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digest

Timber frame buildings
A guide to the construction process

Digest 496

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Timber frame housing under construction at Madley Park, Witney

Timber frame is a well proven, versatile construction method with the following key benefits:
- offsite construction method
- fast erection
- reduction in overall build programme
- reduction in risk of delays
- ease of project planning
- reduction in site storage requirements
- reduction in site waste
- use of a sustainable building material
- achieves a high BREEAM or EcoHomes rating.

Through early involvement of the timber frame specialist from project conception, an optimised design solution and build programme can be formulated.

A technical description of timber frame construction is given on pages 10 and 11.

Timber frame is a modern method of construction (MMC) – using standardised, prefabricated timber wall panels and floors commonly in use in many developed countries – which bears no relation to its Tudor 'post and beam' namesake. Nor does it bear much relation to the form of softwood framing common in the 19th and first half of the 20th centuries. This modern method of constructing housing and other buildings uses advanced breathable membranes, insulation and vapour control layers along with careful detailing to ensure durability. Building regulation requirements for thermal, acoustic and fire performance are all incorporated into the timber frame design.

This Digest is not intended to provide guidance on all the many checks required for timber frame, nor specific technical guidance on the structure and detailing. For guidance on site checks refer to the UK Timber Frame Association publication, *A pocket guide to timber frame construction* (UKTFA, 2004).

Timber frame offers a number of advantages compared with most other forms of construction.

- The package delivery of a complete weathertight structure consisting of inner leaf, internal partitions, floors and roof, within a predictable timetable, helps in meeting construction schedules
- Timber frame construction provides ready routes for wiring and plumbing, significantly reducing the time required for these operations
- The timber frame acts as a template, with predetermined openings. This reduces setting out and results in dimensional accuracy. Windows and doors can be fitted easily
- Construction processes can be undertaken simultaneously, with work, such as wall lining, starting much earlier in the build programme. Brickwork is taken off the critical path

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- Timber frame can lead to reductions in site storage requirements and site waste
- It facilitates increased flexibility in the construction project as a whole. Through faster build programmes, it can lead also to higher turnover
- Timber frame allows prefabricated floor units or 'cassettes' to be installed. It also allows the pre-assembly of trussed rafter roofs on the safe working platform of a lower floor
- Using floor cassettes ensures that all the joists are set at the same level and correctly spaced. Moreover, offsite manufacture enhances quality and speed of construction as well as safety on site
- Internal trades can continue, irrespective of progress on the external envelope, and in a relatively clean environment
- Less risk of delays through bad weather.

Timber frame is one of the fastest methods of construction. It is quite common for a semi-detached unit to be completed from concrete foundation slab to weathertight stage, including roof battens and felt, in only 4 or 5 days. This timespan can be shortened if required. Offsite fabrication processes allow the delivery to site of structural timber panels for both external and internal walls, and floors, on a just-in-time basis. Timber frame suppliers often include in the package the roof trusses, gable spandrel panels and gable ladders; and may also supply and fit the windows, doors, staircases, insulation and cavity barriers.

Through the early involvement of the timber frame design, fabrication and erection team, together with appropriate project planning, the advantages in productivity offered by this method can be realised (Figure 1).

Case study 1

Main Contractor: Bellway Homes

Project: Thames Gateway, Purfleet. Mixed social and private housing comprising 365 flats and houses

Benefits experienced from timber frame compared with traditional methods:

- shorter overall build time
- more flexibility in programming the build sequence
- finishing trades completed earlier
- less affected by poor weather

Special consideration was given to the following:

- using experienced erectors
- using good quality timber
- ensuring accuracy of sole plate fixing and correct packing for levels

Typical construction time for a block of five terraced houses, from slab to completed roof structure, was 10 days.

