STRUCTURAL TIMBER ASSOCIATION
Building solutions in timber

Edinburgh Napier UNIVERSITY

citb

TIMBER FRAME WORKBOOKS

Design

PRACTICAL SKILLS

LEARN
the practical steps of designing timber frame buildings.

Contents

1. Introduction and Welcome

1.1 The STA Design Training Programme

Welcome to your Practical Skills Workbook.

The production of these workbooks has been **supported financially** by **The Construction Industry Training Board (CITB)**. **The Structural Timber Association (STA)** is extremely grateful to them.

Welcome to your Practical Skills gold workbook.

The production of these workbooks has been supported financially by the Construction Industry Training Board (CITB). The Structural Timber Association (STA) is extremely grateful to them.

The Structural Timber Association, on behalf of the industry, has developed this training programme with CITB to provide recognition of the skills and competences of existing timber frame designers together with raising the skill levels of any unskilled or untrained timber frame designers to an acceptable level of competence.

The programme will also provide career paths for timber frame designers and assist young entrants to the timber frame industry. Over time the intention is to allow only those designers, who are qualified, to design timber frame buildings.

A structured training programme has been devised at three levels:

- Design
- Manufacture
- Erection

Each of the three levels is split into three modules:

- Health and Safety
- Knowledge
- Practical Skills

For most of us, our home is our largest expense and we expect it to be built to the highest standards by well trained and suitably qualified people. By using these workbooks, we, as an industry, can now provide you with the opportunity to achieve this goal. Also by having a qualified workforce we can compete with the rest in quality and workmanship.

We hope you enjoy working through this workbook. Please add to it in any way you wish. We look forward to awarding you with your Timber Frame Competency Award qualifications in the near future.

Andrew Carpenter,
Chief Executive, STA.

Education and training. STA/CITB.

If you have any queries or require any further information regarding this booklet seek advice within your own company. You may also contact:

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If you have any general enquiries on any other education and training matter, again either seek advice within your company, or visit

goconstruct.org

STRUCTURAL
TIMBER ASSOCIATION

Building offsite solutions in timber

2. Aims and Objectives

2.1 Target audience

The Design workbook series is aimed at timber frame fabrication designers.

The designers may be based at a timber frame business for the practical part of their training. The workbooks are applicable to designers based at consultancy support businesses and these designers will need to partner with a manufacturer to undertake a factory practical exercise.

The key responsibilities of the timber frame designers are expected, but not limited, to be designing and specifying the timber frame components in accordance with the architects' drawings and the timber frame manufacturing system. For this reason, this workbook includes topics relevant to manufacturing and building design, to ensure the timber frame fabrication designers are aware of the context of their work.

This workbook should be combined with practical application in a timber frame business, including training and support. The learners are encouraged to discuss the topics covered in the workbooks with their colleagues and supervisors.

2.2 Practical skills

This Practical Skills workbook looks at the practices and techniques you need to know and understand in order to become an essential member of your team.

The aim is to give you the necessary practical abilities so that it will help you to develop your all-round skills and understanding by guiding you through the topics to be a timber frame designer.

2.3 What is in this workbook

This workbook is divided into sections, which follow a logical sequence. Please refer to the Contents page for an overview of the sections which are covered in this workbook.

Each section follows a similar pattern:

- you will be given the information to read that explains what you will be required to do, followed by some exercises to complete
- where you see a white activity box, this will indicate that there is a task for you to do. If you can't fit your answers in the space provided, please use a separate sheet
- the activities are designed to help you find out about different topics within the workbook
- at the end of each section there are some questions for you to answer. These are designed to check your understanding and to

identify any areas that you may need to brush up on
- the workbooks have been designed to be enjoyable as well as informative
- on completion of this course you will gain suitable recognition that employers now expect.

2.4 What qualifications can be obtained

The training programme consists of 3 levels:
- Design
- Manufacture
- Erection

Each level of the programme has 3 modules as shown below – each of the levels follow the same structure:
- Health and Safety
- Knowledge
- Practical Skills

Please note:
- this workbook does not replace your own company's documents and/or the main contractor's site rules
- furthermore this workbook supports the small handbook titled: Timber Frame Pocket Guide.

Activity

Take a moment to reflect on the knowledge you would like to gain from this workbook and how it will be useful for your career. Write these points down, they will serve as a motivation reminder throughout your work.

3. Information Interpretation

3.1 Overview

Before starting a design project, it is crucial that you spend the necessary time to become familiar with the project's design, specification, time frame, partners, etc. This foundation will enable you to start your work efficiently and to a high quality standard. Do not hesitate to ask for missing project information if you are certain it has not been provided already, although this may be daunting at first. We will review the main document types you will use as the project progresses.

3.2 Processes – fabrication design, manufacture and erection

Below are some activities and operations commonly undertaken at each stage of the construction process. The list below demonstrates what your activities in the drawing office are and how they are connected with the work of the manufacturing and erection teams.

- **Timber Frame Engineering**
  - Production of drawings (layouts, sections, details)
  - Calculation of loads acting on the timber frame
  - Specification of timber cross sections
  - Calculation of connection loads
  - Specification of connector size and performance
  - Compliance with relevant standards.

- **Fabrication Design (drawing office)**
  - Production of drawings (assembly, architectural, site plans, services, erection etc.)
  - Cutting lists, material lists/ take-offs, loading lists, fastener schedules
  - Specification of connector types
  - Scheduling – materials and delivery
  - Preparation of contracts and administration work
  - Liaison with engineers and architects for the architectural drawings and structural appraisal
  - Liaison with manufacturers and suppliers
  - Liaison with Client
  - Liaison with factory and site.

- **Manufacture (factory)**
  - Health and Safety – safe operation at all times
  - Adherence to drawings, specifications and standard details
  - Adherence to work schedule
  - Cutting and preparing materials
  - Assembling panels
  - Assembling cassettes
  - Assembling modules
  - Installation of membranes
  - Installation of fire stopping measures

- Preparing components and assemblies
- Installation of services
- Installation of linings
- Installation of sub-assemblies
- Storage (materials, finished assemblies and units)
- Packing and sorting materials
- Loading materials
- Receipt and delivery of goods/finished items
- Checks and quality control
- Reporting and rectifying errors.

- **Erection (Site)**
  - Health and Safety – operate safely at all times
  - Correct interpretation of and adherence to drawings and specification
  - Adherence to site assembly drawings and instructions
  - Adherence to work schedule
  - Site inspection
  - Provision of Services and drainage
  - Setting out and laying soleplates
  - Erection and management of scaffolding
  - Kit checks upon arrival
  - Installation of ground floor, where part of the timber frame package
  - Erection of ground floor walls
  - Installation of upper floors
  - Erection of upper walls
  - Erection of roof structure
  - Landing and fixing modules
  - External cladding
  - Provision of appropriately filled and/or covered settlement gaps
  - Installation of temporary bracing
  - Installation of perimeter and partition noggins
  - Installation of membranes, where part of the timber frame package
  - Installation of insulation
  - Metalwork correctly specified and installed
  - Installation of services by follow-on trades
  - Installation of tie down and restraint straps
  - Installation of membranes for moisture control and air tightness
  - Installation of cavity barriers
  - Management of plant
  - Considerate storage of materials
  - Checks and quality control
  - Reporting and rectifying errors and repairing damage
  - Handover (signatures where necessary)
  - Snagging.

3.3 Client instructions

The client will provide you with the necessary information you need to start the timber frame design. This will include items such as:

- a project directory, which outlines all the parties involved, their responsibilities and contact details
- the project time-line (you can add alerts for deadlines to your smartphone calendar so that you stay on track with work and can judge your availability if asked to attend meetings)
- specification
- architect's drawings
- foundations layout
- information relevant to the timber system used
- logistics plans.

Activity
Inspect an architect's set of drawings for a domestic house and list any information you consider to be missing.

3.3.1 Design brief

The design brief should be your first read. This will outline the basic information, and by the end of the project you will probably know the information by heart. The design brief should include:

- address of the project
- intended use of the structure e.g. domestic flats
- scope of the design work
- design standards required, including energy efficiency
- standard and special loadings
- excluded areas from your work, e.g. foundations.

The learner should check that all design brief elements are in place and clearly presented prior to commencing design work. It is good practice to hold a briefing meeting with all team members in your company who will be working on this project, so that everyone is on the same page from the start and has the opportunity to ask your project leader any questions relevant to understanding the project and your scope of work.

3.3.2 Architect's drawings

The architect will supply you with the majority of information required for the project. Usually this will be via PDF documents and dimensioned drawings. It is important that you don't try to scale from the drawings but only use the dimensions provided. In general, the architect will provide the following documents:

- working layout plans with dimensions of each level of the building (look out for section and elevation lines, which will orientate you when reviewing further drawings)
- elevations of the building from all sides
- fully dimensioned sections of the building showing:
    - floor to floor heights
    - storey heights and roof lines
    - window and door gauging
- roof details (eaves, gable sections)
- detailed staircase information including headroom clearance
- robust floor detail build ups
- external wall construction detailing and cladding

Activity
Find a specification example from your company, study it and attach it here for future reference.

- specific architectural or weathering details
- any further information or details relevant to designing the timber frame elements.

3.3.3 Specification

A timber frame specification sets out the component items the manufacturer has contractually agreed to supply (or supply and erect). These tend to be all items associated with the kit itself and any ancillary items the client has requested.

Requirements of other members of the design team (e.g. engineer) may have cost implications and these should be transmitted back to the client/manufacturer. The specification should be thought of as the basis for designing the timber frame kit as it sets out the overall remit for the design.

Accurate, current, detailed and complete specifications ensure that whatever is produced in the factory complies with the customer's request; it adheres to the technical requirements and is in accordance with applicable regulations and standards.

It is imperative that personnel working in the timber frame industry are able to read, understand and interpret specifications and drawings.

The specifications should include references to all the materials to be used in manufacture, including any tolerances that must be adhered to. It is important to be familiar with the style and layout of the specifications which are used in the factory in which you work and even more important to be able to understand and interpret them accurately.

The specifications should be referred to throughout the entire manufacturing process, specifically during operations such as the following:

- selecting raw material
- sawing timber from cutting programmes or cutting lists: materials of the correct specification and dimensions must be selected in accordance with the drawings and so that waste is minimised.
- marking out: once material has been cut each piece should be carefully marked out, preferably in the order of which it is to be used for assembly.
- manufacturing assemblies and components
- fitting membranes
- installing insulation
- marking positions
- fitting finishes.

Activity

Find a foundations layout example from your company, study it and attach it here for future reference.

Activity

What information should be listed on the Structural Engineer's marked up drawing? Consider the specification information you will need for the following categories:

Foundations

Connections

Material types and grades

Load-bearing components

Non-load-bearing components

3.3.4 Structural mark up

The timber frame engineer on the project will generally supply a marked up architects layout drawing. This will indicate such items as truss spans, truss girder positions, internal load bearing walls, lintels / cripple studs, joisting direction / joist sizing / centres and loose trimmers/beam sizes and grades. It will also indicate racking wall positions and requirements.

Further items shown on the structural marked up layout include:

- specification of metalwork items e.g. strapping, hangers, soleplate fixings
- portal frames
- cranked steels
- special nailing.

If the roof is a trussed roof the timber frame engineers should liaise with the roof truss manufacturer's designer to ensure that the roof loads are correctly transferred onto the frame below.

The designer should have a full understanding of the engineer's general requirements for the timber frame superstructure and should discuss with the engineer any areas that may have changed during the design process.

Whilst the designer is not expected to fully understand the calculations themselves he/she should be aware of the importance of the structural information and how any changes to the building may affect this.

Any such changes must be

referred to the engineer for their appraisal and comparison against the calculations earlier produced. Experienced designers may suggest alternative methods of construction to the engineers to solve any particular problems encountered.

Input from the designer should always be welcomed. Changes to the structure should be reflected in revised engineers marked up layouts.

3.3.5 Foundation layout

Line load and point load information should be produced by the timber frame engineer and issued to the foundation designers at the earliest opportunity so that the foundation design can accommodate the loads from the superstructure.

The set of contract drawings issued by the architect and the foundation engineers could include foundation layout information drawings. These foundations layout drawings could indicate where the superstructure can facilitate load-bearing walls and point loads.

The locations of load bearing walls should be approved by the client, the architect or the foundation engineer prior to further timber frame design work being carried out.

Walls designated as load-bearing by the timber frame engineer and the designer must be cross checked against the provided foundation drawing. It is vital that all load-bearing walls supporting the timber frame superstructure correspond correctly to with the foundation drawings.

3.3.6 Manufacturer's stock availability and preferences

Prior to any commencement on a project, the manufacturers should supply all their available timber stock sizes and preferences for use. This will also encompass third party suppliers such as I-beam specialists, steel fabricators, truss manufacturers and joinery companies etc.

The manufacturers can advise the designer firstly what materials were allowed for in their tender and secondly what they would be the most economical choices for the specific design. The designer should try to be as economical as possible by working with the factory and the client to ensure the specification, engineer's requirements and available stock materials are all taken into account during the preparation of the timber frame designs. Most manufacturers have a pre-set stock list and preference of loose items they commonly use and also lead time scales required for ordering non-standard items. Lead times are another important aspect when selecting the materials for specification, especially if work in the timber frame factory has to be sequenced or synchronised.

In general, the timber frame company will have their standard materials in stock and it is important that the designers know what these materials specifications and quantities are. The designers should work as much as possible with the factory's standard materials, because these will often be the most economic solutions and their procurement will generally be arranged through contracts between the timber frame company and the materials manufacturer at set prices. Non-standard materials should only be specified where this is absolutely necessary.

Common considerations on stock availability and preferences:

- sheathing size used, thickness, and type

- soleplate and wall plate build up size
- general lintel material to be used
- decking and sub-decking size used, grade, thickness and type
- floating floor materials and build up
- external, party wall and Internal wall stud sizes, grades and centres
- joisting, I beam and metal web joist size, grade, centres, type, availability
- external timber suppliers stock sizes, grades, type, availability
- external steel suppliers stock sizes, grades, availability
- roof truss material, size, grade, availability
- joinery sizes external / internal, stairs.

3.4 Third party drawings

This information could be from various parties such as lift manufacturers, stair case suppliers, foundation engineers and regulatory authorities etc. The relevance of the information will be in how it might affect or interact with the superstructure timber frame and how it should be catered for in the design process. These areas should be agreed upon before commencement of the manufacturing drawings.

3.5 Services consultants

Prior to the commencement of the manufacturing drawings the location and size of all flues, Soil Vent Pipes (SVPs), extract ducts, etc need to be agreed. Their locations should also be clearly marked on the drawings with dimensions and specifications.

The learner must ensure that they consult drawings which precisely indicate the locations of services, produced by the relevant consultants.

3.6 Logistics

The timber frame designer must also be provided with information to allow him to consider transportation and site access limitations. Transport to site of components and site access for wagon's and cranes should be considered as this may affect how the project is designed. Components should be split to enable the kit to be delivered in the correct manner and erected in an effective way.

Manufacturing processes and schedules should be sequenced such that they enable:

- reduced transport requirements
- avoidance of site traffic problems
- reduced storage requirements both on and off site
- reduced lifting and handling requirements
- reduced downtime on site
- reduced waste
- efficient use of cranage, plant and scaffolding.

Effective communication between all parties both on and off site is critical.

Delivery schedules should be agreed in advance, monitored relative to programme progress and communicated to the factory and hauliers.

Other considerations might be:

- alternative transport methods
- local restrictions, constraints and/ or obstructions
- lifting operation arrangements on site
- site restrictions or access issues

- delays due to unforeseen events e.g. road accidents or road closures and diversions

among others.

Activity

Check with your organisation what the usual transportation requirements are for your products and how these influence the timber design. Furthermore, for the specific project you are working on, enquire about any additional restrictions such as site access. Make notes here for future reference.

4. Setting out

4.1 Overview

The relevant setting out information should be noted on the drawing and must be adhered to. This will ensure that the building dimensions are determined correctly, that the building footprint is correct, and that the building sits in the correct location in relation to its surroundings. The learners should check with their organisation what the standard procedure for setting out the building is in their organisation. Usually there is only one Setting Out Point (SOP) marked on a plan drawing and the dimensioning of the building should start from it. The SOP usually refers to a location, distance and height in relation to another point, for example a point on the foundations.

The Drawing Office will produce the soleplate drawing from the architect's drawings and specification paying particular attention to the following:

- ground floor finish
- wall thickness
- location of any load-bearing elements.

The drawings will be passed to the supervisor(s) for checking where they will be signed and dated. Every drawing that leaves the Drawing Office should leave with the drawing register duly completed.

After checking by the supervisor(s), any changes must be incorporated before being sent to the client with the standard soleplate letter/instruction listing any relevant inclusions.

The date on which the soleplate drawings are issued should be recorded appropriately.

Site assembly drawings will typically follow a similar procedure to those of the soleplate drawings but will include all necessary detailed information to allow the frame to be installed accurately and in the correct manner on site.

4.2 Soleplate

Soleplates are a critical component of timber frame construction. Soleplates are the first timber components to be installed on site and provide the basis from which the rest of the structure is formed. As well as providing a means to accurately locate the structure soleplates also assist in transferring loads to the foundations.

Material, dimensions and profile of soleplates must be adequate to receive the structure.

Positioning, fixing and level can affect the remainder of the construction process and performance of the completed building. Soleplates should be installed prior to delivery of the timber frame.

A damp proof course (DPC) must be installed between the foundation and soleplate to prevent moisture ingress.

'Packing out' of soleplates may be necessary to ensure that the soleplate is level. Packing material must be adequate to support loads applied to the soleplate.

The Drawing Office must ensure that there is an adequate amount of information to allow the soleplate to be installed accurately and correctly.

4.3 Sections and storey heights

Sections must also be produced along with the soleplates at the initial stage to set up the storey heights of the building, the floor build up at ground floor and intermediate levels and the general roof profile indicating total build heights etc.

The external claddings should be outlined on the sections especially in the case of brickwork / masonry so that window / door heads can be coursed into a standard gauge to avoid cutting on site and to allow for the timber shrinkage.

All sections should be fully dimensioned to show component build up and any vital constructional detailing relating to the vertical setting up of the frame.

Ensure that the stairwell openings and the finished floor to floor height allows compliance with the current Building Regulation requirements. At the time of writing this guide the relevant regulations are the following, however check what the most up to date versions are for your project.

In England and Wales:

Approved Document B Fire Safety – Section B1 Means of Warning and Escape

Approved Document K Protection from Falling, Collision and Impact – Section K1 Stairs and Landings

Approved Document M Access to and use of buildings – Sections 2A and 3A

or in Scotland:

within the Technical Handbook for either Domestic or Non-domestic buildings depending on your project type:

2.9 Means of Escape

4.3 Stairs and Ramps

A useful strategy is to ask yourself on the completion of every setting out drawing 'Could I fully erect this building from the dimensions provided?'

4.4 Adjustments

4.4.1 Wall thickness, sheathing, repetition

The designer should consider the wall material build up required for the superstructure timber frame elements and interaction with the other trades and construction materials to be used i.e.: cavities and claddings etc.

Activity

Attach a copy of a setting out drawing produced in your office. Are there sufficient dimensions to fully set out every item accurately and squarely?

The Drawing Office must ensure that there is an adequate amount of information to allow the soleplate to be installed accurately and correctly.

A precise, agreed specification at this stage is vital to avoid costly redesign work and also avoid any alteration on site to foundation / footing work carried out.

4.4.2 Ground floor, warm floor, floating floor, structural floor, suspended ceiling

When setting out the soleplates and sections, at the initial stage, the designer should be aware of the following on construction details required as this has a large impact on both the vertical setting up of the timber frame and also other elements such as stairs etc.

It is essential that the ground floor construction, floating floors at intermediate levels and any suspended ceilings are established and agreed at an early stage.

4.5 Service voids

Service voids may be implemented on various projects for a number of purposes. These can include items such as ducts running vertically up through the building in common areas and also horizontally through floor and roof zones.

The designer should be made aware prior to the drawing stage of any special requirements to be taken into account for services.

It is important to provide temporary protection of voids.

Further reading:

http://www.structuraltimber.co.uk/library

4.6 Basic maths

4.6.1 Pythagoras' Theorem

In a right-angled triangle the side opposite the right angle (90°) is the longest side - this is called the hypotenuse.

The square of the hypotenuse is equal to the sum of the squares of the other 2 sides.

This can be presented using the following equation, often referred to as the 'Pythagorean equation':

$$a^2+b^2=c^2$$

Where;

a = the length of one of the sides other than the hypotenuse

b = the length of the other side other than the hypotenuse

c = the length of the hypotenuse

If two of these lengths are known this equation can be used to determine the third.

For example, to determine the length of the hypotenuse where the length of the other two sides is known:

Where:

a=5 metres

b=10 metres

c=hypotenuse,length unknown

$$5^2+10^2 = c^2$$

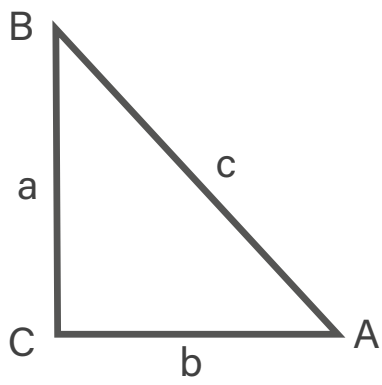
So:

$$25 +100=c^2$$

So:

$$c^2=125$$

So:



$$\text{Sin A}=\frac{\text{opp}}{\text{hyp}}=\frac{a}{c}$$

$$\text{Cos A}=\frac{\text{adj}}{\text{hyp}}=\frac{b}{c}$$

$$\text{Tan A}=\frac{\text{opp}}{\text{adj}}=\frac{a}{b}$$

$$\text{Sin B}=\frac{\text{opp}}{\text{hyp}}=\frac{b}{c}$$

$$\text{Cos B}=\frac{\text{adj}}{\text{hyp}}=\frac{a}{c}$$

$$\text{Tan B}=\frac{\text{opp}}{\text{adj}}=\frac{a}{b}$$

$$c = \sqrt{125}$$

So:

$$c = 11.18 \text{ metres}$$

And, to determine the length of one side where the length of the hypotenuse and the other side are known:

Where:

a=8 metres

b=length unknown

c=12 metres

$$8^2+b^2 = 12^2$$

So:

$$64 + b^2 = 144$$

So:

$$b^2 = 144-64$$

So:

$$b = \sqrt{80}$$

So:

$$b = 8.94 \text{ metres}$$

One practical application of Pythagoras' Theorem may be to check that a panel, cassette or opening is square i.e. that all four corners have an angle of 90°. This can be determined by measuring across both diagonals and comparing the results – if both diagonal measurements are equal then the angles at the corners must be 90°.

4.6.2 Calculating the Properties of Some Common Shapes

The area of a square or rectangle is calculated by multiplying its length by its width:

$$A(\text{square or rectangle}) = l \times w$$

The distance around the outside of a shape is called the perimeter. The length of the perimeter is calculated by adding the length of all the sides together.

As a rectangle has two sets of sides of equal length the **perimeter of a rectangle** can be calculated by multiplying two times its length and adding to that two times its width:

$$P(\text{rectangle}) = 2l + 2w$$

As a square has four sides of equal length the perimeter of a square can be calculated by multiplying the length of any one side by four.

The volume of a square or rectangle is calculated by multiplying its length, width and height:

$$V(\text{rectangle}) = l \times w \times h$$

The **area of a triangle** is half of the length of its base multiplied by its height:

$$A\ (\text{triangle}) = (b \times h)/2$$

The **area of a parallelogram** is calculated by multiplying the length of its base by its height:

$$A(\text{parallelogram}) = b \times h$$

The area of **trapeziums, kites and rhombuses** can be calculated by splitting the shapes into two triangles, finding the area of each, then adding the areas together.

The **diameter of a circle** is the length of a straight line that passes through the circle's centre and terminates on the circle i.e. the width of the circle at its widest point.

The **radius of a circle** is half of its diameter.

The **area of a circle** is calculated by squaring its radius and multiplying it by Pi (π, approximately 3.14):

$$A(\text{circle})=\pi r^2$$

The **circumference (perimeter) of a circle** can be calculated by multiplying its radius by two times Pi (π, approximately 3.14) or by multiplying its diameter by Pi (π);

$$C=2\pi r$$

Or:

$$C=\pi d$$

4.6.3 Trigonometry

The designer should be able to demonstrate the use of basic trigonometry for working out 2D / 3D drawing information. Basic sine, cosine and tangent functions are fundamental in design work on complex structures.

Activity

Find the height A of a right angled triangle where angle A is 25 deg and side B is 2000mm.

5. Layouts

5.1 Overview

Layouts provide the arrangement of components at each floor level throughout the structure, including the roof. Layouts are 2D planar views from the top looking down towards the floor levels. Layouts are typically drawn as horizontal sections taken at 1.2m height from the floor level so that the doors, windows, etc can be included, however this can vary especially with roof plans. Special symbols and drawing line stiles are used for the different components that form layouts and every drawing office uses their developed standard layout templates. The layout drawings should contain the project name and number, block number, date and the designer's name.

5.2 Soleplate and wall plate layouts

The ground floor soleplate layout is a key drawing and is the base for all the following structure. It is an accurate jig for setting out both the superstructure and the substructure.

Soleplate layouts may be required for the upper floor walls.

It should show the setting out dimensions and lengths for all the soleplates across the building. Diagonal dimensions are required to allow the plan shape to be set out squarely.

Also shown on the soleplate layout are the following:

- soleplate depth
- soleplate clips (if applicable)
- masonry nail centres (if applicable)
- positions of door openings
- schedule of lengths or reference to a schedule
- substructure horizontal setting out tolerances
- substructure vertical setting out tolerances
- internal wall positions.

5.3 General layout

A general arrangement and setting out drawing for each floor level may also be issued, at approval stage, to show the location of all openings and any extra internal sheathing to walls.

Wall panel layouts vary in detail in accordance with the individual timber frame manufacturer's requirements. All wall panel layouts should clearly show an onsite erector where the components should be located on site and any information relating to the joining of wall panels and loose fix beams etc.

The basic wall information should show a general plan indicating the following:

- panel references or codes and their location on plan
- window and door locations
- special loose member fixing notes and details
- dimensions.

All wall panel layouts should clearly show an onsite erector where the components should be located on site and any joining and connection information.

More detailed plans will additionally show:

- dimensional setting out of windows and doors
- structural information and notation
- stair diagrams
- room dimensions.

5.4 Floor layout

Floor layouts may show the complete floor area. In the case of larger structures, floor layout drawings may be part of a series of drawings covering the whole building, each drawing showing a segment of the floor layout.

The purpose of the drawing is to locate all structural items within the floor area.

Typically I-joists or open web beams are used for joists in floor and roof cassettes though other joist types may be used, including solid timber. Joist types are described in more detail in the Knowledge section.

Engineered Wood Products (EWP) such as LVL, Glulam or PSL may be used in conjunction with I-joists and open web joists at locations where heavy loads are to be transferred e.g. stair trimmers. EWP such as LVL is typically used for edge binders/rim boards at the perimeter of the floor.

5.4.1 Loose Solid Joists

Solid timber joists have been used traditionally for the construction of floors though nowadays there are many alternatives available such as I-joists and open web joists, the details of which are outlined below.

Some of the main features and benefits of solid timber joists are as follows:

- solid timber joists are traditional and as such a familiar product which people are comfortable working with and have experience working with
- solid timber for structural use is strength graded
- performance values are available for solid timber for structural use
- solid timber joists can be cut, processed and worked by traditional tools and methods both in the factory and on site
- solid timber can be finger jointed to produce lengths longer than can be 'naturally' produced
- solid timber is easily treated with preservative, water repellent and fire retardant treatments.

