3.0 Current Practice and Procedures

This chapter examines the practice and procedures of timber frame construction in Ireland.

3.1 Properties of Timber

Timber is a natural organic cellular material. It can be harvested, sawn, dried and finished to meet the requirements of the construction industry. Timber can be described as either softwood or hardwood. Softwood comes from coniferous trees such as pine and spruce. Hardwood comes from broad-leaved trees such as oak and poplar. Immediately after harvesting timber contains a large quantity of water and removing it by drying renders it usable as a building material. As timber dries, it shrinks.

3.1.1 Physical Characteristics

The physical properties of timber vary by species and include density, strength, grain, colour, and combustibility. Timber also exhibits a range of natural defects such as knots and slope of grain. During the drying process, timber can develop shakes, checks and splits. These defects, both natural and as a result of drying, can all affect the structural performance of timber. In the manufacturing process, defects are graded out so that each timber component meets the design specification of the structure.

3.1.2 Structural Characteristics

The strength and stiffness of timber varies with species, largely as a result of changes in timber density and moisture content. For classification purposes, species with similar properties are grouped together. Standards are set forth by the Irish Standards, NSAI, for the use of strength-graded timber. Irish Standard IS EN 338:1995 Structural Timber-Strength Classes outlines the characteristics of strength and stiffness for softwoods and hardwoods. The timber grade most commonly used in the construction of timber frame houses in Ireland is Strength Class C16. Timber is graded visually in accordance with IS EN 518 or by machine in accordance with IS EN 519. Factors that determine the strength classification of timber include species, density, slope of grain, knots, ring width and defects such as checks, splits and rot. Other important factors for strength include timber moisture content, temperature and load duration. All structural timber is required to be marked with an information stamp detailing the strength class, and species. Most of the solid timber used in the construction of timber frame buildings in Ireland is European whitewood.

3.1.3 Thermal Properties

3.1.3.1 Dry wood is a poor conductor of heat and it is this characteristic that renders wood suitable for use as internal paneling, the sheathing of timber-framed buildings and as handles for cooking utensils. The low thermal conductivity of wood is partially due to the conductivity of cell wall materials but also due to the cellular nature of wood, which in its dry state contains a large
volume of air.

3.1.3.2 Timber does not shrink or swell significantly in response to changes in temperature unless those changes are also accompanied by a change in moisture content. However, under prolonged exposure to temperatures in excess of 60°C, thermal degradation, as evidenced by a loss of strength and toughness will occur.

3.1.4 Durability

3.1.4.1 Trees consist of layers of bark, cambium, sapwood and heartwood. The sapwood and heartwood are converted to give solid timber and wood-based products. Around the outside of the tree is a band (typically 50 mm-75 mm) of often lighter coloured sapwood, which in the living tree conducts water from the roots to the leaves. Inside the sapwood is the heartwood; this zone is often, but not always, a darker colour than the sapwood. The function of the heartwood is to provide mechanical support for the tree. Sapwood should be regarded as having low resistance to fungal decay or insect attack regardless of species; the resistance of heartwood varies significantly depending on species.

3.1.4.2 The ability of timber to resist organisms that cause decay is referred to as natural durability. The durability of buildings can be enhanced by use of naturally durable timber species, by preservative treatment of less durable species and by good practice in design and construction to protect the timber from degrading influences. The use of very durable/durable timber species and/or preservative treatments should not substitute for good practice in design and construction.

3.1.4.3 IS EN 355 Hazard classes of wood and wood-based products against biological attack Part 1: 1992 Classification of hazard classes, describes five hazard classes which help the designer evaluate the risk of fungal decay and insect attack which may occur.

3.1.4.4 The durability of timber is determined and rated in accordance with IS EN 350 Durability of wood and wood-based products – Natural durability of solid wood Part 1: 1994 Guide to the principles of testing and classification of the natural durability of wood.

3.1.4.5 IS EN 350 Durability of wood and wood based products-Natural durability of solid wood Part 2: 1994 Guide to the natural durability and treatability of selected wood species of importance in Europe, places timber species into the classes shown below based upon their performance in tests carried out in accordance with BS EN 350: Part 1.

- very durable
- durable
- moderately durable
- slightly durable
- not durable

3.1.4.6 The heartwood timber commonly used in the construction of dwellings is either slightly durable or not durable. Preservative treatment of non-durable timber with fungicides and insecticides,
increases the natural resistance against fungal decay and insect attack.

3.1.4.7 It is common practice to keep timber in house construction away from contact with the ground or other moisture bearing material such as masonry rising walls or other masonry exposed to the environment. This is achieved by the use of damp proof membranes and/or damp proof courses.

3.1.4.8 When kept at a moisture content below 22% timber will exceed the 60-year life expectancy required for buildings given in BS 7543: 1992. However, if timber is subjected to an environment where its moisture content may rise above 22%, e.g. as a result of poor workmanship, the failure of a cladding system or poor detailing around openings, then it may suffer from fungal decay.

3.1.4.9 Extensive research of completed houses carried out by TRADA shows that after about two years, the moisture content of timber studs within a properly completed wall is around 14% - well below the threshold for fungal decay. When the timber remains dry and below the nominal decay threshold of 22% moisture content, the timber will remain structurally sound. Fungal decay will only occur when timber is in prolonged contact with the ground, damp masonry or other damp conditions, which raise its moisture content above 22%. See fig. 3.3.

3.1.4.10 Insect attack is much less dependent on timber moisture content. However, it is most likely to occur when timber is unseasoned or wet. In Ireland, insect damage is most commonly caused by the common furniture beetle (*anobium punctatum*). Infestation is less likely to occur in dry timber.

### 3.1.5 Combustibility

3.1.5.1 Timber is a combustible material. Burning occurs at a predictable speed known as the charring rate. Different timbers char at varying rates, largely as function of their density with the higher density timbers charring more slowly. For structural timbers listed in the code of practice for the design of structural timber, BS 5268: Part 2, this rate of depletion is taken as 20 mm in 30 minutes from each exposed face. Certain of the denser hardwoods (>650kg/m³) used for structural purposes merit rates of 15 mm in 30 minutes, e.g. keraing, teak, greenheart, jarrah. Timbers of lower density will char more quickly, e.g. western red cedar is quoted as 25 mm in 30 minutes.

