Chapter 4

Attic Construction Using Modern Engineered Timber Components

The considerable growth in the use of attic construction to make the maximum use of the building envelope, coupled with the lack of skilled building labour, has resulted in the rapid development of engineered timber components for use not only in floors, but also in the construction of the roof element itself. This chapter addresses the developments, many of which, like trussed rafters, are trade-named products developed by specialist timber engineering companies. For that reason some of the illustrations in this chapter, like those in Chapter 6 which deals with trussed rafter systems, are drawn from the various manufacturers' technical and trade literature.

THE FLOOR

Engineered timber in the various forms illustrated in Fig. 3.13 has existed for some considerable time. However, the demand from the house building industry in general for a product of better quality than solid timber coupled with the need for faster installation and also a stiffer floor without creaks and squeaks, has lead to an explosion of engineered timber 'joists'. A recently reported statistic indicates that in 2005 some 50% of all new homes now use such products in their floor construction, accounting for around 65 000 houses in the UK alone. Bearing in mind that an engineered timber joist clearly costs considerably more than a simple soft wood joist, it is worth considering the advantages of the product before looking at the various types available and the construction methods used.

(1) Better quality floor construction
A stiffer floor giving better 'feel' to the user, and a quieter construction avoiding the shrinkage so often associated with conventional timber. Most engineered joist systems strongly recommend that the floor deck is screwed and/or glued to the surface to prevent floorboard joint movement.
(2) Faster construction
Claims of 66% reduction in time to install the floor, i.e. typically half a day to install an engineered floor compared to one and a half days with traditional

construction. With an engineered floor the floor joist system is delivered as a pack of premanufactured components to precise length, including trimmers and blockings etc., where as with traditional construction, soft wood joists to the nearest standard available length would be delivered which then have to be cut, notched and trimmed as necessary before installation.

(3) Reduced cost
No wastage – every joist and trimmer is engineered to fit, and the better quality floor means no remedial costs in correcting shrinkage problems for the house builder.

Engineered timber, being a manufactured product, often carries a proprietary name such as Truss Joist, Parallam, Posi-Joist, BCI Joist, Finn Joist etc. but they fall into three main categories:

(1) 'I' beams;
(2) Laminated solid timber;
(3) Fabricated timber using metal connector plates.

All of these fabrications seek to engineer the natural defects of solid soft wood out of the product, i.e. knots, splits, variable slope of grain and density, to provide a stronger product of higher overall performance than that of its individual components, generally resulting in a better span to depth ratio than solid natural timber, without the associated shrinkage and distortion which occurs even with dry timbers. The following is a review of the different types listed above.

'I' beams

These concentrate the forces imposed on the component when being used as a joist, beam, purlin or rafter into the top and bottom flanges resulting in the 'I' shape so familiar with steel beams. A clear advantage is that they are lighter to handle compared to a solid timber beam of similar performance. The flange, i.e. the top and bottom member, can either be in solid conventional timber, or a further piece of engineered timber similar to the laminated timber described below. The web is again constructed of a man-made timber product, which could be highly compressed timber fibres commonly known as hardboard, or OSB (oriented strand board) or plywood. The flanges and web are usually joined by high performance gluing in the factory. When being made to specific length, the ends will usually be solid blocked to carry the stresses at the load bearing point (see Fig. 4.1).

Laminated solid timber

Glulam is of course laminated solid timber and can be seen in Fig. 3.13. However, most of the laminated timbers used as joists, beams and purlins etc. now use much thinner laminates and are more akin to plywood construction in the thickness of the veneers (see Fig. 4.2), than the traditional 30 mm or 40 mm thick laminates used with

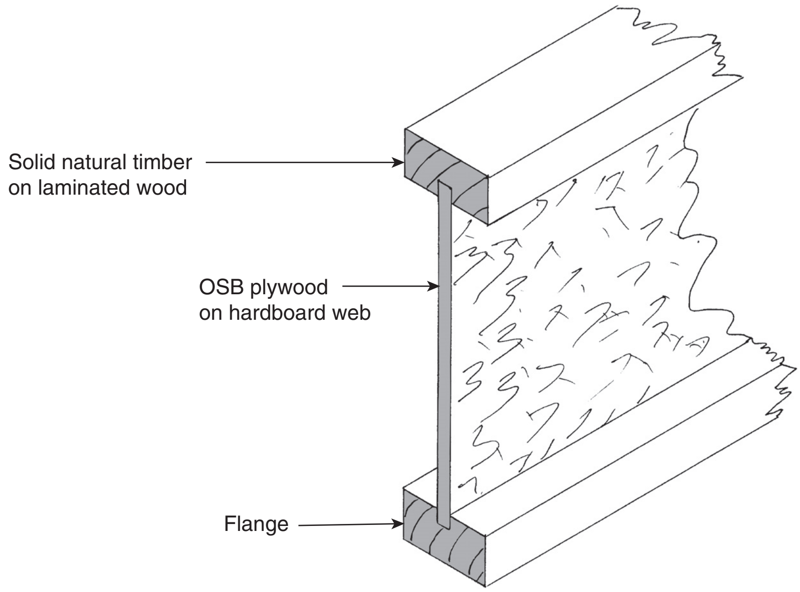

Fig. 4.1 Timber I beam.

conventional glulam. However, unlike conventional plywood where alternative veneers have timber grain laid at right angles to one another, most of the products in this category have laminates parallel to one another bonded by high performance adhesives. The trade name of one such beam, Parallam, describes its construction. This particular product is of course solid, but unlike a piece of solid timber is extremely stable, and again unlike a piece of solid timber, has all of the major strength reducing features engineered out thus enabling it to develop the strength of an almost perfect piece of timber, giving an even higher performance. Such timbers are often used as trimmers and purlins and in other areas of high stress for that reason. Typically then, this type of product could be found as a trimmer supporting the 'I' beam described above.

Fabricated timber using metal nail plate connectors

This product, illustrated in Fig. 4.3, is invariably the product of the trussed rafter manufacturer as it uses the same engineering and manufacturing technology used to produce the now common trussed rafter roof construction assemblies. Unlike the trussed purlin illustrated in Fig. 3.13, the top and bottom timber flanges for this form of engineered joist or beam lie flat rather than vertically. This of course gives an improved bearing area for both the floor decking and the ceiling and increases the bearing area of the joist itself where it is built into the wall or set on a hanger. Posi Joist by Mitek, Eco Joist by Gang Nail, and Wolfs Easi-Joist all use similar construction to that shown in Fig. 4.3. Each, of course, have their own

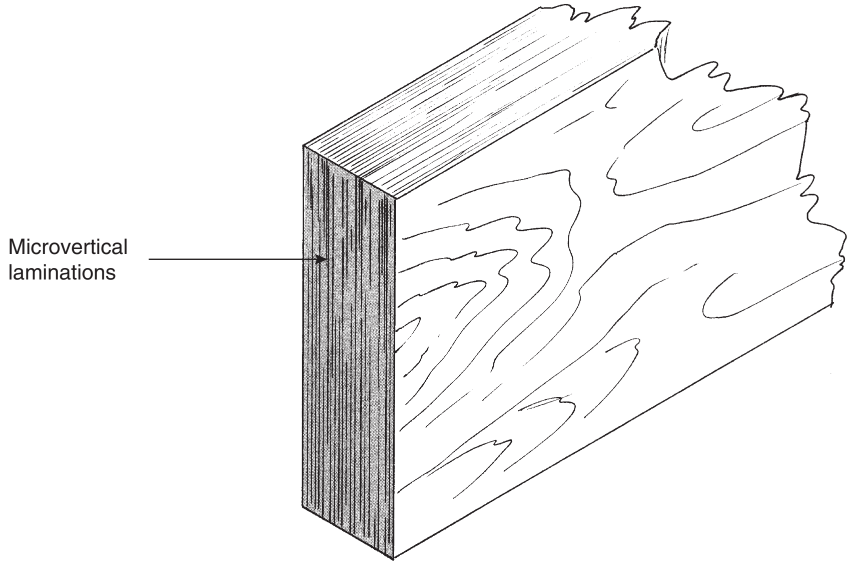

Fig. 4.2 Micro laminated timber beam.