Case study 2

Main Contractor: Leadbitter Construction

Project: Madley Park, Witney. Mixed private and housing association properties (see photograph on page 1)

Phase 1: 41 units comprising two-bedroom and three-bedroom flats, town houses and bungalows. Half the site was traditional build, half timber frame. The timber frame half was completed 10 weeks ahead of the schedule for the traditional build programme (total contract period was 56 weeks)

Phase 2: 59 units, all in timber frame. The first 34 units were completed 12 weeks ahead of schedule

Benefits experienced from timber frame compared with traditional methods:

- consistent delivery
- ability to meet decreasing contract periods
- more project control
- construction process less affected by weather
- easier to plan following trades
- fewer construction problems

Typical construction programme for a two-storey block of three two-bedroom houses was to:

Day 1: erect the ground floor including the first floor deck

Day 2: erect the trussed rafter roof on the first floor deck

Day 3: remove the roof and complete first floor wall panels

Day 4: place the roof; complete the fascias and soffits

Days 5 and 6: complete roof tiling

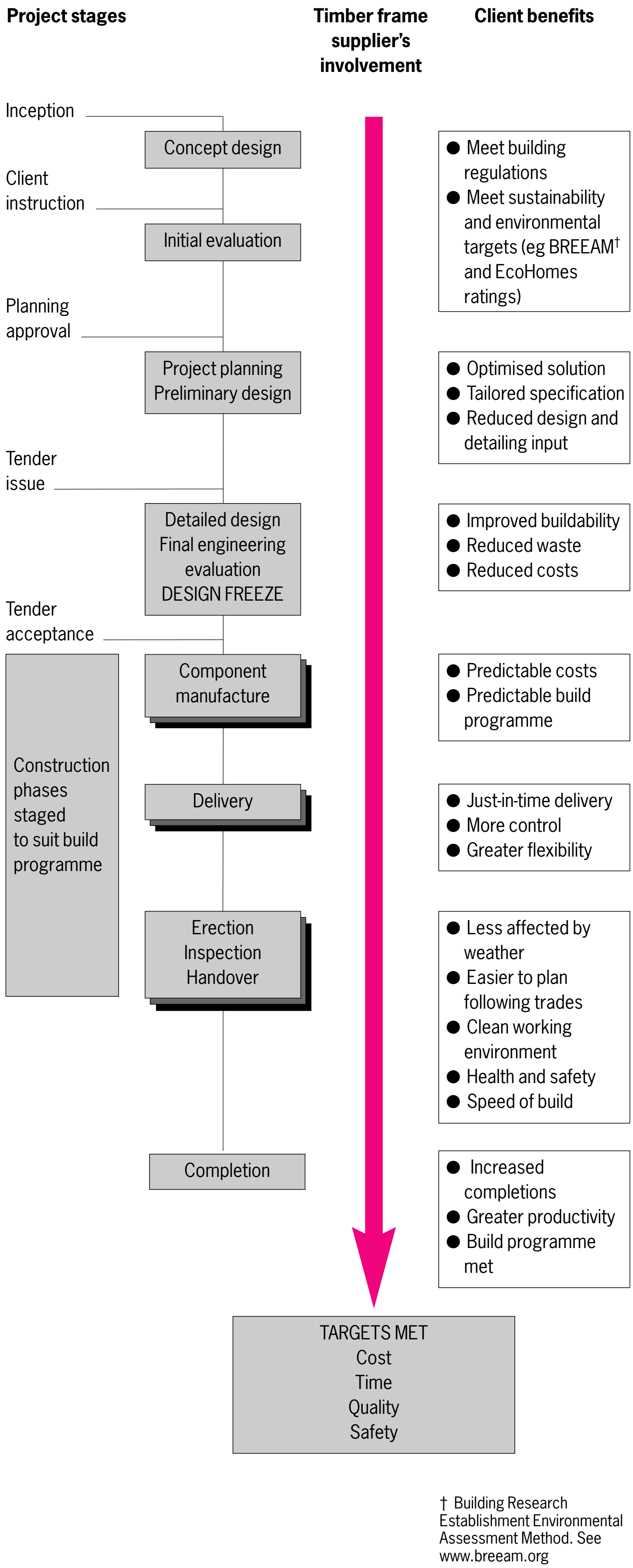

Figure 1 Typical timber frame procurement and construction process

The procurement and construction process

Project inception

Timber frame can be considered for the following markets:

- private housing, including flats
- social housing, including flats
- commercial buildings (eg hotels, offices, schools and hospitals).

