a range offering safe working loads up to 40 kN and are suitable for most applications where members meet at 90°.

The medium duty girder hanger is suitable for supporting two or three 35mm thick trussed rafters nailed together to form a girder, up to a safe working load of 17kN.

The range of heavy duty girder hangers are suitable for two, three and four ply girders of timber thickness 35mm and 47mm.

They provide a range offering safe working loads up to 40kN and are suitable for most applications where members meet at 90°.

A 25mm horn should be detailed on the oncoming girder to allow for the projecting bolt heads.

Where girders intersect at an angle other than 90°, or where several members come together, special hangers can be fabricated. An adequate fixing area must be provided on the support girder and torsional forces must be restrained. Metalwork is usually finished by hot dipped galvanising, but a paint finish, to the Client's specification, can be provided.

SUPPORT CONDITIONS

FIGURE 5.06 *MEDIUM DUTY GIRDER HANGER*

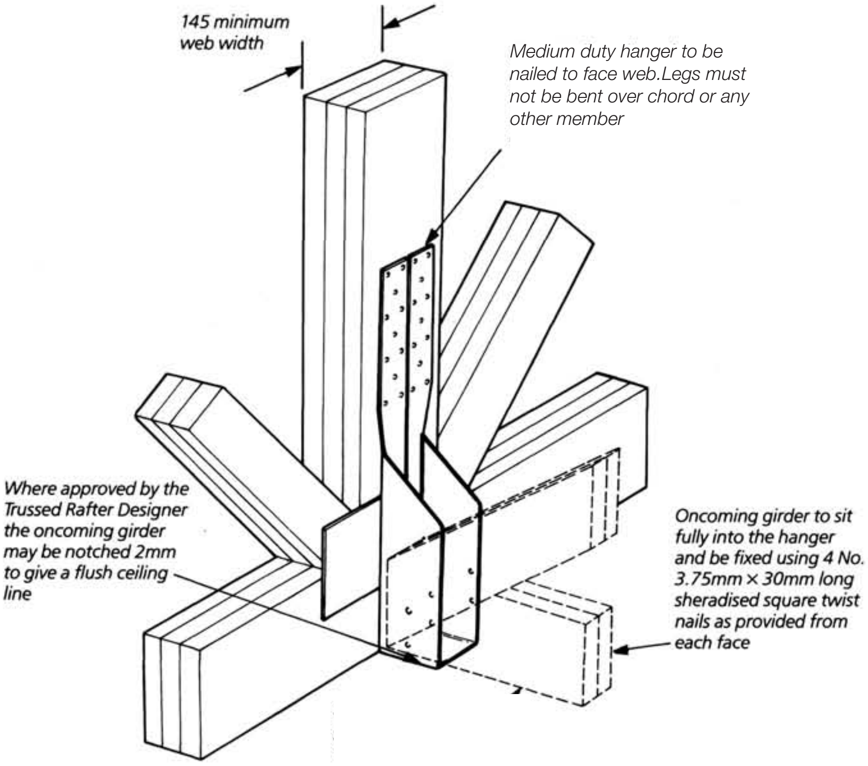
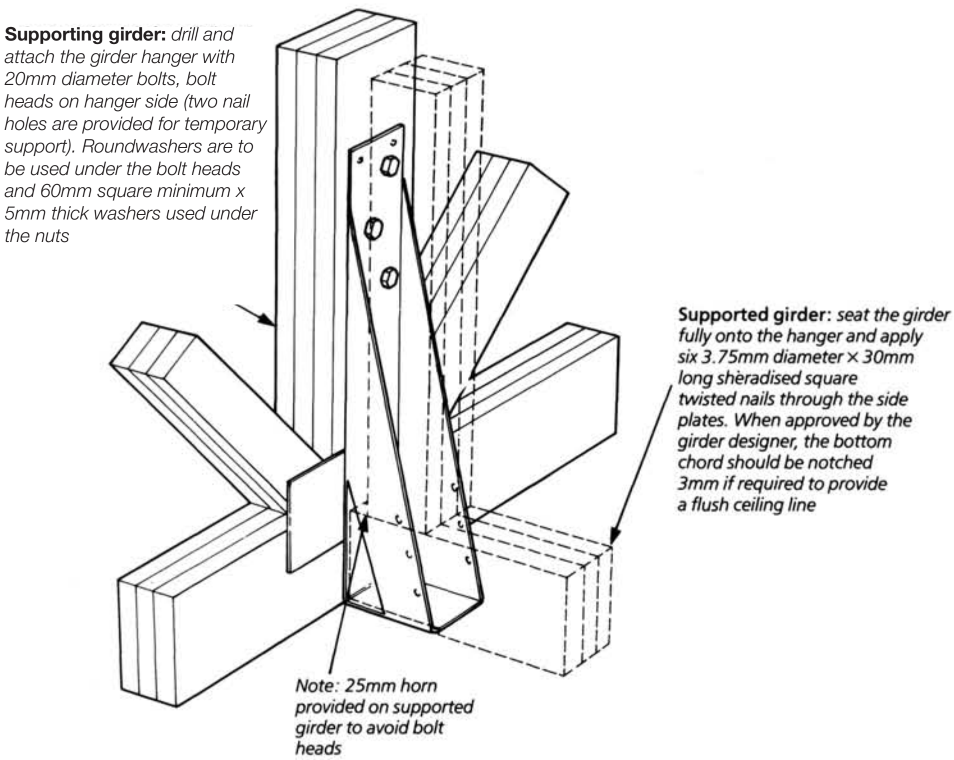


FIGURE 5.07 *HEAVY DUTY GIRDER HANGER*



SUPPORT CONDITIONS

Support Provided by Masonry

The design of a wall support or a hanger built into the wall, requires a knowledge of the types of masonry and mortars employed, the structural action of the wall and considerable masonry design experience. Delegating this responsibility to the Trussed Rafter Designer is therefore both wrong and potentially dangerous. The design of all masonry fixings must always remain the responsibility of the Building Designer.

Where trussed rafters are to be fixed to or supported on masonry, reactions will be provided by the Trussed Rafter Designer. Where these reactions are too large to suit proprietory masonry hangers, horn supports can be used. At internal support walls care should be taken to ensure these do not penetrate the masonry, unless secondary fire protection is provided at the ends of the timber.

SPECIAL DETAILS

In line with the objective of this manual, to provide a comprehensive reference guide to the design of trussed rafter roofs, this section considers a number of special details that occur. Fire precautions are reviewed, the required connections between the walls and roof are given, together with support details for water tanks and services. Particular emphasis is devoted to the detailing of loose infill areas, including framing to dogleg turns.

Water Tank Location and Support

Even a small domestic cold water storage tank weighs a third of a tonne, whilst a large tank, say for a hospital building, can exceed 10 tonnes. The following will enable the Building Designer to make adequate provision for a tank in the majority of buildings:

• Advise the Trussed Rafter Designer of the size and location of the tank.

• For domestic 230 litre or 300 litre net capacity tanks, specify the tank support timbers in accordance with Figure 6.01, stating whether load is spread over three or four trusses.

• For larger tanks, agree the support points with the Trussed Rafter Designer and design the support timber in accordance with BS5268: Part 2.

• Where headroom is limited joist hangers can be used, as Figure 6.02.

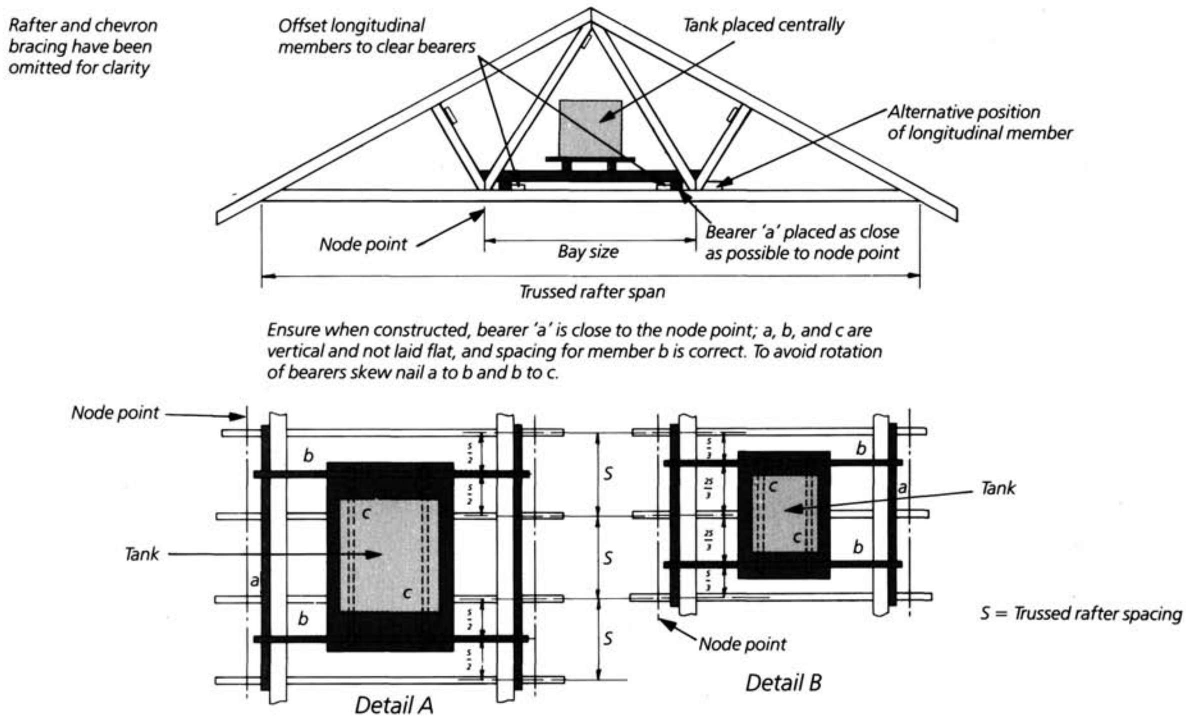
• Chipboard is not recommended for the tank platform. Plywood or timber is preferred.

• Where tanks cannot be located within the web configuration, they are usually supported between multiple trusses (Figure 6.03).

• Where extra head height is required, for showers and the like, the tank must not be supported off the webs or hung from the rafters. A framework must be designed following the principles of Figure 6.01. A typical detail is given in Figure 6.04, which transfers the load to the node points assumed by the trussed rafter design.

• Figure 6.05 illustrates the alternative locations for the tank in an attic truss. The space is sometimes limited requiring smaller tanks to be used in tandemto provide the required capacity.

FIGURE 6.01 *WATER TANK SUPPORT*



SIZES FOR SUPPORT MEMBERS				
Tank capacity to marked waterline	Minimum member size (mm)		Max. trussed rafter span for fink (m)	Max. bay size for other configurations (m)
	a and c	b		
Detail A not more than 300 litres on 4 trussed rafters	47x72	2/35x97 or 1/47x120	6.50	2.20
	47x72	2/35x120 or 1/47x145	9.00	2.80
	47x72	2/35x145	12.00	3.80
Detail B not more than 230 litres on 3 trussed rafters	47x72	1/47x97	6.50	2.20
	47x72	2/35x97 or 1/47x120	9.00	2.80
	47x72	2/35x120 or 1/47x145	12.00	3.80

SPECIAL DETAILS

FIGURE 6.02 *ALTERNATIVE TANK SUPPORT DETAIL*

Where space is limited the alternative arrangement may be adopted to provide more headroom above the tank platform. A minimum of 25mm should be left between bearer 'b' and the ceiling to allow for a long-term deflection. Bearer 'c' should be clear of the ceiling ties for the same reason.

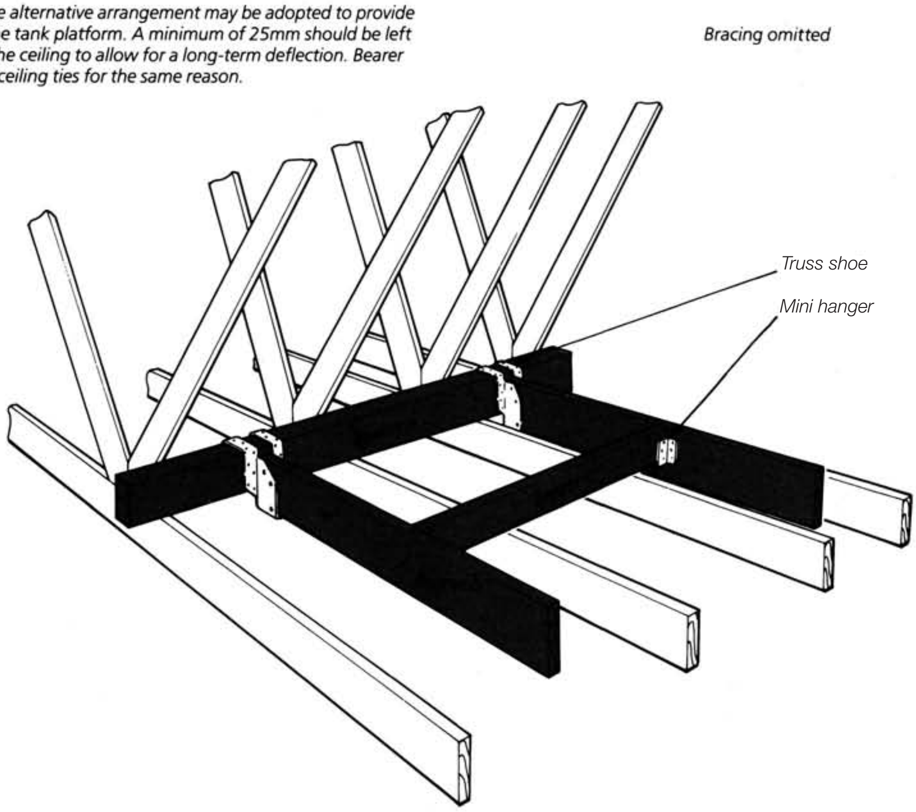
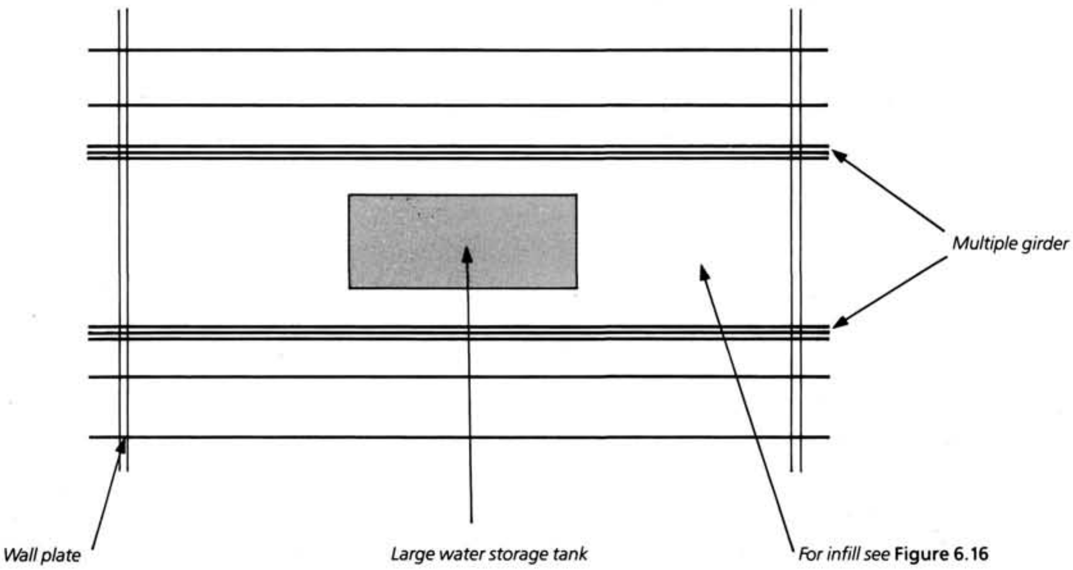


FIGURE 6.03 *LARGE TANK SUPPORT*

Tank load transferred to nodes of girders by framework detailed by Building Designer.



SPECIAL DETAILS

FIGURE 6.04 *ELEVATED WATER STORAGE TANK*

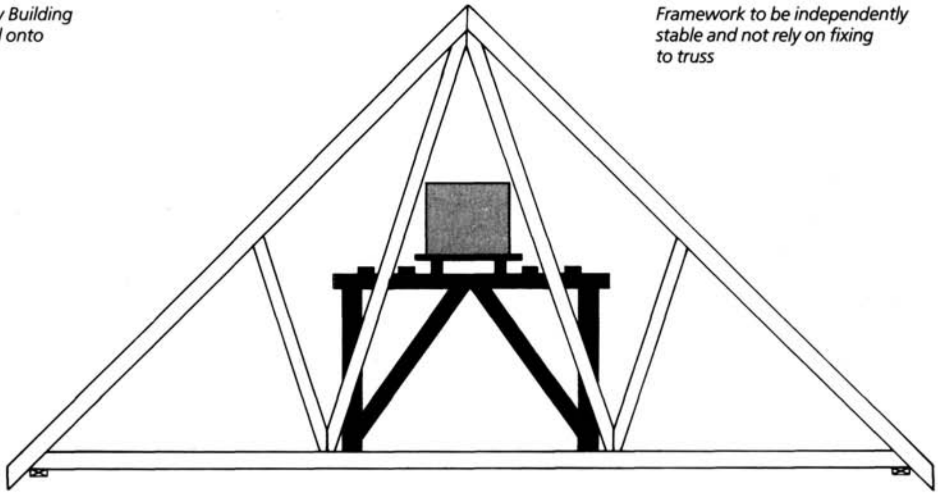
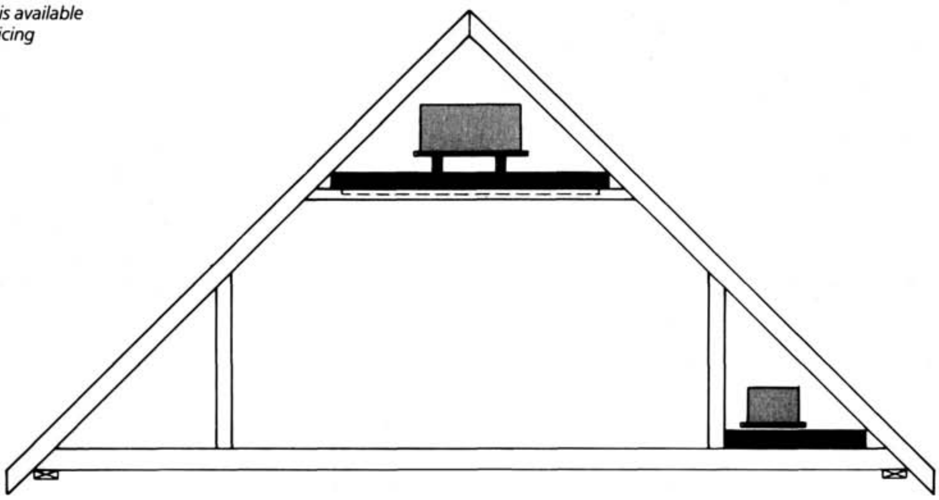


FIGURE 6.05 *TANK LOCATION IN ATTIC TRUSSED RAFTERS*



Support for Services

As discussed in Section 3, loads from services fall into two categories, i.e. major items, which have to be treated individually, and service runs, such as pipework and ducting, for which an allowance is made of a uniformly distributed load.

Major Items

If major equipment is to be collected together in a plant room, support should be provided independent of the roof structure. If, however, a more discrete layout is adopted, items such as fans, control panels, and air handling units, can readily be supported by the trussed rafter roof system.

Support on the bottom chord follows identical principles to those for cold water storage tanks discussed earlier. Support from the top chord requires more care in the design of the hanger fixings and should only be considered where support on the bottom chord is impractical. Nailed fixings designed in accordance with BS5268: Part 2 should normally be used.

Bolted fixings are only applicable where a high degree of site supervision is assured, and the chord size is increased in depth to allow for the loss in strength due to the bolt hole.

Service Runs

Figures 6.06 to 6.08 detail a number of ways of supporting service runs. Normally, a pipe or duct will be supported every three or four trusses. For multiple runs this can lead to overloading if all services are supported on the same truss.

A more even distribution of load is achieved by staggering the supports (Figure 6.06a) or by using timber stools which spread the load onto the node points of two trusses (Figure 6.07).