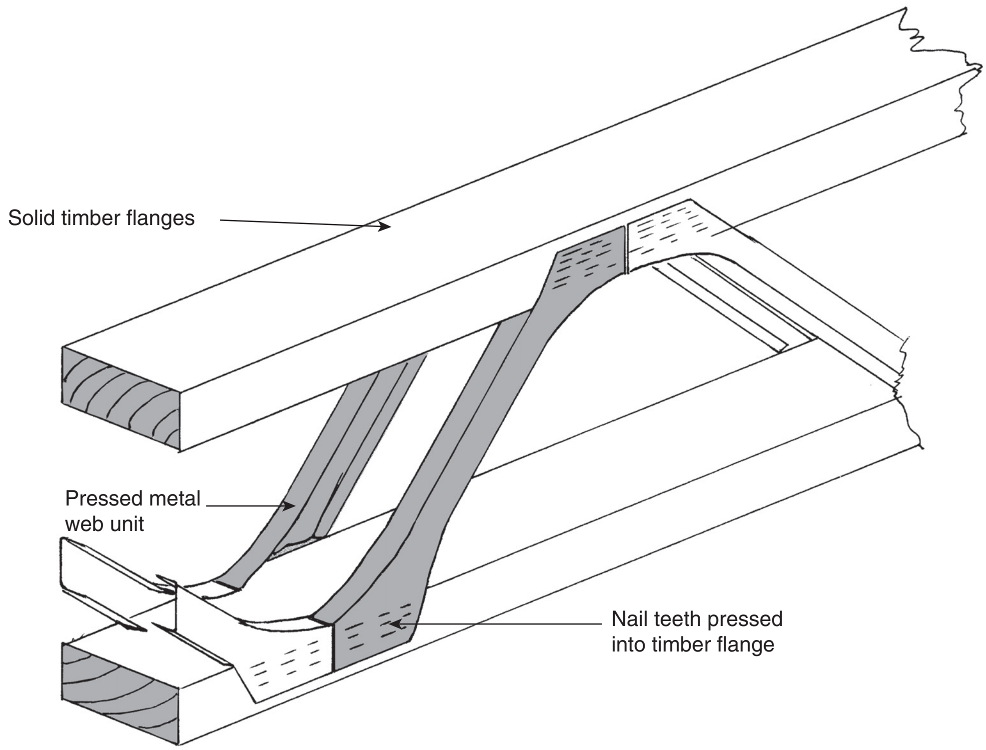

Fig. 4.3 Metal nail plate and timber beam.

design of 'V' shaped metal strut connector system, where as Alpines' Twin–I Beam uses conventional punched metal rectangular plates with vertical timber struts between the flanges as illustrated in Fig. 4.4, but Alpine revert to timbers being used vertically rather than horizontally with the systems mentioned above, although the timber is generally much thicker than one would find in roof truss construction, again to give the better support for floor and ceiling.

All of the punched metal plate connected types give copious open space for services between the joists, thus avoiding the potential problems of incorrect notching and boring for services which is so often one of the problems with the use of even conventional solid soft wood floor joists. Over notching with the installation of pipes on the upper surface, and electrical installation on the lower surface, can dramatically decrease the joist's performance. Clearly with the 'I' beam and the solid laminated beams, the question of piercing for services has to be addressed and the manufacturers' literature should be carefully adhered to as to avoid weakening the floor diaphragm being constructed.

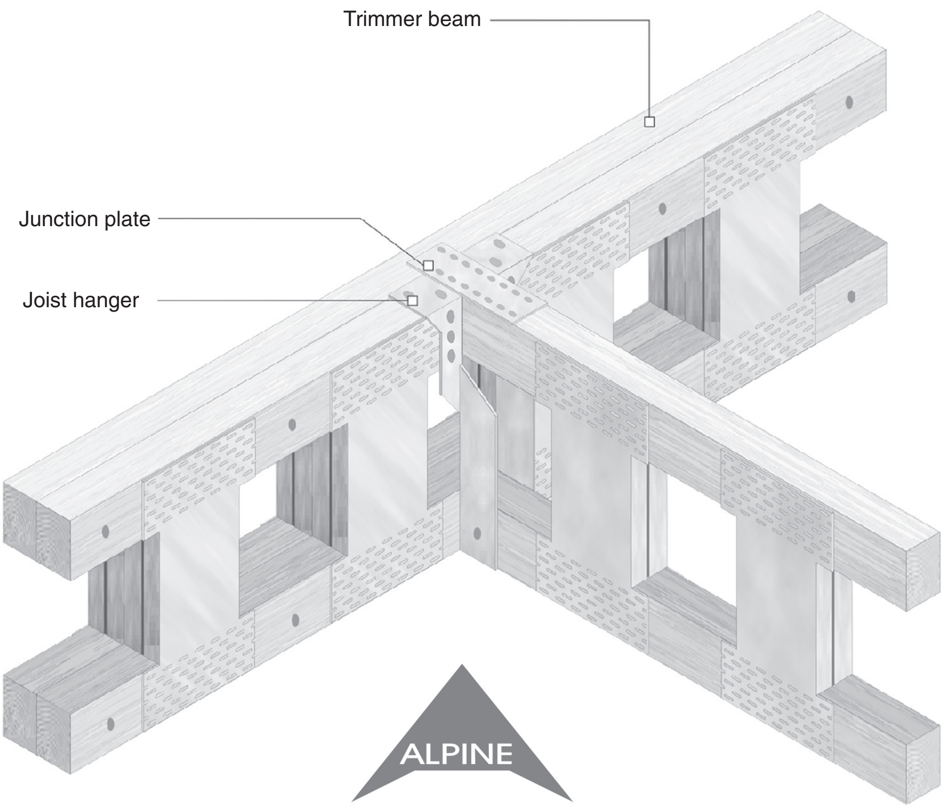

Fig. 4.4 Twin-I beam detail.

Warning

When using any of the engineered components mentioned above *do not cut, notch or bore holes* in any element without checking with the designer or manufacturer. To indicate the limitations of such boring, please see Fig. 4.5 reproduced from Trus Joist's technical manual. It should be noted that this applies to this particular manufacturer's product, but similar information is available from all of the manufactured joist and beam companies. It should be carefully noted that *no notching* of top or bottom flange, i.e. the most highly stressed areas, is allowed.

ATTIC CONSTRUCTION USING ENGINEERED TIMBER COMPONENTS

This section deals with the construction of attic roofs incorporating the engineered timber components described above for the floor diaphragm, and explores these and other new developments in engineered components for the roof element of the attic. This section is therefore particularly relevant for new house construction, but is equally applicable to the replacement roof when building an attic on an existing structure, i.e. roof replacement.