3.1.5.2 The rate of charring is little affected by the severity of the fire, so for an hour's exposure, the depletions are 40 mm for most structural timbers and 30 mm for the denser hardwoods. This enables the fire resistance of simple timber elements to be calculated. A predictive method is published in BS 5268: Part 4: Fire resistance of timber structures.

3.1.5.3 The fire resistance of many timber structures, such as timber frame buildings, is achieved by a combination of the lining material, the timber structure and the insulation. The terms "reaction to fire" and "resistance to fire", describe different behavioural characteristics of a material.

- Fire resistance describes the ability of a building...
element to provide its structural or compartmentation function in the event of a fire.

- Reaction to fire refers to a material's behaviour when exposed to fire and is used to establish what contribution the material will make to the fire's growth and spread. It is relatively simple to improve the reaction to fire performance of wood-based products using standard treatments and coatings.

- Surface spread of flame is the current test methodology used to establish the likelihood of flame traveling along the wall or ceiling surfaces to other areas of the building. Materials may be assigned a classification from Class 1 (little risk of fire spread) to Class 4 (some risk of fire spread). Untreated timber and panel products typically fall into Class 3, although fire retardant impregnation or coating systems can raise performance to Class 1.

- The Fire Propagation test is used to determine the likely contribution a material will make to the growth of the fire. Essentially it measures the heat released from the material in a fire. A series of performance indices are provided by the test and these are interpreted in Building Regulations documents as part of the requirements for Class 0 materials. Class 0 is not derived from any single test methodology but is a material having Class 1 surfaces (based on the surface spread of flame test) and suitably low fire propagation indices. Most timber and wood-based materials can achieve Class 0 when treated with a suitable fire retardant impregnation or coating system. Non-combustibility is a pass/fail test that determines whether a material burns or not. Wood-based products, whether treated or not, are deemed combustible.

- Materials of limited combustibility are also defined in Building Regulations. There are several means by which this classification can be achieved but wood-based materials do not fully satisfy any of them and therefore should not be used in situations where this is a requirement.

3.1.6 Dimensional Stability

3.1.6.1 The dimensional stability of timber in-service varies from species to species with moisture content and according to the direction of fibres within individual pieces of timber. Timber used in construction is dimensionally stable along the grain but less stable across the grain. The differential movement that this lack of dimensional stability creates is a design constraint that must be considered and properly accommodated in the design of timber frame walls. It especially becomes critical in taller buildings where the cumulative effect of timber movement can cause joints, sealants, openings and other junctures to fail.

3.1.6.2 In the design of timber frame buildings, shrinkage must be allowed for at each floor level. This is done by leaving clearance gaps, typically 8 mm per storey, around openings, wall penetrations
and the junctions between different constructions. Multi-storey timber frame buildings must take into account the cumulative effect of shrinkage at each floor.

3.2 Timber Frame Systems

3.2.1 Timber frame construction is a building system in which plywood, oriented strand board (OSB) or a similar sheet material is nailed to a timber framework of walls, floors and sometimes roof components, forming structural panels. These are assembled to form a rigid structure designed to support and transfer all dead, live and wind loads to the building foundations. Plywood, OSB or similar sheathing materials contribute fundamentally to building stability as well as effecting enclosure of the frame for weather protection during the construction process. Currently, the system most prevalent in Ireland is platform frame panel. This accounts for approximately 90% of all timber frame houses built in Ireland.

3.2.2 The regular spacing of studs, joists and roof members in a timber frame building leads naturally to the use of a simple planning grid at the design stage. Since most sheathing, lining and flooring materials are supplied in sheets 2400 mm long and 120 mm or 600 mm wide, the most obvious structural grids are 400 mm or 600 mm.

3.2.3 Platform frame system

In this system, each storey is erected on top of the platform formed by the building’s foundations or the floor of the storey below. In effect, the previous floor becomes the working platform for the next. The building’s timber frame structure is braced as work proceeds, providing a platform on which walls and internal partitions of the next floor are constructed.

3.2.3.1 Open panel platform frame system

3.2.3.1.1 Most of the timber frame buildings constructed in Ireland consist of single storey panels. Panels of up to 3.6 m long may be manhandled into position, larger panels require the use of a crane. They are produced by the timber frame manufacturer in a factory and delivered to site as open panels, which consist of a sheathed timber frame (studs, plates and lintels), covered with a breather membrane. Openings for windows and doors are created during the manufacturing process. This system is commonly referred to as ‘open panel’ timber frame kit construction. Internal linings, insulation, a vapour control layer, services and claddings are applied on site.

3.2.3.1.2 Most timber frame buildings, have concrete ground floors, timber intermediate floors and trussed rafter roofs. However, floor and roof panels prefabricated in the factory and known as cassettes are also possible.

3.2.3.2 Closed panel platform frame system

3.2.3.2.1 The ‘closed panel’ system is a method of manufacturing panels that develops on the open panel form of construction by including factory fitted insulation and internal linings. Depending on the precise form of closed panel construction adopted, the vapour control layer, which is not required by all forms

Current Practice and Procedures 3.5
of timber frame construction, services, windows, doors and even claddings may be added to the timber frame panel in the factory. When compared with ‘open panel’ construction a greater level of design input is required before manufacture and the resulting structure is less flexible to site changes. The manufacture of closed panel systems places a great emphasis on quality control systems in the factory as manufacturing errors are harder to identify on site. Floor and roof cassettes may also be manufactured as closed panels.

