



TIMBER FRAME WORKBOOKS

Manufacturing PRACTICAL SKILLS



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1. Introduction and Welcome

1.1 The STA Manufacturing 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.

The Structural Timber Association, on behalf of the industry, has developed this training programme with CITB to provide recognition of the skills and competencies 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 in to 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.

Indrew J. Carphiter

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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The e-Centre

Cooperage Way Business Village

Alloa

FK10 3LY

United Kingdom

Tel: 01259 272140

Fax: 01259 272141

Email: office@structuraltimber.co.uk

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

goconstruct.org



2. Aims and Objectives of the Training

2.1 Target audience

The Manufacturing workbook series is aimed at timber frame manufacturers, all staff who are involved in the manufacturing of timber frame components on the shop floor of a timber frame business.

The manufacturer should be based at a timber frame business for the practical part of their training.

The key responsibilities of the timber frame manufacturers are expected to be, but not limited to, dealing with goods inwards, cutting of materials, assembling timber frame component on benches or using mechanised and automated manufacturing equipment, and quality inspecting and preparing the manufactured timber frame products for despatch.

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 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 allround skills and understanding by guiding you through the topics to be a timber frame manufacturer.

2.3 What is in this workbook

This workbook is divided in to 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 (example given below), 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.



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.



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, which is published by the STA and for STA members is available for free download from the link below:

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

3. Goods Inwards

3.1 Overview

Before we start to look at any Manufacturing or Production skills, stand back and look at the factory from a distance or if you like a 'birds eye' view of the plant.

The first point will be Goods Inward, which is where all the items and stock purchased are delivered and checked.

In the manufacture of timber frame buildings, Goods Inwards has a vital role to play in keeping the production lines open.

You are now required to go and discover for yourself just what the responsibilities of this part of the business have and the main ones for you to note are listed below:

When checking goods:

- General Inspection
- Check quality and quantity
- Dimensions
- Moisture
- Compliance with Purchase
 Order
- Check for any Non conformance

Goods Receipt:

Booking into stock

Non-Conformance:

 Rejection procedures and isolation of return Goods.

Safe Storage, Protection and Identification of:

- Timber
- Engineered timber (e.g. I Beams)
- Board
- Insulation
- Plasterboard
- Steel
- Hardware
- Other items not listed above.

Find out exactly your own Goods Inward procedure then draw your own flowchart alongside.

3.2 Goods inward process

3.2.1 Compliance with the Purchase Order

A purchase order is raised to purchase goods and specifies at the very least the quantity and



Activity

Attach (or draw) and study the Goods Inward process used in your organisation.

description of goods ordered. The PO should be referred to upon receipt of goods to ensure that the goods received are in compliance with those specified on the purchase order.

3.2.2 Goods receipt note

The Goods Receipt Note (GRN) is a record of the receipt of goods at Goods Inward or a similar point of receipt and is used as confirmation that the goods have been received satisfactorily and are in compliance with the purchase order. If goods have been inspected and are found to be satisfactory and in compliance then the GRN can be signed off, the items booked in to stock and the documentation (delivery note, GRN etc.) passed to the appropriate person (e.g. the Accounts Department) for invoice matching in accordance with the standard operating procedure(s).

3.3 Checking goods

Documented standard operating procedures should be in place to detail the process and operations for receipt of goods and corrective actions for goods which deviate from those ordered.

Checking goods upon receipt and any resultant actions taken wherever necessary ensures that the correct items have been supplied in the correct quantities and that steps are taken to rectify any issues at the earliest opportunity where this is not the case.

There may be long lead times for the replacement of items which have been supplied incorrectly or other factors involved which are more readily resolved at an early stage. It may be necessary to review and amend schedules and plans as a result and issues arising as a result of similar errors when identified or highlighted at a later stage in the construction process may have a greater impact on scheduling and planning.

3.4 Moisture content of timber

3.4.1 Overview

Moisture content is the amount of moisture in timber or woodbased material and is expressed as a percentage of its dry weight. The moisture content of timber on receipt is typically checked using a moisture meter which estimates the amount of moisture in the timber by electrical resistance or capacitance depending on the type of meter used.

3.4.2 Importance of moisture content in timber

Timber as a building material (as with any) relies on its durability and for timber this is a measure of its resistance to attack by insects and fungi over considerable time.

The most effective means of preventing fungal attack is to ensure that the moisture content of timber remains below 20%.

Increased resistance to attack by insects and fungi can be enhanced by the application of preservative treatments.

Modern timber frame buildings are therefore treated to provide additional protection against both damp and pests.

These risks are minimised by allowing the wood to dry properly before it is used and downstream by good building maintenance using recommended stains, paints and preservatives.



Explain in your own words what is done and the purpose of each step: General inspection Check quality and quantity Dimensions Moisture The most effective means of preventing fungal attack is to ensure that the moisture content of timber remains below 20%.



Moisture content is the amount of moisture in the timber or woodbased products and is expressed as a percentage of the oven dry weight.

As the timber dries, water is removed from the cell voids, until the fibre saturation point is reached at about 28% moisture content.

After this the water held in the cell walls is removed and the timber starts to shrink.

The equilibrium moisture content is the point at which the timber or wood-based product neither gains nor loses moisture when exposed to a constant condition of temperature and humidity.

Moisture content of timber on site, in the yard or in buildings is generally measured using a moisture meter.

The electrical resistance between two probes provides a reading, which is then converted using a chart into the final value.

The moisture content can be calculated from the formula:

MC (%)= $\frac{(\text{wet mass - dry mass})}{\text{wet mass}} *100$

3.4.3 Practical points

You should also be aware that the movement within the wood due to swelling and shrinkage with changing moisture content is greatest parallel to the growth rings rather than at right angles to them. Movement in the length is virtually nil.

The degree of movement varies between types of wood and for some uses can be a significant factor in the choice of timber.

Strength Grade Markings will indicate the condition of the wood supplied so you must take the appropriate action to keep it in that condition by careful storage or handling etc.

Timber treated with water-borne preservatives must be re- dried to appropriate moisture content after treatment.

I-Joists must be protected from the weather prior to installation and must not be used in applications where they will be permanently exposed to weather, or will reach moisture content greater than 16%.

Moisture content should be maximum 20%.

Timber Joists in multi rise buildings (i.e. over 4 levels) will normally be around 12% moisture content.

Timber is typically installed at 20% moisture content but will reduce to around 10% in the heated building.

As timber dries out, its crosssection shrinks and the structure settles. This means allowances have to be made and will affect 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 and becomes much more of an issue as the building height is increased (i.e. multi-storey).

Overall, ALWAYS keep the timber

- Dry
- Off The Ground
- Well Ventilated

3.5 Other considerations / points to note

3.5.1 Quality and Quantity

A series of standard checks (visual inspection) should be made to ensure that items received are of satisfactory quality, free from



What should be the moisture content of the timber you work with?

What would be the consequences if the timber you were using was above the figure given above?

What precautions MUST be taken with timber used for the manufacture and construction of timber frame buildings with regards to moisture?



Activity

It is best to combine theory with practice. Therefore, measure the moisture content of different sized timber you work with and enter their values below. defects and damage and that the correct quantity has been supplied. The quality and quantity of the goods should be in compliance with the purchase order and specification.

3.5.2 Dimensions

A series of standard checks (physical measurements) should be made to ensure that the items received are dimensionally correct and in accordance with the purchase order and specification.

3.5.3 Checking for Non-Conformance

Items should be (visually) inspected to ensure that they comply with the purchase order and specification. The nature and extent of the inspection shall be related upon the requirements, type and specification of the items themselves and so will vary accordingly.

Typically, goods will be inspected to identify:

- Defects or defective components
- Damage sustained during manufacture, storage, uplift, transit or on receipt
- Issues which have arisen as a result of poor workmanship or manufacturing error
- Items or parts of items that have been supplied in error

3.5.4 Booking in Stock

Standard operating procedure(s) should be in place to detail the process for booking in stock to ensure it is correct, recorded and stored in the appropriate location.

3.6 Safe storage, protection and identification

Factory should have areas for safe storage, stacking and protection of all the materials which they hold in stock and use.

Different materials require different storage conditions and should be stored in accordance with the manufacturer's instructions and recommendations.

The conditions and methods in which goods are stored are important. Storing goods appropriately, under the correct conditions and in the correct manner ensures that their properties are maintained and that no damage or deterioration/ degradation is sustained during storage.

Generally timber materials should be stored off of the ground (e.g. upon bearers), protected from moisture (e.g. covered) and well ventilated (e.g. stacked such that air can circulate).

Typically, storage can be separated in to two broad categories:

- Goods in: raw materials (typically supplied by others)
- Goods out: components, assemblies, units produced in the factory (typically for supply to others).

Some things to bear in mind are when considering storage is:

- Location
- Environmental conditions
- Protection / covering
- Orientation
- Bearing
- Obstructions
- Stacking.

3.7 Stacking and protection of materials

Care should be taken to ensure that components, assemblies or units are not damaged as a result of their own self-weight or by (similar/ batched) items stacked upon them. When stacked items at the bottom of the stack should be capable of withstanding/resisting loads applied/imposed by items stacked upon it or measures put in place to ensure that no damage occurs (e.g. using bearers or packing pieces to support upper loads at hard points). Items should be stacked safely to ensure that stacks are stable and not liable to collapse potentially causing damage and/or injury.

Materials must be stored appropriately, safely, protected where necessary and always in accordance with the manufacturer's instructions.



Protected timber storage outdoors. James Jones.





Find out what the rules for storage of the following materials are in your organisation: Timber Engineered timber (e.g. I Beams Board Insulation Plasterboard Steel Hardware Other items not listed above.



List below the raw materials that will need to be stacked and stored, along with any precautions relevant to each material.



Activity

Having completed the above exercises, you should now be able to prepare a bullet point Job Description for employees in the Goods Inward Department below.

4. Production Information

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 be referred to throughout the entire manufacturing process, specifically during operations such as:

- Selecting raw material
- Sawing timber from cutting programmes or cutting lists
- Marking out
- Manufacturing assemblies and components
- Fitting membranes
- Installing insulation
- Marking positions
- Fitting finishes
- among others:

The specifications should include references to all the materials to be used in manufacture, including any tolerances that must be adhered to. The detailed drawings will be covered in the next Section.

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.

4.1 Drawings

Technical drawings are the starting point of the manufacturing process. All stage of production are dictated by the technical drawings produced in the drawing office. The responsibilities of the drawing office include production of correct production sequence drawings, sole plate layouts, manufacturing drawings and liaise with the engineers. The learner should be familiar with the typical drawing types and how to read them.

Overall, the manufacturing process starts from the drawings, is based on the drawings and if in doubt you should refer back to the drawings.

At the start the learner should familiarise themselves with the scale of the job they will be working on, the time-frame and the overall design. Then you can look into more detail at the standard timber frame elements, their construction, the production schedule, afterwards at the non-standard elements. Finally, the learner should investigate carefully the technical details and visualise how those will be produced.

Important points to consider when working with drawings:

When using any drawing, it is important to only use the dimensions provided and **NOT** to scale from the drawings.

When working with all Production Drawings, Cutting Lists and Loading Lists ensure they have been signed and dated by the person who is responsible for their design. This could also include anything produced by outside persons / companies who are not directly employed your own company.

There will usually be some form of a Check Box for you or someone else to complete on all the Production Drawings, Cutting Lists and Loading Lists. For instance:

- Checked by: Cutting lists, Loading lists
- Cut by: Cutting lists
- Made by : Production Drawings
- Loaded by: Loading Lists



Activity

Make a list below of all the types of Drawings used by your company and highlight those specific to you. Better still make a copy of those you use and insert into this Workbook.

Always add the date and complete any other relevant check box that applies to you.

The Drawing Office should then check that all the details on the

Production Drawings, Cutting Lists and Loading Lists are correct before issuing to the Checking / Finishing Department.

Job completion will normally be recorded in the contract book and dated.

4.2 Production / site drawings and schedules

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 be referred to throughout the entire manufacturing process, specifically during operations such as:

- Selecting raw material
- Sawing timber from cutting programmes or cutting lists
- Marking out
- Manufacturing assemblies and components
- Fitting membranes
- Installing insulation
- Marking positions
- Fitting finishes

among others.

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.

