

Multi-storey timber frame construction

Guy Lewis (M) Associate Director, CCB Evolution Ltd. (formerly Chiltern Clarke Bond Ltd.) discusses the structural design of timber frame buildings

Timber frame is increasingly being used for four to seven storey residential construction but there is little education for structural engineers in the design and construction of timber frame buildings.

This technical note addresses some of the structural issues associated with the design and detailing of multi-storey timber frame buildings and introduces the 'Rim Beam Method' for achieving robustness for Class 2B buildings. It also identifies good practice to ensure a quality finished timber frame building, including detailing for durability and differential movement, fire and acoustic design, construction issues and the work of 'follow-on-trades'.

The author, in his role as Senior Structural Engineer at consultants CCB Evolution Limited, has had considerable experience of the structural design, detailing and inspection of multi-storey timber framed buildings, constructed in the UK using 'Platform Frame' techniques.

Platform timber frame v. framed structures

Conventional 'Platform Frame' relies on a cellular plan form with all timber frame wall and floor components fixed to each other. Unlike other structural arrangements such as post and beam frames with infrequent shear walls, 'portalised' frames or braced bays, timber platform frame relies on the diaphragm action of the floors to transfer horizontal forces to a distributed layout of load bearing walls. The load bearing walls provide both vertical support and horizontal racking and shear resistance.

The platform timber frame method of building has many advantages including speed of construction due to the lack of any 'wet' trades, relatively low foundation loads and the predominance of 'off-site' manufacture of floor 'cassettes' and wall panels, which is not weather sensitive. The use of factory-made components, fully assembled into cassettes, is potentially safer during construction and arguably has reduced dependence on skilled site operatives.

From the sustainability viewpoint, platform timber frame can lead to economic use of materials, reduced site wastage during construction and reduced energy requirements during service¹. The use of



timber from 'managed' sources is also inherently sustainable.

Performance proven by test

History of use, and full-size testing carried out by TRADA and BRE on the six-storey timber-frame 2000 research project (known as TF2000) at BRE Cardington in from 1995 to 2000 have demonstrated that timber frame buildings have inherent resistance to accidental damage. *'For standard platform timber frame construction, the assessments and tests have verified reasonable robustness requirements, when the panels are keyed into each intersection of the building and appropriately nailed together'*²

Until a few years ago, the number of storeys in timber-frame buildings in the UK was limited by fire regulations. However, this restriction was lifted in 1991³ allowing up to eight storeys for the first time (in England and Wales) without any additional fire resistance requirements other than those existing for many three-storey buildings. Furthermore, full scale fire tests on TF2000 also showed that compartmentation and building integrity



Fig 1. Five-storey timber-framed structure designed by CCB Evolution at Finborough Road, London for Gilmac Design & Build Ltd

Fig 2. Six-storey TF2000 timber framed structure built by TRADA/BRE at Cardington 1995-2000

was maintained throughout the tests. TF2000 therefore opened up the possibilities for timber frame buildings in excess of the perceived technical limit of four storeys (Fig 2).

Permanent & temporary stability

Stability of load bearing walls

Timber wall studs rely on the sheathing and lining materials fixed to them to provide lateral restraint against stud buckling. Plasterboard linings, however, are fixed later in the build process, prior to which the timber studs will be carrying building loads, which, in some instances, may be higher than the in-service loads as the plasterboard packs can be located on floors prior to being fixed. Unsheathed wall studs may not be adequately laterally restrained before plasterboard is fixed and the designer should check the temporary condition for lateral buckling of the studs with a construction imposed load to see if mid-height noggins are required to reduce the temporary stud slenderness.

External wall studs also carry wind loads, transmitted to them by the cladding via wall ties or battens. Unless it can be demonstrated that the stiffening effect of the cladding adequately prevents excessive stud deflection, stud deflection calculations due to wind loads can be the governing load case for the design of 89 deep wall studs, which are commonly used for external walls. This failure mode should be checked by designers, but is often overlooked.

Compartment ties

Each section of the building between compartment walls may need to be considered separately for stability during the construction stage. During the permanent condition, adjacent sections of building between compartment walls can be assumed to act as a whole and metal compartment ties must be designed to transmit horizontal loads through the structure and across compartment walls in compression or tension only.

