chapter 5

Building methods and construction technologies

OVERVIEW

Whatever type of building you may be involved in constructing, there are certain elements that must be included and certain principles that must be followed. For example, a block of flats and a warehouse will both have foundations, a roof, and so on.

At Level 2, you learned about the basic elements of a building. In this chapter, you will look in greater depth at the main elements and principles of building work and the materials used.

This chapter should be read in conjunction with Chapter 6, which looks specifically at the energy efficiency and sustainability of different building methods and materials.

This chapter will cover:

- foundations
- exterior walls
- internal walls
- floors
- roofs.

Insulation, which is now an important aspect of walls, flooring and roofing, is dealt with in Chapter 6.

Foundations

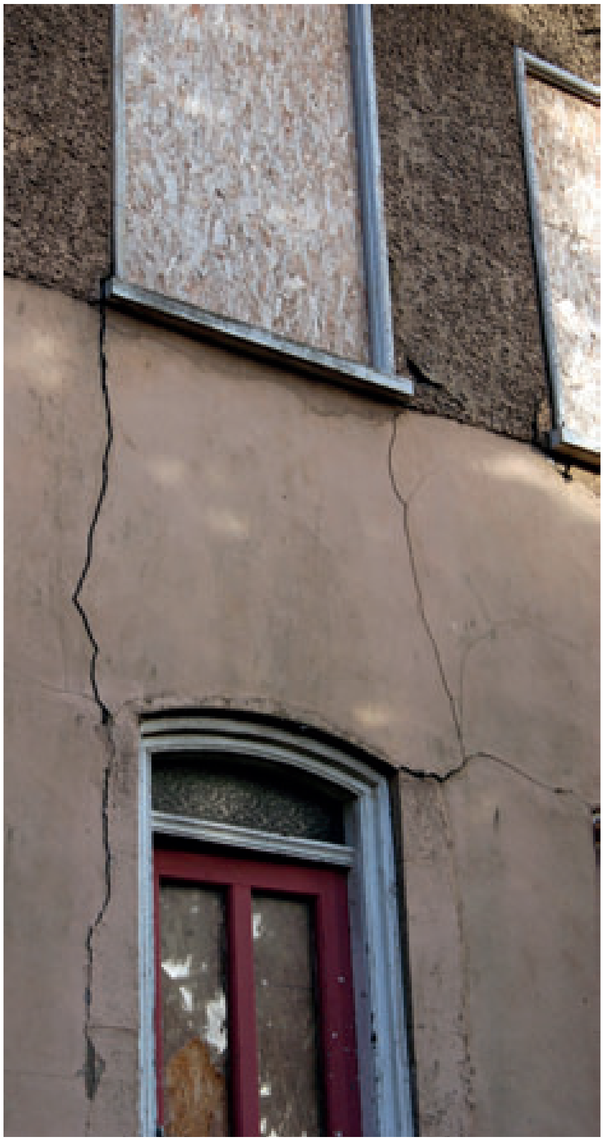
Any building work will start with the foundations. The design of any foundation will depend on a number of factors including ground conditions, soil type, the location of drains and trees in relation to the building, and any loads that may be generated, either by the structure or naturally.

The purpose of foundations

Definition

Dead load – the weight of the structure

Imposed load – the additional weight/loading that may be placed on the structure itself



A building damaged through subsidence

The foundations of a building ensure that all **dead** and **imposed loads** are safely absorbed and transmitted through to the natural foundation or sub-soils on which the building is constructed. Failure to adequately absorb and transmit these loads will result in the stability of the building being compromised, and will undoubtedly cause structural damage.

Foundations must also be able to allow for ground movement brought about by the soil shrinking as it dries out and expanding as it becomes wet. The severity of shrinkage or expansion depends on the type of soil you are building on.

Frost may also affect ground movement, particularly in soils that hold water for long periods. When this retained water freezes, it can make the sub-soil expand.

Tree roots and future excavations can also cause movement that affects the sub-soil.

Types of soil

As you can imagine there are many different types of soils. For foundation design purposes, these have been categorised as follows:

- rock
- gravel
- clay
- sand
- silt.

Each of these categories of sub-soil can be broken down even further: for example,

- clay which is sandy and very soft in its composition
- clay which is sandy but very stiff in its composition.

This information will be of most interest to the architect, but nonetheless is of the utmost importance when designing the foundation.

A number of calculations are used to determine the size and make-up of the foundation. These calculations take into account the **load-bearing capacity of the subsoil**. Calculations for some of the more common types of foundations can be found in the current *Building Regulations*. However, these published calculations cannot possibly cover all situations. Ultimately it will be down to the expertise of the building design teams to accurately calculate the bearing capacity of soils and the make-up of the foundation.

In the early stages of the design process, before any construction work begins, a site investigation will be carried out to ascertain any conditions, situations or surrounding sites which may affect the proposed construction work. A great deal of data will need to be established during site investigations, including:

- position of boundary fences and hedges
- location and depth of services, including gas, electricity, water, telephone cables, drains and sewers
- existing buildings which need to be demolished or protected
- position, height, girth and spread of trees
- types of soil and the depths of these various soils.

The local authorities will normally provide information relating to the location of services, existing buildings, planning restrictions, preservation orders and boundary demarcation. However, all of these will still need to be identified and confirmed through the site investigation. In particular, hidden services will need to be located with the use of modern electronic surveying equipment.

Definition

Load-bearing capacity of subsoil – the load that can be safely carried by the soil without any adverse settlement

Find out

Look at the different methods and equipment used to locate and identify various hidden services.

Find out

How are the different soil tests carried out?

Did you know?

Site investigations or surveys will also establish the contours of the site. This will identify where certain areas of the site will need to be reduced or increased in height. An area of the site may need to be built up in order to mask surrounding features outside the boundaries of the proposed building project.

Activity

In an area designated by your trainer, carry out a site survey and record your results.

Find out

How can plant growth affect some structures?

Soil investigations are critical. Samples of the soil are taken from various points around the site and tested for their composition and for any contamination. Some soils contain chemicals that can seriously damage the foundation concrete. These chemicals include sodium and magnesium sulphates. The effects of these chemicals on the concrete can be counteracted with the use of sulphate-resistant cements.

Many different tests can be carried out on soil. Some are carried out on site; others need to be carried out in laboratories. Tests on soil include:

- penetration tests – to establish density of soil
- compression tests – to establish shear strength of the soil or its load-bearing capacity
- various laboratory tests – to establish particle size, moisture content, humus content and chemical content.

Once all site investigations have been completed and all necessary information and data has been established in relation to the proposed building project, site clearance can take place.

Site clearance

The main purpose of site clearance is to remove existing buildings, waste, vegetation and, most importantly, the surface layer of soil referred to as topsoil. It is necessary to remove this layer of soil, as it is unsuitable to build on. This surface layer of soil is difficult to compact down due to the high content of vegetable matter, which makes the composition of the soil soft and loose. The topsoil also contains various chemicals that encourage plant growth, which may adversely affect some structures over time.

The process of removing the topsoil can be very costly, in terms of both labour and transportation. The site investigations will determine the volume of topsoil that needs to be removed.

Removing soil from a site

In some instances, the excavated topsoil may not be transported off site. Where building projects include garden plots, the topsoil may just need to be stored on site, thus reducing excessive labour and transportation costs. However, where this is the case, the topsoil must be stored well away from areas where buildings are to be erected or materials are to be stored, to prevent contamination of soils or materials.

Once the site clearance is complete, excavations for the foundations can start.

Trench excavation

In most modern-day construction projects, trenches are excavated by mechanical means. Although this is an expensive method, it reduces labour time and the risks associated with manual excavation work. Even with the use of machines to carry out excavations, an element of manual labour will still be needed to clean up the excavation work: loose soil from both the base and sides of the trench will have to be removed, and the sides of the trench will have to be finished vertically.

Manual labour is still required for excavating trenches on some projects where machine access is limited and where only small strip foundations of minimum depths are required.

Trenches to be excavated are identified by lines attached to and stretched between profiles. This is the most accurate method of ensuring trenches are dug to the exact widths.

Excavation work must be carefully planned as workers are killed or seriously injured every year while working in and around trenches. Thorough risk assessments need to be carried out and method statements produced prior to any excavation work commencing.

Potential hazards are numerous and include: possible collapse of the sides of the trench, hitting hidden services, plant machinery falling into the trench and people falling into the trench.

One main cause of trench collapse is the poor placement of materials near to sides of the trench. Not only can materials cause trench collapse, but they may also fall into the trench onto workers. Materials should not be stored near to trenches. Where there is a need to place materials close to the trench for use in the trench itself, always ensure these are kept to a minimum, stacked correctly and used quickly and, most importantly, ensure the trench sides are supported.

Trenches are often excavated by mechanical means

Did you know?

The Health and Safety Executive has produced detailed documents that deal exclusively with safety in excavations. These documents can be downloaded from the HSE website or obtained upon request direct from the HSE.

Regulations relating to safety in excavations are set out in the *Construction Regulations* and these must be strictly adhered to during the work.

Activity

Using sketches, show the different ways of supporting trench excavations.

Trench support

The type and extent of support required in an excavated trench will depend predominantly on the depth of the trench and the stability of the subsoil.

Traditionally, trench support was provided just by using varying lengths and sizes of timber, which can easily be cut to required lengths. However, timber can become unreliable under certain loadings, pressures and weather conditions and can fail in its purpose.

More modern types of materials have been introduced as less costly and time-consuming methods of providing the required support. These materials include steel sheeting, rails and props. Trench support can be provided with a mixture of both timber and steel components.

Here you can see the methods of providing support in trenches with differing materials and a combination of these materials.

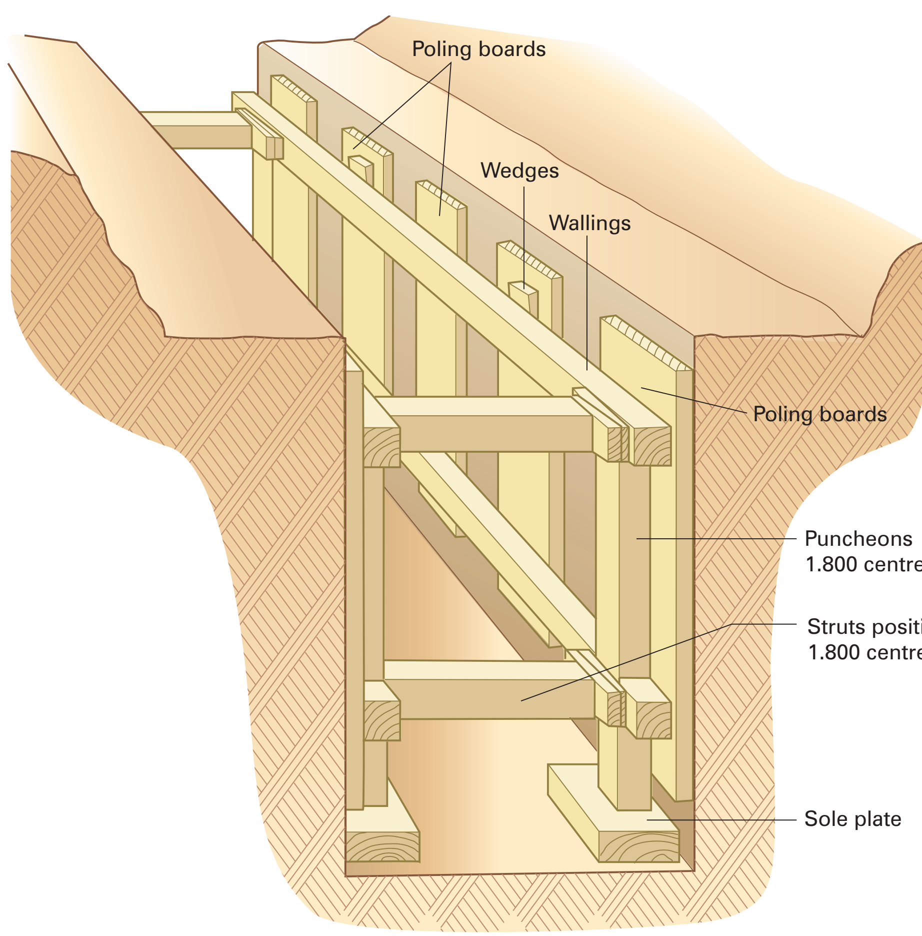


Figure 5.1 Timber used in trench support

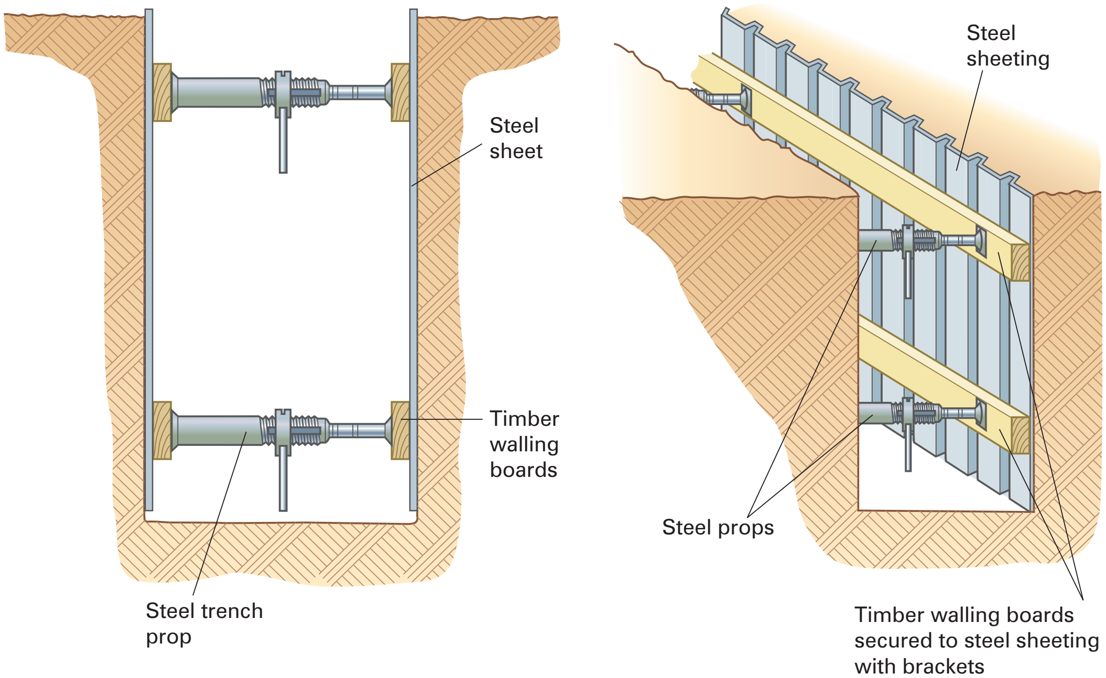


Figure 5.2 Combination of timber and steel used in trench support

The amount of timber or other materials required to provide adequate temporary support will be determined by the characteristics of the soil and the soil's ability to remain stable during the time over which the work is carried out. The atmospheric conditions will also affect the soil's ability to remain stable. The longer the soil is exposed to the natural elements, the more chance there is of the soil shrinking or expanding.

Without support, soil will have a natural angle of repose: in other words, the angle at which the soil will rest without collapsing or moving. Again, this will be affected by the natural elements to which the soil is exposed. It is virtually impossible to accurately establish the exact angle at which a type of soil will settle, so it is always advisable to provide more support than is actually required.

Site engineers will carry out calculations in relation to the support requirements for trenches.

Temporary barriers or fences should also be provided around the perimeters of all trenches, to prevent people falling into the trenches and also to prevent materials from being knocked into them. Good trench support methods will incorporate extended trench side supports, which provide a barrier – similar to a toe board on a scaffold – to prevent materials being kicked or knocked into the trench. Where barriers or fences are impractical, then trenches should be covered with suitable sheet materials.

In addition to the supports already mentioned, any services which run through the excavated trenches (in particular drains and gas pipes) need to be supported, especially where the ground has to be excavated underneath them.

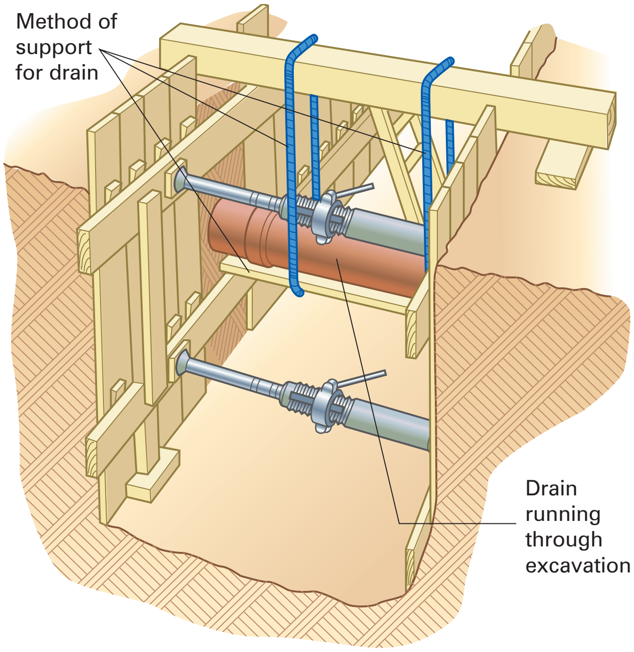


Figure 5.3 Support for drains running through an excavation

Where trenches have to be excavated close to existing buildings, it may be necessary to provide support to the elevation adjacent to the excavation. This is due to the fact that, as ground is taken away from around the existing foundations, the loads will not be adequately and evenly distributed and absorbed into the natural or sub-foundation, possibly causing the structure to collapse. This support is known as shoring.

One other factor that can affect the safety of workers in excavations and the stability of the soil is surface water. Surface water can be found at varying levels within the soil and, depending on the depth, trenches can easily cause flooding. Where this occurs, water pumps will need to be used to keep the trench clear. Failure to keep the trench free of water during construction will not only make operations difficult, but may also weaken and loosen the support systems due to soil displacement.

