STRUCTURAL
TIMBER ASSOCIATION

Building solutions in timber

Why Timber Frame?

A guide to the benefits of timber frame construction

Why choose timber frame?

Timber Frame has many benefits over other construction methods. This guide uses a benefits matrix to focus on your needs.

	Technical Performance	Reduced Waste	Skills & Knowledge	Sustainability	Whole Life Cost	Quality & Reliability	Health & Safety	Cost	Whole Building Package
Developer	•	•	•	•		•	•	•	•
Social Housing Provider	•	•	•	•	•	•	•	•	•
Self Build	•	•	•	•	•	•	•	•	•
Architect	•		•	•		•	•	•	
Structural Engineer	•		•			•	•	•	
Build Contractor	•	•	•		•	•	•	•	•
Quantity Surveyor	•		•	•	•		•	•	•

Contents

Based on the MSc project work of Tom Williams to whom the STA offer their thanks.

Introduction to timber frame

Wood at the heart of a sustainable building

Wood is an exceptional construction material. It is highly versatile, has good thermal properties and is strong and renewable. At a time when sustainable development is at the forefront of construction and key issues such as climate change dominate our future thinking, wood is an outstanding renewable material that offers a range of environmental benefits[1].

Wood is the natural renewable material

The material is so versatile that we have many wood products and names to cover the range of applications and uses. This document covers only a few of those applications. Timber is the term the UK typically use to describe wood as used for structural members. Timber frame is a general term to encompass the method of structurally forming a building using wood products; this guide, however, introduces the reader to the whole building performance using timber frame where the fabric energy efficiency, acoustic performance and fire robustness is delivered.

Timber frame accounts for 70% of all housing stock in the developed world (Sustainable Homes, 2000) but only accounts for 2.4% of the housing stock in the UK (DCLG, 2008). Timber frame represents 24% of the UK housing market annually (Timbertrends 2014).

Timber frame in the UK is a competitive and innovative building technique with the potential to meet many of the UK's future building needs. This guide has been developed to educate and inform parties on the benefits of timber frame.

The benefits in this guide have been taken from independent resources.

Timber is the traditional building material

History books show that the traditional construction techniques used from generation to generation made use of grown, natural resources to provide the structural frame for homes. Today, we find that the term traditional construction is taken to mean masonry house building techniques of this generation which is not correct. The panel or post frame timber building has been successfully applied through the centuries to meet the changing demands of designers to achieve the required performance needs of buildings - in fact timber frame was the first form of prefabrication. Outside of the UK, timber frame remains the dominant method of housing construction (Sustainable Homes, 2000). Timber frame continues to evolve to respond to changing building regulations and changes in the construction industry offering technically advanced material selection and design methodologies combined with building performance to achieve a sustainable and cost effective future.

Figure 1: Authentic 15th C House, 21st C Timber Frame House

1. Making Wood Work – Quote from BRE – the UK's leading building material and construction method assessor.

UK future housing requirement

The UK housing industry is faced by two key challenges:

1. How to meet Government housing quantity targets

2. How to meet Government housing environmental targets

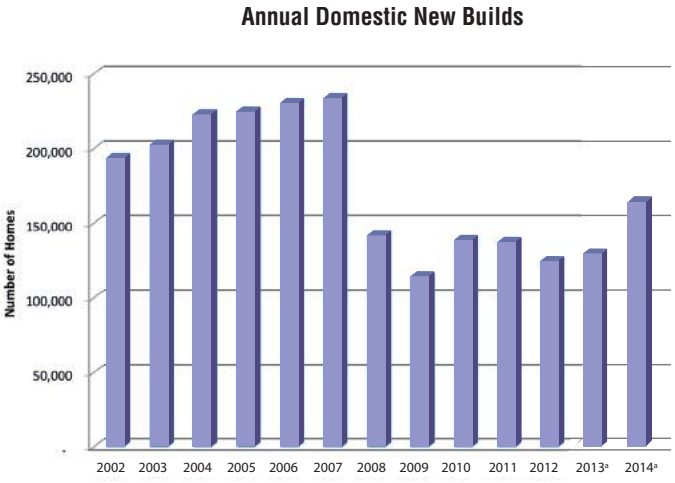
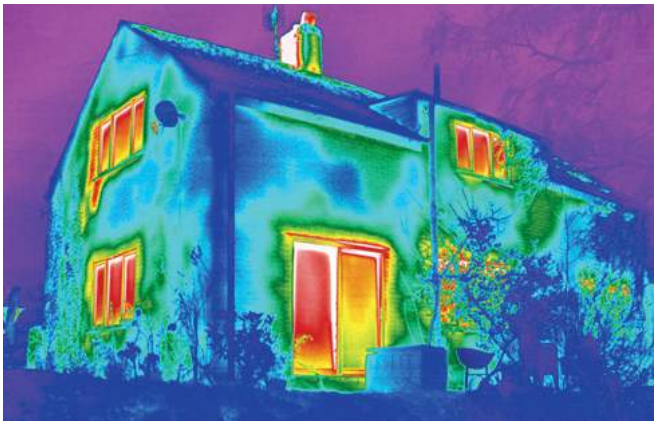


Figure 2: Annual New Housing Builds[a] (STA Values)

There are countless reports on the housing deficit. The general view is that 250,000 new homes spanning from private builds to housing associations are needed per annum. The fact that we have a housing shortage is not disputed by any Government party. To prevent a severe housing short fall, the UK requires a rapid and systematic response from the Government and housing industry to meet escalating demand.

Other building requirements

Figure 2 does not consider the commercial demand for the building of care homes, hotels, schools and student accommodation which are considerable. The fact is that timber frame provides a structural medium which provides the framework for high performance buildings to meet present and future needs.



