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Subject: Timber frame
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with minor corrections

Introduction to timber frame construction

Modern methods of timber frame construction were introduced into the UK in the 1960s and are a fully accepted method of building. There are now many examples of multi-storey timber frame buildings of six or seven storeys across the UK. As for any other form of construction, timber framed buildings must comply with the requirements of UK building legislation.

Exova BM TRADA recommends *Eurocode 5* [1] for structural design of timber. However, this Wood Information Sheet (WIS) includes a summary of variations when using *BS 5268-2 Structural use of timber. Code of practice for permissible stress design, materials and workmanship* [2]. Designers migrating to Eurocode 5 will miss much of the practical advice found in the BS 5268 family of standards. When published by BSI, *PD 6693 Complimentary information for use with Eurocode 5* will incorporate much of that material.

This WIS is an overview of the subject with signposts to more detailed sources that are listed at the end.

Contents

Figure 1: Modern timber frame construction

Key points

- The method of timber frame construction generally used in the UK is known as platform frame.
- Timber framed construction reduces site work and allows fast completion, due to prefabrication. As there need not be any wet trades, this avoids the drying out time necessary with masonry construction and reduces the remedial 'snagging' required.
- 'Open panels' (studs, rails, lintels, sheathing and breather membrane) that have been manufactured in a factory environment are delivered to site and craned onto a 'platform', which is formed by the building foundations and sole plate.
- When installed, upper floor decks form further working platforms for wall panels to be erected.
- Higher levels of prefabrication can be achieved with 'closed panels' where the insulation, services, vapour control layer, internal linings, and possibly also the joinery and cladding are all applied in the factory
- A significant effect of the 2010 revisions to the building regulations (which demand a 25% reduction in heat loss over the 2006 requirements) is that 140mm may no longer be sufficient to accommodate the insulation needed. Exova BM TRADA recommends an insulated service zone on the inner face of the timber frame external walls. This increases the nominal wall depth to 190mm.
- The proposed revisions to building regulations in 2013 will impose a further step change in thermal performance, which will prompt another rethink of all building systems.
- Wall panels are braced by sheathing with wood-based sheet materials nailed or stapled to the framing members.
- Controlling the passage of moisture through the wall using membranes is a critical aspect of the design.

Benefits of timber frame construction

The benefits of off-site prefabrication are becoming more widely recognised throughout the construction industry. For the designer, the timber frame method offers flexible planning, a variety of ways to achieve excellent energy efficiency, economic use of materials and a wide range of external finishes. Compared with masonry construction, timber frame is more accurate and the lower overall dead weight of the structure, particularly if light cladding is used, may permit lighter foundations.

For the contractor, timber framed construction reduces site work and allows fast completion, due to prefabrication. As there need not be any wet trades, this avoids the drying out time necessary with masonry construction and reduces the remedial 'snagging' required.

For the occupant of the house, the high level of insulation possible can reduce the cost of heating. Comfortable room temperatures are quickly reached and economically maintained when the heating is on. Dry construction means that decoration can be carried out soon after completion of the building without risk of cracking and deterioration of finishes. Timber framed buildings are also easy to customise and extend.

Related publications

TRADA's book *Timber frame construction, 5th edition* [3] contains detailed guidance on timber frame construction. This takes account of the 2010 changes in England and Wales Building Regulations and the 2011 changes in the Building Standards in Scotland. The following publications precede these changes; hence you may need to adapt the principles in order to achieve the enhanced thermal performance now demanded.

BRE/TRADA's book *Multi-storey timber frame buildings – a design guide* [4] offers additional guidance for buildings of four to seven storeys.

TRADA's *Timber Frame: Standard details for houses and flats* [5] provides details for houses up to 3 storeys tall requiring 30 minutes fire resistance and flats requiring 60 minutes fire resistance.

TRADA published *Timber frame: details for thermal performance* [6] in response to the increased emphasis on thermal bridging in the current building regulations.

But before specifying the details, refer to TRADA's *Low-energy timber frame buildings* [7], which describes how to optimise the layout to achieve 'low-energy' designs, together with guidance on envelope performance and details for ventilation, airsealing and insulations.

