सत्यमेव जयते
Ministry of Rural Development
Government of India

Handbook for Rural Masons


Basic knowledge


Setting out


Masonry works


Concrete works


Toilets

International
Labour
Organization

Handbook for rural masons

New Delhi, March 2017

International Labour Organization

Ministry of Rural Development
Government of India

Acknowledgements

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- SKAT - Swiss Centre for Development Cooperation in Technology and Management, Switzerland
- Telangana State Housing Corporation, Hyderabad
- United Nations Development Programme, New Delhi

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The initial technical team for the preparation of the training material consisted of Mr Andreas Beusch, ILO Training Specialist, Mr Akunuri Murali, Telangana and Ms Mona Chhabra Anand, Technical Consultant MoRD/UNDP. This second edition of the Learning Units and the Handbook was prepared by Andreas Beusch, Akunuri Murali and Bjorn Johannessen.

Foreword

Capacity development and training has formed a central part of ILO's support to rural development programmes during the last 40 years. Experience has shown that training of artisans and other field staff has been a key to the success of many such programmes. This training initiative for rural masons in India's low-cost rural housing programme is not only expected to result in quality infrastructure but will also contribute to providing productive employment, thus promoting the joint efforts of the Government and the ILO in promoting the Decent Work agenda in rural areas.

It is recognized that effective rural infrastructure programmes have the potential of offering several benefits besides quality infrastructure assets. As an essential part of Governments' effort to provide inclusive growth, these programmes also allow for the inclusion of many social policy objectives. Programmes of this nature may also be used as a practical and efficient vehicle for skills development, increasing employment opportunities as well as stimulating rural economies.

While focusing on the technical skills required for the specific needs of the rural housing scheme, it is acknowledged that this training contributes to human resource development for the sector as a whole. This is also recognised through the national occupational standards, on which basis this training material was developed.

The construction industry consists of a large variety of entrepreneurs. While larger infrastructure projects normally make use of registered contractors, it is common practice to engage the services of informal builders and artisans with varying skills levels for private house construction. The rural housing programme provides a good opportunity to strengthen capacity in this segment of the industry and also bring these human resources over to the formal sector. Furthermore, this

initiative will provide future house owners outside this programme with a reliable local source of skilled manpower.

Forming part of a comprehensive training package, including a trainer's guide and training posters, this handbook is meant for the rural masons, providing a easy accessible reference guide covering the most common work activities when building a house.

In recognition of the widely different conditions found in rural areas across India, the handbook attempts to focus on basic work activities that tend to be found most places. It also promotes work methods and choice of tools, materials and equipment that is affordable to local builders in rural areas. Equally, the designs and materials described support the construction of sober but good quality and safe housing.

As always, the handbook draws on the collective experience of past work experience in India as well as of the authors and others as well as a wealth of existing literature developed by the ILO and others. This handbook should also be considered as a resource book for developing guidelines and manuals reflecting the exact conditions and building practices in a particular state or region in the country.

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Section 1
Basic knowledge

1.1 Introduction

The Ministry of Rural Development deals with housing needs of rural people living below the poverty line. The typical house under the Government's housing programme is a modest, low-cost but good quality building that is suitable for families living in rural areas. Local masons and builders can construct these houses applying simple, mainstream construction methods relying on locally available building materials.

1.2 Typical layout of rural houses

Houses built for the poor under the Government's housing programme usually consist of two rooms, a kitchen and an external toilet.

The particular design and technical specifications for rural houses vary, depending on local conditions, such as available materials, local building practices, climate and topography, and also on the specific standards preferred by the respective State Governments.

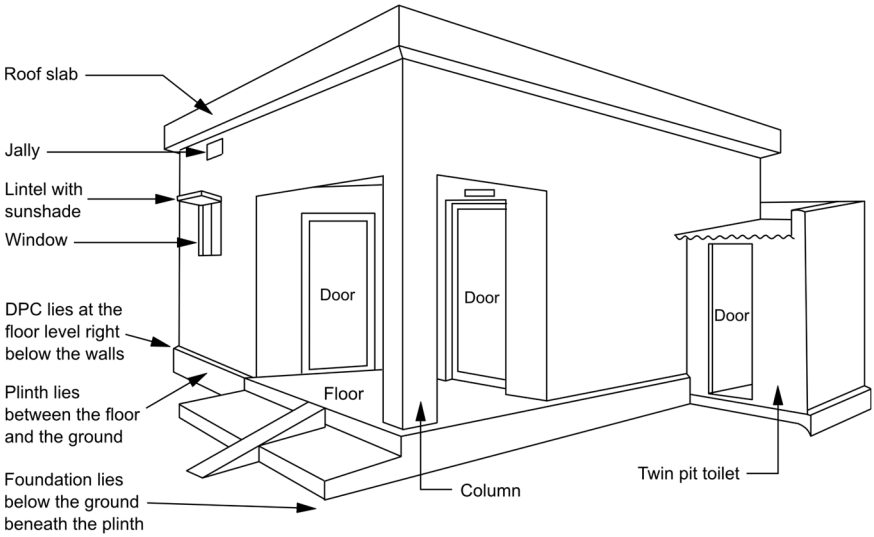
1.3 Structural features

The house needs to be built on stable ground in a location where there is limited risk of flooding. A solid foundation is required to carry the entire weight of the house and to avoid any major settlements once it is completed. A plinth wall makes sure the ground floor in the building is sufficiently elevated above the surrounding ground, thereby avoiding surface water to enter the house.

Walls are usually built from clay bricks or cement blocks. The walls are designed so they are strong enough to support the roof. Concrete lintels above doors, windows and ventilators support the walls above such openings. Lintels can be extended to provide shade from the sun.

The standard design usually consists of a one-storey house with a flat reinforced concrete roof. The roof rests on the walls and where necessary supported by columns.

The figure below illustrates these key structural components of the house:



1.4 The main building elements

Foundation

Every house needs a sound foundation on which the weight of the building can be evenly distributed into the ground. The foundations need to be solid enough to avoid settlements that can cause damages to the house.

The foundations are placed below the existing ground level to a depth where firm soils are found. Trenches are therefore excavated to reach the desired depth.

Plinth

The plinth is essentially the wall between the foundations up to the level of the ground floor. It is constructed immediately above the ground level on top of the foundation. Its purpose is to raise the ground floor to a level where surface water cannot enter the building.

Plinth beam

Depending on the type of building and ground conditions, a plinth beam may need to be constructed to give additional stability to the building. Plinth beams are constructed using reinforced concrete.

There is no need for a concrete plinth beam where the soil under the foundation is strong and firm.

Damp proof course, DPC

A damp proof course hinders surface water to rise into the walls. The DPC can be constructed using concrete with a 1:2:4 cement, sand, stone mix, containing an

aqua-proof compound. A DPC is not required where a plinth beam is constructed, since the beam would also perform like a seal.

Floor

Floors can be built using a variety of materials. Care should be taken that the ground below is well compacted. The floor should prevent dampness from rising to the top. It also needs a firm and smooth surface that can easily be kept clean.

A concrete floor is commonly used in rural houses, consisting of a layer of about 75mm lean concrete and on top a 40 to 50mm thick concrete slab, which is finished with 4 to 6mm cement slurry surface.

Walls can be built from different materials. They need to be strong enough to support the roof, to provide protection from the outside weather and also offer security and privacy.

The walls for rural houses are usually built using clay bricks or cement blocks. If the walls are very long, columns need to be constructed to provide sufficient support for the roof.

Openings in the walls are usually provided for doors, windows and ventilation. Doors and windows can be of timber or metal. They are mounted in a frame and securely fixed into the wall. Doors and windows can be purchased ready-made and are usually supplied with a frame.

Lintels are constructed to support the wall above openings, usually consisting of a reinforced concrete beam. Also stone slabs can be used if good material is available and the load above the opening is not excessive.

Lintels can also be extended to provide shade above windows, doors and other openings.

Roof slab

The roof provides protection for the building and the people living in it. Roof slabs are constructed using reinforced concrete. The roof needs to be properly connected with the walls on which it rests. It needs to be watertight to avoid rainwater entering the building.

Toilet

Every home needs a toilet. It can be located inside the house or close by. Twin pit flush toilets are commonly used in rural areas and are also the preferred design in the Government rural housing programme.

1.5 Construction sequence and activities

The construction of a house follows a logical sequence of construction activities as follows:

(i) Levelling the ground before marking out the house foundation
(ii) Setting out the foundations with fixed reference points
(iii) Excavating trenches for foundations
(iv) Constructing foundations (concrete and masonry)
(v) Plinth construction using stone masonry
(vi) Laying a Damp Proof Course (DPC)
(vii) Reinforced concrete plinth beam (though usually not required)
(viii) Constructing walls using bricks, blocks or stone
(ix) Constructing lintels and sunshades
(x) Installing windows and door frames
(xi) Laying a roof slab including shuttering, placing reinforcement and concrete works
(xii) Plastering walls
(xiii) Laying a floor
(xiv) Constructing a twin pit toilet
(xv) Painting or white washing

1.6 Tools for masonry works

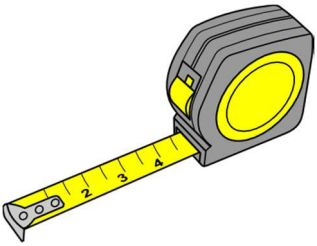
Every mason needs a standard set of appropriate tools for measuring, carrying out works and for continuously checking the precision of the work in progress. It is important to use the correct tools for a particular job, keep them clean after use and to maintain them in good working order.

Good quality handles are important for both safety purposes and ease of use. They need to be tightly fastened, smooth and have the correct length and shape for a firm grip. Cutting and splitting edges of mason hammers, chisels, hoes, pickaxes and crow-bars should always be kept sharp.

Typical tools to be used by rural masons include three types, namely measuring tools, mason's work tools and common construction tools.

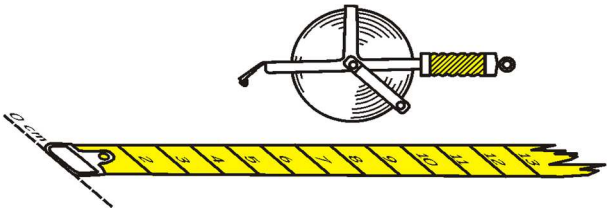
Measuring tools

Tape measures



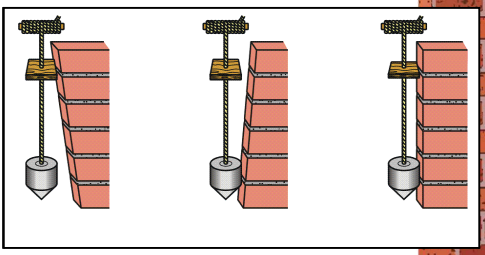
Measuring tapes come in different lengths. The three metre steel tape is commonly used for measuring short distances. Select a tape with both Metric and Imperial units of measurement.

Longer measuring tapes can be of different lengths ranging from 10 metres to 30 metres. Care must be taken not to damage the ring at the end of the tape where the 0-point is.



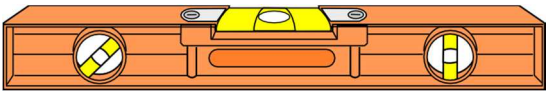
Plumb bob

The plumb bob is used to check whether a surface is vertical. The string is held between two fingers, with a distance plate square against the surface to be checked. Whether a wall is vertical is established by comparing the surface of the wall with the plumb bob string.



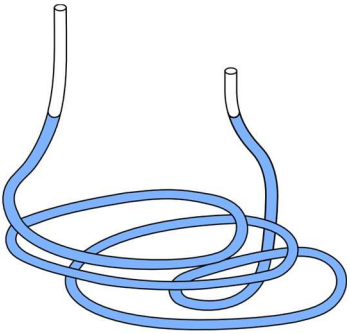
Spirit level

The spirit level is used to check both horizontal and vertical surfaces. The vials of the level indicate the horizontality or verticality of a surface depending on the position of the air bubbles inside. Although the spirit level can be more efficient for checking small vertical surfaces, a plumb bob would be more appropriate for a larger surface.

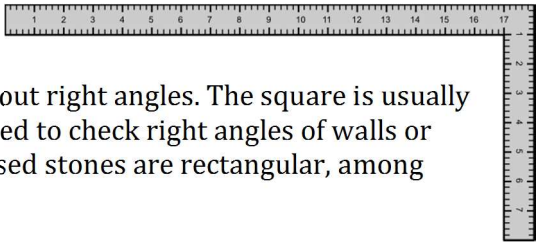


Water tube level

The water tube level (or pipe level) is an ideal instrument for transferring levels on a building site. It can also be used around corners where there is no direct sight. The level is made of a transparent hose filled with water. Scale markings can be made on staffs to allow for level readings.



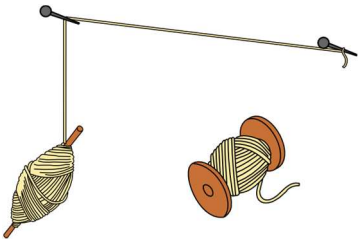
Mason's square



The mason's square is used to check or set out right angles. The square is usually made of steel and is used to check right angles of walls or to check whether dressed stones are rectangular, among others.

String with pegs (mason's line)

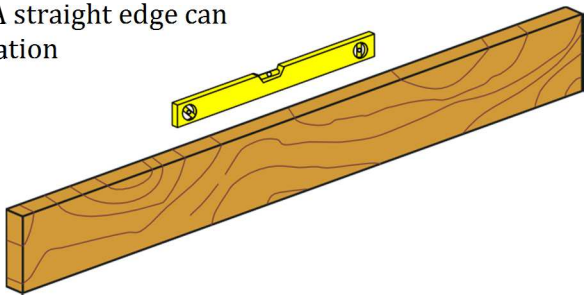
The mason's line allows for the laying of level and straight courses of bricks, stone or concrete blocks. A string, stretched between two pegs, guides the mason to follow a straight and horizontal line when laying a course of bricks, blocks or stones.



The string is also used to set out the position of the house, to establish its corners and exact location of foundations and walls. When excavating foundation trenches, a string line can be used to indicate the exact location of the trench.

Straight edge

The straight edge is useful when transferring levels over a short distance, levelling surfaces or checking the evenness of a surface. Straight edges can be of wood (a straight timber board) or light metal, such as aluminium, and should ideally be about 1.5 to 2 metres long. A straight edge can be used in combination with a spirit level to transfer levels and check that a wall is even and vertical.



Standard masonry tools

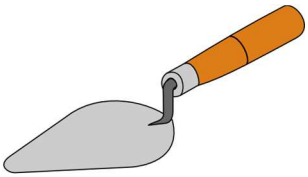
Mortar pan

Mortar pans are made of steel or plastic and used to hold mortar, ready for use, within the reach of the mason. The mortar pan should be cleaned out, washed and dried after each use.

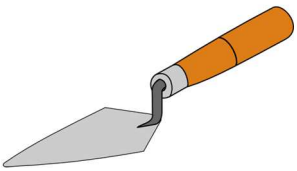
Trowels

For masonry work there are principally two types of trowels, the brick laying trowel and the pointing trowel.

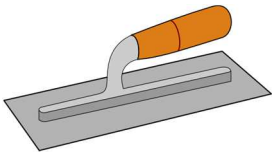
The brick-laying trowel is used to place and spread the mortar. It has a broad steel blade and usually a wooden handle.

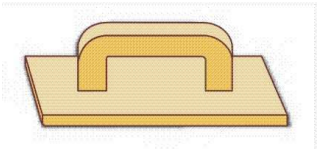


The pointing trowel has a narrower and pointed blade and can be used to place mortar where the stone-laying trowel is too large. It is also used in jointing work for pressing mortar into the joints.



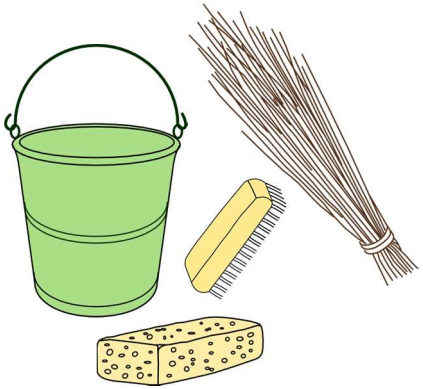
Floats are made of wood or metal. They are used to hold small portions of mortar, for example when pointing or filling small holes with mortar. Floats are also used to level mortar or concrete surfaces, for example slabs, wall crowns, etc.





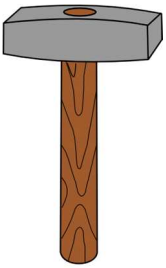
Brooms, brushes, buckets and sponges

The work areas should be left clean with no mortar on the ground when the job is completed. A metal brush is used to clean bricks and stone. Only clean bricks and stone should be used. All bricks and stones are somewhat porous. Before they are placed, stones are dampened with clean water to prevent them from drawing water from the mortar. A sponge is useful for the final cleaning of completed walls after pointing.



Club and mason's hammers

The club and mason's hammers are essential tools to cut and shape stone, bricks and blocks. The club hammer is mainly used in combination with chisels, but can also be used for rough shaping of rock and bricks.



Club hammer

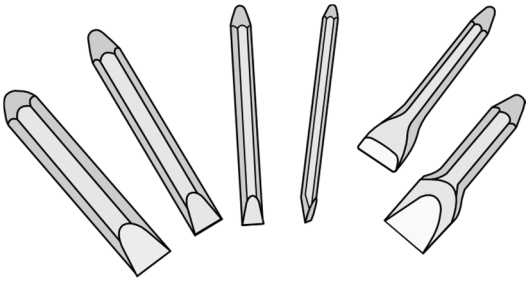
The mason's hammer has a sharp end and is therefore more accurate for cutting bricks and stone. It needs to be sharpened from time to time.

Mason's hammer

Both hammers are fixed with a proper wooden handle that does not splinter and provides a good grip. Metal handles are not recommended as they can easily strain your wrist.

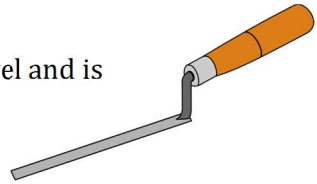
Chisels are mainly used to cut and dress stones. The most common types used by masons are point chisels (with a sharp point at the end) and the flat chisels (with a flat but sharp blade at the end).

Chisels need to be sharpened from time to time. The best sharpening quality is achieved if forged by a blacksmith.



Jointer

The jointer is formed like a narrow trowel and is used to 'point' the joints.

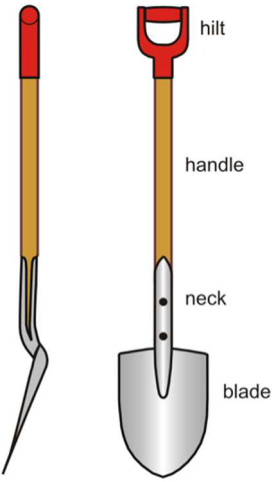


Common construction tools

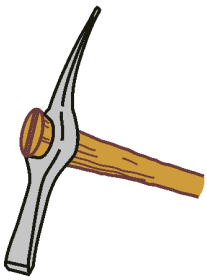
Besides the specialised mason's tools there are also some other hand tools that are required on site, for activities such as excavation work, mixing of mortar and concrete, preparing formwork, etc.

Shovel and pickaxe

A commonly used shovel has a round mouth blade and a wooden handle with a cross-grip at its end. A shovel to be used for construction works needs to be heavy duty.



pickaxe

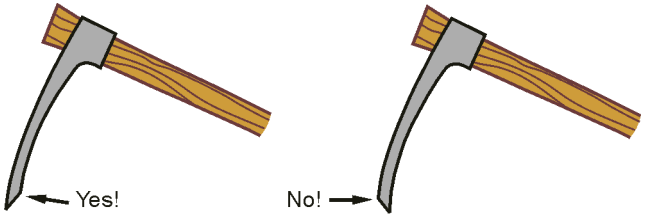


The pickaxe is a construction tool with a head that is sharply tipped on one side and has a flat and sharp end on the other side. The handle is of hardwood.

Shovels and pickaxes are mainly used for excavation works. The shovel is also used for mixing mortar and concrete.

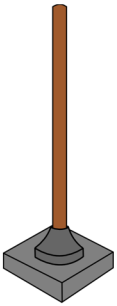
Hoe

The hoe is a common tool for excavating soft and medium-hard soil. It is basically an agricultural tool but also used on construction sites. The blade should be of hardened steel and needs to be sharpened once in a while. The handle should be of smoothened hard wood and securely fixed to the blade.

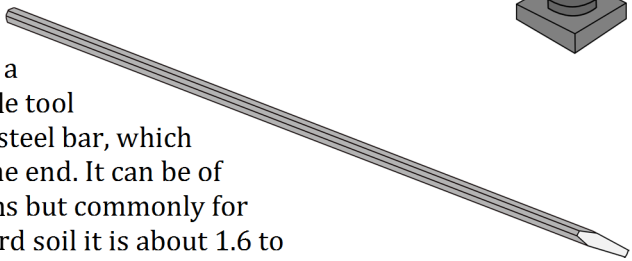


Earth rammer

Earth rammers are used to compact small areas, such as the backfill of foundation trenches. To achieve good compaction, the thickness of the layers of soil should not exceed 8 - 10cm. A good rammer should weigh at least 10kg.

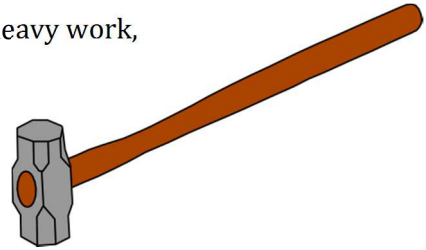


Crowbar



The crowbar is a relatively simple tool consisting of a steel bar, which is pointed at one end. It can be of different lengths but commonly for breaking up hard soil it is about 1.6 to 2 metres long.

Sledgehammer



Sledgehammers are used for heavy work, mainly for breaking stone and when hammering split wedges into rocks. The hammerhead should have a weight of about 4 to 4.5 kg, made from hardened carbon steel. Both sides are usually flat. The handle is preferably of hardwood and about 80 to 100cm long.

Additional tools

Besides the tools mentioned above, the following items are useful on a building site:

- Pair of pliers for tying reinforcement bars,
- Bending table or stand with bending levers for bending reinforcement bars,
- Carpenter saw for preparing shuttering and scaffolding,
- Batching box for measuring cement, sand and aggregate for mixing,
- Vibrator for mechanical compaction of concrete, if available.

1.7 Construction materials

Sand is used when mixing mortar and concrete. Mortar is a mixture of sand, cement and water while concrete consists of cement, sand, stone and water. The sand should be:

✓ Clean - free from dirt and

organic material

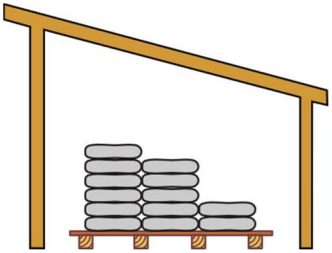
- ✓ Containing a limited amount of clay (not more than 8%)
- ✓ Grains should be of a certain size, not bigger than 2.36mm and not smaller that 0.15mm. Use a sieve to separate larger particles and debris.
- ✓ Beach sand should never be used for mortar and concrete as it contains salt. Salty water reduces the strength of concrete.

Quarry dust may be used in places where sand is not available for certain purposes, e.g. cement mortar.

Stone of different sizes is a key ingredient in concrete, providing its compressive strength. Stone should be clean, free from dirt, clay, organic material and dust. Two sizes of stones are commonly used:

- Fine = 12.5mm to 20mm
- Coarse = 25mm to 40mm

Cement is the binder in mortar and concrete. It is usually supplied in bags of 25kg or 50kg and should be marked ISI. Do not use cement older than three months as it has lost some of its strength. Cement bags should be carefully handled and kept dry at all times. Bags should be stored dry and in a well ventilated room, thereby avoiding moisture.



