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26th MARCH 2009

TIMBER FRAME CONSTRUCTION

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I.S. 440 – TIMBER FRAME DWELLINGS

A BRIEF SUMMARY

Publication date:

The expected publication date is around May 2009.

The standard was funded by the Department of Environment, Heritage and Local Government and by the Irish Timber Frame Manufacturers' Association. The initial drafts were produced by the Building Research Establishment working with Timber Design Services.

The standard covers materials, design, manufacture, construction details, site work and services.

This is a brief summary describing some of the main sections of the standard. However, the standard is in the final stages of editing and some minor changes may still occur.

Scope (section 1)

The standard applies to housing and apartments up to and including 4 storeys with a maximum height of 10m to the upper floor and with a fire resistance not exceeding 60 minutes. The external wall should have a ventilated and drained cavity and the external cladding should be masonry or timber; where these conditions are not met, the external wall weathering system should have appropriate certification. Much of the contents of the standard would also apply to other building purpose groups.

Normative references (section 2) and Terms and definitions (Section 3)

Normative references re a list of standards that the standard uses must be followed (informative references are optional or advisory).

Responsibilities (section 4)

The responsibilities are defined by subject rather than the specific responsibilities being assigned to the appropriate people (such as timber frame manufacturer, builder, project manager etc.). Listing the responsibilities was thought important as it is possible that a builder-developer could separately source the different building components such as the timber frame kit, roof trusses, floor systems and erect and finish the building without anyone co-ordinating the design or understanding the different elements. Important aspects of design could be missed and should errors occur then the specification and responsibilities for remedial measures (and indeed for signing off for the whole building) would be unclear.

The standard currently requires the signing off and certification of the design, manufacture, erection and finishing of the building. In addition different aspects of the building have to be specified; e.g. the building's fire resistance, the building purpose group, floor loads etc.

Inspection and supervision are recognised also as being important and the requirement to inspect fire stops, cavity barriers, services and separating walls are specifically mentioned. Also mentioned for example are supervision of the erection and advisory site inspections (under manufacture).

The standard does require a higher degree of site control and inspection especially for apartments. The use of check lists is seen as a means of ensuring proper site control and of demonstrating that such control exists.

An important requirement is that comprehensive site fixing schedules must be supplied.

For a domestic dwelling the standard requires:

- The provision of site erection instructions, construction details and site fixing schedules.
- The certification of the structural design (timber frame walls, floors and roof), the manufacture of the timber frame components, the site erection and of the completed building.
- The inspection of fire stops, cavity barriers, separating walls and the external timber cladding. In addition the competed timber frame structure especially following the installation of services shall be inspected.

Materials (Section 5)

This gives information on materials used in manufacture and site. There is a requirement that timber in the external wall are preservative treated (with the exception of the header joist).

Important requirements are proprietary cavity barriers are required to have been tested and be marked with the manufacturers' name, the fire rating, the range of cavity widths for which it is suitable and to have a covering made from non-recycled plastic; the covering is required to give adequate protection from moisture and damage.

Wall ties are required to be made from austenitic stainless steel and bear the manufacturers' mark. The wall tie manufacturers are required to provide information on the wall tie centres for different wind pressures, suitable cavity widths and the vertical movement capacity of the ties.

A distinction is made between and anchor straps (at or below DPC level – they must be austenitic stainless steel) and holding down straps (e.g. for trusses on the inner external wall leaf, any strap in the external wall should have a level of corrosion resistance appropriate to service class 2. Both materials should bear the manufacturers' identification mark.

Design (Section 6)

This section covers structural design and the design of the panels i.e. essentially the construction details, how the different components interact and function.

Structural calculations are required to be clear and comprehensive and there is a list of items to be checked. From this it is possible to draft a checklist for the structural calculations and it would make sense for a manufacturer to draft such a check list for their structural design engineers. It would also make sense for anyone checking or requesting calculations to have or request a checklist (filled in and signed) from the timber frame designer as well as perhaps a structural certificate.

There is a requirement for a summary of the calculations to be produced showing the important design requirements; this would typically show items such as non-standard nailing for wall panels, special holding down and special nailing requirements, cripple stud and lintel information. These summary sheets are seen as important for site checks.

Design using software shall have an explanatory document outlining the basis and assumptions made in the programme. The idea being that any printout will be able to be followed and specific figures traced.