Below are some of the main stages of the manufacture and construction process, the various specifications upon which they depend and those which are typically produced during each stage:

Production drawings aspects:

Dependent upon:

- Architectural drawings
- Specification
- Structural appraisal
- Specifications produced:
 - Production and site assembly drawings
 - Material, cutting and loading lists for production

4.3 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 persons or companies who are not directly employed by the timber frame manufacturer.

It is common for cutting lists 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 To work and excel in the timber frame industry you must be able to read, understand and interpret specifications and drawings.



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 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.

4.4 Specifications

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

4.5 Structural take off

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



1. Why are cutting lists produced?

2. Write down all the cutting lists used in your company.

3. What checks are made on the finished cutting lists and by whom?

4. What problems (if any) are experienced with the distribution and execution of the cutting lists?

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 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. Structural take off aspects:

- Dependent upon:
 - Architectural drawings
 - Specification
 - Specifications produced:
 - Structural appraisal (issued to client)
 - Material take off

4.6 Plasterboard and insulation schedules

- Dependent upon:
 - Architectural drawings
 - Kit drawings
 - Specification
- Specifications produced:
 - Material take off for site and purchasing department

4.7 Sequence of manufacture

Included with the specifications will be the production sequence for the timber frame manufacturing process.

Manufacturing production lines follow set sequences that have been developed to produce maximum output at the lowest possible cost within set boundaries.

Production lines can be broadly categorised as:

- **Manual:** Processes are undertaken by hand by factory operatives. Manual lines have the maximum level of human interaction
- Semi-automated: Mixture
 of manual and automated
 processes i.e. partially
 automated some operations
 are undertaken manually and
 some automatically. Semi automated lines require
 moderate human intervention
 the level of which depends

largely upon the level of automation - the ratio of manual vs automated operations.

• Fully automated: Variety of automated control systems for operating equipment and machinery. Savings can be made on labour and time and improvements made to precision and accuracy, ultimately resulting in a more predictable output and scheduling. Fully automated lines might be mechanical, hydraulic/ pneumatic, electrical, computer driven or a combination of each. Fully automated lines may be left to run continuously without supervision and require minimal human intervention.

The various stages and sequence of manufacture for timber frame construction can broadly divided into a number of steps, although it is important to note that the process will largely vary depending on how the company operates and the methods they employ.

A typical example of the sequence of manufacture is given below:

- Receipt of goods, inspection and storage of incoming materials and supplies
- Transfer of materials to the correct location for storage or processing. (Non-conforming items to quarantine) (material batched appropriately for processing) Preparing materials and tools for the various

operations to be undertaken

- Selection, processing, marking and preparation of raw materials
- Manufacturing of components, assemblies, units (depending on build method)
- Manufacturing and construction of wall and gable panels
- Application of breather membrane and VCL where applicable
- Installation of insulation where applicable
- Manufacturing cassettes where applicable
- Finishing of all manufactured products
- Inspection, quality checks and sign off
- Recoding and reporting of inspection and test results
- Packing (including ancillaries and additional parts as per specification) and protection for transport and storage on site
- Loading for transport
- Completion of all paperwork as necessary at each of the above stages.



Activity

Insert the Production Line flow diagrams on which you work.

Manufacturing production lines follow set sequences that have been developed to produce maximum output at the lowest possible cost within set boundaries.



4.8 Site processes / sequence of events

A typical example of the sequence of construction on site prior to and upon receipt of the timber frame kit is given below:

- Site inspection before
 commencement of work
- Necessary site work undertaken before timber frame kit arrives
- Setting out of sole plates
- Inspection of kit upon delivery
- Organise storage on site
- Start construction

4.9 Gantt charts

Of all the project management tools this is probably the simplest to understand, the easiest to use and the most comprehensive.

It allows you to predict the outcomes of time, cost, quality and quantity and then come back to the beginning.

It helps you to think about people, resources, dates, overlaps and key elements of the process, and you can concertina 10 separate Gantt Charts into one overall chart.

A Gantt chart is a horizontal bar chart that graphically displays the time relationship of the steps in manufacture.

It is named after Henry Gantt, the industrial engineer who introduced the procedure in the early 1900s.

A horizontal line is placed on a chart to show both the task and time period it will take to complete it.

When completed, the Gantt chart shows the flow of activities in sequence as well as those that can be underway at the same time.

To create a Gantt chart, you need to list the steps required to complete a

task and estimate the time required for each step. Then list the steps down the left side of the chart and time intervals along the bottom. Draw a horizontal line across the chart for each step, starting at the beginning date or time and ending at the completion date of that step. It is best to create the Gantt chart using a computer or a tablet, as this makes the process easier and allows for quick edits should the time-line of the project change. Free tools are available on-line, also free Excel templates, however the learner is advised to check what their organisation's standards are for creating and updating Gantt charts.

Some parallel steps can be carried out at the same time with one taking longer than the other.

This allows some flexibility for the start of the shorter steps, as long as the work is finished in time to follow on with subsequent steps. This situation can be shown by a dotted line that continues to when it must be completed.

When the Gantt chart is finished, you will be able to see the minimum total of time for the project, the proper sequence of steps and which steps can be underway at the same time.

You can then use the Gantt chart to track actual progress. This is usually done by drawing a line in a different colour below the original line to show the actual against planned beginning and end dates of each step. This allows you to quickly assess whether or not you are on track to meet customer delivery dates.

Gantt charts are limited in their ability to show the interdependencies of some activities. Where the steps flow in a simple sequence of events, they can portray adequate information for project management. However, when several steps are underway at the same time and a high level of interdependency exists among the various steps, PERT diagrams are a better choice.

4.10 PERT diagrams

PERT stands for Programme Evaluation and Review Technique.

For planning purposes it is more sophisticated than a Gantt chart, because it is best suited to processes with many steps.

In a PERT diagram events or tasks are usually represented by circles or other closed shapes.

Arrows are used to connect the circles or shapes together. A nonactivity can be represented by a dotted line, which could be the time between two events for which no work is required (lapsed time).

PERT diagrams are at their most useful if they show (on the activity line) the time for completing an activity.

Time is recorded in a unit appropriate for the task at hand,

with days being the most common but hours, weeks or even months being occasionally used.

Some diagrams may show two numbers for time estimates - a high estimate and a low estimate.

The most sophisticated PERT diagrams are drawn on a time scale, with the horizontal projection of connecting arrows drawn to represent the amount of time required for that particular activity. This can incorporate slack time in the project.

To draw a PERT diagram:

List the steps required and estimate the time taken to complete each step.

Next, draw a network of the relationships between the steps, keeping in mind the importance of proper sequencing.

The number of the step from your list is written in the appropriate circle to identify that step.

The time to complete the step is shown on the arrow. Several steps can be underway at the same time and are shown on different



Activity

Find out if Gantt charts are used in your organisation and how they are produced. Attach an example to this page of the workbook and make notes on the critical connections between activities. Ask 'why' questions to really understand the diagrammed process. paths. Be sure to include all distinguishable steps.

A PERT diagram not only shows the relationship between various steps but serves as an easy way to calculate the critical path.

The critical path is the path that represents the longest path through the diagram and as such identifies all the essential steps that must be completed on time to avoid any delay in finishing the complete job.

The critical path is shown as a solid line in the example that follows.

A PERT diagram will be increased in value by recording the time taken for each step to be completed.

Actual time can be written over the estimated time to maintain a running tally of actual versus planned time along a critical path. This makes it a useful tool for evaluation purposes later.

It is best to create a PERT diagram using a computer or a tablet, as this will allow for ease of creation and modifications as the project develops. There are free and commercial software packages available for PERT chart creation.



Find out if PERT charts are used in your organisation, for what purposes and how they are created and updated. Attach an example PERT diagram to this page of the workbook and make notes on the sequence of activities. Focus on the critical path and understand its impact on the overall project.



The conventional view of a production process as a conversion process that can be divided hierarchically into sub processes (Koskela, L. ,2000, An exploration towards a production theory and its application to construction, Espoo: VTT Publications)



5. Manufacturing Tools and Equipment

5.1 Overview

Work equipment can be defined as any machinery, appliance, apparatus, tool or installation for use at work. This includes equipment which employees provide for their own use at work.

The use of work equipment can be defined as any activity involving work equipment and includes starting, stopping, programming, setting, transporting, repairing, modifying, maintaining, servicing and cleaning.

The term 'use of equipment' is not necessarily limited to a single operation.

The following operations are examples of 'use of equipment':

- Starting or stopping
- Repairing
- Modifying
- Maintaining
- Servicing
- Cleaning
- Transporting

You must always read the manufacturer's instructions before using a tool. Mistakes can be costly and unnecessary.

5.2 Hand tools

5.2.1 Stanley Knife

A Stanley knife is a handheld utility knife with a short, durable, sharp, replaceable and commonly retractable blade used for manually cutting materials such membranes. The handle is typically hollow providing storage for additional blades.

5.2.2 Measuring tape

A hand-held measuring tape is an essential in your hand tool kit. This is used by propping one end to the start of the measurement and pulling the tape to the other end of the measured area, then noting or marking the measurement.

5.2.3 Jigs

Jigs are templates, which enable manufacturing of repetitive elements to identical standard. You may use jigs for roof elements to ensure a consistent angle or for measurement of distances on standard-sized components.

5.2.4 Hammers

You won't likely use hammers when working in a timber frame manufacturing facility due to the extensive use of nail guns, described below.

5.2.5 Screwdrivers

Screwdrivers may be used in some miscellaneous tasks, however they likely won't be part of your daily tools arsenal.



Can you list below the tools and equipment that you are competent to use? (Hand tools & Power tools)

5.3 Power tools and equipment

5.3.1 Planer Thicknesser

A planer thicknesser or thickness planer is used to reduce the section size of timber materials and/or create finished surfaces. A planer or planer/thicknesser comprises a cutting head or barrel on to which are mounted the cutting knives, a set of rollers which draw/feed the material through the machine and an adjustable table. Material can be run over the table to plane one side of the material or under the table (between the rollers) to reduce the material to the desired dimensions.

Manual hand planers are available and are seldom used in modern manufacture other than for fine adjustment or alteration on site.

5.3.2 Electric drill

Electric drills may be used to create holes in timber. They can be either battery or cord power supplied. It is important to become familiar with using a drill correctly before manufacturing a product, as the technique requires some practice to master.

5.3.3 Impact driver

Impact drivers are similar to electric drills, however they are used for elements which require more power – such as dense woods. Impact drivers have two to three times more torque (turning force) than the electric drills and are therefore used for the most heavyduty drilling tasks. Combination drill and impact driver tools are also available on the market.



5.4 Nail guns

A nail gun is used to mechanically drive fasteners in to timber. The nails can be propelled by a variety of means, most typically using compressed gas or compressed air. The nails themselves are collated, typically bound with paper, plastic or wire in strips or coils in a magazine. Although nail guns using compressed gas or air are most common electric models, either corded (110/240v) or battery powered are available though much less common. See section 1 paragraph 14 also.

Nail guns are used extensively in timber frame manufacture, typically for fixing timber to timber and sheathing materials. Nail guns are used in workshops during assembly in timber frame manufacturing and also on site during erection etc.

Nail guns for timber have built in safety features and typically before the gun can be fired by pulling the trigger the nose guard must be retracted a sufficient distance to activate the firing mechanism.

Nail guns may be mounted on automated CNC machines such as a nailing bridge which can be programmed to fix nails at specific locations.

5.4.1 Pneumatic (Compressed Air) Nail Gun

The most common type of nail gun is the pneumatic nail gun in which the fastener is propelled by compressed air, typically generated by a compressor via an airline.

The compressor generates a constant supply of compressed air into a distributed airline that will have several points to connect air operated equipment to.

Compressed air is released when the trigger is operated and drives a piston and the blade downward, propelling the nail out of the chamber.

5.4.2 Portable (Compressed Gas/Battery) Nail Gun

Portable nail guns generate their power by internal combustion flammable gas is injected in to into a cylinder. A small fan in the combustion chamber vaporises the gas, mixing it with the air before a spark ignites it.

This design typically has a double trigger mechanism. To hammer a nail, you need to pull the trigger and press the barrel up against the surface at the same time.

5.4.3 Positive Placement Gun

Positive placement nail guns have a 'nib' in the barrel which can be placed in a hole and the fastener fired in to the hole. Positive placement nailers are typically used for nailing connectors such as joist hangers, straps or brackets.