Water is a key ingredient in mortar and concrete. It is also essential for curing mortar and concrete.

- Water should be clean. It can be taken from rivers, lakes, wells and taps.
- Salt water, surface run-off water and water with other chemical or organic impurities should never be used.
- Dirty water with organic particles can be poured into a drum and used once such particles have settled at the bottom (use only the clean upper part of the water).
- Water on site is best kept in drums.

Bricks are manufactured from burnt clay and used for a variety of building structures. For rural houses they are mainly used for constructing the walls.

- The bricks should be uniform in size, (conventionally 22.5cm x 10.5cm x 7.5cm) but can vary in size and shape from area to area. All sides should be straight and rectangular to each other.
- Bricks should be without cracks and should not easily break (for testing drop a brick from shoulder height).
- Brick should be free from holes, cracks, air bubbles, lumps, etc. Break a brick to check inside.
- The brick should be hard. When scratched with a sharp tool, no impression is formed on a good brick.
- Bricks are good if there is a clear ringing sound when two bricks are struck together

Concrete blocks

Solid and hollow blocks are commonly used for structures. For rural houses they are mainly used for constructing the walls. There is a large variety of products available.

Rubble stone is natural stone suitable for building walls, foundations and plinths. Stone for construction works should be:

- strong, without cracks,
- free from dust and dirt,
- of rectangular shape thereby making it ideal for masonry works,
- not too long, too flat or too round, making it difficult to use in construction.

Reinforcement steel

Steel reinforcement bars are used to increase the tension strength of concrete. Reinforced concrete is used for roof slabs, lintels and where necessary for foundations, beams and columns.

High strength steel bars are commonly used in construction.

Timber is commonly used for formwork, scaffolding and in roof trusses. Frames for doors and windows can be made from hardwoods.

- Timber for shuttering and formwork should be plain, clean and without holes.
- Timber for frames and doors should preferably be of hardwood, plain and clean. It may be necessary to treat frames against termite infestation.

1.8 Safety on site

Work on construction sites needs to be organised in a manner, taking adequate precaution against potential dangers and thereby ensuring that accidents and injuries are avoided. Some hazards are not obvious and may only result in injuries after some time.

Organize the site layout for efficient and safe work

When commencing a new building project, it is useful to prepare a site layout. A badly planned and unmanaged site is one of the root causes for many accidents. Accidents may occur due to fall of material, collisions between workers and material or due to obstruction from unfinished building components. Therefore, the site plan should include adequate space for storage of materials, tools, sand and aggregate, work areas and where rubbish should be disposed. A well planned building site not only improves safety on site but also increases work productivity.

Protective clothing

Workers on building sites are at risk of falling objects that may cause serious injury. Wearing a helmet (also called a hard hat) is then a must.

Facemasks protect from inhaling unhealthy dust. Over time, stone and cement dust entering the lungs may have a severe impact on your health.

Eyes need protection, particularly when chiselling, grinding and cutting stone. Chips and splinters can severely damage your eyes and therefore it is necessary to wear protective goggles. Goggles are also useful when mixing and pouring concrete.

Safety construction boots and gumboots protect against sharp objects penetrating the sole and from falling objects. Sandals or slippers should not be allowed.

Gloves should always be worn when working with rough objects, cutting material or working with cement.

Protective clothing should be issued to all workers. The durable material used in work clothing protects from scratches and minor cuts. Bright colours with reflective bands allow the workers to be easily spotted by vehicles and fellow workers.

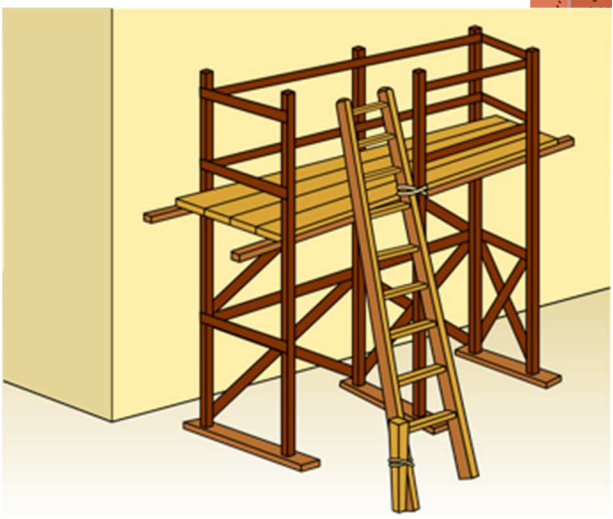
Working at heights

Guardrails are one of the most effective measures to prevent accidental falls from heights on any building site. They may be used on the edges of buildings and on scaffolding, as well as next to deep excavations. Excavations for pit latrines are best protected by covering them.

Ensure that the ground is level and is stable to support the scaffold. Start erecting from the bottom to the top (or, if dismantling, from the top to the bottom). Scaffolds need a strong working platform to ensure they can be used safely, supporting both workers and materials.

Make sure the structure is stable by adding sufficient bracing. The scaffold should be secured to the building in enough places to provide sufficient support to prevent it from overturning. Make sure the scaffold has strong guardrails on the outside to prevent accidental falls.

Ladders should be in good condition and safely secured. Wobbly ladders with the wrong height and not properly anchored can cause serious accidents. Ensure that ladders are placed at an angle of about 70 degrees and that the top of the ladder extends at least one metre over the platform. Check that all the steps of the ladders are strong enough and there is no damage or cracks.



Safe lifting of heavy objects

Lifetime injuries are often caused on construction sites because of wrong lifting of heavy objects. Do not attempt to lift by bending forward.

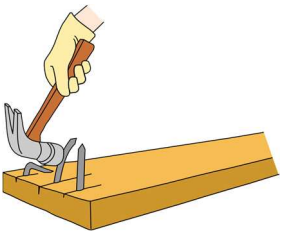
Bend your hips and knees to squat down to the load, keep it close to your body, and straighten your legs to lift. Never lift a heavy object above shoulder level. Avoid turning or twisting your body while lifting or holding a heavy object.

Do not lift heavy objects of more than 30kgs alone, but ask for help.

Keep the work site tidy

Keep the site clean and free of debris. Keep access roads and walkways clear, allowing for easy and safe movement and transport of building materials.

Pay special attention to removing nails and other sharp materials that can cause serious foot injuries. Allocate sufficient time to tidy up the worksite at the end of each day.



Tools and materials need to be sorted and stored safely. Stacks of materials should not be taller than the human height and

organised in a manner that lifting materials is possible without causing physical injury to anyone.

Tools and equipment

Machines used on building sites, such as electric saws, cutters, grinders and cement mixers, should when possible be used at designated work areas, allowing for safe distance from other workers. Make sure tools and equipment are clean and well maintained and ensure that there is safe wiring and connections for electricity supply. Use the appropriate protective gear when using various tools.

First aid

A complete first aid box should be kept on every construction site and available all times. In case of an emergency, it is important to know where the nearest hospital or doctor can be found or called. Keep the phone number ready.

Drinking water

Sufficient and clean drinking water should be available on site. Make sure there are extra supplies of water when works take place in hot weather. No alcoholic drinks or drugs are allowed on a site.

Daily personal safety habits:

Every day before starting work, make sure that:

- ✓ Safety gear is readily available, such as helmet, gloves, goggles, dust masks and protective shoes.
- ✓ The first aid box is on site and it is well stocked.
- ✓ Clean drinking water is available.
- ✓ All the material is properly stacked and well off the walking paths and work areas so as not to hinder free and safe passage.
- ✓ All tools on site are well maintained and in good working order before use.
- ✓ Scaffolds are secure and railings are fixed on the open sides.

All workers should be informed about the necessary safety measures on site.

1.9 Construction measurements and calculations

Metric units used in construction works

Most construction works rely on units of measurement based on the Metric System. This is also called MKS (Metre, Kilogram, Second) system. Besides the Metric System there are also other systems in use, such as the Imperial System. This is also referred to as the FPS (Foot, Pound, Second) system.

The table below shows commonly used metric units, their standard abbreviations as well as conversions between units.

Common units of measurement			
	Unit	Abbreviation	Example
Length	Kilometre Metre Centimetre Millimetre	km m cm mm	5 kilometres = 5km = 5,000 m 3 metres = 3m = 300 cm 50 centimetres = 50cm = 500 mm 250 millimetres = 250mm
Area	Square metre	m^2	10 square metres = $10m^2$
Volume	Cubic metre Litres (liquids)	m^3 l	2 cubic metres = $2m^3$ = 2,000 litres 3 litres = 3l
Weight	Tonne Kilograms Grams	t kg g	2 tonnes = 2t = 2,000 kg 3 kilograms = 3kg = 3,000 g 100 grams = 100 g
Density	Kilograms per cubic metre	kg/m^3	2 kilograms per cubic metre=$2kg/m^3$

The general term 'length' is used to define linear measurements. The standard unit for length is the metre (m). For shorter lengths, the centimetre (1m = 100cm) is commonly used which in turn can be subdivided into millimetres (1cm = 10mm). Longer distances are measured in kilometres (1000m = 1km).

For building works the common measurements are 'metres', 'centimetres' and 'millimetres'.

The table below describes the relations between these metric measurement units of lengths:

Conversion of lengths in the Metric System

Unit	Millimetre (mm)	Centimetre (cm)	Metre (m)	Kilometre (km)
1mm	1	0.1	0.001	
1cm	10	1	0.01	
1m	1,000	100	1	0.001
1km	1,000,000	100,000	1,000	1

Imperial units used in construction works

Some measurements may be indicated in the Imperial System using *inches, feet* and *yards*. For longer distances, *miles* are used. For building works, the units *inches* and *feet* are commonly used.

Converting lengths in the Imperial System

Unit	Inch	Foot	Yard
1 Inch	1	0.0833…	0.0277…
1 Foot	12	1	0.333…
1 Yard	36	3	1

Both measuring systems are used in building works. At times, it is therefore necessary to convert units of measurement from one system to the other. The table below describes how Metric and Imperial units compare.

Conversion between Metric and Imperial units

1 metre = 3.28 feet = 39.3701 inches
1 centimetre = 0.29 inches
1 millimetre = 0.039 inches

1 foot = 0.3048 metres = 30.48 centimetres
1 inch = 0.0254 metres = 2.54 centimetres = 25.4 millimetres

When purchasing a measuring tape, make sure it has both Metric and Imperial units.

Areas

In the Metric System a m^2 is the measure of an area of a square having sides whose length is 1m. Consequently every unit of length can be converted into an area if it is multiplied by itself. Therefore:

mm x mm = mm^2	cm x cm = cm^2	m x m = m^2	km x km = km^2

Other special units are:

10m x 10m = $100m^2$ = 1re	100m x 100m = $10,000m^2$ = 1hectare

It is always advisable when working out areas to make sure that all units are the same.

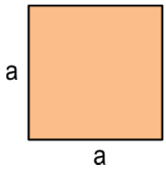
Conversion of areas

	mm^2	cm^2	m^2
$1mm^2$	1	0.01	0,000001
$1cm^2$	100	1	0,0001
$1m^2$	1,000,000	10,000	1

To convert the area to one unit higher multiply it by 100 and from a higher to a lower unit divide it by 100 as shown in the table above.

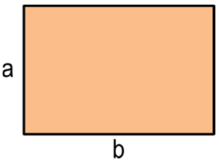
The table below shows how to calculate the area of common geometrical shapes.

CALCULATING AREAS

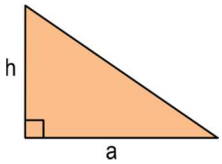


Square:

a x a

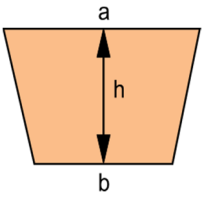


Rectangle: a x b

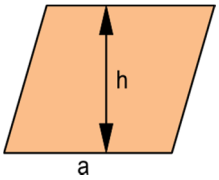


Triangle:

$\frac{a \times h}{2}$

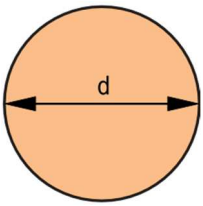


Trapezoid: $\frac{a + b}{2} \times h$



Rhombus:

a x h



Circle:

Area = $\frac{d^2 \times \pi}{4}$

or

Area = $\frac{22}{7} \times \frac{d}{2} \times \frac{d}{2}$

Circumference = d x 22/7

Volumes

In the Metric System, a cubic metre is a measurement of volume, representing a cube where all sides measure 1m by 1m. Volumes are calculated by multiplying a base area (e.g. m^2) with a third dimension. Therefore:

$mm^2 \times mm = mm^3$	$cm^2 \times cm = cm^3$	$m^2 \times m = m^3$	$km^2 \times km = km^3$

The most important units for construction works are cm^3 and m^3.

To change a volume from one unit to the next lower or higher one, multiply or divide the quantity by 1000 respectively.

Conversion of volumes

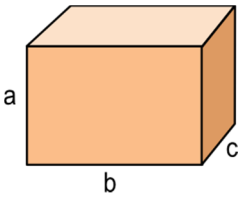
	cm^3	dm^3 (1 litre)	m^3
$1cm^3$	1	0.001	0.000001
$1dm^3$	1000	1	0.001
$1m^3$	1,000,000	1,000	1

Calculating volumes

Rectangular prism (box)

The calculation of various size boxes is most common in construction works. For example it may be necessary to calculate the volume in a gauge box, the volume of concrete required for a roof slab or the quantities of earth to be excavated for a foundation.

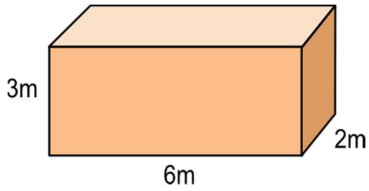
Calculation Formula:



Rectangular prism:

$V = a \times b \times c$

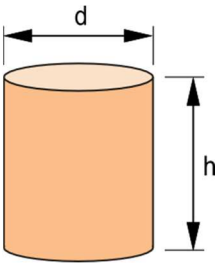
Example:



Volume = 3m x 6m x 2m = $36m^3$

Cylinder (drum)

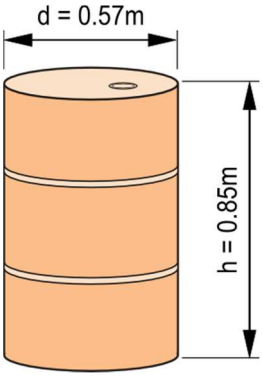
Cylindrical forms are also common in construction. For example most containers containing liquids are cylindrical.



Calculation formula:

$$V = \text{Area} \times h = \frac{22}{7} \times \frac{d^2}{4} \times h$$

Example:



Volume =

$$\frac{22}{7} \times \frac{0.57^2}{4}\ \text{cm}^2 \times 0.85\text{m} = 0.217\text{m}^3$$

= 217 litres

Section 2
Setting out construction works

2.1 Interpreting construction drawings

Construction drawings describe the exact positions, dimensions and levels of essential structures, e.g. walls, windows, doors and columns. The drawings also show the exact measurements of these elements and describe the materials to be used. Construction drawings for private housing usually consist of:

(i) *Plan:* showing all walls and openings as seen from above (bird's eye view) with dimensions.
(ii) *Section:* showing levels, dimensions and construction details in a vertical view (as if cut through with a knife). To show all

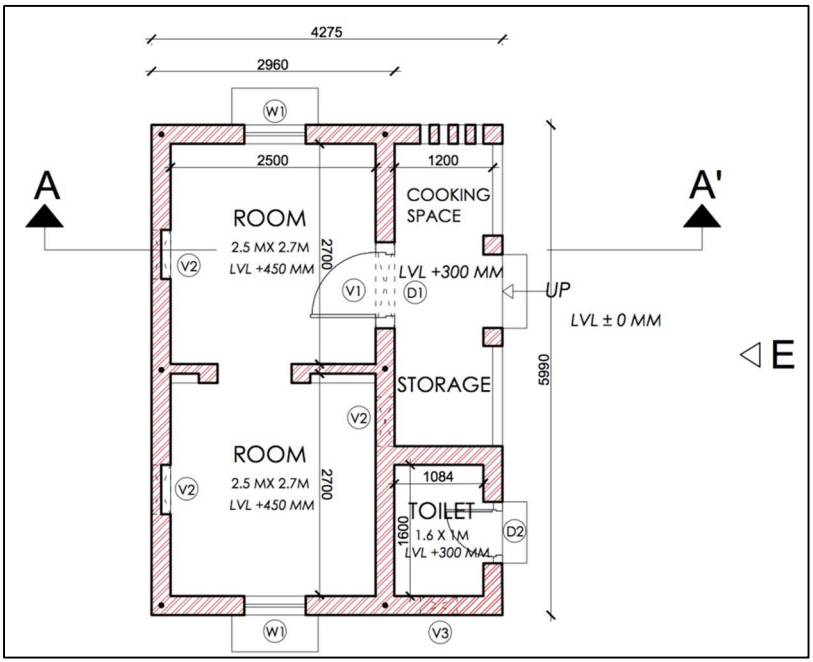
the important details of a structure, several sections may be required.

(iii) *Elevation*: showing the outside (face) of the building.

Plan drawings

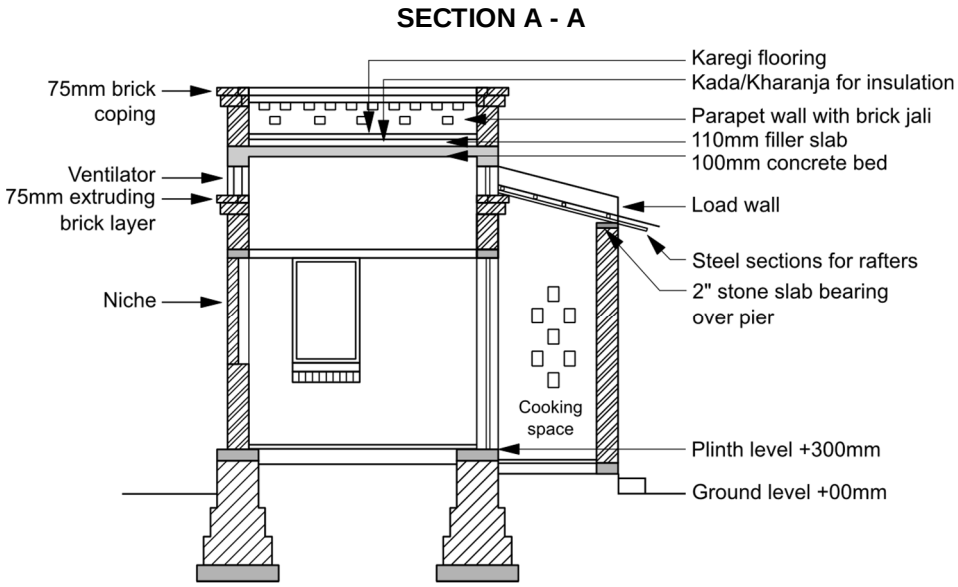
The plan is the view seen when looking directly down from above. It provides information about:

- Overall length and width,
- Dimensions of parts of the construction,
- Position and size of windows and door openings,
- Function of areas and position of elements such as kitchen, toilet, etc.,
- Scale of the plan.



Section drawings

It is often necessary to show all the details of a building - including those that are normally hidden. To do this, imagine that the building has been cut through or sectioned. The position of a section is indicated on the plan using a section line.



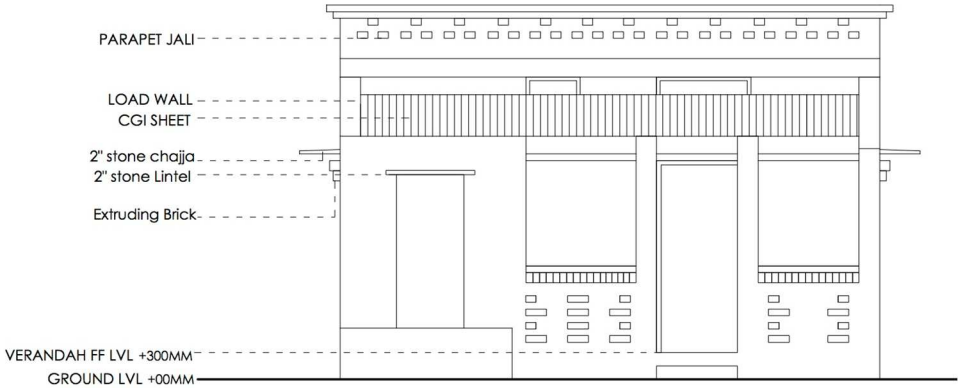
A section view differs from an elevation, as it shows the details through the construction. It can provide information about:

- the shape and size of the foundation,
- positioning of reinforcement steel,
- floor and ground levels,
- roof structure,
- the position and dimensions of windows and doors.

Elevation drawings

An elevation is the view from one side of the house when looking at it from outside. It provides information about:

- shape of the building from each direction,
- height of the construction,
- positions and dimensions of doors and windows, roof shape.



2.2 Setting out

Setting out consists of establishing the exact position and measurements of the house and its components according to the dimensions specified in the drawings. Before commencing setting out works it is useful to clear the ground of any debris, vegetation and other obstructions. Ideally, the ground should be level, although in hilly areas houses can also be built on slopes.

The first step is to determine the exact location of the house by establishing the precise positions of all corners of the building. This is usually done by fixing reference points located outside the actual perimeter of the house. From these fixed reference points

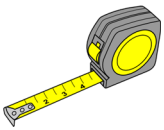
it is possible to re-measure and check the exact position of the foundation and main walls.

Following the measurements found in the construction plan, the building is set out with reference points marked on stone or brick *pedestals* that indicate the exact location of the centre lines of the main walls. From these points the corners of the house are transferred to the actual location. It is important to check that the corners are set out in an exact right angle. Once the position of the corners has been established, the building perimeter is actually already determined and the centre lines of the outer walls can be marked using string lines.

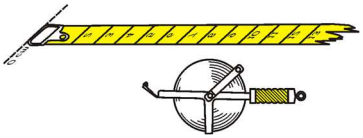
Simple methods can be used for this activity as shown in Worksheet S1.

Measuring tools for setting out:

Steel tape (3 metres)

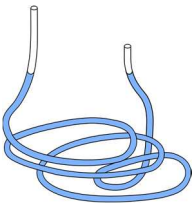


Measuring tape

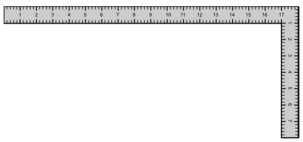


Plum bob

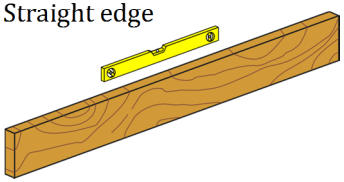
Water tube level



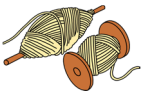
Mason's square



Straight edge



String and pegs



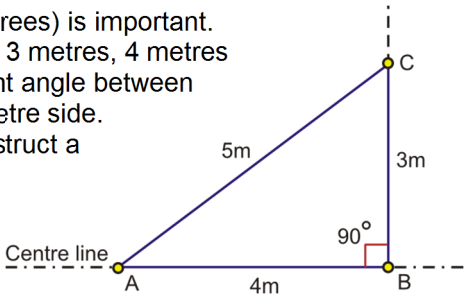
Spirit level

Worksheet
Setting out a right angle

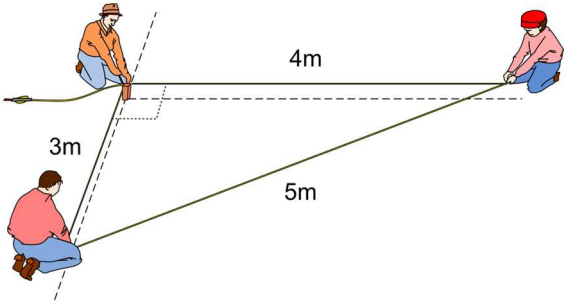
S1

Work method:

Ensuring right angles (90 degrees) is important. A triangle with sides of length 3 metres, 4 metres and 5 metres, produces a right angle between the 3-metre side and the 4-metre side. One can therefore easily construct a right angle using only a tape measure as follows:



1. Measure the length A to B of 4 metres along the centre line from where a perpendicular line needs to be defined. Place pegs exactly at points A and B.
2. Hold the zero point of the tape measure on the peg A.
3. A second person holds the 8.0 metre mark on the tape at peg B.
4. A third person holds the tape measure on mark 5.0 metres, which will lead to point C when the tape measure is pulled tight. Set a peg on point C.
5. Extend the now perpendicular line from point B to point C to any length as required.



