TRANSFORMING HOW WE BUILD HOMES

Work package 5:

DFMA Guide to Timber Panelised MMC System (Design for Manufacture and Assembly)

March 2021

EXECUTIVE SUMMARY

DFMA (Design for Manufacture and Assembly) is an important consideration to optimise and maximise the use of panelised MMC systems. Through considering design decisions and evolving design detailing, early in the design life cycle, housing designs can be optimised to make best use of panelised MMC, leading to lower costs and improved quality, whilst increasing surety of construction execution. This guide provides information and knowledge on critical areas of design, such that manufacturing and construction of panelised MMC system can be maximised and complexities removed.

DFMA is an industrialised approach common in many manufacturing environments. This was first evolved in the automotive industry, where car design was configured to streamline and deliver efficient manufacturing, of the differing car assembles and products produced. The principle of DFMA is to play to the strengths of the MMC system being used, whilst being fully aware of where MMC constraints, limit design or create issues that add cost or disrupt the construction process.

This work package was delivered by the AIMCH MMC manufacturing partner Stewart Milne Timber Systems (SMTS), part of Stewart Milne Group (SMG). SMTS worked collaboratively by sharing DFMA information with AIMCH developer partners (Stewart Milne Homes, Barratt Developments and London & Quadrant) to evolve and consider DFMA Guidance in use, at developer and AIMCH consortium level. The DFMA guide is targeted at designers or specifiers of homes, interested but less knowledgeable, in using panelised MMC systems.

The work package developed a DFMA Guide specific to timber based panelised MMC systems, trialled during the AIMCH site prototyping. These include open and closed panel timber frame MMC technologies. The guide covers 6 core areas of design consideration, providing guidance on the most cost effective way to design homes. It highlights areas where MMC may constrain the design process, offering solutions to design out potential conflicts, that help deliver a more robust cost effective solution. The 6 core areas are:

1. Design Sequence - Key Decisions
2. Design Constraints – Limiting factors
3. Structural Principles – Walls, Floors and Roofs
4. Differential Movement – Cladding interfaces
5. Building Services – Plumbing and electrical Interfaces
6. Windows & Doors – openings and setting out

In some instances, the design parameters may over rule the DFMA guidance. In these situations, the DFMA Guide flags these to the user, so that design decisions are made with the full knowledge of the consequences that may arise. It is important to ensure that construction teams are fully aware early in the DFMA process, where additional site work or clashes will arise, such that the impacts are fully understood, established and planned into the construction delivery process. There should be no surprises, ideally issues should be designed out using DFMA guidance, but it may be in certain high valued design justifications, that these are reflected in additional costs or time. Either way the DFMA Guide acts as a useful prompt to design out or recognise where design will impact construction accordingly.

The DFMA Guide, thought to be one of the first its kind, will be used in the development of AIMCH Industrialised Housing Designs, suitable for affordable housing development. This work is being progressed by Stewart Milne Group and London and Quadrant and will provide an off the shelf pre-designed and MMC value engineered pattern book of homes. SMTS will make available the DFMA guide for use with clients interested in designing homes, using their range of panelised timber frame open and closed Offsite MMC technologies.

DFMA in conjunction with design standardisation and 3D BIM modelling (Building Information Modelling) can be very powerful tools to transform housing design and delivery, leveraging learnings from the automotive sector, where these approaches have excelled. AIMCH ambition is through the creation and exploitation of future industrialised housing designs, that embrace DFMA, standardisation, BIM and MMC, yet deliver high quality, functional and appealing homes, AIMCH will fuel a path to delivering more homes, at an affordable cost.

Future housing designs will be commercially evaluated, through detailed desk top commercial analyse, the cost effectiveness of this approach and the standardisation solutions created. To support the commercial evaluations an innovation call to the supply chain market will be completed. This will seek suppliers keen to engage and exploit the standardisation considerations evolved from this work package. It is anticipated that suppliers will welcome the opportunity to engage and facilitate further collaboration, overcoming any technical challenges and developing a viability point, attractive to the AIMCH developer partners.

It is hoped that once promising solutions are technically robust and commercially attractive, these will be trialled on live developments/plots with the AIMCH developer partners. Outcomes from trials will be commercially evaluated within WP8 and findings reported.

Standardisation of sub-assemblies and the creation of product families, within housing design, as a mainstream industrialised process, is a significant shift for the AIMCH developers and wider industry. This will take many years to embrace, embed and deliver to the scale, capability and benefits shown by the automotive sector. However, these innovative collaborative studies, believed to be the first of their kind, show real promise in the potential to embrace standardisation as a positive attribute and not as a perceived negative thing.

AIMCH partners are already seeing business opportunities where this work can be exploited within their businesses. In the case of Stewart Milne Homes, the recommendations have been utilised in the creation on a new housing range for deployment within the business in the next 12-36 months. Similarly, L&Q have adopted the information for the standardisation of their medium-high rise apartments developments, where there is strong potential for offsite manufactured modular bathroom pods, to be commercially viable at scale and beneficial to construction on site.

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CONTENTS

BACKGROUND & OVERVIEW

Design for Manufacture and Assembly (DFMA) is critical to an effective industrialised housing approach using MMC. The automotive industry has shown how DFMA can be leveraged to derive significant business benefits, such as lowering costs, increasing productivity and improving quality.

Within WP5, led by the AIMCH MMC manufacturing partner Stewart Milne Timber Systems (SMTS), the team worked collaboratively by sharing DFMA information with AIMCH developer partners (Stewart Milne Homes, Barratt Developments and London & Quadrant) to evolve and consider DFMA Guidance in use, at developer and AIMCH consortium level. The DFMA guide is targeted at designers or specifiers of homes, interested but less knowledgeable, in using panelised MMC systems.

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AUTHORS AND THANKS

The AIMCH partners greatly appreciate the contribution of Stewart Milne Timber Systems and their technical team, in the collaborative delivery of this DFMA guide.

Frank Strachan

John Simpson

Graham Mackie

Grant Sanderson

David Bell

Jason Connor

Dan Hickman

John Smith

DESIGN SEQUENCE

Purpose

To identify the flow of information from Architect, to client, to timber frame manufacturer and to the rest of the design team throughout a project. The point at which a timber frame specialist is brought onboard will change the outcome of a project and may reduce abortive fees also.

The value of Engagement with the Timber frame specialist

Early engagement:

If possible, try to bring on the Timber Frame Specialist at the point that architectural planning drawings are nearing completion (As a client adviser during RIBA stage 1). This will give the Timber Frame Specialist a chance to suggest minor improvements to the buildings before the constraints of planning permission restrict the possible changes.

We may suggest items such as:

- Aligning loadbearing walls,
- Refining layouts to achieve support for beams,
- Refining foundation lines to realise savings,
- Improve eaves, verge, aperture details

Medium term engagement:

Bringing in a Timber Frame Specialist at the point planning is granted and drawings are completed to 1:50 scale with dimensions (RIBA stage 3) means that the Timber Frame Specialist will have a chance to ask queries on design intent and be able to make a timber frame solution work for the project. There will likely not be enough time for the Timber Frame Specialist to add value.

We may suggest items such as:

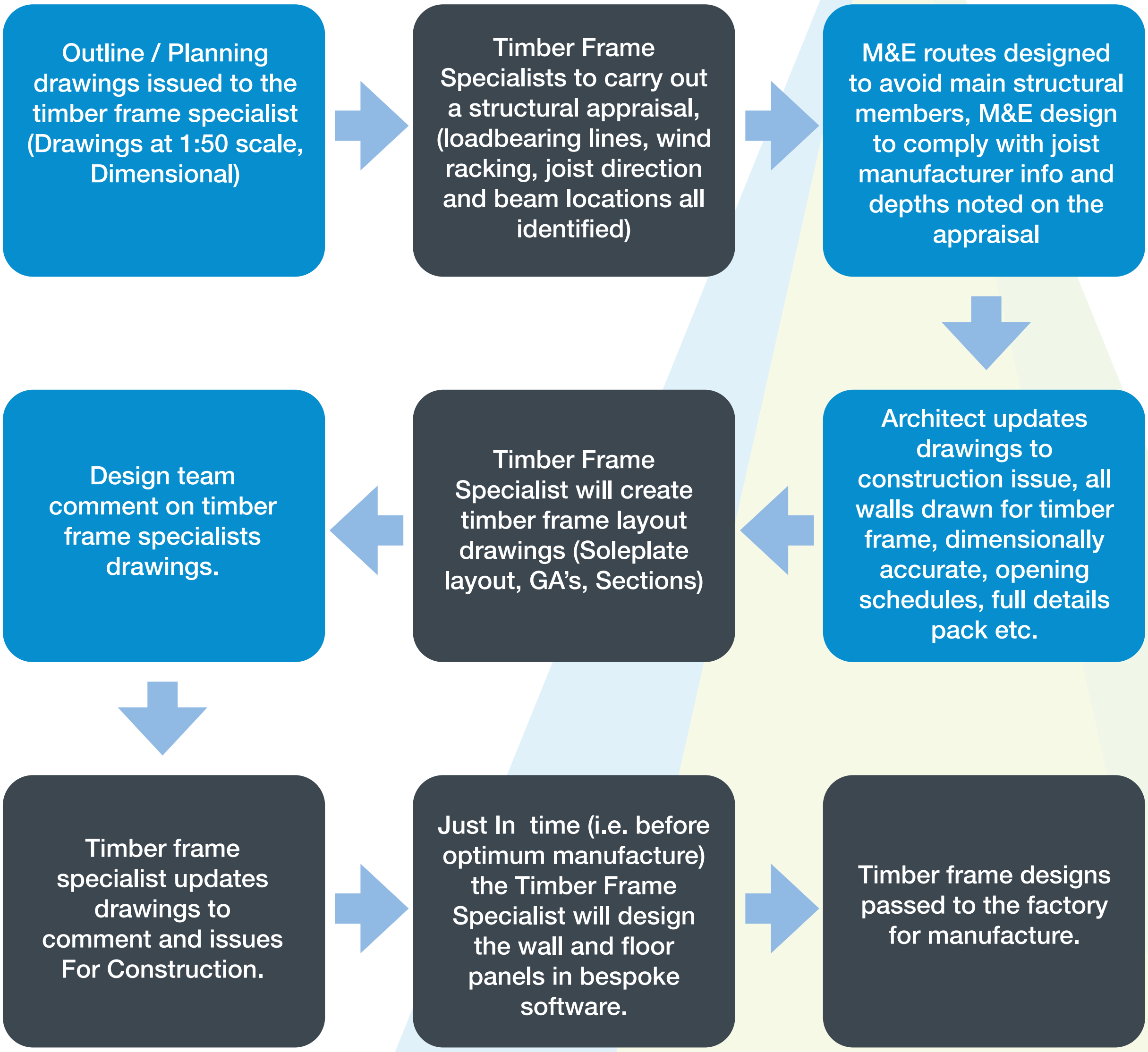
- Rationalise stairwell support,
- Clarify detailing for the current design

Late engagement:

If a Timber Frame Supplier is appointed later in the project, there is no opportunity for adding value to a project and there is also a chance that design detailing could be rushed.

Flow of drawing information

How best to work-up drawings for a timber frame project, once designs are agreed, passing the information around the design team. Ensure that the lead-in time to site allows for this process to be followed.



Outline / Planning drawings issued to the timber frame specialist (Drawings at 1:50 scale, Dimensional)

Timber Frame Specialists to carry out a structural appraisal, (loadbearing lines, wind racking, joist direction and beam locations all identified)

M&E routes designed to avoid main structural members, M&E design to comply with joist manufacturer info and depths noted on the appraisal

Architect updates drawings to construction issue, all walls drawn for timber frame, dimensionally accurate, opening schedules, full details pack etc.

Timber Frame Specialist will create timber frame layout drawings (Soleplate layout, GA's, Sections)

Design team comment on timber frame specialists drawings.

Timber frame specialist updates drawings to comment and issues For Construction.

Just In time (i.e. before optimum manufacture) the Timber Frame Specialist will design the wall and floor panels in bespoke software.

Timber frame designs passed to the factory for manufacture.

DESIGN CONSTRAINTS

Building heights

How to measure a building height

In relation to the below, for both Scotland and also England and Wales, the following method should be used to measure the height of a building:

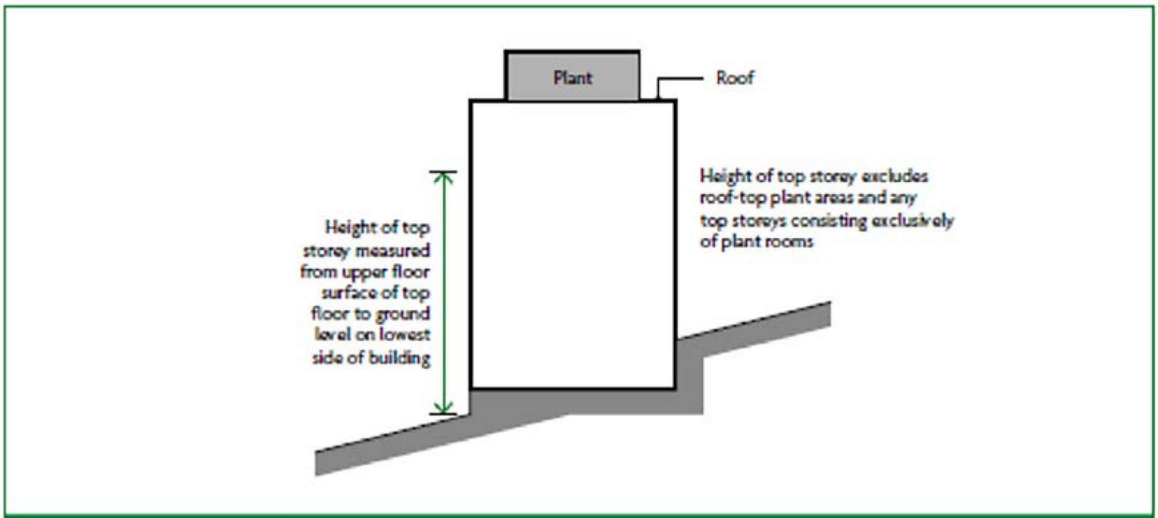


Diagram D6 Height of top storey in building

Building Heights in Scotland

Building heights in Scotland are restricted to 18m for fully brickwork clad timber frame. For timber frame buildings, between 11m and 18m, these must be clad with min A2 external cladding material. Ideally supported with BS 8414 spread of flame façade fire test. All multi occupancy buildings in Scotland must have sprinklers from March 2021. All stairwell enclosures and escape stairs must be non-combustible materials either concrete of steel.

Building Heights in England and Wales

Building heights in England and Wales are restricted to 18m for fully brickwork clad timber frame. For timber frame buildings, up to 18m, these must be clad with min A2 external cladding material. Ideally supported with BS 8414 spread of flame façade fire test. Multi occupancy buildings in England below 18m do not require to have sprinklers. All stairwell enclosures and escape stairs can be timber frame and timber starlight's, providing they comply with regulatory fire requirements, with minimum of 60 min fire resistance.

NOTE: Approved Document B Fire Standard Consultation is underway. This is likely to demand more stringent compliance requirements in the future, possibly like that required in Scotland. In addition, the trigger height is under review. This may limit timber frame buildings to 11m (4 storey) but this has not been finalised.

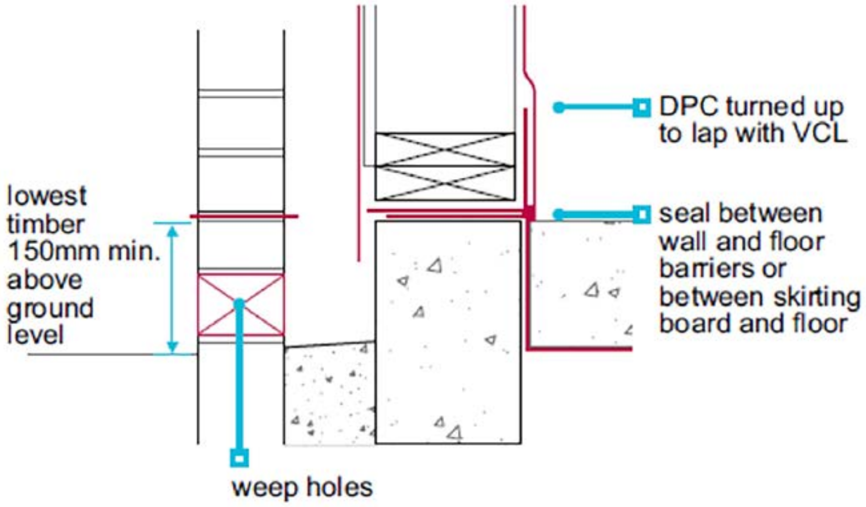
Sigma II buildings in England & Wales and in Scotland

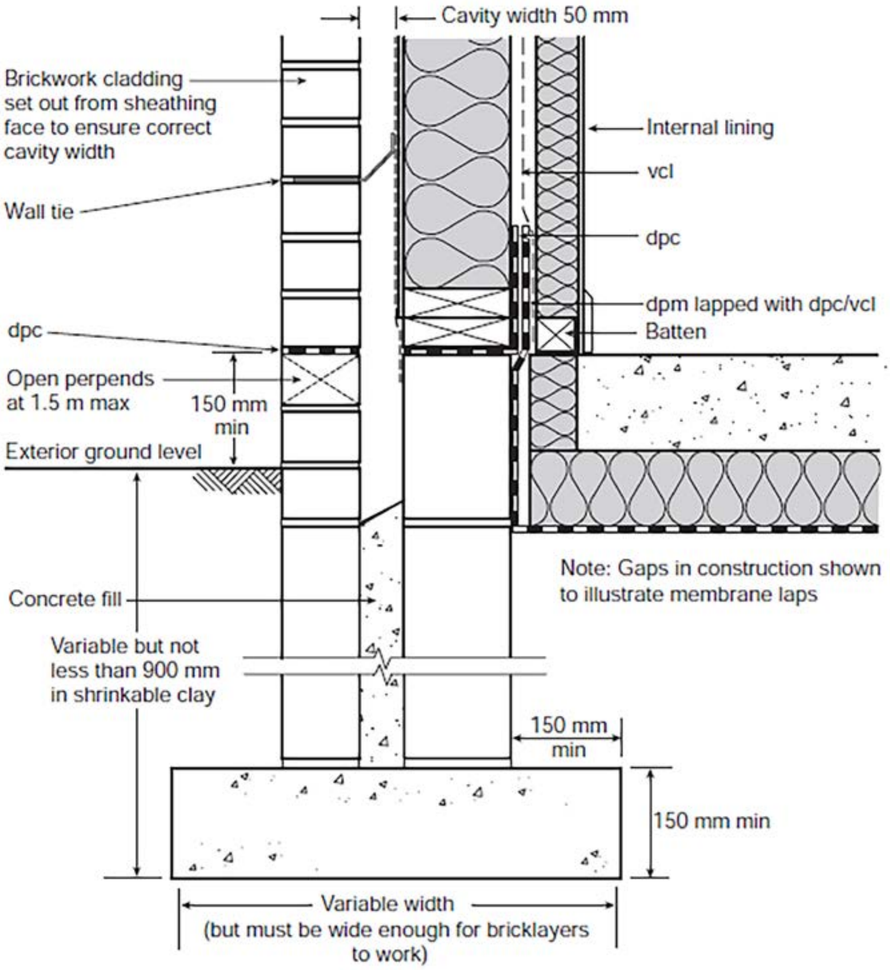
Regardless of the height of a Sigma II closed panel timber building system, the designers need to be aware of any cladding which is not full brickwork. The Sigma II BBA certification has no declaration of performance for 'surface spread of flame'. For masonry clad Sigma II buildings, it is possible to demonstrate this compliance. Whereas other cladding types, need information on surface spread of flame before this can be deemed acceptable.

The Relationship of Timber Frame to the External Ground Level

Widely regarded standard practises

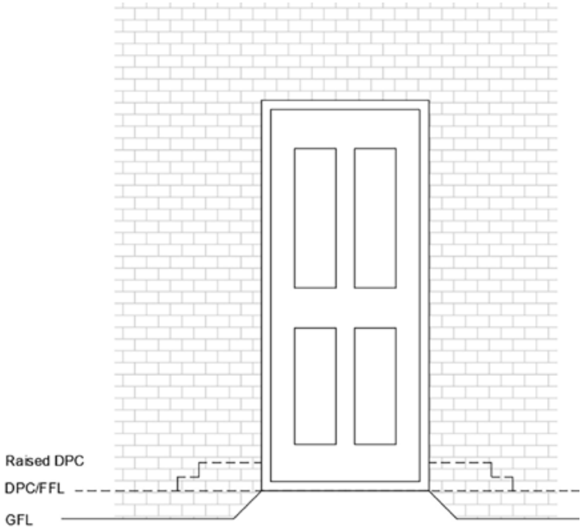
The NHBC guidance on the external walls for a timber frame building stipulates that a timber frame should be 150mm above the external ground floor level. Typically, this works by having the FFL 150mm above the external ground floor level also, and using a upstand block (if required) from the structural slab level to the finished floor level to give the timber frame a solid base on which to sit.

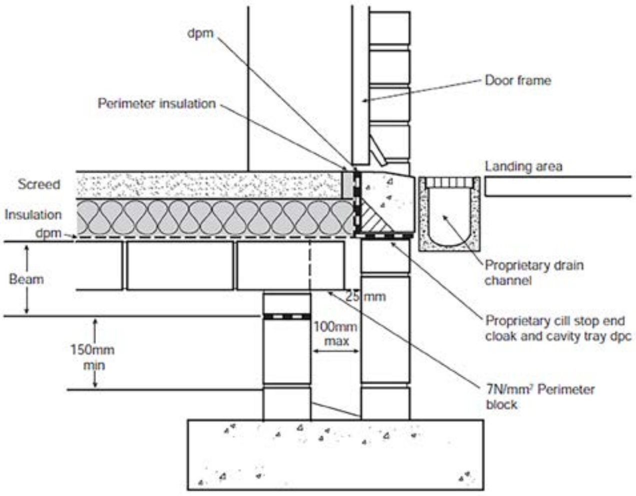




Front / Rear entrance doors (level threshold)

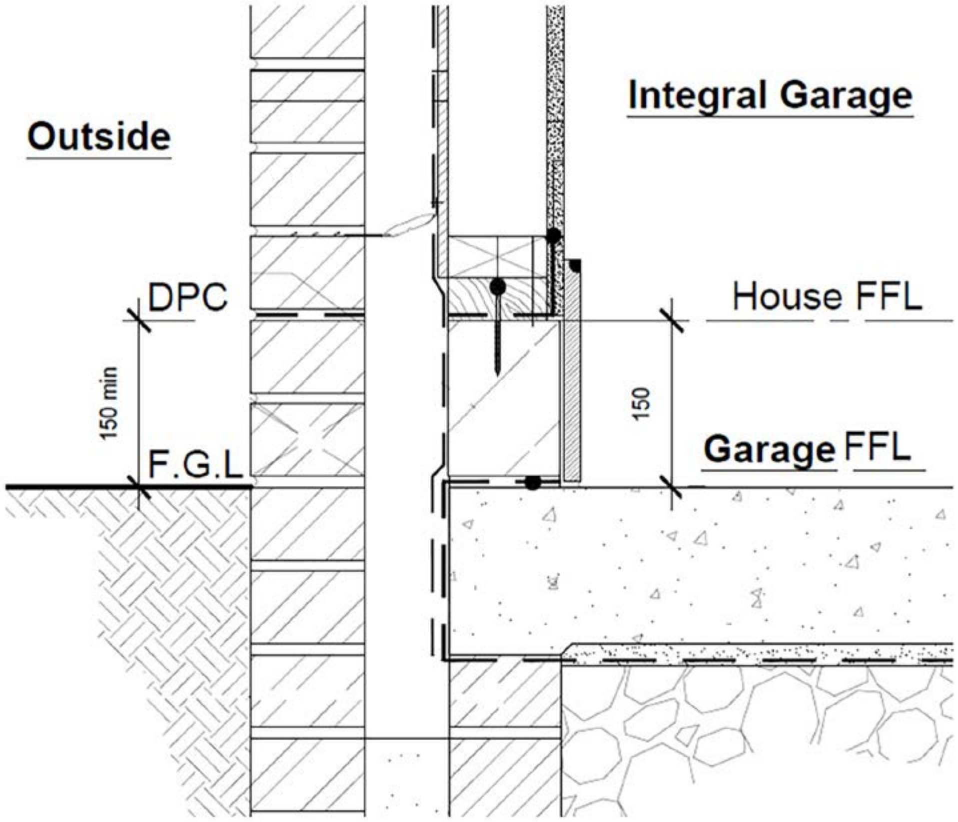
Level thresholds are permitted to front / rear entrance doors, the level threshold should have a locally raised DPC to account for this. Also consider the use of a drain channel.





Integral Garages

At integral garages, the same detail and levels should apply to the timber frame, that is; 150mm above external ground floor level, atop a upstand block, with the top of the upstand block flush with the finished floor level of the rest of the dwelling (the FFL of the living room, or Kitchen for instance)



Steps in level through a terrace:

As the ground level and FFL of a terrace increases or decreases, it is imperative to maintain the +150mm dimension between the external ground level and the Timber Frame / Ground Floor Finished Floor Level. A 'Cut and Fill' approach to the surrounding ground level can mean a minimisation of the labour required to do this. See the below sketches to illustrate the point:

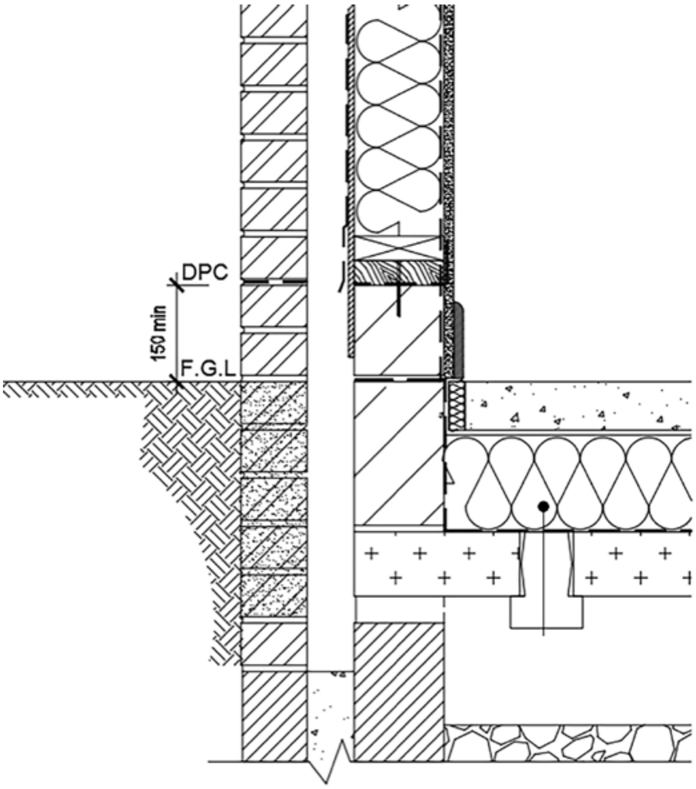
Alternative details, and the items to consider

There are times where the project has been designed from an early stage with a external ground floor level at the same level as the finished floor, that means, that the blockwork upstand will only bring the timber frame level with the external wall.

In some cases, alternative details are devised and issued for submission to the NHBC (or LABC, Premier etc) for review. In most cases these details do not gain approval, some are noted below alongside the reasons they are eventually abandoned:

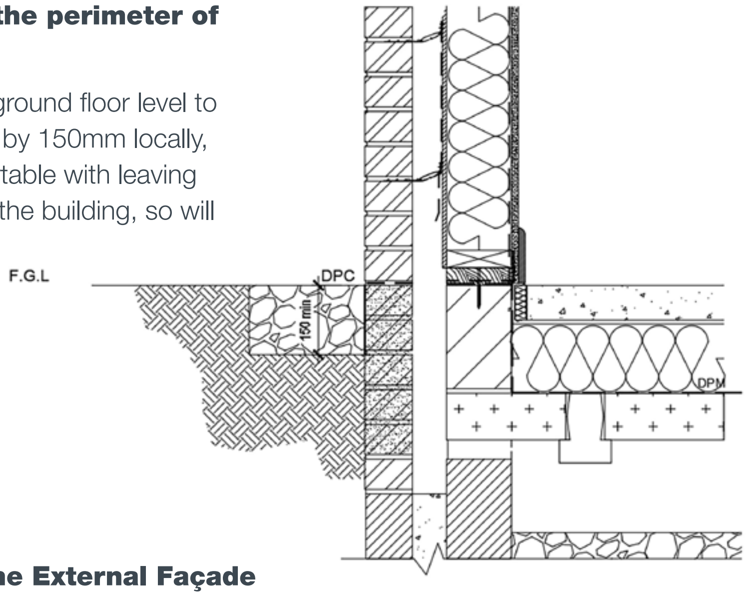
Maintain the 150mm above GFL by increasing the block upstand

In this case the initial logic is sound, the timber frame is now back to being 150mm above the external ground floor level, however on closer inspection there are a few new issues to consider. The plasterboard to the room will now need to fix to both timber frame and also to blockwork, the timber frame will encounter a small amount of differential movement whereas the blockwork will not, this may lead to creasing of the plasterboard around the perimeter of the plot. Furthermore, this creates a likely cold-bridge to the plot, as the cavity must remain drained and vented.



Reduce the floor level locally to the perimeter of the building

Again, the logic here is sound, that the ground floor level to the perimeter of the building is dropped by 150mm locally, however most designers are not comfortable with leaving a clear ‘trench’ around the perimeter of the building, so will want to infill this ‘trench’ with stone / gravel etc. At this point it is no longer clear that the ground level is 150mm below the timber frame, i.e. what proportion of the stone / gravel should be attributed to the ground floor level? For this reason, the building insurers reject the detail.



Timber Frame interaction with the External Façade

Some of the well-known benefits of timber frame are:

- efficient offsite manufacture,
- speed of build
- light weight when compared to brickwork / blockwork.

Any introduction of steps in layout from floor to floor, however, will have a number of effects on the timber frame and should be avoided if possible. The changes in layout mean additional support beams and posts are required. These beams and posts then lead to a concentration of point loads within the building, (where large portions of floors are supported on beams, the bearing of these beams becomes a ‘point load’). This higher than normal load to such a small area could lead to the increase of differential movement to a specific portion of a building and should be carefully considered. It can also mean additional consideration within the supporting ground floor construction.

These types of changes in layout can also lead to longer build programmes as scaffold is adapted. Where possible it is advised to design a timber frame building so that all loadbearing lines align.

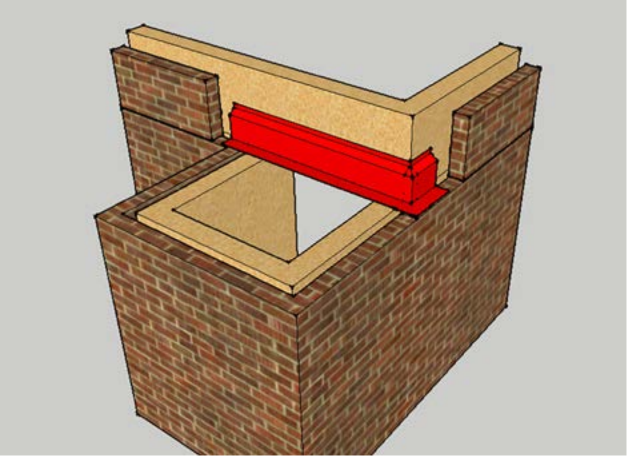
Brickwork façade over a low level roof or building projection

Where an external façade above a projection such as this example to the side, is brickwork, this will obviously require support. Timber Frame cannot directly support brickwork above and as such an alternative support is needed, this applies to housing and apartments. Some ways to overcome unsupported brickwork over timber frame below are outlined below.

L Shaped brick support Lintel

Use of a normal brickwork lintel for timber frame profile, this time with an added return to stop the lintel profile being visible in the external façade:

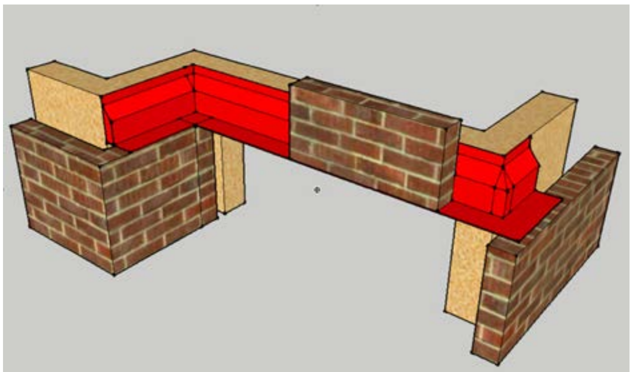
The span of these lintels is usually limited to approx. 3m, though this depends on loads etc. each side requires a minimum of 150mm bearing onto brickwork.



S Shaped brick support lintel

Like an L Shaped lintel above, the S Shaped lintel is for use where a 150mm of bearing cannot be provided:

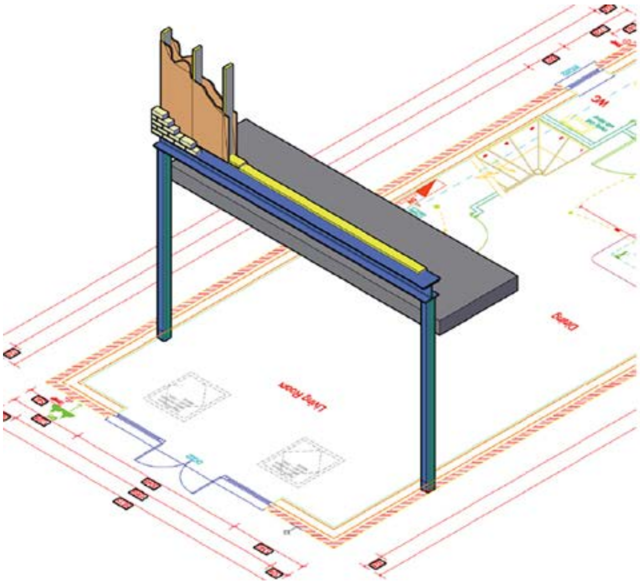
Like the L Shaped lintels, the span is limited to approx. 3m.

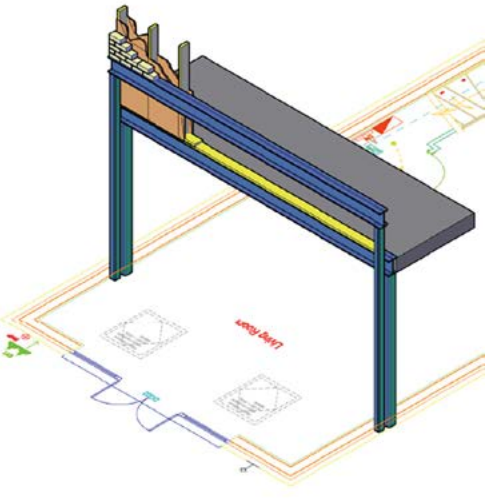


Goalpost

On longer spans, or facades producing higher loads, then a steel goalpost can be required, the posts are designed to sit within the line of the timber frames inner leaf, so the external façade is not broken up with a steel section.

Dependent on the loads required, spans and preferred heights, this can be achieved by a single, larger cross-section goalpost, or two smaller cross-section goalposts. The webs of the steel sections will be fully insulated onsite to avoid cold-bridging.