Although most of the discussion above has referred to 'floors', the sloping rafter element of one side of an attic is in effect a floor tilted to the appropriate pitch. Instead of carrying the dead load of the furniture and fittings and the live load of the occupants, the rafter plane carries the dead load of the tiles (and snow), and the live loads of winds plus possible loads from any high level ceiling and water tanks installed in the space above. Using engineered timber components for attic rafters is similar to the use of these components in floors. Trimming openings in the floor for a stairwell, becomes a trimmed opening for the dormer of the roof window. Ease of access for installing services is equally necessary through rafters as it is through the floor, and the larger spans required of attic rafters are easily achievable with engineered timber components. Some of these engineered components can also be used for purlins on the smaller spans, and on longer spans engineered components can be produced to the length required without the necessity for joining soft wood timber purlins, but of course may need internal purlin supports. The depth of engineered timber components also allows excellent space to install a large thickness of insulation to give better performance without the need for battening down the sloping ceiling area of a conventional solid timber rafter or even that of an attic truss rafter, and also allows good space for ventilation. Special end detailing is of course necessary at the eaves to wall plate or floor diaphragm construction, as the floor diaphragm is being used as a tie in most instances. The engineered timber rafters form simple 'couples', as illustrated in Fig. 1.1, but are often able to carry much greater loads. Typical wall plate and eaves details for 'I' beam rafter construction can be seen in Fig. 4.6.

Reference can also be made to illustration 7.16 which shows an attic construction using Gang-Nail fabricated floor and roof beams.

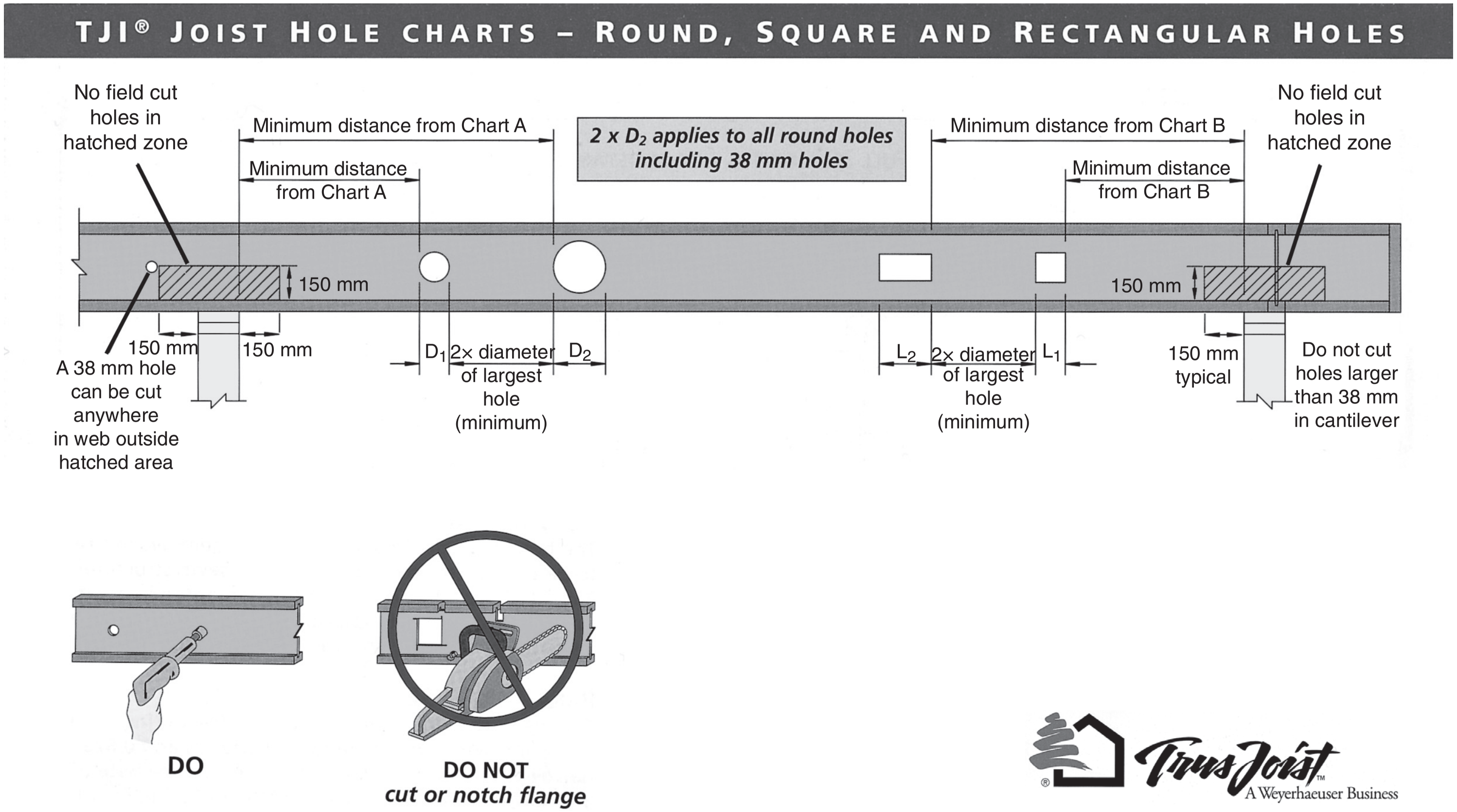

Fig. 4.5 Typical cutting restrictions in timber I beam. Technical Guide – United Kingdom/Ireland; Silent Floor® and Roof Framing Systems; Reorder #GB-1001. Copyright (2002) Boise, Idaho: Trus Joist, a Weyerhaeuser business. Reproduced with permission. All rights reserved.