Some of the reasons why I-joists and open web joists may be selected instead of solid timber joists are given below.

Floor joist layouts should be prepared taking into account the floor joist size requested by the manufacturer or architect and most importantly as specified by the engineer. The layout should be drawn up showing the entire load-bearing supporting walls below. The supporting walls should be dimensioned to establish joist lengths etc and to confirm their location.

The engineer's structural marked up layouts should be implemented with joist spacing and setting out of stairwell trimmers etc. Stairwells should also be set out against an advised size from the architect. Clear headroom heights above stair flights should be established to comply with the section information and Building Control requirements.

Trimmers, timber beams, and steel beams (referenced to manufacturing drawings) in the floors should all be clearly annotated showing their location and any fixing details. Soil and Vent Pipes (SVP) / service duct

positions if known should be trimmed and marked up for setting out on site. Joist spacing should be dimensioned on the layouts as well as any specific blocking locations for supporting loads from above etc.

The general joist size, grades, lengths, and decking specification should be indicated on the drawing as well as any site fixing notation.

Blockings, noggins (dwangs), hangers and header joists should be specified and located.

All loads from posts located within load bearing walls should be transmitted through the floor zone by solid blocking or compression blocks.

5.4.2 Loose I-beam Joists

An I-joist is a composite engineered timber joist of a similar cross section profile to steel I-beams and typically comprises solid timber or Engineered Wood Product (EWP), most typically laminated veneer lumber (LVL), top and bottom flanges bonded in parallel to a web of wood panel material such as OSB or hardboard though I-joists with corrugated steel, LVL or solid timber webs are available yet less common. The web is typically inserted into grooves in both flanges and glued.

I-joists are typically used as joists, studs and rafters for floor, wall and roof applications. I-joists can be used for domestic, commercial and industrial applications.

I-joists may be used as a core component of floor cassettes, wall panels and roof cassettes assembled offsite.

There are several I-joist systems available produced by different manufacturers.

Some of the main features and benefits of I-joists are as follows:

- manufacturers offer a range of standard section sizes similar to typical solid timber section sizes. Typically, a range of standard approved connectors and solid EWP members are also available to suit standard I-joist section sizes
- I-joists typically weigh less than solid timber members of an equivalent section size and so have an excellent strength to weight ratio
- I-joists are versatile and can be designed and used effectively for wall, floor and roof applications
- I-joists are typically simple to install, potentially resulting in increased time savings and reduced labour costs
- holes can be readily created in the web for accommodation of services
- span tables, performance values, standard construction details, specification and installation guides are provided in the manufacturer's literature
- I-joists are manufactured offsite ensuring consistent quality, reliability and uniformity and are dimensionally stable and will resist distortion such as shrinking and warping providing the manufacturer's literature is adhered to
- I-joists form part of a system and are complimented with solid EWP of similar section sizes for use as elements such as trimmers and rim board, among others
- I-joists are typically cut to length in the factory, reducing waste and negating the need to cut on site
- I-joist manufacturers provide design software, training and support specifically for their joist system
- I-joists are available in long lengths allowing for long

I-joist roof system

Open web joist in a factory shop floor

clear spans thus speeding up construction by eliminating the need to lap joists over bearing walls or supporting beams.

The learner should refer to the appropriate manufacturer's manual for detailed information.

5.4.3 Loose Metal Web Joists

An open web beam is a composite engineered joist and typically comprises solid timber top and bottom chords plated together in parallel with punched metal webs pressed into the chords, though open web beams with timber webs plated to the top and bottom chords or similar are available yet less common.

Open web beams are typically used as joists, studs and rafters for floor, wall and roof applications. Open web beams can be used for domestic, commercial and industrial applications.

Open web beams may be used as a core component of floor cassettes, wall panels and roof cassettes assembled offsite.

There are several open web beam systems available produced by different manufacturers.

Open web beams and I-joists share a number of advantages.

Some of the main features and benefits of Open web beams are as follows:

- manufacturer's offer a range of standard section sizes similar to typical solid timber section sizes. Typically, a range of standard approved connectors and solid EWP members are also available to suit standard Open Web Beam section sizes
- open web beams typically weigh less than solid timber members of an equivalent section size and so have an excellent strength to weight ratio
- open web beams are versatile and can be designed and used effectively for wall, floor and roof applications
- open web beams are typically simple to install, potentially resulting in increased time savings and reduced labour costs
- open web beams have large openings between the chords and allow for easy installation of services in the voids without the need to cut, notch or drill
- open web beams offer flexibility at the design stage as the webs can be positioned to suit particular applications and conditions and reinforcement can be incorporated to enhance performance where necessary
- span tables, performance values, standard construction details, specification and installation guides are provided in the manufacturer's literature
- open web beams are manufactured offsite ensuring consistent quality, reliability and uniformity and are dimensionally stable providing the manufacturer's literature is adhered to
- open web beams form part of a system and are complimented with solid EWP or solid timber of similar section sizes for use as elements such as trimmers and rim board among others
- open web beams are manufactured to length, reducing waste and negating the need to cut on site
- open web beam manufacturers provide design software, training and support specifically for their joist system
- open web beams are available in long lengths allowing for long clear spans thus speeding up construction by eliminating the need to lap joists over bearing walls or supporting beams.

Generally loose metal web joist layouts are similar to 'I' beam joist layouts except for:

- joists may be top hung
- strongback bridging may be required.

Refer to the appropriate manufacturer's manual for detailed information.

5.4.4 Multiple/Multi-ply Joists

In locations where there is a requirement for increased load carrying capacity e.g. trimmer joists which carry the combined load of the trimmed joists at stair openings it may be necessary to provide multiple joists.

Ensure that the correct joist type, specification and fixing detail is used. Typically, multiple joists are fixed together using metal clips or structural timber screws.

Where the multi-ply trimmer joist is composed of I-joists it may be necessary to install web fillers – check the manufacturer's instructions.

Solid EWP sections may be used rather than joining multiple members but this shall largely be determined by cost, compatibility and availability.

5.4.5 Engineered Wood Products in Floors

Engineered wood products (EWP) are products manufactured from timber strips, chips, strands, particles, veneers and/or fibres which are mechanically bonded together using adhesive or other fixing methods in order to create durable composite materials typically for structural applications. The separate structural systems are expanded upon in the paragraphs below.

EWP is widely used in timber frame construction and potentially offers the following benefits:

- enhanced structural performance
- increased dimensions
- greater spans and scope of application
- ease of installation
- ease of lifting and handling
- improved structural and dimensional consistency
- reduction in moisture content
- reduction of waste/reuse of waste for production.

Glue-Laminated Timber (Glulam)

Cross-Laminated Timber (CLT)

Laminated Veneer Lumber (LVL)

CLT

Cross Laminated Timber is manufactured from timber planks, glued in perpendicular layers under high pressure, either mechanically pressed or in a vacuum bag to form a planar product. In the factory the cross-laminated solid timber panels can be cut to the required shape and size. Further to this routing and holes for services and connections can be easily incorporated within the panels as required.

Glulam

Glued Laminated Timber comprises a number of layers of dimensioned timber bonded together with structural adhesive to increase structural performance. By laminating a number of smaller timber elements a single larger strong structural member is manufactured. GLT is primarily used as post or beam heavy timber framing elements, as well as curved and arched structural shapes. Glulam is used in conjunction with CLT and other solid timber products in building projects ranging in size and type servicing residential and commercial construction alike.

LVL

Laminated Veneer Lumber is a timber composite that comprises laminated wood veneer assembled using adhesives. LVL is manufactured from thin peeled veneers of wood typically 3mm thick, glued with structural adhesive. Generally, the grain runs parallel to the main axis of the member; however veneers may also be included that run perpendicular to the axis of the member (cross-banding).

DLT, Brettstapel

Dowel Laminated Timber is a product that is fabricated from softwood timber lamellas stacked in one plane and connected with hardwood timber dowels at regular centres. This relatively simple method of construction has the potential to utilise lower grade timber which would otherwise be unsuitable for use in construction, to form load-bearing solid timber wall, floor and roof panels. The fixation between the planks is achieved by inserting hardwood dowels with a moisture content lower than the lamellas into regularly spaced pre-drilled holes that run perpendicularly to the lamellas; over time the dowels expand to achieve moisture equilibrium thus 'locking' the lamellas together and creating a structural load-bearing system.

NLT

In Nail Laminated Timber, planar-stacked lamellas or plank products are connected with steel or aluminium shank nails or screws fastening. NLT is suitable for roof and floor elements of limited span but requires racking sheathing to produce lateral resistance if to be used as a wall element and therefore is more suitable for use in low to medium-rise residential and commercial construction.

These and other EWP may be used in conjunction with I-joists and open web joists at locations where heavy loads are to be carried/ transferred e.g. trimmers or posts/ columns or for long unsupported spans. EWP such as LVL is typically used for rim boards at the perimeter of the floor.

Furthermore, solid timber EWP can be used as structural floor panels, erected on site using lifting straps and suitable lifting equipment. Common layout drawings considerations are:

- panel codes indicated clearly
- panel dimensioned clearly
- openings identified with codes

and dimensioned

- EWP system properties indicated in the notes, e.g. depth, strength grade, visual quality, tolerances.

Consult the manufacturer's manual for further information on layout and specification of their components.

5.4.6 Any of the above sent to site in Floor Cassette form

Floor cassettes are an alternative means to installing the floor traditionally - that is installing each floor component individually on site. Floor cassettes are manufactured offsite and installed onsite and are similar in configuration to pre-insulated or closed panel timber frame elements.

It is common practice within the timber frame industry to include engineered timber products such as I-joists or open web joists into the structure as they lend themselves well to this application and by utilising engineered timber products into cassettes structural performance can be enhanced with the potential for large spans.

The frame of the floor cassette may include elements such as rim beams, trimmers, connectors, openings for stair wells and services, noggins/dwangs at perimeters and as supports for partitions, blocking, multiple members etc. where appropriate. All of these should be clearly marked on the layout drawings.

Floor joist layouts that indicate floor cassettes may contain less detail as the main floor construction information will be shown on the manufacturing drawings.

The floor cassette layout should indicate:

- cassette references and locations
- overall cassette dimensions
- cassette orientation
- crash deck reference and location
- joint strip locations where used
- site fixed blockings
- floor beam locations
- cassette connection information
- edge detail references
- references to other drawings.

5.5 Roof layout

Roof layouts provide a plan view of the building, locating all structural components and loose items.

All internal and external supporting walls should be indicated plus other support items including beams. Trussed rafters and loose timbers should be located from fixed positions on the building, such as corners.

Truss rafter and gable ladder reference numbers should be used to identify components. Loose rafters, ceiling joists, purlins, hip and valley beams should be notated with their size and grade.

Diagonal and longitudinal bracing should be clearly indicated on the layout.

Roofs are generally fixed together using an array of straps, clips, anchors and hangers. Each of these should be shown on the layout together with their product description.

Layouts may also include outline truss profiles and sections and details through special or non standard areas.

Notes form an important part of the roof layout drawing as they include references to other drawings, size, laps and fixings of braces, handling, storage and erection notes and restriction notes to site modifications of components.

For example, notes can state that trusses should not be cut, trimmed, notched or drilled without approval from the engineer.

It must be made clear whether setting out dimensions are to centrelines or to the face of trussed rafters and girders.

6. Manufacturing Drawings

6.1 Overview

Drawings are an essential part of any manufacturing process or operation.

It is the responsibility of the Drawing Office to ensure:

- orders are programmed correctly
- manufacturing drawings are accurate, current and correct
- soleplate and site drawings are accurate, current and correct
- that there is effective communication and liaison with the engineer.

6.1.1 Programming Orders

The Drawing Office will receive a copy of the order from the Sales Department from which a provisional delivery date shall be booked and manufacturing/ production informed.

All working drawings will aim to be produced and complete in sufficient time before delivery wherever possible. If this is not the case then the Contracts Department and Production must be informed as soon as possible.

Once the drawings have been received corresponding records and information must be updated accordingly e.g. Job Number, client details etc.

6.1.2 Producing Accurate Manufacturing Drawings

It is the responsibility of the Drawing Office to ensure that the latest set of drawings are provided and re-issued if any amendments are made. Subsequent revisions will supersede any earlier issue or duplicate drawings. It is important to check that the drawings which are being working to are the current and correct set.

In addition, it is the Drawing Office's responsibility to:

- obtain all external and internal joinery sizes
- liaise with the engineer for structural calculations
- foreword any cross-sections and layouts which may be of assistance to the engineer with their calculations
- confirm all deviations from the architect's drawings with the client, in writing if necessary. Then highlight any changes on latest drawings indicating when and with whom they were agreed
- note any alterations that may involve a cost implication such that the appropriate person can advise the client on any possible change in cost
- carefully read the specification, and inform production as soon as possible of any non-stock or bespoke products and materials.

6.1.3 Working Drawings

All working drawings must be precise, accurate and unambiguous. They should carry all relevant information as necessary.

Once the working drawings have been completed a full set should be produced for the supervisor(s) to check.

Activity

What are the designer's guidelines in your company? Find out and attach a copy here for future reference.

Every drawing that is sent to the supervisor(s) must be signed or initialled and dated.

A set should also be sent to the client with 'PRELIMINARY' or equivalent marked on the covering letter for their information.

After checking by the supervisor(s), any changes should be completed before release.

A final set of drawings together with any calculations can now be sent to the in-house distribution list plus those outside including a client's pack.

Every drawing that leaves the Drawing Office should be entered into a formal register.

6.1.4 Production Drawings

Production drawings must be precise, accurate and unambiguous. They should state descriptions, specification and/or references, dimensions, special conditions and exact quantities or amounts of materials to be used, loaded and/or processed.

When working with production drawings it is important to ensure they have been signed/initialled and dated by the person who is responsible for having produced them. This could also include anything produced by external persons or companies who are not directly employed by the timber frame manufacturer.

Typically, production drawings will have a check box or equivalent system of approval/sign-off for each of the relevant people to sign and/or initial to confirm that they have checked, understood and adhered to the drawings. The current date should also be added to the drawings upon providing a signature and/or initials.

The Drawing Office should then check that all the details on the production drawings and corresponding cutting and loading lists are accurate and correct before issuing.

The production drawings should also show if there are any clear CDM regulation warnings, such as unusual construction assembly methods, that will be unfamiliar to the regular installer.

Typically, job completion will be recorded and dated in the contract book or equivalent.

6.2 Designer's guidelines

The designer should be provided with a list of guidelines which indicate the factory's preferences on available timber from stock, preferred overall component sizes, sheathing preferences etc. Drawings should be produced to reflect these guidelines. Where the guidelines can not be met (eg. Special wide panel) a clear note should be added to the drawings focusing attention on this area.

6.3 Roofs

Spandrel panel: structural timber frame panel fabricated to match the profile of the roof in order to form a party or gable wall. Spandrel panels are installed parallel or perpendicular to the roof trusses/ rafters.

Spandrel panels are constructed in a similar manner to wall panels and typically comprise a structural frame, dry lining and membranes as appropriate. A spandrel panel may also be referred to as a gable panel.

Gable ladder: provides a structural connection between roof trusses and spandrel panels. Gable ladders typically protrude beyond the spandrel panel to create eaves and are often used to provide a fixing for soffits and fascia's. Gable ladders comprise a simple timber frame of parallel members which span the roof structure and are connected at regular centres with shorter members such that the finished element resembles a ladder.

6.3.1 Trussed rafters

Modern trussed rafters are individually designed prefabricated structural components made from strength-graded timber members of the same thickness, joined together with punched metal plate connectors. Metal plate connectors would be considered semi-rigid; however, there are different forms of systems that can be formed from stiff glued joints to pinned bolted connections depending on the structural use and available fabrication methods.

Trusses provide a structural framework to support the roof fabric of building, room ceilings and, in some cases, floors. They are generally spaced at 600mm centres or less, replacing the 'common rafter' in a traditional or 'cut' roof, hence the term 'trussed rafter.'

In addition to roof systems, trusses can be formed to act as support to floors, scaffolding systems, bridges and overhead gantries. Truss systems can also be used to provide bracing and stability in both the horizontal and vertical plane in shear wall systems for example. Roof trusses (also referred to as trussed rafters) are the most commonly used method for forming the roof structure.

Designed in almost any shape or size, roof trusses provide a rigid strong framework that will carry the load of a roof to the outside walls and withstand external forces such as wind and snow loads.

A typical roof truss comprises a bottom chord, top chords, webs and punched metal connector plates.

Trusses are typically delivered to site as prefabricated components and installed on to the wall plates at regular centres. The roof structure may be constructed at ground level and craned into position on top of the upper storey walls.

Once the trusses are installed on the wall head lateral stability is provided by the installation of timber lateral bracing. 'Knee' bracing, comprising diagonal

Further reading:

STA. Advice Note. 11 ParaptWall Coping Principles for Structural Timber Frame

http://www.structuraltimber.co.uk/library

Activity

What are the current codes of practice for structural roof design in your area? Write the references here clearly so that you can look back on them easily during design work.

supports of the trusses before the roof is sheeted, are to be avoided in trussed rafter design. This is because they impose unnecessary loads on the trusses if the connections are made with too many nails/screws or they are ineffective if the connection is made with too few nails/screws.

A large variety of truss types are available covering a wide range of roof structures and building types.

All trussed rafter designs should be prepared in full accordance with the relevant British Standard codes of Practice and the relevant Euro Codes. Designs should also meet the requirements of the current statutory Building Regulations.

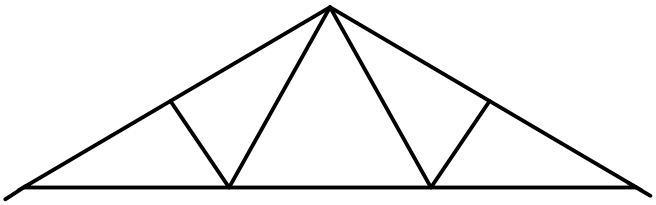
Drawings should be cross referenced to the manhandling regulations of trussed rafters and provide notes for the crane or fork lift: weight/reach/accessibility.

The trussed rafter configuration should indicate the longitudinal bracing. Diagonal wind bracing should be shown on the profiles. Any pre-cut notching/birds-mouths to be fully detailed and dimensioned.

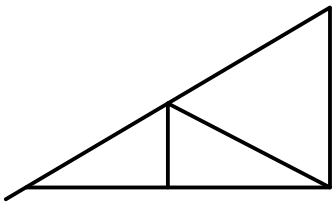
Further information on trussed rafters can be found in the Trussed Rafter Association Handbook.

Some of the most common types of trusses are as follows:

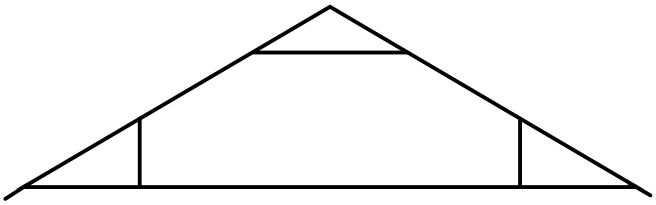
- Fink: the most common truss design
- Queen post: most commonly used for garages
- King post: used for small span applications
- Mono: most commonly used for porches and hip ends
- Raised tie mono: may be used 'back to back' with a parallel chord truss to create high ceilings
- Parallel chord / beam: girder versions (multiple members) are capable of supporting high loads over large spans
- Scissor: used for sloping ceiling designs
- Howe: most commonly used to support other trusses
- Fan: sometimes used when a smaller rafter size is required than a fink can't provide
- Double W: most commonly used for long spans
- Hip: used in hip ends and flat roofs
- Half hip: used to form mono pitch hip ends
- Attic: provides an unobstructed roof space for occupation
- Valley frames: reduced frames to marry one roof into another
- Asymmetric: useful where there



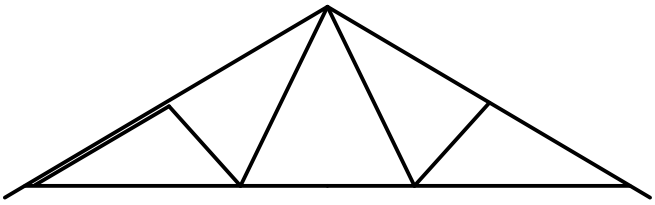
FINK



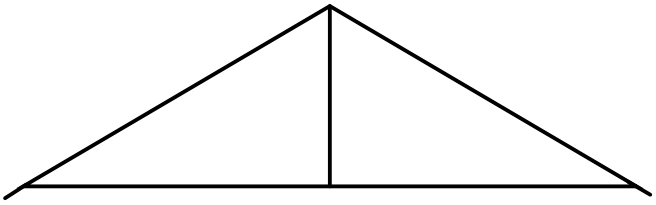
MONO



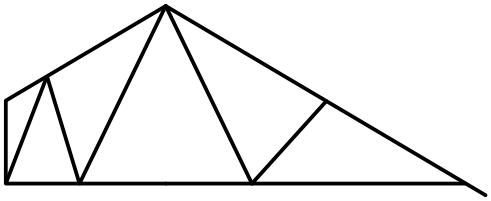
ATTIC FRAME



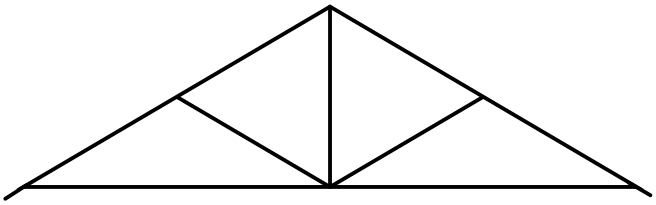
SHORT CANTILEVER



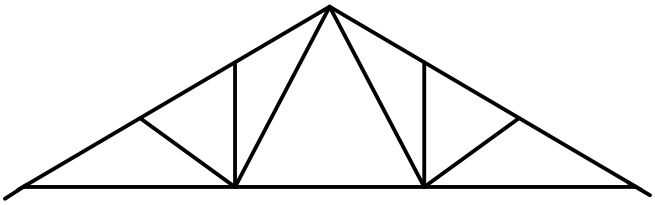
KING POST



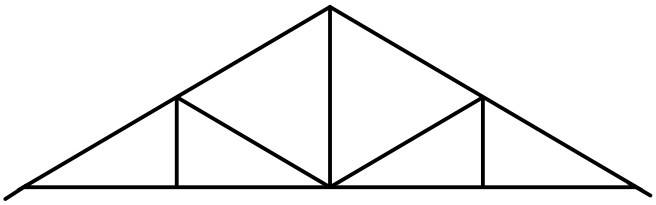
BOBTAIL / STUD END



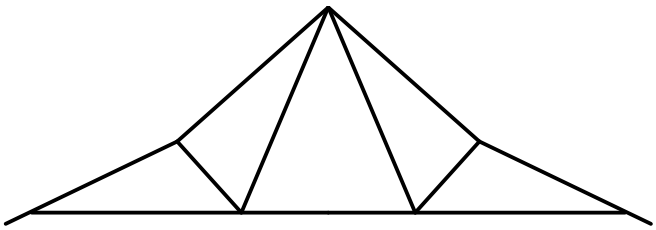
QUEEN POST



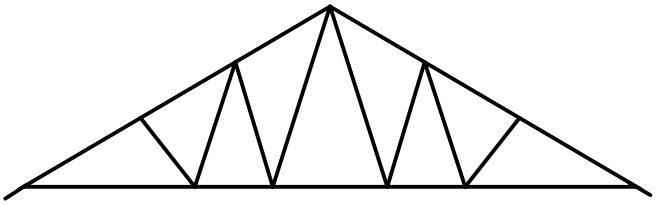
FAN



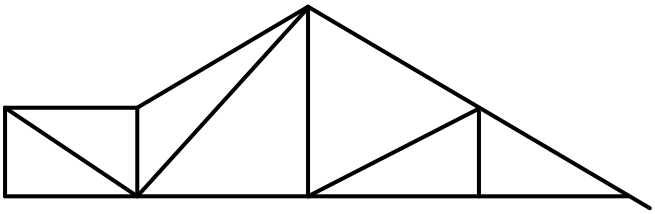
HOWE



PAGODA



DOUBLE W



COMBINATION

is an elevation to match, but the maximum truss height is restricted

- Short cantilever: a relief rafter may be added
- Long cantilever: cantilever webs are usually included
- Bobtail / stub end: truss designed with one end cut back
- Top hat: due to transport height restrictions the truss is supplied as a base truss and a capping frame
- Raised tie / collar: height of the ceiling may be limited due to a combination of span, pitch and roof loading
- Vaulted ceiling: a slightly more flexible alternative design for a raised ceiling
- Bowstring / barrel vault: typically used with metal sheeting systems
- Pagoda: the pitch of the roof becomes steeper
- Stepped ceiling: allows for more light to be available
- Combination: combination of profiles for different design details on either elevation
- Specials: bespoke design to suit a large range of special requirements.

The manufacturing truss profile should show:

- length of the bottom chord (overall length and clear span)
- top and bottom chord live and dead loads
- the horizontal distance from the end of the bottom chord to the bottom edge of the top chord (overhang length)
- the number of trusses required (trusses are most often spaced between 300-600mm centres)
- style/type of cut for the ends of the top chord
- style/type of gable end and associated special trusses if applicable
- roof pitch
- soffit framing design detail
- slope of interior/bottom chord on scissor trusses
- cantilever positions
- truss thickness
- number of ply for girders
- fixings between each truss ply in girders
- support points.

The overall length is the measurement taken from outside of wall-plate to outside of wall-plate. The run determines the quantity of trusses needed.

Most roof-scapes extend past the external walls providing an eaves or verge overhang.