Labour:	**Tools:**	**Material:**
• Rural mason • Labourers to assist	• Tape measure • Hammer	• String • Pegs

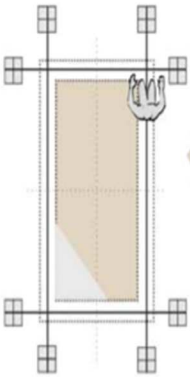
Quality checkpoints:

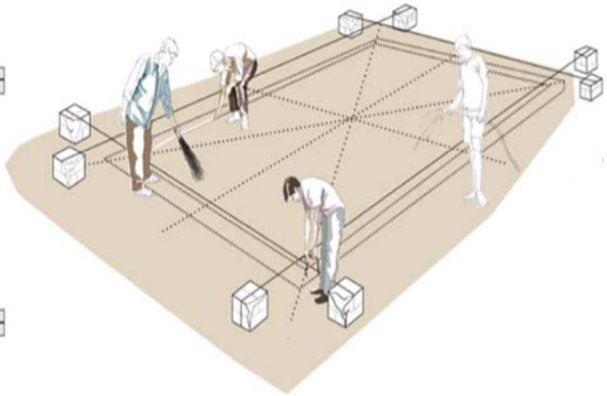
- ✓ After constructing the right angle check again that the triangle lengths represent exactly the 3:4:5 proportions.
- ✓ Ensure that all reference pegs are firmly fixed.

Worksheet
Setting out the building perimeter
S2

Work method:

1. Clear and level the ground where the house will be located.
2. Place solid pedestals on all corners, approximately 1.5 m away from the planned outside walls of the building.
3. Ideally all pedestals should be of the same height. Keep the string tight and well off the ground.
4. Mark the centre of the outer walls using a string line and tape measure. Fix the string tightly so it does not sag.
5. The string lines should cross each other at a right angle. Use the 3:4:5 string method to obtain the 90 degree angles for the house corners (ref. Worksheet S1).
6. Check the diagonals and ensure that they are of equal length.





Labour:	**Tools:**	**Material:**
• Rural mason • Labourers to assist	• Tape measure • Plumb bob	• Bricks or stone for pedestals • Cement mortar for pedestals • Strong string

Quality checkpoints:

- ✓ Make sure the pedestals are solid enough and do not easily shift.
- ✓ Check that the measured dimensions on the ground conform with the drawings.
- ✓ Check that all corners have a right angle and that the two diagonals are or equal length.

Transferring levels

Besides fixing the horizontal position of the corners and walls of the house, it is also necessary to establish the exact levels for each of the building elements. Usually, a benchmark ground level is used from where all other levels can be transferred and checked.

The water tube level is a simple and ideal instrument to transfer and check levels on building sites. Accurate measurements are possible, for example for building foundations, or to secure that lintels are placed at the same level. Equally, when the floors have to be cast to a uniform level, one can mark the respective level using the water tube all along the wall.

The water tube level is also an effective tool for transferring or checking levels over longer distances and around corners. For more confined masonry activities the use of a spirit level in

combination with a straight edge (wooden levelling plank) is usually more appropriate.

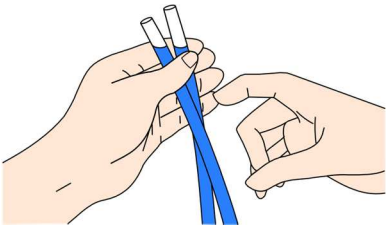
For checking levels when carrying out masonry works, the use of a spirit level is best suited, sometimes in combination with a straight edge for checking longer objects.

Worksheet
Transferring levels using a water tube level

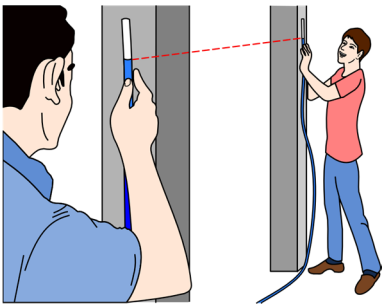
S3

Work method:

1. Use a transparent 10m long water tube and fill it with water.

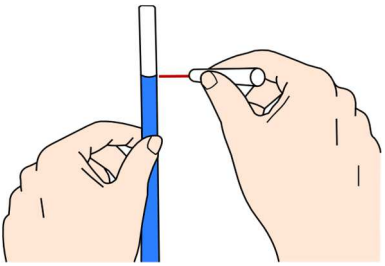


2. Hold both ends of the tube vertically so that no water escapes. Tap with a finger along the tubing to loosen and expel any trapped air bubbles. Hold the ends of the tube even with one another, and verify that the water lines up equally. Continue tapping the tube to remove any air bubbles.



3. Identify the reference level to be transferred to another location. Mark it clearly.

4. Have an assistant stand at the reference point positioning the tube so that the water line in the tube is exactly on the marked reference level.



5. The level of the water line can now be marked wherever required. For example, mark the level on a wall and measure from that mark any height that you need to define or check.

Labour:	**Tools:**	**Material:**
• Rural mason • Labourer to assist	• Water tube level • Tape measure and marker	None

Quality checkpoints:

✓ Use a transparent water tube without any kinks or other damages.

Section 3
Masonry works

Masonry works for rural houses consists of six distinct activities that follow each other in a logical construction sequence:

(i) Excavating trenches for foundations and backfilling after constructing foundations)
(ii) Constructing the foundations
(iii) Brick and block masonry works or stone masonry works
(iv) Installing doors, windows, lintels and ventilators
(v) Plastering of walls
(vi) IPS flooring

3.1 Excavation and backfilling for foundations

Foundations for houses need to be placed on firm ground that can carry the load of the building. Surface soils are usually unsuitable for supporting the foundation and therefore trenches are excavated to a depth where suitable firm soil is reached. The minimum depth of a foundation for a rural house should be 60 cm - even where soils are very hard. The trenches should be wide enough to accommodate the foundation and to provide sufficient working space.

Checkpoints for excavation works:

- ✓ Check and ensure that excavation is carried out to the required dimensions using the most appropriate tools.
- ✓ Check and ensure that the desired slope of earth is maintained during the digging activity and, if necessary, support the vertical sides of the excavation to avoid that trench walls collapse.
- ✓ Ensure that the soils are disposed away from the excavated trenches, using appropriate tools and equipment such as spades, wheelbarrows, pans, etc.
- ✓ Check for loose material, soil lumps, pebbles on achieving the desired earth level.
- ✓ Ensure that surface-dressing work is carried out by safely, disposing loose material, gravels, plant roots, sludge, muck or debris as per requirement at appropriate locations.
- ✓ Ensure adequate compaction of the base using hand rammers.

After constructing the foundations, the trenches are backfilled. Good quality material from excavation can be used. Surface soils or organic material should not be used. Backfilling is done in layers that are firmly compacted.

Checkpoints for backfilling works

- ✓ Check and remove gravels, oversized aggregate, organic matter from the soil prior to be used in backfilling as per site conditions.
- ✓ Ensure that soils are placed and spread maintaining uniform layers of maximum 10 cm thickness.
- ✓ Ensure that water is sprinkled uniformly over the layer to be compacted as and when required.
- ✓ Check and ensure that the compaction of the soil is carried out as instructed.
- ✓ Check to ensure that backfilling and compaction of excavated trenches, pits surrounding the structures or at necessary locations conforms to the work specifications.

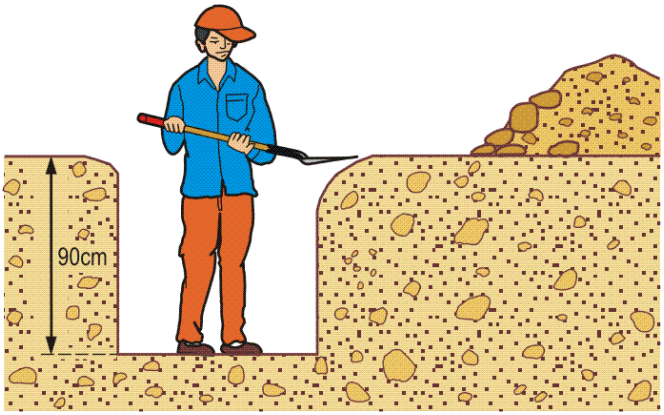
Worksheet
Excavating foundation trenches

Work method:

1. Set out the trenches to be excavated with pegs (width of the foundations plus working space of minimum 30cm on both sides), using the already established fixed reference points (refer to Worksheet S2 for details).

2. Assess the quality of the soil to determine whether the excavation can be done with vertical walls or whether safe slopes are required. You may have to dig a test hole to determine the soil quality.

3. First remove the topsoil and any debris plus organic matter, and deposit it away from the construction site.



Labour:	**Tools:**
• Rural mason for setting out and supervision • Labourers for excavation	• String line with plumb bob • Water tube and spirit levels • Tape measure

Quality checkpoints:

✓ Check the exact width and depth of the foundation trench.

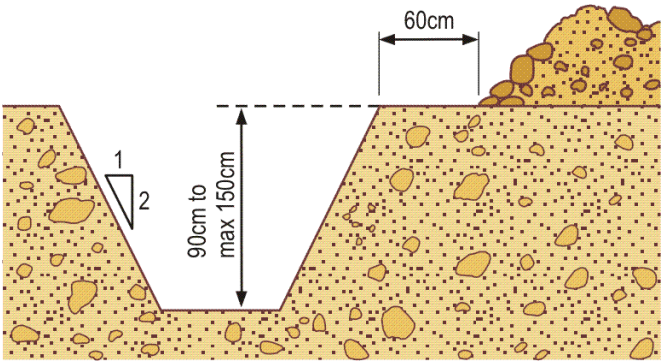
M1

4. Excavate the trench and deposit the material neatly at least 60cm away from the trench. The same material is later used for backfilling.

Take the necessary preventive measures to avoid the trench walls from caving in. With firm soil and where the trench is less than 90cm deep, the walls can be kept vertical. In less firm or wet soils where the trench is deeper the walls should be sloped. The slope angle depends on the soil quality but should not be less than 2:1.

Vertical walls or placing the excavated material too close to the trench can cause caving in of the trench walls. In shallow trenches this just creates additional work.

In deep trenches, this must be avoided by all means as it can severely harm the workers. In trenches deeper than 150cm, it may be necessary to support the walls from caving in.



- Shovels and hoes
- Crow bar and pickaxe for hard soil

Material:
None

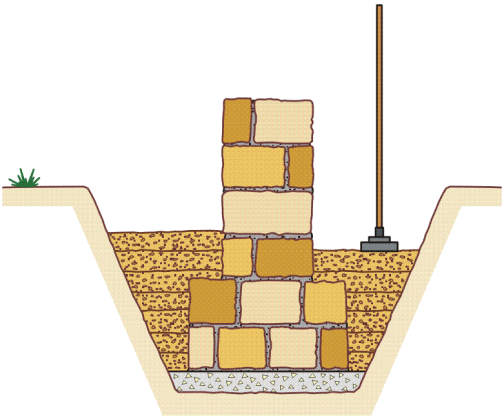
✓ Confirm level and horizontality of the bottom using a tube level.
✓ Check the evenness using a straight edge and a spirit level.

Worksheet
Backfilling foundations

M2

Work method:

1. Carefully fill deposited excavation material on both sides of the foundation in layers not exceeding 10cm. Use a rake to spread and level the loose material to form a uniform layer.
2. Moisten the backfilling soil if it is dry by sprinkling it with water.
3. Compact each layer with an earth rammer until properly compacted. Take care not to damage the foundation.
4. Continue layer by layer equally on both sides until reaching the desired level – usually slightly higher than the level of the surrounding terrain.
5. Dispose of excess excavation material at a safe location away from the work site.



Labour:	**Tools:**	**Material:**
• Rural mason for supervision • Labourers for backfilling and compaction	• Shovel • Rake • Earth rammer	• Excavated material of good quality for backfilling • Water to moisten the soil, if too dry.

Quality checkpoints:

- ✓ Check and approve the material to be used. Check its moisture content. If the soil is too dry, sprinkle water before compacting.
- ✓ Continuously check the thickness of the layers.
- ✓ Check achieved compaction degree before placing the next layer.

3.2 Constructing foundations

After excavating the trenches the actual foundations can be constructed. For rural houses these are mostly strip foundations. Depending on the load bearing capacity of the ground, the size (width and height) of the foundations is decided. An engineer may need to approve the size and design of the foundation.

In most cases the house foundation can be constructed using bricks, cement blocks or rubble stone depending on the availability of such materials. However, it is important to use only good quality bricks, blocks or stone as the case may be.

Types of soils in foundations

The entire house rests on the foundation, and hence the foundation needs to reach a depth where a layer of firm ground is found. The minimum depth of a foundation for a rural house should be 60 cm - even where soils are very hard.

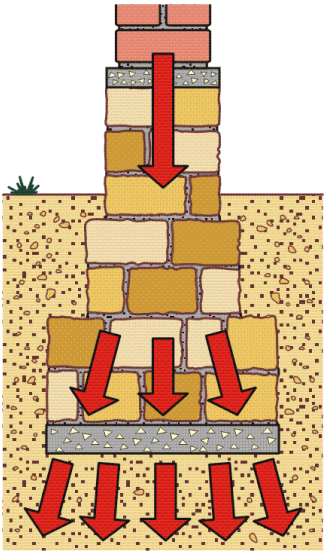
The ground upon which the house stands has a defined load bearing capacity, which depends on the nature of the ground. If the soil is wet the bearing capacity is reduced significantly. Therefore, foundations on wet ground do not fulfil the requirements for houses.

Suitability of soils in foundations	
Rock	Provides the best load bearing base. Instead of cutting rock, it can be levelled using lean concrete.
Gravel	Gravel provides the second best option. It has good bearing capacity and provides good stability for the structure.
Sand	Usually not recommended as a foundation bed as it requires a complicated and expensive foundation.
Silt, clay	It is not the preferable, if other options are available. Do provide a reasonable bearing capacity, if water is avoided from this foundation

The size of the foundation

The size of the foundation is designed according to the load bearing capacity of the ground on which the foundation rests. The load to be applied is the weight of the house, which the foundation needs to transfer to the ground.

The engineer or building site technician needs to carefully study the best location for the foundations and their design, taking into consideration any presence of ground water (the water table), old backfills or soft or muddy soils that can make the structure unstable.



Strip foundations, that support the weight of the entire wall, are the easiest and most common foundations used in house construction. The width of a strip foundation depends on the bearing capacity of the ground, and the thickness of the wall.

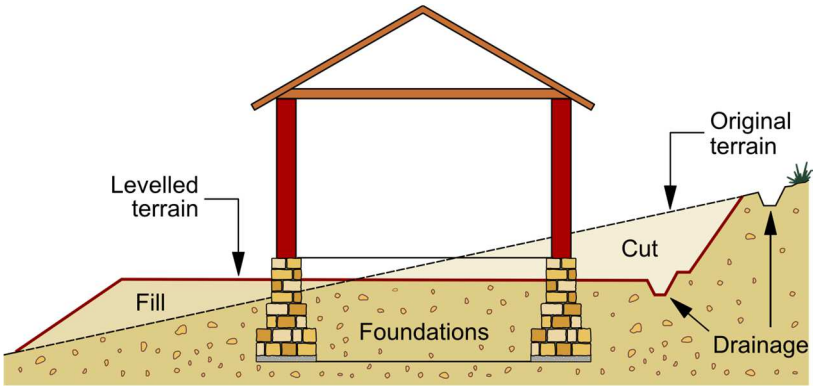
Foundations are generally twice as wide as the wall they are meant to support in order to distribute the load of the wall over as large a surface as possible within the ground.

Foundations in sloping terrain

Foundations always need to be level. Therefore, if the house plot is located in sloping terrain, the ground first needs to be levelled to secure the necessary space. This implies that part of the plot will need to be excavated, using the excavated soils as a fill. Since the original soils (in-situ soils) are usually more stable and already well compacted, avoid placing any part of the foundation on the fill. It is important that the foundations reach down to

undisturbed firm ground on all sides of the house. Fills have a tendency to continue consolidating even if properly compacted.

It is also necessary to drain water away from the house to prevent it running down into the foundations.



Foundation depths and width	
Depth of foundation	The depth of the foundation depends on the local conditions. It is recommended to use a minimum of: • 60 cm • Depth to hard layer of soils.
Width of the foundation	Depends on the load on the foundation, generally twice as wide as the wall they are to support in order to distribute the load of the wall over as large a surface as possible.

Checkpoints when constructing foundations:

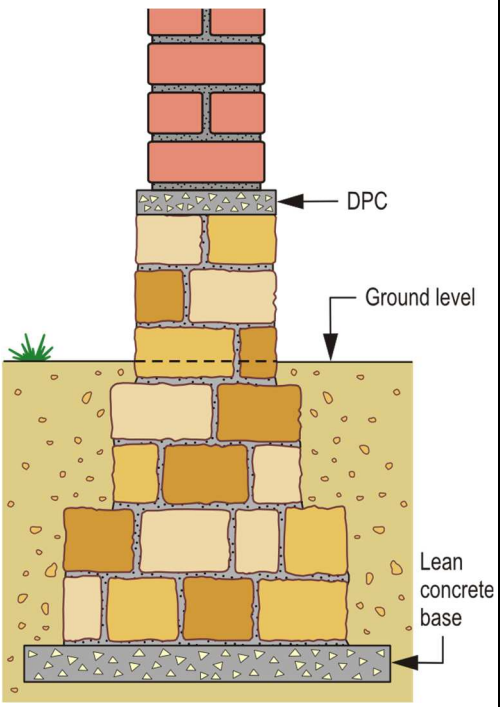
✓ The soil of the foundation bed should be uniform. If this is not the case, it is better to shift the building to a location where the soils are uniform.

- ✓ The foundation bed should be horizontal and level. In many places the house is built on sloping ground. Before excavating the trenches, it is common practice to first establish a level surface on which the house is built. Excavated soils may be used as fills to extend the level area. Foundations, however, need to reach down to firm ground below the depth of any landfill.
- ✓ The depth of the foundation below the ground depends on the nature of the soils available. Topsoil including organic matter should be removed.
- ✓ Erosion of the foundation has to be carefully considered. Precautionary measures have to be taken to drain the rainwater around the structure so that it cannot expose the foundation and affect it.
- ✓ In cold climates, the foundation needs to be deep enough to avoid that the foundation bed freezes. Freezing causes the expansion of the soil, which creates a strong force that can lift up the structure and cause cracks in the foundation and walls.
- ✓ Ensure that the foundation trench is clear from any loose material or debris.
- ✓ When the excavation is complete, the foundation should be built as quickly as possible, especially during the rainy season (to prevent swelling of the ground due to rainwater or caving in of the trench walls).

Worksheet
Building the foundation up to plinth level
M3

Work method:

1. Ensure that the bottom of the foundation trench is clean, dry, level and to the correct depth. Compact any soft spots with an earth rammer. *For excavation trenches, refer to Worksheet M1.*
2. Check the levels again using a tube level. Mark the level in the trench corners as a benchmark for (i) the lean concrete base and (ii) the levels for each course of bricks or stone. Fix a string between the marked corners as a guide for each course of stone.
3. At the bottom of the trench place a 5 cm layer of lean concrete (1:5:10).
4. Lay the first course of stone, bricks or blocks. Make sure all joints are fully filled with mortar before adding the next layer.
5. Complete sufficient courses to reach up to ground level using a mortar mix of 1:6. *Refer to Worksheets M4, M5, M6, M7 and M8 for details on masonry works.*
6. Add two more courses up to plinth level, reaching some 50 cm above ground level.
7. Place a Damp Proof Course (DPC) of 5 cm. This needs to be watertight. Use a 1:2:4 mix proportion with 12 mm stone, and add an aqua-proof compound in the rate of 1 kg per bag of cement.



Worksheet (continued)
Building the foundation up to plinth level

M3

Work method - continued:

8. Ensure proper curing of the foundation and plinth wall by covering the works with moist gunny bags and regularly sprinkle with water. *For backfilling refer to worksheet M2.*

Masonry works for foundations should be performed with great care, skill and patience to ensure that the foundation is able to support the house and protect the walls from moisture from the ground.

Labour:	**Tools:**	**Material:**
• Rural mason • Labourers to assist with preparing material	• Shovel, rake and earth rammer • Straight edge and spirit level • Complete masonry tool set • Water tube and spirit level • Measuring tape	• Lean concrete for base, 1:5:10 • Random rubble stone for foundation • Dressed stones for plinth • Mortar • Aqua-proof compound • String

Quality checkpoints:

- ✓ Make sure level of the foundation bed is correct and that the soils are firm and compact.
- ✓ Ensure all stone is of good quality and contain no cracks.
- ✓ Check that the mortar has a correct mix of cement and sand and correct water content.
- ✓ Verify that the position of the first foundation layer is correct, at the right level and width.
- ✓ Continuously check levels and position (vertical and horizontal) of each layer.
- ✓ The DPC layer should be level, smooth and cover the entire crown of the foundation/plinth.

3.3 Brick and block masonry works

Brick and block masonry is the core activity of a rural mason. The mason has to be able to determine the required wall and bond type in accordance with the drawings. The preparatory activities need to be carried out in a planned manner to secure the necessary tools, materials and labour before the works commence.

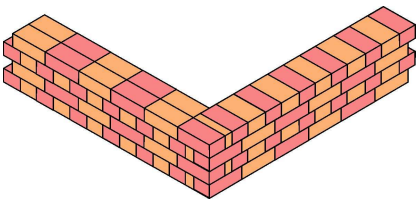
Wall and bond types

In rural housing works brick masonry is used for building:

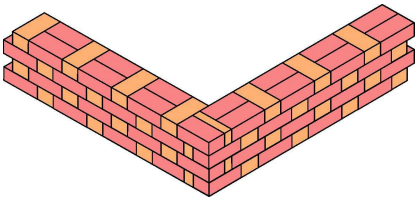
- *Load bearing walls* that carry the weight of the roof.
- *Non-load bearing walls* that do not carry any load but are merely there to separate rooms.
- *Columns* used in rural houses when walls are long and therefore require intermediate strengthening or in verandas.
- *Foundations and plinths:* These are the vertical extension of the foundations up to the level of the floor of the house.

The bonds between bricks are organised in a manner to avoid that the position of vertical joints in one course are in the same position in the next course. The staggering of the joints in each course, using various patterns, will increase the strength and cohesion of a wall. Common bonds used in housing works include the English bond, Flemish bond and the Rat-trap bond. Each of these bond types has different positioning of the bricks.

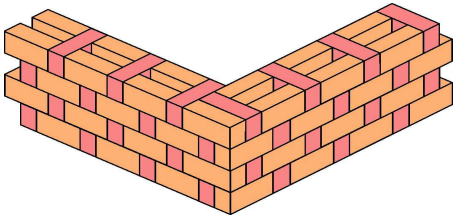
English bond



Flemish bond



Rat-trap bond



Rat-trap bonds are equally strong as English or Flemish Bonds. There are several advantages using the Rat-trap bond. It reduces the number of bricks by 25%. Equally, the consumption of mortar is reduced. Secondly, the voids acts as a thermal insulator, so inside temperatures have less variations, especially in extreme weather conditions.

Plastering of the exterior surface is normally not required when using a Rat-trap bond.

Checkpoints for preparing brick/block masonry works:

Before starting the masonry works, it is necessary to prepare the work. For this some planning is required on a daily basis.