Table 3.1 Comparison of Open and Closed Panel Systems

<table>
<thead>
<tr>
<th>Open Panel System</th>
<th>Potential Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Potential Problems</strong></td>
</tr>
<tr>
<td>Lower prefabrication costs</td>
<td>Greater levels of labour required on site</td>
</tr>
<tr>
<td>Less design input</td>
<td>Insulation and internal linings must be delivered just in time</td>
</tr>
<tr>
<td>Open panels are more robust and can withstand greater levels of abuse in transit and erection than other panel types. Also damage and errors are cheaper and easier to rectify</td>
<td>Frame vulnerable to abuse by other trades after erection, e.g. notching by plumbers and electricians</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Closed Panel System</th>
<th>Potential Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Potential Problems</strong></td>
</tr>
<tr>
<td>Lower levels of labour required on site</td>
<td>Higher prefabrication costs and higher levels of manufacturing investment required</td>
</tr>
<tr>
<td>Factory controlled installation of insulation, internal linings and services</td>
<td>May require heavy plant machinery</td>
</tr>
<tr>
<td>Frame less vulnerable to abuse by other trades on site</td>
<td>Design and manufacturing errors are costly to rectify</td>
</tr>
<tr>
<td>Greater degree of quality control</td>
<td>Frame more vulnerable to damage during transport and installation and on site modification may be harder</td>
</tr>
</tbody>
</table>

3.2.4 Balloon Frame Construction

3.2.4.1 The Balloon Frame system can be used in the construction of two storey buildings. Its key feature is the use of vertical wall panels that are the same height as the building. The floor joists are hung from the inside face of the external walls by the use of joist hangers or ledgers and the roof is framed conventionally. The principal benefits of this method of construction are that it enables continuity of insulation up the external face of the timber frame to be achieved more easily and reduces the amount of differential movement that occurs by reducing the amount of cross sectional timber present in the external wall. The building height is restricted to two storeys because of the length of timber available.

3.2.4.2 The Balloon Frame method was used in the USA throughout the 1920s but has since been replaced by platform-
based methods. It is virtually non-existent in Ireland. The Amphion Consortium, a group of approximately 25 UK housing associations and their supply chain partner Torwood Homes, a large timber frame manufacturer, investigated the potential for a modified version of balloon framing in the UK and concluded that it was not compatible with modern timber frame practice. In rejecting the method they focused on issues of buildability, health and safety, transportability and the availability of timber in long lengths.

### 3.2.5 Volumetric

3.2.5.1 This involves the factory fabrication of timber ‘box’ units or modules, which form one or more rooms. They may be supplied as open panel units. However, this negates many of the advantages of factory manufacture and they are normally supplied with at least the insulation, internal linings and service conduits already fitted. Many volumetric buildings are delivered to site with services, windows, doors and claddings already complete. This method is best suited to buildings with repetitive units, such as hostels, hotels or nursing homes and requires the use of a crane during the erection process.

### 3.2.6 Post and Beam

3.2.6.1 Post and Beam construction consists of a load-bearing system of posts and beams with lightweight timber or glazed infill panels giving protection from the weather. The post and beam structure provides resistance to vertical loads and racing resistance is provided either by the infill panels or diagonal bracing depending on how the infill panels are designed.

3.2.6.2 In the UK, this method is most popular in the specialist ‘traditional appearance’ market. More contemporary post and beam houses are common elsewhere in Europe, particularly in Germany, Austria and the Netherlands, and are now beginning to appear on the Irish market. Post and beam structures are dependent on methods of bracing to attain required racking strength.

### 3.2.7 SIPS (Structural Insulated Panels)

While this system is outside the scope of this report it is mentioned here due to its timber panel content.

3.2.7.1 SIPS consist of a solid core of rigid foam insulation sandwiched between OSB or other wood-based panel. The OSB is bonded directly to the rigid foam insulation. Completed panels are light in weight, very stiff and enable the construction of building elements with very low U-values. Window and door openings are cut into the completed panels after manufacture. SIPS panels are erected using a platform-based method and offered with varying amounts of factory prefabrication in terms of service integration, fitted windows and claddings, etc. The use of SIPS has yet to take off in UK or Irish markets. It would appear that this is partially due to a lack of end user confidence over long-term performance.

### 3.3 Common Methods of Construction Practice

The following is a description of common methods of timber frame construction:
3.3.1 Stick Built

3.3.1.1 A small number of specialist contractors erect timber frames on site building the frames in-situ stick by stick. A variant of this system replaces in-situ stick-by-stick construction with site-manufactured panels. These systems, which are particularly popular in the USA and Canada require skilled carpenters able to fabricate and erect frames on site.

3.3.2 Manufactured Kits, Structural Frame Only

3.3.2.1 As already explained most of the timber frame buildings constructed in Ireland are built using the platform frame method with timber frame kits supplied as open panels.

3.3.2.2 Our research shows that factory manufacturing of timber frames is preferred in Ireland as the quality can be closely controlled with most design and manufacturing problems identified and corrected before the timber frame is delivered to site ready for erection. If problems are subsequently identified on site they are relatively easy to correct. Most timber frame manufacturers in Ireland and the UK manufacture panels by hand. Automation does exist in the form of cross cut saws, panel saws and nail guns but the actual panel assembly is usually done by hand. A few companies have installed automated panel-making machines. However, with the confidence and experience in their use limited, the level of uptake in the industry is currently low.

3.3.2.3 Closed panel timber frame systems are not manufactured in Ireland to any significant degree. However, recent experience with these systems in the UK and previous experience in Canada, particularly with manufacturers producing larger numbers of panels (say more than 1000 houses per year), is mixed. Current practice within the construction industry means that design issues are often not resolved fully until after the structural framework for a building has been delivered to site and is complete. This causes conflict with the manufacture of closed panel systems, which require full details to be prepared before manufacturing can begin, as all services, openings and possibly cladding systems have to be integrated.

3.3.2.4 Our experience is that pressure to begin work on site can mean that the timber frame manufacturer is forced into producing components that are not fully designed and are therefore liable to change. The above, combined with the difficulty of checking the design and erection of partially erected closed panel timber frame buildings on site suggests that they may be not be appropriate for certain parts of the Irish market, notably large scale private and social housing developments, at the present time. However, potential future advances, principally in the design of timber frame buildings, may enable the potential improvement in building quality offered by timber frame construction to be realised. In contrast, small scale (say less than 500 houses per year) closed panel manufacturers in the UK and mainland Europe has encountered fewer difficulties. This is due to a combination of factors including building form and function, contract type and the amount of design time available, and the ability to manufacture smaller numbers of houses using systems with relatively little reliance on automated systems.
3.3.3 Manufactured Kits, Turnkey House

3.3.3.1 A significant number of manufacturers in Europe and North America, principally Canada, are building closed panel systems for timber frame housing which include internal linings, external claddings and services. Some of them are also able to provide a ‘Turnkey House’ including windows, doors, roofs and even fitted kitchens and bathrooms. These timber frame kits are the subjects of ETAG 007 ‘Guideline for European Technical Approval of Timber Frame Building Kits’ (EOTA, 2001).