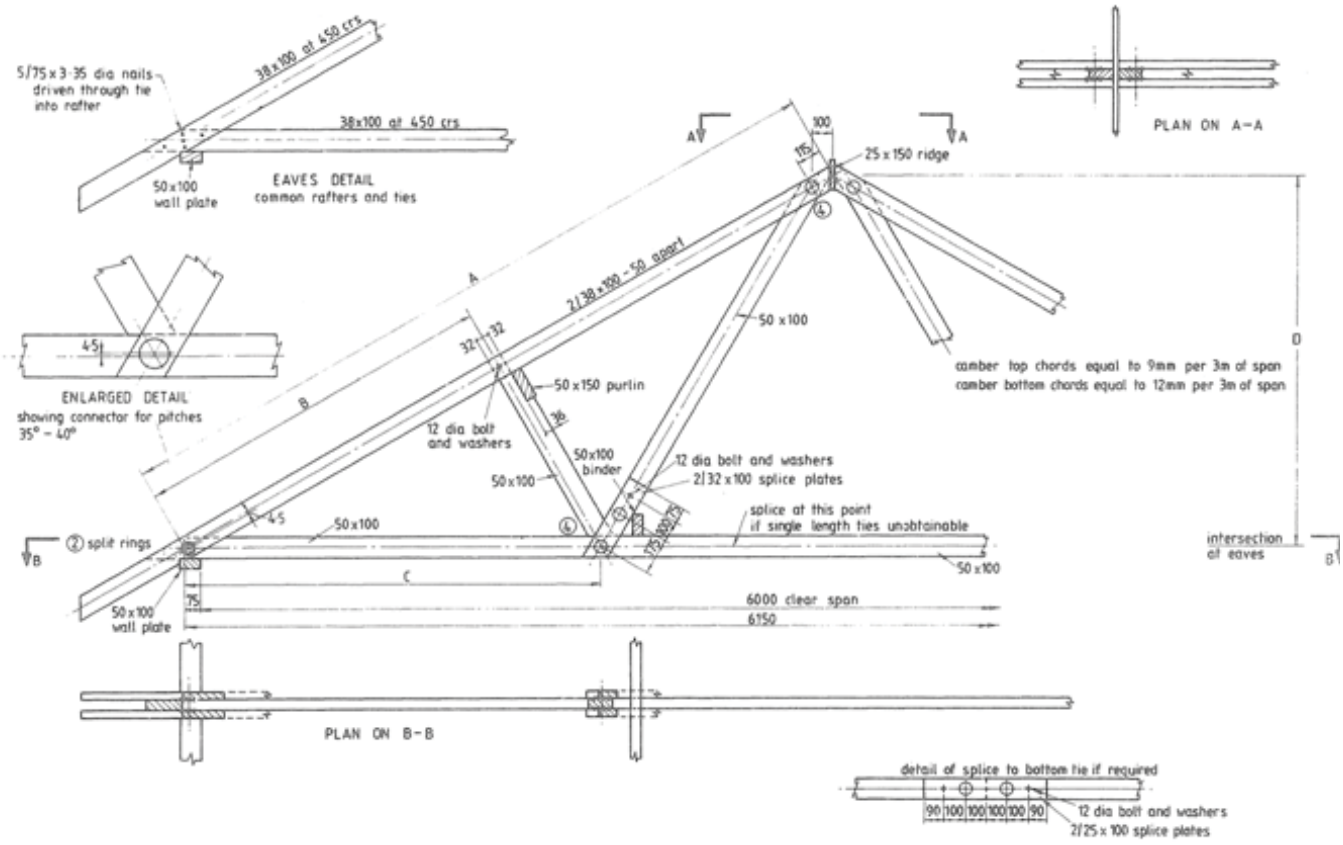
The overall heel height is the vertical distance of the truss above the outside edge of the wall-plate.

A cantilever truss occurs where the bottom chord is extended out over a bearing point.

Cantilever trusses occur when the external supporting wall is inserted for part or all of its length.

6.3.2 Roof Cassettes

Roof cassettes are an alternative means to installing the roof traditionally - that is installing each roof component individually on site. Roof cassettes can be used as an alternative to attic trusses to provide an unobstructed roof space for occupation.
Roof cassettes are similar in construction to floor and wall cassettes and are manufactured offsite and installed onsite. Roof cassettes generally comprise a frame structure (typically rafters, structural sheathing and timber frame connectors) and may have insulation, membranes and internal linings installed in the factory prior to delivery.



Typical engineered timber truss spanning a 6m domestic roof (Arnold Page, 2007, Manual for the design of timber building structures to Eurocode 5, IStructE & TRADA)

6.4 Floors

Timber frame floors are load bearing elements which separate areas within a single occupancy or separate occupancies. They generally comprise timber joists, a structural deck, insulation, floor finish and ceiling finish.

Floor cassette drawings should contain all the information needed by the factory to manufacture the panel.

Drawings should clearly indicate:

- lengths
- joist type (solid or 'I' section)
- cross sectional dimensions
- grade
- spacing
- decking
- hanger positions and type
- noggins (dwangs)
- blockings
- service openings
- fixings
- overall cassette plan dimensions
- headers
- decking set backs and overhangs
- weight of cassette
- orientation markings
- lifting positions.

Cutting information and any special details may also be shown on these drawings.

6.4.1 Intermediate floors

Intermediate floors are those contained within a single occupancy to divide them into compartments. Once installed the intermediate floor provides a working platform from which the upper storeys for each floor are constructed.

Intermediate floors typically comprise a ceiling lining such as plasterboard, installed on the underside of the floor joists, typically solid timber, I-joists or open web joists, with a sub-deck such as OSB, plywood, or particle board, fitted to the top of the joists with a floor finish applied to the top of the sub-deck. Insulation may be fitted between the joists and between the sub-deck and floor finish if appropriate.

6.4.2 Separating floors

Separating floors are those that separate different occupancies or purpose groups or which divide a large building into a number of smaller compartments for the purpose of fire resistance.

Separating floors are typically of similar construction to intermediate floors and typically comprise a ceiling lining such as plasterboard, installed on the underside of the floor joists, typically solid timber, I-joists or open web joists, with insulation fitted between the joists, a sub-deck and floor finish.

6.4.3 Loose joists

Traditionally, timber floors are constructed by cutting and installing solid timber joists, noggins/dwangs, perimeter boards, trimmers, connectors, insulation, sub-deck, floor and ceiling finishes etc. individually on site from material typically delivered in packs and stored on site.

A more modern approach when constructing floors on site using loose materials is to use engineered timber floors, such as I-joist or open web joist floors for example, which are specifically designed and then supplied in organised packs with all joist components pre-cut and the appropriate connectors supplied, alongside a floor layout and installation guidance.

Activity

Find out what the recommended tolerances for floor cassette design are in your company and write them down here for future reference.

6.4.4 Floor cassettes

Floor cassettes are an alternative means to installing the floor traditionally - that is installing each floor component individually on site. Floor cassettes are manufactured offsite and installed onsite and are similar in configuration to pre-insulated or closed panel timber frame elements. Floor cassettes generally comprise a frame structure (typically joists, structural sheathing and timber frame connectors) and may have insulation, membranes and internal (ceiling) linings installed in the factory prior to delivery; otherwise these may be installed on site.

6.5 Wall panels

Wall panel drawings should contain all the information needed by the factory to manufacture the panel.

Wall panel elevations should indicate:

- overall panel dimensions
- opening sizes and positions
- stud size and grade
- stud locations
- cripple studs and lintels
- sheathing type and thickness
- sheathing nailing
- panel junction studs
- corner junction studs
- noggins (dwangs)
- factory fixed rails

6.5.1 Wall panels types and purpose

Timber frame wall panels are typically floor to ceiling height panels comprising a structural frame, sheathing material and insulating material. Wall panels may be load-bearing or non-load-bearing. The extent of factory prefabrication and panel type and specification varies, typically open panel, pre-insulated or closed panels, SIPs or solid timber panels are specified.

Sub assemblies: typically, any sub-assemblies or sub-components that are to be incorporated into the panel should be fabricated first in accordance with the relevant

drawings and specification. These will differ depending on the panel design and features though, among others, might include elements such as lintels and multiple/cripple studs for example.

Open panels: single sheathed panel comprising a structural frame, typically studs at regular centres affixed to top and bottom rails, typically of the same material and section size, and sheathed on one side with a structural sheathing board and a breather membrane applied as appropriate, although the breather membrane may be fitted onsite. Insulation, internal linings, windows, doors, services, other membranes etc. are typically fitted on site once the open panels have been installed

Pre-insulated (closed) panel: double sheathed panel comprising a structural frame, typically studs at regular centres affixed to rails, typically of the same material and section size, filled with insulation and sheathed on both sides with structural sheathing boards and membranes applied as appropriate. Pre-insulated panels may feature elements such as internal linings, joinery components, windows, doors, services, membranes, external cladding etc. Pre-insulated or closed panels may also be referred to as wall cassettes.

Structural Insulated Panels (SIPs): formed using a core of rigid insulation adhesively bonded between two sheathing elements. The rigid foam is commonly expanded or extruded polystyrene or urethane but can be other products. Structural sheathing boards are adhesively bonded to a rigid foam core. Rebates are left in the core material to accommodate connection details, typically splice connections. Openings should be designed for during construction with panels fabricated to allow a frame to be incorporated into the panels where necessary.

Solid timber panel: may be of CLT, NLT or DLT construction forming a solid panel product by laminating timber components. Door and window openings may be formed in the panels. Elements may be installed/affixed to the panels in the factory though this will be largely dependent upon the design and manufacture processes.

6.5.2 External wall panels

At their core external timber frame walls are essentially of similar construction to internal timber frame walls, comprising at least a structural timber frame, structural sheathing material, insulating material and appropriate membranes. External wall panels typically form the internal leaf of the external wall and are load-bearing, that is they carry and transfer load. External walls typically comprise timber frame panels (internal leaf) and an external skin or leaf, most commonly masonry such as brick or block. The timber frame panel and external leaf are typically separated with a cavity and the external leaf fixed to the internal leaf using wall ties at regular vertical and horizontal centres. Depending on the type of construction the external leaf may be supported independently by the foundations or attached to and supported by the timber frame.

External timber frame wall panels are capable of providing better thermal performance than traditional masonry walls of comparable thickness. Timber frame panels may also be used as an external leaf. Careful design consideration must be given to load carrying capacity, durability, fire resistance, air tightness, condensation control and water tightness, among others. Where this is the case an external render or cladding system is typically applied

Annotations and dimensions must be very clearly shown on the drawings to enable the crew on site to erect the timber kit and integrate other components with the timber frame.

Structural Insulated Panel (SIP)

Services integration in roof space.

to the external face of the panel to provide durability, withstand weathering and provide the desired architectural appearance.

6.5.3 Internal Load-bearing and Non-Load-bearing Wall Panels

Load-bearing and non-load-bearing internal walls are typically of similar construction to one another though the elements of a load-bearing wall must provide enhanced load carrying capacity. This may be achieved through use of larger elements, stronger/stiffer elements, reducing centre to centre distances of elements, enhanced fixing details or fixing elements together to create multiple-ply elements, among others.

Load-bearing walls: must be designed and constructed in such a manner that they effectively and safely support and transfer loads to the foundations without undue movement. Upper storey, floor, roof and wind loads must be taken in to consideration.

Non-load-bearing walls: separate areas of a building and neither carry nor transfer loads.

Partitions: separate two or more areas of a building of the same occupation. Internal walls may be load-bearing or non-load-bearing. Typically, an internal wall in a timber frame dwelling will be of single leaf construction and comprise timber studs sheathed and/or lined on both faces with a suitable insulation material between the stud bays.

Separating/party walls: party walls, or separating walls, separate dwellings or areas of different purpose groups or occupation from one another. Party walls may also be used to divide buildings with large floor areas into smaller compartments to provide greater safety in the event of fire. Service penetrations in party walls should be avoided or kept to a minimum.

Party walls typically comprise two independent frames with a cavity between them. The frames are typically disconnected unless party wall straps are specified to provide restraint. There are limits on party wall straps and the Robust Details should be followed in their specification.

Examples of types of buildings with party walls are semi-detached houses, terraced houses, or flats.

6.6 Steel frames / columns, beams

Steelwork drawings should contain all the information needed by the steel fabricator to manufacture the individual members and their connections.

They should include:

- overall lengths
- steel cross section dimensions
- steelwork weight per metre
- overall weight
- hole sizes and positions
- notch sizes and positions
- size and number of bolts
- size, type and location of welds
- any special steel grade
- surface protective treatment.

6.6.1 Shot firing connections to steel

It may be necessary to shot fire timber to steel, a common example being fixing a timber runner, web packer or ledger to a steel section to fix joist hangers or to steel sections for example.

Shot firing uses high tensile nails fired from a gun using cartridges through the timber and into the steel to secure both together.

Shot firing equipment can be potentially very dangerous because they are essentially guns and should only be used by properly training personnel who have a licence to operate them.

It is important to ensure that fasteners of the correct specification and length are used based upon the thickness and type of material to be fastened. It is also important to consider the Construction Design and Management (CDM) Regulation 2015.

Activity

Investigate and describe the terms 'scissor truss', 'web stiffeners' and 'backer blocks'

7. Cutting

7.1 Saw types

A saw comprises a blade, wire or chain with a toothed edge for cutting material, most commonly timber and timber-based materials.

There are many different types of saws used for timber frame manufacture - they are most commonly designed for a particular purpose but may serve a number of purposes. Saws may be manual or mechanically powered and may be fixed or hand-held. Saws may be mounted or an integral part of a CNC machine.

Some examples of saws that are commonly used for timber frame manufacture are given below:

- up-cut saw
- table saw
- panel saw
- wall saw
- chop saw
- radial arm saw
- circular saw
- jigsaw
- reciprocating saw
- band saw
- chain saw
- CNC saw
- hand saw.

7.2 Cutting Lists

A cutting list is a detailed list/schedule which specifies the material that is to be selected and how it is to be processed.

Careful consideration and effort must be made when producing cutting lists to ensure that material is used economically such that any waste is minimised or reused wherever possible.

Cutting lists must be precise, accurate and unambiguous. They should state descriptions, specifications and/or references, dimensions, special conditions and exact quantities or amounts of materials to be processed. It may be necessary to provide drawings or diagrams to effectively communicate information.

As is the case with production drawings, when working with cutting lists it is important to ensure they have been signed/initialled and dated by the person who is responsible for having produced them. This could also include anything produced by external people or companies who are not directly employed by the timber frame manufacturer.

It is common for cutting lists to have a check box or equivalent system of approval/sign-off for each of the relevant people to sign and/or initial to confirm that they have checked, understood and adhered to the list. The current date should also be added to the cutting list upon providing a signature and/or initials.

Cutting lists may be generated by a computer system from the designed timber frame building. The project is separated into fabricated items and loose components. The computer system then collates all the component information into groups of items (for example panels

Computer Aided Manufacturing (CAM) can aid organise and process materials in such a manner that the production of waste is minimised.

of each level) and outputs the cutting list to present all the plates, studs, lintels, sheathing etc. in a form that manufacturers can select from their timber stock.

The data from the computer generated cutting files also has the ability to be electronically transferred to computer aided manufacture (CAM) that can cut components accordingly.

7.3 Hand cutting lists

These are generally schedules of timber items taken from hand prepared drawings and panel elevations etc, i.e.: a non-computer generated drawing package for the timber frame. They should list all items showing lengths, cross section dimensions, grades and angle cuts.

7.4 Computer generated paper and electronic cutting (CAD/CAM)

These are timber schedules / material take-off lists that are generated by a computer system from the designed timber frame building. The project is split down into fabricated items and loose components. The computer system then collates all the component information into groups of items (for example panels of each level) and outputs the cutting list to present all the plates, studs, lintels, sheathing etc in a form that manufacturers can select from their timber stock.

The data from the computer generated cutting files also has the ability to be electronically transferred to Computer Automated Machines (CAM) that can cut and build wall and floor components on the shop floor.

7.4.1 Optimising Material

Material should be selected, organised and processed in such a manner that the production of waste is minimised.

Although they may vary each factory shall have means of optimising saws and materials. It is important for the operator to become familiar with these methods and to adhere to them.

Careful consideration must be given as to how best to select and cut material to produce only the smallest offcuts or to eliminate offcuts entirely. Unnecessarily long or large sections of material should not be selected if materials of a shorter length or size are available. If producing a long or large off-cut is unavoidable consideration should be given as to how the off-cut could be used elsewhere, perhaps as part of a separate operation which required smaller sections of material.

Care should also be taken to ensure that material is cut in accordance with the cutting list and that dimensions are checked and accurately measured prior to cutting to ensure that no waste is produced as a result of error.

Precision is also key. It is important to remember that the thickness of the saw blade, or 'saw draft' has a cumulative effect and will contribute to the amount of pieces that can be cut from one parent piece.

Where the same operation is to be repeated multiple times e.g. a number of lengths of the same material are to be cut to the same length, measuring, marking and cutting each piece individually is needlessly time consuming and inconsistent. In such cases methods to optimise material and time and to ensure consistency should be implemented. For example:

when using a radial arm saw to cut lengths of timber a stop may be fixed in the appropriate position and the end of the timber moved along the bench to abut the stop before drawing the saw across its depth then repeating.

When using a table saw to cut panel material the fence may be fixed in the appropriate position and the edge of the panel ran along the fence and through the saw.

Again, when cutting multiple pieces, care should be taken to ensure that the correct size of material is selected and used to ensure the optimum number of pieces and minimal waste is produced from each parent piece.

Effectively optimising material becomes more challenging where material is to be cut to irregular shapes or at angles for instance. It is often helpful if drawings are provided alongside cutting lists for more complex cutting operations.

Cutting accurately and considerately to reduce the number of offcuts or to eliminate them altogether wherever possible not only minimises waste but also minimises the work that both the saw and operator have to do. In addition to optimising materials and reducing waste this also results in increased productivity.

Automated machines offer high precision and are resource efficient. Typically, a CNC machine's software will include a function whereby cutting and loading lists will be automatically generated in accordance with the design, using the optimum amount of material. The correct batch of material will be selected, loaded, fed into, then cut by the machine in accordance with the programme.

It is important to always bear in mind:

- select the appropriate saw for the job. Each saw type has a specific purpose to which it is best suited
- select and process materials to ensure that waste is minimised
- how best to cut material to produce the maximum number of pieces and minimise waste
- how offcuts from one process may be used for another
- the thickness of the saw draft
- use aids such as stops and fences wherever possible.

7.5 Batching Material

Materials should be selected and organised into bundles, packs or 'batches' corresponding with materials necessary to produce one or more components or by materials of similar dimensions and/or characteristics for a specific purpose in accordance with the corresponding specification and/or cutting list.

Picking then batching materials as and when they are required ensures that only the correct quantity and type of material is processed as appropriate.

During batching, no matter what saw is used, materials must be organised in a manner that ensures there are as few offcuts as possible and that any offcuts are of minimal size.

It is important to remember that materials should be arranged in the order that they are to be used at the next stage such that the first items stacked are the last items that are required at the next stage – first on, last off. This saves time and unnecessary double-handling.

Batches should be referenced to ensure that it is clear what the material is to be used for and how it is to be processed. Any references on individual pieces should be marked on 'exposed' faces to

Picking then batching materials as and when they are required ensures that only the correct quantity and type of material is processed as appropriate.

ensure that they can be read when the material is arranged in packs.

Personnel should be mindful of ensuring that an adequate quantity of material is available for the specific purpose whilst also bearing in mind that waste must be kept to a minimum.

It is important for operators to familiarise themselves with how batching is organised and managed in the factory in which they work and to understand the reasons for batching materials.

7.6 Reducing Waste and Damage to Materials

Factory processes and site operations should be organised and managed to ensure that waste and damage to material is kept to a minimum.

Materials should be selected (purchased or taken from stock) and processed in such a manner that only sufficient quantities of material of the correct specification as necessary to service given schedules and meet current production requirements are used as and when they are required.

Cutting lists should be prepared taking into consideration the quantity, specification and dimensions of the raw materials that are to be used and the quantity and dimensions of offcuts produced to ensure that waste is minimised or reused elsewhere. Waste timber may even be burned to provide heating for the factory and/or offices.

Any waste that cannot be reused in the factory should be responsibly disposed of in accordance with the company's environmental policy or similar.

Materials should be stored in the appropriate location, transferred from one location to another only when appropriate to do so and all circulation for personnel and vehicles must be kept clear in accordance with standard operating procedures.

Activity

List out the main headings from a cutting list produced in your office.

8. Load Transference

8.1 Overview

By definition, timber frame construction is a method of construction whereby timber members and sheathing are combined to form a structural frame which effectively transmits horizontal and vertical loads (e.g. those applied by self-weight and wind) to the foundations. Therefore, understanding the load types and paths within timber frame buildings is crucial for safe structural design. The aim of structural design is to provide stability to the building. The following sections discuss the most commonly designed for vertical and horizontal loads.

The designer should be familiar with the 'dead' loadings that are generated by the building and the 'live loads' generated by its occupants and external forces. These travel through the building structure, down to the foundations from the roof, floors, and walls.

Loads are measured in force per area, most often kN/m².

8.2 Vertical loads

8.2.1 Dead loads

Dead loads are the loads of the building itself, that is the structural timber frame, the roof, wall and floor structures, the cladding, windows, doors, roof tiles, etc. Firstly, the building must be structurally stable under the forces of gravity acting from the listed components. In general, the dead loads remain constant throughout the building's use.

8.2.2 Live loads

Live loads change throughout the building's useful life, as they reflect the changing forces imposed by the building occupants, their furniture, etc. Live loads are calculated using established estimate loads per room and building type. For example, the live loads in a hotel building will be different from those in a school building or a house.

8.2.3 Roof loads

Roof loads are caused by the additional vertical forces acting on the roof during and after snowfall. The weight of snow accumulates on the roof structure and imposes additional live loads on the building. The structural design must accommodate for these loads to ensure the structural stability of the building in the case of high snowfall. The shape of the roof, the roof surface and the building surroundings all impact design for snow loads.

8.3 Horizontal loads

8.3.1 Wind / racking

The rapid movement of air causes wind forces, which in turn cause areas with positive pressure on the wind-swept surface of the building and negative pressure on the opposite building surface.

The walls carry this horizontal wind load down to ground level utilising their racking resistance. At each level sufficient fastenings are required to transmit the accumulating load to the floor or foundations below.

The structural engineer's marked up layout shows racking walls, special nailing specifications, and roof/floor-wall connection requirements. These must all be accounted for in the timber frame designs and manufacturing information.

8.3.2 Uplift

In the case of extreme horizontal wind loads the roof of the building may be uplifted from the structure, therefore causing great damage and risk to people's lives.

Protrusions, such as roof overhangs can create high wind load areas in the case of wind forces acting with high velocity.

Truss clips are the normal method of restraining roof members but higher uplift forces may require special detailing.

8.4 Disproportionate collapse

The timber frame designer should be familiar with any special requirements to resist disproportionate collapse. Disproportionate collapse is a structural building failure caused by an external force, in which some areas of the building are more damaged than others.

Methods by which progressive collapse may occur in a timber building are the following:

- loss of equilibrium of part or all of the structure
- failure by excessive deformation
- failure as a mechanism
- failure due to rupture
- failure due to loss of stability.

In timber kit buildings, platform construction is usually sufficient to prevent disproportionate collapse.

8.5 Load drawings

All of the above structural information must be clearly identified in the timber frame design information packages produced for manufacturing, site erection, and structural checking.

Clearly identified information on general layout drawings can alleviate many of the questions that may be raised by checking supervisory staff and regulatory authorities etc.

Using the engineer's structural mark up information the drawings and details should be prepared by the designer to show support for all these loads. Particular attention should be paid to larger point loads, making sure all stud posts align down through the timber frame from roof level to foundation. Floor zones should be fully blocked under these posts.

8.6 Loading Lists

A loading list is a detailed list which specifies the material that is to be loaded.

Loading lists must be precise, accurate and unambiguous. They should state descriptions, specifications and/or references, dimensions, special conditions and exact quantities or amounts of materials to be loaded.

As is the case with production drawings and cutting lists, when working with loading lists it is important to ensure they have been signed/initialled and dated by

the person who is responsible for having produced them. This could also include anything produced by external people or companies who are not directly employed by the timber frame manufacturer.

It is common for loading lists to have a check box or equivalent system of approval/sign-off for each of the relevant people to sign and/or initial to confirm that they have checked, understood and adhered to the list. The current date should be added to the loading list along signature/initials.

Activity
What conditions contribute to uplift forces on a roof?

Activity
Describe how a trussed girder load on a 2 storey house is transmitted to the ground floor slab level.

Activity
Describe why internal racking walls may be required in a building.

9. Drawing Standards

9.1 Overview

Manufacturing/Production drawings can be defined as 'drawn information, prepared by the design team for use by the manufacturing and construction teams, the main purpose of which is to define the size, shape, and location of the structure's parts, and the overall construction of the building.'

The preparation of the drawings may be by the manufacturer's design office or can involve external consultant designers. Under traditional forms of contract most of the drawing process will be pre-contract, but with forms of contract that involve design by the manufacturer some may be post-contract.

Manufacturing and production drawings should complement the contract specification, which can be defined as 'written information prepared by the estimating and design teams for use by the manufacturing and construction teams, the main purpose of which is to define the components to be used, the quality of work, any performance specification, and the sequence under which the work is to be carried out.'

The term 'drawing' should be used to refer to a physical sheet of paper with graphics, text and a title block. The equivalent in Computer Aided Design (CAD) terms is the 'drawing file,' which is produced from an assembly of model files and drawing templates with notes and dimensions. Only when the 'drawing file' is plotted on paper to a particular scale is the traditional drawing produced.

Schedules of components and material cutting lists are often included in sets of manufacturing/production drawings.

In addition to CAD technology, you may work with **Building Information Modelling (BIM),** in which drawings are produced from a single 3D model with information attached to each building component. With BIM different drawings are updated automatically and simultaneously with changes in the model. Furthermore, schedules of components can be generated and updated automatically.

9.2 Qualities of good manufacturing drawings

Most importantly, manufacturing drawings have to be clear, correct and easy to read. Dimensions and labels are critical as scaling from the drawings should be avoided. Dimensions should be given in vertical, horizontal and diagonal directions for clarity. Good design drawings are updated regularly and these updates are included in the drawings' title boxes with the initials of the person who did each update.

9.3 Technical coordination

Coordination is required between all members of the external design team e.g. client, architect, foundation engineer, service consultants.

Timber frame design is a collaborative process.

Components should have consistent names when shown on different drawings. 'Clashes', i.e. different components occurring in the same or overlapping position, or encroaching on the clearances required by others, must be avoided. Floor joist and roof truss layouts should be produced to avoid building services.

Ducts and other service routes must be of adequate size, and must allow for suitable access for installation, maintenance, repair, alteration and possibly eventual replacement of the services.

Small projects may be prepared by one designer. This reduces the possibility of errors and discrepancies as the designer will have a thorough knowledge of the complete building. On a large project, with several designers & technicians, and perhaps other design companies working remotely, co-ordination is a key issue. Drawings produced by one designer should be passed to the other members of the design team to ensure accuracy, consistency and correct integration of components.

Every area or component of the structure should be clearly located in all three dimensions, either by its relationship with grid lines and a height datum, or by figured dimensions to other parts of the structure. Dimensions should correspond with and be consistent with other associated dimensions.

9.3.1 Liaison with the engineer

The Drawing Office should communicate effectively with the engineer throughout.

Typically, the following drawings and information would be used for communicating information when liaising with the engineer:

- site plan
- soleplate drawings
- floor plans
- cross sections
- elevations
- wall thickness
- joist types/system
- roof construction
- tile weight
- any other relevant information.

9.4 Drawing types and their content

The content of drawings should be correct, complete and easy to understand. Disjointed information can easily lead to parts of it being overlooked.

As far as is practical and appropriate duplication of drawn information should be avoided and this should help reduce the chance of discrepancies arising in the course of revision. Both duplication and disjointed information can be reduced by consistent use of the following 'standard' types of drawing.

9.4.1 General arrangement drawings

These should allow the user to:

- gain an understanding of the layout and make-up of the manufacture and construction of the building;
- determine setting out dimensions;
- locate and identify the areas and parts of the building, e.g. rooms, levels, structural frame components; structural floor and roof components;
- pick up references to more specific information, particularly to manufacturing drawings.

9.4.2 Layout drawings

These should allow the user to:

- understand how parts of the building relate to each other and how they are constructed
- pick up references to more specific information, particularly to the specification and any additional component drawings.

9.4.3 Component drawings

These should give all the dedicated information required for the manufacture of specific components.

9.4.4 Annotation

The manufacturing / production / construction drawings generally give information about size, shape and location of the various parts of the building's structure. Each component should be clearly identified to ensure they are correctly located.

Drawing titles should help to identify the content of drawings. Notes may also be necessary to add further information. E.g. 'this drawing must be read in conjunction with section 3456/A/1.'

Some items of annotation are simply to clarify the drawing name and the location of the information, e.g. 'Soleplate Layout', or 'Ground Floor Plan.' The purpose of many notes though is to identify and cross refer to related information given elsewhere, e.g:

- references to other drawings/ details
- references to specification documents.

Written information on drawings should be appropriate to that drawing. Standard notes should be checked to ensure that all items are applicable to the project and that any unnecessary information is removed. Where revisions are carried out to the drawing, the notes should also be updated.