For structural engineers, TRADA's *Timber Frame Housing: UK Structural recommendations* [8] covers methods for the design and checking of timber frame buildings, following BS 5268-2. It does not take account of Eurocode 5 for structural design of timber.

For site managers, TRADA's *Site manager's pocket guide to timber frame* [9] contains information on best practice, and a list of important 'Dos and Don'ts'.

Related information sheets:

- *WIS 0-5: Timber frame building – materials specification* [10]
- *WIS 0-10: Surveys of timber frame houses* [11]
- *WIS 0-11: Improving the thermal performance of existing timber frame buildings* [12]
- *WIS 1-10: Principles of pitched roof construction* [13]
- *WIS 1-29: Trussed rafters* [14]
- *WIS 1-35: Breather membranes for timber frame walls* [15]
- *WIS 1-36: Timber joist and deck floors – avoiding movement* [16]
- *WIS 1-41: Strutting in timber floors* [17]
- *WIS 1-42: Timber I-joists: applications and design* [18]
- *WIS 1-48: Timber Frame Construction: Sole Plates* [19]
- *WIS 1-49: Cladding for timber frame buildings* [20]
- *WIS 2/3-16: Preservative treatment for timber: a guide to specification* [21]
- *WIS 2/3-57: Specifying wood-based panels for structural use* [22]
- *WIS 2/3-64: Timber frame design for flood-prone sites* [23]
- *WIS 4-7: Timber strength grading and strength classes* [24]
- *WIS 4-12: Care of timber and wood-based products on building sites* [25]
- *WIS 4-14: Moisture in timber* [26]
- *WIS 4-15: Condensation control in dwellings* [27]
- *WIS 4-30: Fire performance of timber frame dwellings* [28]
- *WIS 4-32: Acoustic performance in residential timber frame developments* [29].

Method of construction

The method of timber frame construction generally used in the UK is known as platform frame. The vast majority (approximately 95%) of the timber frame buildings being built in the UK follow a relatively simple tried and trusted pattern. 'Open panels' (studs,

rails, lintels, sheathing and breather membrane) that have been manufactured in a factory environment are delivered to site and craned onto a 'platform', which is formed by the building foundations and sole plate. Sometimes rigid insulation is also pre-fitted into stud voids.

The panels are fixed into position with nails and then floors are installed to create another platform. The floor is either cassettes or loose joists (now frequently engineered joists), with a wood-based panel structural deck. Another set of panels is positioned and fixed on top of the first floor platform and the process can be repeated to create a building of the required design height. The final part of the erection process is to position, fix and brace the roof, normally trussed rafters. 'Open panel' structures, such as this, are then dry-lined after the installation of services, insulation and a vapour control layer on site.

Higher levels of prefabrication can be achieved with 'closed panels' where the insulation, services, vapour control layer, internal linings, and possibly also the joinery and cladding are all applied in the factory. In the UK, some manufacturers produce such panels but the effects of weather on materials, speed of construction and details of erection on site must be carefully considered.

For structural design of load-bearing walls, follow Eurocode 5.

Variation when using BS 5268

For dwelling up to seven storeys, follow *BS 5268-6.1 Structural use of timber. Code of practice for timber frame walls. Dwellings not exceeding seven storeys* [30].

For buildings other than dwellings, follow *BS 5268-6.2: Structural use of timber. Code of practice for timber frame walls. Buildings other than dwellings not exceeding four storeys* [31].