3.3.3.2 Such turnkey houses have been recently introduced to the Irish house-building market, particularly from Canada. They normally consist of complete wall and floor assemblies supplied to site ready for erection. They are being targeted at the self builder and small private house builder market at present and are of particular interest to those with an interest in energy efficiency due to their excellent thermal performance characteristics. It is unlikely that these buildings, which are aimed at a niche market, will become mainstream in Ireland in the short to medium term.

3.3.3.3 The basic function of the external wall system is to provide protection from the elements, structural resistance to wind, support to floors, protection from sound, resistance to fire and surface spread of flame. They are also required to have a level of thermal performance (insulation and air-sealing), provide a barrier against unwanted entry and are a decorative design feature.

3.4.1 Typical Construction

3.4.1.1 Typically the external wall consists of the structural frame, which is lined internally, clad externally and provided with a ventilated cavity, breather membrane and vapour control layer.

![Figure 3.11](Fig. 3.11 Photograph of three storey TF terraced housing under construction. Note the vertical stripes where the manufacturer has marked the blue coloured breather membrane for easier location of the vertical timber studs which will facilitate installation of the masonry wall ties or battens (depending on the cladding system used).)

3.4.1.2 In addition to the main components, damp proof courses, flashings, cavity barriers, cavity trays, and other miscellaneous components complete the external wall system. It is noted by the Consortium based on our research of practice in the timber frame industry, both in Ireland and elsewhere around the world, that timber frame...
external wall systems vary in detail:

- **Type, grade and dimensions of materials used** e.g. the choice between plywood and OSB sheathing, the use of nails or staples to fix the sheathing to the studs, the use of solid timber or I-joist floors.
- **Presence, position and orientation of material** e.g. the use of so-called reverse or breathing wall constructions which do not employ a vapour control layer, the inclusion of extra insulation within the cavity of a timber frame external wall or the use of sheathing boards across rather than along the studs.

3.4.1.3 Differing environmental conditions, availability of materials, cost, construction practices, labour skills and availability, building regulations and cultural and manufacturing preferences are some of the influences which create this variation in design and construction practice.

3.4.2 External Cladding
The external cladding is the first defence against wind and moisture. The cladding must be durable, impervious or resistant to moisture and be installed in a manner that will keep the majority of moisture out of the external timber frame wall while allowing water vapour produced inside the building and moisture that has penetrated or bypassed the cladding to escape. This normally requires the cladding to be provided with a ventilated cavity behind it.

![Fig. 3.12 Typical timber frame wall components for a timber frame wall with brick cladding on masonry rising walls and concrete ground slab.](image-url)
3.4.2.1 Brick, Block and Render Cladding
In Ireland, brick, and block and render are used extensively in the cladding of timber frame buildings. These masonry products provide a durable rain screen when installed properly. They are generally secured to the timber frame structure with stainless steel wall ties with a 50 mm ventilated and drained cavity between them and the sheathing of the timber frame. Wall ties are normally installed at a density of 4.4m², which equates to a vertical spacing of 375 mm with wall studs at 600 mm centres (5 brick courses). However, at openings they are normally required at 300 mm vertical centres and must be positioned within 225 mm of the jambs.

3.4.2.2 Timber Cladding
3.4.2.2.1 Although the number of buildings clad entirely in timber is likely to remain low, evidence suggests an increase in the number of buildings where whole elevations or parts of elevations are clad in timber. The species encountered most frequently are European whitewood, European redwood and western red cedar but Douglas fir, larch, European oak and iroko are also used. Cladding boards are normally fixed to battens fixed to the timber frame sheathing. The battens permit the drainage of water which may penetrate the cladding and also allow for ventilation of the back face of the cladding which is important for the long term durability of the cladding. Correctly detailed and carefully specified and installed timber cladding will meet the 60 year lifetime requirements of many housing providers.

3.4.2.2.2 If specifications permit sapwood in the timber used for cladding then a preservative treatment is required regardless of the durability of the heartwood as all sapwood is not durable. If heartwood only is permitted then for timbers species that are considered durable (e.g. oak) or very durable (jarrah) no preservative treatment is required. For those timbers with heartwood that is not durable or slightly durable (e.g. European redwood and European whitewood) a preservative treatment is required. For timber species with heartwood that is moderately durable the situation is slightly more complex. For moderately durable timber species (e.g. Douglas fir and larch) the situation is slightly more complex and preservative treatments may or may not be required depending on the service life desired and the level of design, specification and installation expertise available. There is a trend towards the use of green (i.e. unseasoned) timber for cladding. Where this is being considered it is arguable that specialist advice should be taken to ensure correct detailing and specification and in particular that the amount of movement anticipated can be accommodated.
3.4.2.3 Render on Metal Lath

Render on metal lath supported by battens fixed to the sheathing of the timber frame has been used in localised areas e.g. at dormer sides, bay windows or other small external features of buildings in Ireland. In their ‘House Building Manual’, HomeBond, the largest providers of structural guarantee insurance for the housing market in Ireland, advise on good practice in typical masonry and timber frame construction. In particular the HomeBond manual cautions about cracking of the render and the printing through of the pattern of battens behind. Current practice, as advised by HomeBond, is to use treated timber battens and counter battens, a galvanized or stainless steel metal lath and render finish (Fig. 3.15).

3.4.2.4 Modified Synthetic Render

Modified synthetic render systems are relatively new to the Irish market. However, they have been used elsewhere in Europe. They consist of approximately 3 layers (around 6 mm in total) of polymer modified synthetic render applied over a layer of mesh reinforcement which is fixed to an appropriate carrier board e.g. calcium silicate or recycled glass boards. The carrier board is separated from the timber frame by a cavity and is supported by vertical battens fixed to the timber frame.

3.4.2.5 Externally Insulated Facade System (EIFS)

3.4.2.5.1 EIFS consists of expanded polystyrene rigid foam (EPS) insulation panels bonded to a modified render system as described above. The foam panels are commonly between 50 and 100mm in thickness, with tongue and grooved joints. The finish is spray applied on site to a thickness of 5-6 mm and sometimes hand trowelled to achieve the desired finish. The foam panels are fastened mechanically or with adhesives directly to the sheathing. The fibreglass and synthetic render forms a face-sealed barrier designed to resist water penetration at its outer surface. Expansion control joints and interfaces with other materials and building components such as windows and doors are detailed and sealed to prevent water intrusion.