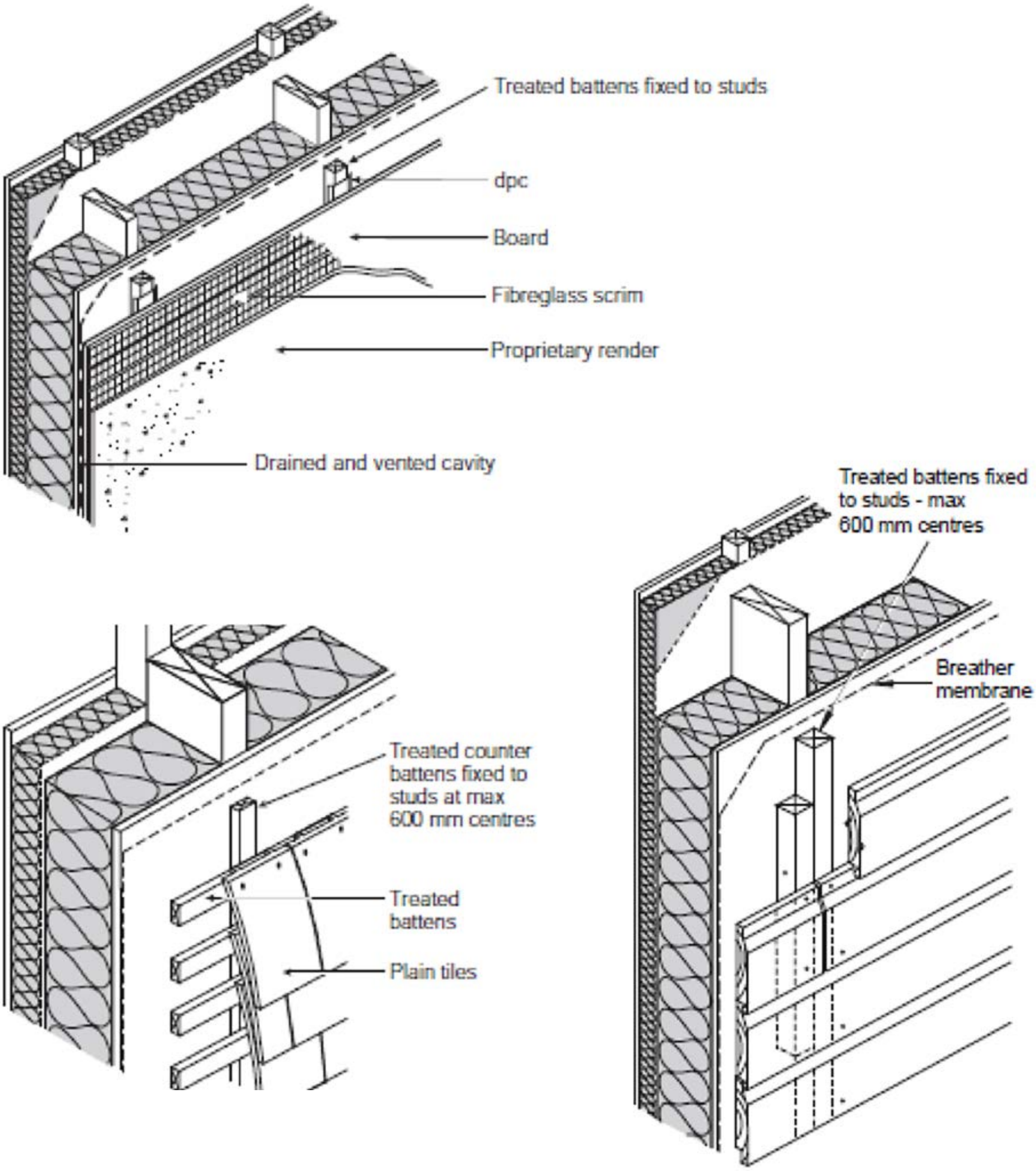


Lightweight alternatives

A popular option where the external façade steps in at upper levels is to replace facing brickwork with a lightweight alternative, such as:

- brick slips
- weatherboard
- tile hanging
- render on boards

in these cases, the lightweight façade is supported by battens and cross-battens back onto the timber frame:



Cantilever Balconies

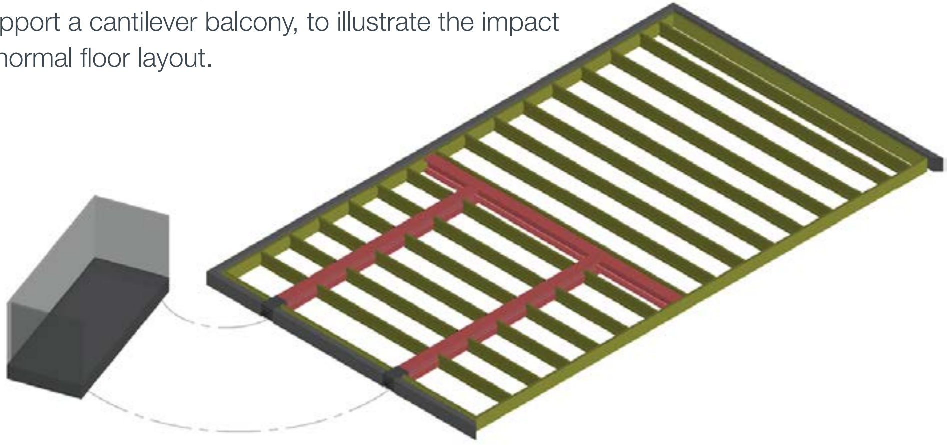
Balconies which do not have posts to the ground, as shown in the sketch to the right.

Where possible, balconies such as this should have posts reinstated back to the ground floor, this can either be by 2No posts to the front and a robust fixing to the facing brickwork, or by 4No posts.

If this is not possible then the balconies have to be supported by back span steels travelling far into the plot, with a thermal break bracket at the external wall line to stop cold-bridging.

Using back span steels for this type of balcony creates a high-proportion of manually constructed floor panels (as the steels sit within the floor zone, disrupting the spans of the joists). This also means that large portions of the floor are spanning onto the back span steels, the bearing of these steels becomes a 'point load'. This higher than normal concentrated load could lead to the increase of differential movement to a specific portion of a building and should be carefully considered.

Below is a sketch of the back span steels and thermal brackets required to support a cantilever balcony, to illustrate the impact this has on a normal floor layout.



Juliette Balconies

As a Juliette balcony does not have a floor to support, this frame can be fixed back to the structure without the need for 'back span' members. There are two common arrangements for fixing a Juliette balcony:

Fix back to masonry (most popular method)

By fixing the Juliette Balcony to the masonry, the fixing does not need to account for differential movement (Compressible seals etc). the masonry in these areas should have increased wall-ties back to the timber frame to ensure that the masonry is suitably supported.

Fix back to timber frame (less popular method)

Where the option to fix the Juliette Balcony to the timber frame is chosen, special detailing should be considered to the interaction between the balcony and the brickwork, as the balcony will now move with the timber frame over time.

The diagram to the side shows this consideration:

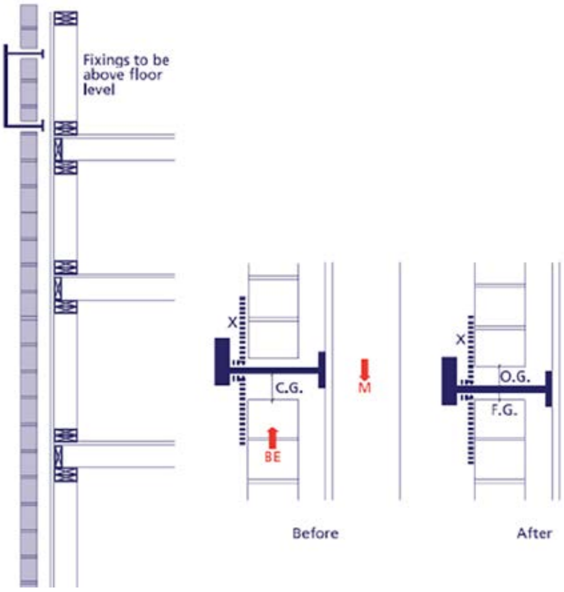
BE = Brickwork Expansion

M = Movement direction of the timber frame

C.G. = Constructed Gap

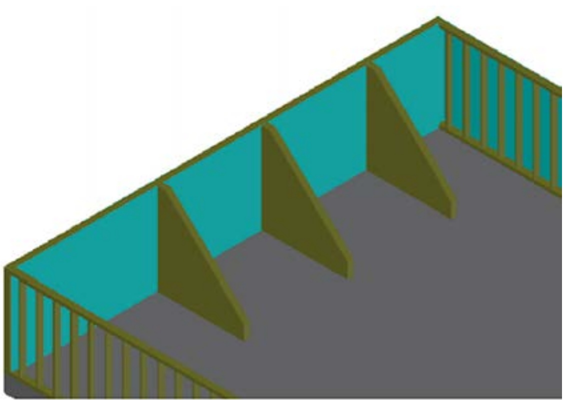
F.G. = Finished Gap

O.G. = Opened Gap



Parapet walls and copings

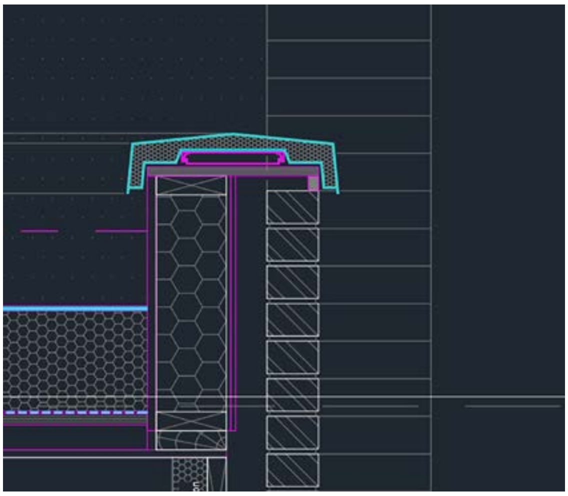
Parapet walls to a timber frame building are still a structural internal leaf, that is to say, the external leaf is relying on the internal timber frame parapet wall for lateral stability.



Parapet wall heights are a significant factor to consider as the parapets are susceptible to wind loads. If parapets are too high, there is a chance that they will need to have a specific restraint detail, in some cases this would be a buttress panel perpendicular to the direction of the parapets (example shown below). It is important to consider this as multiple buttress panels could hinder the drainage of the roof. As well as cause additional beam requirements within the superstructure.

With regards to copings, stone copings are not recommended for a timber frame build. As the coping detail needs to be designed for differential movement this would mean that a stone coping could only be supported by the inner or outer leaf.

A common coping detail is for pressed aluminium or GRP, supported by the inner leaf timber frame and oversailing (but not supported by) the external leaf. With this detail it is possible to design the coping slightly higher than the external leaf to allow for a compressible seal between the top of the external leaf and the underside of the coping. Detail opposite.



STRUCTURAL PRINCIPLES

Overview

This section is intended to illustrate typical solutions to the design of conventional timber frame construction and show the principals involved. It is not intended to provide a single prescriptive solution for the design of housing, rather show the implications of decision making at the conceptual design stage.

The structural design of all timber frame buildings will be carried out by a structural engineer following completion of the architectural drawings. See section 05 “Sequence for house type design” which describes when to engage with the timber frame specialist and structural engineer.

The specifics of preferred component sizes i.e. wall panel and floor panel dimensions (widths, lengths, depths, product types etc) and build methods will vary between manufacturers to reflect their own supply chain and production equipment, however despite these variances, the principles set out in this chapter will assist towards achieving an efficient timber frame design solution.

Timber Frame Design Overview

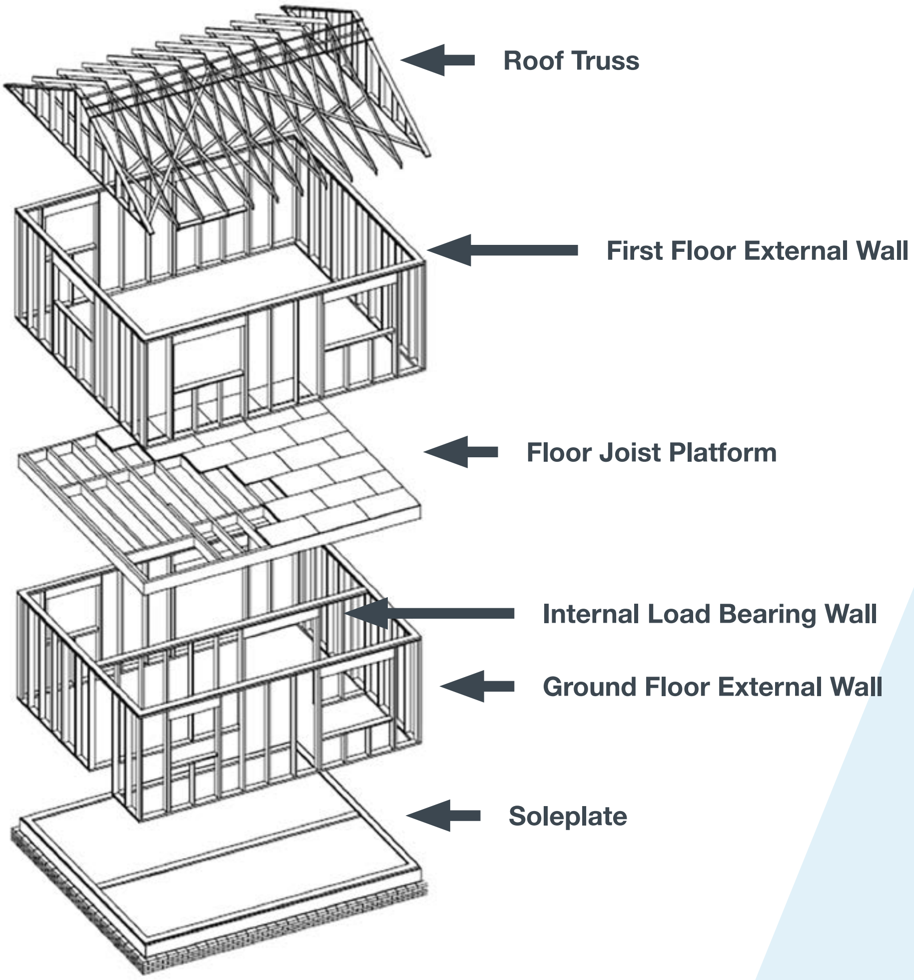
Timber frame construction uses timber studs and rails, together with a structural sheathing board, to form a structural frame which transfers loads through the building, both vertical loads form the building fabric and "live" load from people / fixtures & fittings etc, as well as horizontal loads, typically wind loadings.

The basic elements are as described in the following diagram:

- Roof Trusses, forms roof structure
- External wall panels (first floor)
- Floor joists
- External wall panels (ground floor)
- Internal Racking Walls
- Soleplate

Note: non-load bearing internal panels have been removed for clarity of diagram.

To achieve overall stability, timber frame construction relies on the diaphragm action of the floor structure to transfer horizontal forces to the load bearing walls, both internal and external walls. These load bearing walls provide both vertical support and horizontal racking resistance.



Removal, or part removal, of any of these structural elements can influence the structural design of the building, and whilst alternative solutions can be put in place, they can have performance and cost implications.

The load bearing elements of a timber frame wall typically include the following components:

i) Wall panel studs carry vertical loads from the building and horizontal loads from wind pressures

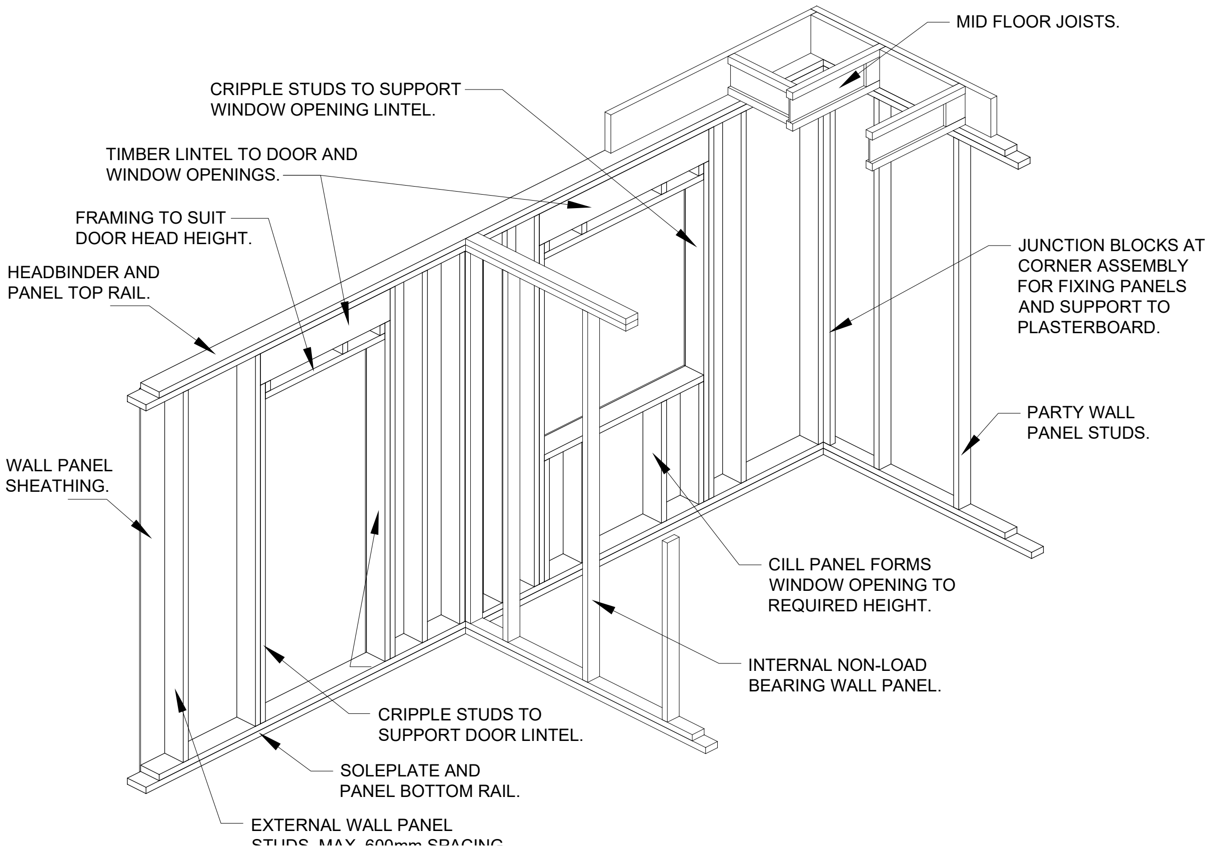
ii) Panel top and bottom rails which connect the studs and form a panel

iii) Sheathing boards provide resistance to racking forces

iv) Soleplates fixed to the foundation or floor and provide setting out for the wall panels

v) Head binders connect the wall panels, and in combination with the top rail, distributes floor loads to the studs when joists are not aligned with studs.

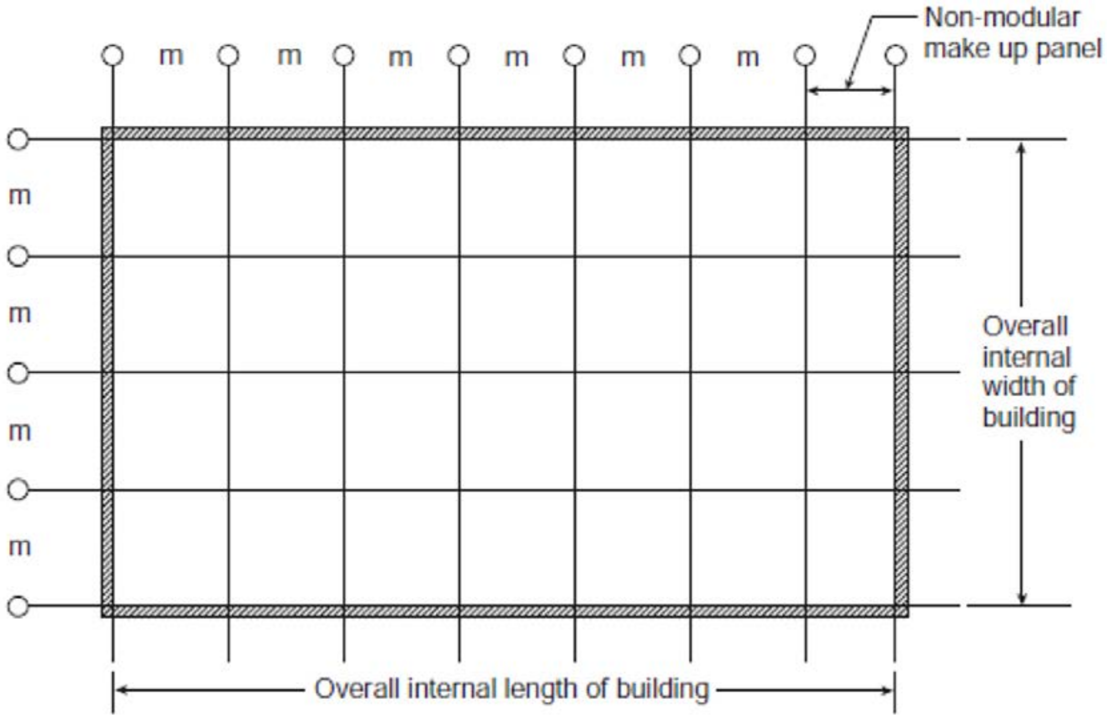
vi) Lintels and cripple studs transfer vertical and horizontal loads to either side of window and door openings.



Structural Grid Setting Out

The regular spacing of wall panel studs, floor joists and roof members in a timber frame design leads to the use of a simple grid at the design stage, typically based on 600mm centres given that most sheathing, lining and flooring materials are supplied in sheets 2400mm long and 1200mm or 600mm wide.

It is unusual for building designs to conclude exactly on a building length to suit a 600mm grid, however a “turn-out” dimension can be utilised at the end of the building.

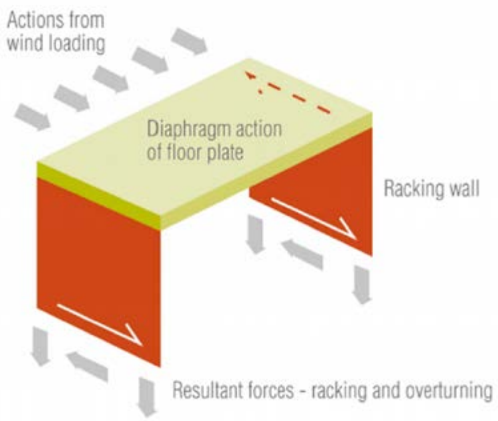


The most common spacing for walls and floors are 400mm and 600mm, and engineers will typically adopt the same principles while carrying out the structural analysis.

Whilst many factors will influence the building size and shape, not least the architectural brief, for efficient timber frame design the building designer should consider maximum floor joists spans and locations of internal load bearing walls to ensure the timber frame design can remain within these 400mm and 600mm joist spacing.

Load Bearing Walls & Racking Resistance

A key consideration is building stability. In the context of timber frame designs, the primary structural rigidity against horizontal wind loading is provided by the sheathing board which is applied to the stud framework. Typically, OSB3 is used as sheathing material and is applied to external and internal walls.



Wind loading applied to an elevation is transferred vertically via the wall panels into horizontal diaphragms formed by the roof and floor structures. The horizontal diaphragms are supported by sheathed external and internal walls which transfer the load sequentially down to the substructure.

The important consideration for the building designer is to provide enough walls within the design which can be used as racking. If the design is open plan layout with large openings to the front and rear of the house, then it is likely that there will not be enough wall panel area to resist the applied wind loads.

Were possible use any internal load bearing walls to provide support for building stability, known as racking walls. It is possible to make these walls dual purpose and to support the floor joists also. This is described later within this document.

Gable and party walls are normally longer and contain less or no openings and therefore in general offer enough wall area to provide racking resistance.

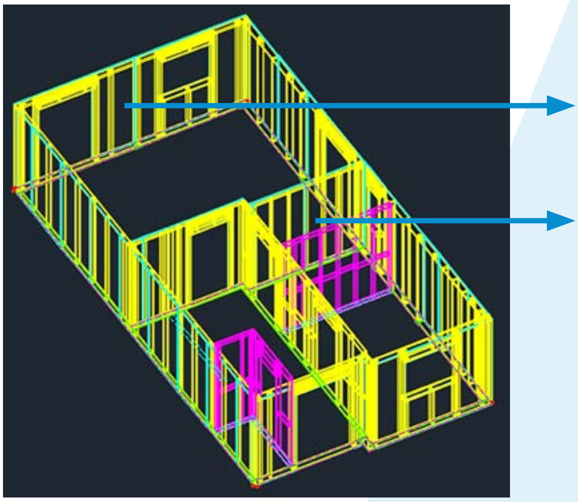
The wind load applied to a structure is variable and is determined by the site location which will have a specific wind speed and altitude, determined from the relevant standards.

This is a complex calculation and the walls available to be used for racking resistance will be assessed by the by the structural engineer to establish if the capacity is equal to, or greater than the wind load applied. However, the building designer should take cognisance of the structural requirements when setting out the design and can engage the engineer for advice. Section 5: Sequence for House Type Design provides guidance on who to engage and how to approach these decisions.

It is not to say that clear span buildings cannot be designed, there are methods of increasing racking resistance to timber frame, and in order of preference include:

- Increased nailing of the OSB sheathing to walls
- Addition of racking walls internally
- Double layers of OSB sheathing to racking walls (external or internal)
- Addition of steel racking frames or proprietary racking products

Diagram: Layout including internal racking walls providing building stability



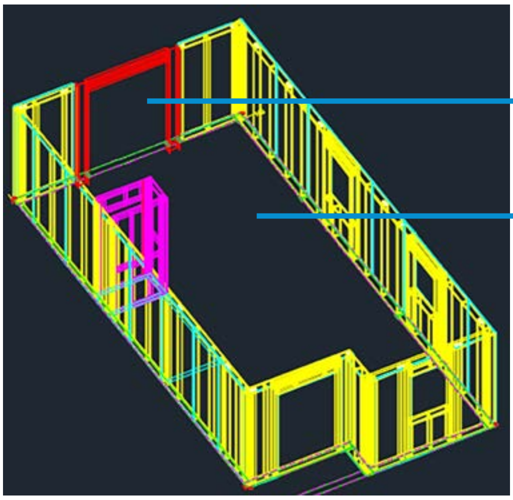
Openings designed to allow areas of external wall panel

Racking wall internally provides building stability when sheathed with structural board

An efficient timber frame design will include internal load bearing walls and areas of external wall panels between / either side of external window and door openings.

Structural stability can be provided by others means, e.g. racking frames, however these can be expensive and require careful detailing with respect to settlement, support at foundation level, cold bridging through the external wall, and connections between the steel and timber frame elements.

Diagram: Layout without internal racking walls

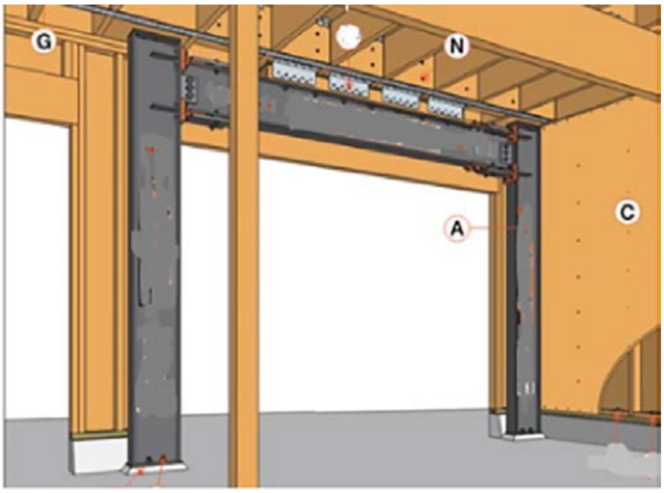


Portal frames or proprietary racking product to provide structural stability

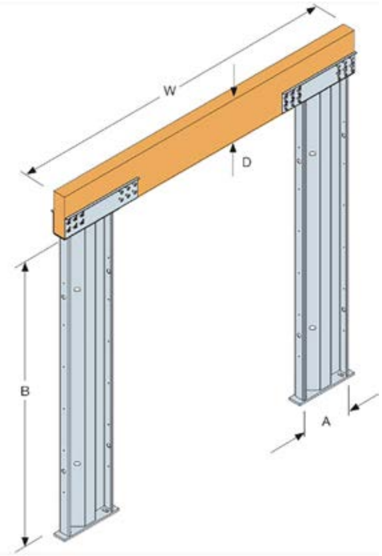
Open plan layout at ground floor level and large opening to rear results in no available racking walls

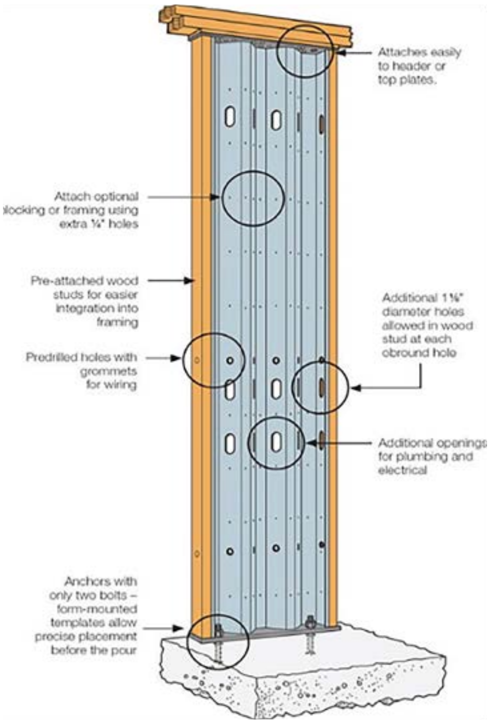
Racking Portals & Frames

These diagrams show how steelwork would be integrated into the timber frame structure and offer a structural solution of varying capacities, albeit with cost and detailing implications. Therefore, for these reasons avoid this design requirement when possible.



Portal Frame





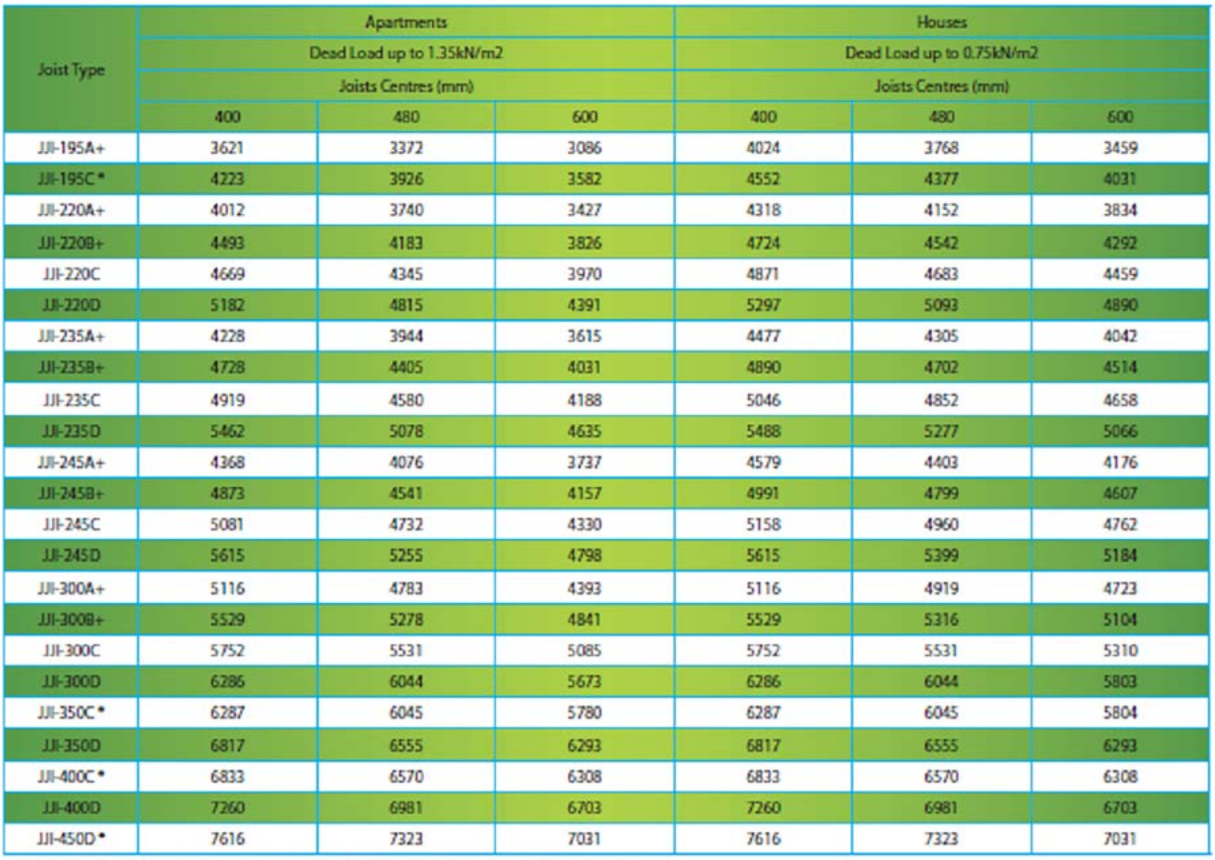
Proprietary Steel Bracing Panels;

Floor Joist Design

Section 07 of this guide provides detailed information on floor joist design criteria, loadings, deflection limits, load span tables etc and will assist with decision making. Timber frame manufacturers use a range of different joist types, including solid timber, I-beam and metal webs products, each of which have different benefits. These joists types also have varying widths and depths to suit the span and loading conditions.

Most manufacturers and joist suppliers will be able to provide technical advice and some form of span tables to assist the building designer with their decisions. The timber frame manufacturer will also be able to assist with these design decisions to best reflect their products.

Example Joist Span Table:



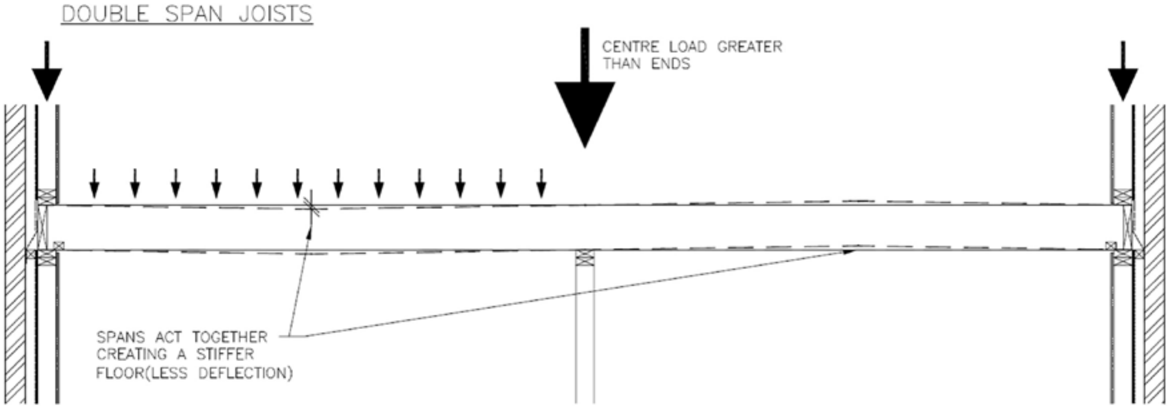
Joist Type	Apartments			Houses		
	Dead Load up to 1.35kN/m2			Dead Load up to 0.75kN/m2		
	Joists Centres (mm)			Joists Centres (mm)		
	400	480	600	400	480	600
JJI-195A+	3621	3372	3086	4024	3768	3459
JJI-195C *	4223	3926	3582	4552	4377	4031
JJI-220A+	4012	3740	3427	4318	4152	3834
JJI-220B+	4493	4183	3826	4724	4542	4292
JJI-220C	4669	4345	3970	4871	4683	4459
JJI-220D	5182	4815	4391	5297	5093	4890
JJI-235A+	4228	3944	3615	4477	4305	4042
JJI-235B+	4728	4405	4031	4890	4702	4514
JJI-235C	4919	4580	4188	5046	4852	4658
JJI-235D	5462	5078	4635	5488	5277	5066
JJI-245A+	4368	4076	3737	4579	4403	4176
JJI-245B+	4873	4541	4157	4991	4799	4607
JJI-245C	5081	4732	4330	5158	4960	4762
JJI-245D	5615	5255	4798	5615	5399	5184
JJI-300A+	5116	4783	4393	5116	4919	4723
JJI-300B+	5529	5278	4841	5529	5316	5104
JJI-300C	5752	5531	5085	5752	5531	5310
JJI-300D	6286	6044	5673	6286	6044	5803
JJI-350C *	6287	6045	5780	6287	6045	5804
JJI-350D	6817	6555	6293	6817	6555	6293
JJI-400C *	6833	6570	6308	6833	6570	6308
JJI-400D	7260	6981	6703	7260	6981	6703
JJI-450D *	7616	7323	7031	7616	7323	7031

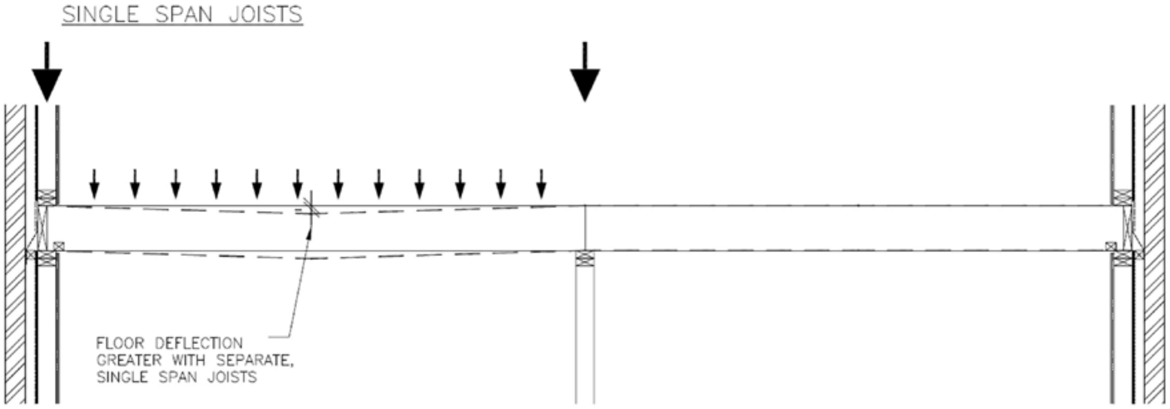
Table 15. Maximum Engineering Span for Domestic Intermediate Floors

You can see from this table that joist centres of 400mm / 480mm / 600mm are listed. It is possible to design floor joists to even closer centres and fall within the same 600mm grid system e.g. by use of 300mm or even 200mm centres, and whilst this may be structurally acceptable it will not be the most efficient design and does not allow working space between joists for follow on trades to install electrical cabling, plumbing routes, data, waste pipes etc. This type of close centre joist setting out is better avoided, with preference given to either the addition of load bearing support lines or using a deeper joist will offer longer span options.