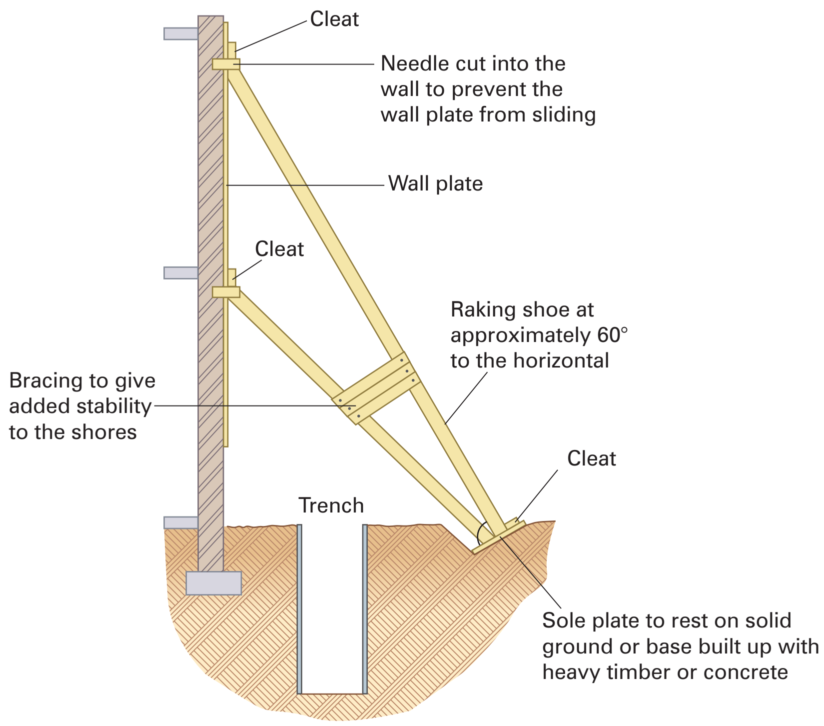


Figure 5.4 Raking shores used to support an existing building

Types of foundation

As previously stated, the design of a foundation will be down to the architect and structural design team. The final decision on the suitability and depth of the foundation, and on the thickness of the concrete, will rest with the local authority's building control department.

Strip foundations

The most commonly used strip foundation is the 'narrow strip' foundation, which is used for small domestic dwellings and low-rise structures. Once the trench has been excavated, it is filled with concrete to within 4–5 courses of the ground level DPC. The level of the concrete fill can be reduced in height, but this makes it difficult for the bricklayer due to the confined area in which to lay bricks or blocks.

The depth of this type of foundation must be such that the subsoil acting as the natural foundation cannot be affected by the weather. This depth would normally not be less than 1 m.

The narrow strip foundation is not suitable for buildings with heavy structural loading or where the subsoil is weak in terms of supporting the combined loads imposed on it. Where this is the case, a wide strip foundation is needed.

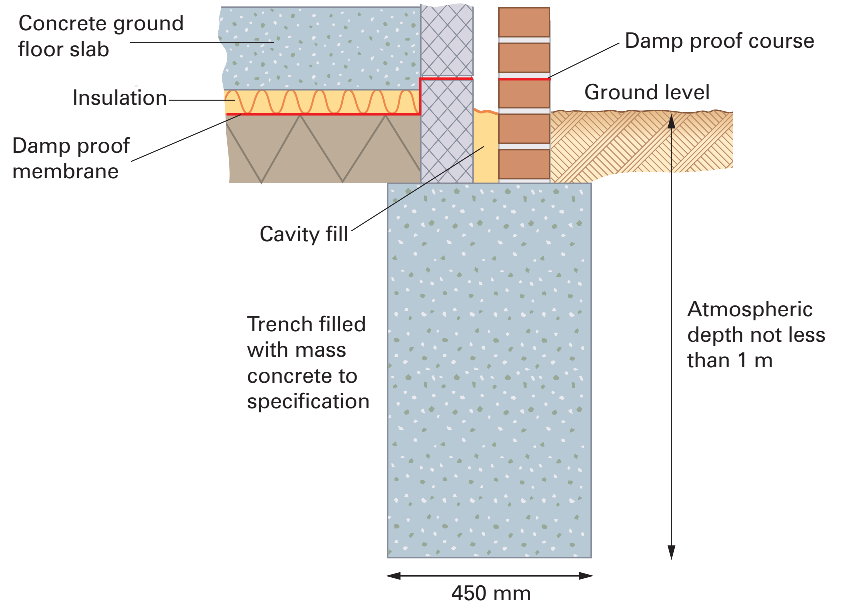


Figure 5.5 Narrow strip foundation

Wide strip foundations

Wide strip foundations consist of steel reinforcement placed within the concrete base of the foundation. This removes the need to increase the depth considerably in order to spread the heavier loads adequately.

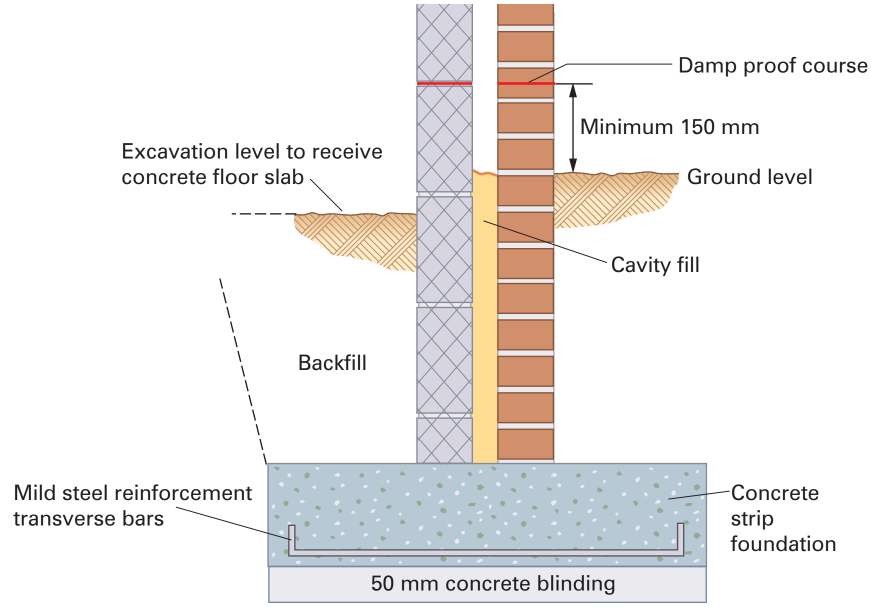


Figure 5.6 Wide strip foundation

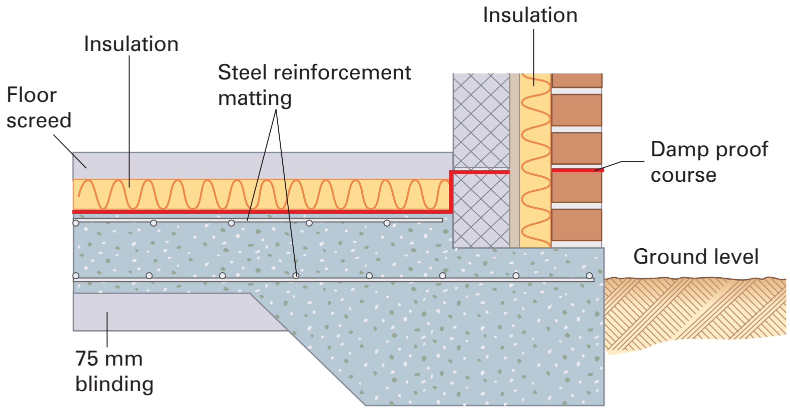


Figure 5.7 Raft foundation

Raft foundations

These types of foundation are used where the soil has poor bearing capacity, making the soil prone to settlement. A raft foundation consists of a slab of reinforced concrete covering the entire base of the structure. The depth of the concrete is greater around the edges of the raft in order to protect the load-bearing soil directly beneath the raft from further effects of moisture taken in from the surrounding area.

Pad foundations

Pad foundations are used where the main loads of a structure are imposed at certain points. An example would be where brick or steel columns support the weight of floors or roof members, and walls between the columns are of non-load-bearing cladding panels. The simplest form of pad foundation is where individual concrete pads are placed at various points around the base of the structure, and concrete ground beams span across them. The individual concrete pads will absorb the main imposed loads, while the beams will help support the walls.

The depth of a pad foundation will depend on the load being imposed on it; in some instances, it may be necessary to use steel reinforcement to prevent excessive depths of concrete. This type of pad foundation can reduce the amount of excavation work required, as trenches do not need to be dug out around the entire base of the proposed structure.

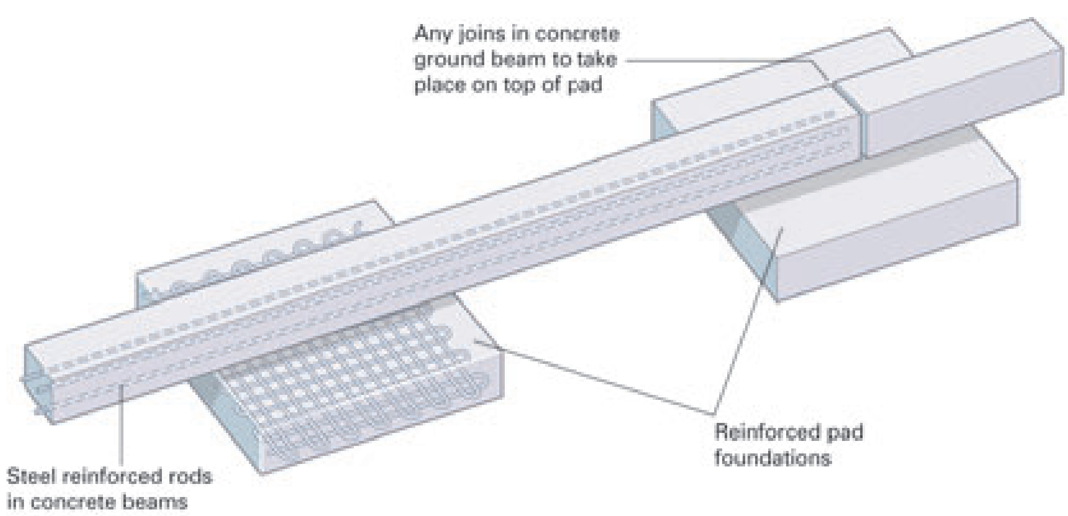


Figure 5.8 Square pad foundation with spanning ground beams

Piled foundations

There are a large number of different types of piled foundations, each with an individual purpose in relation to the type of structure and ground conditions.

Short bored piled foundations are the most common piled foundations. They are predominantly used for domestic buildings where the soil is prone to movement, particularly at depths below 1 m.

A series of holes are bored, by mechanical means, around the perimeter of the base of the proposed building. The diameter of the bored holes will normally be between 250 and 350 mm and can extend to depths of up to 4 m. Once the holes have been bored, shuttering is constructed to form lightweight reinforced concrete beams, which span across the bored piles. The bored holes are then filled with concrete, with reinforcement projecting from the top of the pile concrete, so it can be incorporated into the concrete beams that span the piles.

As with the pad foundation, short bored piled foundations can significantly reduce the amount of excavated soil because there is no need to excavate deep trenches around the perimeter of the proposed structure.

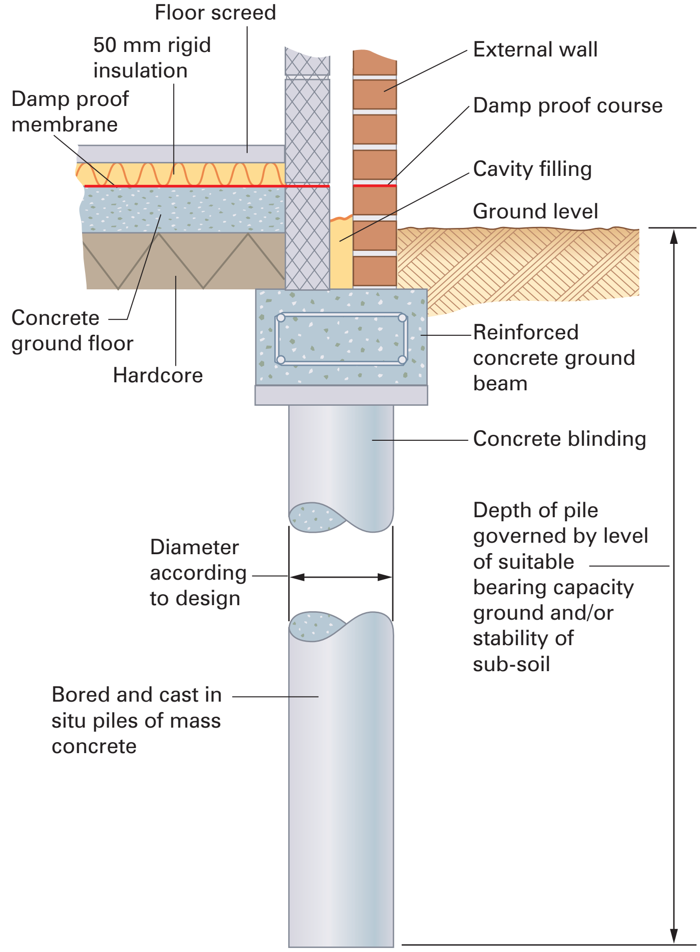


Figure 5.9 Typical short bored piled foundation

Stepped foundations

A stepped foundation is used on sloping ground. The height of each step should not be greater than the thickness of the concrete, and should not be greater than 450 mm. Where possible, the height of the step should coincide with brick course height in order to avoid oversized mortar bed joints and eliminate the need for split brick courses. The overlap of the concrete to that below should not be less than 300 mm or less than the thickness of the concrete.

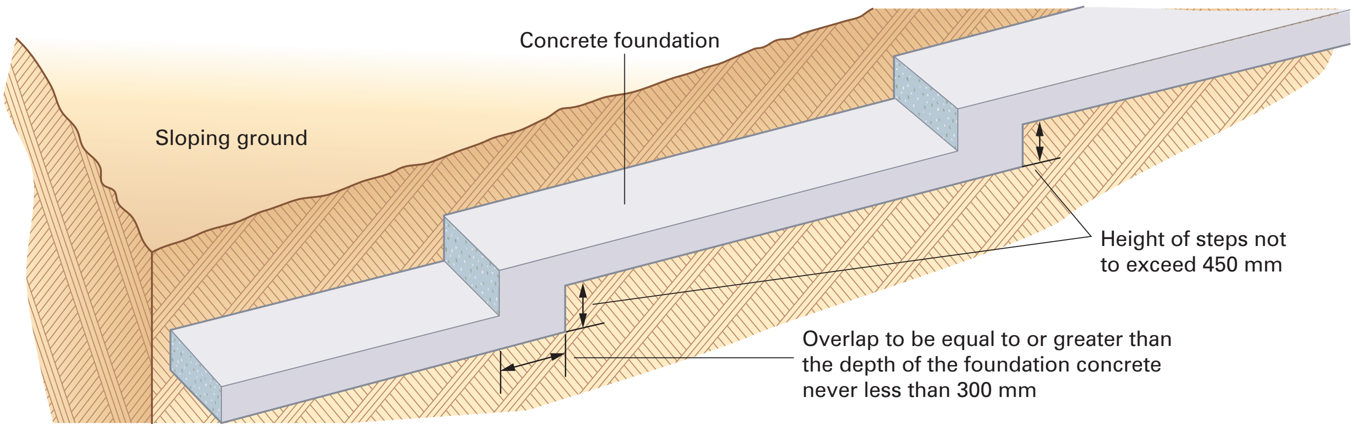


Figure 5.10 Typical stepped foundation

Activity

Sketch the following different types of foundation:

- strip foundation
- wide strip foundation
- raft foundation
- pad foundation
- piled foundation
- stepped foundation.

Knowledge refresher

1. What should happen before any construction work commences on a building project?
2. State three factors that influence the design of a foundation.
3. Explain what is meant by a 'dead load'.
4. Explain what is meant by an 'imposed load'.
5. During a site investigation, certain data need to be collected. Name three types of data that have to be recorded.
6. Why must excavation work be carefully planned before it is carried out?
7. Name three categories of soil.
8. Name three types of foundation.
9. How can surface water affect excavation work?
10. In a stepped foundation, what is the recommended maximum height of each concrete step?

What would you do?

1 You have been tasked with building a garage. You decide not to go with a soil survey as this is an extra expense, and you just put in a standard strip foundation. What could go wrong? What could the cost implications be? What other implications could there be?

2 You have been asked by your boss to enter an excavation to clean out some loose soil. The excavation is 1.5 m deep, and has been excavated for a foundation. There are no supports on the excavation sides and overnight there has been a considerable amount of rainfall. Your boss shouts at you to get on with it as the concrete for the foundation will be here in 10 minutes. What should you do? What could the implications be if you do it? What could the implications be if you don't?

Exterior walls

External walls come in a variety of types, but the most common is cavity walling. Cavity walling is simply two masonry walls built parallel to each other, with a gap between acting as the cavity. The cavity wall acts as a barrier to weather, with the outer leaf preventing rain and wind penetrating the inner leaf. The cavity is usually filled with insulation to prevent heat loss.

How cavity walls are constructed

Cavity walls mainly consist of a brick outer skin and a blockwork inner skin. There are instances where the outer skin may be made of block and then rendered or covered by tile hanging. The minimum cavity size allowed is 75 mm but the cavity size is normally governed by the type and thickness of insulation to be used and whether the cavity is to be fully filled or partially filled with insulation.

The thickness of blocks used will also govern the overall size of the cavity wall. On older properties, the internal blocks were always of 100 mm thickness. Nowadays, due to the emphasis on energy conservation and efficiency, blocks are more likely to be 125 mm or more.