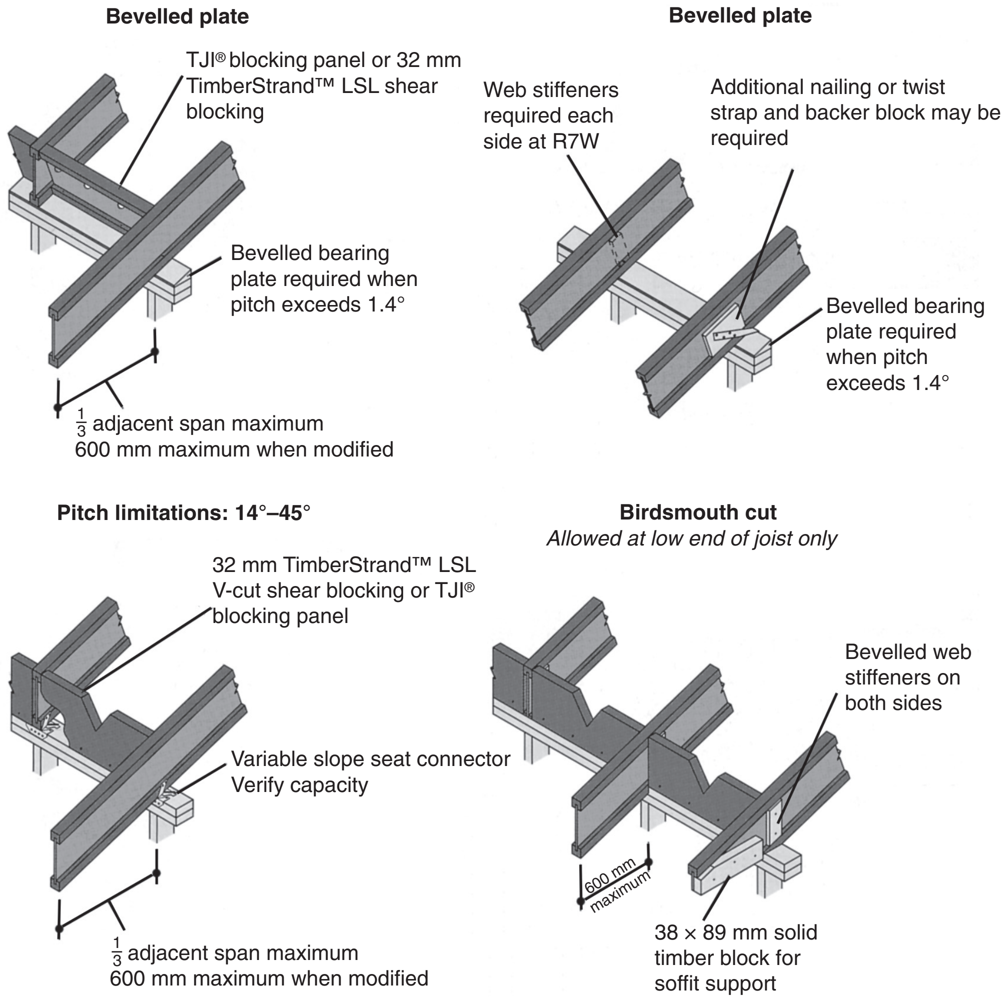

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Fig. 4.6 Typical I beam eaves details. Technical Guide – United Kingdom/Ireland; Silent Floor® and Roof Framing Systems; Reorder #GB-1001. Copyright (2002) Boise, Idaho: Trus Joist, a Weyerhaeuser business. Reproduced with permission. All rights reserved.

Trimming openings for stairs, dormer and roof windows in 'I' beam constructions

With traditional construction using natural solid timber joists and rafters, general advice can be seen as illustrated in Fig. 3.18b. For engineered timber joists and rafters, the trimming must be designed as part of the whole floor diaphragm, or roof slope construction, with components selected, detailed, and manufactured to fit. The use of special metal hangers designed to carry the larger profile of engineered components plus cleats, fixings and correct nailing or bolting is essential. For that reason it is not possible to cover in this text every manufacturer's detail but typical techniques can be seen in Figs 4.7 for floor diaphragms and 4.8 for roof structures.

Engineered timber beams and trussed rafter fabrications for attic construction

Attic roof construction using conventional methods has been detailed in Chapter 3. Further conventional floor and trussed rafter attic construction is dealt with in Chapter 6; Fig. 6.15 illustrates a construction suitable for conversions, Fig. 6.17 illustrates conventional floor joists with cross wall purlins and trussed rafter assemblies, and Fig. 6.18 illustrates a conventional trussed rafter attic constructed roof. What follows is a combination of the use of engineered timber joists which have been discussed at length above, and simple trussed rafter fabrications. Again the method at the time of drafting this revision, was being promoted by one particular company, Trus Joist, but undoubtedly will be followed by others in the future.

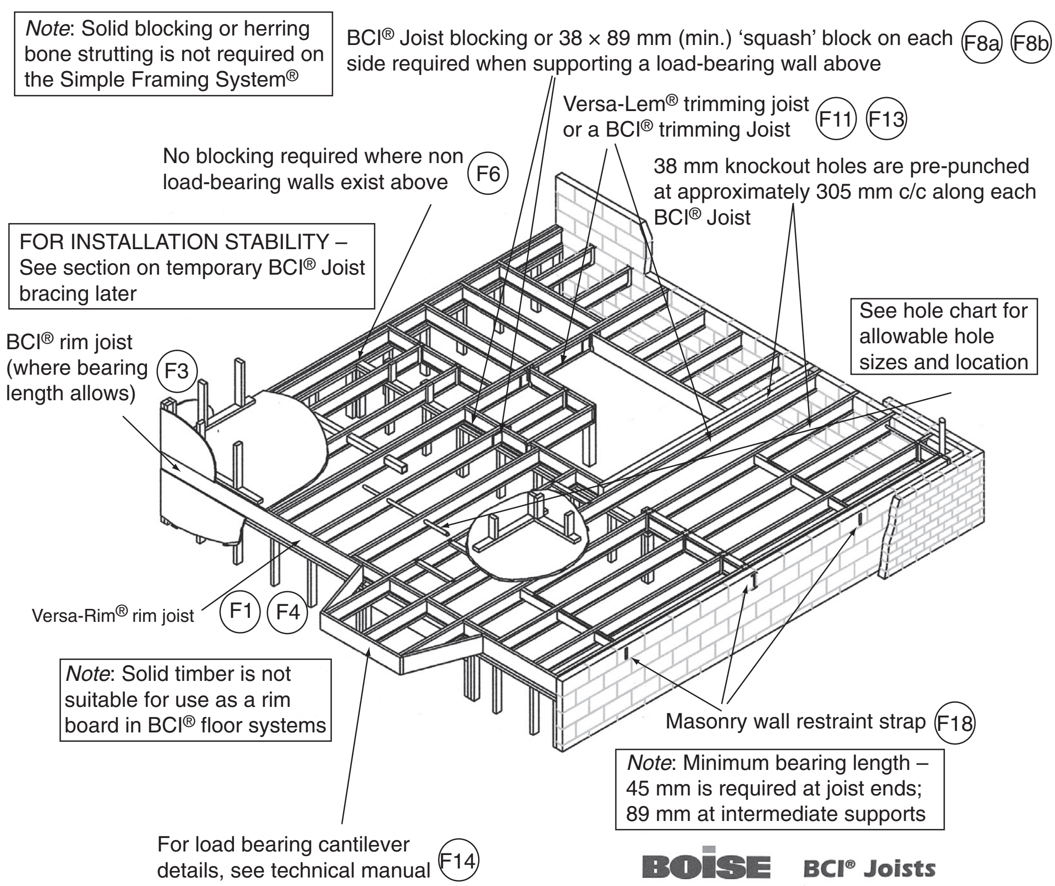


Fig. 4.7 Typical I beam floor framing layout.