FIGURE 6.06 *SERVICES SUPPORTED ON BOTTOM CHORDS*

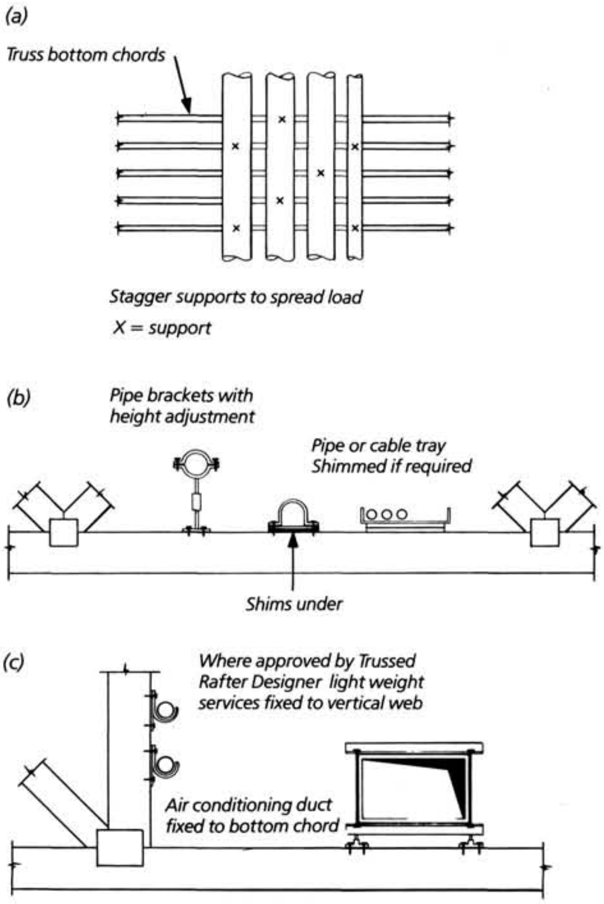


FIGURE 6.07 *SERVICES SUPPORTED ON STOOLS*

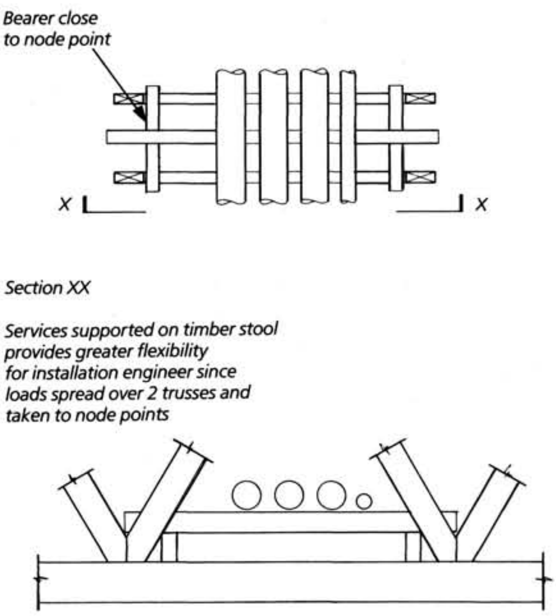
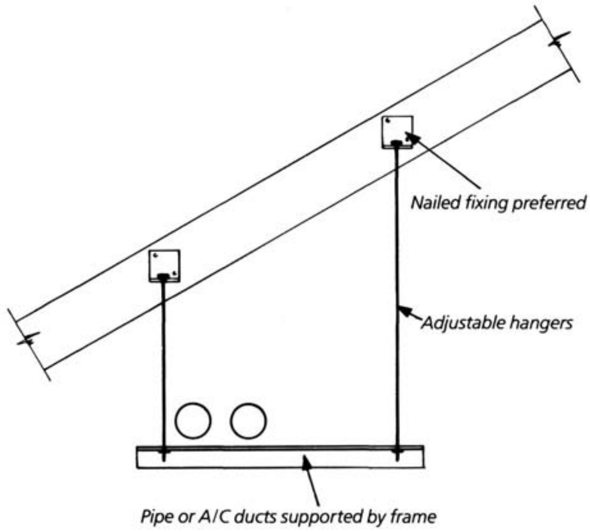


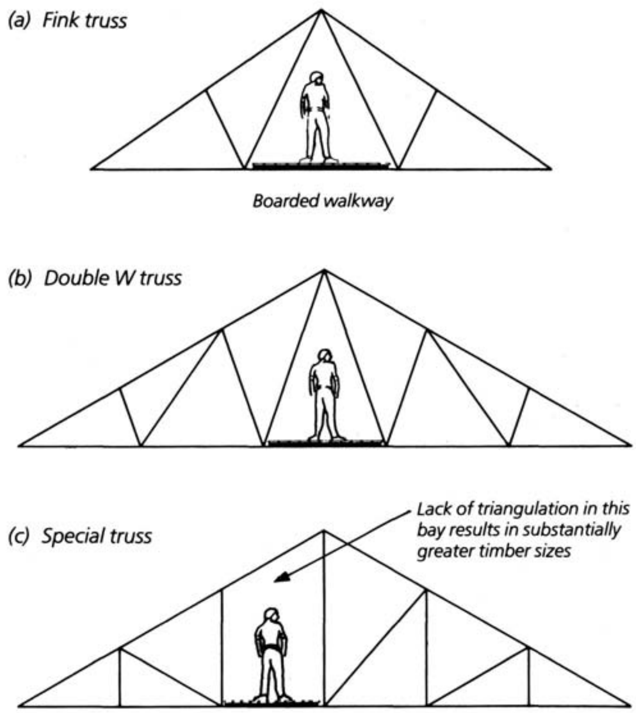
FIGURE 6.08 *SERVICES SUSPENDED FROM RAFTER*



Access to Services

Some buildings, for example hospitals, require a large number of the services to be located in the roof. In these situations the provision of an access walkway may be necessary. This can usually be achieved within normal web configurations (Figure 6.09a and b). Details, such as Figure 6.09c, should be avoided. The lack of triangulation in this form results in an inefficient trussed rafter, requiring twice the amount of timber.

FIGURE 6.09 *ACCESS TO ROOF VOID*



SPECIAL DETAILS

Site Infill

It is impractical and uneconomic to prefabricate some sections of a roof. These areas are constructed using loose timbers, often referred to as either site infill, loose timbering, site framing or stick built. Support is nearly always provided by trussed rafter girders or multiple trusses. These girders support purlins and binders at every node point which, in turn, support the infill rafters and ceiling joists. It is essential that all nodes are used, otherwise the girders can be severely overstressed. The procedure is best described by example, the following cases being considered in detail:

- Small infill areas, e.g. hatch and chimney trimming
- Cranked or dogleg turns
- Large infill areas

Responsibility for detailing these areas rests with the Building Designer, who should ensure that the Trussed Rafter Designer has correctly allowed for the loads on girders generated by the infill timber.

Small Infill Areas

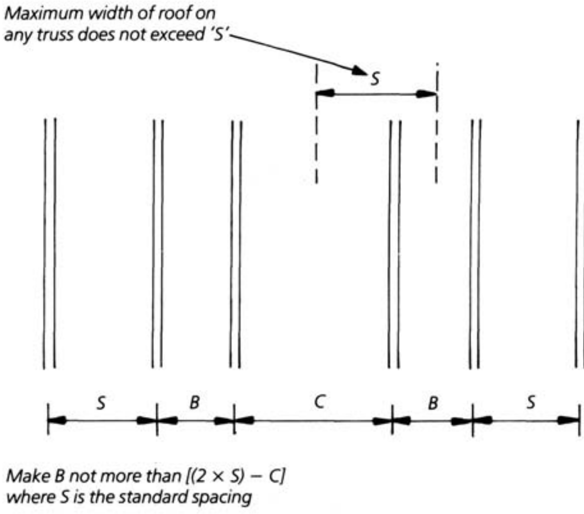
Every effort should be made to accommodate openings within the trussed rafter design spacing. Where this cannot be achieved the spacing of the trusses adjacent to the opening may be increased as shown in Figure 6.10, where:

S is the design spacing of the trussed rafters;

B is the distance between the centres of the trimming trussed rafter and the adjacent trussed rafter;

C is the nominal width of the required opening, and does not exceed 2 x S.

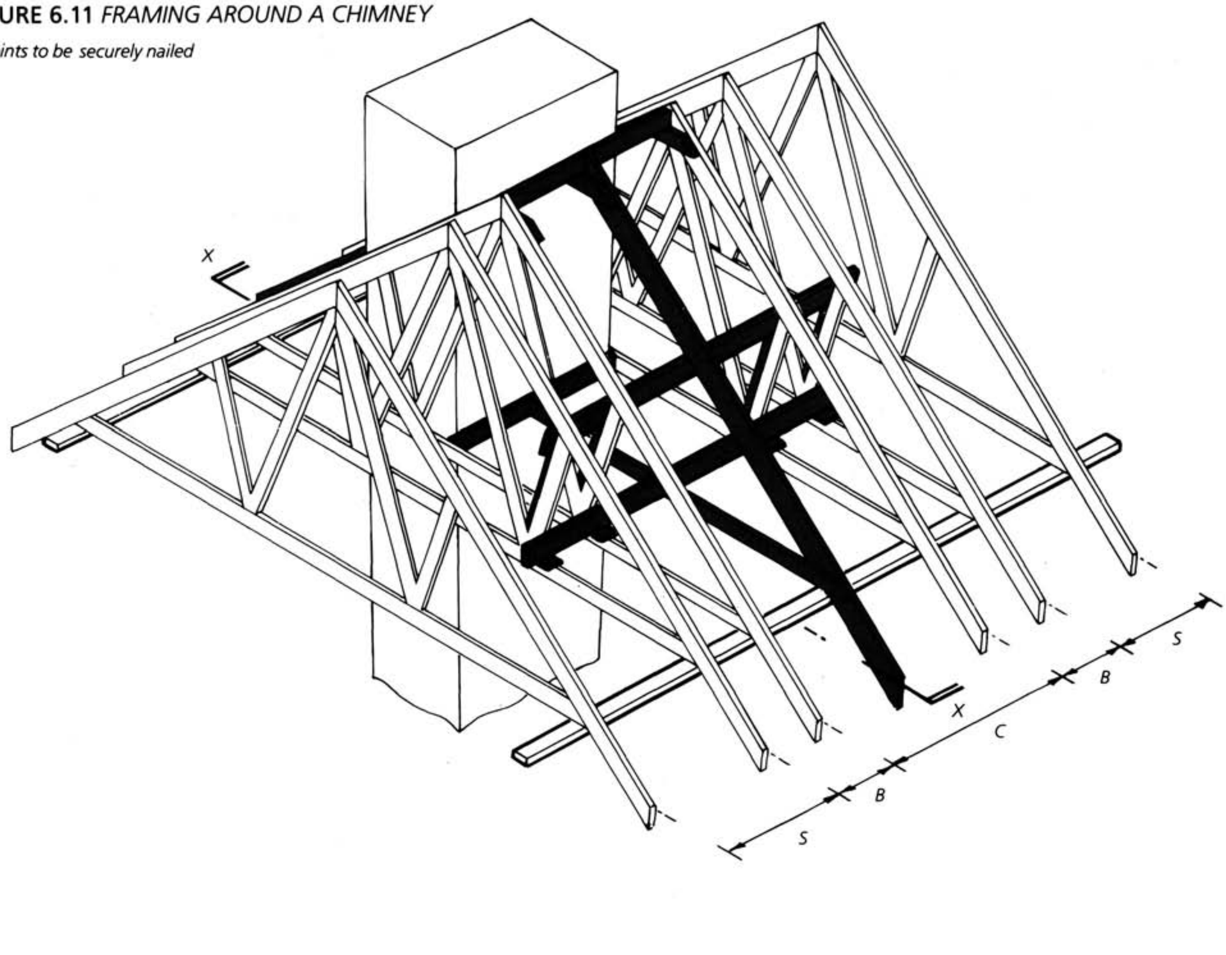
FIGURE 6.10 *REVISED TRUSS SPACING AT SMALL OPENINGS*



Loose timbers will be required to support the tiles and ceiling around the opening. Typical details for framing around a chimney are given in Figure 6.11, but the principles apply to other openings also.

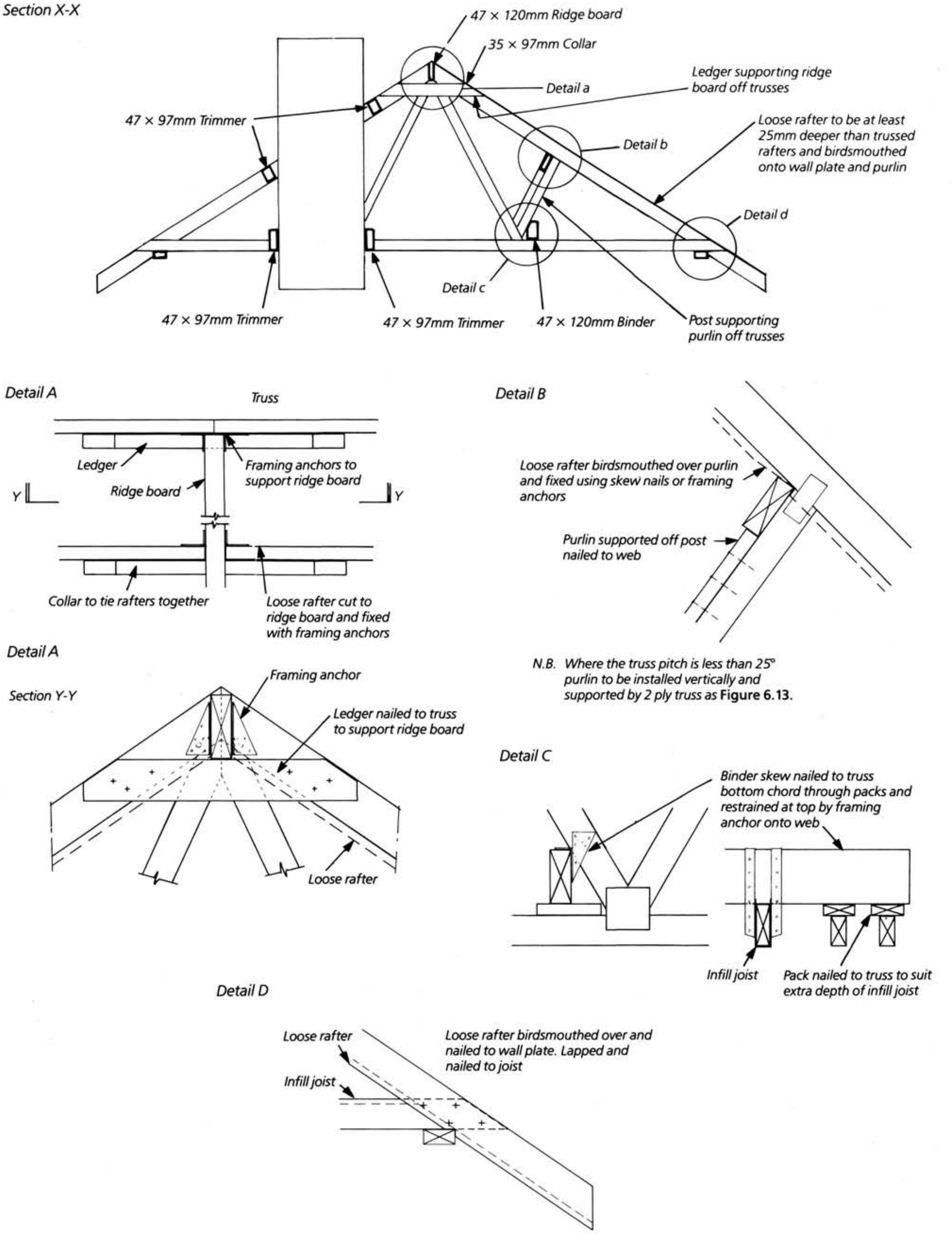
FIGURE 6.11 *FRAMING AROUND A CHIMNEY*

All joints to be securely nailed



SPECIAL DETAILS

FIGURE 6.11 *FRAMING AROUND A CHIMNEY*



SPECIAL DETAILS

Where the two trimming trusses each side of the opening are nominally fixed together with nails at 600mm centres along all members, an opening of up to three standard spacings may be used as in Figure 6.12.

The purlins in this case must be 47mm x 169mm, installed vertically using metal hangers as in Figure 6.13. The binders and ridge board should be increased to 47mm x 169mm and the trimmer to 47mm x 120mm.

FIGURE 6.12 *DOUBLE TRUSS OPENING*

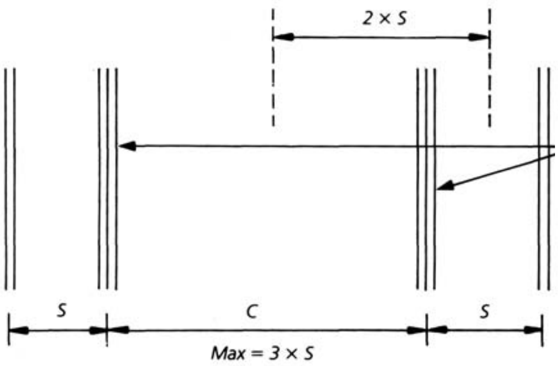


FIGURE 6.12 *DOUBLE TRUSS OPENING*

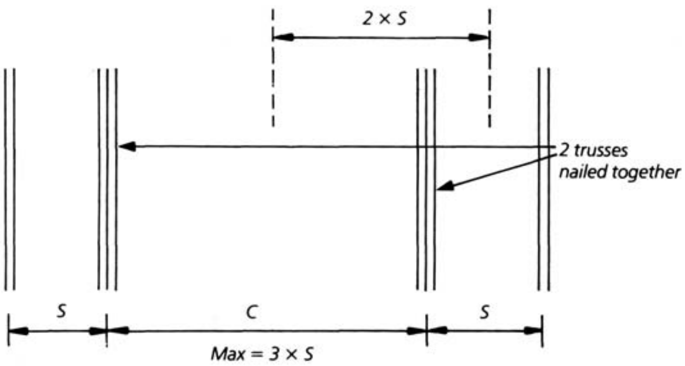
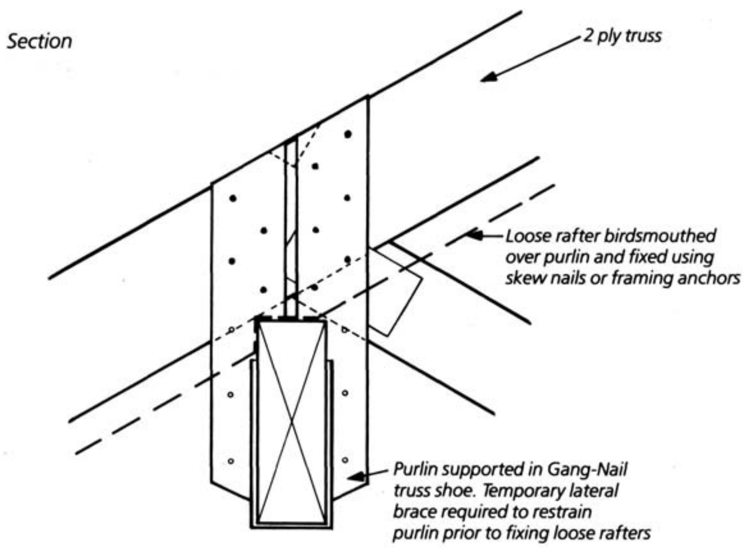


FIGURE 6.13 *VERTICAL PURLIN SUPPORT*



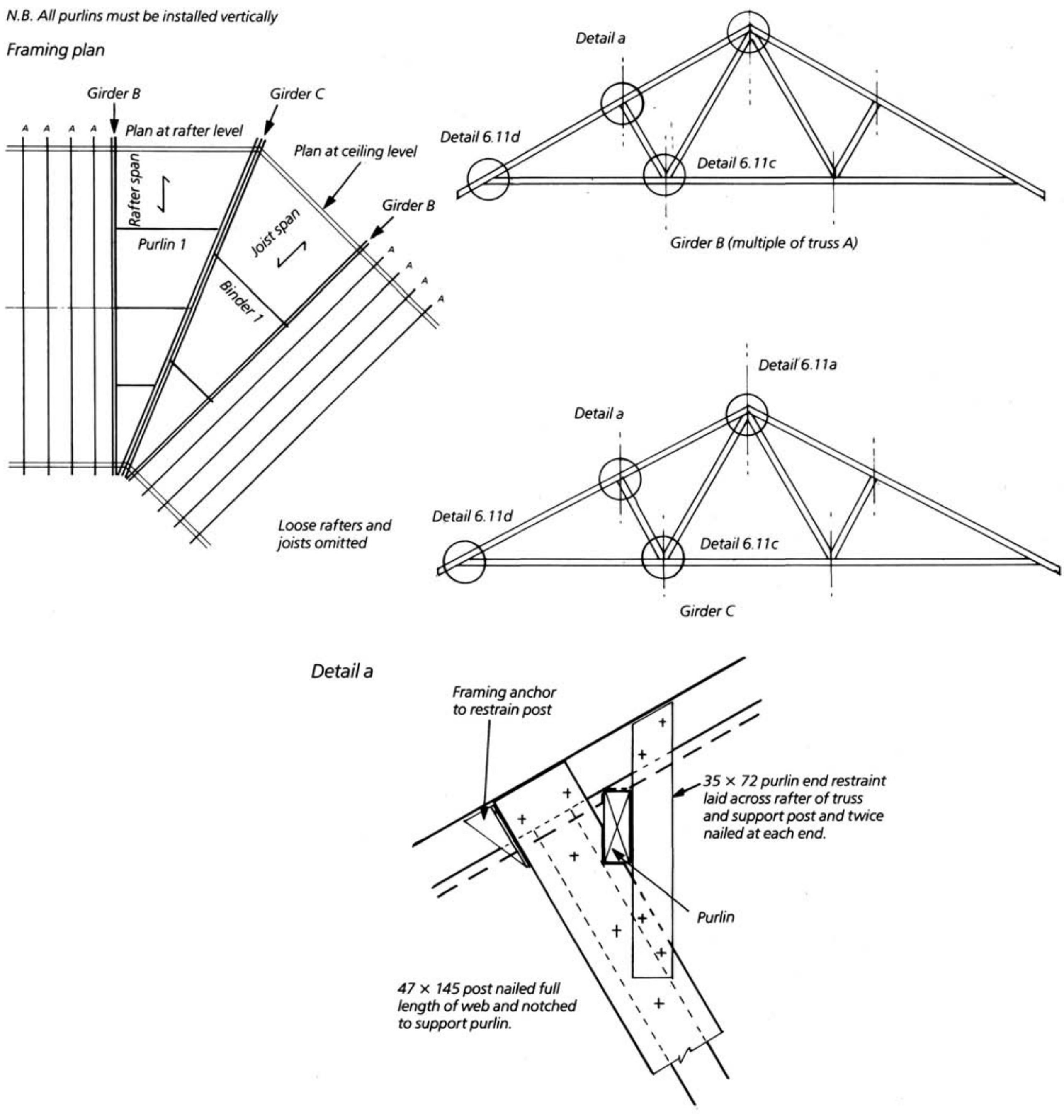
The above recommendations for chimney openings assume:

- that the purlin,binder and ridge board are C24 or better;
- a fink profile truss of 12m maximum span at 600mm centres;
- standard loading on the rafter and ceiling tie equivalent to concrete interlocking tiles with a plasterboard ceiling;
- for all cases where the roof pitch is less than 25° the purlins are installed vertically and supported on 2-ply trusses, as Figures 6.12 and 6.13;
- the infill rafter and ceiling joist are detailed by the Building Designer.
- depending on the design of the chimney flue and stack, appropriate clearance is allowed between timber and chimney.