3.4.2.5.2 EIFS are not currently used in housing construction in Ireland but have been used extensively in Germany, USA and Canada. During our research of this area the Consortium noted instances of failures in housing construction in some locations where these systems are more common. These failures warranted further investigation, which is presented in case study format in Appendix 3.
3.4.2.6. Tiles
Vertical tile hanging using concrete or clay tiles or natural or fibre cement slates can provide a long life, low maintenance cladding to timber frame structures. Mathematical tiles can provide a cladding similar in appearance to brickwork but are not commonly used. Tiles or slates are fixed to horizontal preservative treated timber battens, which are nailed to the studs in the timber frame wall. In severely exposed conditions vertical counter battens permit more efficient drainage of water driven through the tile joints. Firestopping at party walls needs to be installed carefully if it is to be effective.

3.4.3. The Ventilated and Drained Cavity

3.4.3.1 The ventilated cavity is intended to limit the transfer of moisture to the internal components of the external timber frame walls. The provision of a ventilated cavity in the external wall of a timber framed house is currently accepted as good practice in Ireland and is a necessity if the building is to be accepted for the HomeBond house warranty scheme. It is proposed in both traditional masonry and timber frame houses as good practice in TGD C of the Building Regulations.

3.4.3.2 While common practice in Ireland and the UK, the ventilated cavity is not used in all timber frame buildings constructed in Scandinavia, Austria, Germany, Canada and the USA. During our research we collected and considered information relating to failures in the performance of timber frame housing in the USA, Canada and New Zealand. The failures manifested themselves in the condition known as the 'leaky condo crisis' or the 'leaky building syndrome'. They are considered in more detail in Appendix 3 of this report. We concluded that the omission of the ventilated and drained cavity was a significant contributing factor in these failures. The Consortium also notes that Scandinavia, Germany and Austria have not experienced similar levels of failure even though the ventilated cavity had been omitted. It is our opinion, that national/regional differences in environmental factors e.g. wind, rain and humidity combined with variable standards of quality and quality control in design, manufacture and erection contributed to the disparate performance of external timber frame wall constructions.

3.4.4 Timber Frame Structural Elements

3.4.4.1 Timber studs form the main structural components of the timber frame house and transfer vertical loads to the ground floor concrete slab and foundations. The properties and issues of relevance here have been outlined previously in section 3.1.2.

3.4.4.2 Increasingly, the solid timber components of floors in timber frame buildings are being replaced with floors constructed from timber I-joists. There is currently no Irish or European Standard for these products. However, all of the brands available in Ireland are supported by third party certification in the form of a BBA certificate or a Q-Mark.

Fig. 3.16 Tile cladding over treated timber battens and cross battens with maintained ventilated cavity.
3.4.5. Sheathing

Sheathing generally consists of sheet materials such as plywood, OSB or other sheet material, which provides racking strength to the timber frame structure. The qualities of the material as well as its durability are fundamental to the overall durability and strength of the timber structure. Plywood suitable for use in timber frame buildings are listed in BS 5268: Part 2. OSB must comply with Class 3 or Class 4 of IS EN 300 Oriented strand board.

3.4.6. Insulation

The insulation provides thermal protection to the house. Insulation types include rigid foam insulation, mineral wool in the form of glass or rock fibre, natural wool insulation, treated recycled paper, etc. The majority of timber frame buildings constructed at present are insulated with mineral wool. Insulation increases the thermal performance of the timber frame wall. The thickness of insulation required is dependent on the thermal properties of the various types available and this in turn will influence the dimension of the timber studs.

3.4.7. Breather Membrane

3.4.7.1 It is normal practice in Ireland to cover the timber sheathing of external wall panels with a breather membrane. The membrane is normally fitted in the factory and provides protection against water during transport, erection and whilst the cladding is being installed. In addition, the breather membrane prevents water that has penetrated through the cladding from reaching the internal fabric of the building. The breather membrane allows water vapour to pass out of a building but prevents water from coming in.

3.4.7.2 Modern high performance breather membranes consist of non-woven polyolefin fibres or spun bonded polypropylene. Traditional building papers are not appropriate.

3.4.7.3 Improper installation of the membrane or subsequent damage or the use of inappropriate materials can result in water intrusion, leading to damp conditions within the wall. These damp conditions will raise the moisture content of the timber frame structure and increase the risk of fungal decay of the timber and other wood-based components present in the wall.

3.4.7.4 The breather membrane is a fundamental component of conventional timber frame wall structures and is required to ensure the durability of the whole construction. Care is required to maintain its condition throughout manufacture, transport and erection. Notwithstanding the above it is also important that follow-on trades, and in particular, bricklayers and plumbers and window installers do not damage it.
3.4.8. The Vapour Control Layer (vcl)

3.4.8.1 In common with all building structures, it is necessary to ensure that under normal conditions, surface mould and condensation are avoided. In timber frame walls, thermal insulation is placed between the studs, maintaining internal surface temperatures above dew point level and thus avoiding surface condensation.

3.4.8.2 To avoid the risk of harmful condensation within the structure of the wall a vcl is positioned between the inner wall surface and the insulation. Its function is to control the amount of water vapour passing through the wall. Materials commonly used include 125 micron polyethylene sheet and vapour control plasterboard comprising a metallised polyester film bonded to the back face of a plasterboard sheet.

3.4.8.3 As a guide, harmful condensation will not occur in timber frame walls when the vapour resistances of materials on the warm side of the insulation are at least five times greater than those on the cold side. Test evidence under a wide range of conditions shows that under normal circumstances, harmful condensation is unlikely to occur within the wall as a result of small perforations or tears. However, every effort should be made to locate and repair such damage to increase the margin of safety.

3.4.8.4 The vcl acts to prevent internal moisture build up within the insulation and timber frame structure. The inclusion of a vcl is accepted good practice in Ireland, the UK, Canada, USA, and those parts of Europe where ‘conventional’ timber frame wall constructions are used. In other parts of Europe where so called ‘reverse’ or ‘breathing wall’ constructions are used a vcl will not always be required.

Fig.3.17 Conventional timber frame wall with VCL on warm inner face of timber framing.

