

# CONSTRUCTION TECHNOLOGY 1: HOUSE CONSTRUCTION

## OUTLINE ANSWERS TO REVIEW TASKS

Chapter/ Section	Page	Answer
1.1	8	<p>Thermally light buildings are physically light in weight and have a fabric which has little capacity to absorb heat. Such buildings respond quickly to changes in external temperatures.</p> <p>By contrast thermally heavy often have a heavy dense fabric which reflects some heat and absorbs much of the rest. They insulate the interior by reacting slowly to variations in external temperature.</p>
1.1	12	<p>List of performance requirements may include:</p> <ul style="list-style-type: none"><li>structural stability</li><li>durability</li><li>thermal insulation exclusion of moisture and protection from the weather</li><li>acoustic insulation</li><li>flexibility (changing user needs)</li><li>aesthetics</li></ul>
1.2	16	<p>Tensile – forces resulting from a tendency to stretch Torsional – resistance to forces tending to twist Shear – forces resisting a tendency for one part of a loaded member to slide passed another and fracture</p>
1.3	21	<p>The function of foundation is to transfer loads to the ground with safety, efficiency and economy, but fundamentally the aim is to spread the load from the wall (in this case) over sufficient area to ensure that the ground can cope with the load, leaving the wall stable.</p>
1.3	24	<p>Steel beams are generally of <b>I</b> profile. We know that when a beam bends under load (smile fashion) that the maximum compression force is experienced in the very top of the beam, and here we have a major part of the steel beam's material in the form of a flange.</p> <p>Similarly, the maximum tensile force in a bending beam occurs in the lowest region of its material, and here we have the other flange.</p> <p>Clearly, the <b>I</b> profile suits the way that a beam is expected to bend, as it places the material in the flanges where it is needed to resist load.</p>

2.2 34 Five from:

*Nature of the soil* (possible justification – we need to know many characteristics of the soil; particle size and shape, tendency to be dimensionally unstable during changes of moisture content, chemical pollutants).

*The thickness of the layers of soil* (possible justification – once we know the characteristics of the soil, the thickness of layers will help the decision of the form of foundation that is to be selected as we know the depth to which the ground feels the impression of load through different foundation forms).

*The strength of the soil* (possible justification – this correlates directly with two other factors, the load from the building and the area over which the load needs to be spread by using a foundation).

*Contaminants in the soil* (possible justification – these need to be viewed from the standpoint of possible injury to the health of construction workers or to the later building occupants, and also in respect of potential damage to the materials used in the ground).

*The degree of moisture present* (possible justification – this may influence the water used when mixing materials used in the soil, such as concrete; it may also have a deteriorating effect on certain materials and an effect may be expected as a result on specification selection).

*The existence of a water table* (possible justification – this may influence the need to temporarily lower the water level using dewatering techniques; it is also likely to influence the water content of mixed concrete; there will usually be other readings of the water table as the work commences to see if there has been any change).

*Location of existing services* (possible justification – it is important that these are not damaged during the works from a safety and a present user point of view, the location may be important to the design of possible connections to existing).

2.3 40 Planning permission and Building Regulation approval.

Construction Design and Management regulations general application tends to be where the job is likely to last more than 30 days or where there are five or more workers on the site at any one time.

The CDM regulations concern health and safety and involve the assembly of a health and safety plan.