Figure 2: Installing open panels. Photo: Castleoak Group

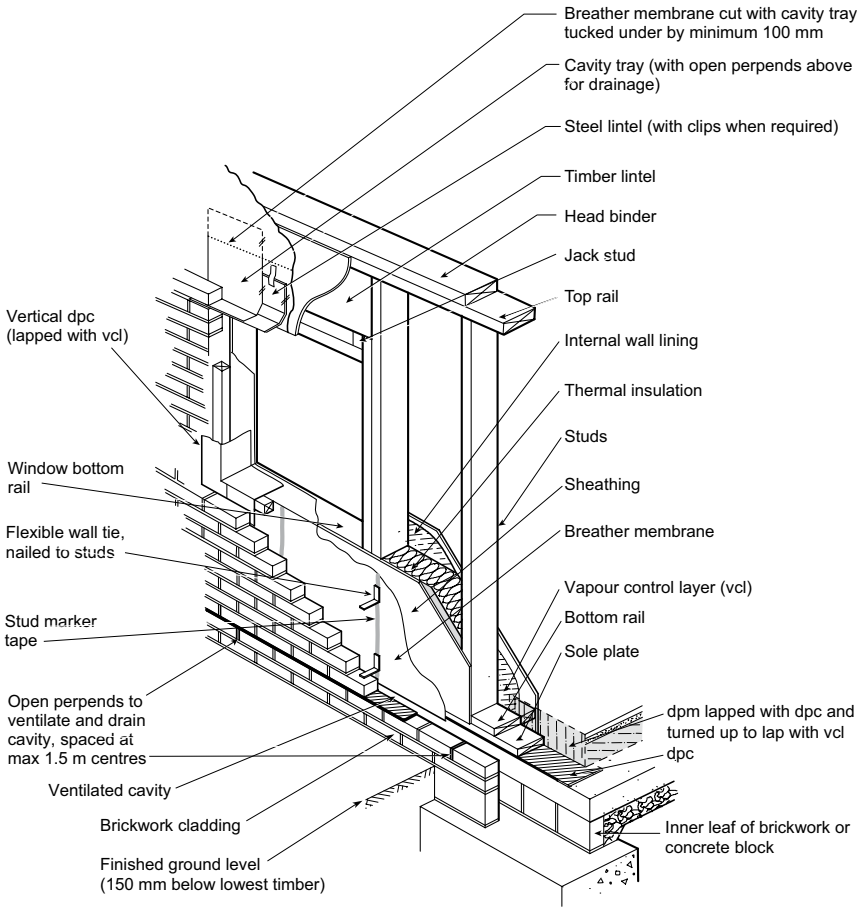

Figure 3: Externally sheathed timber frame wall with brick cladding

External walls

In timber frame construction the framed wall panels carry all the vertical and horizontal loads to the foundations. If brick or block cladding is used, this is supported directly off the foundations but the cladding does not carry any loads other than its own self weight. However, light claddings, such as timber boarding, tile hanging or render on mesh are supported directly off the wall panels. For this reason it is important for the structural engineer to be aware of the cladding type.

The stud framework is the vertical loadbearing skeleton of the external wall. The framework consists of vertical studs and horizontal rails. All these structural members must be of strength graded timber, normally preservative-treated to ensure durability. Studs for buildings are most commonly 38mm x 140mm. Larger sizes may be used to provide for an increased thickness of insulation.

A significant effect of the 2010 revisions to the building regulations (which demand a 25% reduction in heat loss over the 2006 requirements) is that 140mm may no longer be sufficient to accommodate the insulation needed. In *Timber frame construction, 5th edition*, we addressed the key areas of air-tightness, thermal performance and thermal bridging by introducing an insulated service zone on the inner face of the timber frame external walls (nominally 50mm in depth). This zone allows the vapour and air control layer to be free from service penetrations and requires all laps and junctions to be detailed well, that is, all membrane laps mechanically fixed and clamped behind battens to studs and rails. It also allows the installation of more insulation between the battens, which if run horizontally can improve the U-value of the wall and helps to reduce thermal bridging.

Although this increases the nominal wall depth from 140mm to 190mm, timber frame retains it traditional advantages over masonry, such as superior airtightness and ability to retain insulation within the depth of the structure.

The proposed revisions to building regulations in 2013 will impose a further step change in thermal performance, which will prompt another rethink of all building systems.

The studs are butt jointed and nailed to rails of the same section. Studs are normally spaced at 600mm centres, although 400mm centres or closer may be used. These spacings ensure an economic use of 1200mm x 2400mm sheathing boards.