In many cases residential developments are mixed, with a requirement for the inclusion of affordable housing.

The client's reasons for considering timber frame instead of a traditional method may be a combination of any of the following:

- responsibility for the design of the main structural element, apart from the foundations, is covered by the timber frame specialist
- supervision of workmanship is the responsibility of the timber frame manufacturer reducing the workload of the main contractor
- a single point of purchase for the timber frame package, including the roof, helps to reduce the main contractor's estimating and purchasing workload
- a versatile and capable building system
- sustainable construction
- a predictable build programme – firm dates established for deliveries make site planning easier, particularly on sites with difficult access
- speed of project turnaround
- a reduced risk of delays
- predictable costs
- health and safety compliance
- overcoming traditional skills shortages
- overall quality

The priorities of these drivers depend on the type of client and the nature of the project, and may change with differing market conditions and for other reasons over the lifespan of the project. The priorities may also be different for differing roles within the organisation.

The timber frame industry provides a variety of services. Most firms produce floor and wall panels to order, and may also provide full design, fabrication and erection services for the whole structure including the roof. The timber frame specialist has responsibility for the design of the structural frame which is usually offered as a lump sum fixed price.

Initial evaluation and concept design

The client should provide at an early stage the following:

- building usage and loadings
- performance criteria for floors and walls
- cladding type
- roof type and covering
- eaves and verge details
- door and window details
- outline architectural drawings
- level of prefabrication required
- site details including any constraints on access, deliveries and lifting
- health and safety information
- proposed build programme and start date

Early interaction between the client (or developer) and the timber frame designer will facilitate an economical approach that provides an optimised solution, reducing material waste. Many timber frame clients have found that a partnering approach, from project inception through to completion, has produced a specification tailored to the construction method. This can result in reduced construction costs, increased buildability, and minimises any potential design and specification error.

At the concept design stage, timber frame manufacturers can provide indicative prices and outline build programmes.

The client, the timber frame manufacturer and erector should agree on risk assessments and method statements.

Case study 3

Main Contractor: Ellier Developments Ltd

Project: Hunterswood, Ballycullen Road, Dublin. Private, high density housing Total of 649 units consisting of 403 houses, 246 single and two-storey apartments. Construction started in 2002, due to complete in 2006

Reasons for choosing timber frame:

- reduction in procurement time
- ability to increase or decrease production in order to take full advantage of any uplift in sales and yet limit any exposure if sales decreased.

Benefits from timber frame:

- increased annual unit completions (by 40%) without increased direct labour costs and exposure.
- reduced accident rate, improved safety and welfare for site staff
- ease of design

The first three months of production on site proved difficult with subcontractors who had no previous experience with timber frame. Procedures with regard to first and second fix had to be reviewed and new method statements implemented. Timber frame needs to be embraced as a whole. Managing a site split between timber frame and traditional build would prove extremely difficult and any benefits of timber frame would be lost.

Project planning

Key milestones should be agreed in advance to allow the timber frame manufacturer to plan design and fabrication processes, deliveries and site erection efficiently. The reduction in downtime for the manufacturer helps to minimise costs to all parties, reduces uncertainty, and allows the build programme to be adhered to.

To plan an effective build programme, the timber frame manufacturer (who generally provides an erection service) will need to receive the full detailed design information in good time. The timber frame erector will need to receive a clear and concise brief for site management. A realistic build programme should be agreed by all. The timber frame manufacturer will also require a full brief on contractual responsibilities including health and safety. Key health and safety requirements are:

- Construction (Design and Management) Regulations
- risk assessments
- method statements
- full scaffolding
- fall prevention and arrest methodologies
- control of lifting operations
- any necessary training, and training records
- site security
- manual handling.