Cranked or dogleg turns

Cranked or dogleg turns, as described in Section 4, involve large areas of loose infill (Figure 6.14).

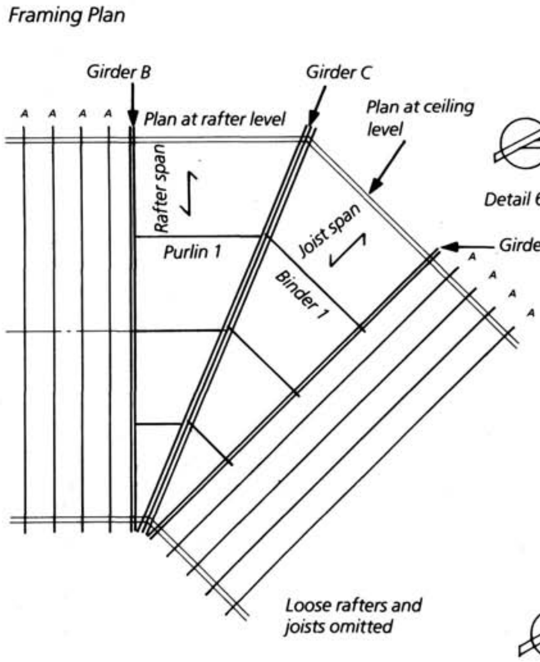
FIGURE 6.14 *FRAMING A DOGLEG TURN – FINK GIRDERS*

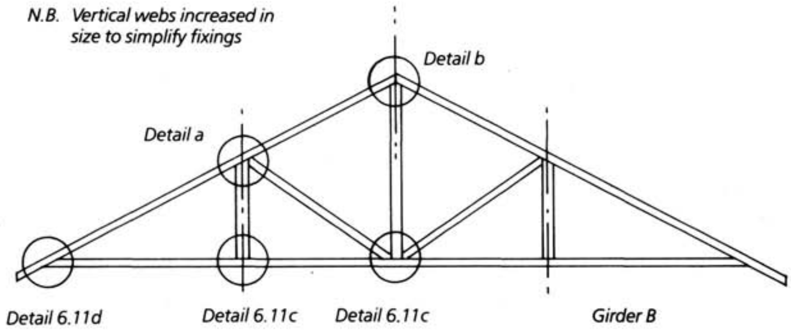


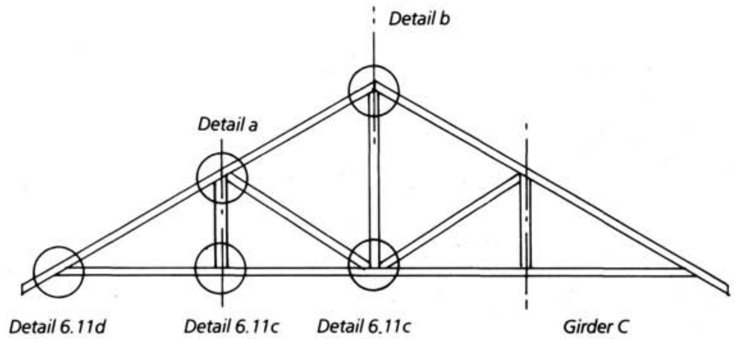
Girder C should be a similar profile to Girder B to ensure that the node points line up when locating the purlins and binders. Where for small spans and/or small turn angles the total UDL load on Purlin 1 is not greater than 4.5kN, Girder B can be a multiple of truss A. For larger intersections, where the purlin loads exceed 4.5kN, it is recommended that the profiles of Girders B and C should be chosen to have vertical webs, similar to Figure 6.15. The vertical web width can then easily be increased to accommodate the fixing for the purlin. The number of bays is dependent on span and pitch but generally 2 metres is a comfortable bay size.

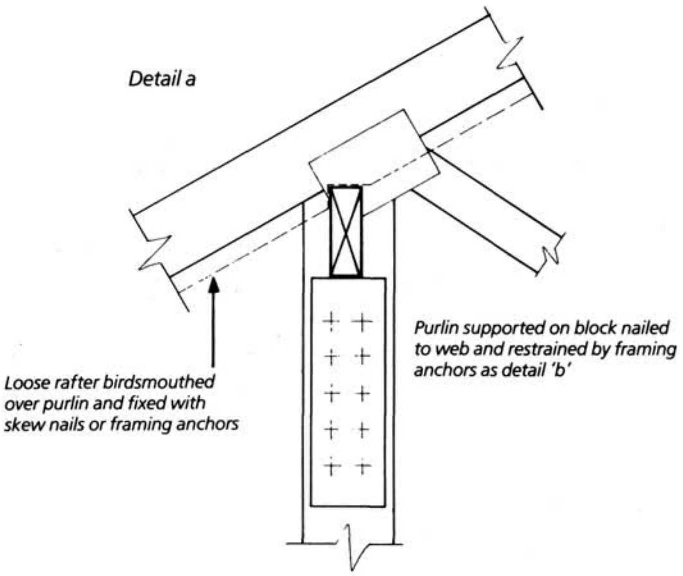
SPECIAL DETAILS

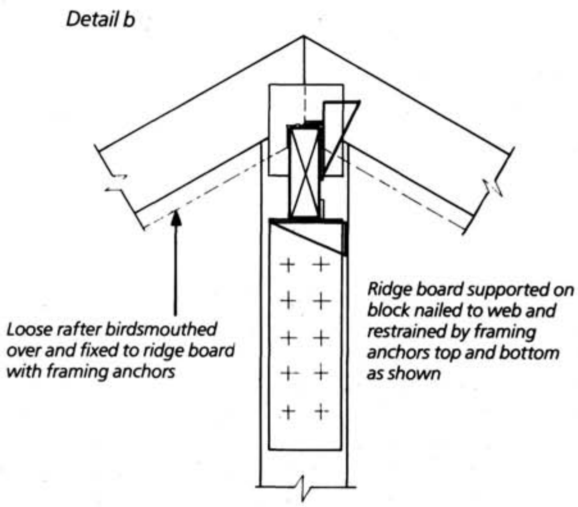
FIGURE 6.15 *FRAMING A DOGLEG TURN – HOWE GIRDERS*











It is a simple matter to check the purlin load, as the following example.

Assume:

Roof Covering	- Concrete interlocking tiles ($685N/m^2$ on slope)
Main Span	- 8 m
Pitch	- 25°
Angle turned	- 45°
Girder Profile	- Fink

Top Chord Load - Dead $\frac{685}{\text{Cos}25°} = 756N/m^2$ on Plan

-Imposed = $750N/m^2$

Total $1506N/m^2$ on Plan

Assume Girder B is a multiple of A and check load on Purlin 1.

Maximum Purlin Span
$= {}^3/4 \times 8 \times \text{Tan}22.5 = 2.48m$

Loose Rafter Span $= 8/4 = 2.0m$

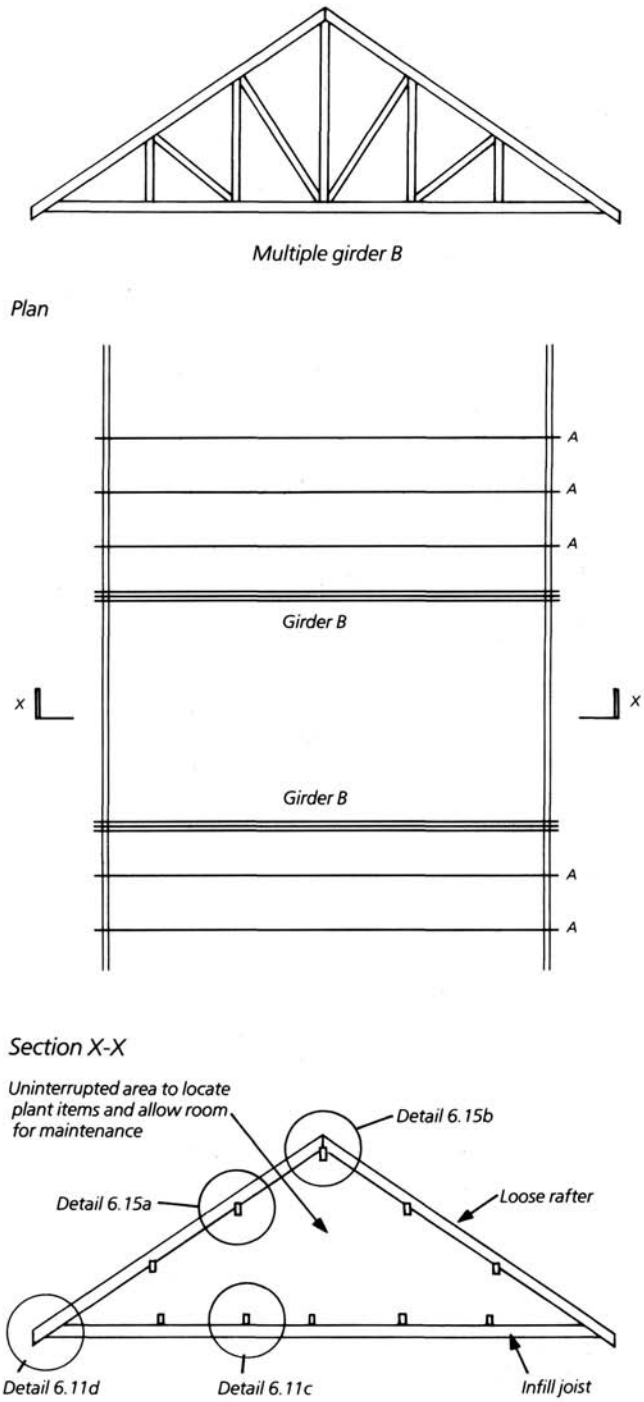
Therefore load on purlin
$= 2.48 \times 2 \times 1506 = 7.5kN > 4.5kN$

Hence vertical webs required. Use Howe profile for Girders B and C, as Figure 6.15.

Large Infill Areas

Large infill areas occur where, in order to house substantial water storage tanks, for example, an uninterrupted roof void is required free of any internal web members. Girders are located both sides of the zone, supporting the infill timbers and also if required the items of plant, as figure 6.16. The details follow similar principles to those discussed already,except that heavy duty hangers may be required where the binders also support the plant loads.

FIGURE 6.16 *LARGE INFILL AREAS*



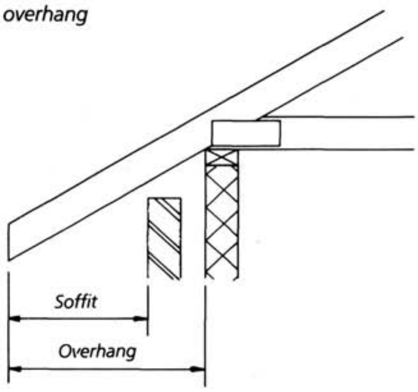
SPECIAL DETAILS

Wide Eaves Soffits

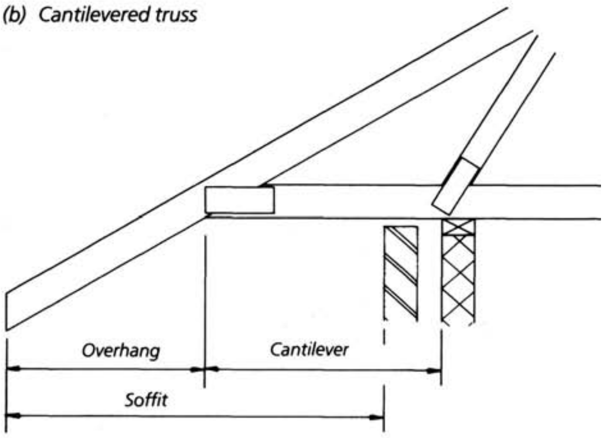
The majority of roofs project a small distance beyond the face of the external walls. This is normally referred to as a soffit and is achieved by providing a rafter overhang as discussed in Section 2 and illustrated in Figure 6.17a. Where larger soffits are required, they are usually provided by either the appropriate rafter overhang or by cantilevering the truss, as in Figure 6.17b.

FIGURE 6.17 *WIDE EAVES SOFFITS*

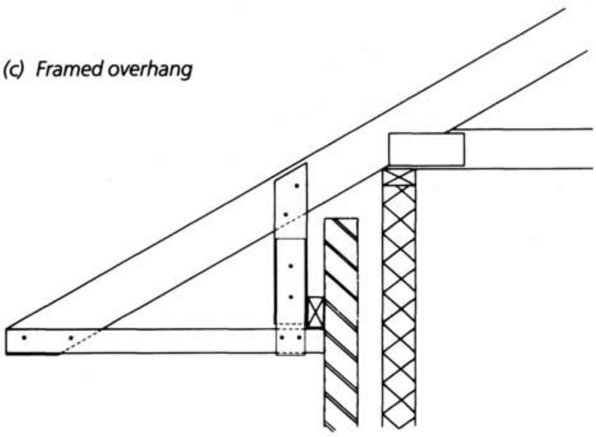
(a) Rafter overhang



(b) Cantilevered truss



(c) Framed overhang



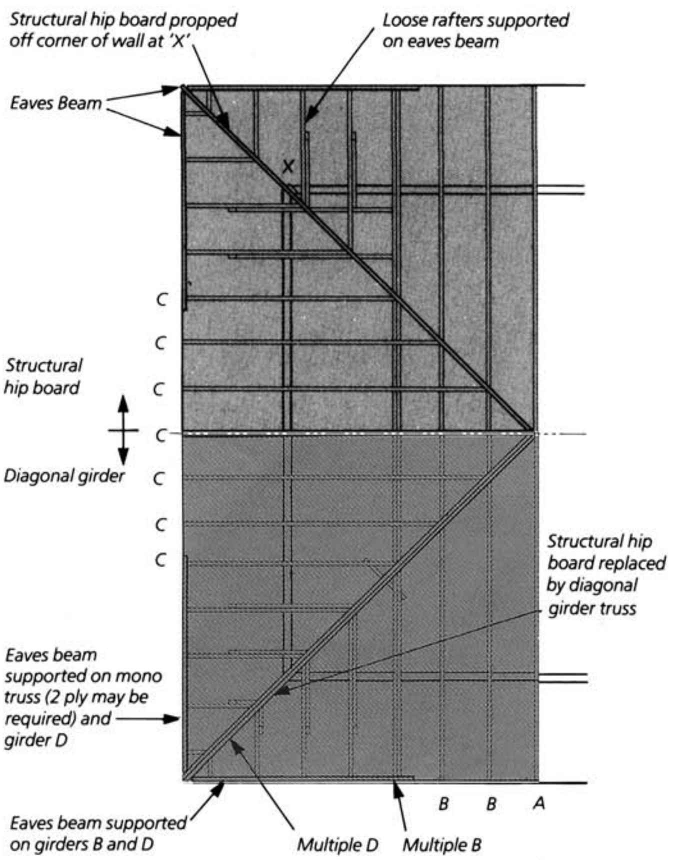
Detail 'b' is far easier to achieve than Detail 'a', since it is controlled by the span of the trussed rafter and often a cantilever of Span/4 can be achieved. Detail 'a' on the other hand is controlled by the rafter size and typically for depths up to 145mm and standard loads, the overhang can be nine times the rafter depth for C24 and TR26 where the spacing of the trussed rafters does not exceed 600mm and the roof pitch is not greater than 35°.

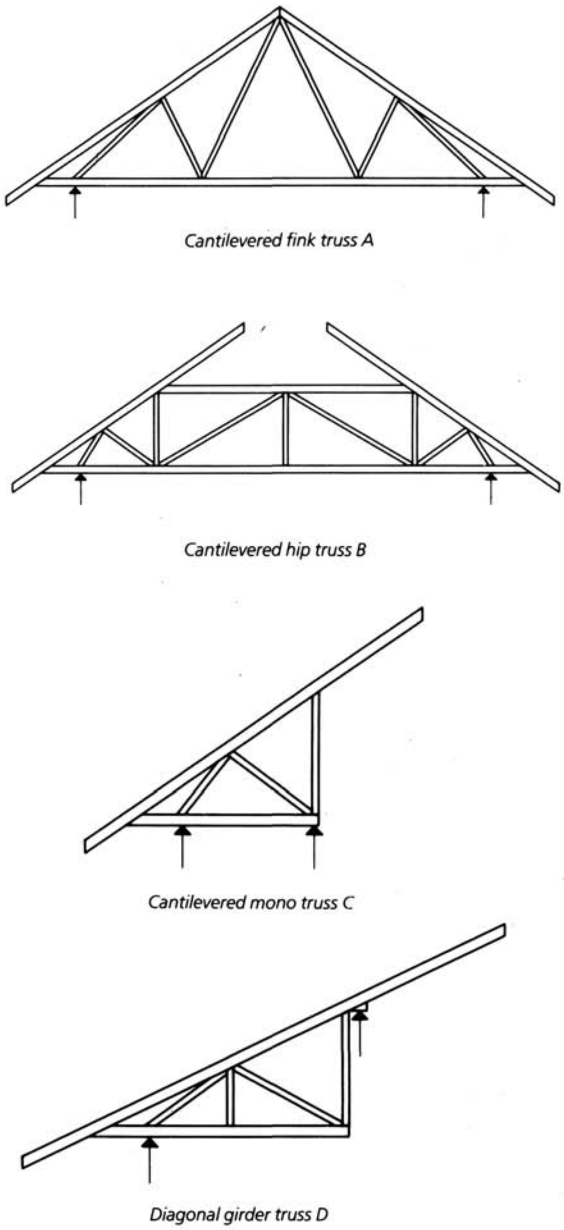
With some soffit details it is possible to extend the scope of Detail 'a' by framing the overhang (Figure 6.17c), details of which must be provided by the Building Designer.

Cantilevered Hip Ends

Where cantilevered hip ends are planned, the Building Designer should ensure that adequate support can be provided for the corner infill area. Two possible methods are shown in Figure 6.18. For small cantilevers a structural hip board is used, propped off the corner of the wall and cantilevering out to support eaves beams. For larger cantilevers, the hip board is replaced by a diagonal girder. The eaves beams in either case support the loose rafters and adequate eaves depth must be allowed to accommodate the beams.

FIGURE 6.18 *CANTILEVERED HIP END*





Large rafter overhangs on hip ends present similar problems to those already discussed and structural eaves beams will often be required.

SPECIAL DETAILS

Gable Ladders

Gable Ladders are used at gable ends to provide an overhanging verge. As shown in Figure 6.19, a gable ladder consists of two rafter members joined together and supported by cross noggings built into the brickwork. The gable ladder should be nailed to the last truss only after the gable wall is built up and able to provide support. It should never be allowed to hang unsupported. The last truss should be located such that the ladder projection (a) is not greater than the supported distance (b).

Where the gable ladder width exceeds the truss spacing, additional support will be required for the tile battens. Internoggings should be used, staggered to assist nailing (Figure 6.20a). Where the rafter depth is at least 120mm, the alternative shown in Figure 6.20b may be used.