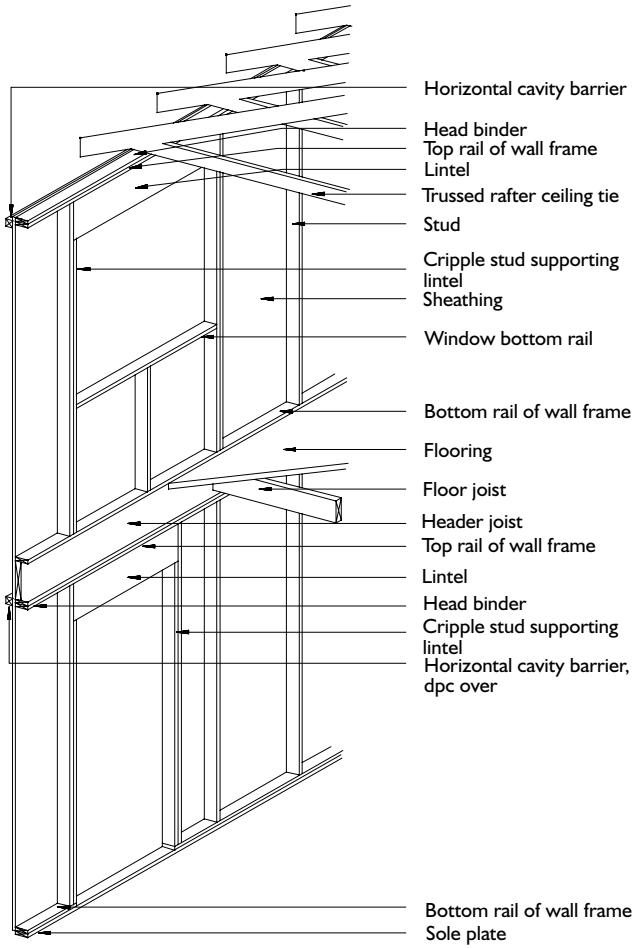

Figure 4: Typical external wall construction

Wall panels are braced by sheathing with wood-based sheet materials nailed or stapled to the framing members in a precise nailing pattern justified by the structural engineer. The sheathing provides the necessary panel stiffness to resist lateral (racking) forces due to wind loads. Sheathing is most commonly oriented strand board (OSB), but other wood-based panels such as plywood and bitumen impregnated fibreboard are also used.

Wall panels include window and door openings which are typically framed with additional studs known as 'cripple' studs which support loadbearing timber lintels.

Panel size and level of prefabrication dictates whether manual or crane lifting is to be used on site. If erected by crane, walls may be made up of single elevation large panels, otherwise smaller panels are nailed together to make up the full wall length.

Sheathing is most often fixed on the outside of the stud frame. With this arrangement, an effective vapour control layer is normally required on the 'warm' side of the insulation to limit

the amount of water vapour entering the wall panel. The vapour control layer may be a separate polythene sheet or plasterboard with an integral vapour control layer. Sheathing can be fitted on the inside of the studs but in this case, erection procedures and the order of work installation of services needs careful consideration. A service void formed using timber battens on the inside of the wall could be used.

A lining of typically plasterboard is fixed on the inside of the framing and is part of the inherent fire resistance of the wall. The cavities between the studs and rail framing are filled with insulation. The outer face of the sheathing (or the framing and insulation if the sheathing is on the inside) is normally covered by a breather membrane, which protects the panels during construction and provides a second line of defence against any wind-driven rain that may penetrate the completed external cladding.

The breather membrane is usually of a plastic fibre material, strong enough to resist site and wind damage, which is weather resistant but allows the escape of water vapour from the construction. Reflective types of breather membrane enhance the thermal performance of the wall if installed correctly.

Cladding to external walls

External cladding to the timber frame is frequently brick or blockwork connected to the timber wall panels by flexible stainless steel wall ties. These ties are designed to transfer wind loading on the masonry to the wall panels; they must also allow for any differential vertical movement between the cladding and panels due to shrinkage, settlement and compression of the cross-sectional timber (rails, binders, floor and roof joists) in the construction. It is important that this movement is allowed for in detailing any

