Name

_____

Teacher

_____

Learning aims

In this unit you will:

A - Understand the structural performance required for low-rise construction

B - Explore how sub-structures are constructed

C - Explore how superstructures are constructed.

Learning aim A: Understand the structural performance required for low-rise construction

Topic A.1 Performance requirements

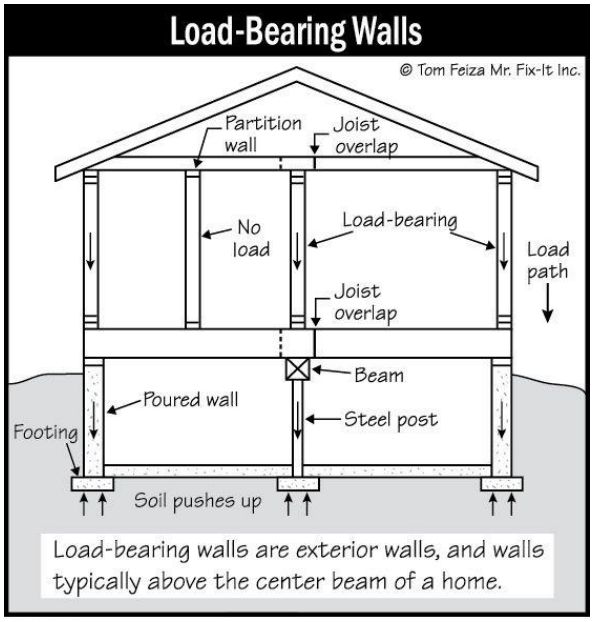
What must a low-rise building be able to do?

Have strength and stability from - Resist live, dead and dynamic loads to include:

Self - weight

Stability

Use



Wind

Strength

Snow

Transfer of loads to foundations:

Roof to walls and floors to walls.

How buildings achieve their required strength – for the following, understand what is required, where it is required, why it is done and how it is achieved:

What is MORTAR?

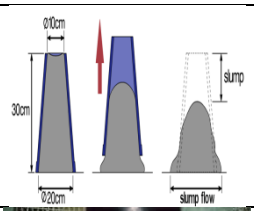
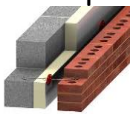
Mortar is used to hold building materials such as brick or stone together.

What is CONCRETE?

Concrete is a mixture of sand, cement, and water, but it also contains rock chippings or gravel which makes it much stronger and more durable than mortar. It is best used for support, such as beams, walls, or other building foundations.

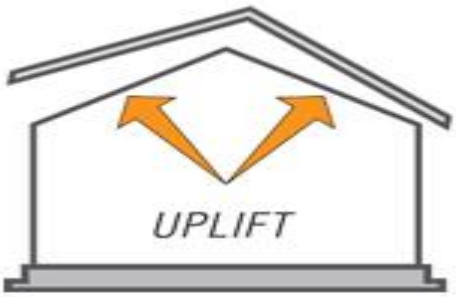
Testing materials

	Grading of hard core	Mot Type 1 is simply crushed Limestone that meets the requirement of the Department of Transport Specification for Highway Works.

	Slump testing	Slump testing checks that the ratio of water and cement in wet concrete is correct. If wet concrete loses its shape or slumps too easily, the balance is not right.
	Compressive testing of concrete	Compressive strength testing checks that the hardened concrete is strong enough to withstand loads.
	Stress grading of structural timber	Timber is used in structures such as frames of buildings or roof trusses, as well as in doors and windows. The strength of various types of timber is tested. Timber is then sorted into various groups. This process is called stress grading or strength grading.
	Mortar testing	Mortar testing is performed by making cubes of mortar to check how much water can pass through it, or if there are any gaps causing leakage.
Specification of materials:		
British Standards, (EN) European numbers	Start BS or EN	
Strength classifications of concrete, bricks, blocks, mortar, timber	Depends on the use of the material. Some are required for high strength or appearance	
Adding strength - Materials		
Concrete/steel composite 	Reinforced concrete is a combination of traditional cement concrete with reinforcements (steel bar). This combination is made to utilise the compressive strength of concrete and tensile strength of steel simultaneously.	
Wood/plastic composite 	WPCs do not corrode and are highly resistant to rot, decay, and Marine Borer attack, though they do absorb water into the wood fibres embedded within the material. They have good workability and can be shaped using conventional woodworking tools.	
Building regulation requirements for buildings not exceeding 12 m high		
Wall-tie spacing 	Wall tie should have a minimum embedment of 50mm in each leaf	

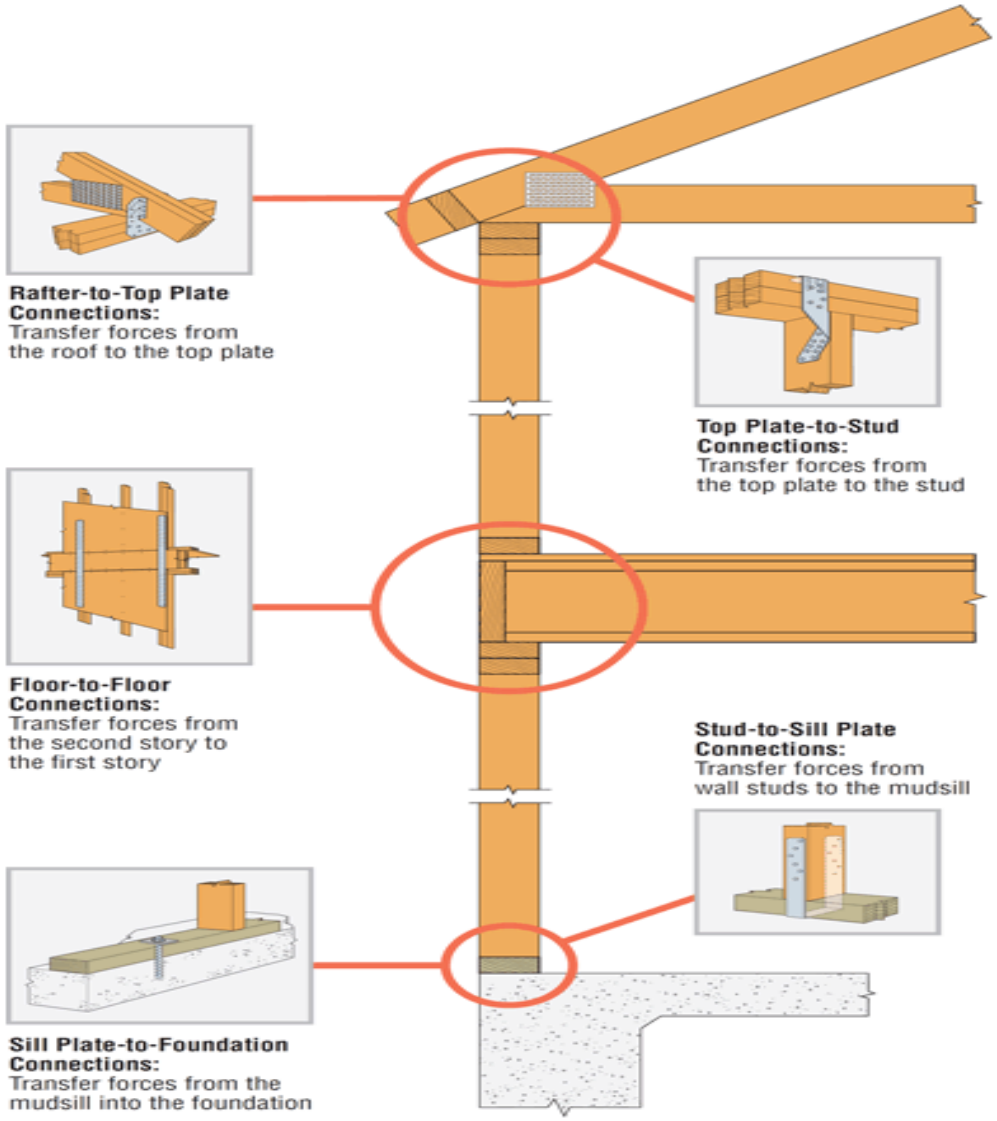
Height restrictions Masonry Wall buildings 	**<u>Masonry walls :</u>** • Not more than 3 storeys • Maximum building height of 15 m Maximum • 12m length between supporting walls • Wind speed verses the allowable height of building • Openings in walls not more than 3 m in length
Height restrictions Timber frame homes 	**<u>Timber frame walls</u>** • Not more than 2 storeys • Maximum building height of 10 m • Maximum 10m length between supporting walls
Internal walls 	• You cannot take a wall down that is load bearing. • Provide adequate separation - in terms of fire resistance and thermal insulation • Any door provided in such a wall should have adequate fire resistance and be self-closing. • The new separating wall may also need to provide sound insulation.