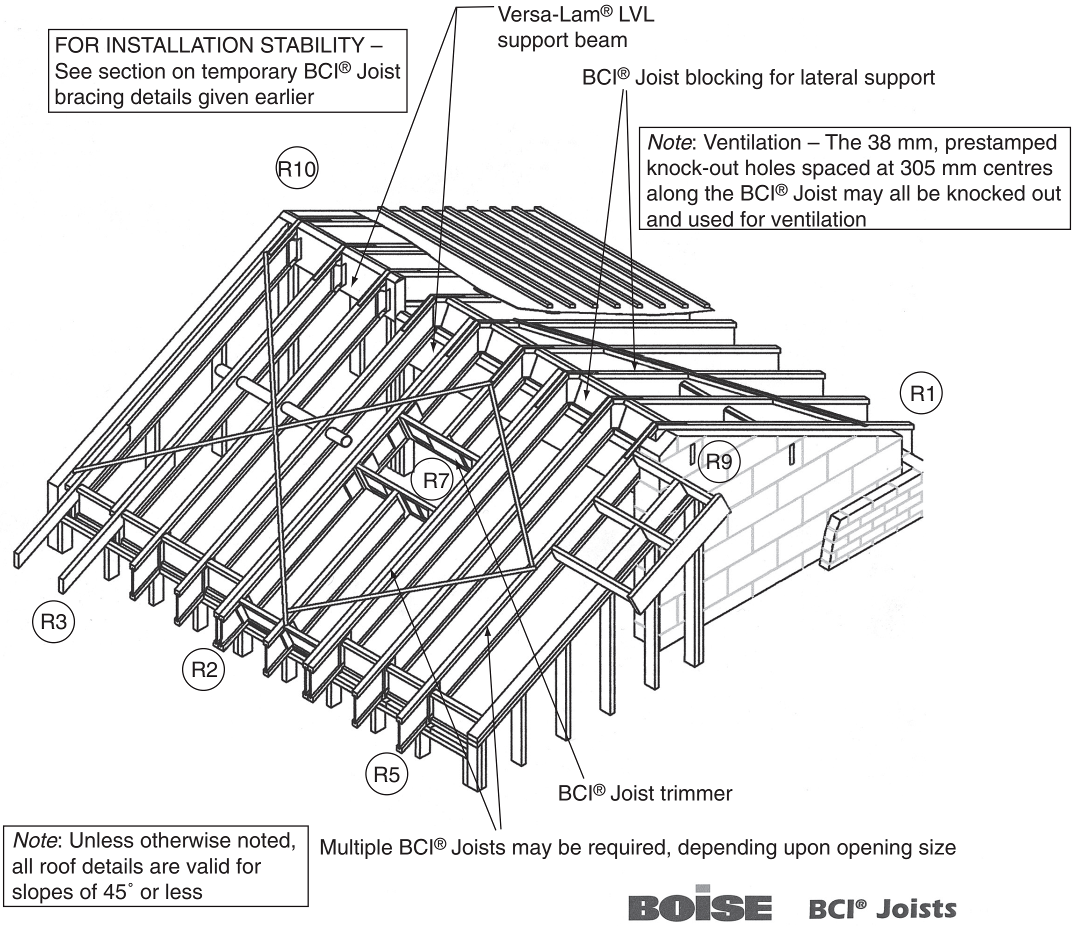


Fig. 4.8 Typical I beam roof framing layout.

™Trus Joist is one of the companies manufacturing engineered timber 'I' beams and, recognising that there is a considerable market for attic construction, has developed Spatial Roof. This is a room-in-the-roof or attic construction which interestingly combines engineered timber 'I' beams and trussed rafter assemblies. Recognising that there are problems in hoisting and erecting the bulky true trussed rafter attic (as illustrated in Fig. 6.18), this method seeks to provide relatively lightweight components thus acknowledging the recommendations of the manual lifting regulations aimed at avoiding personal injury to those erecting large and heavy structures. By taking the conventional 'I' beam floor diaphragm, and covering this with a waterproof floor decking, the method quickly creates a sound and solid working platform from which to erect the roof element of the attic. The waterproof platform provides protection for the building below allowing other works to continue whilst the roof is under construction. This also lends it admirably to roof replacement projects referred to later in Chapter 12. It should again be noted that this is an individually engineered designed system for each structure, the design and products being supplied as a package as with a conventional truss rafter roof. This ensures full compliance with Building Regulation requirements, making both the floor and roof structure very easy for the building designer as this is prepared for him by the manufacturer. Figure 4.9 illustrates the construction principles of this system.

First, the first (or second) floor structure is constructed using Trus Joist 'I' beams. The 'I' beams are engineered items using Microlam flanges and Performance Plus OSB (Orientated Strand Board) webs. Just as it is not possible to make a Wolf or Gang-Nail truss rafter without the correct products and equipment, the same rationale applies to these engineered beams – they *must* be factory made where quality of raw material and assembly is carefully controlled. These, like all other engineered timber items, are not simply pieces of 4 × 2 glued to a piece of OSB from the timber merchant. There are a number of waterproof deckings available, one such being Weatherdek 2, which uses a specially made moisture resistant tongue and groove chipboard with the upper surface sealed with a factory applied protective film. This system uses special adhesives to bond the decking to the 'I' beams held in place by the specified nailing system. The tongue and groove joints between the panels are glued, and a final waterproof joint covered tape is applied. The decking system provides a safe waterproof working platform which (with appropriate edge protection) satisfies the Work at Height Regulations. It also provides Trus Joists' Silent Floor, designed to provide a squeak free flooring system devoid of shrinkage and unevenness so often associated with traditional timber joist and board construction.

Metalwork, connectors and hangers

With the growth in engineered timber beams there has been an equal growth in the availability of special metal connecting devices and hangers. Many of these components carry heavier loads than conventional floor joists, mostly because they are able to span greater distances without support. It is essential that these connections are properly detailed and the correct connecting metalwork specified. Furthermore, it is equally critical that the metalwork is correctly connected to the timber component and most of the proprietary products have special details at support or connecting points to enhance their performance and allow for better and therefore stronger fixings to be achieved. Reference should be made to the technical handbook for the product being specified.

Figure 4.10 illustrates one particular type of metal hanger showing that used to connect both metal web beams and 'I' beams. It will be noted that on the 'I' beam the blocking mentioned above is used in the illustration entitled 'Enhanced ITB Installation'. The illustration is taken from Simpson Strong-Tie technical manual which illustrates all of their products and gives safe working loads for each connection. Further metalwork from the company is illustrated in Fig. 7.3. Full details are available in the bibliography.

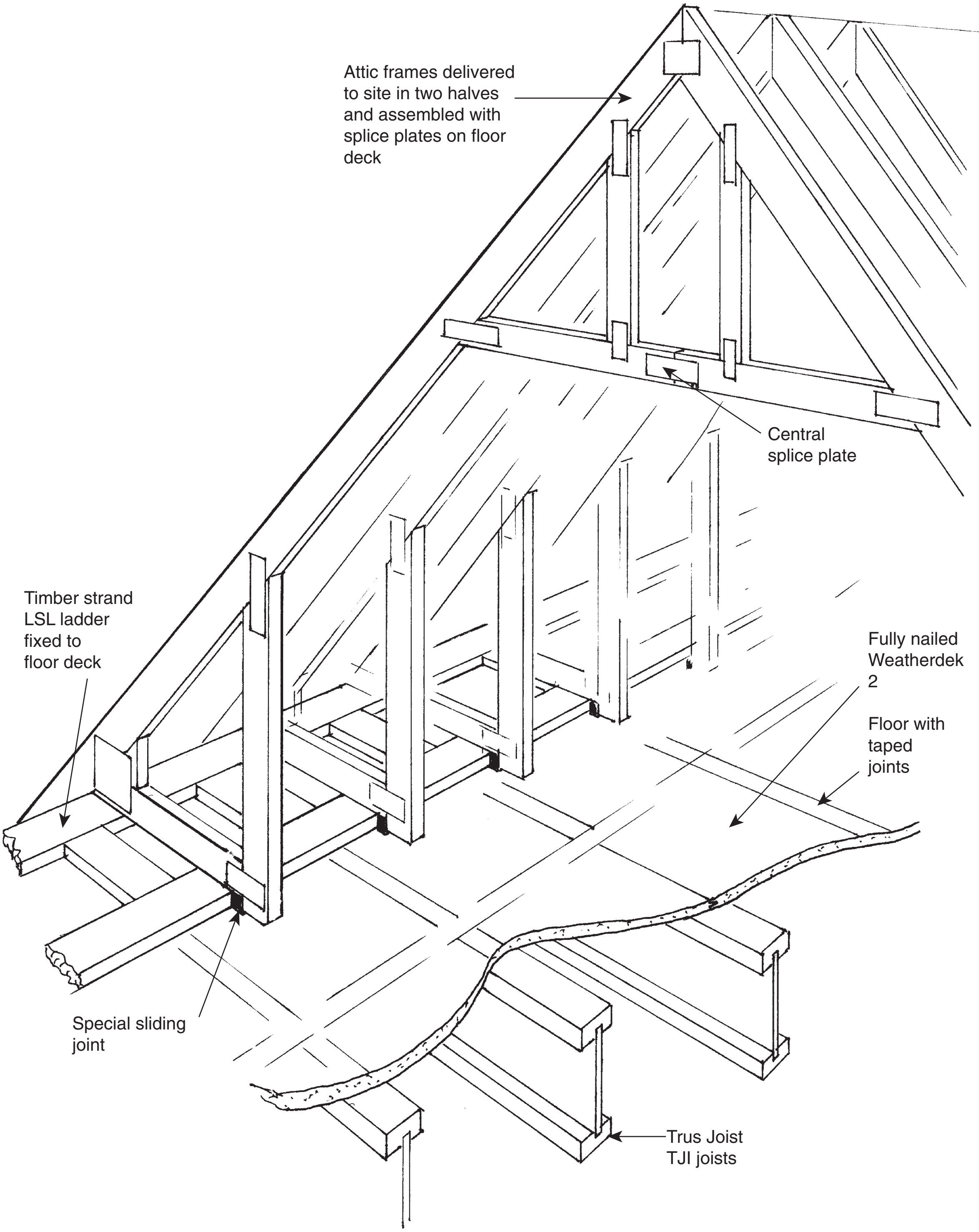


Fig. 4.9 Schematic illustration of Spatial Roof™. Spatial Roof is a patented design.