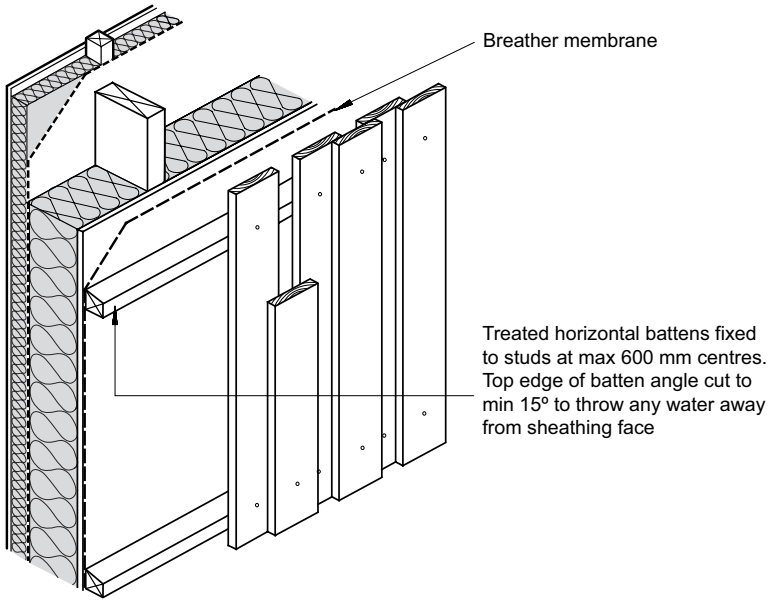

Figure 5: External wall with vertical board-on-board cladding

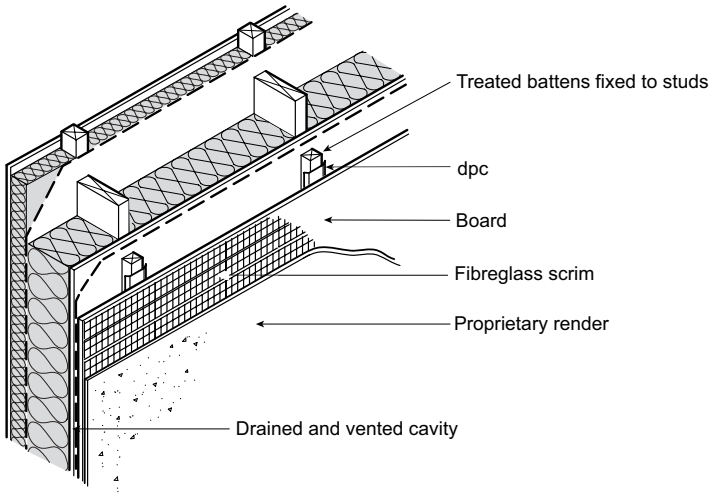

Figure 6: External wall with proprietary render system on backing board

construction such as roof soffits, verges, window sills and balconies that are attached to the frame but project into or through the masonry cladding.

This differential movement becomes even more significant with increasing height of the building.

There is a wide range of lightweight cladding materials available such as clay tiles, slates, brick slips, timber boarding, cement render or proprietary systems. These are normally supported on preservative-treated softwood battens fixed to the studwork to provide a drained and vented cavity to ensure that any water that penetrates the cladding, or vapour from the building fabric, can diffuse or drain away.

Light combustible claddings are permitted where the distance of the cladding from the boundary complies with the unprotected area rule in building regulations. Brick or blockwork provides adequate external fire resistance irrespective of distance from the

boundary. Brick or blockwork clad timber frame walls provide similar sound insulation from external noise as masonry cavity walls, but the level of sound insulation will ultimately depend on the acoustic resistance of any openings in the wall.

TRADA's *External timber cladding* [32] offers guidance on how to specify timber cladding, what species to use, what to expect in use and maintenance requirements.

Internal walls

Internal loadbearing and non-loadbearing walls are constructed of timber framing with plasterboard both sides. A loadbearing internal wall typically requires loadbearing lintels over openings, supported on cripple studs and will have to meet the same fire performance as external walls and the floors they support.

Where better acoustic performance is required between rooms, such as bathrooms and bedrooms, mineral wool is used between the studs or the plasterboard lining specification improved.

Party walls

These are normally constructed from two separate timber framed walls with a cavity between. Insulation is fitted to the frames, and plasterboard in two layers (with joints staggered) is used to line the room sides of the party wall in order to provide required levels of fire resistance and sound insulation.

