chapter 4

Principles of building

OVERVIEW

Whatever type of building is being constructed there are certain principles/elements that must be included, for example a block of flats and a warehouse will all have foundations, a roof, etc.

In Chapter 1, you learned about different types of building. In this chapter, you will have a more in-depth look at the elements behind the main principles of building work.

This chapter will cover the following topics:

- Structural loading
- Substructure
- Superstructure
- Primary elements
- Secondary elements
- Finishing elements
- Services.

These topics can be found in the following modules:

CC 2003K	CC 2003S

This chapter will only look briefly at the components contained within buildings. For more detailed information on carpentry components, check the relevant chapter in this book For all other components, check the relevant book from Heinemann's Carillion Construction series.

Structural loading

The main parts of a building that are in place to carry a load are said to be in a constant state of **stress**.

There are three main types of stress:

- Tension pulls or stretches a material and can have a lengthening effect.
- Compression squeezes the material and can have a shortening effect.
- Shear occurs when one part of a component slips or slides over another causing a slicing effect.

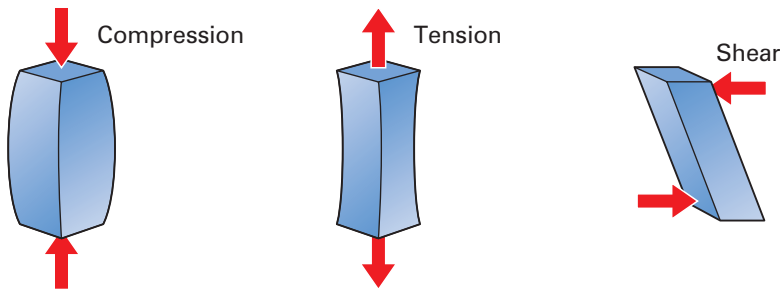


Figure 4.1 The three types of stress

To cause one of these types of stress a component or member must be under the strain of a load. Within construction there are two main types of loading:

- Dead load – the weight of the building itself and the materials used to construct the building, covering components such as floors and roofs.
- Imposed loads – any moveable loads like furniture as well as natural forces such as wind, rain and snow.

To cope with the loads that a building must withstand there are load-bearing structural members strategically placed throughout the building.

There are three main types of load bearing members:

- Horizontal members – One of the most common type of horizontal members is a floor joist, which carries the load and transfers it back to its point of support. The horizontal member, when under loading, can bend and be in all three types of stress, with the top in compression, the bottom in tension and the ends in shear.

Definition

stress - a body that has a constant force or system of forces exerted upon it resulting in strain or deformation

Remember

Where you are in the country will determine what materials you use for constructing. For example, some places with a lot of snowfall will require stronger structures to deal with the extra load from the snow

The bending can be contained by using correctly stress-graded materials or by adding a load-bearing wall to support the floor.

- Vertical members – Any walls or columns that are in place to transfer the loads from above (including horizontal members) down to the substructure and foundations have vertical members. Vertical members are usually in a compression state.
- Bracing members – Bracing members are usually fitted diagonally to form a triangle which stiffens the structure. Bracing members can be found in roofs and even on scaffolding. Bracing is usually in compression or tension.

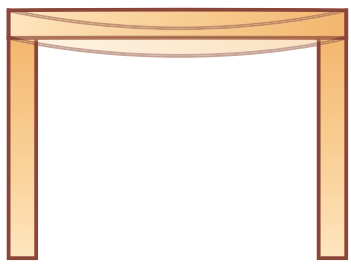


Figure 4.2 Horizontal structural members

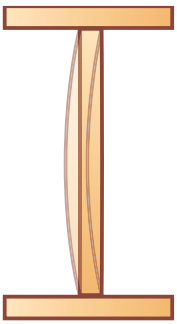


Figure 4.3 Vertical structural members

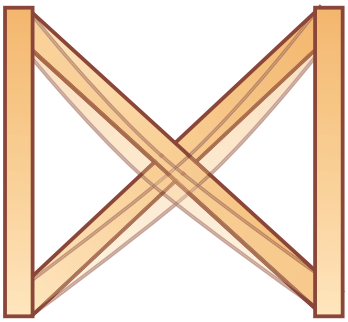


Figure 4.4 Bracing structural members

Substructure

All buildings will start with the substructure – that is, all of the structure below ground and up to and including the damp proof course (DPC). The purpose of the substructure is to receive the loads from the main building (superstructure) and transfer them safely down to a suitable load-bearing layer of ground.