- ✓ *Estimating the amount of material required:*
  - The number of bricks or blocks depends on the size of the wall, the type of bond and size of bricks or blocks. Also add 10% for wastage.
  - The amount of sand and cement depends on the size of the wall, type of masonry and preferred mortar mixture.
  - Water for mixing mortar and wetting the bricks or blocks.
- ✓ *Assembling tools and protective equipment for the job at hand:*
  - Standard mason's tool set for masonry works.
  - Measuring tools: tape measure, water tube level, straight edge with spirit level, mason's square, plumb bob, string (mason's line) with pegs or clamps.
  - Protective equipment: helmet, facemask, goggles, good boots and gloves.

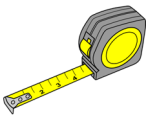
✓ *Setting out the walls:*

- Re-establish the wall corners and lines according to the site plan (drawings) using string line and a mason's square. Mark the external side of the walls on top of the foundation.
- Measure and mark where the openings (doors and windows) will be located.

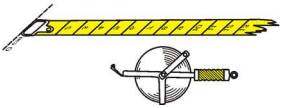
Countercheck the levels, e.g. the top of the DPC. This layer needs to be horizontal. If necessary make the first corrections to ensure the walls start with horizontal and uniform courses.

Standard tools for masonry work

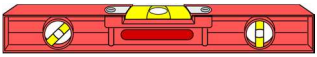
Steel tape (3m)



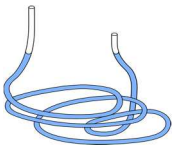
Measuring tape



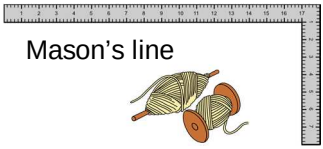
Spirit level



Water tube level



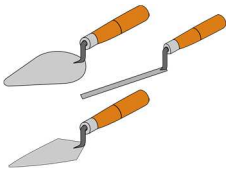
Mason's square



Mason's line

Plum bob

Trowels & Jointer

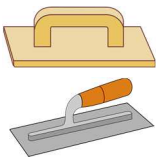


Stone mason hammer

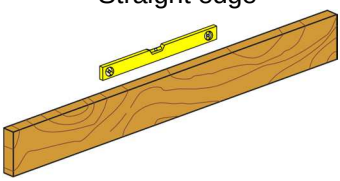
Mortar pan

Brushes, bucket & sponges

Floats

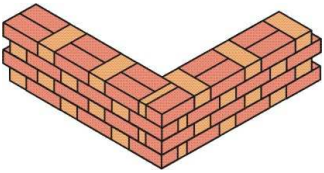
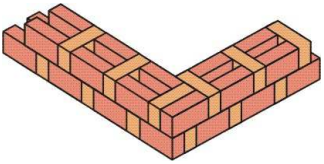


Straight edge



Materials for masonry works

Materials for masonry are essentially bricks and mortar, with the approximate material requirements for each cubic metre of brick wall as shown in the table below:

Material required for brick masonry	
Type	Material for 1m^3 of completed wall
English and Flemish bonds with mortar 1:6:  Width of joints = 1.2 - 1.5 cm Brick size = 22.5 x 10.5 x 7.5 cm	Bricks = No. 512 Cement = 48 kg (1 bag) Sand = 0.2 m^3
Rat-trap bond with mortar 1:6:  Width of joints = 1.2 - 1.5 cm Brick size = 22.5 x 10.5 x 7.5 cm	Bricks = No. 385 Cement = 36 kg Sand = 0.15 m^3

Cement mortar

Good mortar used for masonry works consists of cement, sand and water in correct proportions thereby creating a pliable mass that is easy to handle during the masonry works. The specification of cement mortar is defined in terms of the proportions of cement and sand. For example, the ratio of 1:6 implies that the mortar consists of one part of cement and six parts of sand.

Make sure the cement is still within its expiry date. Fresh cement produces a stronger mortar. Check that the cement is lump free and has not been damaged during storage.

The sand needs to be clean and of a certain grain size, small enough to pass through a 2.36mm sieve. It is often useful to separate debris, organic matter and oversize stones from the sand by sieving it. Best is to use river sand.

Water used for mortar needs to be clean. The best is to use potable water. Salt water cannot be used, as it will compromise the strength of the mortar.

Mortar for masonry works is commonly mixed by hand. You will need a clean and level surface for the mixing. Do not mix the mortar on the ground, as you do not want any soils in the mix. Alternatively, a large plastic tub will do the job. Smaller amounts can be mixed in a bucket.

When mixing mortar by hand, a uniform mixture of sand and cement is first prepared (turned at least 3 times), before adding water. Water should be added sparingly to avoid the mortar becoming too fluid. If too much water is added, the mortar not only looses its strength but also spills out when the bricks are positioned.

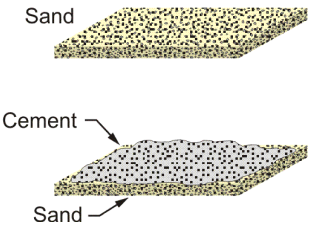
Since the mortar sets relatively fast, it should never be mixed in larger quantities that what can be used during the next hour. Do not use mortar that has already hardened.

Keep the mortar away from strong sun that may dry out the mix. A canvas to cover the fresh mix may be useful to protect it from excessive sun and wind.

Worksheet
Mixing mortar

M4

Work method:



1. Place and spread six parts of sand on a clean platform or hard surface.
2. Add one part of cement on top of the sand.
3. Thoroughly mix the sand and cement until a uniform grey mixture is achieved. The general rule is that sand and cement is mixed dry together at least three times before adding water. It is important to achieve a consistently uniform mix.

4. Rake the mix together and dig a well in the centre of the heap and carefully add water. Add the water in portions to avoid ending up with a too wet mix.

5. Carefully shovel the dry mix into the water in the middle of the heap and continue mixing until the mortar has a uniform mass with the preferred consistency.

Labour:	**Tools:**	**Material:**
• Rural mason • Labourers to assist	• Clean platform for mixing • Shovels • A measured box or buckets for batching • Water buckets	• Clean sand cement • Mortar • Clean water • Canvas to protect mortar from sunshine

Quality checkpoints:

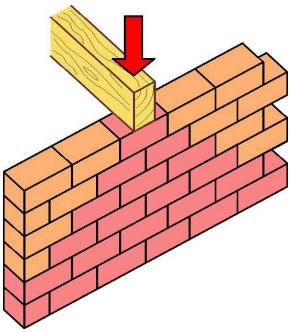
- ✓ Check that the cement has not expired and does not contain any lumps.
- ✓ Check that the sand is clean and with correct grain size.
- ✓ Ensure that the water is clean – do not use salt water.
- ✓ Check that batching is done correctly, to an appropriate amount and with the desired mix ratio.
- ✓ When mixing make sure the mortar is not too wet or too dry.
- ✓ Ensure that the mortar used is fresh.

Brick and block laying

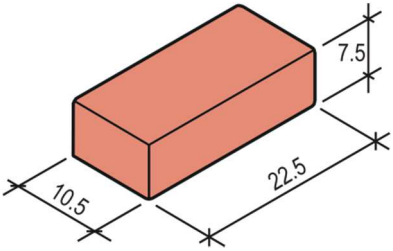
The art of masonry is the accurate laying of bricks or blocks by ensuring:

- ✓ correct measurements as per the drawings,
- ✓ accurate vertical lines (plumb),
- ✓ accurate horizontal lines,
- ✓ accurate levels.

The building methods for bricks or blocks are the same. Joints between bricks should never be in line with the joints in the course below. Good bonding between courses ensures that the forces applied to the wall are effectively distributed as shown in the figure below. The structure then remains stable and strong and functions as one unit. Unbounded or insufficient bonding results in vertical joints with the accompanying risk of failure.



The term bonding means the arrangements of bricks in which no vertical joint of one course is exactly above the one below. That means the bricks are laid in such a way that they overlap and breaks the joint below. The amount of overlay is generally half the length of a brick. The minimum lap is 1/4 of the length of a brick.



Clay bricks with the dimensions 22.5 x 10.5 x 7.5cm are handy to work with and suitable for all kinds of bonding.

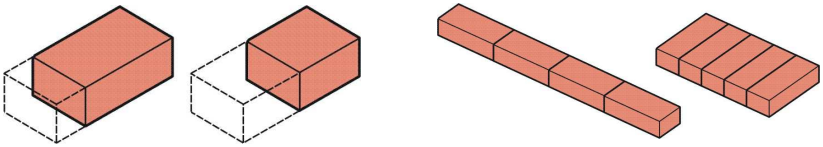
For horizontal joints (mortar bed) the thickness of 12mm to a maximum of 15mm is recommended for brickwork to ensure:

- ✓ levelling of the mortar bed, □
- ✓ placing of bricks completely immersed in mortar, and □

- ✓ no uneven or incomplete support of the bricks due to stones in the mortar.

Too thick horizontal joints (more than 12mm to 15mm) are a waste of costly mortar (cement), and weaken the structure. The joints are the weakest part of the masonry structure. For the vertical joints (buttering) a thickness of 10mm to 12mm is recommended for brickwork for the same reasons.

In order to obtain a good bond it is necessary to insert "bats" (parts of bricks). Some of the commonly used brick terms are:



three-quarter brick half brick stretchers headers

To prevent the crushing of bricks, use bonding of as many full bricks as possible, and insert where necessary three quarter and half bricks.

Pointing for brick masonry

The main reason for pointing the surface of block or brickwork joints is to increase its weather resistance and provide a neat and good-looking finish to the wall.

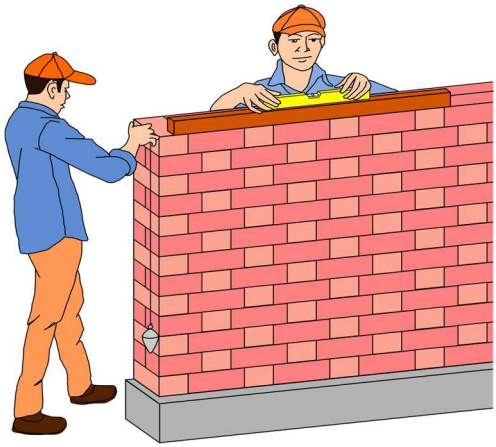
Pointing can take place at the same time as constructing the brickwork using ordinary mortar in which the bricks are bedded.

Another method is to finish the masonry works first and then later carry out the pointing with a 1:2 cement mortar. The joints are then raked out, brushed, washed and filled with fresh mortar. Ideally to save cement and mason-days it is better to take up pointing simultaneously with the actual brick laying.

Worksheet
Brick and block masonry – general application
M5

Work method:

1. Mark the external side of the walls on the plinth.
2. Clean the foundation with a steel brush and wet it properly.
3. Lay the first two courses without mortar to check that the correct bond is achieved. Always start at two ends or corners.
4. Cement bricks are cleaned and sprinkled with water before use. Burnt bricks are soaked in water for one minute. This avoids the bricks from absorbing water from the mortar, reducing the quality of the mortar. If the bricks are not clean, the mortar does not bond properly, which may produce cracks from swelling and shrinking.
5. Check the quality of every brick by performing a sound test before using it.
6. Build the corners four to five courses high and stretch a mason's line from one corner to the other. The string is used to ensure that each course is straight and level. Keep the string tight to avoid any sagging.



Caution:

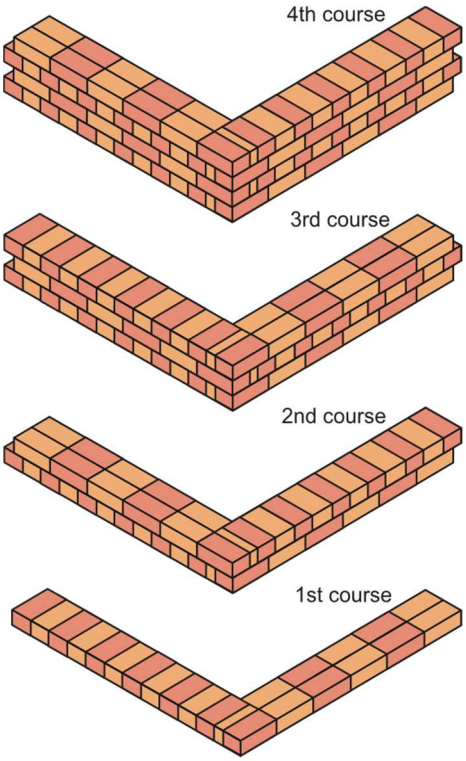
- Never use a quarter brick at the end of a wall. Use as many full bricks as possible.
- Use the same bond throughout the wall.
- Leftover mortar after each course should be cleaned from the bricks as well as from the ground. If clean, the mortar can be re-used.
- The maximum height of brick wall built per day should not exceed 10 courses.

Worksheet
Brick masonry – English bond

M6

Work method:

1. Mark the exact position of the outer wall on the plinth.
2. First lay the first two courses using "dry bricks" - without mortar – in order to arrange the correct bonding pattern. Identify where bricks need to be cut and check the thickness of the vertical joints.
3. Begin the wall with a stretcher course. Start work by first laying the corner bricks. Use a spirit level to check that the corner bricks are horizontal in both directions and vertical at the corner line.



Labour:	**Tools:**
• Rural mason • Labourers to assist	• Standard masonry tool set • Shovel • Buckets to soak bricks/ blocks

Quality checkpoints:

✓ Check that all corners remain vertical at all times.
✓ Check that the level of each course is correct (height of courses = one brick plus one joint).
✓ Ensure the mason's line is tightly pulled to avoid any sagging.
✓ Make sure that the joints are between 10 and 15 mm thick.

M6

4. Continue laying bricks off the corner in both directions. In one direction it will be a stretcher course and in the other a header course. In the header course the second brick is a half-size brick to make sure the bonding is correct.
5. Start the second course, again in the corner, but now place the corner bricks in the opposite direction from the corner bricks in the first course. Again check horizontal and vertical directions.
6. The third course is exactly the same as the first course and the fourth course is identical to the second course.
7. Build all walls simultaneously for better bonding. The maximum height of the brick wall built each day should not exceed 10 courses.

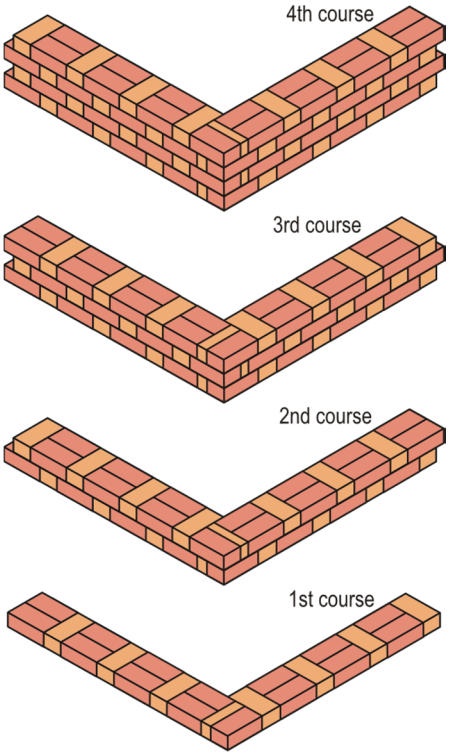
• Gunny bags to protect wall from direct sunshine	**Material:** • Bricks ready next to the mason • Mortar ready next to the mason • Water for wetting bricks

✓ All joints should be fully filled with mortar.
✓ Use a plumb bob to check that every wall is vertical.
✓ Immediately remove excess mortar protruding from the joints.
✓ In hot weather, ensure that the completed wall is covered with wet gunny bags.

Worksheet
Brick masonry – Flemish bond

Work method:

1. Mark the exact position of the outer wall on the plinth.
2. First lay the first two courses using “dry bricks” - without mortar – in order to arrange the correct bonding pattern. Identify where bricks need to be cut and check the thickness of the vertical joints.
3. Start work at a corner by first laying the corner bricks. Check with a spirit level that the corner bricks are horizontal in both directions and vertical at the corner line.
4. Continue with the following bricks off the corner in both directions by alternating stretchers with headers.



Labour:
- Rural mason
- Labourers to assist

Tools:
- Standard masonry tool set
- Shovel
- Buckets to soak bricks/blocks

Quality checkpoints:
- ✓ Check that all corners remain vertical at all times.
- ✓ Check that the level of each course is correct (height of courses = one brick plus one joint).
- ✓ Ensure the mason’s line is tightly pulled to avoid any sagging.
- ✓ Make sure the joints are between 10mm and 15mm.

M7

5. Start with the second course again in the corner, but now place the corner bricks in the opposite direction from the corner bricks in the first course. Again check horizontal and vertical directions and ensure the correct thickness of the joints (not more than 15mm).
6. The third course is exactly the same as the first course and the fourth course is the same as the second course.
7. Build all walls simultaneously for better bonding. The maximum height of the brick wall built each day should not exceed 10 courses.

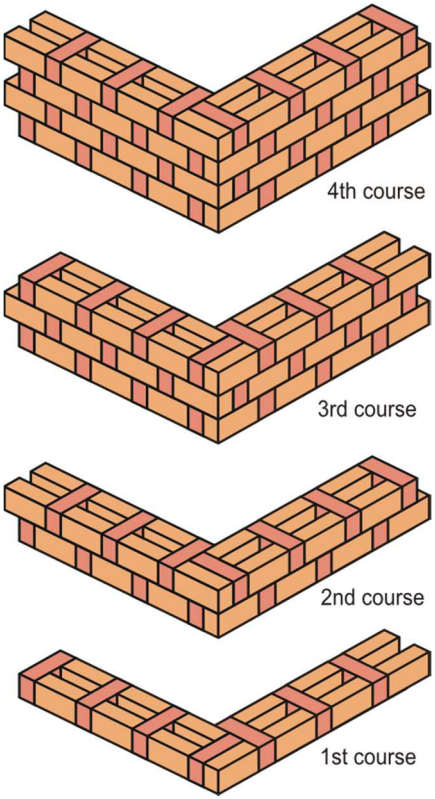
• Gunny bags to protect wall from direct sunshine	**Material:** • Bricks ready next to the mason • Mortar ready next to the mason • Water for wetting bricks

✓ All joints should be fully filled with mortar.
✓ Use a plumb bob to check that every wall is vertical.
✓ Immediately remove excess mortar protruding from the joints.
✓ In hot weather, ensure that completed works are covered with wet gunny bags.

Worksheet
Brick masonry – Rat-trap bond

Work method:

1. Lay out exactly the proposed structure (wall) by marking the external side of the walls on top of the foundation.
2. Lay the first two courses using 'dry' bricks without mortar. This allows you to arrange proper bonding, identify where bricks need to be cut and to check the thickness of the vertical joints.
3. Note: For the Rat-Trap bond all bricks are laid on their narrower side – vertically.
4. Start work by setting the two corner bricks. Check with a spirit level that the corner bricks are horizontal in both directions and vertical at the corner line.



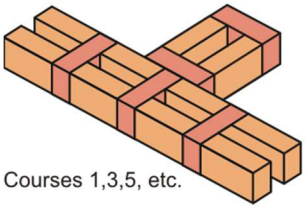
Labour:	**Tools:**
• Rural mason • Labourers to assist	• Standard masonry tool set • Shovel • Buckets with water to soak bricks

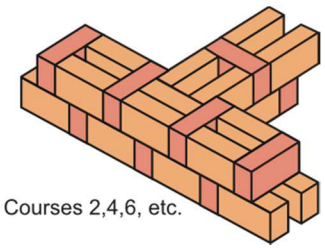
Quality checkpoints:

- ✓ Check that all corners remain vertical at all times.
- ✓ Check that the level of each course is correct (height of courses = one brick plus one joint).
- ✓ Ensure the mason's line is tightly pulled to avoid any sagging.
- ✓ Make sure the joints are between 10mm and 15mm.

M8

5. Continue laying bricks in both directions from the corner by alternating stretchers with headers and leaving a cavity in the middle. Do not fill the cavity with mortar or with any other material.
6. Start with the second course again in the corner, but now place the two corner bricks in the opposite direction from the corner brick in the first course. Again, check horizontal and vertical directions and ensure correct thickness of the joints (not more than 15mm).
7. The third course is exactly the same as the first course and the fourth course is the same as the second course.
8. Build all walls simultaneously for better bonding. The maximum height of the brick wall built each day should not exceed 10 courses.
9. Special bonding arrangements are required for T-junctions:





• Mortar pans for carrying and keeping mortar • Gunny bags to cover wall from sunshine	**Material:** • Bricks ready next to the mason • Mortar ready next to the mason • Water for wetting stones

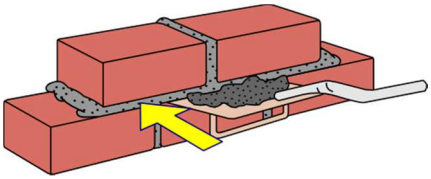
✓ All joints should be fully filled with mortar.
✓ Use a plumb bob to check that every wall is vertical.
✓ Immediately remove any excess mortar protruding from the joints.
✓ In hot weather, cover the completed wall with wet gunny bags at the end of the day.

Worksheet
Pointing brick masonry

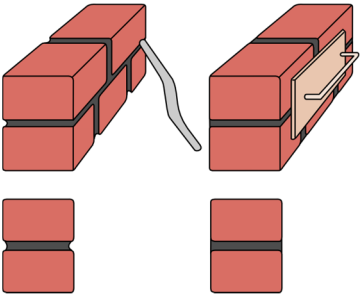
M9

Work method:

1. Rake out the joint to a depth of about 1 to 1.5 cm. This is best to do not later than one day after the wall has been built while the mortar is still soft.
2. Brush and clean the joints so they are free from dust and mortar debris.
3. Wet the joints and fill with cement mortar 1:2. Pointing can be flush or keyed.



Filling the mortar joints



Recessed joints flush joints

4. Brush all bricks clean until there are no more remaining mortar stains.

Labour:	**Tools:**	**Material:**
• Rural mason • Labourers to assist	• Standard masonry tool set • Buckets • Brush to clean joints and wall • Gunny bags to cover wall from direct sunshine	• Mortar ready next to the mason • Water for wetting joints

Quality checkpoints:

✓ Ensure all joints are properly raked and cleaned out.
✓ Ensure all joints are properly filled and nicely keyed.
✓ Ensure the wall is clean and that leftover mortar on the ground is removed.
✓ Protect the wall from sun and rain by covering it with gunny bags.

3.4 Stone masonry

Good stone masonry requires advanced skills from a rural mason. The mason has to be able to determine the required wall and bond type in accordance with the drawings. The preparatory activities need to be carried out in a planned manner to ensure that the right material, tools and labour are available.

Stonewalls are usually not plastered and are therefore seen by everybody. The quality of these walls is therefore the 'business card' of the rural mason.

Wall and masonry types

In rural housing works, stone masonry can be applied for:

- *Load bearing walls,* i.e. walls that support the weight of other building components, such as the roof.
- *Non-load bearing walls* which do not support any load but are merely there to separate rooms.
- *Columns* used in rural houses if the walls are long and therefore require intermediate support or to carry roof trusses.
- *Footings*, also called *'plinths'*, consisting of vertical extensions of the foundations up to the level of the floor inside the house.
- *Foundations*, serving the purpose of transferring the weight of the building to the ground.

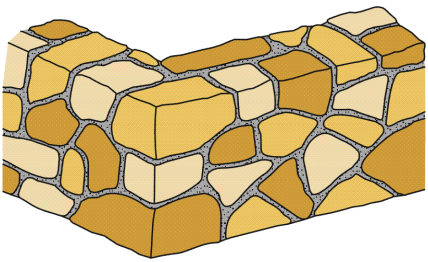
Stone masonry can be classified in various ways, as for instance, according to the kind of stones used, surface finishing, bonding, etc.