This comes at a time when the Government is also promising reductions in carbon emissions and the nation's environmental impact. Agreements such as Kyoto Protocol have been made between the world's nations with strict reduction targets being created. In 2004, more than a quarter of carbon emissions in the UK were produced by housing (Code for Sustainable homes 2006). For the UK to achieve Government emissions targets, housing will therefore play a big part in the solution.

To reduce these emissions the Government proposes an ambitious target of all new homes being carbon neutral from 2016. (DCLG, 2012)

Timber framed homes could be best suited to meet the UK's housing needs when compared to other construction methods. Many believe that timber frame construction could play a vital role in meeting Government housing quantity and environmental targets in the short timescale required.

1. Technical performance

This section focuses on the industry's knowledge of materials and structure, defining timber frame properties and briefly exploring the advantages of products and off-site manufacture.

Explained in this section:

- Standards
- Modern construction methods
- The benefits of prefabrication
- Engineered wood products
- Acoustic performance
- Air tightness
- Fire robustness

Standards

Standards provide safety and reliability. They also ensure compatibility with other trades and industries.

Timber Frame Construction Guide
TRADA

Timber Frame Pocket Site Guide
STA

Many other resources exist and are available through the Structural Timber Association, TRADA and BRE.

Prefabrication

The most significant advantage of timber frame is the ability to prefabricate components in a safe off-site environment. Many of these advantages are discussed in this guide.

Prefabrication allows:

- Reduced time on site to weather tightness.
- Reduced waste.
- Reduced defects.
- Increased air tightness.
- Reduced overall construction time on site.
- Reduced quantity of site labour and required skills.
- Components are removed from the critical path.
- The influence of weather on programme is reduced.
- Reduced time working at height.

As stated; prefabricating will reduce a structure's time to weather tightness: Figure 3 displays the results of a National Audit Office report into modern methods of construction (NAO. 2005). It can be seen from Figure 3 that 'time to weather tight' for open panel timber frame is 55% less than masonry construction.

Typical time to weather tight as a proportion of brick and block requirements

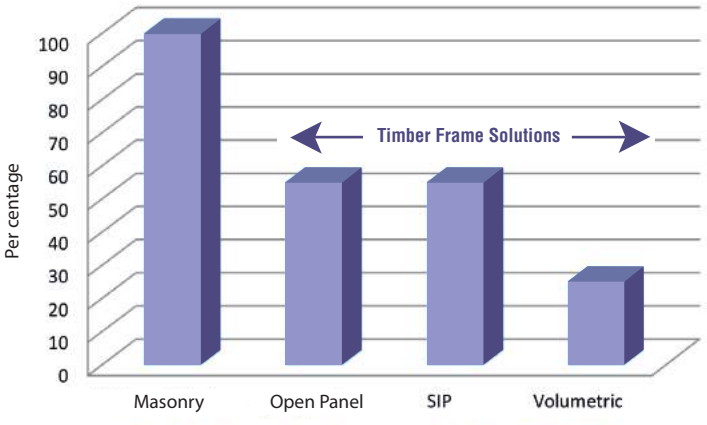


Figure 3: Construction time to weather tight (based on NAO. 2005) where masonry is taken at 100% and timber frame is a ratio of this value.

Key: SIP = Structural Insulated Panel
Brick and block - structural masonry
Volumetric - whole house units pre built in a factory - walls + floors + ceilings

Construction Methods

Modern methods of construction include:

- Open panel
- Pre-insulated panel
- Closed panel
- Structurally Insulated Panels (SIPS)
- Cross Laminated Timber (CLT)
- Volumetric

Open Panel

The open panel system provides the structural frame - from which site installed insulation, services and plasterboard elements are added.

The buildings wall and floor plans are divided into panels which can be assembled on site to provide a weather tight working environment once windows are installed.

Pre-insulated panel

Open panel with factory installed insulation.

Closed Panel

The structural frame as in 'Open Panel' construction, but includes factory fitted insulation and inner sheathing boards to close off the panel. Advanced closed panels include pre-fitted windows, service battens, services and plasterboard.

The advantages of closed panels include more value added in the factory, quicker assembly on site, less waste on site.

Structurally Insulated Panels (SIP)

A SIP is a structural panel comprising structural boards, typically oriented strand board (OSB) that encase a rigid insulation board - sometimes called a sandwich panel.

Cross Laminated Timber (CLT)

Part of the solid wood panel family of products, CLT consists of perpendicularly alternating laminations of softwood creating a solid panel.

CLT is a build method in its own right and is used for walls, floors and roofs. The advantages of CLT include a reduced structural depth compared to joisted floor beams with quick and easy fitting on site. CLT also improves site safety with less time working at height over open cassettes.

Volumetric

A volumetric frame consists of large portions of a structure completed in a workshop environment and delivered to site whole.

These can be whole rooms including fixtures and fittings which are 'plugged' together on site. These properties make them ideal for a quick erect of repetitive design layout.

Engineered Wood Products

An engineered wood product (EWP) is a composite materials derived from wood bound with adhesive. The structure consists of veneers, fibres or boards glued under heat and pressure.

EWPs include:

- Laminated Veneer Lumber (LVL)
- Laminated Strand Lumber (LSL)
- Glulam beams (Glued Laminated timber)
- Composite timber webbed joists

The benefits of EWPs are briefly listed below:

- EWPs overcome dimensional limitations
- Lightweight
- High strength properties
- Minimise waste
- Manufactured with low moisture content to give dimensional stability
- Dimensions are accurate
- Shape can be optimised: Composite I beams or T beams and trusses.
- Can be manufactured with camber
- Can be shaped for creative architectural use
- Some EWPs manufactured from recycled materials

Acoustic Performance

It has been demonstrated by past research, conducted by TRADA and post completion testing that the acoustic performance of modern timber frame party wall assemblies can be built to meet the requirements of the building regulations. The below figure has been created using data from the robust details.