In general, if design decisions allow for large panel floor design this will offer the best production outputs with more area per floor panel manufactured. Normally this means joists span the long direction of the house and has a requirement for internal load bearing walls. These walls can be dual purpose, used to support the floor joist and to provide lateral racking resistance to the building. In most cases this can eliminate the requirement for racking frames described earlier.

This design approach, with joists spanning continuous over a central load bearing wall, would be known in engineering terms as multiple span, rather than single span, illustrated as follows:



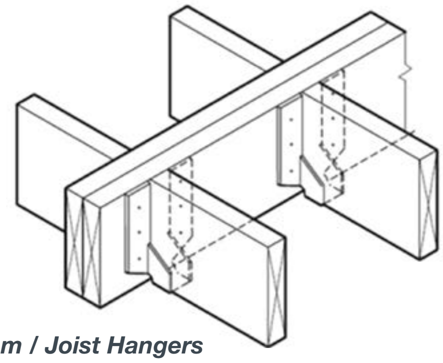


In addition to increased production, there are engineering benefits to multiple span joists compared to single span. In simple terms the deflection on the joists either side of the load bearing wall act together to “cancel” each other out meaning a more efficient joist can be engineered.

It is true that with multiple-span continuous joists, the reactions (loads at supports) concentrate at the center span and decrease at the ends, whereas simple single-span joists that are broken at the centre wall and reactions are equal at each end of the joist. This does mean that on occasion the mid span load bearing wall panel stud specfication has to be increased to accommodate this extra load, but in most domestic conditions this is realtively insignificant and will be offset by the benefits gained within the floor panel design and manufacture.

Therefore we would recommend that double span joists be used where possible. The only limitation is the spec and spans of the joists. Most engineered joists come in lengths of up to 12m which will adequatly fit most standard houses.

Floor Trimmers and Beam Design



Beam / Joist Hangers

It is understood, and accepted, that most house type designs will require some form of trimming and beams e.g. around stairwells. It is also easy to see how these add complication and cost to the design through the introduction of structural beams and joist hangers and should be simplified whenever possible. Various beams and joist hanger types exist and will be specified to suit the spans and loading conditions for the beam.

Whenever possible the designer should always look to minimise the requirement for trimming and keep as simple as possible, including consideration to:

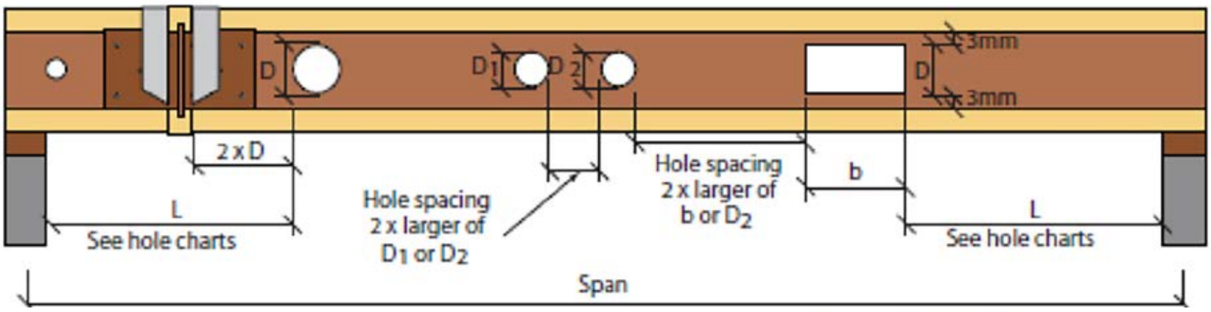
- Stairwell voids run parallel with joists spans
- Services routed within floors run parallel with joists
- Services located above the floor joist e.g. pipe boxing / vanity units (if routes are perpendicular to joist spans)

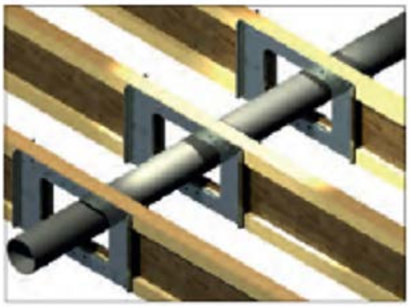
It is mainly the larger services that require the most consideration with respect to floor design e.g. drainage pipes and ventilation ducts. There may also be areas where concentration of services occurs e.g. electric meter's, water tanks, boilers to be considered.

Most of the electrical wiring, plumbing for heating, and water supply can be accommodated within standard holing and drilling allowances. Joist and timber frame manufacturers will be able to provide detailed information relating to holing and drilling to reflect their product and for different loading conditions.

Example service hole chart and diagram:

Joist Depth (mm)	Joist Span (mm)	Hole Size (mm)													
		50		75		100		125		150		175		200	
		○+□	▭	○+□	▭	○+□	▭	○+□	▭	○+□	▭	○+□	▭	○+□	▭
220	3000	300	300	361	656	721	838	838	1159						
	3500	300	300	500	824	895	1024	1024	1375						
	4000	300	300	651	1001	1078	1216	1216	1596						
	4500	300	449	813	1186	1268	1415	1415	1819						
	4890	300	566	945	1334	1420	1574	1574	1996						
235	3000	300	300	300	566	656	873	873	1217						
	3500	300	300	325	725	824	1062	1062	1440						
	4000	300	300	463	894	1000	1258	1258	1665						
	4500	300	300	612	1072	1185	1460	1460	1893						
	5066	300	382	794	1282	1402	1693	1693	2154						
245	3000	300	300	300	482	586	865	865	1252	955	1252				
	3500	300	300	300	632	747	1053	1053	1478	1152	1478				
	4000	300	300	300	794	918	1248	1248	1706	1355	1706				
	4500	300	300	457	965	1097	1449	1449	1937	1563	1937				
	5184	300	300	666	1212	1353	1731	1731	2256	1854	2256				
300	4000	300	300	300	300	300	803	803	1308	1230	1542	1477	1883	1572	1883
	4500	300	300	300	300	300	975	975	1513	1430	1762	1693	2126	1795	2126
	5000	300	300	300	300	449	1154	1154	1722	1635	1985	1912	2369	2019	2369
	5500	300	300	300	535	670	1341	1341	1935	1844	2210	2135	2613	2247	2613
	5803	300	300	300	687	822	1456	1456	2066	1972	2348	2271	2761	2385	2761

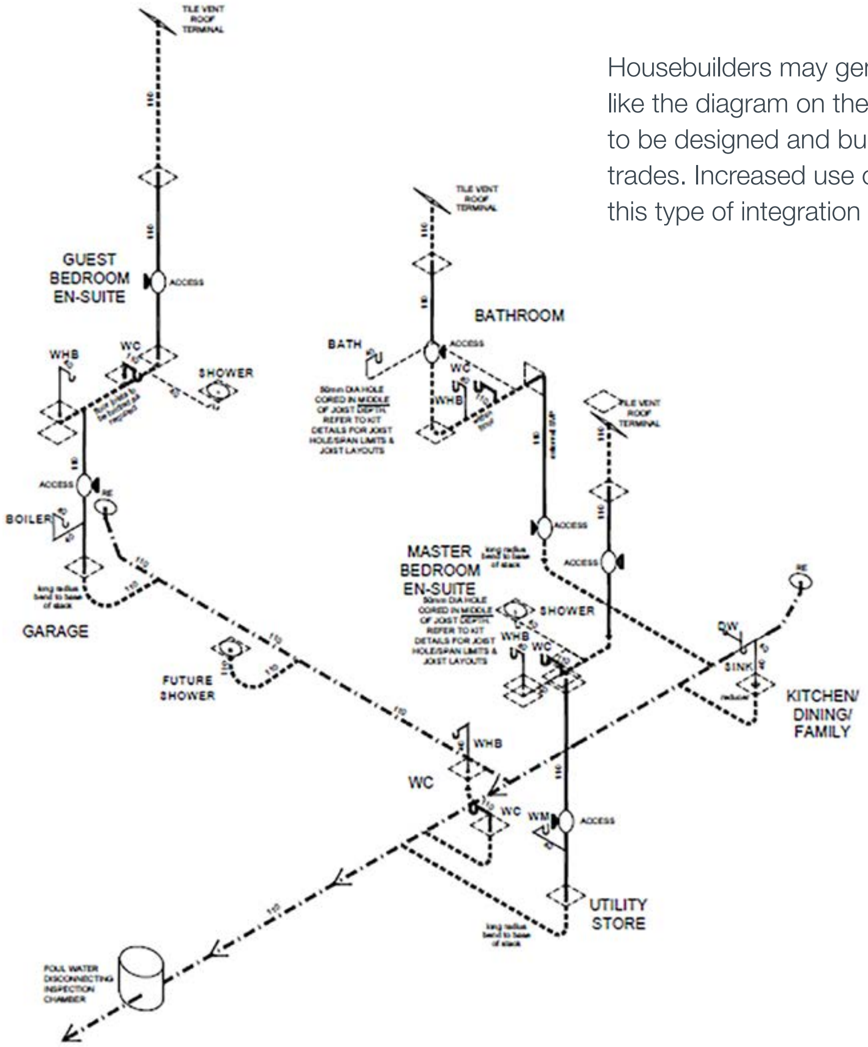




There are methods of providing reinforcing of joists to allow holes in excess of standard allowances, stiffener plates shown in example, however these add time and cost to the design and manufacture.

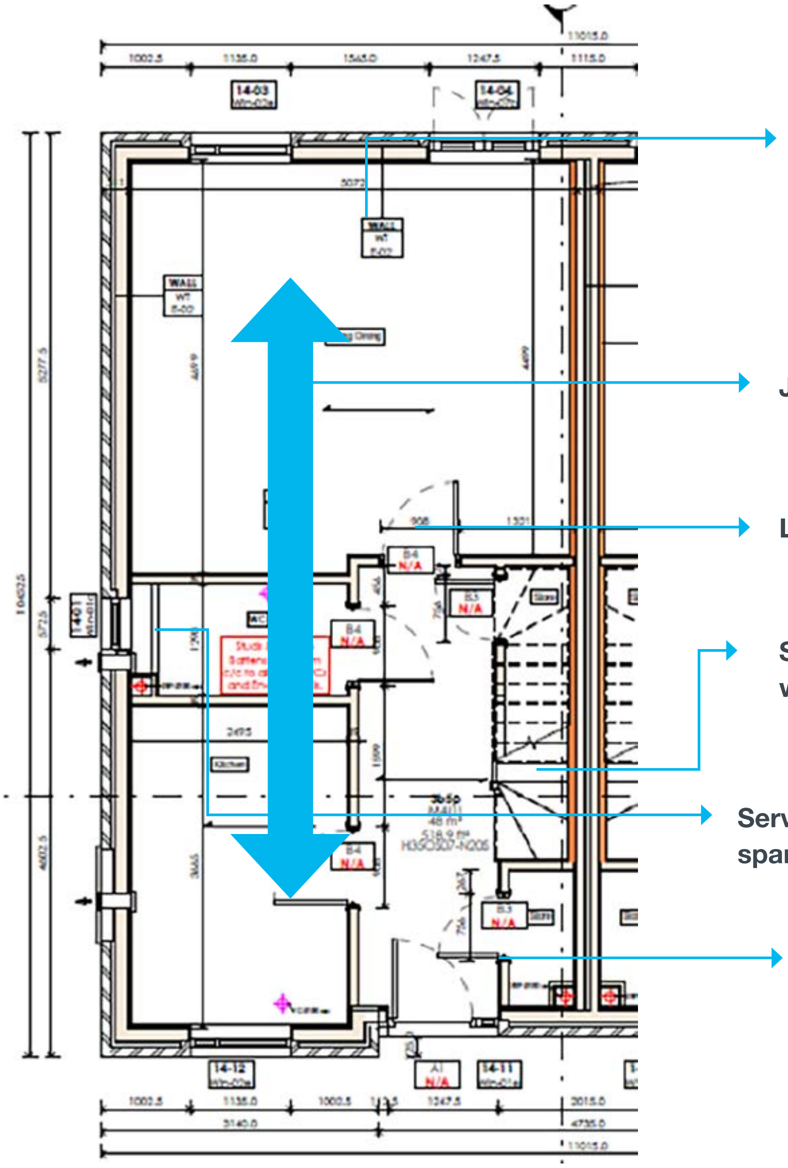
It may be a requirement to incorporate small lengths of services into the design and passing through one or two joists using these types of product, however avoid when possible.

The building designer will understand the services strategy to help with decision making or may take specialist advice where appropriate. There will normally be different ways to design the services around the timber frame, or vice versa, and to some extent this becomes an interactive process between the design team to establish the best solution.



Housebuilders may generate services schematics, like the diagram on the left, to illustrate what is going to be designed and built, and to help integrate all the trades. Increased use of BIM techniques can take this type of integration to a more digitalised level.

The following diagrams are examples indicating the implications of what has been described on different house type designs.



Area of external wall provides racking resistance (front and rear of house)

Joist spans length of house

Load bearing and racking wall

Stairwell positioned parallel with joist spans

Services run parallel with joist span

Simple stairwell trimming

In this example the central wall is used as load bearing and will offer an efficient joist design spanning front to back. This same internal wall offers racking resistance and in conjunction with the front and back walls provides enough overall building stability.

The stairwell aperture and SVP pipe routes run perpendicular with the joist span meaning no additional trimming is necessary. Ideally any extract ventilation routes will run front to back, although in this instance the kitchen extract is located on the gable wall which can be readily accommodated.

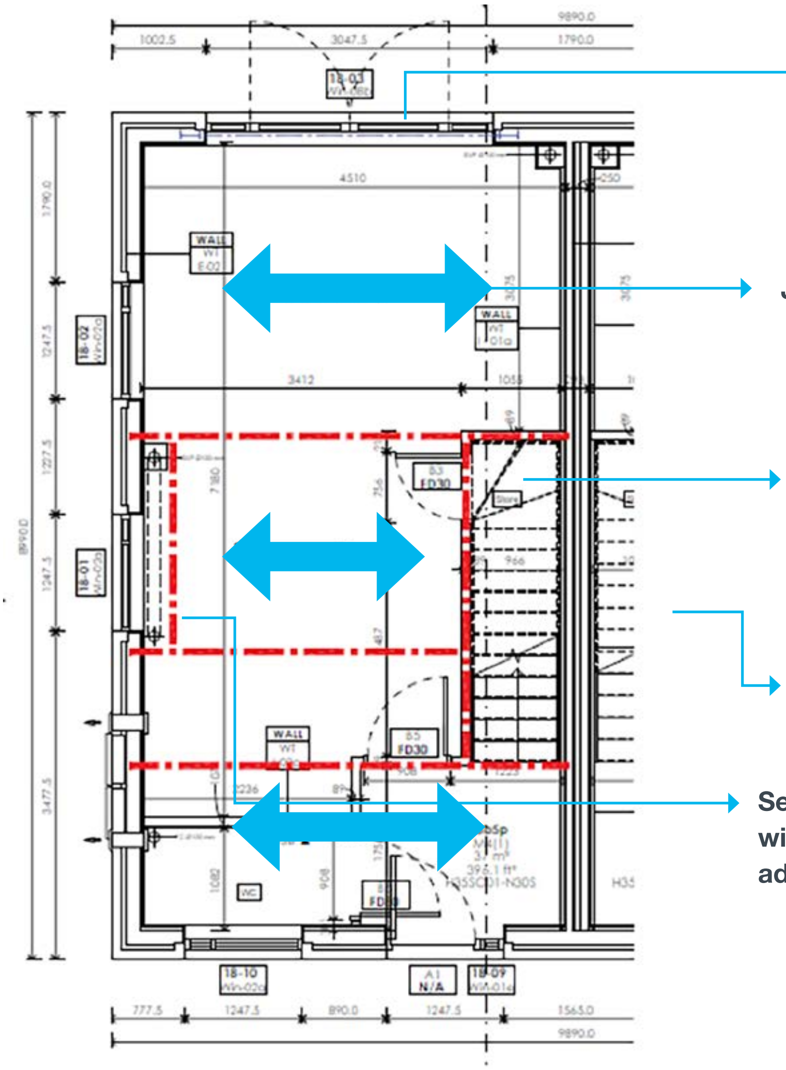
One of the main considerations the building designer will give to floor panel widths is the stairwell design, ideally the long dimension of the stairwell aperture will be orientated parallel with the floor joist spans.

Design of pipe routes should also be considered to locate the main services parallel to the floor joists e.g. SVP routes, ventilation etc. Generally, there is more flexibility to electrical wiring and small diameter plumbing, provided joist centres have been considered. See section 11 for further information on services integration.

The maximum width of individual floor panels will generally be influenced by transportation widths and decided by the timber frame manufacturer. Currently any panel in excess of 2.9m wide requires police notification to transport to site and will be avoided if possible.

The principles adopted within this example result in an efficient timber frame design and manufacture.

The following example shows some of the challenges associated with joists spanning the short direction, large openings to external walls, open plan design and service / stair voids spanning perpendicular to the joist span direction.



No external or internal racking walls results in introduction of steel racking frame

Joists span side to side

Stairwell aperture perpendicular with joist span direction results in heavy floor trimming

Stairwell void perpendicular to joist leads to wide floor panel

Services void perpendicular with joist span results in additional floor trimming

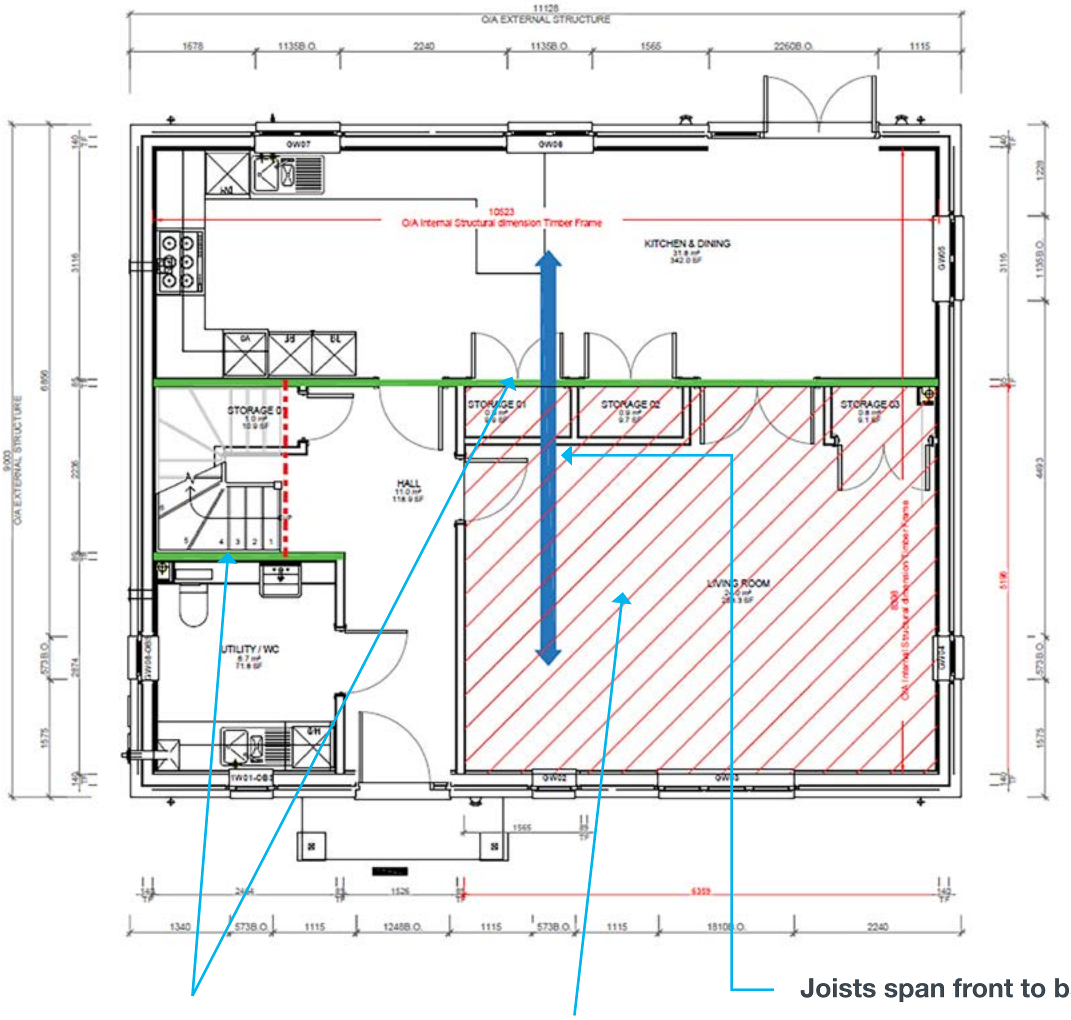
In this example house type layout, there are minimal internal walls which can be used for load bearing or racking purposes, and the front / back external walls have door / window openings meaning overall limited availability for racking within the timber frame element. In this instance the racking resistance can only be achieved by the introduction of a steel racking frame within the rear wall panel.

You can see with both the stairwell aperture and SVP void running perpendicular to the floor joist span there is added complication with trimmers in the floor joist structure.

Where multiple trimmers are included as illustrated in this example there is also the issue of cumulative deflection in the floor joists to consider. This is experience when a joist is supported on a trimmer which is already subject to deflection, and subsequently requires some careful design considerations to avoid an un-even floor.

Cumulative deflection is further explained in Section 7, but this issue is best avoided where possible.

Example detached House.



Joists span front to back

Load bearing and racking wall provides support to floor joists and stair trimmer

Maximum joist spans are to be considered to large open span areas (shown shaded)

The above shows an example ground floor layout to a detached house. In this example there is a continuous load bearing wall through the centre of the house which is ideal for supporting the floor joists and providing racking stability to the building.

Joists all span in one direction which allows good optimisation of floor panels. Any service runs will ideally run front to back between the floor joists to avoid pockets in the joists. The extract ducts shown at the kitchen and Utility in this example are located close to the gable wall and do not cut through joists, therefore can be readily accommodated.

The larger open area, indicated hatched, should be considered to ensure that the span of the joists is not greater than what can be achieved. Closer joists centres will be required in this area or if the dimensions cannot be minimised deeper joists may be required.

Whilst it is recognised that it may not always be possible, the building design should consider where changes of joist span directions occur to ensure that floor panels can be set out for ease of manufacture and that any future maintenance issues are minimise.

Storey Rod Heights

Storey rods are a vertical section through your building. These are drawn to detail wall heights, floor depths, window and door head & cill heights, roof eaves setting out and pitch and the timber frame settlement allowances at each level.

When detailing building heights, there are various factors to consider, including:

- Standard wall panel heights
- Standard plasterboard sizes
- Standard window heights and sizes
- Standard Door Sizes
- Provision for wall panel lintels
- Floor build ups
- Stair sizes and headroom
- External cladding – Brick / Block coursing or cladding systems
- Interaction between timber frame and external cladding (settlement)

Standardising vertical sections in housing and flats, will help maintain constant floor to floor dimensions. Floor joist depths should also be kept uniform where possible with the joist span capacity adjusted by altering joist spacing or joist type.

One effective solution is to design the internal finished floor to ceiling sizes, to suit standardised plasterboard sheet sizes, this speeds up fitting on site, and the external OSB/Ply sheathing can be cut under factory conditions.

It will be good practice to set vertical heights to suit brick coursing, even if the building is to constructed using blockwork with a render finish or if a cladding system is to be adopted. Keeping this uniform height will allow the same timber frame structure to be adopted and generate the benefits described earlier, but with different external cladding systems.

Whilst it is not practical to illustrate every potential storey rod section within this document for different manufacturers and joists depths or architectural requirements, the benefits described can usually be incorporated.

The storey rod development is inter linked with other decisions as the building design develops, including load bearing lines, joists depths, project specification, and should not be looked at in isolation. It is important to be aware that the timber frame supply chain can be consulted as described in Section 4: Sequence of Design to establish maximum benefit.

The following example storey rod illustrates the benefits described and is based on using 2.4m plasterboard internally and 235mm floor joists, summarised as follows:

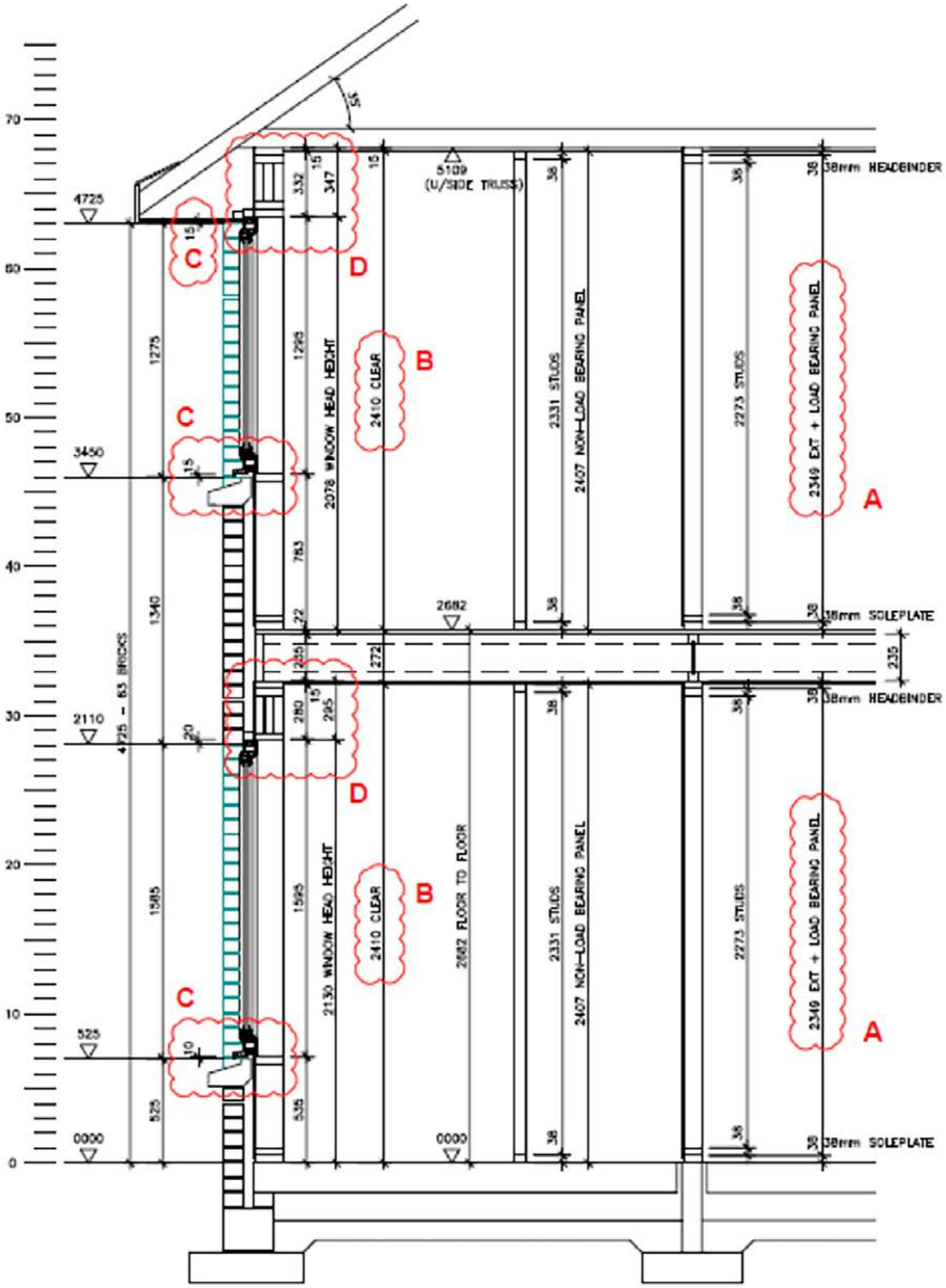
A – wall panel heights uniform between ground and first floor level, allowing for optimum manufacture.

B – internal clear height is maintained at 2410mm to allow the use of 2.4m boards without the requirement for site cutting to height, and in turn helps minimise waste.

C – allowance for differential movement. See section 12 for further information on differential movement.

D – Provision for lintels to door and window openings within the wall panels.

Example Storey Rod:

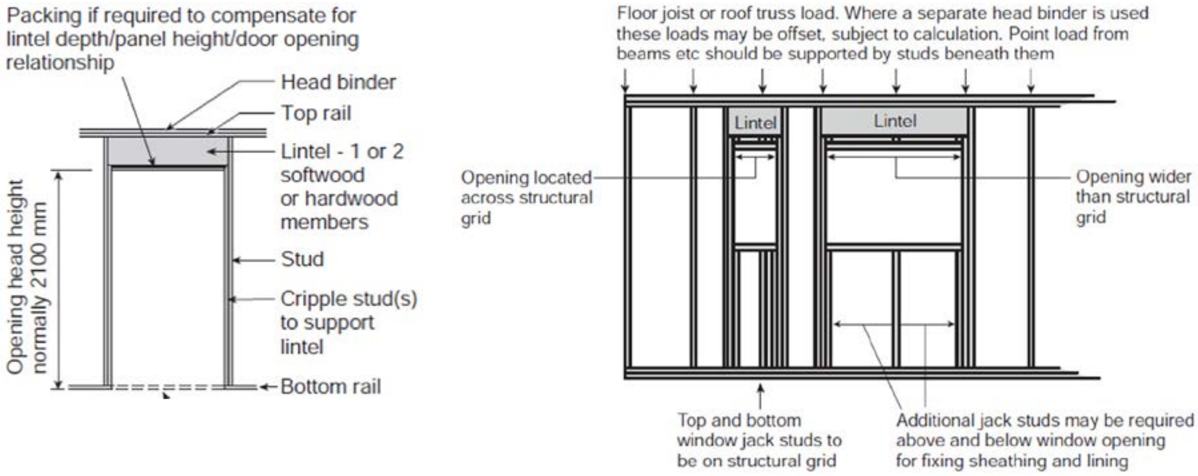


Wall Panel Lintels

Lintels are incorporated into the timber frame structure to transfer loads from the floor and roof above to either side of the window or door opening. Timber lintels are enough in the majority of domestic load applications.

The important point here is to allow enough space for structural lintels within the wall panels when determining storey rods, that is the distance between the window head and the underside of the floor joists. Minimum distance is shown later in this chapter.

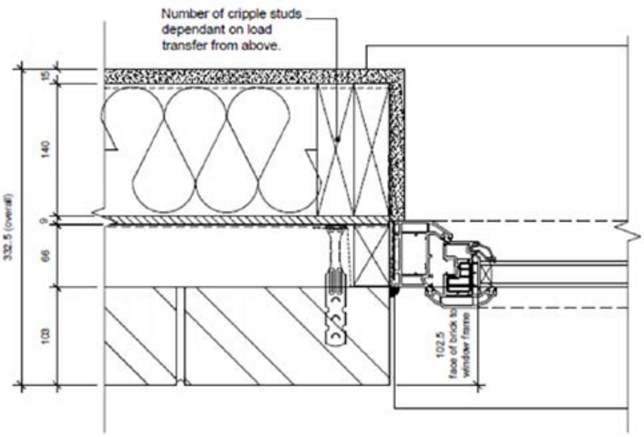
Lintels: This diagram shows timber lintels within the wall panels. Additional timber rails can be added below the structural lintel to achieve a preferred window or door head height.



The structural requirement of each lintel will likely not be known at this stage of the building design, and different manufacturers have preferred products, however if enough allowance is incorporated into the storey rod, most opening widths in a typical domestic property can have a timber lintel contained within the wall panel. There are different strength grades, depths and widths of timber products available in the market, allowing the structural engineer to engineer accordingly to the depths provided. Typically, these can range between 140mm to 300mm deep.

The engineer can be briefed to design either the minimum structural requirement for each individual opening or to check a preferred uniform size depending on individual manufacturers preferences. While it might seem sensible to always use the material of the smallest section size, there are other factors to be taken into consideration such as material procurement and production detailing. Manufacturers may adopt one lintel depth to satisfy the structural requirement of all openings.

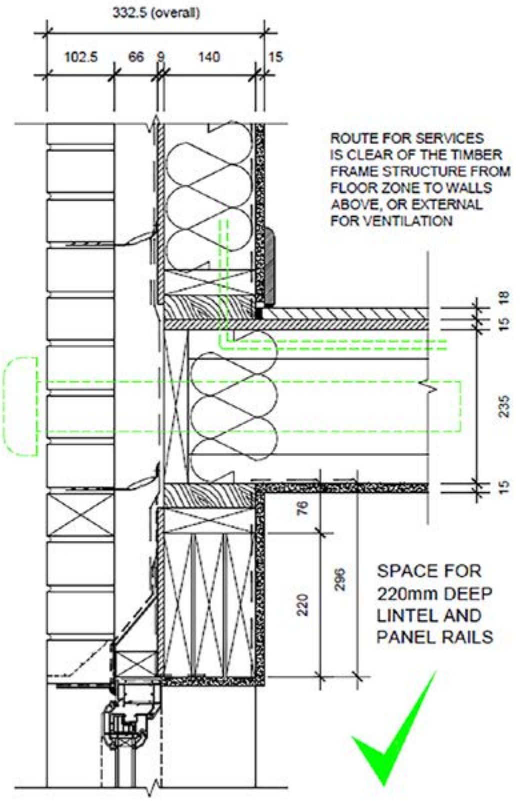
The number of cripple studs required to support the lintel will be determined by the loads which are to be transferred from above. There is normally a minimum of 2 No studs at this location, primarily for detailing purposes, but this can easily be increased by the timber frame manufacturer.



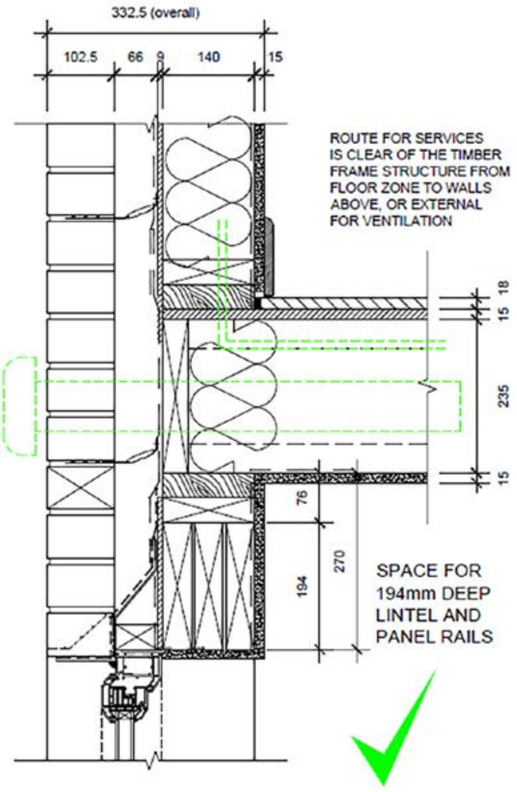
Example Window Jam Detail

The following illustrations show room for 220mm and 194mm deep lintels, which will cover most window widths and load conditions. This detail shows a relatively straight forward arrangement for the walls and floors and, importantly also provides routes for services to travel within the floor zone into the wall panel above, or through to the external face. These must be drilled through the timber frame within accepted tolerances. Separate info is available from suppliers on this topic.

The 220mm option is in alignment with the storey rod section described earlier, while 194mm provides an alternative for different windows, building heights, joists depths etc.

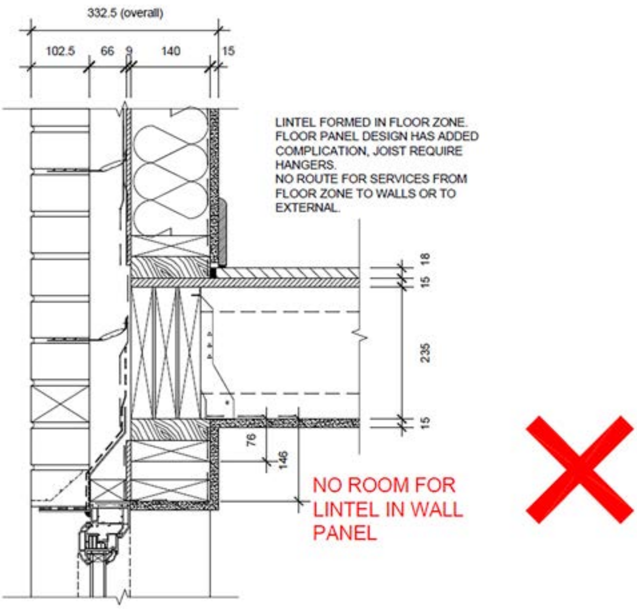


220mm lintel within wall panel



194mm lintel within wall panel.