FIGURE 6.19 *GABLE LADDERS*

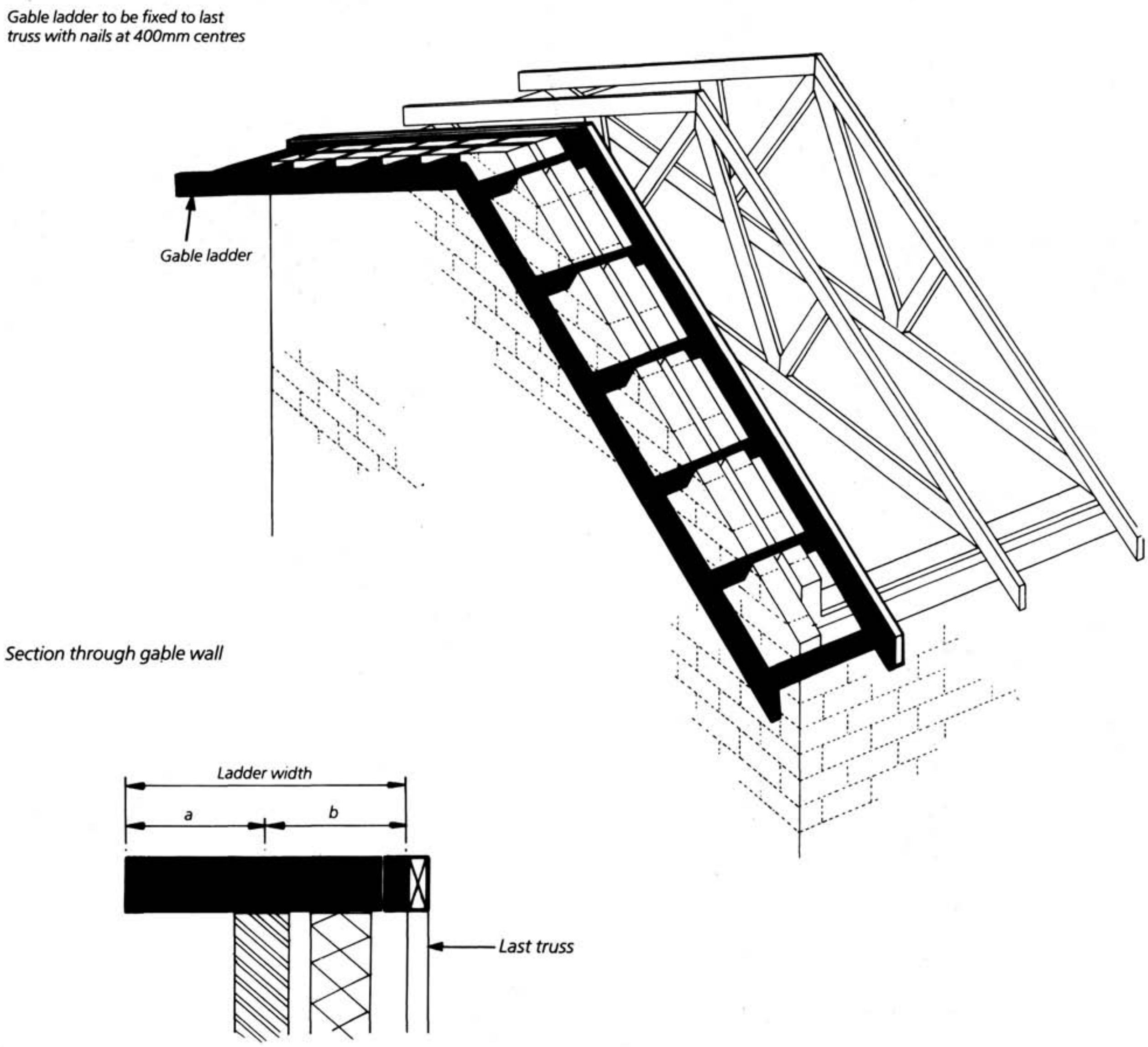
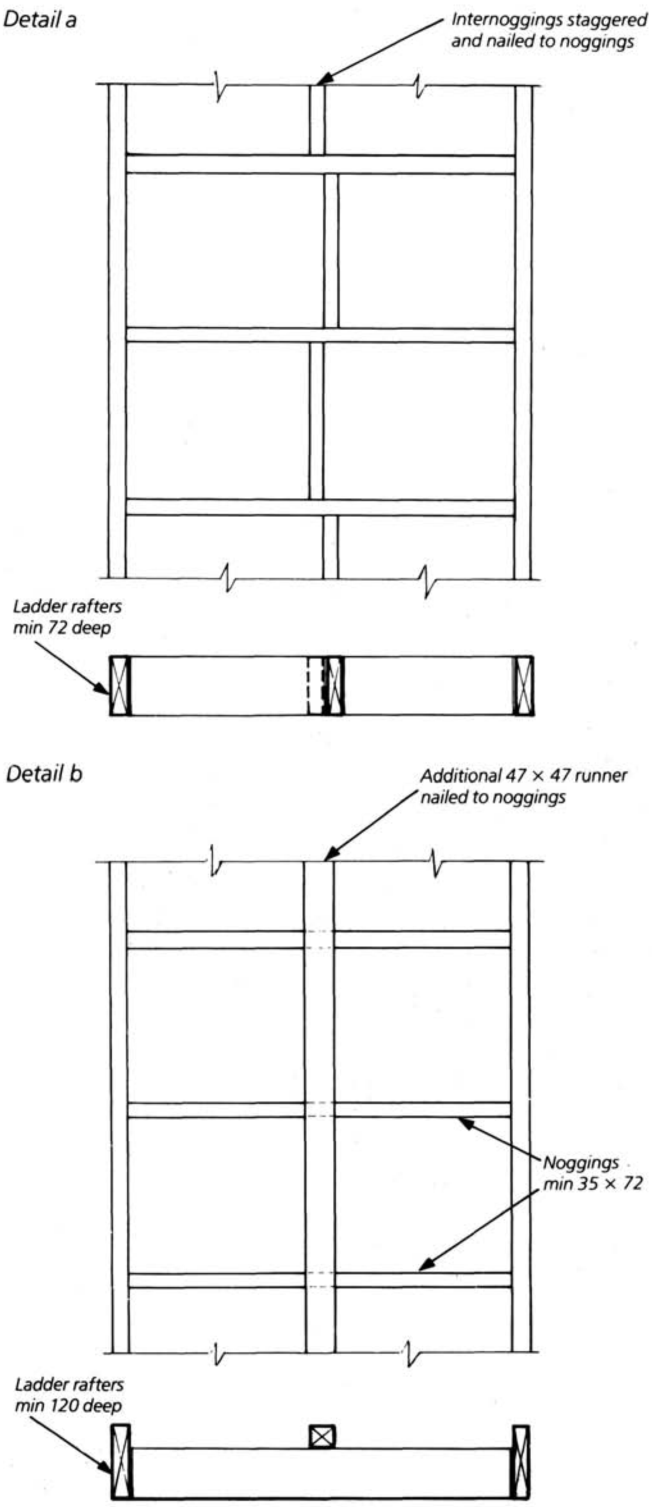


FIGURE 6.20 *WIDE GABLE LADDER*



The Building Designer should pay particular attention to:

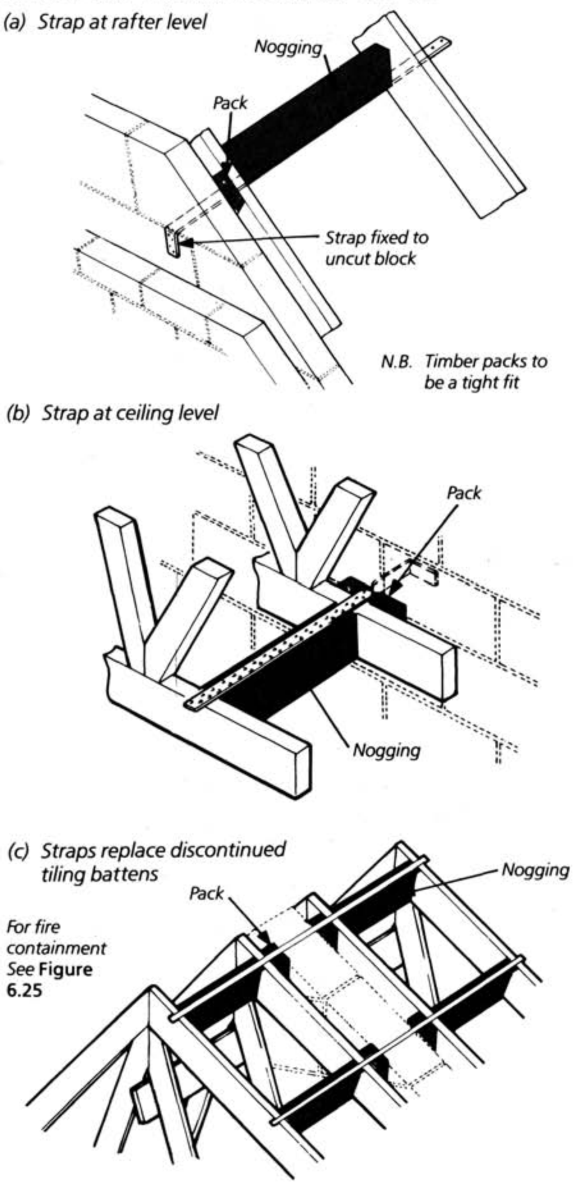
- Gable ladders wider than twice the truss spacing. These require special details.
- Wind uplift, which should be carefully checked on all gable ladders. Straps to prevent movement will often be required.

Lateral Support to Walls at Roof Level

The trussed rafter roof structure should be connected adequately to external masonry or timber frame walls and any other vertical load bearing elements of a building. As explained in Section 7, this is to provide the necessary lateral support to walls at roof level. The responsibility for the design of these connections rests with the Building Designer.

Generally, connections should be made to the rafter with 30mm x 5mm thick galvanised steel straps, fixed to at least two trusses and a nogging with 3.35mm x 50mm long wire nails (Figure 6.21a). On gable walls they should be spaced at not more than 2m centres at rafter and ceiling tie levels. Party walls should have restraining straps at ceiling tie level (Figure 6.21b), with the strap connected to two or more trusses on each side of the wall.

FIGURE 6.21 *LATERAL RESTRAINT STRAPS*



If the tiling battens are to be discontinued over a party wall (Figure 6.21c), then lateral restraint must be provided in addition to that required to transfer longitudinal bracing forces. This should consist of straps (or equivalent), adequately protected against corrosion, with a minimum cross sectional area of 50mm2. These straps should be spaced at not more than 1.5m centres and fixed to two rafter members and noggings on each side of the party wall by 3.35mm x 50mm long wire nails.

Extraneous Support

Trussed rafters must only be supported at the positions assumed in design if overstressing, unsightly roof lines, or damage to the finishes are to be avoided. Two particular problem areas are party walls and internal partitions.

Party walls should be stopped 25mm below the tops of rafters to allow the roof to deflect without sitting on the wall. This will prevent an unsightly hump appearing in the ridge line, where this detail is not followed. Fire stopping this detail is discussec later. It is advisable to erect non-loadbearing walls after the tiling has been completed.

This allows deflection to take place under dead load, thereby reducing the risk of cracks appearing in the ceiling finishes or distress being caused to the trussed rafters (Figure 11.14b). Alternatively, if partitions are of brick or block, the final course can be omitted until tiling has been completed.

Fire Precautions

The control of the spread of fire within a building is an extensive subject fully described in Approved Document B2/3/4 Fire Spread. The following is therefore confined to items shown by experience to merit special mention.

Preventing Fire Spread Between Dwellings

It is a requirement of the Building Regulations that fire should be prevented from passing from one dwelling or compartment to the adjacent dwelling or compartment. The Building Research Establishment has noted two areas in a roof where this principle is often neglected or inadequately carried out; at boxed eaves and at the junction between the roof and wall.

Boxed Eaves it is important to recognise that fires are known to have spread between dwellings in the manner shown in Figure 6.22. This can be prevented by adopting the following principles, which ensure that there is a complete separation in the plane of the wall between dwellings that cannot be bypassed by fire.

• Design to simplify the shape of the void to be closed. Consider extending the separating wall to the outer face of the external wall within the eaves (A, Figure 6.23).

• Do not carry the separating wall over an uninterrupted wall plate: movements in the timber will disrupt the brickwork or blockwork.

Select material for filling the eaves void that can be readily cut to profile-or, better, that is sufficiently resilient to achieve a tight fit without gaps.

• Ensure that the filling material can be securely fixed without support from the soffit board: it must remain in place if the soffit board is destroyed by fire.

• Consider using:
(a) Wire reinforced mineral wool, 50mm thick (B, Figure 6.23);
(b) Mineral wool, wired to expanded metal lath for support;
(c) Semi-rigid mineral wool batt, spiked or wedged in place;
(d) Compressed mineral board cut to close fit;
(e) Plywood, not less than 19mm thick and treated with a flame retardant, cut to close fit;
(f) Sand:cement (or pre-mixed vermiculite:cement) render on expanded metal lath.

FIGURE 6.22 *BOXED EAVES – ROUTES FOR SPREAD OF FIRE*

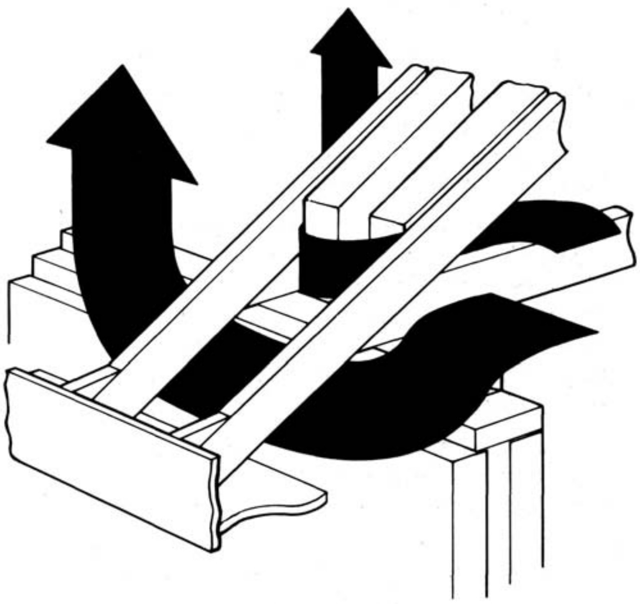
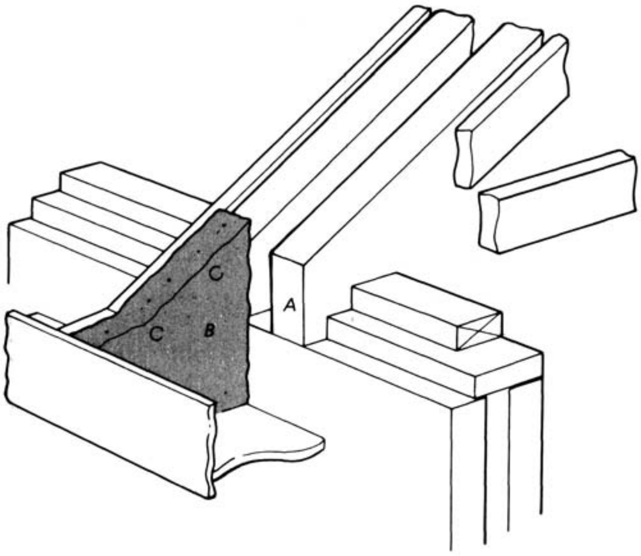


FIGURE 6.23 *BOXED EAVES – FIRE CONTAINED IN DWELLING*



Junction between Roof and Wall-There are three common defects that allow fire to bypass the separating wall (Figure 6.24):

• No attempt is made to prevent it.

• Mineral wool pushed between the top of the wall and the underside of the sarking felt after roofing has been completed, leaving an unsealed gap between the felt and the roof.

• After battening, a mortar bed is trowelled onto the wall under and between the battens; this method also leaves unsealed voids beneath the tiles. Since the battens are supported by the mortar where they cross the wall, it also leads to subsequent hogging of the roof at the separating wall and possible displacement of the tiles.

As in the previous case, it is essential that there is a complete separation in the plane of the wall which cannot be bypassed by fire. To achieve this:

• Ensure that the top of the separating wall-when trimmed to the slope of the roof and mortared if necessary to achieve a fair line-is about 25mm below the top edges of the adjacent rafters. This will minimise the risk of hogging of the roof.

• Select for fire-stopping a rock-wool, slag-wool or glass fibre quilt that is resilient enough to fill irregular spaces, but not so resilient as to lift or dislodge tiles.

• Ensure that, before felting and battening, the quilt is laid down on the top edge of the separating wall, with the edges tucked between faces of the wall and adjoining rafters to keep it in place initially (A, Figure 6.25).

• Ensure that, after felting and battening, lengths of quilt are laid between battens as tiling proceeds or fixed by spot sticking in place before tiling (B, Figure 6.25).

• Instruct the site to check, either as tiling proceeds or later by lifting tile ends, that the quilt is in place.

• Do not use intumescent materials-they are not suitable for this application.

FIGURE 6.24 *SEPARATING WALL – ROUTES FOR SPREAD OF FIRE*

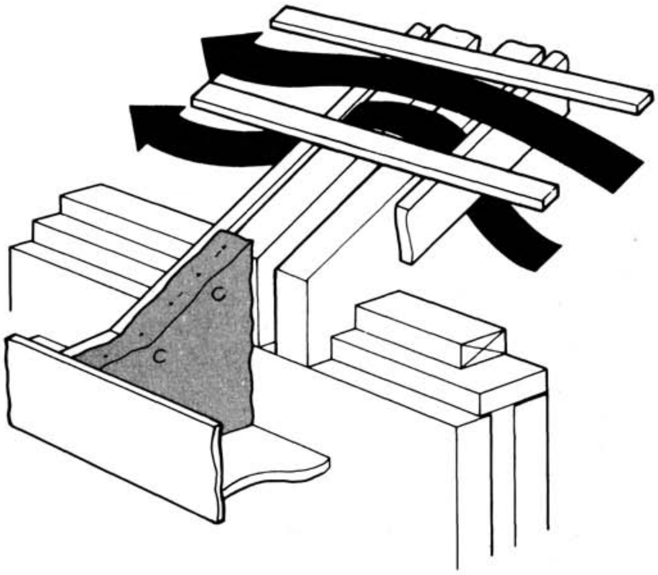
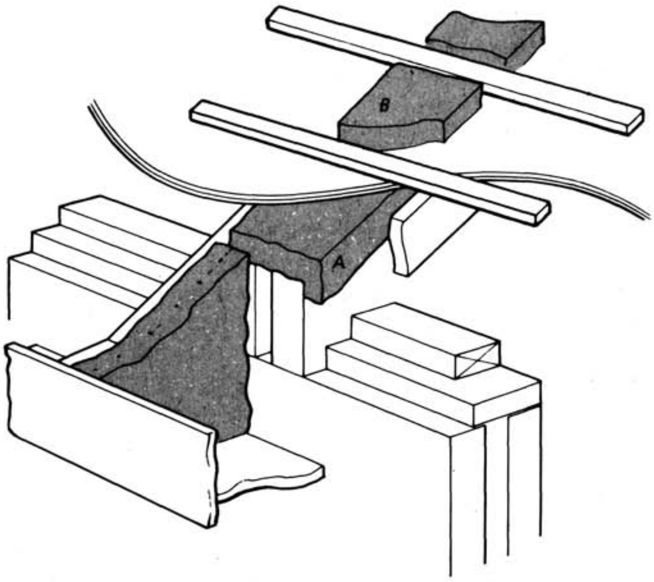


FIGURE 6.25 *SEPARATING WALL – FIRE CONTAINED IN DWELLING*

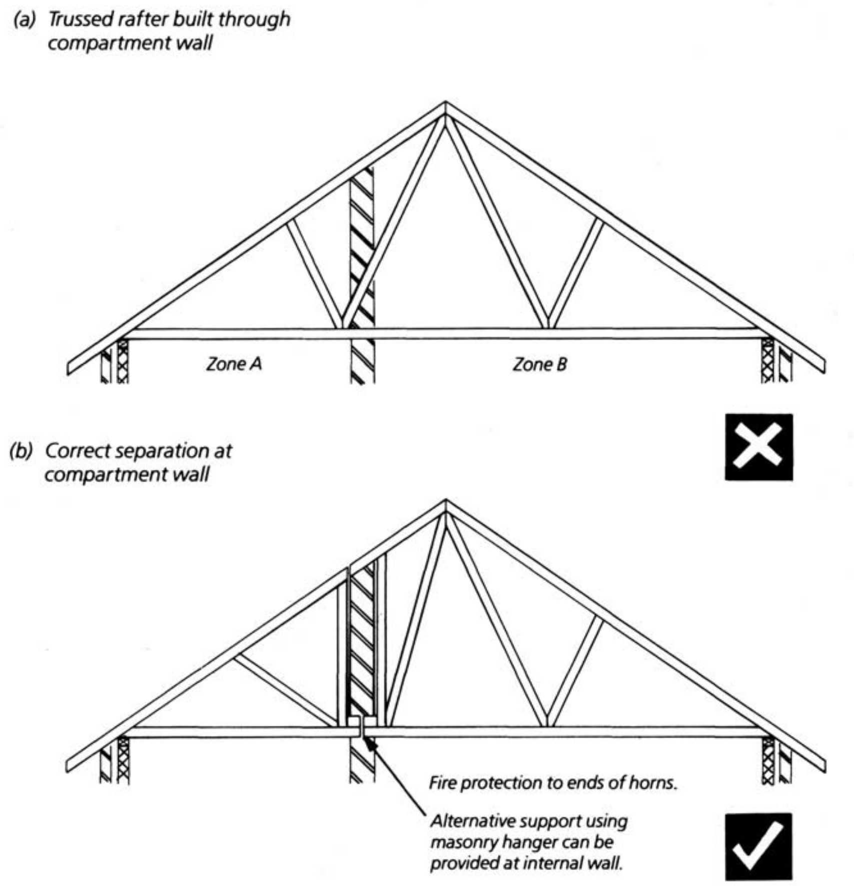


Fire Compartments

A trussed rafter can only perform correctly if each member within it remains intact. For this reason they should never be taken through a compartmental wall as in Figure 6.26a.

A fire in Zone B that seriously weakens the truss will result in a total collapse of the roof over Zones A and B. The correct solution is to provide the truss in two structurally separate parts (Figure 6.26b).

FIGURE 6.26 *FIRE WALLS*



Fire Resistance of Attic Trusses

The floor of an attic truss must provide the modified half hour fire resistance, except where constructed over a garage when the full half hour fire resistance is required. The most practical way of achieving this is to provide a suitable ceiling lining over the full extent of the attic trusses. The use of methods involving plasterboard caps, nailed locally to the truss to mask the connector plates, is discouraged. It is difficult to ensure that the plasterboard caps are fitted initially and replaced if damaged or removed during construction.