Designs can be to BS 5268 or Eurocode 5 (EC5) although perhaps EC5 does not yet cover the racking resistance of walls in a satisfactory manner and the requirements for overturning are higher than for designs to the current standard BS 5268-6.

There is requirement for the engineer to sign off on any in-house (i.e. designs not carried out by the timber frame design engineer). By signing of it was meant that the design was compatible with the timber frame design – essentially in terms of span direction, fire resistance and weights.

Some aspects of design have still to be resolved for example the issues surrounding floor joists (particularly engineered joists) spanning across a compartment floor are covered but it may be that in the final version these joists will stop at the compartment walls which will make fore stopping simpler.

Manufacture (Section 7)

This section is based on a draft EN. There was consideration given to limiting distortion (mainly bow and spring) in the timber members making up a panel but this was dropped and the limits were imposed on the panel instead; this is of course useful for any site checks.

Table 3 — Panel tolerances

Panel dimension		Tolerance (mm)		
		Wall	Floor	Roof
Length	≤ 3 m	+0 / -5	+0 / -5	+0 / -5
	> 3 m	+0 / -7	+0 / -7	+0 / -7
Height	≤ 3 m	±3	-	-
Width	> 3 m	-	+0 / -5	+0 / -5
Thickness		±3	±3	±5
Diagonal	≤ 6 m	±5	±5	±5
	> 6 m	±7	±7	±7
Openings		±3	±3	±3

Negative tolerances on openings are probably not a good idea as it could mean that windows and doors might not fit.

Table 4 — Maximum panel distortion

Panel distortion	Maximum tolerance (mm)		
	Wall	Floor	Roof
Bow across face	3 mm	10 mm	10 mm
Spring along edge	4 mm	3 mm	6 mm
Note The tolerances for distortion are independent of panel dimensions			

Bow in a wall mainly affects the bottom and top rail and the fixing of plasterboard to a stud. Spring in a wall occurs where the stud is out from the plane of the wall; it is almost impossible to fix plasterboard if the spring is 6mm or more. Spring can also give rise to nail popping.

There are quiet tight tolerances on nailing:

The mean value of the measured centres of the mechanical fasteners shall not be less than the prescribed centres.

The edge distances of the mechanical fasteners shall not be less than 75 % of the prescribed edge distances for more than 15 % of the mechanical fasteners.

Fasteners shall not be over punched by greater than 2mm below the surface for 9mm sheathing (and in proportion for other thicknesses). Over punching shall not occur in more than 20% of fasteners and in no more than 10% of fasteners within 500mm of wall panel corners. The latter was put in because the wall panels and fixings are more highly stressed at wall panel corners.

All panels must be marked to identify their location within the building and these marks should correspond with the panel layout drawings. Wall panels should be marked indicating the panel top or bottom; this should help reduce panel misplacement which is rare anyway. Quality marking usually with a tag includes:

- manufacturer's name
- name of notified body certifying the factory production control system
- registration number issued by the notified body
- reference to this Irish Standard

Non-load bearing internal wall are not required to have a mark or tag.

Construction details (Section 8)

This gives some construction details which are not meant to be restrictive although generally they do represent the more common details. This section also gives some requirements in relation to detailing and deals with the different timber frame elements (mainly walls and floors) but also deals with some of the associated components such as wall ties, cavity barriers, fire stops etc.

The fixing of internal linings is dealt with in detail and party/compartment walls are well covered as are compartment floors.

External timber cladding is only touched on in the standard; more details were drafted but were not included in the standard and the detailing has been left to the appropriate designer.

Site work (Section 9)

This section to some extent goes with section 8 and it was hard in some instances to separate different requirements into the appropriate section. One major part of this section deals with site tolerances on the substructure and concrete base as well as the erection of wall and floor panels.

Table 6 — Construction tolerances - Concrete base and foundation walls

Base and walls		**Tolerance** (mm)
Length of walls		±10
Length of diagonals	Up to 10 m	±5
	Over 10 m	±10
Level of base surface		±5 from datum, variation 10 mm maximum
Overall length of base and perimeter footing		±10
Straightness of base edges		±10

Table 7 — Construction tolerances for sole plates

Dimension		Tolerance (mm)
Length		±10
Length of diagonals	Up to 10 m	±5
	Over 10 m	±10
Sole plate overhang		±10 (to substructure)
Level		±5
Setting out		±10 (from set out line)
Packing (max.)		15