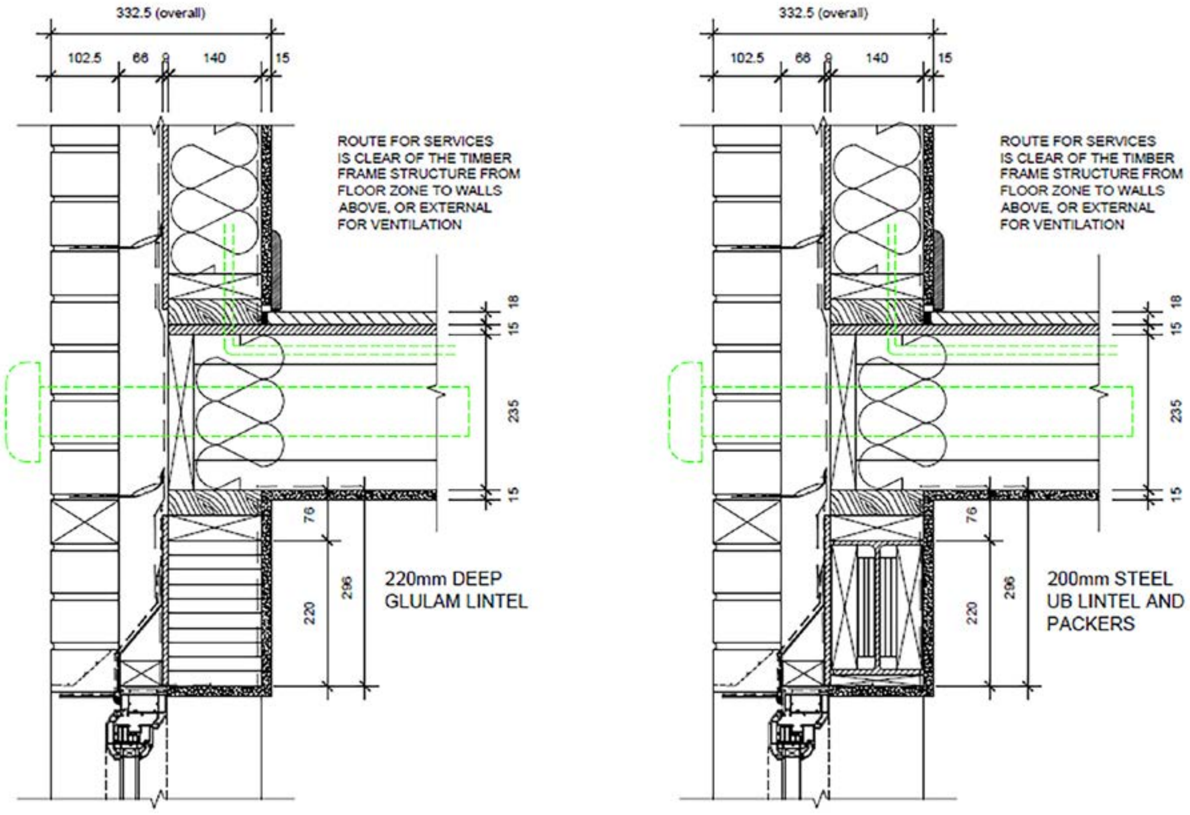
The following diagram shows a similar detail but with no room for the lintel in the wall panel, therefore it must be moved into the floor zone. While structurally possible this leads to difficult floor panel detailing, introduces the requirement for joist hangers, and constricts the available routes for services. This type of detailing should be avoided wherever possible.



Whilst acknowledged earlier in this chapter that the exact structural requirements may not be know at this stage of the building design development, if the designer can adopt these principles it gives the engineer options for using different structural products on wider openings should timber not be sufficient.

For example, if there is a large sliding wide patio door or combination door / window which carries load from the floor, roof or windows above, the engineer can specify the use of glulam or laminated stand products in lieu of timber. In extreme cases where heavily loaded a steel beam can be inserted in lieu of the 220mm lintel. This is not possible if there is no room left between the window head and underside of the floor zone.

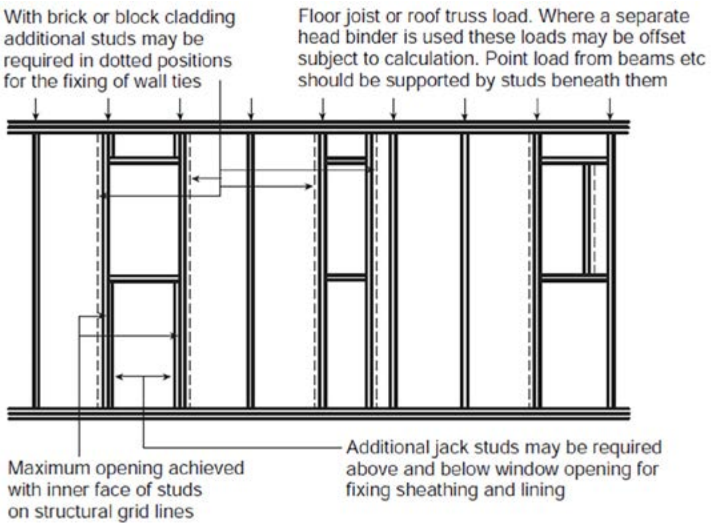
Example: Glulam and Steel Beam options.

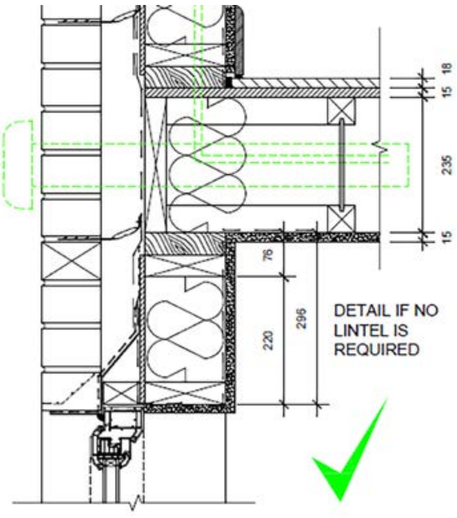


Where possible the use of more expensive products will be avoided. The purpose of this illustration is to demonstrate that the use of preferred storey rod heights, which make allowance for lintel depths within the wall, will give the structural engineer the flexibility to design most scenarios without compromising floor panel and services designs.

There are normally some openings within a house which do not require lintels, for example openings in gable walls may have no floor or roof loads. The timber frame manufacturer can take account of these situations and omit the structural lintel where appropriate. The architectural design will normally have windows set at the same height around the building which is preferred for manufacturing.

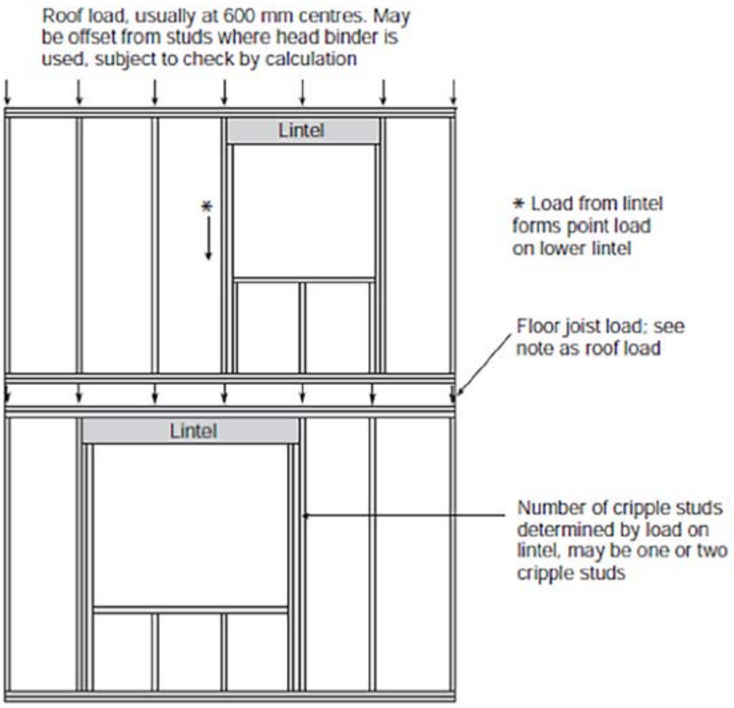
Diagram: No structural Lintel





Staggered window openings at different floor levels or point loads from above can result in lintels to the lower floor openings being more heavily loaded. The structural engineer will determine the requirements by calculation. Whilst not always possible, if there is an opportunity to align the position of windows between floor levels then this should be done. The more important factor is to make sure the storey rod and window head heights make allowance for lintels in the wall panels.

Staggered Window Diagram:



Stair Design

There are numerous different stair designs, detailing and specifications which may be specified on a project. As with the manufacture of most products there are benefits which come from maintaining standard dimensions for stair flights, including heights, widths, riser / going etc.

A separate AIMCH project has been undertaken on “standardisation” of stair designs and can be referred to for further information. This will set out the basic sizes to adopt into the overall house design and will influence how the stairwell aperture is integrated into the timber frame.

It is important not to move away from these pre-defined sizes otherwise we lose the benefits of standardisation and return to bespoke design and manufacture.

Building regulations requirements are not covered within this document. It is normal that the building designer will understand these relative to the governing body for each area of the UK and design the building accordingly.

Example Stair Configurations:

STRAIGHT FLIGHT

- Most cost effective stair type
- Usually positioned against a wall on one side, but can be either between walls, or set in middle of hallway with handrail on both sides
- Suitable for narrow, deep houses
- Suitable for commercial projects / communal stairwells in apartments

SINGLE WINDER

- Used where access at either top or bottom is perpendicular to the stair
- Used where space is a premium
- Usually positioned against a wall on one side
- Winder section can be at top or bottom of stair or in the middle for a corner application.
- Not suitable for commercial projects / communal stairwells in apartments

HALF LANDING

- Cost effective way to form stair when long narrow space is not available
- Installed between walls on either side
- Mid landing would be part of the structure as opposed to the stair
- Suitable for commercial projects / communal stairwells in apartments

DOUBLE WINDER

- Used where access at both top and bottom is perpendicular to the stair
- Used where space is a premium
- Usually positioned against a wall on one side
- Not suitable for commercial projects / communal stairwells in apartments

QUARTER LANDING

- Another cost effective way to form a stair, where space is a premium
- Installed between walls on either side
- Suitable for commercial projects / communal stairwells in apartments
- Work well in split level houses types, with access off landings

TRIPLE WINDER

- Used on very small units, where floor space is very limited
- Alternate option to pre-formed spiral stairs
- Would be fixed in corner of a building, with solid wall in middle for structural support

Once the stair design has been established for the house type i.e. straight flight, half landing, top winder etc the designer can start to consider how this is integrated into the timber frame structure.

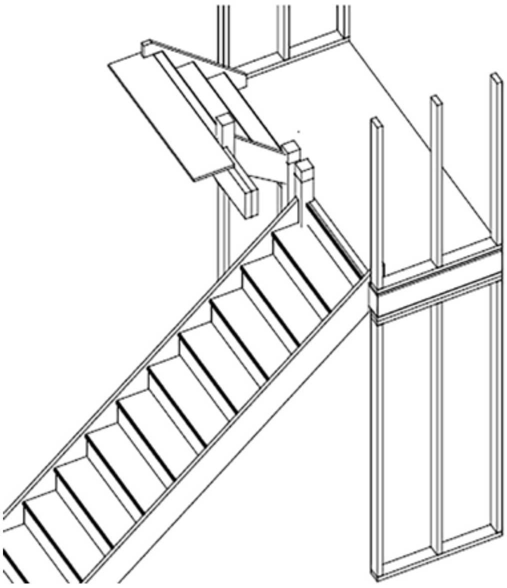
We discussed earlier in this document the principles of best practice regarding how to set-out floor span directions in relation to the stair void, and the support of associated stair void trimmers.

Other considerations include support of half or quarter landings, fixing details, headroom and integration of any nearby services.

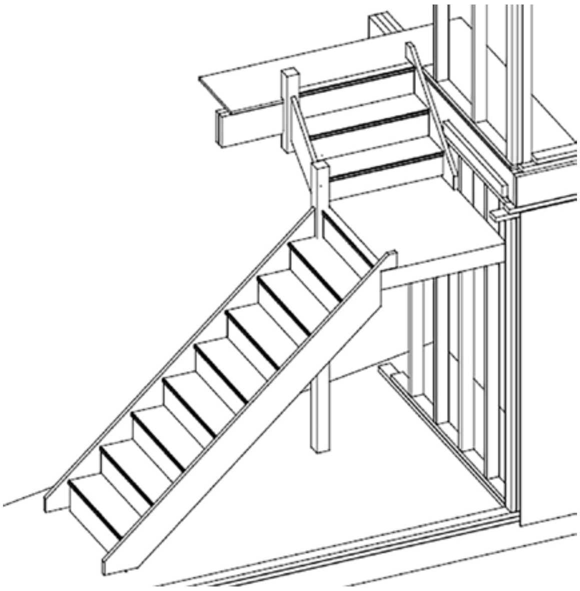
Support of Landings

Half landings by their design will have walls either side, and are used to support the landing joists, in turn means these walls become load bearing, while quarter landings can be supported on adjacent walls and full height structural newel posts.

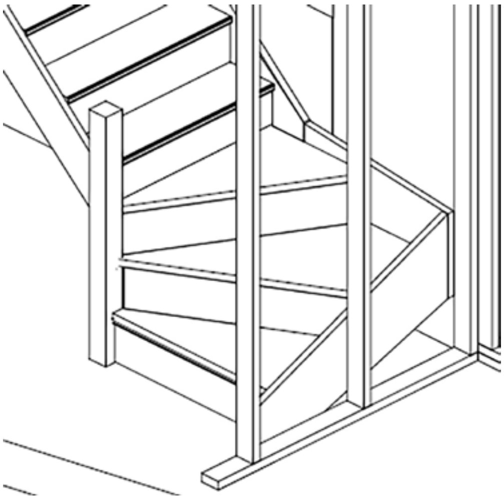
Winders are part of the stairwell carcass and are supported via the surrounding walls and newel posts, either off the ground floor structure for a bottom winder or fixed to the mid floor joist platform for a top winder.



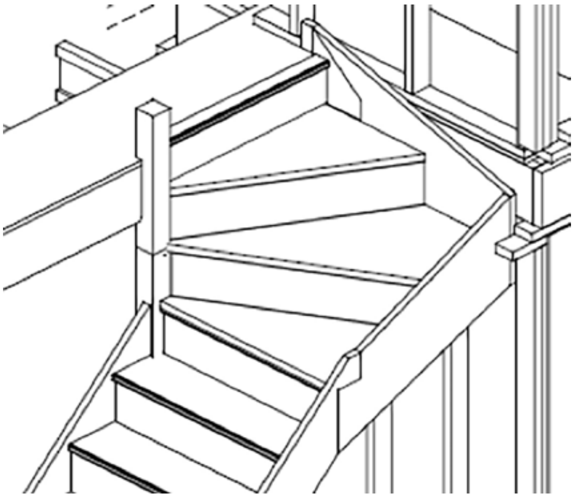
Half Landing: Support on adjacent Walls



Quarter Landing: Support on Newel Post and Walls



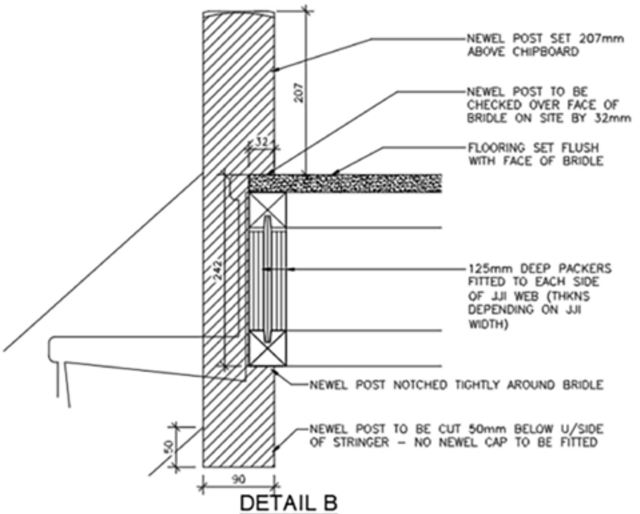
Bottom Winder: Newel Post on slab



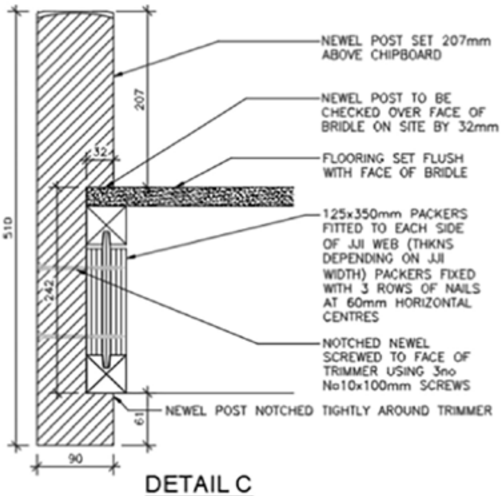
Top Winder: Newel Post on Trimmer

Newel post sizes can vary on size and specification depending on the supplier, but the basic principles of support are the same. The newel post will be notched to form a fixing joint over the floor structure. Refer to individual manufacturer's technical literature for further information on dimensions and fixings details.

Newel post detail at mid floor joists:



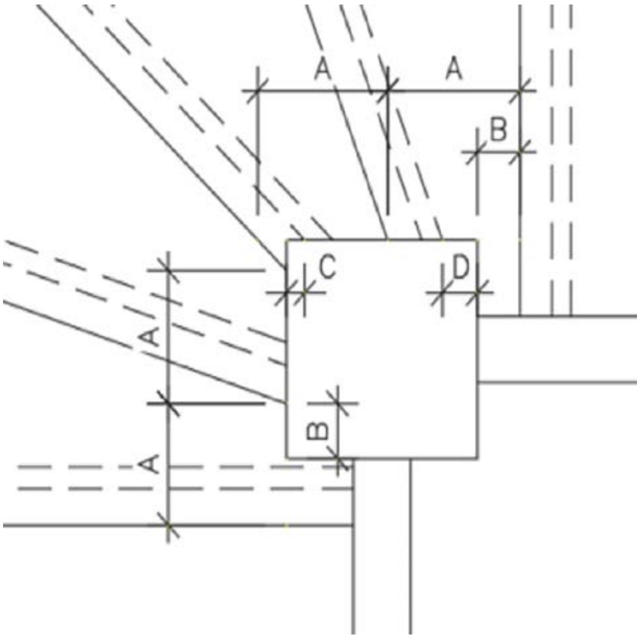
DETAIL B
NEWEL AT TOP OF STAIR/BRIDLE



DETAIL C
NEWEL POST AT LANDING BALUSTRADE

There are important dimensions around the newel post e.g. 50mm minimum tread width at narrow end, and preferred manufacture sizes. It is important not to change these minimum dimensions in order to save space, instead look to change the room dimensions. Refer to separate AIMCH Standardisation of Stairs which provides pre-defined stair module sizes.

Good practice setting out of goings and risers around a newel post at the narrow end is illustrated as follows. Dimension A shows the minimum tread width requirement, while dimensions B, C and D are preferred sizes for manufacturing and finish. These dimensions B, C and D will vary between manufacturers depending on their equipment but expect the principles to be similar.



A = 50mm minimum tread width at narrow end.

B = 20mm minimum, this is not a technical requirement, but is good practice for manufacture and finish

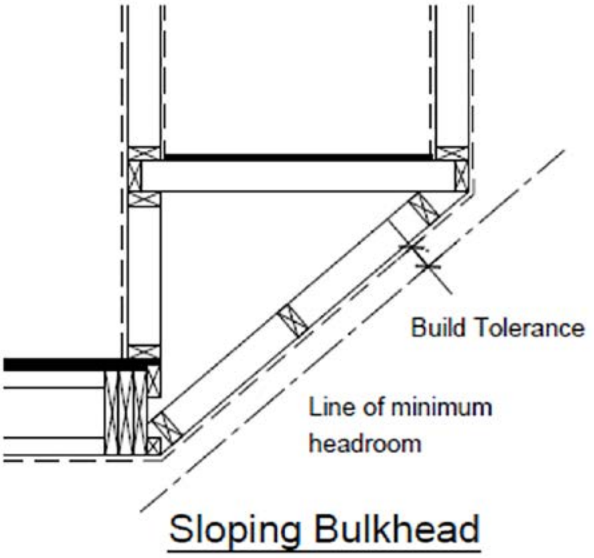
C = 10mm minimum, this is not a technical requirement, but is good practice for manufacture and finish

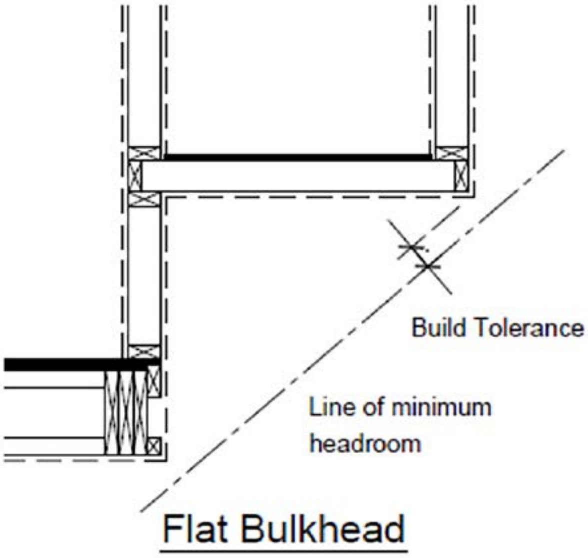
D = 15mm Minimum, a this is not a technical requirement, but is good practice for manufacture and finish

Headroom

A basic requirement of regulations is minimum headroom to the stairs which designers will be aware of. It is not uncommon for a store cupboard to be located above the stairs and there are different shapes and sizes adopted depending on the availability of space.

Example shows sloping and flat bulkhead options. These will be set out to suit the house geometry and taking account of adjacent room sizes as well as headroom, and vary between different house types, therefore no set size for these.

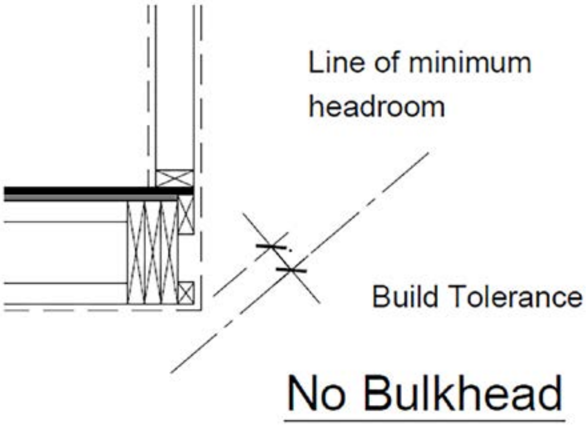




If possible do not locate hot water cylinders above the bulkhead as this will be a concentration of weight and there may not have easy pipe routes away from this cupboard.

Also consider allowing enough build tolerance to the minimum height requirement, 75-100mm may be considered a prudent allowance.

There are house types which do not contain any bulkhead and for these only minimum headroom requirements should be considered.



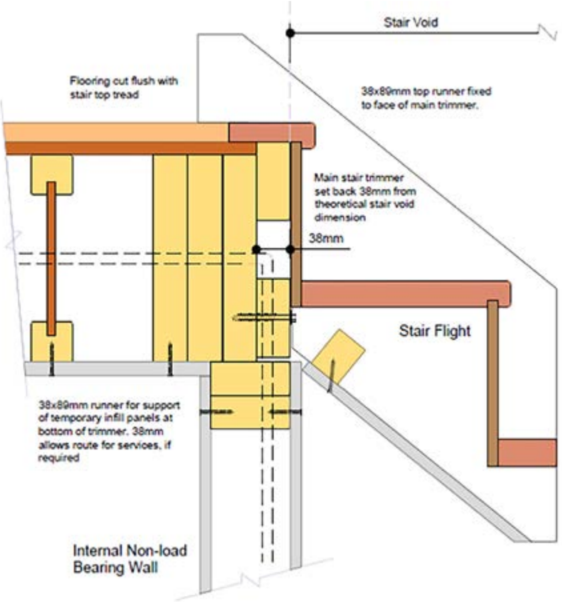
Services Below Stairs

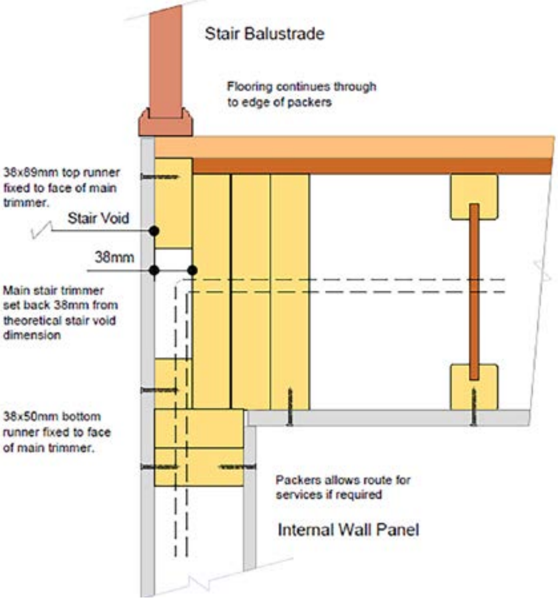
It is not un-common for services to be located close to the stairs, for example, electrical switch boards may be located within cupboards under the stair and hot water cylinder in cupboards above the stair, therefore access and exit points for these services should be considered.

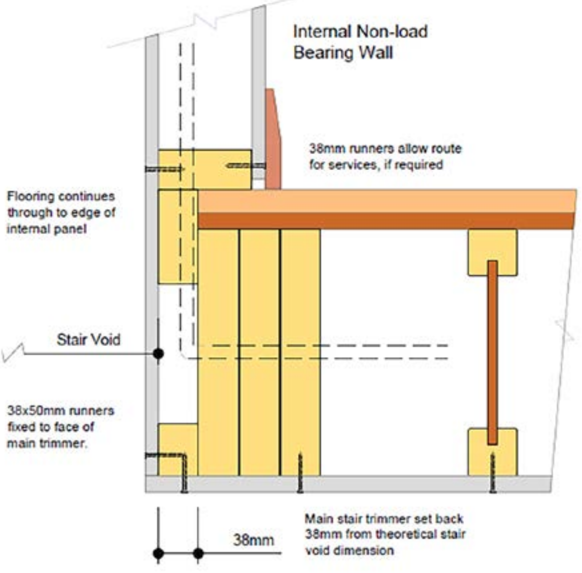
Provided the services routes are known the timber frame design details can incorporate allowances for service routes into walls above and below by moving the main trimmers.

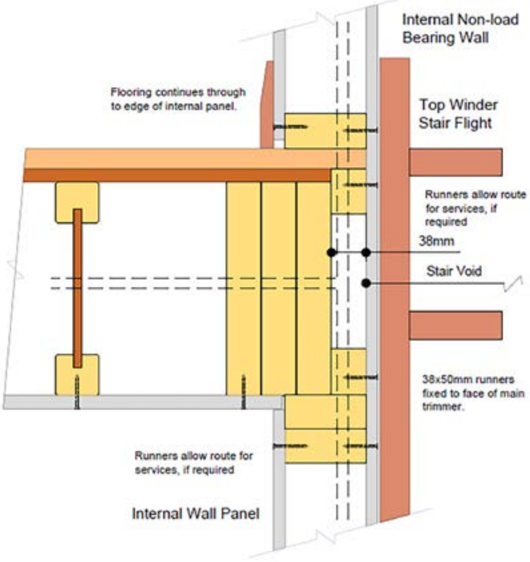
The basic principle of this detailing is to provide additional timber packers to the face of the main structural trimmer. These packers can be drilled easily to allow services to travel vertically into walls above or below, while the main structural trimmer remains intact. The services can be drilled through the centre height of the main trimmer if you remain within allowable drilling zones.

Example details









Summary

The following section is representative of a typical 2 storey house showing references to the topics covered within this chapter.

A: Provision for Racking Stability - Enough wall area is provided on external walls to front and rear of house, and via the inclusion of an internal load bearing wall.

B: Joist Span – Floor joists span front to back offering large panel manufacture and are supported on mid span load bearing wall.

C: Load Bearing Wall – Load bearing wall at approx. mid span is dual purpose, providing racking capacity and load bearing support to floor joists.

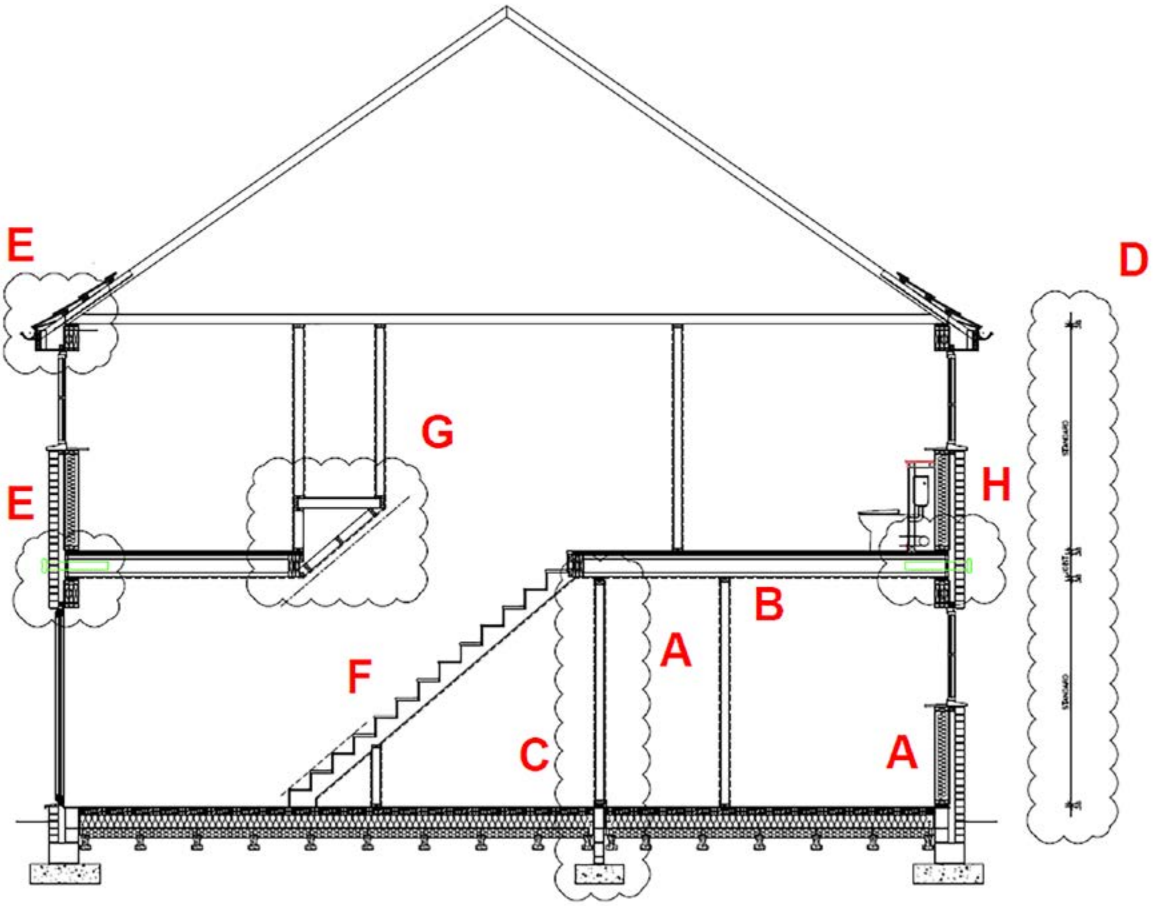
D: Storey Rod – The building is set out to uniform wall panel heights, and to reflect standard plasterboard sizes internally.

E: Lintels – Window head heights are set to allow lintels to be manufactured within the wall panels, allowing for optimum manufacture and keeping floor zone clear for services.

F: Stairs – Stairwell designed parallel with floor joist span, sizes adopted from the Standardisation of Stairs project, and consider support of winder flights or landings.

G: Stair Bulkhead – Designed to suit house type layout, but consideration to minimum head heights and support of store above.

H: Services – Designed in conjunction with the timber frame structure, including routes parallel with floor joist spans or above floors within bathroom units.



DIFFERENTIAL MOVEMENT

What is it?

Differential Movement is the name given to the reduction in height of a Timber Frame building over the first two years of use. The term also relates to any Brickwork Expansion that may occur, and in doing so the term refers to all aspects concerning the movement of building elements in a Timber Frame structure.

Why does it happen?

Differential Movement happens when the building has load applied to it, which means in some cases you may see Differential Movement from the point of roof tiles and plasterboard being added to the structure. Differential Movement also happens when the moisture content of the timber reduces, by good airflow during construction and by central heating once constructed.

Where does it happen?

Differential Movement occurs almost entirely in cross grain timbers (also known as horizontal timbers) these can be, but are not limited to, Soleplate, Bottom Rail, Top Rail, Head binder, Joists and Floor Decking. See fig 1.

Note that the shortening of vertical studs is negligible.

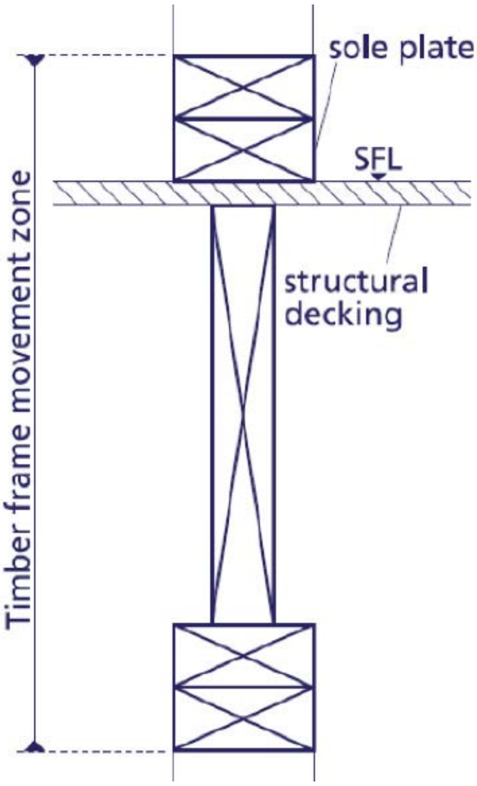


Fig 1, cross grain members in a Timber Frame structure

How and When does it happen?

There are four recognised stages to Differential Movement:

- Reduction in the moisture content of the timber (which will occur gradually over as much as the first two years)
- Load Applied to the building (this occurs during the build process and is complete at the end of the construction period)
- Compression of studs under load (Which is a minor movement and will occur gradually over as much as the first two years)
- Brickwork Expansion (changes in temperature, moisture expansion, elastic deformation & settlement)

How should you design for Differential Movement?

Load Applied to the Building

The movement related to load being applied to the building is the first stage of Differential Movement to occur. As the Timber Frame is constructed there will be small gaps between the members (Fig 2) meaning that the building is initially taller than designed. As more load is applied to the structure, these gaps will reduce. This brings the Timber Frame structure back in line with the design (Fig 3).

Because the result of this phase of Differential Movement is for the structure to return to the designed size, there is no need to account for this phase of Differential Movement in the design.

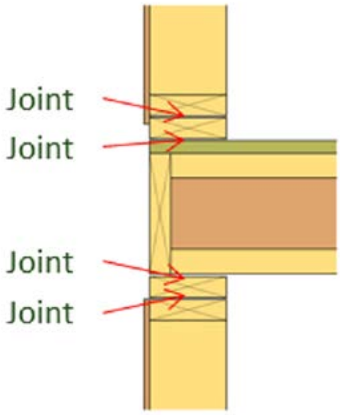


Fig 2, Gaps between members before Timber Frame is loaded

Compression of studs under load

This refers to the continued dimensional accuracy of the vertical timbers (studs), the change to the structure due to this alone is negligible.

Because the result of this phase of Differential Movement is negligible, there is no need to account for this phase of Differential Movement in the design.

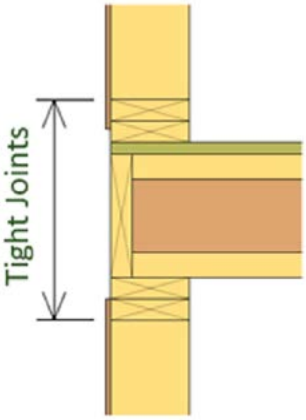
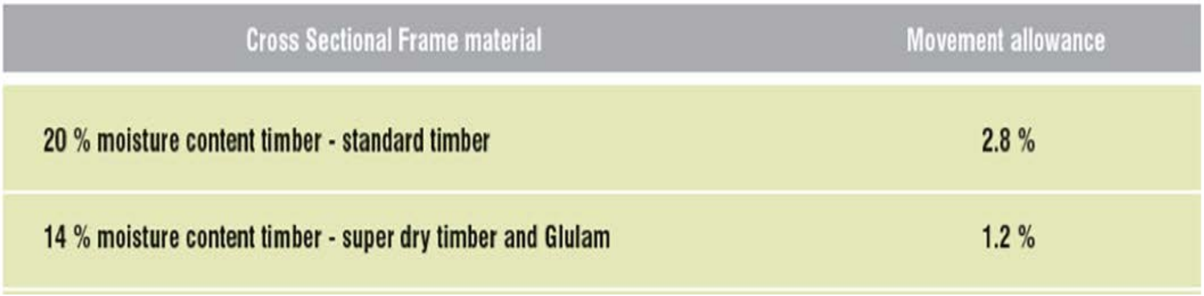


Fig 3, Gaps between members remove d once Timber Frame is loaded

Reduction in the moisture content of the timber

Timber Frame should have a moisture content of 20% or less at the point the plasterboard is installed. Over the course of two years (that is, two 'central heating seasons') the timber will dry out to around 10-13% moisture content. This results in Differential Movement as the timbers change in cross-sectional size, the vast majority of this movement will occur in the zone noted in Fig 1.

As we know the starting moisture content, and the end moisture content, it is possible to put figures to this movement, see Fig 4.