Fig.3.18 External wall construction with internal sheathing that is intended to act as a vapour control layer.
3.4.8.5 Some timber frame manufacturers in Europe do not use a conventional vl and instead rely on vapour permeability of different layers within the wall to maintain the 5:1 ratio described above. The permeability of each of the materials used in these cases is critical to control the movement of moisture and allow adequate dissipation of condensation from within the structure of the building.

3.4.8.6 Constructions similar to that shown above have been used successfully in the UK and are proposed for use in the Irish market. They are often described as breathing wall constructions. Based on our research and analysis of this issue the Consortium is of the view that, before these systems become widely available in Ireland the manufacturers producing them should be required to prove, through independent certification, that they are appropriate for use in the Irish climate.

3.4.9. Preservative treatment

3.4.9.1 There are many examples of untreated timber frame buildings in the UK, Scandinavia and North America, which are performing satisfactorily. This is possible because in a well designed and constructed timber frame building all of the timber components, with the possible exception of sole plates and battens, will be at moisture contents significantly lower than the threshold for fungal decay. In service timber in floor zones will stabilise at between 8 and 12% and that in external wall zones and suspended ground floors at 10-14%. Even sole plates and battens will spend much of their service life below this threshold. However, for certain and possibly prolonged periods their moisture content will rise above the threshold. Moreover, the potential disruption and cost of carrying out remedial work should problems occur indicate that certain elements within a timber frame building would benefit from preservative treatment.

![Fig.3.19 A Timber frame wall where the condensation is controlled by internal sheathing, linings and insulation. These are relied upon to prevent condensation within the wall.](image-url)
3.4.9.2 Current practice in Ireland is that the components listed below are treated when they are produced from timber that is moderately durable or less:

- Sole plates
- Bottom members of wall frame when they rest directly on the damp proof course
- Timber cavity barriers in external cavity walls (these are also protected by a separate vertical dpc)
- Cladding battens

3.4.9.3 BS 5268: Part 5 outlines a means of specifying preservative treatment based on a risk analysis (technical and economical). However, it mostly leaves the ultimate decision in the hands of the specifier. Guarantee and warranty providers have specific requirements, which remove the decision for treatment from the specifier. European standards follow a very different approach to preservative treatment. Under the new system, the specifier defines the level of treatment that will give the required length of protection in a particular environment. This is defined in terms of preservative penetration and retention. Guidance on the combination of penetration and retention required to give a level of protection to meet the required service life of a component in a particular hazard class is not yet available in a definitive form (i.e. a European Standard has not yet been published). The European approach to the specification of preservative treatment will not be implemented until this guidance is available.

3.4.9.4 Recent changes in EU legislation mean that copper, chromium, arsenic preservatives (currently used to treat sole plates, battens and cavity barriers) will be phased out by the third quarter of 2004 and will be replaced by chromium and arsenic free formulations that use copper in conjunction with an organic biocide. Other components in the external leaf of the wall are now mostly treated with mixed emulsion formulations, which are replacing the ‘traditional’ light organic solvent preservatives.

3.5. Timber Frame Internal Wall Construction

3.5.1 The primary function of internal walls is to separate internal spaces within or between dwellings and create rooms. Internal walls can be either load-bearing or non-load-bearing and depending on the type of dwelling under consideration they may require specific fire ratings and/or acoustic ratings to comply with the Building Regulations e.g. internal party walls between houses and compartment walls between apartments are subject to such regulation. The fire rating of internal partitions is normally attained by applying layers of non-combustible linings such as plasterboard in prescribed thicknesses using specific fixing schedules. These non combustible layers, when combined with the remainder of the structure, e.g. studs, plates, sheathing and insulation, enable defined levels of fire resistance performance to be reached.

Fig.3.20 Photo of double studded wall with insulation for required sound insulation.
3.5.2 Acoustic performance is usually attained by the same plasterboard layers that serve to protect a dwelling from the spread of fire. Where there is a particularly high requirement for acoustic separation (e.g. in semi-detached houses or between adjacent flats in an apartment buildings), walls may be required to be constructed in two leaves separated by an air space.

3.5.3 In all cases adherence to the relevant manufacturer’s instructions is essential to ensure compliance with the required rating.

3.6 Intermediate Floor Construction

3.6.1 In timber frame structures the intermediate floors act generally as a diaphragm to transmit wind loads to the wall structure. In all other respects the intermediate floors are similar to intermediate timber floors in buildings of masonry wall construction.

3.6.2 When it is required to have fire resistance from the floor below; the joists, floor decking and ceiling linings work as a composite construction to achieve the required resistance. Currently the Building Regulations do not impose requirements for acoustic performance of intermediate floors within the same unit. However, some specifiers already use mineral wool to improve performance. Similarly, there are no requirements for thermal performance, except when the floor projects out beyond the wall beneath, and is over an open area, such as a car port, or an unheated space such as a garage or where it is at the edge of an attic room adjoining the ventilated roof space.

3.7 Compartment Floors

3.7.1 ‘Party floors’ are described in the Building Regulations as compartment floors depending upon the function being considered.

3.7.2 There are three types of compartment floors. These are:

- Floors which separate dwellings from other dwellings and from other parts of the same building which are not used as dwellings.
- Floors which separate different occupancies and purpose groups (excluding dwellings) within a building.
- Floors which are required to subdivide a large building into compartments of specified size or volume, for the purposes of fire containment.

3.7.3 Compartment floors between dwellings may be of timber construction subject to limitation of 4 storeys and 10 m and are required to have fire resistance from below. The ceiling, the joists and the floor decking working as a composite construction achieve this and also provide the required surface spread of flame performance. In practice, the thickness of plasterboard lining required for sound resistance is sufficient to enable the floor to achieve 60 minutes, fire resistance. The walls supporting the floor must have the same fire resistance as the floor.
3.7.4 Resistance to airborne and impact sound is required and is achieved by separating the floor deck from the ‘walking surface’ by floating layers incorporating sufficient mass in the floor deck and the ceiling to reduce sound transmission. Prescriptive details are given in TGD E. There are requirements for thermal performance, where the floor projects out beyond the wall beneath, and is over an open area, such as a car port, or an unheated space such as a garage or where it is at the edge of an attic room adjoining the ventilated roof space.