The main part of the substructure is the foundations. When a building is at the planning stage, the entire area – including the soil – will be surveyed to check what depth, width and size of foundation will be required. This is vital: the wrong foundation could lead to the building subsiding or even collapsing.

All buildings have a substructure

Did you know?

During the surveying of the soil, the density and strength of the soil are tested and laboratory tests check for harmful chemicals contained within the soil

The main type of foundation is a strip foundation. Depending on the survey reports and the type of building, one of four types of foundation will usually be used.

- Narrow strip foundation – the most common foundation used for most domestic dwellings and low-rise structures.

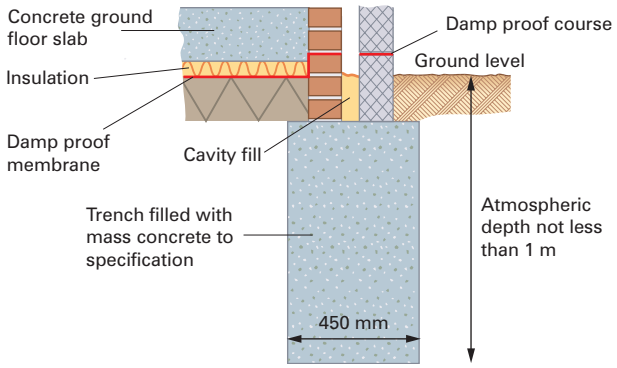


Figure 4.5 Narrow strip foundation

- Wide strip foundation – used for heavier structures or where weak soil is found.

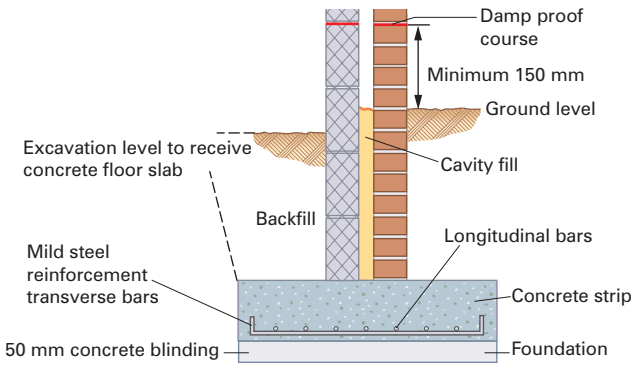


Figure 4.6 Wide strip foundation

- Raft foundation – used where very poor soil is found. This is basically a slab of concrete that is thicker around the edges.

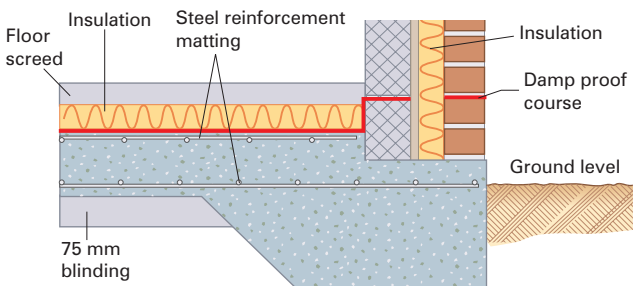


Figure 4.7 Raft foundation

- Pad foundation – where pads are placed at strategic points, with concrete beams placed across the pad to spread the load.

Once the substructure is in place, the building is then built on top of it.

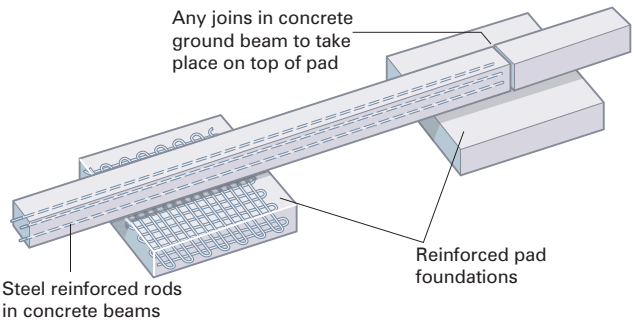


Figure 4.8 Pad foundation

Superstructure

The superstructure covers everything above the substructure, from walls to floors to roofing. The purpose of the superstructure is to enclose and divide space, as well as spread loads safely into the substructure.