- 2.4 47 Gas – yellow, cold water – mid blue
- Foul drains carry discharges from all sanitary appliances.
- Surface water drains carry rainwater.
- 2.5 53 Part C: Preparation of site and resistance to ground moisture.
- Strip level – reached after removal of topsoil
- Formation level – the level at which we start to form the ground floor, reached after the exercise of reduced level excavation
- 3.1 59 A method of building based on prefabricated components to be assembled on site. This has two variants – *open systems*, which could accept modular sized prefabricated components from other manufacturers, and *closed systems*, which are self-contained with no ability to accept the components manufactured elsewhere.
- 3.2 62 MMC solutions for housing affect the design, construction process and overall costs of the project due to the nature of the construction form and the sequence of production and assembly. A general feature of MMC solutions is that they rely on pre-fabrication or pre-manufacture of components and systems. This should assist in ensuring quality and consistency but requires the design to be repeated to ensure that the desired economies of manufacture are achieved. As such there is likely to be less scope for bespoke design solutions and the MMC forms are likely to be standardised and capable of relatively high volume construction. This approach requires that the design is ‘frozen’ early in the procurement process to exclude unnecessary and costly changes from the production sequence. The benefit of this approach is that the unit costs should be reduced due to economies of scale, reduced waste and more efficient production techniques. The construction process then relies on assembly of pre-manufactured components and systems or even whole volumetric units. One cost implication of this is that the client will need to be able to fund the manufacture of the units before site activity begins. Hence, the cash flow is front-loaded.
- 3.2 67 Modern MMC systems share some key features with older system building approaches in that they adopt mass manufacture and industrialised techniques to minimise labour input and site based activity. However, modern quality control processes, design detailing and training of operatives is significantly advanced over those earlier attempts at developing systems.

- 3.3 73 The RIBA Plan of Work aimed to divide the construction process into a series of phases to represent recognisable groups of activities.
- Inception – the first idea of the need for a building Feasibility – examination of the financial viability of the proposal.
- Outline proposals – working up some sketches and ideas for the design
- 3.4 77 An *S curve* graph plots expenditure against time showing the outlay to date.
- The steeper the graph, the greater the expenditure over time.
- Cash flow is important to developers because the profitability of any scheme relies on minimising cost outlay and maximising benefit. Typically, developers will fund projects through investments or borrowings. Each of these has costs associated with it so developers will seek to manage cash inflow and cash expenditure so they match as closely as possible. They will also seek to make sure that borrowing is managed at a minimum level.
- 4.1 92 The need to select foundations solutions to effectively increase the spread of load to the ground may arise from two sources: higher levels of building load or poorer ground bearing capacities.
- The depth of the foundation may need to vary to suit the level in the ground where suitable strength exists for load transfer.
- This may mean that deep foundation solutions, such as end bearing piles, may be the only economic option.
- 4.1 97 Foundations act as the interface between buildings and the ground. In most cases the loads from the building and the ground conditions a relatively fixed. Hence, the most likely variable that can be used to adjust the interface will be the foundation design which can be used to cater for the load/support interaction by adjusting contact area (to reduce pressure) or depth (to seek higher loadbearing strata)
- Deeper foundations tend to be used with higher loads as the high levels of compression experienced at greater depth results in higher bearing capacity.
- The angle of repose affects the ability of the soil to remain stable without support during excavation. Soils with low angles of repose will need greater support to stop trenches collapsing and will thus lend themselves to shallower forms. Alternatively soils such as clays may facilitate foundation formation without such support, as with trench fill types.

High proportion of voids – cohesive such as silts and clays; voids in larger particle cohesionless soils tend sometimes to be large  
Compressible – cohesive silts and clays at shallow depths  
High permeability – cohesionless  
Low permeability – cohesive  
Variable volume with moisture content – certain cohesive  
Able to support self – cohesive

- 4.3 103 Possible different foundation forms for dwellings are considered in terms of shallow forms and deep forms. They may include:

Shallow forms: Strip foundations, Reinforced strip foundations, Deep strip (or trench-fill) foundations and raft foundations.  
Deep forms: piles foundations which may be driven, bored or based on grout injection or continuous flight auger.

- 4.3 106 By shear – the unreinforced strip footing is tied to the recommendations of the Building Regulations Part A, s.E, which suggests that the thickness of the concrete strip should not be less than the dimension of the projection from the face of the foundations wall and not less than 150 mm, whichever is the greatest.

Failure by bending is also a possibility if the above Building Regulation dimensions were ignored.

Loads will come from the weight of the building elements such as floors, walls and roofing, together with live loads from people and furnishings. These are transmitted through the loadbearing walls to the foundations below ground.

- 4.3 107 Excavation of oversite  
Setting out  
Excavation of trench  
Trimming of trench sides  
Timbering of trench sides  
Levelling and trimming trench bottoms  
Placement of concrete

- 4.3 107 It is a feature of this foundation form that the trench is mechanically excavated, the trench base consolidated by the excavator bucket, and the concrete poured into the trench from ground level. As no earthwork support is used, the ground must be self-supporting, and this restricts the application of this foundation type to cohesive soils.