Table 8 — Construction tolerances for wall panel erection

Dimension		Tolerance (mm)
Plumb in any story height		±10 (see Note 1)
Line panels within		±3 (see Note 2)
Length	Up to 10 m	±5
	Over 10 m	±10
Level		±5
Wall edges straight		±10
Head plate level		±5
Notes 1. Not greater than 10 mm accumulative over total building height 2. Using the sole plate or bottom rail as a template		

Table 9 — Construction tolerances for floor panel erection

Dimension		Tolerance (mm)
Level		±2 (see Note 1)
Length	Up to 10 m	±5
	Over 10 m	±10
Edge		±10 (see Note 2)
Notes 1. With adjacent panels 2. With outer wall panel edge		

There are quality control requirements on site work as well as requirements to check on going work. Beside ongoing checks on the construction they require sub-contractors and other critical personnel to be fully briefed on the requirements for timber frame construction.

Services (Section 10)

This section deals with electrical wiring and plumbing. The need to consider de-rating the electrical wiring and/or its placement in ducting has to be considered.

Chimneys should not breach a party wall unless they are part of an approved system.

Vents and chimney flues are to be sealed at the timber frame wall panel and the external cladding.

Annexes A & B

The standard deals with differential movement in Annex A and gives items that should be considered in various checklists in Annex B. Differential movement is considered differently than in the UK where the UK timber frame association gives movement allowances. The approach in the Irish Standard allows the amount of movement to be catered for to be calculated knowing the moisture content of different components; it follows the approach inherent in timber standards and allows greater flexibility for the designer.

INFORMATION REQUIRED FOR AN APPRAISAL

Prior to an inspection some information is usually required on the building. Typical information on a building, usually obtained from the manufacturer, would include;

1 Timber frame calculations
2 Truss calculations
3 Construction details
4 Site fixing schedule
5 General site information

1 Timber Frame Calculations

Most timber frame manufacturers use external consultants in private practice. Presently all designs are to BS 5268 parts 2 and 6; part 6 is the main standard and covers wall panel racking, overturning and sliding and in understanding calculations it is necessary to be familiar with this standard.

Detailed calculations should be asked for but there should also be a summary of these calculations detailing the main points arising from design and usually these will be adequate to check the building. For a dwelling the summary calculations are typically about 2 or 3 pages and include;

- Studs, justification of studs, bearing stress
- Lintels and cripple studs
- Nailing for sheathing, structure and holding down, but see also the Site Fixing Schedule
- Sheathing, additional layers, thickness
- Floor joists, strength class, size, spacing, direction
- Roof fixings, especially for lightweight roofs
- Trusses, bracing, details where they bear on party walls
- Beams and trimmers
- External and internal racking walls
- Wind beams, external walls at stairs

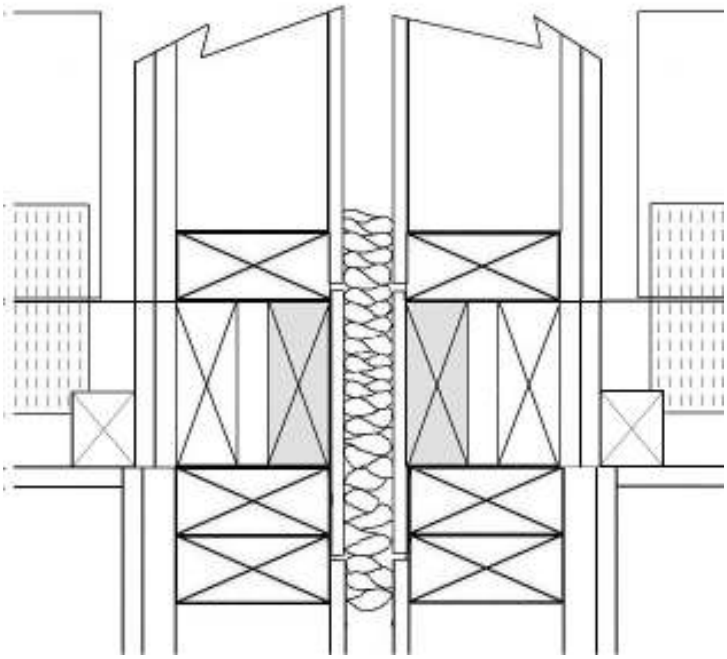
Calculations can vary considerably in detail and approach. The vast majority of calculations are detailed and satisfactory but some calculations can lack detail especially with engineers unfamiliar with Timber Frame. Calculations using software can be hard to interpret and IS 440 requires software to have an explanatory document to aid understanding. A calculation checklist, based on IS 440, would provide a short summary of what has been checked and should ensure that nothing is overlooked in the design.

