# Chapter 2

# Unit 101: Principles of building construction, information and communication

Working in the building industry involves more than just the physical construction of buildings such as laying blocks, screwing timber together or soldering pipes. Building is an expensive business and for the work to progress smoothly (and on budget) the work needs to be well organised.

This involves interpreting information such as drawings, specifications and schedules. It also involves calculating quantities and dimensions and knowing how to communicate well with others.

By reading this chapter you will know about:

1. Identifying information used in the workplace.
2. Environmental considerations in relation to construction.
3. Construction of foundations.
4. Construction of internal and external walls.
5. Construction of floors.
6. Construction of roofs.
7. Communicating in the workplace.

# TECHNICAL INFORMATION

This section will discuss the three main sources of technical information that are used when constructing buildings:

- working drawings and **specifications**
- schedules
- **bill of quantities**.

These are all essential information and form the contract documents (those that govern the construction of a building). All documentation needs to be correctly interpreted and correctly used. The contract documents need to be looked after and stored (filed) correctly and safely. If documents are left lying around they will become difficult to read and pages may be lost, leading to errors. The contract documents will need to be **archived** at the end of the contract, so they can be referred back to in case of any query or dispute over the work carried out or the materials used.

**Specification**
A contract document that gives information about the quality of materials and standards of workmanship required

**Bill of quantities**
A document containing quantities, descriptions and cost of works and resources

**Archived**
Kept in storage

## DRAWING SCALES

It is impossible to fit a full-sized drawing of a building onto a sheet of paper, so it is necessary to **scale** (shrink) the size of the building to enable it to fit. The building has to be shrunk in proportion; this makes it possible to convert measurements on the drawing into real measurements that can be used. Scale rules are made specifically for this purpose.

**Scale**
The ratio of the size on a drawing to the size of the real thing that it represents


Triangular scale rule

**INDUSTRY TIP**
Do not scale from photocopies because these can easily become distorted in the process of photocopying.

**INDUSTRY TIP**
If a drawing has **dimensions**, use these instead of using a scale rule to take a measurement.

How do scale rules work? Let's say we are using a scale of 1:5. That means that what we draw – using the sizes on the scale rule – will be five times smaller on the drawing than the object's actual size. So, a line 30mm long will represent an object 150mm long (30 × 5 = 150).

**Dimension**
A measurement

**The British Standards Institute's** BS 1192 (Drawing office practice) gives a range of standard scales that are used for various drawing types and scale rules are manufactured to meet this purpose.

**British Standards Institute**

The British Standards Institute (BSI) is the UK organisation that develops and publishes standards in the UK

## SCALES IN COMMON USE

| Scale | Use |
|---|---|
| 1:1 | Full size (used for rods) |
| 1:2<br>1:5<br>1:10 | Building details |
| 1:20<br>1:50<br>1:100<br>1:200 | Plans, elevations and sections |
| 1:200<br>1:500<br>1:1250 | Site plans |
| 1:1250<br>1:2500 | Location plans |

The documents these scales are used for are described on pages 49–51.

**ACTIVITY**

Work out the following:

| Scale size | Scale | Actual size |
|---|---|---|
| 10mm | 1:10 | 100mm |
| 25mm | 1:20 | a) |
| b) | 1:50 | 300mm |
| 50mm | 1:200 | c) |

Answers: a) 500mm, b) 6mm, c) 10m

## DATUM POINTS

Heights of buildings and the relative heights of components within the building are calculated from a common **datum point**. Datum points are determined by transferring a known fixed height from a bench mark. There are two types of datum point:

- A permanent Ordnance bench mark (OBM) is a given height on an Ordnance Survey map. This fixed height is described as a value, eg so many metres above sea level (as calculated from the average sea height at Newlyn, Cornwall).
- A temporary bench mark (TBM) is set up on site.

**Datum point**

A fixed point or height from which reference levels can be taken. The datum point is used to transfer levels across a building site. It represents the finished floor level (FFL) on a dwelling

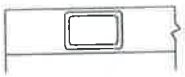
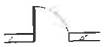
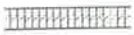
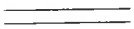
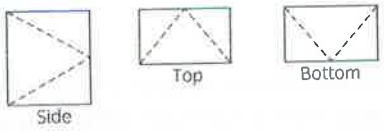
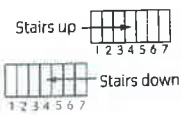
Ordnance and temporary bench marks

**ACTIVITY**

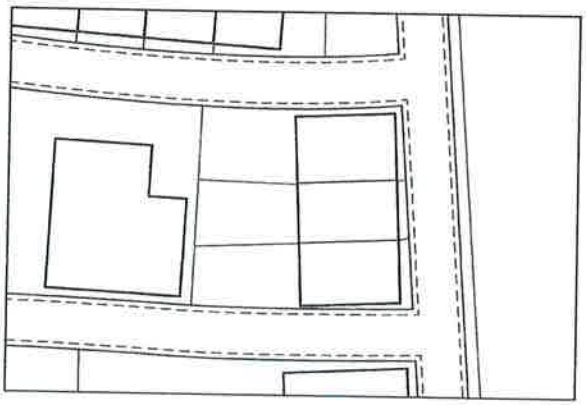
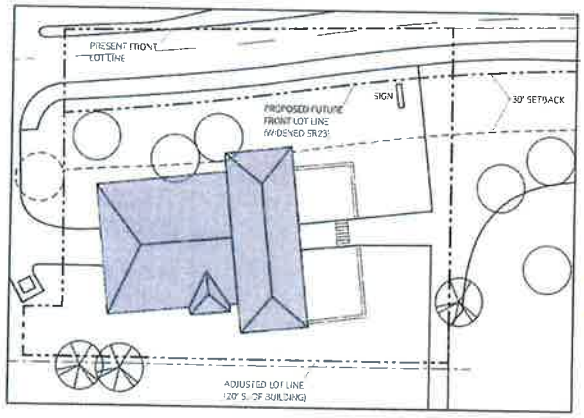
Find your local OBM or your site TBM.

## BASIC DRAWING SYMBOLS (HATCHINGS)

Standard symbols, also known as hatching symbols, are used on drawings as a means of passing on information simply. If all the parts of a building were labelled in writing, the drawing would soon become very crowded. Additionally, it is important to use standard symbols so that everyone can read them and they mean the same to everyone. The following images are just some of the standard symbols used.

| | | | | |
|---|---|---|---|---|
|  Sink |  Sinktop |   Wash basin |  Bath |  Shower tray |
|  WC |  Window |  Door |  Radiator |  Lamp |
|  Switch |  Socket |  North symbol |  Sawn timber (unwrot) |  Concrete |
|  Insulation |  Brickwork |  Blockwork |  Stonework |  Earth (subsoil) |
|  Cement screed |  Damp proof course/ membrane |  Hardcore |   Hinging position of windows |   Stairs up and down |
|  Timber – softwood. Machined all round (wrot) |  Timber – hardwood. Machined all round (wrot) | | | |

## INFORMATION SOURCES

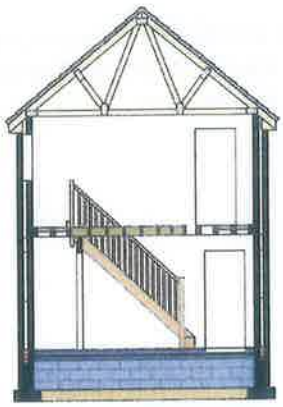
| Type of drawing | Description |
|---|---|
| **Location drawings** | Usually prepared by an **architect** or **architectural technician**. Show the location of the building plot, position of the building and areas within the building. The term location drawings covers all of the drawings in this table. |
| **Block plans**  | Show the proposed development in relation to its surrounding properties. The scales used are 1:1250 or 1:2500. Very little detail is available from this type of plan. The direction North is usually shown. |
| **Site plans**   | Show the plot in more detail, with drain runs, road layouts and the size and position of the existing building (and any extensions proposed) in relation to the property boundary. A scale of 1:500 or 1:200 is used.<br>The Planning Portal sometimes refers to site plans as block plans, but the two types of plan have been distinguished in this book. |

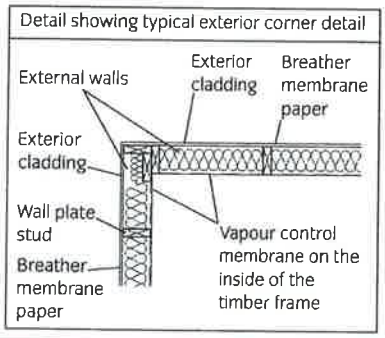
**Architect**

A trained professional who designs a structure and represents the client who wants the structure built. They are responsible for the production of the working drawings. They supervise the construction of buildings or other large structures

**Architectural technician**

A draftsperson who works in an architectural practice

| Type of drawing | Description |
|---|---|
| **Floor plans**<br>  | Show the positioning of walls, size of rooms along with the positioning of elements within the building such as units. |
| **Elevations**<br>  | Show a building from a particular side and show the positioning of features such as doors and windows. |
| **Sections**<br>  | Show in greater detail what the section of a component looks like and how it might fit in relation to another component. A typical example would be a cross-section of a window showing the size of the features and how they fit together. Using these drawings it is possible to determine the positions of rooms, windows, doors, kitchen units and so on. Elevations are shown. These drawings are more detailed, and are often scaled to provide construction measurements. Some of the scales used are 1:200, 1:100, 1:50, 1:10, 1:5 and 1:1. A scale of 1:1 is full size. |

| Type of drawing | Description |
|---|---|
| **Construction drawings (Detail drawings)**<br>  <br> | Show details of construction, normally as a cross-section. |

## SPECIFICATIONS

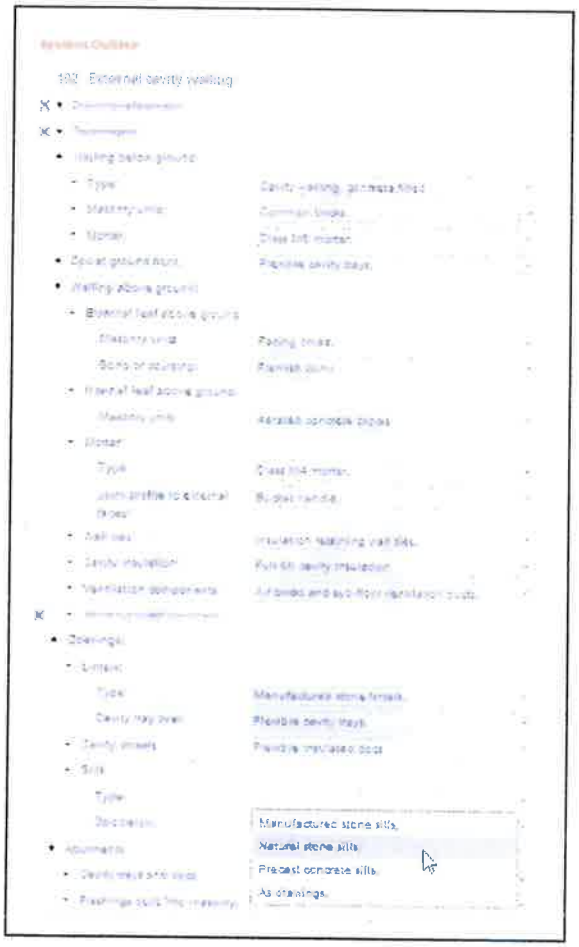
A specification accompanies the working drawings. It gives further information that cannot be shown on the drawings, because the drawings need to be clear and not covered in notes. A specification would include information such as:

- the colour of paint required
- a specific timber species
- the brick type required
- the plaster finish required.

It is prepared by construction professionals such as architects and building services engineers. They can be produced from previous project specifications, in-house documents or master specifications such as the National Building Specification (NBS). The NBS is owned by the Royal Institute of British Architects (RIBA).