- 4.3            111    Although these answers are generalisations, subject to other factors, a possible list is:
- Situation 1: raft or strip
  - Situation 2: deep strip
  - Situation 3: wide strip
  - Situation 4: raft

- 4.3 120 (answers may be subject to other factors)
1. (a) displacement piles  
(b) replacement piles  
(c) lined replacement piles or displacement  
(d) replacement piles  
(e) replacement piles
  2. Key issues are speed and low disturbance. Economy generally relates to the numbers of piles being placed.
  3. A main feature of driven piles is that ground consolidation occurs by vibration. Economy generally relates to the numbers of piles being placed.
- 5.1 129 A main factor is ground moisture, and this tends to influence the porosity of the materials chosen for use below ground.
- Contaminants in the ground or ground moisture may also be influential; sulphates, for example, will affect any cement-containing materials.
- Pressures from the soil or the building can also affect the condition of the walls.
- Tanking involves the application of impervious membranes to the structure to resist moisture penetration. These may be applied to horizontal or vertical surfaces, but are often particularly associated with application to vertical surfaces of walls.
- 5.2 133 To resist pressures from the ground or buildings.
- To intercept cavity moisture which might penetrate the outer skin of the cavity wall and to encourage it to leave the wall at ground level.
- Foundation blockwork – savings in time and labour, creation of a solid wall in one operation negating the need to fill the cavity from concrete strip level.
- Deep strip – speed with far less labour involvement when compared with ordinary strip footings (uses more concrete than the ordinary strip, but the labour savings outweigh this).
- 5.2 Open Cavity; this is now rare in walls above ground due to the need to provide suitable insulation to achieve required levels of energy conservation. A possible advantage of the open cavity is that the route for potential passage of moisture to the interior is interrupted entirely. However, below ground there is the possibility of the cavity to fill with water and for

the loads on the wall to distort the structure by compressing the cavity. There is also the ability to inspect the cavity in the event of possible defects or issues both during and after construction.

Filled cavity construction ensures that the water below ground does not fill the cavity but the primary benefit is that the cavity fill resists the lateral pressure applied by the ground, which could cause deformation of the wall.

The use of trench block provides a wall below ground that is robust and which does not have any potential for cavity deformation due to its solid form. It has the added benefit of reducing labour input by negating the need to build inner and outer leaves.

Deep strip foundations remove a substantial part of the wall below ground and replace it with mass concrete. This is faster and cheaper than the other alternatives but can be used only in soils that have high degrees of cohesiveness.

5.3            140    From – water, gas, electricity, telecommunications, drainage.

Large diameter pipes (e.g. drainage)  
Small diameter pipes (e.g. water or gas)  
Cables (e.g. electricity or telecommunications)

A common service trench ensures that all of the service entries to a property are provided in a controlled and coordinated fashion. There is the added benefit of localisation of services resulting in lower levels of excavation and lower risk of accidental damage to services in use.

Common service trenches pose the risk of confusion between individual utilities and services connections. However, this is overcome by careful colour coding of different types and by adhering to protocols regarding depth and location of services.

6.1            147    Cost ranking by perception Cheapest: Solid Concrete, Moderate Suspended Concrete, Most expensive: Suspended Timber.

The total area of floors being laid will be influential on cost/m<sup>2</sup> of each solution, but as a generalisation the cheapest is likely to be the concrete solid floor, then the concrete suspended floor; the timber will be most expensive.



Labour content is a key issue, but the basic materials need consideration also.

Voids below ground floor will provide useful routes for central heating pipes and cable services.

6.2 153 Power float or screed.

Sand blinding is used to fill the gaps between the stone or broken brick of the hardcore layer in order to provide a flat surface to receive the damp-proof membrane.

Without the blinding, concrete poured onto the dpm would probably cause a puncture on the sharp edges of the hardcore base.

Cold bridge points generally occur where dense components link or abut to create a pathway between the cold exterior and the warm interior. These will vary from individual case to case. In broad terms the issue is avoided by ensuring thermal breaks in such potential pathways that introduce insulation material between the denser elements of structure and fabric.