5.4.4 Spit Gun

Cartridge guns, commonly referred to as Spit guns (although Spit is a company name much like a vacuum cleaner is commonly referred to as a Hoover) are very high powered and typically used for fixing to concrete and steel. Powder cartridges are used to propel the fastener.

5.4.5 Stick Nailer

Stick nailers may be pneumatic or gas. Nails are bound in-line a strip, typically with paper and adhesive or wire. Each time a nail is fired a mechanism drives the next nail in the strip in to the chamber, ready to be fired.
5.4.6 Coil Nailer

Coil nailers may be pneumatic or gas. Nails are bound in a coil or roll, typically with plastic or wire. Each time a nail is fired a mechanism drives the next nail in the strip in to the chamber, ready to be fired.

5.4.7 Stapler

Staplers are similar in principle to standard nail guns but fire mechanical staples rather than nails. These may be pneumatic or gas operation and staples are typically supplied in strips. Staplers are typically used for fixing sheathing materials.

Manual staplers are available in the form of a traditional staple gun or hammer stapler. These are typically used for fixing membranes such as breather paper.

5.4.8 Screw Gun

A screw gun or driver is similar in principle to a standard drill but has a nose rather than a chuck and designed specifically for driving screws as opposed to drilling holes. The nose accommodates interchangeable bits making screw guns versatile and suitable for the majority of screwing operations. When pressure is applied the clutch engages and drives the screw.

Some screw guns, such as collated model types with collated strips or magazines, have a motor which runs constantly while the trigger is pressed and the screw is driven when pressure is applied to the nose. The depth to which collated screw guns drive screws can typically be set. Collated screw guns are typically used for installing plasterboard or sheathing materials.

Long screw guns are available for fixing deck and flooring materials, negating the need for the operator to bend or kneel.

An impact driver is similar in principle to a screw gun and typically used for high torque operations such as fixing larger fixings which require greater torque to install.



Activity

What nail guns are used in the company you are based? What is the correct way to use each?

5.5 Saws

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 handheld. Saws may be mounted or an integral part of a CNC machine.

6. Production Control

6.1 Overview

Throughout production it is important that checks are made to raw materials, components and completed assemblies to ensure that they meet requirements.

It is important that a system exists which enables effective monitoring and checking of resource, process and outgoing products to ensure quality and consistency and that whatever is produced in the factory complies with the drawings, specifications and standards.

Production drawings should include all references to the materials used in the manufacture, all information necessary for correct fitting and assembly and include allowable tolerances where appropriate.

6.2 Capacity plan

Capacity planning is a key factor 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.

6.3 Production schedule

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, 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.

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 can be

complex to compile and will probably involve computer programmes at some stage during the process.

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.

6.4 Manual job tracking

6.4.1 Notice boards

Work schedules may be handwritten upon physical notice boards and updated accordingly.

Handwritten schedules are easily accessible and adequate for clearly and effectively displaying pertinent information to all relevant personnel, however as they rely on being manually updated and adjusted as situations change they are more prone to human error than an automated system and are readily defaced, adjusted or erased.

Although handwritten schedules are adequate for simple, less detailed schedules they don't typically lend themselves well to more complex and detailed schedules and the extent of information presented is limited by physical space. If the same schedule is to be displayed at multiple points of contact then it is important that all such schedules

Find out what your Capacity Plan includes and what Levels are set.



Activity

You should now collect together the Production Schedules and make copies to insert at this point in the Workbook and be prepared to explain them in full. Capacity planning is a key factor as it defines the production capacity of the factory. These are set limits at which products can be manufactured.



are updated accordingly.

Handwritten schedules may be used in conjunction with computer generated scheduling.

It is important to become familiar with and be able to accurately interpret the company's scheduling methods and systems, how they are delivered and how they are managed.

6.4.2 Job cards

The factory may operate a manual job tracking system such as a physical job card system for control, tracking, planning and reporting on the flow of work in the factory.

Job cards are a manual method of production control, enabling tracking and planning throughout the manufacturing process.

A job card traces the progress of each component and provides the relevant details of a job to be performed in the factory. Job cards are a method of authorising and instructing operators to undertake production work.

The content and format of job cards, the methods employed and the operation of a manual job tracking system are likely to differ from one company to another but are likely to be similar in principal.

Typically, job cards will be created and issued at the start of the manufacturing process then manually populated by operators accordingly at each stage as the component progresses through the factory.

In general job cards will also provide information on the time it takes to complete each key stage of manufacture and the material necessary to complete job. In addition to job tracking job cards are used to allocate material and labour costs and improve factory

process and efficiency.

Job cards may include information such as:

- Component details
- Associated operation
- Operator identification
- Quantity to be manufactured
- Planned manufacturing schedule
- Time allowance / actual time taken
- Any additional instructions, comments and/or notes
- Inspection report
- Destination of the component (following most recent or previous operation)

6.5 Automated job tracking

6.5.1 Computer generated schedules

Computer generated schedules are more easily adjusted, updated, maintained, managed and disseminated than manual schedules. It's easier to ensure that the information is current and accurate and, unless access is restricted or limited to certain users, they can be accessed and called up from any computer workstation as necessary.

Computer generated schedules allow for clear and precise presentation of more complex and detailed schedules which are easy to interpret. The level of detail and information presented is not restricted by physical space such as it is when using manual scheduling methods such as schedules handwritten on paper or a notice board. They can only be adjusted by members of staff who are authorised to do so.

Computer generated schedules may be automatically updated

when used in conjunction with automated job tracking.

Computer generated schedules may be used in conjunction with manual, hand written scheduling.

It is important to become familiar with and be able to accurately interpret the company's scheduling methods and systems, how they are delivered and how they are managed.

6.5.2 Barcodes and QR codes

The factory may operate an automated job tracking IT system such as barcode/QR code scanning system for control, tracking, planning and reporting on the flow of work in the factory from production to delivery.

Manufactured components are each labeled with a unique printed barcode/QR code issued specifically to that component. The label is repeatedly scanned at key stages of the manufacturing and delivery/distribution process as it progresses through the factory.

Machines may incorporate scanners which automatically scan

components as they travel through each workstation, or components may be scanned manually using handheld scanners, or components may be scanned using a combination of both methods.

The factory's computer system monitors the component's progress and status as it is assembled, quality checked and readied for loading and delivery. The number of units manufactured is also tracked as the codes are scanned, ensuring that accurate records, including information such as times, durations and dates, are recorded. The computer system monitors where each component is located at each stage of the manufacturing and delivery/distribution process.

Barcode/QR code scanning enables improved efficiency, reductions in non-conformances and human error, identification of bottlenecks, and a reduction in paperwork and associated manual tracking operations. Automated job tracking software may be used to generate and update schedules.

7. Preparing for manufacture

This section covers common processes and skills required for timber frame manufacture.

As already stated at the beginning of the Practical section given the various operational differences, wide range of methods employed throughout the industry it is necessary to tailor corresponding training programmes to reflect the specific environment in which the learner is operating.

Learners are to consolidate their own knowledge and practical experience to underpin knowledge by sourcing their own information, becoming familiar with and gaining experience in their work place, and learning to use the appropriate and relevant parts of this section as necessary.

Operatives may be performing a number of different tasks in the production facility. It is important to focus first upon learning the tasks which are relevant to their practical application.

7.1 Saw shop

It is imperative that all operators familiarise themselves with the machinery in the saw shop that they have to use on a day to day basis in order to fulfill their job and that they are fully trained and competent to do so. Operatives must understand the purpose of each of the items of equipment in the saw shop and only use the sawing equipment for which they are trained.

7.1.1 Saw types and purpose

Some examples of manually operated and automated saws that are commonly used for processing timber and wood-based materials for timber frame manufacture are given below:

- Up-cut saw
- Table saw
- Panel saw
- Wall saw or vertical panel saw
- Chop saw
- Radial arm saw
- Circular saw
- Jigsaw
- Reciprocating saw
- Band saw
- Chain saw
- CNC saw
- Hand saw

The operator should be able to identify each item of sawing equipment relevant to their role and understand its purpose.

Once the material has been cut it can be transferred to the next work station(s) for further processing e.g. assembly.

7.1.2 Batching material

Materials should be selected and organised in to 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. Materials must be organised into bundles, or 'batches' corresponding with materials necessary to produce components or by materials of similar dimensions and/ or characteristic.



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 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.

7.1.3 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 suitable 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.

Do	

What saws will you be using during your training and what is the correct way to use each?



Activity

How is batching organised in your factory?

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 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 in to then cut by the machine in accordance with the programme. 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

7.1.4 Manual operation

The factory you are working with will have standard methods for operation of the available manual saws. Because of the wide variety of saws available on the market, it is important to become familiar with the specific saw operation methods in the company you are working for.

7.1.5 Automatic operation

CNC saws are generally safer to use than manual saws. Your organisation will have specific procedures for use of available CNC saws.

7.1.6 Cutting OSB and ply

Your organisation will have specific procedures for OSB and plywood cutting.

7.2 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. This job is made easier if each piece has been arranged in the saw shop in the order in which it is to be picked for marking out. What exactly is to be marked out will be dependent upon the component that is being marked and the purpose for marking. Some general examples are given below.

Among many others the process of marking out might include for example:

- Wall stud positions along bottom and top rails
- Positions of openings, lintels and cripple studs
- Floor joist and joist hanger positions on rim beams
- Trusses and truss clip locations
 on head binders
- Reference numbers of individual elements and assembled components
- The relationship with or location of an assembled component with the corresponding part or parts of the structure

Accuracy and precision are key. It is recommended that everything be checked and re-checked to prevent any errors. It is important to bear in mind that any errors may have a cumulative effect, particularly where the same error is repeated multiple times. Bear in mind that the effect of any errors which are made during manufacture may be magnified when encountered on site and it may not be possible to remedy such issues easily or quickly on site.

The production drawings should include all references to the materials to be used for manufacture, including any tolerances and material specification and/or characteristics where appropriate e.g. moisture content, strength grade, special conditions etc.







How are the saws and material optimised in your factory?



Activity

What are the different types of manual saws used in the organisation you are working for and what are the method statements for the saw operation? Make notes below.



Make notes on the CNC saw use procedure or method statement use in your organisation.



Activity

What are the tools and operation methods for cutting OSB and plywood in the organisation you are working for? Make notes below.

The fabrication of the various units encountered will typically follow a regular grid pattern when they are erected. This regular spacing of studs (walls), joists (floors) and roof members during manufacture allows for simple planning during the design phase. Most panel products for sheathing, lining and flooring applications are supplied in 600x2400mm or 1200x2400mm sheets which allow for 400mm or 600mm structural grids, enabling easier and more straightforward fixing and reducing the amount of cutting and wastage of sheet materials. This also ensures that there are no 'flying joints' i.e. all joints where sheet materials abut lie over the member to which they are to be fixed, and that fixings don't miss those members when the sheet materials are fixed.

It is important when marking out to ensure that measurements are adhered to exactly and marked precisely otherwise inevitably issues on site will arise if sheet materials do not fit.

Marks should be made on 'exposed' faces such that they are still clearly visible and referred to during assembly.

All marks should be legible and unambiguous. Again, precision and careful consideration is key – for example, using a thick marker to mark fine lines for the purpose of accurately locating one member with another should be avoided as the thickness of the line is likely to result in inaccurate placement, whereas using the same thick marker to clearly mark reference numbers would be acceptable.

Any marks that are made in error must be satisfactorily erased or clearly marked as incorrect before replacing with the correct mark to prevent incorrect marks being referred to during assembly.

It is recommended that during training operators participate in site visits such that they can gain an understanding of the effects that such issues during manufacture might create on site.

Assembled items should be marked with reference numbers which correspond to the appropriate drawings.

Care should be taken to ensure the following prior to progressing:

- That dimensions and specification of material transferred from the saw shop are checked and inspected to ensure they are correct
- That the correct and current drawings are being referred to
- That all measurements are accurate and correct
- That all markings are precise, clearly visible and unambiguous
- That assembled components are clearly marked for site and that all reference numbers correspond with the appropriate drawings.



Activity

Please list the marking out procedures you follow for the various timber frame components you fabricate and supervise. (use separate A4 shee)

8. Wall panel fabrication

8.1 Overview

The fabrication process and sequence will be dependent upon the type of factory in which you work the type of wall panels typically produced and the methods employed. This handbook focuses on the manual process though it is important where automated methods are used for operatives to add and adapt methods specific to the factory in which they work.

This section assumes that materials required for manufacture have already been cut and sized and that reference numbers have been marked upon components as appropriate.