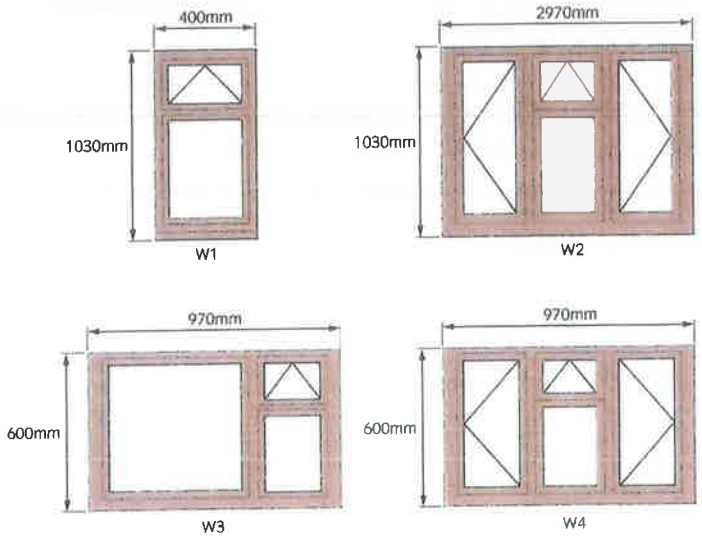
**INDUSTRY TIP**

Operatives need to refer to the specification before, during and on completion of a project to make sure all criteria have been met.




Example of a specification

## COMPONENT RANGE DRAWINGS




Component range drawing of windows

A component range drawing shows the range of components available from a manufacturer. It includes:

- sizes available
- coding for ordering purposes
- availability (whether it can be bought off-the-shelf or if pre-ordering is required).

Availability is particularly important when planning delivery dates. Schedules reference this type of drawing.

## SCHEDULES

A schedule is used to record repeated design information that applies to a range of components or fittings, such as:

- windows
- doors
- kitchen units
- joinery fittings.

A schedule is mainly used on bigger sites where there are multiples of several designs of houses, with each type having different components and fittings. It avoids a house being given the wrong component or fitting.

A schedule is usually used in conjunction with a component range drawing and a floor plan.

In a typical plan, the doors and windows are labelled D1, D2, W1, W2 etc. These components would be included in the schedule, which would provide additional information on them. For example see the following schedule.

**Master Internal Door Schedule**

| Ref: | Door size | S.O. width | S.O. height | Lintel type | FD30 | Self closing | Floor level |
|---|---|---|---|---|---|---|---|
| D1 | 838×1981 | 900 | 2040 | BOX | Yes | Yes | GROUND FLOOR |
| D2 | 838×1981 | 900 | 2040 | BOX | Yes | Yes | GROUND FLOOR |
| D3 | 762×1981 | 824 | 2040 | BOX | No | No | GROUND FLOOR |
| D4 | 838×1981 | 900 | 2040 | N/A | Yes | No | GROUND FLOOR |
| D5 | 838×1981 | 900 | 2040 | BOX | Yes | Yes | GROUND FLOOR |
| D6 | 762×1981 | 824 | 2040 | BOX | Yes | Yes | FIRST FLOOR |
| D7 | 762×1981 | 824 | 2040 | BOX | Yes | Yes | FIRST FLOOR |
| D8 | 762×1981 | 824 | 2040 | N/A | Yes | No | FIRST FLOOR |
| D9 | 762×1981 | 824 | 2040 | BOX | Yes | Yes | FIRST FLOOR |
| D10 | 762×1981 | 824 | 2040 | N/A | No | No | FIRST FLOOR |
| D11 | 686×1981 | 748 | 2040 | N/A | Yes | No | SECOND FLOOR |
| D12 | 762×1981 | 824 | 2040 | BOX | Yes | Yes | SECOND FLOOR |
| D13 | 762×1981 | 824 | 2040 | 100 HD BOX | Yes | Yes | SECOND FLOOR |
| D14 | 686×1981 | 748 | 2040 | N/A | No | No | SECOND FLOOR |

Example of a schedule

## BILLS OF QUANTITIES

A bill of quantities is produced by the quantity surveyor and describes everything that is required for the job based on the drawings, specification and schedules. A bill of quantities contains the following information:

- *Preliminaries*: General information including the names of the client and architect, details of the work and descriptions of the site.
- *Preambles*: Like the specification, this outlines the quality and description of materials and workmanship, etc.
- *Measured quantities*: A description of how each task and material is to be measured, with measurements in metres (linear and square), hours, litres, kilogrammes and the number of components required.

The completed document is sent out to contractors who will then price the work and enter the costs into the blank spaces. The bill of quantities ensures that all the contractors are pricing for the job using the same information.

**BILL OF QUANTITIES**

(Assuming Civil Engineering Standard Method of Measurement (CESSM3) is used.)

| Number | Item description | Unit | Quantity | Rate | Amount £ | Amount p |
|---|---|---|---|---|---|---|
| | **CLASS A: GENERAL ITEMS** | | | | | |
| | Specified Requirements | | | | | |
| | Testing of Materials | | | | | |
| A250 | Testing of recycled and secondary aggregates | sum | | | | |
| | Information to be provided by the Contractor | | | | | |
| A290 | Production of Materials Management Plan | sum | | | | |
| | Method Related Charges | | | | | |
| | Recycling Plant / Equipment | | | | | |
| A339.01 | Mobilise; Fixed | sum | | | | |
| A339.02 | Operate; Time-Related | sum | | | | |
| A339.03 | De-mobilise; Fixed | sum | | | | |
| | **CLASS D: DEMOLITION AND SITE CLEARANCE** | | | | | |
| | Other Structures | | | | | |
| D522.01 | Other structures; Concrete; | sum | | | | |
| D522.02 | Grading / processing of demolition material to produce recycled and secondary aggregates | $m^3$ | 70 | | | |
| D522.03 | Disposal of demolition material offsite | $m^3$ | 30 | | | |
| | **CLASS E: EARTHWORKS** | | | | | |
| | Excavation Ancillaries | | | | | |

Bill of quantities

## WORK SCHEDULES

It is very important indeed that the progress of work is planned out. A work schedule or programme of work is an easy way of showing what work is to be carried out and when. This is usually shown in the form of a bar chart called a Gantt chart. The chart lists the tasks that need to be done on the left-hand side and shows a timeline across the top. The site manager or trade supervisors can quickly tell from looking at this chart:

- if work is keeping to schedule
- what materials, equipment and labour are required
- when they are required.

**INDUSTRY TIP**

Use of a planning document such as a Gantt chart will reduce waste and ensure effective use of labour.

Materials very often have a **lead-in time** and so cannot be delivered immediately. These need to be ordered and delivered at the correct time. Labour planning is also required as the trades may be working elsewhere when needed.

**Lead-in time**

The time taken between ordering an item and it being delivered

| | Time (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| Prepare the ground | | | | | | | |
| Spread foundations | | | | | | | |
| Lay cables for services | | | | | | | |
| Build walls up to DPC | | | | | | | |
| Proposed time in green | | | | | | | |

Gantt chart

## CALCULATING QUANTITIES FOR MATERIALS

Calculations are required throughout the building process. It is important that these calculations are accurate, as mistakes can be very expensive. A company can lose a lot of money if it underestimates:

- the amount of materials required
- how much they cost
- how long it will take to complete a job.

It could also lead to the company gaining a bad reputation for not being able to complete a job on time and in budget.

Materials are usually better priced if bought in bulk, whereas a buy-as-you go approach can cost more.

Consider these points when buying materials:

- Is there sufficient storage room for delivered materials?
- Is there a risk of the materials being damaged if there is nowhere suitable to store them or if they are delivered too early?
- Will it be a problem to obtain the same style, colour or quality of product if they are not all ordered at the same time?
- Will over-ordering cause lots of wastage?

These and many other considerations will help determine when and in what quantity materials are ordered.

Some wastage is unavoidable. Allowances must be made for wastage, eg cut bricks that cannot be re-used, short ends of timber, partly full paint cans. Up to 5% waste is allowed for bricks and blocks and 10% for timber and paint.

It may be that all the materials are ordered by the office or supervisory staff, but you still need to know how to recognise and calculate material requirements. Deliveries have to be checked before the delivery note is signed and the driver leaves. Any discrepancies in the type or quantity of materials, or any materials that have arrived damaged, must be recorded on the delivery note and reported to the supervisor. Any discrepancies will need to be followed up and new delivery times arranged.

You must be able to identify basic materials and carry out basic calculations. You will often have to collect sufficient materials to carry out a particular operation. Being able to measure accurately will mean you can make the most economic use of materials and therefore reduce waste.

Deliveries must be checked before signing the delivery note

## UNITS OF MEASUREMENT

The construction industry uses metric units as standard; however, you may come across some older measures called imperial units.

| Units for measuring | Metric units | Imperial units |
|---|---|---|
| **Length** | millimetre (mm)<br>metre (m)<br>kilometre (km) | inch (in) or "<br>eg 6" (6 inches)<br>foot (ft) or '<br>eg 8' (8 foot) |
| **Liquid** | millilitre (ml)<br>litre (l) | pint (pt) |
| **Weight** | gramme (g)<br>kilogramme (kg)<br>tonne (t) | pound (lb) |

**ACTIVITY**

Look online to find out:

- What other imperial units are still commonly used?
- How many millimetres are there in an inch?
- How many litres are there in a gallon?

| Units for measuring | Quantities | Example |
|---|---|---|
| **Length** | There are 1,000mm in 1m<br>There are 1,000m in 1km | 1mm x 1,000 = 1m<br>1m x 1,000 = 1km<br>6,250mm can be shown as 6.250m<br>6,250m can be shown as 6.250km |
| **Liquid** | There are 1,000ml in 1l | 1ml x 1,000 = 1l |
| **Weight** | There are 1,000g in 1kg<br>There are 1,000kg in 1t | 1g x 1,000 = 1kg<br>1kg x 1,000 = 1t |

## CALCULATIONS

Four basic mathematical operations are used in construction calculations.

### ADDITION

The addition of two or more numbers is shown with a plus sign (+).

**Example**

A stack of bricks is 3 bricks long and 2 bricks high. It contains 6 bricks.

$$3 + 3 = \mathbf{6}$$

More examples:

$$5 + 2 = \mathbf{7}$$

$$19 + 12 = \mathbf{31}$$

$$234 + 105 = \mathbf{339}$$

Pallet of bricks

### SUBTRACTION

The reduction of one number by another number is shown with a minus sign (–).

**Example**

A pallet containing 100 bricks is delivered on site, but you only need 88 bricks. How many are left over?

$$100 - 88 = \mathbf{12}$$

More examples:

$$5 - 2 = \mathbf{3}$$

$$19 - 12 = \mathbf{7}$$

$$234 - 105 = \mathbf{129}$$

## MULTIPLICATION

The scaling of one number by another number is shown with a multiplication sign (×).

**Example**

A stack of bricks is 3 bricks long and 2 bricks high. It contains 6 bricks.

$$3 \times 2 = \mathbf{6}$$

More examples:

$$19 \times 12 = \mathbf{228}$$

$$234 \times 10 = \mathbf{2{,}340}$$

$$234 \times 105 = \mathbf{24{,}570}$$

In the two last examples, the comma (,) is used to show we are in the thousands. In words we would say, twenty-four thousand, five hundred and seventy.

## DIVISION

Sharing one number by another number in equal parts (how many times it goes into the number) is shown with a division sign (÷).