Several ways to achieve the fire resistance are given by the plasterboard manufacturers. The Building Designer must advise the Trussed Rafter Designer of the elected method, to ensure any additional load is allowed for in the design of the truss.

SECTION 7

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).

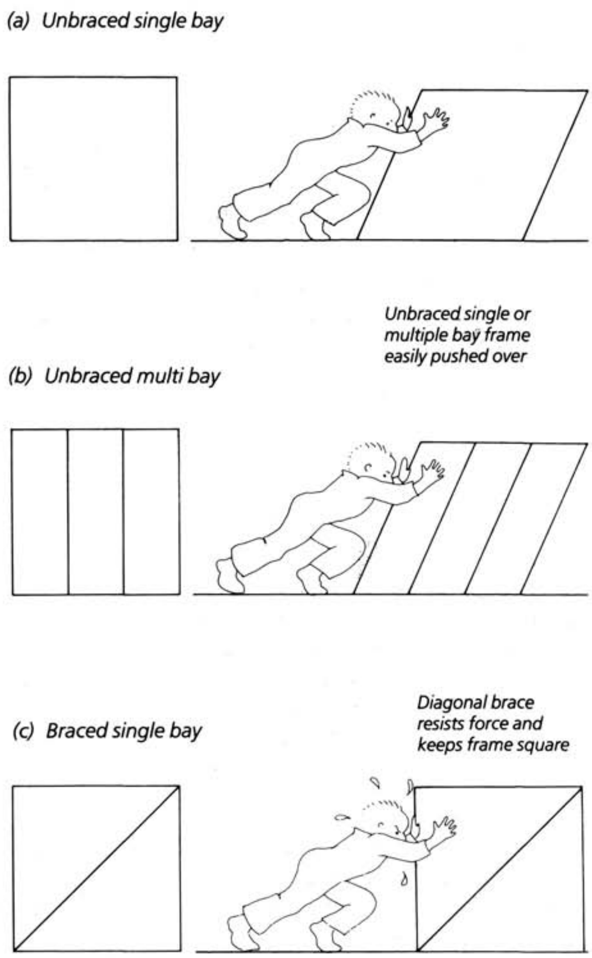
(iii) All bracing members are nailed to every trussed rafter they cross with two 3.35mm diameter x 65mm long galvanised round wire nails.

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*

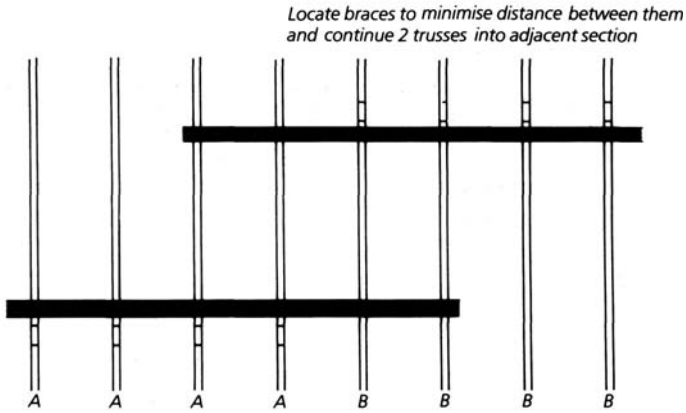
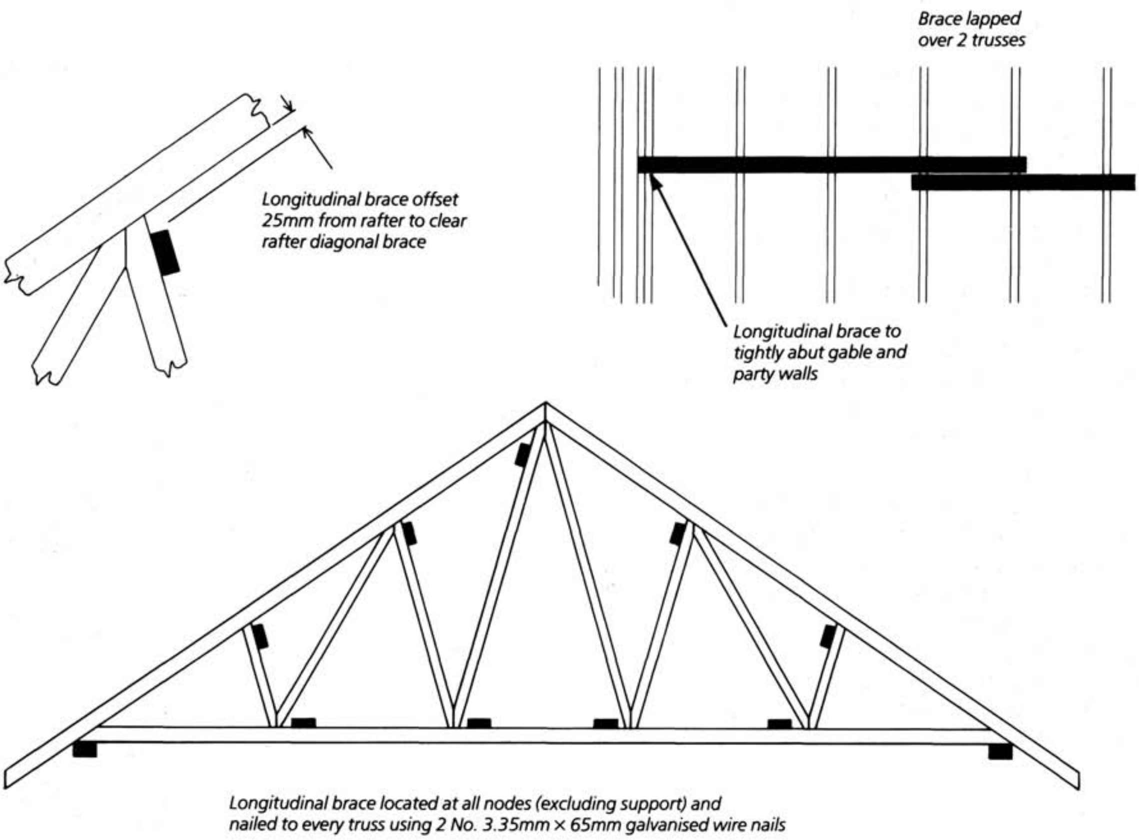


FIGURE 7.02 *LONGITUDINAL BRACING*

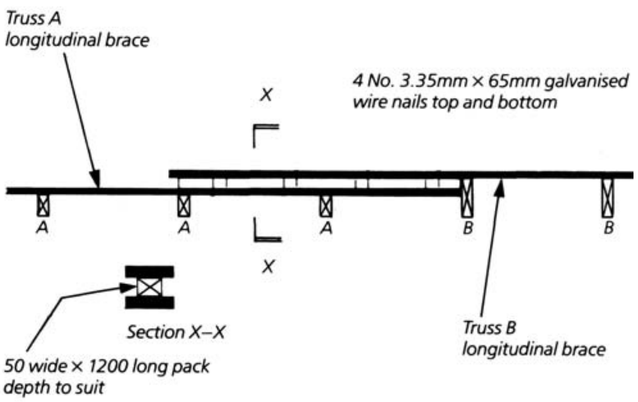
N.B. Other bracing omitted.



BRACING

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*

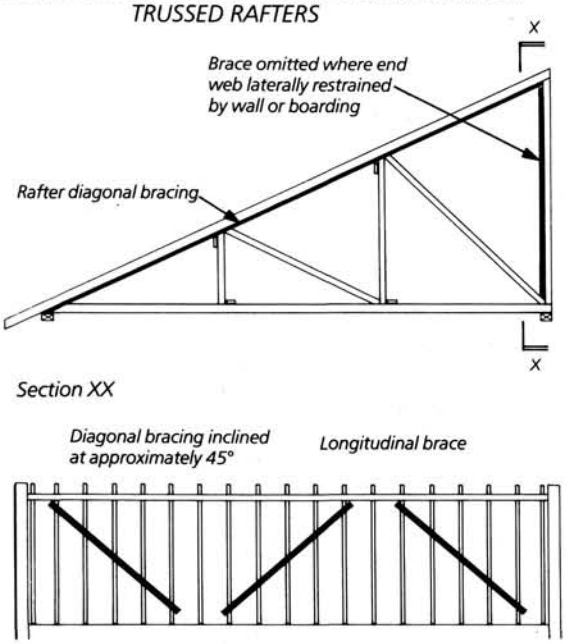
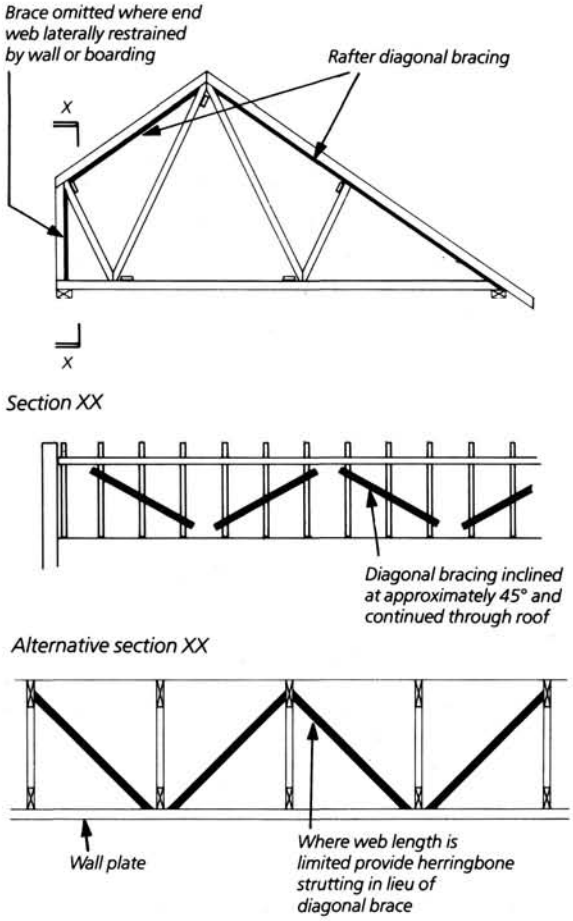


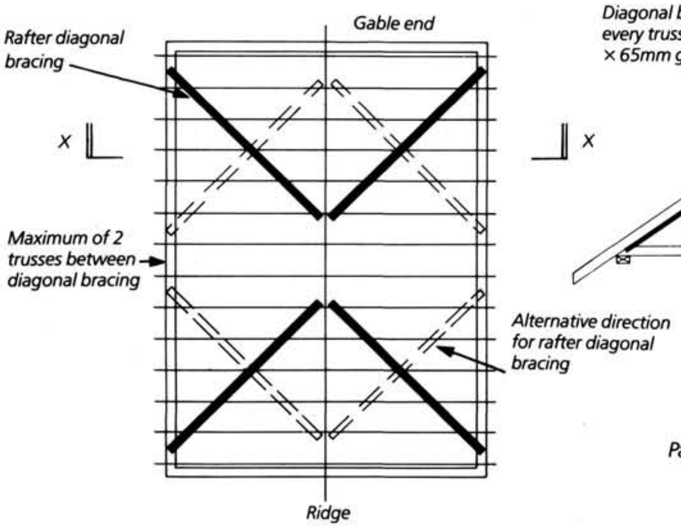
FIGURE 7.07 *DIAGONAL BRACING ON STUBBED TRUSSED RAFTERS*



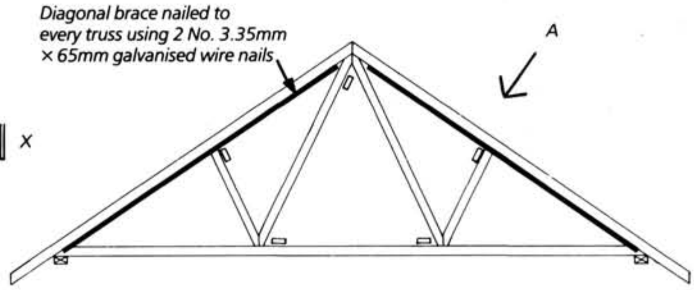
BRACING

FIGURE 7.05 *RAFTER DIAGONAL BRACING*

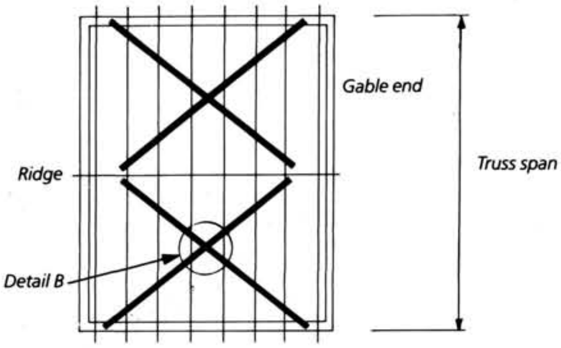
Plan of rafter diagonal bracing



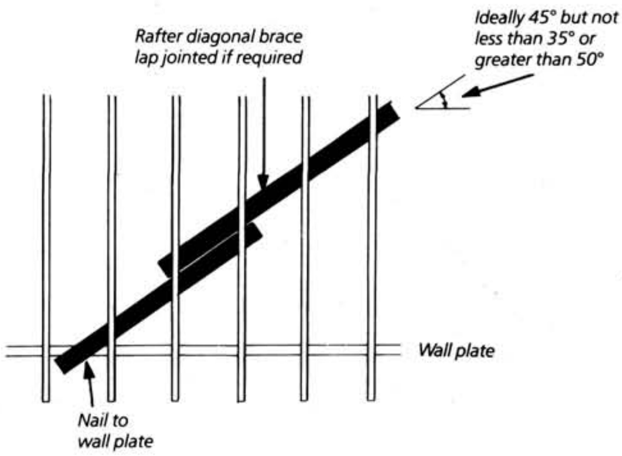
Section XX



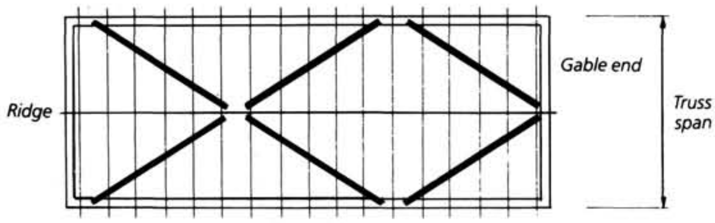
Plan of rafter diagonal bracing – narrow fronted roof



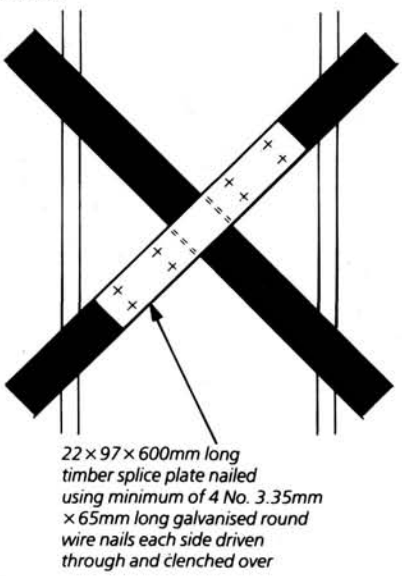
Part view on arrow A



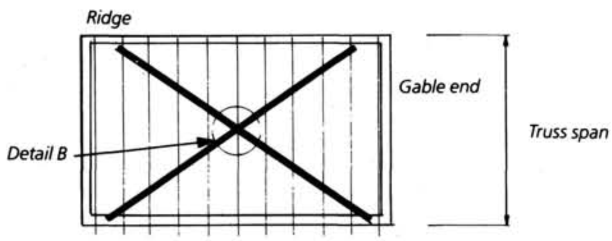
Plan of rafter diagonal bracing – wide fronted roof



Detail B



Plan of rafter diagonal bracing – monopitched roof



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*

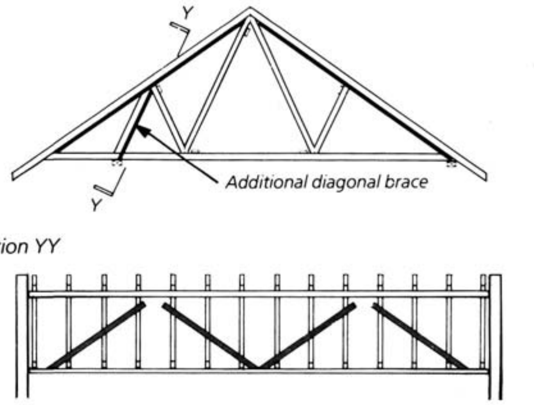
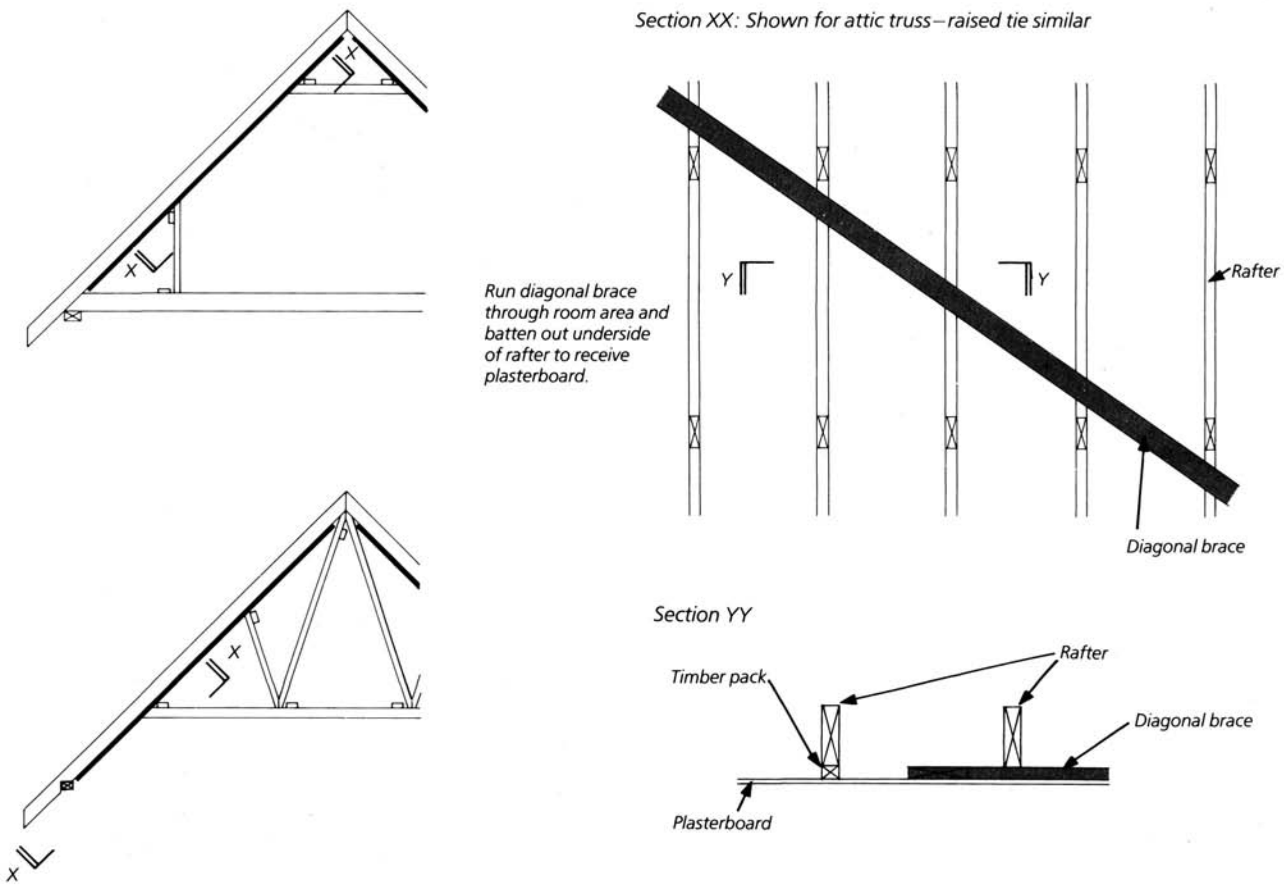


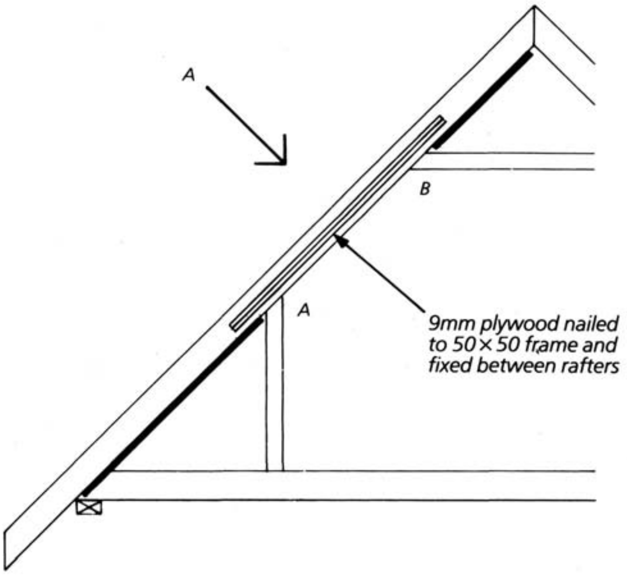
FIGURE 7.09 *RAFTER DIAGONAL BRACE – ATTIC AND RAISED TIE TRUSSED RAFTERS*



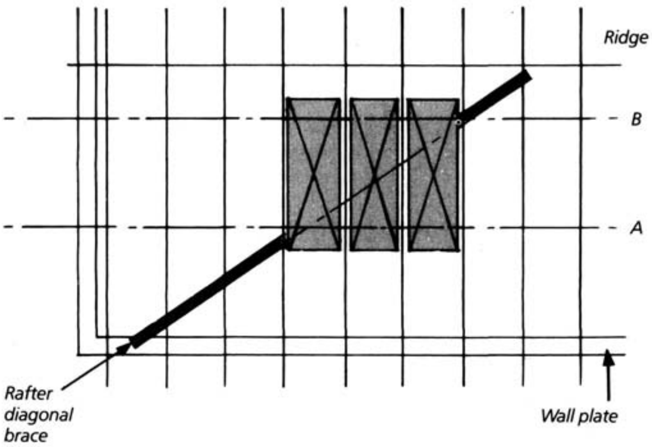
BRACING

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*



View A



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.