9.4.5 References to other drawings

Particular drawing references should be used rather than references to 'see engineer's drawings' or 'to be read in conjunction with all relevant drawings.'

Ease of use and confidence in the information is likely to be gained if any referencing displays a straight forward pattern of links between the drawings in a set. Almost all references should lead from general arrangement drawings to manufacturing drawings and onto component drawings. The locations of larger scale details should be clearly shown by section lines or circles on the general arrangement drawings.

9.4.6 References to specifications

It is impractical to give full specification information as notes on the drawings. Abbreviated specification information given on the drawings may conflict with the main document if copied incorrectly or may lead the contractor to act without referring back to the full specification.

Therefore specification information is best given only in the specification document. Drawings should identify the different kinds and items of work, but not specify them. This should be by using a few select words with, as necessary, a reference to the relevant item in the specification.

Where a specification is used, the notes should be minimal, yet sufficient. For example in the case of floor joists:

- floor joists
- C24 grade softwood
- headers treated
- 44 x 194mm

Details of a closed panel at the CCG OSM factory.

- 400mm centres
- item 6.08 in the Specification Document.

The appropriate annotation may therefore be **'44x194 mm C24 treated joists at 400 mm cts. See item 6.08'.** The rest of the specification information such as type of treatment and type and grade of softwood can be found by following up the reference to the specification.

9.5 Drawing arrangement

On larger projects the arrangement of a set of drawings will have a major impact on the people using them in helping them to follow the drawings and assisting in the retrieval of information. Generally, the larger and more complex the project, the more important is the arrangement of the manufacturing/production drawings. On smaller projects arrangement is less important, particularly if the titles of the drawings are concise but specific, and there is good cross-referencing from general arrangement drawings through to details.

The key to good arrangement is the dividing of the whole set of manufacturing/production drawings into clearly defined groups, with a total make-up that is simple and easy to follow. It is important to remember that although the drawings may have been produced electronically, for most of the time they will be stored and used on site in paper form. Whatever arrangement is adopted, it should be set out clearly on the Drawing Issue Register.

Grouping of the drawings could be by any one or more of the following:

9.5.1 Grouping by type of information

This is well established in design offices, the main categories being:

- General Arrangement drawings (plans, sections and elevations)
- Construction drawings (details of component layouts and junctions between them)
- Component details (actual manufacturing details of the components themselves, e.g. panel elevations; truss profiles).

You should be able to follow through the different types of information easily, starting with the General Arrangement drawings, which as necessary will refer to the supporting Manufacturing and Construction drawings. Component drawings will need to be produced to specifically detail all items shown on the Construction drawings.

The General Arrangement drawings are often produced on large sheets of paper (A1 or A2), and the Manufacturing and Component drawings on a smaller size (A3 or A4).

9.5.2 Grouping by parts of the building

On larger projects the number of drawings in the groupings described above can be considerable, and sub-division of some groups may be of benefit. The common factor between producers and users of drawings is the building itself, so sub-grouping drawings by the parts of the building they detail is an effective method.

However, if a separate drawing is produced for every part of a building, the result can be a mass of disjointed information. This can be reduced by:

- classifying details by their main parts

- levels
- plot numbers
- detail code references.

Where the General Arrangement and/or Manufacturing drawings will benefit from division into sub-groups, these can be chosen to suit the main specialist works included in the project. Examples include floor cassettes, steel goal-posts, roof trusses, etc.

Specialist sub-contractors should be required to produce their detailed design drawings so that they work with and integrate with the timber frame drawings in the overall set of project details.

9.5.3 Grouping by location

The plans for some projects may not fit at a suitable scale onto one drawing sheet. The site or building should then be split into phases, areas or blocks.

Where possible the breaks between these parts should occur at natural construction junctions where little additional information is needed. The effect of this on the arrangement of the project drawings will depend on the nature of the design:

- if the areas or blocks are completely independent and have different designs, each can be considered as if it were a separate project and sub-divided into other groups.
- if the layout of the areas or blocks differ but their detail design is similar, some other grouping (e.g. General Arrangement, Construction, Component) should set the drawing structure. The areas or blocks can then form clear sub-groups of, for example, the General Arrangement drawings only.
- if the layouts of the areas or blocks are the same, creating 'standard' location drawings can avoid unnecessary repetition. An example of this is drawings for house types.

9.5.4 Keeping it simple

The various types of grouping described above should be used sensibly, avoiding over-complication. It is important to make the overall arrangement simple and easy to follow and understand.

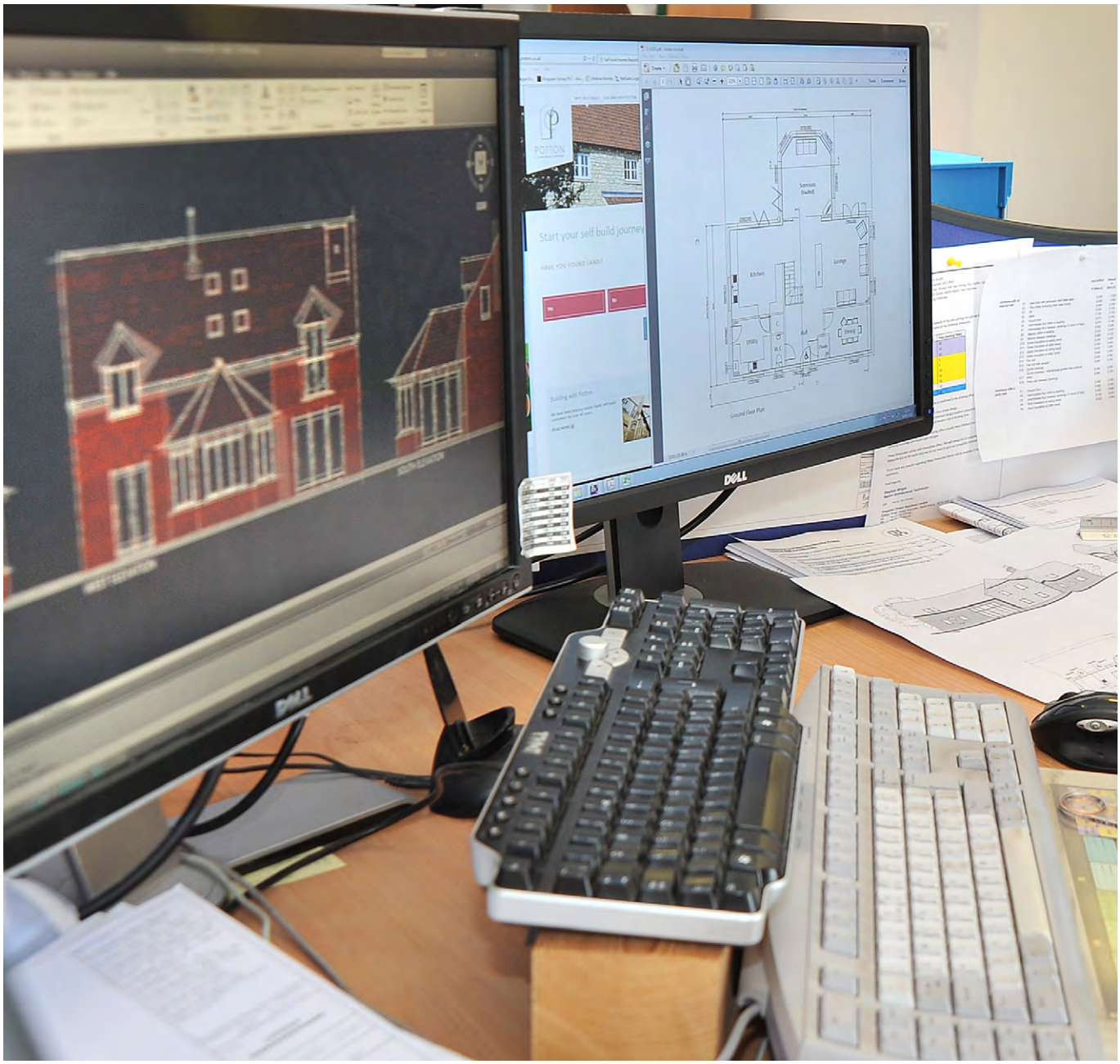
9.6 CAD standards

CAD standards are specified by BS 1192-5:1998 'Construction drawing practice. Guide for structuring and exchange of CAD data' or may be established by a company to assist in the use and exchange of data contained within the drawing files.

Typically, CAD standards cover the naming and use of layers and line types, the appearance of text and dimensions and the title block format:

- Fonts – style should be constant with the size dependent on the levels of information indicated and should always be readable at the proposed printed scale
- Lines – the use of appropriate widths, colours and line types assist in the clear presentation of drawings and are used in the conjunction with the drawing layers
- Layers – incorporating layers enables the designer to name and separate objects within a drawing
- File names – drawing file names, incorporating the drawing number, should assist in the organizing and management of the project during the design stage and also enable straight forward archiving and retrieval of the information when necessary.

Typically, CAD standards cover the naming and use of layers and line types, the appearance of text and dimensions and the title block format.



Activity

What is the current national CAD standard and what is the CAD standard applied in your company, in terms of fonts, lines, layers, file names, sheet sizes , scale and numbering of titles?

9.6.1 Sheet sizes

To enable handling, reference and storage it is helpful if drawing sheets within any group are of the same size. The use of more than one sheet size for a project set can be suitable because it helps identify drawings of different groups, e.g. A1 for General Arrangement drawings, A2 for Construction drawings and A2 & A3 for Manufacturing drawings. Standard sizes are:

- **A0:** an inconvenient size for handling and storing, but may be useful for showing large areas such as block plans at a reasonable scale. It can be used for a one-off drawing in a set of otherwise smaller sheets.
- **A1:** this is a convenient size for handling and storing. Large enough to accept most General Arrangement drawings, but sub-division of building areas may be necessary. Suitable for Construction and Manufacturing drawings on larger projects.
- **A2:** suitable for Manufacturing and Detail drawings, allowing flexibility in the choice of scales. This size may be large enough for General Arrangement and Construction drawings for some projects.
- **A3:** suitable for areas of a building, or individual house/flat types. Can be easily photocopied and can be bound into book form. Also, can easily be handled and referred to in the factory and onsite.
- **A4:** suitable for specific component drawings. Easily photocopied and bound into book form but sometimes too small to accommodate all details on a project. Downside can be large amount of disjointed information occurring, requiring reference to lots of drawing sheets for information about one part of the building.

9.6.2 Scale

Sheet sizes and scales are inter-related, and can effect the arrangement of the set of manufacturing / production and construction drawings. Typical scales are 1:200, 1:100, 1:50, 1:5, progressing from less to more detail shown on the drawings. The choice of scales should:

- allow clear understanding of the information, e.g. A 1:100 plan may be acceptable for general layout and providing references to other drawings, but for setting out timber frame panels etc, it would be better shown at 1:50.
- allow easy comparison of information, e.g. General Arrangement plans showing different areas should be to the

same scale.

- allow the user to refer directly from General Arrangement drawings to Construction drawings.
- give preference to the requirement for clarity of information rather than, for example, wishing to keep all sheet sizes the same.

9.6.3 Numbering

The purpose of numbering is to give each drawing a unique place within the set. This allows the correct flow of drawing information together with practical filing and retrieval. Drawing numbers usually fall into three parts:

- a project identification number - this is useful for office purposes, but is sometimes ignored for communications within the project
- a group identifier reference, e.g. GA for General Arrangement drawing
- a sequential number giving unique identification within the group identifier reference, e.g. GA/01, GA/02, GA/03 etc.

The most commonly used grouping is the type of information, i.e. General Arrangement, Construction and Component. On larger projects where 'part of building' identification is required further sub-identification is necessary, i.e. A/GA/01, A/GA/02.

Identification numbers can be useful if used selectively, but if more than one or two are used in any combination the drawing numbers will become too complicated. Sequential numbers should follow any identification numbers, and will most commonly be of two or three digits.

As with the arrangement of drawings the main principle should be simplicity and clarity. Numbers should be both informative and easy to understand. To help this different 'parts' within drawing numbers should be separated visually, e.g.:

- GA/101 (General Arrangement/ sequential number).
- A/GA/101 (Area of building/ general arrangement/sequential number).

9.6.4 Titles (title blocks)

Even when sets of manufacturing/ construction drawings are well arranged and numbered, finding particular information quickly is, to a certain extent, dependant on good, accurate titling. Titling should:

- achieve a balance between briefness and identification of the contents
- use consistent terminology, e.g. 'area' or 'block'; 'plan' or 'layout'.

Drawing titles should normally be sufficient to answer the following questions:

- where does the information apply, e.g. Block B - First Floor
- what type of information does the drawing contain, e.g. Panel Layout
- what type of drawing is it, e.g. plan, section, elevation, details, etc.

9.7 Drawing issues and revisions

Contractors are used to managing projects using paper based information, although issuing drawings in a suitable electronic format can be very useful as they are more easily distributed.

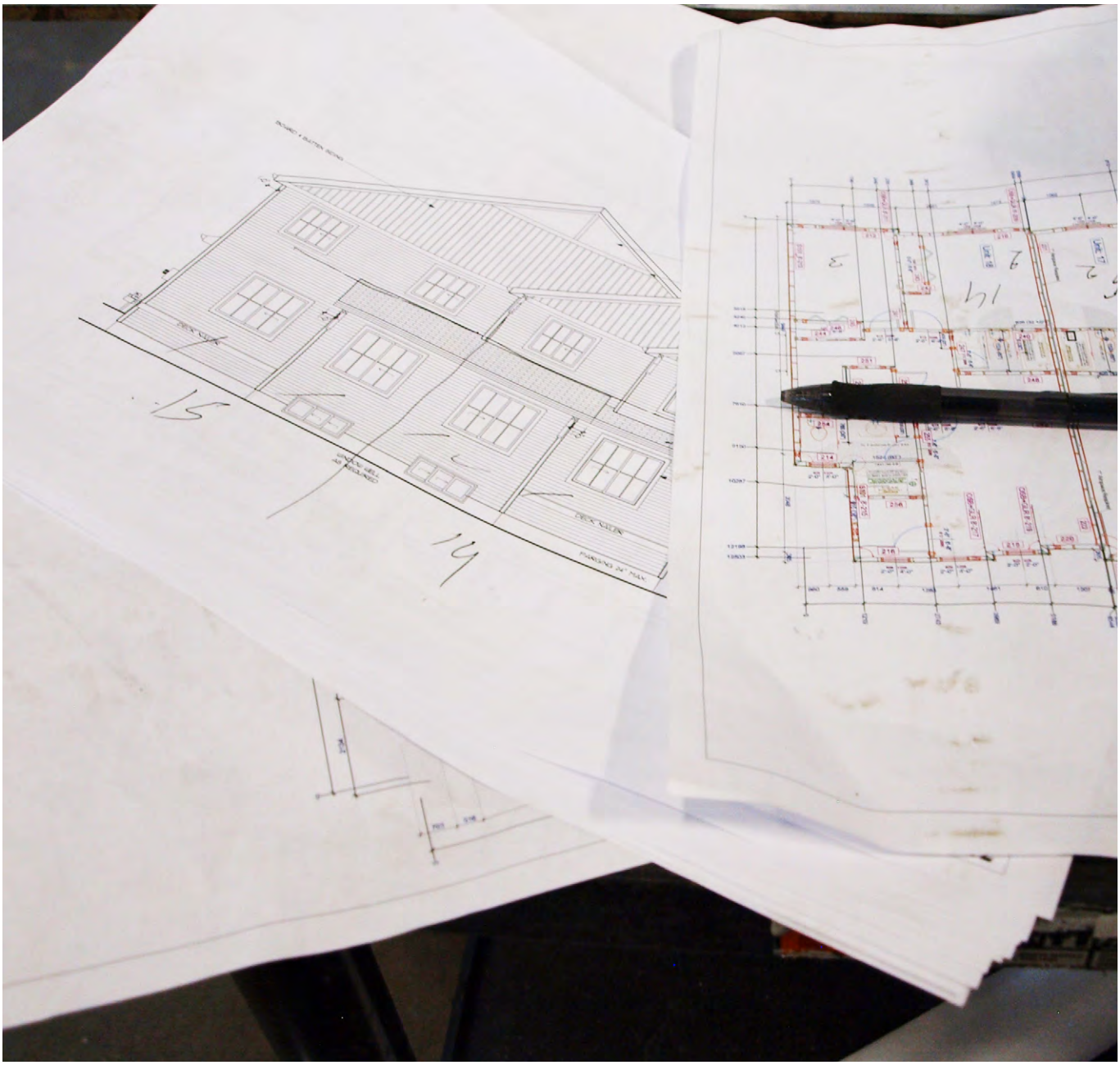
There will often be pressure to issue drawings before they are complete. Issuing a drawing before it contains the information required to meet its purpose should be resisted. Comprehensive checking and

Activity
Show an example of a typical drawing number indicating the function of each part.

Activity
What items should be included in a drawing title block?

Activity
List out the headings and drawing numbers for a project you have worked on.

The timber frame designer should create a complete model of the building that will allow it to be manufactured and erected efficiently and correctly.



approval should always be carried out before issue to ensure that subsequent revision is reduced.

Revisions occur for many reasons, e.g. changes in client requirements, addition of information not previously available, or correction of errors. Whatever the reason it is essential that they are implemented recorded and communicated in a controlled manner.

In principle all drawings affected by a revision, including drawings by other designers, should be brought up to date as soon as the change has been agreed. In practice, during the design stage, frequent issuing of updates that reflect only minor changes can interfere with the logical progress of the work and increase drawing costs unnecessarily. However, delay in issuing updated information can cause abortive design work and increase construction costs significantly. A balance has to be found and the significance and urgency of the information should be considered before issue.

When a drawing is revised, a short but comprehensive description of the revision, and its date, should be added under consecutive revision letters within a space adjacent to the title panel. Wherever possible, some form of drawing highlighting should be used to identify the location of the revision on the drawing, .e.g. revision clouds.

9.7.2 Obtaining and Following the Correct Information

It is critical that the correct and up to date information is made available to all relevant personnel to ensure that they can fulfil their duties effectively. It is important that all information is unambiguous, accurate, easily understood i.e. not unnecessarily complex, correctly interpreted, and that all the necessary and relevant information is available, complete and adhered to.

Information must be of the latest revision and any incorrect or inconsistent information should be reported to the appropriate person such that it can be investigated then revised and reissued if necessary.

Some examples of information typically encountered during manufacture:

- drawings
- specifications
- job instructions
- assembly procedures
- cutting lists
- loading lists
- quality specification
- manufacturer's literature

among others.

Drawings that accurately and clearly describe the structure of the timber frame building are the key to constructing beautiful buildings.

10. Regulations, Standards and Certification Schemes

In order that buildings are constructed in a safe and durable manner using approved materials, products and components, various standards are set, both by government and private organisations, some of which are mandatory and others voluntary. Certification schemes and products approvals ensure and guarantee the quality of the construction product.

Compliance with relevant regulations and standards is compulsory on all projects. It is vital that the timber frame designer is familiar with the certification schemes used by their company and that they have a good working knowledge of the relevant and current building regulations and standards.

10.1 Building regulations

The Building Regulations exist to ensure the health and safety of people in and around all type of building (domestic, commercial and industrial). They also provide for energy conservation, suitable access and use of buildings.

They define the technical performance of building work. For example:

- set out notification procedures to follow when starting, carrying out and completing building work
- set out the requirements with which the individual aspects of building design and construction must comply.

10.1.1 Approved Documents – England and Wales

For additional information and to assist with complying with the Building Regulations a series of Approved Documents (AD) are available:

AD A	Structure
AD B	Fire safety
AD C	Site preparation and resistance to contaminates and moisture
AD D	Toxic substances
AD E	Resistance to sound
AD F	Ventilation
AD G	Sanitation, hot water safety and water efficiency
AD H	Drainage and waste disposal
AD J	Combustion appliances and fuel storage systems
AD K	Protection from falling, collision and impact
AD L	Conservation of fuel and power
AD M	Access to and use of buildings
AD P	Electrical safety
AD Q	Security in dwellings
AD R	High speed electronic communications networks
AD 7	Material and workmanship

10.1.2 Technical Handbooks – Scotland

The Building Standards (Scotland) Regulations are legal requirements laid down by the Scottish Parliament that are intended to provide reasonable standards for the purpose of securing the health, safety, welfare and convenience of people in and around buildings, for conserving fuel and power and for furthering the achievement of sustainable development.

The functions of the Building Standards (Scotland) Regulations are:

- to prepare the building regulations and write guidance on how to meet the regulations
- to provide views on compliance to help verifiers make decisions
- to grant relaxations of the regulations in exceptional cases
- to maintain a register of Approved Certifiers
- to monitor and audit the certification system
- to monitor and audit the performance of verifiers
- to verify Crown building work.

Further information:

http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/BSD

10.2 BS ENs and Eurocodes

The European Standards (ENs) are applicable across the single European market countries and are used to enable trade between these countries through a uniform standard.

Each European single market country, including the UK, adopts the EN standards in its home language and standard system. In the UK this is in the form of British Standards (BS ENs).

More recently, the European Structural Eurocodes have been made applicable in the UK.

The Eurocodes comprise 10 European standards in 58 parts, including National Annexes, which provide the basis for structural and geotechnical design within the EU. These superseded existing national standards in March 2010.

The Eurocodes provide:

- design criteria and methods of achieving the necessary requirements for mechanical resistance, stability and resistance to fire
- a common understanding of the design of structures
- a framework for creating harmonised technical specifications for CE marking of construction products in accordance with the Construction Products Regulation.

The Eurocodes provide uniform structural design guidance across the European Union countries. Similarly to ENs, the UK complies with the Structural Eurocodes through import into BS ENs, whose structure and timber frame standards are listed below. The learner is advised to consult the most up-to-date standard relevant to their specific design for every project, as the standards are frequently updated. Moreover, a flowchart for timber frame design has been provided within the Eurocodes, shown below.

In the Eurocodes the structural design in buildings is defined as being either within limit states and therefore safe and satisfactory, or out of limit states and therefore unsafe and unsatisfactory. There are two types of limit states.

The Eurocodes comprise 10 European standards in 58 parts, including National Annexes, which provide the basis for structural and geotechnical design within the EU.

Ultimate limit states (ULS): associated with forms of structural failure or collapses; relevant to safety conditions

Serviceability limit states (SLS): associated with normal service conditions, such as deflection and vibration; relevant to comfort and appearance conditions

Eurocode 0: Basis of Structural design

Eurocode 1: Actions on Structures

Eurocode 2: Design of Concrete structures

Eurocode 3: Design of Steel structures

Eurocode 4: Design of Composite Steel and Concrete structures

Eurocode 5: Design of Timber structures

BS EN 1995-1-1:2004+A1:2008 Eurocode 5. Design of timber structures. General. Common rules and rules for buildings

NA to BS EN 1995-1-1:2004+A1:2008 (National Annex)

BS EN 1995-1-2:2004 Eurocode 5. Design of timber structures. General. Structural fire design

NA to BS EN 1995-1-2:2004 (National Annex)

BS EN 1995-2:2004 Eurocode 5. Design of timber structures. Bridges

NA to BS EN 1995-2:2004 (National Annex)

Eurocode 6: Design of Masonry structures

Eurocode 7: Geotechnical Design

Eurocode 8: Design of structures for earthquake resistance

Eurocode 9: Design of aluminium structures

In connection with timber frame design, the following British Standards are also used in industry:

BS 5268-3:2006. Structural use of timber. Code of practice for trussed rafter roofs

BS 5268-6.1:1996. Structural use of timber. Code of practice for timber frame walls

BS 5268-6.2:2001. Structural use of timber. Code of practice for timber frame walls. Buildings other than dwellings not exceeding four storeys

BS 5268-2:1990. Structural use of timber. Recommendations for the calculation basis for span tables. Purlins supporting rafters

BS 8417:2011+A1:2014 Preservation of wood. Code of practice

BS 8103-3:2009 Structural design of low-rise buildings. Code of practice for timber floors and roofs for housing

BS 6399-2:1997. Loading for buildings. Code of practice for wind loads

10.3 National House Building Council (NHBC)

The NHBC is a standard setting body and leading warranty and insurance provider for new dwellings in the UK. A 10 year warranty and insurance policy is provided to new home buyers.

Key services provided:

- a register of builders and developers who agree to comply with the NHBC Rules and Standards
- setting and maintaining

construction standards for new homes
- consultancy and testing of acoustics, air leakage, energy, sustainability and health and safety
- inspecting at key stages of new home construction
- providing building control services in England and Wales
- providing a 'Build-mark' warranty and insurance policy for new homes
- providing technical and engineering advice
- produce a Housing Market Report and other information publications
- provide training on health and safety and technical topics
- publish standards including the Quality Management Services (QMS) and Construction Quality Reviews (CQR).

The NHBC Standards provide guidance on meeting the technical requirements and recommendations for external and internal timber frame walls, flat and pitched roofs and both solid and engineered joist floors.

http://www.nhbc.co.uk/Builders/ProductsandServices/TechZone/nhbcstandards/

10.4 Local Authority Building Control (LABC)

LABC is the largest building control service in England and Wales with 3,000 building control surveyors and a 75% market share across all building sectors.

LABC represents all local authority building control teams in England and Wales. Their members work co-operatively with building owners, home owners, architects, plan drawers, developers, building contractors and other professionals to ensure buildings are safe, healthy and efficient to meet the standards set by the building regulations.

Local Authority Building Standards Scotland (LABSS) represents Scotland's 32 local authority building standards services. Their members work in local authorities and aim to protect the public interest by ensuring that all new buildings and those being altered, extended or converted comply with the building regulations and technical standards.

LABC Warranty and Premier Guarantee work in partnership with LABC throughout England and Wales to provide new home and structural warranties.

https://www.labc.co.uk/

10.5 Exova BM TRADA Q-Mark

The BM Trada Q-Mark is a product guarantee system, which certifies the building products quality of manufacturing, handling and compliance with regulations. There are several schemes under the BM Trada Q-Mark:

- Acoustic window
- Building insulation products
- Building systems
- Construction certification
- Engineered floor products
- Engineered wood products
- Engineering & design protocol
- Enhanced lifetime performance of doors
- Enhanced security door
- Enhanced security window
- Fire door manufacture
- Flat glass
- High performance timber window
- Insulating glass units
- Marine plywood

- Paint application
- Solid wood panelling & cladding
- Timber frame elements
- Timber tiling batten
- Trussed rafter
- Window general performance
- Wood based panels
- Wood flooring.

Further information:

https://www.exovabmtrada.com/en-gb/certification/

10.6 Trussed Rafter Association (TRA)

The TRA represents trussed rafter manufacturers throughout the UK.

Its aims are:

- to encourage architects, engineers and specifiers to choose trussed rafters
- to offer expert advice and technical information on trussed rafters
- to implement common design and safety standards
- to develop the professional status of members and their employees
- to provide marketing activities, which promote the benefits of trussed rafters
- to support members through a range of services.

Further information:

www.tra.org.uk

10.7 Construction Products Regulation (CPR)

The CPR is a legislative document governing the introduction of construction products into the market. The CPR lays down the conditions for sale and supply of construction products in the EU and harmonises the methods of testing, declaration of a product's performance and the assessment of verification of constancy of performance.

The CPR outlines the responsibilities of parties involved e.g. manufacturers, importers, test labs, certification bodies and:

- breaks down technical barriers to trade and allow free movement of goods in the EU
- provide a system of harmonised technical specifications to establish harmonised requirements for product performance
- installs a framework of Notified Bodies
- enables CE marking of products.