**Example**

$$5 \div 2 = \mathbf{2.5}$$

$$36 \div 12 = \mathbf{3}$$

$$600 \div 4 = \mathbf{150}$$

**ACTIVITY**

Try these sums:

1. 29 + 51
2. 79 – 23
3. 54 × 76
4. 23 ÷ 4
5. Show three quarters as a decimal fraction.

Answers: 1) 80, 2) 56, 3) 4,104, 4) 5.75, 5) 0.75

## LINEAR LENGTH

Linear means how long a number of items would measure from end to end if laid in a straight line. Examples of things that are calculated in linear measurements are:

- skirting board
- lengths of timber
- rope
- building line
- wallpaper.

Skirting boards are calculated using 'linear' measurements

We use this form of measurement when working out how much of one of the materials listed above we need, eg to find out how much

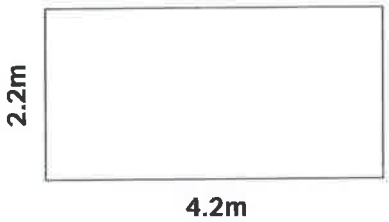
A joiner measuring a room

**Perimeter**
The distance around an object or room

skirting board is required for a room. First, we need to measure the **perimeter** (sides) of a room. To find the linear length we add the length of all four sides together. This can be done in two ways: adding or multiplying.

### Example 1

A site carpenter has been asked how many metres of skirting are required for the rooms below.




They can add all the sides together:

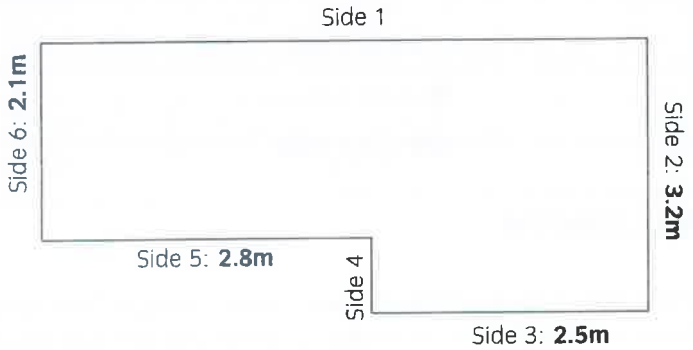
$$2.2 + 4.2 + 2.2 + 4.2 = 12.8\text{m}$$

Or, they can multiply each side by 2, and add them together:

$$(2.2 \times 2) + (4.2 \times 2) = 12.8\text{m}$$

Either way, **12.8m** is the correct answer.

### Example 2




To work out the perimeter of this room we need to add all the sides together. In this example each side has been given a reference number, so all we need to do is add all the sides together, like this:

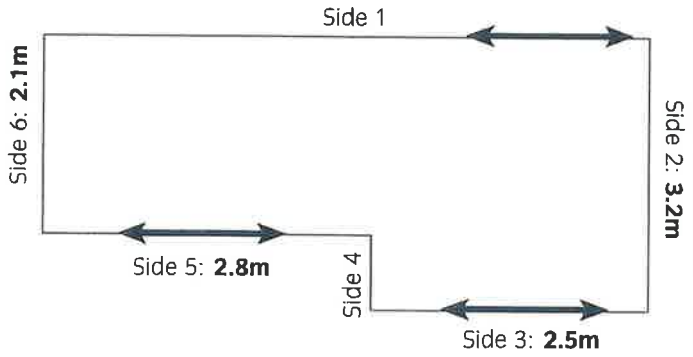
side 1 (side 3 + side 5) + side 2 + side 3 + side 4 (side 2 – side 6) + side 5 + side 6

Now, let's show the working out: (2.8 + 2.5) + 3.2 + 2.5 + (3.2 – 2.1) + 2.8 + 2.1 = 17m

The amount of skirting board required is **17m**.

Now let's put some door openings in. This symbol ⟷ represents an opening.

**Example 3**




On side 1 there is an opening 0.9m wide, on side 3 there is an opening 1.5m wide and on side 5 there is an opening 2.1m wide.

We know from Example 2 that the perimeter of the room is 17m. We now need to remove the openings. Skirting board will not be needed for the openings.

*Step 1*

Add together the lengths of the three combined openings:

0.9 + 1.5 + 2.1 = 4.5m

*Step 2*

Deduct this from 17m:

17 – 4.5 = 12.5m

The linear length of skirting board required is 12.5m.

*Step 3*

However, this calculation does not take into account any waste. We would normally add 10% extra to allow for waste:

12.5 + 10% = 12.5 + 1.25 = 13.75m

The total amount of skirting board required is **13.75m**.

## PERCENTAGES

An easy way to find a percentage (%) of a number is to divide the number by 100 and then multiply it by the percentage you require.

**Example**

Increase 19m by 12%

19 ÷ 100 = 0.19

0.19 × 12 = 2.28

19 + 2.28 = 21.28m

Total required **21.28m**.

**ACTIVITY**

1 Increase 49m by 10%
2 Increase 27m by 20%
3 Increase 34m by 17.5%
4 Decrease 22m by 5%

Answers: 1) 53.9m, 2) 32.4m, 3) 39.95m, 4) 20.9m

## AREA

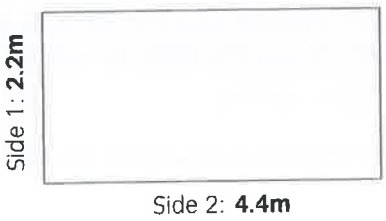
To find out how much material is required to cover a surface such as a **floor** or wall you need to calculate its area. Area is the measurements of a two-dimensional surface, eg the surface of floors, walls, glass or a roof.

**Floors**
The structured layers of a building, eg ground floor, first floor, second floor

To find the area of a surface you need to multiply its length by its width (L × W) or one side by the other. This will give you an answer which is expressed in square units ($^2$). For example, mm$^2$, m$^2$ or km$^2$.

**Example 1**

A bricklayer has been asked to work out the area of the floors below.



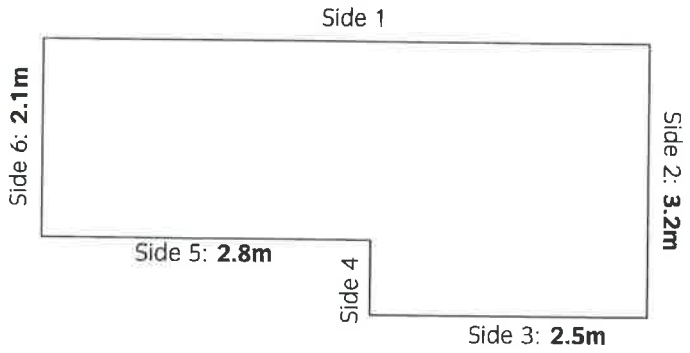

side 1 × side 2 = floor area

2.2 × 4.4 = 9.68m$^2$

The total floor area is **9.68m$^2$**.

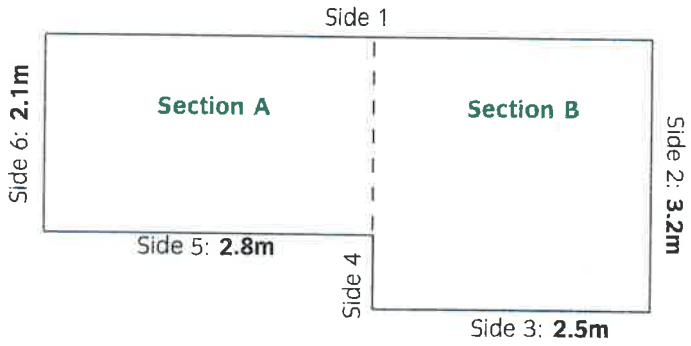
Irregularly shaped areas can be calculated by breaking up the area into sections that can be worked out easily, and then adding them together.

**Example 2**




*Step 1*

Divide the area into two parts, and then calculate the area of each part. The easiest way to do this is to divide it into two smaller sections:




*Step 2*

Work out the areas of section A and section B:

section A: 2.1 × 2.8 = 5.88m²

section B: 2.5 × 3.2 = 8m²

*Step 3*

Add the areas of section A and section B together:

section A + section B = total floor area

5.88 + 8 = 13.88m²

The total floor area is **13.88m²**.

Irregularly shaped rooms can be split into sections to calculate the area

A tiler tiling a floor

**INDUSTRY TIP**

Remember, there are 1,000mm in a metre so we show the sum as 0.305m in Example 3.

**ACTIVITY**

Find the area of the following measurements:

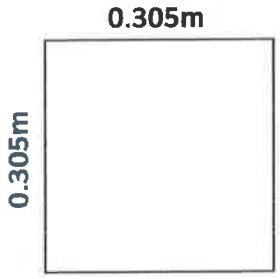
1. 2.1m × 2.4m
2. 0.9m × 2.7m
3. 250mm × 3.4m

Answers: 1) 5.04m², 2) 2.43m², 3) 0.85m²

Now let's say the floor requires tiling. The tiler needs to calculate the number of floor tiles required.

**Example 3**

The size of each floor tile is 305mm × 305mm. We can also show this as 0.305m × 0.305m.




How many floor tiles are required for the floor area in Example 2? The total floor area is 13.88m².

*Step 1*

Calculate the area of one tile. As the floor area is given in m², we need to calculate the size of the tile in the same unit, ie m².

0.305 × 0.305 = 0.093m²

*Step 2*

Now you need to divide the total floor area by the area of one tile to find out the total number of tiles required.

total floor area ÷ area of one tile = total number of tiles

13.88 ÷ 0.093 = 149.247 tiles

This number is rounded up to the next full tile, so a total of 150 floor tiles are required.

*Step 3*

However, this total does not allow for any waste.

Add 5% to allow for waste:

150 + 5% = 158 tiles (to the next full tile)

Let's look at the working out:

150 ÷ 100 = 1.5 tiles (this is 1%)

1.5 × 5 = 7.5 tiles (this is 5%)

5% of 150 tiles, rounded up to the next full tile, is 8 tiles.

Therefore **158 tiles** are required.

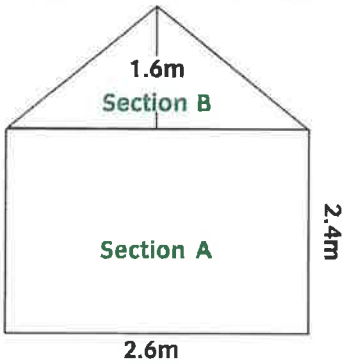
## AREA OF A TRIANGLE

Sometimes you will be required to work out an area that includes a triangle.

A decorator measuring a room

**Example 1**

A painter has been asked to work out how much paint will be needed to paint the front of this house.




*Step 1*

Divide the area up into a rectangular section (section A) and a triangular section (section B).

*Step 2*

Find the area of section A:

$2.4 \times 2.6 = 6.24m^2$

The area of section A is $6.24m^2$.

*Step 3*

Find the area of section B

The area of a triangle can be found by multiplying the base by the height, then dividing by 2.

(base x height) ÷ 2 = area

$2.6 \times 1.6 = 4.16$

$4.16 \div 2 = 2.08m^2$

The area of section B is $2.08m^2$.

*Step 4*

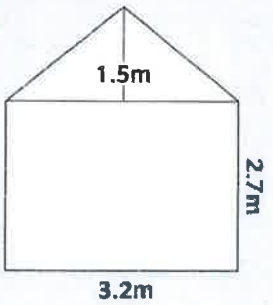
area of section A + area of section B = total wall area

$6.24 + 2.08 = 8.32m^2$

The total wall area is **$8.32m^2$**.

**ACTIVITY**

Look at the diagram. Work out the area of the wall in order to arrange the delivery of sufficient paint.