In all cases, the cavity size will be set out to the drawing with overall measurements specified by the architect and to local authority requirements.

Once the **foundations** have been concreted the **sub-structural walling** can be constructed, usually by using blocks for both walls (see Figure 5.11).

Definition

Foundations – concrete bases supporting walls

Sub-structural walling – brickwork between the foundation concrete and the horizontal damp proof course (DPC)

Remember

The correct size must be used for the internal wall, with the cavity size to suit.

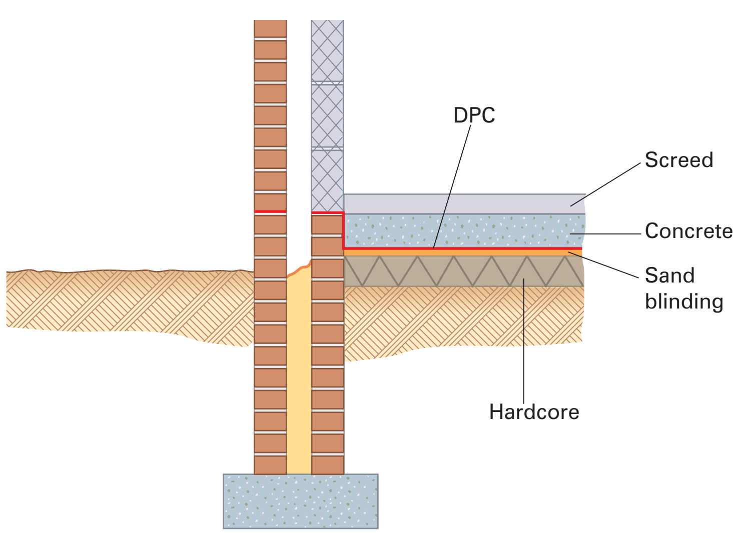


Figure 5.11 Section of sub-structural walling

In some situations trench blocks may be used below ground level and then traditional cavity work constructed up to the damp proof course (DPC). A horizontal DPC must be inserted at a minimum height of 150 mm above ground level to both walls. This is to prevent damp rising, below ground, up through the block and brickwork to penetrate to the inside. The cavity must also be filled with weak concrete to ground level to help the sub-structural walling resist lateral pressure.

Cavity walls above DPC

The older, traditional way to build a cavity wall is to build the brickwork first and then the blockwork. Now, due to the introduction of insulation into the cavity, the blockwork is generally built first, especially when the cavity is partially filled with insulation. This is because the insulation requires holding in place against the internal block wall, by means of special clips that are attached to the **wall ties**. In most cases the clips are made of plastic as they do not rust or rot. The reason for clipping the insulation is to stop it from moving away from the blocks, which would cause the loss of warmth to the interior of the building, as well as causing a possible **bridge** of the cavity, which could cause a damp problem.

The brick courses should be gauged at 75 mm per course but sometimes course sizes may change slightly to accommodate window or door heights. In most instances these positions and measurements are designed to work to the standard gauge size. This will also allow the blockwork to run level at every third course of brick, although the main reason will be explained in the wall tie section below.

On most large sites, patent types of corner profile are used rather than building traditional corners (see Figure 5.12). These allow the brickwork to be built faster and, if set up correctly, more accurately. But they must also be marked for the gauge accurately and it makes sense to mark window sill heights or **window heads** and door heights so they do not get missed, which would result in brickwork being taken down.

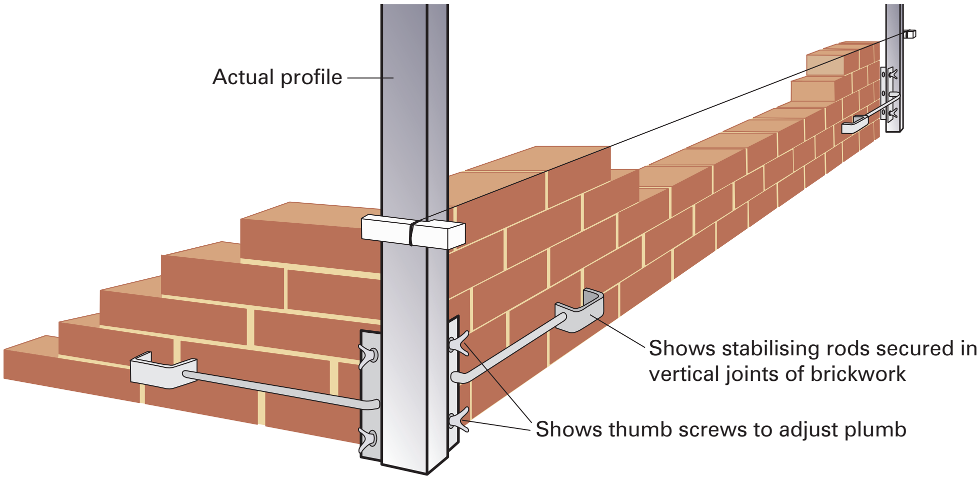


Figure 5.12 A corner profile set up

Activity

Sketch a section through a cavity wall including DPC and wall ties.

Definition

Wall ties – stainless steel or plastic fixings to tie cavity walls together

Bridge – where moisture can be transferred from the outer wall to the inner leaf by material touching both walls

Window head – top of a window

Wall ties

Wall ties are a very important part of a cavity wall as they tie the internal and external walls together, resulting in a stronger job. If we built cavity walls to any great height without connecting them together, the walls would be very unstable and could possibly collapse.

A wall tie should be:

1. rust-proof
2. rot-proof
3. of sufficient strength
4. able to resist moisture.

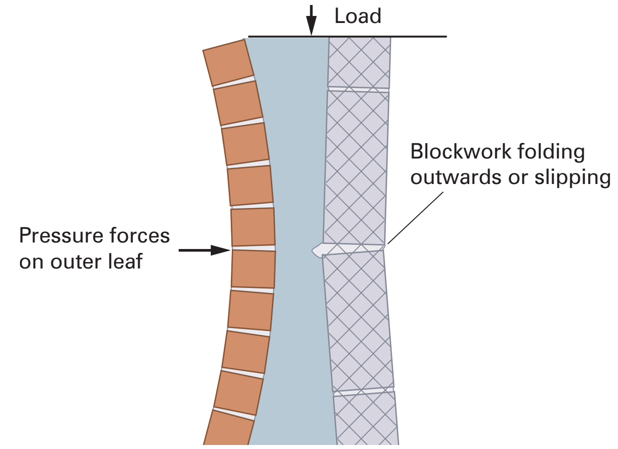


Figure 5.13 Section of wall without wall ties

There are many designs of wall tie currently on the market, with a wide selection suitable for all types of construction methods. One of the most common types used when tying together brick and block leaves is the masonry general purpose tie. These ties are made from very strong stainless steel, and incorporate a twist in the steel at the mid point of the length. This twist forms a drip system, which prevents the passage of water from the outer to the inner leaf of the structure.

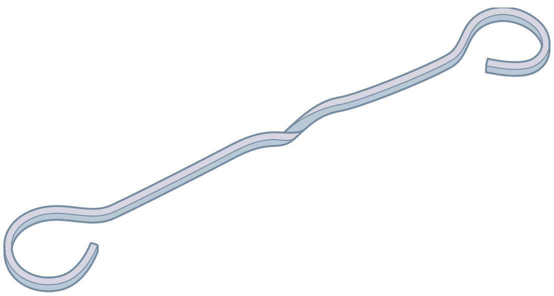


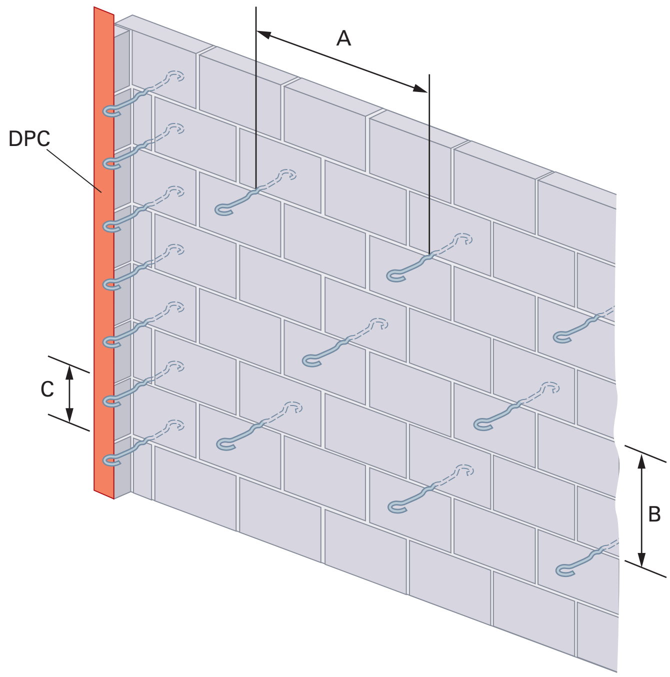
Figure 5.14 General purpose wall tie

You must take care to keep the wall ties clean when they are placed in the wall: if bridging occurs, it may result in moisture penetrating the internal wall.

The positioning and density of wall ties

In cavity walling where both the outer and inner leaves are 90 mm or thicker, you should use ties at not less than 2.5 per square metre, with 900 mm maximum horizontal distance by a maximum 450 mm vertical distance and staggered.

At positions such as vertical edges of an opening, unreturned or unbonded edges and vertical expansion joints, you need to use additional ties at a maximum of 300 mm in height (usually 225 mm to suit block course height) and located not more than 225 mm from the edge. Wall ties should be bedded into each skin of the cavity wall to a minimum distance of 50 mm.



A 900 mm maximum horizontal distance

B 450 mm maximum vertical distance

C Additional ties, 300 mm maximum vertical distance

Figure 5.15 Spacing of wall ties

Did you know?

Any batten can be used as long as the width is the same as the cavity space.

Definition

Cavity batten – a timber piece laid in a cavity to prevent mortar droppings falling down the cavity

Keeping a cavity wall clean

It is important to keep the cavity clean to prevent dampness. If mortar is allowed to fall to the bottom of the cavity it can build up and allow the damp to cross and enter the building. Mortar can also become lodged on the wall ties and create a bridge for moisture to cross. We can prevent this by the use of **cavity battens**, pieces of timber the thickness of the cavity laid on to the wall ties and attached by wires or string (to prevent dropping down the cavity) to the wall and lifted alternately as the wall progresses.

The bottom of the wall can be kept clean by either leaving bricks out or bedding bricks with sand so they can be taken out to clean the cavity. These are called core holes and are situated every fourth brick along the wall to make it easy to clean out each day. Once the wall is completed the bricks are bedded into place.

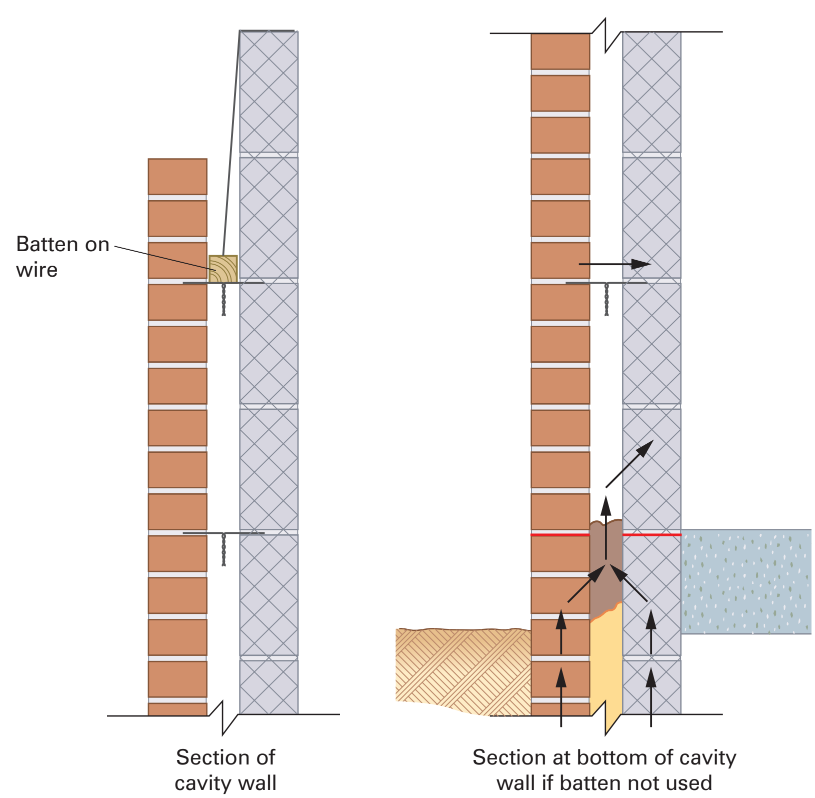


Figure 5.16 Cavity batten in use

Remember

Clean at the end of each day, as the mortar will go hard. Good practice is to lay hessian across the wall ties and remove it at the end of each day to clear any mortar that has dropped down the cavity.

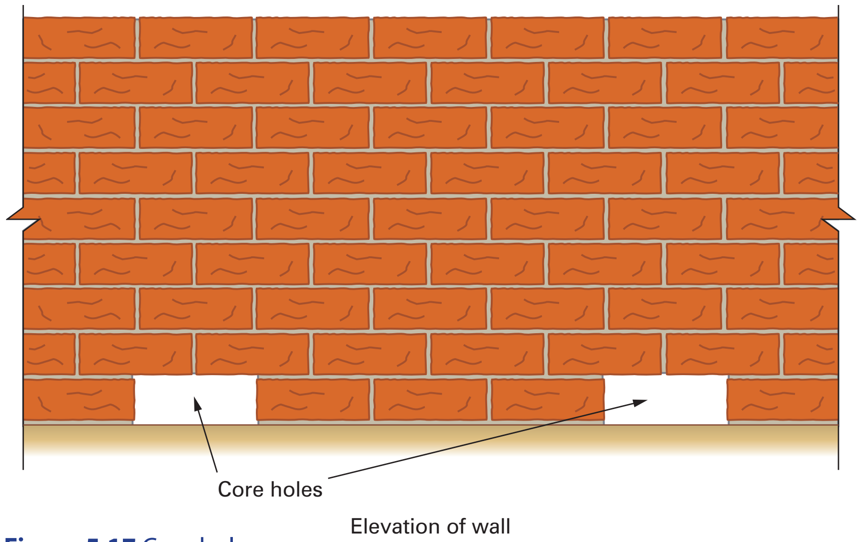


Figure 5.17 Core holes

Steps to take to prevent damp penetration

- Set out openings carefully to avoid awkward bonds.
- Care is needed in construction to make sure dampness or water does not enter the building.
- DPCs and wall ties should be carefully positioned.
- Steel cavity lintels should have minimum 150 mm bearings solidly bedded in the correct position.
- Weep holes should be put in at 450 mm centres immediately above the lintel in the outer leaf.

No insulation has been shown in the drawings because they only show one situation. In most cavity wall construction, insulation of one kind or another will have to be incorporated to satisfy current *Building Regulations*.

Remember

You must read your drawings and specifications carefully to see what is required and always fix insulation to manufacturers' instructions.

Fire spread

In addition to the prevention of damp penetration and cold bridging, there is a requirement under the *Building Regulations* that cavities and concealed spaces in a structure or fabric of a building are sealed by using cavity barriers or fire stopping. This cuts down the hidden spread of smoke or flames in the event of fire breaking out in a building.

Closing at eaves level

The cavity walls have to be 'closed off' at roof level for two main reasons:

1. To prevent heat loss and the spread of fire.
2. To prevent birds or vermin entering and nesting.

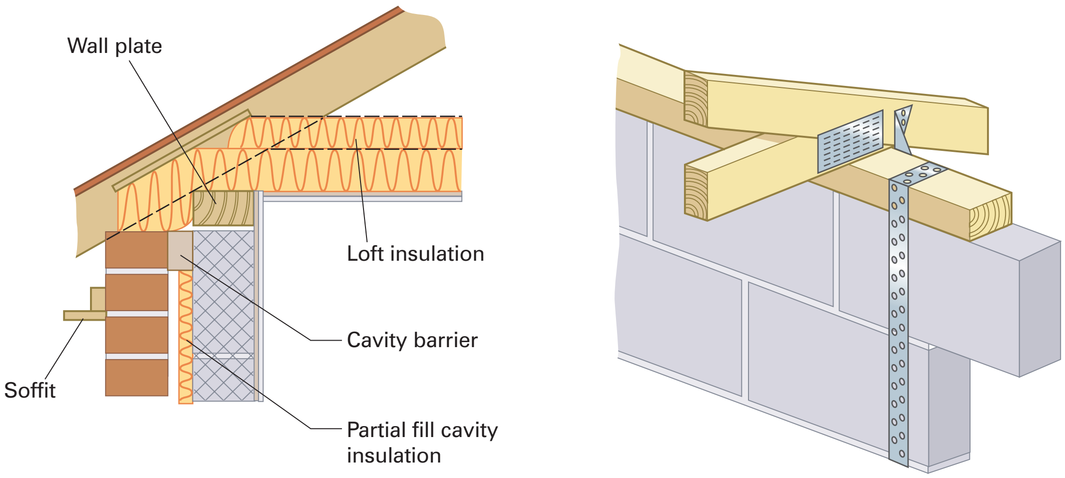


Figure 5.18 Roof section

This area of the wall is where the roof is connected, by means of a timber wall plate bedded on to the inner leaf. The plate is then secured by means of restraint straps that are galvanised 'L' shaped straps screwed to the top of the wall plate and down the blockwork. This holds the roof structure firmly in place and also prevents the roof from spreading under the weight of the tiles, etc. The minimum distance that the straps should be apart is 1.2 m. In some instances they may be connected directly from the roof truss to the wall.

If a gable wall is required, restraint straps should be used to secure the roof to the end wall (see Figure 5.18).