3.7.5 In timber frame structures compartment floors act generally as a diaphragm to transmit wind loads to the wall structure. The structural design of the floor should be carried out in accordance with the requirements of BS 5268: Part 2.

3.7.6 Floors may be constructed using any materials and methods provided they meet the requirements of the Building Regulations for structural stability, fire resistance and sound attenuation. Specified constructions are given in the TGDs. The building control authorities may require test evidence of fire and sound attenuation to substantiate performance claims.

3.7.7 The current TGD E, includes three floor specifications which have been developed and used over a number of years and are accepted as providing adequate sound insulation and satisfactory fire resistance. These are described as:

- Platform floor with absorbent material
- Ribbed floor with absorbent blanket
- Ribbed floor with heavy pugging (dry sand fill)

3.7.8 In neither of the ribbed floor designs can the floor deck be used to provide lateral stiffness i.e. act as a diaphragm to the timber frame structure and for this reason the platform floor is recommended for use in timber frame buildings.

3.7.9 Other constructions have been designed and tested and can be shown to provide adequate sound insulation. The floors tend to gain improved performance by de-coupling the ceiling from the floor joists by using a ‘resilient’ bar or additional set of joists to support the ceiling. Further improvement in performance can be gained by adding more weight to the upper layers of the floor.

### 3.8 Roof Construction

3.8.1 There are no specific differences in the roof construction of a timber frame building compared to other types of construction. However, it is important to ensure that additional studs or posts in the timber frame wall panels adequately support any point loads from the roof (from purlins, hips and valleys, etc.).

3.8.2 The structural design of roofs should be in accordance with IS 193 if trussed rafter roofs are being used, including the relevant recommendations for bracing. There are no Building Regulation requirements for fire resistance except when the roof is used as a habitable space. In this case the walls and floors should have the same fire resistance as other walls and floors in the building.
3.8.3 Any party walls that run through the roof space, should provide the same period of fire resistance as that required beneath the roof space. The surface spread of flame requirement for the ceiling to the roof space is the same as those for ceilings to intermediate floors. There are limitations on the type of roof covering material and supporting construction that can be used adjacent to the junction with party walls, or within specified distances of the site boundary.

3.8.4 The minimum thermal insulation requirements for roofs are set out in TGD L. Pitched roofs with insulation at ceiling level or between rafters and cold flat roofs incorporate ventilation to reduce the risk of condensation. In pitched roofs with insulation at rafter level and in cold roofs a vcl is included beneath the insulation. The requirement for ventilation at eaves and ridge or above the insulation in a cold roof can mean that the depth of the rafters is often determined by thermal rather than structural requirements. The specification of a breathable underlay used in conjunction with an appropriate internal lining can obviate the need for the ventilation space between the insulation and the underlay, with ventilation provided in a counter batten space.

3.9 Services

3.9.1 The installation of electrical, telecommunications, plumbing, heating and ventilation services in timber frame buildings can be achieved quickly and efficiently, using the spaces formed in the framing to locate cables, pipes and ducts. Installation in floor and roof framing is no different from any other form of construction. In all load-bearing elements care is required to maintain fire resistance. Services should not be placed in party walls or compartment floors. When services are required at separating walls or compartment floors, battened out services zones provide an appropriate alternative.

3.9.2 Services can be installed into panels in the factory, thereby reducing the amount of work required on site. However, this is not often done in Ireland. Electrical services should be installed in accordance with BS 7671 Requirements for electrical installations, IEE Wiring Regulations.

3.9.3 Solid fuel, oil and gas heating appliances can all be installed in timber frame buildings providing the work is done in accordance with the requirements of the Building Regulations and any third party guarantee or warranty provider.

3.10 Conclusions on Current Practice and Procedures

3.10.1 Timber frame system, method of construction and manufacturing options.
3.10.2 A wide variety of different timber frame systems, methods of construction and manufacturing options are possible. However, most of these are best suited to niche market situations where the purchaser is looking for something different in terms of appearance (e.g. traditional or modern) or performance (e.g. a building that is particularly energy efficient), or perhaps site requirements dictate a particular approach (e.g. a remote site where stick building may become desirable).

3.10.3 Overwhelmingly, Irish timber frame manufacturers have adopted a conservative approach to timber frame manufacture. Open panels, mostly manufactured by hand, are erected using the platform frame system. The industry is gradually moving towards larger panels that cannot be handled into position and require use of a crane during the erection process. Once the timber frame is erected services, insulation, a vapour control layer and dry-lining are installed on site. The external face of the building is cladding, typically with a rain screen cladding, windows and doors are installed and the roof is constructed. It is our opinion that, from a purely technical point of view, the manufacturing and construction process as described above has many benefits:

- Design and manufacturing are relatively simple and because of this there is a good degree of flexibility to accommodate unanticipated changes to design.
- The completed, erected structural frame is easy to check; all structural members are accessible, marks identifying material quality can be seen clearly, and fixing details can be investigated.
- The work of follow-on trades can be inspected trade by trade and any inadequacies identified and corrected.

3.10.4 In this regard the natural conservatism of the construction industry, which is so often criticised, may well be applauded. For despite the potential improvement in quality that a move towards closed panel timber frame theoretically brings we believe that until the construction industry gains more experience of timber frame buildings any move away from open panel construction should be approached slowly and with caution.

3.10.5 External wall construction

3.10.5.1 A conventional timber frame wall, as described earlier, consists of 8 layers or materials, each of which has a specific function:

- protection from moisture penetration
- permitting vapour transmission
- giving racking resistance
- withstanding compression loads
- providing thermal insulation
- providing vapour transmission
- contributing to acoustic and fire performance
- providing a decorating surface
3.10.5.2 Apart from relatively minor changes to the nature of the materials used, the basic construction has remained unchanged for over 40 years and has proved itself to be cost effective, robust, and flexible in terms of building design. As with timber frame systems, methods of construction and manufacturing options where there is a high degree of consistency in approach, the majority of timber frame buildings in Ireland utilise a conventional wall construction.

3.10.5.3 Many other constructions are possible and whilst some of these (e.g. certain types of reverse and/or breathing walls) may be appropriate for the Irish market providing they obtain appropriate certification, it is our opinion that, at the present time, others are not. With specific regard to this we are particularly concerned that the degree of protection against the ingress of moisture provided by the presence of a drained and ventilated cavity immediately behind the external cladding should not be underestimated.