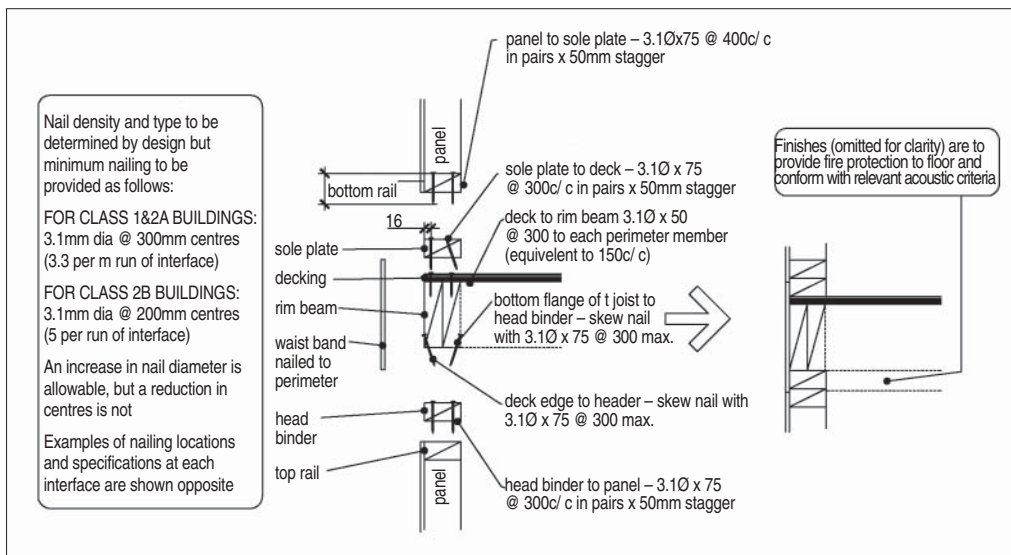
Metal compartment ties are generally provided across compartment cavities at not exceeding 1200mm c/c to tie adjacent sections of the structure together. The ties provide load transfer if designed appropriately, but there is a limit to the amount of load that can be carried by the tie because the size and spacing of the ties is limited by acoustic regulations.

Racking resistance

If plasterboard is to be used for racking in addition to Category 1 sheathing boards, it should be correctly fixed and fully supported on all edges as specified by BS 5268: Part 6.1:1996⁴.

Typically, it is necessary to ensure that the lower half of the framing has adequate racking resistance without the contributions of plasterboard, as reliance on temporary bracing on large multi-storey construction has proven to be more complex than low-rise projects⁵.

The design guidance given in BS 5268



Part 6.1:1996⁴ currently limits the application of these codes to four storeys. A new committee is understood to be updating these codes for use up to seven storeys, but until this is issued, designers have to use judgment in applying the rules given in the current codes.

One aspect that should be considered is the stiffness of multi-storey frames. The existing codes are based on small-scale tests and experience of low-rise construction. The specific horizontal deflection limit given in the codes is height/300 which, if realised, would lead to significant sway of multi-storey timber frames. The designer must therefore use judgment in limiting the expected sway of multi-storey buildings during the design process.

Holding-down straps and soleplate fixings

In addition to the racking and stud stability checks, sliding, overturning and roof uplift resistance also require checking before claddings and linings are fixed and the roof finishes are in place, at which point the dead weight of the building may be at its least. As well as proprietary fixings at wall plate and soleplate levels, the nailed fixings at the intermediate levels should also be checked.

The fixing schedule

A fixing schedule should be provided by the building designer to the fabricator and timber frame erector to ensure that all the designed connections, and the fixings required are identified for both factory and site connections. The industry has standards that have been established for low-rise construction but the higher loads from multi-storey frames require increased nail fixings at member interfaces. The ‘experience’ of factory operatives or site erectors should not be relied upon to ensure that all interfaces are adequately nailed as experience of the author has shown that this is not always the case.

Wall panel detailing and continuity of vertical load paths

Head binders laid on top of wall panels can act as continuous structural beam

Fig 3. Diagram of exploded floor detail showing minimum nailing densities

elements carrying joist point loads to the studs below and should be designed accordingly for non-coincident joists and studs unless the manufacturing and erection process is carefully controlled to ensure that all joists will be aligned with a supporting wall stud.

Stud clusters must be provided beneath all beam and girder bearings to ensure that bearing stresses are not exceeded. This load path must be continuous through floor zones, where solid members may need to be provided, and wall panels at lower storeys all the way to a suitable foundation.