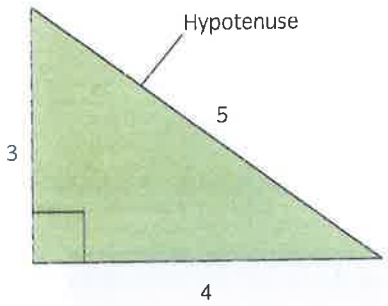

Answer: $11.04m^2$

## RIGHT-ANGLED TRIANGLE

**Hypotenuse**
The longest side of a right-angled triangle. It is always opposite the right angle

Now let's look at the right-angled triangle below. It has three sides, A, B and C. Pythagorean theorem tells us that in a right-angled triangle the **hypotenuse** is equal to the sum of the square of the lengths of the two other sides, in other words $a^2 + b^2 = c^2$. In this example the hypotenuse is side C.

Using the Pythagorean theorem we can work out the length of any side.



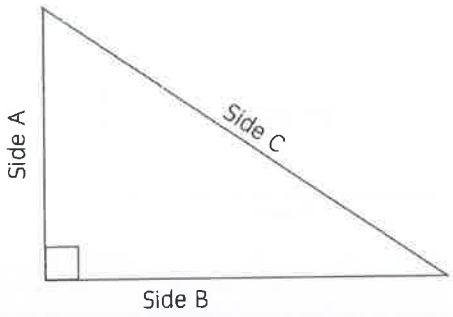
The hypotenuse

**INDUSTRY TIP**

If a triangle has a small square in the corner, this shows you the corner is a right angle.

### Example 1

If side A is 3m long and side B is 4m long, what is the length of side C?




$3 \times 3 = 9$

$4 \times 4 = 16$

$9 + 16 = 25$

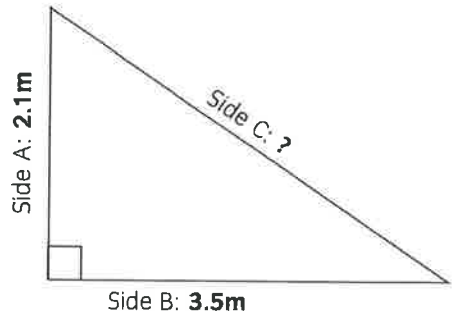
$\sqrt{25} = 5$

($\sqrt{}$ means square root. A square root of a number is the number that is multiplied by itself, in this case $5 \times 5 = 25$)

Side C is **5m** long.

### Example 2

A joiner has been asked to work out the length of a roof (side C).




2.1 x 2.1 (side A) = 4.41

3.5 x 3.5 (side B) = 12.25

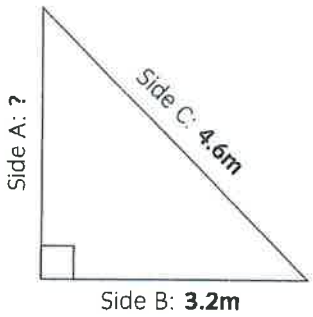
4.41 + 12.25 = 16.66

√16.66 = 4.08m

The length of side C is **4.08m**.

### Example 3

A bricklayer needs to find the rise of a roof (side A).




3.2 x 3.2 (side B) = 10.24

4.6 x 4.6 (side C) = 21.16

21.16 – 10.24 = 10.92

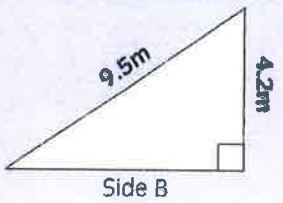
√10.92 = 3.30m

The length of side A is **3.3m**.

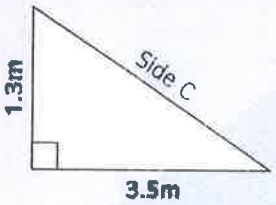
### ACTIVITY

Use Pythagorean theorem to answer following questions:

1 What is the length of side B?




2 What is the length of side C?




Answers: 1) 8.5m, 2) 3.73m

## PERIMETERS AND AREAS OF CIRCLES

**Circumference**
The distance around the edge of a circle

**Diameter**
The length of a straight line going through the centre of a circle connecting two points on its circumference

Sometimes you are required to find the perimeter or **circumference** of a circle.

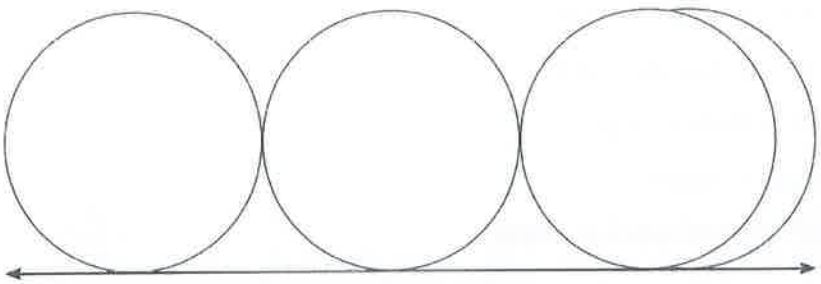
circumference of a circle = $\pi \times$ **diameter**

$$C = \pi d$$

$\pi$ (or 'pi') is the number of times that the diameter of a circle will divide into the circumference.

$\pi = 3.142$

This is equal to the number of diameters in one revolution of a circle. It is the same for any sized circle.



There are 3.142 diameters in one complete revolution

**Example 1**

A joiner is making a circular window that has a diameter of 600mm. Its circumference is:

$0.600 \times 3.142 =$ **1.885m**

The diameter of a circle from a given circumference is:

$$\text{diameter} = \text{circumference} \div \pi$$

**Example 2**

A window has a circumference of 2.250m. Its diameter is:

$2.250 \div 3.142 =$ **0.716m** (or 716mm)

**Radius**
The length of a line from the centre to a point on the circumference of a circle. It is exactly half the length of the diameter

The area of a circle is found by:

area of a circle = $\pi \times$ **radius**$^2$ (radius is equal to half the diameter)

### Example 3

A painter needs to paint a circle that is 1.2m in diameter and is required to find the area of the circle to enable them to order the correct quantity of paint.

1.2 ÷ 2 = **0.6m** (the radius)

3.142 × 0.6m² = **1.13m²**

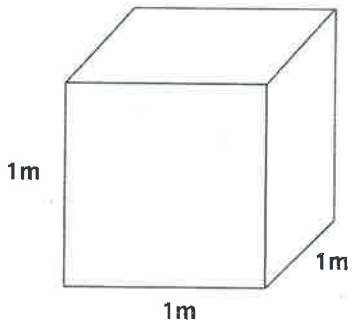
## VOLUME

The volume of an object is the total space it takes up, eg a tin of paint, a foundation for a wall or the capacity of a concrete mixer, and is shown as m³ (cubic metres). To find the volume of an object you must multiply length by width by height.

volume = length × width × height

### Example 1

Each side of this cube is 1m. The total space it takes up is 1m³.




1m × 1m × 1m = **1m³**

### Example 2

A bricklayer has been asked to work out how many m³ of **concrete** is required for a strip foundation. The size of the foundation is 3.2m long, 0.600m wide and 0.900m deep.

length × width × height = volume

3.2 × 0.600 × 0.900 = 1.728m³

The volume of concrete needed for the strip foundation is **1.728m³**.

### ACTIVITY

A joiner has been set two tasks:

1. Find the circumference of a brick opening in a wall for a circular window frame.
2. Work out the area of the window.

The diameter of the opening is 900mm. Work out the answers to the tasks.

Answers: 1) 2.827m, 2) 0.636m²

### INDUSTRY TIP

Remember r² is the same as r × r (r = radius).

A bricklayer taking levels

**Concrete**

Composed of cement, sand and stone, of varying size and in varying proportions

To work out the volume of a cylinder:

$$\text{volume} = \pi r^2 h \ (\pi \times r^2 \times h)$$

## ACTIVITY

A bricklayer has been given two tasks:

1. Measure the volume of a strip foundation measuring 4.250m long, 1.1m wide and 1m deep.
2. Find the volume of four pile foundations (see page 80) each measuring 2.5m deep, with a diameter of 0.9m.

Work out the answers to the tasks.

Answers: 1) 4.675m³, 2) 6.36m³

### Example 3

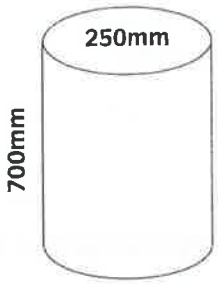
A joiner has a tin of preservative and needs to know its volume. The tin has a diameter of 250mm and a height of 700mm.

$\pi r^2 h \ (\pi \times r^2 \times h)$ = volume

The radius (r) is half the diameter:

$250 \div 2 = 125\text{mm}$

$3.142 \times 0.125^2 \times 0.700 = 0.034\text{m}^3$




The volume of the tin of paint is **0.034m³**.

## COMMUNICATION

Good communication is vital to the smooth running of any building project.

Communication involves sharing thoughts, information and ideas between people. For communication to be effective, information must be:

- given in a clear way
- received without misunderstanding.

It has been said that to be a good communicator it is just as important to be a good listener as it is to be a good speaker! Good communication leads to a safer and more efficient workplace, not to mention helping to maintain a pleasant working environment.

Most sites will have policies and procedures in place that govern the chain of command and communication between supervisory staff and workers.

**INDUSTRY TIP**

Before communicating something it is good to gather your thoughts. Have relevant information to hand, eg a drawing, and take notes if required.

## ACTIVITY

A customer has asked for the best steps to take before painting the skirting board in their new home. You have been asked to reply to the customer and give advice on the best way for them to do this.

Decide on the best form of communication and list all the information you should give along with the stages they should follow.

## WRITTEN COMMUNICATION

There are many methods of communication within the building industry. In this chapter we have discussed drawings, schedules and specifications etc. The architect uses these methods to communicate details about the building to the team who will **tender** for and erect the building.

**Tender**
To suplpy a client with a fixed quotation for the work

Communication is usually electronic via email (with or without attachments) or through intranet sites. Drawings are very commonly distributed in electronic formats which are printed on to paper when required. Messages are often given via text.

**INDUSTRY TIP**
Messages that are passed on by word of mouth are open to interpretation, so written messages can often be clearer.

Sometimes communication will be via a memorandum (memo), a written form of communication with a message.

Site rules, risk assessments and method statements (see Chapter 1) communicate safety information.