Lateral and vertical restraint: floor- and roof-tie positions / resist the spread of the walls / resist uplift from wind loadings



When wind flows over the roof of the structure, it creates a strong lifting force on the roof which can cause it to break away.

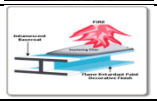
When wind blows against the side of the structure it exerts a lateral force that causes it to lean over (rack) to one side.



What needs to be learnt - Fire resistance

How buildings are protected against fire and maintain their structural integrity – for the following, understand what is required, why it is done and how it is achieved:

Fire-resistant materials: What in construction can help to prevent the spread of fire?

	Plasterboard
	Concrete
	Blockwork
	Intumescent paint

Fire compartments and fire barriers (separating building design requirements – walls, separating floors, door closes, and fire-resistant doors)

Designing for fires

Detection - alert

Fire alarm systems

Smoke detection

Slow down the spread of fire

Cavity fire barriers

Sprinkler system

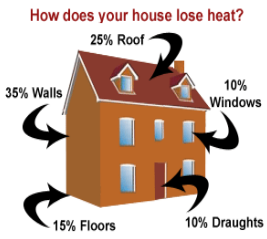
Safety for people

Fire escapes

Refuge areas

Thermal insulation - How buildings are insulated against heat loss – for the following, understand why it is done, what types of thermal insulation and resistant materials are used, and where it is provided:

What is the purpose of insulation?



1 - Reduction of heat loss from a building

2 – Save money for owner by reducing energy costs

3 - Prevention of the loss of heated air through gaps within a building or structure

4 - Providing an acceptable U-value in accordance with regulations

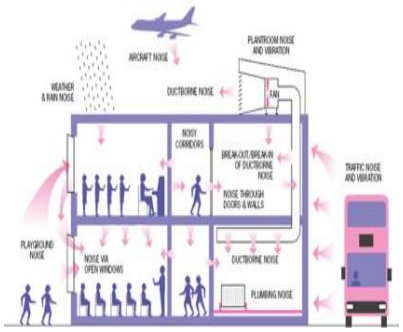
Types of insulation:

Image	MATERIAL	Advantage	Disadvantage
	Sheep's wool	Can be reused and recycled Absorbs extra moisture	Has some non-renewable material Thermal conductivity can increase if compressed
	Mineral wool	Excellent heat insulators and sound absorbers.	Though not immune to the effects of a sufficiently hot fire, the fire resistance of fiberglass
	Glass fibre	Fire resistant Does not rot Can be recycled	Made from silica, which is not a renewable material Carbon emissions during its production

	Cellulose / recycled paper	Made from recycled material Can be reused and recycled	Paper dust during installation Can release gases from the printing inks on the recycled paper
	Foam	Seals-off all air sealing the voids throughout the insulated area. Adds structural strength to the building It has the highest performance of all insulation It is permanent and will not sag or settle	The upfront cost is higher than conventional insulation. The installation process is longer. The process could be messier.
Advantages of one type over another:			
Types of thermally resistant materials (keeps heat in):			
	Aerated lightweight concrete blocks		
	Timber		
	Lightweight screeds (screeding mortar)		
Location of insulation:			
1 - Cavity insulation			
2 - Wall insulation			
3 - Roofing insulation			
4 - Flooring insulation			
5 - Double glazing			
6 - Draught strips			

Sound insulation - How buildings meet their required sound resistance – for the following, understand why it is used, what is required to be provided, where it is required, and how sound resistance is achieved:

What is the purpose of sound insulation?



1 - It is to resist the passage of sound through a structure

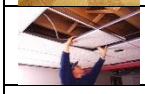
2 - preventing nuisance and noise disturbance of adjacent neighbours

3 - reduce external infrastructure noise

4 - reduce aircraft noise

5 - provide confidentiality

Types of sound insulation:

	Triple glazing
	Heavy-density blockwork
	Sound insulation quilt
	Plasterboard layers
	Flooring mats
	Carpeting
	Acoustic ceilings

Location of sound insulation:

1 - floor

2 - wall and ceiling construction between adjacent rooms and flats

3 - internal partition walls

4 - windows

5 - doors

How is sound insulation designed for?

1 - adding material with density

2 - utilisation of robust design details

3 - sound isolation of structures

4 - Reduction of transference by using machinery silencers.

Weather resistance - How buildings achieve their resistance to the weather elements – for the following, understand why it is done, what types of materials are used, and where they are provided:

What is the purpose of weather resistance?

1 - To keep occupants in an acceptable environment

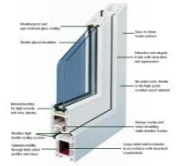
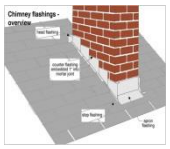
2 - Thermal comfort (warmth) of occupants

3 – Control humidity levels

4 - Prevention of damage to finishes

5 - Prevention of water staining

Materials and location of weather proofing:

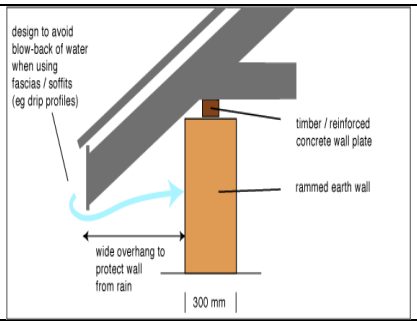
Location	Image	Type of sealant/waterproofing
Guttering		Plastic non- corrosive piping or aluminium
Window and door openings		Double glazing Weather seals and sealants
External walls and features 		Flashings!!! Weather seals and sealants
Use of falls 		Proper design of falls in reinforced concrete flat roofs is most important in creating flow paths to suitable discharge points. For a roof to be effective, surface water should be discharged quickly without ponding or stagnation. Next, it is important to select the appropriate waterproofing membrane. As the roof is constantly exposed to direct sunlight and rain, it is likely to experience tremendous thermal stresses that will affect its physical properties and performance. Pre-formed waterproofing membranes generally will perform better than liquid applied membrane as it can bridge over cracks and gaps better. Also, as they are more resistant to indentations caused by traffic, they are suited for large flat roofs areas exposed to foot traffic.