3.10.5.4 Our research has determined that countries (i.e. Canada, New Zealand and USA) with far more technical and cultural appreciation of timber frame than exists currently in Ireland have suffered widespread problems in timber frame buildings and that a major contributing factor to these failures was the lack of a drained and ventilated cavity and cladding failures.

3.10.5.5 If timber frame buildings are to perform as desired and have a long service life they need to be protected from moisture ingress. We have already stressed the importance of the cavity in providing part of this protection; the roles of the breather membrane and vapour control layer are equally important. Whilst, the functions of these two layers are almost diametrically opposed, their physical form is similar; they are both thin sheet materials. In practice, this means that both layers are relatively fragile and if not treated carefully are easy to damage. Whilst experience shows that small tears in both breather membranes and vapour control layers do not result in major building failures it is good practice to repair any damage before these important elements of the construction are obscured by the cladding or covered with dry-lining.

3.10.5.6 It is common practice in Ireland that certain components within a timber frame building receive a preservative treatment. As discussed earlier, whilst the technical risk of component failure is relatively low, the economic cost of repair and/or replacement is high. Changes in specification standards and incoming European legislation will alter the type of specification required and the chemical nature of any treatment used but should not be allowed to reduce the requirement for preservative treatment.

3.10.6 Internal walls, floors and roofs

Where required, the thermal, fire and sound performance of timber frame buildings meets and can, in some cases, comfortably exceed the requirements of the Building Regulations, e.g. the sound performance of timber frame party walls. However, other aspects of the performance of timber frame buildings is less strong, e.g. the sound performance of timber compartment floors. In order to meet the requirements of the Building Regulations, it is important that details are constructed as drawn and specified.
3.10.7 Services

3.10.7.1 Services in timber frame buildings are relatively easy to install providing those responsible for there installation recognise that some special requirements apply. The Consortium believes it is important that sufficient emphasis is placed on achieving prescribed levels of fire and acoustic performance by ensuring that details are designed, specified and constructed so as to maintain the required levels of fire and acoustic separation. Routes for services must be planned in advance and detailed to avoid breeches in performance of compartment and separating walls.

3.10.8 External cladding

3.10.8.1 The majority of properties in Ireland are clad with bricks or block and render. History has shown that constructions of this type perform well when applied to timber frame buildings and are capable of meeting the 60-year life expectancy required by DoEHLG.

3.10.8.2 There is also considerable experience of various forms of tile hanging and render on metal lath supported on battens and counter battens. However, we note that the use of both of the methods of cladding is, in practice, restricted to relatively localised areas, e.g. bay windows and dormer ‘cheeks’. Such systems have been used to clad larger areas and entire wall elevations in the UK and providing they have appropriate third party certification the Consortium sees no reason to restrict their application in Ireland.

3.10.8.3 There is currently much interest in the use of external timber cladding. It is our conclusion that correctly designed, specified and constructed timber cladding will meet the service life requirements expected by the DoEHLG and that timber offers a usefully attractive and potentially sustainable and renewable alternative to masonry claddings. At present the timber used for external cladding tends to be purchased from a timber or builders’ merchant against the requirements of a specification developed by the building designer. The material is not supplied as a ‘product solution’ and therefore tends not to be supported with third party certification. However, design guidance is available to assist specifiers in preparing technically competent designs.

3.10.8.4 Synthetic renders, carried on a non-combustible carrier board and supported by preservative treated timber battens forming a drained and ventilated cavity are a relatively new cladding method recently introduced to the Irish market. There is considerable experience in the use of such systems in other parts of Europe and providing they have appropriate third party certification for use in the Irish weather conditions and are shown to meet durability requirements, the Consortium sees no reason to restrict their application. In contrast it is our opinion that externally insulated cladding systems, which do not require the use of a ventilated and drained cavity, are not appropriate for timber frame construction. See appendix 3 for case studies on cladding failures.

3.11 Recommendations:
R.3.1. Where a timber frame manufacturer is proposing a departure from the standard open panel, platform frame method of construction they should be required to support their proposed form of construction by providing appropriate third party certification, i.e. Agrément Certificate.

R.3.2. The ventilated and drained cavity is an essential feature for timber frame construction in Ireland. TGD C (Site Preparation and Moisture Resistance) should call up suitable reference material, e.g. proposed Timber frame Code of Practice (see recommendation R.4.2. below).

R.3.3. Subject to R.3.4. all solid timber members in the external wall or ventilated and drained cavity of timber frame houses and apartments should be subjected to a preservative treatment as specified in British and European Standards. These standards should be listed in TGD C (Site Preparation and Moisture Resistance) and TGD D (Materials and Workmanship). TGDs should also include reference to the proposed Timber Frame Code of Practice (see also recommendation R.4.2.).

R.3.4. Omission of the preservative treatment should only be permitted for components that are constructed from the heartwood of timber species categorised as ‘durable’ or ‘very durable’, protected by suitable breather membrane or damp proof course as appropriate. This option must be shown by way of Agrément certification to meet the requirements of durability in the specific conditions of use in Ireland.

R.3.5. New cladding materials or systems, that have not been proven in the Irish climate should undergo assessment by an independent competent body, allowing for the specific climatic and site conditions in which the material or system is to be used and assessment of its appropriateness for use on a timber frame structure. This can be achieved by the Agrément Certification process in accordance with the Irish Agrément Board (IAB).

R.3.6. Timber cladding should only be fixed over preservative treated timber battens. TGD C (Site Preparation and Moisture Resistance) and TGD D (Materials and Workmanship) should be amended to direct specifiers to suitable sources of technical guidance on this issue such as the proposed Timber Frame Code of Practice (see also recommendation R.4.2.).

R.3.7. The timber frame manufacturers should issue a Method Statement document with timber frame kits, when delivered to site, to ensure that clear instructions are available to erectors and contractors.

R.3.8. Customised training in timber frame construction should be developed by FAS, ITFMA and third level institutions for erection crews and site managers.
R.3.9. Customised education and training in timber frame construction for the design/project supervision professions should be developed by the DESHEA, relevant third level institutions, professional bodies (as part of continuing professional development programmes), in conjunction with the ITFMA.