### SITE PAPERWORK

Communication on site is aided by the use of paperwork and without it no building site could operate. It is an important method of communication between operatives and supervisory staff, builders, architects and clients.

| Type of paperwork | Description |
|---|---|
| **Timesheet** | Used to record the hours completed each day, and is usually the basis on which pay is calculated. Timesheets also help to work out how much the job has cost in working hours, and can give information for future estimating work when working up a tender. |

**Timesheet**

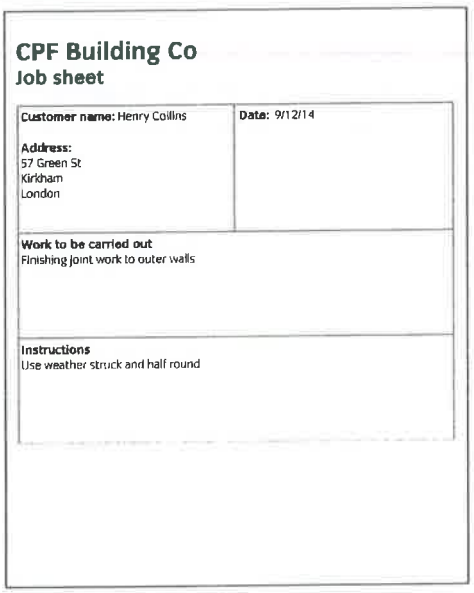
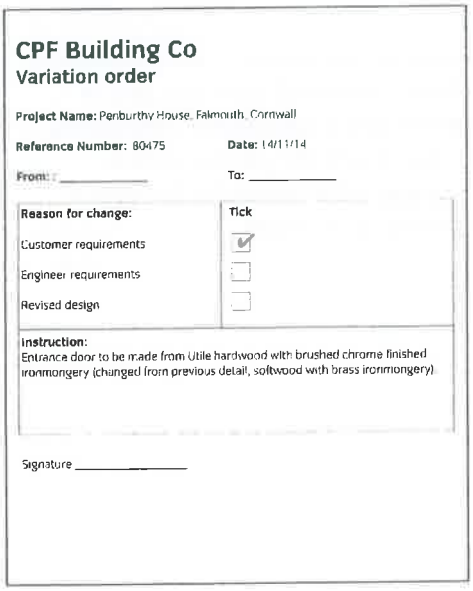
| Employer: CPF Building Co | Employee Name: Louise Miranda | Week starting: 17/6/14 |
|---|---|---|

Date: 21/6/13

| Day | Job/Job Number | Start Time | Finish Time | Total Hours | Overtime |
|---|---|---|---|---|---|
| Monday | Penburthy, Falmouth 0897 | 9am | 6pm | 8 | |
| Tuesday | Penburthy, Falmouth 0897 | 9am | 6pm | 8 | |
| Wednesday | Penburthy, Falmouth 0897 | 8.30am | 5.30pm | 8 | |
| Thursday | Trelawney, Truro 0901 | 11am | 8pm | 8 | 2 |
| Friday | Trelawney, Truro 0901 | 11am | 7pm | 7 | 1 |
| Saturday | Trelawney, Truro 0901 | 9am | 1pm | 4 | |
| Totals | | | | 43 | 3 |

Employee's signature: _____

Supervisor's signature: _____

| Type of paperwork | Description |
|---|---|
| **Job sheet**<br>  | Gives details of a job to be carried out, sometimes with material requirements and hours given to complete the task. |
| **Variation order**<br>**Confirmation notice**<br>**Architect's instruction**<br>  | Sometimes alterations are made to the contract which changes the work to be completed, eg a client may wish to move a door position or request a different brick finish. This usually involves a variation to the cost. This work should not be carried out until a variation order and a confirmation notice have been issued.<br><br>Architect's instructions are instructions given by an architect, first verbally and then in writing to a site agent as work progresses and questions inevitably arise over details and specifications. |

**CPF Building Co**
**Job sheet**

| **Customer name:** Henry Collins<br><br>**Address:**<br>57 Green St<br>Kirkham<br>London | **Date:** 9/12/14 |
|---|---|
| **Work to be carried out**<br>Finishing joint work to outer walls | |
| **Instructions**<br>Use weather struck and half round | |

**CPF Building Co**
**Variation order**

**Project Name:** Penburthy House, Falmouth, Cornwall

**Reference Number:** 80475 **Date:** 14/11/14

**From:** _____ **To:** _____

| **Reason for change:** | **Tick** |
|---|---|
| Customer requirements | ☑ |
| Engineer requirements | ☐ |
| Revised design | ☐ |

**Instruction:**
Entrance door to be made from Utile hardwood with brushed chrome finished ironmongery (changed from previous detail, softwood with brass ironmongery).

Signature _____

| Type of paperwork | Description |
|---|---|
| **Requisition order**<br><br>**CPF Building Co**<br>**Requisition order**<br><br>**Supplier Information:** Construction Supplies Ltd **Date:** 9/12/14<br>**Contract Address/Delivery Address:** Penburthy House, Falmouth, Cornwall<br>**Tel number:** 0207294333<br>**Order Number:** 26213263CPF<br><br>Item number / Description / Quantity / Unit/Unit Price / Total<br>X22433 / 75mm 4mm gauge countersunk brass screws slotted / 100 / 30p / £30<br>YK7334 / Brass cups to suit / 100 / 5p / £5<br>V23879 / Sadikkens water based clear varnish / 1 litre / £20.00 / £20.00<br>Total: / / / / £55.00<br><br>**Authorised by:** Denzil Penburthy | Filled out to order materials from a supplier or central store. These usually have to be authorised by a supervisor before they can be used. |
| **Delivery note**<br><br>**Construction Supplies Ltd**<br>**Delivery note**<br><br>**Customer name and address:** CPF Building Co, Penburthy House, Falmouth, Cornwall<br>**Delivery Date:** 16/12/14<br>**Delivery time:** 9am<br>**Order number:** 26213263CPF<br><br>Item number / Quantity / Description / Unit Price / Total<br>X22433 / 100 / 75mm 4mm gauge countersunk brass screws slotted / 30p / £30<br>YK7334 / 100 / Brass cups to suit / 5p / £5<br>V23879 / 1 litre / Sadikkens water based clear varnish / £20 / £20<br><br>Subtotal £55.00<br>VAT 20%<br>Total £66.00<br><br>**Discrepancies:** .....<br>**Customer Signature:** .....<br>**Print name:** .....<br>**Date:** ..... | Accompanies a delivery. Goods have to be checked for quantity and quality before the note is signed. Any discrepancies are recorded on the delivery note. Goods that are not suitable (because they are not as ordered or because they are of poor quality) can be refused and returned to the supplier. |

| Type of paperwork | Description |
|---|---|
| **Delivery record**<br><br>**Davids & Co**<br>**Monthly delivery record**<br>**Customer name and address:** CPF Building Co, Penburthy House, Falmouth, Cornwall<br>**Customer order date:** 28th May 2014<br><br>Item number / Quantity / Description / Unit Price / Date Delivered<br>BS3647 / 2 / 1 tonne bag of building sand / £60 / 3/6/14<br>CM4324 / 12 / 25kg bags of cement / £224 / 17/6/14<br><br>**Customer Signature:** .....<br>**Print name:** .....<br>**Date:** ..... | Every month a supplier will issue a delivery record that lists all the materials or hire used for that month. |
| **Invoice**<br><br>**Davids & Co**<br>**Invoice**<br>**Invoice number:** 75856<br>**PO number:** 4700095685<br>**Date:** 2nd January 2014<br><br>**Company name and address:** Davids & Co, 228 West Retail Park, Ivybridge, Plymouth<br>**Customer name and address:** CPF Building Co, Penburthy House, Falmouth, Cornwall<br>**VAT registration number:** 063694542<br><br>For:<br>Item number / Quantity / Description / Unit Price<br>BS3647 / 2 / 1 tonne bag of building sand / £30<br>CM4324 / 12 / 25kg bags of cement / £224<br><br>Subtotal £2748.00<br>VAT 20%<br>Total £3297.60<br><br>**Please make cheques payable to Davids & Co**<br>**Payment due in 30 days** | Sent by a supplier. It lists the services or materials supplied along with the price the contractor is requested to pay. There will be a time limit within which to pay. Sometimes there will be a discount for quick payment or penalties for late payment. |
| **Site diary**<br><br>  | This will be filled out daily. It records anything of note that happens on site such as deliveries, absences or occurrences, eg delay due to the weather. |

## VERBAL COMMUNICATION

Often, managers, supervisors, work colleagues and trades communicate verbally. This can be face to face or over a telephone. Although this is the most common form of communication, it is also the most unreliable.

Mistakes are often made while communicating verbally. The person giving the information might make an error. The person receiving the information might misunderstand something because the information is unclear or it is noisy in the background, or because they later forget the details of the conversation.

Confusion can be minimised by recording conversations or by using a form of written communication. If there is a record it can be used for future reference and help to clear up any misunderstandings.

### ACTIVITY

Find a partner. Choose a particular health and safety issue – this may be something you have seen at your training centre or on site. Prepare some basic notes. Assume the roles of operative and supervisor and discuss the issue. Swap roles and discuss the problem again. Afterwards, write down the solutions on which you agreed.
What type of approach works best? Does preparation help? Why should you write down the results of your discussion?

### TAKING A TELEPHONE MESSAGE

It is a good idea to take down details of telephone calls and many companies provide documentation for this purpose. When taking a message it is important to record the following details:

- *Content*: This is the most important part of the message – the actual information being relayed. Take and write down as many details as possible.
- *Date and time*: Messages are often time sensitive, and may require an urgent response.
- *Who the message is for*: Ensure the person gets the message by giving it to them or leaving it in a place where they will find it.
- *Contact name and details*: Write down the name of the person leaving the message, and how to get back to them with a response.

An operative taking notes during a phone call

## UNACCEPTABLE COMMUNICATION

When communicating, it is very important to stay calm. Think about what you are going to say. An angry word will often encourage an angry response. However, keeping calm and composed will often diffuse a stressful situation. A shouting match rarely ends with a good or productive result.

There are several types of communication that are unacceptable and could result in unemployment. Unacceptable communication includes:

- aggressive communication such as swearing or using inappropriate hand gestures

- racist or sexist comments or gestures
- showing prejudice against people with disabilities.

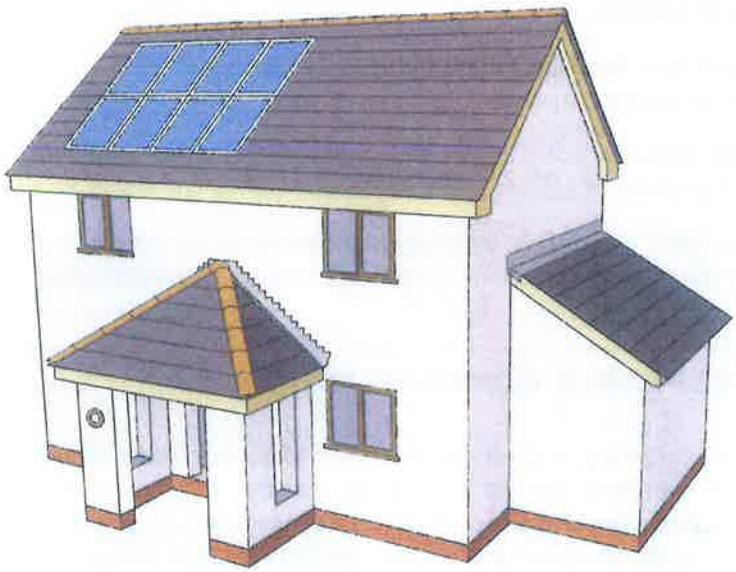
This type of behaviour shows a lack of respect for others and does not create a safe or pleasant working environment. It will also give your company a poor image if customers see or hear this behaviour. Acting in this way is likely to result in trouble for you and your employer and could even result in a **tribunal** and loss of employment.

**Tribunal**
A judgement made in court

## KNOWLEDGE OF THE CONSTRUCTION INDUSTRY AND BUILT ENVIRONMENT

Buildings come in a wide variety of types in relation to appearance and methods of construction. Despite the variety of buildings, they all have design features in common. In this section we will discuss various parts of buildings and their purpose.

We will also discuss sustainable construction – how buildings can be designed to sit better within the environment, with lower pollution levels and energy requirements both during the building process and when in use.



A house with solar panels

## FOUNDATIONS

**Foundations** serve as a good base on which to put the building. They need to be capable of carrying the weight of the building and any further load that may be put upon it. These are known as **dead loads** and **imposed loads**.

Foundations must be designed to resist any potential movement in the ground on which the building will sit. Ground conditions can vary widely. Soil samples are taken to help decide on the type of foundation to use. This usually takes the form of bore holes dug or drilled around the site. These samples are sent away for testing in a laboratory. The results will identify:

- the soil condition (clay or sandy)
- the depth of the soil
- the depth of the water table
- if any contaminations are present.

The soil condition is important: clay soil drains poorly and can move if it gets waterlogged or dries out completely. Sandy soils drain very well, but can become unstable. A foundation that is suitable for the ground type and load of the building will be designed.