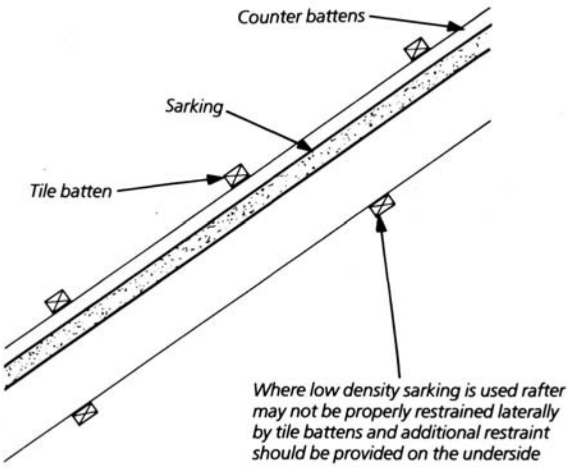
Battens should not be less than 1.2m in length and be continuous over at least two spans. They should be fixed to every rafter member which they cross, or on which they are jointed, with nails of the appropriate size and type specified by BS5534.

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*



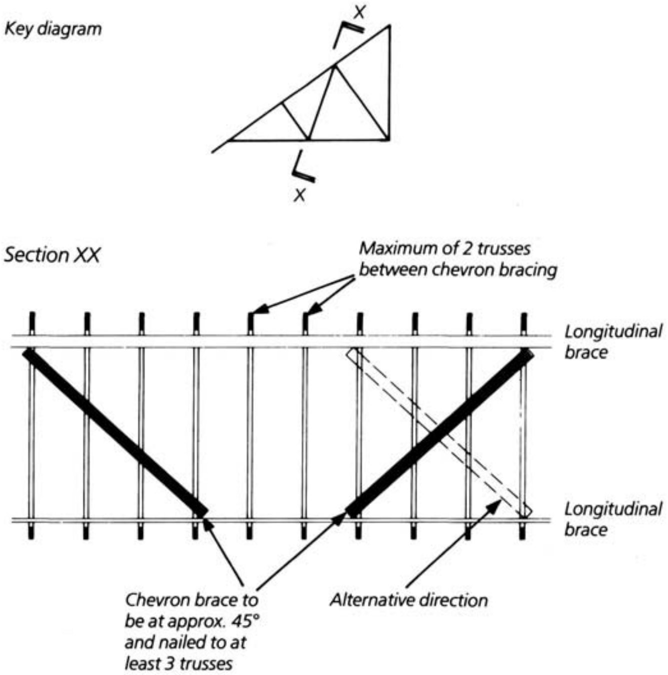
Web Chevron Bracing

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.

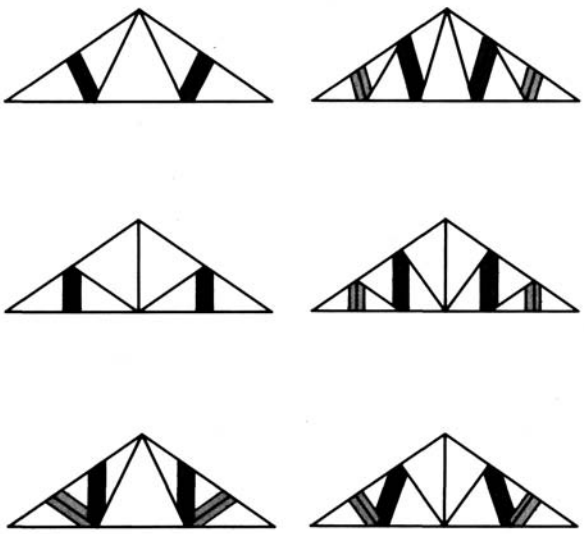
BRACING

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).

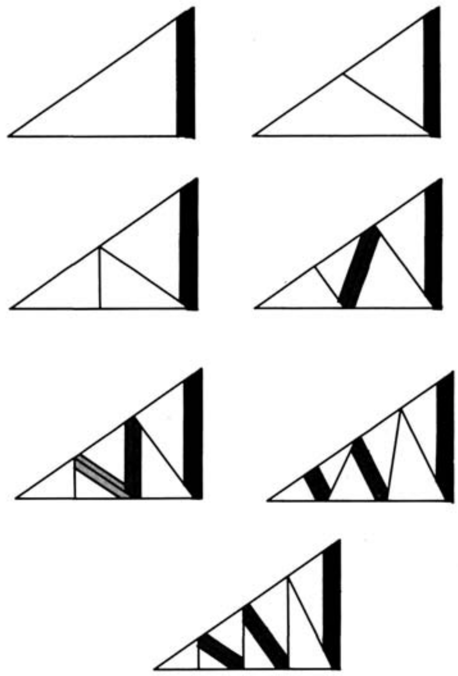
FIGURE 7.13 *CHEVRON BRACING FOR DUOPITCH TRUSSED RAFTERS*



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

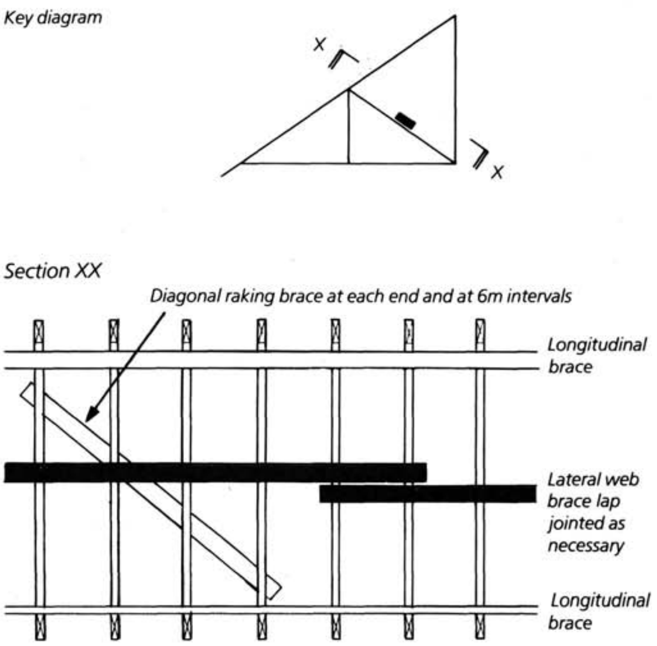
Web lateral braces are a function of the design of the trussed rafter and should be requested by the Trussed Rafter Designer. They are required on compression members to prevent lateral buckling resulting from the compression force and/or the length of the member.

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).

BRACING

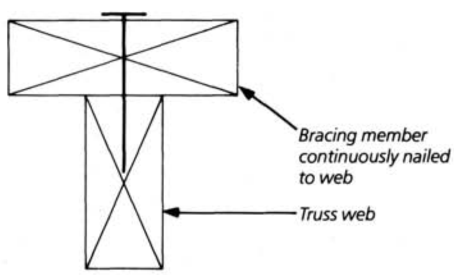
FIGURE 7.15 *WEB BRACE*

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:

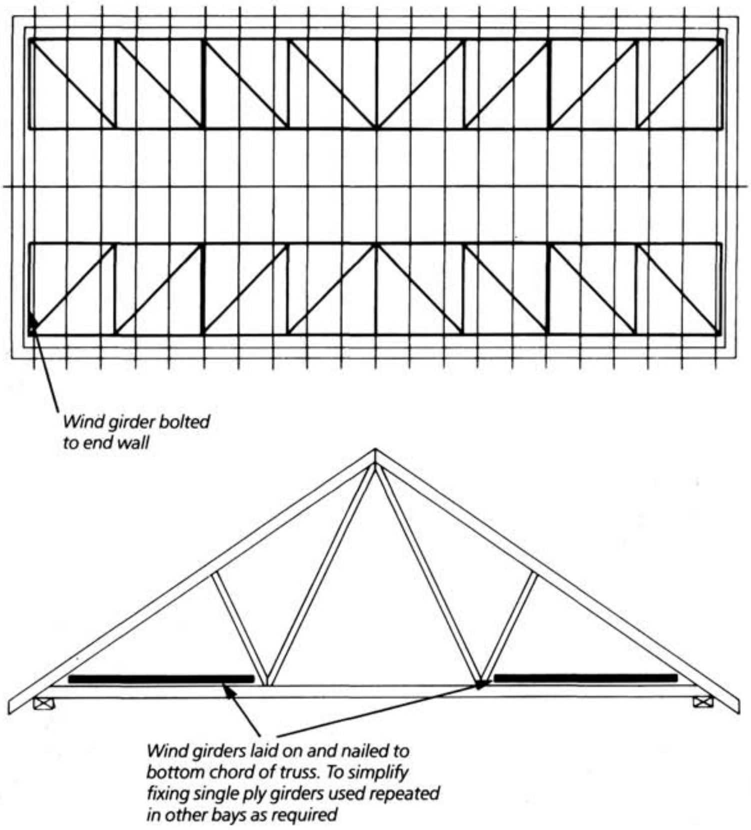
(i) Designed bracing.
(ii) Plywood diaphragms.
(iii) Wind girders.
(iv) Reinforced supporting structure.

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

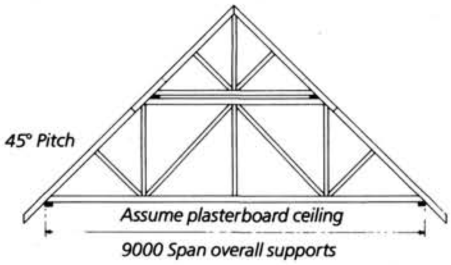
As noted in Section 9, the erection of a two-part truss, where no structural continuity is assumed, must be done in two stages. The first stage is to erect and fully brace the lower section, treating it as an independent roof, as illustrated by the example given in Figure 7.18.

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.

BRACING

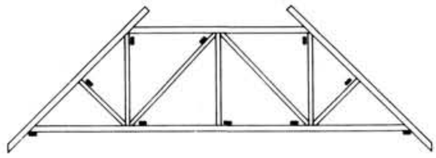
FIGURE 7.18 *TWO PART TRUSS STABILITY BRACING*

EXAMPLE



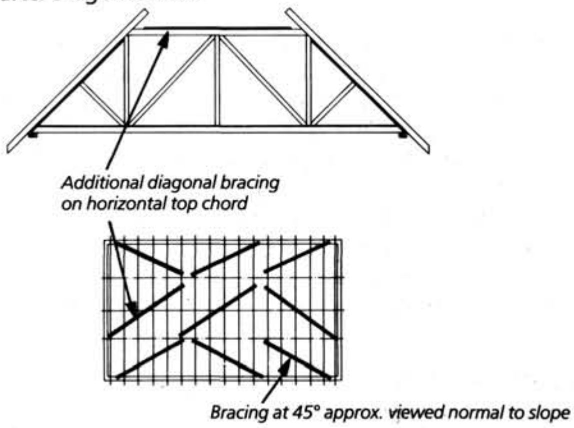
LONGITUDINAL BRACING

Longitudinal Bracing



RAFTER DIAGONAL BRACING

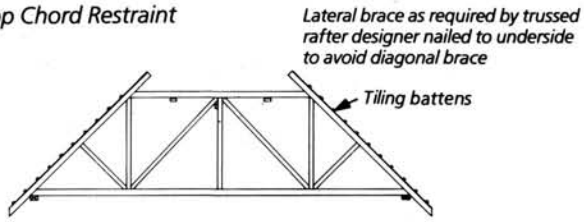
Rafter Diagonal Brace



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.

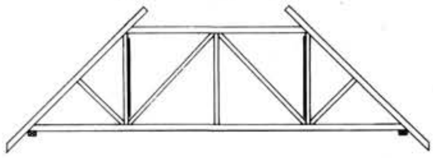
Top Chord Restraint



CHEVRON BRACING

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

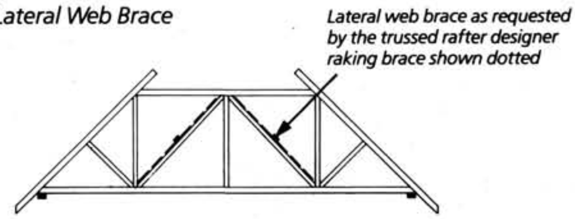
Chevron Bracing



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



SPECIFICATION AND QUOTATION REQUIREMENTS

Specification

The following is a model specification for illustrative purposes only. It offers guidance for the majority of situations but should not be viewed as the only acceptable criteria which can be used.

Trussed Rafters

Trussed rafters are lightweight frameworks, usually triangulated and spaced at intervals of 600mm. They shall be made from timber members of the same thickness fastened together in one plane by connector plates. Except where modified by this specification trussed rafters shall satisfy the requirements of BS5268:Part3.

Timber

Where finger jointed timber is to be used, the Trussed Rafter Designer shall state this clearly on all calculations and drawings. Finger jointed timber shall not be introduced after the calculations have been approved without the written approval of the Building Designer. All timber dimensions referred to in calculations or shown on drawings shall be the actual sizes required, and not the nominal sizes.

Connector Plates

Punched metal plate connectors shall be manufactured by Gang-Nail Systems Limited and comply with current Agrement certificates.

Preservative Treatment

Copper/Chrome/Arsenic (CCA) preservative shall not be used. Where preservative treatment is specified, it must be of the organic solvent type. Timber treated with fire retardants shall not be used.

Information Required by the Trussed Rafter Designer

The specification gives a general description of what is required but it is also necessary for the client or his agent to provide specific detailed information. The following list is an extension of that given in BS5268:Part3.

(a) The height and location of the building, with reference to any unusual wind conditions.

(b) The external profile of the trussed rafter, including any allowances required for tolerances.

(c) The span of the trussed rafter.

(d) The pitch or pitches of the roof.

(e) Drawings showing fire walls, the position and type of support, roof shapes and any special requirement.

(f) The type and weights of roof tiles or covering, including sarking, insulation and ceiling materials.

(g) The size and approximate position of any water tanks to be supported on the trussed rafters.

(h) The overhang of rafters at eaves and other eaves details.

(i) The positions and dimensions of hatches, chimneys and other openings.

(j) The service use of the building with reference to any unusual environmental conditions and, if required, the type of preservative treatment.

(k) The spacing of trussed rafters and special timber sizes where these are required to match existing construction.

(l) The load per square metre to be allowed for services and the proposed support method, if applicable.

(m) The type, position, load and method of support for any plant, fittings, partitions, etc., supported by the trussed rafters.

SPECIFICATION AND QUOTATION REQUIREMENTS

Quotation

Apart from very straightforward cases, trussed rafter fabricators prefer not to receive Bills of Quantities but clear roof drawings and a trussed rafter specification. Ideally, the drawings should show only the outline of the truss, leaving the designer to decide on the web configuration, hip system, etc. This will always produce the most economic solution, since it allows the tenderer to use his expertise and tender a solution that fits his methods and equipment.

If trussed rafters are to be incorporated into Bills of Quantities, they should not be broken down into timber, plates, labour, etc., but itemised as complete units, along with the information described previously.

As explained in Section 9, trussed rafters should not be stored at the fabricators works or on site for long periods. The timing of production runs must therefore be linked to delivery dates. When obtaining quotations for housing sites or large contracts, an indication of the call-off (i.e. the number of trusses required in each delivery) must be given; not just the total number required, if claims for extra costs are to be avoided. This is brought about by the fact that the manufacturing cost for trussed rafters is composed of two elements:

Set-Up - This is a fixed cost for the time taken to set-up the jig; independent of the number of trusses produced.

Production - The cost of producing the trussed rafters; proportional to the number of trusses produced.

It will therefore be seen that unit production costs increase as the number of trusses decrease.

Information Provided by the Trussed Rafter Designer

BS5268: Part 3 requires the Trussed Rafter Designer to provide his client with the following information. This provides a checklist for the client to ensure that the trussed rafters supplied are suitable for their intended use:

(1) Finished sizes, species, stress grades or strength classes of members.

(2) The types, sizes and positions of all jointing devices, with tolerances or the number of effective teeth or nails required in each member at each joint.

(3) The positions and sizes of all bearings.

(4) Loadings and other conditions for which the trussed rafters are designed.

(5) The spacing of trussed rafters.

(6) The positions, fixings and sizes of any lateral supports necessary to prevent the buckling of compression members, such as rafters and struts. *

(7) The method of support for tanks and ancillary equipment, together with the capacity or magnitude of additional load assumed.

(8) The range of reactions to be accommodated at the support positions, including those required to resist wind uplift forces.

(9) The basis of design.

(10) Details of any changes in spacing to accommodate chimneys or openings.

(11) Any special precautions for handling and erection, in addition to those covered by BS5268:Part 3.

* NOTE: 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.

SITE PRACTICE

In this section each site operation is considered and recommendations given to ensure that trussed rafters are handled, erected and fixed correctly. The causes and remedies of some common misalignments are discussed, and accepted tolerances are given.

Delivery

Delivery is made to site on suitable transport provided by the Gang-Nail truss fabricator. The truss fabricator will normally bear responsibility for the trussed rafters up to the point where they are off-loaded onto site: thereupon they become the responsibility of the contractor.

The delivery should be checked to ensure that it complies with the specification and that the quantities and dimensions are correct. Any discrepancies must immediately be brought to the attention of the supplier.

Site Storage

Site storage is intended to be temporary prior to erection. The fabrication and delivery of trussed rafters should, therefore, be organised to minimise the storage time both at the manufacturer's premises and on site. Where storage on site is likely to exceed two weeks, or during bad weather, trussed rafters should be protected by a waterproof cover which is arranged so as to allow free access of air for ventilation.

Trussed rafters should at all times be stored to avoid contact with the ground and vegetation and should be so supported as to prevent any distortion. Preferably, they should be stored vertically, on bearers located at the points of support assumed in the design, and with suitable props to maintain them in the vertical position.

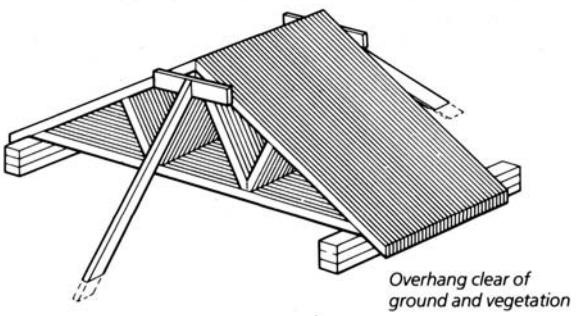
Some manufacturers and builders prefer however to invert the trussed rafters and support them in special frameworks clear of the ground. When trussed rafters are stored horizontally they should be supported on bearers located at every joint, with additional intermediate supports for long spans.

Ensure by careful planning that trusses are stacked in the order they will be required. Damage caused by rough handling often results where this is not done, as the next truss required is located in the middle of the group.

Vertical Storage

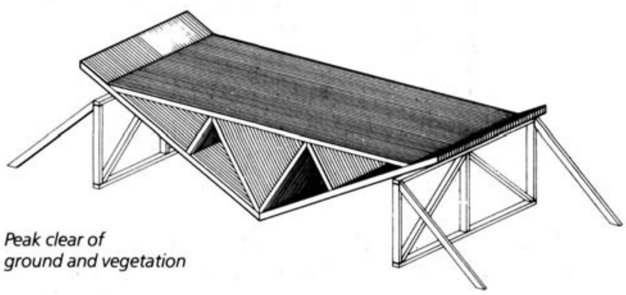
Where trusses are stored in the upright position, stacking should be carried out against a firm and safe support. They should be supported at the positions where the wall plate would normally occur and at such a height as to ensure that any rafter overhang clears the ground (Figure 9.01).

FIGURE 9.01 *VERTICAL STORAGE*



Care is required when removing the props or releasing the banding, since there may be a tendency for the trusses to spring forward and consequently topple over. Where the trussed rafters are stored inverted, support must generally be provided near to the rafter node points (Figure 9.02). If approved in writing by the Trussed Rafter Designer, they may also be supported at the ceiling tie node points.

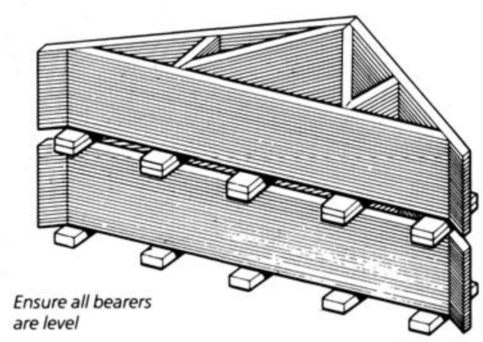
FIGURE 9.02 *INVERTED STORAGE*



Horizontal Storage

Where trusses are laid flat, bearers should be placed to give level support at close centres, sufficient to prevent long-term deformation of all truss members. If subsequently bearers are placed at different heights, they should be vertically in line with those underneath.