A typical milestone checklist for a design-and-build timber frame project will involve:

- letter of intent covering design fees
- receipt of full project drawings
- technical assessment
- production of the engineer's line and point loads
- revision and final checking of drawings
- design freeze
- a formal order
- issue of the sole plate and storey rod drawings for approval
- client approval
- final engineering approval
- production of template layout drawings
- client approval of template layouts
- preparation of manufacturing drawings
- manufacture of the timber frame package
- frequent project briefing meetings
- delivery
- erection
- handover
- final review meeting.

Preliminary design stage

Timber frame is a versatile and very capable building system. It can be used with various types of cladding (eg brick, render and timber). However, the integration of materials, such as steel and concrete, into floor and wall elements of timber frame construction requires special consideration due to the movement of timber with changes in moisture content. On-site fabrication of specialised panels (eg for curved walls), or use of non-panellised components, is possible without affecting the building method or performance as a whole.

While timber frame is a versatile method of construction, certain building features – for example, brickwork at upper set-back elevations and cantilevered balconies – require special design attention. Long floor spans can be achieved by using engineered wood products or by designing the floor deck as a stressed skin panel however these will require specialist design and construction techniques. Platform timber frame is ideally suited to cellular layouts with loadbearing partitioning in vertical alignment through the building.

To maximise the benefits and economy of timber frame, the following should be achieved:

- designing within the limits of standard timber components (eg joists)
- using standard sizes of timber and engineered wood products
- designing within the limits of transportation, lifting and manual handling
- designing to coordinate the timber frame with brickwork (building heights, widths, openings etc)
- avoiding changes in vertical load lines
- adopting a dimensional grid to suit standard sizes of openings and building components
- increasing the level of replication of panels and panel layouts as much as possible
- repeating floor layouts
- using standard stair rise configurations and ceiling heights
- keeping floor levels the same throughout (steps between dwellings can be dealt with easily)
- tailoring the design to suit plasterboard and flooring board sizes to avoid site cutting and wastage of materials.
- Predetermining the service voids

At the preliminary design stage, measures to reduce potential problems with differential movement between the timber frame and the external skin should be considered, in particular for multi-storey timber frame (Grantham and Enjily, 2003).

These measures include:

- avoiding interfacing with other forms of construction that have different movement characteristics
- avoiding abutment with existing buildings
- minimising the amount of cross-grain timber
- keeping the amount of cross-grain timber constant at each level
- using specially conditioned timber
- specifying an alternative cladding to brick (eg weatherboarding or tiles)
- using floor-to-floor panel frame or vertical panel frame construction instead of platform frame
- incorporating provision for differential movement at openings
- installing the correct type of wall ties (eg sliding ties).

The timber frame designer may need to make additional provision for differential movement where multiple-ply sole plates are exposed to rainwater before frame erection. The design should also take into account differential movement between solid timber or glulaminated timber headers or rim beams and engineered wood joists used for the main floor construction.

Engineering evaluation and detailed design

All timber frame construction, from single storey to multi-storey, has to be designed within the rigours of BS 5268 or Eurocode 5 (BS EN 1995-1). Guidance is also available in *Timber frame construction* (TRADA, 2001), and *Multi-storey timber frame buildings – a design guide* (Grantham and Enjily, 2003). The design can either be supplied by the timber frame specialist, or be based on the specifications and drawings provided by an architect. In the latter case, the timber frame manufacturer will require:

- scaled floor plans (typically 1:50) showing layout; dimensions to structural faces (unfinished); dimensioned internal, external and party walls; dimensioned openings; and staircase position and key service configurations
- elevations (typically 1:100) showing external cladding types and positions, including the roof coverings
- staircase details in plan and in section (typically 1:20) showing all dimensions including position of quarter and half landings, structural openings in floors, tread going and riser dimensions, and balustrade configurations and fixings
- sections (typically 1:20) showing finished floor heights, structural floor zone dimensions, floor finishes, relationship of finished ground floor to brick coursing and external structural openings
- proposed start date and build programme.