The external wall can be built to the height of the top of the truss so as not to leave gaps, or 'closed off' by building blocks laid flat to cover the cavity above the external soffit line from inside, avoiding damp penetration. In some instances the cavity may be left open with the cavity insulation used as the seal.

Timber-kit houses

Timber-kit houses are becoming more and more popular as they can be erected to a windtight and watertight stage within a few days. The principle is similar to a cavity wall, but here the inner skin is a timber frame, which is clad in timber sheet material and covered in a breathable membrane, to prevent water and moisture penetrating the timber. The outer skin is usually face brickwork.

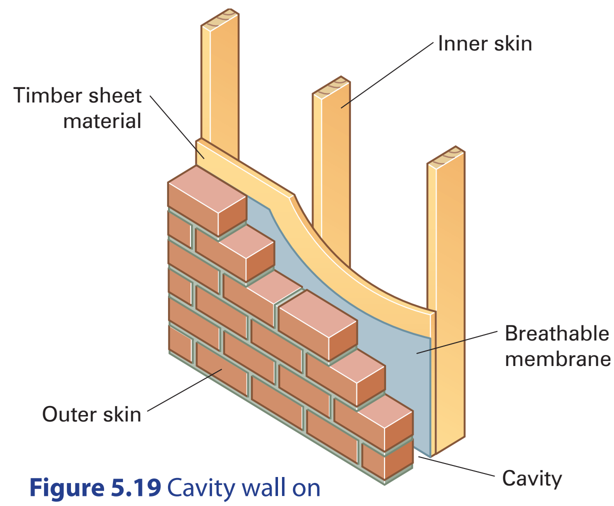


Figure 5.19 Cavity wall on a timber-kit house

Constructing timber-kit houses

Timber-kit house construction starts off in exactly the same way as any house build, with the foundations and the cavity wall built up to DPC level. However, from then on, the construction method is completely

Activity

Find out the cost of a standard timber-kit panel, then compare the price to building an area the same size in traditional cavity walling.

Activity

Find out the thermal properties of both timber-kit and traditional cavity wall construction.

Safety tip

Load-bearing walls must not be altered without first providing temporary supports to carry the load until the work has been complete.

Activity

Find out the thermal properties of both a timber stud wall and an internal solid block wall.

different, as the interior skin of the cavity is timber framed as opposed to block work. The timber-kit house is created in panels within a factory environment and delivered in sections on the back of a lorry.

The timber panels are lifted into place (usually by crane) and are bolted together. Once the wall panels are in place, the exterior face brickwork can begin.

There are also other types of exterior walling, such as solid stone or log cabin style. Industrial buildings may have steel walls clad in sheet metal.

Internal walls

Internal walls are either load bearing – meaning they support any upper floors or roof – or are non-load-bearing, used to divide the floor space into rooms.

Internal walls also come in a variety of styles. Here is a list of the most common types.

- **Solid block walls** – simple block work, either covered with plasterboard or plastered over to give a smooth finish, to which wallpaper or paint is applied. Solid block walls offer low thermal and sound insulation qualities, but advances in technology and materials means that blocks manufactured from a lightweight aggregate can give better sound and heat insulation.
- **Solid brick walling** – usually made with face brickwork as a decorative finish. It is unusual for all walls within a house to be made from brickwork.
- **Timber stud walling** – more common in timber kit houses and newer buildings. Timber stud walling is also preferred when dividing an existing room, as it is quicker to erect. Clad in plasterboard and plastered to a smooth finish, timber stud partitions can be made more fire resistant and sound/thermal qualities can be improved with the addition of insulation or different types of plasterboard. Another benefit of timber stud walling is that timber noggins can be placed within the stud to give additional fixings for components such as radiators or wall units. Timber stud walling can also be load bearing, in which case thicker timbers are used.
- **Metal stud walling** – similar to timber stud, except metal studs are used and the plasterboard is screwed to the studding.
- **Grounds lats** – timber battens that are fixed to a concrete or stone wall to provide a flat surface, to which plasterboard is attached and a plaster finish applied

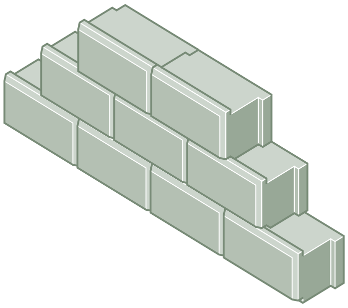


Figure 5.20 Solid block wall

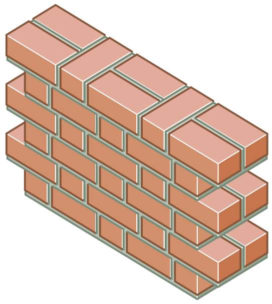


Figure 5.21 Solid brick wall

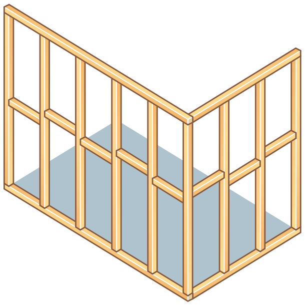


Figure 5.22 Timber stud wall

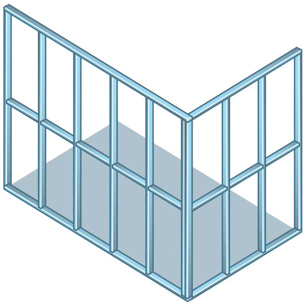


Figure 5.23 Metal stud wall

Knowledge refresher

1 What is the minimum cavity size for a cavity wall?

2 What is the purpose of wall ties in a cavity wall?

3 State one advantage of using a corner profile.

4 What is the main reason a cavity needs to be kept clean?

5 Outline three steps to take to prevent damp penetration in a cavity wall.

6 Give two reasons why cavity walls have to be closed off at roof level.

7 State one advantage of using timber kit as opposed to cavity walling.

8 How are timber panels in a kit house joined together?

9 How could a timber stud wall be made more soundproof?

10 Describe how a solid internal block wall can be finished.

What would you do?

1 You are going to build your own house. Using the information you gained from previous Activities and what you know, what type of house should you build: cavity or kit?

2 You have been tasked with creating an opening in an internal block work wall. What can you do to check if the wall is load bearing? What should be done if the wall is load bearing? What could the consequences be if the wall is load bearing and you create the opening without shoring?

Floors

Floors have a number of standard components, including the following:

- **DPC**

This is the damp proof course that is inserted into both skins of the external cavity wall construction. It should be a proprietary product that is tested and has a long life expectancy.

- **DPM**

This is the damp proof membrane, which is placed in large sheets within the floor structure so it can resist the passage of moisture and rising damp. This keeps the floors dry. The DPM should be taken up vertically and tucked into the DPC to form a complete seal. All DPM should be lapped by at least 300 mm, with any joints taped.

- **Screeds**

Floor screeds are considered in the solid concrete floor section (see page 118). They provide a finish to the concrete surface, cover up services and provide a level for floor finishes to be applied to. They also provide falls to floors: for example, in a wet room for the shower waste.

- **Wall plate**

The wall plate is on top of the sleeper wall that supports the floor joists. It has a DPC underneath it to prevent damp penetrating the timber. Wall plates should be treated.

The most common types of flooring used are:

- suspended timber floors
- solid concrete floors
- pre-cast beam floors
- floating floors.

Suspended timber floors

Suspended timber floors can be fitted at any level, from top floor to ground floor. In the next few pages, you will look at:

- basic structure
- joists
- construction methods
- floor coverings.

Basic structure

Suspended timber floors are constructed with timbers known as joists, which are spaced parallel to each other spanning the distance of the building. Suspended timber floors are similar to traditional roofs in that they can be single or double, a single floor being supported at the two ends only and a double floor supported at the two ends and in the middle by way of a honeycombed sleeper/dwarf wall, steel beam or load-bearing partition.

Definition

Damp proof course (DPC) – a substance that is used to prevent damp from penetrating a building

All floors must be constructed to comply with the *Building Regulations*, in particular Part C, which is concerned with damp. The bricklayer must insert a **damp proof course (DPC)** between the brick or block work when building the walls, situated no less than 150 mm above ground level. This prevents moisture moving from the ground to the upper side of the floor. No timbers are allowed below the DPC. Air bricks, which are built into the external walls of the building, allow air to circulate round the underfloor area, keeping the moisture content below the dry rot limit of 20 per cent, thus preventing dry rot.

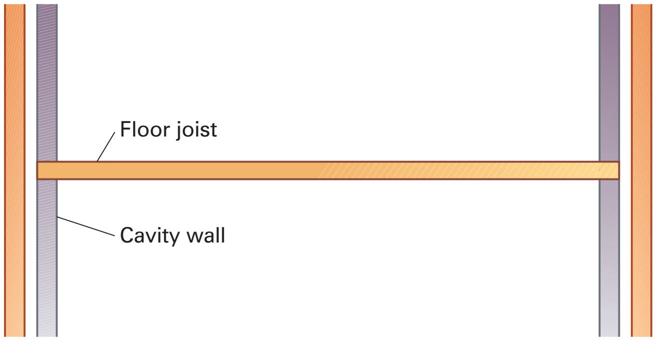


Figure 5.24 Single floor

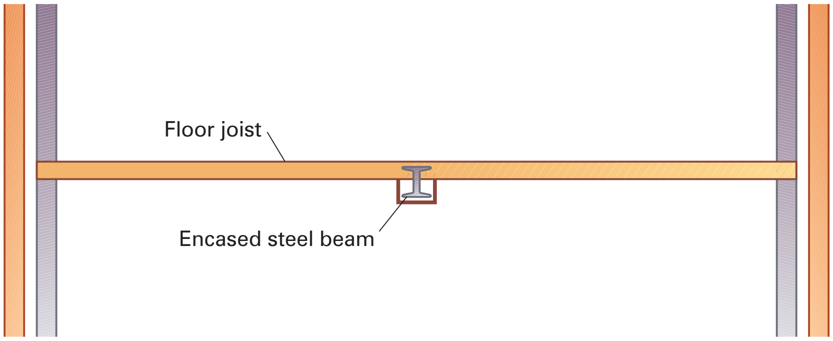


Figure 5.25 Double floor

Joists

In domestic dwellings suspended upper floors are usually single floors, with the joist supported at each end by the structural walls but, if support is required, a load-bearing partition is used. The joists that span from one side of the building to the other are called bridging joists, but any joists that are affected by an opening in the floor such as a stairwell or chimney are called trimmer, trimming and trimmed joists.

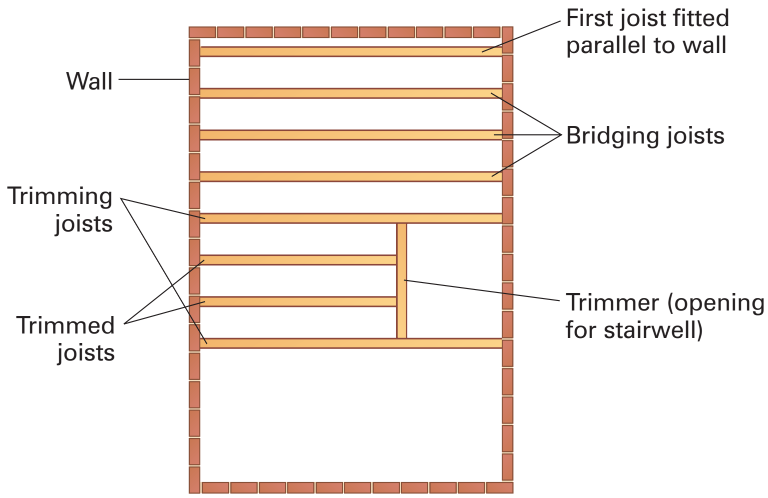


Figure 5.26 Joists and trimmers

Types of joist

As well as the traditional method of using solid timber joists, there are now alternatives available. These are the most common.

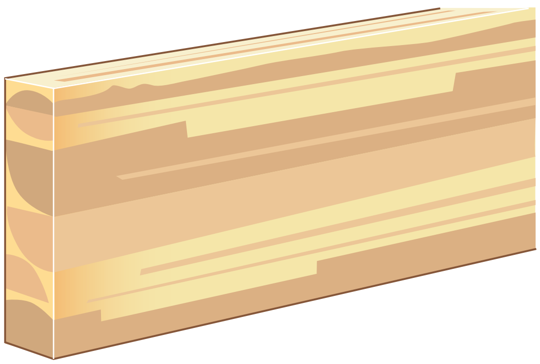


Figure 5.27 Laminated joist

Laminated joists

These were originally used for spanning large distances, as a laminated beam could be made to any size, but now they are more commonly used as an environmental alternative to solid timber – recycled timber can be used in the laminating process. They are more expensive than solid timber, as the joists have to be manufactured.

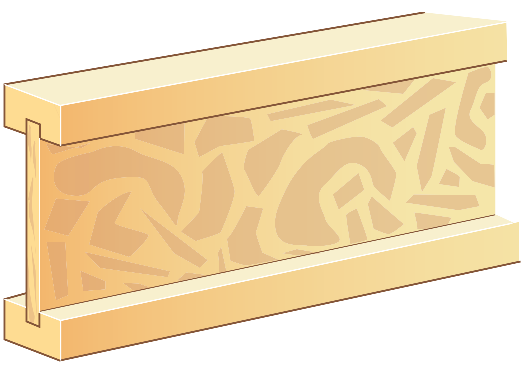


Figure 5.28 I type joist

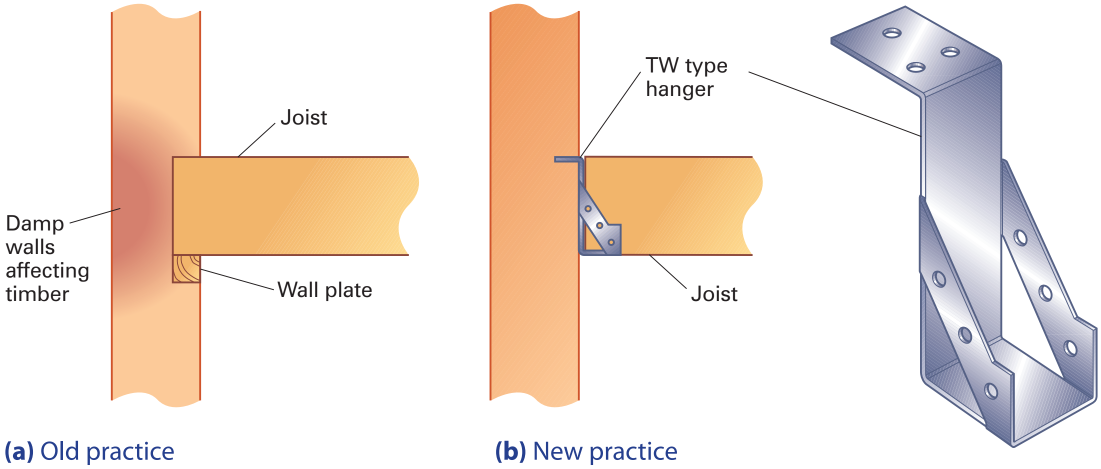
I type joists

These are now some of the most commonly used joists in the construction industry: they are particularly popular in new build and are the only joists used in timber kit house construction. I type beam joists are lighter and more environmentally friendly as they use a composite panel in the centre, usually made from oriented strand board, which can be made from recycled timber.

The following construction method shows how to fit solid timber joists but whichever joists you use, the methods are the same.

Construction methods

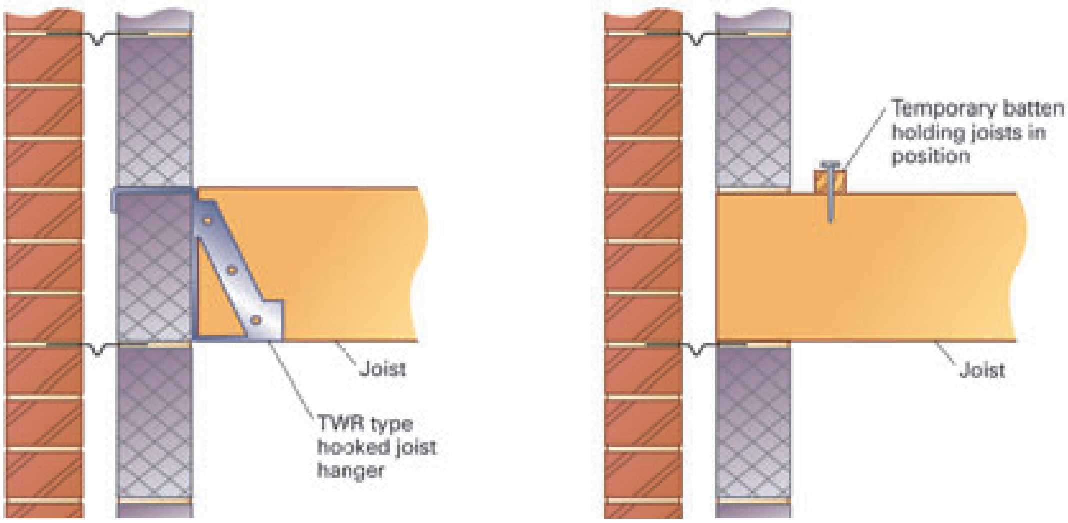
A suspended timber floor must be supported either end. The figures below show ways of doing this.



(a) Old practice

(b) New practice

Figure 5.29 Solid floor bearings



(a) Joist hanger bearing

(b) Built-in bearing

Figure 5.30 Cavity wall bearings

If a timber floor has to trim an opening, there must be a joint between the trimming and the trimmer joists. Traditionally, a **tusk tenon joint** was used (even now, this is sometimes preferred) between the trimming and the trimmer joist. If the joint is formed correctly a tusk tenon is extremely strong, but making one is time-consuming. A more modern method is to use a metal framing anchor or timber-to-timber joist hanger.