Robustness

Class 2A or 2B building for disproportionate collapse?

Requirement A3 will now apply to all buildings, not just those over four storeys. It applies to all buildings in England and Wales, which had not started on site by 1 December 2004. Most residential buildings will fall into Class 2A or 2B of Table 11 of *Building Regulations Approved Document A*⁶.

Class 2A buildings

The Building Regulations state that for Class 2A buildings, robustness will be achieved by providing effective horizontal

ties, or effective anchorage of suspended floors to walls.

For Class 2A buildings, the approach is to adopt good building practice of providing lateral restraint to walls and common anchorage details of floors to walls. The design process should involve checking the capacity of the component interfaces (e.g. panel rail to soleplate, soleplate to floor deck, floor joists to head binder and head binder to panel rail) against the variable horizontal wind forces. The timber frame designer should therefore be providing a robust connection at each and every junction as part of the normal design process⁷.

For conventional timber frame buildings of cellular plan form UK Timber Frame Association (UKFTA) has recommended that the effective anchorage of floors to walls will be achieved with a minimum density of nails equivalent of 3.1mm dia at 3.3/m/run-of-wall junction⁷ (Fig 3).

Class 2B buildings

The Building Regulations state that for Class 2B buildings, robustness will be achieved by providing effective horizontal ties together with effective vertical ties or by checking that upon notional removal of a load bearing wall (one at a time in each storey of the building) the building remains stable and that the area of floor at any storey at risk of collapse does not exceed 15% of the floor area of that storey or 70m², whichever is the smaller, and does not exceed further than the immediate adjacent storeys.

Where the notional removal of lengths of walls would result in an extent of damage in excess of the above limit, then the use of a ‘key element’ design approach for an accidental design loading of 34 kN/m² applied in the horizontal and vertical directions to the ‘key element’ shall be adequate. Trada’s 2003 publication⁵ provides design guidance for Class 2B buildings where notional removal of load-bearing walls is part of the design check to comply with Regulation A3.

For conventional timber-frame buildings of cellular plan form UKFTA has recommended that the effective anchorage

Fig 4. Seven-storey timber-framed structure designed by Chiltern Clarke Bond Ltd at Newcastle-under-Lyme for Taylor Lane Timber Frame Ltd s which used top-hung open web joists supported on a rim beam



of floors to walls will be achieved with a minimum density of nails equivalent of 3.1mm dia at 5/m run-of-wall junction⁷ (Fig 3).

In checking the robustness of timber-frame buildings, engineers are to apply judgment-based thinking to the likely 3-dimensional structural behaviour of a building backed, where appropriate, with a 2-dimensional structural assessment of discrete elements. The TF2000 full-size testing has shown that this approach is conservative but appropriate to determining the robustness of platform-frame construction in buildings such as the medium-rise TF2000 building⁵.

One method adopted to satisfy the notional removal of wall panels and used by the author in the design of multi-storey structures, can be best described as 'The Rim Beam Method'.

The Rim Beam Method

This method allows joisted floor structures to be assembled in the factory as 'cassettes' with a 'rim board' used to connect the ends of the joists together for transportation and which remains as a vertical load transfer element in the completed structure. A separate 'rim beam', which is usually installed loose on site, spans between intersecting return walls or 'key elements' and acts as a bridging member.

Calculation checks are carried out on the principal of notional removal of wall panels, one at a time, between intersecting return walls or defined key elements. For external panels the minimum length of wall to be considered is 2.4m, with no maximum length. For internal walls the maximum length of wall to be considered is 2.25H where H is the clear height of the panel between lateral supports.

The rim beam is incorporated loose in the floor zone at the end of all simply-supported joists to prop the wall panel and floor structure at each level, following notional removal of a wall panel between intersecting return walls or defined key elements beneath the rim beam. Unless the joists are 'top-hung' over the rim beam, the floors at the same level as the rim beam are only nominally connected to this beam by the nailing together of the two members, and are therefore assumed to collapse (or cantilever if continuous joists have been used, albeit with significant deformation). A check should be carried out to ensure that the resulting floor collapse will not be disproportionate to the event and will constitute less than 15% of the floor area of that storey or 70m², whichever is the smaller.