In addition to the above the timber frame designer may have further requirements. The client should ensure all design details are available to meet the agreed key milestones. Late changes to the timber frame design should be avoided: the design should be frozen at the earliest stage possible. The timber framer normally supplies a full set of structural calculations and the Hb353b NHBC certificate, or equivalent.

Manufacture and delivery

The build programme should be tailored to allow the timber frame manufacturer to sequence fabrication, enabling:

- reduced transport requirements
- avoidance of site traffic problems
- reduced storage requirements
- minimised lifting and handling requirements
- reduced labour downtime on site
- reduced material handling and wastage
- maximum use to be made of standard, pre-designed frame types
- efficient use to be made of cranage and scaffolding.

Liaison between the overall project manager, the timber frame erection crew and the timber frame contracts manager will assist in panels being delivered to site at the planned times, and allow both the erection crew and the panel fabricators to keep to the construction programme.

Deliveries should be timed to make efficient use of available labour and lifting gear, and to avoid unnecessary storage on site and double handling. Consultation between the erection crew and timber frame manufacturer can ensure that construction progresses smoothly and without interruption at critical stages. Depending on the size of the project, deliveries can be staged; typically, for a block of five terraced units, the ground floor wall panels will be delivered and erected on day one, the floor cassettes on day two, the second storey wall panels on day three, and so on.

Figure 2 Packs of numbered panels, supplied with bearers and in logical order

Crane locations should be shown on the site plan and agreed with the erection crew. When lifting large packs of wall panels onto floor decks, care must be taken to avoid overstressing the structure. If necessary, packs can be broken down into smaller loads and provided with suitable bearers. The project's structural engineer should be consulted over positioning of heavy items which should be considered at the project planning and design stages.

The timber frame manufacturer must ensure that the timber frame panels have designated lifting points, and are stacked for transport correctly and in a logical order for the build sequence (Figure 2). On delivery the panels must be checked for damage. Panels should be clearly numbered to ensure their correct location in the finished structure. The panels should be easily separable to minimise handling and avoid crowding the working deck. All packed panels and any loose material should be lifted securely.

Adequate provision should be made for delivery of the timber frame panels, including:

- clear instructions to drivers and site staff
- traffic management plans
- designated set down areas for materials
- designated personnel in charge of receiving the delivery
- standing areas for lorries and cranes, including space for turning
- cranage with suitable reach and capacity
- level temporary storage space
- bearers to keep panels off the ground
- weather protection which maintains ventilation

Trussed rafters should be stored in accordance with advice given by the Trussed Rafter Association (TRA, 1999). Good site practice should be maintained over the whole of the site including keeping it tidy and secure during working and non-working hours.

Preparing the base (foundations and ground floor slab)

The timber frame designer will define the requirements for the ground floor slab (or footings in the case of a suspended timber ground floor) in terms of size, layout and tolerances; and will be able to provide the line and point loads required for foundation design. The base construction should be programmed to provide a suitably accurate and cured base for timber frame construction. Generally the timber frame contracts manager will check the slab accuracy one week before erection.

It is important that the ground floor slab is constructed within the tolerances specified by the timber frame designer since the wall panels of the timber frame are placed on sole plates which rest on the ground floor slab. The sole plates act as a template for the building as a whole. Therefore, the accuracy of this template is critical. Packing underneath the sole plates is acceptable (up to a limit of 15 mm) to enable tolerances to be met and also to reduce settlement of the frame as construction proceeds.

Sometimes multiple-ply sole plates provide formwork for the ground floor screed (Figure 3). It is not best practice to leave sole plates exposed to rain since it is crucial that they are maintained at an acceptable level of moisture content before the construction of the ground floor starts. This will help to minimise cross-grain movement and reduce the differential movement of the timber frame with other non-timber parts of the building.