Within the superstructure, you will find the primary, secondary and finishing elements, as well as the services.

Primary elements

The primary elements are the main supporting, enclosing and protecting elements of the superstructure. They divide space and provide floor-to-floor access.

The main primary elements are:

- walls
- floors
- roofs
- stairs.

Walls

There are two main types of wall within a building: external and internal.

External walls

External walls come in a variety of styles, but the most common is cavity walling. Cavity walling is simply two brick 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.

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

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.

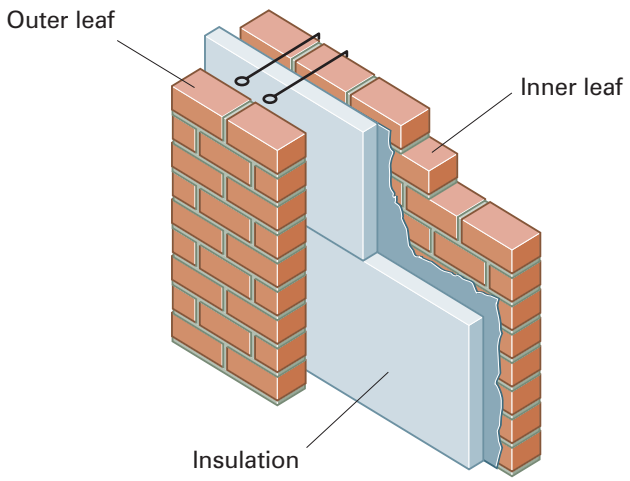


Figure 4.9 A cavity wall

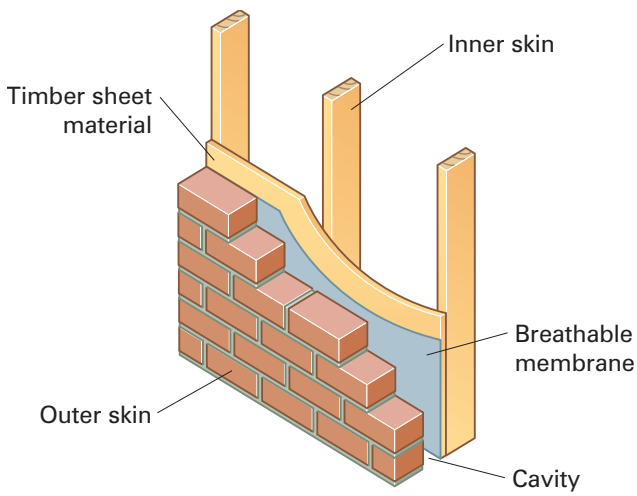


Figure 4.10 A timber and cavity wall

Safety tip

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

Internal walls

Internal walls are either load bearing – meaning they support any upper floors or roof – or are in place to divide rooms into shapes and sizes.

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 such as thermalite blocks 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.