As for all forms of construction, any space between the underside of roof tiling and the party wall must be fire stopped.

Where regulations permit services and electrical wiring in party walls they must be detailed so as to maintain fire and acoustic performance.

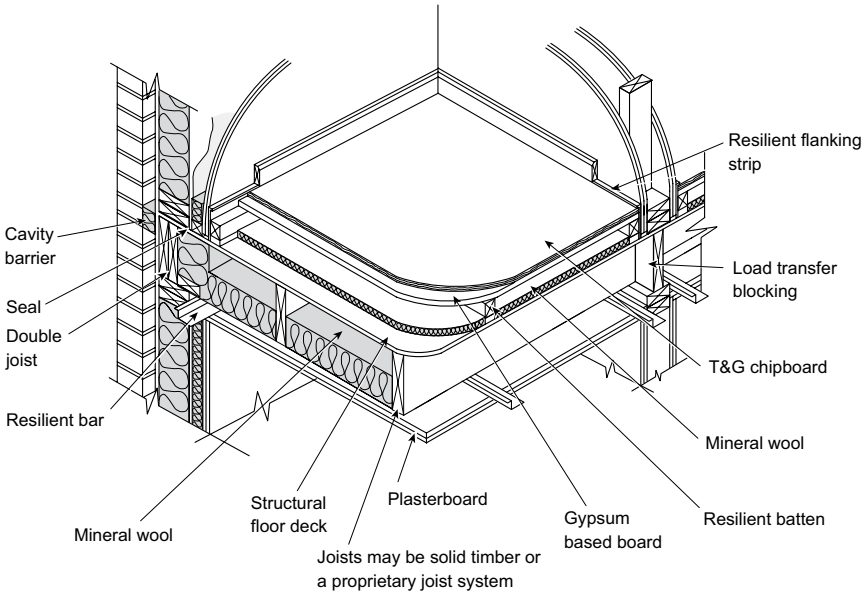

Figure 7: Party floor with solid timber joists

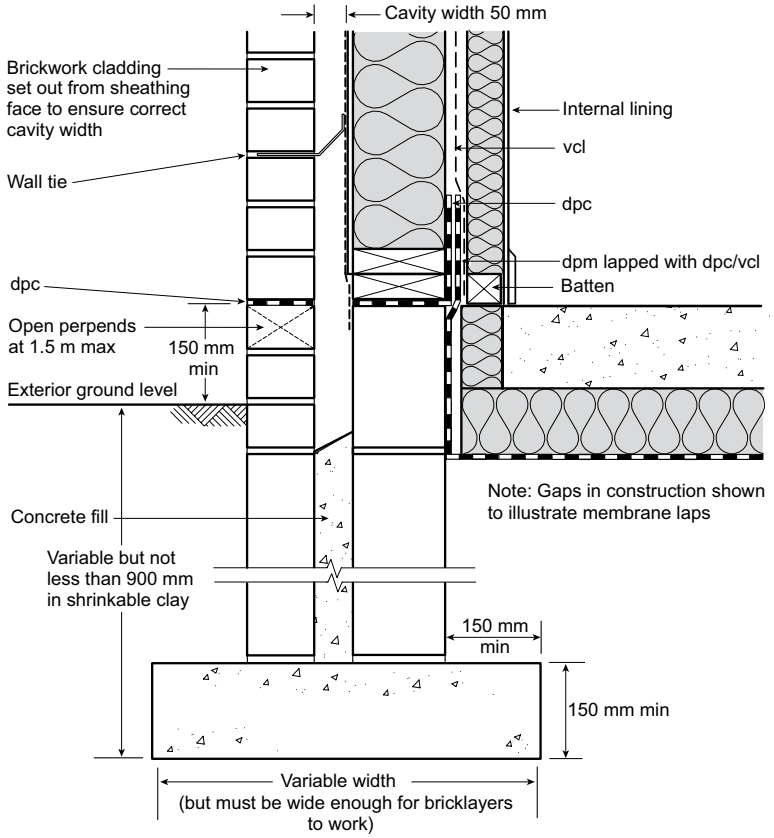

Figure 8: Strip foundation with masonry cladding

Another significant change in the England and Wales Approved Document L 2010 is that designers must consider the thermal performance of cavity party wall structures. In order to assume zero heat loss through the party wall, all cavities within a party wall must be filled with insulation. This poses a number of sequencing and construction changes for sheathing timber party walls that we explain in *Timber frame construction, 5th edition*.