The CPR outlines the Basic Requirements for Construction Works (BRCW), separated into 7 essential characteristics which are to be assessed as appropriate for each specific product:

- mechanical resistance and stability
- safety in case of fire
- hygiene, health and the environment
- safety and accessibility in use
- protection against noise
- energy economy and heat retention
- sustainable use of natural resources.

Note that some characteristics may not apply to the particular product's end use.

The only way to demonstrate that a product complies with the CPR is by applying the CE marking.

10.8 CE Marking

CE marking for products covered by a harmonised standard (hEN), or conforming to a European Technical Assessment (ETA) issued for the product, became mandatory across the EU from 1st July 2013.

The CE marking is a key indicator of a product's compliance with relevant standards, essential requirements and EU legislation.

The CE marking is a regulatory mark which must be affixed prior to the product being placed on the market.

CE marking:

- applies to all products covered by a harmonised standard (hEN) or a European Technical Assessment (ETA)
- signifies that a product conforms with all EU directives or regulations that apply to it
- process which a product undergoes to verify that it is fit for a specific purpose
- it is not a statement of quality but rather a declaration confirming that the product is fit for purpose and has been subject to measures to ensure that's the case
- allows unsafe products to be removed from the market
- applies to all countries in the European Economic Area (EEA)
- facilitates free movement of goods by eliminating technical barriers to trade and administrative burdens for circulation of goods in the EEA
- doesn't indicate that the product was manufactured in the EEA but that it has been appropriately assessed before being placed on the market
- CE marking is the responsibility of the manufacturer or authorised representative i.e. importer or distributor.

Not all products require CE Marking, only those subject to relevant directives or regulations. Construction products are subject to the Construction Product Regulation or CPR.

The CE marking must be:

- accompanied with a Declaration of Performance (DoP) and supporting technical documentation
- marked upon the product (where practicable) and be visible, legible and indelible
- marked upon corresponding packaging and literature.

Voluntary markings in addition to the CE mark may be added but must fulfil a different function and mustn't cause confusion or reduce legibility.

10.8.1 Harmonised technical specifications

Harmonised Technical Specifications define the methods of assessing and declaring the relevant performance characteristics of the product. Standard assessment methods are agreed collectively by member states.

These may be either:

- Harmonised European Standards (hENs)
- European Assessment Documents (EADs)
- both hENs and EADs provide information on the regulated characteristics that a product must satisfy to enable CE marking.
- hENs are developed and produced by the European Committee for Standardisation (CEN)
- EADs are developed and produced for products which are not covered by hENs by the European Organisation for

Most products used in timber construction are now covered by hENs and as such must be CE marked.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Fax:01309 671720

Technical Approvals (EOTA)

Harmonised Technical Specifications contain, at least:

- a general description of the construction product and its intended use
- essential characteristics relevant for the intended use
- methods and criteria for assessing the performance
- Factory Production Control (FPC).

10.8.3 Harmonised European Standards (hENs)

A hEN is a published document containing technical information to define practice in a consistent, repeatable manner. They are international standards with an "ISO" and/or "EN" prefix.

The national standard "BS" refers to British Standards. As such "BS EN" (sometimes "BS EN ISO") is the UK version of a European harmonised standard.

Note however that not all BS ENs are hENs. A European standard is adopted by a European standards body but is not harmonised unless it is subject to a mandate and a reference is published in the Official Journal of the EU (OJEU).

hEN's are 'special' ENs which have an ANNEX ZA and enables a product in compliance with that EN to be CE marked.

Standards outline the requirements which must be met (and provide guidance on how to verify that products meet these requirements):

- **Annex ZA of an hEN** contains clauses which address the provision of the CPR:
- **Annex ZA.1** defines product characteristics and clauses within the standard which outlines the test method(s)
- **Annex ZA.2 (AVCP)** defines the process for conformity assessment and tasks to be undertaken by the manufacturer and Notified Body
- **Annex ZA.3** defines the process for CE Marking and labelling

10.8.4 European Assessment Document (EAD)

An EAD may be developed for construction products which are not covered, or fully covered by a hEN. An EAD provides the basis for a European Technical Approval (ETA), enabling CE marking of products, and details how to meet requirements of the CPR.

An EAD may already exist where another manufacturer has applied for an ETA for CE marking of an identical or similar product. Under these circumstances, it is not mandatory to apply for an ETA and so CE marking of the product remains voluntary. Note if the manufacturer chooses to request an ETA, enabling them to apply the CE marking to their product, then it becomes mandatory for them to do so.

EADs have a section which serves the same function as Annex ZA of hENs.

10.8.5 European Technical Approval (ETA)

An ETA is means for a manufacturer to CE mark a product where the product is not or not fully covered by an existing hEN or the product is already covered by an EAD.

An ETA is a document which provides information on the performance of a construction product, defines the product and its intended use and provides the basis for a Declaration of Performance to be drawn up by the manufacturer.

An ETA contains:

- general information on the manufacturer, product type, name

and place of manufacture
- declaration of product performance and reference to methods used for assessment
- technical details necessary for the implementation of the AVCP system.

10.8.6 National product approvals

National approvals are an option where no hEN or EAD exists and the manufacturer wishes to certify their product, but doesn't want to apply for an ETA.

National approvals:

- support a manufacturer's declaration
- provide increased confidence and provide reassurance for suppliers
- recognised by local authorities, building control, government departments, warranty providers
- accelerate market acceptance
- under national approvals products still undergo a rigorous process including testing, inspection and monitoring.

Examples:

- BBA Agrément Certificate
- BM TRADA Q-Mark

10.9 Timber certification and grading

Third party consultancy and certification businesses provide certification on strength grades of timber and is therefore important for timber frame designers to be aware of. The services are the following:

- visual strength grading of softwoods and hardwoods
- machine strength grading of softwoods and hardwoods
- machine and visual strength grading of scaffold boards
- FSC/PEFC/Other Chain of custody for sustainable forest management, which includes:
    - access to markets
    - risk management
    - availability and choice
    - compliance with legislation
    - logo and label
    - business sustainability
    - traceability
    - CE marking
    - finger jointing
    - ISO 9001 Quality Management System (BS EN 9001)
- greater efficiency and consistent control of major business processes
- regulation of successful working practices
- increased customer satisfaction
- greater consistency in the quality of products and services
- ISO 14001 Environmental Management System (BS EN 14001)
- better management of environmental risks
- increased access to new customers and business partners
- demonstration of legal and regulatory compliance
- overall cost savings in terms of consumption, waste and recycling
- OHSAS 18001

10.10 STA Certification Schemes

10.10.1 Site Safe

Site Safe has been developed by the Structural Timber Association (STA) 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.

SITE SAFE
ACCREDITED USER

Activity

Which certification schemes and standards does your company comply with? Specifically, include in your comment compliance with STA certification schemes.

The STA expects its structural timber building system members - including manufacturers, fabricators and contractors - plus erector/installer members (who may also work directly with principle contractors /clients), to adopt the principles of Site Safe and register all sites they are involved with.

10.10.2 STA Assure

STA Assure is designed to benefit both clients and members by promoting the differing accreditations and quality standards held by individual STA member companies. This scheme offers reassurances to the construction community that STA members meet or even exceed current legislation and regulatory requirements. The STA Assure accreditation highlights the differing levels of quality procedures, management systems and product performance standards, together with external accreditations held by STA members.

STA ASSURE

http://www.structuraltimber.co.uk

11. Typical Construction Details

The company you work for will likely have an archive of standard construction details. These provide a useful starting point for technical design and studying them will be a great introduction to detail standards. However, the learner should be aware that the details need to be modified for the specific project. Moreover, new improved details will be added continuously to the detail library so the learner should ensure they refer to the latest versions.

11.1 Clients

The client's requirements for the building are usually established by the architect's drawings and specification. These may include construction details.

Close attention should be given to the requirements regarding the timber frame such as the type of cladding and base for the soleplate. Where specific connection details for the timber frame are indicated, these may, with the client/architect's agreement, be modified to suit the factory methods of manufacture and the engineer's structural requirements.

11.2 Manufacturers

Manufacturers usually produce typical construction details to show how their components are joined together and to ensure that the timber frame structures produced are compatible with the adjacent claddings, joinery and substructure. Typical details you may use include window, door and insulation connections.

11.3 Design consultants

Where manufacturers have insufficient capacity to produce the designs for their projects, external design consultants are employed to carry out this role.

Consultants are required to be flexible as they may work for many different clients with varying stock materials, manufacturing limitations (e.g. maximum panel size) and connection details. Any construction details issued by the consultants should reflect these variations whilst also fully complying with the necessary regulations.

The learner may either work with external consultants for the timber frame design or receive information from design consultants regarding specific products. For example, windows installation details to achieve low U-values and air leakages may be provided by an external consultant.

11.4 Robust details

Robust details are approved acoustic solutions. These details contain wall and floor construction details that have achieved the status of robust details for Part E of the Building Regulations (England and Wales) 'Resistance to the passage of sound.' Every building built using robust details needs to be registered.

The use of robust details provides an alternative to pre-completion sound testing. It is important that separating walls/floors and their associated junctions and

flanking conditions are drawn and constructed entirely in accordance with the relevant robust detail to ensure that pre-completion testing is not requested by building control.

Activity

List the main headings for all the types of Typical Construction Details available in your office.

12. Office Procedures

12.1 Overview

Office procedures are both useful and imperative for the design of timber frame buildings. The learner may already be familiar with some of the procedures in the company they work for. Standardised templates, drawing, revision and quality control procedures ensure that any work produced in the drawing office of your company is of consistent quality and accuracy.

12.2 Drawing

Technical drawings form the basis of communication between designers and between structural timber designers and other parties involved in the projects. Drawings that accurately and clearly describe the structure of the timber frame building are the primary requirement for all parties.

The timber frame designer should intelligently interpret all the input information to create a complete model of the building that will allow it to be manufactured and erected efficiently and correctly. The drawings will be used by many different people, each with their own requirements. Understanding these requirements is vital to the production of clear, efficient drawings.

The design offices should have clear procedures for the production of drawings by their designers.

12.3 Revising

New information is often provided to the designer after the drawing work has commenced. This should be evaluated and then incorporated into the drawings once full agreement to the changes has been reached. Late alterations may require revised engineering calculations and may incur additional design charges.

If drawings have been issued it is essential that the revised drawings are re-issued incorporating the next revision number and a relevant revision note. This should ensure that the latest drawing is always used.

12.3.1 Soleplates / wall plates

The Drawing Office must ensure that there is an adequate amount of information to allow the soleplate to be installed accurately and correctly.

The Drawing Office will produce the soleplate drawing from the architect's drawings and specification paying particular attention to the following:

- ground floor finish
- wall thickness
- location of any load bearing elements.

The drawings will be passed to the supervisor(s) for checking where they will be signed and dated. Every drawing that leaves the Drawing Office should leave with the drawing register duly completed.

The structural timber designer should check the following aspects

Checking

Once the drawings are completed they should be independently and thoroughly checked against the original order, specification and any revised requirements. They should also be checked to ensure they comply with:

1) current stock
2) material lists
3) standard details
4) engineer's requirements
5) factory procedures
6) be clear and complete.

regarding the soleplates and wall plates:

- size, build up and grade
- position on foundations
- DPC's and fixings
- relationship to internal finished floor levels
- notation
- dimensions including diagonals
- Fireplaces, Soil Vent Pipes, Portal Frames, Steel Posts
- load-bearing walls indicated
- steps in levels
- suspended floor details, (refer to joisting checks)
- wall plate details
- awareness of shrinkage tolerances.

After checking by the supervisor(s), any changes must be incorporated before being sent to the client with the standard soleplate letter/ instruction listing any relevant inclusions.

The date on which the soleplate drawings are issued should be recorded appropriately.

Site assembly drawings will typically follow a similar procedure to those of the soleplate drawings but will include all necessary detailed information to allow the frame to be installed accurately and in the correct manner on site.

12.3.2 Sections

The structural timber designer should check that the following aspects are clearly and correctly labelled regarding the section drawings:

- soleplate and wall plate build up indicated
- Damp Proof Courses and fixings

Activity

List the main items that should be shown on a timber frame house section drawing.

indicated clearly
- wall thickness clearly marked, both external and internal
- window and door heads gauged into brickwork and dimensioned from DPC
- storey height, panel height and head binders are all dimensioned per every level
- floor joists, deck, sub deck, floating floor build up shown
- lintel zones indicated with cavity barriers and brickwork lintels shown
- stair graphs, headroom and bulkheads indicated and dimensioned
- portal frames and steel beams are all indicated with all useful dimensions
- upper roof overhangs, pitches, eaves and gable details shown and dimensioned
- lower roofs, porch and bay window details shown.

12.3.3 Walls

The structural timber designer should check that the following aspects are clearly and correctly labelled regarding the wall drawings:

- wall lines match soleplate setting out and floor perimeters
- window and door apertures are positioned to section heights, brickwork coursing
- rooms notation shown
- stair diagrams indicated
- maximum component sizes not exceeded
- clearance of wall penetrations e.g. flues, boiler openings
- all layouts are fully dimensioned
- studs specification matches engineering requirements
- portal frames, porches, bay windows are clearly indicated
- storey heights, panels and head binders are drawn correctly
- loose down-stand beam notches are indicated and dimensioned
- any roof splays are set correctly for panel angle cutting
- any posts and special connection details are indicated
- stud grid are set to line with trusses and joists if required
- lintels and cripple studs are checked against calculations
- panel laps, junctions and notches are detailed correctly
- loose on site stud-work areas are indicated
- anchor straps are located correctly and clearly indicated
- sheathing and racking special requirements are indicated on the relevant drawings
- panel components work in CDM, H&S, logistics perimeters
- all notation, special details and engineer's comments are added in sequential order and alongside the relevant drawing information.

12.3.4 Floors

The structural timber designer should check that the following aspects are clearly and correctly labelled regarding the floor drawings:

- joist size, grade and centres are all the same as the engineering calculations
- decking includes correct specification, size and grade to suit purpose such as deck or sub deck
- stairwells are positioned, dimensioned and trimmed as per the engineering calculations
- trim holes for chimneys, SVPs, ducts, hoists etc are all indicated and dimensioned
- all floor layouts are notated and fully dimensioned
- all point loads are blocked out and noted visibly for transfer of loads

- blocking and bridging, bracing are indicated at mid spans and 3rd spans etc
- extra joisting and ladders are added under partitions
- all metalwork is clearly indicated and referenced for take off of components, including steel beams
- cutting lists are indicated on drawings if required
- notation to 3rd party information added such as I-beam or metal web joists etc.

Designers Note: when 3rd party floor designs for engineered joists are carried out the designer should check the basic structural information against the engineer marked up drawings for compliance.

12.3.5 Roofs

The structural timber designer should check that the following aspects are clearly and correctly labelled regarding the roof drawings:

- all supporting walls are indicated on plans and clearly dimensioned
- roof trusses, rafters and loose infill material is indicated on plan
- trimmed holes are indicated and dimensioned, such as the ducts, lift shafts, chimneys, velux, dormers etc
- purlin, beams, binders and infill material are all noted, sized, graded and dimensioned
- roof truss bracing are indicated and referenced, including any sheathed areas etc
- general roof model has been cross checked against architect's and engineer's drawings
- roof tile and tank stand positions are indicated on plans
- special services requirements are indicated, such as support for solar panels, heat exchangers
- roof pitches, cantilevers, eaves and verge overhangs are noted and dimensioned
- fully dimensioned roof setting out information is shown, including a grid
- gable ladder, valley areas, hip ends are shown and referenced
- truss profiles are shown with bearing points, pitch, material sizes, bracing, quantities and trussed rafter reference numbers
- attic trusses room sizes are indicated and support points, check height restrictions
- raised tie truss and rafter details are indicated clearly with any scab material noted
- full roof notation and standard referencing and all metalwork and connections are noted.

12.3.6 Metalwork / steelwork

The structural timber designer should check that the following aspects are clearly and correctly labelled regarding the metalwork drawings:

- steelwork has been shown for fabrication with sizes, grades, lengths, plates, welds, holes and bolting details etc
- format of drawing is clearly detailed for external 3rd party fabrication
- goal posts, racking frames, cranked steels have been detailed with consideration for the logistics of handling, deliveries and site erection, fabrication and Health & Safety
- all treatment of steel work has been indicated and is in agreement with specifications etc
- all quantities for items are clearly definable per plot, block, build phase or other etc.

12.3.7 Engineered timber products

Engineered timber products specification is specific

depending on the system used. The considerations from the previous sections will apply for the engineered timber products depending on the application. For example, a CLT wall or Glulam floor element will be checked according to the wall and floor requirements, respectively. It is especially important to consider the following when checking the engineered timber product drawings:

- the correct product is specified – terms such as CLT and LVL; open web joists and I-joists are very similar and may become confused
- compliance requirements with the BS ENs, for example plywood compliance with BS EN 12369-2:2004
- if working with an engineered timber manufacturer from abroad, that the dimensions are presented in the agreed format. For example, some manufacturers on the continent work in cm instead of mm
- opening sizes have been confirmed by the responsible stake-holder, such as service pipes openings; and that these are clearly labelled and dimensioned on the drawings
- that any openings and product sizing is in accordance with the tolerances of the timber product manufacturer; for example, CAM saws used for CLT openings work to mm precision
- the sequence for engineered product manufacturing and delivery has been approved by all parties and has been designed to optimise time. For example, just-in-time deliveries for CLT panel installation onsite
- strength grades and structural performance are clearly labelled and in accordance with the engineering calculations
- the requirements for product handling and storage are clear, for example PEFC certification or moisture content tolerances
- fixings are clearly specified and numbered, for example screw type, length, diameter, distribution and manufacturer
- if applicable, lifting strap positions are clearly labelled and in accordance with calculations.

12.3.8 Volumetric timber construction

If working with volumetric timber systems with a higher level of prefabrication (also called modules), the following are specific considerations when checking drawings:

- buildability has been considered realistically and any special details have been discussed with the production team. The assembly of wall and floor panels for example may be different for systems with different build-up
- internal finishes have been agreed on by the client and are clearly marked on the drawings, including the exact specification, manufacturer and special notes for installation. For example, a colour name and code may be required for paint specification and a note on tile arrangement may have to be added
- the installation of building services (Mechanical, Electrical and Plumbing (MEP)) has been confirmed by the relevant parties and there are no clashes with the structure or between the services
- the buildability of the services has been analysed and improved for efficient work
- the MEP fixtures have been approved by the client, and their project number, dimensions, model, manufacturer and installation requirements are clearly labelled on the drawings
- the produced schedules for MEP fixtures and other components

correspond to the components specified in the drawings

- air tightness requirements have been considered and their solution is clearly labelled on the relevant drawings, including additional notes for manufacturing and construction to achieve the set values

12.4 Issuing

Your company will have a standard issue sheet template, which you will use to record the issuing of produced drawings. This is an important step to ensure that the latest versions of the documents are used and available to all relevant parties. Not all drawings will be issued to all parties and there will be different project milestones for issuing different types of drawings.

12.5 Time scales

12.5.1 Capacity Planning

Capacity planning is a key factor in time scales as it defines the production capacity of the factory. These are set limits at which products can be manufactured.

The production planning already detailed earlier in the manual using Gantt Charts and PERT Diagrams are helpful for determining the production capacity of the factory but there are many factors that may occur on a daily basis that will change capacity levels.

A good organisation will react quickly to these changes by being flexible enough to cope with whatever is thrown at them in terms of people, plant, downtime, supplies etc.

In the ideal world, the order book is full, everyone is competent and knows exactly what they are doing, and are better than their competitors. Also, the factory is operating correctly with no faults or breakdowns and running at optimum capacity. However, in the real world this is seldom the case.

Capacity when measured against actual production provides you with the efficiency levels at which you are operating.

These can be represented in many ways but usually in the form of visual methods such as graphs, pie charts or bar diagrams which give a quick visual indicator on the current daily, weekly and monthly production levels.

12.5.2 Production Scheduling

There will be some degree of difference throughout the industry on how production schedules are produced and managed and what form they take but all will have the common goal of maximising capacity at the lowest possible cost and time.

Plant type and layout will also affect how the schedule is prepared and what it contains.

In general production schedules will have specific targets and deadlines which must be achieved otherwise penalties may be incurred.

It is important to be familiar with and be able to accurately interpret all the production schedules across the factory as they may have several layers or levels.

It should be evident from critical path analysis where any bottlenecks are so it is important to ensure that such activities remain as trouble free as possible.

If the factory operates shift patterns and/or handovers then it is important to ensure that the handover brief is clear, concise,

A good organisation will react quickly to changes by being flexible enough to cope with whatever is thrown at them in terms of people, plant, downtime & supplies..

Activity

What are the main differences between timber frame panels, engineered timber and volumetric timber specification and drawing checking?

Activity

Enquire an informed colleague regarding the issuing procedures at your company and take notes on the template retrieval, general milestones and types of information issued to and by each party.

easily understood and contains a suitable level of detail. The handover brief should contain a comprehensive review, the current state of the production schedule and any hot spots to be aware of. Poor handovers should not be tolerated and tend to reflect a disordered and careless workforce.

12.5.3 Production Tracking

Scheduling is a process that allows the workload to be based upon the real capacity of available resources, for example elements such as:

- equipment and machines
- labour
- tooling
- materials.

However, it is important to bear in mind that the availability of these resources can change **rapidly and often**.

Production schedules should be flexible, contingencies planned for and options assessed from different perspectives in order to identify and assess if any improvements can be made.

Schedules may change as a result of studying the following:

- Gantt charts and schedule performance
- order trace charts
- due date compliance
- bottleneck identification
- job analysis
- material availability and allocation.

Production schedules may be handwritten, computer generated or a combination of both. While handwritten schedules e.g. on a notice board in the factory, are easily accessible and perfectly adequate for displaying pertinent information to personnel, computer generated schedules are more easily adjusted, maintained and managed ensuring that information is current and accurate.

Job tracking may be undertaken in a similar manner either by tracking manually e.g. using a physical job card system or by tracking automatically e.g. electronic barcode/QR code scanning.

12.6 Quality control and design office procedures

The manufacturer should establish documentation and implement controls to ensure the design processes are in accordance with specifications, standards, and requirements and that the drawings which it issues continually conform to the specifications and that the products meet the performance criteria that they declare.

Quality control and design office procedures provide documented, permanent and internal control of production which is robust, traceable and repeatable and ensures quality and consistency for process and product, and ultimately good service to the customer.

Quality Management Systems (QMS) are important for ensuring a consistent and efficient production method in the factory. Across the industry, each company will have specific procedures for ensuring quality in the design office and in the production area. The learners is advised to become familiar with these procedures in their workplace. A QMS which complies with ISO 9000 must be implemented during the design stage if the design is to be considered compliant with Eurocode 5.

Typically, the QMS will cover each stage of the project design work:

- Quotation – provision of price for a product based on initial information

- Order – following the quotation, an order for the timber systems may be placed
- Design Brief – the client requirements for the project, ensuring that all relevant information for the timber frame is included
- File assembly - gathering all relevant project requirements and document in a new project file
- Project coordinator appointment – allocating one person to coordinate the project drawings production
- File issue – distribution and version update of drawings
- Project reassessment – re-evaluation methods for the project, internally or externally
- Structural calculations – method statements for typical calculation procedures
- Initial drawing issue for approval – completed drawings issued to all relevant parties, usually the client
- Customer amendments and approval – feedback and mark-up of the drawings by the client, this should include methods for dealing with design changes by the client
- Full drawing issue – after a thorough check, distribution of updated drawings to all relevant parties
- Final approval – thorough check of all provided drawings before manufacturing
- Feed back / comments from factory and site – incorporating suggestions for improvement in a document and apply them in following projects.

For further information please refer to the BRE Digest 496

https://www.forestry.gov.uk/pdf/Timber-frame-buildings-a-guide-to-the-construction-process_D496.pdf/$FILE/Timber-frame-buildings-a-guide-to-the-construction-process_D496.pdf

Activity

Read, mark up and attach your office checking procedure.

13. Building Types and their Structural Specifics

Activity
What building types do you consider unsuitable for timber frame construction? Come back to your notes after you have read this section and compare your views to the information presented here.

There are a large variety of projects, which can be constructed using timber frame. The most typically constructed timber frame projects are residential, however the benefits of timber products such as low embodied carbon and healthy indoor environment, are also relevant to education and commercial buildings. The number of timber buildings is increasing constantly both nationally and globally, facilitated by the introduction of engineered timber products, whose structural qualities are comparable to steel. The market for timber buildings is growing rapidly, especially due to the need to provide more housing in the UK.

For specific information on loads for each building type and space category, refer to Table NA2 of EN 1991-1-1 Categories for residential, social, commercial and administration areas including additional sub-categories for the UK; and Table NA3 of EN 1991-1-1 – Imposed loads on floors, balconies and stairs in building; or to the updated legislative equivalent at the time of reading this workbook.

13.1 Residential

The most commonly built timber buildings are homes, whose increase in construction is one of the main goals for the industry. The majority of timber frame residential buildings are privately owned domestic houses and flats. Houses

can vary from 1 to 4 storeys whilst flats may be constructed up to 7 storeys in general. However, the rental sector is increasing especially in urban areas and apartment buildings up to 10 storeys have been constructed in London. The floor imposed loading is similar in both (1.5kN/m^2) but the floor dead load for flats is higher due to the need for a greater sound mass between dwellings.

13.2 Social

Homes funded by Housing Associations and Local Authorities for rental or shared ownership are referred to as social or affordable dwellings. They are built to a detailed specification with specific minimum room sizes. It is often a planning requirement that social dwellings are included in a site.

13.3 Retail

Retail buildings are used to sell goods to consumers. Floor imposed loads are greater, spans may be large and there will be special requirements for the interior of the retail units. If designing a retail centre, the separate tenants will often have unique requirements which have to be included in the brief.

13.4 Offices

The places of work and business are where people spend the most time of their days, after their homes. It is therefore important to consider requirements for healthy working environments such as natural lighting, natural ventilation and natural materials. Large span open plan offices are often constructed, including smaller meeting rooms and break rooms. Because of the equipment and density of people, heavier floor loads are imposed (2.5 - 5.0 kN/m^2). Offices will also need special disproportionate collapse design requirements.

13.5 Care homes

Buildings designed to cater for the care of those in need to recover from illness or nursing care due to their elderly age. Care homes can be laid out as with rooms on both sides of a central corridor or a series of houses with different purposes. Because of the need for easy access, care homes are constructed 1, up to 2 storeys high.

13.6 Hotels

Regular sized rooms connected by corridors to multiple stair wells and lift shafts. Their repetitious layouts make factory production particularly attractive, especially for volumetric construction. Linen rooms may require additional imposed floor loading, whereas dining rooms and kitchens may have other specific structural requirements. Hotels will also need special disproportionate collapse design requirements.

13.7 Student accommodation

These buildings are designed for multiple occupancy on or near educational establishments. The repetitive layouts are conducive to using timber frame construction, engineered timber construction, volumetric timber construction and timber pods with bathrooms.

13.8 Schools

Timber is a particularly suitable material for schools, because of its environmental properties such as natural humidity regulation. There are many types of schools, from small local nurseries and primary schools, to large academies. With the expansion in population in the UK, there is an increasing demand for new schools of all types. The school layouts vary greatly from small classrooms to large open halls. Wall panel heights may be large and imposed floor loading are heavier (generally 3kN/m^2). Timber frame has fundamental benefits in assisting schools to become zero carbon operations as required by government. Schools will also need special disproportionate collapse design requirements.