With self certification it is difficult to question any calculations and they probably shouldn't be looked at in any detail unless there are serious concerns about the design. They should be kept on file and asking for them at least ensures that that are present. However the summary sheets are important for site inspections and these should be looked at prior the inspection.

2 Truss calculations

These are important as they give information about bracing details but are not solely a timber frame issue.

In terms of timber frame, an important factor is how trusses bear on the party wall. Truss fabricators do not tend to appreciate timber frame fire and acoustic requirements and may produce details or profiles not really suitable for timber frame; for example it is very difficult to properly fire stop a sloping rafter coming onto a party wall. About the only way that this can work is if the truss has a stub end. The construction details should be looked at to determine the fire stop details and that they are appropriate to the building.



3 Construction Details

These are provided by the timber frame manufacturer and are usually standard or generic and not specific. As such they often cover most details used in a dwelling but there may also be specific or special details for a particular building .e.g. a balcony, a stepped party wall or a special engineering detail.

Most construction details are similar over all manufacturers with few significant differences. Once one set of construction details have been looked at, it should lead to a good understanding of timber frame.

4 Site Fixing Schedules

Great importance has been put on these in IS 440. Essentially they should contain information and effectively instructions for all fixings on site.

They should only be in one or two places and should not be buried in the calculations (which will not be read by the timber frame erectors) nor should they be spread out in the different information going to site. They should be foremost in only one or two documents in a format suitable for site use. They can also be in other areas such as specific construction details and site erection information.

The Site Fixing Schedules should be checked against the calculation summary sheet to make sure they agree.

5 General site information

This would include erection instructions which are probably not necessary for inspection purposes. It should include checklists, base plans and panel location plans. Also included might be information on plasterboard linings (and perhaps their fixings), fire stops, cavity barriers, wall ties etc.

This information may or may not be relevant to a site inspection.

Fire test reports

Fire test results or reports may be included (or requested) always read these. In the absence of these there may be an assessment by a recognised fire test house; these should be read to ensure they apply to the building, component or material being used.

Assessments can be difficult to deal with as sometimes they may make inappropriate assumptions to justify their conclusions.

The following should be checked:

Is there a validity date or limit on the report?
Was the test carried out by an accredited or recognised laboratory?
Does the test actually satisfy the requirements for the products use?
Does the report adequately describe the test and the product or its use?

SITE INSPECTIONS

These can be difficult due to the speed of erection. Often a site visit will occur after substantial work has been completed and this means that important aspects of the construction will not be visible.

In carrying out an inspection it is probably wise not to give too much advice and certainly any independent consultant being used by Building Control should be advised to put any issues in writing after an inspection. A checklist would be useful and a hand written summary of any issues raised during the inspection especially where further information is required would speed up communications. In offering advice care must be taken not to take responsibility for the construction and buildings will often take action on advice quickly, viewing it as an instruction and the work may not be visible on the next site visit.

To carry out an inspection you will need at least the calculation summary and the Site Fixing Schedules (although the calculation summary might contain enough information on site fixing). The following is a brief summary of some of the items relating to site inspection.

1 Fixings

Usually only spot checks would be made on the connections (length, diameter, number, durability), and you would get a feel especially for the frequency of the fixings as you walk through a site. See if the erector is using a checklist or a Site Fixing Schedule, this might influence you on how detailed a check you make on fixings. If the building is straight forward e.g. a simple dwelling then an experienced erector should know what he's doing without too much reference to documentation which he should have studied beforehand anyway.

Ensure fixings go into timber and not air, ensure that there is enough timber or the fixings are long enough. Check any special areas e.g. if additional nails are required fro a particular wall panel.

<u>Sole plates</u>

Check the fixings frequently and type of fixings to the Site Fixing Schedule. Soleplates are usually shot fired down with masonry nails. Try and obtain a sample fixing and check the diameter, length and where appropriate the metal or corrosion resistance.

<u>Wall panel to sole plate/substructure</u>

These fixings should be the same as for the soleplate (frequency and diameter). Again a sample should be obtained and checked fixings to the Site Fixing Schedule.

Check that the anchor straps and their fixings are austenitic stainless steel (non magnetic).

<u>Wall panel to wall panel</u>

These should be fixed together through the adjacent end studs; the minimum design requirement is with 3.35 x 75 nails at 300 centres. Nails on site are usually 3.1mm x 75 or 90. The 90mm skew nailed at 300mm should be ok (with points clenched).