Rubble masonry is composed of stones with any shape. They are found in quarries or in the open field. The quarried variety is preferable because they are stronger and usually of a more rectangular shape, which is better for masonry works. Their

faces are sharper and form a better hold for the mortar than the weather worn and smoother surfaces of field stones. However, in some areas, non-round field stones are also used for house construction.

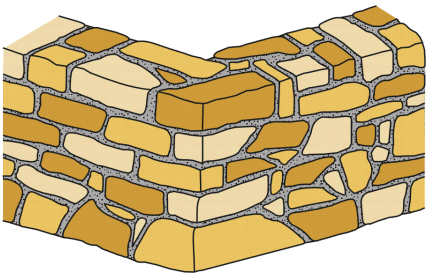
There are three kinds of rubble masonry, known as:

Undressed rubble



This kind of masonry covers all shapes and sizes of stones in which faces, joints and beds do not follow any particular pattern. No attention is given to the level of the courses. With good attention to the surface finish, it is still possible to achieve an attractive wall.

Random dressed rubble



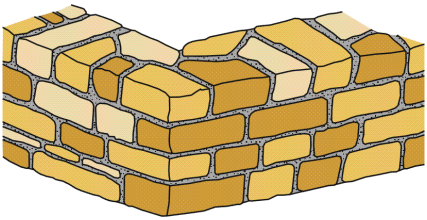
In this kind of rubble masonry all the stones have well shaped faces. In laying the stones special attention is given to bringing each course to as near level as possible.

The difference between undressed and random dressed rubble can be seen in the surface finish. In random dressed rubble smaller stones are used than in undressed rubble.

Dressed rubble

With dressed rubble more efforts are given to shaping the stones. The faces are close to rectangular and the height of all the stones should be nearly the same. When laying the stones, special

attention is given to the bond stones, the height of each course and a proper alignment.



In all the above types of masonry, bond stones should be used (long stones across the entire width of the wall, also called headers) at the rate of 120cm intervals to secure adequate strength in the wall.

Preparatory activities for stone masonry works

Before starting the stone masonry works, it is necessary to prepare for it. For this some planning is required on a daily basis.

✓ *Estimating the amount of material required:*
- Estimate the quantity of rubble stone based on the size of the wall and size of stones, the type of bond and shape of stones. Add 30% for wastage for un-coursed rubble and about 20% for random or coursed rubble.
- Calculate the amount of sand and cement, depending on the size of the wall, type of masonry and mortar mixture required.
- Make water available on site for mixing mortar and wetting the stones.

✓ *Assembling the necessary tools and protective equipment:*
- Special tools are required for quarrying and dressing the stones, such as crowbars, sledgehammers, chisels and club hammers.
- Standard mason's tool set for stone masonry.
- Measuring tools: tape measure, water tube level, straight edge with spirit level, mason's square, plumb bob, string line with pegs or clamps.
- Protective equipment: helmet, facemask, goggles, good boots and gloves.

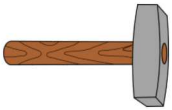
✓ *Setting out the walls to be built:*

- Re-establish the wall corners and lines according to the site plan, using a string line. Mark the *external* side of the walls on top of the foundation.
- Measure and mark where the openings (doors and windows) will be located.

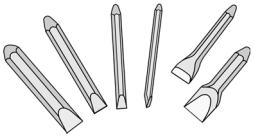
Countercheck the levels, e.g. the bottom of trenches and top of DPC. These surfaces should be horizontal. If necessary first make corrections to ensure the walls start with horizontal and uniform courses.

Standard tools for stone masonry work

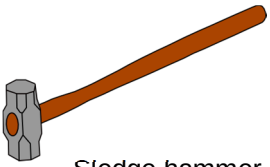
Stone masonry requires the same tools as for brickwork. In addition, the following tools are required:



Club hammer



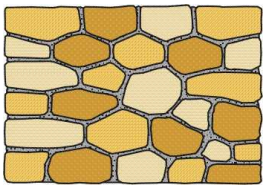
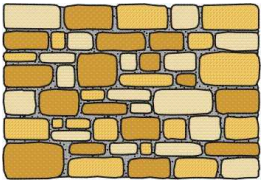
Chisels



Sledge hammer

Materials for stone masonry works

Materials for masonry consist of rubble or dressed stone and mortar. The following table shows the approximate material requirements for each cubic metre of wall.

Material required for stone masonry		
Type	Width of joints	Material for 1m^3 of finished wall
Undressed rubble stone masonry  The stone is not specifically cut or shaped. To build a wall with proper bonding using undressed rubble stone requires well-developed skills from a mason.	1 to 4 cm	Stone: approx. 1.3-1.5m^3 (includes waste) Mortar 1:6 Cement = 85 kg Sand = 0.35 m^3
Random dressed and dressed rubble stone masonry  The stone is shaped to a rectangular prism. It is easier to produce a wall with proper bonding and uniform surfaces using this stone.	1 to 2.5 cm	Stone: approx. 1.2 m^3 (includes waste) Mortar 1:6 Cement = 75 kg Sand = 0.32 m^3

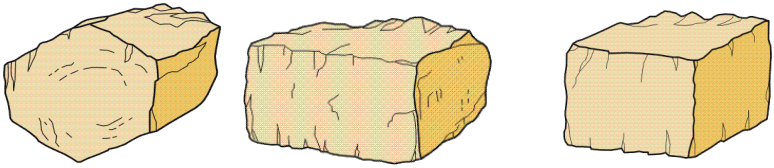
Cement mortar

The same mortar is used for stone masonry as for brick/block masonry – refer to Section 3.3. with Worksheet M4 above for details on requirements and how to mix mortar.

Preparing the stone

Shaping (dressing) stones takes time and patience. It is the task of the rural mason to prepare the stones to the required size and shape.

The following shapes of stones are used for construction:



Line stones

Stones placed between corner stones are referred to as line stones. They should have (but not necessarily) a flat and even surface. The combination of flat surfaces at the corners and rough hammer dressed line stones give the stone masonry an attractive appearance.

Corner stones

Two faces should be squared and shaped with a chisel and a club hammer to a flat surface, or at least hammer dressed to allow for accurate plumbing.

Stone quality

A good stone should be hard. It should be possible to dress a stone without it crumbling. In general, stone found on the surface is less durable than quarried stone. Still, there are a number of rock types found on the surface that are of sufficient quality to be used in house construction.

The hardness of stone can easily be checked with a hammer. Strong rock resists a hammer blow and does not disintegrate when being shaped.

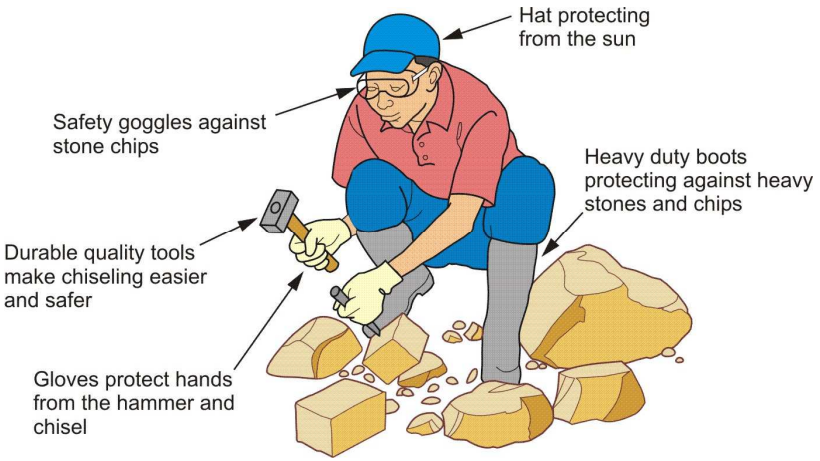
Some types of rock such as sandstone are more porous and may absorb water. If the rock is hard enough, it can still be used, but it is then important to add a damp proof course on the plinth.

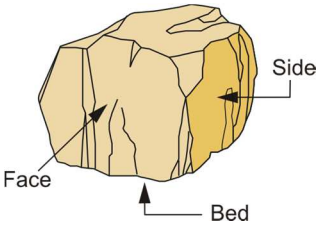
Worksheet
Shaping stones

M10

Work method:

1. Prepare the work ground, tools and safety equipment.
2. Clean the stone to be dressed, e.g. using a brush and water.
3. First cut it roughly on all sides, to the extent possible using its natural shape. Stones should be of size and weight that can be carried by one person.
4. Dress the face to a plane and check it with a straight edge.
5. Select the stones that could be used as corners and shape the reverse face.
6. Make sure all dressed stones are clean and stockpile them neatly.
7. Clean the work area from debris. Stone chips may be used as backfilling material for foundations or plinths.





The surfaces that may need to be shaped are:

- Face (for the surface of the wall)
- Bed (the side on which the stone rests)
- Side

Labour:	**Tools:**	**Material:**
Rural mason and/ or trained chiseller	• Measuring tape • Mason's square • Sledge hammer and chisel hammer • Chisels – various shapes • Shovel (for waste disposal)	• Good quality rubble stone

Quality checkpoints:

✓ Check that all stones are clean and without any cracks and have the desired size and shape (random dressed or dressed).

✓ Check that the dressed stone faces are smooth.

Laying stone

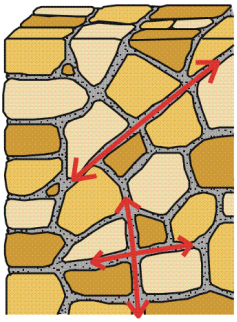
The art of stone masonry is the accurate laying of rubble stone by ensuring:

- ✓ correct measurements as per plan,
- ✓ accurate vertical walls,
- ✓ horizontal courses,
- ✓ accurate levels, and
- ✓ good bonding.

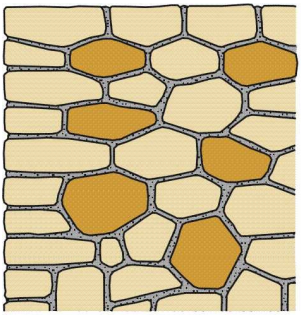
The work methods for ensuring level and straight courses of stone and vertical walls are the same as for brick masonry. It is advisable to have one string for the inner wall and a second for the outer side, and to work with two masons at the same time. While one mason builds on the outside, the other mason builds the inside of the wall.

Checkpoints for proper bonding in stone masonry:

- ✓ Bond stones (also called headers) should extend not less than 2/3 of the thickness of the wall.
- ✓ Bond stones should be used (long stones across the entire width of the wall) at 120 cm intervals to ensure proper bonding.
- ✓ The vertical joints of each course should break with the joints of the course below.
- ✓ The largest stones should be used for the lowest courses.
- ✓ Stratified stones (deposited rock with horizontal layers) should be laid on their natural beds (layers to be horizontal – not vertical).

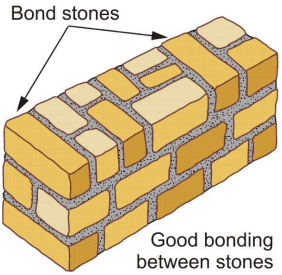


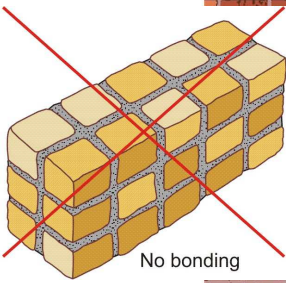
Poor bonding due to vertical joints continue through several courses



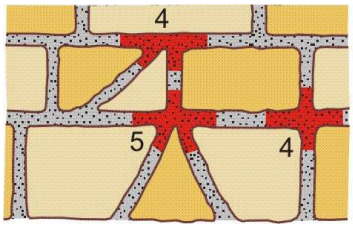
Good bonding as a result of (i) vertical joints being broken by the next course and (ii) good use of bond stones

Correct bonding is essential for stone masonry. Placing bond stones at frequent intervals increases the cohesive strength of the wall.





The joints should be in staggered rows, thereby ensuring that stones in overlaying layers produce good overlap above joints in the underlying course. The ideal is to allow for a maximum of three intersecting joints. More intersecting joints will result in poor bonding and reduce the strength of the wall.



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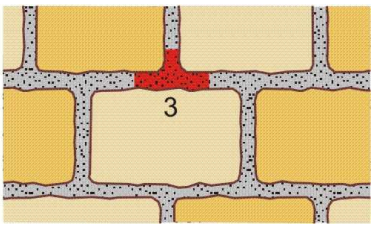
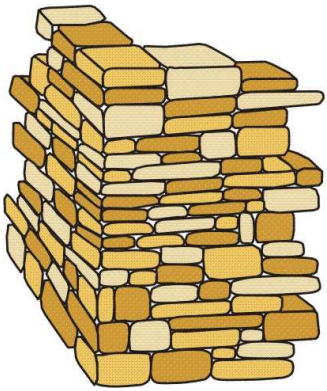


Correct

Reinforcing the corners

Corners are more vulnerable and need special attention. There, the largest stones are placed in the corners thereby obtaining good bonding between the corner stones and the adjacent wall stones.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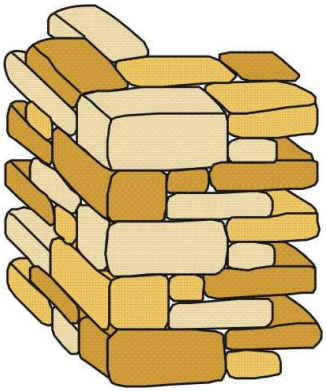

Correct

Worksheet
Stone masonry
M11

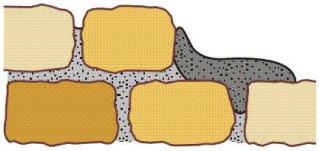
Work method:

1. *Preparation*

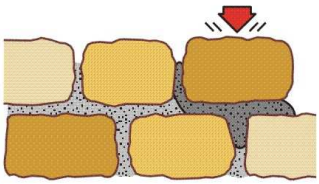
- Set out exactly the proposed structure by marking the sides of the walls on the foundation or on the trench bed.
- Clean the foundation with a steel brush, wet it properly and if necessary rough it by chiselling.
- Two masons should work at the same time on a wall, one inside and one outside.
- Use crack-free and washed stone.
- A stiff mortar should be used. Never fill the inside of the wall with slurry mortar because this will reduce the strength.

2. Construction

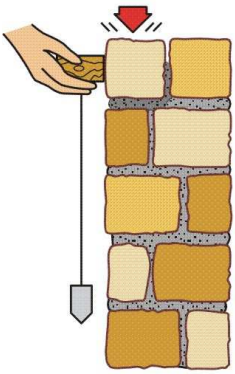
- Use the largest and straightest stones on the ground and as corner stones.
- Use two-faced shaped and squared stone for corners as well as for the top of the wall.
- The stones are laid on a mortar bed and then tapped gently into the mortar with a hammer.
- Build the corner stones inside and outside, then stretch a string on each side and build in between these strings.



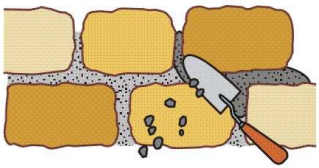
Apply a 3 cm thick layer of mortar



Place the stone in position



Check that the wall is vertical with a plumb bob or spirit level



Remove any excess mortar

- Leftover mortar from each course should be cleaned from the stones as well as from the ground and can be used in the next course.
- The overlap of the stones should be minimum 10cm.
- The face and the inner part of the wall should be built at the same time.
- The joints should not be thicker than 2.0-2.5 cm but never less than 1.0 cm, depending also on the size of the stone.
- Small pieces of stone are used for better seating of the shaped stone but they should not be visible at the outside of the wall. These stone chips need to be well embedded in mortar.

Labour:	**Tools:**	**Material:**
2 rural masons and assistants	• Standard masonry tool set • Shovel • Buckets with water to soak stones • Gunny bags	• Good quality rubble stone • Mortar ready next to the mason • Water

Quality checkpoints:

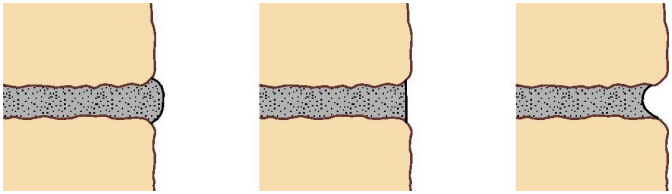
✓ Ensure proper bonding of the stone.
✓ Use a plumb bob to check that all walls remain vertical.
✓ Ensure all joints are fully filled with mortar and all stones are fully embedded in mortar.
✓ Immediately remove excess mortar protruding from the joints.
✓ In hot weather, cover the completed works with wet gunny bags.

Worksheet
Pointing stone masonry
M12

Work method:

1. Rake out the joints to a depth of about 3 to 4 cm. This is best to do not later than one day after the wall has been built, while the mortar is still relatively soft.
2. Clean the joints so they are free from dust and mortar debris.
3. Wet the joints and fill with a 1:2 mortar mix, using fine sand.
4. The pointing of the joints can be projecting, flush or keyed.
5. Smooth the joints with the pointing trowel
6. Brush all stones clean so there is no remaining mortar stains.

There are three types of joints:



Projecting joint | Flush joint | Keyed joint

The flush joint is the recommended pointing for masonry walls in rural house construction.
Pointing the joints protect the wall from wind and moisture entering into or though the wall. Pointed masonry foundations resist water from wet soils entering the wall.

Labour:	**Tools:**	**Material:**
Rural mason and assistant	• Standard masonry tool set • Buckets with water to wet the joints • Brush for cleaning joints and walls • Canvas to cover the walls from direct sunshine or rain	• Mortar ready next to the mason • Water for wetting joints

Quality checkpoints:

- ✓ Ensure that all joints are properly raked and cleaned out.
- ✓ Check that the joints are properly filled and nicely keyed.
- ✓ Ensure that the walls are clean and that any leftover mortar on the ground is removed.
- ✓ Allow the mortar in the joints to cure properly and avoid that the mortar dries out from sunshine or is washed out by rain.

3.5 Installing doors, windows, lintels and ventilators

Installing frames for doors and windows

Doors and windows are fixed into wooden or sometimes metal frames. Frames are installed together with the on-going masonry work to ensure they are properly fixed into the wall and that they fit exactly into the opening.

Great care should be taken to ensure that the frames are fixed without being twisted. The doors and windows should fit exactly onto the frame. *For working details refer to Worksheet M13.*

Constructing lintels and sunshades

Lintels are the small beams constructed above openings for doors, windows and terraces. The lintels are built into the walls once the masonry reaches the top level of the door and window frames.

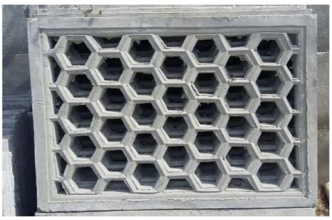
Sunshades are extensions of lintels, creating small cantilever slabs above windows and doors in rural houses, basically to provide shade and to prevent rain sprinkling into the room. The thickness of the lintel varies from 15 cm to 30 cm depending on the size of the opening. In some places sunshades are not taken up to reduce costs.

The wall on both sides of the door, window or other opening supports the lintel. Therefore the masonry work up to the level of the lintel needs to be completed before starting the installation of the lintel. *For working details refer to Worksheet M14.*

Installation of ventilators

Ventilators are prefabricated elements that are integrated into the wall right below the roof. Commonly, there are two different types:

Cement Jally: These are usually prefabricated concrete blocks with integrated ventilation holes. Ready-made ventilators are usually available from local suppliers.



Jallys are also made of steel. They can easily be integrated into the wall.

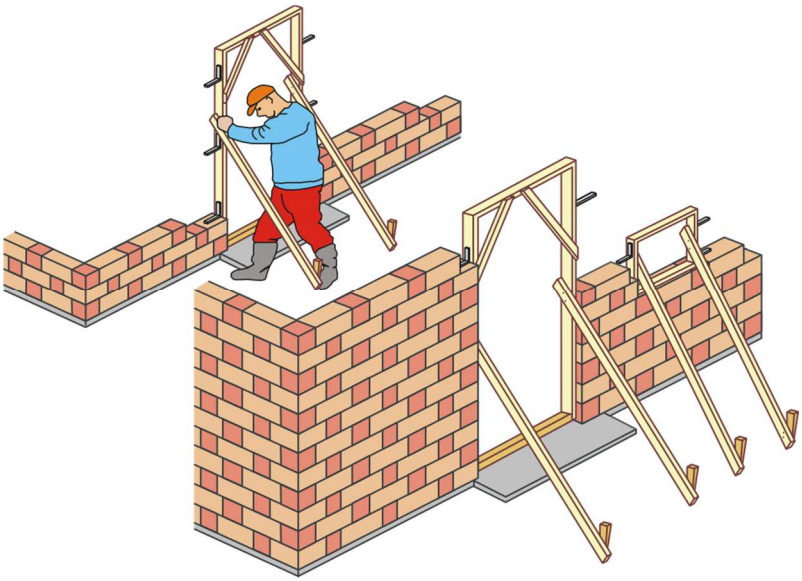
When constructing the walls, these ventilators are normally positioned just below the roof slab. The exact position of these ventilators is shown in the construction drawings.

Worksheet
Installing door and window frames

M13

Work method:

1. Mark the exact locations of the doors and windows when setting out the walls before commencing the masonry work.
2. Place the frame at the marked locations and hold it upright with temporary support. These are usually timber supports, which are firmly fixed into the ground.
3. Construct the masonry walls next to the frames.
4. Grout between the frame and wall, filling all gaps with mortar.



Labour:	**Tools:**	**Material:**
Rural mason and assistant(s)	• Standard masonry tool set • Saw and hammer to fix support battens	• Door and window frames • Timber boards/battens • Nails • Mortar for grouting

Quality checkpoints:

✓ Check that the frames are in the correct position.

✓ Ensure no deformation of the frames takes place.

Worksheet
Constructing lintels and sunshades
M14

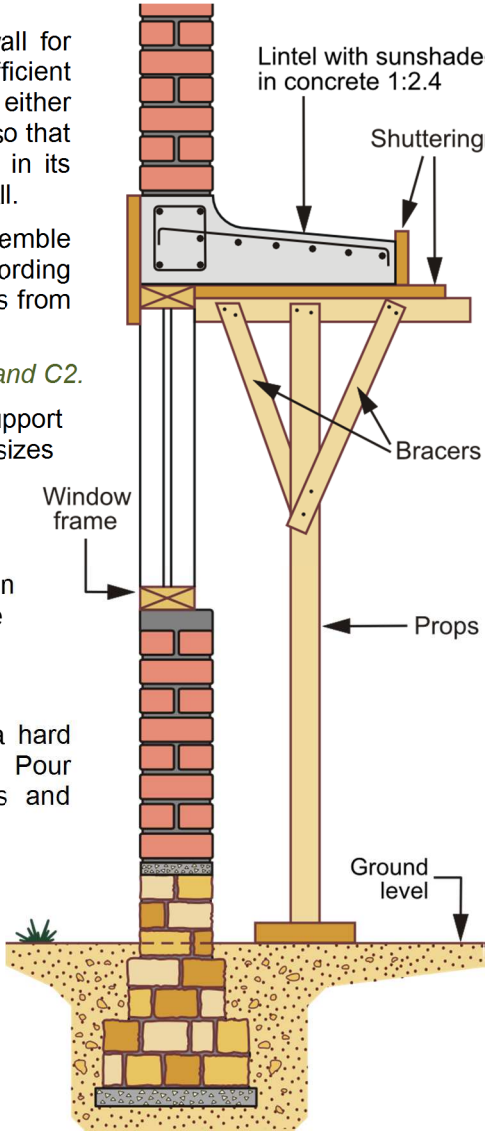
Work method:

1. Remove bricks in the wall for 15 cm width for sufficient support for the lintel on either side of the opening and so that the lintel can be placed in its correct position in the wall.
2. Cut, bend and assemble reinforcement bars according to the plan or instructions from the engineer.

   Refer to worksheets C1 and C2.
3. Cut shuttering boards, support and props to the correct sizes and assemble the formworks to the correct shape and position.
4. Place the reinforcement in the correct position in the formworks.