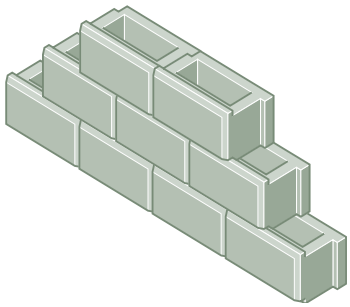


Figure 4.11 Solid block wall

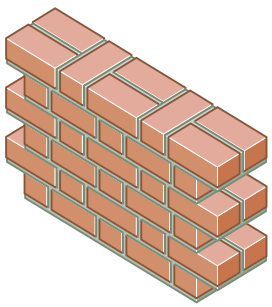


Figure 4.12 Solid brick wall

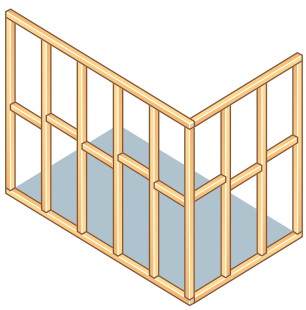


Figure 4.13 Timber stud wall

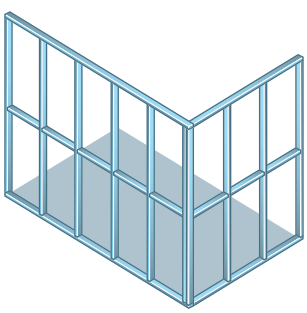


Figure 4.14 Metal stud wall

- 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.

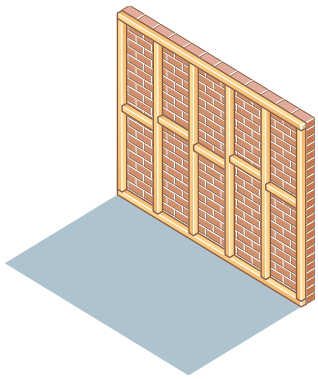


Figure 4.15 Ground lats

Floors

There are two main types of floor: ground and upper.

Ground floors

There are a few main types of ground floor. These are the ones you will most often come across.

- Suspended timber floor – a floor where timber joists are used to span the floor. The size of floor span determines the depth and thickness of the timbers used. The joists are either built into the inner skin of brickwork, sat upon small walls (dwarf/sleeper wall), or some form of joist hanger is used. The joists should span the shortest distance and sometimes dwarf/sleeper walls are built in the middle of the span to give extra support or to go underneath load-bearing walls. The top of the floor is decked with a suitable material (usually chipboard or solid pine tongue and groove boards). As the floor is suspended, usually with crawl spaces underneath, it is vital to have air bricks fitted, allowing air to flow under the floor, preventing high moisture content and timber rot.
- Solid concrete floor – concrete floors are more durable and are constructed on a sub-base incorporating hardcore, damp proof membranes and insulation. The depth of the hardcore and concrete will depend on the building and will be set by the *Building Regulations* and the local authority. Underfloor heating can be incorporated into a solid concrete floor. Great care must be taken when finishing the floor to ensure it is even and level.
- Floating floor – basic timber floor constructions that are laid on a solid concrete floor. The timbers are laid in a similar way to joists, though 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.