6.3 159 By applying rigid insulation boarding below the floor boarding supported on battens attached to the joists or by metal lathing running between the joists.

To support the floor joists, eliminating the need to build the joists into external walls, where they would be vulnerable to moisture absorption.

To help create a void below the floor which can be used to ventilate the floor timbers preventing possible rot conditions.

A cement based screed is usually applied to the surface.

Speed of completion, less labour intensity, not as vulnerable to moisture-related problems as timber.

7.1 166 Three from:

strength and stability  
exclusion of moisture/weather  
thermal insulation  
durability  
acoustic insulation  
aesthetics

Personalised selection of important criterion to be justified by comments.

- 7.1 168 It may allow dampness caused by rainfall to penetrate to the interior of the wall.
- It tends to have poorer thermal insulation properties than other insulated wall solutions.
- 7.1 177 SAP stands for Standard Assessment Procedure and is a figure (1–100) based on the cost of annual energy costs for space heating and generation of hot water. The higher ratings tend to reflect better efficiency. In more recent versions of the Building Regulations the SAP is linked to the TER (Target Emission Rate) and DER (Dwelling Emission Rate) to set parameters for the design of the external envelope, fabric and services and whilst allowing for flexibility in approach.
- Cold bridging is caused by construction detailing which allows concentrated heat flow from inside to outside the property. The effect is often to create condensation on interior surfaces.
- 7.2 186 Traditional cavity walls have exterior skins of clay brickwork and interior skins of insulated blockwork. It is important that the sizes of these components are coordinated in order that courses of bricks and blocks allow mortar joints to occur at the same level as we wish to build-in wall ties between the skins.
- A standard course of bricks is 75 mm (65 mm high brick with 10 mm mortar joint), and a standard course of blocks 225 mm (215 mm high block and 10 mm mortar joint). This means that every three brick courses the mortar joints of the bricks and blocks will be at the same level.
- Wall ties tend to be built-in every two block courses (450 mm vertically) or, if you prefer, every six brick courses.
- Various alternative solutions exist. The positioning of insulation material can have a great effect on the thermal performance of the wall in both solid and cavity forms. The external positioning results in the wall fabric absorbing heat from the interior space. This may take some time before reaching steady state. If it is positioned internally, however, the fabric is insulated from the interior space and hence does not absorb heat; this allows the building to respond quickly to heat input.
- 7.3 193 Moisture barriers to the outside of the frame are used to keep out rainfall until the exterior finish of the wall is constructed (perhaps an outer facing brick skin).

Vapour checks are applied to the inside face of the framed walls before application of the plasterboard finish. Their aim is to prevent moisture vapour in the air of the property penetrating the wall and potentially forming condensation in the wall body, which could create rot.

The balloon frame technique tends to adopt an approach in which wall panels are manufactured that extend to the full height of the building with internal floors inserted afterwards. The platform frame tends to adopt storey height panels and the intermediate floors are installed sequentially as the building height increases storey by storey.

Timber frame construction offers several benefits in terms of sustainability in that:

Replenishable, managed timber resource is used

There is reduced embodied energy compared to traditional construction forms

Waste is minimised through industrial manufacturing techniques

Completed timber frame dwellings offer potential for highly insulated, low energy solutions.

- 7.3            201    Movement gaps at the top of exterior skins of brickwork to allow the roof which bears onto the frame to move up and down without stressing the top of the brickwork.

Flexible corrugated wall ties which allow the timber-framed wall to move without stressing the brickwork, but at the same time maintain the connection between brick and timber-framed skins.

Compressible movement strips are also incorporated below windows which traverse the two skins, allowing movement in just the same way as the gaps left at the top of outer brick skins.

Minimum 30 minutes.

Cavity barriers and fire stops are the main way of assisting compliance with the Building Regulations. These tend to have a 60 minutes performance rating.

- 7.4            211    Stick build essentially requires the structure of the building to be assembled on site from a kit of pre-prepared members to create upright, horizontal and oblique sections of the structural frame.

Panelised construction is based on the manufacture of complete panel sections at a factory, which are then assembled on site to create the external enclosure and internal sub-division of the building.