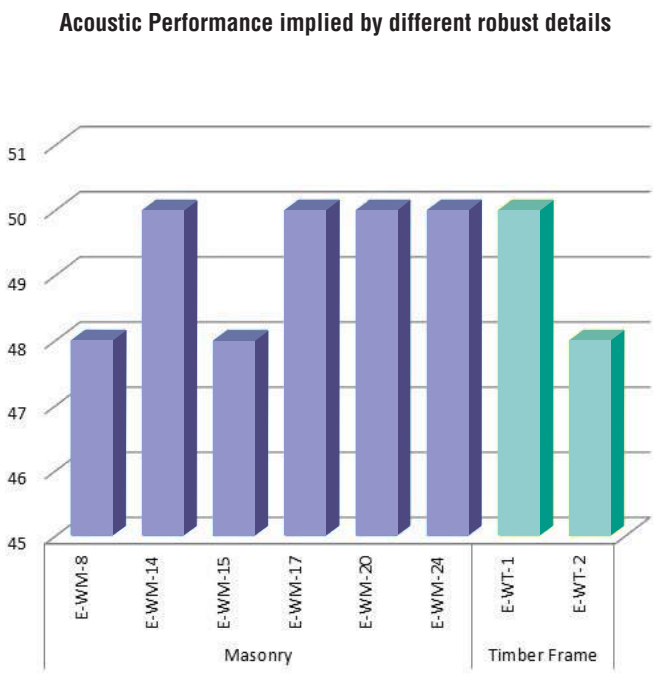


Figure 4: Acoustic Performance to robust details for timber frame party walls

Air Tightness Performance

The majority of heat is lost from a building by uncontrolled ventilation. "Air tightness is strongly influenced by the type of construction. Theoretically, certain types of construction are intrinsically more airtight than other methods of construction." (Leeds Sustainability Institute. n.d)

The consequences of poor air tightness are:

- Increased energy use
- Reduced thermal comfort
- Reduced air quality
- Increased moisture damage

The information from Leeds Sustainability Institute has been used to create Figure 5 below.

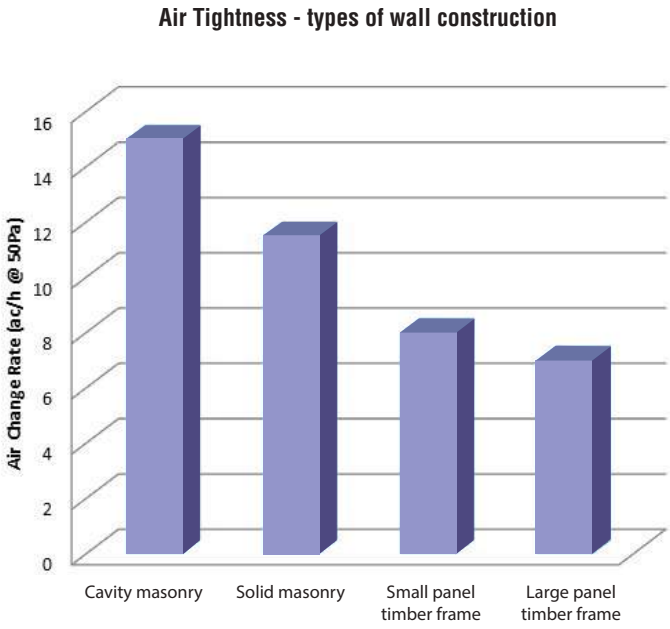


Figure 5: Wall type – air tightness, lower values indicate better performance.

Fire Robustness

Timber frame buildings are designed and built to deliver robust, building regulation compliant dwellings. In 2010, the Department of Communities and Local Government for England (DCLG) released statistics on fires, which showed that there is no greater risk of fire occurring in a timber frame home.

The DCLG review the building regulations to ensure that homes are safe when built to the regulations. Timber frame is an acceptable method of build and is not penalised in the regulations for good reason. Whilst it is clear that timber, where left exposed, can provide a fuel for a fire, it is designed either to be protected against exposure by coving with materials like plasterboard or when exposed will be designed to be of sufficient cross section to maintain a structural strength after losing some of its section from charring. Unlike other common structural materials residual timber does not lose its strength in a fire condition.

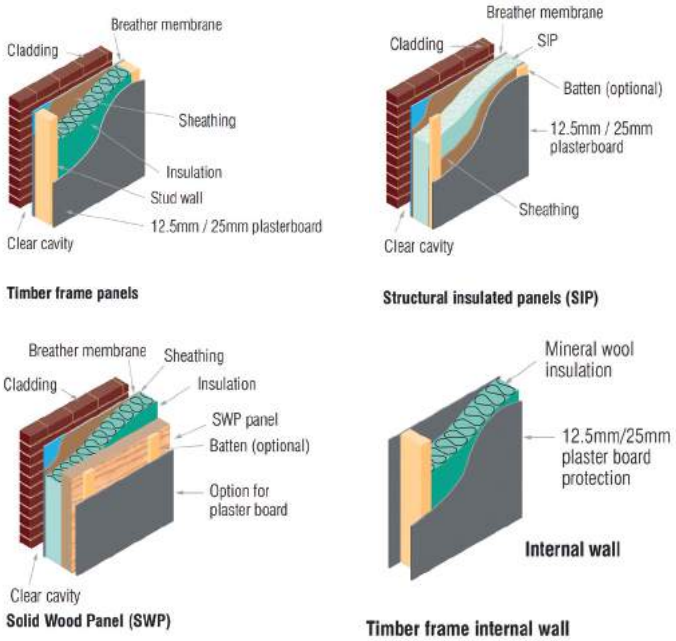


Figure 6:
Extract from STA advice note 7.1 Diagrammatic fire protection and solutions in timber structures - typical wall build ups for fire resistance.