The rim beams are supported at wall junctions by solid stud groups. It is important that the rim beam supporting the greater load (the one supporting the floor joists) has a full bearing on at least two studs at the panel junction and to achieve this, the wall panels are often lapped in the opposite manner to the rim beams. If no stud clusters are present below the rim beam bearing, proprietary or fabricated hangers are provided off adjacent rim

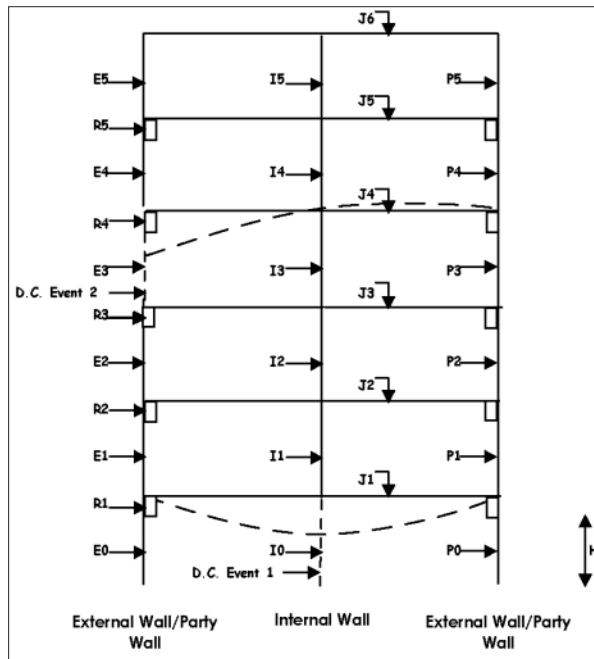


Fig 5. Diagrammatic Rim Beam Method frame drawing (see 'Panel 1: Rim beam')

beams to ensure that a support is available.

The rim beams and their connections are designed to support the full dead load of a single level of floor structure plus 33% of the imposed loads on the floor. A duration of load factor of $k_3 = 2.00$ and deflection limit of $L/30$ are applicable for this load case.

Continuous joist spans (I-joists and open-web joists are easily available and transportable in lengths of up to 11m) are used wherever possible to avoid the need for rim beams on internal supports. Where internal load-bearing walls are notionally removed, the joists are assumed to act in double span at each level and support the floor loads described above plus the weight of a (now non-load bearing) wall panel supported off the double-spanning joists.

In this way, a continuous 'perimeter' of loose rim beams is provided at external and compartment walls, with 'casseted' floor decks being located inside of the rim beam perimeter. The need to provide a

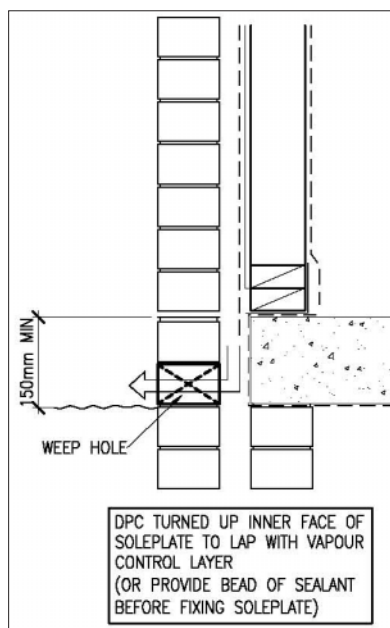


Fig. 6. Ground floor soleplate detail (Courtesy NHBC Standards Section 6.2, April 2002)

Panel 1: Rim beam

D.C Event 1: Notional removal of internal wall panel IO of maximum length 2.25H where H is the clear height of the panel between lateral supports

Continuous joist spans J1-J5 avoid the need for rim beams on internal supports. On removal of the supporting wall IO the joists act in double span at each subsequent level and support the floor loads plus a single storey height of (now non-load bearing) wall panel I1-I5 supported off the double-spanning joists.

D.C. Event 2: Notional removal of external wall panel E3 (party walls similar) between intersecting return walls or defined key elements

Rim beams are incorporated loose in the floor zone at the end of cassetted floor joists. Following removal of wall panel E3, unless the joists are 'top-hung' over the rim beam, joists J4 are assumed to collapse or cantilever and a check should be carried out to ensure that the resulting floor collapse will constitute less than 15% of the floor area of that storey or 70 sqm, whichever is the smaller. Rim beam R4 is designed to support panel E4 and floor joists J5 by 'bridging' over the notionally removed wall panel. Subsequent rim beams R5 support wall panels E5 and joists J6.