13.9 Specials

Any other classification. These buildings may have unusual shape, loading and design requirements. In this case with perhaps the need for portal frames to provide stability. Designers should be as flexible as possible to encourage the use of timber frame on as many different types of building as possible. New engineered timber products enable the design of buildings in timber, which would have previously been constructed in steel and concrete, so thorough research should be done for each proposed project. These buildings are ideal opportunities for technology, product and process innovation.

13.10 Low, medium and high rise

Dwellings from 1 to 4 storeys – these require only minimal additional strengthening provisions to resist disproportionate collapse.

Dwellings from 5 to 7 storeys – these buildings have additional requirements to resist disproportionate collapse and special consideration needs to be given to accommodating or eliminating differential movement. Lift shafts are required and can be constructed of either concrete or engineered timber.

Dwellings above 7 storeys – constructed up to 10 storeys using CLT, mainly in London.

13.11 Large span structures

Buildings which require a large clear span can be constructed in timber using engineered timber products such as Glulam. Sports halls, breweries and train stations are a few examples, such as the Canary Wharf station in London, which features a semi-sheltered garden.

Activity

Describe a project produced by your office including any special features that affected the design.

14. Design considerations

Timber frame systems are designed to operate to tight tolerances so lend themselves well and are compatible with the use of IT.

Timber frame manufacturers produce their own drawings before commencing manufacture.

Most manufacturers in the UK will operate Computer Aided Design (CAD) software to take bespoke schemes and produce timber frame solutions.

With CAD, a computer aided design tool acts as a platform for the end user to produce a customised conceptual design based on the standard components that reflect their requirements.

These produce panel layouts, material take-off and cutting lists. In some instances the software also controls the saws in the factory to optimise the useful material from each piece of timber and minimise waste.

It is important for designers and clients alike to understand that timber frame can provide flexible design solutions, rather than rigid boxes often portrayed. Conversely, it is also necessary to expect that to reduce waste (materials, labour, design time, etc.) it will be necessary to work with standard components wherever possible to maximise the manufacturing efficiencies.

The structural design of all timber frame buildings must be approved by a structural engineer. All design work has to be completed prior to manufacture.

CAD technologies can be leveraged into manufacturing by using CNC and CAD/CAM technologies for manufacture:

- Computer Numerical Control (CNC): a CNC machine is a production machine that is controlled electronically via computer technologies to reduce production time and increase quality and efficiency. The CNC machine therefore uses digital information to control the movements of tools and parts for processes such as cutting
- Computer Aided Manufacture (CAM): controlling the manufacturing machines utilising computer software is regarded as computer aided manufacture, if this is integrated with the CAD it is regarded as CAD/CAM.

Most manufacturers use production lines to assemble components, panels and units.

14.1 Wall panels

14.1.1 Timber component tolerances

BS EN 336:2013 gives tolerance allowances for cross-sectional timber structural timber. In length, timber components cannot deviate negatively and if they have an upper positive deviation tolerance, that should be noted in the timber order.

14.1.2 Wall panel tolerances

BS EN 12871:2013 gives tolerances for timber panels, when measured

It is important for designers and clients alike to understand that timber frame can provide flexible design solutions.

under specific relative humidity and temperatures:

Length: +0.0 mm / - 3.0 mm

Width: +0.0 mm / - 3.0 mm

Linear expansion due to change in RH: 4 mm

14.1.3 External Wall Panels typical build up

- Studs
- Rails
- Noggings
- Head binder
- Top and bottom rails for openings
- Lintel
- Sheathing (external/cavity)

Open panel components end at this line, pre-insulated or closed panels additionally include the items below:

- Insulation
- Lining (internal)
- Membranes
- Wall ties
- Lintel
- Fire stops
- Cavity barriers

External cladding may be brick, block with a cement render, tiles, slates, timber boards, render on battens, timber or metal panel or system specific render systems with integrated insulation or similar system.

14.1.4 Load-bearing Internal Wall Panels

- Studs
- Rails
- Noggings
- Head binder
- Lintel (above door openings)
- Insulation
- Linings

14.1.5 Non-load-bearing Internal Wall Panels

- Studs
- Rails
- Noggings
- Head binder (for continuity)
- Insulation
- Linings

14.1.6 Party Walls

- Studs

Activity

Explain how buildings manufactured and erected outside the permitted tolerances could affect a completed timber frame structure.

- Rails
- Noggings
- Head binder
- Sheathing
- Insulation (between stud bays and in the cavity where appropriate)
- Cavity barriers (where specified)
- Netlon mesh
- Bracing
- Party wall straps (at head of leaves)

14.2 Floors

Further information on structural properties, sizes and spans is available in BS 8103-3:2009.

14.2.1 Soleplates

Typically specified as either:
- Damp Proof Course (DPC)
- solid timber, width as per wall panel bottom rails.

14.2.2 I-joists

I-Joists are generally simple and straightforward to install for several reasons:
- I-joists are typically cut to length in the factory in accordance with the corresponding design and specification, negating the need to cut to length on site
- I-joists are typically delivered to site in packs alongside the corresponding components, drawings and specifications and ready to install. Typically, the components will be marked with a unique reference which correspond with those on the drawings
- I-joists are installed in accordance with the manufacturer's literature and the corresponding drawings and specifications provided
- I-joists can be worked and fastened with traditional framing tools and fasteners with no requirement for special tools
- where necessary positions along the I-joist can be reinforced using backer blocks at locations of incoming members and/or web stiffeners at location of bearing/support. Backer blocks and web stiffeners are typically plywood
- I-joists can be fixed together to create multi-ply members for enhanced performance
- I-joists must be correctly braced before they can be used as a working platform.

The manufacturer's literature, drawings and specifications should always be referred to or the manufacturer's technical support be contacted for guidance if in any doubt.

Cutting and Holing

Holes can be made in I-joist webs to accommodate services such as electrical wiring, plumbing and ductwork. Typically, the web will be manufactured with a number of pre-punched knock-outs at regular centres along its length which can be knocked out with a hammer, thus eliminating the need for a saw. Holes can be carefully cut or drilled at locations other than the knock-outs but the manufacturer's literature must be adhered to so as not to reduce the performance of the member by cutting holes that are too large and/or positioned too closely to one another, to the edges and ends of the web, bearing/supports, incoming members and/or cantilevers.

Metalwork is available which allows for larger holes to be cut in webs to accommodate larger services such as HVAC or cable trays.

The manufacturer's literature, drawings and specifications should always be referred to or the manufacturer's technical support be contacted for guidance if in any

doubt.

14.2.3 Open web joists

Open web beams are generally simple and straightforward to install for several reasons:

- open web beams are manufactured to length and designed for specific applications in accordance with the relevant specification negating the need to cut to length or modify on site
- open web beams may have a trimmable 'horn' at each end to make minor adjustments on site to accommodate dimensional tolerance between supports
- open web beams are typically delivered to site in packs alongside the corresponding components, drawings and specifications and ready to install. Typically, the components will be marked with a unique reference number which correspond with those on the drawings
- open web beams are designed to be installed in a specific orientation. It is important to ensure that the beam is installed with the top chord to the top
- open web beams are installed in accordance with the manufacturer's literature and the corresponding drawings and specifications as provided
- open web beams can be fastened together to create multi-ply members for enhanced performance
- open web beams must be correctly braced before they can be used as a working platform.

The manufacturer's literature, drawings and specifications should always be referred to or the manufacturer's technical support be contacted for guidance if in any doubt.

14.2.4 Floor cassettes

The frame of the floor cassette may include elements such as rim beams, trimmers, connectors, openings for stair wells and services, noggins/dwangs at perimeters and as supports for partitions, blocking, multiple members etc. where appropriate.

It is common practice within the timber frame industry to include engineered timber products such as I-joists or open web joists into the structure as they lend themselves well to this application and by utilising engineered timber products into cassettes structural performance can be enhanced with the potential for large spans.

Internal elements are placed according to design specification on framing table, connected and braced using mechanical fasteners. Sheathing is then placed onto surface to create a cassette.

Floor cassettes are typically lifted into place using appropriate lifting apparatus and connected to the supporting structure. A significant advantage of floor cassettes is that once landed and secured they provide a safe working platform, enhancing speed and health and safety on site.

14.2.5 Engineered Wood Products (EWP) and Wood Based Products

- Solid timber
- I-joists
- Open web joists
- Box beams
- Glued laminated timber (Glulam/ GLT)
- Laminated Veneer Lumber (LVL)
- Parallel Strand Lumber (PSL) / Laminated Strand Lumber (LSL)
- Cross Laminated Timber (CLT) and variations of CLT:
    - Nailed Cross Laminated Timber (NCLT)

A significant advantage of floor cassettes is that once landed and secured they provide a safe working platform, enhancing speed and health and safety on site.

- Interlocking Cross Laminated Timber (ICLT)
- Nail Laminated Timber (NLT)
- Dowel Laminated Timber (DLT)
- Structural insulated panels (SIPs)
- Trusses.

14.2.6 Intermediate Floor typical build up

- Rim board/header members
- Floor joists
- Insulation if appropriate for acoustic performance
- Stairwell trimmers
- Joist hangers and connectors
- Restraint straps
- Noggings, blocking, strutting
- Floor deck
- Floor finish
- Ceiling lining

14.2.7 Separating Floor typical build up

- Rim board/header members
- Floor joists
- Insulation (between joists and between floor battens)
- Joist hangers and connectors
- Restraint straps
- Noggings, blocking, strutting
- Floor deck
- Floor battens
- Gypsum 'plank'
- Floor finish
- Flanking strip
- Resilient bar
- Ceiling lining

14.2.8 Sacrificial elements

The cassette may feature temporary, sacrificial elements such as covers for stairwell openings for example. Ensure that these are detailed and installed correctly and in accordance with the drawings and specification.

A jig or line may be used or temporary bracing may be installed to provide stability to the cassette while it is being assembled. Standard procedures for the particular method employed must be adhered to.

14.3 Roofs

In general, there are two types of roof constructions, cold (uninsulated structure) and warm (insulated structure) roofs. Whether the roof is flat or pitched, adequate ventilation should be provided. Further guidance is provided in PD CEN/TR 12872:2014.

Further information on structural properties, sizes and spans is available in BS 8103-3:2009.

14.3.1 Trussed rafter roofs typical build up

- Fink trusses
- Noggings
- Truss clips
- Truss shoes
- Framing anchors
- Tie-down straps
- Restraint straps
- Gable ladders
- Bracing
- Sarking
- Membranes
- Counter battens
- Tile battens
- Fascia boards
- Soffit framing
- Soffit panels

14.3.2 Gable End build up

- Spandrel panel
- Gable ladder

14.3.3 Hip End build up

- Girder truss
- Hip trusses
- Hip rafters / boards

Activity

List the metalwork usually used in the construction of a trussed rafter roof.

- Mono trusses
- Trim rafters

14.3.4 Valley build up

- Valley trusses
- Valley rafters / boards

14.3.5 Roof cassettes

Roof cassettes are an alternative means to installing the roof by traditional means - that is installing each roof component individually on site. Roof cassettes can be used as an alternative to attic trusses to provide an unobstructed roof space for occupation. Roof cassettes are similar in construction to floor and wall cassettes and are manufactured offsite and installed onsite. Roof cassettes generally comprise a frame structure (typically edge binders, rafters, structural sheathing and timber frame connectors) and may have insulation, membranes and internal linings installed in the factory prior to delivery.

It is common practice within the timber frame industry to include engineered timber products such as I-joists or open web joists into the structure as they lend themselves well to this application and by utilising engineered timber products into cassettes structural performance can be enhanced with the potential for large spans.

Internal elements are placed according to design specification on framing table, connected and braced using mechanical fasteners. Sheathing is then placed onto surface to create a cassette.

Roof cassettes are typically lifted into place using appropriate lifting apparatus and connected to the supporting structure.

A growing number of unique modular roofing systems which utilise roof cassettes, typically in conjunction with spandrel panels, purlins, intermediate trusses and/or rafters are available.

Panels should be erected accurately, aligned and positioned, and fastened to adjacent wall panels, floor and roof in accordance with the detailed drawings.

14.4 Construction considerations

This section covers typical construction considerations. The learner should note that construction conditions should be designed for according to the Eurocodes, as part of the transient design situations.

There are many alternative build methods and systems available as described in earlier sections.

This section serves only to offer a basic understanding of what may be involved and the common elements which a typical (open panel, platform frame) timber frame structure might comprise.

The learners should obtain further details from the company in which they work and ensure that they are familiar with the methods and systems they employ.

It is also helpful for the learner to gain an understanding and appreciation of the build methods and systems employed by others in the timber frame sector.

Whilst drawings are accurately set out to the nearest millimetre the designer should be aware of the permissible erection tolerances.

Floors should be erected accurately in accordance with the drawings.

14.4.1 Foundations

Foundations are required under all but the lightest load positions. The timber frame designer should check that the final foundation layout matches the positions of all external, party and internal load bearing walls and that any isolated posts have foundation support.

Common foundation types:

- strip
- trench fill
- raft

14.4.2 Ground floor construction

Ground floors may be constructed as ground bearing or suspended. The suspended floors are usually designed in timber or pre-cast concrete with a ventilated space below the floor.

All ground floors should be constructed accurately and level to allow the soleplate to be laid within the required tolerances (see soleplate erection tolerances).

As this is the interface between the timber frame and the substructure it is important that there is cooperation between the timber frame designer and the foundation engineer. The fixing down of the soleplate to the ground floor in particular needs to be discussed to ensure that the fixings are compatible with the ground floor construction.

14.4.3 Concrete Slab and Insulated Ground Floor

- insulation
- concrete slab
- membranes
- floor battens
- floor deck
- floor finish

14.4.4 Suspended Ground Floor

- ground cover
- membranes
- rim board/header members
- floor joists
- joist hangers and connectors
- noggings, blocking
- insulation w/supporting mesh or similar. Rigid insulation supported on battens
- floor deck
- floor finish

14.4.5 Lifting tools

Components may be lifted by hand, hydraulic lift, fork lift truck or crane. Hand lifting should only be used if there is sufficient manpower to safely handle a component. None of the mechanical methods should be used if their safe load capacity could be exceeded.

Lifting holes or strops may be incorporated into a component to assist in its lifting. Lifting points may be indicated on the component drawings (e.g. trussed rafters).

The method of lifting must not damage the component.

Where multiple components are lifted (e.g. whole roof sections) the lifting method should be designed to spread the load evenly and to ensure that no part of a component is overstressed.

14.4.6 Handling and Transportation Equipment

A wide range of equipment and machinery is available to facilitate a number of lifting activities commonly undertaken for timber frame manufacture.

Loads should be assessed prior to lifting e.g. dimensions, weight, centre of gravity, palleted or un-palleted etc. and the appropriate item(s) of lifting equipment for each specific lifting operation must be used in accordance with all relevant instruction to ensure that items are lifted, transferred and placed safely and without incurring any damage.

14.4.7 Hoists

Manual and powered pulley driven hoists are available for safely lifting a range of materials that exceeds manual lifting limits. Typically used in conjunction with gantries and slings.

14.4.8 Slings

Slings are used in conjunction with other items of equipment and/ or machinery such as hoists and overhead cranes to allow safe lifting and transfer of materials which exceed manual lifting limits. Slings are available in various lengths are rated by safe working load and should be selected appropriately to ensure that the load to be lifted does not exceed the capacity of the sling. Different types of slings e.g. chain, wire and synthetic material, are available.

14.4.9 Loading for Transportation

It is important to consider the methods for loading e.g. by forklift or overhead gantry, and how items are loaded for transportation to ensure that the most suitable and safest methods are used to lift and transfer materials:

- assess the load prior to lifting e.g. dimensions, weight, centre of gravity
- the appropriate item(s) of equipment and/or machinery must be used for each particular lifting operation
- loads must be securely stacked and made safe by securing with straps wherever necessary
- bear in mind load distribution and centres of gravity of the loads and the transport
- care should be taken during loading to ensure that loads aren't damaged by striking other loads or the transport itself, or by dropping
- loads should be placed such that space is used economically
- the load may need to be covered before it leaves the factory
- care should be taken to prevent damage to loads e.g. by crushing or sliding, by avoiding placing heavy items or loads on top of lighter and easily damaged loads,

and/or securing loads so that they don't move in transit

- care should be taken when loading to ensure that no injury is caused to personnel, including the operator and those in their vicinity. All necessary safety measures must be taken.
- once the load is placed and secured as necessary slings or forks should be fully removed before drawing the hoist or forklift away from the load
- care should be taken to ensure that the load can be unloaded safely at the receiving end i.e. on site. Items should not be allowed to move in transit such that they could become unstable and be unsafe to remove from the transport
- all loads should be secured in place where necessary
- it is important to be aware of everyone in the vicinity and ensure that they are aware of you
- bearers should be used where necessary and should not be placed such that they make the load unstable
- a guide should be used to assist the lifting operation if necessary. Any guide must be appropriately qualified to do so.

Lifting should be by mechanical means wherever possible. Lift manually only if there is no alternative and it is safe to do so, ensuring that the operation does not exceed manual handling limits.

14.4.10 Overhead Crane

An overhead crane is a type of crane commonly used in the factory for timber frame manufacture. An overhead crane comprises parallel runways with a bridge spanning the work space which travels along the runways. The hoist travels along the bridge such that it can be manoeuvred to access all areas of the work space. Overhead cranes are typically mechanically operated. Loads can be lifted and transferred from one area of the work space to another or on to transport.

Where the bridge is supported on legs running on parallel rails fixed at ground level the crane is commonly referred to as a gantry crane.

14.4.11 Palletisers

A pallet truck, pallet jack or pump truck is a tool used to lift and transfer palletised loads over short distances within the factory though they are sometimes used to organise loads inside a trailer or for similar operations. A pallet truck comprises forks, a handle/jack and wheels. The width or separation distance between the forks is typically fixed and cannot be adjusted though the height is adjustable to allow loads to be lifted and transferred.

A pallet truck operates in principle like a hydraulic jack. The forks of the pallet truck can be raised or 'jacked up' hydraulically by manipulating or 'pumping' the handle and lowered by pressing a lever on the handle. They can be easily manoeuvred by rotating the handle to change the direction of travel.

Pallet trucks are most commonly operated manually but automatic electrically powered pallet trucks are available.

Traditional pallet trucks are not suitable for picking materials from locations other than from the ground. Some powered pallet trucks predominantly used for picking stock more closely resemble the front portion of a forklift truck. Typically, the width between the forks can be adjusted and the forks themselves raised or lowered to a greater degree to allow access to shelfing etc.

14.4.12 Forklifts

A forklift truck, most commonly referred to simply as a forklift, is a powered truck used to lift and transfer loads over short distances. A forklift generally comprises forks, mast, driver cab, power plant, counterbalance and wheels.

As with all tools and items of equipment safety is paramount where forklift trucks are concerned. Forklifts are versatile and greatly reduce the requirement for manual intervention as they are capable of carrying large, bulky, irregular and heavy loads though such loads can reduce and impair the driver's visibility - care must be taken to avoid collision and injury.

It is imperative that anyone wishing to operate a forklift truck undertake the appropriate training such that they can operate it safely and in the correct manner.

Forklifts are very versatile and can be utilised for a wide range of lifting, transfer and loading operations. The separation distance of the forks can be adjusted and the forks themselves raised or lowered by travelling up and down rails on the mast. The mast can be tilted forwards or backwards. The forks on some forklifts have the ability to shift from side to side to make small lateral adjustments. The hydraulics which power these operations is controlled by the driver using levers in the cab.

Forklifts typically have rear wheel steering which provides enhanced manoeuvrability in tight spaces and more difficult cornering situations. The operator steers the forklift using a steering wheel in the driver cab.

Forklifts are rated for loads at a specified maximum weight and centre of gravity (CoG). Every forklift should have a plate which displays this information. This information must be adhered to at all times and loads must not exceed those specified.

Forklifts are inherently unstable. Both the forklift and load must be considered as single unit. The centre of gravity constantly shifts as the forklift and load move.

Forklifts may be propelled by gas (typically propane in a canister), electricity (batteries/fuel cells) or diesel fuel (internal combustion). Each type has characteristics, advantages and disadvantages.

14.4.13 Combi/ Side Loader

A combi loader or side loader is a variation on the standard forklift truck but, as the name implies, side loaders are designed to lift loads with forks from the side of the truck as opposed to the front. Side loaders are suitable for carrying wide or long loads and for travelling along and navigating narrow aisles which may pose problems for traditional forklift trucks.

14.4.14 Machinery Risks

There is always an element of risk associated with operating machinery. The risk of an accident occurring and/or the consequences of an accident can be reduced or removed.

Examples of some methods which can be employed to reduce risk are as follows:

- appropriate training and awareness
- standardised safe methods of work
- risk assessments
- provision of physical safety measures such as guards and covers
- provision of PPE
- clean, tidy and well-lit work areas
- restricted access to areas around the machines

- emergency controls and braking
- proper maintenance and repair schedules
- use of equipment or aids such as push sticks.

A comprehensive risk assessment (RA) should be produced for each tool and item of equipment. RA's should be reviewed at regular intervals and revised if necessary. All operators must read and understand the relevant operating procedure, instructions and risk assessment for the specific item of equipment prior to operation. Risk and the corresponding appropriate and effective measures or means applied to reduce the risk associated with using the item of equipment should each be identified and recorded. Hazards associated with the use of the equipment must be identified and the likelihood of each hazard occurring, the people affected and the likely consequences should the hazard occur determined. The overall risk can be reduced by identifying and applying/implanting effective control measures to reduce the likelihood of the hazardous event occurring and/or the severity of the consequences should the hazardous event occur.

14.4.15 Lifting considerations

All lifting operations involving lifting equipment must be properly planned by a competent person, known as the appointed person and operations are appropriately supervised and carried out in a safe manner.

All equipment used for lifting must be fit for purpose, appropriate for the task, suitably marked and, in many cases, subject to statutory periodic 'thorough examination'. Records must be kept of all thorough examinations and any defects found must be reported to both the person responsible for the equipment and the relevant enforcing authority.

14.4.16 Control of Lifting Operations

The type and scale of lifting operations will depend on the nature of the workplace and the size of components being manufactured, e.g. cassette floors will require more sophisticated lifting operations to be undertaken.

An appointed person is someone who is competent to plan, organise and manage the lift and plan all lifting operations.

It is important for the operator to have necessary training and experience before partaking in lifting operations as they will need to be able to:

- assess the proposed lift to provide for selection of equipment, position of the crane and draw up a plan for instruction and supervision to enable the work to be carried out safely
- ensure that all tests, inspections, examinations and maintenance have been carried out, and that there is a procedure for reporting defects and completing necessary works
- have the confidence to stop lifting operations if you think there is a danger and to carry out additional assessment to ensure that the lifting operation can be completed safely.

The appointed person does not need to be on site during the lift but the Lift Supervisor must strictly follow the lifting plan.

14.4.17 Lift Supervisor and Slinger Banksman

These are the specialist roles you will come across on site where lifting operations take place.

Each one must be qualified to

Activity

Sketch out the lifting points for a large 'L' shaped floor panel.

undertake these duties. Those who are not qualified should not be involved.

14.4.18 Cranes and other lifting devices

When cranes are in use on-site and operating, the following qualified personnel are required:

- Driver: responsible for operating the crane
- Lift Supervisor: responsible for the lifting operations
- Banksman: responsible for communicating with the driver to ensure safe movement of the load
- Slinger: responsible for securing the load to the crane correctly and safely.

14.4.19 Manual Handling

Manual handling can be defined as any moving or supported of a load (including the lifting, pushing, pulling, or carrying) by hand or by bodily force.

It is important to ensure that hoists, telehandlers and other plant or equipment are available so that manual handling and lifting are kept to a minimum.

If mechanical means for lifting are not available and loads have to be handled manually then they must be handled or lifted in the correct manner, by personnel with appropriate training, employing the correct lifting and handling techniques.

As well as the weight, the awkwardness of the lift must be taken into account. Body movements such as bending, stretching, and twisting must also be taken into consideration.

It is important to remember that mechanical lifting methods should be used if it is foreseeable that manual handling is likely to cause injury. Risk assessments must be followed and steps taken to reduce the risk of personal injury.

14.4.20 Method and sequence of erection

All erection work should be carried out in accordance with the Health and Safety Workbook and the CDM Regulations.

Wall panels

Wall panels should be erected in sequence starting with two corner panels. Each panel should be temporarily braced to ensure that it remains vertical and safe from collapse.

Once all the wall panels for a particular level are erected they must be connected by head binders (or similar arrangement) and nailed both to the adjoining panels and to the structure below in accordance with the fixing schedule.

Panels should be erected accurately, aligned and positioned, and fastened to adjacent wall panels, floor and roof in accordance with the detailed drawings.

Floors

Loose floor joists are set out to the drawing centres. Blockings, strutting, headers and decking are added following the timber frame designer's drawings.

Floor cassettes are erected by crane ensuring each panel is placed in its correct position and the right way round. Once the position has been checked the appropriate nailing should be used to connect panels together and to secure them to the wall panels below.

Roofs

The timber frame designer should have in mind a safe, practical method of erection for the roof as their design is produced.

Activity

Sketch out a lifting method for safely raising a 5m section of a trussed rafter roof from ground level to first floor eaves level. (use separate A4 sheet)

This should prevent both any damage to the roof components and injury to individuals. Temporary bracing should be supplied where necessary.

14.4.21 Temporary materials considerations

The designer should consider the building in all its temporary conditions. Without the load from internal finishes, claddings, tiles and imposed loads a structure may be temporarily vulnerable to high wind loads. These could cause the building to slide or overturn. Care should be taken that the drawings show any necessary fixings, designed by the engineer, to restrain the building in this temporary condition.

14.5 Production considerations

14.5.1 Production control

Production control is a type of factory control which is implemented to effectively predict, plan and schedule work and takes in to consideration:

- manpower and skills
- materials
- capacity
- operations
- duration
- cost.

Effective production control regulates and monitors process and output to ensure that the required specifications i.e. quality, quantity, lead times etc. are successfully achieved.

14.5.2 Material availability

Timber structures should be designed using the manufacturer's standard stock items wherever possible.

When special or non stock materials are needed they should be identified as early as possible to enable them to be purchased in good time.

14.5.3 Improving Work Output

Work output can be optimised by implementing a system whereby scheduled operations, processes and levels of performance within a factory are monitored then assessed and scrutinised to ensure that they have been undertaken effectively and in accordance with corresponding schedules. Where any elements are identified as not being in accordance they are subject to further investigation to determine likely reasons and identify then implement potential solutions or means of improving. This ensures a continuous strive for improvement and optimisation.

14.5.4 Size and weight of components

Timber frame components vary greatly in size and weight. They should be designed to enable them to be safely manufactured, transported and erected. The designer must be informed of the maximum widths, lengths and weights that can be accommodated by the factory together with the restrictions imposed by transport and the lifting capacity of any on site cranes. All components must be marked with their weight. Refer to the Health and Safety workbook for further information on safe handling of components according to their weight.

14.5.5 Door and window schedules

Door and window schedules should indicate the size and location of joinery and should include the structural opening size or the required opening tolerances. The wall manufacturing drawings cannot be produced without accurate opening dimensions.

The learner's drawing office will have a standard template for window and door schedules. It is important that the schedules indicate the component code within the project, manufacturer, type, material, sizes, U-values, code and if available a small image for ease of identification. Schedules are typically generated using CAD software by labelling each door and window in the project files and taking them off manually in a schedule file. BIM software can automate this process for increased efficiency.

Activity

Why should all components be marked with their weight?