**Foundation**
Used to spread the load of a building to the subsoil

**Dead load**
The weight of all the materials used to construct the building

**Imposed load**
Additional loads that may be placed on the structure, eg people, furniture, wind and snow

**INDUSTRY TIP**
The type of foundation to be used will usually be decided by the architect and a structural engineer and will be the result of tests.

## TYPES OF FOUNDATION

Different types of structures, such as detached houses, high-rise and low-rise buildings, will all require different types of foundation.


High-rise building

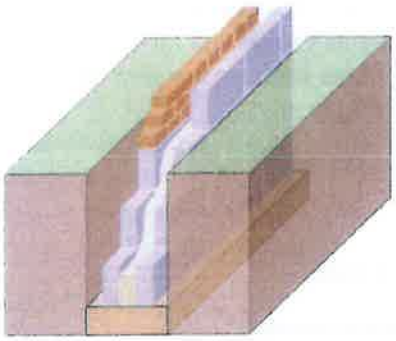

Low-rise building


Detached house

**OUR HOUSE**

What type of foundation does the building you are sitting in have? How can you tell? Why was that foundation type chosen? Look at the foundations used in 'Our House' as a further guide.

## STRIP FOUNDATIONS



Traditional strip foundation

A strip foundation is the traditional type of foundation used for residential developments (ordinary houses). It is formed by digging a trench to the required width and depth as determined by the soil conditions and the weight of the structure. It is either filled with concrete or a layer of concrete is poured into the bottom. This layer must be a minimum of 150mm thick and is commonly 225mm thick.

**Footings**
The substructure below ground level. These are projecting courses at the base of a wall

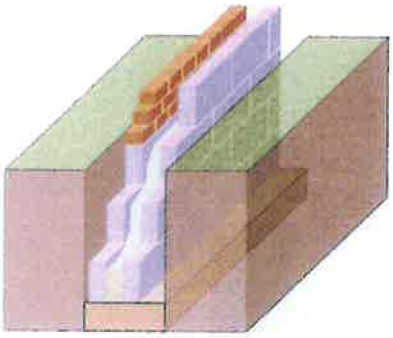
**Damp proof course (DPC)**
A layer of plastic that prevents damp rising up through a wall needs to be positioned at least 150mm above ground level

**Footings** are brought up to the level of the **damp proof course** (DPC) using concrete blocks or bricks. These are set out from the centre of the strip of concrete in order to spread the weight evenly. A variety of specialist bricks and blocks are used for this purpose. They need to be able to resist water penetration and therefore frost damage.

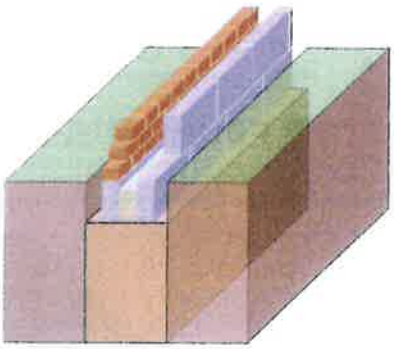
Engineering brick

Trench block

It can be economical to fill the trench up to the top with concrete rather than build a substructure – this is known as trench fill. Sometimes it is necessary to build on the edge of the concrete – this is known as an eccentric foundation.

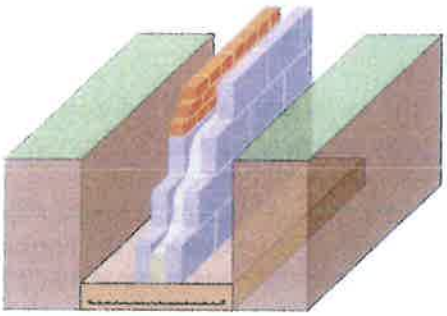


Eccentric foundation



Trench fill foundation

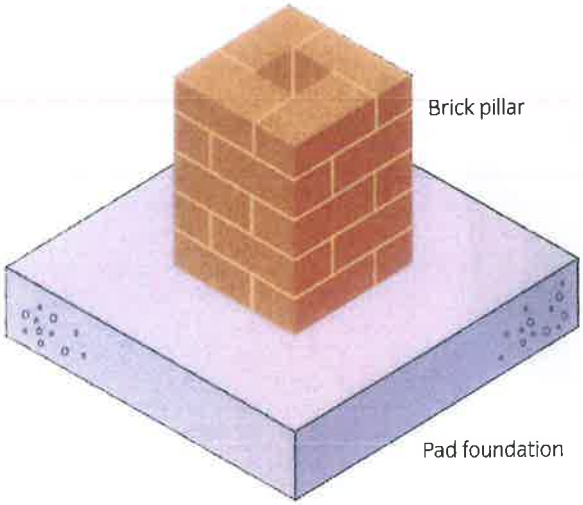
## WIDE STRIP FOUNDATIONS



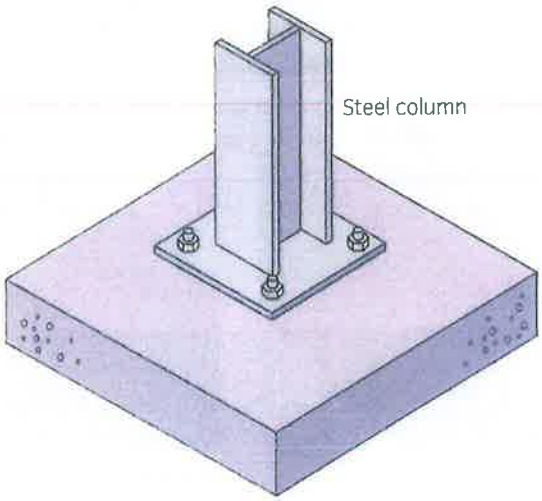
Wide strip foundation

A wide strip foundation is very similar to a strip foundation in most of its aspects. The main difference between the two is that a wide strip foundation has steel reinforcements placed within the concrete. The steel gives considerably more strength to the foundation and enables greater loads to be placed on it. Without the steel reinforcements the foundation would need to be much deeper and would need vast amounts of concrete.

## PAD FOUNDATIONS




Pad foundation



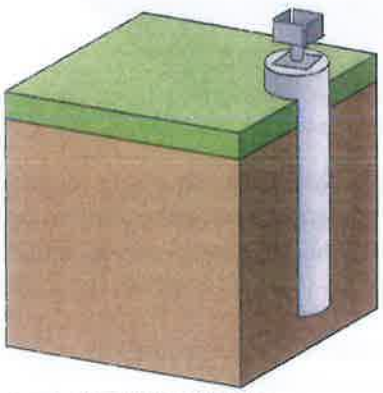

Pad foundation with bolts

A pad foundation is used to support a point load such as a column in a steel-framed building. This type of foundation often has bolts set into the top ready for fixing the steel.

**INDUSTRY TIP**

Foundations are made from concrete. Concrete is made from fine and coarse aggregate (crushed stone) and cement mixed with water. Water reacts with the cement causing it to harden and lock the aggregates together. Concrete is very strong under compression (when weight is put upon it) but is weak when it is pulled (put under tension); therefore steel rods are cast into it to make it stronger.

## PILE FOUNDATIONS



A cylindrical pile foundation

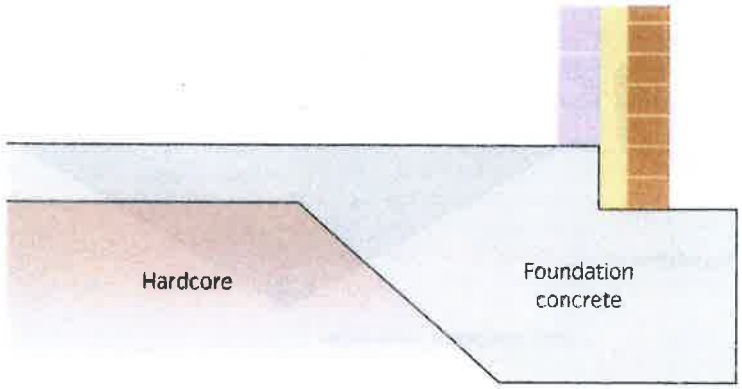
**Friction**

Resistance between the surface of the concrete foundation and the soil around it

Deep piles are used to transfer the load through unsuitable soil layers into the harder layers of ground below, even down to rock if required (known as end bearing). Some piles use **friction** to provide support. This is known as skin friction. Tall buildings (and especially narrow buildings such as chimneys or towers) have large lateral forces due to side winds and pile foundations resist these forces well.

## RAFT FOUNDATIONS

A raft foundation is often laid over an area of softer soil that would be unsuitable for a strip foundation. A raft foundation is a slab of concrete covering the entire base of the building; it spreads the weight of the building over a wider area but still maintains a deeper base around the load-bearing walls.




Raft foundation

# FLOORS

Floors can be divided into two main categories:

- ground floors
- upper floors.

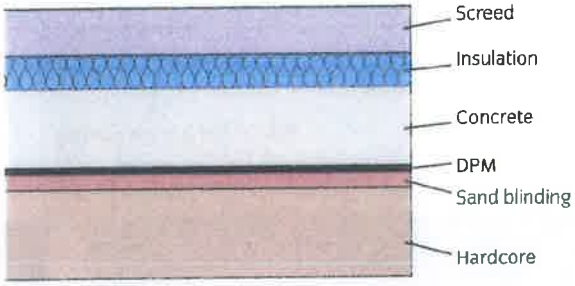
Floors are required to be load bearing, and there is a wide variety of construction methods depending on the type of building and potential load that will be imposed upon the floor. Floors also may need to prevent:

- heat loss
- transfer of sound
- moisture penetration.

# GROUND FLOORS

These may be either solid ground floors or suspended floors.

## SOLID FLOORS




Concrete floor

**Hardcore**
A mixture of crushed stone and sand laid and compacted to give a good base for the concrete

**Damp proof membrane (DPM)**
An impermeable layer that prevents damp coming up through the floor. A layer of sand known as blinding is placed below the DPM to prevent any sharp stones below piercing the membrane when the concrete is poured

**Insulation**
Materials used to retain heat and improve the thermal value of a building; may also be used for managing sound transfer

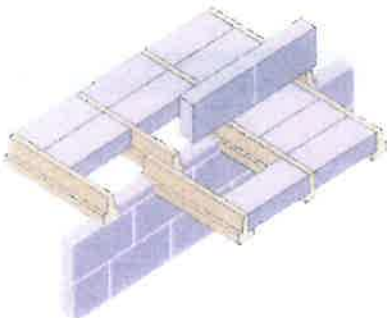
Solid concrete floors are laid upon **hardcore** and have a **damp proof membrane** (DPM) built into them to prevent damp coming up through the floor. **Insulation** is also laid into the floor to reduce heat loss. It is important that the insulation is not affected by the high water content of the wet concrete when being poured.

Steel reinforcement can also be used within the concrete to increase strength and reduce cracks.

Concrete with steel reinforcement

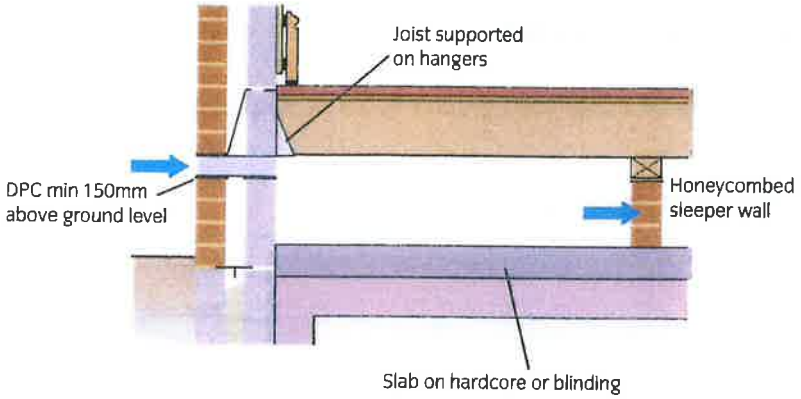
## HOLLOW AND SUSPENDED FLOORS

Upper floors, and some ground floors, are suspended or hollow meaning that instead of resting on the ground beneath, the load is transferred via beams to the walls. Two types of beam used are Posi-Joist and I-beam. Timber joists are usually covered with either chip board or solid timber floor boards.