Rim beams are designed to support a single storey of wall panel plus the full dead load, plus 33% of the imposed loads of a single level of floor structure. Continuous joists are designed to support a single storey of wall panel plus the full dead load, plus 33% of the imposed loads on that floor. A duration of load factor of $k_3=2.00$ and deflection limit of $L/30$ are applicable for accidental load case.

horizontal tie force, that is part of the 'post and beam' design approach in concrete and steel, is avoided by the notional removal of load-bearing elements. The rim beams are tied back to the floor diaphragm with the minimum nailing densities described earlier.

Other methods of achieving the support for walls and floors following notional removal of wall panels are possible such as:

- the use of 'room-size' floor cassettes with cassette rim boards acting as rim beams, bridging over removed wall panels;
- 'loose' floor construction with joists hangered from loose rim beams, which bridge over removed wall panels;
- where joist span-lengths are repetitive using alternate double-spanning joists with selected walls designed as deep beams.

However, the rim beam method has the advantage of enabling floors to be fabricated as cassettes and enables fairly complex building plans and large room sizes to be accommodated.

The design chosen will probably rely on engineering judgment to some extent. As such it is important that it is peer-reviewed by experienced senior engineers and is fully documented, quoting sources where appropriate⁸.

Designing for durability

The vast majority of timber frame build-

ings in the UK use softwoods rated as non-durable for the structural components. However, properly designed and constructed timber buildings do not rely upon preservative treatments for durability⁹.

A correctly detailed wall framework, with adequate ventilation, is designed so that it will maintain an equilibrium moisture content considerably less than the 22% threshold that could allow fungal growth to occur. It is, however, common practice for the structural components in the external wall to be preservative treated as an insurance against any future failure of the weather-resistant cladding.

Wall framing above DPC level is generally classified to Risk Category C2 and treatment would generally be by double vacuum organic solvents or water-based micro-emulsions. Soleplates carry a higher risk category of C3, where organic solvent preservatives are required.

Furthermore, Trada and insuring bodies such as NHBC and Zurich recommend that all structural timber, irrespective of its preservative treatment or detailing, should be located a minimum of 150mm above finished ground level. This can have a number of effects on the detailing of the lower storey of timber-frame wall panels, often requiring 'durable' plinths of concrete or masonry to be provided around the full external perimeter of the building to lift the timber-frame elements 150mm above finished ground level (Fig 6).

Detailing for differential movement

Why does differential movement happen?

The coefficient of thermal expansion for timber along the grain is small. The thermal conductivity of wood is much lower than steel. For these two reasons it is normal in timber buildings not to use any movement joints to cater for temperature movement, but care must be taken to avoid cumulative cross-grain movement¹⁰.

Kiln-dried softwood timber is typically installed in buildings at 20% moisture content. Over time this will reduce down to around 10% in the internal walls of a heated building. As it dries out, cross-sectional timber in the structure shrinks and the whole structure settles.

Differential movement can therefore occur between the timber-frame inner wall and masonry outer cladding, resulting from shrinkage of the structural frame due to drying out of the cross-sectional timber elements (rails, binders, floor and roof joists) and the expansion of clay bricks or shrinkage of concrete blocks due to thermal changes and swelling or drying-out. Additional movements occur due to slight elastic shortening, creep and 'bedding-in' of structural elements.

Movement may be reduced by using engineered wood joists or super-dried timber at 12% moisture content but it is also important to ensure that detailing is correct to allow for settlement as it will not

usually be possible to omit all kiln-dried softwood from the building make-up as this would not be cost effective.

Effect on claddings, linings, windows and openings and vertical services

For cladding supported off the timber frame (e.g. timber boarding) the differential movement of the timber frame must be accommodated in the cladding system by providing movement joints between the cladding panels at suitable locations. As the frame moves the supported elements of cladding will move with it. Any abutment at the base of the cladding (e.g. at the junction with a terrace, low-level roof or ground-supported cladding) will also require sufficient movement capacity to take up this frame movement.

For cladding supported independently of the timber frame (e.g. masonry), the differential movement of the timber frame must be accommodated by providing movement joints between the cladding and the timber frame at suitable locations, usually at window cills, at eaves level and at the bottom of any openings. Cladding wall ties must also be designed to accommodate the timber frame movement.

As a result, any material or component which is attached to the timber-frame structure and overhangs or projects through the masonry cladding must have a gap beneath it to allow differential movement to take place without damage to the structure or the cladding.