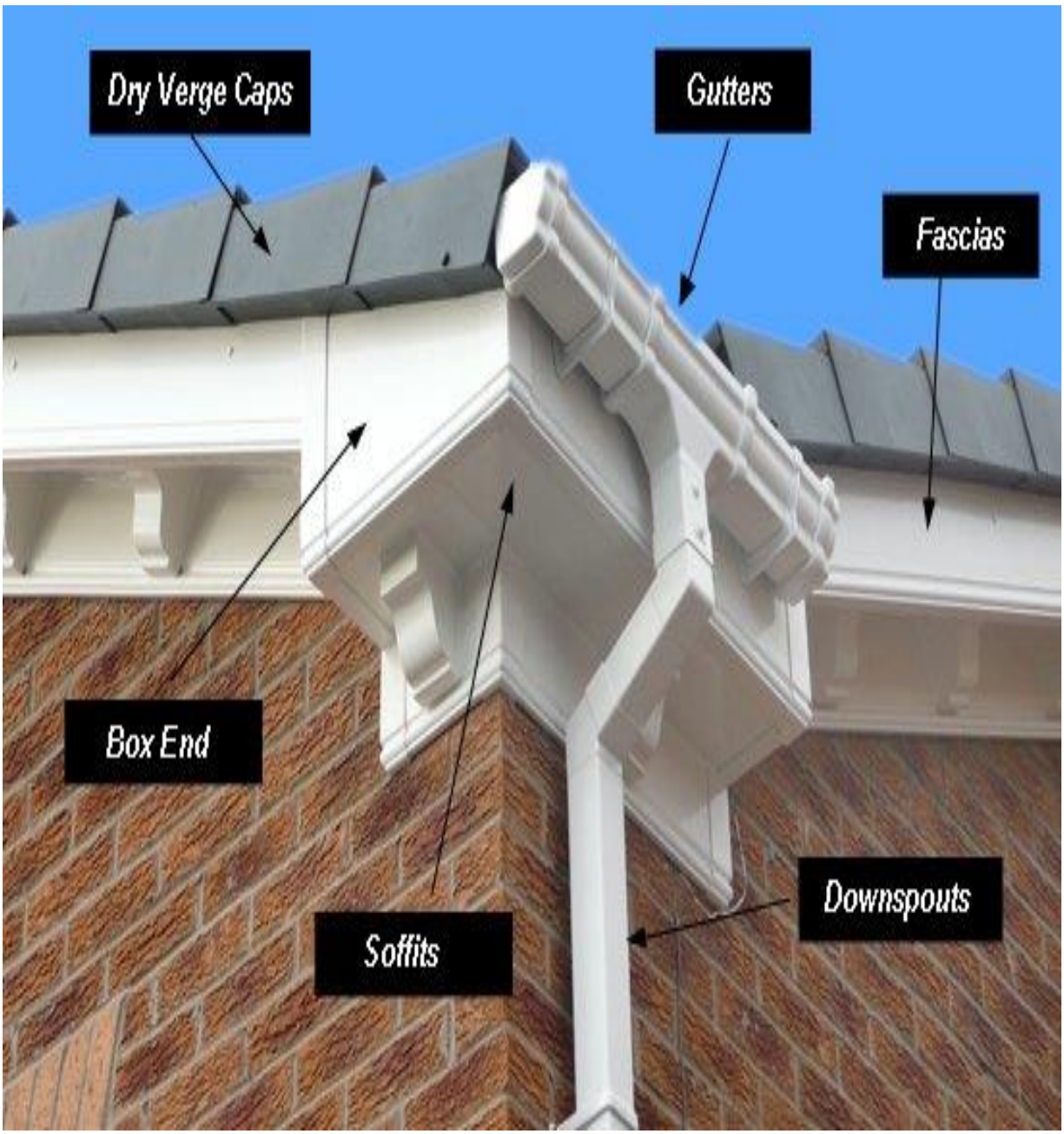
Ventilation ducts

Weather sealants / weather seals

Roof finishes / Overhanging eaves.