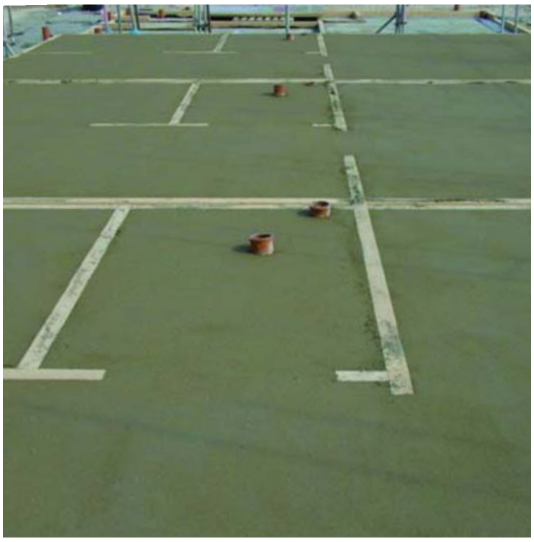

Figure 3 Screeded base with sole plates in position

Scaffolding

The scaffolding is usually the main contractor's responsibility (Figure 4). Consultation should be made with the timber frame erector on the requirements for scaffolding. Sufficient clearance needs to be provided both for fixing panels and lifting the trussed rafter roof while maintaining safety. Independent scaffolding must be designed and safe, and should not be modified without authorisation.

Figure 4 Scaffolding in place before erection of the frame

Erection

The site erection team should be fully trained and properly briefed to ensure that the timber frame is constructed in accordance with the design. Prior to erection of the timber frame, the project manager should ensure that all the relevant trades are available, carefully programmed and briefed.

Before erection of the panels starts, the timber frame erector should prepare all of the necessary risk assessments, method statements, and other health and safety requirements.

The erector will normally handle all of the requirements for dressing DPCs and waterproof membranes, as well as ensuring the appropriate tolerances for, and accuracy of, wall panel locations. Site supervisor's checklists detailing tolerances are given by the Timber Research and Development Association (TRADA, 2001) and BRE (Grantham and Enjily, 2003). Information is also available from the UK Timber Frame Association (UKTFA, 2004).

Deliveries of materials, such as plasterboard and flooring for follow-on trades, should be organised so that these materials are placed within the structure as erection proceeds (Figure 5). This avoids having to store these materials unprotected at ground level, or manhandle materials through windows or up stairwells which can be difficult or impractical. Positions for loading out the structure should be agreed in advance with the timber frame designer who should consider these loads in the design calculations.

Figure 5 Pack of plasterboards placed within a structure as erection proceeds

The construction sequence should be planned and executed in a controlled manner. To minimise differential movement between a brick outer leaf and the timber frame, it helps to incorporate as much of the dead loading as possible to take up any gaps in the construction, and also to apply initial elastic deflection to the frame prior to bricklaying. Dead loads include roof tiles, plasterboard and flooring.

When lifting pre-assembled trussed rafter roofs, the roof or truss designer's recommendations should be followed to avoid overstressing the trusses or buckling the structure. This will involve providing adequate temporary bracing, the correct lifting equipment and level bearers. The completed trussed rafter roof should be braced to the roof designer's requirements in line with TRA guidance (Trussed Rafter Association, 1999) and BS 5268-3 (Figures 6 and 7).

Having weatherproofed the structure, sufficient time should be allowed for the frame to dry before further work is undertaken.

Figure 6 Temporary fixing of trussed rafters on the safe working platform of a lower deck

Figure 7 Lifting pre-assembled trussed rafter roof sections

Handover

The level of completion provided by the timber frame erector depends on the contract, but often involves handover of a complete weathertight package comprising inner leaf, internal partitions, floors and trussed rafter roof. If fixing the roof with felt and battens is the responsibility of a different contractor, clearly this has to be organised in advance. The timber frame erector may also fix the necessary fire stops and complete the installation of the breather membrane.