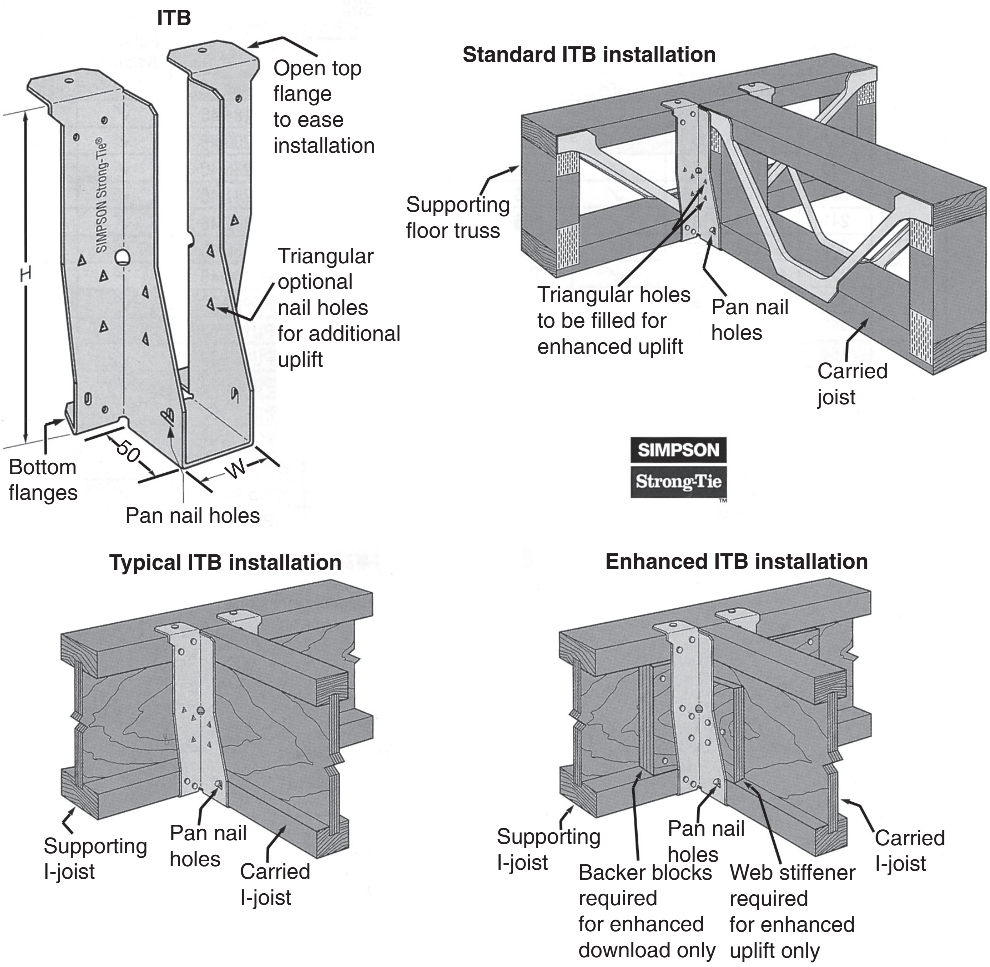


Fig. 4.10 A metal connector for engineered beams.

The roof element

Spatial Roof then uses an engineered 'Timber Strand' LSL interface ladder nailed to the top of the timber deck at the eaves positions, this working with the decking to form a girder on each side of the roof between the gables. All of this work is safely done from the sound working deck and using easily manhandled components. The roof structure itself is made of pressed metal plate timber assemblies from the truss rafter factory but, to ensure that these can be safely lifted, they are supplied as two rafter units per truss, each with its own stud for the attic room wall, and an assembly for the ceiling. These are assembled on the floor deck into one attic unit. Whilst the majority of this 'attic' is formed by conventional stress graded soft wood, the stud wall member being highly stressed is formed of Timber Strand LSL engineered timber. A special detail at the base ensures the interface ladder controls the horizontal spread, but allows the floor deck to deflect under load independent of the roof structure. This simple construction is suitable for both the professional builder and the self-build enthusiast because it does not involve the use of cranes or other heavy lifting equipment and allows easy and safe working whilst allowing the contractor to use the very latest timber engineering technology.

The normal rules apply for the trimming of openings both in the roof and the floor diaphragm. Spatial Roof, Timber Strand LSL and Trus Joist Silent Floor are all registered trade marks and copyright of Trus Joist, full details of which can be found in the bibliography.

Panels, insulated panels and cassette constructed attics

Roof panels and cassette construction continue the current trend towards factory produced engineered timber components. In principle they are a panel comprised of rafter and decking or multiple purlin and decking, i.e. prefabricated structural components running from wall plate to ridge or gable to gable (or some other internal cross roof supporting wall). The simplest prefabrication is a panel comprised of ply or similar sheathing fixed to rafters; the insulated panel is as above but with insulation usually a weatherproof rigid foam applied between the rafters. The cassette is a more complete component in that it provides water resistant sheathing, insulation encapsulated in an integral ceiling, i.e. a component with waterproof sarking or upper cladding, the structure in the form of the joists, insulation, and a ceiling which is either ready for decoration, or can have some other decorative cladding applied over it.

Panels

TRADA offers design guidance on panel roof construction in their Wood Information Sheet 'Room in the Roof Construction for New Houses'. The panel consists of a stress graded softwood rafter formed into panels by cladding with ply, OSB or other suitable sheathing. For larger spans the method would require engineered stress skin design where the decking thickness and specification plus nailing or gluing centres would be closely specified by the structural engineer to ensure full performance of the panel. TRADA have championed this form of construction for many years, but it appears that the economic climate and lack of skilled labour are now right for it to come to the fore.