A standard timber frame panel of dimensions 2400x2400mm with no openings comprises horizontal bottom and top rails separated by studs, all of the same section size. The studs are fixed at equal centres, typically 600mm centre to centre spacing, to the top and bottom rails using nails, then the panel sheathed and/or lined on one side (open panel, typically OSB) or both sides (pre-insulated panel, typically OSB on the external face and plasterboard on the internal face) with OSB which is affixed to the studs and rails to create a wall panel. In general, insulation will be installed in open panels once they've been installed on site, whereas the insulation in preinsulated panels will be installed in the factory after the sheathing has been fixed and before the linings have been fitted. A breather membrane is typically applied to the external (cavity side) face and

a vapour control layer applied to the internal face between the frame and the linings (pre-insulated panel).

Before proceeding it is important to ensure that the work area is safe, tidy and free from obstructions. Debris left on a bench can cause obstructions during fabrication and affect the quality of the finished panel.

This section focuses on a basic open and closed frame panels without openings but the techniques can be applied to other forms of wall panel construction and more complex designs.

Panels with openings typically include features such multiple studs and lintels and sheathing and linings must be cut accordingly to accommodate openings. Panels which are to be subjected to high point loads and uniformly distributed loads typically incorporate features such as multiple studs. Such features are not covered here but the learner should be aware of them and through experience learn how to manufacture wall panels with such detailing.

Skills and techniques learned in the Practical section can be expanded upon and applied to the fabrication of panel types specific to the factory in which the operator works.













Computer Aided Manufacturing (CAM)





8.2 Use of tools

It is important that the appropriate tool is selected for each particular job or operation. Using a tool that is unsuitable may result in injury and/ or non-conforming product.

Personnel must be aware of where each tool is located, how it is to be stored and take care to return it to its proper location once they have finished using it.

All personnel must be fully trained and competent to use the tools necessary to fulfill their role.

Some tools and equipment which are commonly used when manufacturing wall panels include:

- Nail guns
- Screw guns
- Stapler
- Table/bench and jig
- Square
- Measuring tape
- Hammer
- Clamps

8.3 Sub assembly

Typically, any sub-assemblies or sub-components that are to be incorporated in to 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.

8.3.1 Fasteners

It is important to ensure that the correct fasteners are used and that the specification is as per the panel drawings. The following should be checked to ensure that the fasteners are of the correct specification:

- Dimensions
- Shank diameter
- Length
- Profile
- Annular ring shank
- Smooth
- Helical or square twist
- Other
- Finish
- Galvanised
- Bright zinc
- Stainless steel
- Other

8.3.2 Measuring and Marking Out

If the timber for the frame has not already been marked out after cutting, then measuring and marking out should be undertaken at this stage.

The sequence for marking stud locations is straightforward providing that the correct drawings are referred to when marking the panel top and bottom rails for stud locations.

Stud centres may be marked with a single line though it is preferable and more accurate to mark two lines, each corresponding to one face of the stud, such that the distance between them matches the thickness of the stud, ensuring accurate placement.

Ensure that measurements on the top and bottom rail are all taken from the same side. Care should be taken to ensure that studs are positioned at corresponding locations at the top and bottom rails i.e. that the positions marked on the rails are not offset, resulting in the studs becoming skewed.

The location and dimensions of

	7	

List below ALL the tools you will be using for the fabrication process.



Activity

How is batching organised in your factory?

any holes for provision of services should be marked out where applicable.

As well as marks for location and assembly the panel (typically both sides of the bottom rail) should also be clearly marked with a panel reference number which corresponds to the panel drawings.

All the marking out must be completed before proceeding. The stud positions may be marked out on the jig or bench though it is still recommended that locations are checked.

Marking out is outlined in more detail in an earlier section.

8.3.3 Laying Out / Laying Up

The top and bottom rails should be laid out first. If a jig or line is used it should be adjusted to correspond with the required dimensions of the panel, though this will be dependent on the configuration of the jig. Where appropriate the rails shall be laid out to abut stops on the jig.

The studs should be laid out perpendicularly in between the top and bottom rails and positioned approximately using the marks on the top and bottom rails. Depending on the configuration of the jig or line, studs may abut stops adjusted to correspond with the required stud centre distance as appropriate.

The first stud is often referred to as the 'leading stud', the last stud as the 'trailing stud' and the studs in between those as the 'intermediate studs.' The voids between the studs are referred to as the 'stud bays.'

Once the studs and rails have been satisfactorily laid out and checked the frame can be fastened together.

8.3.4 Fixing the Frame

Typically, each stud is fixed with two nails at both the top and bottom of the stud. Using two nails rather than a single nail restricts the stud's ability to rotate and provides a more robust connection.

Nails are fixed through the rails in to the end grain of the studs. Fasteners must be accurately positioned and care must be taken to observe edge and end distances as fixing too close to edges or ends of timber members can result in splitting, damage and protruding nails which might affect the panel's performance, cause issues when installing the panel, adjacent panels or other components and can be hazardous during handling and manoeuvring.

Care should be taken to ensure that fasteners aren't over-driven or under-driven or protruding. When using a nail gun either situation can typically be remedied by adjusting the depth setting and/or adjusting the pressure.

Fixing locations should be specified on the panel drawings or specification.

Each stud should be fixed along the rail in turn, ensuring that each stud is accurately located in the correct position before fastening. Once the studs have been fixed to one rail the same operation should be repeated on the opposite rail, ensuring that the studs line up and are straight.

Where specified noggings (also referred to as noggins or dwangs) are fixed between the studs, across the stud bays. Where these are to be fixed along the same line they are typically staggered for ease of nailing, or otherwise lined through and skew nailed.

Check around the panel to ensure that everything is in the correct position, all fasteners have been Instructions, specification and components for the panel frame are displayed from a CAM file



Consumables such as nails, screws and staples are organised and clearly

Using a CAM file, the assembly process is automated, which provides consistent quality



fixed and that there is no damage or protruding or over-driven fasteners.

Once the frame has been fastened it should be checked for squareness either by using a set square or by checking the dimensions across the diagonals – if the frame is square the dimensions across the diagonals should be identical.

Refer to the panel drawings throughout to ensure that the frame is configured in accordance with them.

If the jig or line allows the frame can be secured in position.

Once checks are complete and the frame has been satisfactorily fastened together the panel is ready to receive the sheathing boards.

8.4 Sheathing

8.4.1 Locating Sheathing Boards

Sheathing boards should be offered up to the top of the frame. If the sheathing board and frame are both square and of the correct dimensions, then their edges should align around the perimeter. Care should be taken to ensure that the sheathing doesn't protrude beyond the edges of the frame.

Typically, the sheathing boards should be adjusted such that they do not abut. A small and consistent gap of approximately 2mm should be left between the boards to allow expansion.

Once the sheathing boards have been satisfactorily positioned they are ready to be fixed in position.

8.4.2 Fixing Sheathing Boards

The fasteners for fixing the sheathing are typically of a different specification to the framing fasteners used to fix the frame. Ensure that the correct fasteners are used to fix the sheathing boards. Fasteners must be of the appropriate specification for the type of sheathing board.

Fastener locations should be specified on the panel drawings. Typical fixing centres for a standard open frame timber panel are 300mm c/c at the perimeter of the sheathing boards (NOT the perimeter of the frame) and 150mm c/c on intermediate studs.

The simplest method is to first fix the sheathing boards at the corners or similar to secure it in place, ensuring that the sheathing boards remain in the correct location and flat, then continues to fix the remainder once the sheathing board has been secured. The same process should be repeated for subsequent sheathing boards.

Care should be taken to ensure that fasteners are located accurately on the studs and rails and that no sheathing fasteners cause the frame to split or miss the frame altogether.

Ensure that end and edge distances are observed as fasteners that are fixed too close to the edge or edges of sheathing can result in damage to the edges or 'break-out' of the sheathing material.

Again, care should be taken to ensure that fasteners aren't over-driven or under-driven or protruding.

It is important to remember that timber frame panels largely rely on the sheathing boards and a robust connection between the sheathing and the frame to provide rigidity and strength. Incorrectly fixed or located fasteners can adversely affect the performance of the panel.

Check to ensure that the sheathing has been fixed correctly and that all fasteners have been inserted, and

00	Activity	
	Explain your jig set up	



Explain each step of the frame fabrication and the correct connections to be used at each stage. (use separate A4 sheets)



When nailing the timber what is the correct depth you work to below the wood surface? What is meant by over nailing timber? What is meant by under nailing timber? How do you avoid splitting the timber, and what do you do if you split it? How do you ensure the frame is square? Why are noggings (dwangs) inserted into the frame and how are they nailed and at what spacing?



Attach here the timber panel manufacturing flowchart for your company



Activity

List below the final checks you would make when the basic timber frame is complete.

List three main problem areas when making timber frames and how to resolve them.

1.		
2.		
3.		

that a gap has been left between sheathing boards.

Once the sheathing has been satisfactorily installed the panel is ready to receive the breather membrane.

- Open panels: Only one side is sheathed in the factory. Any other linings are installed on site
- Closed panels: Once one side is sheathed the panel is flipped over (using a butterfly table or similar method), the insulation installed as appropriate, then the other side sheathed/lined as appropriate to 'close' the panel

8.5 Breather membrane and insulation

8.5.1 Installing the 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.

The breather membrane should be fitted to the cavity side of external panels.

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. 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 by stapling a piece of breather membrane over the damaged area. The repair should be done as the damage occurs, using the same material, adequately lapped around the existing material and securely stapled.

Stud positions should be clearly marked as appropriate to ensure that their locations can be readily identified.

Checks should be made to ensure that the breather membrane has been installed and securely correctly and that it is free from damage.

8.5.2 Installing the 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



List below the various types of sheating you can fit to panels and the correct nails, nailing patterns and spacing to use with each.

If your company's method is different, attach the correct flowchart here.



Activity

What purpose does the Breather membrane serve?

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.

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.

8.5.3 Insulation

Insulation may be either installed on site (open panel) or in the factory (pre-insulated panel). The process of installing the insulation is identical.

- **Open panel:** Insulation is typically installed on site once the panels have been erected and before the panel is closed with sheathing/lining 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-insulated (may be closed panel): Insulation is typically installed in the factory either before the panel is closed with sheathing/lining 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.

Various types of insulation are available. It is important for the operative to become familiar with the insulation that is used in the factory in which they work and how to correctly install it.



Activity

If the process of fitting the breather membrane differs at your factory, draw or attach the correct flowchart here.



Explain the process for fitting the breather membrane to the panel.

What is the correct type of staple to use?

What is the correct stapling pattern and spacing?

With is the correct lapping top and bottom of the panel?

Some typical examples of insulating materials available for use in timber frame construction are:

- Man-made insulating materials
 - Stone wool
 - Glass wool
 - Rigid polyurethane (PUR)
 - Rigid polyisocyanurate (PIR)
 - Expanded polystyrene (EPS)
- Environmental insulating materials
 - Wood fibre
 - Blown cellulose
 - Textile residue

During design and construction narrow or inaccessible voids between studs or components should be avoided wherever possible as these will be difficult to install insulating material.

Insulation should be installed once one side of the panel is sheathed/ lined.

It is important to ensure that:

- The correct specification of material is used
- The thickness and/or depth of fill and any tolerances are in accordance with the design and specification
- Any debris is removed prior to installing insulation
- Areas where services are present are adequately insulated and that the continuity of the insulating material is maintained wherever possible
- There is a uniform fit and thickness or depth of fill throughout entire panel. There should be no gaps
- Where there are no physical breaks e.g. studs, insulation should be continuous
- Insulation is installed such that it fits tightly (interference/ friction fit) to prevent slumping or sagging over time. It may be necessary to use a fixing

method such as adhesive or staples where advised

For EPS or fibre fill, that voids are fully filled

Note that it is difficult to open panels to rectify errors once sheathing has been fully installed on both faces so care must be taken to ensure that insulating materials are correctly installed.

Care must be taken to ensure that insulation is protected from moisture and remains dry during transport and installation.


8.6 Insulation net and plasterboard

8.6.1 Overview

Insulation net is used to support insulation in horizontal or vertical panels. Plasterboard is the most common internal lining material and is available in different thicknesses and densities for enhanced acoustic, thermal and fire performance.