ADDITIONAL INFORMATION

See STA Advice Note Part 1 - Design concepts for the in-service life of the building

Construction Site Fires

The figures below show the proportion of timber frame dwellings constructed in 2010 and the proportion of timber frame site fires recorded in England (DCLG 2010a). It can be seen that the quantity of site fires in timber frame is proportionally less compared to other methods of construction.

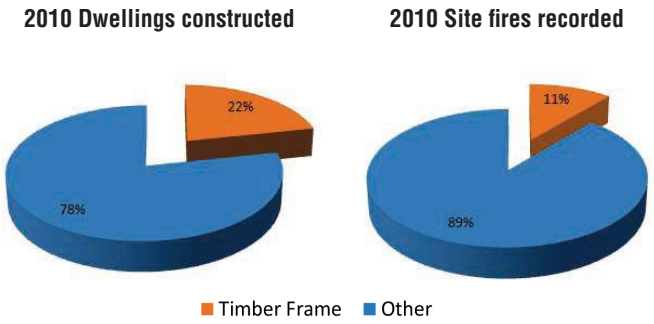


Figure 7: Comparison between dwellings constructed and site fires recorded

To further reduce site fires the STA has implemented 'Site Safe'. To ensure its members work closely with principal contractors/clients to give clear concise information and assistance to the principal contractor regarding fire safety on construction sites."

Only STA members have the Site Safe Policy and compliance with the site safe documents is becoming more recognised by insurance companies as a means of reducing on site fires regardless of the materials it is built from.

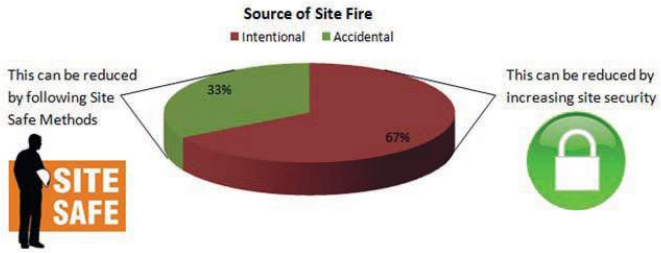


Figure 8: Sources of Site fires

2. Reduced Waste

The building industry contributes 32% of all waste nationally (BRE. 2006). To combat this, UK Government is proposing a target of a "Zero Waste Economy" (Gov.UK. 2014); meaning, waste may still be produced but not before removal of all financially and environmentally valuable resources.

Three key statements can be made with regards to waste:

1. Site waste has an inherent value

2. Timber waste can be mostly recycled

3. Using timber frame reduces site waste

The value of the waste being disposed of is considerable compared to the cost of the disposal (WRAP. 2007). It is therefore in the interest of all parties to reduce the quantity of site waste and to retain any value.

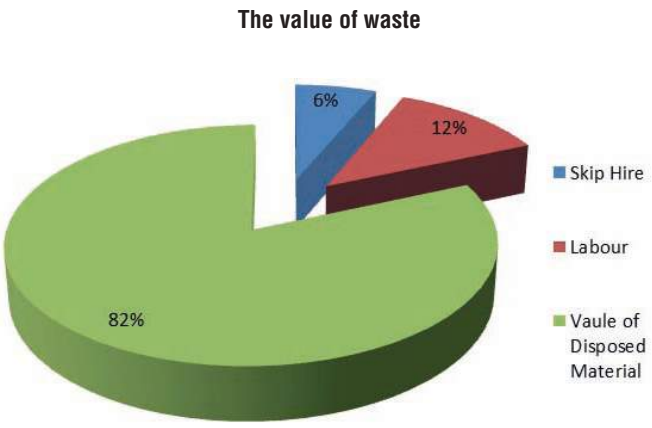


Figure 9: The Value of Waste

Due to prefabrication the use of timber frame will "reduce the amount of waste generated on site by up to 40%" (WRAP). Prefabricated components are delivered on site, cut to size with a detailed ancillary list, meaning less over-ordering of materials and on site mistakes generating waste.

In addition it should be noted that the majority of timber waste generated can be recovered or recycled. Figure 10 displays the destination of timber waste from site.

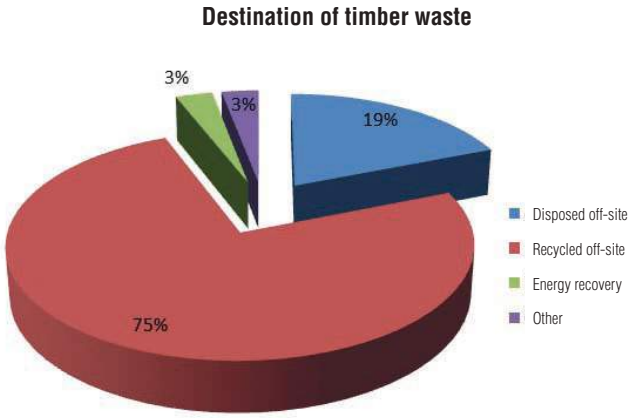


Figure 10: Destination of timber waste

By recycling or recovering energy from waste the potential cost of disposal would be dramatically reduced with the majority of "waste" becoming a valuable commodity.

3. Skills and Knowledge

"Skills shortages are increasing across all of the trades but bricklayers remain particularly scarce due to strong demand from the housing sector" RICS. 2014.

Timber frame reduces the critical path for brick layers and spreads site labour across multiple labour pools. The reduction in brick laying required can be seen in Figure 11 below.