Trada Timber Frame Construction Ltd.⁹ recommends that gaps of at least 3mm, 11mm and 19mm are allowed for at the bottom of openings in the ground, first and second storeys respectively of a three storey building, and 21mm at the eaves level. These are typical allowances. Each frame should be assessed individually by the summation of the actual quantities of cross-grained timber occurring in the structure for shrinkage and allowances made for elastic shortening, creep and 'bedding-in' of structural elements.

Continuous linings in stairwells and shafts are also prone to buckling as the timber frame shrinks. Linings should therefore allow for horizontal joints (backed by solid members) at floor levels to accommodate the frame movement.

Furthermore, site supervision must be adequate to guarantee that proper movement joints, as specified by the design team are incorporated.

Vertical services such as SVPs and RWP, which are connected to the timber frame, should also be able to accommodate movement of the structural frame, which may be in the region of 8mm per storey. Engineers responsible for the specification of these items need to be aware when specifying pipe collars and continuous elements in the building of this tendency to 'crush' any vertical services.

Fire design

The achievement of fire resistance

Correct plasterboard fixing and correct location and installation of cavity barriers

and fire-stops is essential to achieve the design fire performance. If the plasterboard fixings are inadequate, the boards will fail early during fire. Plasterboard may also be required for the racking resistance, in which case it is essential that the Fixing Schedule provided by the timber-frame engineer is complied with. Close site supervision is essential to ensure that those fixing plasterboard are aware of the increased fixing requirements.

Acoustic design

Testing has shown that the standard of workmanship is crucial in ensuring that the expected acoustic performance is met. For acoustics, maintaining structural separation and correct installation of insulation is essential. Air sealing is also essential. If air can pass through gaps in the construction then so can noise.

Construction

Protecting the works from rain

Timber frame is typically installed at moisture contents of about 18% although some elements may be at 20% during the winter months. Soleplates can become saturated if standing water is allowed and timber should be protected from getting wet as much as is reasonably practical by removing standing water.

The use of taped joints on chipboard or OSB sub-decking will not guarantee that water will not seep into joints but may significantly reduce the chances. All openings and gaps are sources of water ingress and the use of membranes such as VisqueenTM should be considered to protect openings before windows are installed.

Storage of timber-frame panels, truss rafters, loose timber and engineered timber should ensure that members are not in contact with the ground and are covered against driving rain using ventilated covers.

Dry lining and closing-in of timber frame should only be carried out when the moisture content of the timber is below 16%. Closing-in of damp timber may lead to mould growth and in some instances decay. Saturated timber deck boards, I joists, glued-laminated timber and engineered timber materials should all be replaced. Forced drying of these products is likely to create problems with performance and may cause warping or excessive shrinkage.

Tolerances and erection

Timber frame is an accurate building method. However, accurate foundations are essential to a successful timber frame. Any faults at this stage only become exaggerated as each storey is erected. Foundations and slabs must be checked for level and square, and if foundations are not within recommended tolerances, they must be rectified before panel erection starts.

The correct levelling of timber soleplates is essential to ensure that subse-

quent wall panels are erected plumb and to the correct levels. Soleplates must be continuously packed along their entire length. If shims are used to achieve the correct level, these should be located under all load bearing studs and the soleplate should still be continuously grouted.

Recommendations for construction tolerances are given by Trada Technology Ltd⁹ and UKTFA¹¹.

'Loading-out' and 'first-fix services'

Plasterboard pallets are usually 'loaded-out' on the floors as the structure progresses. This has the advantage of placing materials at the correct level in the building for future fixing, but also helps to 'bed-in' the frame as it is erected.

However, lightweight joisted floors are particularly susceptible to irreversible damage from large stacked loads during construction. Pallets of plasterboard can easily exceed the design imposed loading allowance of a domestic floor of 1.5kN/sq.m (equivalent to just 160mm of stacked plasterboard of density 950 kg/cu m). Where large stacks of material are required, temporary props should be installed to support material packs through all floors to a suitable foundation and adequate temporary bracing provided to the supporting wall panels.

Timber-frame structures are also prone to damage from those installing 'first-fix' services, where adequate provision for these services has not been allowed for in the design. I-joists can generally accommodate holes of certain sizes through their webs, but their flanges should not be cut. Head binders and the top and bottom rails of wall panels are also important structural members, but these are often cut through during services installation with little regard for their structural function.