Traditional tusk tenon joint

Joist hanger

Fitting floor joists

Before the carpenter can begin constructing the floor, the bricklayer needs to build the honeycomb sleeper walls. This type of walling has gaps in each course to allow the free flow of air through the underfloor area. It is on these sleeper walls that the carpenter lays his timber wall plate, which will provide a fixing for the floor joists.

The following pages describe the steps in fitting floor joists.

Activity

Sketch a section through a suspended timber floor, showing how the flooring is supported.

Definition

Tusk tenon joint – a kind of mortise and tenon joint that uses a wedge-shaped key to hold the joint together

Activity

With the aid of a sketch, explain the purpose of a joist hanger and how it functions.

Activity

Sketch a tusk tenon joint.

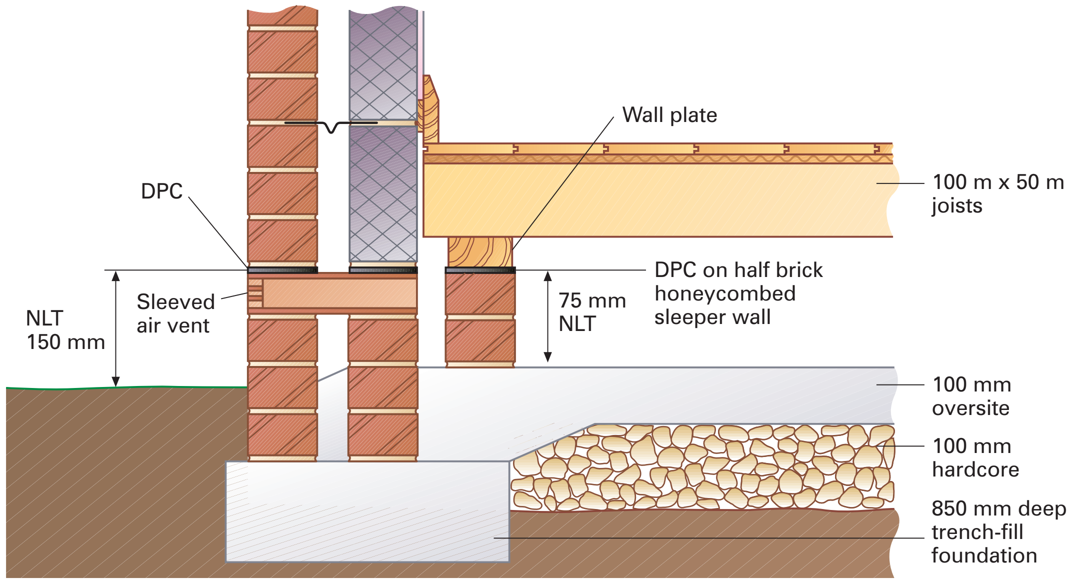


Figure 5.31 Section through floor and wall

Step 1 Bed and level the wall plate onto the sleeper wall with the DPC under it.

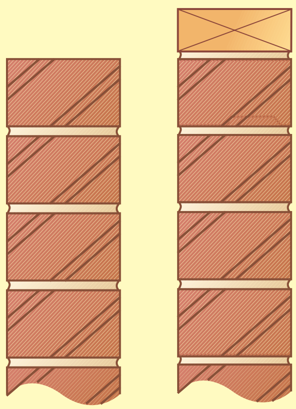


Figure 5.32 Step 1 Bed in the wall plate

Step 2 Cut joists to length and seal the ends with a coloured preservative. Mark out the wall plate with the required centres, space the joists out and fix temporary battens near each end to hold the joists in position. Ends should be kept away from walls by approximately 12 mm. It is important to ensure that the camber is turned upwards.

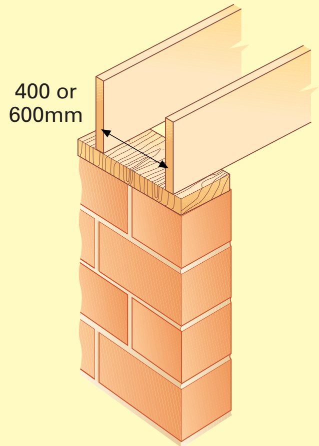


Figure 5.33 Step 2 Space out joists

Step 3 Fix the first joist parallel to the wall with a gap of 50 mm. Fix trimming and trimmer joists next to maintain the accuracy of the opening.

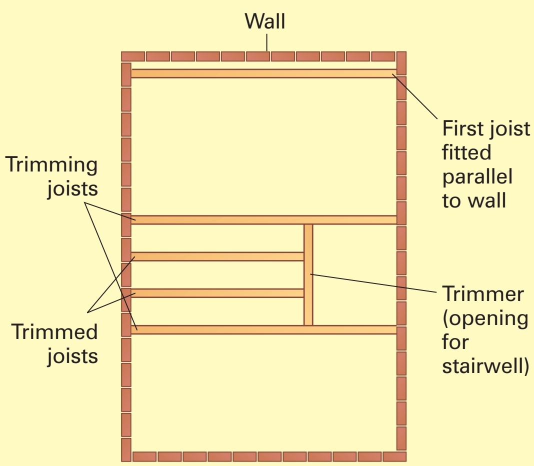


Figure 5.34 Step 3 Fit first joist and trimmers

Step 4 Fix subsequent joists at the required spacing as far as the opposite wall. Spacing will depend on the size of joist and/or floor covering, but usually 400 mm to 600 mm centres are used.

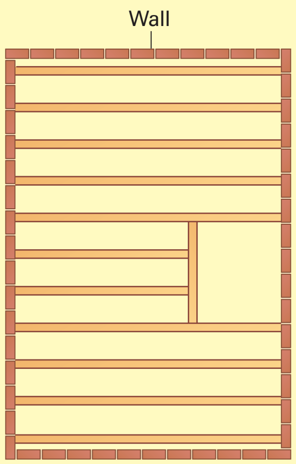


Figure 5.35 Step 4 Fit remaining joists

Step 5 Fit folding wedges to keep the end joists parallel to the wall. Overtightening is to be avoided in case the wall is strained.

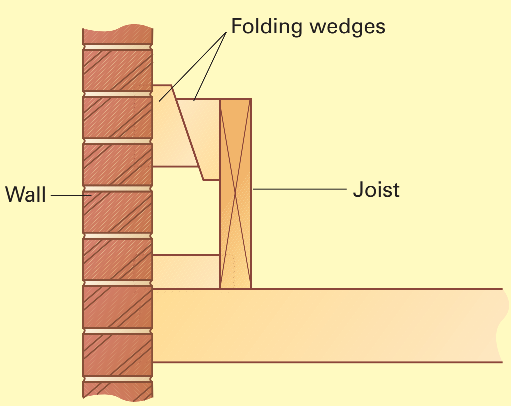


Figure 5.36 Step 5 Fit folding wedges

Activity

In an area designated by your trainer, install flooring joists, including bridging for an opening.

Remember

It is very important to clean the underfloor area before fitting the flooring, as timber cuttings or shavings are likely to attract moisture.

Activity

In an area designated by your trainer, install both solid and herringbone strutting.

Definition

Skew-nailed – nailed with the nails at an angle

Step 6 Check that the joists are level with a straight edge or line and, if necessary, pack with slate or DPC.

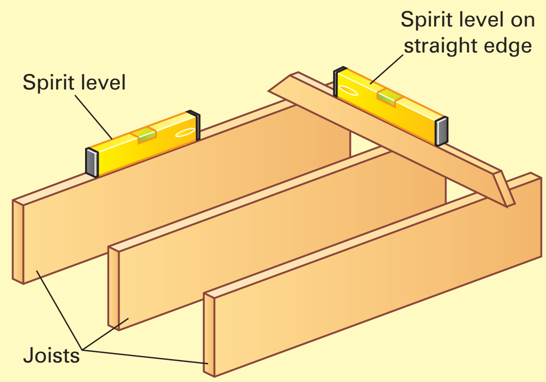


Figure 5.37 Step 6 Ensure joists are level

Step 7 Fit restraining straps and, if the joists span more than 3.5 m, fit strutting and bridging, described in more detail next.

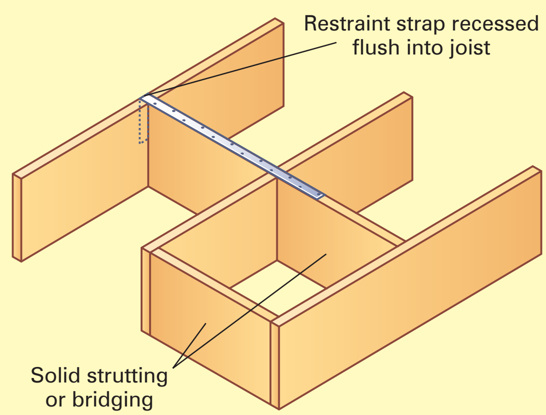


Figure 5.38 Step 7 Fix restraining straps, struts and bridges

Strutting and bridging

When joists span more than 3.5 m, a row of struts must be fixed midway between each joist. Strutting or bridging stiffens the floor in the same way that noggins stiffen timber stud partitions, preventing movement and twisting, which is useful when fitting flooring and ceiling covering. A number of methods are used, but the main ones are solid bridging, herringbone strutting and steel strutting.

Solid bridging

For solid bridging, timber struts the same depth as the joists are cut to fit tightly between each joist and **skew-nailed** in place. A disadvantage of solid bridging is that it tends to loosen when the joists shrink.

Solid bridging

Herringbone strutting

Here timber battens (usually 50 × 25 mm) are cut to fit diagonally between the joists. A small saw cut is put into the ends of the battens before nailing to avoid the battens splitting. This will remain tight even after joist shrinkage. The following steps describe the fitting of timber herringbone strutting.

Step 1 Nail a temporary batten near the line of strutting to keep the joists spaced at the correct centres.

Space joists

Step 2 Mark the depth of a joist across the edge of the two joists, then measure 12 mm inside one of the lines and remark the joists. The 12 mm less than the depth of the joist ensures that the struts will finish just below the floor and ceiling level (as shown in step 5).

Mark joist depths

Step 3 Lay the strut across two joists at a diagonal to the lines drawn in Step 2.

Lay struts across two joists at a diagonal

Step 4 Draw a pencil line underneath as shown in Step 3 and cut to the mark. This will provide the correct angle for nailing.

Cut to the mark

Step 5 Fix the strut between the two joists. The struts should finish just below the floor and ceiling level. This prevents the struts from interfering with the floor and ceiling if movement occurs.

Fix the strut

Steel strutting

There are two types of galvanised steel herringbone struts available.

The first has angled lugs for fixing with the minimum 38 mm round head wire nails.

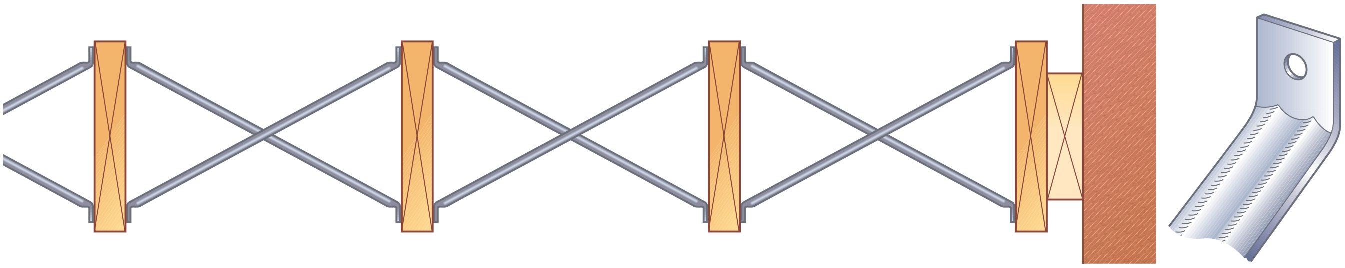


Figure 5.39 Catric® steel joist struts

The second has pointed ends, which bed themselves into joists when forced in at the bottom and pulled down at the top. Unlike other types of strutting, this type is best fixed from below.

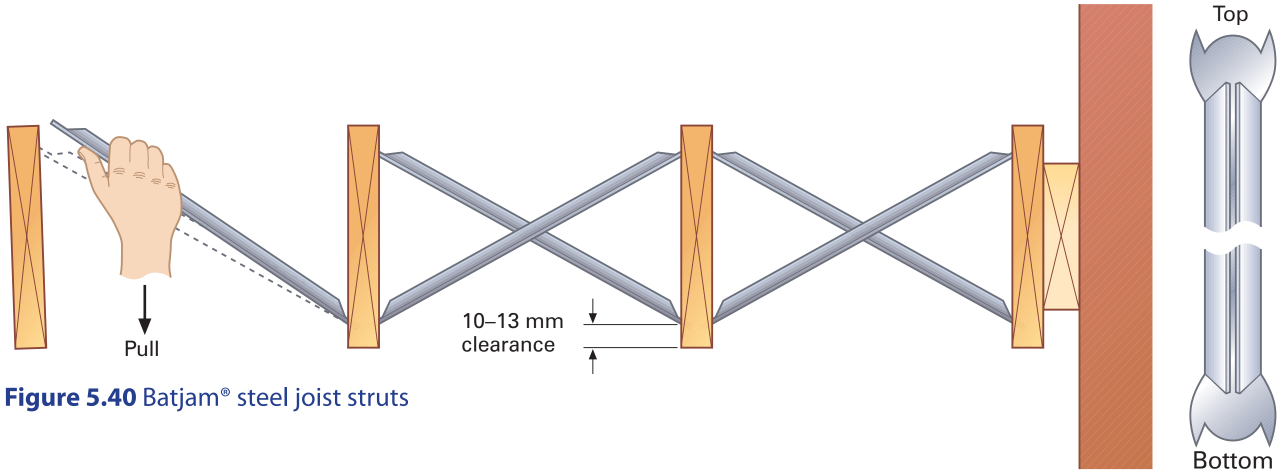


Figure 5.40 Batjam® steel joist struts

The disadvantage of steel strutting is that it only comes in set sizes, to fit centres of 400, 450 and 600 mm. This is a disadvantage as there will always be a space in the construction of a floor that is smaller than the required centres.

Restraint straps

Anchoring straps, normally referred to as restraint straps, are needed to restrict any possible movement of the floor and walls due to wind pressure. They are made from galvanised steel, 5 mm thick for horizontal restraints and 2.5 mm for vertical restraints, 30 mm wide and up to 1.2 m in length. Holes are punched along the length to provide fixing points.

When the joists run parallel to the walls, the straps will need to be housed into the joist to allow the strap to sit flush with the top of the joist, keeping the floor even. The anchors should be fixed at a maximum of 2 m centre to centre. More information can be found in schedule 7 of the *Building Regulations*.

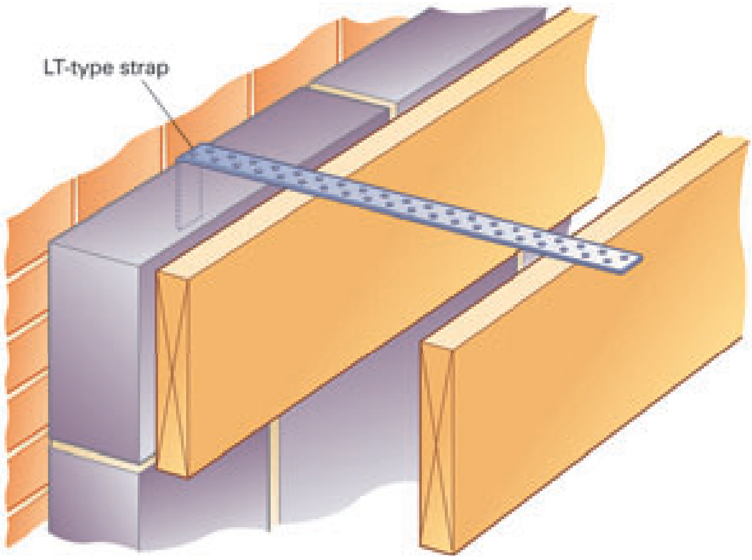


Figure 5.41 Restraint straps for joists parallel or at right angles to a wall

Floor coverings

Softwood flooring

Softwood flooring can be used at either ground or upper floor levels. It usually consists of 25 × 150 mm tongued and grooved (T&G) boards. The tongue is slightly off centre to provide extra wear on the surface that will be walked upon.

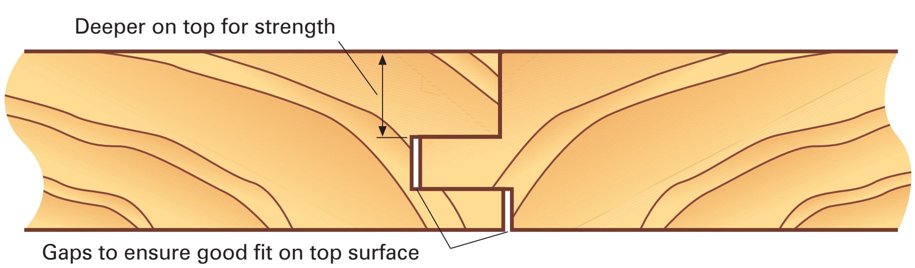


Figure 5.42 Section through softwood covering

When boards are joined together, the joints should be staggered evenly throughout the floor to give it strength. They should never be placed next to each other, as this prevents the joists from being tied together properly. The boards are either fixed with floor brads nailed through the surface and punched below flush, or secret nailed with lost head nails through the tongue. The nails used should be 2½ times the thickness of the floorboard.