See below



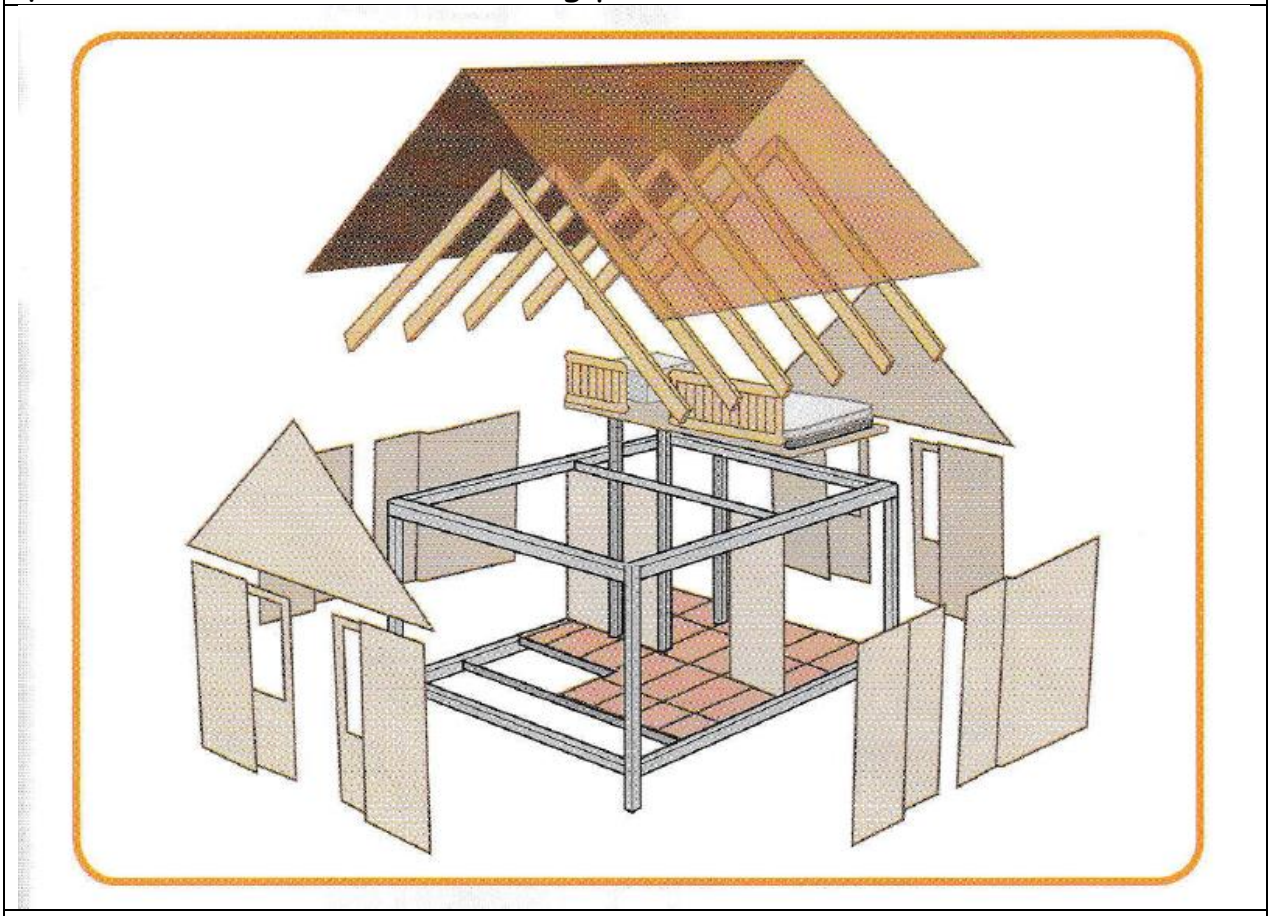


What needs to be learnt – Sustainability - Sustainability is preserving resources for future generations and minimising the impact of construction activities on the natural environment. For the following, understand why it is done, how it is achieved, what sustainable materials are used for construction and where they are used:
What is the purpose of sustainability?
1 - reduction in building energy use
2 - conserving finite resources
3 - reduction in carbon emissions to the atmosphere
4 - reduction in pollution and wastage
Methods of improving sustainability?
1 - building orientation for light and heat in the UK
2 - reduction in the use of greenfield sites
3 - brownfield re-use of sites
4 - recycling waste materials into new products
5 - low embodied energy materials
6 - green renewable natural materials
7 - using local suppliers
8 - prefabrication of elements
9 - reduction in construction wastage
Sustainable Materials:

	Hemp and lime rendering finishes
	Sheep's wool insulation
	Straw construction of walls
	Timber: cedar cladding, softwoods in timber framing
	Recycled aluminium: (guttering, downpipes)

WHY prefabricate?

Reduce time and wastage by using local suppliers, ordering the right quantities of materials and using prefabricated materials.



Main types of prefabrication

Timber-framed - these use timber studs clad with external plywood to form panels. The panels are nailed together, insulated and clad externally in a finish such as brickwork or timber cladding.

Steel channel framed - this uses steel channels to form panels which are clad in architectural styles to form a building. This type of prefabrication is useful for office-type construction.

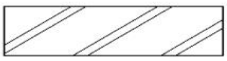
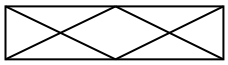
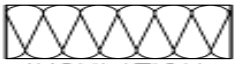
Bonded brickwork - there are now modern methods of construction that employ brickwork bonded together using resins in a factory to form solid brick panels. The panels are placed and bolted together to form a structure.

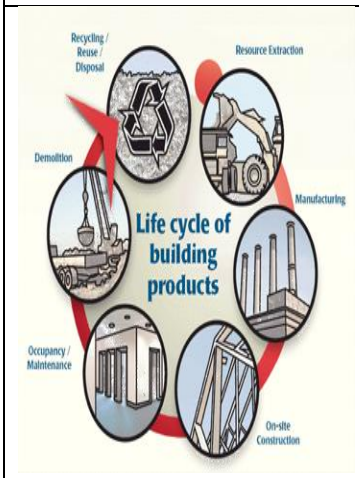
Module prefabrication - many hotels are now formed by bolting together modules that have all the services connected (for example, a bathroom module).

Advantages of prefabrication
1 - It saves time on site - a building can be delivered more quickly and can be watertight in less than two weeks, allowing trades such as electricians to start earlier.
2 - It reduces the need for wet trades, where a building has to be allowed to dry out before it can be finished.
3 - It uses less skilled labour and thus saves costs.
4 - Prefabricated units can have better insulation properties.
5 - Factory-produced quality is maintained.
6 - Prefabrication uses sustainable materials and is environmentally friendly.
7- Prefabricated units can be recycled after their useful life is over.
8 - It can be clad in a variety of materials.

Topic A.2 Common structural forms for low-rise construction
For the following construction methods, understand how they are designed and detailed, what the terminology of each component is called, how and why each method differs, and the advantages and disadvantages of each structural form.

Learners will need to be able to demonstrate the use of sketching techniques.

Diagram/symbols	MEANING
	Brickwork
	Block work
	Concrete
	Stone
	Soil/earth
	Timber
	Plywood
	Hardcore
	Insulation
	Damp poof course (DPC)



Embodied Energy - Definition

Embodied energy is the energy consumed by all of the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery.

<u>Traditional cavity wall construction (Masonry Wall):</u> load-bearing elements:

- brickwork and blockwork,
- blockwork outer and blockwork inner
- with external rendered finishes (hemp, brickwork)

Advantages of traditional cavity wall construction:

With insulation they can have a very low U value.

Very little maintenance is needed to keep these constructions lasting a long time.

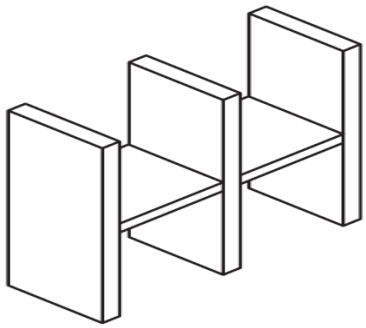
Finding skilled workers to work on them will be very simple

Construction all happens on-site – easy to fix mistakes

Improved fire resistance over timber structures

Less noise pollution invading your house from outside

Cross-wall construction: load-bearing cross-wall element, relationships of connecting floors, prefabricated concrete cross wall, use of cross-wall construction in accommodation units



Advantges of cross-wall construction

1 - Cross-wall buildings are stable

2 - Have good acoustic values

3 - Require little maintenance

4 - They are quick to erect, offering the client a rapid room occupancy programme

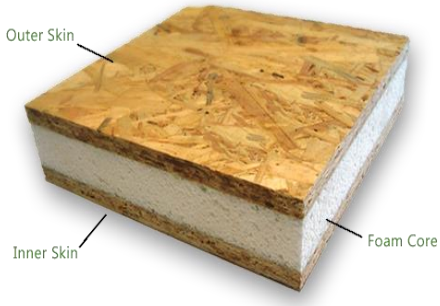
5 - The precast components are brought to site ready to be placed within the structure

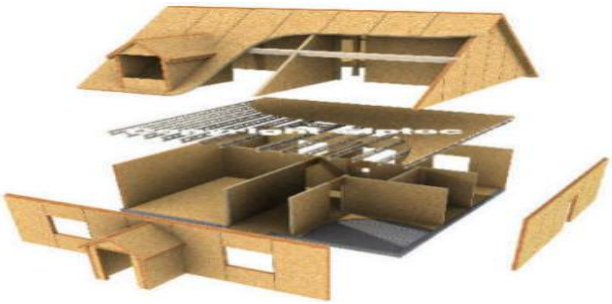
6 - This method has excellent levels of fire resistance