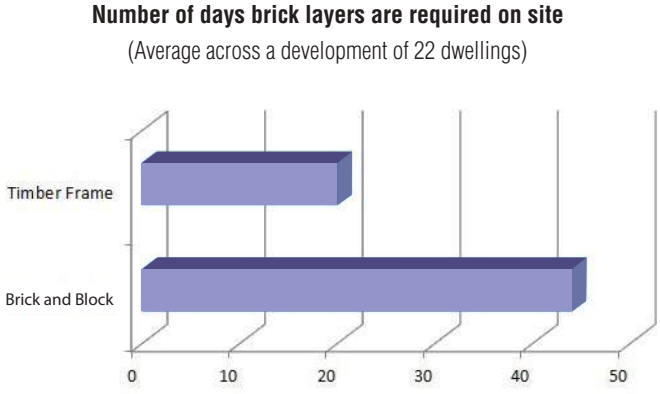


Figure 11: Number of days brick layers required on site (NAO, 2005)

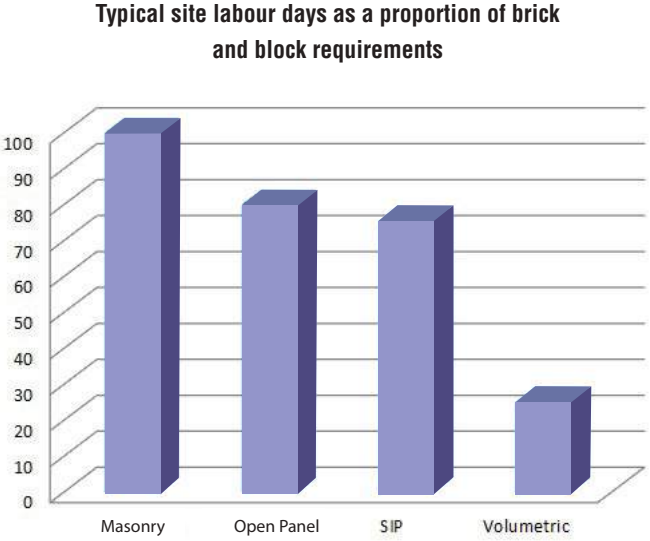


Figure 12: Typical site labour days as a proportion of brick and block requirements (NAO, 2005)

Figure 12 displays the typical number of site labour days for different types of timber frame as a proportion of brick and block construction. This data is a perfect example of the reduction in site skills required compared to masonry construction.

A spread labour pool reduces load on individual trades minimising the likelihood of labour shortages and delays. The graphic below displays the labour pools required for each trade.

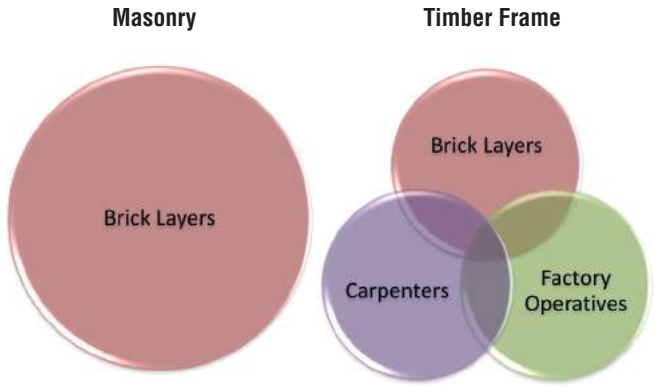


Figure 13: Trade Pools Masonry and Timber Frame

Prefabrication allows a building to be made weather tight without the input of brick layers, meaning timber frame is not as badly affected by shortages of bricks and block layers compared to masonry construction. The accelerated time to water tight also allows follow on trades to begin sooner regardless of the progress of external brickwork.

4. Sustainability

4.1 Key facts on sustainability in the UK

In 2004 more than a quarter of carbon emissions in the UK were produced by housing (Code for Sustainable homes 2006). Agreements such as the Kyoto Protocol have been made between the world's nations with strict targets of carbon reduction. To achieve these carbon reduction targets a change in the housing industry is required.

4.2 The UK Government's future housing policies

To reduce carbon emissions the Government proposes an ambitious target of all new homes being carbon neutral from 2016. (Department for Communities and Local Government, 2012)

4.3 Higher environmental credentials will result in increased costs unless properly managed.

Below is a chart (Department for Communities and Local Government, 2012) displaying the anticipated increase in costs of a standard 3 bed semi detached house built to 2006 building regulations.

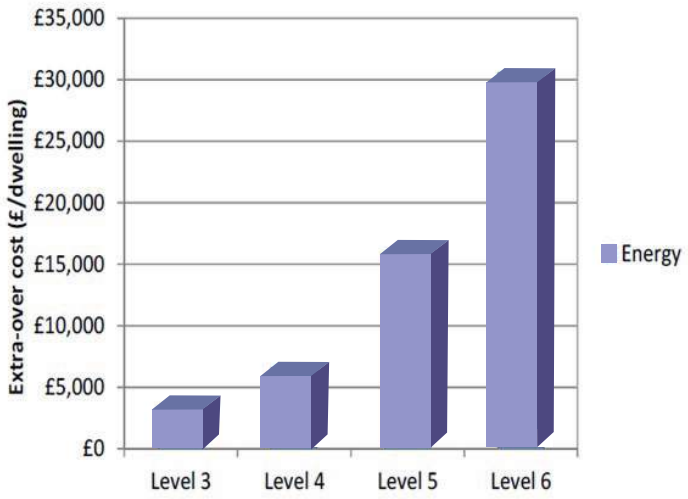


Figure 14: The cost of the code for a 3 bed semi detached house

4.4 Timber frame has superior environmental credential

In terms of sustainability, timber is possibly the only renewable resource in the construction sector and contains less embodied energy than comparable building materials (Sustainable Homes, 2000).

As buildings become more energy efficient the embodied energy of the structure represents an increasingly larger fraction of the buildings use of energy.

Table 1: Comparison of materials (Bren, L, et al, 1996)

	Embodied Energy kg of CO2 per m3	
Material	released	Stored
Steel	5320	0
Concrete	120	0
Timber	15	250

Figure 15 displays a comparison of traditional and timber frame buildings with respect to embodied carbon (Forestry Commission, 2006).