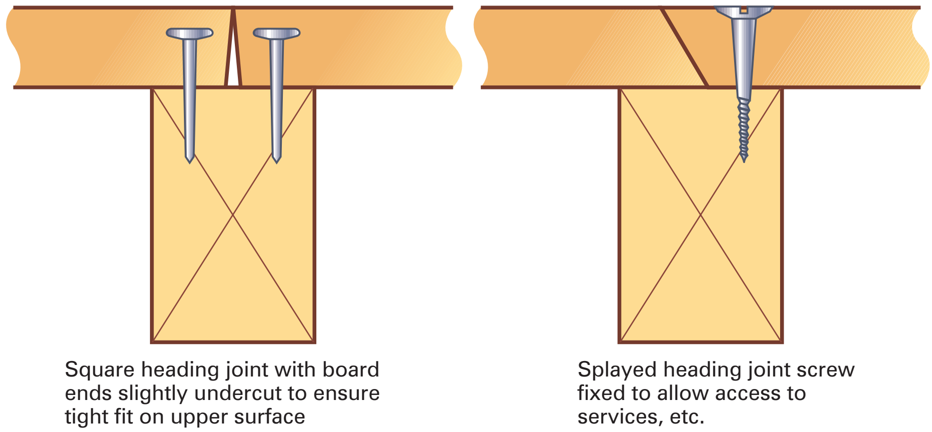


Figure 5.43 Square and splayed heading

The first board is nailed down about 10–12 mm from the wall. The remaining boards can be fixed four to six boards at a time, leaving a 10–12 mm gap around the perimeter to allow for expansion. This gap will eventually be covered by the skirting board.

There are two methods of clamping the boards before fixing:

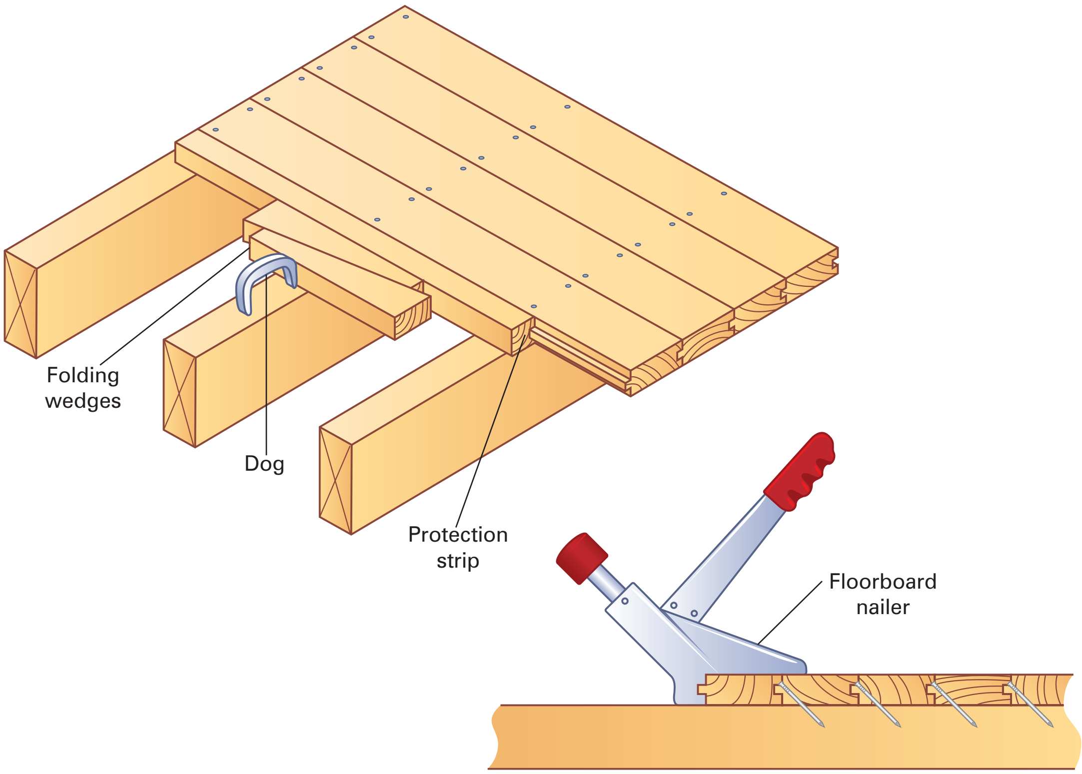


Figure 5.44 Clamping methods

Chipboard flooring

Flooring-grade chipboard is increasingly being used for domestic floors. It is available in sheet sizes of 2440 × 600 × 18 mm and can be square edged or tongued and grooved on all edges, the latter being preferred. If square-edged chipboard is used it must be supported along every joint.

Tongued and grooved boards are laid end to end, at right angles to the joists. Cross-joints should be staggered and, as with softwood flooring, expansion gaps of 10–12 mm left around the perimeter. The ends must be supported.

When setting out the floor joists, the spacing should be set to avoid any unnecessary wastage. The boards should be glued along all joints and fixed using either 50–65 mm annular ring shank nails or 50–65 mm screws. Access traps must be created in the flooring to allow access to services such as gas and water.

(a) Chipboard floor

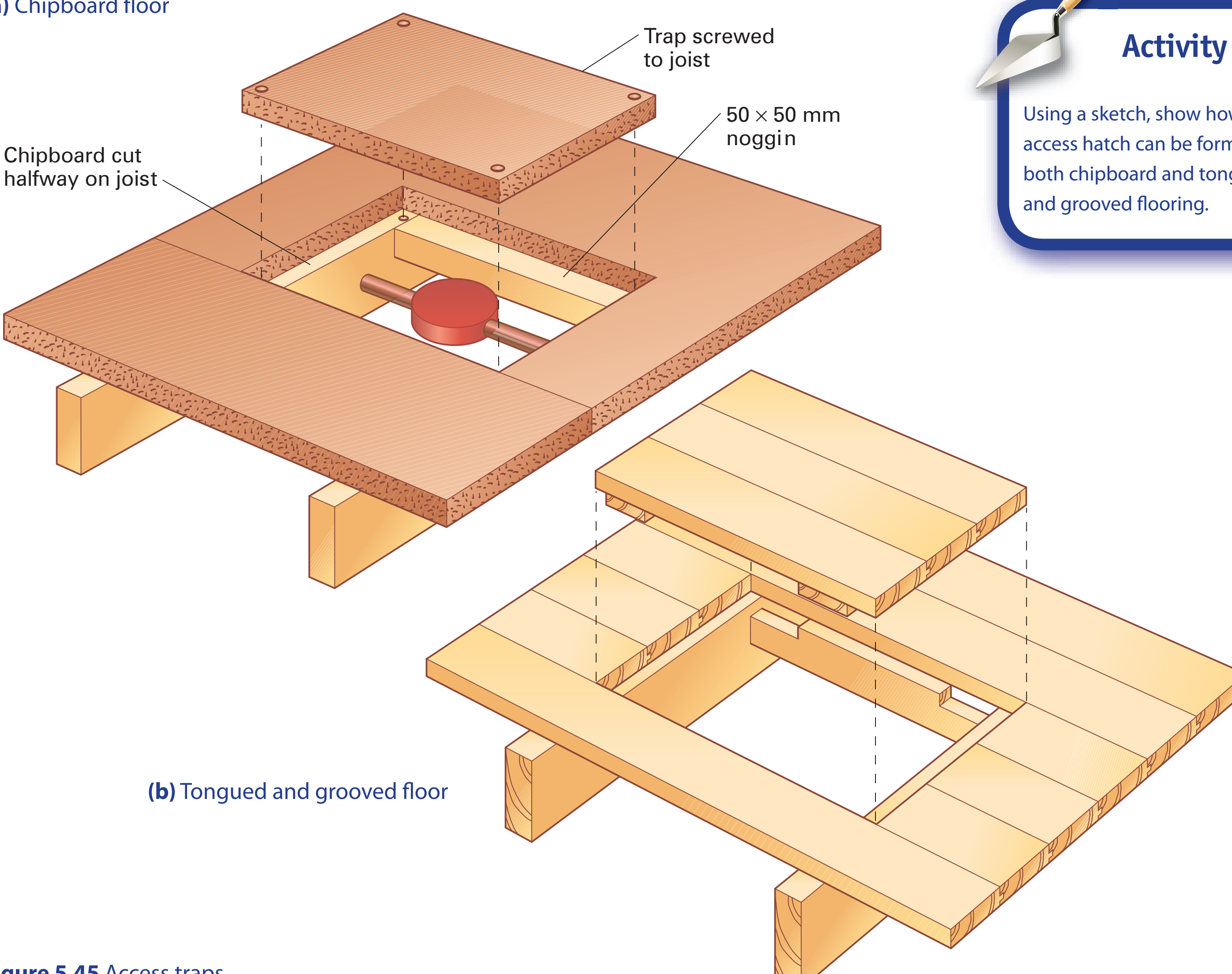


Figure 5.45 Access traps

Activity

Using a sketch, show how an access hatch can be formed in both chipboard and tongue and grooved flooring.

Solid concrete floors

Solid concrete floors are more durable than suspended timber floors. They are constructed on a sub-base incorporating hardcore, damp proof membranes and insulation. The depth of the hardcore and concrete will depend on the nature of the building, and will be set by the Building Regulations and the local authority.

In the next few pages, you will look at:

- formwork for concrete floors
- reinforcement
- compacting of concrete
- surface finishes
- curing.

Any concreting job has to be supported at the sides to prevent the concrete just running off and this support comes in the way of formwork.

Formwork for ground floors

Floors for buildings such as factories and warehouses etc. have large areas and would be difficult to lay in one slab. Floors of this type are usually laid in alternative strips up to 4.5 m wide, running the full length of the building (see Figure 5.46). The actual formwork would be similar to that used for paths.

Activity

Using a sketch, show how formwork for ground floors can be created.

Activity

In an area designated by your trainer, create formwork for concrete flooring.

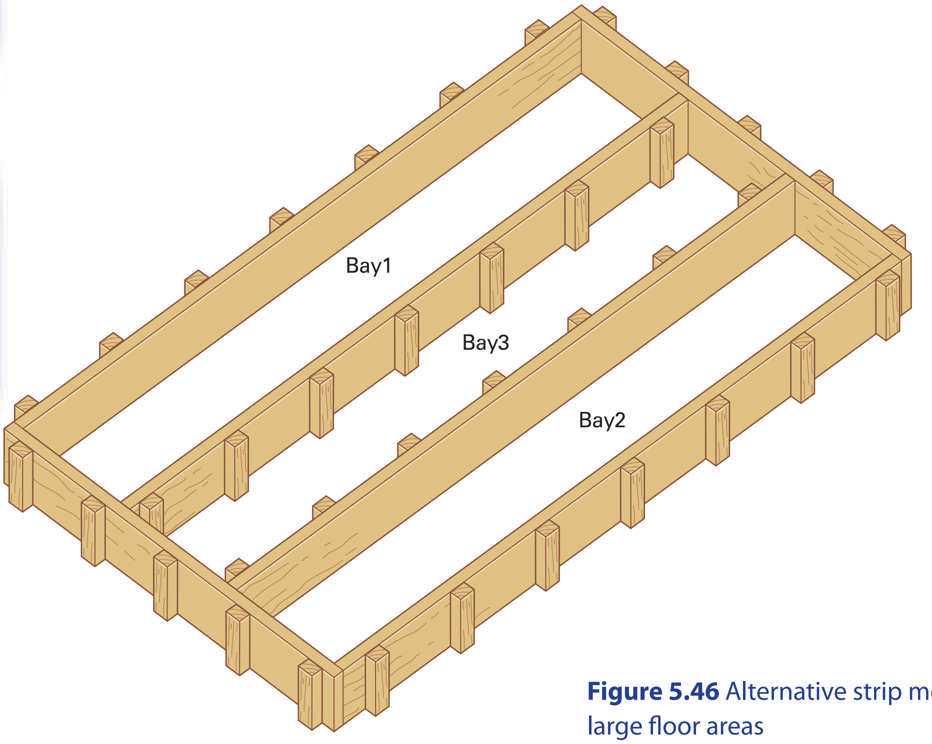


Figure 5.46 Alternative strip method used for large floor areas

Reinforcement

Concrete is strong in **compression** but weak in **tension** so, to prevent concrete from being 'pulled' apart when under pressure, steel reinforcement is provided. The type and position of the reinforcement will be specified by the structural engineer.

Definition

Compression – being squeezed or squashed together

Tension – being stretched

The reinforcement must always have a suitable thickness of concrete cover to prevent the steel from rusting if exposed to moisture or air. The amount of cover required depends upon the location of the site with respect to exposure conditions, and ranges from 20 mm in mild exposure to 60 mm for very severe exposure to water.

To prevent the reinforcement from touching the formwork, spacers made from concrete, fibre cement or plastic are used. They are available in several shapes and various sizes to give the correct cover.

Steel reinforcement of concrete

Compacting

When concrete has been placed, it contains trapped air in the form of voids. To get rid of these voids we must compact the concrete. The more workable the concrete the easier it would be to compact, but also if the concrete is too wet, the excess water will reduce the strength of the concrete.

Failure to compact concrete results in:

- reduction in the strength of the concrete
- water entering the concrete, which could damage the reinforcement
- visual defects, such as honeycombing on the surface.

The method of compaction depends on the thickness and the purpose of the concrete. For oversite concrete, floors and pathways up to 100 mm thick, manual compaction with a tamper board may be sufficient. This requires slightly overfilling the formwork and tamping down with the tamper board. For larger spans the tamper board may be fitted with handles.

Tamper board with handles

For slabs up to 150 mm thick, a vibrating beam tamper should be used. This is simply a tamper board with a petrol-driven vibrating unit bolted on. The beam is laid on the concrete with its motor running and is pulled along the slab.

For deeper structures, such as retaining walls for example, a poker vibrator would be required. The poker vibrator is a vibrating tube at the end of a flexible drive connected to a petrol motor. The pokers are available in various diameters from 25 mm to 75 mm.

The concrete should be laid in layers of 600 mm with the poker in vertically and penetrating the layer below by 100 mm. The concrete is vibrated until the air bubbles stop and the poker is then lifted slowly and placed 150 to 1000 mm from this incision, depending on the diameter of the vibrator.

Surface finishes

Vibrating beam tamper

Vibrating poker in use

Surface finishes for slabs may be:

- **Tamped finish.** Simply using a straight edge or tamper board when compacting the concrete will leave a rough finish to the floor, ideal for a path or drive surface, giving grip to vehicles and pedestrians. This finish may also be used if a further layer is to be applied to give a good bond.
- **Float and brush finish.** After **screeding** off the concrete with a straight edge, the surface is floated off using a steel or wooden float and then brushed lightly with a soft brush (see photo opposite). Again, this would be suitable for pathways and drives.

- **Steel float finish.** After screeding off using a straight edge, a steel float is applied to the surface. This finish attracts particles of cement to the surface, causing the concrete to become impermeable to water but also very slippery when wet. This is not very suitable for outside but ideal for use indoors for floors, etc.
- **Power trowelling/float.** Three hours after laying, a power float is applied to the surface of the concrete. After a further delay to allow surface water to evaporate, a power trowel is then used. A power float has a rotating circular disc or four large flat blades powered by a petrol engine. The edges of the blades are turned up to prevent them digging into the concrete slab. This finish would most likely be used in factories where a large floor area would be needed.
- **Power grinding.** This is a technique used to provide a durable wearing surface without further treatment. The concrete is laid, compacted and trowel finished. After 1 to 7 days the floor is ground, removing the top 1–2 mm, leaving a polished concrete surface.

Brushed concrete finish

Power float

Surface treatment for other surfaces may be:

- **Plain smooth surfaces.** After the formwork has been struck, the concrete may be polished with a carborundum stone, giving a polished water-resistant finish.
- **Textured and profiled finish.** A simple textured finish may be made by using rough sawn boards to make the formwork. When struck, the concrete takes on the texture of these boards. A profiled finish can be made by using a lining inside the formwork. The linings may be made from polystyrene or flexible rubber-like plastics, and gives a pattern to the finished concrete.
- **Ribbed finish.** These are made by fixing timber battens to the formwork.

Ribbed concrete finish

Definition

Screeding – levelling off concrete by adding a final layer

Remember

Make sure you always clean all tampers and tools after use.

Did you know?

The success of surface finishes depends largely on timing. You need to be aware of the setting times in order to apply the finish.

Activity

In the area where you previously created the formwork, pour, compact and finish concrete.

Remember

If the water is allowed to evaporate from the mix shortly after the concrete is placed, there is less time for the cement to 'go off'.

Remember

In hot weather the concrete must be placed quickly and not left standing for too long.

Safety tip

Take precautions in hot weather against the effect of the sun on your skin, for example wear sun block and a T-shirt.

- **Exposed aggregate finish.** The coarse aggregate is exposed by removing the sand and cement from the finished concrete with a sand blaster. Another method of producing this finish is by applying a chemical retarder to the formwork, which prevents the cement in contact with it from hardening. When the formwork is removed, the mortar is brushed away to uncover the aggregate in the hardened concrete.

Curing

When concrete is mixed, the quantity of water is accurately added to allow for hydration to take place. The longer we can keep this chemical reaction going, the stronger the concrete will become.

To allow the concrete to achieve its maximum strength, the chemical reaction must be allowed to keep going for as long as possible. To do this we must 'cure' the concrete. This is done by keeping the concrete damp and preventing it from drying out too quickly.

Curing can be done by:

1. Spraying the concrete with a chemical sealer, which dries to leave a film of resin to seal the surface and reduces the loss of moisture.
2. Spraying the concrete with water, which replaces any lost water and keeps the concrete damp. This can also be done by placing sand or hessian cloth or other similar material on the concrete and dampening.
3. Covering the concrete with a plastic sheet or building paper, preventing wind and sun from evaporating the water into the air. Any evaporated moisture due to the heat will condense on the polythene and drip back on to the concrete surface.

Concreting in hot weather

When concreting in temperatures over 20°C, there is a reduction in workability due to the water being lost through evaporation. The cement also tends to react more quickly with water, causing the concrete to set rapidly.

To remedy the problem of the concrete setting quickly, a 'retarding mixture' may be used. This slows down the initial reaction between the cement and water, allowing the concrete to remain workable for longer.

Extra water may be added at the time of mixing so that the workability would be correct at the time of placing.

Water must *not* be added during the placing of the concrete, to make it more workable, after the initial set has taken place in the concrete.