8.6.2 Insulation net installation

Insulation net is attached simply by stapling to the timber studs. A single layer of net can usually support a 100-250mm insulation layer up to 450mm spacing between floor studs. Higher spacing can be achieved by using higher grade net material or doubling the net layer. Insulation net is manufactured from polypropylene and is rot-proof and chemicalproof making it durable. Some manufacturers recycle plastic waste to make insulation net, making it a more sustainable option.

8.6.3 Plasterboard nailing and screwing

Traditionally plasterboard is installed using nails though with the advancement of powered screw guns with collated fasteners offering improved speed and accuracy screwing of plasterboard has become more common.

To provide a positive fixing it is important that when inserting fasteners that the paper layer of the plasterboard is not broken by the fastener head by over-driving. This is easily achieved by using a tool with a depth setting feature.

In addition to providing a positive fixing, accurate fixing at the correct depth reduces the likelihood of filler popping off of the fixing heads as the timber frame settles. Wall fixing centres are typically between 150 and 300mm though it is important to always refer and adhere to the manufacturer's literature.

Where double layers of plasterboard are fitted e.g. at party walls, joints should be staggered and care taken to also stagger the fastener centres to ensure that fasteners in the second layer do not clash with those of the first layer. Fasteners for fixing the second layer should be longer to ensure adequate penetration through both layers and in to the frame. Always refer and adhere to the manufacturer's literature.

In order to achieve adequate fire protection and reduce fire spread good workmanship and accuracy are essential when installing plasterboard. It is critical that plasterboard is installed correctly with edges fully supported.

8.7 Stud tapes (taping and filling)

Taping and filling are methods to finishing the surface. Specialist tools are required for this task, such as different types jointing knives and an internal angle tool. Different manufacturers will have specific instructions of how to use their tape and filler products and it is important to become familiar with these before proceeding with the task of stud tapes.

The internal lining has to satisfy 3 requirements:

- Provide a finish on the inner face of external walls and to both faces of internal walls.
- Contribute to the racking resistance of the wall on external and load bearing walls.
- Add to the fire resistance of the wall



Explain the process for fitting the Netlon to the panel.

What is the primary function of fitting Netlon to panels?

Explain how Netlon is fitted and what checks are made to ensure it is correct?

What precautions must you take when fitting plasterboard?

8.8 Quality tolerance and inspection

Minimum and maximum permissible values must be observed and adhered to.

The accumulation of seemingly minor errors can result in comparatively major errors, especially once on site.

There should be a measured allowance for small deviations from nominal values. These should be clearly specified. Tolerance values are often determined by calculation, previous experience, testing and/or regulations. By specifying permissible tolerances some allowance is made for deviating from the nominal values to account for human and machine error or deviation in dimensions or properties of materials.

Tolerance values must be predetermined to provide values against which to check and compare at inspection stage. Maximum tolerances must be determined, specified and adhered to. During inspection, checks are undertaken to ensure that measured values are within tolerance and in accordance with the design and specification.

Some examples of tolerance ranges may be: dimensional (e.g. cross section/panel size, fastener spacing, location/positioning, diagonal/square etc.), moisture content, density, temperature and humidity (e.g. manufacturing / storage environment)

Ensuring that components are manufactured in adherence with the tolerance values ensures that they are fit for purpose and won't cause issues or have any consequences further on in the construction process or in service

If any measurement is found to be out with the specified tolerance

the error should be rectified if practicable or discarded if beyond revision/repair.

Situations where values which fall widely out with the tolerance range or occur regularly must be investigated to determine the (root) cause and steps be taken to eliminate it and ensure it's not repeated.

8.9 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.

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.

The frame which forms each independent leaf of a typical party wall is fabricated in the same manner as the frame of an open or pre-insulated panel as described above.

Once the sheathing/lining has been installed to one face the panel is flipped over and insulation installed between the stud bays. To retain the insulation a lightweight mesh or netting e.g. Netlon, is fitted over the open side of the panel using staples fixed to the studs and rails. Mesh should fully cover the face of the panel and be fixed at centres adequate to ensure that the insulation is effectively retained. Both leaves are connected on site using party wall straps at the head of the panels, fixed at 1200mm horizontal centres.

The cavity formed between the leaves may also be insulated. If the cavity is insulated the insulation is typically installed before the second leaf of the party wall is installed though insulation may be blown in or similar once both leaves of the party wall have been installed and the building is weather tight.

Care must be taken to ensure that insulation is protected from moisture and remains dry during transport and installation.

Where linings are installed on site the leaves of the party wall should be temporarily braced. The bracing is removed upon installation of the plasterboard.

Party walls are typically lined with two layers of dense plasterboard with a minimum combined thickness of 30mm. This is typically achieved by using two layers of 15mm plasterboard or one layer of 19mm plasterboard or one layer of 19mm plasterboard plank and one layer of 12.5mm plasterboard. Joints in double layers of plasterboard must be staggered and fastener centres staggered to ensure that they do not clash.

8.10 Gable /spandrel panels

Spandrel panels for gable ends are fabricated using a similar process to that employed for standard timber frame wall panels; with the main exception being that a spandrel panel's profile matches that of the roof rather than having a square profile like a wall panel. As such spandrel panels are a little more complex to cut and assemble as they involve mitre cuts for studs and rails and angled cuts of sheathing material. Spandrel panels may comprise multiple sections which are manufactured off site then fastened together on site to form the gable.

Spandrel panels may be used externally (gable end) or as a continuation of the party wall to separate dwellings (terraced houses). Where spandrel panels are used to separate dwellings their construction will typically be more akin to that of a party wall as described earlier in this section, such that they meet fire, acoustic and thermal requirements.

A gable end spandrel panel frame with an isosceles triangle profile typically comprises a horizontal bottom rail and angled top rails separated by studs of the same section size which are located at regular centres, typically 600mm centre to centre spacing. Each subsequent stud is progressively longer than the preceding one from the eaves to the ridge, then progressively shorter again from the ridge to the eaves on the opposite side. Each stud is square cut at the end where it abuts the bottom rail and mitre cut at an angle corresponding to the pitch of the roof at the opposite end where it abuts the top rail.

Gable end spandrel panels are typically sheathed on one side with OSB which is affixed to the studs and rails in the same manner as for wall panels. Care should be taken to ensure that the OSB doesn't protrude beyond the edges of the frame and that gaps are left between the sheathing boards to allow expansion. Once the sheathing has been fixed the breather membrane can be applied to the sheathing in the same manner as for wall panels.



Taping and filling is preferred to skim coating of the plasterboard. Why?



Activity

Attach here the quality check list used at your timber frame company. Test going through the checlist on an example panel to become familiar with the process.





Open Timber Panels consisting of a timber stud frame and OSB on one side.





Closed Timber Panels consisting of a timber stud frame, insulation, OSB on both sides and battens for services.

Spandrel panels which separate dwellings are typically lined with two layers of dense plasterboard with a minimum combined thickness of 30mm. This is typically achieved by using two layers of 15mm plasterboard or one layer of 19mm plasterboard or one layer of 19mm plasterboard plank and one layer of 12.5mm plasterboard. Joints in double layers of plasterboard must be staggered and fastener centres staggered to ensure that they do not clash.

Spandrel panels may incorporate features such as pockets to receive ridge beams or purlins, or ledgers to receive roof cassettes or purlins for example. Spandrels may have openings and incorporate a lintel above openings and multiple studs. Where such features exist sheathing and lining must be cut accordingly to accommodate them.

8.11 Open and pre-insulated panels

A standard timber frame panel of dimensions 2400x2400mm with no openings comprises horizontal bottom and top rails separated by studs, all of the same section size. The studs are fixed at equal centres, typically 600mm centre to centre spacing, to the top and bottom rails using nails, then the panel sheathed and/or lined on one side (open panel, typically OSB) or both sides (pre-insulated panel, typically OSB on the external face and plasterboard on the internal face) with OSB which is affixed to the studs and rails to create a wall panel. In general, insulation will be installed in open panels once they've been installed on site, whereas the insulation in preinsulated panels will be installed in the factory after the sheathing has been fixed and before the linings have been fitted. A breather membrane is typically applied to the external (cavity side) face and

a vapour control layer applied to the internal face between the frame and the linings (pre-insulated panel).

This section focuses on a basic open and closed frame panels without openings but the techniques can be applied to other forms of wall panel construction and more complex designs.

8.12 External wall (loadbearing with brick leaf)

External walls differ from internal walls, in that they have more insulation, care is given to moisture control, air tightness and are subjected to high loads. External walls also have openings for windows are doors, which make their manufacturing more complex than that of open and pre-insulated panels without openings.

Panels with openings typically include features such multiple studs and lintels and sheathing and linings must be cut accordingly to accommodate openings. Panels which are to be subjected to high point loads and uniformly distributed loads typically incorporate features such as multiple studs. Such features are not covered here but the learner should be aware of them and through experience learn how to manufacture wall panels with such detailing.

8.13 Services

Services in open panels are most commonly installed on site once the panels have been installed, whereas services in pre-insulated 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.

Service runs may be incorporated within the panel itself, 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 in to 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.

Practical points

Do not notch studs to accommodate service runs.

Drill within the specified limits.



9. Shot Firing Connections to Steel

9.1 Overview

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 fix joist hangers directly to steel sections for example.

9.2 Common tools and fixings

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. Cartridge types are typically coloured according to power. It is important to be aware of what is available, their purpose and to select the correct cartridge type.

Some shot firers have magazine attachments and a power dial so that the power can be adjusted as necessary. It's important to note that if the power is set too high the nail and washer will penetrate straight through the timber, and that if it is set too low the washer will not be pulled up hard against the timber, both resulting in a poor and inadequate fixing which may be unsafe. It's advisable when first setting the power to try each setting on scrap material similar to that which is to be fixed until the correct power is achieved.

As with all tools it is important when using shot firing equipment that it is used in a responsible manner and that internal and manufacturer's instructions, maintenance schedules and PPE requirements are adhered to.



Activity

What tools are used in your factory for shot firing connections to steel? What is the correct and safe way to use these tools?

10. Floor Cassettes

10.1 Overview

Floor cassettes are an alternative means to installing the floor by traditional means - 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 panel timber frame elements. Floor cassettes generally comprise a frame structure (typically edge binders, 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.

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 is 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.

As is the case for wall panels materials must be cut to size and marked out before fabrication can commence.

The fabrication process will be dependent upon the type of factory in which you work the type of floor cassettes typically produced and the methods employed. This handbook focuses on the manual process though it is important where automated methods are used for operatives to add and adapt methods specific to the factory in which they work.

This section assumes that materials required for manufacture have already been cut and sized and that reference numbers have been marked upon components as appropriate.

Before proceeding it is important to ensure that the work area is safe, tidy and free from obstructions. Debris left on a bench can cause obstructions during fabrication and affect the quality of the finished cassette.

This section focuses on basic floor but the techniques can be applied to other forms of cassette assembly and more complex designs. 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



10.2 Use of tools

It is important that the appropriate tool is selected for each particular job or operation. Using a tool that is unsuitable may result in injury and/ or non-conforming product.

Personnel must be aware of where each tool is located, how it is to be stored and take care to return it to its proper location once they have finished using it.

All personnel must be fully trained and competent to use the tools necessary to fulfill their role.

Some tools and equipment which are commonly used when manufacturing floor and roof cassettes include:

- Nail guns
- Screw guns
- Drill
- Hole saw
- Stapler
- Table/bench, jig and/or line
- Square
- Measuring tape
- Hammer
- Clamps

10.3 Joist systems

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.

10.3.1 Multiple and 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.

Always adhere to the drawings, specification and manufacturer's instructions when joining multiple members.

Due to their weight multiple members may require different handling and lifting arrangements to those of single members.

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

Ensure that multiple members are securely fixed prior to lifting and installing.

10.4 Blocking / noggins / dwangs

Perimeter noggings, also commonly referred to as noggins or dwangs are short lengths of timber or EWP installed between the joists at locations around the perimeter of the floor to support the edge of the structural deck.

What are the main functions Cassette Floors must meet during, manufacture, site erection and future life?



Activity

List below ALL the tools you will be using for the wall and floor fabrication processes (separately).



At this stage of your career you should be familiar with the different types of joist systems used in timber frame buildings. Please list below the different types of joist systems you are familiar with. Partition noggings, noggins or dwangs are short length of timber or EWP installed between the joists at the appropriate locations and at regular centres to support partitions installed above on the structural deck.