Floor structure to lower wall panel

This would include the head binder. You would expect the fixings requirements of floor to head binder and head binder to lower panel to be the same as for wall panel to soleplate. Fixing may be at an angle, from the outside or inside. If the nails are too short they will not go into enough timber.

Upper panel to floor structure

It is important to check that fixings actually go into timber especially around the external walls. The frequency of these fixings would be expected to be less than those of the lower wall panels but check the Site Fixing Schedule.

Roof to Upper wall panel

This includes roof to head binder, head binder to wall panel. The fixings should be the same as for the fixings of the wall panel to the floor structure.

The roof may have holding down requirements. Any holding down details should be to the wall panel (and not just the head binder).

2 General walk through the interior

There is adequate timber to fix plasterboard to; sometime timber does have to be added on site because of mistakes in fabrication.

Make sure that insulation can be fitted and that there are no cold spots especially at external wall corners.

Make sure that there is timber under any large point loads (e.g. girder trusses) and that this timber is present right though the floors and lower all panels and right to the substructure.

Check for any excessive notching or drilling especially of truss members and load bearing studs.

Check lintel supports; that there are no gaps and the right number of cripple studs are present.

Check that nothing has been altered; members cut etc. Check that any remedial work complies with written instructions and any drawings. This applies to roof trusses as well.

Check that non load bearing walls are non-load bearing especially for trusses.

Check that the horizontal fire stop in the party wall at floor level is continuous, fills the cavity and is at the correct height. Check the vertical fire stop in the party wall ends as well (continuous, fills the cavity and no gaps with the horizontal fire stops and eaves box and non-combustible board.

With 2.7m high panels, check if bridging is present at 2.4m height for sheathing and plasterboard.

Check for gaps in party wall (top and bottom of panels) especially due to bow.

For timber frame panels a check should be made for the presence pf a NSAI tag, giving the registration number of the manufacturer. The NSAI web site can be checked for confirmation that the manufacturer is registered.

For roof trusses, the first thing to look for is a NSAI tag giving the fabricators name, registration number and strength class of the timber. The NSAI web site can be checked for confirmation that the fabricator is registered.

Copies of certificates can be asked for from the timber frame designer and manufacturer; it is hoped that in the near future appropriate certificates will also be available from the erector and builder (as referred to in IS 440).

3 Outside work

Check cavity barriers; marked, no gaps, not damaged. With timber cavity barriers make sure they are at least 38mm thick. Mortar droppings and poor masonry work can compromise cavity barriers.

Any damage to the breather membrane should be repaired. The membrane should be lapped over lower membranes and laps stapled in place.

Lintel DPCs should not be fixed to the face of the breather membrane; the breather membrane should lap over the DPC. Some manufacturers fix the DPC in the factory otherwise the breather membrane will have to be cut on site and the DPC slipped under the membrane.

Anchor straps should not be kicked in but should cross the cavity and go 50mm into the external masonry leaf.

The eaves box should be properly constructed. It is hard to see how a eaves box can be properly constructed without using non-combustible boards; the boxes should be filled with mineral fibre.

Wall ties should be at the correct spacing and be fixed into timber studs. The wall tie centres should be specified in the design and Site Fixing Schedule.

Vents and flues should have a cavity barrier and be sealed for fire and air tightness to the external wall leaf and the internal timber frame leaf.

4 Final internal works

Use a moisture meter to check the moisture content of the timber (not more than 18% in general). Sheathing would be expected to have a moisture content 3% less that the adjacent timber members.

Check that the insulation is properly supported and no gaps.

Check VCL is present and not damaged. It should be sealed at service points,

Check plasterboard lining. Timber noggings in place - should be present around floor and ceiling perimeter. In general all plasterboard edges should be backed by timber.

Check nail/screw lengths and centres. Each plasterboard layer needs to be fixed independently.

In party wall 19mm plank should be laid horizontally, vertical joints over studs, horizontal joints do not need to be timber backed but bound edge to bound edge – cut edges should be over timber.

12.5mm board laid vertically with vertical joints staggered (as far as possible with those of the plank). Vertical joints must be over timber.

In roof space check usually 2 layers of 12.5mm plasterboard are used. Timber noggings may be needed at 2.4m height, no horizontal joints and vertical joints of each layer should be staggered (and over timber).

Check the support of ceiling plasterboard.