Concreting in cold weather

Water expands when freezing. This can cause permanent damage if the concrete is allowed to freeze when freshly laid or in hardened concrete that has not reached enough strength (5 N/mm^2, which takes 48 hours).

Concreting should not take place when the temperature is 2˚C or less. If the temperature is only slightly above 2˚C, mixing water should be heated.

After being laid, the concrete should be kept warm by covering with insulating quilts, which allows the cement to continue its reaction with the water and prevents it from freezing.

Beam and block floors

Construction of these floors is generally quite simple. Unlike solid floor construction, they can be fitted at both ground floor level and upper floor levels.

Depending on site conditions, beam and block floors can be installed in most types of weather and by using a variety of methods including mobile cranes or other site lifting plant or by hand.

Standard beam and block floors consist of 150 mm and 225 mm beams with standard 100 mm deep concrete building blocks inserted between the beams.

The beams are pre-cast away from the site environment and are pre-stressed with high tensile steel wires suited to the environment and purpose for which they are to be used.

Once the blocks have been placed in position, the floor should be grouted with sand / cement grout consisting of four parts sand to one part cement. The grout should be brushed into the joints between the beams and the blocks in order to stabilise the floor.

Insulation can be slung underneath the beams or over the blocks where it is to be covered with a suitable finish.

The illustration shows a typical beam and block floor construction. The air brick is there to ventilate the airspace below the floor.

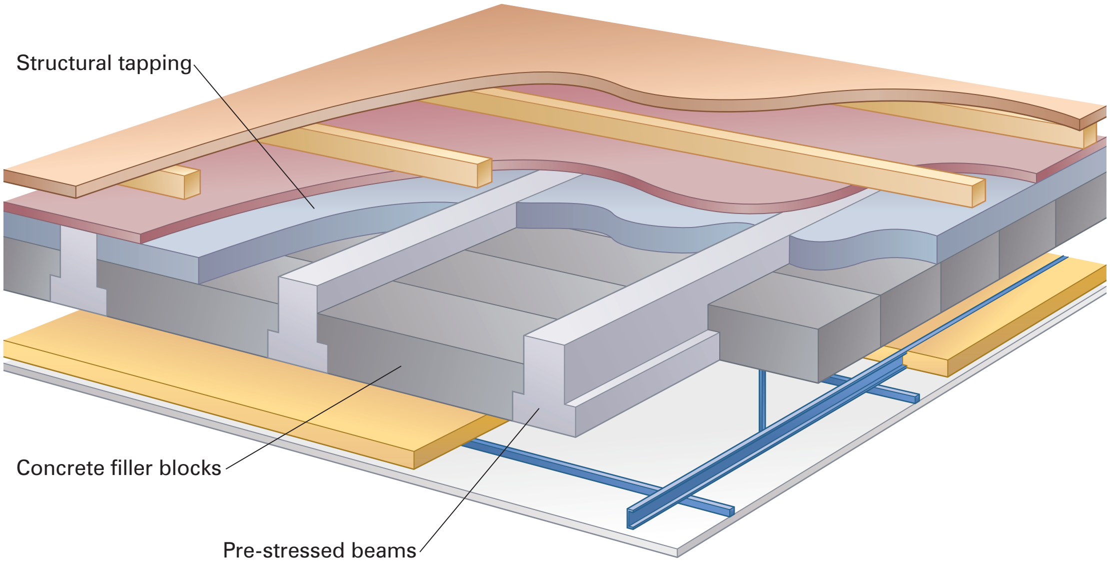


Figure 5.47 Typical beam and block floor

Safety tip

The beams in a beam and block floor can be heavy, so you may need a crane to position them on the external walls safely.

Floating floors

These are basic timber floor constructions that are laid on a solid concrete floor. The timbers are laid in a similar way to joists, although they are usually 50 mm thick maximum as there is no need for support. The timbers are laid on the floor at predetermined centres, and are not fixed to the concrete base (hence floating floor); the decking is then fixed on the timbers. Insulation or underfloor heating can be placed between the timbers to enhance the thermal and acoustic properties.

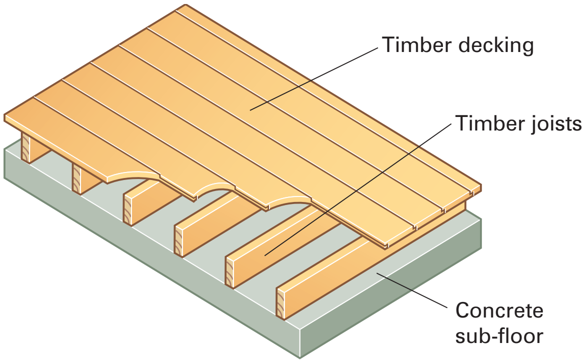


Figure 5.48 Floating floor

This type of floor 'floats' on a cushion of insulation. Floating floors are normally manufactured from chipboard – either standard or moisture-resistant – for use in bathrooms. This type of floor is ideal for refurbishment work and where insulation upgrading is required.

Activity

Draw a sketch to show how floating floors are created.

Knowledge refresher

1. List the four most common types of floor construction.
2. On a suspended timber floor, what is the difference between a single and a double floor?
3. How can the depth of a timber joist be worked out?
4. What is the difference between solid and herringbone strutting?
5. State the purpose of formwork in concrete floors.
6. Why is reinforcement used in solid concrete flooring?
7. Why is concrete compacted?
8. Describe three ways of finishing a concrete floor.
9. Where would a floating floor be laid?

What would you do?

1 You have been asked to quote for building a garage. The client is unsure of what type of floor to have. They ask your opinion. What type of floor would you select? Why would you select that type of floor? What could influence your selection?

2 You have been tasked with joisting an upper floor. You fit the herringbone strutting but, when it comes to fitting the floor and plasterboarding the ceiling, the strutting is interfering with both the floor and the ceiling. What could have caused this? What could be done to rectify it?

Remember

A roof with an angle of *more* than 10 degrees is classified as a pitched roof.

Definition

Fibreglass – a material made from glass fibres and a resin that starts in liquid form then hardens to be very strong

Did you know?

If a puddle forms on a roof and is not cleared away quickly, over a period of years the water will eventually work its way through.

Activity

Use sketches to show different types of fall on a flat roof.

Roofing

Although there are several different types of roofing, all roofs will technically be either a flat roof or a pitched roof.

Flat roofs

A flat roof is any roof which has its upper surface inclined at an angle (also known as the fall, slope or pitch) not exceeding 10 degrees.

A flat roof has a fall to allow rainwater to run off, preventing puddles forming as they can put extra weight on the roof and cause leaks. Flat roofs will eventually leak, so most are guaranteed for only 10 years (every 10 years or so the roof will have to be stripped back and re-covered). Today **fibreglass** flat roofs are available that last much longer, so some companies will give a 25-year guarantee on their roof. Installing a fibreglass roof is a job for specialist roofers.

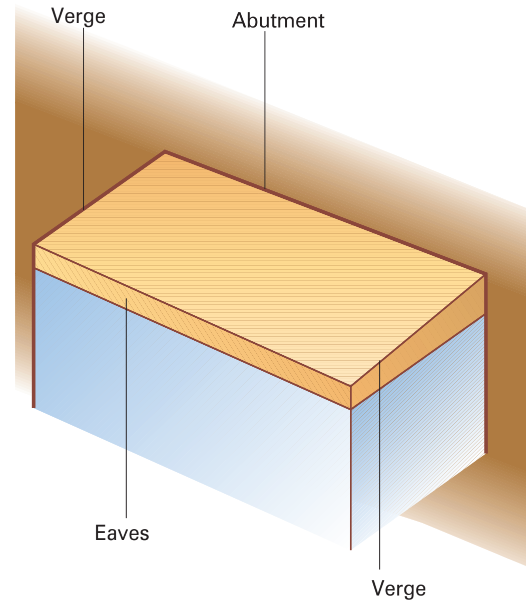


Figure 5.49 Flat roof terminology

The amount of fall should be sufficient to clear water away to the outlet pipe(s) or guttering as quickly as possible across the whole roof surface. This may involve a single direction of fall or several directional changes of fall such as:

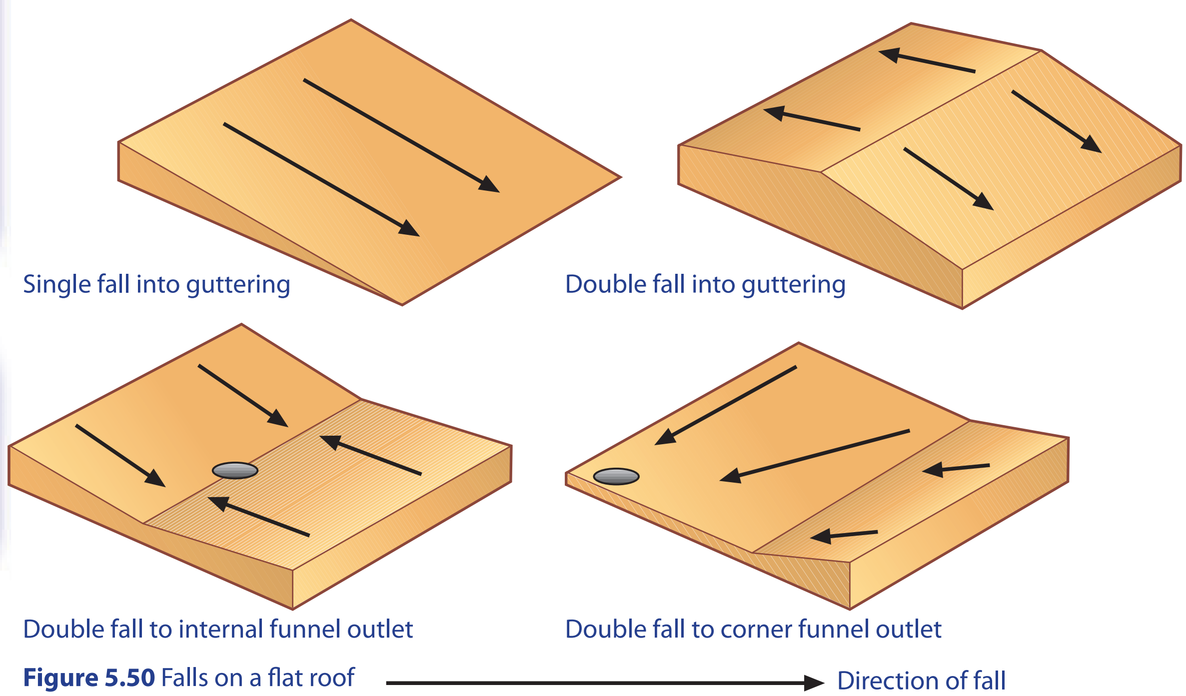


Figure 5.50 Falls on a flat roof

Pitched roofs

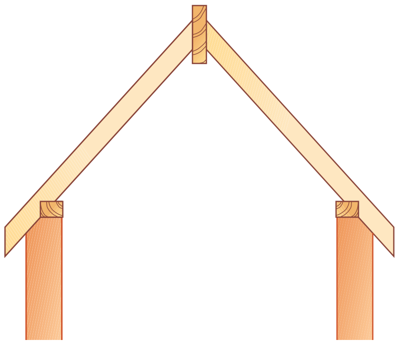


Figure 5.51 Single roof

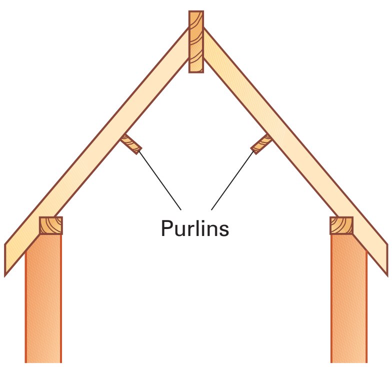


Figure 5.52 Double roof

There are several different types of **pitched roof** but most are constructed in one of two ways.

- **Trussed roof** – A prefabricated pitched roof specially manufactured prior to delivery on site, saving timber as well as making the process easier and quicker. Trussed roofs can also span greater distances without the need for support from intermediate walls.
- **Traditional roof** – A roof entirely constructed on site from loose timber sections using simple jointing methods.

Roof types

A pitched roof can be constructed either as a single roof, where the rafters do not require any intermediate support, or a double roof where the rafters are supported. Single roofs are used over a short span such as a garage; double roofs are used to span a longer distance such as a house or factory.

> **Safety tip**
>
> Roofing requires working at height so always use the appropriate access equipment (i.e. a scaffold or at least properly secured ladders, trestles or a temporary working platform).

> **Activity**
>
> Use sketches to show the difference between a single roof and a double roof.

There are many different types of pitched roof including:

- **mono pitch** with a single pitch
- **lean-to** with a single pitch, which butts up to an existing building
- **duo pitch** with **gable ends**

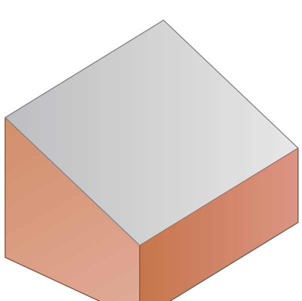


Figure 5.53 Mono pitch roof

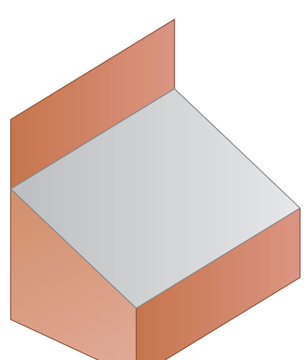


Figure 5.54 Lean-to roof

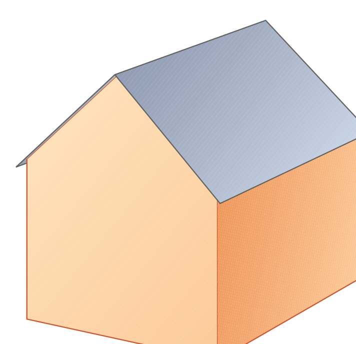


Figure 5.55 Duo pitch roof with gable ends

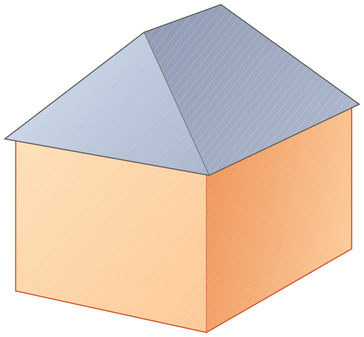


Figure 5.56 Hipped roof

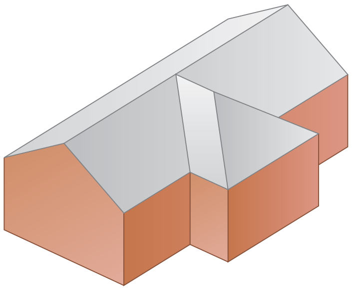


Figure 5.57 Over hip roof

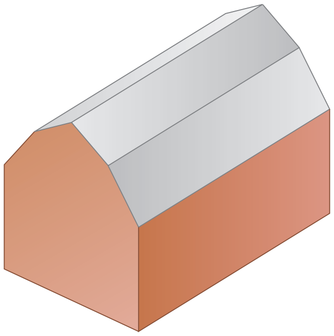


Figure 5.58 Mansard roof

- **hipped roof** with hip ends incorporating crown, hip and jack rafters
- **over hip** with gable ends, hips and valleys incorporating valley and cripple rafters
- **mansard** with gable ends and two different pitches used mainly when the roof space is to be used as a room
- **gable hip** or **gambrel** – double-pitched roof with a small gable (gablet) at the ridge and the lower part a half-hip
- **jerkin-head** or **barn hip** – double-pitched roof hipped from the ridge part-way to the eaves, with the remainder gabled.

The type of roof used will be selected by the client and architect.

Trussed rafters

Most roofing on domestic dwellings now comprises factory-made trussed rafters. These are made of stress graded, **PAR** timber to a wide variety of designs, depending on requirements. All joints are butt jointed and held together with fixing plates, face fixed on either side. These plates are usually made of galvanised steel and either nailed or factory pressed. They may also be **gang-nailed** gusset plates made of 12 mm resin bonded plywood.

Definition

PAR – a term used for timber that has been 'planed all round'

Gang-nailed – galvanised plate with spikes used to secure butt joints

One of the main advantages of this type of roof is the clear span achieved, as there is no need for intermediate, load-bearing partition walls. Standard trusses are strong enough to resist the eventual load of the roofing materials. However, they are not able to withstand pressures applied by lateral bending. Hence, damage is most likely to occur during delivery, movement across site, site storage or lifting into position.

Wall plates are bedded as described above. Following this, the positions of the trusses can be marked at a maximum of 600 mm between centres along each wall plate. The sequence of operations then varies between gable and hipped roofs.