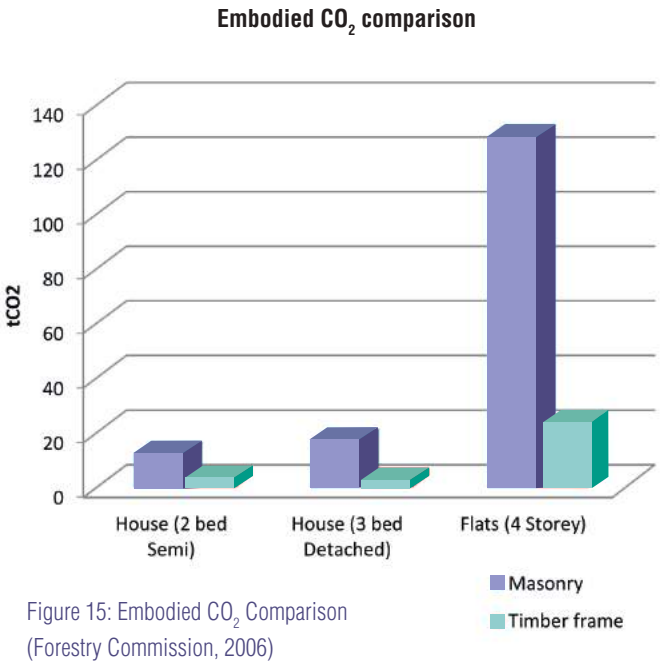


Figure 15: Embodied CO_2 Comparison (Forestry Commission, 2006)

Figure 15 shows that dwellings built in timber frame can result in a saving of up to 86% of green-house gas emissions embodied in the material compared to masonry construction.

5. Whole Life Cost

4.5 Timber frame can be the solution to future building specification

Timber frame has proven solutions to reduce energy usage in the building on account of the fabric energy efficiency

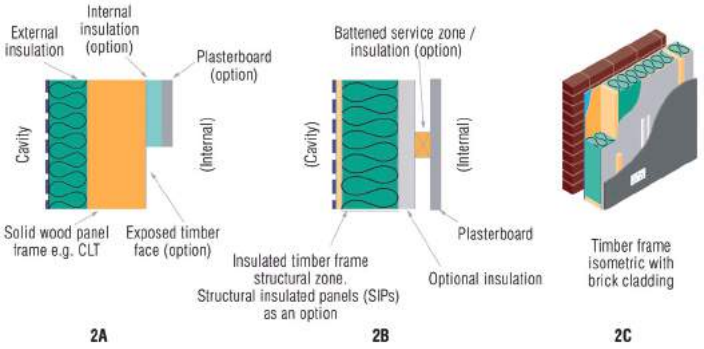


Figure 16: The wall fabric and construction details influence the energy efficiency of the building. Concept ideas shown only.

Extract from STA advice note 6.1

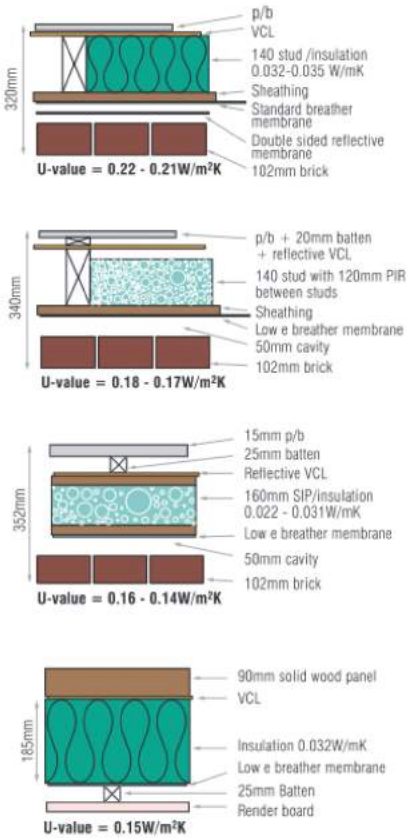


Figure 17: Extract from STA advice note 6.1

5.1 Defining Whole Life Costing

Whole life costing (WLC) is a method of calculating the cost associated with a project over its complete lifespan. “Whole-life costing analysis accounts not only for capital costs, but also for the total operational (fuel bill) and maintenance costs, which are summed over the lifetime of the building.” Encraft (2014).

5.2 Why it is important?

Capital costs represent only a fraction - around 10% to 20% (Construction. 2014) of total costs. The majority of costs are found to be in operation and maintenance.

The advantages of performing a WLC exercise are summarised below:

- Minimises the risks of unexpected costs, disturbance and loss of income.” (BRE. 2014) “Encourages the use of best value building designs” (BRE. 2014)
- Optimises the total cost of occupation by balancing initial capitol and running costs.
- Ensures risk and cost analysis of loss of functional performance due to failure or inadequate maintenance occurs. (CE. 2014).
- Promotes realistic budgeting for operation maintenance and repair.
- Provides data on actual performance compared to predicted performance. (CE. 2014).

5.3 Data on timber frame performance

WLC data is available from Passivehaus case studies: A report on Passiv Haus WLC stated that "in the majority of scenarios (and even if it costs 10% more to build), a Passiv Haus will have lower whole-life costs than a traditional new build." (Encraft. 2014) The higher capital costs were recovered in all cases by the buildings' lower energy and service requirements.