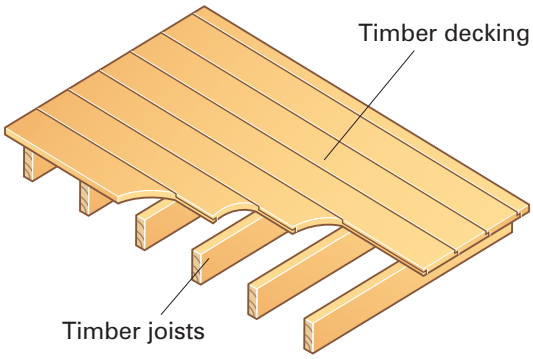


Figure 4.16 Suspended timber floor

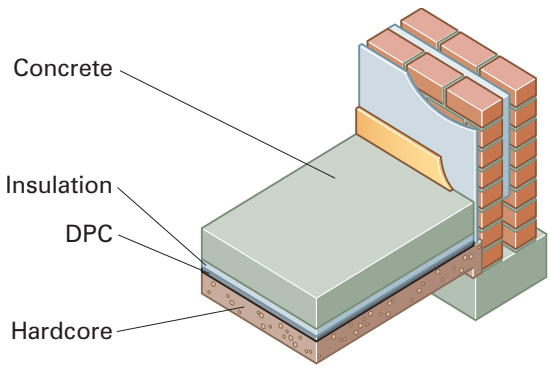


Figure 4.17 Solid concrete floor

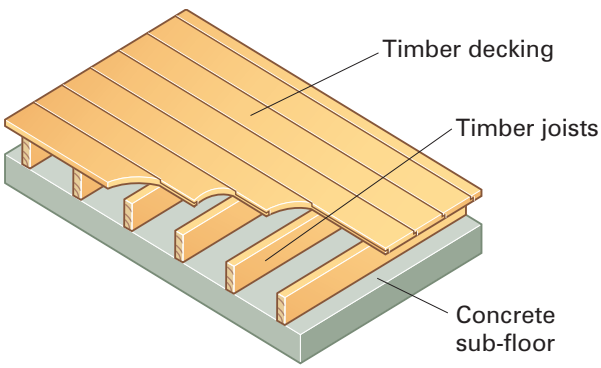


Figure 4.18 Floating floor

Upper floors

Again, solid concrete slabs can be used in larger buildings, but the most common type of upper floor is the suspended timber floor. As before, the joists are either built into the inner skin of brickwork or supported on some form of joist hanger. Spanning the shortest distance, with load-bearing walls acting as supports, it is vital that **regularised joists** are used as a level floor and ceiling are required. The tops of the joists are again decked out, with the underside being clad in plasterboard and insulation placed between the joists to help with thermal and sound properties.

Did you know?

Sometimes metal beams are used to span floors and act as load-bearing members. These beams are either dipped in a chemical coating or painted to prevent rust

Roofs

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

Definition

Regularised joists – joists that are all the same depth

Firring pieces – tapered strips of timber

Flat roofs

A flat roof is a roof with a pitch of 10° or less. The pitch is usually achieved through laying the joists at a pitch, or by using **firring pieces**.

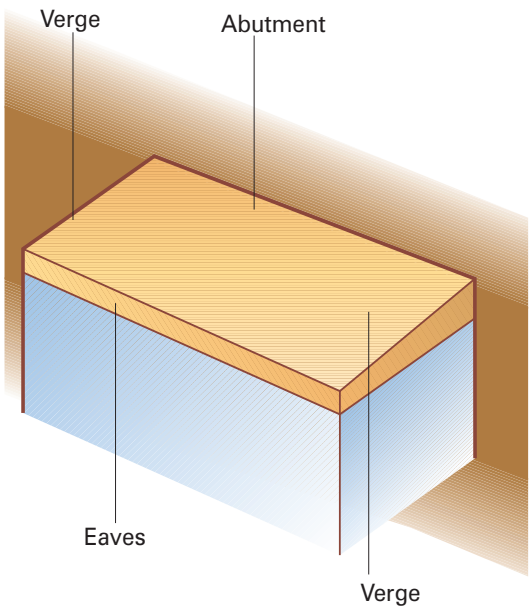


Figure 4.19 Flat roof terminology

The main construction method for a flat roof is similar to that for a suspended timber floor, with the edges of the joists being supported either via a hanger or built into the brickwork, or even a combination of both. Once the joists are laid and firring pieces are fitted (if required), insulation and a vapour barrier are put in place. The roof is then decked on top and usually plasterboarded on the underside. The decking on a flat roof must be waterproof, and can be made from a wide variety of materials, including fibreglass or bitumen-covered boarding with felt layered on it.

Drainage of flat roofs is vital. The edge where the fall leads to must have suitable guttering to allow rainwater to run away, and not down the face of the wall.

Pitched roofs

There are several types of pitch roof, from the basic gable roof to more complex roofs such as mansard roofs. Whichever type of roof is being fitted to a building, it will most likely be constructed in one of the following ways.

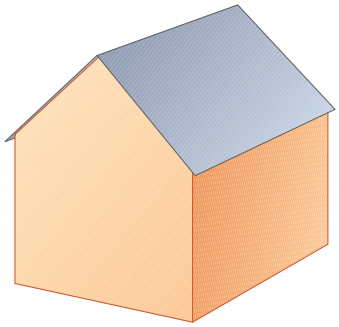


Figure 4.20 Duo pitch roof with gable ends

- Prefabricated truss roof – as the name implies, this is a roof that has prefabricated members called trusses. Trusses are used to spread the load of the roof and to give it the required shape. Trusses are factory-made, delivered to site and lifted into place, usually by a crane. They are also easy and quick to fit: either they are nailed to a wall plate or held in place by truss clips. Once fitted, bracing is attached to keep the trusses level and secure from wind. Felt is then fixed to the trusses and tiles or slate are used to keep the roof and dwelling waterproof.