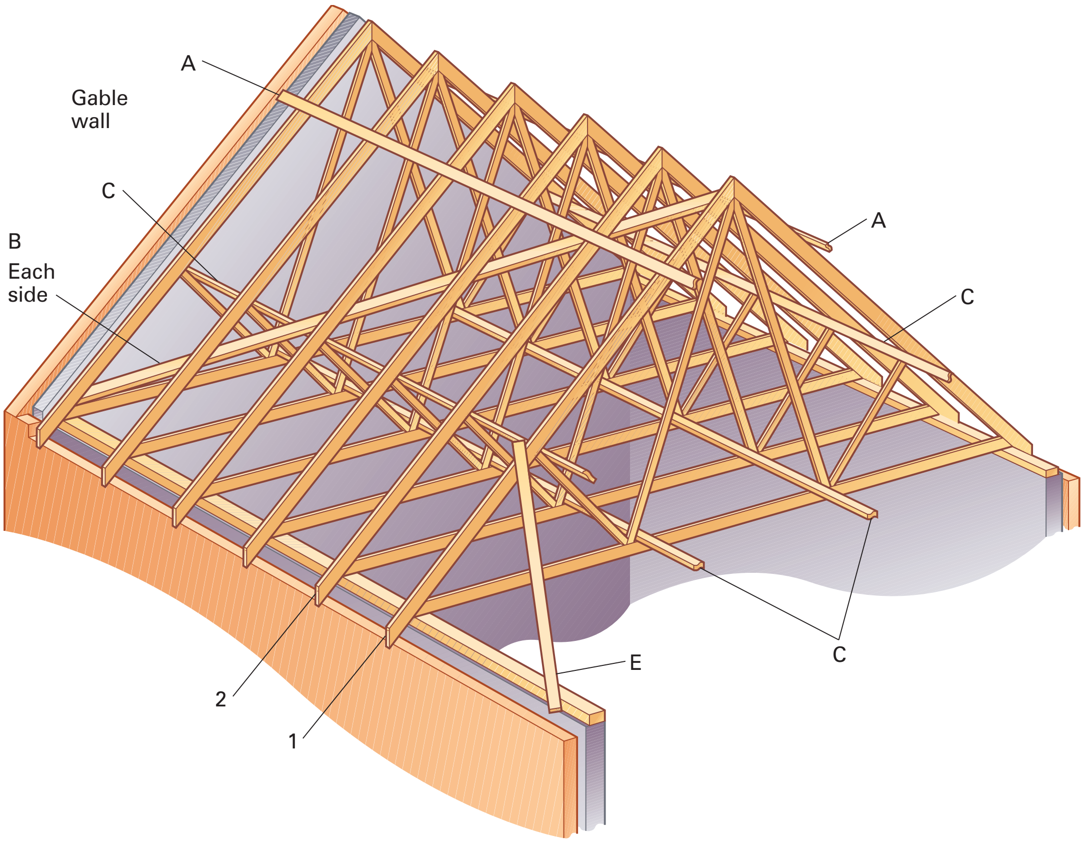


Figure 5.59 Erection of common trussed rafters

Remember

Never alter a trussed rafter without the structural designer's approval.

Hipped roofs

In a fully hipped roof there are no gables and the eaves run around the perimeter, so there is no roof ladder or bargeboard.

Marking out for a hipped roof

All bevels or angles cut on a hipped roof are based on the right-angled triangle and the roof members can be set out using the following two methods:

- **Roofing ready reckoner** – a book that lists in table form all the angles and lengths of the various rafters for any span or rise of roof.
- **Geometry** – working with scale drawings and basic mathematic principles to give you the lengths and angles of all rafters.

The ready reckoner will be looked at later in this chapter, so for now we will concentrate on geometry.

Pythagoras' theorem

When setting out a hipped roof, you need to know Pythagoras' theorem. Pythagoras states that 'the square on the hypotenuse of a right-angled triangle is equal to the sum of the squares on the other two sides'. For the carpenter, the 'hypotenuse' is the rafter length, while the 'other two sides' are the run and the rise.

From Pythagoras' theorem, we get this calculation:

$A = \sqrt{B^2 + C^2}$ ($\sqrt{}$ means the square root and ^{2} means squared)

If we again look at our right-angled triangle we can break it down to:

A (the rafter length – the distance we want to know)

B^2 (the rise, multiplied by itself)

C^2 (the run, multiplied by itself).

Therefore, we have all we need to find out the length of our rafter (A):

$A = \sqrt{4^2 + 3^2}$

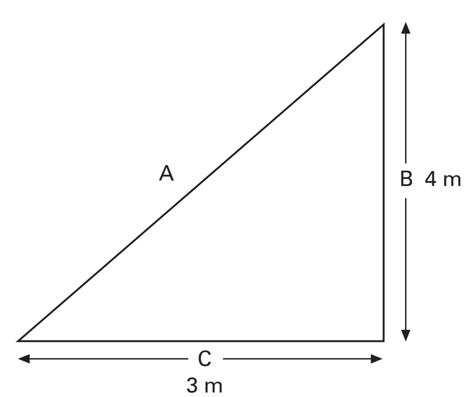
$A = \sqrt{4 \times 4 + 3 \times 3}$

$A = \sqrt{16 + 9}$

$A = \sqrt{25}$

$A = 5$

so our rafter would be 5 m long.



Did you know?

The three angles in a triangle always add up to 180 degrees.

Finishing a roof at the gable and eaves

There are two types of finish for a gable end:

- a flush finish, where the bargeboard is fixed directly onto the gable wall
- a roof ladder – a frame built to give an overhang and to which the bargeboard and soffit are fixed.

The most common way is to use a roof ladder which, when creating an overhang, stops rainwater running down the face of the gable wall.

The continuation of the fascia board around the verge of the roof is called the bargeboard. Usually the bargeboard is fixed to the roof ladder and has a built-up section at the bottom to encase the wall plate.

The simplest way of marking out the bargeboard is to temporarily fix it in place and use a level to mark the plumb and seat cut.

Activity

Use sketches to show how a gable ladder and bargeboard are fitted.

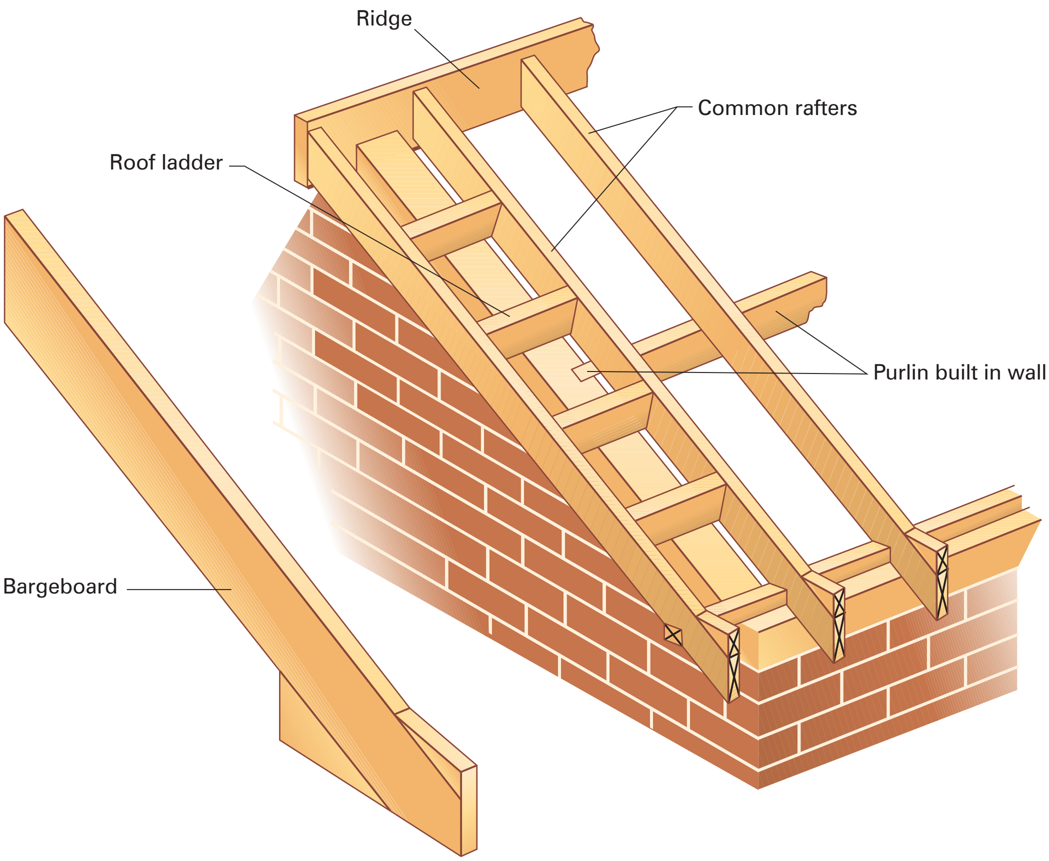


Figure 5.60 Roof ladder with bargeboard fitted

Did you know?

Without soffit ventilation, air cannot flow through the roof space, which can cause problems such as dry rot.

Eaves details

The eaves are how the lower part of the roof is finished where it meets the wall, and incorporates fascia and soffit. The fascia is the vertical board fixed to the ends of the rafters. It is used to close the eaves and allow fixing for rainwater pipes. The soffit is the horizontal board fixed to the bottom of the rafters and the wall. It is used to close the roof space to prevent birds or insects from nesting there, and usually incorporates ventilation to help prevent rot.

There are various ways of finishing a roof at the eaves; we will look at the four most common.

Flush eaves

Here the eaves are finished as close to the wall as possible. There is no soffit, but a small gap is left for ventilation.

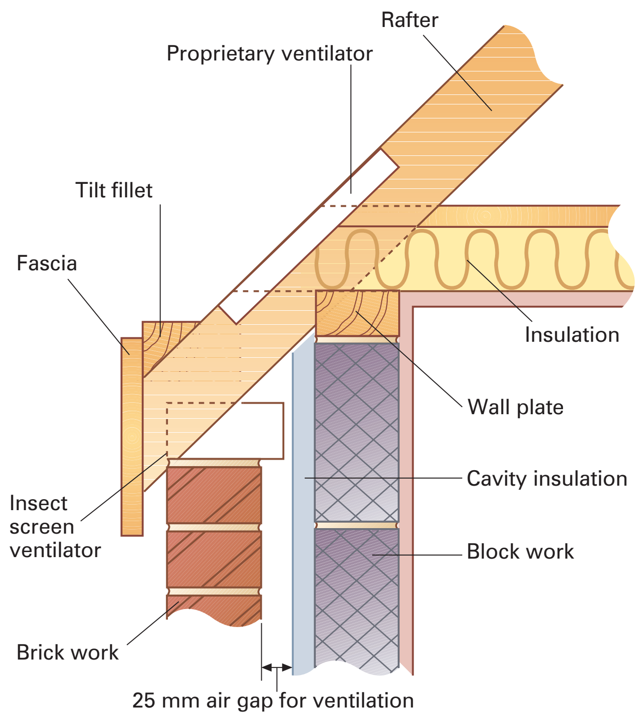


Figure 5.61 Flush eaves

Open eaves

An open eaves is where the bottom of the rafter feet are planed as they are exposed. The rafter feet project beyond the outer wall and eaves boards are fitted to the top of the rafters to hide the underside of the roof cladding. The rainwater pipes are fitted via brackets fixed to the rafter ends.

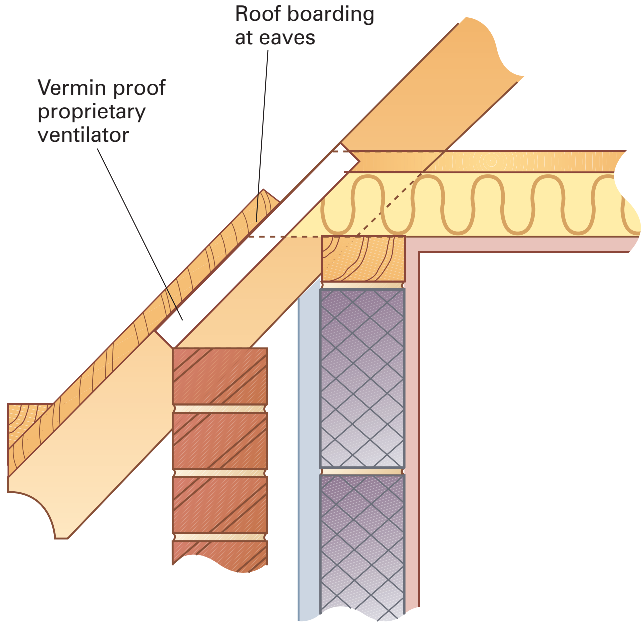


Figure 5.62 Open eaves

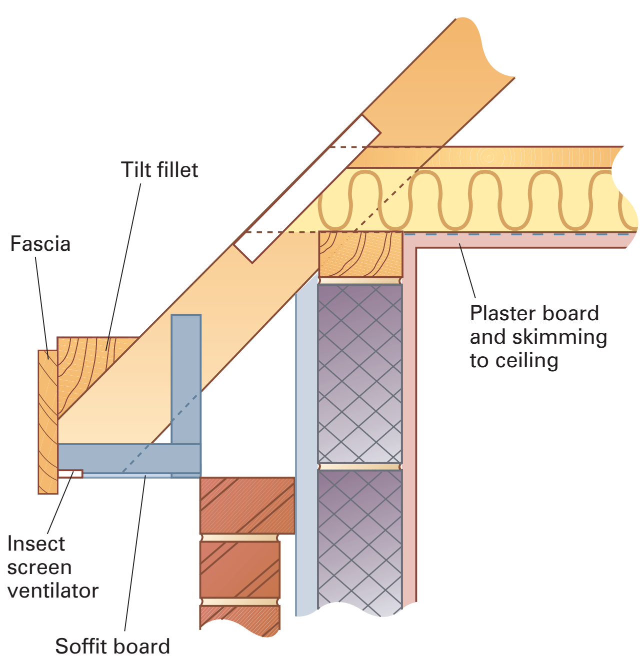


Figure 5.63 Closed eaves

Closed eaves

Closed eaves are completely closed or boxed in. The ends of the rafters are cut to allow the fascia and soffit to be fitted. The roof is ventilated either by ventilation strips incorporated into the soffit or by holes drilled into the soffit with insect-proof netting over them. If closed eaves are to be re-clad due to rot you must ensure that the ventilation areas are not covered up.

Definition

Sprocket – a piece of timber bolted to the side of the rafter to reduce the pitch at the eaves

Sprocketed eaves

Sprocketed eaves are used where the roof has a sharp pitch. The **sprocket** reduces the pitch at the eaves, slowing down the flow of rainwater and stopping it overshooting the guttering. Sprockets can either be fixed to the top edge of the rafter or bolted onto the side.

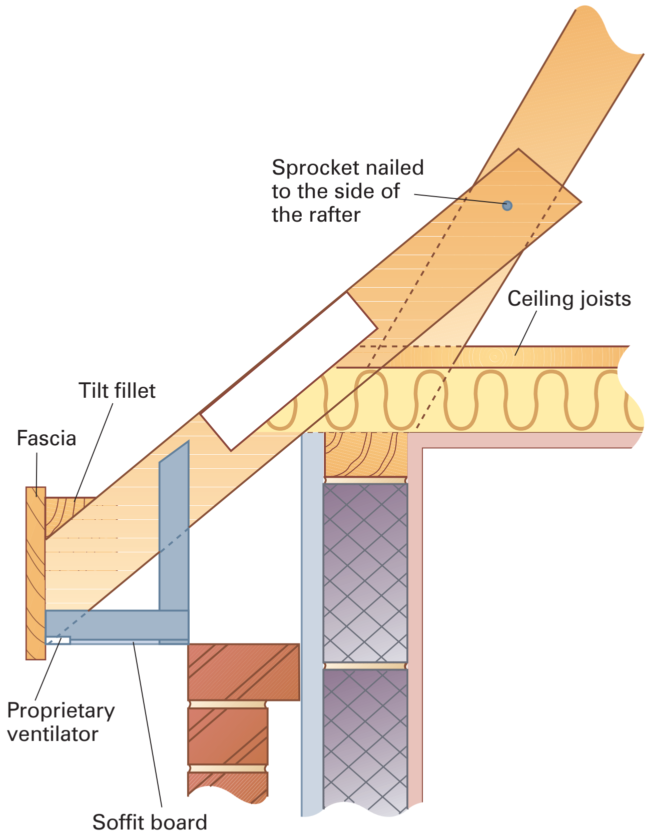


Figure 5.64 Sprocketed eaves

Did you know?

Where you live may have an effect on your choice of roof: in areas more prone to bad weather, the roof will need to be stronger.

Roof coverings

Once all the rafters are on the roof, the final thing is to cover it. There are two main methods of covering a roof, each using different components. Factors affecting the choice of roof covering include what the local weather is like and what load the roof will have to take.

Method 1

This method is usually used in the north of the country where the roof may be expected to take additional weight from snow.

1. Clad the roof surface with a man-made board such as OSB or exterior grade plywood.
2. Cover the roof with roofing felt starting at the bottom and ensuring the felt is overlapped to stop water getting in.
3. Fit the felt battens (battens fixed vertically and placed to keep the felt down while allowing ventilation) and the tile battens (battens fixed horizontally and accurately spaced to allow the tiles to be fitted with the correct overlap).
4. Finally, fit the tiles and cement on the ridge.

Method 2

This is the most common way of covering a roof.

1. Fit felt directly onto the rafters.
2. Fit the tile battens at the correct spacing.
3. Fit the tiles and cement on the ridge.

Another way to cover a roof involves using slate instead of tiles. Slate-covered roofing is a specialised job as the slates often have to be cut to fit, so roofers usually carry this out.

Knowledge refresher

1 What is the definition of a flat roof?

2 What is the difference between a truss roof and a cut roof?

3 Explain the difference between a hip and a gable end.

4 What is the purpose of a roof ladder?

5 Describe an 'I' type joist.

What would you do?

You have been asked to quote for building a garage. The client is unsure about what type of roof to have. They ask your opinion. What type of roof would you select? Why would you select that type of roof? What could influence your selection?

Find out

What is a steel portal frame used for in commercial building construction?

Element	Domestic	Commercial
Foundations	Traditional strip footings Raft foundations on poor load-bearing ground Mass-fill trench foundations	Piled foundations with pile caps Ground beams Raft foundations with edge beam Pad foundations
Structural frame	Traditional cavity wall Timber-framed construction Load-bearing insulated formwork	Steel portal frame Steel columns and beams Composite construction Concrete frameworks
Cladding	Facing brickwork Rendering Timber cladding Clay tiles	Insulated composite cladding panels Steel powder-coated panels Brickwork facing skin dwarf walls Timber cladding
Flooring	Solid concrete floors Beam and block Traditional timber flooring joists	Solid reinforced concrete floors, power-floated with edge beams
Roofing	Roof trusses with interlocking roof tiles Traditional roof timbering with clay/concrete roof tiles	Insulated cladding panels

Table 5.1 Comparison between domestic and commercial construction techniques