FIGURE 9.03 *HORIZONTAL STORAGE*



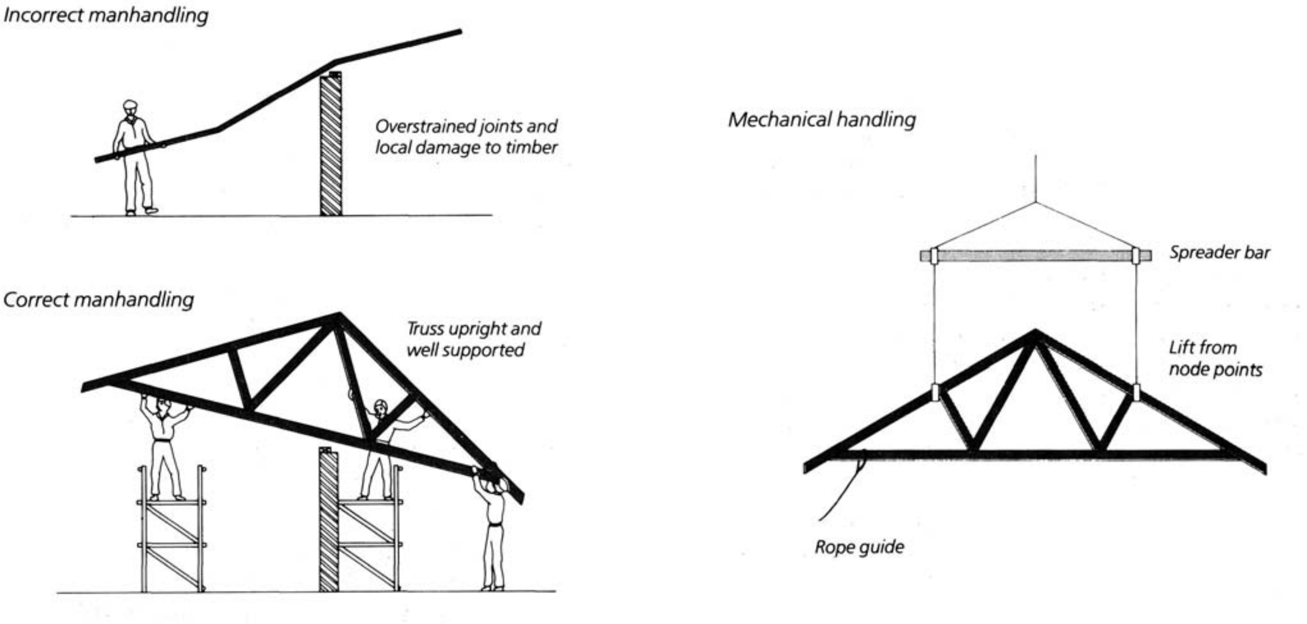
SITE PRACTICE

Handling

Normally the greatest stress which truss joints will undergo is that caused by handling. It is important, therefore, to carefully plan the handling of trusses, taking into account weight, size, access, lift height and whether manual or mechanical handling is required (Figure 9.04).

Wherever possible the points for lifting should be at the eaves joints, with the truss in the vertical plane - apex uppermost. Handling should always be carried out with the utmost care to avoid possible damage to both timber and connector plates. Gang-Nail fabricators are able to provide unit weights and advice on any special precautions for handling trussed rafters.

FIGURE 9.04 *MECHANICAL HANDLING AND MANHANDLING TRUSSED RAFTERS*



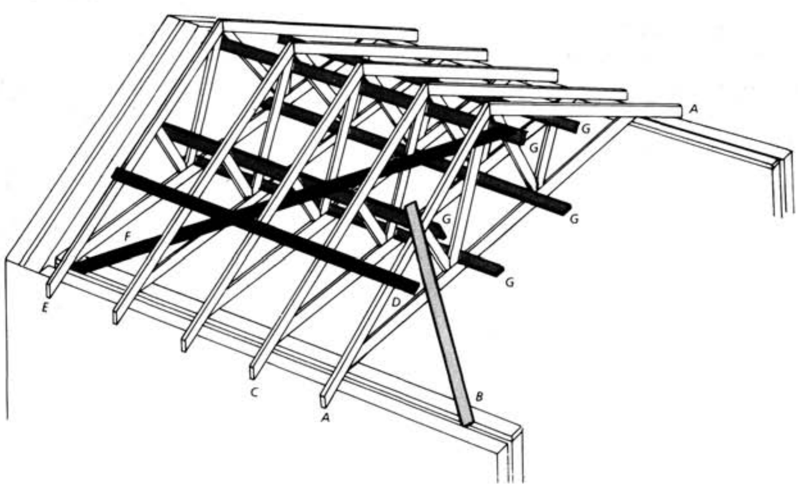
Erection Procedure

The Builder should consider, in conjunction with the Building Designer, the erection procedures to be used and the provision of temporary bracing, rigging and any other specialised equipment required to enable the trussed rafters to be erected safely, without damage, in accordance with design requirements and having due regard to possible windy conditions.

Supports should be prepared as indicated in Section 5 to the correct level and position. Guidance on trussed rafter bracing is given in Section 7, but the contractor must refer to the specific details issued by the Building Designer.

The following procedure illustrated in Figure 9.05 is suggested for most domestic size roofs. It is assumed that the wall plates have been checked and are level and that the correct holding-down fixings have been made by the builder. The erection team must also have studied and fully understood all relevant drawings and details before work commences.

FIGURE 9.05 *ERECTION METHOD FOR DOMESTIC ROOFS*



(a) Mark the position of each trussed rafter along both wall plates.

(b) Erect the first trussed rafter, designated A, at the position which will coincide with the uppermost point of the diagonal brace (F) when it is installed later. Use the temporary raking braces (B) fixed to the rafter members and the wall plates to hold this trussed rafter in the correct position, straight and vertical. For clarity, only one raking brace is shown in Figure 9.05, but these should be fixed to both rafter members and be of sufficient length to maintain the trussed rafter in position during the erection of the remaining trussed rafters.

(c) Erect trussed rafter (C) and brace back to (A) with temporary battens (D) at suitable intervals along the rafter and ceiling tie members. Repeat this procedure until the last trussed rafter (E) is erected, checking by eye to ensure an acceptable ceiling and rafter plane is achieved.

(d) Fix the permanent diagonal braces (F) ensuring that each top end is as high up the last trussed rafter (A) as is possible and that each bottom end extends over the wall plate to which it should be nailed. For clarity, only one permanent brace is shown in Figure 9.05, but these should be installed on both sides of the roof.

(e) Fix the longitudinal members (G) making sure that the ceiling ties are accurately spaced at the correct centres.

(f) Fix all remaining longitudinal, diagonal and chevron bracing required on the internal members of the trussed rafters, as specified.

(g) Additional trusses may be erected by temporarily bracing off the completed end.

Erection Tolerance

Immediately prior to fixing the permanent bracing and tiling battens or sarking, all trussed rafters should be checked for straightness and vertical alignment. Whilst every effort should be taken to erect trussed rafters as near vertical as possible, the maximum permitted deviations from the vertical given in BS5268:Part 3 are shown in Table 9.01.

TABLE 9.01 *MAXIMUM PERMISSIBLE DEVIATIONS FROM VERTICAL*

Rise of trussed rafter (m)	1	2	3	4 or more
Deviation from vertical (mm)	10	15	20	25

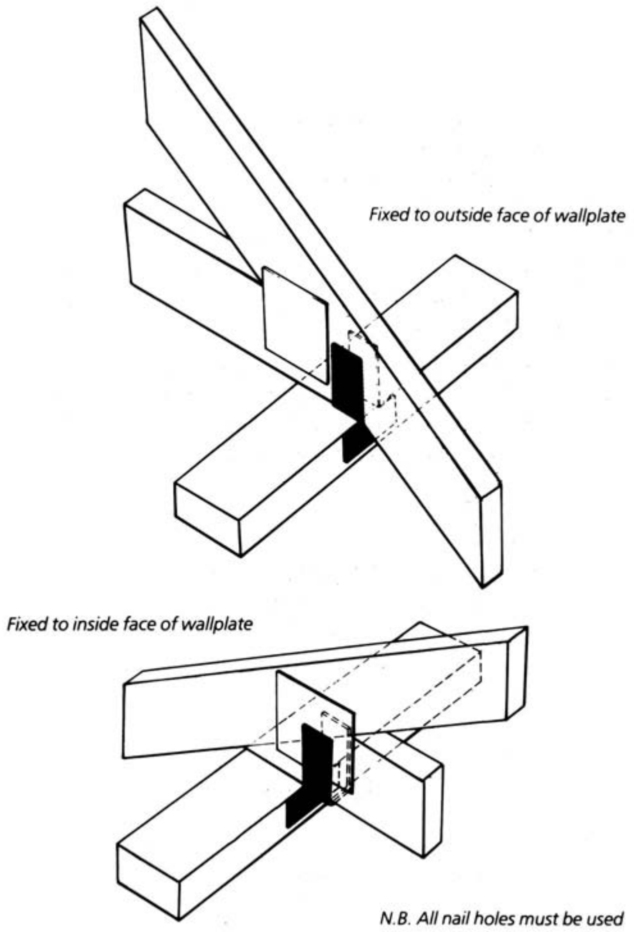
After erection, a maximum bow of 10mm may be permitted in any trussed rafter member, provided it is adequately secured in the complete roof to prevent the bow from increasing. For rafter members, this maximum bow is measured from a line between the apex and eaves joint.

Fixing

Gang-Nail trussed rafters are computer designed components, manufactured under quality controlled factory conditions. The same care should be applied when fixing the trusses and it is strongly recommended that truss clips are used to secure the trussed rafter to the wall plates or bearing points (Figure 9.06).

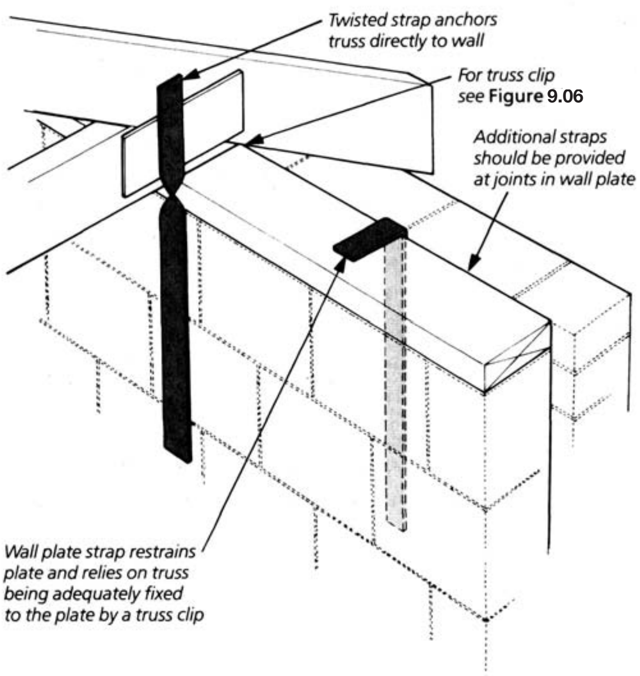
Skew nailing should only be considered where the workmanship on site is of a sufficiently high standard to ensure that the fasteners, joints, timber members and bearings will not be damaged by careless positioning or overdriving of the nails. The minimum fixing at each bearing position should consist of two 4.5mm x 100mm long galvanised round wire nails, which are skew nailed from each side of the trussed rafter into the wall plate or bearing. Where nailing through the punched metal plate cannot be avoided, the nails should be driven through the holes in the fasteners.

FIGURE 9.06 *TRUSS CLIP FIXING*



Under conditions where wind uplift forces are greater than the dead load , the truss clip and anchorage strap should be used (Figure 9.07).

FIGURE 9.07 *RESTRAINT AGAINST UPLIFT*



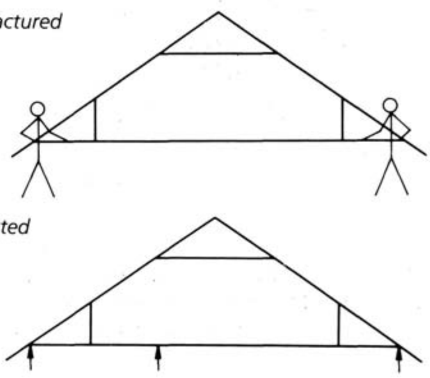
Trussed rafters should be supported only at the designed bearing points. It is advisable, therefore, to erect internal non-loadbearing walls after the roof tiling has been completed. This allows deflection to take place under dead load and reduces the risk of cracks appearing in ceiling finishes. Alternatively, if partitions are of brick or block, the final course can be omitted until the tiling has been completed.

Where non-loadbearing partitions are pre-made or site constructed using timber studding, they should be an easy fit and must not be forced against the underside of the trussed rafter. (See also Section 5 'Support Conditions').

Symmetry

In some instances, trussed rafters may appear to be symmetrical when being handled, but are not supported symmetrically (Figure 9.08).

FIGURE 9.08 *SYMMETRY IN TRUSSES*



The manufacturer will attempt to locate the splice joints in the chord members symmetrically about the centreline. In the example shown in Figure 9.08, this is often not possible and erection instructions will be issued stating clearly where the splice joints are to be located in the final structure.

Erection of Hip Ends

Section 4 describes in detail the general arrangement of a number of hip ends and hip corners. The procedure outlined here is for the erection of a standard centres hip end, but the principles can be applied to other hip layouts.

The hip girder is a primary structural member made up of two or three hip trusses nailed together. It is strongly recommended that the girder is nailed together by the supplier to ensure it performs correctly. Where the units are supplied loose for nailing together on site, the correct number of plies and the nailing pattern stipulated by the supplier must be followed.

The erection sequence (Figure 9.09) is then as follows:

(1) Fix the first standard truss a distance of half its span along the wall plate measured to the face of the truss. (Figure 9.09a).

(2) Complete the erection of the standard trusses and brace them.

(3) Fix the ledger rail to the first standard truss at a height to suit the hip board.

(4) Measure the span of the monopitch truss and transpose this dimension onto the wall plate. A simple check is to measure from this mark to the face of the truss A. It should be equal to (Number of Intermediates + 1) x truss spacing
Thus, for 2 intermediates, and truss centres of 600:
(2 + 1)x 600= 1800
Mark the position of the intermediate truss(es) on the wall plates. (Figure 9.09b).

(5) Erect the girder and intermediate trusses using temporary bracing. (Figure 9.09c).

(6) Using a string line from the corner to the apex of the standard truss, cut back the flying rafters allowing for the width of the hip board. Note: Only the flying rafter can be cut, on no account must plates be interfered with or the main body of the truss cut or notched.

(7) Nail a truss shoe to the bottom chord of the girder and fix the central monopitch truss. (Figure 9.09d).

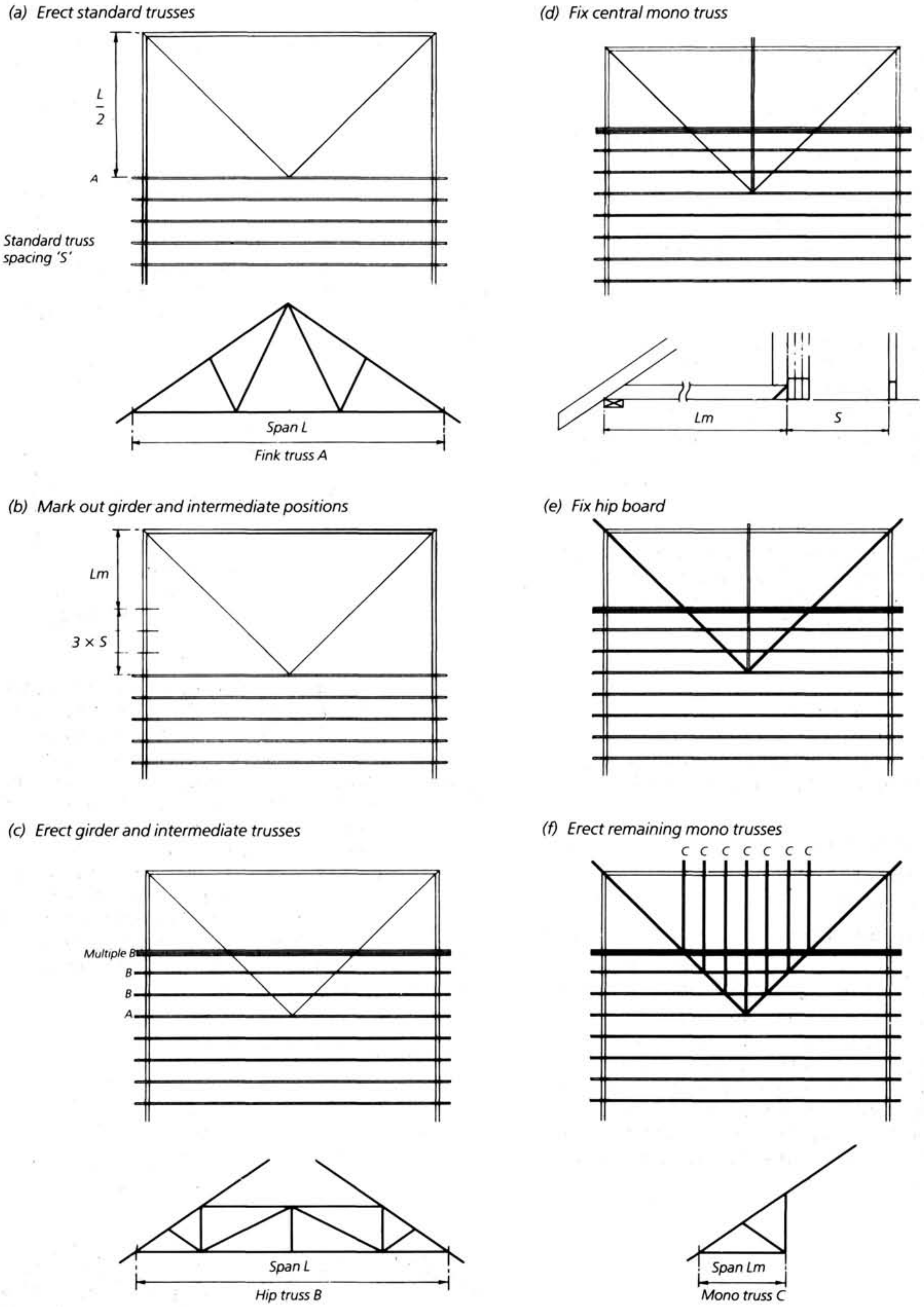
(8) Erect the hip boards, carefully cutting the birdsmouth support at the wall plate, girder and ledger. (Figure 9.09e).

(9) Complete the erection of the monopitch trusses, trimming the flying rafters as necessary and nailing all flying rafters to the hip board. (Figure 9.09f).

(10) Fix in place the loose ceiling joists using mini hangers.

(11) Cut and fix the loose rafters.

FIGURE 9.09 *ERECTION OF STANDARD CENTRES HIP SYSTEM*



Erection of Two-Part Trusses

Section 4 describes the various types of two-part trusses that can occur. For erection purposes, these can be divided into those that are structurally connected and those which are independent.

Structurally Connected

The structural connection can be horizontal or vertical, although the latter seldom occurs. The units can be joined together prior to erection or erected using temporary supports and then connected together. The choice of method is influenced by a number of factors, including design, access, building height and lifting capacity. The chosen method should therefore be agreed between the Trussed Rafter Designer, Building Designer and Contractor following the principles outlined earlier.

Structurally Independent

An important point to note, and one that should be strictly adhered to, is that the erection and bracing of the lower section should be completed before commencing erection of the upper section. For both sections, the erection principles described earlier should be applied, and the bracing should be in accordance with Section 7.

Tolerances

The objective of each stage in the construction cycle is to produce a functional building that is pleasing to the eye. To achieve this, it is necessary to understand the tolerances that can occur at each stage and how they relate to one another.

Trussed Rafters

BS5268:Part 3 requires that within each specified design, the overall horizontal and vertical dimensions of a trussed rafter (Figure 9.10) should not deviate from the specified dimensions by more than the following:

For spans not greater than 7.50m: ±6mm

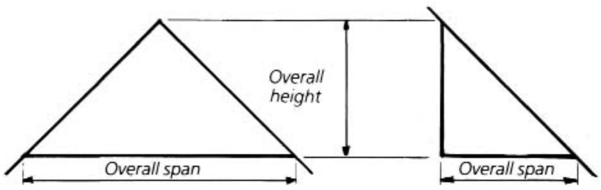
For spans greater than 7.50m but

not greater than 12.0m: ±9mm

For spans greater than 12.0m: ±12mm

In addition, within any continuous roof the differences between the overall horizontal and vertical dimensions of similar trussed rafters should not exceed 10mm. For these purposes a continuous roof is defined as any unbroken length of roof over a building, as distinct from the roof areas over separate dwellings. Although not specifically referred to by BS5268: Part 3, it is reasonable also to expect all other node points not to vary by more than 10mm from one another in any one continuous roof.