Cross Sectional Frame material	Movement allowance
20 % moisture content timber - standard timber	2.8 %
14 % moisture content timber - super dry timber and Glulam	1.2 %

Fig 4, approximate movement allowance through the reduction in moisture content

This means that a 38mm horizontal timber should be expected to accrue approximately 1mm of Differential Movement. Whereas a 235mm Glulam timber should be expected to accrue approximately 2.5mm of Differential Movement.

Because the result of this phase of Differential Movement is significant, the design will need to account for this phase of Differential Movement. See pages 05-13 for examples of details to consider.

Brickwork Expansion

Dependent on the type of brick used, it is possible for a brick to still be 'growing' many years after leaving the kiln. Using clay bricks as an example, this can be from 0.3mm per meter to 1.6mm per meter, though general bricks tend to have a more stable range over the years. The production method, temperature and moisture content tend to have the largest impact on brickwork expansion.

How much Differential Movement to calculate?

Considering all the above, we can now design for Differential Movement. A 'normal' mid-floor zone will look like the one shown in Fig1, 2 & 3. The below is based on those examples. The specification of each project may differ though, and this calculation should be project specific.

We expect the 4No 38mm horizontal timbers to reduce in size by approx.1mm each.

We expect the 1No 235mm Glulam floor timber to reduce in size by approx. 2.5mm.

We also know to expect approx. 1mm of brickwork expansion per storey.

In the Fig 1, 2 & 3 the movement of the Timber Frame compared to the brickwork will be approx. 7mm.

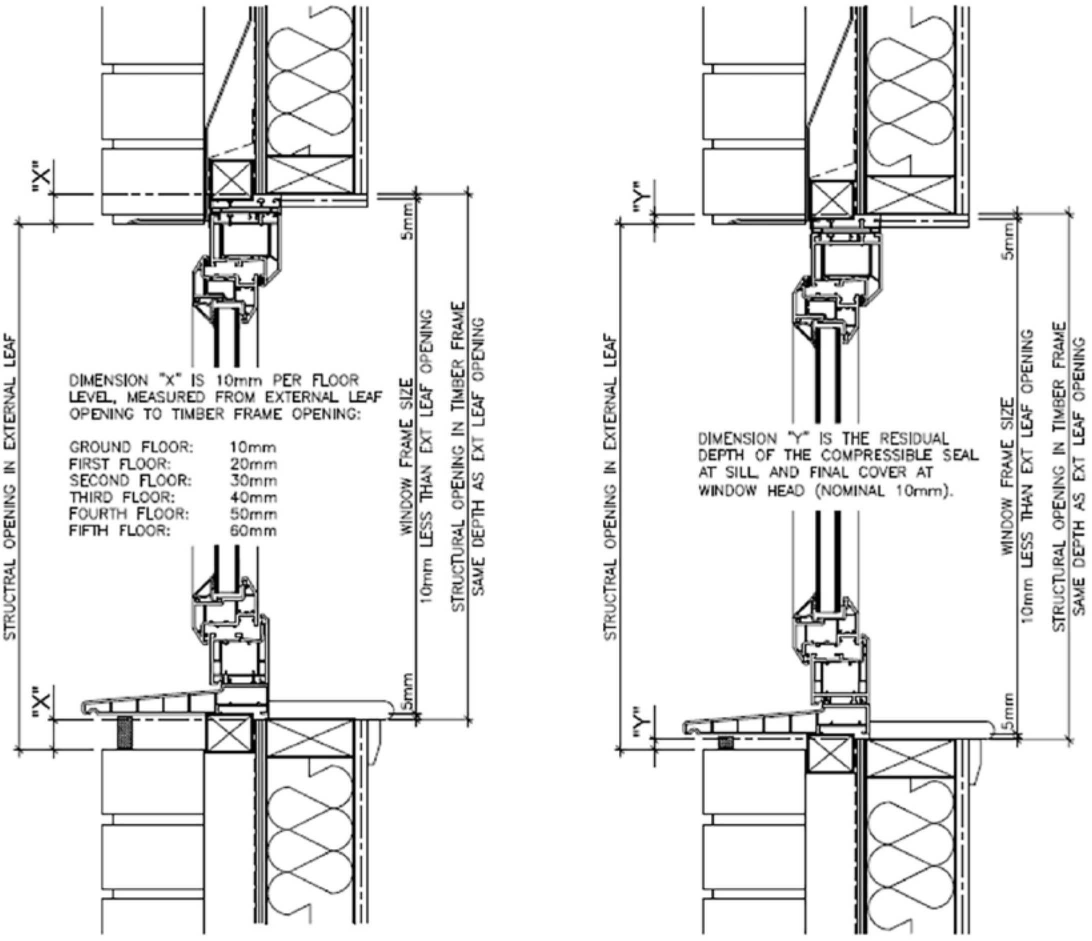
If the above example (7mm movement) were to use a compressible seal which had a residual depth of 3mm, then 10mm Differential Movement should be designed per storey.

IMPORTANT NOTE: When considering Differential Movement, there should also be consideration to the residual depth of any compressible seals. That is, a compressible seal cannot compress to 0mm thickness, therefore an additional measurement should take this final dimension into account. Specific manufacturers datasheets should be referenced in this instance.

Window Cill and Head

When designing a Window detail for a Timber Frame building, be aware that the window frame should only be fixed to the Timber Frame. Meaning that it will move independently of the external façade.

Fig5, Differential Movement when window frames are behind brickwork



DIMENSION "X" IS 10mm PER FLOOR LEVEL, MEASURED FROM EXTERNAL LEAF OPENING TO TIMBER FRAME OPENING:

GROUND FLOOR:	10mm
FIRST FLOOR:	20mm
SECOND FLOOR:	30mm
THIRD FLOOR:	40mm
FOURTH FLOOR:	50mm
FIFTH FLOOR:	60mm

DIMENSION "Y" IS THE RESIDUAL DEPTH OF THE COMPRESSIBLE SEAL AT SILL AND FINAL COVER AT WINDOW HEAD (NOMINAL 10mm).

VERTICAL SECTION
PRE-SETTLEMENT DETAIL

VERTICAL SECTION
POST-SETTLEMENT DETAIL

Note the cumulative dimensions per storey, a 10mm Differential Movement dimension on the ground floor would mean a 40mm Differential Movement dimension on the third floor.

To avoid confusion or abortive design works, it is worthwhile compiling a window and door opening schedule with at least the following identified for each aperture:

- **External Leaf structural opening size**
- **Timber Frame structural opening size**
- **Window Frame Size**

Note the cumulative dimensions per storey, a 10mm Differential Movement dimension on the ground floor would mean a 40mm Differential Movement dimension on the third floor.

Also Note, as the window frame is within the line of the brick, the window frame head must start flush with the brickwork structural opening (otherwise it would clash with the brick above). As the same Differential Movement applies, there will still be a 10mm requirement at the Cill. This means that on the ground floor the Timber Frame structural opening height will be 10mm LESS than the Brickwork Structural opening height. On the third floor, this would mean that the Timber Frame structural opening height will be 40mm LESS than the Brickwork Structural opening height.

Construction Detailing

Eaves

When designing an eaves detail for a Timber Frame building, be aware that the Fascia and soffit (if applicable) should only be fixed to the Timber Frame. Meaning they will move independently of the external façade.

Depending on client preference, the soffit can either stop short of the face of the brickwork to allow the brick to carry through (Fig 7) or the soffit can go back all the way to the Timber Frame, with the brickwork finishing below it (Fig 8). Both details require consideration for Differential Movement.

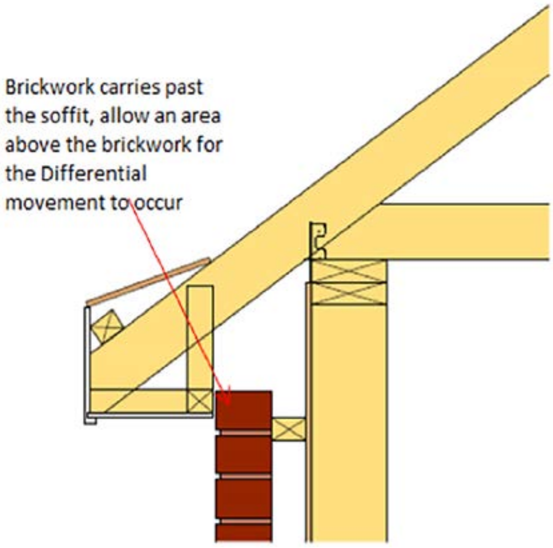


Fig 7, soffit to the face of the brickwork

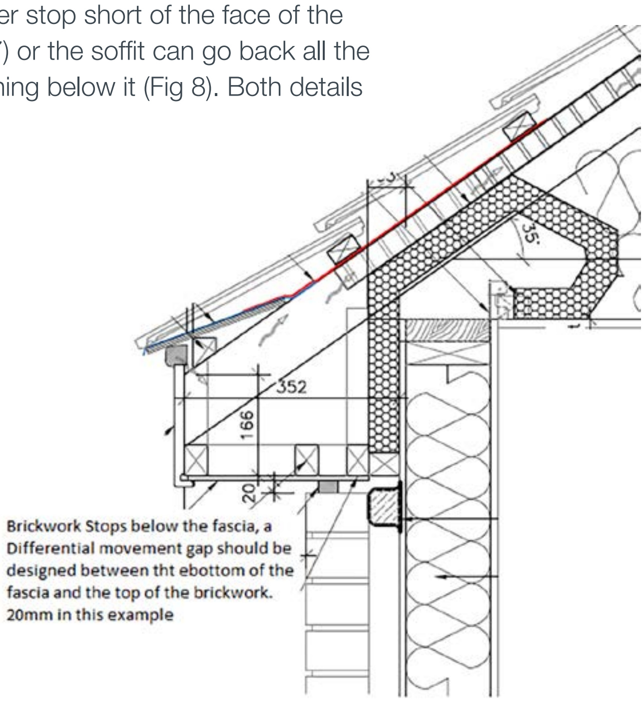


Fig 8, brickwork stops underneath the fascia

For windows, the amount of Differential Movement for the eaves detail increases dependant on how many stories of Timber Frame there are. Remember to count the horizontal timbers and to allow for the brickwork expansion and the residual depth of the compressible seal (if required)

Consider the sequence of installation for brickwork, soffit and any compressible seals.

Also Consider the detail over window heads, this will need its own eaves detail drawn.

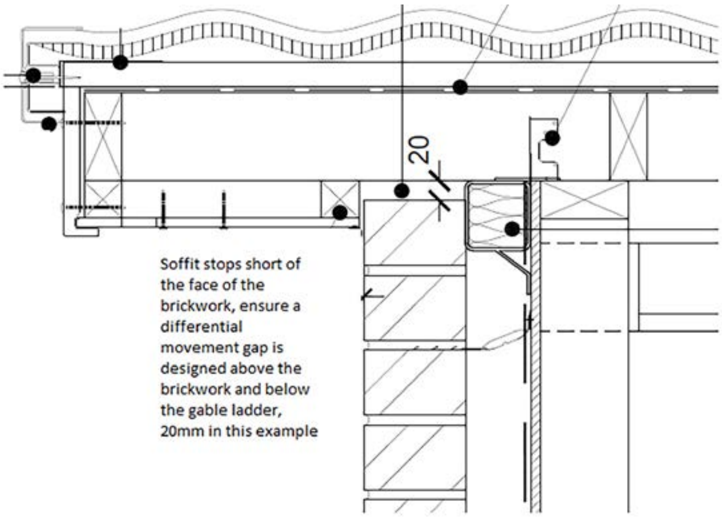
Verge

When designing a verge detail for a Timber Frame building, be aware that the Barge and soffit (if applicable) should only be fixed to the Timber Frame. Meaning they will move independently of the external façade.

Depending on client preference, the soffit can either stop short of the face of the brickwork to allow the brick to carry through (Fig 9) or the soffit can go back all the way to the Timber Frame, with the brickwork finishing below it (Fig 10). Both details require consideration for Differential Movement.

Consider the sequence of installation for brickwork, soffit and compressible seals.

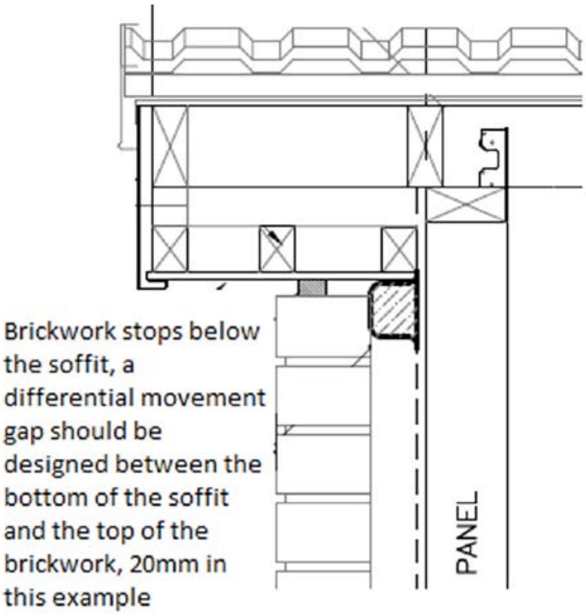
Also Consider if the detail requires cut bricks.



Soffit stops short of the face of the brickwork, ensure a differential movement gap is designed above the brickwork and below the gable ladder, 20mm in this example

Fig 9, soffit to the face of the brickwork

Similarly, to windows, the amount of Differential Movement for the verge detail increases dependant on how many stories of Timber Frame there are. Remember to count the horizontal timbers and to allow for the brickwork expansion and the residual depth of the compressible seal (if required)



Brickwork stops below the soffit, a differential movement gap should be designed between the bottom of the soffit and the top of the brickwork, 20mm in this example

Stairwells (up to 3 storeys)

A stairwell will typically allow the inhabitant to see the internal linings of both the ground floor and first floor on the same wall, any deviations between the two can be more noticeable here.

As the majority of the Differential Movement occurs at the mid-floor zone, it is possible to see plasterboards 'bulging' out at this location if they butt joint at the mid floor. (as Differential Movement occurs, the boards that are fixed to the studs above are pressed against the boards fixed to the studs below).

If boards are staggered in the outer layer over the mid-floor, as shown below in Fig 11, then the movement is significantly less noticeable. This staggering does not use any additional boards as the other outer board can be used above and below the staggered board (shown in red)

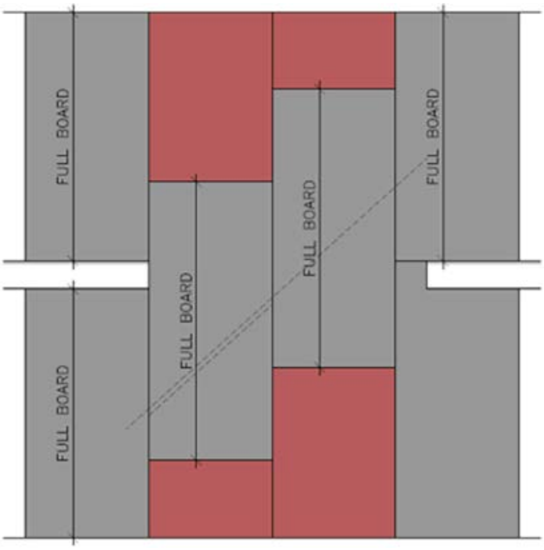


Fig 11, staggered outer boards at stairwells (2st and 2.5st)

Stairwells (3 storeys and over)

At stairwells of 3st and above, simply staggering the plasterboard will no longer work and as such a different detail should be considered. Below in Fig 12, the plasterboards are not staggered at the mid-floor zone, and instead a compressible gap is left, covered by an apron.

It is important that the apron is only fixed to either the upper, or lower plasterboard, and not both. This will ensure that the plasterboards can move with the Timber Frame without undue stress at the joint.

Be sure to use a pliable sealant / intumescent that can accommodate the movement. Ensure that the joint is present in both layers of plasterboard (if applicable)

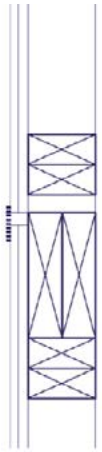
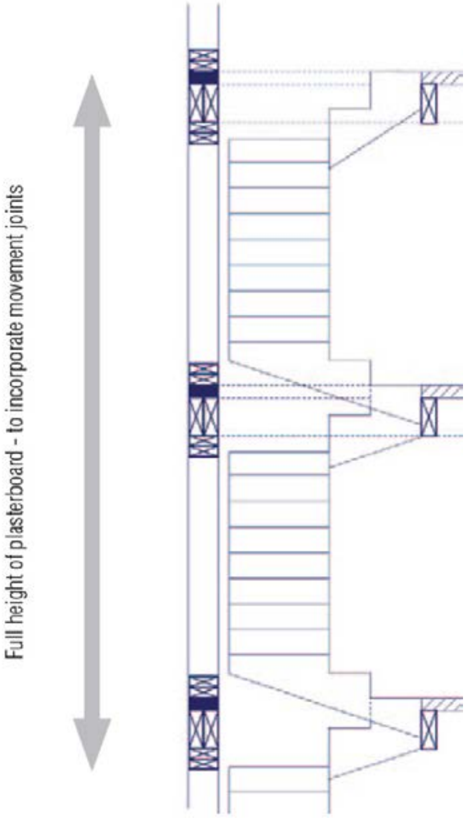


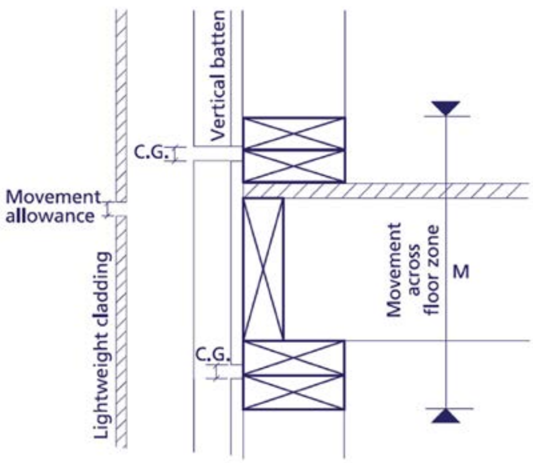
Fig 12, compressible movement gap and apron at stairwells (3st and over)

Unlike Windows, eaves and verge in brick clad buildings, the Differential Movement gap at the mid-floor for a lightweight external cladding will be the same on every floor. That is because it is the relationship between the Timber Frame and battens / cladding which are fixed to it and not the Timber Frame and the brickwork (which is independent)

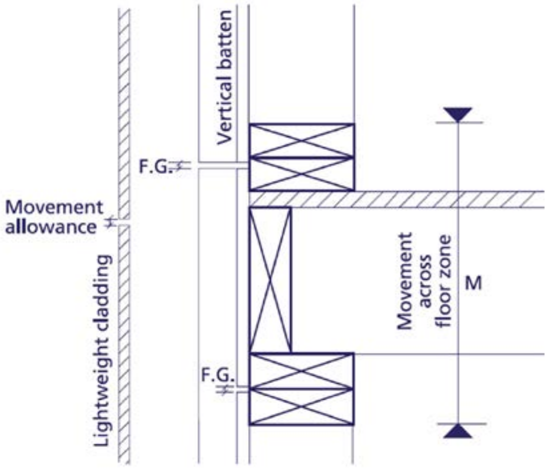


Lightweight Cladding at Mid- Floors

Where cladding is supported directly off the Timber Frame (usually on battens), then a joint is required at the mid-floor zones. Ensure that a sealing system is used that can accommodate the movement allowance.

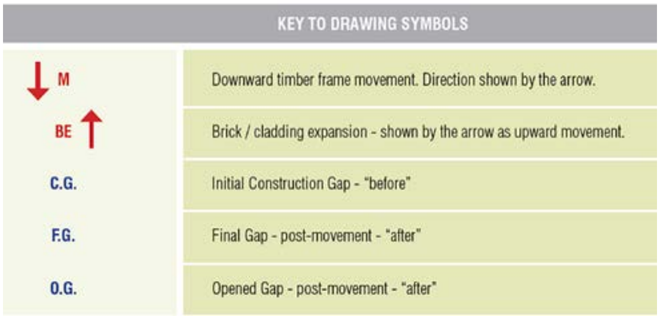


Before



After

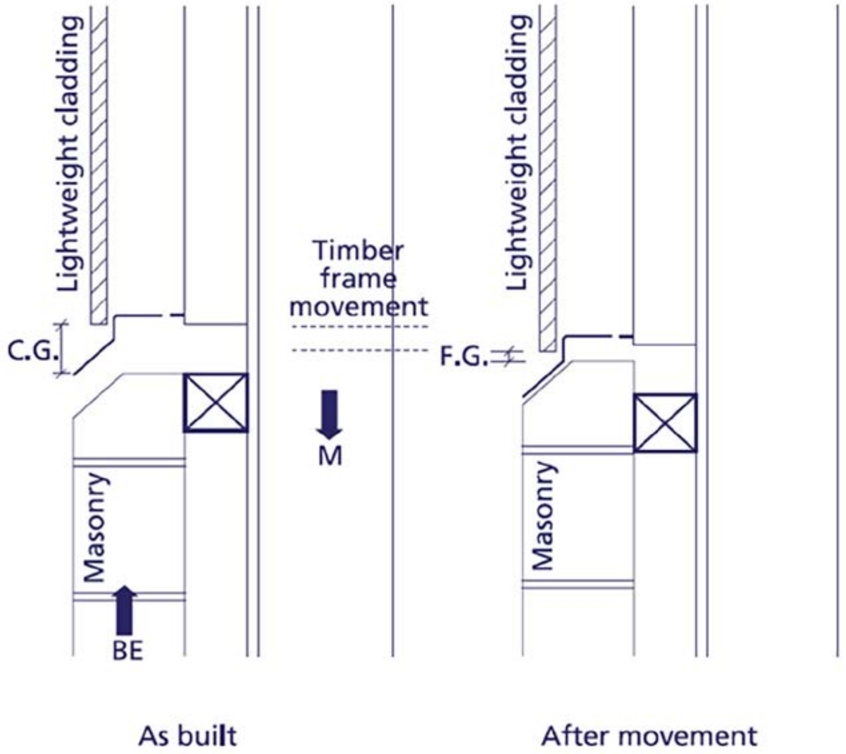
Unlike Windows, eaves and verge in brick clad buildings, the Differential Movement gap at the stairwell will be the same on every floor. That is because it is the relationship between the Timber Frame and plasterboard which is fixed to it and not the Timber Frame and the brickwork (which is independent)

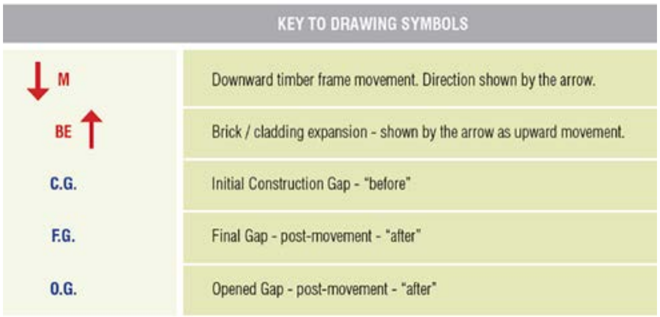


KEY TO DRAWING SYMBOLS	
↓ M	Downward timber frame movement. Direction shown by the arrow.
BE ↑	Brick / cladding expansion - shown by the arrow as upward movement.
C.G.	Initial Construction Gap - "before"
F.G.	Final Gap - post-movement - "after"
O.G.	Opened Gap - post-movement - "after"

Lightweight claddings interaction with brick below

Where lightweight cladding on battens (moving with the Timber Frame) meets brickwork façade (independent of the Timber Frame) then a Differential Movement gap should be designed.





KEY TO DRAWING SYMBOLS	
↓ M	Downward timber frame movement. Direction shown by the arrow.
BE ↑	Brick / cladding expansion - shown by the arrow as upward movement.
C.G.	Initial Construction Gap - "before"
F.G.	Final Gap - post-movement - "after"
O.G.	Opened Gap - post-movement - "after"

Similarly, to Windows, eaves and verge in brick clad buildings, the Differential Movement gap at the intersection of lightweight cladding and brickwork increases dependant on how many stories of Timber Frame there are. Remember to count the horizontal timbers from ground floor and to allow for the brickwork expansion and the residual depth of the compressible seal (if required)

BUILDING SERVICES

Separating Wall Service Routes

To maintain the fire and acoustic performance of the separating party walls, no services can be installed behind the double plasterboard. Where services are required on party walls, a service zone should be created with timber strapping and an additional layer of plasterboard.

In areas with minimal services where it is not possible to incorporate a service zone, it is acceptable to follow the stepped and staggered services detail below, ensuring that the 60 minute fire integrity is maintained using intumescent mastic and putty pads.

Gas pipes are not to be installed within compartment walls.

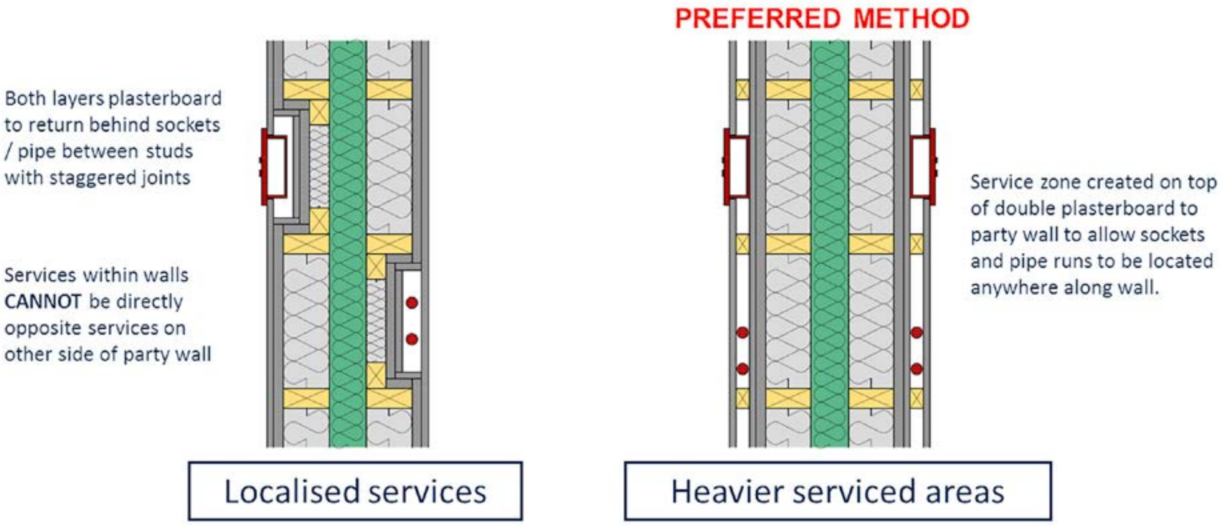


Figure 1 Services in Party Walls

Timber Frame Settlement – Impact on Services

For general principals of timber frame settlement, please refer to the differential movement section.

All service penetrations through external walls also need to consider the impact of differential movement between the timber frame and masonry cladding. Where extract flues pass through the wall, these should be fixed to the timber frame only, with a gap between the underside of the flue and the top of the masonry below allowing, for 10mm per storey height. Service penetrations should also be sleeved through the timber frame wall, as well as have cavity barriers within the cavity.

Where vertical services pass through the mid floor zone within the timber frame, a flexible section should be incorporated to allow for the vertical settlement, with the pipe fixed at the top of the wall panel below, and bottom of the wall panel above.

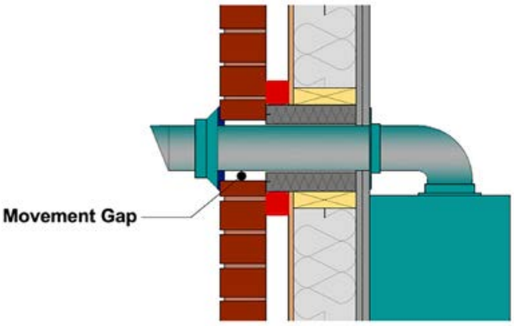


Figure 2 Boiler Flue Penetrating External Wall

Where vertical services pass through the mid floor zone within the timber frame, a flexible section should be incorporated to allow for the vertical settlement, with the pipe fixed at the top of the wall panel below, and bottom of the wall panel above.

Where Soil Vent Pipes (SVPs) pass through upper floors, these need to allow for the vertical settlement at each level. This is achieved by incorporating a joint in the pipe either directly above or below each floor level and leaving min 10mm in the compression fixing to allow for the movement. Care should also be taken to ensure enough run on horizontal pipe runs between appliances and the SVP to allow for movement.

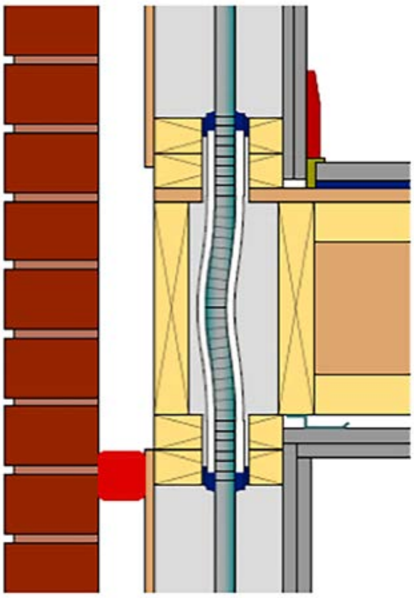
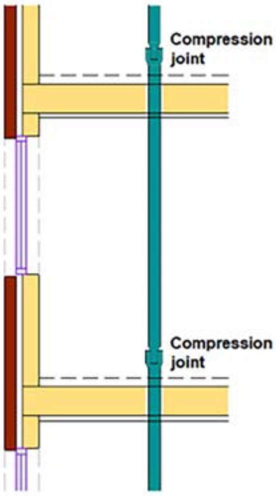


Figure 3 Vertical Services – Gas Flexible Section



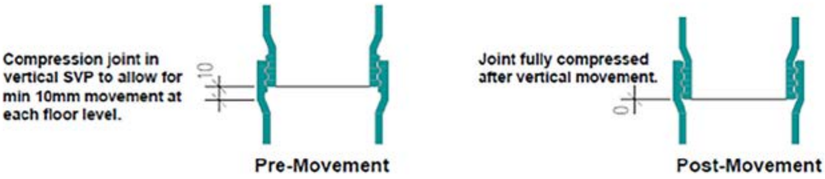


Figure 4 & 5 Vertical Services – SVP stack & Compression Joint

For timber frame apartments in Scotland, where the communal stairwells are constructed in masonry or steel frame, there will be differential movement to consider at all flat entrance doors as well as the roof over the stairwell. Separate guidance should be sought from Stewart Milne Timber System as early as possible in the design development stage to ensure detailing for differential movement and key junctions are considered in the designs.

Photo Voltaic Panels on Roofs

When using PV panels on roofs it is important to consider whether these will be inlayed or set on top of a tiled roof. Depending on the weight of the system, it is possible that additional holding down will be required to hold down the roof truss and timber frame structure below. Therefore, it is important that the location of PV panels is clearly shown on the architectural layouts and elevations.

Installation on flat roofs will often require ballast to hold down the PV system, again it is important that an accurate weight and location is provided including this ballast which will be imposed on the roof structure.

Services within Apartments

Installation of services within timber frame apartments follow the same basic principles of all other forms of construction, with vertical risers within the communal stairwells, then branching into each individual apartment with fire-stopping when passing through party walls.

Separating Floor Service Routes

No horizontal services can be run within the joist zone for timber frame separating floors. It is possible to run services within the acoustic floor batten zone for E-FT-1 for the apartment directly above, however any ventilation ducts at ceiling level will need to run within a service void, as pipework and ventilation cannot be run within the joist zone. The service routes for the ground floor apartments also needs to be considered where the ground floor will generally be a concrete floor slab, so all services including water and heating will need to be run in a service void at ceiling level.

Separating floor E-FT-5 has a ceiling service zone as standard, as there is no void above the sub-deck to route services through.

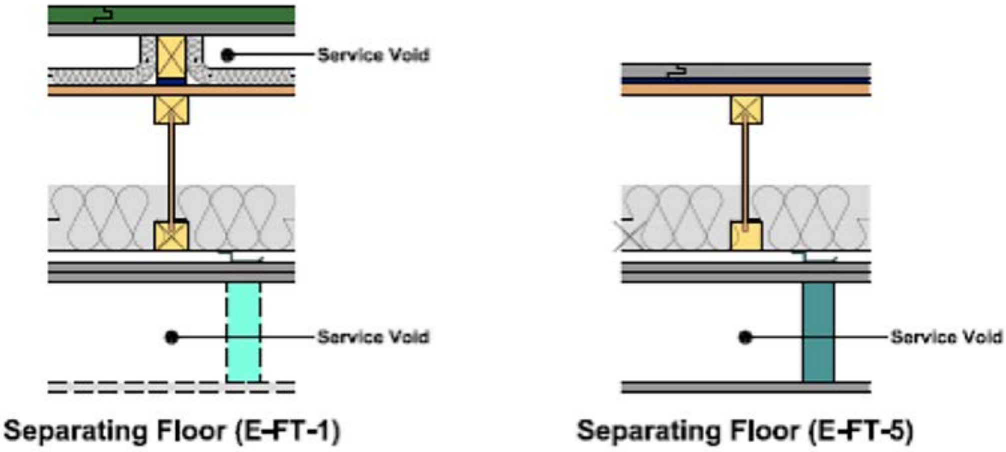


Figure 5 Separating Floors – Service Void

Where vertical risers (soil vent pipes) pass through separating floors, fire collars are required against the underside of the double plasterboard to the ceiling. Pipe boxes should also have double layer of 12.5mm plasterboard and 25mm sound deadening quilt to maintain acoustic separation between apartments in line with Section 7 of the requirements of the Robust Details E-FT-1 and E-FT-5.

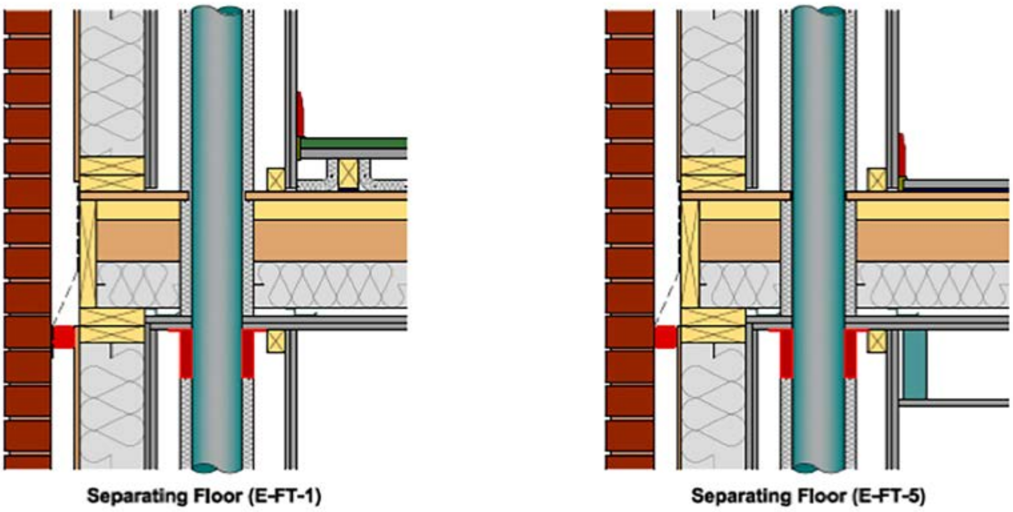


Figure 6 Separating Floor – Fire Collars

Gas Services

To achieve 2013 Building Regulations, it is likely that apartments will require the incorporation of a gas powered heating and hot water system. Internally routing gas services to apartments is possible however it is complex and is likely to be difficult to construct accurately. For standard apartment types it is recommended that vertical gas risers are run externally. The simplest way to incorporate vertical gas risers is to fix the gas pipe directly to the external brickwork with Munson rings, although it is critical to ensure ventilation and vertical settlement of the timber frame are allowed for where gas pipes pass through the external wall into each apartment. Strict compliance with the details included within the appendices of this document is required, this includes:

- An additional emergency control valve (AECV) is to be located as soon as practicable after the gas supply enters the building. This needs to be accessible, and prior to the gas supply splitting to feed a hob etc.
- The use of a continuous sleeved flexible gas pipe; such as Trac Pipe; through external walls between the external vertical riser and the AECV.
- Penetration for gas pipe in external panel must miss vertical stud locations.
- Penetration for gas pipe through OSB in external panel must be oversized above the pipe by approx. 10mm per floor to allow for differential movement.

When designing bespoke apartment types, it is preferable to incorporate the vertical gas risers on the external face of the building. If considered at an earlier stage this can become a design feature.