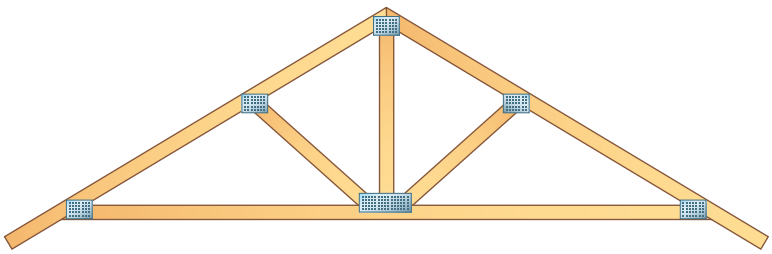


Figure 4.21 Prefabricated wooden roof truss

- Traditional/cut roof – an alternative to trusses, the cut roof uses loose timbers that are cut in-situ to give the roof its shape and spread the relevant load. More time-consuming and difficult to fit than trusses, the cut roof uses rafters that are individually cut and fixed in place, with two rafters forming a sort of truss. Once the rafters are all fixed, the roof is finished with felt and tiles or slate.

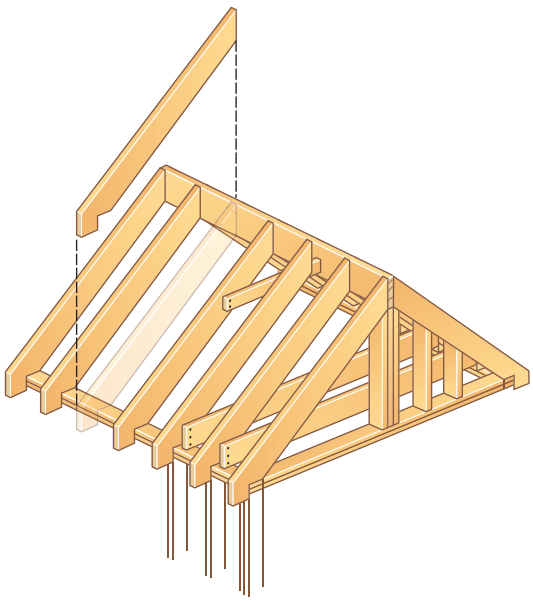


Figure 4.22 Individually cut rafters

Metal trusses can also be used for industrial or more complex buildings.

To finish a roof where it meets the exterior wall (eaves), you must fix a vertical timber board (fascia) and a horizontal board (soffit) to the foot of the rafters/trusses. The fascia and soffit are used to close off the roof space from insects and birds.

Did you know?

Due to the fact that heat rises, the majority of heat loss that occurs is through a building's roof. Insulation such as mineral wool or polystyrene must be fitted to roof spaces and ideally any intermediate floors

Ventilators are attached to the soffits to allow air into the roof space, preventing rot, and guttering is attached to the fascia board to channel the rainwater into a drain.

Stairs

Stairs are used to provide access between different floors of a dwelling or to gain access to a higher/lower area. Stairs are made up of a number of steps, and each continuous set of steps running in the same direction is known as a flight. Steps are made of vertical boards called risers and horizontal boards called treads.

There are various types of stair, ranging from spiral staircases(often fitted where there is a lack of space) to multi-flight staircases, such as dog-leg or half-turn stairs.

Stairs are strictly governed by the *Building Regulations*, and there are numerous requirements that must be adhered to when constructing and installing them.

Stairs are generally made from three types of material:

- timber – the most common type of stair, used widely in almost all buildings
- in-situ-cast concrete – a wooden frame is constructed around the stairwell and concrete is poured into the frame, forming the staircase
- pre-cast concrete – concrete cast in large moulds to form the staircase, usually found in flat stairwells and other areas of heavy use
- steel – usually found on the exterior of buildings in the form of fire escapes, etc.