14.6 Acoustic performance considerations

Sound insulation between and within dwellings must be provided. Separating walls and floors which divide attached dwellings (flats, maisonettes, terraced and semi-detached dwellings) must be designed and manufactured and installed correctly to provide adequate resistance to airborne, impact and flanking sound transmission.

Timber frame designers should be aware of the necessary construction to form high quality separating walls and floors.

Timber Frame houses, flats and rooms for other residential purposes should meet the requirements of the Approved Documents.

The standards provide for methods and materials that best suit the Acoustic needs for constructing suitable timber framed wall or floor solutions.

The requirements set high standards for sound insulation within and between habitable areas, and include requirements for sound insulation of party walls and floors between rooms for residential purposes in buildings such as hotels, hostels, nursing homes and student accommodation.

Whilst many of the elements needed to resist the passage of sound are added later to the structural frame a designer should be take account of the following:

- Robust Details
- minimum floor joist depths
- sequence of working
- prefixed lining layers e.g. roof party peaks
- finished floor levels
- overall wall and floor thicknesses
- party wall strap limitations.

14.6.1 Separating floors

Enhanced resistance to sound transmission in a separating floor is typically achieved by:

- increasing the mass of the walking surface and/or ceiling materials i.e. by using a denser sheathing material or adding additional layers
- increasing the overall depth of the separating floor
- installing thicker and/or denser insulation between the floor joists
- separating the sub-deck from the walking surface e.g. a floating floor on battens with a resilient layer
- reducing the connection between the joists and ceiling, most typically by installing resilient bars between the ceiling lining and the underside of the floor joists, though alternative systems e.g. metal frame ceiling or similar may be used
- adding insulation between floor battens
- installing flanking strips at the perimeter to separate the floating floor from the walls
- installing the appropriate number and type of noggings (noggins/dwangs)

14.6.2 Robust Standard Details

The Robust Details Scheme offers an alternative to pre-completion testing for new build adjoining dwellings i.e. dwellings which share a separating floor and/or party wall, for satisfying Part E of the Building Regulations (England & Wales).

The Robust Details Scheme can be used in Scotland as an alternative to pre-completion testing for new build dwellings to demonstrate compliance with Section 5.

The Robust Details Scheme can be used in Northern Ireland as an alternative to pre-completion testing for new build dwellings to demonstrate compliance with Part G.

A Robust Detail is a party wall or separating floor detail which has been assessed and approved by Robust Details Ltd. to consistently meet the requirements of the aforementioned regulations.

The Robust Details Handbook specifies (with photos) the approved Robust Details for party walls and separating floors of timber and masonry construction.

Buildings must be registered with Robust Details prior to commencing work on site.

This is a process whereby if the new build construction designs adopted are registered via robust details then pre-completion testing is not required. Site managers are required to complete check lists of the works and the site may be visited by a Robust Detail Inspector to check the works and undertake a sample test. Robust Detail separating walls and floors which appear in the RD Handbook have already been tested and approved, and are designed to have a mean performance better than the regulations, and thus do not require pre-completion testing. Approximately 70% of all new housing in England and Wales is registered with robust details.

The status of having a Robust Detail wall or floor system is recognised across the UK and simplifies the specification and approvals process.

14.6.3 Standard Details (Wall and Floor Construction)

Refer to the Robust Standards Details Handbook for information of all standard details, including detailed drawings.

14.6.4 Airborne, Impact and Flanking Transmission

- **Airborne transmission:** this is the level of sound insulation provided by the separating wall or floor for attached houses and apartments. This is measured in decibels (dB) in the completed building and compared to the relevant criteria such as $D_{nT,w}$ + C_{tr} for England and Wales and $D_{nT,w}$ for Scotland and Northern Ireland. The higher the value the better the insulation to protect against neighbour noise such as television, voices, music etc.
- **Impact transmission:** this is the level of sound transmission through a separating floor for apartments. This is measured in decibels (dB) in the completed building and uses the $L'_{nT,w}$ criteria across the UK. The lower the value the less sound is transmitted from footfall noise etc.
- **Flanking transmission:** flanking sound transmission affects both airborne and impact sound insulation, and is the term used to describe a sound transmission path (structural or airborne) that is not directly through a separating wall or floor. Commonly the external wall can provide such pathways. Interpretation of laboratory sound insulation test results must account for flanking sound transmission.
- **Laboratory Sound Insulation:** for internal walls and floor, the building regulations require a level of sound insulation as determined by a laboratory sound insulation test. Laboratory testing is undertaken within a test suite that suppresses flanking sound transmission so that only the subject wall/floor insulation is measured. The criteria for laboratory test results is R_w airborne of L_w impact (dB). The higher the value the better the insulation performance of the internal wall or floor.

14.7 Thermal performance considerations

The thermal performance of a building is considered an important factor in the way it operates and is constructed. The main objective of a buildings thermal performance is to be able to withstand the temperature and climatic fluctuations or hazards which it could encounter. The better the performance, the less energy is lost through its fabric which indicates that the building will need less energy to heat or cool its interior. This in turn will reduce energy bills, lay off pressure on fossil fuel depletion, and reduce the buildings carbon footprint thus becoming an environmentally sound building.

Thermal performance refers to how effectively a structure responds to changes in external temperatures during daily and seasonal cycles.

Thermal properties related to the envelope of a building are of great interest when assessing a buildings performance. It's important to take into consideration the way energy is contained or lost in a building and how this is achieved. To control this, buildings have an envelope which consists of its floor, walls, roof, windows, and doors; and it controls the temperature differences between outdoor and indoor fluctuations.

The buildings envelope is derived from different building materials and components which possess different thermal properties controlling the amount and rate of energy leakage. Depending on its thermal properties and the way each component is placed the amount of heat loss can be calculated and regulated.

The correct selection of materials for the reduction of heat loss is best undertaken early in the design stage.

Under the current regulations timber frame must incorporate high levels of insulation within the manufactured units.

Insulation should be installed throughout the building, most typically:

- **Walls:** in an un-insulated building around 35% of the heat loss is through the walls. This however is easily prevented and reduced with proper insulation. Different materials and methods may be used depending upon the wall structure
- **Roof/loft space:** in a poorly insulated building approximately 25% of the heat loss is through the roof space. Heat generated indoors rises and conducts itself through the ceiling and meets a cold and sometimes humid void with a high volume of space. This in combination with materials in close contact with external conditions results in an easy escape route for generated heat.
    - **Cold roof construction:** generally, the roof space is unventilated and sealed and insulation is situated in the ceiling zone
    - **Warm roof construction:** generally, the roof space is ventilated and sealed and insulation material is situated in the rafters.
- **Floors:** for floors the percentage of heat loss is an average of approximately 15%. Insulation should be installed in the floor zone to prevent heat loss through the floor.
- **Piping & storage tanks:** it's advisable to insulate all components which contain and transport usable water as much as possible especially those used for hot water. Cold water piping should be insulated to prevent them from freezing and becoming damaged. Water tanks should also be insulated.

14.7.1 Thermal transmittance (U-value)

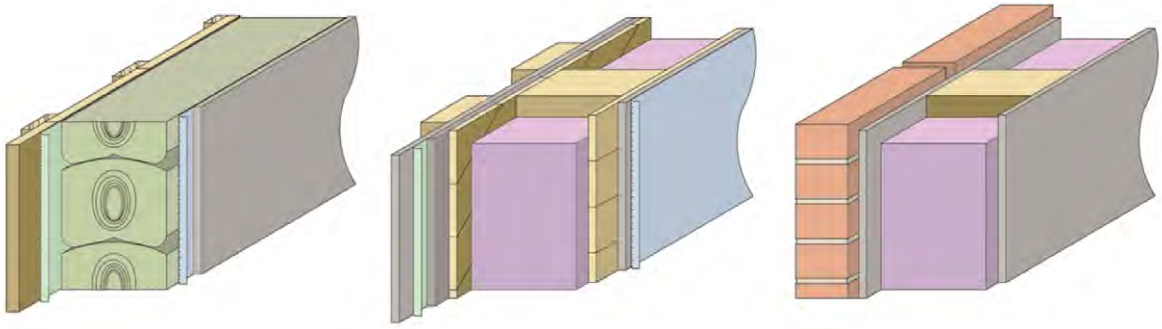
All heat transfer modes are used when heat passes out of a buildings envelope. The overall rate of transmission is known as the thermal transmittance.

Layers of different materials conduct heat at different rates. All of these factors can be measured and described by the thermal transmittance coefficient widely known as the U-value (W/m^2K). This coefficient measures the rate of heat flow in watts through 1 square metre of a structure when there is a temperature difference across the structure of 1° (C or K). These calculations are mainly aimed at building components based on various materials.

14.7.2 Factors effecting thermal performance (and heat loss)

Some factors which may affect a building's thermal performance and contribute to heat loss are:

- insulation properties of the building envelope: a building that is well insulated limits heat loss
- exposure to the exterior: the greater the exposure the greater the heat loss – determined by type of building i.e. terraced, detached, semi-detached, flats etc.
- indoor and outdoor temperature differential: a large fluctuation between in and outdoor temperatures increases heat loss by convection
- air change rate: warm air leaving the building is replaced with cold air. Air infiltration can happen through windows, doors (openings) and badly joined components



a) log wall in the 1930s

b) Timber wall with saw dust insulation in the 1950s

c) Timber wall with brick facade and mineral wool insulation in the 1970s and 80s

The energy-efficiency of timber construction has improved over the years through increased insulation and thermal bridge reductions.

To prevent thermal bridging a series of thermal breaks are incorporated at the design stage. An excellent example of this is in lintels across windows and door openings.

- external climate contact: wind blowing directly against a surface e.g. a wall or roof increases the heat transfer. This effect influences the surface U-value of materials
- efficiency of services and patterns of use: heat can be recycled for space heating and water heating.
- U-values of the individual components: e.g. wall, roof, openings/windows
- material specification: correctly specified products installed as per manufacturer's instructions
- workmanship: all elements must be correctly installed in accordance with the design, regulations and manufacturer's instruction
- air tightness
- thermal bridging
- natural light (solar gain)
- heating system
- artificial lighting
- ventilation

Note that insulation materials also contribute to the fire resistance and acoustic performance of the building element.

14.7.3 Insulation Material

One of the ways to reduce temperature fluctuation and reduce heat loss is to insulate all components of a building as much as possible. To maintain constant temperatures in a building it is necessary to limit and reduce the rate at which heat can be conducted through a component. Insulation can work in two ways; either limiting solar gains to pass into a building, typically during summer months, or by keeping buildings heated and keeping heat that is produced inside the building, typically during winter months.

Insulation materials can generally be divided into two types; man-made/synthetic and environmental/natural. Both have very similar effects but differ in the means by which they are obtained or produced.

The majority of manufactured or industrial insulating materials are man-made and mass produced in such a way that they can be widely and easily obtained. Some of these materials have a high embodied energy, that is they require a large amount of energy to produce, and therefore can counter effect the purpose of reducing carbon emissions of other building materials.

Environmental products are the opposite as they are obtained by greener means and may originate from vegetation, animal fur, recycled materials, and re-use or surplus of textiles for example. They tend to be more locally sourced and have low embodied energy i.e. they require little energy to produce, as they can be recycled and so are a by-product of another process or have previously fitted another purpose.

14.7.4 Types of Insulation

Some typical examples of insulating materials available for use in timber frame construction are:

- Man-made insulating materials:
  - Mineral wool
  - Rock wool
  - Fibreglass
  - Rigid polyurethane (PUR)
  - Rigid polyisocyanurate (PIR)
  - Expanded polystyrene (EPS)
  - Lightweight concrete
- Environmental insulating materials
  - Wood fibre
  - Cork/cork granules
  - Newspaper
  - Sheep's wool
  - Hemp
  - Textile residue

14.7.5 Installation of Insulating Materials On and Off Site

- **Open panel:** insulation is typically installed on site once the panels have been erected and before the panel is closed with sheathing material. Insulation must be cut to the correct dimensions carefully installed to fully and tightly fill stud bays. Any joints must be lapped to ensure that there are no gaps. Care should be taken to ensure that the fit and thickness are uniform throughout.
- **Pre-insuldated (Closed panel):** insulation is typically installed in the factory either before the panel is closed with sheathing material e.g. mineral wool roll or slabs, or once the panel has been closed, that is sheathing material has been fixed on both sides e.g. EPS or fibre fill. Care should be taken to ensure that fit and thickness or depth of fill is uniform throughout.
- **Cassettes:** the methods employed to insulate cassettes are largely similar to those of pre-insulated or closed panels.
- **SIPs:** due to the nature of SIPs panels insulating material forms an integral part of the panel itself.

14.7.6 Thermal Bridging

Thermal bridging (may also be referred to as cold bridging) occurs when part of the building envelope is penetrated by a material/component with high thermal conductivity and at interfaces between elements of the structure where there is a gap or discontinuity in the insulation material.

Thermal bridging reduces energy efficiency and allows moisture in the form of condensation (air quality issues and degradation) of materials and issues with thermal comfort, air quality issues and degradation of materials.

Low energy efficient construction – one cause may be thermal bridging.

Thermal bridging typically occurs in walls, windows, doors, roofs and floors. It occurs when a material passes over insulation creating a cold bridge which causes heat to escape in corners, around windows, doors, and in any component. Cold bridges also appear where insulation is unable to make contact in areas such as between rafters, cornered walls where a cavity is discontinuous, or where a steel beam thermally conducts heat and bypasses insulation systems. This occurs as heat flows through the easiest path from a heated space to the outside – usually the path with the least resistance.

Thermal bridging can create other problems. When a surface temperature of an inner face of the wall falls below dew point (condensation saturation point) temperature humidity appears, producing mould. This can create larger U-values in materials and increase thermal conduction. This effect is enhanced where there is no ventilation.

To prevent thermal bridging a series of thermal breaks are incorporated at the design stage. An excellent example of this is in lintels across windows and door openings. Traditionally a single concrete member supported both leaves of cavity walls facilitating the passage of heat. Now a rigid insulating material is used under the traditional cavity insulating fill and thus reduces thermal bridging through cavity gaps. Other materials around window frames are used like cavity closers. Another way to prevent bridging is to combine aluminium frames of windows and doors with a lower thermally conductive material like timber which can internally wrap around the frame. In corners, it can be difficult to avoid bridging

specially with perimeters of solid ground floors. Wall insulation usually can avoid this but it's where cavities can't meet in corners that heat loss can occur. Also walls not meeting adequately underneath the floor slabs can present bridging. Linking rigid insulation in critical meeting points within the wall and the floor can solve most cases. In roofs this can also occur where wall insulation does not connect with loft insulation creating a break in those corners.

14.7.7 Air Tightness

The effects of wind hitting the external envelope of a building affects the rate at which it can lose heated air and enhance infiltration within various building components. Infiltration can happen when many materials are bonded with each other but have been placed poorly and small holes, cracks, or dents appear making the component "leaky" - in other words the building is not air tight. By ensuring a building is air tight, heated air can be prevented from escaping. Usually this occurs at badly fitted windows and doors or between lintels or window sills.

The term "air tightness" can be a controversial one in energy efficient construction methods as it is necessary to reduce infiltration but also important that buildings become self- breathable or ventilated to reduce condensation yet also increase buildings comfort by taking in fresh, breathable air for its occupants. Air tightness tests can be made to determine how much air is escaping from a building. Infrared equipment may also be used to pinpoint exactly where air is leaking.

The importance of careful consideration at the design stage, maintaining a high standard of construction and paying close attention to detailing while assembling components should not be underestimated – each individually or in combination may be as beneficial as physically increasing the amount of insulation. As small as a crack or hole can be, air has an easy way out and can eventually become the main problem in dampness and air leakage in a building.

Ways to reduce infiltration include:

- using insulated sealed doors
- insulated cavity closers around window sills to prevent thermal bridging.

Other than that, a properly fitted window with sufficient sealant and careful cornering can reduce heat loss. Careful consideration should be made to older constructions with single layered walls as cracks and holes in corners are common and if ignored can increase infiltration.

NB: In accordance with the Building Regulations it is a mandatory requirement that developers verify the air tightness of a sample of new buildings on any development. This can be achieved by air leakage testing.

14.7.8 Thermal requirements for intermediate floors

There are no thermal insulation requirements for intermediate floors other than a few exceptions:

- where a floor projects beyond the wall beneath
- where a floor is over an unheated space such as a garage
- where the floor forms an upper balcony
- where the floor abuts a roof space which is adjacent to an attic room.

14.7.9 Building Regulations

Guidance on how to meet the relevant requirements for each of the regions in the UK are given

in the following publications and associated documents referenced within:

- England and Wales: Approved Document L (Conservation of fuel and power)
- Scotland: Technical Handbook Section 6 (Energy)
- Northern Ireland: Technical Booklet Parts F1 & F2 (Conservation of fuel and power).

These should be read in conjunction with the relevant associated documents. It is essential to have an understanding of the requirements for fire performance in timber frame construction.

14.8 Fire performance considerations

Party walls, or separating walls, separate dwellings or areas of different purpose groups or occupation from one another. Party walls may also be used to divide buildings with large floor areas into smaller compartments to provide greater safety in the event of fire.

Party walls must provide a continuous vertical barrier to fire for the full height of the building including the roof space.

Party walls typically comprise two independent frames with a cavity between them. The frames are typically disconnected unless party wall straps are specified to provide restraint.

All buildings must provide the degree of Fire Resistance as set out in the Building Regulations.

14.8.1 Walls and partitions

Generally 30-minute fire resistance is provided by 1 layer of 12.5mm Plasterboard and 60 minutes by two layers.

The 12.5mm + 19mm plasterboard + insulation used on party walls for sound also meets the necessary fire requirements.

14.8.2 Floors

30-minute fire resistance is generally provided by:

- 38 mm (min) breadth solid timber joists at 600 mm centres
- any structurally suitable floor decking (15 mm min)
- 12.5 mm plasterboard ceiling fixed to joists (and noggins at board edges) with joints taped and filled.

60-minute fire resistance is generally provided by:

- not less than 30 mm plasterboard laid perpendicular to joists with joints staggered, joints in outer layer taped and filled. Edge joints in outer layer supported by noggins where required.

Note – fire integrity of engineered wood joists will be verified by the component manufacturer.

Where necessary the designer should be able to advise the architect on both the appropriate fire resistance requirements and on how this is best achieved on a timber frame building.

14.8.3 Fire Stopping

Fire stops provide a seal to close an imperfection of fit or design tolerance between elements or components, to restrict the passage of fire or smoke.

Designers should ensure that fire stops on dwellings are indicated:

1. **At the top of a compartment (party) wall taken up to the underside of a roof covering** to maintain the continuity of fire resistance. Eaves voids must be closed off at party wall locations. These are both formed by the use of

Activity
Describe how the fire resistance requirements for a timber frame building are shown in your documentation.

compressed mineral wool.

2. **Around pipework, SVPs, stacks, extract ducts and flues where penetrating compartment floors**. This is normally formed by the use of proprietary intumescent collars.

14.9 Connections

- Joist hangers
- Face fix
- Top fix
- Light, medium and heavy duty
- I-joist specific
- Open web beam specific
- Truss shoes
- Skewed
- Specials
- Clips for multiple members
- Clips for noggings
- Restraint straps
- Tie-down straps
- Party wall straps
- Truss clips
- Nail plates
- Soleplate anchors
- Angle brackets
- Framing anchors
- Wall ties – standard and high movement
- Fasteners and fixings
- Collated screws
- Collated nails
- Structural screws

Furher reading on timber connections:

Hairstans, R. (2010). Off-site and modern methods of timber construction – a sustainable approach (1st ed.). High Wycombe: TRADA Technology Ltd.

14.9.1 Dowel type fasteners

According to BS EN 1995-1-1 Section 8, nails, staples, bolts, plain steel dowels and screws

are categorised as dowel-type fasteners. Furthermore, split ring, shear plate and toothed plate connectors as described in BS EN 1995-1-1 8.9 and 8.10, require the use of bolt, nut and washer sets to complete the connection and therefore dowel-type fasteners principles apply for these connectors as well. The connection specification depends on the load-carrying capability of the fastener and on the embedding strength of the elements being connected.

14.9.2 Multiple fastener connections

In the case of multiple fastener connections, the load-carrying capacity of the combined fasteners is smaller than the summated load-carrying capacity of the separate fasteners. When specifying such connections the learner must consider spacing rules and angle of the connection, amongst others.

14.9.3 Nailed connections

In general, nail spacing is dependent upon the load-carrying capacity parallel to the grain. If the characteristic density of the timber is greater than 500 kg/m^3 and the diameter of the nail exceeds 6mm, the timber should be pre-drilled.

14.9.4 Bolted connections

Bolts are dowel-type fasteners with heads and nuts, which should be tightened so that the members fit closely and should be re-tightened when the timber has reached equilibrium moisture content.

Bolt holes should be no more than 1mm larger in diameter than the bolt.

The spacing between bolts depends on the angle and location of the connection.

14.9.5 Dowelled connections

Dowels are slender cylindrical rods made of steel, whose minimum diameter covered by the regulations is 6mm. The maximum dowel diameter is 30mm. The spacing of the dowels depends on the angle and location of the connection.

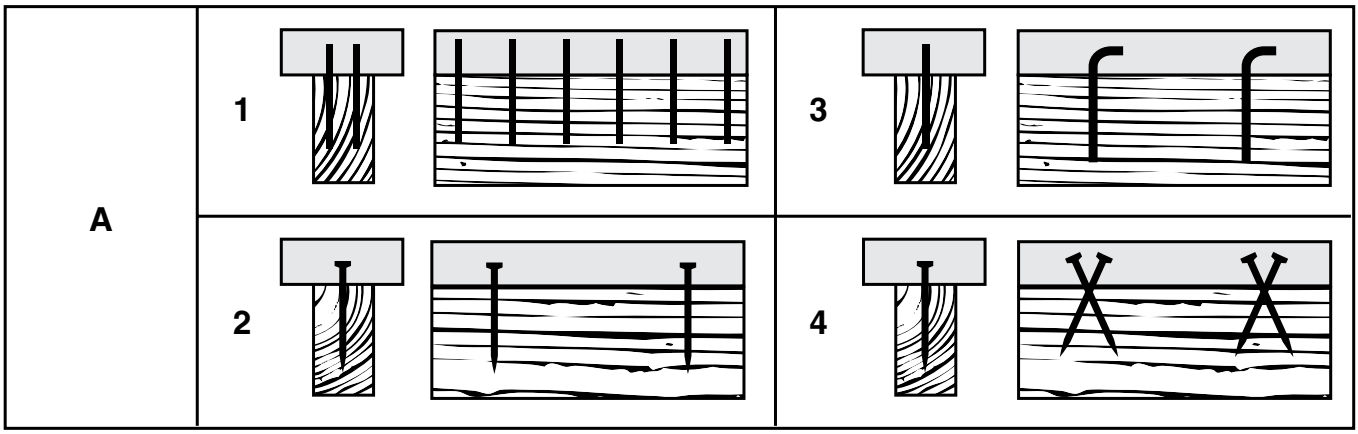
14.9.6 Screwed connections

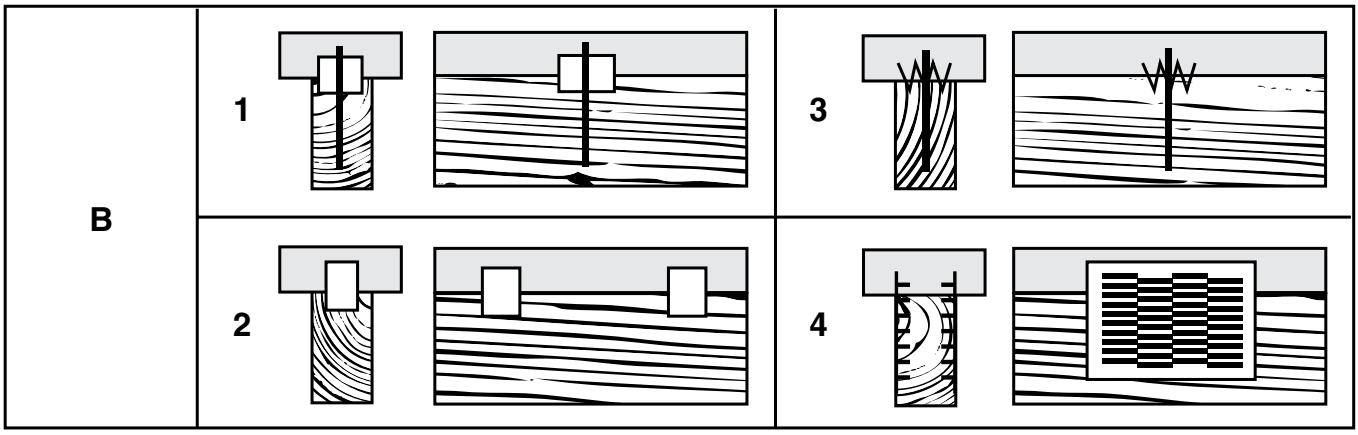
Typical wood screws are coach screws, countersunk screws and

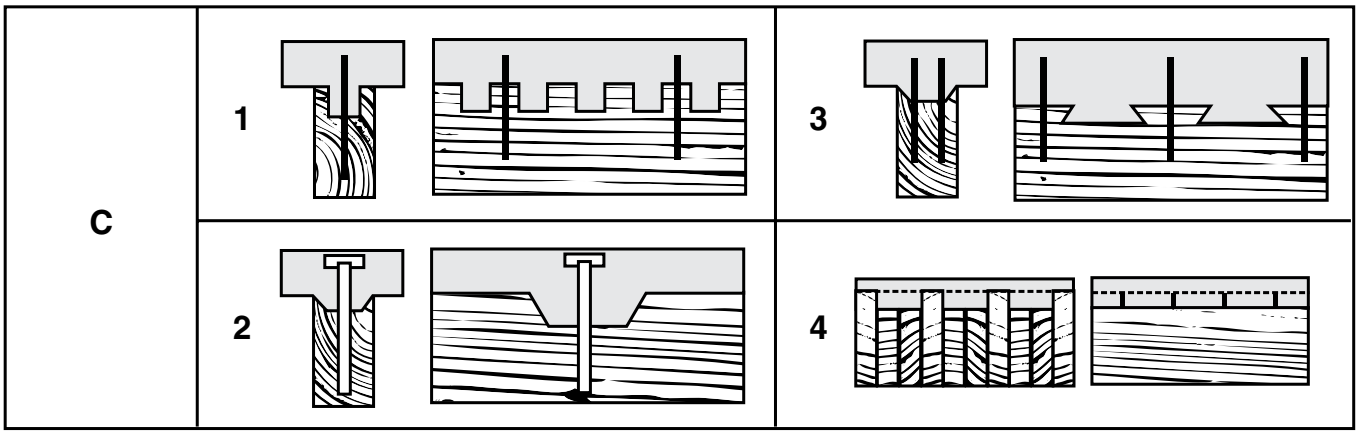
Activity

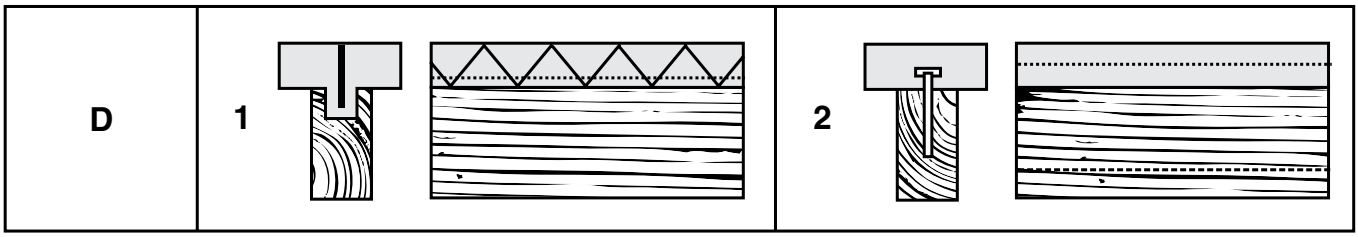
Before using these standards references check if they are still in use, standards become outdated as knowledge and technology advance.