Disadvantages of cross-wall construction
Uses a lot of concrete which has a large carbon footprint associated to it.
(High levels of embodied energy)

Structural: insulated panels (SIPS)

Includes panel finishes (brickwork, blockwork and render, insulation and timber cladding, hemp rendering, tiling), panel function (panel design to support load), position of insulation





Advantages of structural insulated panels (SIPs)

1 - Outer skin can have a range of finishes

2 - Excellent insulation properties

3 - Very flexible design creativity

4 - Sustainable materials used

5 - Low levels of waste

6 - Fast construction method

Timber-framed construction: timber framing use, position of insulation, vapour/moisture barriers including damp-proof membranes, position of plywood on panels, connection binder details, external brick cladding, methods of tying external finish to supporting panel, formation of openings, panel/secondary finishes (brickwork, blockwork and render, insulation and timber cladding, hemp rendering, tiling), panel function (panel design to support load).

Advantages of timber frame construction
1 - Reduced site labour and construction times
2 - Reduced time to weather the structure
3 - Low embodied energy if constructed in local timber
4 - Recyclable materials
5 - Factory controlled quality assurance and fabrication
Disadvantages of timber frame construction
1- Additional design and engineering time
2 – Careful planning because it can be a fire hazard
3 - Can decay of timber when exposed to water
What needs to be learnt **Learning aim B: Explore how sub-structures are constructed** **Topic B.1 Preconstruction work** For the following activities that have to be completed before work can begin on site, understand why they are carried out, what has to be provided on a site, and how it is accomplished. Learners will need to be able to demonstrate the use of sketching techniques.
Desk-based preconstruction:
Legal requirements
construction health and safety plan
method statements and risk assessments
informing the Health and Safety Executive (HSE)
Planning
Scaled site layout plan indicating site accommodation
Welfare facilities
Storage accommodation
Compounds
Temporary roads and hard standing
Fixed plant
Fire precaution measures

Producing a programme of work or scheduling of activities or resources
Purchasing of resources
Organising safety signs
Statutory notices including footpath closures
Road crossings
Traffic management
<u>Site - based</u> preconstruction:
Demolition and clearance of existing structures:
Sustainable demolition and recycling on Brownfield sites
Tree removal
General site clearance of vegetation
Enabling work
Protection of existing services (water, gas, electricity)
Formation of access and egress routes
Installation of temporary supports
Site set-up:
Fencing, gates and security of the site
Temporary lighting
Decontamination works
Installation of site accommodation and associated services
Signage
Creation of storage compounds and hard standing
Temporary works required to construct and support
END

Topic B.2 Sub-structure groundworks

How sub-structures are constructed safely. For the following, understand what is used, why it is used (including potential hazards), where it is used and how it is achieved.

Learners will need to be able to demonstrate the use of sketching techniques.

Hazards associated with groundworks:

Excavation plant/machinery

Collapse of the sides or soil

Movement of ground water

Avoiding existing services gas and electricity supply

Confined space

Water Control

Removing surface water during excavation (simple sump pumping)

Permanent control of sub-soil water (land drainage)

Methods of support to the sides of the excavation (earthwork support)

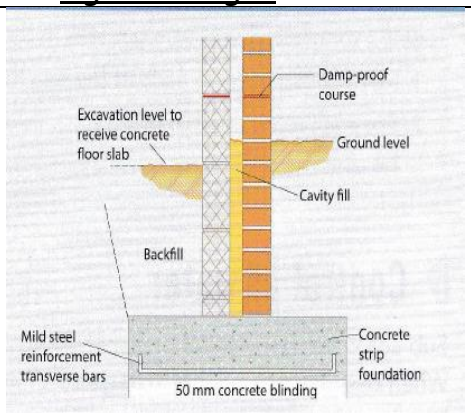
Steel trench sheets, timbering, hydraulic trench supports, aluminium walling

Function of a foundation

To safely transmit the loads of the building to the sub-soil, to settle within acceptable limits for settlement, to support the loads of the building for its lifespan

Understand how foundations are detailed: the different types used to support a low-rise building

Strip - commonly used in low-rise construction such as houses where the soil has the right strength.



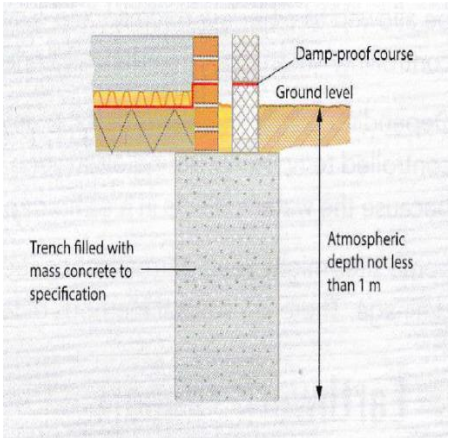
Advantage

- Traditional method understood by site staff
- involves doing brick and blockwork in trenches

Disadvantage

- Might take longer
- Can be hazardous as the soil can get loosened
- Might need trench support

Deep strip or mass fill - used for similar types of buildings, quick to construct.



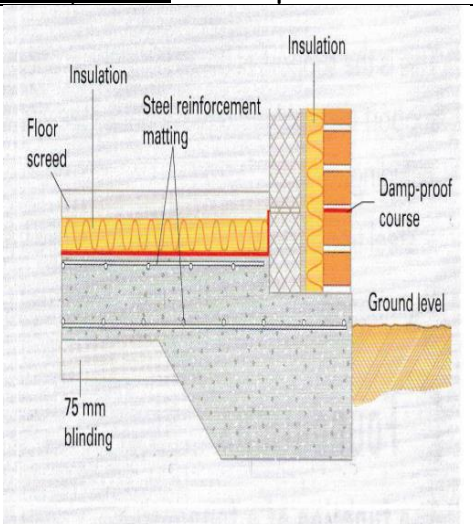
Advantage

- No brick or blockwork needed in trenches
- Faster method of construction

Disadvantage

- Could be more expensive

Raft foundation – used where soil does not have the same strength or where heavy loads are expected. These are used for commercial or industrial buildings.



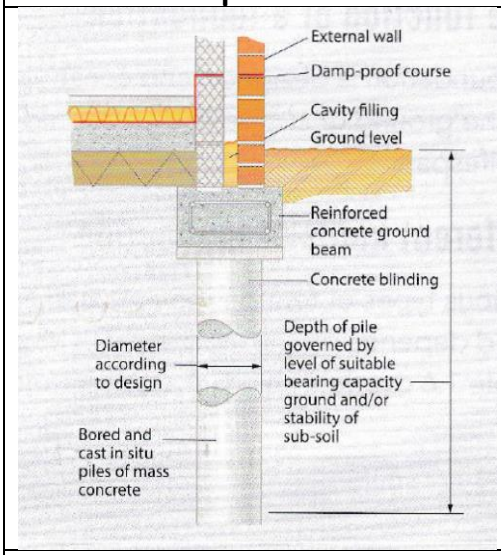
Advantage

- Provides good foundation where soil is variable
- Can be used as a floor
- Can be used to fit in services

Disadvantage

- Expensive to construct
- Can crack if not constructed correctly
- Needs formwork

Short bored piles



Advantage

- Provides foundation when the soil is weak
- Quick to construct

Disadvantage

- Expensive
- Construction causes
- A lot of noise making them

Need to know - Detailing and terminology - strip and deep strip, trench/mass fill, raft, short bored piles and ground beam, engineering brickwork to DPC and cavity fill weepholes, selection of appropriate foundation for a variety of ground conditions, the advantages/disadvantages of each foundation type

NOTES:

What needs to be learnt - *understand how ground floors are detailed*: sub-floor ventilation and the advantages/disadvantages of each floor type.