   Refer to worksheet C3.
5. Mix 1:2:4 concrete on a hard and clean surface. Pour concrete into formworks and compact.

   Refer to worksheet C7.
6. Cure the concrete for a minimum of 14 days. Ideally, the curing should be given 21 days for all beams, lintels and sunshades. Cover the concrete with



wet gunny bags to facilitate the curing and protect it from sunshine.

7. The shuttering on the vertical sides can be removed after 14 days – but leave the support in place.
8. Once the shutters are removed, check for honeycombs. Remove any loose aggregate and fill the voids with cement mortar 1:4.

Labour:	**Tools:**	**Material:**
Rural mason and labourers to assist with shuttering and concrete works	• Standard masonry tool set • Saw and hammer • Gunny bags for curing concrete	• Timber boards, props and struts • Nails • Reinforcement bars, wire • Concrete

Quality checkpoints:

- ✓ Check that the formwork is in the correct position, that it is straight and at correct levels.
- ✓ Check that the reinforcement is firmly fixed in the correct position.
- ✓ Secure sufficient support on both sides of the wall.
- ✓ Ensure that the concrete is mixed to correct proportions.
- ✓ Ensure continuous curing for 14 days, keeping the concrete moist and protected from the sun.
- ✓ Do not remove the props before 14 days.

3.6 Plastering

Walls are plastered to obtain a smooth finish to the surfaces. Plastering of the exterior walls also preserves and protects them from weather by acting as a protective layer. Plastering on a building's interiors conceals poor workmanship of brickwork and masonry joints, if any. It also covers walls and ceilings with fine mortar, which acts as the base that is essential for painting or whitewashing.

In order not to waste material and to achieve good quality plaster the careful establishment of wall lines is required before starting the actual plastering activity. Careful and skilled finishing is required to assure a uniform, smooth and good-looking surface.

As plastering makes a surface smooth, durable and prepares it for further finishing through painting, it is important to treat and improve the surface so that the quality of plastering is durable and at its best.

Generally, masonry walls are constructed to perfect plumbs and lines (horizontal, vertical and diagonal) on the interior side of the wall. As the quality of the brick may not be perfect in rural areas, the outside wall is generally not to perfect plumb. Hence the outside is plastered in two coats:

(i) first layer of 16 mm thickness using a cement mortar with ratio of 1:6
(ii) second layer of 4 mm thickness using cement mortar with ratio of 1:4

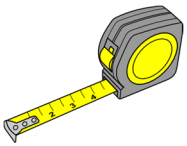
The interior side of the wall requires only one layer of 12 mm thickness, using cement mortar with a ratio 1:5 or 1:4.

The quantities of necessary materials are shown in the table below:

Material requirements for plastering (for 10 square metres)			
Plaster type	Mortar ratio	Cement	Sand
12 mm single coat	1:5	43.2 kg	0.15 m^3
20 mm two coats	First coat: 1:6 (16 mm) Second coat: 1:4 (4 mm)	43.2 kg 14.4 kg (Total: 57.6 kg)	0.22 m^3
20 mm single coat	1:5	60.48 kg	0.21 m^3

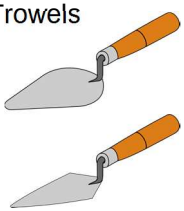
Tools used for plastering

Steel tape (3 metres)



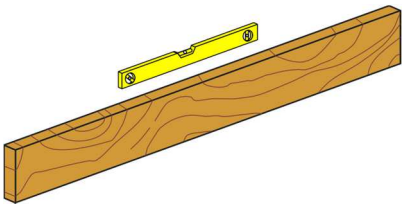
Mason's square

Trowels

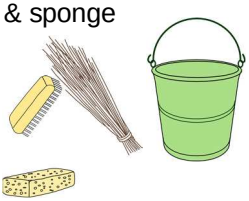


Plum bob

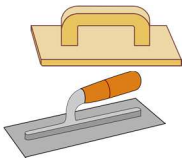
Straight edge with spirit level



Brush, bucket & sponge



Floats



String

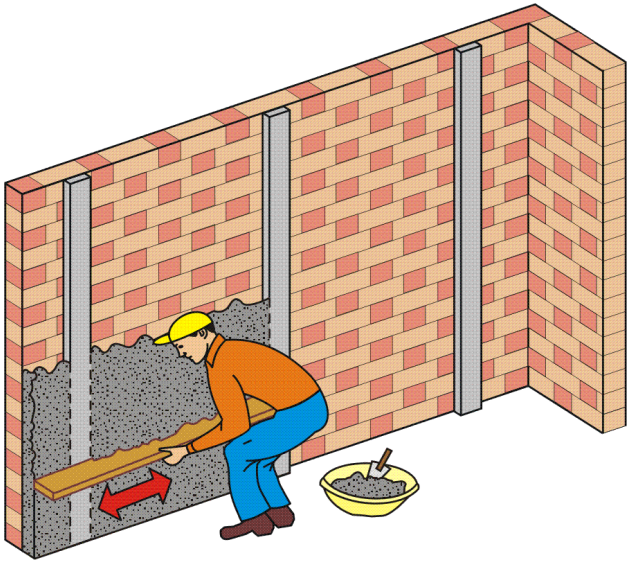
Mortar pan

Worksheet Plastering — M15

Work method:

The main steps to follow when plastering a wall surface are:

1. Use a brush to clean the surface and joints.
2. Rake the joints to remove any loose or protruding mortar and knock any projections off the surface. Fill any cavities with mortar.
3. Water the entire surface evenly before starting plastering. Make sure the wall is sufficiently moist so water is not drawn from the mortar.
4. Check that the wall is uniformly lined using a string line and a straight edge with a spirit level.
5. If the surface is uniform across the entire wall, place guide strips of mortar of 12 mm thickness and with a width of 10 cm to 15 cm. The first and last strips should be about 15cm from the corners. Intermediate strips are added with a spacing of 100 to 120cm, depending on the length of the straight edge at hand.



6. After one day, fill the space between the guide strips with mortar 1:6 using a trowel. Make sure there is proper contact between the mortar and the underlying surface. The plaster should be slightly thicker than the guide strips.
7. Using a straight edge, screed the mortar to the same thickness as the strips. Use a float for the final smoothening as soon as a section has been plastered and levelled.
8. Plaster the entire wall the same day.
9. Cure the wall for at least 14 days by keeping it moist.

Labour:	**Tools:**	**Material:**
Rural mason and worker to prepare mortar	• Standard masonry tool set • Shovel	• Mortar • Water

Quality checkpoints:

- ✓ All cavities should be filled and levelled before starting plastering.
- ✓ The surface should be level and free from projections.
- ✓ Check that all lines (horizontal, vertical and diagonal) are level and uniform.
- ✓ Ensure that the final surface is uniform and smooth.

3.6 Concrete flooring (IPS)

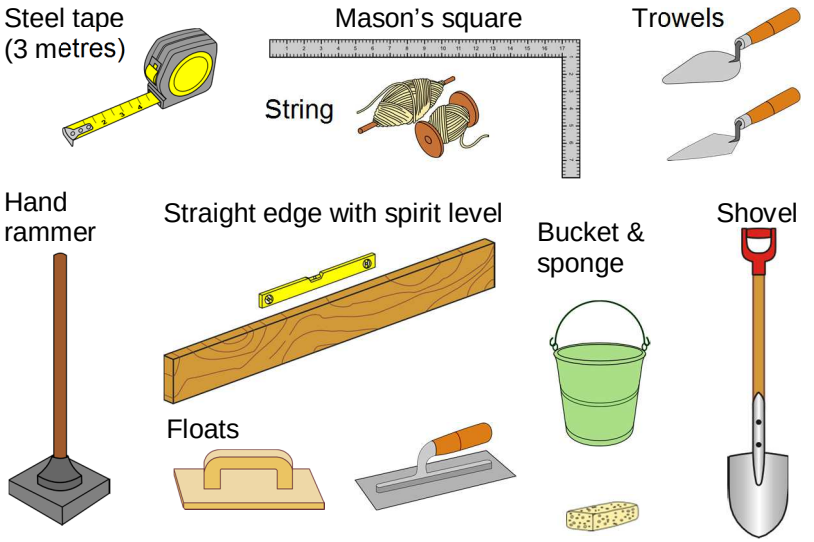
Preparation and laying IPS flooring

IPS flooring is part of the finishing works. It is done after completing the roof slab and plastering the walls.

The concrete floor is placed on top of a firm base produced by filling gravel to the correct level and compacting it well. The IPS floor consist of three distinct layers:

Flooring layer	Thickness	Concrete mix proportion
Base layer (lean concrete)	7.5 cm	1:5:10 (cement : sand : aggregate)
Top layer (regular concrete)	4 to 5 cm	1:2:4 (cement : sand : aggregate)
Surface (cement slurry)	2 to 4 mm	Cement slurry 1:2 (cement : fine sand) for a smooth finish. Red oxide may be used for aesthetics of flooring.

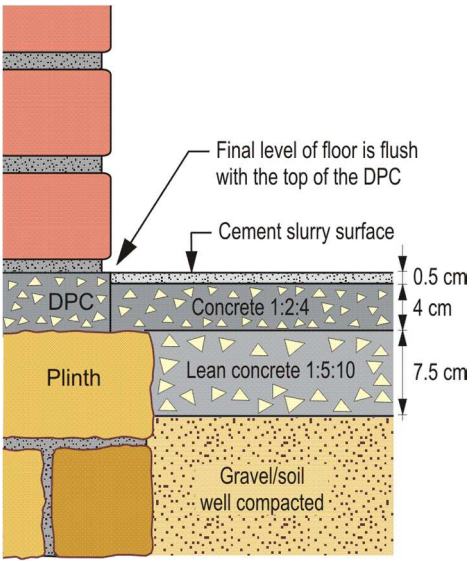
Tools required for building the floor



Worksheet
Concrete flooring

Work method:

1. Place and level the gravel layer, sprinkle it with water and compact well.
2. Ensure that the level of the finished floor will be flush with the top of the damp proof course, DPC, in the walls. Therefore, the surface of the levelled and compacted soils should be 12 cm lower than the DPC top.
3. Mix lean concrete 1:5:10 using 40mm stone.
4. Pour the lean concrete on the prepared, well compacted gravel/soil surface with a compacted thickness of 7.5cm. Level it out and compact well.



5. Mix concrete 1:2:4 using 20mm stone.

Labour:	**Tools:**	
Rural mason and workers to assist	• Standard masonry tool set • Shovel • Rake	• Earth rammer • Clean surface to mix concrete

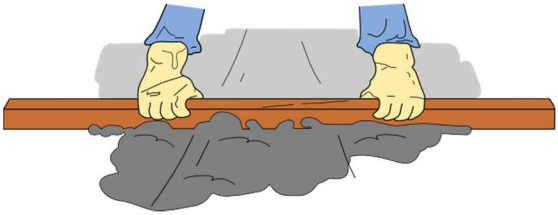
Quality checkpoints:

✓ Check the level of the compacted gravel surface.

✓ Make sure the concrete has the correct mixtures. Control the water content.

M16

6. Place the concrete on top of the base layer with a thickness of 4 cm. Level it out using a wooden straight edge and compact well.



7. Finally apply a fine cement slurry 1:2 (use fine sand), 'wet-in-wet' with a thickness of 4 to 6mm. Red oxide powder may be added on top of the wet slurry and troweled off using a float.
8. When the slurry is still fresh, grid lines should be drawn using a thread line. The small groves formed as grid lines help to accommodate minor cracks if any develop in the floor.
9. Curing is required for a minimum of 21 days by spreading used gunny bags over the surface and keeping them continuously wet.

Material:

- Gravel or selected soils
- Cement and sand
- Aggregate 40mm and 20mm
- Water
- Red oxide powder
- Gunny bags

✓ Ensure well compacted and levelled concrete layers.

✓ Ensure a smooth and good-looking slurry surface.

Section 4
Concrete works

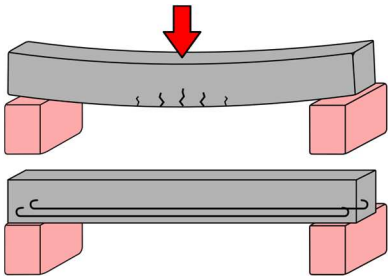
4.1 Concrete for rural house construction

Concrete is a common building material used in a number of structures, such as floors, walls, columns, lintels, beams and roofs. It can be cast in any desired shape and fashion and is therefore applicable for most building purposes. Concrete does not rot, rust or decay and is resistant to wind, water, rodents and insects. Concrete works for rural houses consists of three distinct activities:

- Installing reinforcement steel
- Erecting the formworks
- Mixing and pouring concrete

Concrete consists of cement, sand and coarse aggregate mixed together with water. The aggregate is a mixture of stone of various sizes. When water is added, a chemical process takes place primarily with cement, causing the mix to harden.

While concrete performs well under compression, it does not tolerate tension well. To improve its strength, steel bars are added to the concrete in places where tensile stress is expected to occur - such as in beams and slabs.

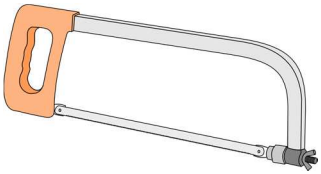


Consequently the load bearing capacity of this composite material, called Reinforced Cement Concrete, (RCC), is significantly better compared to when concrete or steel members are used in isolation. With reinforcement steel firmly embedded into the concrete, it can be used to build strong load-bearing structures such as columns, beams and slabs.

Concrete is cast in moulds referred to as formwork or shuttering. Usually, the formwork used for walls, columns, beams and slabs is assembled by joining wooden boards edge on edge. The advantage of using wood is that it can easily be used to create any required shape. Plywood, laminated boards and metal are also commonly used for formwork.

4.2 Placing reinforcement steel

Drawings would normally describe where and how steel bars are installed in reinforced concrete. Details are given for the type, size and shape of the steel bars as well as their location and spacing.



Steel bars can be cut and bent at site using simple hand tools, such as a hacksaw. The length and shape of the bars are given in the bar bending schedule that comes with the drawings. They can subsequently be placed and fixed as per the drawings.

Type and characteristics of reinforcement steel

Reinforcement steel is normally provided as individual steel bars or welded together into a mesh. The bars are used for beams and columns, while the mesh is prepared for large surfaces such as slabs and walls. Common diameters of steel bars are 6, 8, 10, 12, 16, 18, 20, 22, 25 and 32 mm.

There are essentially two types of reinforcement bars, used for two different purposes. The main bars take most of the tension forces. In addition stirrup bars are used to keep the main bars in position when pouring concrete. The distribution bars also contribute to the strength of the concrete by spreading the loads and thus allowing the main bars to perform more effectively. The stirrups are made from bars with the smallest diameters.

The reinforcement is placed in the area where tension occurs. In slabs and beams this is usually at the bottom of the structure. The bars need to be adequately covered with concrete to avoid

any corrosion of the reinforcement. Therefore it is important that the bars do not touch the ground or the formwork. The correct cover is 20 to 25mm for slabs, 25 to 30mm for beams and 40mm for columns.

Reading and interpreting drawings and sketches

Placing of reinforcement bars for structures requires a work drawing or reinforcement plan, containing all the necessary information. The exact measurement of every re-bar is usually indicated in a bar bending schedule, which is prepared together with the drawings. The bar bending schedule is a chart giving a clear picture of bar lengths and diameters, and where the bars should be placed.

Spacer blocks

The reinforcement bars are separated from the formwork with spacer blocks. The spacer blocks are placed in such distance from each other that the reinforcement bars do not sag and touch the ground or the formwork. As a rule of thumb, about 4 to 6 cover blocks are required for each square metre for slabs.

Spacer blocks can easily be made at site. Prepare a 1:4 mortar mix and set it in a flat tray of about 25 mm depth. Remember to use a plastic sheet or oil so that the blocks can easily be removed from the tray when they set. Follow standard good practices of cement use. After the mortar begins to set, carve out small squares with 25 mm sides and insert twisted binding wire in

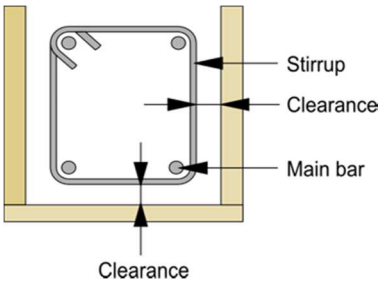
each square. Let these pieces set in the tray for about 24 hours. Then, remove the blocks and place them in a bucket of water or place them in a gunny bag that can be dipped in water to cure for at least 14 days. After that period the cover blocks are ready to use.

For some slabs reinforcement bars are required in two layers within the slab. One layer is placed near the bottom and one layer near the top of the slab. Chairs (brackets) are placed to separate the two layers and keep the top layer at the appropriate height. Three to four chairs are needed on average for each square metre of slab.

Reinforcement chairs

Cutting and bending

For smaller works the reinforcement bars are cut and bent on site. This requires some skills and appropriate tools. The reinforcement bar bending schedule describes what size and type of bars to use and their shape and quantities.



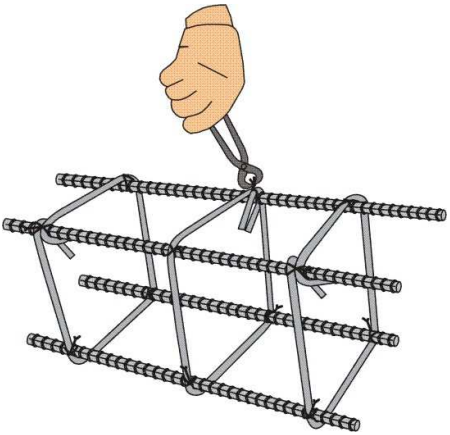
The stirrup is the outer frame that holds the load bearing bars in the right position. These are prepared on site using bars

with a 10mm diameter. The exact length of the stirrup bars needs to be carefully calculated based on the dimensions of the column or beam. The re-bars have to be covered all round with at least 25mm to 30mm concrete. The stirrups therefore need to be cut and bent to dimensions allowing for sufficient coverage. Make sure the end bend is minimum 50mm.

Assembling reinforcement steel

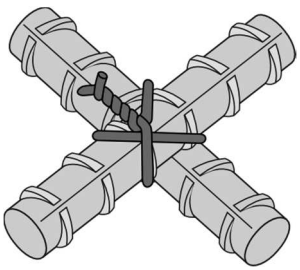
Once the reinforcement steel bars have been cut and bent to the right shape they are ready to be installed in the formworks.

For columns, beams and lintels the reinforcement can be tied together to the correct shape and length before the formwork is installed. You can actually prepare them on the ground ready for installation once the formwork is assembled.



The reinforcement plan describes which main bars and stirrups (distribution bars) to use, where they are to be placed and the distance between them.

The stirrups are tied onto the main bars using binding wire. The main bars are always inside while the stirrups are fixed outside with regular spacing. The stirrups can have different shapes, but should be 'closed' as shown in the figure above. It is important that the stirrups have the correct size to allow for adequate concrete cover.

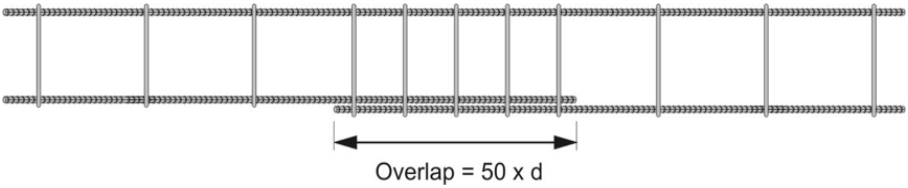


Reinforcement in concrete slabs is

arranged and tied together after completing the formwork. The main bars are placed at the bottom, with the distribution bars laid and fixed on top.

If steel bars need to be extended, some of the critical points to remember are:

- ✓ The overlap length should be at least 50 times the diameter of the bars used.
- ✓ Lapping should not be done close to joints or any other critical areas of the structure.



- ✓ The overlaps should not be concentrated in a single area or straight line as the lap may create a point of vulnerability within the structure.

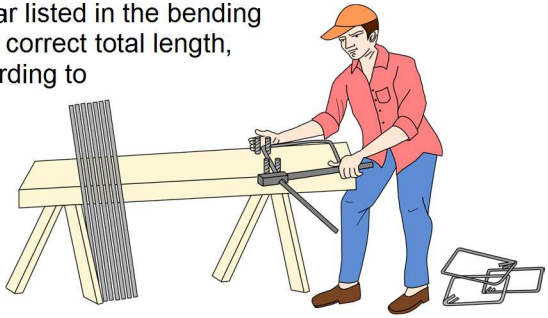
Make sure the surface of the re-bars is clean, free from dirt and certainly not covered with shuttering oil or any other release agent to ensure proper bonding with the concrete.

All bars should be completely surrounded by concrete. This ensures that the concrete and steel complement each other and behave as a single composite material, as well as not exposing the steel to moisture in the air that may lead to corrosion.

Worksheet
Cutting and bending reinforcement bars — C1

Work method:

1. Clear a level area with adequate space for cutting and bending the reinforcement bars.
2. Make sure that you are fully conversant with all the requirements in the bar bending schedule.
3. Assemble the necessary tools including the bending table.
4. Start with the first bar listed in the bending schedule, measure the correct total length, and cut and bend according to the schedule. Use this bar as a pilot piece. Before continuing with the remaining bars, check again that the pilot bar conforms exactly to the required shape and size. If it does, continue preparing the remaining bars of this particular shape. Stack the bars neatly off the ground, keeping them free from mud, oil or any other dirt.



5. Proceed with the same method for each type of bar listed in the bar bending schedule and stack them separately.

Caution: Bars should be bent cold and should not be re-bent to avoid weakening the steel.

Labour:	**Tools:**	**Material:**
• Rural mason, for cutting and bending • Labourer to assist	• Bending table and levers • Hacksaw with extra blades • Hammer and pair of pliers • Tape measure and mason's square	• Reinforcement bars • Binding wire

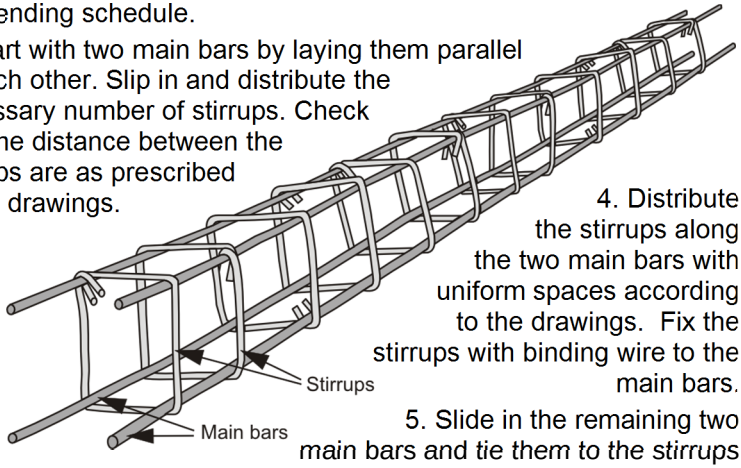
Quality checkpoints:

- ✓ Before cutting and bending check whether the quality and quantity of the reinforcement bars correspond with the re-bar plan and bending schedule.
- ✓ Confirm correct size and shape with the requirements of the bending schedule and ensure that all bars remain clean.

Worksheet
Fixing reinforcement bars for columns and beams
C2

Work method:

1. Prepare a stand or a table for assembling the reinforcement.
2. Check the exact size and shape of the reinforcement bars with the bending schedule.
3. Start with two main bars by laying them parallel to each other. Slip in and distribute the necessary number of stirrups. Check that the distance between the stirrups are as prescribed in the drawings.



4. Distribute the stirrups along the two main bars with uniform spaces according to the drawings. Fix the stirrups with binding wire to the main bars.
5. Slide in the remaining two main bars and tie them to the stirrups while ensuring that the stirrups are perpendicular to the main bars.
6. The assembled reinforcement can now be placed into the correct position in the formworks, i.e. for a column, beam or lintel.
7. Once the reinforcement has been placed, fix spacer blocks of the required thickness to avoid the bars from touching the formwork, thereby ensuring that the bars will be fully covered by concrete.