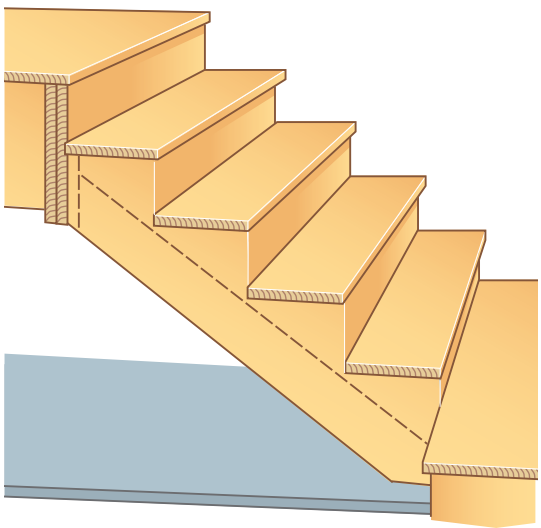


Figure 4.23 A simple staircase

Secondary elements

The secondary elements are not essential to the building's strength or structure, but provide a particular function, such as completing openings in walls, etc.

The main secondary elements are:

- frames and linings
- doors
- windows
- architrave and skirting.

Frames and linings

Frames and linings are fitted around openings, and are used to allow components such as windows and doors to be fitted. The frame or lining is fitted to the wall and usually finished flush with the walls; the joint between the frame or lining and the wall is covered by the architrave.

Doors

The main purpose of a door is to provide access from one room to another, and to allow a space to be closed off for security/thermal/sound reasons.

Doors come in many varieties, shapes and sizes; the type you need will be determined by where the door is being fitted and what for. Exterior doors are generally thicker and are fitted with more ironmongery such as letter plates and locks. Some interior doors will have locks fitted as well, such as bathrooms or doors that need to be secure.

Doors can be solid timber or have glass in them and may be graded for fire resistance.

Windows

Windows are fitted to allow natural light to enter the building with minimal loss of heat. Again, windows come in a variety of shapes and styles. Glass that is fitted in the window can be decorative and heat-loss resistant.

Architraves and skirting

Architraves are decorative mouldings used to hide the gap between frames and the wall finish. Skirting is moulding that covers the gap between the floor and base of a wall. These mouldings come in a variety of **profiles** such as torus and ogee.

Other mouldings also can be used, such as picture and dado rails.

Definition

Profile – the shape of the moulding when you cut through it

Finishing elements

Finishing elements are the final surfaces of an element, which can be functional or decorative.

The main finishing elements are:

- plaster
- render
- paint
- wallpaper.

Plaster

Plaster can be used on a variety of wall surfaces to give a smooth and even finish. The plaster comes in powder form, usually bagged, and is mixed with water until it reaches a consistency that allows it to be applied to the surface and trowelled smooth. Ready-mix plaster is also available, but is more expensive, especially when a lot of surfaces have to be plastered.

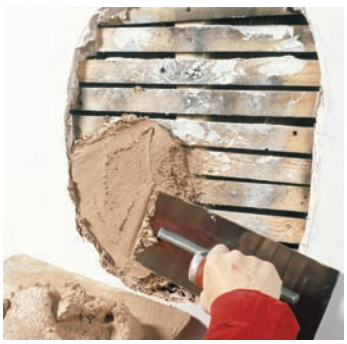
These are the main surfaces to which plaster is applied.

- Brick/block work – prior to application, a bonding agent must first be applied to the wall (usually a coat of watered down PVA), to help the plaster adhere to the surface. Usually a first coat of bonding plaster is applied to the wall to give it a level and flat surface; when this is dry, a second, finish coat is applied. As the finish coat is drying, the plasterer will work on the wall, smoothing it out until it is as smooth as glass.
- Plasterboard – as plasterboard is a flat surface to begin with, a bonding coat is rarely used. Generally, the plasterboard is fixed with the back face (the face with the writing) exposed to give better adhesion. Whether it is a wall or a ceiling, the plasterer will again work the finish coat to a very smooth surface.
- Lath and plaster – this is usually found in old properties. The laths are thin strips of wood, which are fixed to the wall with small gaps between to give the plaster a **key**. Once the laths are fixed the plasterer will apply bonding and finish coats the same as before.