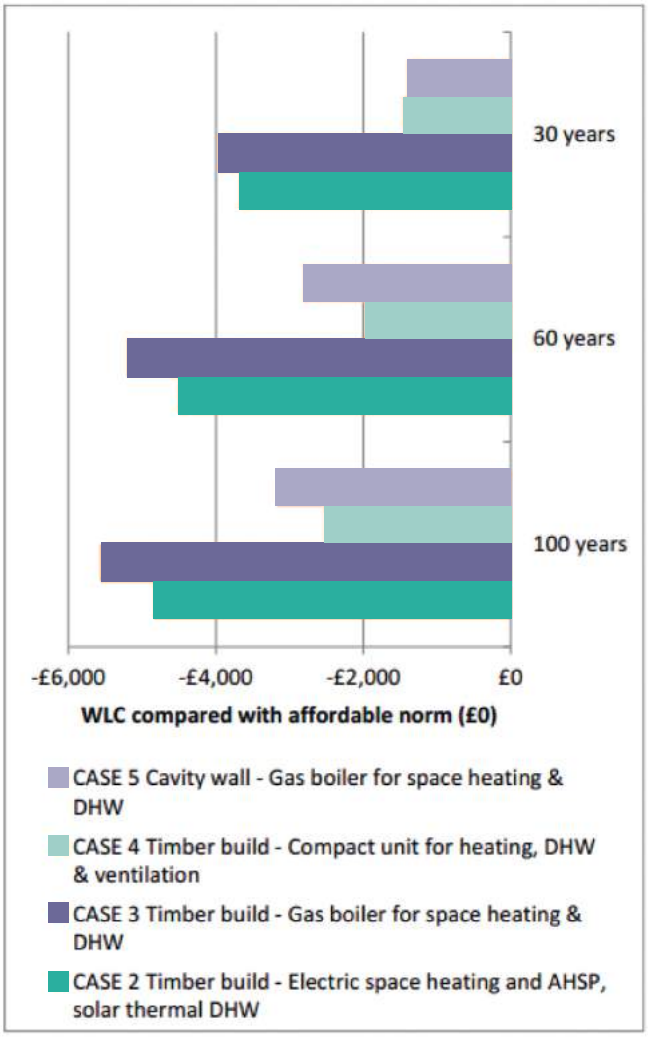


Figure 18: Whole life costing scenarios (Encraft. 2014)

Figure 18 shows the anticipated savings from using different methods of Passiv Haus. (Encraft. 2014) The top two performers with regards to WLC were found to be timber frame structures.

6. Quality and Reliability

90% of homeowners experience defects/snags in new builds. In 2005, the average number of defects per home was 62 (Newhomes. 2013).

The NHBC states: "The most common areas for claims and resolutions in the first two years are superstructure, services and internal finishes." (NHBC, 2014)

This is displayed below in Figure 19. Superstructure is the area of most relevance to timber frame and masonry construction, representing 34% of all snags. A structure type that can reduce these snags will be beneficial.

It has been found from many sources that timber frame performs better than masonry with regards to defects and snags. Statistical data on this subject could not be found but timber frame is believed to be more reliable due to:

- Increased quality due to factory construction
- Increased accuracy
- Quality insured components
- Reduced non conformities
- Life span equal to other forms of construction
- Reduced defects
- Reduced snags

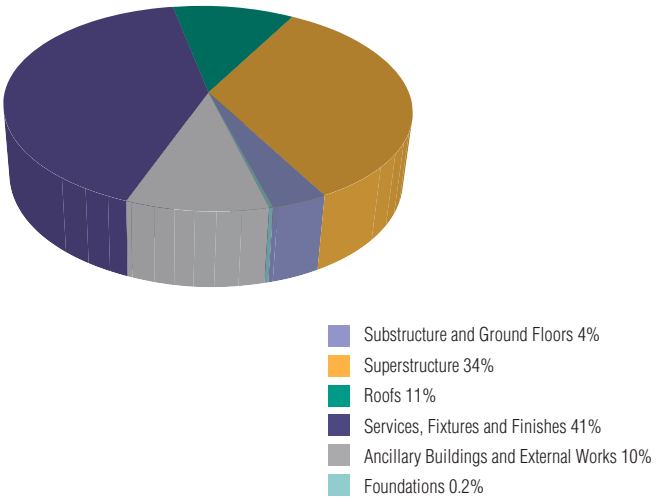


Figure 19: Year 0-2 Defects (NHBC 2014)

7. Health and Safety

Why is Health and Safety an important area when promoting timber frame? In 2012/13 the construction industry reported 3,133 'over 7 day injuries', 1,913 non fatal major injuries and 27 fatalities (HSE. 2013c). This data has been displayed graphically below in Figure 20.

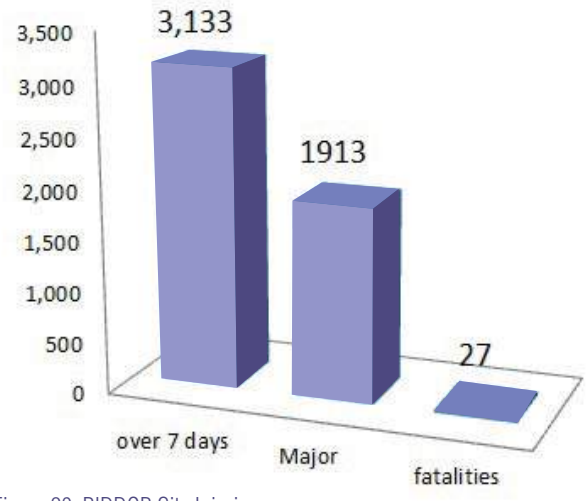


Figure 20: RIDDOR Site Injuries

Health and Safety is significant to the industry as illness and injury results in lost working hours, damage to public relations, and the tragedy of loss of life.

In 2011/12 1.4 million working days were lost in the construction industry, of these, 818k were from ill health whilst 584k were from injury, resulting in a total of 0.7 days lost per worker (LFS, 2012). The cost to the industry of injury and ill health has been estimated at £1.16Bn p.a. (2010/11) (HSE. 2013a).

Prefabrication was again found to be the most significant advantage compared to on site masonry construction. Construction Excellence states prefabrication causes a "25% improvement in site safety thanks to a reduction in the double handling of goods and a corresponding reduction in the risk of slips, trips and falls" (Taylor, S. n.d). Common risks and the advantages of timber frame are shown below.