Labour:	**Tools:**	**Material:**
• Rural mason, for fixing • Labourer to assist	• Pair of pliers • Hammer • Ruler or tape measure and square	• Reinforcement bars cut and bent to correct size • Binding wire

Quality checkpoints:

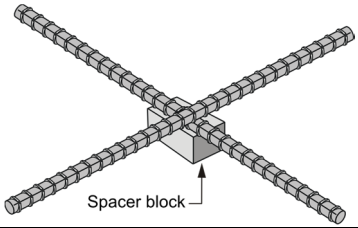
- ✓ Before fixing check the exact dimensions of the beam, column or lintel and its re-bar arrangement.
- ✓ Ensure proper spacing of main bars and stirrups.
- ✓ Ensure tight fixing of main bars and stirrups with binding wire to avoid slippage when pouring concrete.

Worksheet
Fixing reinforcement bars in slabs

C3

Work method:

1. Refer to the reinforcement plan for which bars to use (size, shape and quantity). Also confirm the required spacing between the main bars as well as the distribution bars.
2. Mark the exact position for each main bar with a chalk on the ground or the shuttering. Place the main bars and ensure that the bars are exactly parallel and with the same distance from each other.
3. Place the distribution bars perpendicular to the main bars and on top of them. The slab reinforcement now looks like a big mesh.
4. Bind all distribution bars to the main bars using binding wire. Make sure all knots are firmly tied.
5. When all the bars have been tied together, raise the entire mesh and place it on top of spacer blocks.



Labour:	**Tools:**	**Material:**
• Rural mason for fixing • Labourer to assist	• Ruler or tape measure and square • Marker or chalk • Pliers and hammer	• Reinforcement bars • Binding wire • Chairs • Spacer blocks

Quality checkpoints:

- ✓ Before fixing check the exact reinforcement arrangements as specified in the drawings.
- ✓ Ensure proper spacing and tight binding.
- ✓ Ensure all chairs and spacer blocks are fixed and properly secured.
- ✓ Make sure no reinforcement bars touch the formwork.

4.3 Shuttering works

Concrete is cast into moulds referred to as formwork or shuttering. Usually, the formwork used for walls, columns, beams and slabs are built by joining wooden boards edge on edge. Formwork can be re-used several times if well designed, assembled and maintained. Proper positioning and installation of tie props, support and bracings are essential for ensuring a distortion-free form when pouring concrete.

Preparing wooden shutter boards

Wooden shutters need to be solid enough to support the weight without any deformations or movements. Shutter boards can be re-used many times if the shape and size of concrete structures are the same, e.g. lintels, beams and columns.

Shuttering for footings, columns, beams and slabs

Besides the shutter boards, also tie rods, supports, props and bracings have to be available in good order and sizes as required for the work at hand. Forward planning is essential to ensure that all this material is on site and ready for use, particularly in the case of roof slabs where quite a number of props, stringers and joists are needed. It is important to always clean shuttering material after use and store it safely and protected from the weather.

Scaffolding works

Scaffolding in rural house construction is required for:

- Carrying out masonry works of the upper parts of the walls,
- Installing ventilators,
- Constructing lintels and beams,
- Pouring and compacting concrete for columns,
- Any other work that is required above a height of 1.5 metres from the ground.

Simple but safe scaffolding is required for such works. Usually one level of scaffolding is sufficient. It is important to ensure that necessary safety precautions are made.

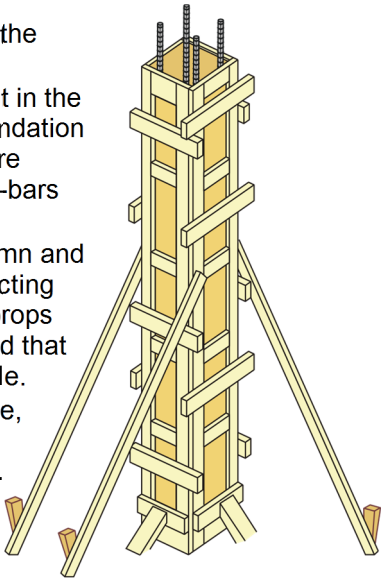
Scaffolding can be safely built using timber, bamboo or metal pipes with couplers. While timber and bamboo is less expensive, these materials cannot be reused as many times as metal pipes.

Safe scaffolding needs to be placed on firm ground, properly braced and if necessary anchored to the building to avoid any collapse of capsizing. Bear in mind that the scaffolding needs to support the weight of the workers as well as the building materials stacked for immediate use.

Worksheet
Shuttering for concrete columns
C4

Work method:

1. Confirm the quality and quantity of available shuttering boards, joists, stringers and props. Coat the inside of the shuttering boards with a light film of shuttering oil.
2. Clean and level the area on which the shuttering will be placed.
3. Place the assembled reinforcement in the correct position and fix it to the foundation or plinth beam. Make sure there are sufficient spacer blocks to avoid re-bars touching the shutter boards.
4. Mark the exact position of the column and place shutter boards on two connecting sides. Fix the boards firmly using props and make sure they are vertical and that the two sides are set at a right angle.
5. Add a shutter board to the third side, while making sure that all the spacer blocks are properly located.
6. Now close the shutter board on the fourth side. Use a plumb bob to check again that the formwork is vertical and that all four corners have right angles. Anchor the shuttering firmly to the ground with struts/props to avoid any movement when pouring concrete.
7. Plug any openings or gaps to avoid any cement paste to seep out.



Labour:	**Tools:**	**Material:**
• Rural mason, for fixing • Labourer to assist	• Saw and hammer • Plumb bob and spirit level • Mason's square	• Shuttering boards • Struts / props • Nails, different sizes • Shuttering oil

Quality checkpoints:

- ✓ Check that the formwork is in the correct position, is vertical and reaches the correct level.
- ✓ Ensure proper anchoring and support with struts and props.
- ✓ Check for any gaps or openings in the formwork.

Worksheet
Shuttering for slabs

Work method:

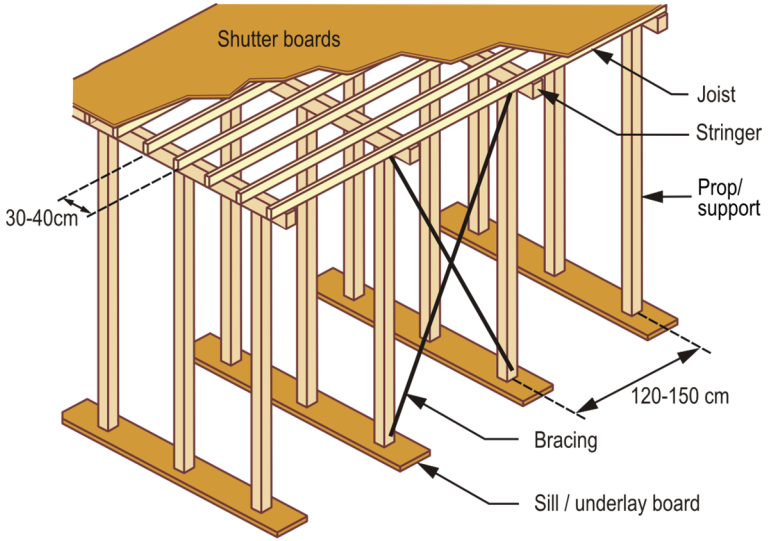
1. Confirm the quality and quantity of the available shuttering material, i.e. boards, joists, stringers, props/support, sills/underlay-boards and bracings.
2. Level the ground on which the shuttering will be erected. Place underlay boards on the ground to provide a firm and safe base for the props. The first and last underlay boards are placed next to the walls. The boards in-between are laid with a spacing of not more than 120 to 150cm.
3. Erect the end props on each of the sill boards (ensure equal and correct length) and on top fix the stringers temporarily (usually 10cm x 10cm). Do not insert pieces of stones or bricks at the bottom. Instead use wooden wedges that are nailed to the sill/underlay board once the correct position and height of the prop is established.
4. Lay all the joists (usually 10x10cm) across the stringers with spacing not exceeding 40cm. Fix lightly with a few nails.
5. Start adjusting the level of the entire shuttering by lifting or lowering the props until the joists are exactly horizontal in all directions. Use wooden wedges at the bottom of the props to adjust their height.

Labour:	**Tools:**
• Rural mason, for erecting the formworks • Labourers to assist	• Saw and hammer • Water tube level and spirit level • Measuring tape and plumb bob

Quality checkpoints:

- ✓ Check that the ground is firm and will not give away when concrete is poured.
- ✓ All props needs to be of strong quality and installed in a vertical position.
- ✓ The spacing between the stringers should not exceed 150cm and between joists not more than 40cm.

C5



6. Now lay the shutter boards on top of the joists and make sure they are as close together as possible to secure tight joints. Once this is done you can now fix all the remaining props and add bracing to avoid tilting of the shuttering structure.
7. At the end, clean the surface of the shuttering boards and apply a light film of shuttering oil.

Material:

- Shuttering boards
- Props, stringers, joists and bracers
- Underlay boards
- Nails, different sizes
- Shuttering oil

✓ Make sure there is sufficient bracing to secure the stability of the formworks.

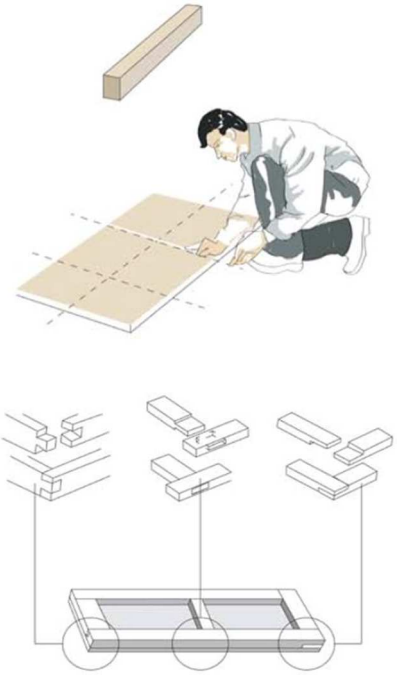
✓ The shuttering should be checked before, during and after concrete works to ensure there are no leaks or sags and no compromise on the personal safety of workers.

✓ Make sure there are no persons underneath the formworks when pouring of concrete.

Information sheet
Preparing wooden shutter boards

Work method:

1. Check the quality of the available timber for the shutter boards, such as plywood and battens. Make sure that the timber is of good quality, straight and clean.
2. Determine the size of the shutter boards, depending on its intended use. For example, for 30cm by 30cm square columns the shutter boards are also 30cm wide while the height depends on the actual column height. Cut battens and boards to the required size.
3. First assemble the frames of the shutter boards using battens with proper joints, e.g. dovetail, tendon, mortise and lap.
4. Apply a light film of shuttering oil on the surface, stack all boards neatly and protect them from weather.



Labour:	**Tools:**	**Material:**
• Rural mason for fixing • Labourer to assist	• Tape measure and mason's square • Marker or chalk • Saw and hammer	• Battens and plywood • Nails, different sizes • Wood glue • Shuttering oil

Quality checkpoints:

✓ Ensure good quality timber.

✓ Ensure correct size and right angles.

Worksheet
Installing scaffolding
C6

Work method:

1. Ensure that the ground where the props will be placed are firm and even.
2. Erect the props and affix horizontal struts. Add bracings to avoid the scaffold from collapsing. Securely tie all joints and connections. Only use good quality material.

3. Secure the scaffold firmly by anchoring it to the wall and support it with struts.
4. Attach guardrails securely on all open sides.
5. Place walk boards at the appropriate level.

Labour:	Tools:	Material:
• Rural mason • Labourer to assist	• Saw • Hammer • Plumb bob • Measuring tape	• Props, struts and bracings • Guardrails and walk boards • Nails, different sizes • Wire and/or rope

Quality and safety checkpoints:

- ✓ Use appropriate timber, bamboo or metal pipes and couplers.
- ✓ Erect the scaffold on clean and firm ground.
- ✓ Confirm that the scaffolding is vertical, properly aligned and to the correct levels.
- ✓ Secure the scaffold firmly to avoid movements and tilting.
- ✓ Ensure proper anchoring of struts and props.
- ✓ Make sure that all joints and connections are securely tied.
- ✓ Use solid walk boards (no sagging, cracks or splinters and wide enough for safe walking and stacking of materials).

4.4 Mixing and pouring concrete

Preparations before mixing and pouring concrete

Manual concrete work is a demanding operation in terms of the various activities and skills required to achieve good quality work. The quality of the formwork, fixing of reinforcement, mixing concrete, pouring and compacting concrete plus finishing and curing are the major activities involved besides other support activities. An efficient work process resulting in good quality concrete can only be achieved if all preparations are carefully considered. These include:

Checkpoints for preparing concrete works:

- ✓ Check that the formwork and reinforcement is stable and firmly anchored.
- ✓ Check the quality of all materials before mixing.
- ✓ Confirm the proportions of the components, i.e. the quantities of aggregate, sand, cement and water.
- ✓ Make sure there is sufficient material available on site.
- ✓ Ensure that all required tools are available and in good order.
- ✓ Organise a sufficient number of labourers available on site for mixing, transporting and pouring the concrete.

Amount of material

Remember that much more than one cubic metre of ingredients is required to produce a cubic metre of concrete. The reason for this is that the cement and sand fills the empty spaces between the larger aggregate. The table below shows the quantities necessary to produce one cubic metre of concrete.

Concrete mix	Material required to produce 1m^3 concrete		
	Cement (kg)	Sand (m^3)	Aggregate (m^3)
1:2:4	6.5 bags (325kg)	0.45	0.90
1:5:10	2.8 bags (140kg)	0.58	1.15

Water-cement ratio when mixing concrete

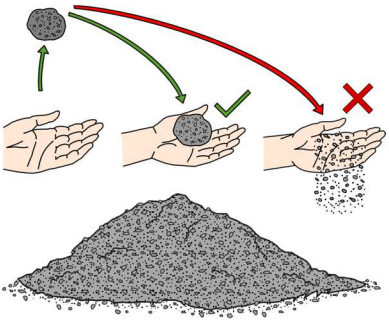
A careful balance of cement to water is required when preparing a mix. The quantity of water divided by the quantity of cement (both measured in kilograms) gives the water - cement ratio. A low water to cement ratio leads to high strength but low workability. A high water to cement ratio produces a low strength concrete but good workability.

Example:
For one 50 kg bag of cement:
- The quantity of water with a ratio of 0.4 means that you add 20 litres of water per bag of cement (0.4 x 50kg = 20 litres)
- The volume of water with a ratio of 0.5 means 25 litres of water per bag of cement (0.5 x 50kg = 25 litres/kg of water)

A common shortcoming in concrete works is the use of too much water because it is then easier to spread and compact the concrete. Water-cement ratios in the range of 0.4 to 0.6 provide a good workability without compromising the strength of the concrete. Hand-mixed concrete requires more water to achieve sufficient workability (water/cement ratio from 0.5 to 0.65).

A rule of the thumb for hand mixing: Use between 20 litres and maximum 25 litres of water for each bag of cement.

The *Laddu test* is a common hands-on procedure to check whether the water-cement ratio is correct. Form a ball of ready mixed concrete in your hand, knead it well, throw it up about 60cm and catch it again. If the mixture retains the form of a ball, then the water-cement ratio is acceptable. The water-cement ratio is not correct if the ball disintegrates when you catch it.



When pouring concrete for columns you may need slightly more water in order to ensure that concrete reaches all corners in the tight space inside the formwork, thereby avoiding any honeycombs.

Manual mixing

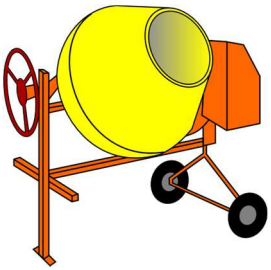
Manual mixing is appropriate for smaller quantities of concrete, such as for the level-course in foundations or lintels, columns, etc. For larger quantities it is more practical to use a concrete mixer.

When mixing is carried out by hand it requires a suitable surface (metal sheets, boards or a lean concrete slab) to ensure that the mix is not contaminated with soil. The surface should be level to prevent water from running off the mixing area. The space needs to be sufficiently large to allow for the required size of batches to be mixed without spilling into surrounding areas. The work process for manual mixing is shown in worksheet C7.

Mechanical mixing

With larger quantities of concrete such as when building a slab, it is easier to use a concrete mixer. Mechanical mixing also produces a more homogeneous mix. The following procedure is recommended for loading concrete mixers:

(i) First place a part of the water into the mixer.
(ii) Charge half the volume of aggregate. The aggregate assists in cleaning the inner surfaces of the drum.
(iii) Add the prescribed amount of sand.
(iv) Add the cement.
(v) Add the remaining aggregate. The concrete mixer should never be completely filled.
(vi) Mix dry for one minute.
(vii) When the aggregate and the cement have been thoroughly mixed, add the



remaining quantity of water and mix for another two minutes.

Make sure all tools, platforms and mixers are thoroughly cleaned after the mixing is complete. Leftover hardened concrete may damage the equipment.

Checkpoints for mixing concrete

- ✓ Too much water reduces the final strength of the concrete.
- ✓ When adding water also consider the existing moisture content of sand and aggregate. After rains it may not be necessary to add the full amount of water as discussed above.
- ✓ Never add more water when a mix is drying up. Instead use a mixture of cement and water if it is necessary to improve the workability of the concrete.
- ✓ Cement or fresh concrete should not come in contact with the skin or eyes. Wearing gloves, a long-sleeved shirt, full-length trousers and boots reduces the exposure. Wet concrete, mortar or cement should be washed from the skin immediately. Eyes need to be flushed with lots of water for at least 20 minutes immediately after contact.
- ✓ A facemask may be required when mixing concrete as the mixing process often creates a lot of dust.

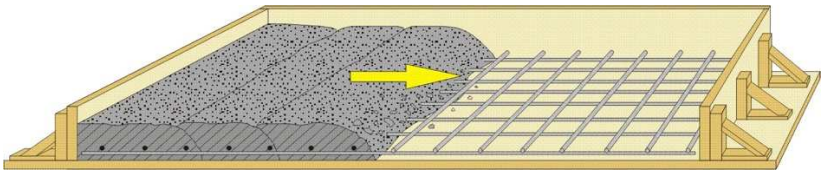
Pouring concrete

After mixing, the concrete needs to be placed and compacted. Placing and compaction of concrete should be done without causing any segregation of its ingredients. When pouring the concrete, care needs to be taken not to damage the formwork or dislodge the reinforcement. The following process takes place:

(i) Place the concrete starting from the corners at the far end of the formwork. Start compacting the concrete immediately after it has been placed. The concrete should be placed in layers not higher than 30 cm when compacted by hand and in layers not higher than 60 cm when compacted by

vibration. Pour the concrete with care, making sure that the reinforcement bars are not dislodged.

(ii) Slabs and floors need to be poured in one continuous operation to avoid any vertical or horizontal joints, which can create planes of weaknesses within the structure.



(iii) If the concrete is not properly compacted, air will remain inside the pour. When it hardens, the concrete then appears with honeycomb spots or rashes.

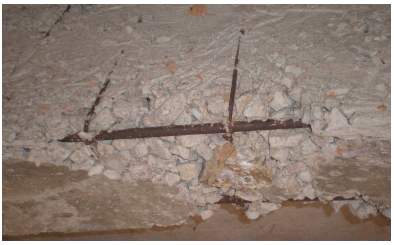
(iv) Consolidation/compaction can be done by hand with hand-tampers or iron rods. When pouring concrete for a large surface such as a roof slab of floor, the compaction needs to commence while still pouring concrete.

(v) A more effective method is to use a poker vibrator. The vibrator is immersed into the concrete at regular intervals of half a metre apart. Vibration should not be longer than 10 seconds in one place and the vibrator should be kept away from the formwork and reinforcement bars. Excessive vibration causes the aggregate to segregate.

(vi) If concrete is not properly poured and compacted, honeycombing and voids will be formed which weakens the structure.

(vii) After the concrete has been properly compacted, the top of the concrete is levelled to a smooth surface with a mason's trowel or a float. For large surfaces, use a straight edge as a screed to level the concrete. The straight edge is worked back and forth in a sawing fashion to level the entire surface.

(viii) Make sure that the correct volume of concrete is poured to the levels marked inside the formwork. Keep an eye on the reinforcement and ensure that the concrete adequately covers the reinforcement bars.



Insufficient coverage of reinforcement

Curing and removal of shuttering

Proper curing essentially consists of keeping the concrete moist during the period during which it is gaining strength. A common method to keep concrete moist is by frequently sprinkling or flooding the surface, or by covering it with wet gunny bags. Covering the concrete with plastic sheets, banana or palm leaves or other materials also reduces the evaporation from bright sun and wind. Delaying the removal of the formworks as long as possible also reduces moisture loss.

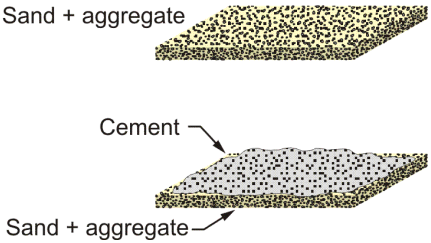
The shuttering should be carefully removed only after the concrete has gained its necessary strength. The table below shows the schedule for removing shuttering for the different structural elements in a rural house.

Concrete structure	Duration before removing shuttering
Columns, sides of beams and slabs	after 2 days
Slab less than 4.5m span	after 14 days
Slab more than 4.5m span	after 21 days
Lintel with sunshade	after 14 days
Below beams less than 6m span	after 14 days
Below beams more than 6m span	after 21days

Worksheet
Manual mixing of concrete

Work method:

1. Before mixing and pouring concrete, check that the formwork is complete and that the reinforcement has been properly assembled.
2. Check the quality of materials prior to mixing concrete: potable water, cement grade and manufacturing date, and quality and purity of sand and aggregate.
3. Concrete for structures (1:2:4):
   a. Place and spread four parts of aggregate and two parts of sand on a clean platform or other hard surface.
   b. Add one part of cement on top of the sand.



   c. Thoroughly mix aggregate, sand and cement until it achieves a uniform grey texture. The general rule is that sand, aggregate and cement are mixed together dry at least three

Labour:	**Tools:**
• Rural mason • Labourers to assist with transporting materials and mixing concrete	• Clean platform for mixing • Shovels or spades • Batching box or measured buckets • Water buckets • Gunny bags to cover concrete

Quality checkpoints:

- ✓ Check that the cement has not passed its expiry date and contains no lumps.
- ✓ Ensure that the sand and aggregate is clean and with the correct grain size.

C7

times before adding water in order to achieve a good mix.

d. Dig a hole in the centre of the heap and carefully add water.

e. Continue mixing until the concrete has the desired consistency. The optimal water content is when the mix allows you to mould a ball in your hand.

4. When mixing lean concrete (1:5:10) use the same procedure as above but with the proportion of one part cement, five parts sand and ten parts aggregate.

Try to limit the amount of water in the mix. Rule of thumb for amount of water to be added: 25 to max. 30 litres of water for each bag of cement. You should be able to form a ball in your hand.

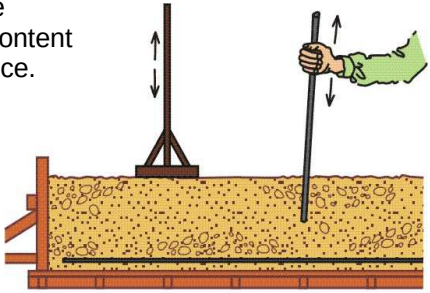
• Clean platform for mixing • Shovels or spades • Batching box or measured buckets • Water buckets • Gunny bags to cover fresh concrete	**Material:** • Clean sand • Correctly graded aggregate • Cement (no lumps, not expired) • Clean water (no salt water)

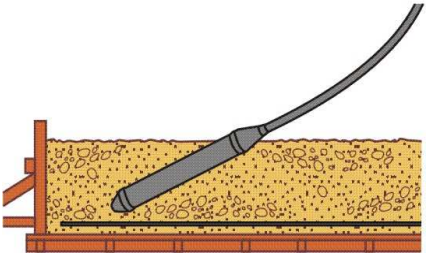
✓ Continuously check that batching is done to correct proportions and numbers of batches.
✓ Continuously check the consistency of the mix and control the use of water.