The timber frame erector should pass on to the client the completed quality control handover documents.

Finishing trades should be programmed to capitalise on the fast erection of the timber frame structure. One advantage of this type of construction is that processes, such as bricklaying and wall lining, can be carried out concurrently.

The trades responsible for installing or fixing the following building components should be fully briefed on the requirements for timber frame design and construction:

- thermal and acoustic insulation
- vapour control layers
- wall linings
- fire stops and cavity barriers
- services (including drilling and notching of joists and studs)
- acoustic flooring
- provision for differential settlement (see below)
- weatherproofing (ventilation, weep holes etc)
- wall ties (including positioning and spacing)
- battens and counter battens for cladding
- cladding interfaces with the timber frame structure

Particular care should be taken in providing for differential movement as the timber frame dries out. Measures include:

- allowing adequate shrinkage gaps below windows and other projections over the outer leaf, including the roof elements
- using the correct type of compressible spacers and fillers. Limits on compressibility should be noted for these materials
- correct installation of services
- providing for differential movement at openings for windows, doors, services, lift shafts, and stairwells, and at roof soffits, junctions between cladding types, etc
- using flexible wall ties in buildings above three storeys.

Elements of timber frame construction

External walls

The external walls (Figure 8) of a timber frame house typically comprise the following:

- plasterboard lining
- polyethylene vapour control layer (500 gauge)
- structural timber frame (usually 89 x 38 mm or 140 x 38 mm studding)
- insulating quilt or bats (fixed between studs)
- sheathing board (usually 9 mm plywood or oriented strand board, OSB)
- breather membrane
- 50 mm clear cavity
- wall ties
- external skin (brickwork, brick slips, render, tiles or weatherboarding)

The timber frame is the load bearing element of the structure, supporting both dead and imposed loads from the floors and roof, together with racking resistance to wind loads.

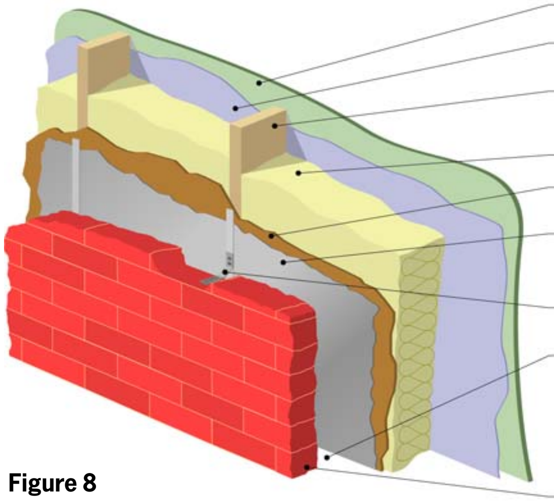

Figure 8
Make-up of a typical external timber frame wall

Stud centres for the timber frame panels are normally at 600 mm. Openings in load bearing panels are supported by integral timber lintels. Point loads imposed by beams, girders or other concentrated high loads can be catered for by additional studs. Higher line loads can be carried by reducing the stud spacings.

Non-load bearing walls

Non-load bearing walls usually consist of 89 mm depth stud frames onto which 12.5 mm plasterboard is fixed with insulation batts between the studs to provide sound resistance. All of the internal partitions, including framing for cupboards, are normally supplied with the timber frame package. This reduces the amount of site-required carpentry to a minimum. The lightweight nature of the construction method makes it relatively easy to change room layouts between dwellings, allowing variation over the development. Where necessary, additional support for partitions is provided by doubling up floor joists or providing blocking between joists.

Separating walls

Separating walls (ie party walls between dwellings) are formed with a clear cavity between independent panels, together with multiple layers of insulation batts and plasterboard. Light gauge restraint straps at storey height maintain stability of the structure without significantly affecting acoustic performance.