Plasterboard with a tapered edge can also be fixed to the walls. In this case, instead of plastering the entire wall, the plasterer will simply fill the nail/screw holes, fit tape where the plasterboard joins are, and fill only the joints. Pre-mixed plaster is usually used for this; when it is dry, a light sanding is required to give a smooth finish. This method is preferred in newer buildings, especially timber kit houses.

Safety tip

To prevent dermatitis, ensure that you wear gloves when working with plaster, render or cement



Lath and plaster

Definition

Key – the end result of a process that prepares a surface, usually by making it rough or grooved, so that paint or some other finish will stick to it

Not all walls are plastered smooth, as some clients may require a rough or patterned finish. Although not technically a plaster, Artex™ is often used to give decorative finishes, especially on ceilings.

Plaster being applied and trowelled

Render

Render is similar to plaster in that it is trowelled on to brick or block work to give a finish. Applied to external walls, the render must be waterproof to prevent damage to the walls. Different finishes are available, from stippling to patterned.

Paint

Paint is applied to various surfaces and is available in many different types to suit the job they are required for. Paint is applied for a variety of reasons, the most common being to:

- protect – steel can be prevented from corroding due to rust, and wood can be prevented from rotting due to moisture and insect attack
- decorate – the appearance of a surface can be improved or given a special effect (for example marbling, wood graining)
- sanitise – a surface can be made more hygienic with the application of a surface coating, preventing penetration and accumulation of germs and dirt, and allowing easier cleaning.

Paint is either water-based or solvent-based. When a paint is water-based, it means that the main liquid part of the paint is water; with a solvent-based paint, a chemical has been used instead of water to dissolve the other components of the paint.

Water-based paint is generally used on walls and ceilings, while solvent-based paint is used on timber mouldings, doors, metals, etc.

There are other surface finishes besides paint such as varnish (used on wood), masonry paint (used on exterior walls) and preservatives, which are used to protect wood from weather and insect attack.

Wallpaper

Wallpapers are used to decorate walls; thicker wallpapers can also hide minor defects.

Basic wallpapers are made from either wood pulp or vinyl.

Wood-pulp papers can be used as preparatory papers or finish papers. Preparatory papers are usually painted with emulsion to provide a finish, or they can be used as a base underneath finish papers. Types of wood-pulp paper include plain, coloured and reinforced lining paper as well as wood chip.

Vinyl wallpaper is a hard-wearing wallpaper made from a PVC layer attached to a pulp backing paper. Types of vinyl paper include patterned, sculptured or blown vinyl.

Wallpaper is hung on a wall using a paste. Not all pastes have the same strength, so make sure you choose the correct paste for the type of paper you are using.

Services

The services are specialist components within a building ranging from running water to electricity.

The main services in a standard house are:

- Electrical – covers all electrical components within the building from lights to sockets. Electrical installation and maintenance work must be undertaken by a fully trained specialist as electricity can kill.
- Mechanical – covers things such as lifts. As with electrical services, work on mechanical services should only be undertaken by a specialist.
- Plumbing – can cover running water as well as gas, but only if the plumber has been recognised and qualified as a gas installation expert.

Remember

All service work must be carried out by a fully trained and competent person

FAQ

How do I know if the materials I am using are strong enough to carry the load?

On the specification you will find details of the sizes and type of materials to be used.

Do I have to fix battens to a wall before I plasterboard it?

No – the method called dot and dab can be used where plaster is dabbed onto the back of the plasterboard and then pushed onto the wall.

On the job: Identifying load-bearing walls

Jay and Ella are out pricing up a job to place a doorway into a solid wall. Jay says that it will only take a few hours to knock through the brickwork and put a frame in. Ella is not so sure: she thinks the wall may be load bearing. How can they check the wall is load bearing? And what should be done if it is?

Knowledge check

1. State the four main principles of building.
2. List the three main types of stress.
3. What is the main purpose of the substructure?
4. List three different types of foundation.
5. What are the four main primary elements?
6. Give a brief description of external walling.
7. What is the difference between a truss roof and a cut roof?
8. What are the four main secondary elements? Why are they secondary?
9. List four main finishing elements.
10. Give a brief description of the process involved with lath and plaster.
11. What is vinyl wallpaper made from?
12. Give three reasons why paint is used.
13. What are the three main services?