Modular construction based on volumetric techniques is based on the assembly of complete sections of the building, such as entire rooms in three dimensions. The modules are then 'stacked' and fixed together to create the building.

Possible criteria might include: cost, lead-in time for manufacture, required building form (modular construction lends itself to cellular forms most readily), height of the building, insulation requirements etc.

- 7.5            241    No entry for part 3  
By using insulated lintels.
- By using insulated vertical dpcs at cavity closures around window and door openings.
- By using vertical insulation at the edges of ground floors against the external wall.
- By sketches to show:  
    the sides of a window opening in a wall  
    the part of the lintel that sits on the wall  
    a horizontal and inclined dpc designed to encourage water to leave the cavity wall, usually through weep holes
- 8.1            255    Sketch to indicate the trimmed joists, the trimming joists, and the trimmer joist.
- 8.2            259    The landing (e.g. quarter turn and half turn stairs)
- From, for example:  
    the guardrailing  
    the rise of the step  
    the going of the step  
    the pitch or angle of the flight of steps

- 9.1            265    Stability – the ability to withstand fire without collapse.  
Integrity – the ability to resist fire penetration.
- Sound reduction is measured by assessing the degree to which airborne sound is diminished by the use of an insulative element such as a partition. The dBA range is used to assess this generally because it mimics closely the range of human hearing. Other assessments that can be used to assess acoustics include measuring impact sound transmission and reverberation times within spaces.
- 9.2            269    The two main classes are loadbearing and non-loadbearing
- This is the classification for surface spread of flame as defined by BS476.
- No entry
- 9.2            272    Layered or laminated.
- Noggins are largely found in studded timber partitions. They brace the vertical studs, preventing distortion, and are also sometimes used to provide a background material on which to fix partition coverings.
- Sound insulation is the degree to which sound is reduced or the passage of sound is inhibited by the presence of an element of structure or fabric. Sound absorption is the degree to which sound within a space is attenuated as the sound waves reflect off surfaces.
- 10.1           278    As warm air rises a large proportion of the heat generated inside the property may be lost through the roof.
- At present, the roof has to provide almost twice the insulation qualities of the external wall.
- The shape, which is basically determined by the pitch or slope of the roof surfaces.
- 10.2           291    Jack rafters are shorter than common rafters as they have to be cut to meet the hip rafter at the hipped end of a roof.
- Typically a purlin would be found at the mid-span of the rafter, providing support for both the rafter and the roof covering.

If more than one purlin is used to each side of the roof slope, these tend to equally divide the length of the rafter (two purlins per slope divide rafters into thirds)

Ties (running to the apex).

Struts (propping the rafter section).

Diagonal bracing is found attached to the underside of rafters on trussed rafter roof structures. The bracing runs upwards from both eaves towards the apex of the roof at both ends of the building.

- 10.3            299    Interlocking tiles may be laid straight up the slope of the roof without the need to stagger between courses.

At the lap position there is a double thickness of material, whereas plain tile and slate coverings have a triple thickness of material at the lap position.

Sarking felt is the secondary line of defence against water penetration of the roof and is found below the roof covering, draped over the rafter sections of the roof. Any water that penetrates the covering is carried by the sarking felt down the roof slope and into the rainwater gutter.

Centre nailed slates are usually found in situations of severe exposure where wind pressures may disturb the roof covering. Coastal locations are typically places where these types of coverings may be contemplated.

- 10.4            302    Sprockets are used to extend a flat roof structure over the external walls of a property in the direction perpendicular to the main span direction of the roof joists.

Firrings are timbers of diminishing sectional size used to provide a slope to the *flat* roof to help shed rainwater.

Wall plates tend to act as distributors of load and in the flat roof situation take point loads from individual joists and spread them across the loadbearing interior skin of the cavity wall.

In the cold deck solution the insulation is below the deck, and in the warm deck solution the insulation is above the deck.

Flat roofs are now uncommon in house construction for a variety of reasons. The most significant are that such forms are less durable than pitched options, they pose potential risks associated with condensation occurrence and they are ill-favoured by planning authorities as they offer poor aesthetic qualities.

- 10.5            305    A timber tilting fillet to break the angle to prevent the felt from fracturing as a result of a too severe a change in direction.