Suspended concrete floor (block and beam)

Precast floor




Suspended wood floor

Posi-Joist

I-beam

## UPPER FLOORS

In most domestic dwellings timber floor joists are used following the same principle as timber ground floors, while in large commercial and industrial buildings solid concrete floors are used.

**INDUSTRY TIP**

Timber joists normally run across the shortest span.

## WALLS

Walling for a building can usually be divided in two categories:

- external
- internal.

Walling can be load or non-load-bearing. Load-bearing walls carry the weight of the floors and roof and transfer this weight down to the foundations. A non-load-bearing wall carries no weight.

**Lintel**
A horizontal member for spanning an opening to support the structure above

**Bond**
The arrangement or pattern of laying bricks and blocks to spread the load through the wall, also for strength and appearance

Walls often have openings in them, eg doors and windows, which will weaken them if they are not constructed correctly. Openings require support (via a **lintel** or arch) across the top to give the wall support and **bond** it together.

## EXTERNAL WALLING

External walls need to:

- keep the elements (wind and rain) out of the building
- look good
- fit into the surrounding landscape.

Several methods of construction are used for external walling. Common construction methods are:

- **solid wall**
- **cavity wall**
- timber framing.

**Solid wall**
Walls of a thickness of one brick and greater

**Cavity wall**
Walling built in two separate skins (usually of different materials) with a void held together by wall ties

### SOLID WALLS

Solid wall

**INDUSTRY TIP**

Remember, cement will give chemical burns so use the correct PPE while using and mixing it.

**ACTIVITY**

What are the walls in the building you are sitting in made from? Why do you think these materials were chosen? What are the advantages or disadvantages of these materials?

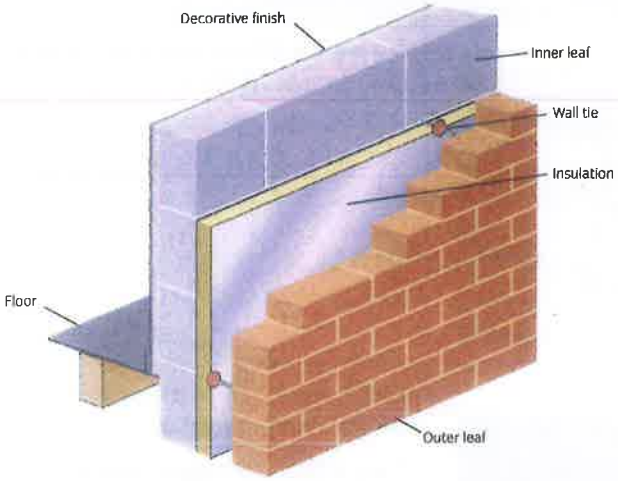
Many older traditional buildings have solid walls made from brick, block or stone: see the following table. Solid walls have the disadvantage of being more easily penetrated by damp. Older solid walls are often upgraded by having insulating and waterproofing layers applied to the outside of the wall.

| Material used | Description |
|---|---|
| **Bricks**  | A very traditional building material made from fired clay, calcium silicate or concrete. A standard sized brick is 215mm × 102.5mm × 65mm. |
| **Blocks**  | These are made of either concrete (crushed stone and cement) or a light-weight cement mixture.<br>They are much bigger than a brick, and are available in various sizes. The most commonly used size is 440mm × 215mm × 100mm.<br>Wider blocks are used for walls where a higher strength or improved sound insulation is required. |
| **Stone**  | A natural building material, which varies widely in use and appearance from area to area.<br>Stone may be cut to a uniform size before use or used in its quarried state. |
| **Mortar**  | This is used between bricks, blocks and stones to bind them together and increase the strength of the wall. It is a mixture of soft sand and cement mixed with water and other additives if required, eg **plasticiser**, colouring or **lime**.<br>It is important that the strength of the mortar is correct for the type of material that is being used to construct the wall. If the mortar has too much cement in the mix it will be so strong that it will not allow movement in the walling due to settlement, and the bricks could crack resulting in the wall needing to be rebuilt.<br>Mortars are mixed to a ratio of materials, eg 1:6. The first number is always the proportion of cement with the second being the proportion of sand. A typical mix ratio for masonry walling is 1:5. |

**Plasticiser**
An additive that is used to make the mortar more pliable and easier to work with

**Lime**
A fine powdered material traditionally used in mortar

## CAVITY WALLS




Cavity wall

**ACTIVITY**

State the minimum performance standards required to meet current building regulations.

**ACTIVITY**

Find out the current minimum width of cavity allowed.

The most common type of external walling used today is cavity wall construction.

Cavity walls are two masonry walls built side by side to form an inner and outer leaf (sometimes called skins). The **leaves** are held together with wall ties. These ties are made from rust- and rot-proof material and are built in as the walls are being constructed. The cavity is partially filled with insulation (typically fibreglass batts or polystyrene boards) as required by the **building regulations**. This reduces heat loss and saves energy.

**Leaves**

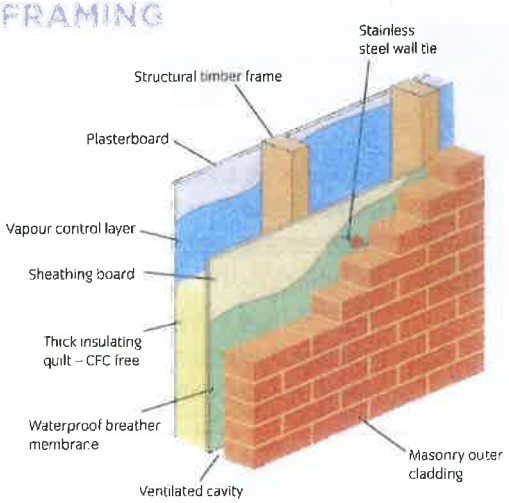
The two walls or skins that make up a cavity wall to comply with current building regulations

**Building regulations**

A series of documents that set out legal requirements for the standards of building work

The inner leaf usually carries any loads from the roof and floors down to the foundations and has a decorative finish on the inside, typically plaster which is either painted or papered. The outer leaf resists the elements and protects the inside of the building.

## TIMBER FRAMING

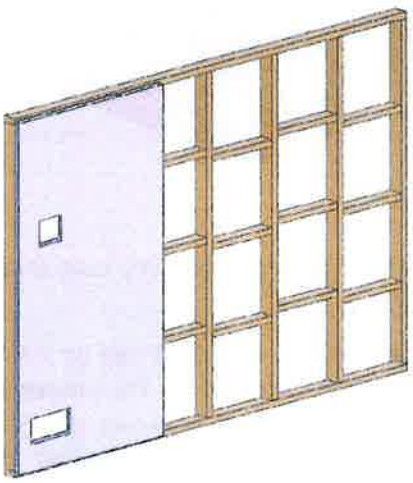



Timber frame wall

Timber framing is both a traditional and modern method of building. Traditional buildings using timber framing were made mostly from oak with various in-fills such as brick or plaster to form the walls. Modern timber frame homes are generally built from softwood and have an outer skin of masonry or are clad with timber or plaster to waterproof the structure. Oak framing, as a traditional building method, is becoming increasingly popular again.

Elizabethan oak frame

### PREFABRICATED WALLS



Prefabricated wall panel

There are a variety of prefabricated products available, generally made in a factory and then transported to site to be erected. These products enable quick and easy building. Often the **services** are pre-installed.

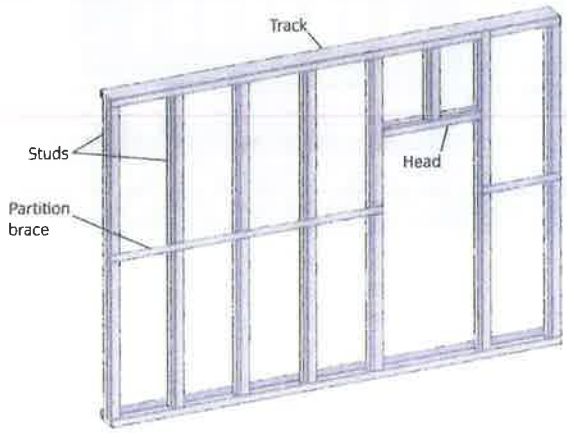
**Services**

Those provided by the utility companies, eg gas, electric and water

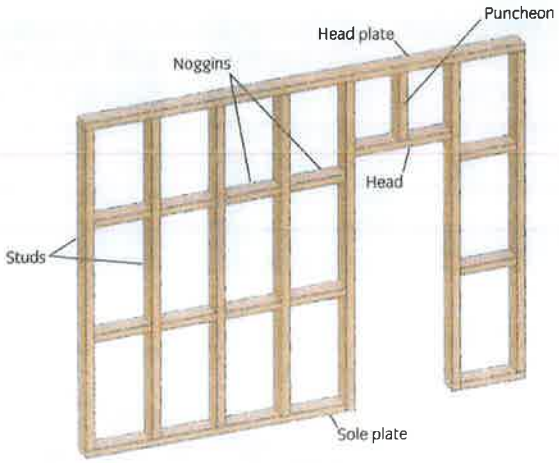
## INTERNAL WALLING

Internal walling can be load or non-load bearing. Internal partitions divide large internal spaces into smaller rooms.

Internal partitions can be made from studwork or masonry. Studwork partitions consist of studs (which can be made from timber or metal) covered with a sheet material (usually plasterboard).



Metal stud wall



Timber stud wall

## WALL FINISHES

External walls made from brick usually have no further finishes added while walls made from blocks are rendered. This is a covering of sand and cement mortar which is then finished with masonry paint.

Internal walls are most often plastered with a thin layer of gypsum plaster over plasterboard; this gives a very smooth hardwearing finish which is then usually finished with emulsion paint or papered coverings.

**INDUSTRY TIP**

At least two coats of emulsion are usually required for new plaster.

It is important to **size** new plaster to give a good base before applying further coverings of paint or paper coverings. This first coat of paint or paste is usually thinned down by 10% with clean water.

**Size**

To apply a watered-down or mist-coat of paint or paste to new plaster

## ROOFS

Roofs are designed to protect the structure below by keeping the weather out. As heat rises, the roof must be well insulated to prevent heat loss and improve the energy efficiency of the building.

## TYPES OF ROOFS

Roofs come in a wide variety of designs as the following pictures show.

Pitched roof

Flat roof

**INDUSTRY TIP**

A flat roof has an incline of up to 10° while a pitched roof has an incline over 10°.

**INDUSTRY TIP**

Timber requires protection from the elements (rain, wind and sun) and this is done using timber coatings. Knotting is applied to prevent heat from the sun drawing resin out of knots in the timber. Primer is applied to give a good key to the paint or stain that is used to provide a finish. Paint also requires undercoat to be applied to give a good finish. Paint and stain can be water or solvent borne (water or oil based).

## ROOF COMPONENTS

Roofs are commonly covered with slates or tiles. Slates are a natural product. Slate is a type of mineral that can be split into thin sheets. Artificial cement fibre slates are also available. Tiles can be made from clay or concrete.

Slate

Cement fibre slate

Roof tiles

A felt is laid below the roofing material to provide additional protection in case some water gets through the tiles.

Flashings are commonly made from lead and are used to provide waterproofing at joints where roofing materials meet walls and around chimneys.

Flashing providing waterproofing

Flashing around a chimney

# SERVICES

Buildings contain services such as:

- water
- electricity
- gas supplies.