Intermediate floors

Floor panels (or cassettes) are often used to form intermediate floors and can consist of solid timber joists, plyweb or metal web beams, or other types of beam. The cassettes can incorporate all of the floor elements such as double joists to support partition loads, trimmers, and trimming joists for stairwell openings, noggings and blocking. Around the floor perimeter a header joist connects adjacent floor panels or acts as a ring beam for the structure. Typical maximum clear floor spans are 4.8 m, with the overall length of the floor panel up to 9.6 m with a typical width of 3.2 m. The floor cassettes arrive on site with predetermined lifting points.

In the case of non-separating floors, the structural decking (usually Type P5 particleboard) can be prefixed. For compartment floors a sub-deck of plywood or OSB is provided which is overlaid with a floating floor after completion of the roof. This sub-deck provides a safe working platform during construction and can include temporary cover for the stairwell. Perimeter support noggings and strutting can either be prefixed or supplied loose. Since all of the joists are set at the same level and properly restrained, this helps to reduce problems in service such as mismatch in levels between different parts of the building.

Roof

Most roofs are formed with trussed rafters, although roof panels are a possible alternative. In the case of timber frame, the head binder of the wall panels provides a ready-fixed, level and straight wall plate on which to fix the trussed rafters. The timber frame also provides a secure fixing point for truss clips, straps and bracing. The timber frame package can also include the gable spandrel panels and gable ladders. Flat roofs can be supplied in the form of cassettes in a similar manner to floors.

Trussed rafter roofs can be assembled in sections on the safe working platform of a lower cassette floor. The part assembled roof can then be lifted off in sections, placed temporarily at ground level (often on the ground floor slab of an adjacent plot) while the final storey of wall panels are erected. When this stage is complete the roof can be lifted back on again (in sections if necessary), fully braced, and then fixed with felt and tiling battens. Aside from the obvious advantages in reduced working at height, this method ensures a perfect fit to the roof.

Foundations

Timber frame construction offers potential for saving on foundations, particularly with multi-storey developments where lightweight cladding (eg render, tiles or weatherboarding) is used instead of brick. In most cases, however, the depth of foundations is governed by building regulations requirements to avoid the effect of ground settlement or heave, while minimum width of footings is determined by the width of cavity wall construction.

Alterations to existing timber frame structures should be made only after consulting with a structural engineer.

Types of timber frame construction

Timber frame is not a single system; there are several main variants.

Platform frame
This method uses prefabricated wall panel units (typically 2.4 m high by 3.6 m wide). These units are usually 'open panel' (ie without plasterboard lining, vapour control layer or insulation), although the external face is dressed with a breather membrane. Each storey is formed using floor-to-ceiling panels with the floor deck becoming the platform for the next set of panels, and so on. This is the most commonly used method in the UK having the advantage that the panels are easy to handle and fix. A panel may constitute the complete side of a building.

In the 'closed panel' variant the wall panels are supplied complete with plasterboard, vapour barrier and insulation, and they may also have windows, doors and services or service routes fitted.

Floor-to-floor panel frame (semi-balloon frame)
The wall panels are storey height rather than floor-to-ceiling, with the intermediate floors being supported (hung) from the insides of the wall panels. This method also has the advantage of reducing cross-sectional timber shrinkage, and allows the vapour barrier and insulation to be dressed continuously up the wall face. However, the connections between the floors and walls require design both for vertical and lateral loads – this may make the method more costly compared with platform frame systems.

Vertical panel frame
Vertical wall panels are supplied to building height and assembled with intermediate floors being supported from the insides of the wall panels in a similar manner to the floor-to-floor panel frame system. This method has the advantage of reducing cross-sectional timber shrinkage, and allows the vapour control layer and insulation to be dressed continuously up the wall face. Again, the design considerations for floor-to-wall connections may make the method more costly than platform frame.

Volumetric
This involves the complete prefabrication of box units (ie wall and floor compartments) which form individual rooms or sections of the building. Highly serviced areas such as kitchens and bathrooms may be supplied as finished pods. Workmanship can be improved by using this method but there are limitations on the size of the units that can be transported.

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