Sketch to show the upturned edge of the felt above the rainwater gutter.

These options are far more durable than traditional felt solutions. This is largely due to advances in materials performance and in particular their ability to cope with movement of the supporting structure leading to expansion and contraction of the material.

- 10.6            311    Rainwater *goods*.

Gutter – two from: stop end, nozzle outlet, corner, or stop end with nozzle outlet

Downpipe: offset (from gutter to wall), shoe

A roof outlet is generally used as a fitting to carry rainwater through the roof covering and structure to connect to an internally located rainwater pipe.

- 10.7      315      The brickwork provides the fire-resistant qualities required by the Building Regulations. Clearly it is important to extend the fire-resistant barrier some distance above the roof covering in case of chimney fires (largely caused by accumulations of soot catching fire).
- 200 mm of quilt is typically used to achieve the  $U$  value.
- 11.2      323      The  $U$  value of single glazing would be around  $5.7 \text{ W/m}^2 \text{ }^\circ\text{C}$ . Compared with 0.45 for walls, this means that the glass will lose approximately 12 times the quantity of heat.
- Ventilation through an openable area of window equivalent to one twentieth of the room floor area is to be provided.
- 11.3      328      Tapers to the frame allow better light penetration into the room.
- PVCu, steel, aluminium.
- A casement window has opening parts which are supported by hinges; a sash has opening parts supported on something other than hinges: pivots, rope cords or springs.
- 11.4      331      Orientation relates to the way that the building or component faces relative to the path of the Sun.
- Typical  $U$  value =  $5.7 \text{ W/m}^2 \text{ }^\circ\text{C}$  for single glazing and  $2.8 \text{ W/m}^2 \text{ }^\circ\text{C}$  for double glazing.
- Translucent glass allows light through but distorts image; patterned glasses are a good example.
- 11.5      333      Three from:
- security
  - aesthetics
  - preserve heat
  - maintain sound insulation
  - durability
  - size to allow household objects to pass
- Hygroscopicity is a characteristic of some building materials (particularly timber) to be able to absorb and lose moisture.



- 11.5            338    From: skeleton, cellular, solid (laminated or boarded)
- Lever furniture refers to the handles used to work the latch mechanism.
- 11.5            339    Door frames are typically used for external doors, while door linings tend to be for internal doors (the name lining implies to lining the width of the opening formed in the partition).
- To create a rebate into which the door can close, with the door closing against the stop.
- 12.2            345    Calcium sulphate.
- Two layers to a total of 13 mm thick
- 12.3            351    9.5, 12.5, and 19 mm thicknesses of basic plasterboard
- A metal angle bead
- Scrim reinforcement is used to cover and reinforce the joints between plasterboard prior to the application of plaster. It is used fundamentally to resist cracking at this location, which would otherwise follow the edge of the plasterboard sheet.
- 12.4            352    Nails with little if any heads hammered through the tongue of tongue and grooved joints between timbers to hide the fixing from view.
- Herringbone and basket weave patterns.
- Parquet is made of thin veneers of timber applied to a material backing. The backing fixed to the floor structure. Wood blocks are of significantly greater thickness (perhaps four times the thickness) and these are laid to the floor as individual blocks, not attached to a sheet of fixing material.

13.2      368      The house building industry has become far more sustainable in recent years and the general trends in construction technology have moved towards environmentally sustainable solutions. However, some of the natural solutions for sustainable construction are limited in adoption due to their potential for high volume building, the need for specialist skills and design knowledge and public acceptability of options that may not be seen as 'mainstream'

No entry

Main differences in terms of sustainability relate to materials selection and use and to thermal performance. Insulation levels have increased massively and the nature of form of modern dwellings aims to reduce unnecessary heat loss through control of air leakage and fenestration. Older buildings with solid walls, open flues, low insulation levels and single glazed windows are far more energy 'hungry'. Buildings of the 1900s and to some extent those of the 1930 had relatively modest environmental footprints in that materials would be sourced quite locally. This was less the case in the 1970s. Modern buildings are designed consciously to reduce environmental impact through careful materials selection and waste reduction as well as consideration of issues such as water usage etc,