£1.16 Billion

The cost of Illness and Injury to the construction Industry

Table 2: Common site risks

Key Risk	Advantage of Timber Frame
Falls from height – 48% of fatal injuries to construction workers and 18% of all construction accidents reported (HSE. 2013c)	Prefabricated timber frame reduces high level work by up 80%
Slips and trips - The most common cause of major injuries (HSE. 2013c)	Complex work is carried out under controlled factory conditions. Site work is reduced with very few small components to represent a hazard
Injury from falling material	Reduction is small components on site reduce the risk of knocking material off scaffolding. Also less waste is produced reducing hazards
Contact with moving vehicles	Reduced concentrating of deliveries due to prefabrication. Also reduced variety of deliveries
Cutting brick and block	No block work reduces hazard to eyes from debris and concrete dust which can cause silicosis
Hazardous substances	Reduction in hazardous substances required. Contact with mortar may cause dermatitis and burns
Manual handling	Large cassettes are assembled in a factory using mechanical lifting equipment. On site the panels are handled by crane reducing the need for manual handling

8. Cost

A complete cost comparison of structure types is not possible due to the differences between the methods involved in construction. This guide has therefore focused on the advantages of timber frame which can result in cost savings.

The most significant saving with regards to timber frame has been found to be reduced construction time.

The advantages of reduced build time do not necessarily directly relate to savings in cost. However NAO (2005) has identified reduced site time equates to:

- Reduced overheads
- Rental income streams start earlier
- Social Housing Grant can be drawn down earlier, reducing interest payments on capital to fund developments

The figure below displays the time saving for project completion. The NAO (2005) found a saving of 22%

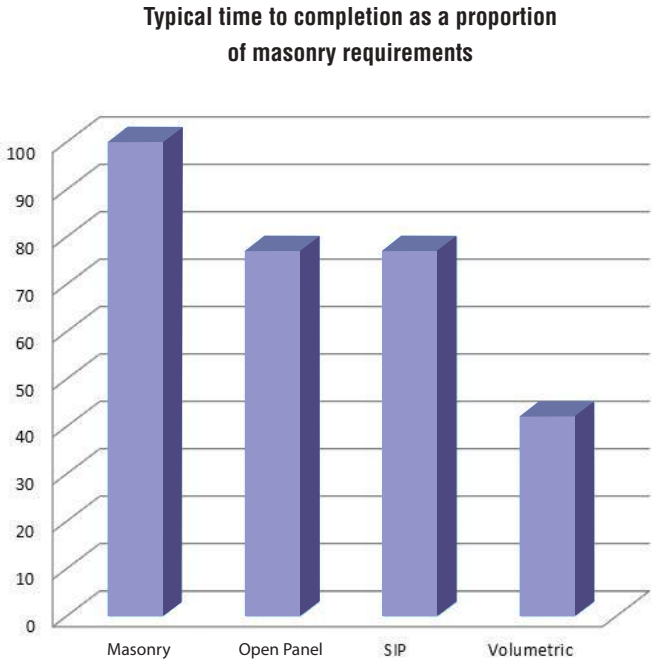


Figure 21: Time saving for project completion. The NAO (2005) found a saving of 22%

Other areas where savings can be made were found to be:

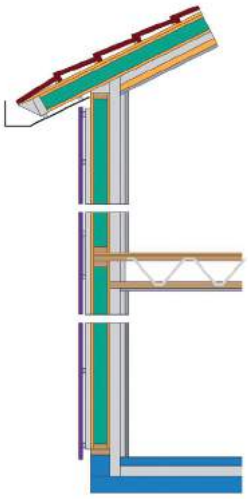
- Snagging costs are reduced because off-site construction elements are subject to the tighter quality control made possible in factory conditions. (NAO, 2005)
- The need for on-site inspection decreases as the amount of off-site work increases. (NAO, 2005)
- Weather has less of an effect on program.

Lack of knowledge of timber frame, particularly cost has been found to be a disadvantage. To solve this, a costing project is under development by Rider Levett Bucknall to create a costing document similar to the Spons price books available for masonry and steel. The intention of the pricing document is to give a greater understanding of the cost of timber frame at an early stage.

9. Whole Building Benefits

Whole building packages are available to meet the demands of the customer. Factory fitted insulation and windows are becoming increasingly common.

Some of the STA member companies are providing factory fitted cladding and services options. Many of the STA members will provide a complete design, supply and construct package to provide a one stop shop to deliver your building.



Design and build structural timber frame offers:

- Low embodied carbon
- Choice of insulation performance
- Airtight construction, proven products and details
- Calculated thermal bridging psi-values
- Manufactured off-site in a quality controlled environment, quick to construct on-site with minimal waste
- Solutions without renewables
- Supply chain choice
- Options for insulation and windows factory fitted
- Service zones and service walls

Summary

Timber frame construction offers many advantages over other forms of construction in terms of speed, cost and quality in order to meet the demand for new housing in the UK. Off-site prefabrication can provide further advantages for timber frame construction, further reducing construction times, costs and health and safety risks.

With the Governments requirement for all new homes to be zero carbon in the future, timber frame construction can provide solutions for highly insulated, airtight homes that will meet the most onerous energy performance requirements. Timber as a material is the only renewable construction material, and offers further sustainability benefits through sequestration of carbon in the material itself. As long as the reuse and recycling of timber at end of life are considered during the design phase, timber frame can offer benefits to the whole life cycle costs of the building.

The risk of fire in completed timber frame buildings is no greater than for any other form of construction. During construction, while the timber frame is still exposed, the potential risk of fire must be considered during the design stage, taking into account all the relevant site constraints. Using appropriate fire risk mitigation strategies, the risk of harm to the general public and nearby buildings can be minimised.

Through the centuries timber frame has shown itself to adapt well to meet the changing requirements of residential dwellings and has the potential to reclaim its title as the traditional form of construction in the UK.

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