Ground floors

A **<u>solid floor</u>** bears directly onto the ground from which it gains its support. It is usually made of solid concrete. Solid floors are made up of:

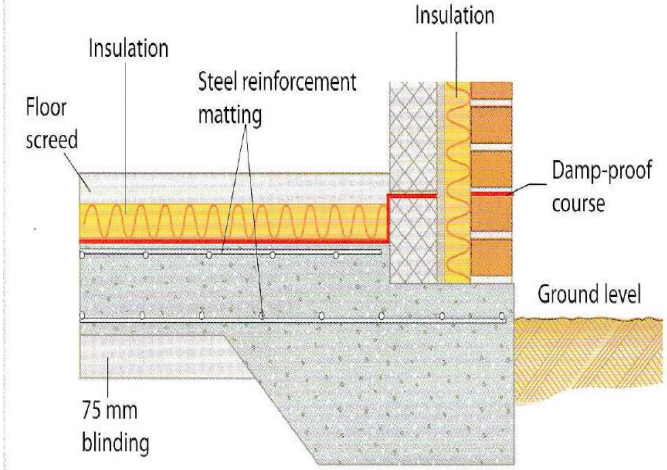


Figure 1.3 Typical solid floor details.

- Hardcore to provide a strong base
- Sand blinding - a layer of sand to even off the surface of the hardcore
- Damp-proof course (DPC)
- Damp-proof membrane (DPM)- this stops moisture transfer from the ground into the building by the overlapping of sheets, the taping of any joints, Linking to DPC and by having a certain thickness of membrane
- Insulation - this should have good compressive strength.

A **<u>suspended floor</u>** is one that is suspended above the ground. It rests on beams spanning between supporting walls. In the modern construction industry, suspended floors are generally built using the beam-and-block method.

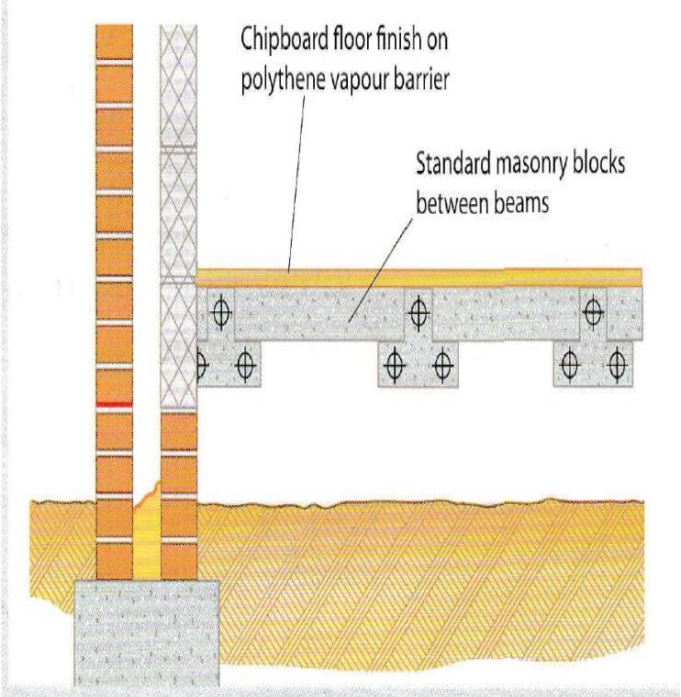


Figure 1.4 A beam-and-block ground floor. The wall below the DPC, often includes an airbrick. This ventilates the empty space below the suspended floor.

<u>Beam-and-block floor</u>

This is a type of suspended floor. It uses precast concrete beams with lightweight concrete blocks as an infill. The method is becoming very popular as it is quick to construct and ensures a high quality. These floors do not need any preparation and put less of a load on the foundations. As they are precast, they can be laid in bad weather.

Learning aim C: Explore how superstructures are constructed
Topic C.1 Superstructures – walls

For the following, understand what is used, where it is used, why it is used and how it is achieved.

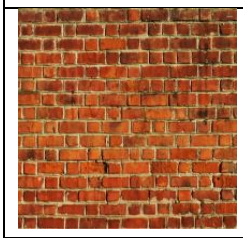
Learners will need to be able to demonstrate the use of sketching techniques.

Understand how walls are detailed: types of construction (cavity masonry, timber frame, insulated panels (SIPs) and their advantages and disadvantages, wall-tie spacing, (timber, metal stud, solid blockwork)

Internal partitions

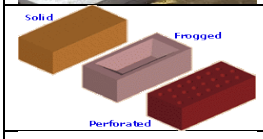
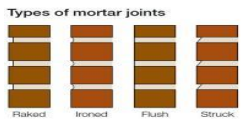
	Timber – quick to erect
	Metal stud - strong, lightweight, less flammable
	Solid blockwork - better sound proofing between rooms

Functions of a wall

	To resist heat transfer
	To reduce sound transmission
	To transfer loads to foundations
	To provide shelter
	To provide security