Early coordination between the main contractor and timber-frame engineer; and clear guidance within the timber frame specification and health and safety plan is essential to ensure that an otherwise adequately designed structure is not rendered inadequate by the work of follow-on trades.

'Add-on items'

Staircases and lifts

Stair flights must be designed for the relevant structural loading category (1.5, 3.0 or 4.0kN/sq.m in accordance with BS 6399-1:1996). Often a domestic style staircase is provided where a stair flight designed for an increased imposed loading should have been provided. The fire resistance requirements of timber stair flights also needs to be agreed with the Fire Officer at an early stage in the design to ensure that timber flights can satisfactorily be used.

Timber-framed lift shafts should be adopted to avoid the problems associated with differential movement between the timber-framed structure and rigid masonry or concrete lift shafts.

Timber framed structures are not generally designed to support the vertical

loads imposed by lift equipment (e.g. lift cars, guides and hydraulic rams etc). Lifts to be installed in timber-framed buildings should therefore be 'self-supporting' for vertical loads. This will generally require that the lift car is provided with its own braced steel supporting structure which takes all vertical loads to suitable foundations.

The detailing of this supporting structure and its connection to the timber-frame structure must take account of the potential for differential movement during construction and in the first 36 months of occupation, due to drying-out, creep and bedding-in of the superstructure.

Balconies

Balconies are usually either 'no access' Juliet balconies fitted back to the masonry or timber frame or self-supporting 'walk-on' balconies with structural posts used to support the balcony vertically, independently of the timber frame.

Cantilevered balconies are not recommended as 'back span' beams and structural timber posts will be required to be built into the timber frame to support the cantilevered elements. This generally breaks up the floors, prohibiting the use of regular floor cassettes and generally requires engineered timber posts in the external walls to resist the large elastic reactions, which may lead to differential shrinkage problems relative to the softwood framing. Uplift in the back-spans must also be carefully checked, as the dead weight of a timber floor may be inadequate to resist such uplift forces.

'Walk-on' balcony frames may be tied back to the structural timber frame or masonry cladding for horizontal restraint only but if connection is made directly to the structural frame, the connections should be detailed for differential vertical movement. If the balcony fixes only to the masonry cladding, a check of the brickwork ties should be carried out and only Type 1 ties in accordance with British Standard DD140-2¹² should be used.

The balcony design can be steel frame or a combination of timber and steel. It is recommended by the NHBC that the vertical elements are not timber due to durability considerations¹³. Joists can be preservative treated or durable timber sections.

Cladding

Lightweight cladding should be adopted at all inset wall locations and external walls visible above lower roofs to avoid supporting 'heavyweight' masonry off the timber structure. The timber frame at these locations would be detailed to support the loads from a 'lightweight' cladding.

Products exist on the market, which appear similar to face brickwork, but are in fact a 'lightweight' system, which may be supported by a timber frame wall. A proprietary system of brick slips supported in a horizontal metal 'carrier tray' fixed to, and supported by, the timber frame was recommended by CCB Evolution on Finborough House, where London Stock

brick slips were used to match the colour of neighbouring buildings.

For masonry cladding, BS DD140-2¹² requires that Type 6 timber frame wall ties are only suitable for buildings up to three storeys in height (not exceeding 15m in height) where the anticipated differential movement between frame and cladding does not exceed 18mm. Above this limit, Type 1 ties, which are able to accommodate greater differential movement due to the fact that they are fixed into continuous vertical channels, should be specified.

Drained and ventilated cavities for the timber frame are essential for good timber frame performance. In no circumstances should the timber frame be erected in horizontal contact with masonry or concrete, even with DPM membranes

Conclusions

Timber frame is a highly efficient method of building for manufacturers, builders and their customers. However, to maximise its potential, the whole team must understand the importance of key design issues and details. The 'Rim Beam Method' is presented as a way of satisfying Building Regulations Approved Document A⁶ for the notional removal of wall panels for Class 2B buildings and has been successfully used in a range of timber structures designed by CCB Evolution up to seven storeys high.

Problems with multi-storey timber frame structures have occurred as a result of poor detailing in relation to accommodating differential movement. The benefits of timber frame can therefore be negated by a lack of attention to detail during design, lack of adequate specification and control of erection and a lack of understanding of key issues on site.

The work of 'follow-on trades' can also have a significant impact on the structural integrity of the completed timber frame structure and these trades need careful site supervision. se

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