In its simplest form the method is no more than sheathed rafters resting on ridge and over purlins and on the wall plate. The more engineered versions of the panel roof uses panels designed to span from ridge to a thrust plate at the 'wall plate' position, giving a completely free triangular attic space maximising the attic volume. Figure 4.11 is taken from the TRADA sheet referred to above and illustrates the design, but incorporates a ceiling tie because of the relatively large floor span and rafter length. The thrust from the roof panel is resisted by the specially shaped hardwood

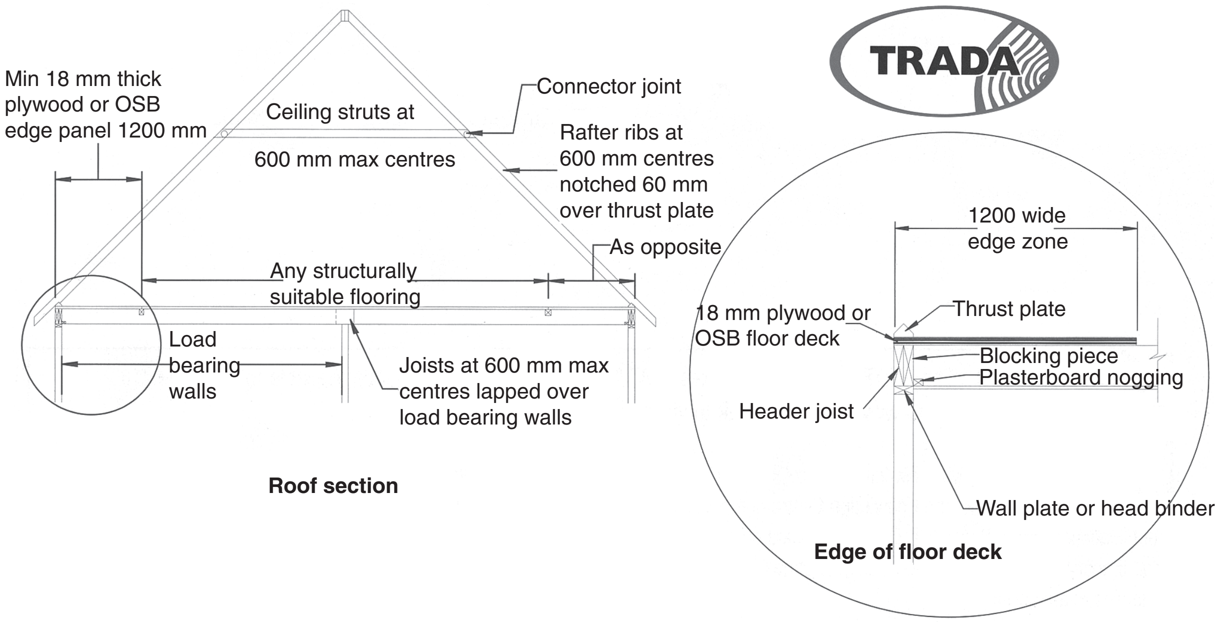


Fig. 4.11 Configuration and edge detail for sheathed roof panel construction.

plate fixed to the floor deck, the outer 1200 mm of which is used as a horizontal beam connected to the joists by a designed nailing pattern, and then to the edge or header joist. As roof panel and floor deck are stressed, openings for roof lights and stairs must be carefully designed. The method could be used with engineered 'I' beam floors which, because of the longer spans available would provide an excellent floor deck diaphragm.

Insulated panels

Whilst the basic panel method described above can be engineered and manufactured either on a suitable platform on site or in a workshop from materials readily available from the timber merchant, insulated panels are usually manufactured in a factory and under a proprietary trade name. One such is made by Unilin Systems and this can be seen in Fig. 4.12. The product consists of conventional softwood rafters and a ceiling panel of various materials; between the rafters is a waterproof insulation filled to within 20 mm of the upper surface of the joist to allow a ventilation gap. There is no top sheathing. Each roof is individually engineered by the company using standard specifications and components. The panels can be up to 1210 mm wide and 8 m long. They require a gable and purlin type construction running as they do from ridge over purlin to wall plate. On long roofs of course the intermediate support for the purlins can be provided by a principal truss. The method can accommodate roof windows and dormers. In its most basic form, the ceiling panel can be moisture re-

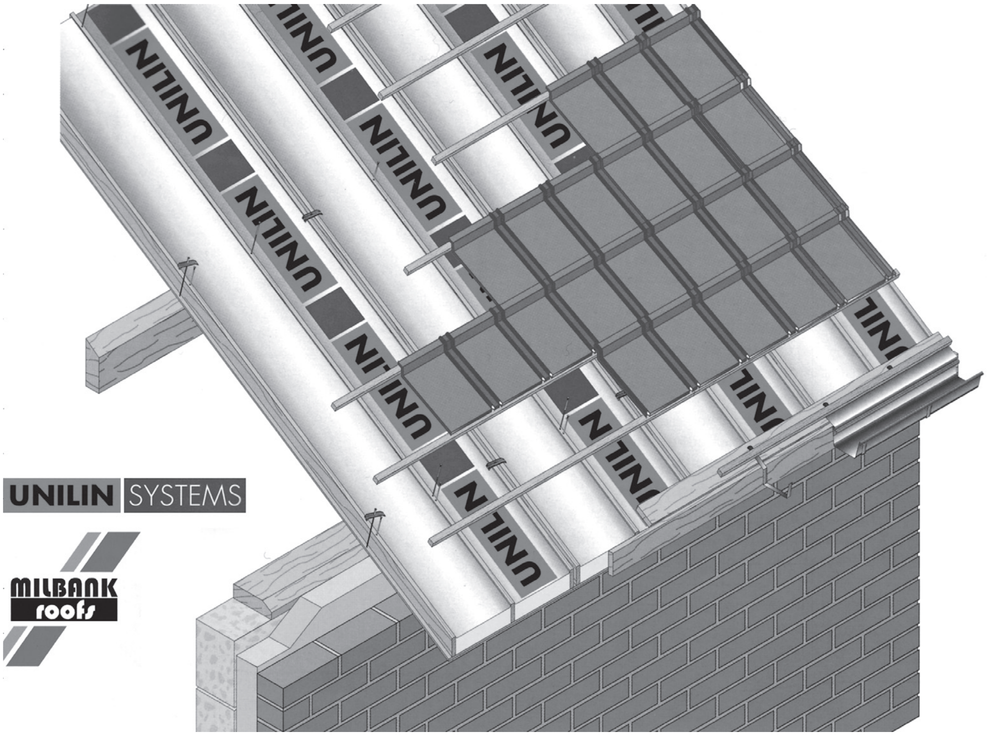


Fig. 4.12 Insulated panel roof.

sistant plasterboard, progressing through a whole range of materials including pre-finished chipboard to tongue and groove boarding and acoustic panels. Thus it can be seen that the ceiling is part of the waterproof structure, the panels being sealed at their longitudinal and horizontal joints with waterproof foam during assembly. Final waterproofing is carried out with tiles and battens in the conventional manner. All fixing for panels to purlins and wall plate are specially developed and provided with the package. Again this method provides a completely free, triangular attic space with no ties, for the designer and occupants to use as they please. Unilin Systems panels are manufactured in Belgium and distributed in the UK by Milbank Roofs, full details of which can be found in the bibliography.

Cassettes

The ever-increasing thermal performance and building quality standards, coupled with the continuous demand for housing and the shortage of skilled labour have led to a resurgence of timber framed house construction, much of this being of the large wall panel type, and including floor cassettes, i.e. completely manufactured large floor panels for crane construction incorporating all joists, blockings, holes for

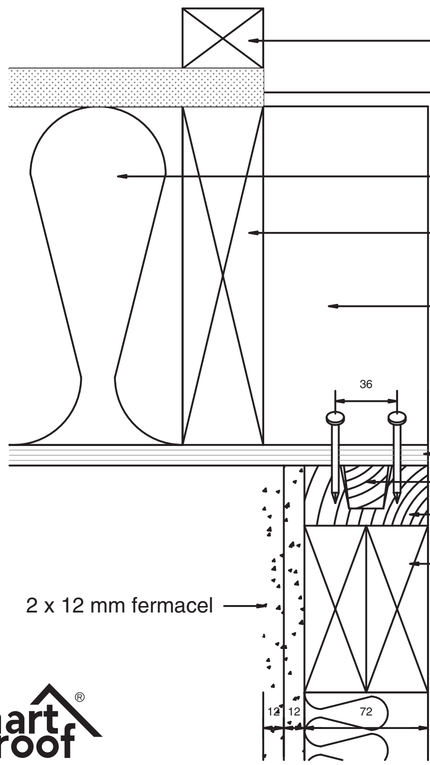
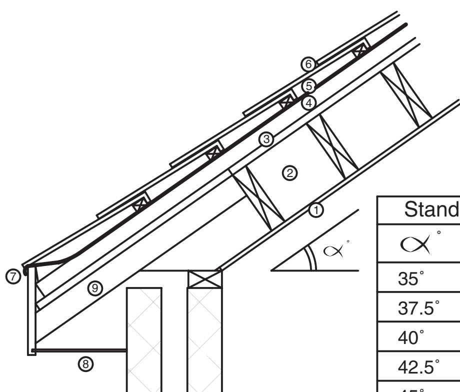


Fig. 4.13a Cassette roof – standard panel to party wall spandrel fixing.