Other structural elements

Floors and roofs in timber frame construction are similar to those used in masonry construction. Ground floors are either an insulated concrete slab or suspended types – either precast concrete or timber. Intermediate floors are either prefabricated floor cassettes or site-built floors. Floor joists are normally at 400mm or 600mm centres, and are of a constant depth to allow wall panels to be all the same height. In platform frame, the floor joists are supported directly on the top rail of the wall panels or on a head binder.

Head binders are used to connect wall panels together and to support floor joists that are not coincident with stud positions. An additional header joist is used around the perimeter of the building to support the upper wall panels and at party walls also to maintain fire and acoustic performance.

Trussed rafter roofs should comply with *Eurocode 5*. They are fixed directly to the wall panels, or to head binders if the trusses do not coincide with stud positions.

Variation when using BS 5268

Trussed rafter roofs should comply with *BS 5268 Structural use of timber. Code of practice for trussed rafter roofs* [33].

Party floors are constructed with timber providing the structural element and various combinations of ancillary components contributing to the required fire and acoustic performance.

Services

The provision for services is simple in timber frame construction, because they can be run in the cavity between the studs of the wall panel. If wet services are run in the external wall, they should be on the warm side of the insulation to avoid condensation from the pipes in the external wall. Care must be taken to seal the vapour control layer around penetrations. The provision of a service cavity formed by using battens fixed to the studs between the vapour control layer and the plasterboard lining is becoming more common, because services do not need to penetrate the vapour control layer, thus improving air tightness. A service zone can also be insulated, improving the thermal performance of the wall. (see also *External walls*).

Prepared jointly by TRADA and BSRIA, *Services in timber frame construction – Guidance for a defect-free interface* [34] promotes best practice for the installation of services in timber-framed buildings.

Preservative treatment

The need for preservative treatment depends on the durability of the timber used and an assessment of the risk of decay or insect attack.

Timbers that are normally treated in timber frame construction are:

- sole plates
- bottom members of wall frames resting directly on the damp-proof course (dpc)
- framing of external wall panels (treatment regarded as optional/desirable under BS 8417, but usually undertaken as insurance)
- timber cavity barriers in external cavity walls (also protected by a separate dpc)
- timber in cold design flat roofs
- timber as a weather-resistant cladding unless it is the heartwood of species of Durability Class 2 (durable) or better
- cladding battens
- tiling battens.

The housing warranty organisations have specific requirements for preservative treatment of timber components.

Treatment of individual members in the manufactured components listed above is most often carried out using micro-emulsion based wood preservatives. These formulations are applied using low pressure treatment methods and have largely replaced 'traditional' light organic solvent preservative formulations. However, because of their position within the building and the difficulty associated with remedial work, sole plates are commonly treated with copper-containing preservatives, which fixes in the wood (that is least susceptible to leaching).

When specifying preservation, follow *BS 8417:2011 Preservation of wood. Code of practice* [35].

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About TRADA

The Timber Research and Development Association (TRADA) is an internationally recognised centre of excellence on the specification and use of timber and wood products.

TRADA is a company limited by guarantee and not-for-profit membership-based organisation. TRADA's origins go back over 80 years and its name is synonymous with independence and authority. Its position in the industry is unique with a diverse membership encompassing companies and individuals from around the world and across the entire wood supply chain, from producers, merchants and manufacturers, to architects, engineers and end users.

Our aim

To provide members with the highest quality information on timber and wood products to enable them to maximise the benefits that timber can provide.

What we do

We seek to achieve this aim through active and on-going programmes of information and research. Information is provided through our website, an extensive collection of printed materials and our training courses.

Research is largely driven by the desire to update and improve our information so that it continues to meet our members' needs in the future.

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