Although the primary function of noggings is to support partitions and edges of sheathing boards they can provide some lateral restraint and help to prevent joists from overturning during assembly, though they should not be relied upon in lieu of proper bracing.

When using solid timber joists and full depth solid timber noggings it is generally simpler to fix noggings in a staggered pattern to allow nailing in to their end grain rather than having to skew-nail or similar.

When using I-joists with full depth I-joist noggings or shallow solid timber noggings, or open web joists with shallow solid timber noggings, Z-clips can be used to install noggings without having to stagger or skew-nail them.

Noggings must be installed at specified locations in accordance with the drawings and specification. If noggings are fixed using timber frame connectors e.g. Z-clips, they must be installed in accordance with the manufacturer's literature.

10.5 Layout

The edge binders should be laid out first, parallel to one-another. If a jig or line is used it should be adjusted to correspond with the required dimensions of the cassette, though this will be dependent on the configuration of the jig. Where appropriate the edge binders should be laid out to abut stops on the jig or line.

The joists should be laid out perpendicularly between the

edge binders and positioned approximately using the marks on the edge binders. Depending on the configuration of the jig or line, joists may abut stops adjusted to correspond with the required joist centre distance as appropriate.

Ensure that the joists have been laid out in the correct location and direction of span and that trimmed openings for staircases and service ducts are vertically aligned and of the correct dimensions.

If joist hangers are used these can be slipped over the ends of the joists before fixing. Ensure that the correct joist hangers have been selected and that they have been laid out in the correct positions. If applicable, any backer blocks or web fillers must be installed in accordance with the manufacturer's instructions.

Trimmers and trimmed joists should be laid out in accordance with the drawings and specifications. If multiple members are to be installed these should be joined prior to laying up the joists.

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.

Once all the components have been satisfactorily laid out, temporary bracing installed and checks made, the frame can be fastened together. It is important to ensure that the layout is in accordance with the drawings and specification.

10.6 Design loads

10.6.1 Overview

Design loads will be calculated by the engineers and suitable structures will be designed and specified by the drawing office, in accordance with the relevant building codes. Overall, there two types of design loads, 'dead' loads which have to do with the loads of the structure due to gravity and 'live' loads, which have to do with external forces such as wind and movement of people. Loads are measured in force per area, most often kN/m².

It is **very important** to follow the drawing office specification drawings because if a component is manufactured incorrectly, then it may not perform to the design load specification, which may cause structural collapse during construction or occupation.

The design loads are connected to the structural performance specified for each component in the timber frame. The main four properties you need to be familiar with are:

- Stress
- Elasticity (deflection)
- Strength class
- Creep

10.6.2 Stress

Stress is the measurement of internal loads within the structure, resulting from external loads. Stress types are bending, tension and compression. It is important to understand that timber is a natural material, whose fibres grow vertically. Therefore, timber performs differently under axial load along the growth direction (termed across the grain) and perpendicular to the growth direction (termed parallel to the grain). The compression and sheer properties of timber are much higher across the grain then perpendicular to the grain.

10.6.3 Elasticity (deflection)

The modulus of elasticity has to do with the deflection of the timber under an applied stress. The deflection of an element refers to the extent to which it is displaced when loaded. In uniformly loaded elements, the deflection is related to both the section, the depth and the length of the element. This is very relevant to floor joists for example, where the increase in length of an element is related to the deflection to the power of 4. So, for example if a 2-metre joist is increased in length by 2 meters (4 meters in total) will result in an increase of deflection 2 to the power of 4, that is 16 times the original deflection. This is only an example and you won't be expected to calculate the deflection of elements, however the example illustrates why it is very important to select timber elements with the correct modulus of elasticity and deflection properties.

10.6.4 Strength class

Timber pieces are strengthgraded to enable their accurate structural use. Timber elements with one and the same strength class will perform similarly under stress, such as bending, tensions and compression. They will also have similar modulus of elasticity. In timber frame manufacturing you will most often use C16 and C24 strength class timber, however higher strength classes may be specified for higher load performance. It is critical to use the strength class of timber specified in the drawing!

10.6.5 Creep

Creep is the gradual deformation of a structural element under

continuous load. The strain (deflection under load) can increase by 60% over a ten-year period under constant load. Creep will be allowed for in the engineering calculations and is therefore something the learner should be aware of but most likely won't need to calculate.

10.6.6 Spanning tables

When manufacturing a floor you will in the first instance refer to a span table, in which the maximum distances that a particular joist can span are listed. These tables also specify the spacing between the joists.

10.7 Fabrication process

The general method for floor manufacturing is listed below, however this may very per your organisation's product and manufacturing systems.

- The drawing will identify the correct location for each Joist.
- The edge binder timber (or ring beam) will also be marked and this will form the perimeter of the floor.
- There will be noggings / dwangs pre-cut to fit in-between the joists at specified centres and locations.
- There will probably be some metalwork such as connector plates, for fixing joists at either end and over load bearing partitions. Also ensure the metal joist hangers are of the correct type.
- Give practical examples on spreading the Joists before Fixing.
- Make sure you work from the correct drawing.
- Lay the joists approximately in their position.
- Ensure the joist dimensions,

grading, spacing and direction of span are correct and that trimmed openings for staircases and ducts are vertically aligned and of the right size.

- Ensure the jig and/or bracing to be used is accurately aligned and stable before starting to fix the joists and any flooring The bracing should remain until the flooring is complete.
- Ensure that the header joist measurements are correct and do not protrude.
- If using double joists these must be correctly located in positions shown, and securely fixed.
- Ensure the metal joist hangers are of the correct type for their location and are firmly fixed as detailed.
- Avoid cutting the bottom edge of the joists other than for hanger seating unless the engineer has specified a notch.
- Ensure metal joist hangers are of the correct type for their location and are firmly fixed in accordance with the instructions.
- Install strutting as specified within the depth of the joist and ensure that it is not oversize causing distortion or bending of the joists.
- The joists are nailed at specified centres to the edge binder forming the perimeter of the floor.
- Noggings /Dwangs are placed in between the joists at specified positions and nailed to the joists.
- When joists are to be extended then use plates or ply gussets with the joint being located over a load-bearing wall.
- Stairwell openings are formed using double joists and double trimmers supported with suitable joist hangers where necessary.
- Ensure that solid blocking is



Give examples on how the floor joists should be pre-cut and numbered for identification and will use either the length of the joist or a code marking.



Activity

Explain exactly how fixing the joists is done.

used as fire-stops between joists where they bear onto the compartment wall.

- You should be aware that Nonload bearing walls must be adequately supported by joists.
- If and when required ensure joist notching and drilling is within the limits specified.
- Be diligent and check the clearance of timber components adjacent to any flues and chimneys.
- State the procedure on how you fix and lay the chipboard or any other type of flooring to the joists.
- The chipboard is laid on top of the floor joists glued and nailed in position with all joints staggered and all ends supported.
- Chipboard
- Other types of flooring
- Additional tasks

10.8 Connectors (hangers and hardware)

It is important to ensure that joist hangers and their fixings are the correct type and specification. Ensure that joist hangers have been installed in the correct location and orientation. Typically, joist hangers should be fully nailed though that may not always necessarily be the case. It is critical that joist hangers and connectors are installed in accordance with the manufacturer's instructions. Joist hangers are designed such that they allow some clearance or tolerance for variations in joist width. Joists should not be violently forced in to joist hangers. Typically, if the joist hanger is too narrow either it or the joist has been incorrectly specified, selected or located.

Where appropriate I-joists or open web members may require web fillers, backer blocks and/ or blocking/strengthening pieces. These must be of the correct specification and fixed in accordance with the joist and connector manufacturers' instructions. Typically for open web joists, strengthening pieces and additional webs at locations along the joist where higher point loads are applied shall be installed during fabrication of the member.

Hangers specifically designed for use with I-joists and open web joists are available and some types may negate the need to install ancillaries such as backers and fillers.

Where multiple members have to be connected together to form stair trimmers clips or structural timber screws may be used. These must be installed in accordance with the manufacturer's literature.

If strutting or strapping between joists has been specified ensure that it correctly installed in accordance with the manufacturer's instructions and does not cause the joists to distort or deform.





Face fix hanger.

Top fix hanger.



Metalwork and fixings/fasteners typically installed in floor and roof cassettes may be:

- Joist hangers
 - Top fix and/or face fix hangers where header members are solid e.g. LVL
 - I-joist specific hangers where header members are I-joists
 - Open web joist specific hangers where header members are open web joists
 - Hangers with internal flanges in areas where external flanges might clash
 - Heavy/high load joist hangers to support stair trimmers
- Z-clips for perimeter and partition noggings
- I-clips for fixing multiple I-joist or open web members
- Structural timber screws for fixing multiple solid members e.g. LVL, I-joists or open web joists
- Herringbone strutting or similar strapping

among others.

10.9 Different floor structures

It is likely to be necessary to manufacture many different types of floors when working in timber frame manufacture. Each cassette that is manufactured might have specific and unique design requirements and characteristics, though generally they will all have to meet the same main functions and common criteria.

For instance, floor cassettes may be manufactured for use as ground floors, intermediate floors, or separating floors. Roofs may be designed to span vertically or horizontally across the roof. Cassettes may be open or closed.

Typically, cassettes should be straightforward to manufacture in the factory, quicker to install on site than traditional floor and roof construction methods and meet all necessary requirements.

Cassettes with openings typically include features such as multiple joists and trimmers, and sheathing and linings must be cut accordingly to accommodate openings. Such features are not covered in detail here but the learner should be aware of them and through experience learn how to manufacture more complex floor and roof cassettes with such detailing.

Skills and techniques learned in the Practical section can be expanded upon and applied to the fabrication of cassette types specific to the factory in which the operator works.

A standard floor cassette typically comprises:

- Solid timber, I-joists or open web joist of a suitable section size relative to the span, application, load conditions and durations, the selection of which shall have been undertaken at the design stage
- EWP members as edge binders/ rim board
- EWP or multiple members at locations where higher loads have to be transferred e.g. at stair openings
- Timber frame connectors e.g. joist hangers
- An OSB, plywood or chipboard deck
- Insulation (most typically closed floor cassettes)
- Plasterboard lining (closed floor cassette).



Please insert the numeric values to complete the following statements with regards to floor manufacture. Please note that these general guidelines may vary per specific manufacturer and it is always best to consult their literature prior to starting manufacturing.

Maximum hole diameter should be _____ of the depth of the

joist.

- Drill holes only at between 0.4 and _____ times the span on the joist centreline.
- Keep holes apart by at least _____ times the hole diameter.
- Keep holes and notches apart by at least _____ mm horizontally.
- Maximum notch depth should be _____the depth of the joist.
- Notch joists only between 0.07 and _____ times the span.



List the connectors you commonly use, their specification, purpose and reasons for selecting them.



Activity

Explain what the following terms mean to you and how they are addressed in your factory. Flooring Sub Floor Service and/or Lifting Holes Temporary Cassettes



Find out or state what the following mean to you in terms of the manufacturing process and list the main reasons and their differences you have to consider. Ground Floor - Floors Acoustic Floors Intermediate Floors

10.10 Quality, tolerances and inspection

Minimum and maximum permissible values must be observed and adhered to.

The accumulation of seemingly minor errors can result in comparatively major errors, especially once on site.

There should be a measured allowance for small deviations from nominal values. These should be clearly specified. Tolerance values are often determined by calculation, previous experience, testing and/or regulations. By specifying permissible tolerances some allowance is made for deviating from the nominal values to account for human and machine error or deviation in dimensions or properties of materials.

Tolerance values must be predetermined to provide values against which to check and compare at inspection stage. Maximum tolerances must be determined, specified and adhered to. During inspection, checks are undertaken to ensure that measured values are within tolerance and in accordance with the design and specification.

Some examples of tolerance ranges may be: dimensional (e.g. cross section/cassette size, fastener spacing, location/positioning, diagonal/square etc.), moisture content, density, temperature and humidity (e.g. manufacturing / storage environment). Ensuring that cassettes are manufactured in adherence with the tolerance values ensures that they are fit for purpose and won't cause issues or have any consequences further on in the construction process or in service.

If any measurement is found to be out with the specified tolerance the error should be rectified if practicable or discarded if beyond revision/repair.

Situations where values which fall widely out with the tolerance range or occur regularly must be investigated to determine the (root) cause and steps are taken to eliminate it.

As each floor is completed **YOU MUST** carry out Quality checks and visual inspection similar to those listed below.