Standard panel	
α°	*d*
35°	212 mm
37.5°	214 mm
40°	218 mm
42.5°	222 mm
45°	227 mm

Key

1. 12 mm structural board
2. Panel core – standard 197 mm
3. Panel closer board – standard 22 mm
4. Counter batten – 38 mm or 50 mm
5. Roofing felt
6. Battens and tiles as traditionally
7. Felt dresses over fascia – fillet as required
8. Soffit width – as required
9. Structural overhang – standard 36 x 72

Fig. 4.13b Cassette roof – eaves setting out.

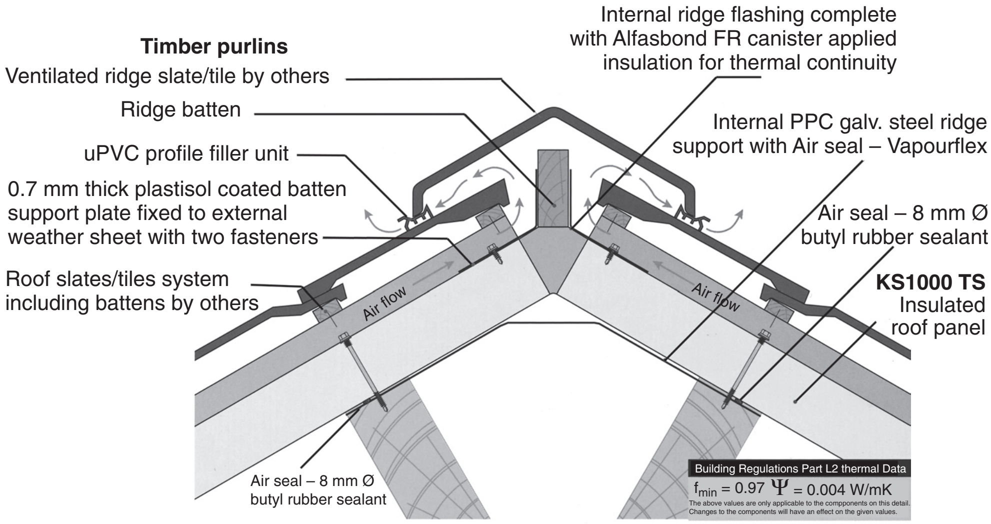


Fig. 4.14a Ridge details.

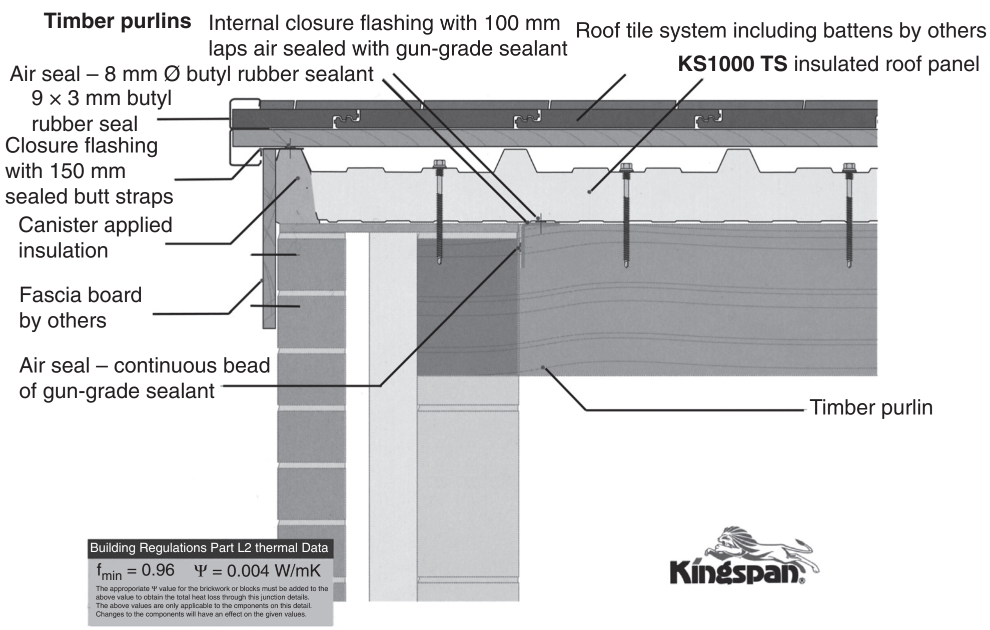


Fig. 4.14b Verge details.

services and prefixed weatherproofed deckings. The factories making these lend themselves ideally to manufacturing roof cassettes. The crane for the erection of these large roof cassettes is already on site having assembled the timber framed house or lowered the floor cassette on to a traditional constructed building. Most of these systems therefore come from timber framed housing manufacturers.

Tradis is one such cassette developed as part of a whole house construction system. It uses engineered 'Masonite' I beams with a ceiling and roof decking sheathing to form a stress skin panel filled with highly efficient insulation. The product is sophisticated in its thermal and vapour control technology and claims highly 'green' credentials. The method provides an instantly weathertight (except for any roof windows or dormers that need to be constructed) roof shell, thus allowing internal working to proceed before tiling is complete. Tradis is manufactured by Excel Industries Ltd. See bibliography for details.

smartroof® is different to the above system in that it spans from gable to gable or some internal cross wall support, i.e. a partition or principle truss. The system consists of stress skin interlocking panels designed to key to the design detail on the timber framed gable panels. The ply ceiling panels are pattern nailed to stress graded trussed rafter type machined timbers, the voids filled with insulation to client specification, which can include environmentally friendly sheep's wool (a commercially available product) and conventional mineral wool. The cassette is sheathed externally with a vapour breathable board, i.e. a structural sarking. Panels have a simple interlocking detail between them connected by nailing to an approved pattern. Openings in this type of cassette, because it is spanning from gable to gable or principal to gable, can provide windows almost the entire width of the roof. It therefore offers greater freedom of roof window location than the ridge to eave cassette options. Figure 4.13 illustrates a smartroof panel anchorage method to the spandrel or gable timber framed panel, and shows a typical eaves detail. Both illustrations are taken from the smartroof technical manual. smartroof is the proprietary name of smartroof Ltd, full details of which can be found in the bibliography.

Kingspan is yet another cassette design which is part of a whole roof system including lightweight tiles. It is suitable for all types of building including domestic, commercial and public buildings, and can be fitted to either steel framed or traditional timber roof structures. The panels are comprised of a ridged foam insulation sandwiched between thin plastic coated steel profiled sheets which give the strength to the cassette. The insulation core can vary from 40 mm to 100 mm. With the foam lower than the cassette ribs, there is good provision for ventilation. Typical details of this method can be seen in Fig. 4.14 which shows a ridge for a purlin roof structure showing the ceiling system and ventilation. Also illustrated is a verge detail suitable for domestic buildings where purlins are used as the structure. Kingspan's technical literature illustrates numerous other ridge, eaves, verge, valley and abutment details.