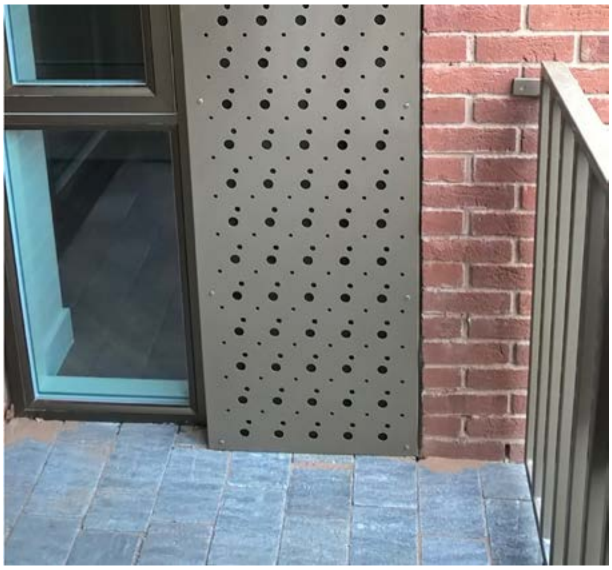


Figure 7 Vertical Riser – Design Feature

Ventilation

Ventilation ductwork can be accommodated within timber frame apartments for either individual extract from kitchens and bathrooms, a centralised mechanical extract ventilation (MEV) system, or a full mechanical heat recovery ventilation (MVHR) system. All ductwork will be run within the ceiling mounted service zone to external wall grills. Care must be taken to allow for differential movement at external walls, with gaps between the underside of the duct and top of the masonry external cladding or utilising flexible ductwork when passing through the wall.

Ventilation ductwork can be accommodated within timber frame houses for either individual extract from kitchens and bathrooms, a centralised mechanical extract ventilation (MEV) system, or a full mechanical heat recovery ventilation (MVHR) system. These systems can be installed within the depth of the floor joist or within a suspended ceiling like apartments. Care must be taken to allow for differential movement at external walls, with gaps between the underside of the duct and top of the masonry external cladding or utilising flexible ductwork when passing through the wall.

It is beneficial to consider the span of floor joists to determine where to route the ventilation ducts. The example below illustrates a mid-terraced house, vent ducts are parallel to joists escaping on the rear elevation (vent ducts shown green). This scenario is better all-round as it simplifies the process and speeds up the build.

Care must be taken to allow for differential movement at external walls, with gaps between the underside of the duct and top of the masonry external cladding or utilising flexible ductwork when passing through the wall.

If possible, we would recommend positioning external ducts between external openings. This allows the option to position a lintel within the floor zone over openings where a greater depth is required. If there were a penetration here, this would not be an option.

Where ventilation is to be perpendicular to the floor joists, there are two options: -

1. Drop the ventilation into a suspended ceiling zone, this could be localised to one room or more if it is beneficial to maintain ceiling heights elsewhere.
2. Core through the joists, however please note: -
    a. Holes can only be made using guidance from the specific joist manufacturer, an example is shown below.

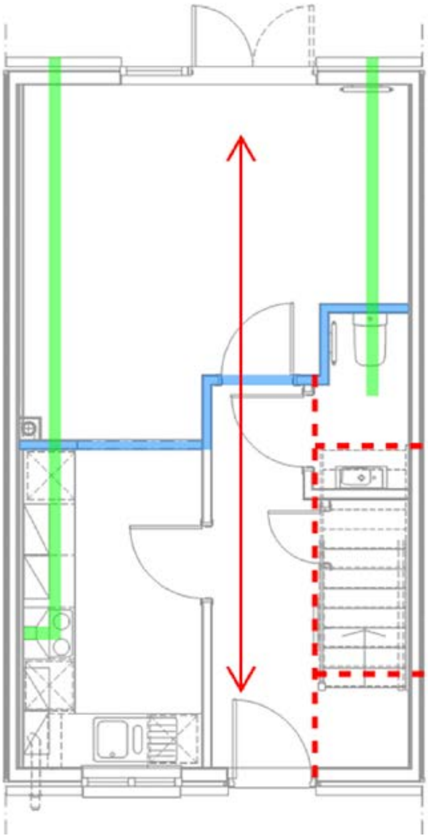
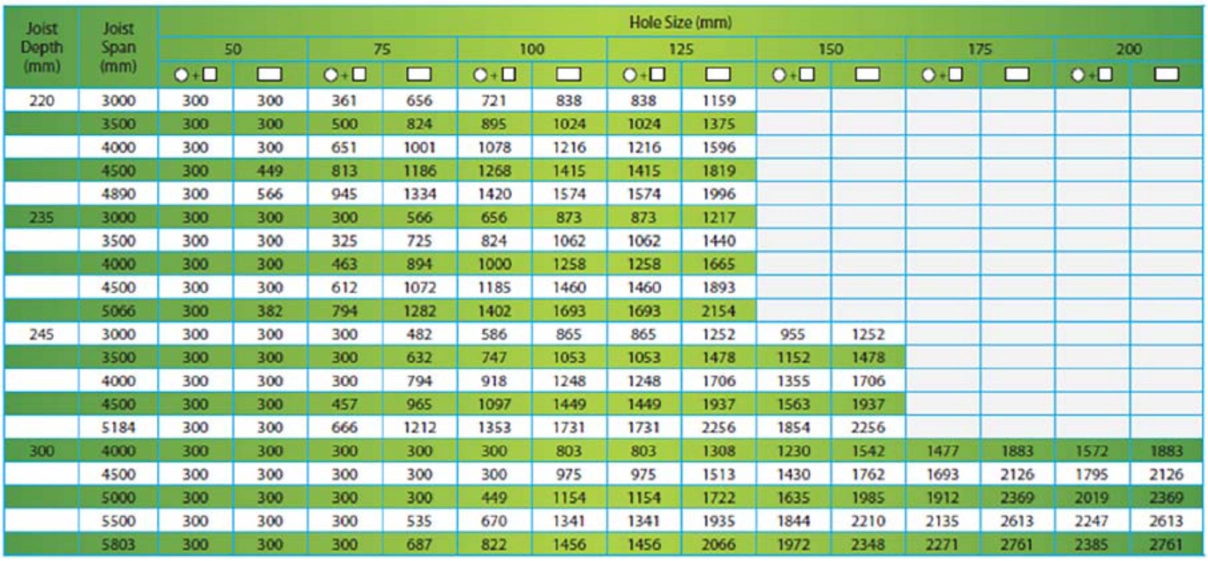
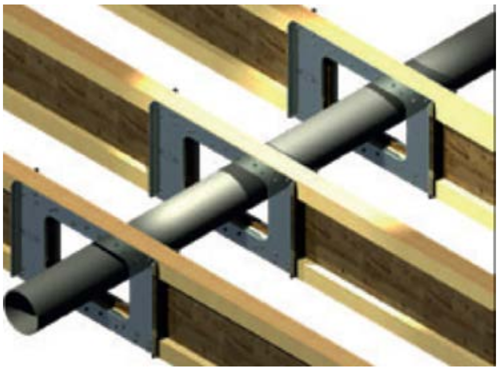


Figure 8 Ventilation Runs – Parallel to Joists



Joist Depth (mm)	Joist Span (mm)	Hole Size (mm)													
		50		75		100		125		150		175		200	
		○+□	▭	○+□	▭	○+□	▭	○+□	▭	○+□	▭	○+□	▭	○+□	▭
220	3000	300	300	361	656	721	838	838	1159						
	3500	300	300	500	824	895	1024	1024	1375						
	4000	300	300	651	1001	1078	1216	1216	1596						
	4500	300	449	813	1186	1268	1415	1415	1819						
	4890	300	566	945	1334	1420	1574	1574	1996						
235	3000	300	300	300	566	656	873	873	1217						
	3500	300	300	325	725	824	1062	1062	1440						
	4000	300	300	463	894	1000	1258	1258	1665						
	4500	300	300	612	1072	1185	1460	1460	1893						
	5066	300	382	794	1282	1402	1693	1693	2154						
245	3000	300	300	300	482	586	865	865	1252	955	1252				
	3500	300	300	300	632	747	1053	1053	1478	1152	1478				
	4000	300	300	300	794	918	1248	1248	1706	1355	1706				
	4500	300	300	457	965	1097	1449	1449	1937	1563	1937				
	5184	300	300	666	1212	1353	1731	1731	2256	1854	2256				
300	4000	300	300	300	300	300	803	803	1308	1230	1542	1477	1883	1572	1883
	4500	300	300	300	300	300	975	975	1513	1430	1762	1693	2126	1795	2126
	5000	300	300	300	300	449	1154	1154	1722	1635	1985	1912	2369	2019	2369
	5500	300	300	300	535	670	1341	1341	1935	1844	2210	2135	2613	2247	2613
	5803	300	300	300	687	822	1456	1456	2066	1972	2348	2271	2761	2385	2761



Above: Figure 9 Joist Holing Guide

If the hole required is out with the specified location, specialist metalwork can be incorporated.

Left: Figure 10 Specialist Holing Metalwork

Opting to pass ventilation ducts through joists can cause issues on site as it can be difficult to pass longer lengths of duct through joists.

Drainage

Drainage pipework can be accommodated within timber frame houses and can run vertically and horizontally. If considered properly into the house design, the build will be much faster with less material offering a significant commercial benefit.

In an ideal situation, upper floor bathrooms and downstairs WC's would stack above one another, and upper floor en-suites would stack above a kitchen for example. This would allow simple vertical SVP pipework to simply pass through the floor with minimal interruption to the joist structure.

This is not always possible; therefore, the next stage is to consider the span of floor joists to determine the most efficient direction to run a horizontal drainage pipe.

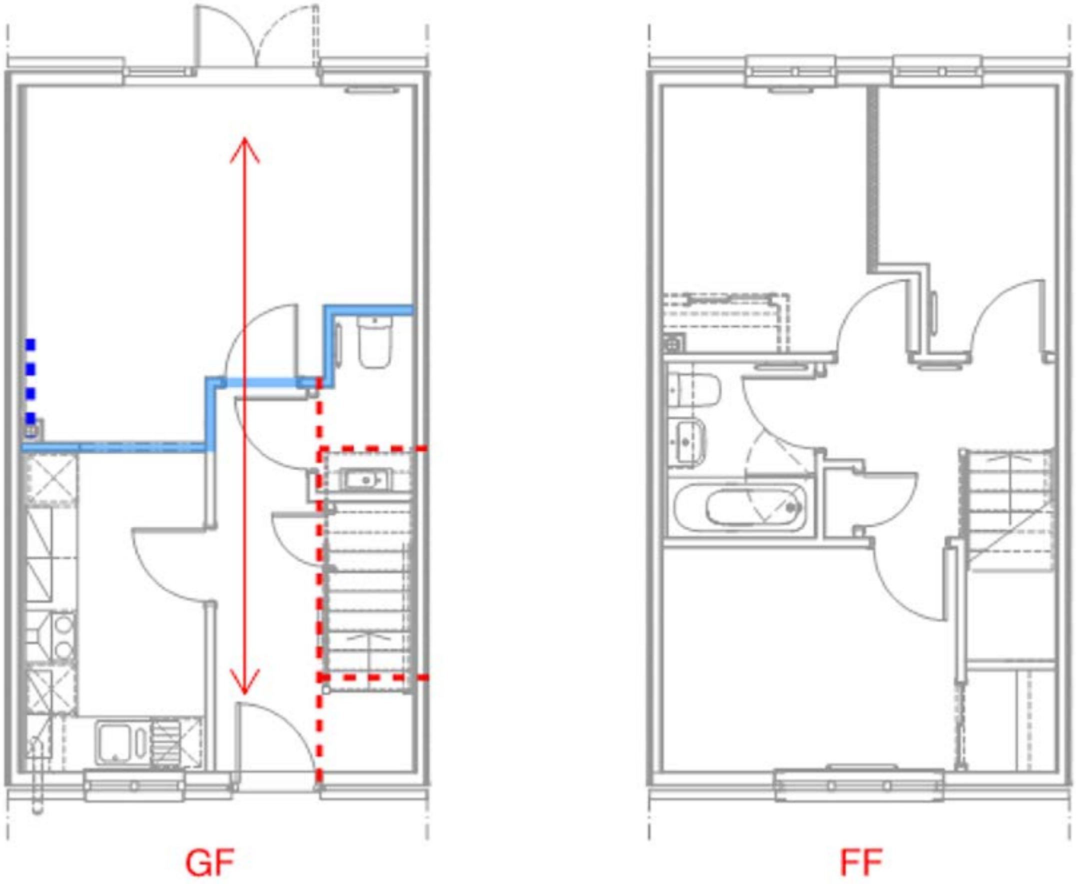
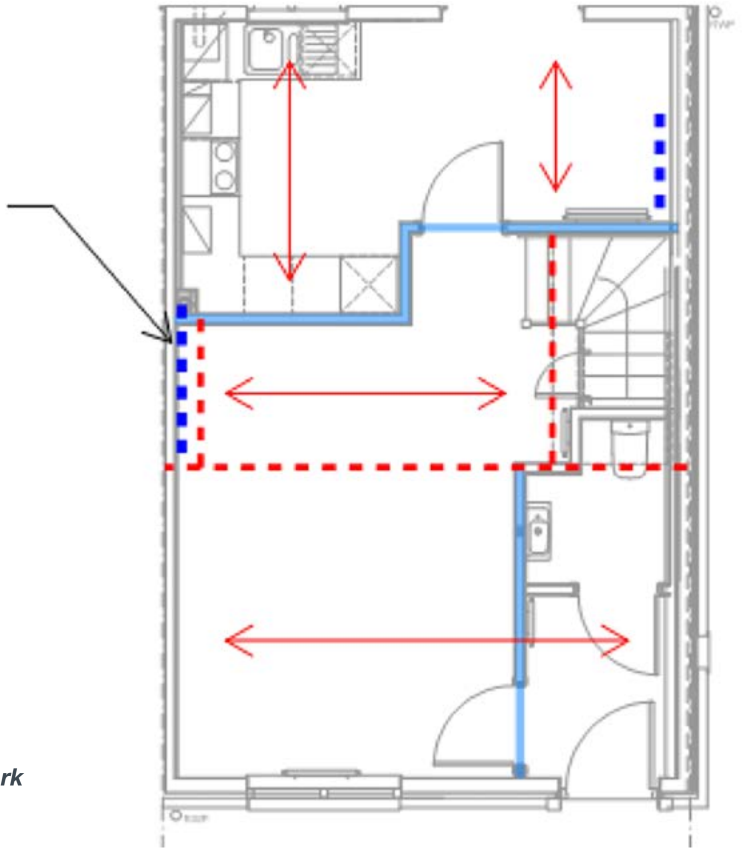


Figure 11 Drainage Pipework Parallel to Joists

The sample above shows a horizontal drainage run within the depth of the floor joists parallel to joists. As the pipework is parallel to the joists, there is little to no impact on the structure of the timber frame.

Where drainage run needs to be perpendicular to the floor joists, there are three options: -

1. **Most efficient** - Drop the ventilation into a suspended ceiling zone, this could be localised to one room or more if it is beneficial to maintain ceiling heights elsewhere.
2. **Less efficient** - Trim the floor joists to create a clear space within the floor zone.



Drainage run
to be trimmed
within floor

Figure 12 Drainage Pipework Perpendicular to Joists

3. Least efficient - Core through the joists, however please note: -

- a. Holes can only be made using guidance from the specific joist manufacturer.
- b. If the hole required is out with the specified location, specialist metalwork can be incorporated.
- c. Opting to pass drainage runs through floor joists can cause issues on site as it can be difficult to pass longer lengths of pipework through joists. This is more onerous than ventilation as there is no option to use a flexible pipe.

L-shaped drainage runs should be avoided as it means coring large holes through trimmers.

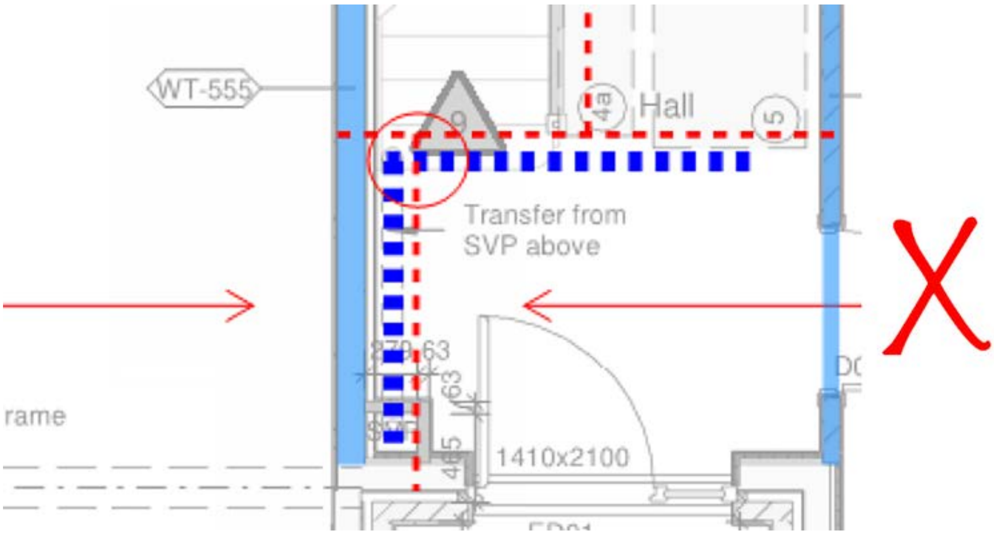


Figure 13 L-Shaped Drainage Run Within a Joisted Floor

Gas Services

Gas pipes can enter a timber frame property as shown in Figure 15 below ensuring to avoid timber studs. Note the drilled hole should be oversized to ensure there is 10mm above to allow for settlement.

Note also the requirement for cavity barriers around the gas pipe.

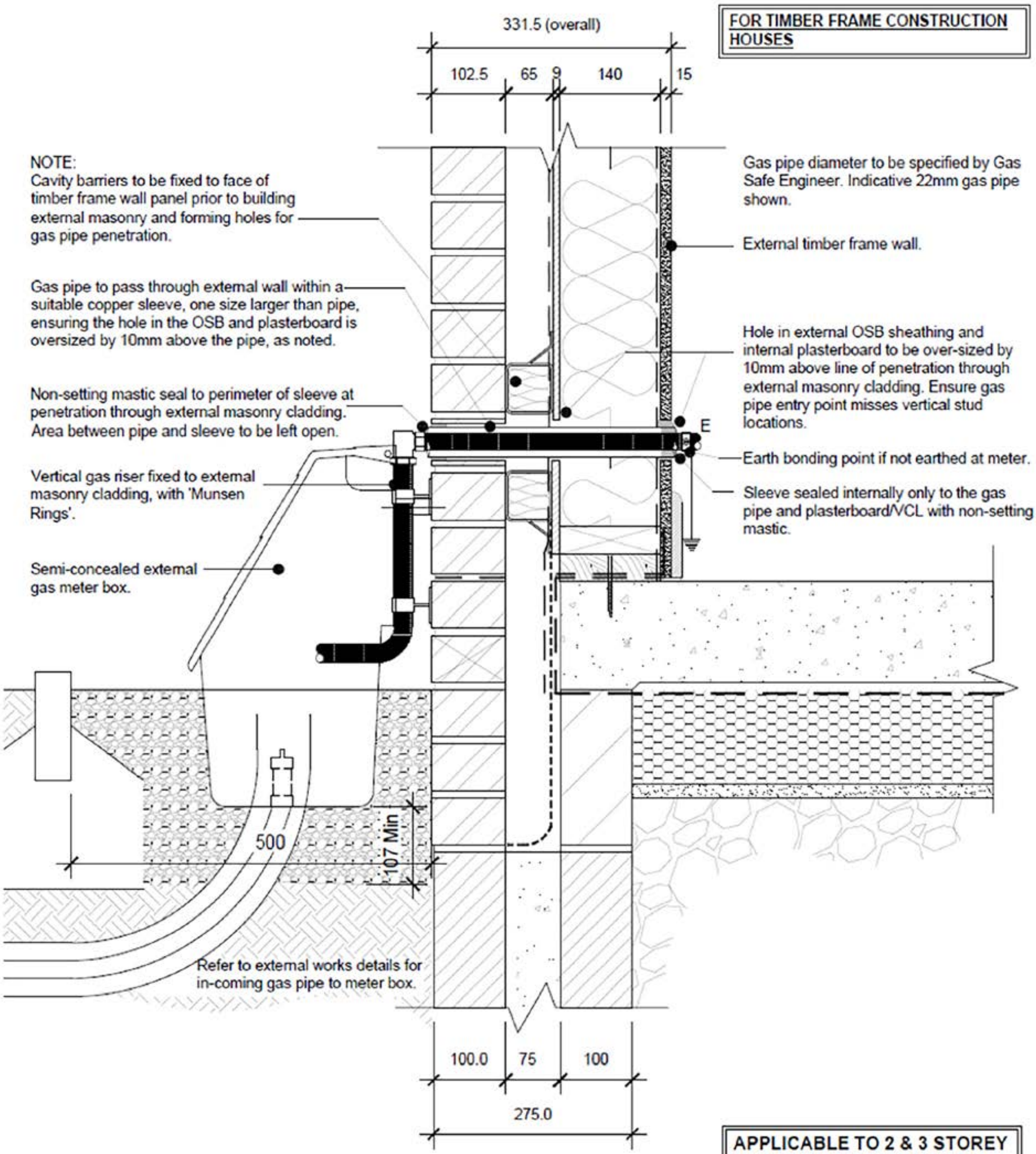
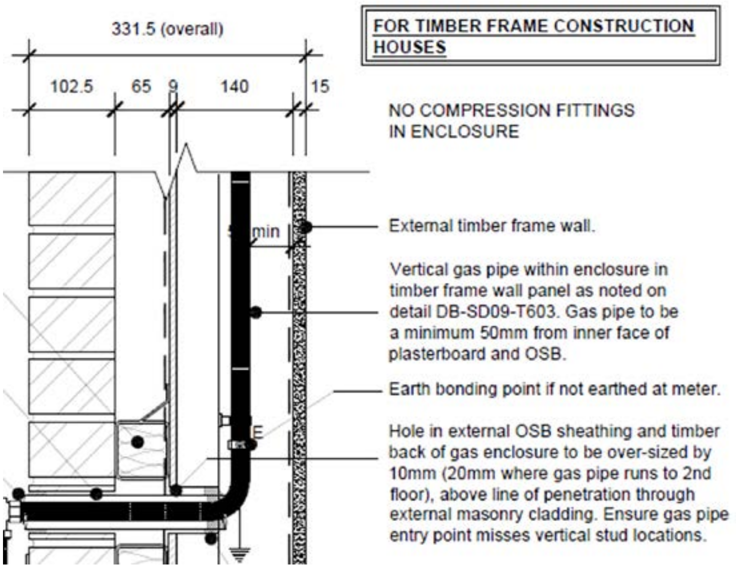


Figure 14 Gas Pipe Entry at Ground Floor External Wall

Figure 16 below illustrates the gas pipe rising vertically through an external wall. Note the gas pipe is to be min 50mm from the inner face of plasterboard and OSB.



FOR TIMBER FRAME CONSTRUCTION HOUSES

NO COMPRESSION FITTINGS IN ENCLOSURE

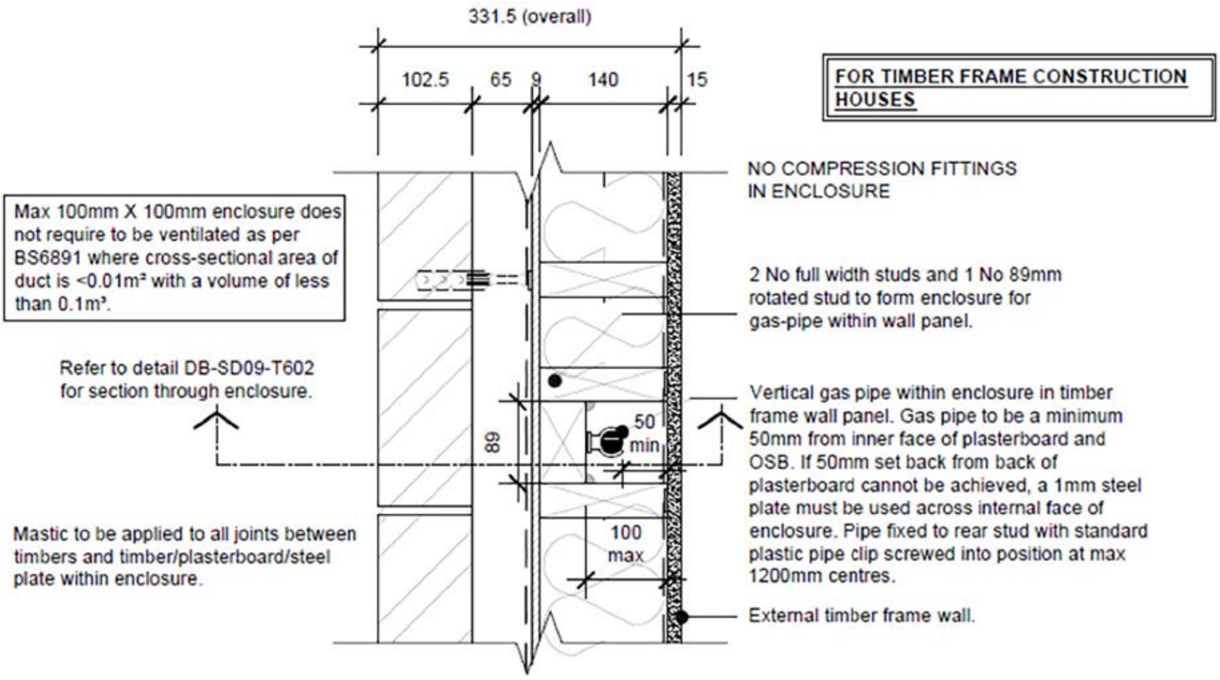
External timber frame wall.

Vertical gas pipe within enclosure in timber frame wall panel as noted on detail DB-SD09-T603. Gas pipe to be a minimum 50mm from inner face of plasterboard and OSB.

Earth bonding point if not earthed at meter.

Hole in external OSB sheathing and timber back of gas enclosure to be over-sized by 10mm (20mm where gas pipe runs to 2nd floor), above line of penetration through external masonry cladding. Ensure gas pipe entry point misses vertical stud locations.

Figure 15 Detail of Vertical Height Enclosure



FOR TIMBER FRAME CONSTRUCTION HOUSES

NO COMPRESSION FITTINGS IN ENCLOSURE

Max 100mm X 100mm enclosure does not require to be ventilated as per BS6891 where cross-sectional area of duct is <0.01m² with a volume of less than 0.1m³.

Refer to detail DB-SD09-T602 for section through enclosure.

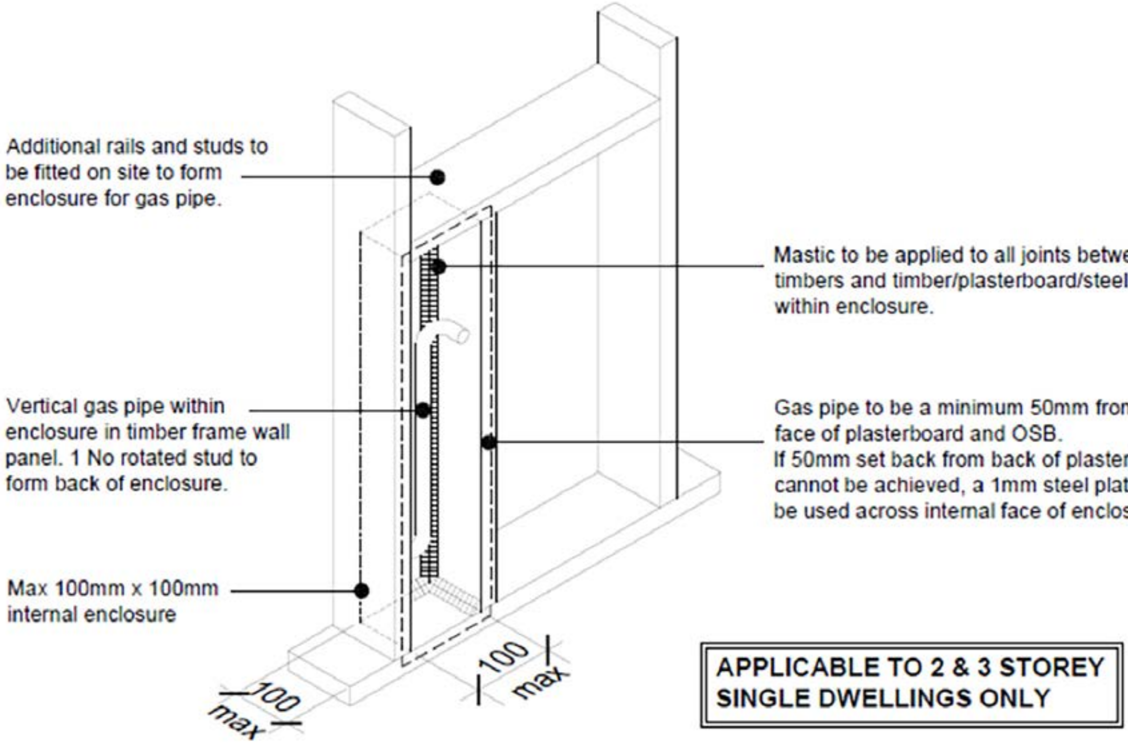
Mastic to be applied to all joints between timbers and timber/plasterboard/steel plate within enclosure.

2 No full width studs and 1 No 89mm rotated stud to form enclosure for gas-pipe within wall panel.

Vertical gas pipe within enclosure in timber frame wall panel. Gas pipe to be a minimum 50mm from inner face of plasterboard and OSB. If 50mm set back from back of plasterboard cannot be achieved, a 1mm steel plate must be used across internal face of enclosure. Pipe fixed to rear stud with standard plastic pipe clip screwed into position at max 1200mm centres.

External timber frame wall.

Figure 16 Plan Detail of Vertical Height Enclosure



Additional rails and studs to be fitted on site to form enclosure for gas pipe.

Vertical gas pipe within enclosure in timber frame wall panel. 1 No rotated stud to form back of enclosure.

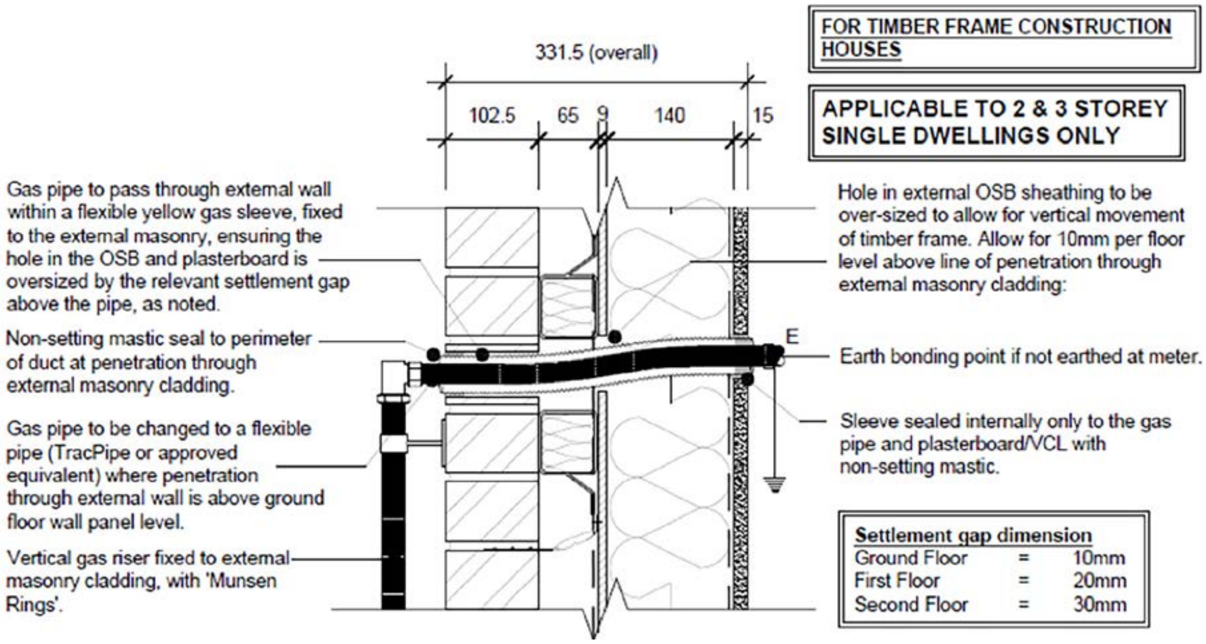
Max 100mm x 100mm internal enclosure

Mastic to be applied to all joints between timbers and timber/plasterboard/steel plate within enclosure.

Gas pipe to be a minimum 50mm from inner face of plasterboard and OSB.
If 50mm set back from back of plasterboard cannot be achieved, a 1mm steel plate must be used across internal face of enclosure.

APPLICABLE TO 2 & 3 STOREY SINGLE DWELLINGS ONLY

Figure 17 Isometric Detail at Appliance Height (e.g. hob connection)



FOR TIMBER FRAME CONSTRUCTION HOUSES

APPLICABLE TO 2 & 3 STOREY SINGLE DWELLINGS ONLY

Gas pipe to pass through external wall within a flexible yellow gas sleeve, fixed to the external masonry, ensuring the hole in the OSB and plasterboard is oversized by the relevant settlement gap above the pipe, as noted.

Non-setting mastic seal to perimeter of duct at penetration through external masonry cladding.

Gas pipe to be changed to a flexible pipe (TracPipe or approved equivalent) where penetration through external wall is above ground floor wall panel level.

Vertical gas riser fixed to external masonry cladding, with 'Munsen Rings'.

Hole in external OSB sheathing to be over-sized to allow for vertical movement of timber frame. Allow for 10mm per floor level above line of penetration through external masonry cladding:

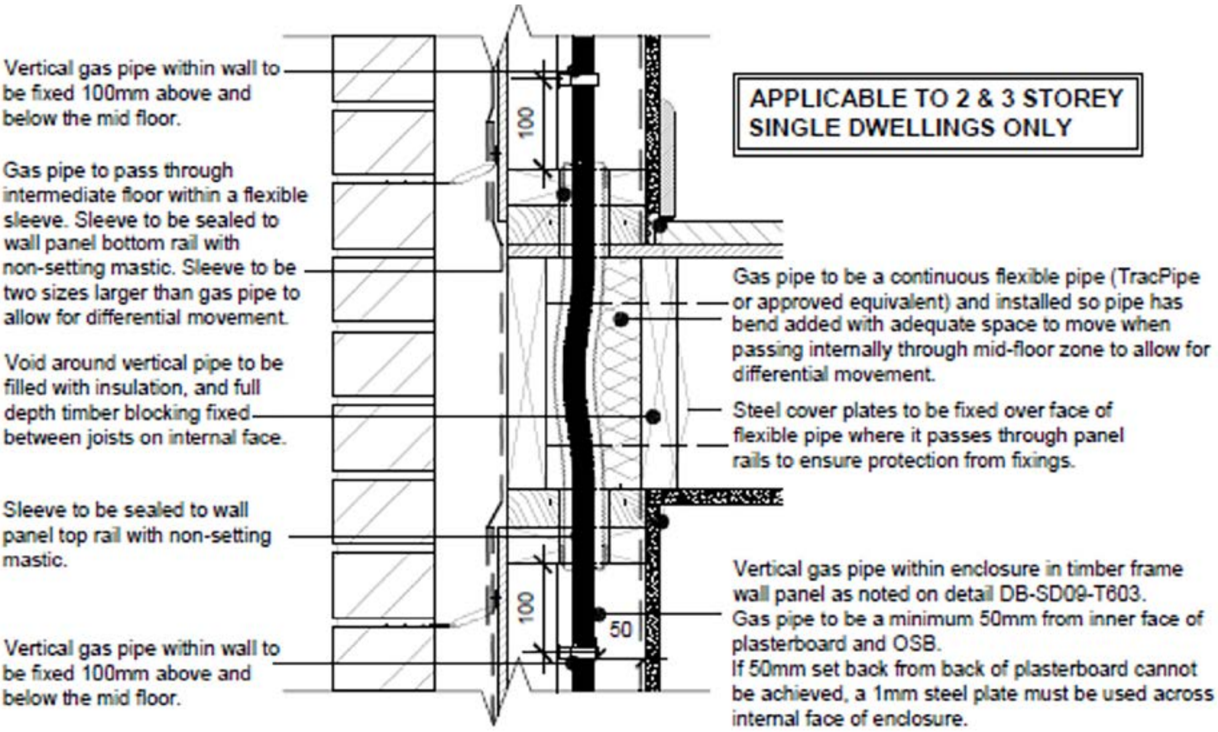
Earth bonding point if not earthed at meter.

Sleeve sealed internally only to the gas pipe and plasterboard/VCL with non-setting mastic.

Settlement gap dimension

Ground Floor	=	10mm
First Floor	=	20mm
Second Floor	=	30mm

Figure 18 External Gas Riser at Upper Floor Entry



APPLICABLE TO 2 & 3 STOREY SINGLE DWELLINGS ONLY

Vertical gas pipe within wall to be fixed 100mm above and below the mid floor.

Gas pipe to pass through intermediate floor within a flexible sleeve. Sleeve to be sealed to wall panel bottom rail with non-setting mastic. Sleeve to be two sizes larger than gas pipe to allow for differential movement.

Void around vertical pipe to be filled with insulation, and full depth timber blocking fixed between joists on internal face.

Sleeve to be sealed to wall panel top rail with non-setting mastic.