In all cases, measure average over metre run, though max, centres should not be exceeded. Where square-edged boards are used, edges must be supported with noggings (dwangs). Boards should be glued to the joists and tongued and grooved joints should also be glued.



Materials Check – find out what the current requirements are for the following elements of the timber frame. Please note that these general guidelines may vary per project and even per panel, so you should always consult the drawings and ask the drawing office for additional information if in doubt.

Moisture content _____min, _____ideal, _____max; (in %) Reference:

Dimensions -

Components <100mm should be +/- ____ mm (tolerance) Reference:

Components > 100mm should be +/- ____ mm (tolerance) Reference:

Treatment (e.g. preservative)

Material used - e.g.	solid timber,	timber I-joist,	composite timber,
steel I beam			

Assembly Check

Overall Size – As a guide F	loors should	d be manufactured t	to within
a tolerance of + mr	m, r	mm	
Reference:			

Diagonal Check - +/-	mm
Reference:	

Aperture Sizes - + ____ mm - ____ mm Reference:

Nails Over/Under Driven

Nail heads in flooring should be punched _____ mm to _____ mm below the surface of the board and screws should be countersunk.

Nail Spacing – For OSB / chipboard flooring, fastenings should be spaced at centres not more than _____ mm apart along both the continuously supported edges and the intermediate supports.

Fastenings should be at least _____ mm from the edge of the board.

References:

Tolerances in the manufacturing process are very important because the precise panel erection on site depends on accurately manufactured panels.



11. Roofs and Trusses

11.1 Overview

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 is 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.

Depending upon the system and design, joists may have to be mitre cut at the eaves and ridge.

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.

A standard roof cassette typically comprises:

- Solid timber, I-joists or open web joist of a suitable section size relative to the span, application, load conditions and durations, the selection of which shall have been undertaken at the design stage
- EWP members as edge binders/ rim board
- EWP or multiple members at locations where higher loads have to be transferred e.g. at window openings
- Timber frame connectors e.g. joist hangers
- OSB or plywood sheathing
- Insulation (most typically closed roof cassettes)
- Plasterboard lining (closed roof cassette)
- Breather membrane
- Vapour control layer (closed roof cassette)
- Tile straps and counter battens.

11.2 Roof structures

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 in to position on top of the upper storey walls.

Once the trussed are installed on the wall head lateral stability is provided by the installation of timber lateral bracing.

11.3 Common truss types

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

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 requires than a fink can 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 in to another
- **Asymmetric:** Useful where there 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.

11.4 Roof structures and procedures

11.4.1 Overview

Roof structures can be formed very simply using lightweight engineered trussed rafters.

These are made from strength graded timber and comprise the rafters on the roof slopes, a horizontal to support the ceiling, and various combinations of cross members to form a frame or truss. The members are usually fixed together using metal plate connectors. The trusses are designed to suit the span and profile of a roof. They are a very cost effective way of forming roofs of houses and attic trusses are becoming more common.

11.4.2 Long span purlins

Long span purlins can be manufactured from premanufactured engineered wood products such as Glulam, Ply-web, Laminated Veneer Lumber (LVL) and similar. Their advantage is that the imperfections in natural timber are removed and large sizes can be manufactured. This allows long lengths to be used similar to steel purlins.

11.4.3 Frame structures

When a building is a frame structure the roof is often formed as an integral part of the frame. That is the floor, wall and roof structures are similarly constructed.

11.4.4 Roof shapes

The shape of roofs can create complications. Hipped ends, where the end of the roof slopes down to the eaves, require careful design. Modern computer systems enable roofs of great complexity to be factory manufactured.

See Table 11.4.4.

11.5 Truss fabrication

11.5.1 Overview

The process will be determined by the type of plant you work on either manual or automatic or a combination of both so once again you will need to add and adapt the following to your own methods of fabrication.

With the materials cut to size, you can start to mark out the truss.

11.5.2 Use of Tools & Equipment

Make sure all the tools you require are available and in good working order and that everyone is competent to use them. Also the



Name	Notes
Gable Ended Roof	The simplest roof shape. Gable can have gable ladders or brick detail.
Hipped Roof	A common relatively simple design to construct, especially with trussed rafters.
Barn Hip Roof	Useful on narrow buildings to provide a roof feature without limiting roof storage space.
Gabled Roof	Similar to a barn hip, it can provide a feature without using too great a length of roof.
Gabled Intersection (Valley)	Usually formed using Girder Trusses (2 or 3 ply multiple trusses) and a set of Valley Frames (Reducing Frames).
Hipped Intersection/ Overlaid Hip	Problems can occur in large spans if, as above, the ridge of the hip is above the main roof.
Right Angled Roof	Different to either intersection as the rear elevation is pitched. A more complex design is required.
Dogleg Roof	Ideally the two spans should be identical allowing easy matching of eaves and ridge height.



Table 11.6 Manufacturing process

Name	Notes
Mark out	Refer to drawings
Set up equipment for truss shape	Check with drawings for correct set up
Layout timber elements	In logical sequence
Position metal plates on connection locations	Use correct plates at correct location, be careful with 4-way connections
Press the metal plates	Correctly and safely
Flip the truss vertically	Following correct and safe procedure
Storage for despatch	Ensure easy retrieval when needed. Store vertically or horizontally, as per drawing specification, in groups for delivery.

correct setting for any machines, jigs etc. are checked and rechecked before the work begins.

11.6 Manufacturing process

See Table 11.6.

11.7 Handling and storing trusses

11.7.1 Overview

The storage of roof trusses is critically important because it ensures the correct specified structural performance of the manufactured product and also ensures that the quality of the product is maintained. Consider the time and attention to detail you have invested in the manufacturing of each truss, you would want to follow the correct storage procedure to prevent any damage occurring to the trusses and therefore eliminating all your hard work.

11.7.2 General handling

In general, there are four main factors the learner should pay attention to during storage:

- Mechanical damage
- Sunlight
- Rain protection
- Ventilation

11.7.3 Typical Mechanical Handling Method

When the trusses need to be loaded or unloaded, the people involved in this process should be prepared, available and familiar with the correct procedure for the task. Method statements will be produced for the projects and truss types and it is important to become familiar with the method statement for each handling method. Do not assume that because a truss is similar to a previously handled truss, the method will be the same. This may cause overstress or damage to the trusses.

Typically, roof trusses will be lifted using a spreader bar, as shown in the diagram below. Lightweight single trusses may also be handled manually to be re-located short distances within the factory.

11.7.4 Storage

The learner must ensure that the correct storage method statement is referred to and applied for each roof truss manufacturing project. Common tools used in truss storage are trestle tops and bearers. The exact positioning of these tools is important to prevent damage to the trusses.

Trusses can be stored either on the ground floor or on suitable platforms.

The temporary support should be in place before the trusses are re-located to prevent contact of the trusses with the ground, surrounding objects of vegetation.

Although the long-term storage of roof trusses on site or exposed to the elements in the shipping yard is undesirable, if this does happen, the trusses need to be adequately protected from the rain with allowance for ventilation.

Activity Identify wi

Identify which truss types are manufactured in your company



Activity

List below how you will organise your team to manufacture a Roof Structure and the tasks you and they will carry out. Also list any special equipment or tools you will use.



List below ALL the tools, jigs and equipment you will be using for the fabrication process:



Activity

Sketch your assembly procedure Flow Chart and explain each step giving the tolerances you work to. (use separate sheet)














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11.7.5 Vertical storage

Always refer to the manufacturing drawings for exact storage specification!

11.7.6 Horizontal storage

Always refer to the manufacturing drawings for exact storage specification!

11.8 Common metalwork and fixings

See Table 11.8.

11.9 Typical construction details

11.9.1 Roof truss connection types

See Table 11.9.1.

11.10 Erection process

11.10.1 Overview

The information in this section is best combined with onsite observation. Ask your supervisor if you can go to a building site and make notes and take photographs of the roof truss erection process.

It is normal for the manufacturer, together with the building designer, to decide on the safest method for erecting the roof trusses. These decisions prevent both damage to the trusses and injury to individuals.

Particular attention should be paid to the additional problems of windy conditions.

The supply of temporary bracing and any specialist equipment should not be forgotten.

11.10.2 Example -domestic roof

Firstly, mark a position for each truss along both wall-plates. Check also that the wall-plates are level. The first truss to be fixed should be one that will have a diagonal rafter brace at its apex (top) when the permanent bracing is complete.

Set this first truss onto the wallplates and prop it in the position, keeping it in place and vertical with a temporary diagonal brace at each wall-plate. Also, try to keep the roof truss vertical during positioning.

Fix and prop the rest of the run of trusses using temporary longitudinal braces (battens) fixed to the rafters and joists, as required. Check all trusses are vertical, straight, correctly spaced, correctly facing and parallel. Fix permanent diagonal braces, then fix permanent longitudinal and any required chevron braces.

Temporarily brace any further trusses off this braced section of roof until permanent bracing is added.

Check that the trusses have been erected as per the designer drawings and are vertical.

Further reading:

Truss Rafter Association

http://www.tra.org.uk/

11.11 Bracing

This is a very brief summary of the bracing of standard trusses. Bracing should be designed and checked by either the building designer or the roof designer. The designers will provide you with drawings for manufacturing. Check the drawings before you start work and make sure that all the information is clear and all necessary dimensions are indicated. If you see any missing

Further reading:

BS EN 1995-1-1:2004+A2:2014. Eurocode 5: Design of timber structures. General. Common rules and rules for buildings



Name	Purpose
Girder to Girder Hanger	Support multiple ply grider trusses from vertical truss members, with an efficient transfer of load between griders. Available in different widths and kN specifications.
Mono Truss Hanger	Support mono trusses from a horizontal timber element. Available with twist nail or twist nail + double shear nailing.
Angle Plate	Used to connect elements, which are perpendicular to each other, for light load applications.
Medium Girder Hanger	Grider to grider connector for medium load applications, fitted to a suitable vertical web member.
Girder Truss Shoe	Connection of girder trusses to horizontal elements. Higher qualified load performance and increased hole centres to spread load over greater area.
Truss Clip	A truss clip attaches girders, trusses and rafters to wall plates to provide wind restraint.
	Used to minimise damage to the ends of a truss when fixing to wall plate. Maximum width available is 50mm
Framing Anchor	A Pair of framing anchors replaces a Truss Clip when the width of timber is more than 50mm. (E.g. Girder Trusses)
Jiffy Hanger	Only used for supporting joists. Never to be used for supporting trusses. Note the short bearing length.
Masonry Hanger	These hangers are built into masonry and will need time for the mortar to set before use. There is a minimum depth of masonry required above the hanger and the load bearing capability is usually limited.
	Never to be used in a timber-to-timber connection.
	Wide choice of depths, widths and types available.
Maxi Speedy Shoe	A versatile hanger that can be used with nails, bolts, coach screws or a combination of fixings.
	Available in an wide range of widths and depths to suit
	supported load.
Girder to Girder Show	Deeper and made of thicker steel than most shoes, they are bolted to a girder truss to support heavy oncoming loads. Not to be used as a masonry hanger.
Cam plate	Cam plates are punched metal plates used to form designed timber joints.
Angle bracket	Angle brackets are used as connectors and anchors.
Coach bolt (cup square)	The length of thread of bolts is usually 2.5 times the diameter.
Square twist nail	Should be used in most builders metalwork
Round wire nail	Used to fix bracing



Table 11.9.1 Roof Truss Connection Types

Image	Note
	To prevent damage to nail- plates and ends of trusses, single ply Trussed Rafters should be fixed to wall- plates using Truss Clips as shown.
	Multiple ply trusses should be fixed using 2 framing anchors per end fixed (Right). Nail all holes using 3.75mm x 30mm long square twist nails.
	Top of hip-boards should be notched over a ledger fixed to the ridge truss.
No contraction of the second s	Additional strapping should be considered for wider ladders. Gable ladders are simply fixed by nailing to end truss.
	Fix battens to prevent valley frames sliding down the roof. Remember to continue the tiling battens beneath rafter of truss for roof restraint.

Image (cont)	Note (cont)
	When fixing loose timbers to match a short cantilever, packing the wall-plate, or fixing a pole-plate to the top of the joists may be required.
	With longer cantilevers, it may be more suitable to post rafters down to the wall- plate.
	Fix a timber scab to the back to form a frame.
	Hipboards can be treated in a similar manner to the detail above.
A Start	Often the length of a hip- board is too long to supply in a single piece.
	The hip-board should be joined over the flat top (hip) girder truss.
	Fix posts and ledgers to truss and notch hip-board over.

or contradicting information, or if you would like clarification, contact the designer before you start manufacturing.