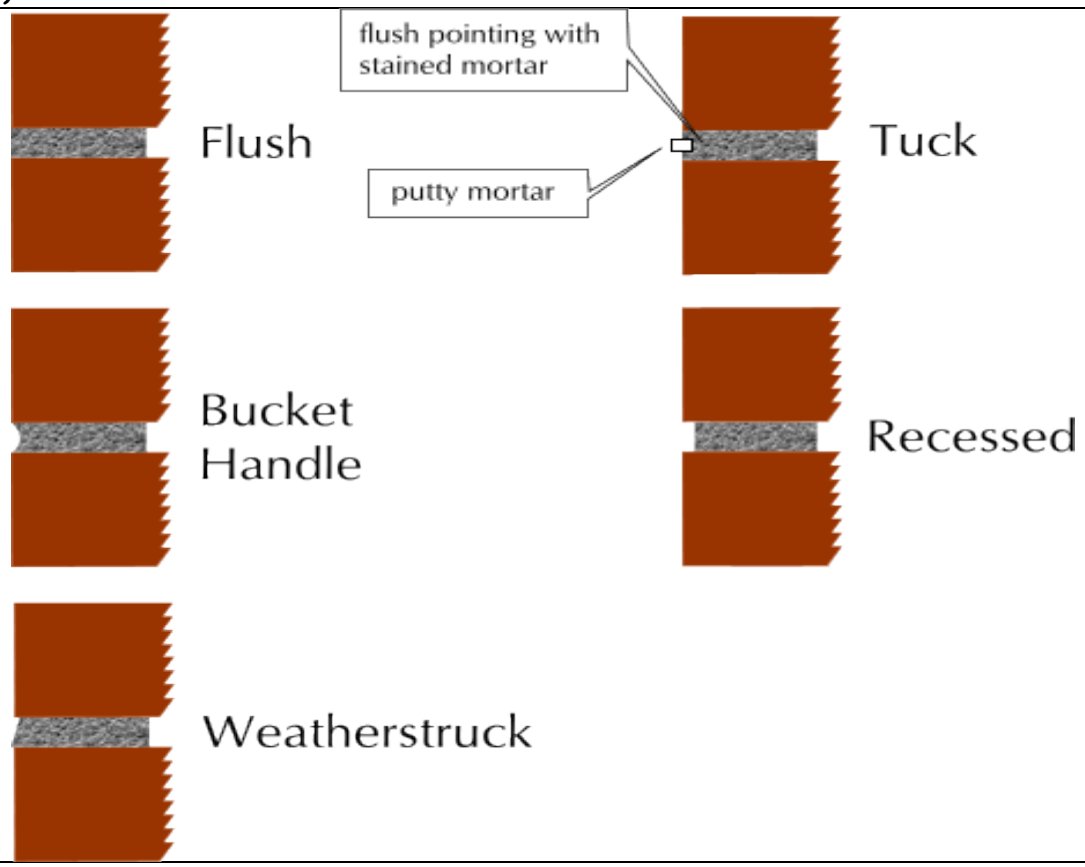
Detailing

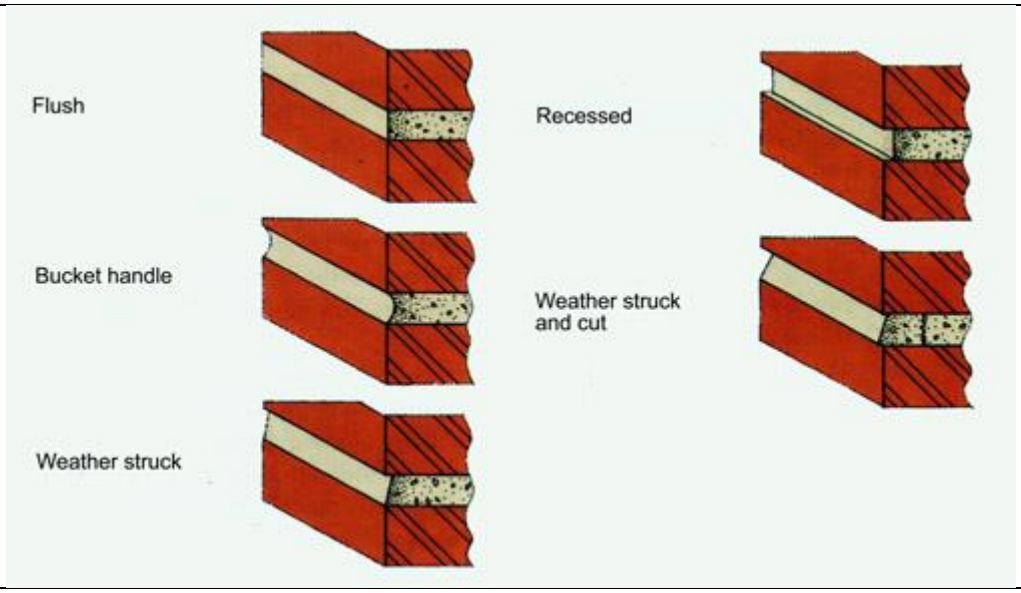
Materials used for building detailing

	Thin joint masonry
	Lightweight thermal blockwork
	Quality of facing bricks
	Types of mortar and colour
	Rendered blockwork

***Types of wall finishes*:, and their advantages and disadvantages**

Facing brickwork (including pointing – bucket handle/tooled, recessed, weathered, flush)





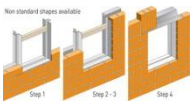
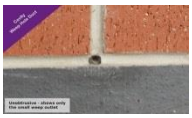
Wall openings and their functions

1 - provide ventilation

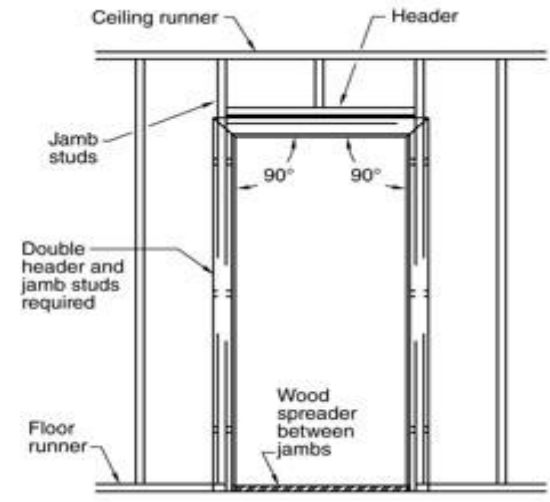
2 - provide light

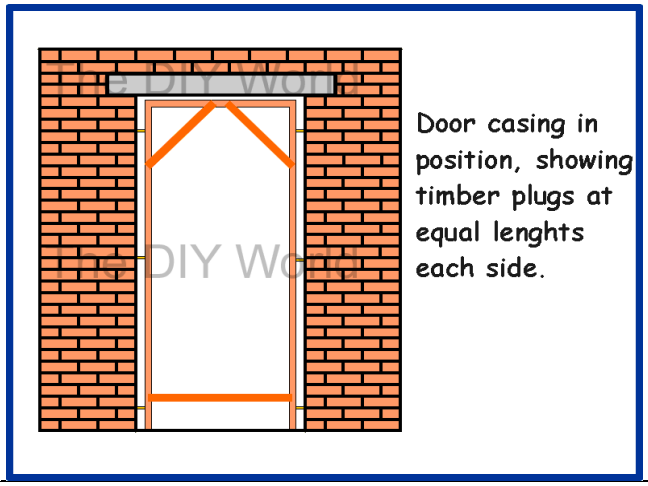
3 - provide aesthetics

Components of a wall opening: lintel, sill, window, door, threshold, damp-proof course, cavity trays, cavity closers, weepholes, and the function of each

Lintel		A horizontal support across the top of a wall opening, such as over a door or a window.
Sill		A piece of material below a door or window to allow rainwater to run off, away from the opening.
Threshold		A strip of material forming the bottom of a doorway.
Cavity tray		A damp-proof course inside a cavity wall, which funnels moisture out of the cavity through weepholes
Cavity closer		This closes off the cavity around a wall opening, reducing heat loss
Weep hole		A small opening in brickwork which allows moisture to escape.

Detailing around wall openings: details of heads, thresholds, sills and jambs, including wall-tie spacing





Functions of detailing:

1 - prevention of damp transfer

2 - continuity of insulation

3 - maintaining structural integrity

4 - load distribution

Topic C.2 Superstructures – floors

For the following, understand what is used, where it is used, why it is used and how it is achieved. Learners will need to be able to demonstrate the use of sketching techniques.