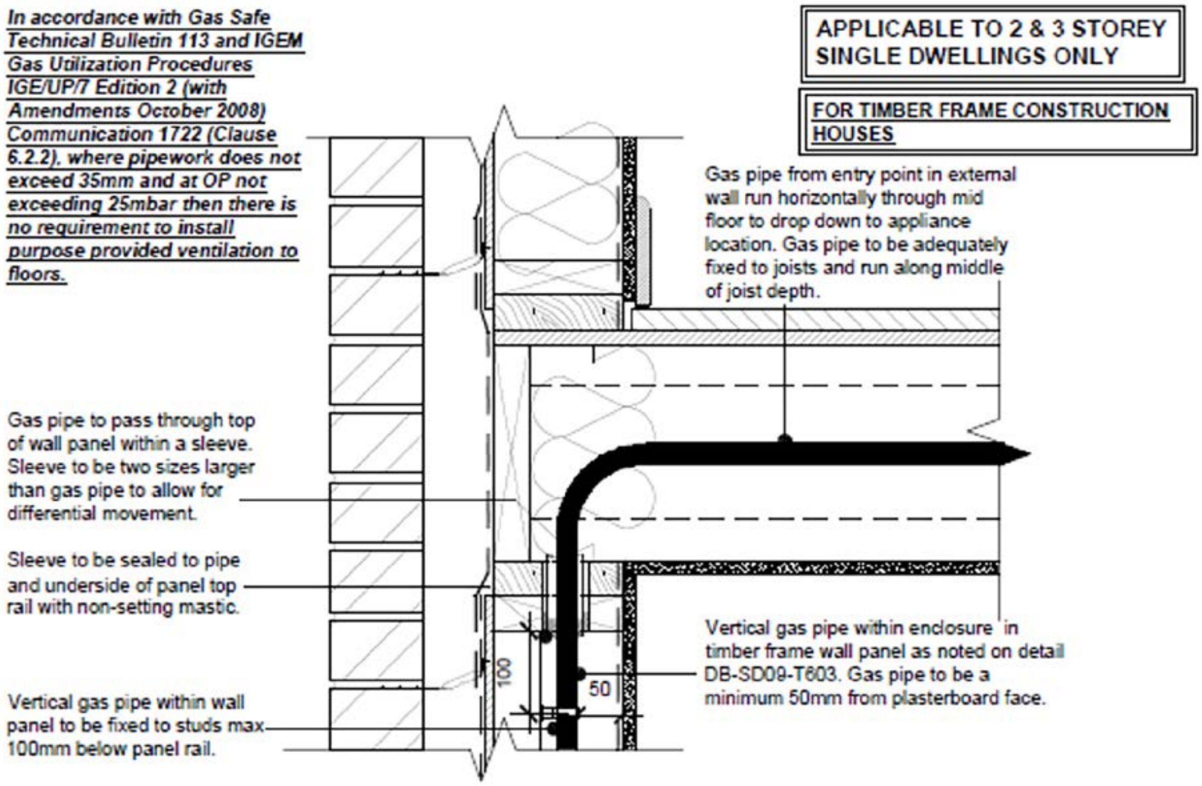
Vertical gas pipe within wall to be fixed 100mm above and below the mid floor.

Gas pipe to be a continuous flexible pipe (TracPipe or approved equivalent) and installed so pipe has bend added with adequate space to move when passing internally through mid-floor zone to allow for differential movement.

Steel cover plates to be fixed over face of flexible pipe where it passes through panel rails to ensure protection from fixings.

Vertical gas pipe within enclosure in timber frame wall panel as noted on detail DB-SD09-T603. Gas pipe to be a minimum 50mm from inner face of plasterboard and OSB. If 50mm set back from back of plasterboard cannot be achieved, a 1mm steel plate must be used across internal face of enclosure.

Figure 19 Internal Gas Riser at Upper Floor Entry



__In accordance with Gas Safe Technical Bulletin 113 and IGEM Gas Utilization Procedures IGE/UP/7 Edition 2 (with Amendments October 2008) Communication 1722 (Clause 6.2.2), where pipework does not exceed 35mm and at OP not exceeding 25mbar then there is no requirement to install purpose provided ventilation to floors.__

APPLICABLE TO 2 & 3 STOREY SINGLE DWELLINGS ONLY

__FOR TIMBER FRAME CONSTRUCTION HOUSES__

Gas pipe from entry point in external wall run horizontally through mid floor to drop down to appliance location. Gas pipe to be adequately fixed to joists and run along middle of joist depth.

Gas pipe to pass through top of wall panel within a sleeve. Sleeve to be two sizes larger than gas pipe to allow for differential movement.

Sleeve to be sealed to pipe and underside of panel top rail with non-setting mastic.

Vertical gas pipe within wall panel to be fixed to studs max 100mm below panel rail.

Vertical gas pipe within enclosure in timber frame wall panel as noted on detail DB-SD09-T603. Gas pipe to be a minimum 50mm from plasterboard face.

Figure 20 Upper Floor Detail at External Wall

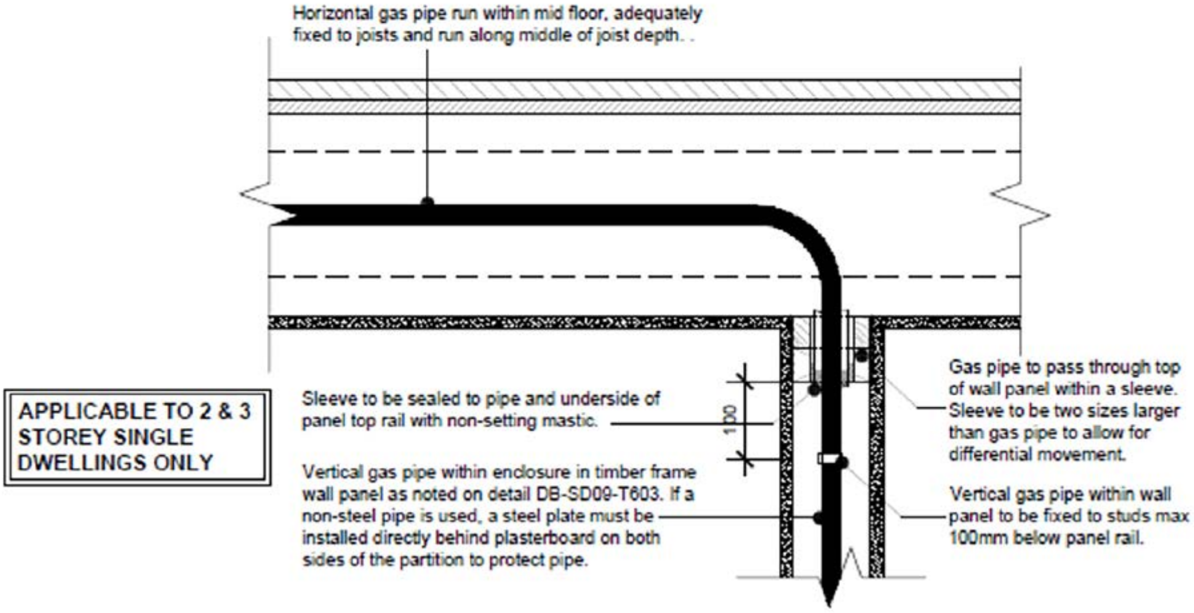
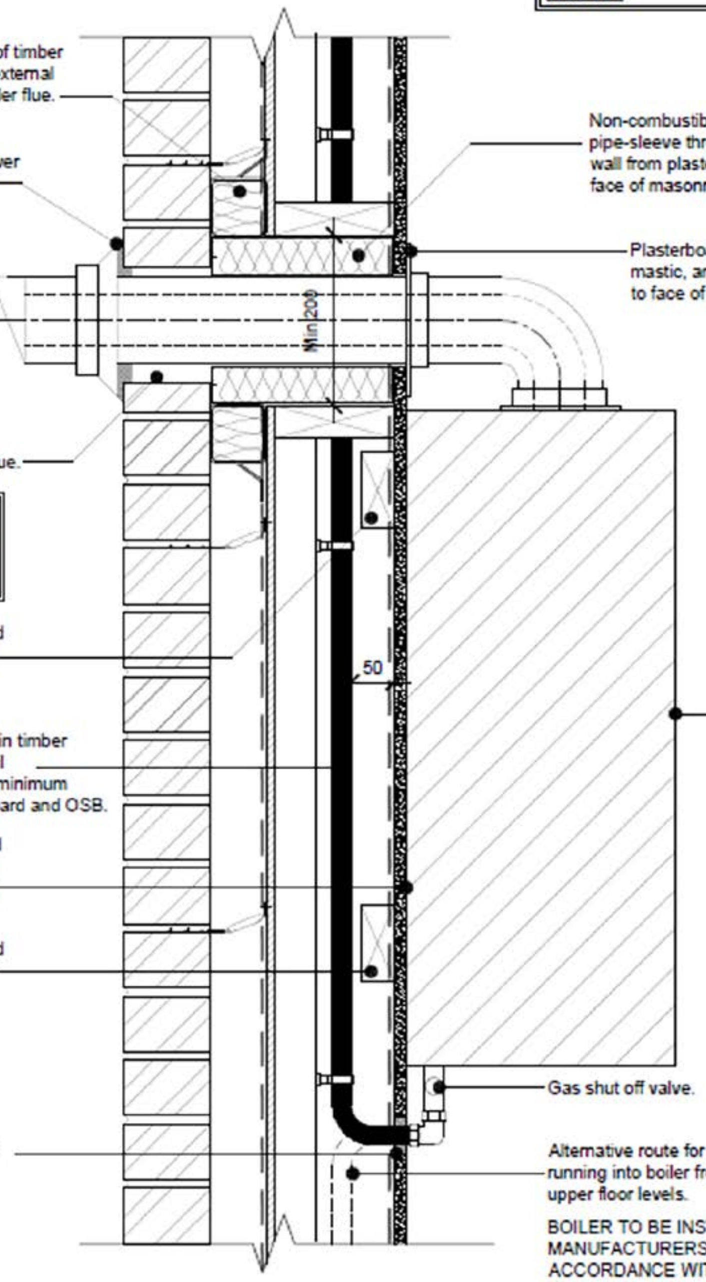


Figure 21 Upper Floor Detail at Internal Wall

FOR TIMBER FRAME CONSTRUCTION HOUSES



NOTE:
Cavity barriers to be fixed to face of timber frame wall panel prior to building external masonry and forming holes for boiler flue.

Mastic seal to perimeter of flue cover at penetration through external masonry cladding.

NOTE:
Boiler and Flue must be fixed to timber frame only, with no direct fixings to external masonry to ensure flue can move freely with timber frame.

Settlement gap between top of masonry and underside of boiler flue.

Settlement gap dimension

Ground Floor	=	10mm
First Floor	=	20mm
Second Floor	=	30mm

Additional timber noggins site fixed to panel at boiler fixing locations.

Vertical gas pipe within enclosure in timber frame wall panel as noted on detail DB-SD09-T603. Gas pipe to be a minimum 50mm from inner face of plasterboard and OSB.

15mm plasterboard with taped and filled joints or 3mm skim coat continuous behind boiler position.

Additional timber noggins site fixed to panel at boiler fixing locations. Refer to boiler manufacturers instructions for fixing locations.

Hole in internal plasterboard to be oversized by 10mm and sealed with non-setting mastic.

Non-combustible mineral wool pipe-sleeve through timber frame wall from plasterboard to back face of masonry cladding.

Plasterboard sealed to flue with mastic, and flue cover-plate fixed to face of plasterboard.

Room sealed balanced flue boiler

Gas shut off valve.

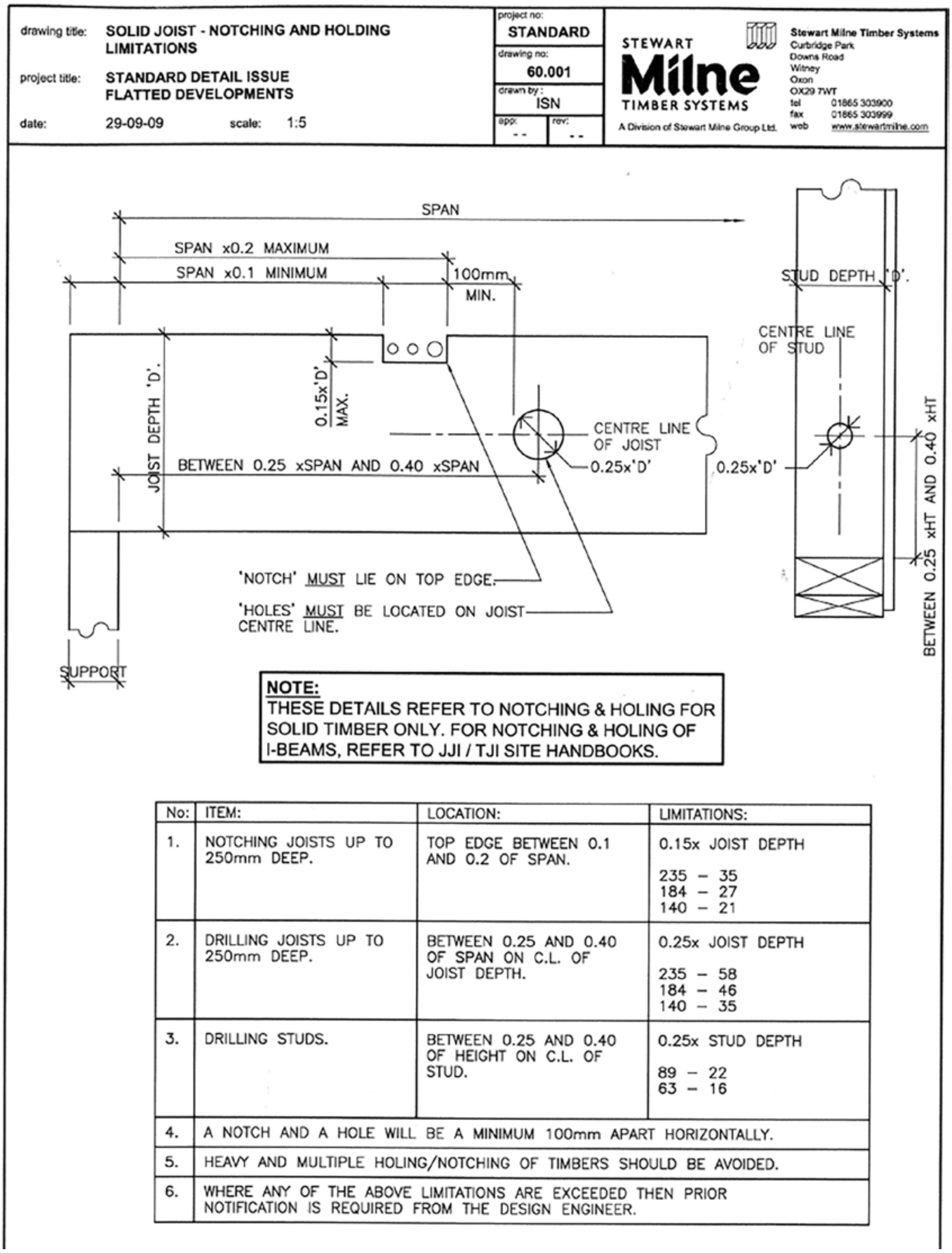
Alternative route for gas pipe running into boiler from below on upper floor levels.

BOILER TO BE INSTALLED TO MANUFACTURERS INSTRUCTIONS IN ACCORDANCE WITH GAS REGULATIONS & BRITISH STANDARDS

Figure 22 Balanced Flue Boiler on External Wall

Radiator pipes

As with all services, it is important to consider routes of pipework and how they will travel through the structure. General holing / notching guides can be followed, refer to Figure 24 below.



drawing title: SOLID JOIST - NOTCHING AND HOLDING LIMITATIONS

project title: STANDARD DETAIL ISSUE FLATTED DEVELOPMENTS

date: 29-09-09 scale: 1:5

project no: STANDARD

drawing no: 60.001

drawn by: ISN

app: -- rev: --

STEWART Milne TIMBER SYSTEMS
A Division of Stewart Milne Group Ltd.

Stewart Milne Timber Systems
Curbridge Park
Downs Road
Witney
Oxon
OX29 7WT
tel 01865 303900
fax 01865 303999
web www.stewartmilne.com

NOTE:
THESE DETAILS REFER TO NOTCHING & HOLING FOR SOLID TIMBER ONLY. FOR NOTCHING & HOLING OF I-BEAMS, REFER TO JJI / TJI SITE HANDBOOKS.

No:	ITEM:	LOCATION:	LIMITATIONS:
1.	NOTCHING JOISTS UP TO 250mm DEEP.	TOP EDGE BETWEEN 0.1 AND 0.2 OF SPAN.	0.15x JOIST DEPTH 235 – 35 184 – 27 140 – 21
2.	DRILLING JOISTS UP TO 250mm DEEP.	BETWEEN 0.25 AND 0.40 OF SPAN ON C.L. OF JOIST DEPTH.	0.25x JOIST DEPTH 235 – 58 184 – 46 140 – 35
3.	DRILLING STUDS.	BETWEEN 0.25 AND 0.40 OF HEIGHT ON C.L. OF STUD.	0.25x STUD DEPTH 89 – 22 63 – 16
4.	A NOTCH AND A HOLE WILL BE A MINIMUM 100mm APART HORIZONTALLY.		
5.	HEAVY AND MULTIPLE HOLING/NOTCHING OF TIMBERS SHOULD BE AVOIDED.		
6.	WHERE ANY OF THE ABOVE LIMITATIONS ARE EXCEEDED THEN PRIOR NOTIFICATION IS REQUIRED FROM THE DESIGN ENGINEER.		

Figure 23 Notching & Holing

It is common to take radiator pipes vertically through a partition and distribute within the first floor. Care should be taken not to drill vertically through a floor joist or trimmer. This should be considered within the design to ensure these pipes can travel unobstructed.

Shower trays & traps

It is common to have low profile shower trays; therefore, it is important to consider the position of the shower trap within the layout. This is to ensure there is no clash with timbers within the floor. Figure 25 below illustrates how joist spacing can be adjusted to avoid shower traps.

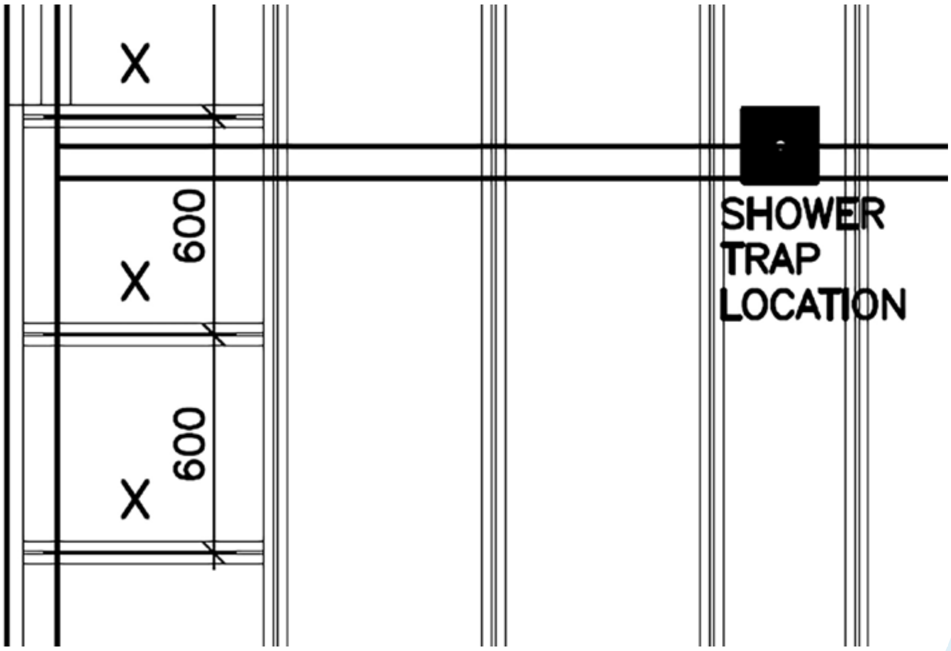


Figure 24 Shower Trap Location Within a Joisted Floor

It is worth considering installing handed shower trays within handed houses. This ensures the joists and shower trap are always designed to avoid each other. Shower traps should be clearly shown on architectural layouts.

WINDOW AND DOOR OPENINGS

Window Detailing

Jamb Details – Fitting Tolerance

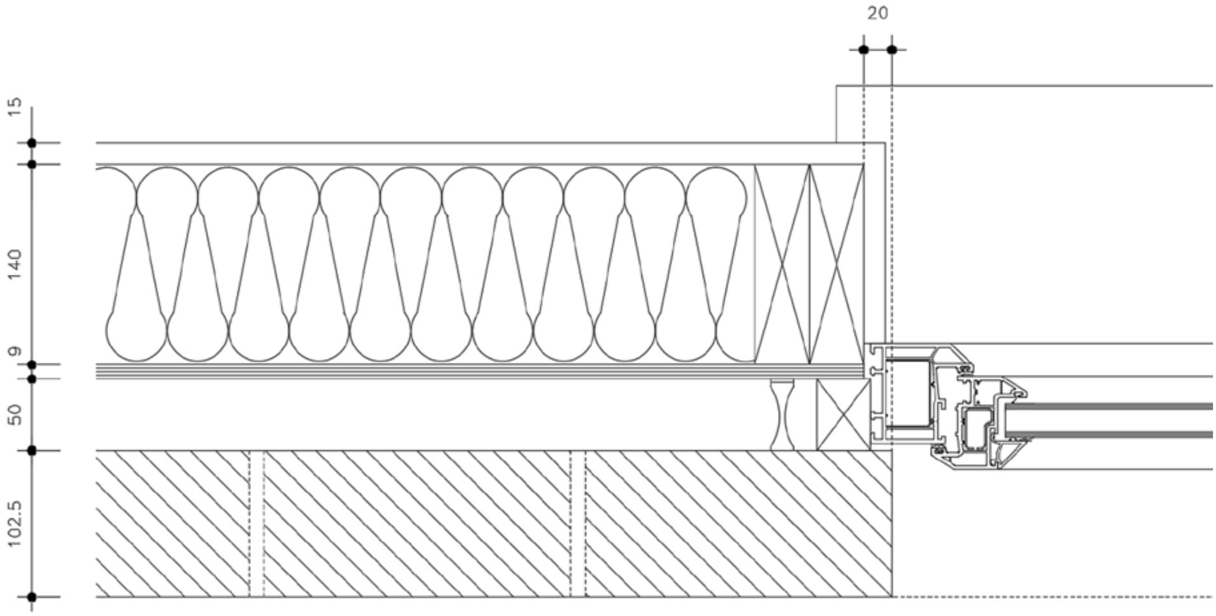


Figure 25 Jamb Detail for Housing

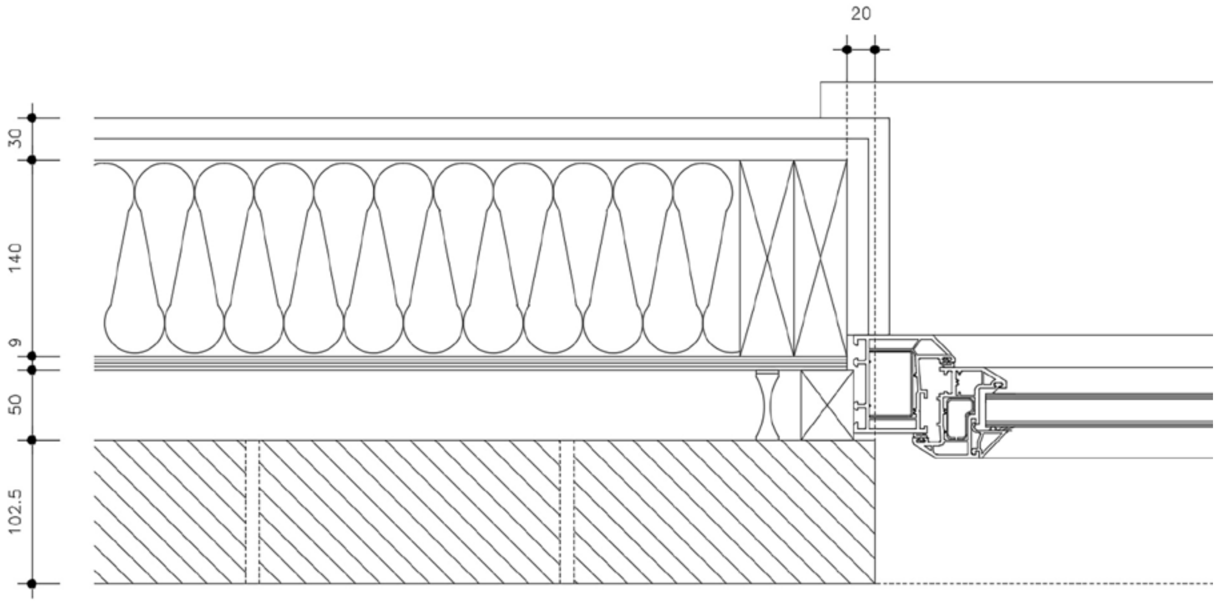


Figure 26 Jamb Detail for Apartments

Head Details – Fitting Tolerance

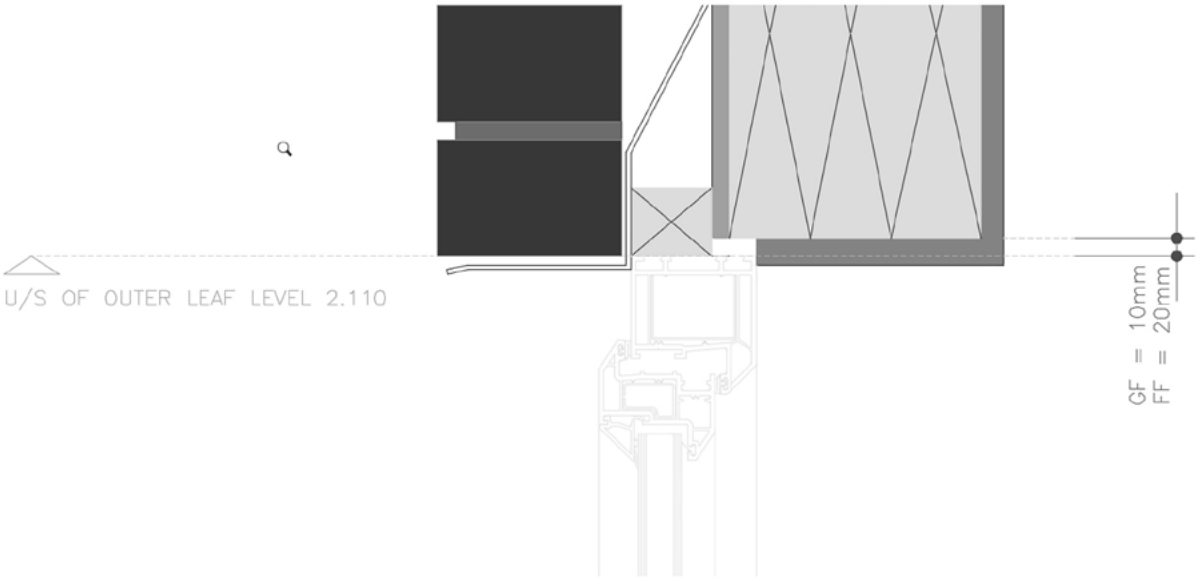


Figure 27 Head Detail for Housing

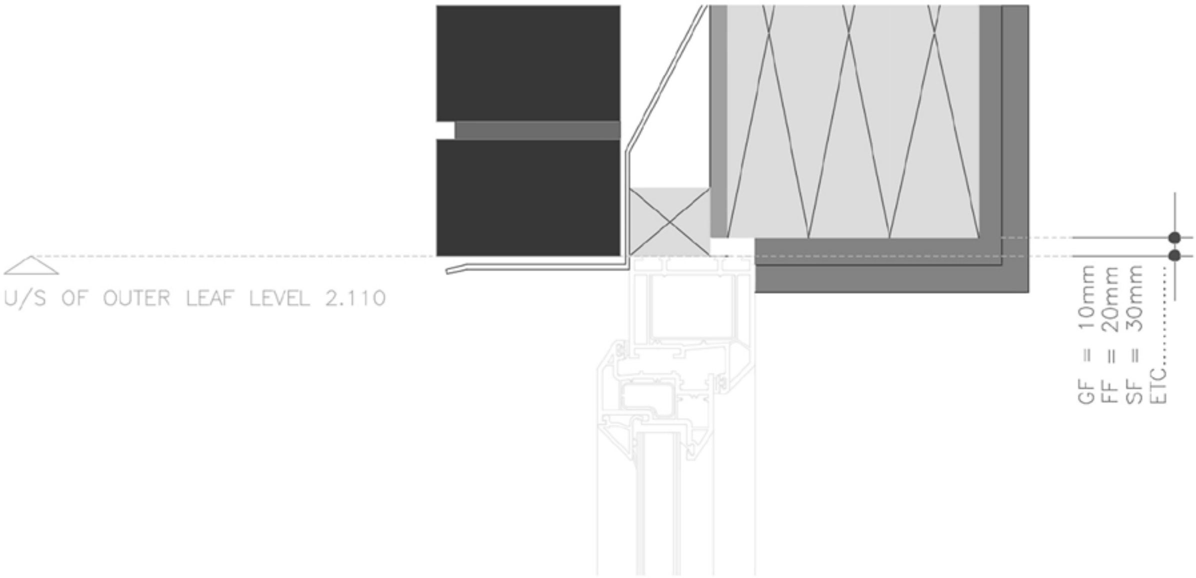


Figure 28 Head Detail for Apartments

Cill Details – Fitting Tolerance

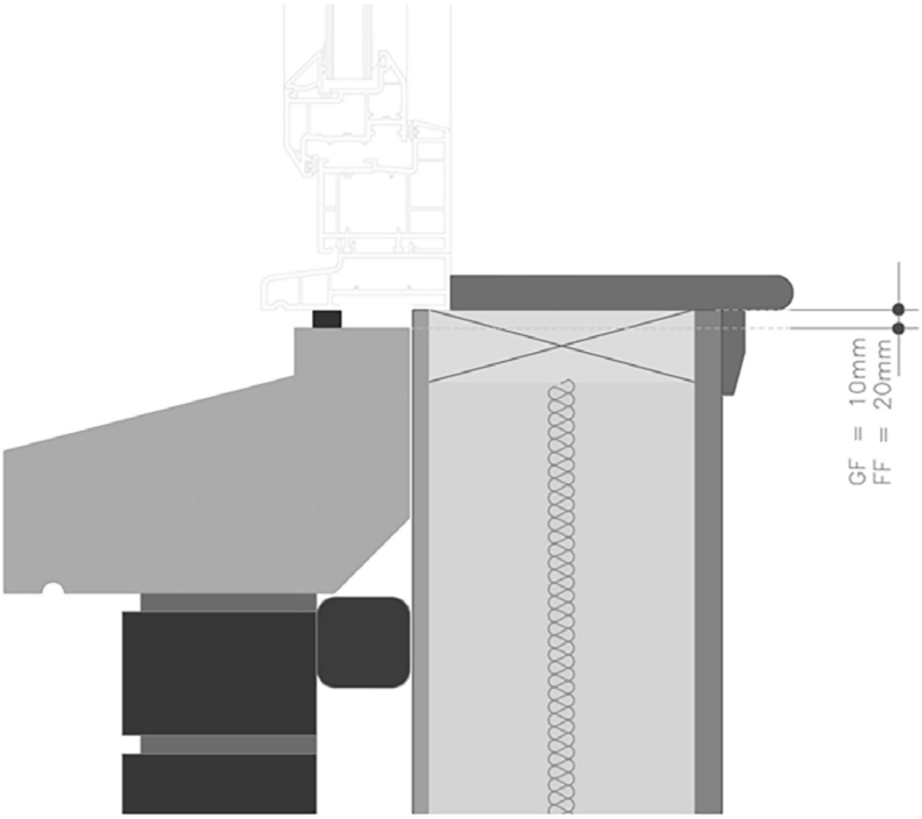


Figure 29 Cill Detail for Housing

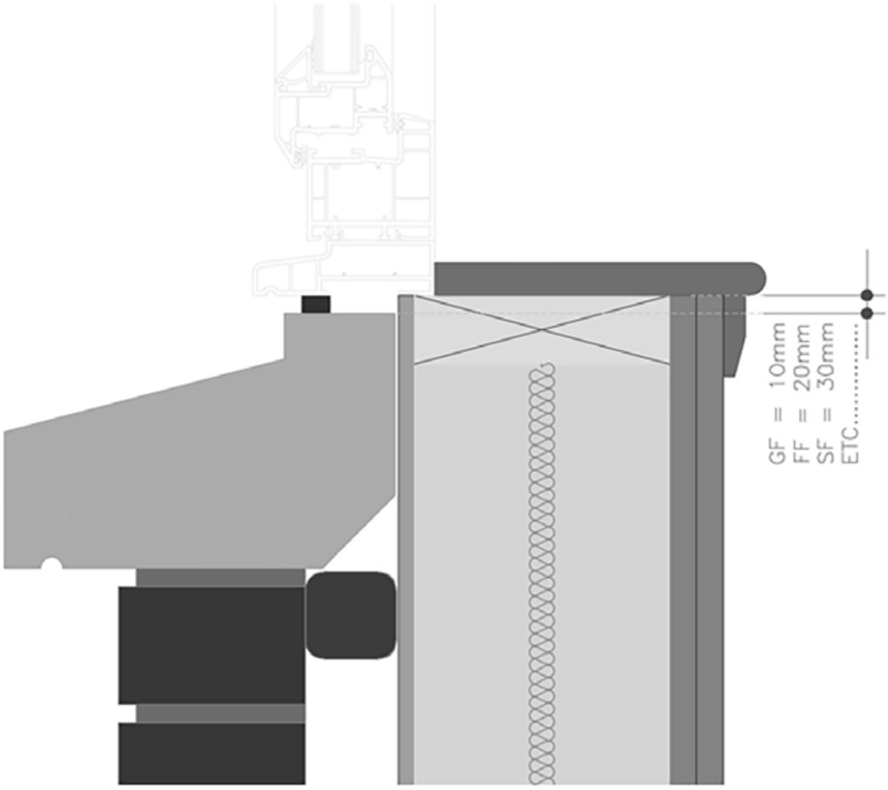
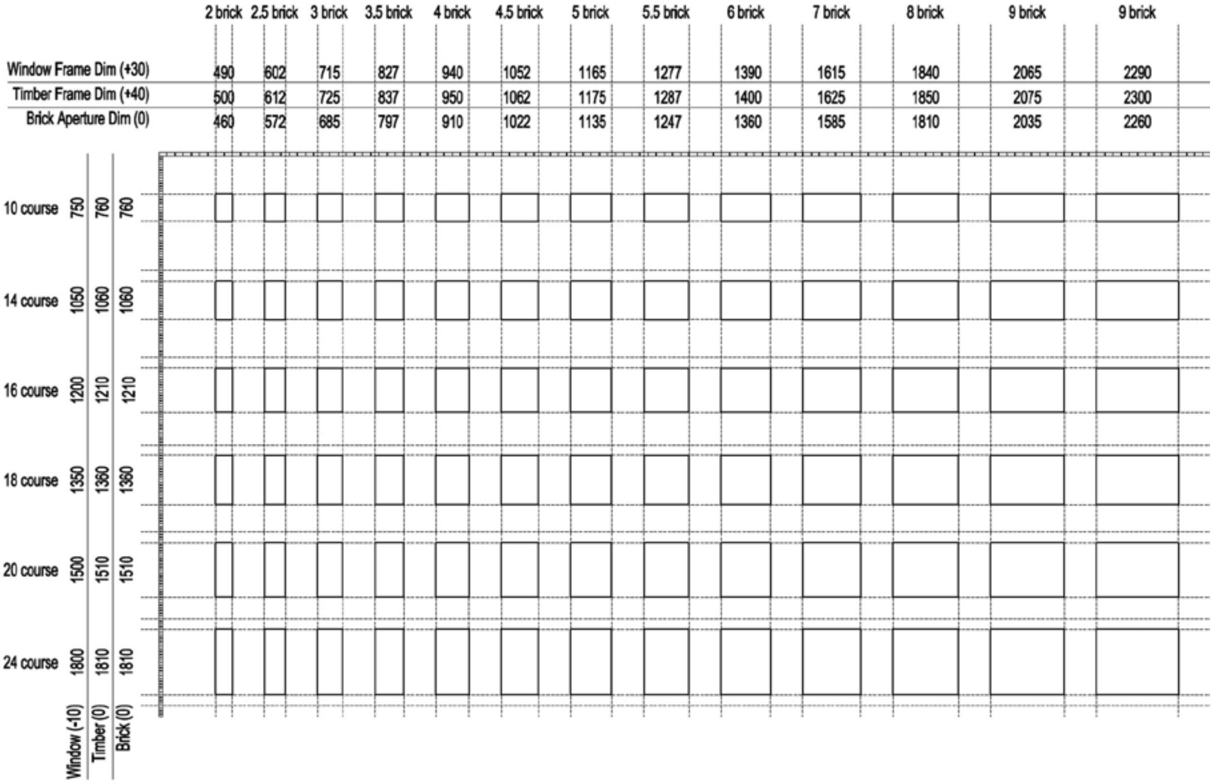


Figure 30 Cill Detail for Apartments

Rationalised Window Sizes

Based on the standard window, jamb, cill and head details above the rationalised window sizes have been listed below in figure 31. This provides detail of the brick aperture, component size and structural kit opening size.