Additionally, waste such as sewage and water run-off have to be considered.

## WATER

Water is brought into a building using pipes. Supply pipes used are usually made of plastic, with internal domestic plumbing being made from plastic or copper. Plumbing is installed using a variety of fittings including tees, elbows and reducers. Bathrooms, kitchens and most heating systems require plumbing.

Copper pipe

Plastic waste water pipe

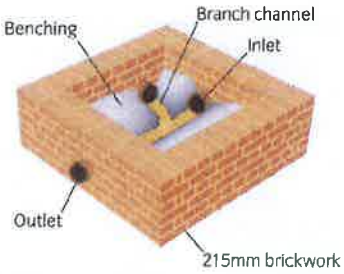
Pipe fittings

Not only is water carried into a building, it is also taken away. Rainwater run-off is collected into gutters and taken away via downpipes and drains and returned to the ground or stored for later use.

Rainwater gutter flowing down pipes and into drain

## SEWAGE

Sewage is taken away from the building via drains and is disposed of either into a sewer or into a septic tank/sewage treatment plant.




Benched drain

Septic tank

Sewage treatment plant

## ELECTRICITY

Electricity is an important service provided to buildings. It powers lighting and heating. It is brought into a building through cables.

Electricity cables, switches and socket

Pipework to boiler

## GAS

Gas is brought into a building using pipes. Gas powers heating systems and provides fuel for cooking.

## OTHER SERVICES

Other services that are installed include telephone systems and other data cables for broadband and entertainment systems.

**ACTIVITY**

What services are being used in the building you are sitting in? How are they brought into the building?

# SUSTAINABILITY

Our planet is a fixed size. Fossil fuels, eg oil and coal, that we take from the ground are not infinite, ie they will run out one day. However, the wind, the sun and the tides will always be there. These are sustainable sources of energy.

Building materials can be sustainable if they are chosen carefully. For example, the process of manufacturing concrete uses a lot of fuel and produces a lot of carbon dioxide (a gas that some say is damaging the climate).

On the other hand, trees absorb carbon dioxide as they grow, look nice and the timber they produce is an excellent building material. However, some timber is harvested from rainforests without thought for the surrounding environment or are harvested to such an extent that certain species are close to extinction. Managed forests where trees are replanted after harvesting provide a sustainable source of timber.

Here are some questions to consider regarding sustainability in construction.

## MATERIALS

- How far have the materials been brought? Locally sourced materials do not have to be transported far, thus reducing fuel use.
- Are the materials sustainably sourced? Has the timber come from a managed forest or has it come from a rainforest with no regard to the environment?
- Have the materials been manufactured with the minimum of energy and waste?

## DESIGN

Is there an alternative design that can be used that uses more sustainable materials? For example, a timber frame instead of concrete block or brick.

The table below shows some sustainable materials.

| Material | Image |
|---|---|
| **Straw bales** |  |
| **Cob (soil)** |  |
| **Timber** |    |
| **Bamboo** |  |

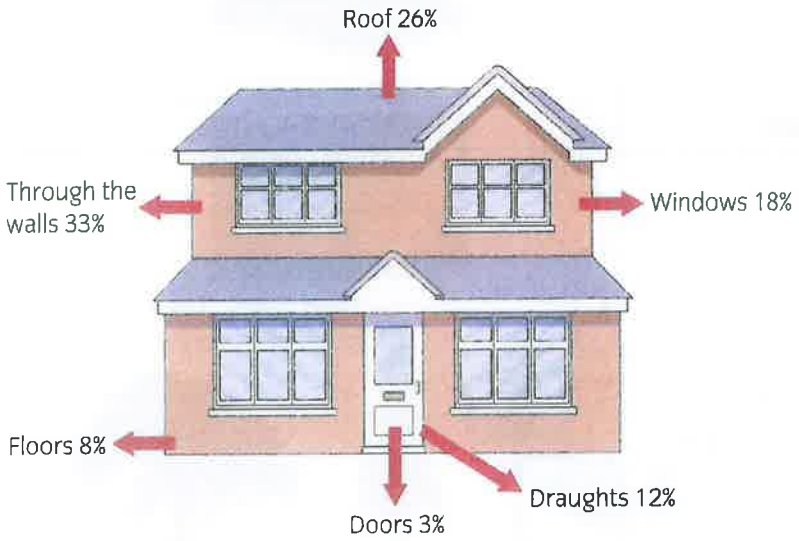
## ENERGY EFFICIENCY

Energy is expensive and is only going to get more expensive. As the population increases more and more energy will be required. This needs to come from somewhere and its production can be damaging to the environment. The less power a building uses the better and if it can produce its own that is a bonus. Energy-saving measures can save a lot of power consumption.

### INSULATION

Light, air-filled materials tend to have better thermal insulation properties than heavy, dense materials. This means that heat cannot easily pass from one side to another and so if these materials are used in a building it will require less heating during the winter and will remain cooler during the summer.

The following drawing shows how much heat a typical home loses through different parts of the property. Better insulation will reduce the amount of heat lost.

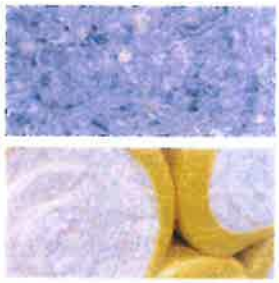



Sources of heat loss from a house

**OUR HOUSE**

What insulation has been used in the building you are sitting in? Is the building energy efficient? Is it cold? Does it take a lot of heating? Take a look at 'Our House' and identify the insulation measures used there.

The table below shows some examples of insulation.

| Type of insulation | Description |
|---|---|
| **Blue jean and lambswool**  | Lambswool is a natural insulator. Blue jean insulation comes from recycled denim. |
| **Fibreglass/Rockwool™**  | This is made from glass, often from old recycled bottles or mineral wool. It holds a lot of air within it and therefore is an excellent insulator. It is also cheap to produce. It does however use up a fair bit of room as it takes a good thickness to comply with building regulations. Similar products include plastic fibre insulation made from plastic bottles and lambswool. |
| **PIR (polyisocyanurate)**  | This is a solid insulation with foil layers on the faces. It is lightweight, rigid and easy to cut and fit. It has excellent insulation properties. Polystyrene is similar to PIR. Although polystyrene is cheaper, its thermal properties are not as good. |
| **Multifoil**   | A modern type of insulation made up of many layers of foil and thin insulation layers. These work by reflecting heat back into the building. Usually used in conjunction with other types of insulation. |
| **Double glazing and draught-proofing measures**  | The elimination of draughts and air flows reduces heat loss and improves efficiency. |

## MAKING BETTER USE OF EXISTING AND FREE ENERGY

### SOLAR POWER

The sun always shines and during the day its light reaches the ground (even on cloudy days). This energy can be used. A simple use of this is to allow sunlight to enter a building. With a little thought in design, light can reach deep into a building via roof lights and light tunnels. This means that internal artificial lighting requirements are reduced, therefore saving energy.

**Solar panel**
A panel that absorbs sun rays to generate electricity or hot water

**Solar panels** can generate hot water or electricity, and once the cost of installation has been covered the energy they produce is totally free.

Solar panels

### HEAT SOURCE AND RECOVERY

Humans give off a fair bit of energy as they go through a normal day (eg body heat, heat given off by hairdryers, cookers, refrigerators and other activities) and this can be conserved. Modern air-conditioning systems take the heat from stale air and put it into the fresh air coming in.

Heat can be taken from the ground and even the air outside.

### WIND POWER

Wind power is becoming more widespread. However some people feel that wind turbines are damaging the visual environment as they spoil the appearance of the countryside. Individuals will have their

own opinion on whether wind power is a good thing or not as there are many considerations to be taken into account.

Wind turbine

## WATER POWER

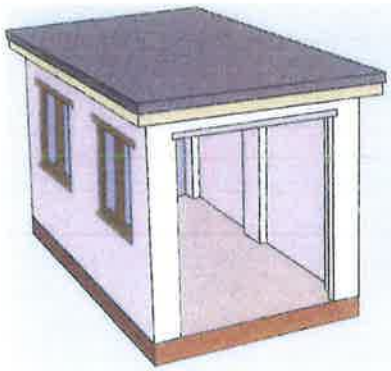
Water is another source of power, whether that be hydro-electric (water from dams turning turbines) or wave power, which is currently under development.

## BIOMASS HEATING

Biomass heating (using wood and other non-fossil fuels) is also becoming more popular as these systems can heat water efficiently as well as heat rooms, and of course a well-insulated building does not require a lot of heating.

## ENERGY-EFFICIENT GOODS AND APPLIANCES

Energy-efficient electrical goods (eg low-energy light bulbs) and appliances (eg dishwashers, fridges and washing machines) which use a reduced amount of power and less water are available.



## Case Study: Kayleigh

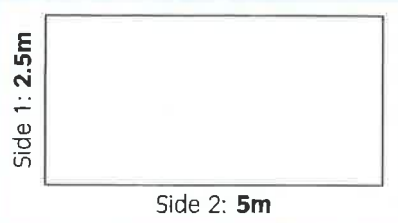
Kayleigh is to build a small single garage at the rear of a house. It must be big enough to accommodate an estate car and give enough room to allow the user to get out and walk around the car. The garage has two windows, an up-and-over door at the front and a flat roof. She has been asked to provide a plan of this garage for the client.

Draw this garage to a scale that will fit onto an A4 piece of paper. Include the window openings, the door, the thickness of the walls (which will be single block) and the piers.

## TEST YOUR KNOWLEDGE

Work through the following questions to check your learning.

**1** What is the perimeter of this room?




- **a** 5m.
- **b** 7m.
- **c** 15m.
- **d** 17m.

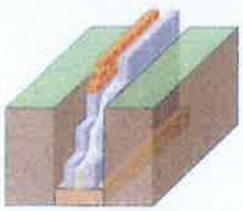
**2** A message that is passed on by word of mouth rather than in writing is

- **a** open to interpretation
- **b** very accurate
- **c** easy to understand if shouted
- **d** easily remembered.

**3** What is a component drawing?

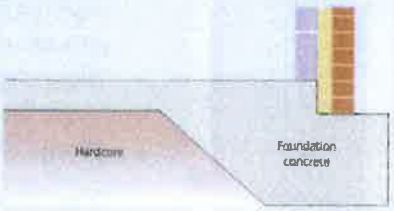
- **a** A plan of the whole building, floor by floor.
- **b** A section through a part of the structure.
- **c** An elevation of the walls.
- **d** A detail in a room.

**4** What is the foundation type shown?



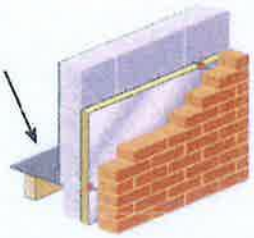
- **a** Strip.
- **b** Pile.
- **c** Raft.
- **d** Pad.

**5** What is the foundation type shown?




- **a** Strip.
- **b** Pile.
- **c** Raft.
- **d** Pad.

**6** What is the component shown?



- **a** Damp proof membrane.
- **b** Strip foundation.
- **c** Damp proof course.
- **d** Raft foundation.

**7** Which one of the following materials has the **best** thermal insulation properties?

- **a** Brick.
- **b** Concrete.
- **c** Glass.
- **d** Polystyrene.

**8** Concrete sets because it contains which one of the following components?

- **a** Aggregate.
- **b** Sand.
- **c** Hardcore.
- **d** Cement.

## TEST YOUR KNOWLEDGE

9 A flat roof has a pitch of less than
- **a** 8°
- **b** 10°
- **c** 12°
- **d** 15°.

10 Load-bearing walls transmit weight down to the
- **a** foundations
- **b** floors
- **c** roof
- **d** windows.