Examples of timber connection details.









round head screws.

Wood screws are mostly suitable for steel to timber and panel to timber connections. If the screw diameter is larger than 5mm, holes should be pre-drilled to avoid splitting the wood.

For laterally loaded smooth shank screws with diameter less than 6mm, the rules for nail connection spacing apply and for those with d>6mm, the spacing rules for dowels apply.

14.9.7 Split ring and shear plate connection

There are many types of split ring and shear plate connections. Ring and shear plate connections vary in diameter between 60mm and 260mm. Split ring and shear plate connections require special consideration to the spacing, end and edge distances of the connectors in a connection.

14.10 Services

Services in open panels are most commonly installed on site once the panels have been installed, whereas services in pre-insulated or closed panels may be installed on site, installed in the factory, or a combination of both.

Care should be taken when cutting, drilling and notching studs and noggings to route services to ensure that the panel and its components retain their structural integrity.

I-joists may have pre-punched knock-outs along the length of the web which can be readily removed to create holes for services. Open web beams allow services to be routed through their webs without creating holes.

Service runs may be incorporated within closed cassettes, in which case care should be taken to ensure that the continuity of the insulation, wherever present, isn't compromised.

A service zone or service void may be created by vertically strapping the panel on the internal face and adding another lining to the straps. This avoids penetrating the wall panel itself and service boxes can be mounted on the innermost lining. Services can be readily installed in the service zone before it is closed.

Installing services in party walls is generally avoided but where this has been specified care should be taken to ensure that they do not affect the acoustic, thermal or fire performance of the party wall. Where service boxes are installed in party walls they should not be located back to back. Installation of services in a party wall should be taken into consideration at the design stage.

Services should be routed in accordance with the specification in an economical manner. Where appropriate access panels should be installed to allow maintenance and repairs.

14.10.1 HVAC and MVHR

Heating, ventilation and air conditioning systems (HVAC) are the services which most directly effect the occupant's environments. The HVAC systems will generally be specified by a mechanical engineer or by a specialist consultant, as the systems need to be sized correctly for the room size and occupancy numbers. HVAC systems consist mainly of boilers, coolers and air pumps.

Mechanical Ventilation Heat Recovery (MVHR) systems utilise hot air emitted from the warmer areas such as kitchens and showers

and utilise the heat to heat the fresh air entering the building through the ventilation system. These systems are specified and installed by specialists.

In the production and construction drawings relating to HVAC and MVHR the timber frame designer should ensure that the opening sizes, locations, equipment clearance and routing are all correctly incorporated in the timber frame drawings.

For further information on the energy saving properties of HVAC and MVHR systems and how they are practically used the learner should refer to the CTV046 Heating Ventilation And Air Conditioning and Heat Recovery Guides by the Carbon Trust.

https://www.carbontrust.com/media/7403/ctv046_heating_ventilation_and_air_conditioning.pdf

https://www.carbontrust.com/resources/guides/energy-efficiency/heat-recovery/

14.11 Cladding

Cladding is a typically non-structural external skin/façade or coating. Although it can play a structural role by contributing to the transfer of wind and impact loads the primary function of cladding is to provide durability, weather resistance and architectural character.

Some other functions served by cladding are:

- contribution to the control of the internal environment
- reducing sound transmission
- providing thermal insulation
- contribution to the reduction in spread of fire
- providing an air tight envelope

Cladding can generally be separated into two broad categories:

- self-supported cladding: supported on the foundations and tied back to the structure
- fully supported cladding: fixed to and fully supported by the timber frame structure.

Some examples of external cladding types are:

- brick
- block with a cement render
- tiles
- slates
- timber boards
- render on battens
- timber or metal panel or system specific render systems with integrated insulation.

Timber boards cladding.

Render cladding.

Brickwork cladding

14.12 Water tightness

Timber structures should be suitably protected from the effects of moisture and have a good level of air tightness. It is necessary to ensure that under normal conditions surface mould on walls and condensation are avoided and that air leakage is reduced. In timber frame walls, thermal insulation is typically packed between the studs, thereby maintaining internal surface temperatures above the dew point and preventing condensation.

Because timber frame buildings incorporate high levels of insulation within the structural elements and can achieve U-values significantly better than the minimum building requirements then water vapour must be adequately controlled.

By ensuring a building is air tight, a reduction of heated air can be prevented from escaping. It is important for the purposes of energy efficiency and thermal comfort of occupants for the building to have a good level of air tightness. As well as increased levels of insulation it is important to reduce air leakage, both warm air leaking out and cold air leaking in. Air leakage must also be reduced such that any benefits of energy efficient heating systems aren't negated.

Water tightness of buildings is achieved by good detailing of the building envelope and by the provision of suitable damp proof courses (DPC) and membranes (DPM).

DPCs should be installed below all ground floor walls, including internal partitions, to protect timber from rising damp and residual construction moisture. DPCs, water-bars and trays should be fitted at openings where needed to prevent rain penetration.

In Scotland, Northern Ireland, the Isle of Man and other places where the exposure to driving rain is Severe or Very Severe, masonry should form a rebate at the reveals of openings to avoid a straight through joint where the frame abuts the masonry.

Breather membranes and other barriers should be lapped so that each joint is protected and moisture drains outwards.

Exposures are defined in NHBC Standards Chapter 6.1, 'External masonry walls' Appendix 6.1-A . A cavity should be provided to reduce the risk of rain penetrating to the frame.

The cavity should be extended at least 150mm below DPC, to form drainage to the cavity by forming a sump to allow water to seep away. This cavity should be kept clear. Weep holes should be provided where necessary to prevent water build up in the cavity.

14.12.1 Vapour Control Layer

In order to reduce the amount of water vapour entering the structure which would then condense as a result of the temperature differential then the internal face of the frame needs to have a greater resistance to water vapour than the external face of the frame. This is achieved by providing a vapour control layer (VCL) on the internal faces, typically behind the linings, on the warm side of the last layer of insulation. Although the VCL may be polythene (or similar) sheathing affixed to the frame it may also be incorporated in the lining e.g. vapour check plasterboard which has a VCL laminated on one face.

Surfaces should be dry and free from dust or debris before the breather membrane is fitted.

The VCL should be securely fastened, lapped at joints and

corners of openings and maintain continuity over the wall surface. To ensure the building envelope is air tight the VCL should be sealed at joints, junctions, corners and openings using a suitable tape or sealing strip compatible with the membrane and as per the manufacturer's instructions. Ripples or folds in the membrane must be avoided. If it is absolutely necessary to incorporate folds at any locations, it is important to ensure that the seal is adequate. Any service penetrations must be adequately sealed.

Cavities should be of a suitable width and adequately vented or ventilated (depending on the location) to prevent the risk of external moisture penetration, prevent the build-up of moisture and allow a degree of movement of air.

Any damage to the VCL e.g. tears or punctures, should be repaired as the damage occurs, using the same material, adequately lapped around the existing material and securely fixed and sealed as appropriate.

14.12.2 Air barrier

Typically, the VCL also serves as a continuous air barrier and improves air tightness by reducing air leakage. In timber frame construction where the VCL is incorporated in the fabric of the building to control moisture it is also the most common means of providing the air barrier. In addition to reducing condensation, as described above, it is also important to provide a VCL to increase the air tightness of the building envelope for the purpose of improved energy efficiency and thermal comfort.

The most effective means of creating an air barrier in timber frame construction is with the VCL, as it can be sealed appropriately, gaskets can be readily provided around service penetrations and tears and/or punctures can be easily repaired.

Alternative means of providing an effective air barrier other than the VCL are:

- wet plaster internally ensuring all elements are covered at junctions, joints and corners
- sealed composite dry lining, sealed using tape or similar around all junctions, joints and corners between the sheathing material e.g. OSB, lining e.g. plasterboard, or other panel systems.

Whatever the means of providing an air barrier it should be installed at first fix and sealed at second fix. It is typically the responsibility of the insulation contractor or the post services contractor to install the air barrier.

14.12.3 Breather Membrane

A breather membrane repels water but is permeable to escaping water vapour. One of the key aspects for ensuring good long-term durability of the structure involves keeping the timber frame dry by providing a drained and vented cavity between the timber and outer cladding.

Reflective breather membranes improve the thermal performance of timber frame walls. The reflective coating reflects heat during warm months and reduces heat loss by inefficiently emitting heat in colder months.

The breather membrane should be installed on the cavity side of the structure.

It is important that the breather membrane is installed correctly and accurately and that it incurs no damage during installation or once it has been installed.

Surfaces should be dry and free

from dust or debris before the breather membrane is fitted.

The breather membrane must be of the correct specification and must be fixed and lapped in accordance with the manufacturer's instructions.

The breather membrane is most typically fixed at regular centres using staples. It is important to observe the staple type, fixing pattern and fixing centres to ensure that the breather membrane is installed correctly and in accordance with the specification.

The breather membrane should be securely fastened, lapped at joints and corners of openings and maintain continuity over the wall surface. Stainless steel staples are most commonly used. Ripples or folds in the breather membrane must be avoided.

PVC strips or similar should be positioned on top of the breather membrane at stud positions to reinforce the membrane and simplify the correct location of wall ties where appropriate i.e. the strips clearly identify the position of the studs.

Any damage to the breather membrane e.g. tears or punctures, should be repaired as the damage occurs, using the same material, adequately lapped around the existing material and securely stapled.

14.12.4 Warm Side of a Timber Frame Structure

The warm side of a timber frame structure is that beyond the internal side of the last layer of insulation.

14.12.5 Moisture Content of Timber Frame

In general, solid timber is typically installed at around 16-18% moisture content, and not greater than 20%, but reduces down to around 10% in a heated building in service.

NB: Timber must be kept at a moisture content below 20% because at moisture content between 20% and 30% there is a risk of fungal attack, subsequent material decay and subsequent structural failure (BS EN 1995, Section 5 Durability).

14.12.6 Considerations Prior to Installing Internally

Surfaces should be dry and free from dust and debris. Ensure everything is correctly fitted and sealed before fitting any linings.

Membranes should be fitted from the lowest level up to prevent any moisture which may run down the wall from running behind them.

Window and Door Openings

Membranes should be lapped into openings, at the corners of openings and be adequately sealed as appropriate and in accordance with the manufacturer's instructions.

Internal Walls

Where internal walls/partitions abut external walls they must not penetrate the air barrier. As such, internal walls should be installed once external walls have been completed.

Services Penetrations

Membrane must be cut at locations where services e.g. pipes, ducts, cables, pass through. Where this is the case gaps around services penetrations and the membrane must be sealed using compatible tape or suitable proprietary sealing system as per manufacturer's instructions. Cavity barriers and where relevant fire stopping should be installed.

Cavity barriers

The cavity should be vented or ventilated (depending on location) although it is not necessary to provide through ventilation.

Ventilation slots should be placed to prevent the ingress of rain or should be below the lowest timber. Weather protected proprietary ventilators are available.

Cavity barriers are provided to close a concealed space against penetration of smoke or flame or provided to restrict their movement.

Designers should ensure that cavity barriers on dwellings are indicated at the following locations:

1. Above the enclosures to a protected stairway in a dwelling house with a floor more than 4.5m above ground level. Additional plasterboard is usually used to provide a fire resisting ceiling over the protected stairway (England and Wales).

2. Sub-dividing cavities that would otherwise form a pathway around a fire separating element and closing the edges of cavities. Horizontal and vertical cavities between two compartment walls or floor are usually filled by mineral wool around the perimeter of the cavity. Additionally the cavity at roof eaves voids should be closed off fire stops which have passed a 60-minute fire test.

3. At the junction between an external cavity wall and a compartment wall that separates buildings. A polythene sleeved mineral wool 'sock' is usually used in these positions.

4. At the top of external cavity walls. Cavity closed as item 3.

5. Around openings (such as window and door openings). Proprietary manufacturer's joinery fixing mouldings may also serve as cavity barriers, where tested for such application or approved.

Timber cavity barriers may be used in place of the mineral wool 'sock' where appropriate.

DPS should be installed around cavity barriers and cavity trays on horizontal barriers.

14.13 Differential movement

As the timber frame dries it shrinks and the overall height reduces resulting in differential movement between the timber frame and other parts of the structure. The compression on the connections is also affected by differential movement. The timber frame elements may move differently to the cladding or other members adjacent to the timber frame elements. This difference between the movement of the cladding and the structure is termed differential movement.

The magnitude of differential movement increases as the structure increases in height - that is higher structures such as those of multi-storey construction will have a greater degree of differential movement as you travel up the structure. An accumulation of these dimensional changes results in the greatest movement being at the top of the structure.

It is important that differential movement is taken into consideration by designers and site personnel. As timber dries out, its cross-section shrinks and the structure settles.

Timber is stable in the longitudinal direction. However, some shrinkage is possible across the grain. This means an allowance has to be made in the floor zone where

joists are lying 'across the grain'. The difference between the timber frame movement and the external brick is the differential movement.

14.13.1 Why differential movement occurs

The main contributing factors to differential movement of the timber frame are:

- changes in moisture content of timber members
- compression of timber members under load
- closing up of joints and connections under load.

Because of the effects of moisture upon timber its dimensions change in relation to its moisture content. As timber dries its moisture content reduces and it shrinks. Conversely as timber becomes wetter its moisture content increase and so it swells.

Dimensional changes in timber do not occur equally in all directions. Generally dimensional changes in timber will be greatest tangentially/parallel to the growth rings and less so radially/perpendicular to the growth rings. The dimensional stability of timber in the longitudinal direction/along the grain is greater yet some shrinkage may still occur although it is likely to be minimal.

Solid timber is typically installed with a moisture content of around 16-18%, and no greater than 20%. Once enclosed the moisture content of the timber in a building will reduce and the timber shrink over a period of time.

The majority of movement in the frame generally occurs within the floor zone as the concentration of timber members which are oriented horizontally tends to be greatest in these areas i.e. wall panel top rail, head binder, joist, soleplate, wall panel bottom rail etc.

Cladding materials also change dimensionally over time but not in tandem with the timber elements.

Building elements will change dimensionally to a different degree and at different rates. Provision must be made to allow such dimensional changes to occur within the structure without sustaining damage.

As the structure is loaded joints and connections between members and elements will also close up to some extent and also contribute to differential movement.

It is generally good practice to 'pre-load' the timber frame structure prior to completion by installing the roof covering e.g. concrete tiles, internal linings and loading out floors prior to installation of external cladding provided that doing so is within structural limits.

14.13.2 Where the differential movement occurs

Differential movement typically occurs at the following locations in a building:

- floor zones
- openings – e.g. at sills, lintels, around windows (depending on construction)
- roof verges and eaves (masonry must stop short of soffit or rafters)
- masonry cladding – typically self-supporting
- non masonry cladding e.g. steel sheathing, timber boards – differential movement between the cladding and the timber frame. May be fixed to the frame
- at locations where timber overhangs brickwork
- flues and chimneys, including false chimneys
- overflow pipes and soil vent pipes
- balconies
- traditionally constructed stair cores

Activity
Provide a sketch elevation of a house indicating the locations of the cavity barriers.

Activity
At what positions should an allowance for differential movement be made and how are these shown on your drawings?

- lift shaft enclosures
- services e.g. soil vent pipes, cables etc. (services running vertically must take into account the shortening of the building).

The degree of differential movement may be more apparent in some locations than in others and increases as the building. Adequate provision for movement must be provided as appropriate.

14.13.3 Implications

As elements which interface with one another change dimensionally at different rates and magnitude allowance must be made to allow movement at such joints. Direct abutment must be avoided to prevent damage from occurring as a result of differential movement.

Any material or component attached to the timber frame structure which overhangs (e.g. cladding, sills, roof eaves) or projects through (soil vent pipe, balconies) the masonry must have an adequate gap which permits the occurrence of differential movement without causing damage to the structure or cladding.

Adequate gaps must be provided between such elements. Gaps must be filled using a compressible sealant or spacers to seal and create a flexible joint. The requirement and location for the provision of movement joints will be dependent upon the design and construction. Refer to drawing details, specification and manufacturer's instructions.

The differential movement between timber and masonry elements becomes greater higher up the structure and gaps become larger.

That being the case provision must be made in upper storeys for this increased movement.

Use of high movement wall ties for levels above 3 storeys where differential movement is likely to exceed the capacity of standard wall ties

To ensure weather tightness it may be necessary to provide flashings to certain elements and at certain locations. Check design, spec and drawings.

Any material or component attached to the timber frame structure which overhangs or projects through masonry cladding must have an adequate gap beneath it to allow differential movement to take place without damage to the structure or the cladding.

Gaps should be explained and their filling specified.

14.13.4 Follow-on trades

The trades responsible for installing affected elements must be briefed and understand the purpose and necessity of providing movement gaps at the locations given above.

To summarise and reiterate, movement gaps should be incorporated in or at:

- floor zones
- openings – e.g. at sills, lintels, around windows (depending on construction)
- roof verges and eaves (masonry must stop short of soffit or rafters)
- masonry cladding – typically self-supporting
- non masonry cladding e.g. steel sheathing, timber boards – differential movement between the cladding and the timber frame. May be fixed to the frame
- at locations where timber overhangs brickwork
- flues and chimneys, including false chimneys
- overflow pipes and soil vent pipes
- balconies

- traditionally constructed stair cores
- lift shaft enclosures
- services e.g. soil vent pipes, cables etc. (services running vertically must take in to account the shortening of the building).

Where possible during the design process allowance for all following service trades should be made.

Solid studs and joists should not be notched unless approval is given by the engineer.

4.14.5 Reducing vertical shrinkage

Vertical shrinkage can be reduced by:

- using engineered wood products e.g. I-joists, open web joists, LVL, Glulam or super-dry timber. These have a lower moisture content, will have been protected from the elements prior to installation and are more dimensionally stable than solid timber
- where solid timber sections are used in floors and walls try to limit the quantity of cross-grained timber that is used as much as is practicable
- ensuring that the design and construction make allowances for settlement
- ensuring that adequate gaps are left to take up the downward movement of the frame
- keeping timber materials as dry as possible
- good workmanship – tightly fitting joints etc.

14.14.6 Control Measures (to Reduce Issues On Site)

Control measures/precautions should be taken on and offsite to reduce potential issues with differential movement:

- ensuring timber materials are kept dry prior to and during construction wherever practicable and in accordance with manufacturer's guidelines.
- design, specification and installation of high movement wall ties, gaps etc.
- leave adequate gaps and fill to create movement joints
- correct and accurate design and detailing
- workmanship
- ensure correct gap filling method and spec. Check compressibility of materials.

Movement joints should be provided to adequately accommodate expected movement and should be detailed and constructed such that they accommodate the expected amount of movement, are weather resistant and durable and are covered by a protective material where expected movement exceeds 35mm.

Activity

Explain how the following on trades could damage the timber frame structure and what they should do to prevent this: joiner, plumber, electrician.

15. Site Work

15.1 Site visits and inspection

All designers should visit site with senior staff members during training. They should be guided through the inspection of the kit to widen their understanding of practical building methodology.

This is an important part of the learners career development and CDM/H&S understanding. Visits should be conducted in full accordance with the Health and Safety requirements for building sites. After a period in the design office, when enough experience has been acquired, they should be able to visit site and carry out an inspection independently. A designer visiting site to inspect a kit should establish that the fundamental structural design principals have been correctly implemented.

This should ensure that the engineer's calculated structural requirements are all in place and that the timber frame kit has been manufactured and erected correctly. Any errors should be recorded (including photographs) and reported in writing.

Examples of reported site errors:

- studs not aligning with loads above
- floors not blocked under point loads
- floor joists incorrectly notched or drilled
- connections / hangers not correctly fixed etc
- soleplates incorrectly fixed
- gaps in insulation
- cavity barriers incorrectly positioned
- tears in breather paper not repaired correctly.

15.1.1 Verbal reports / instructions

Verbal reports and instructions should not normally be given directly to site personnel but items found should be reported back through the correct communication channels. The designer can discuss and enquire regarding construction methods to gather more information, however the instruction must be issued in written form.

15.1.2 Written reports

The designer should prepare a written report if necessary pointing out any areas of concern to the structural engineers and any other personnel.

Reports should include:

- site location
- date of inspection
- area inspected
- areas or items that were inaccessible or covered up
- items of non-compliance
- recommendations to ensure compliance.

The designers focus should concentrate on the structural items in the kit but also report any material or kit deficiencies in general to the required personnel.

15.1.3 Benefits of site inspection

- Designers are very familiar with the details of the timber frame and are able to identify errors
- Suggestions on improvements in the erection may be made by the designer
- Suggestions on improvements in the design may be made by the erector
- Designers gain a better understanding of practical construction
- Construction methods and order of work can be improved.

15.1.4 Suggested site visit intervals

- Ground floor and soleplate construction
- After initial panel erection
- When the roof has been constructed.

Activity

List the main points you raised during a recent site inspection.

16. Final Review

Congratulations!

On behalf of the STA and CITB we hope you have enjoyed this workbook on Practical Skills for Timber Frame Design.

As a reminder we have included below a simple checklist for you in this final review. When arriving on site you should now know what key points to consider before you start work.

Most importantly, once you have been assessed on these Practical Skills in combination with Health and Safety and Knowledge training, you will have reached a level of qualification the industry wishes all timber frame designers to achieve over the next few years.

We hope that you will feel sufficiently pleased with your training experience to encourage other colleagues to use this training and to continue their own personal development.

For most of us our home is our largest expense and we expect it to be built to the highest standards by well-trained and suitably qualified people. By using these Workbooks, we as an industry, can now provide you with the opportunity to achieve this goal. Also by having a qualified workforce we can compete with the rest in quality & workmanship.

Thank you for taking part in this training experience and we hope you will enjoy a successful and satisfying career in our Timber Frame industry.

Summary

Below is a summary of the main points discussed in this workbook:

- Projects generally start with the client instructions, which include a design brief, architect's drawings, specification, structural mark-up, foundation layout and manufacturer's stock availability.
- The Drawing Office will produce the sole plate drawing from the architect's drawings and specification paying particular attention to the ground floor finish, wall thickness and location of any load bearing elements.
- Layouts provide the arrangement of components at each floor level throughout the structure, including the roof. Layouts are 2D planar views from the top looking down towards the floor levels. Layouts are typically drawn as horizontal sections taken at 1.2m height from the floor level so that the doors, windows, etc can be included, however this can vary especially with roof plans. Special symbols and drawing line stiles are used for the different components that form layouts and every drawing office uses their developed standard layout templates.
- It is the responsibility of the Drawing Office to ensure that within the Manufacturing drawings:
    - Orders are programmed correctly
    - Manufacturing drawings are accurate, current and correct
    - Sole plate and site drawings are accurate, current and

correct
    - That there is effective communication and liaison with the Engineer
- Typical Manufacturing drawings are roof systems, floor systems, wall systems and steel elements.
- There are many saw types and the most suitable one should be specified for each component.
- Loads are crucial to structural timber design. The most often designed for loads are vertical (dead, live and roof loads), horizontal (wind and uplift) and disproportionate collapse. Load drawings and loading lists convey information regarding permanent and temporary structural loading.
- The aim of the Drawing office is to produce drawings to a high standard. The term 'drawing' refers to a physical sheet of paper with graphics, text and a title block. The equivalent in Computer Aided Design (CAD) terms is the 'drawing file', which is produced from an assembly of model files and drawing templates with notes and dimensions. Only when the 'drawing file' is plotted on paper to a particular scale is the traditional drawing produced.
- In addition to CAD technology, the learner may work with Building Information Modelling (BIM), in which drawings are produced from a single 3D model with information attached to each building component. With BIM different drawings are updated automatically and simultaneously with changes in the model. Furthermore, schedules of components can be generated and updated automatically.
- Critical aspects of drawings production are: line work, annotation, notes, grouping, sheet size, scale, number, title blocks and revisions management.
- Certifications are voluntary schemes, which ensure and guarantee the quality of the construction product. Compliance with standards is compulsory on all projects. It is of utmost importance that the timber frame designer is familiar with the certification schemes used by their company. Popular schemes are NHBC and Exova BM TRADA Q-Mark.
- All buildings must comply with the current building standards, specific to each country of the United Kingdom: England, Wales, Scotland or Nothern Ireland. Buildings must also comply with the structural Eurocodes, enforced in the UK as BS ENs. Timber certification and grading are important for forestry management and structural performance, respectively.
- The company the learner works for will likely have an archive of standard construction details. These provide a useful starting point for technical design and studying them will be a great introduction to detail standards. However, the learner should be aware that the details need to be modified for the specific project. Moreover, new improved details will be added continuously to the detail library so the learner should ensure they refer to the latest versions.
- Office procedures are both useful and imperative for the design of timber frame buildings. The learner may already be familiar with some of the procedures in the company they work for. Standardised templates, drawing, revision and quality control procedures ensure that any work produced in the drawing office of your company is of consistent quality and accuracy. Drawing, revisions, checks, issues, time management and quality control are critical office procedures.
- There are a large variety

of projects, which can be constructed using timber frame. The most typically constructed timber frame projects are residential, however the benefits of timber products such as low embodied carbon and healthy indoor environment, are also relevant to education and commercial buildings. The number of timber buildings is increasing constantly both nationally and globally, facilitated by the introduction of engineered timber products, whose structural qualities are comparable to steel.

- Design considerations for wall, floor and roof elements are connected to the most up to date Building Regulations and British Standards.
- Construction, production, acoustic, thermal, fire, connection, water tightness and differential movement considerations must be investigated thoroughly per every individual project and resolved holistically, in line with the current Building Regulations and British Standards.
- The learner will benefit greatly from regular site inspection, which should focus on CDM, Health and Safety and structural compliance inspections. A combination of practical site knowledge and theoretical regulations understanding will enhance the quality of the learner's work.

These workbooks have been prepared by the Structural Timber Association, in conjunction with CITB, on behalf of the industry.

STA and CITB operates a continuous improvement policy and would therefore be very grateful to receive any review comments for further editions.

Thank you.

Candidate and supervisor's final sign off

On completion of this workbook the named candidate and authorised supervisor are required to complete this final sign off declaration to confirm that:

- All aspects of the workbook have been successfully completed by the named candidate in accordance with the workbook and scheme requirements
- The named candidate has met the minimum experience requirements (1 year) in accordance with scheme requirements
- The named candidate is ready to register and undertake the online test.

CANDIDATE NAME	
COMPANY	
TEL No.	
EMAIL	

Candidate declaration

I can confirm that I have successfully completed this workbook in accordance with workbook and scheme requirements, have met the scheme minimum experience requirement of 1 year and am ready to register and undertake the online test.

CANDIDATE NAME _____

CANDIDATE SIGNATURE _____

DATE OF DECLARATION _____

SUPERVISOR NAME	
JOB TITLE	
COMPANY	
TEL No.	
EMAIL	

Authorised supervisor declaration

I can confirm that the named candidate has successfully completed this workbook in accordance with workbook and scheme requirements, has met the scheme minimum experience requirement of 1 year and is ready to register and undertake the online test.

SUPERVISOR NAME _____

SUPERVISOR SIGNATURE _____

DATE OF DECLARATION _____

NOTE: This workbook must be retained and presented for STA audit purposes upon request.

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