	2 brick	2.5 brick	3 brick	3.5 brick	4 brick	4.5 brick	5 brick	5.5 brick	6 brick	7 brick	8 brick	9 brick	9 brick
Window Frame Dim (+30)	490	602	715	827	940	1052	1165	1277	1390	1615	1840	2065	2290
Timber Frame Dim (+40)	500	612	725	837	950	1062	1175	1287	1400	1625	1850	2075	2300
Brick Aperture Dim (0)	460	572	685	797	910	1022	1135	1247	1360	1585	1810	2035	2260

	Window (-10)	Timber (0)	Brick (0)
10 course	750	760	760
14 course	1050	1060	1060
16 course	1200	1210	1210
18 course	1350	1360	1360
20 course	1500	1510	1510
24 course	1800	1810	1810

Figure 31 Table of Standard Window Sizes

Corner and Bay Windows

When arranging corner or bay windows it is advisable to allow for a post (min width equal to wall thickness i.e. 140mm) to be positioned within the corner of the timber frame wall to allow for a lintel to be fitted without the need for complex steel/cantilever solutions.

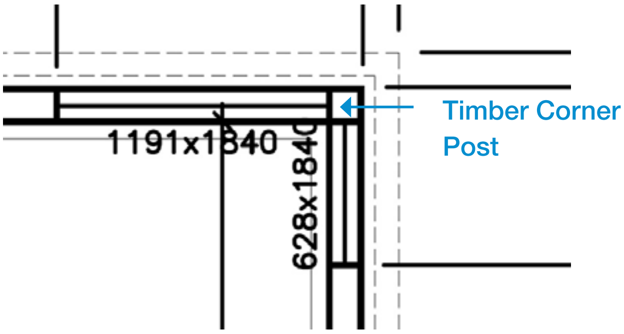


Figure 32 Corner Window Plan

Externally it would be preferable that the area above the corner windows be clad with a light weight cladding to negate the need for a complex steel solution.

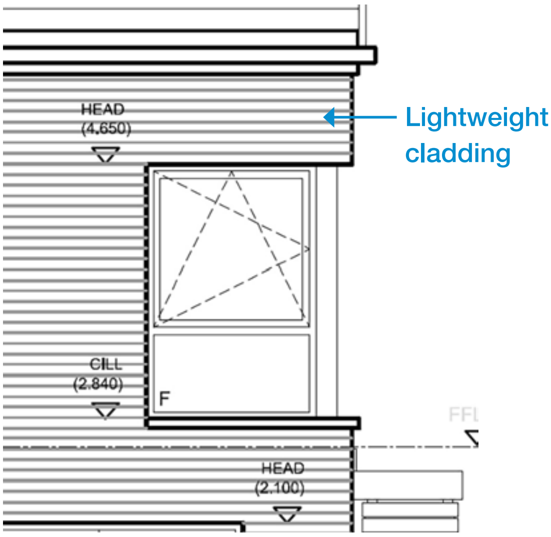


Figure 33 Corner Window Elevation

Factory Fitted Windows & Detailing

Background

The following has been summarised from ‘SMTS Factory Fitted Windows & External Doors Process Manual’. This manual is available upon request. SMTS factory fitted windows is an NHBC Accepts approved system.

The factory fitting of windows is an offering for customers that may wish to have these pre-fitted in the factory, for various quality, speed, safety and commercial reasons. The factory fitting of windows is out with the scope of SMTS Sigma II BBA approval. The factory fitting of windows is increasingly becoming attractive to customers, whom wish to enhance the basic timber frame structural carcass offered. This is in line with the government shift towards greater use of MMC, offsite manufacturing and lean construction practises, improving quality and as-built performance.

SMTS have developed a supply chain, design detailing, factory installation process and site commissioning practises, in partnership with preferred suppliers, using established and well proven site fitting techniques currently used on site. This utilises the timber cavity barrier pre-fitted to the window, to secure the window into the aperture in its final position, significantly reducing works on site and improving quality.

Scope

Typically limited by weight/size as follows:

1. Windows – up to 2.7m wide, by 1.9m high & 120kg max weight
2. Approved UPVC System Profile – Eurocell Logik 70 Range
3. Approved Suppliers
    a. Nationwide Windows & Doors
    b. Scotia Windows & Doors

Responsibilities

The design responsibility for the specification and regulatory compliance of windows and French doors from the Approved Supplier rests with the Client (in conjunction with the Principal Designer), in collaboration with the Approved Supplier. This includes the selection of glazing, frames designated as accessible entrances, egress escape windows and the provision of background ventilation. Frames have been tested up to BS6375 2400 exposure category dependent on size.

Further responsibilities are noted in ‘SMTS Factory Fitted Windows & External Doors Process Manual’.

Procurement Process

The SMTS offer to factory fit windows, is only available, from the approved suppliers. Clients keen to take up this offer deal direct with the approved supplier to provide quotations & design information, utilising SMTS factory fitted process, for which the suppliers are very knowledgeable of.

Factory Fitted Installation

All UPVC elements are factory fitted & stacked in accordance with the design information below.

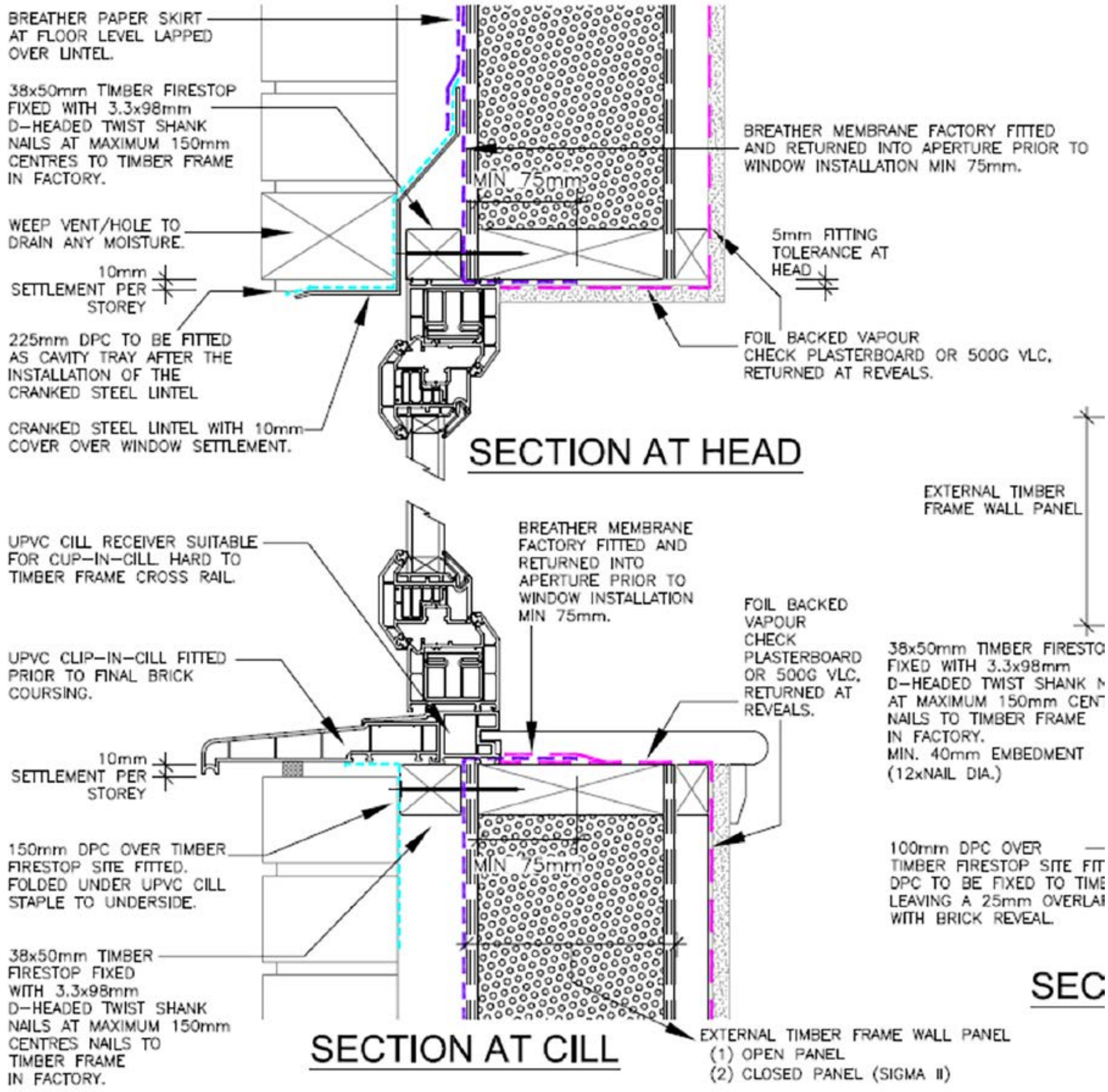


Figure 34 Section Through SMTS Factory Fitted Window (FFW)

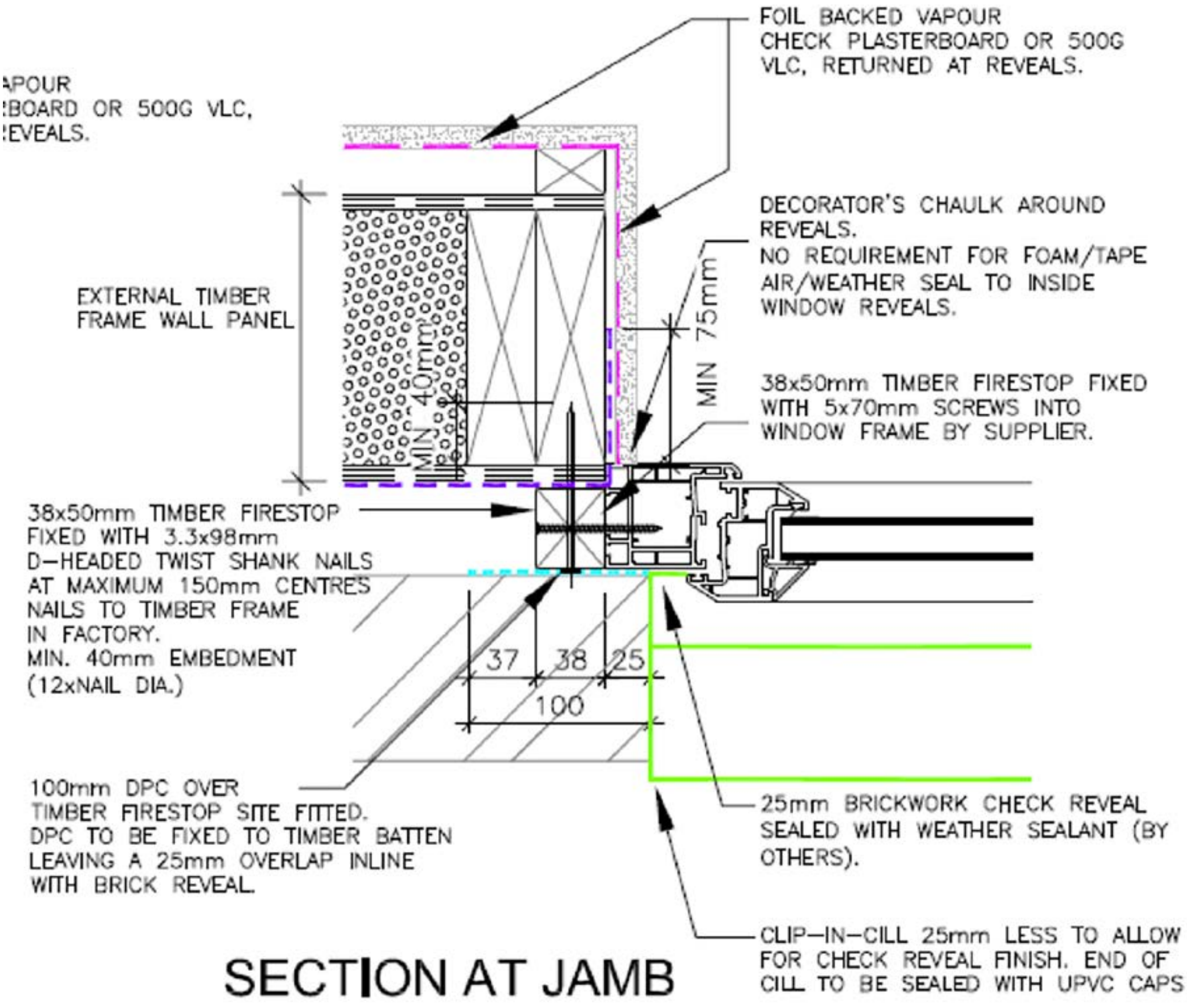
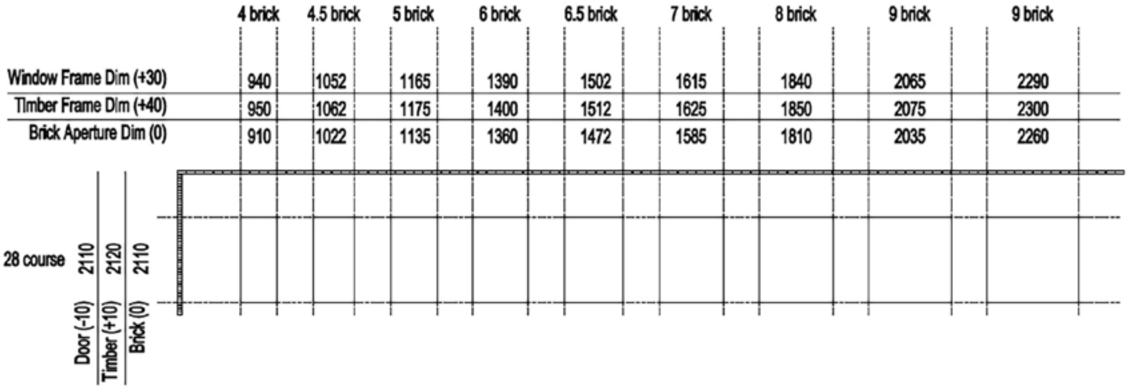


Figure 35 Plan View of SMTS Factory Fitted Window Jamb (FFW)

Section 2 – Doors

Based on the standard window jamb and head details above the rationalised door sizes have been listed below in figure 18. This provides detail of the brick aperture, component size and structural kit opening size.

Openings over 1135mm wide will typically account for French doors or door & sidelight.



	4 brick	4.5 brick	5 brick	6 brick	6.5 brick	7 brick	8 brick	9 brick	9 brick
Window Frame Dim (+30)	940	1052	1165	1390	1502	1615	1840	2065	2290
Timber Frame Dim (+40)	950	1062	1175	1400	1512	1625	1850	2075	2300
Brick Aperture Dim (0)	910	1022	1135	1360	1472	1585	1810	2035	2260

28 course
Door (-10) 2110
Timber (+10) 2120
Brick (0) 2110

Figure 36 Table of Standard Door Sizes

Handed Windows & Doors

It is beneficial to review the handing of windows and doors. As you will see from figure 10 below, many house builders hand windows for opposite handed plots. This gives no elevational or architectural benefit and adds to the number of window & door variants.

Having less window & door variants has the following benefits on site: -

1. **Quicker** & simpler to install due to having less variants to sort.
2. **Quality** - Less chance of problems windows being installed into the wrong aperture.
3. **Commercial Benefit** – In addition to the reasons above the windows & doors will be less expensive due to window manufacturer efficiencies.

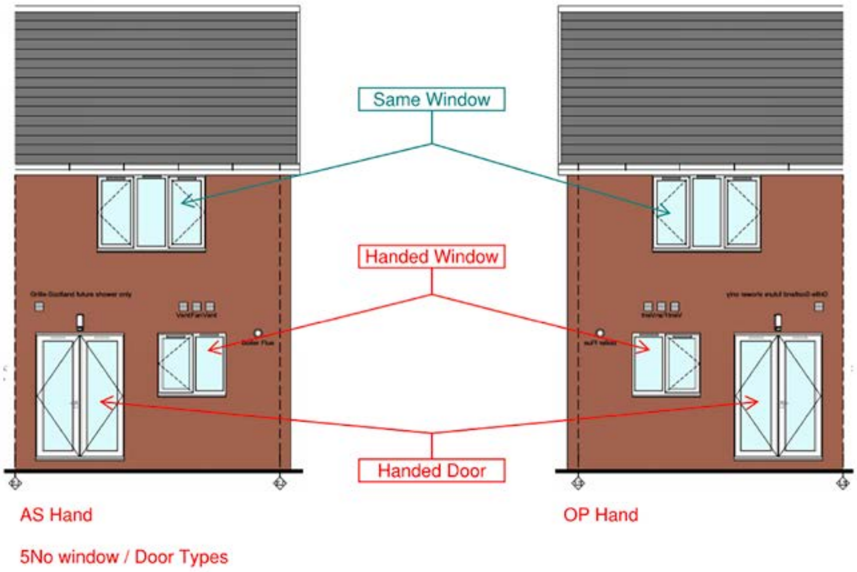


Figure 37 AS & OP Handed Windows & Doors

Figure 20 illustrates the subtle change to use AS handed components on the AS & OP variants which reduces the number of windows & doors on this elevation from 5No to 3No.

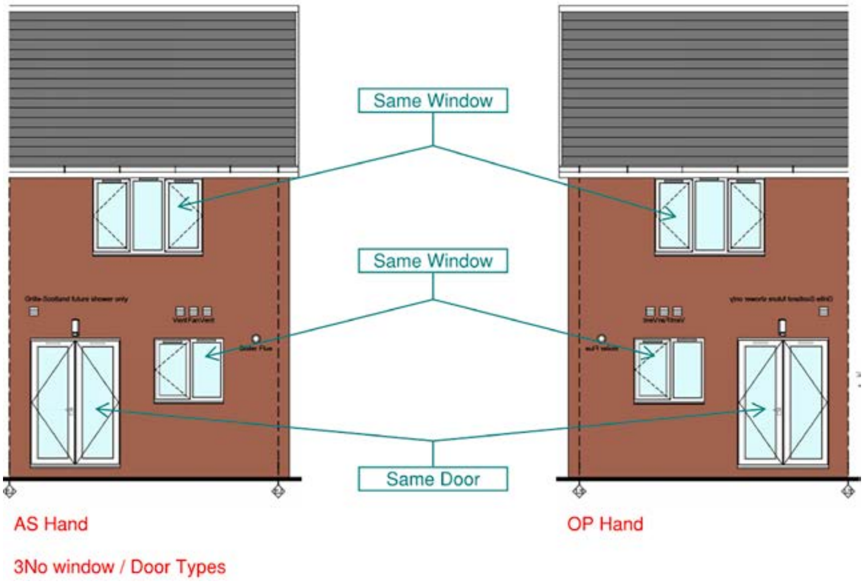


Figure 38 AS Handed Windows & Doors

Locking Handles & Window Styles

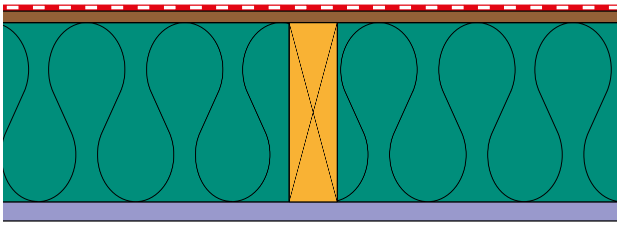
In addition to reviewing window handing consider installing locking handles to all windows. This reduces the amount of window types which a) reduces the chance of a window being installed in the wrong aperture b) commercial benefit due to economies of scale & c) gives the end customer a better specification.

Window style order of efficiency

1. Side Hung Casement Windows
2. Tilt & Turn Windows
3. Fully Reversable Windows
4. Mock Sash or Sliding Sash Windows

COMMON WALL CONSTRUCTIONS

1. WT1 external wall (REI 30 minutes)



VERIFICATION DETAILS

Based on testing to	BS EN 1365-1:2012 (loaded)
Load applied	100% of in-service design capacity
Field of application	Wall panels up to 2.7m high
3rd party peer review	Milner Associates in collaboration with BRE Global

	MATERIAL	FIXING
INNER FACE	1 x minimum 15mm Type A, D or F plasterboard. All joints mesh taped and filled ***NOTE:*** *Horizontal board joints require minimum 38mm x 63mm C16 timber noggins at board joint*	In accordance with BG, Knauf or Siniat fixings requirements Typically, 3.5mm x 38mm self-tapping drywall screws @ maximum 300mm CTRS
	Vapour control layer or vapour check plasterboard	VCL stapled to studs and top/bottom rails
OUTER FACE	Minimum 9mm sheathing (OSB/3, plywood or euro-class A1/ A2 boarding)	In accordance with structural engineer's fixing requirements Typically, 2.81mm x 50mm smooth shank nails @ 150mm CTRS (perimeter) and 300mm CTRS (intermediate studs)
	Breather paper and marker tapes ***NOTE:*** *Differing breather membranes have no detrimental impact on the fire resistance performance*	Stapled to studs and top/bottom rails
INSULATION	Minimum full fill mineral wool roll, with minimum thermal conductivity of 0.040 W/mK and density of 18kg/m^3 (glass or stone wool)	Friction fitted without fixings
STUDS	Minimum 38mm x 140mm C16 CLS timber @ 600mm CTRS ***NOTE:*** *Studs at closer centres and multiple stud clusters, has no detrimental impact on fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 3.1mm x 88mm twist shank nails, 2 per stud
NOGGINS	Timber ancillary or structural noggins, as required ***NOTE:*** *The addition of noggins has no detrimental impact on the fire resistance performance*	Typically, 3.1mm x 88mm twist shank nails, 2 per stud to noggin

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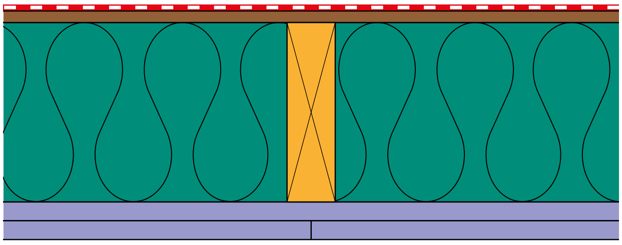
2. WT2 external wall (REI 60 minutes)



VERIFICATION DETAILS

Based on testing to	BS EN 1365-1:2012 (loaded)
Load applied	100% of in-service design capacity
Field of application	Wall panels up to 2.7m high
3rd party peer review	Milner Associates in collaboration with BRE Global

	MATERIAL	FIXING
INNER FACE	Final layer - 1 x minimum 15mm Type A, D or F plasterboard. All joints mesh taped and filled ***NOTE:** Plasterboard to have staggered vertical joints*	In accordance with BG, Knauf or Siniat fixings requirements Typically, 3.5mm x 60mm self-tapping drywall screws @ maximum 300mm CTRS
	First layer - 1 x minimum 15mm Type A, D or F plasterboard. The board joints do not need to be taped and filled ***NOTE:** Horizontal board joints in both layers, require minimum 38mm x 63mm C16 timber noggins at board joint*	In accordance with BG, Knauf or Siniat fixings requirements Typically, 3.5mm x 38mm self-tapping drywall screws @ maximum 300mm CTRS
	Vapour control layer or vapour check plasterboard (Type A)	VCL stapled to studs and top/bottom rails
OUTER FACE	Minimum 9mm sheathing (OSB/3, plywood or euro-class A1/A2 boarding)	In accordance with structural engineer's fixing requirements Typically, 2.81mm x 50mm smooth shank nails @ 150mm CTRS (perimeter) and 300mm CTRS (intermediate studs)
	Breather paper and marker tapes ***NOTE:** Differing breather membranes have no detrimental impact on the fire resistance performance*	Stapled to studs and top/bottom rails
INSULATION	Minimum full fill mineral wool roll, with minimum thermal conductivity of 0.040 W/mK and density of 18kg/m^3 (glass or stone wool)	Friction fitted without fixings
STUDS	Minimum 38mm x 140mm C16 CLS timber @ 600mm CTRS ***NOTE:** Studs at closer centres and multiple stud clusters, has no detrimental impact on fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 3.1mm x 88mm twist shank nails, 2 per stud
NOGGINS	Timber ancillary or structural noggins, as required ***NOTE:** The addition of noggins has no detrimental impact on the fire resistance performance*	Typically, 3.1mm x 88mm twist shank nails, 2 per stud to noggin

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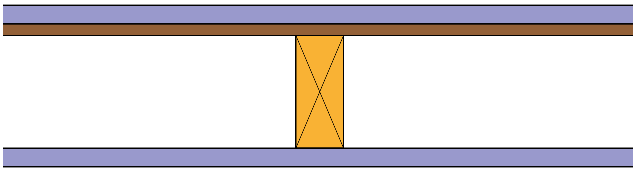
5. WT5 internal loadbearing wall (REI 30 minutes)



VERIFICATION DETAILS

Based on testing to	BS EN 1365-1:2012 (loaded)
Load applied	100% of in-service design capacity
Field of application	Wall panels up to 2.7m high
3rd party peer review	Milner Associates in collaboration with BRE Global

	MATERIAL	FIXING
INNER AND OUTER FACE	1 x minimum 15mm Type A, D or F plasterboard. All joints mesh taped and filled ***NOTE:*** *Horizontal board joints require minimum 38mm x 63mm C16 timber noggins at board joint*	In accordance with BG, Knauf or Siniat fixings requirements Typically, 3.5mm x 38mm self-tapping drywall screws @ maximum 300mm CTRS Tightly site fitted between studs, in accordance with manufacturer's recommendations or factory fitted using metal clips to timber frame manufacturer's details
INSULATION	Optional - for acoustic/thermal purposes, full or partial fill, mineral wool roll insulation (glass or stone wool) ***NOTE:*** *The addition of mineral wool insulation has no detrimental impact on the fire resistance performance*	Friction fitted without fixings
STUDS	Minimum 38mm x 89mm C16 CLS timber @ 600mm CTRS ***NOTE:*** *The addition of studs at closer centres and multiple stud clusters, has no detrimental impact on fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 3.1mm x 88mm twist shank nails, 2 per stud
UNSHEATHED OPTION	1 x row 38mm x 89mm C16 CLS timber mid height noggins, staggered ***NOTE:*** *The addition of mid-height noggins has no detrimental impact on fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 3.1mm x 88mm twist shank nails, 2 per stud/noggin connection
SHEATHED OPTION	Minimum 9mm sheathing (OSB/3, plywood or euro-class A1/A2 boarding) ***NOTE:*** *Sheathing is an optional requirement for structural purposes* ***NOTE:*** *The addition of sheathing has no detrimental impact on fire resistance*	In accordance with structural engineer's fixing requirements Typically, 2.81mm x 50mm smooth shank nails @ 150mm CTRS (perimeter) and 300mm CTRS (intermediate studs)
NOGGINS	Timber ancillary or structural noggins, as required ***NOTE:*** *The addition of noggins has no detrimental impact on the fire resistance performance*	Typically, 3.1mm x 88mm twist shank nails, 2 per stud to noggin

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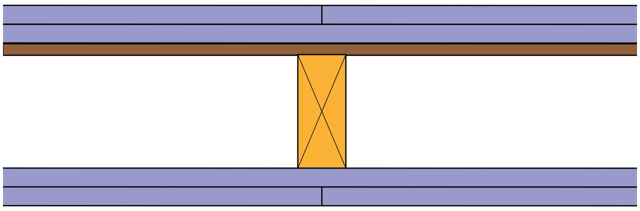
6. WT6 internal loadbearing wall (REI 60 minutes)

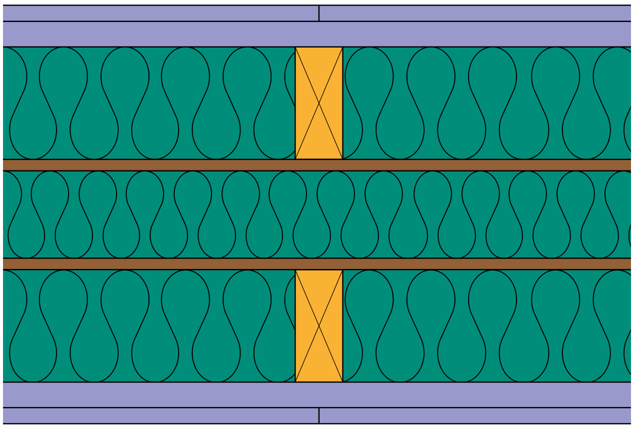


VERIFICATION DETAILS

Based on testing to	BS EN 1365-1:2012 (loaded)
Load applied	100% of in-service design capacity
Field of application	Wall panels up to 2.7m high
3rd party peer review	Milner Associates in collaboration with BRE Global

	MATERIAL	FIXING
INNER AND OUTER FACE	Final layer - 1 x minimum 15mm Type A, D or F plasterboard. All joints mesh taped and filled ***NOTE:*** *Plasterboard to have staggered vertical joints*	In accordance with BG, Knauf or Siniat fixings requirements Typically, 3.5mm x 60mm self-tapping drywall screws @ maximum 300mm CTRS
	First layer - 1 x minimum 15mm Type A, D or F plasterboard. The board joints do not need to be taped and filled ***NOTE:*** *Horizontal board joints in both layers, require minimum 38mm x 63mm C16 timber noggins at board joint*	In accordance with BG, Knauf or Siniat fixings requirements Typically, 3.5mm x 38mm self-tapping drywall screws @ maximum 300mm CTRS
INSULATION	Optional – for acoustic/thermal purposes, full or partial fill, mineral wool roll insulation (glass or stone wool) ***NOTE:*** *The addition of mineral wool insulation has no detrimental impact on the fire resistance performance*	Friction fitted without fixings
STUDS	Minimum 38mm x 89mm C16 CLS timber @ 600mm CTRS ***NOTE:*** *The addition of studs at closer centres and multiple stud clusters, has no detrimental impact on fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 3.1mm x 88mm twist shank nails, 2 per stud
UNSHEATHED OPTION	1 x row 38mm x 89mm C16 CLS timber mid height noggins, staggered ***NOTE:*** *The addition of mid-height noggins has no detrimental impact on fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 3.1mm x 88mm twist shank nails, 2 per stud/noggin connection
SHEATHED OPTION	Minimum 9mm sheathing (OSB/3, plywood or euro-class A1/A2 boarding) ***NOTE:*** *Sheathing is an optional requirement for structural purposes* ***NOTE:*** *The addition of sheathing has no detrimental impact on fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 2.81mm x 50mm smooth shank nails @ 150mm CTRS (perimeter) and 300mm CTRS (intermediate studs)
NOGGINS	Timber ancillary or structural noggins, as required ***NOTE:*** *The addition of noggins has no detrimental impact on the fire resistance performance*	Typically, 3.1mm x 88mm twist shank nails, 2 per stud to noggin

7. WT7 Party wall (REI 60 minutes)



VERIFICATION DETAILS

Based on testing to	BS EN 1365-1:2012 (loaded)
Load applied	100% of in-service design capacity
Field of application	Wall panels up to 2.7m high
3rd party peer review	Milner Associates in collaboration with BRE Global
Robust details	Compliant with wall types E-FT-1 and E-FT-2

	MATERIAL	**FIXING**
INNER AND OUTER FACE	Final layer - 1 x minimum 12.5mm Type A plasterboard. All joints mesh taped and filled ***NOTE:*** *Plasterboard to have staggered vertical joints. All Horizontal board joints in final layer, require minimum 38mm x 63mm C16 timber noggins at board joint*	In accordance with BG, Knauf or Siniat fixings requirements Typically, 3.5mm x 60mm self-tapping drywall screws @ maximum 300mm CTRS
	First layer - 1 x minimum 19mm Type A plasterboard (Gyproc Plank), 600mm x 2400mm fitted horizontally and staggered, no noggins on long edges. The board joints do not need to be taped and filled	In accordance with BG, Knauf or Siniat fixings requirements Typically, 3.5mm x 45mm self-tapping drywall screws @ maximum 300mm CTRS
INSULATION	Studwork - minimum 90mm mineral wool party wall acoustic roll (18kg/m^2), between studs in each partition (glass or stone wool)	Insulation rolls friction fitted vertically between studs
	Cavity - minimum 50mm glass wool party wall acoustic roll (min 18kg/m^2) to cavity between each partition (glass or stone wool)	Insulation rolls friction fitted horizontally in 600mm wide layers and butt jointed
STUDS	2 x 38mm x 89mm C16 CLS timber @ maximum 600mm CTRS in a separated twin leaf formation, with minimum 50mm cavity space between sheathing ***NOTE:*** *The addition of studs at closer centres and multiple stud clusters, has no detrimental impact on fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 3.1mm x 88mm twist shank nails, 2 per stud

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7. WT7 Party wall (REI 60 minutes) cont…/

	MATERIAL	**FIXING**
UNSHEATHED OPTION	Subject to structural engineer's design requirements, 1 x row 38mm x 89mm C16 CLS timber mid-height noggins, staggered to each timber partition, maybe required ***NOTE:*** *The addition of sheathing has no detrimental impact on the fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 3.1mm x 88mm twist shank nails, 2 per stud/noggin connection
SHEATHED OPTION	Minimum 9mm sheathing (OSB/3, plywood or euro-class A1/A2 boarding) to cavity faces ***NOTE:*** *Sheathing can be absent, single sided or double sided (back to back) In accordance with Robust Details wall types E-WT-1 and E-WT-2* ***NOTE:*** *The addition of sheathing has no detrimental impact on the fire resistance performance*	In accordance with structural engineer's fixing requirements Typically, 2.81mm x 50mm smooth shank nails @ 150mm CTRS (perimeter) and 300mm CTRS (intermediate studs)
NOGGINS	Timber ancillary noggins, as required ***NOTE:*** *The addition of noggins has no detrimental impact on the fire resistance performance*	Typically, 3.1mm x 88mm twist shank nails, 2 per stud to noggin

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USEFUL LINKS

The following are links to websites where further detailed information on Timber Frame panelised MMC construction can be found.

Stewart Milne Timber Systems

The UK's leading Offsite Timber MMC systems provider & AIMCH partner

Website www.stewartmilnetimbersystems.com

E-mail timber@stewartmilne.com

Phone 0845 835 1527

Structural Timber Association

The Trade Association for the structural timber sector

Website www.structuraltimber.co.uk

E-mail office@stricturaltimber.co.uk

Technical Helpline technical@structuraltimber.co.uk

Phone 01259 272 140

National House Building Council

The UK's leading provider of Building Warranties and a building control approved inspector

Website www.nhbc.co.uk

Technical Guidance, External Timber Frame Walls Chapter 6.2 www.nhbc.co.uk/builders/products-and-services/techzone/nhbc-standards/technical-guidance

Phone 0344 633 1000

NEXT STEPS

The DFMA Guide, thought to be one of the first its kind, will be used in the development of AIMCH Industrialised Housing Designs, suitable for affordable housing development, embracing Design Standardisation and 3D BIM modelling approach, developed as part of WP5 outputs within the AIMCH project.

This work is being progressed by Stewart Milne Group and London and Quadrant and will provide an off the shelf pre-designed and MMC value engineered pattern book of homes. These housing designs will be commercially evaluated within WP8, through detailed desk top commercial analyse the cost effectiveness of this approach and the standardisation solutions created.

SMTS will make available the DFMA guide for use with clients interested in designing homes, using their range of panelised timber frame open and closed Offsite MMC technologies.

DFMA within housing design, as a mainstream industrialised process, is a significant shift for the AIMCH developers and wider industry. This will take many years to embrace, embed and deliver to the scale, capability and benefits shown by the automotive sector. This DFMA Guide, believed to be one of the first of their kind, show's real promise in the potential to embrace DFMA as a positive attribute and not as a perceived negative thing.

AIMCH partners are already seeing business opportunities where this work can be exploited within their businesses. In the case of Stewart Milne Homes, the DFMA guide has been utilised in the creation on a new housing range for deployment within the business in the next 12-36 months. Similarly, L&Q have adopted the information for use in there housing portfolio development work, embracing panelised MMC systems.

The DFMA Guide is available as a free download from the AIMCH website www.aimch.co.uk with a dedicated web page explaining more about the DFMA Guide and its use by designers, for wider sector benefit, awareness and impact.

Summary & Conclusions

This is sizable AIMCH deliverable and tackles a subject often discussed but difficult to tangibly realise. The DFMA Guide for panelised timber MMC systems, provides a model example to support a step change in attitude, towards industrialised thinking and working together to solve the challenges of DFMA, standardisation and deployment of industrialised housing design practises.

The DFMA Guide, thought to be one of the first its kind, will be used in the development of AIMCH Industrialised Housing Designs, suitable for affordable housing development, embracing Design Standardisation and 3D BIM modelling approach, developed as part of WP5 outputs within the AIMCH project.

DFMA in conjunction with design standardisation and 3D BIM modelling (Building Information Modelling) can be very powerful tools to transform housing design and delivery, leveraging learnings from the automotive sector, where these approaches have excelled.

AIMCH ambition is through the creation and exploitation of future industrialised housing designs, that embrace DFMA, Standardisation, BIM and MMC, delivering high quality, functional and appealing homes, AIMCH will fuel a path to delivering more industrialised homes, at an affordable cost.

This report is part of the AIMCH project which is developing all areas of modern methods of construction in housebuilding. For more information on the full scope and outputs of the project visit aimch.co.uk and follow us on LinkedIn and Twitter.

AIMCH

TRANSFORMING HOW WE BUILD HOMES

mtc Manufacturing Technology Centre

L&Q

CONSTRUCTION SCOTLAND INNOVATION CENTRE

FORSTER GROUP

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BARRATT DEVELOPMENTS PLC BUILDING EXCELLENCE SINCE 1958

INDUSTRIAL STRATEGY

UK Research and Innovation

@AIMCH2

aimch

aimch@cs-ic.org