Worksheet
Pouring, compacting and curing concrete

Work method:

1. Check the formwork for any dirt, gaps (leakage) and misalignment. Also check for unsecured or insufficient props, bracings and other support arrangements.
2. Make sure the concrete has the correct proportions and water content – with a consistency like curd-rice.
3. Wet the shuttering with clean water just before pouring concrete.
4. Pour concrete in layers that can be easily compacted: by hand, not more than 30cm and by vibrator, not more than 60cm.
5. Pour and compact the concrete without any break until the entire job is completed.
6. Use an iron rod to compact columns. Also knock the shuttering lightly from the outside with a wooden hammer.





Labour:	**Tools:**
• Rural mason to supervise • Labourers to assist in transporting, pouring and compacting concrete	• Complete masonry tool set • Shovels and rakes • Buckets to carry concrete and water • Iron rods and wooden dampers

Quality checkpoints:

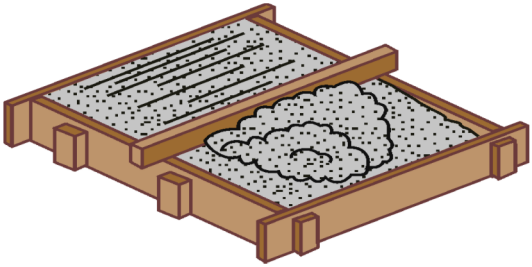
✓ Check the quality, alignment, support structure and cleanliness of the formwork and reinforcement before pouring concrete.

✓ Check that the scaffolding is properly installed with necessary safety precautions.

C8

As soon as the cement slurry seeps through the shuttering gaps, then compaction has been achieved (provided the water content is correct).

7. When hand compacting slabs, first use iron rods and then finish off with wooden tampers.
8. When compacting using a vibrator never keep the vibrator on the same spot for more than 10 seconds. Avoid touching the reinforcement bars or formwork.
9. When pouring slabs, start at on one end of the shuttering. Immediately compact and screed the surface using rakes and long straight edges. Fill any depressions and screed again.



10. Use a large size float to finish and smoothen the surface.
11. Immediately cover the surface with a PVC sheet or wet gunny bags.
12. Cure the concrete continuously for at least 14 days. Do not remove the shuttering before 14 days for spans below 4.5m and 21 days for spans more than 4.5m.

• Wooden hammer • Vibrator for mechanical compaction • Straight edge • Gunny bags to cover the fresh concrete	**Material:** • Ready mixed concrete (see Worksheet C7) • Water

✓ Continuously check the consistency of the concrete.
✓ Control the height of layers and ensure proper compaction.
✓ Ensure that the final surface receive a proper finishing.
✓ Make adequate arrangements to ensure that continuous curing takes place for the prescribed number of days.

Section 5
Toilet construction – fittings and fixtures

5.1 Purpose and importance of the toilet

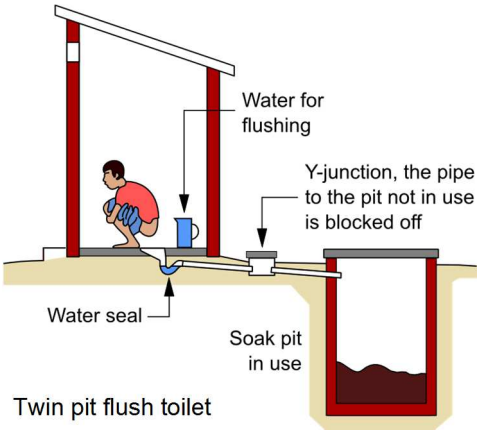
Every house needs a toilet. As part of making the nation free from open defecation, the Government is committed to construct toilets as part of its housing programme. Many states are providing additional assistance to the construction of toilets. Other national programmes, such as the Swatch Bharath mission and MGNREGA also support the construction of toilets. Generally, twin pit toilets are constructed as part of the housing programme.

Open defecation is the root cause of many health hazards and nutritional deficiencies among the rural poor and especially children. The lack of awareness on the use of toilets and a lack of resources to build toilets commonly result in open defecation. Therefore, it is mandatory to include a toilet as part of the houses built under the rural housing programme. The rural mason therefore needs to know how to construct a toilet.

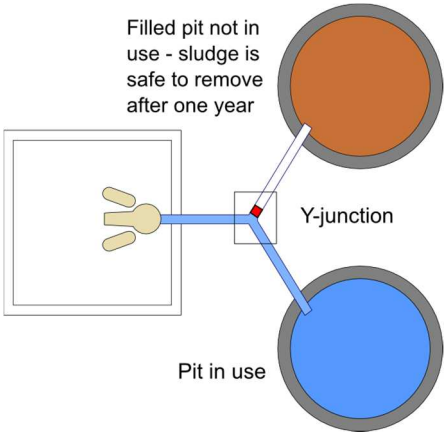
Important features of twin pit toilets

There is a great variety of toilets commonly in use in rural India, ranging from single pit toilets to twin pit flush toilets and the use of septic tanks. In urban areas, toilets are preferably connected to a network of sewer pipes. Under its rural sanitation programmes, the Government is promoting the twin pit flush toilet.

In this design, two leach pits are connected to one single pour-flush toilet. At any given time only one pit is in use. Once one of the pits is full, the other pit is put into use, receiving excreta and wastewater. The toilet has a permanent super-structure like a room for privacy purposes. It can also be used as a bathroom if the size is slightly increased. The toilet can also be constructed inside the house, while the pits remain located outside the house.



Twin pit flush toilet



The following are the different components of toilets to be taken up under the housing programme.

Twin pits

Two circular pits are dug at a distance of a metre from each other. Each pit has a diameter of 0.9 m and depth of 1 m. The walls are constructed either by prefabricated concrete rings

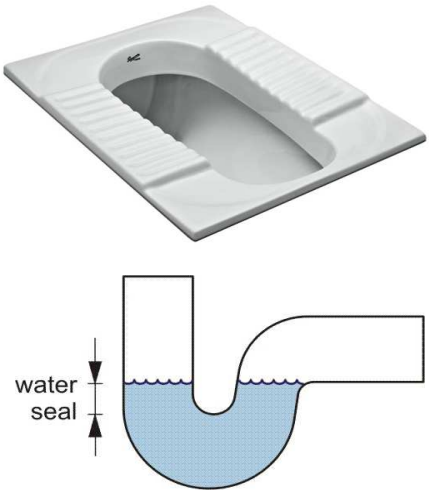
or with in-situ brick masonry. Each pit should have a pre-cast reinforced concrete cover of 5 cm thickness. If the walls are constructed with bricks there should be weep holes left at the rate of two holes in every layer of brick course. These holes allow water to exit and be absorbed into the surrounding ground.

Junction box

The junction box is constructed to direct flow of excreta and water from the toilet pan to the pits. The junction box is constructed in a 'Y' shape allowing the excreta and water to reach one pit at the time. The junction chamber is constructed from bricks and mortar and connected with clay, PVC or asbestos pipes.

Toilet pans and water seals

The efficiency of the entire toilet depends on the accurate positioning of the toilet pan and thus creating a proper water seal. The toilet pan is connected to the Y-junction chamber through a pipe. The 'P' shaped trap, which forms part of the toilet pan contains the water seal. The presence of water in the curved pipe inside the toilet pan works as a seal preventing foul smell to travel from the pit to the toilet room.



The correct positioning of the pan secures the presence of the water seal. Hence the mason needs to know how to position the toilet pan in a perfect horizontal position. The correct position of the P trap perfectly horizontal is critical to ensure that the water seal performs as desired.

Toilet room

The construction of the toilet room consists of building the foundations, plinth, masonry walls, roof, flooring and installing a door.

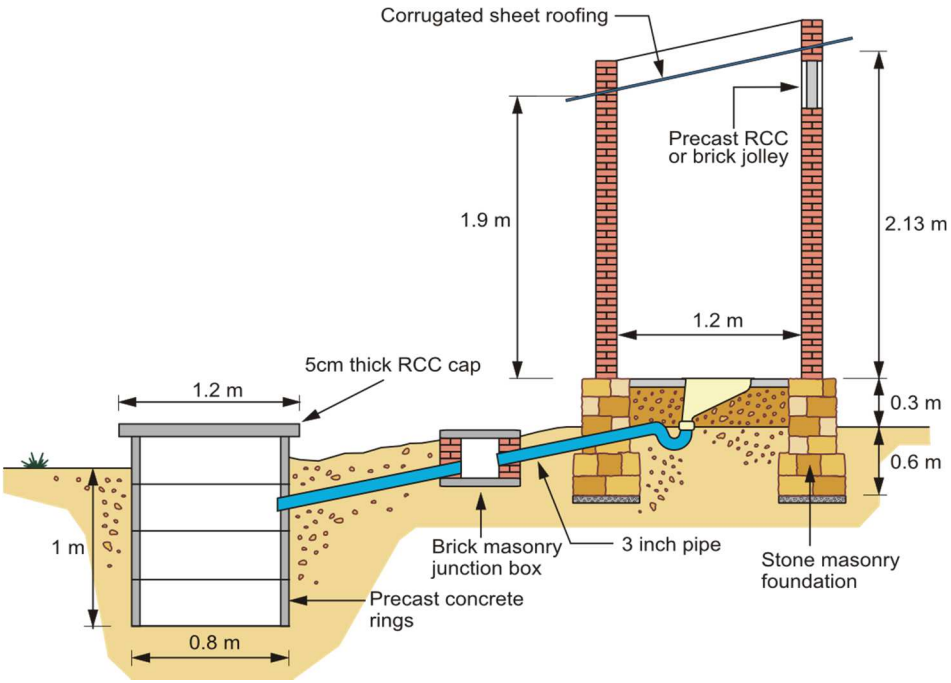
5.2 Sequence of activities in constructing a toilet

The various activities for constructing a toilet needs to be planned in the following sequence to ensure that the construction is smooth and avoids any dismantling work.

This sequence also makes sure that the desired slopes are secured for the outflow from the toilet.

(i) Pit construction
(ii) Foundations up to plinth of the main room
(iii) Positioning of the toilet pan
(iv) Construction of the junction box
(v) Fixing the pipes
(vi) Superstructure of toilet room

Common dimensions applied in toilets for rural houses are shown in the illustration below.



5.3 Construction of twin pit toilets

The function of the pits is to receive and store the effluents from the toilet. The walls inside the pits are supported with brick or stone masonry or using prefabricated concrete rings available in the market.

Worksheet
Constructing twin pits for toilets

Work method:

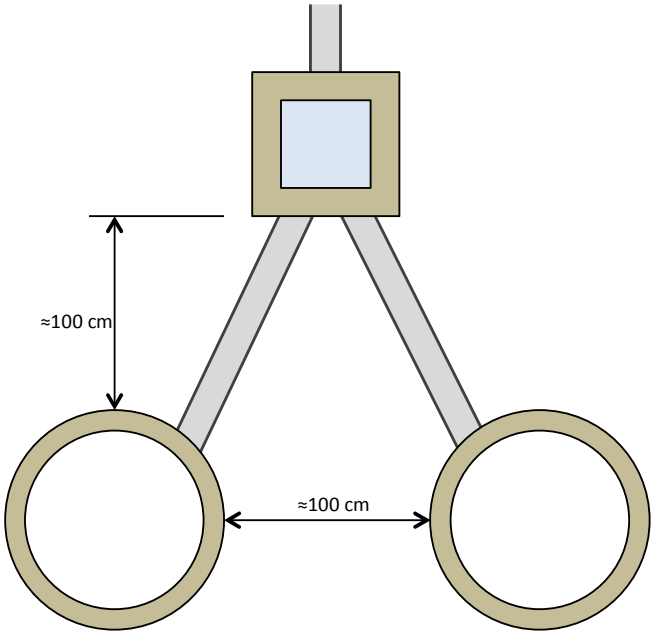
1. Consult the house owner for the location of the toilet. If the owner follows *vastu* it is better to leave the choice of the location to him/her.
2. Using a string, set out the first pit with a diameter of 0.9 m. Set out the second pit at a distance of one metre from the first pit with the same diameter. Place the two pits at a distance of at least 1.6 m from the main room of the toilet.
3. Dig the pits down to 0.9 m depth using a crowbar and a shovel. Deposit the excavated soil in a safe location away from the pits. This soil will not be used - hence it may be used for landscaping around the house or disposed off.
4. Construct a foundation footing with 22.5 cm width and 100 mm thick using brick or stone in cement mortar 1:3.
5. The pits are lined with brick masonry of 10 cm thickness (one brick wide). Leave seep holes of half a brick size. These holes allow water to be absorbed into the surrounding soil. The pit can also be lined with prefabricated concrete rings.
6. The brick masonry should be cured for a minimum of 14 days.
7. Build the pit lining up to ground level. The masonry wall above ground may be easier to construct after connecting the pipe from the junction chamber. Ensure that the pipes from the junction box have sufficient slope to easily discharge by gravity into the pits.

Labour:	**Tools:**
• Rural mason • Labourers to assist	• Tape measure • Complete masonry tool set • Crow bar and shovel

Quality checkpoints:

✓ Check the position of all elements and their levels to ensure that water is able to flow into the pit.

T1



8. The pits are sealed with a concrete cover with a thickness of 50 mm. The cover may be done in two segments so that it is easily lifted and fixed on to the pit.
9. Follow the same construction process for the second pit.

• Mortar pan • Plumb bob • Water tube and spirit level	**Material:** • Bricks or concrete rings • Cement and sand for mortar • Steel bars for reinforcement • Clean water for cement mortar

✓ Check the depth and width of the pits during the excavation works.
✓ If the pits are lined with bricks, strictly follow the instructions as described in the masonry worksheets.

Water seal

Water sealing is an important concept the rural mason needs to understand in order to install the toilet. The purpose of the water seal has already been explained. Toilet pans with built-in water seals are also available in the market. These may prove to be more cost effective.

Positioning the toilet pan

Positioning the toilet pan exactly horizontal is an important skill the rural mason needs to master. If the pan is not positioned exactly horizontal, insufficient water will be retained in the neck portion and a proper water seal is not formed. This allows foul smell and insects to enter the toilet and make it unusable. Therefore, it is important to position the toilet pan in a perfect horizontal position.

Foundation for the toilet room

Foundations for a toilet as part of a rural house can be built using bricks, stone or concrete blocks. The depth of the foundation depends on the type of soils. Generally, the depth should be 45 to 90 cm. The foundation width should be 45 to 60 cm. A levelling course with 10 cm thickness using lean concrete is placed beneath the stone masonry foundation.

Plinth construction

The plinth is the masonry wall above ground up to 30 cm height. The width of the plinth wall may be 30 cm. Generally, stone masonry is recommended for plinth walls. Brick or concrete blocks may also be used in case stone is not available.

Masonry walls

The walls are built on top of the plinth using brick, stone or concrete block masonry. The height of the wall on the backside of the toilet room should be 1.9 m and 2.15 m on the front side. The difference of 25 cm between the two walls is to create a slope on the roof to allow rainwater to drain off. A finishing course of 30 cm height masonry is added after laying the roofing sheets.

Roofing

To keep the cost to a minimum, GI or tin sheets are preferred for the roof. Wooden rafters may be used to support the roofing. Iron angles or tubular steel members may also be used as rafters.

Plastering and colour wash/white wash

When the masonry is constructed with clay bricks it is common practice to plaster the walls using a 1:3 cement mortar with a 12 mm thickness. The plastering is done as explained in Section 3. Sometimes the plastering is only applied to the external walls to save costs, leaving the inside walls without any plaster.

Flooring

Flooring around the toilet pan can either be with IPS (CC) flooring or with a stone slab. The IPS flooring is explained in Section 3. The floor needs a solid base consisting of hard soils or gravel filled up to plinth level and well compacted using a hand rammer. Finish of the base with a layer of 75-100 mm lean concrete.

Worksheet
Constructing the toilet room

Work method:

1. Set out the exact location of the toilet room (internal dimensions 1m x 1.2m), junction chamber (0.3m x 0.3m) and the twin pits.

2. Foundations for the toilet room up to plinth:

a) Excavate the trenches for the foundations to a depth of 0.7m unless otherwise required due to site conditions. The trench should be dug 0.6 m on either side of the centre-line. Make sure the bottom of the trench is firm, level and dry and that there is no remaining loose soil.

b) Place lean concrete 1:5:10 to a thickness of 5 to 10 cm.

c) Prepare cement mortar 1:6 for the stone masonry foundations.

d) Construct the first footing using stone masonry with a width of 0.6 m and to a depth of 0.3 m.

e) Construct a second footing 0.45 m wide to a depth of 0.3 m below ground and 0.3 m above ground. The masonry above ground will also function as the plinth.

3. Masonry walls

a) Prepare cement mortar 1:6 for the masonry walls.

b) The walls above the plinth can be built using red brick, stone or concrete blocks. The front wall should have a height of 1.9m and the rear wall should be 2.15m. The sidewalls are sloped accordingly.

c) A 25 cm slope is provided to allow water to drain off the roof. Add another 30 cm height of masonry after laying the roof sheets.

d) Plastering the walls is optional, depending on the financial capacity of the house owner. Plastering is not required for the stone masonry or walls made from concrete blocks.

For masonry details refer to the masonry worksheets.

4. Roofing

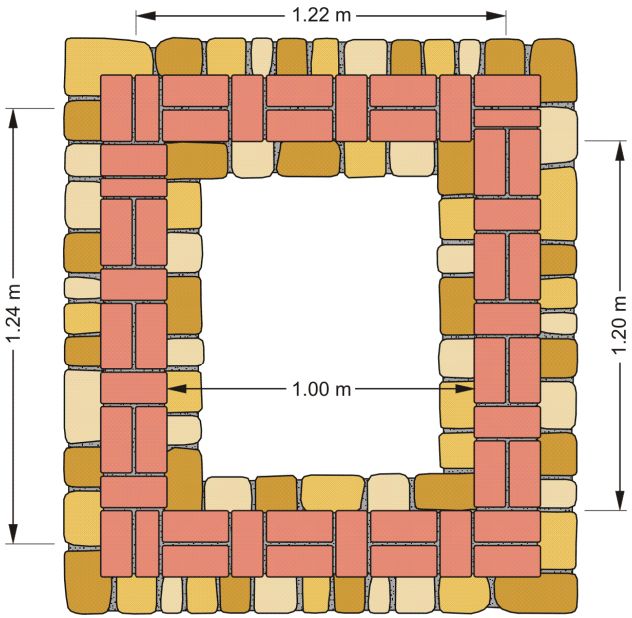
a) Install three rafters made from wood, tubular or angular steel to support the roof.

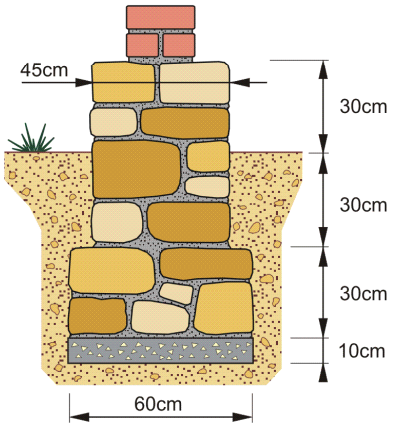
b) Fix the three rafters in parallel to the wall.

c) Place roofing sheets on the rafters using ‘J’ bolts.

d) Once the roofing sheets are fixed, extend the walls 22 cm above

T2





the sheets. This holds the sheets firm against wind.

e) Anchor the ends of the rafters properly in the walls.

5. Plastering and painting/white washing

a) Clean the walls, removing any protruding mortar.
b) Wet the walls with water before plastering.
c) Plaster walls with 1:6 mortar to a 12 mm thickness.
d) Ensure that the plaster is cured for a minimum of 14 days.

For plastering details refer to Worksheet M16.

6. Flooring

a) Fill the plinth with gravel and compact in layers of 100 mm thickness. Sprinkle water on each layer for good compaction.
b) Prepare lean concrete of 1:5:10 mix using 65-75 mm stone
c) Place the concrete up to a thickness of 100 mm. Ensure that the concrete is laid 50 mm below the top of the plinth.
d) Prepare concrete with a 1:2:4 mix. Lay the concrete with 50 mm thickness. It should be compacted with a rammer. The concrete should be flush with the top of the toilet pan.
e) Finish by applying cement slurry on the surface while the concrete is not yet cured. Red oxide may be used over the slurry to improve the aesthetics of flooring.

Labour:	**Tools:**	**Material:**
• Rural mason • Labourers to assist	• Complete masonry tool set • Plumb bob • Water tube and spirit level • Hammer and saw	• Bricks, sand and cement • Course aggregate • Clean water • 75 mm AC/HDPE/clay pipe • Roofing sheet and J-bolts • Nails, various sizes

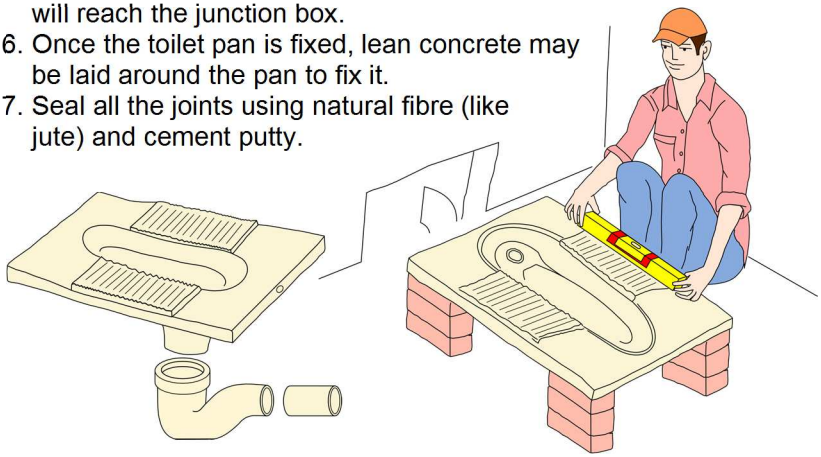
Quality checkpoints:

✓ The level of the concrete floor should be flush with the top of the toilet pan and the top of the plinth so that when the floor is washed the water easily flows into the toilet pan.
✓ Do not spill mortar on the toilet pan when building the walls. The toilet pan should be covered with used cloths or gunny bags to avoid any mortar or concrete entering the toilet pan or P-trap.
✓ All concrete and masonry works should be cured for 14 days.

Worksheet
Positioning the toilet pan
T3

Work method:

1. Ensure that the masonry up to plinth is constructed
2. Fix the toilet pan temporarily on loose bricks. Ensure that the top of the pan is in line with the plinth level.
3. Check whether the top of the pan is level by setting the spirit level on the surface of the pan. Check the levels in all directions.
4. Once it is perfectly levelled, fix the toilet pan at the plinth level using sand underneath.
5. Connect the pipe extending it to the outside of the plinth so that it will reach the junction box.
6. Once the toilet pan is fixed, lean concrete may be laid around the pan to fix it.
7. Seal all the joints using natural fibre (like jute) and cement putty.



Labour:	Tools:	Material:
• Rural mason • Labourers to assist	• Complete masonry tool set • Water tube and spirit level • Measuring tape	• Bricks • Toilet pan • 75 mm AC, HDPE or clay pipes • Sand and cement and stone

Quality checkpoints:

- ✓ Check the correct positioning and level of the pan.
- ✓ Make sure the connections between the pan, P-trap, outflow pipe and junction box are properly sealed.
- ✓ Ensure that the masonry works follow the instructions as detailed in the masonry worksheets.

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