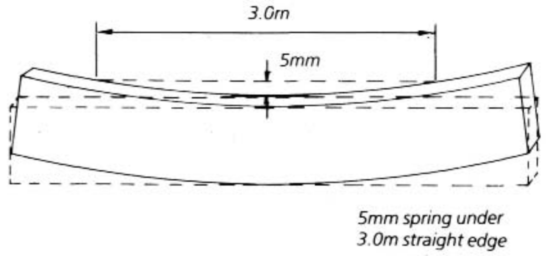
FIGURE 9.10 *OVERALL DIMENSIONS*



For the purposes of this figure only the overall span is shown irrespective of support positions

The timber must also satisfy the deviation allowance of BS5268: Part 3, which permits the maximum spring to be 5mm per 3m length (Figure 9.11). The jig will largely remove any spring at the node points and it is therefore only realised at mid-bay. Rarely is an accumulation of nodal deviation and spring a problem to the alignment of finishes.

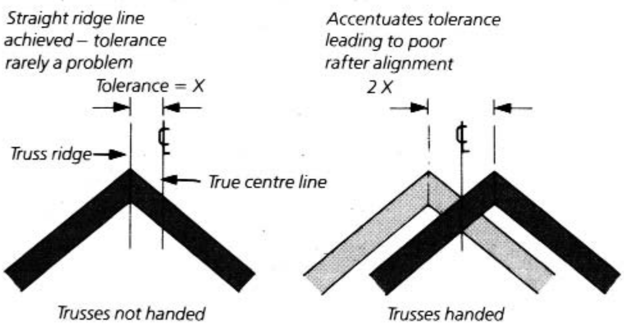
FIGURE 9.11 *SPRING IN TIMBER*



The effect of manufacturing tolerances can be doubled by 'handing' trusses (Figure 9.12). This is sometimes done by accident during erection, or by instruction from misguided supervisory staff who believe the handing of chord splices produces a stronger roof. The design of a splice joint takes account of all stress criteria and trusses should never be handed but erected relative to their neighbour as they were in the jig.

Some manufacturers mark one rafter so it is easy on site to see if trusses have been handed. Another convenient check is to compare the bottom chord splices. Since the trusses will have been manufactured with common splice positions, they can often be used to indicate where handing has occurred.

FIGURE 9.12 *HANDING OF TRUSSED RAFTERS*



SITE PRACTICE

Support Structure

Unless some form of factory manufactured frame is used, building dimensions will often be found to vary by ±25mm in plan dimension and ±25mm in level. In a large number of cases these tolerances are taken up during roof construction without detriment to the finishes or structure, for example Figure 9.13.

In some instances, or with some building shapes, these tolerances do cause poor alignment and remedial action will be required (Figure 9.14).

FIGURE 9.13 *SITE TOLERANCES – WALL PLATE LEVELS*

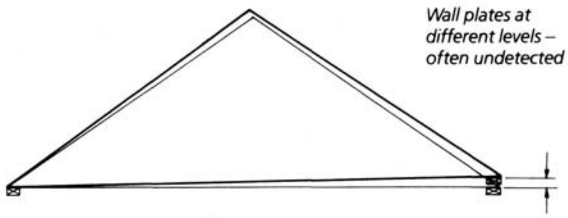
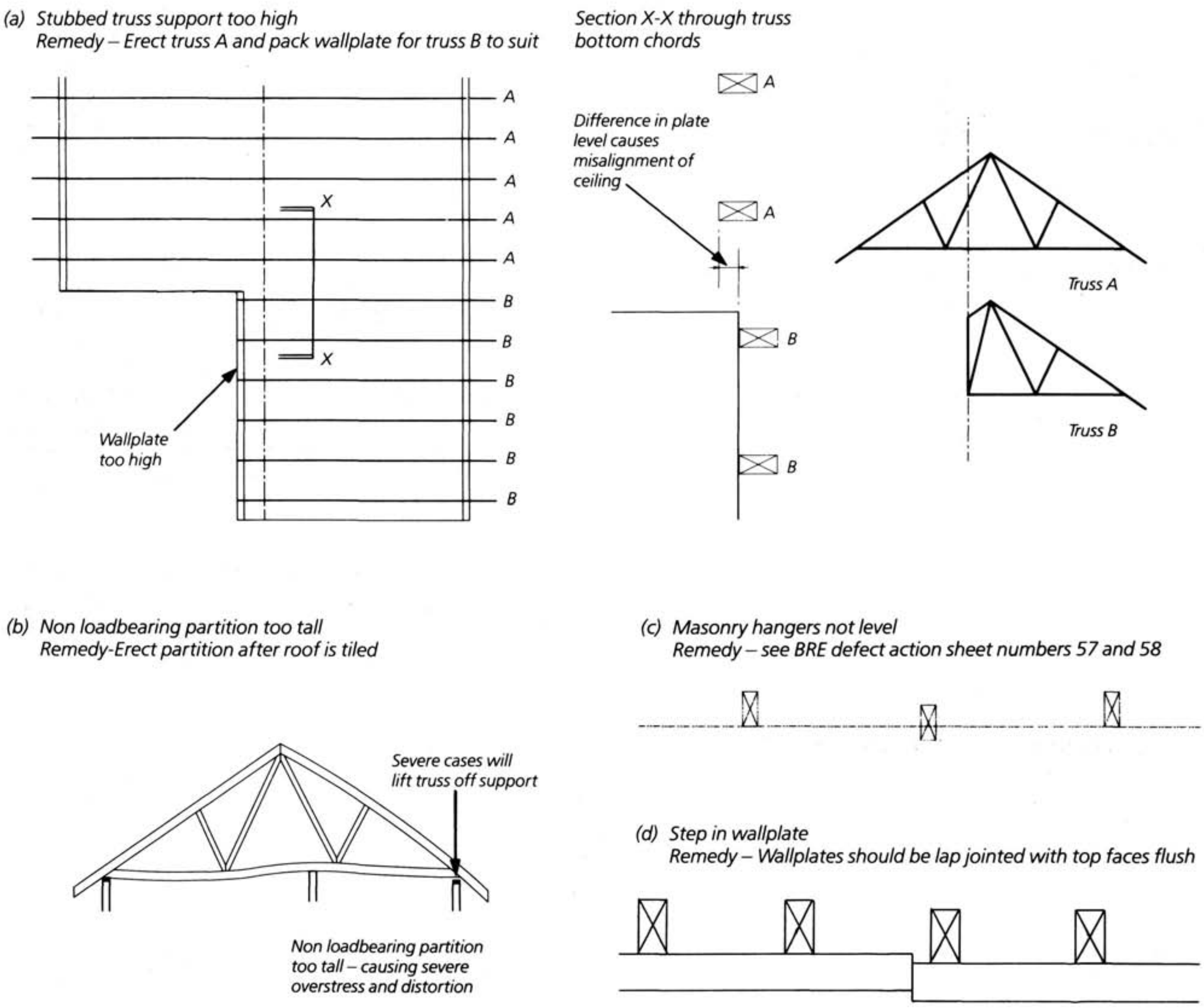


FIGURE 9.14 *MISALIGNMENT RESULTING FROM LEVEL OF SUPPORTS*



Erection

This can be divided into setting out measurements and the actual erection. Dealing with the setting out aspect first, it must be appreciated that since the trussed rafters are factory made, they must be located in the correct position or they may not fit the roof geometry.

Obviously the problem does not exist for a straight run of trusses but will be noticeable for hip ends and other roof shapes where the trusses are not all parallel. The hipped roof in Figure 9.15 shows clearly the result of poor positioning of the apex truss. To prevent this problem the Building Designer should produce a layout plan, providing clear setting out information which must be adhered to on site.

FIGURE 9.15 *APEX TRUSS MISPOSITIONED*

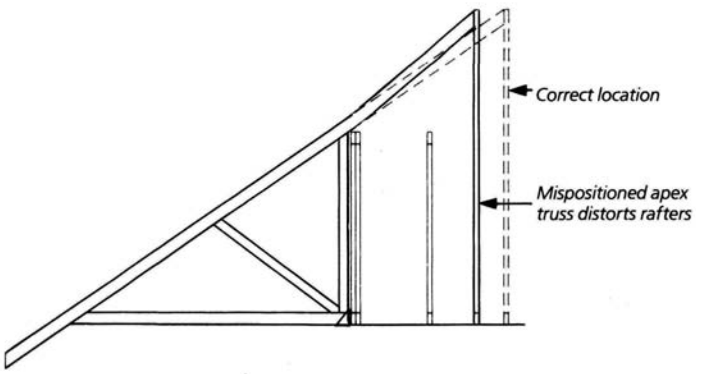
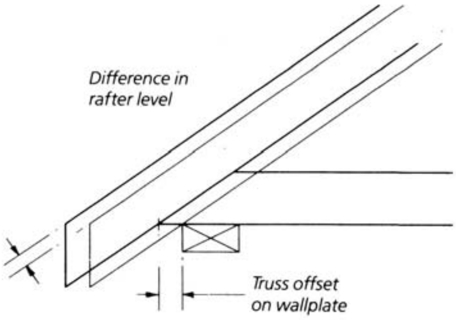


Figure 9.16 shows how the erection of the truss onto the wall plate can affect the rafter alignment. This is more acute for steeper pitches but is rarely a problem by itself.

FIGURE 9.16 *TRUSS MISPOSITIONED ON WALLPLATE*



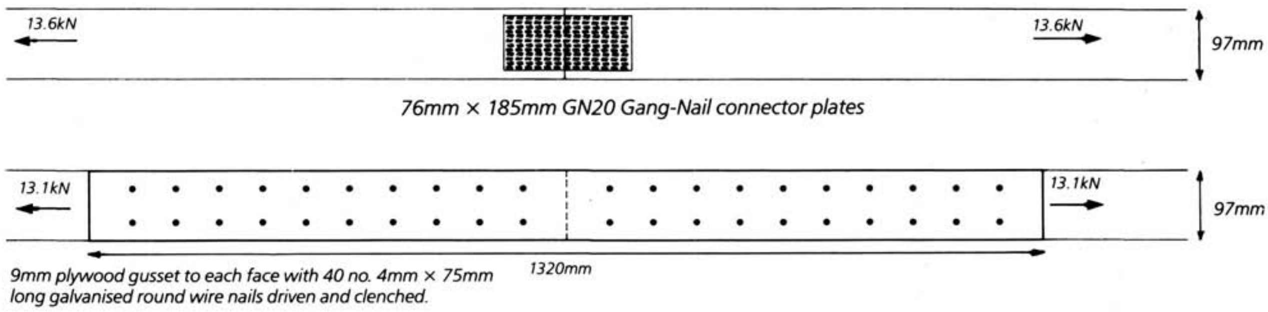
Although the individual tolerances have, for simplicity, been treated in isolation, it is their interaction that influences the ceiling or rafter alignment. It has not been possible to obtain authoritative tolerances for plasterboard and tiles, but experience suggests that differences in level between adjacent members at 600mm spacing of 10mm are rarely a problem as isolated cases. Where problems are highlighted, building tolerances and erection are usually the major contributory factors and, with reasonable care, it should be possible to largely eradicate these. Site staff are encouraged to check all possible tolerances before rejecting the trusses, as rarely are the trusses the main cause of any misalignment.

Remedial Work

Even experienced members of the project team frequently underestimate the strength of trussed rafters and in particular Gang-Nail connector plates. Given in Figure 9.17 is a joint using small Gang-Nail connectors and a joint of equivalent strength using nailed plywood gussets. This clearly demonstrates the strength of the Gang-Nail connector plates and why it is important to refer any truss damage to the supplier, to enable a properly engineered repair solution to be designed.

In no circumstances should a trussed rafter be cut or otherwise modified or repaired except in accordance with precise written or drawn instructions issued and approved by the Trussed Rafter Designer.

FIGURE 9.17 *JOINTS OF EQUIVALENT STRENGTH*



GLOSSARY OF TERMS

Apex/Peak
The uppermost point of a truss.

Attic Truss/Room-in-the-Roof
A truss forming the top storey of a dwelling. Characterised by a central habitable area free of web members with large timber members elsewhere. May have to be assembled partly on site because of transport difficulties.

Battens
Small timber members spanning over trusses and supporting tiles, slates, etc.

Bearer
A member designed to distribute loads onto a number of trusses.

Bearing
The part of a truss receiving structural support, usually from a wall plate.

Binder
A longitudinal member nailed to trusses to maintain correct spacing.

Birdsmouth
A notch in the underside of a loose rafter to allow a horizontal seating at a point of support (not normally used on trussed rafters except with a raised tie feature).

Blocking
Short timbers fixed between chords to laterally brace them - at least 70% as deep as chords.

Bobtail
See STUB END.

Bottom Chord/Ceiling Joist/Tie
The lower member of a truss, normally horizontal, which carries the ceiling construction, storage loads and water tank.

Bracing
See STABILITY BRACING.

Building Designer
The person responsible for the structural stability and integrity of a building as a whole.

Camber
An upward vertical displacement built into a truss in order to compensate for anticipated deflection caused by applied loads.

Cantilever
The part of a structural member or truss that extends beyond its bearing.

Ceiling Joist
See BOTTOM CHORD.

Chevron Bracing
Diagonal bracing nailed to the truss in the plane of specified webs to add stability.

Chords
See BOTTOM CHORD and TOP CHORD.

Combined Stress Index (C.S.I.)
Measures how much of the strength of a member is being used by the design.

Concentrated Load
A load applied at a point.

Connector Plate/Fastener/Nail Plate
Metal plate having integral teeth punched from the plate material. Used for joining timbers in one plane with no overlap. Supplied by system owners and the subject of an Agrement Certificate. Not usually for site application.

Cripple Rafter/Jack Rafter
An infill rafter completing the roof surface in areas such as the corners of hip ends.

Dead Load
The permanent load produced by the fabric of the building.

Deflection
The deformation caused by the loads.

Design Load
Collectively the loads for which the unit is designed.

Duo/Dual-Pitch Truss
A truss with two top chords meeting at an apex and not necessarily being at the same pitch on both sides.

Dwangs
See NOGGING.

Eaves
The line where the rafter meets the wall.

Extended Rafter/Raised Tie Truss
A truss which is supported at a point on the extension of the rafter, beyond the point where the bottom chord meets the top chord. N.B. Such trusses must be the subject of a special design.

Fabricator
A company engaged in the manufacture of trussed rafters.

Fastener
See CONNECTOR PLATE.

GLOSSARY OF TERMS

Fink Truss
Named after the original designer. A duopitch truss, the two top chords having the same pitch and the webs forming a letter W. The most common truss type used for dwellings.

Firring Piece
A tapered timber member used to give a fall to flat roof areas.

French Heel
A heel joint where the top chord sits on the top of the bottom chord.

Gable End
The end wall (parallel to the individual trusses) extended up vertically to the plane of the top chords of the trusses.

Gable Ladder
Components used to bridge across a gable end to form the roof overhang.

Gang-Nail
Registered tradename of Gang-Nail Systems Limited.

Girder Truss
A truss comprising two or more individual trusses fixed together and designed to carry exceptional loads such as those imparted by other trusses.

Hanger
A metal component designed to provide a connection between a truss or other component and its support.

Heel
The part of a truss where the top and bottom chords intersect, normally where a truss is supported.

Hip Board
A raking member extending from ridge to corner in hip end construction.

Hip Corner
A corner turn in a building incorporating a hip end.

Hip End
An alternative to a gable end. The end wall is finished to the same height as the adjacent walls. The roof inclines from the end wall usually at the same pitch as the main trusses. See HIP SET.

Hip Set
The trusses and possibly loose timber forming a hip end.

Horn/Nib
The projection of the bottom chord of a trussed rafter built into masonry as a bearing. Used on monopitch and stub end trusses.

Imposed Load
The load produced by occupancy and use including storage, people, moveable partitions and snow, but not wind.

Internal Member/Web
A timber member used to transmit forces between chords.

Intersection
The area where one roof meets another.

Jack Rafter
See CRIPPLE RAFTER.

Jig/Pedestal
Equipment used in the laying out and clamping in position of the components of a truss prior to pressing.

Live Load
A term often used instead of IMPOSED LOAD.

Longitudinal Bracing
Component of STABILITY BRACING.

Loose Timber
Members not forming part of a truss but necessary for the formation of the roof. See CRIPPLE RAFTER.

Monopitch Truss
A truss in the form of a right-angled triangle, having a single top chord.

Nail Plate
See CONNECTOR PLATE.

Nib
See HORN.

Node
Point on a truss where members intersect.

Nogging
Timber pieces fitted at right angles between the chords of trusses to form fixing points for ceiling materials.

Overhang
Measurement on plan from the intersection point of the underside of top and bottom chords to the end cut of the rafter.

Padstone
A concrete slab built in a wall to distribute the pressure from a concentrated load onto a large area of wall.

Part Profile
See STUB END.

GLOSSARY OF TERMS

Peak
See APEX.

Pedestal
See JIG.

Permissible Stresses
Design stresses for grades of timber published in BS5268:Part 2

Pitch
The angle of the chord (usually rafter) to the horizontal measured in degrees.

Plate
See CONNECTOR PLATE.

Plate Location/Position Tolerance
Acceptable deviation from specified location. Design allowance is 5mm in both orthogonal directions. May be specified greater.

Pole Plate
Timber, often the same size as the wall plate and laid on top of the wall plate to assist support of infill timbers.

Press
Hydraulic equipment used to embed connector plates into timber.

Purlins
Timber members spanning over trusses and supporting cladding such as galvanised corrugated steel sheet. Also, spanning between trusses and supporting loose rafters.

Quarter Point
The point on the rafter where an internal member/web connects in a "FINK" type trussed rafter.

Rafter
See TOP CHORD.

Rafter Diagonal Bracing
Component of STABILITY BRACING.

Raised Tie Truss
See EXTENDED RAFTER TRUSS.

Reducing Trusses
See VALLEY FRAMES.

Remedial Detail
A modification produced by the Trussed Rafter Designer to overcome a problem with the trussed rafter after its manufacture.

Return Span
The span of a truss being supported by a girder.

Ridge
The line formed by truss apexes.

Ridge Board
Timber running along a ridge and sandwiched between oncoming loose rafters.

Roof Designer
The person responsible for the design of the roof as a whole so that it is stable in itself and is capable of transmitting wind forces on walls and roof to suitable buttressing walls. The Roof Designer is appointed by the Building Designer or can be the Building Designer himself.

Room-in-the-Roof
See ATTIC TRUSS.

Scab
Additional timber connected to a truss to effect a splice, extension or local reinforcement.

Setting-Out-Point
The point on a truss where the undersides of the top and bottom chords intersect.

Skew Nailing
Driving nails at angles into the surfaces to be joined. method of fixing trussed rafters to wall plate by use of nails applied through chords.

Span
Span over all wall plates. The distance between the outside edge of the two supporting wall plates and sometimes equal to overall length of bottom chord.

Spandrel Panel
Timber frame, triangular panel forming gable wall above ceiling line.

Splice
A joint between two in-line members employing a metal connector plate or glued finger joint.

Stability Bracing
An arrangement of loose timbers installed in the roof space to provide lateral support to truss members and to the trusses.

Strap
Metal component designed to fix trusses and wall plates to walls. Heavy duty type for lateral fixing and standard used for holding down.

Stub End
A truss type formed by the truncation of a normal triangular truss.

GLOSSARY OF TERMS

Superchord
A means of providing deep chord members by connecting together two members at there edge using Gang-Nail connector plates, used to locally reinforce extended chord trusses and attic trusses.

System Owner
Owner of an integrated system of truss design and manufacture. Provides fabricators with application software, design expertise and fabrication machinery, In addition to the manufacture of nail plates (e.g. Gang-Nail System Ltd)

Temporary Bracing
An arrangment of diagonal loose timbers installed for safety during erection. Often incorporated with permanent STABILITY BRACING.

Third Point
Point on a ceiling joist where an internal member/web connects in “Fink” truss.

Tie
See BOTTOM CHORD

Timber Stresss Grading
The classification of timber into different structural qualities based on strength.

Top Chord/ Rafter
The uppermost member of a truss normally carrying the roof covering and snow.

Tosh Nailing
See SKEW NAILING.

TRA
Trussed Rafter Association. Organisation which represents the truss industry.

TRADA Quality Assurance Scheme
Formalised method of quality control in the manufacture of trusses administered by the Timber Research and Development Association.

Trimmer
A timber member used to frame openings.

Truss/TrussedRafter
A lightweight framework, normally triangulated, spaced at intervals generally not exceeding 0.6m and made from timber members of the same thickness fastened together in one plane by metal fasteners or plywood gussets.

Trussed Rafter Designer
The person responsible for the design of the trussed rafter as a component and for specifying the points where bracing is required.

Truss Clip
A metal component designed to provide a structural connection of trusses to wall plates, to resist wind uplift forces and to eliminate the disadvantages of skew nailing.

Truss Shoe
A metal component designed to support and provide a structural connection/support of a truss to a girder or beam.

Uniformly Distributed Load(UDL)
A Load that is uniformly spread over the full length of a member.

Valley Board
A raking member from ridge to corner in valley construction.

Valley Jack Trusses/Valley Set
Infill frames used to continue the roofline where one roof intersects another.

Verge
The line where the trussed rafters meet gable wall.

Wall Plate
A timber member laid along the supporting walls on which the roof trusses bear. Not less than 75mm wide.

Web
See INTERNAL MEMBER

Web Longitudinal Bracing
a component of STABILITY BRACING.

Wind Bracing
An arrangement of loose timbers or other structural system installled in the roof space to form diaphragms in the planes of the rafters and ceiling ties to transmit wind forces to suitable shear walls.

Gang-Nail Systems Limited
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