Understand how floors are detailed: types of construction (intermediate); solid, timber, engineered timber and their advantages and disadvantages

Functions of a floor:

1 - To provide a level surface

2 - To reduce sound transmission

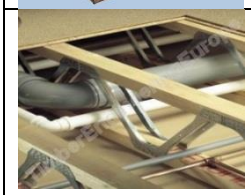
3 - To transfer loads to walls

4 - To provide accommodation of services

Materials used to build floors:

Stress-graded timber joists

Beam and block (Concrete)

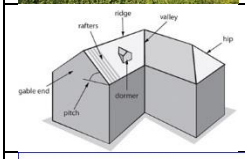
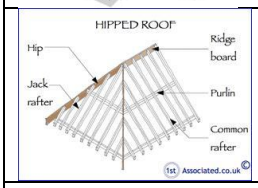


Eco-joists - A slightly more expensive option is the Eco-Joist system which combines timber and nail plated steel webs that have integral voids that allow simple passage of all service ducting, wiring and plumbing. These can be used on the ground, intermediate floors and roof joists.

	engineered timber joists
	precast concrete planks
Types of floor finishes:	
	Screeded
	Chipboard
	Moisture-resistant chipboard
	Tongue and grooved softwood floorboards
	Skirting's
Components of a floor and the function of each:	
	Supporting joists – to hold up floor
	Structure – depends but supporting framework
	Floor covering – Carpet, lino, etc
	Wall support- can be metal supports
	Skirting's - to finish bottom edges avoid scuffed walls

What needs to be learnt
Topic C.3 Superstructures – roofs
For the following, understand what is used, where it is used, why it is used and how it is achieved. Learners will need to be able to demonstrate the use of sketching techniques.

Understand how roofs are detailed: types of construction – their specific maintenance and advantages and disadvantages, the terminology used to label a roof detail

	Flat
	Lean-to
	Mono pitch
	Double pitch
	Gable end
	Hipped end

Functions of a roof:

1 - To provide a method of discharging rainfall away from the building

2 - To waterproof the structure

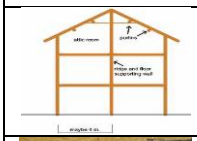
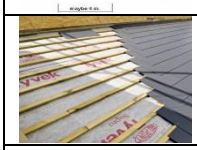
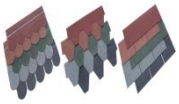
3 - To provide a recreational area

4 - Aesthetics

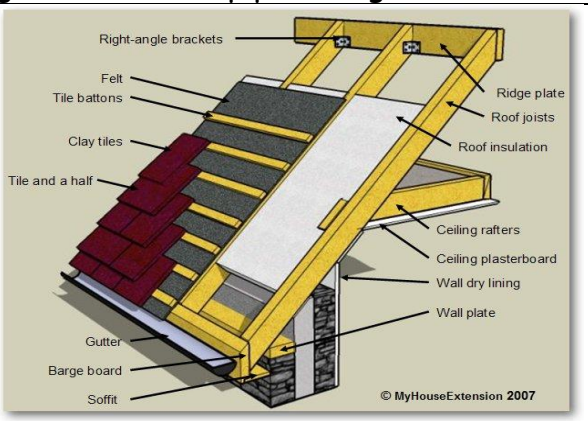
5 - Provides additional accommodation/space

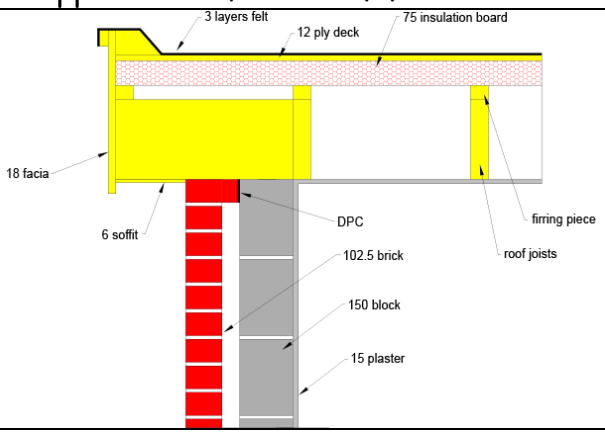
NOTES:

Materials used: in roofing details

	Trussed rafters
	Traditional timber roof with purlins
	Breather membrane
	Tile felt
	Tile battens
	Roof tiles
	Bitumen felt

Types of roof finishes: types of roof finish employed for each type of roof, fixing of finishes, felt and tile battens, three-layer felt construction, rain water goods and downpipes, stages involved in the application of the roof finishes





Components of a roof: common rafters, jack rafters, cripple jack rafters, wall plates, roof trusses, binders, diagonal wind bracing, ridgeboard, fascia, eaves, valley, soffit, gable, hip, dormer window, insulation and the function of each.

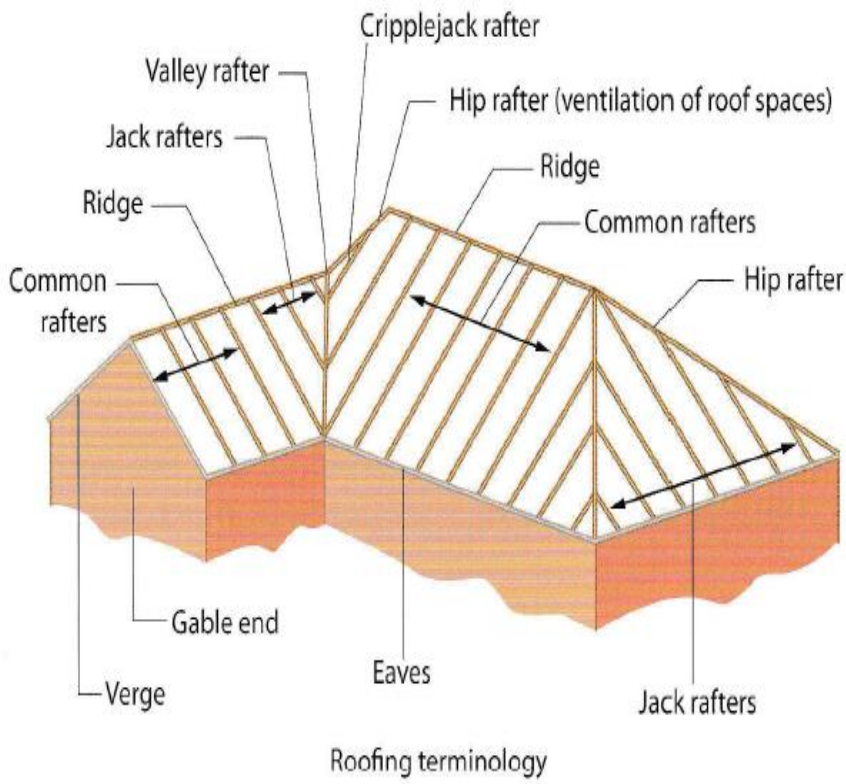


Figure 1.6 Different parts of a pitched roof. What advantages do you think a pitched roof has over a flat roof?