It is important not to rely on rules of thumb known in the trade, but to examine the project drawings carefully as each project will vary.

- Lift trusses onto wall plate, ensure they are parallel and vertical and temporarily braced.
- Fix longitudinal braces at all unrestrained nodes.
- Fix rafter diagonal braces at as near an angle of 45 degrees, on plan, as possible.
- Longitudinal braces should be continued onto all peak panels and nailed with specified number of nails.
- Any Joints in braces should be lapped over as specified per drawings.
- In some cases, the design of the truss will require lateral web or web integrity braces. This will be clearly indicated on the drawings. If in doubt
- Tiling battens form one element of roof bracing. Normally it will be assumed that they will be laid onto the rafters as specified in the project drawings.
- Areas such as under valley frames should also be battened, as indicated in the project drawings.

Summary

For more information please visit the Trussed Rafter Association website:

Trussed Rafter Association

http://www.tra.org.uk/trussedrafters.php?id=37



12. Quality Control

12.1 Overview

It is common for timber frame manufacturers to establish, document, implement and maintain a Quality Management System (QMS) to ensure quality and consistency of the products which they manufacture to continually meet performance criteria and customer requirements.

A QMS details the organisational structure, policies, procedures and resources necessary for the implementation of effective quality control, in accordance with the requirements of recognised standards, to ensure that defined targets are continually achieved.

A QMS will typically comprise and focus upon the following elements:

- Documentation
- Policies
- Management
- Customer focus
- Planning
- Documented processes and procedures for manufacture
- Roles and responsibilities, authority and communication
- Resource management
- Human resources
- Infrastructure
- Work environment
- Design, development and product realisation
- Procurement and provision of services
- Equipment
- Monitoring and measurement
- Control of non-conformities/

non- conforming product

Continuous improvement

among others.

Timber frame manufacturers typically operate a QMS to ensure that their products are of consistently high quality and that their customers are satisfied that the product which they are purchasing is fit for purpose and in accordance with the specification.

Measuring the quality of a product and detecting any changes to the quality are both important features of the quality control process.

As timber frame components are manufactured in a factory they lend themselves well to strict quality control. This is a significant advantage when compared to traditional masonry construction on site.

It is important to familiarise themselves with the parts of the QMS relevant to their role and to ensure that it is always adhered to.

There are a number of product certification schemes for construction products.

It is important for staff to be aware of the product certification scheme and associated standards to which the company in which they work operates under and is certified to, if any.

12.2 Workmanship

12.2.1 Overview

Workmanship refers to ' the skill with which something was made or done' (Cambridge Dictionary) and therefore during the manufacturing stage your workmanship is the opportunity to demonstrate your skills. Attention to detail is an important part of workmanship, such as ensuring that the edges of cut timber are straight and smooth, that the nails are aligned perfectly and that the product is made exactly to size.

12.2.2 Workmanship requirements

At minimum, the quality of your workmanship needs to pass your organisation's quality control system. Examples include:

- Ensuring that sub-assemblies
 are within manufacturing
 tolerances
- Measuring diagonals
- Double-checking against the drawing dimensions and specifications
- Going through the process of manufacturing step by step, never skipping any steps
- Never passing on items below your organisation's workmanship quality to the next manufacturing station
- Do it right first time to avoid re-work
- Pay attention to your actions constantly, if someone stops you for a quick conversation, do not continues your production activity

12.2.3 Possible workmanship Issues

Some potential workmanship issues to be aware of in **party walls** are as follows:

Stud depth

- Distance between wall linings
- Insulation correctly installed to ensure continuity and that no slump may occur during transportation
- Incorrect installation of materials e.g. plasterboard and insulation types
- Cavity width between leaves
- Gaps & voids in plasterboard finishes
- Staggered joints in wall linings
- Sealed joints
- Correct installation of services (service ducts, sockets, switches)
- Connections between leaves
- Fasteners.

Some potential workmanship issues to be aware of for in **separating floors** are as follows:

- Correct installation of resilient bars on ceiling e.g. orientation of bars, removal of kinked/ damaged sections, use of correct screw length for lining boards
- Correct installation of ceiling system
- Correct installation of ceiling lining – fasteners shouldn't touch or penetrate floor joists
- Correct installation of insulation

 no gaps or voids
- Joints taped and filled (continuous)
- Correct installation of floor battens e.g. batten layout, battens orientation, fixing lengths
- Correct installation of flanking strips e.g. returned and folded under skirting boards
- Correct installation of services
 e.g. stacked services should not
 'fuse' floating floor systems



Activity

List below what you consider to be the most important points when checking on workmanship to create a "Right First Time" culture.



Activity

Find out what the workmanship requirements are in your organisation. Keep this list by your side during the start of manufacturing so that you can easily refer to it and the good practice will become standard practice for you. (attach herer or in computer folder)



Activity

Talk with others in your team about ways to streamline the work process overall. For example, could the nail locations be drawn on the timber studs in advance if nailing takes a long time, or could you reposition some of the tools to make your work easier? Make some brainstorming notes here and discuss with your supervisors. Similar to car manufacturing, quality control is critical to manufacturing an accurate timber frame component or sub-assembly.



12.3 Handovers

12.3.1 Overview

A 'handover' is the process of 'giving of control of or responsibility for something to someone else' (Cambridge Dictionary). This is the most critical point of the contract or the work package as it marks the completion of the work to a satisfactory standard.

12.3.2 Types

In timber frame manufacturing two types of handovers are referred to:

- Shift handover: when you pass the responsibility for continuing the work to a colleague at the end of your shift
- Project handover: when the possession of the timber frame elements passes to the client. This is often the most activityintense stage of the contract as it is critical that the client receives their product on time and to a high standard, to enable payment for the product from the client to the organisation you work for.

12.3.3 Processes

The shift handover is fairly straightforward and is an integral part of working day-to-day in timber frame manufacturing. The learner should become familiar with the process and checklist for shift handover in your organisation, if you have not already been informed about this.

The project contract hand-over process is more complex and is critical to the continuing operations at your timber frame manufacturing organisation. The hand-over is often completed onsite, after the timber frame has been erected and checked using a standard quality inspection sheet. Should any errors be found during the quality inspection, those need to be remediated before the handover process can be completed. Therefore, it is important that the workmanship of each panel and their assembly are done to a high standard, to avoid delays to the project schedule and project payments.

12.4 Quality inspection

There are many types quality inspections, from the day-today checks that the learner and their supervisor will perform during manufacturing, to quality control procedures within the company to ensure that the project is constructed to the client specifications, to external detailed audits (discussed below).

It is important to know what the quality procedures in your organisation are and to aim for quality pass of the products you manufacture.

Examples of different types of quality inspection sheets are included below.

12.5 Certification scheme examples

External audit quality control and inspection schemes provide objective guarantee of the manufactured product and manufacturing process quality. External thorough inspections are often referred to as audits, in which the organisation or a part of the organisation are systematically inspected, analysed and benchmarked against the required quality standards. Benchmarking is also possible against the standard company practices in the UK, which can reveal whether your organisation is in front or behind 'the curve!

12.5.1 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
- Enhances 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.bmtrada.com/

12.5.2 Other inspection and certification schemes:

- Trussed Rafter Association
- National House Building Control
- Local Authority Building Control

- CE Marking
- 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)
- ISO 9001 BS EN ISO 9001:2015 Quality management systems. Requirements
- 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



12.6 STA Quality Certification Schemes

12.6.1 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.

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.



Activity

Talk with others in your team about ways to streamline the work process overall. For example, could the nail locations be drawn on the timber studs in advance if nailing takes a long time, or could you reposition some of the tools to make your work easier? Make some brainstorming notes here and discuss with your supervisors.



Activity

Find and attach an example of a quality inspection sheet from your company.



ACTIVITY

Which certification schemes and standards does your company comply with? How do their requirements affect your work? Include notes on STA accreditation schemes among others.

12.6.2 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.



Further information:

http://www.structuraltimber. co.uk

13. Housekeeping and Tidiness

13.1 Overview

Housekeeping and tidiness are essential to the smooth operation of the factory. Consider how much easier it is to manufacture a wall panel for example if you have all the tools needed at a hand's distance rather than scattered around the factory for unknown reasons. This example embodies the 1926 quote by Henry Ford that ' Henry Ford wrote in 1926 that 'Good work requires good tools in a good organised environment!

Housekeeping and good organisation impact not only your manufacturing process, but also the productivity of the entire factory you are part of. The timely waste disposal, use of recycling bins, clearly labelled and neat stock storage, tools organisation, dust control and sub-assembly storage are all part of good housekeeping.

13.2 Methods and systems for continuous improvement

13.2.1 5S

The most often applied housekeeping method in timber frame manufacturing is 5S. No matter what type of Production System you follow 5S has been recognised as a key strategy by many of the winners of Britain's Best Factories Awards. 5S is part of the Japanese Lean manufacturing strategies, which aim to eliminated different types of waste in the manufacturing processes (e.g. time, transport, re-work...). 5S is not just about cleanliness; it is about the functional organisation of the workplace, so that work can be done in an efficient, safe and nonfrustrating environment.

The S's of the 5S are originally Japanese words, that have been adopted to try and use 5 meaningful English words beginning with S.

Sort

The first step of 5S involves getting rid of rubbish and clutter as you might expect, it also includes cleaning, getting rid of dust and oil etc. By getting rid of these unused items you can free up space, reduce the number of obstacles you have to walk around and find other more important items needed on a daily basis much more quickly.

Straighten

This phase of 5S is all about keeping things in their rightful place. Tools are put where they are needed, often-utilising shadow boards thereby making sure they are to hand and labelled as they should be.

Shine

Daily 5 - 10 minute cleaning routines are established to maintain a clean and tidy working environment. Operators are made responsible for their own working area keeping equipment clean and in good order and making sure tools are where they should be.

Systemise

You could sum up this phase of 5S as "Maintaining routine". Once the workplace has got through the first three phases it is often difficult to keep it up to the new standards you have set yourself. Do not underestimate how difficult it will be to maintain your new tidy work area to instil this mind set into your employees.

Sustain

From now on, we are moving into the area of ongoing improvement. All the previous steps of 5S have been about creating and maintaining a clean and tidy working environment. This phase of 5S is about moving forward not just maintaining the standards you've set yourself but building on those and raising the bar. It means not just cleaning up spills and leaks but tackling the underlying causes of those problems. In order to do this it required that records be kept of problems, when they occur, how often, how long they lasted etc. Having identified the biggest problems action to tackle the sources of those problems can be targeted accordingly.

13.2.2 5S adaptations

The company you are working for may have adapted the general 5S methodology to the particular timber frame manufacturing methods and production facility. This is good practice to make the housekeeping standards specific to the company and target week points.

Further information:

O'Connor, R. and Swain, B. (2013) Implementing Lean in construction: Lean tools and techniques – an introduction. London: CIRIA.





Activity

Find out what the housekeeping standards and methods are in the company you work for. Make some notes or attach a copy here and mark out which of these would come to you naturally and which you will have to make an effort to implement. You may decide to use a red-yellow-green highlight system and attach this list to your working area so as to improve your housekeeping.

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.

Here are a few we hope you will remember:

- The goods inwards process
- How to read production information, such as drawings, cuttings lists and specifications
- How to safely and correctly use the relevant manufacturing tools and equipment for each stage of the manufacturing process
- How to implement production control, such as production scheduling and job tracking
- How to prepare materials for manufacturing, including batching, optimisation and cutting
- How to manufacture a wall panel
- How to manufacture floor cassettes
- How to manufacture roof trusses
- How to implement quality control and its importance for the handover process
- The importance of good housekeeping

Most importantly, once you have been assessed on these Practical Skills in combination with Health and Safety and Knowledge Workbooks, you will have reached the highest level of qualification available for timber frame design in the UK and a level which the industry wishes all timber frame designers will 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.

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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Whilst the STA/CITB have had these workbooks prepared to provide guidance on timber frame construction, the STA/CITB accepts no liability and offers no warranties in relation to them and their contents to the fullest extent applicable law can exclude such liability. Users therefore are required to satisfy themselves as to the suitability of the contents of this guidance for their specific intended purpose.

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TIMBER FRAME WORKBOOKS





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