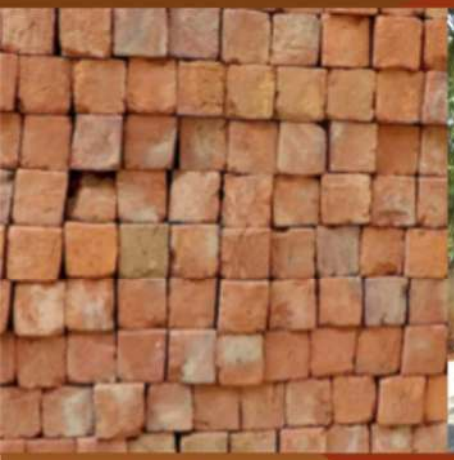
सत्यमेव जयते

Ministry of Rural Development
Government of India

Training rural masons

Learning unit 1



Basic knowledge

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Organization

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Preface

For construction works in the context of rural India, a significant stakeholder is indeed the rural mason or local builder who often acts as a total solution provider for aspirants of a durable home. Given the limited access to specialised services in rural areas, the rural mason invariably ends up shouldering the responsibility of undertaking multiple (specialised) tasks at each stage of the construction of a house.

This training initiative intends to boost the capacity of existing builders operating as masons in rural areas, many of whom are essentially 'semi skilled' when viewed against the current National Qualifications Framework. The intention is that these 'semi-skilled masons' will be building the State sponsored housing, and are therefore equipped through this training programme with the necessary skills to fulfil their role as 'total solution providers'.

It is recognised that rural masons may not have the time and opportunity to attend a central (mostly residential) training programme as is generally practiced for vocational skills development. Any disruptions in their day-to-day livelihood efforts owing to centralised and off-site training are often seen as a limiting factor. The current initiative attempts to overcome these barriers in the following ways:

(i) Training is designed in a decentralised manner, at the village level, wherein the trainee masons need not travel too far from home and gainfully benefit from an 'earn while learning approach' as a rural house is built by the trainees.
(ii) Sufficient inputs and aids for the master trainers to present the necessary technical knowledge through visually rich teaching aids (accompanying posters) and the trainee's handbook.
(iii) The trainee handbook itself describes the essential dos and don'ts along with ready reference details to simple house construction works in an illustrated format.

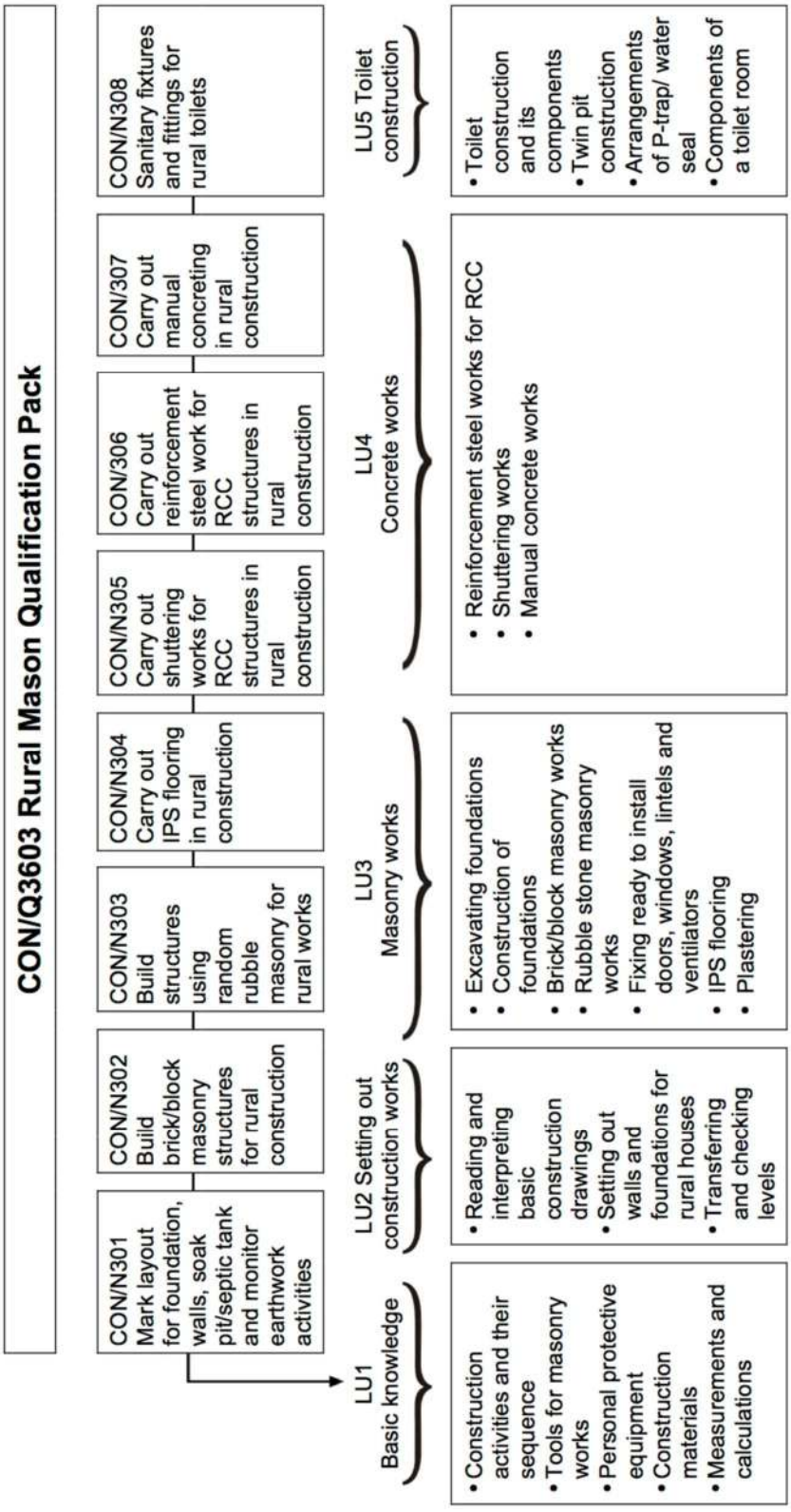
In this backdrop, the rural mason training kit comprises of the following aids:

(i) Trainer's Guide, consisting of:
    Learning Unit 1: Basic knowledge
    Learning Unit 2: Setting out construction works
    Learning Unit 3: Masonry works
    Learning Unit 4: Concrete works
    Learning Unit 5: Toilet construction - fittings and fixtures
(ii) Training Posters (corresponding to each Learning Unit)
(iii) Trainee Handbook

The Learning Units follow the Qualification Pack developed specifically for the rural masons. Each Learning Unit covers one category of activities to be carried out in the field. In combination with the worksheets and posters, the intention is to deliver these to the trainees as part of constructing a model house. Detailed worksheets have been prepared to describe the hands-on components of the training. These have also been included in the posters as an aid to field work guidance for the trainer. The table below captures the relationships between the training kit and the components defined in the Qualification Pack, thus providing the framework for the training.

The training material draws from existing literature sources in India and other countries as well as the extensive experience of the technical team. These have been attributed credit where possible, nonetheless, the books are very much an output of shared learning from the field and are therefore humbly dedicated back to the larger community of learners.

The training kit should be considered living documents, open to additions and modifications, as the training is rolled-out in different states with their own specific building practices, prevalent site conditions and human resource contexts.



Acknowledgements

This second version of the training kit for rural masons is the outcome of teamwork and consistent support from several persons and agencies. We are thankful to all who provided inputs and guidance to the production of the training material.

Special gratitude goes to Shri. Rajeev Sadanandan, IAS, earlier Joint Secretary, Shri. S. Rakesh Kumar, Deputy Secretary, and other officials of the Ministry of Rural Development for their constant encouragement and guidance and to Ms Pannuda Boonpala, and Ms Anjana Chellani of the International Labour Organization for their support and facilitation of the entire exercise.

The following organisations deserve a special mention for sharing some of their training material for reference:

- Building Materials and Technology Promotion Council, New Delhi
- Development Alternatives, New Delhi
- OP Jindal Community College
- SKAT - Swiss Centre for Development Cooperation in Technology and Management, Switzerland
- Telangana State Housing Corporation, Hyderabad
- United Nations Development Programme, New Delhi

Officers, trainers and trainees of the State Governments in Jharkhand, Maharashtra, Chhattisgarh, Uttarakhand and Rajasthan contributed by way of their experiences in pilot training of trainers and semi-skilled masons.

The initial technical team for the preparation of the training material consisted of Mr Andreas Beusch, ILO Training Specialist, Mr Akunuri Murali, Telengana 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.

Learning Unit 1
Basic knowledge

1.1 Introduction

The objective of the low-cost rural housing programme of the Ministry of Rural Development is to provide proper accommodation for the rural poor.. The typical rural house under the Government's housing programme is a modest, low cost but good quality building. Rural masons can construct these houses using simple construction methods and locally available materials.

This Learning Unit provides the necessary information to be able to describe a rural house with all its structural elements and how it is constructed from the foundation to the roof and the required tools, safety equipment and building materials.

This Learning Unit does not address specific work activities but is instead meant to provide the basic knowledge a rural mason should comprehend to be able to competently carry out the practical works involved in the construction of rural houses.

First, the Learning Unit provides information in terms of basic construction concepts:

- Main features of a typical rural house;
- All activities involved in the construction of rural houses and their logical sequence.

Secondly, the Learning Unit lists the required resources that are commonly used for rural house construction, such as:

- Hand tools and measuring aids appropriate for house construction;
- Protective equipment to be used on site;
- Common building materials used in the construction of rural houses.

Thirdly, the Learning Unit also provides reference information for:

- Simple construction calculations and common measurements;
- Essential safety measures on building sites.

The purpose of this Learning Unit is to *enable a rural mason to describe a typical rural house, the construction activities and their correct sequence, to describe and use the common mason tools and protective equipment, and to identify the required construction material.*

By the end of this Learning Unit, it is expected that the rural mason will be able to:

(i) Describe the features of a typical rural house.
(ii) Describe the construction activities in their logic sequence.
(iii) Identify and use the appropriate tools for masonry works.
(iv) Identify and use the appropriate personal protective equipment.
(v) Apply calculations applicable for rural house construction.
(vi) Describe the common materials used for the construction of rural houses and estimate the quantities required for construction works.

1.2 Typical features of a rural house

This section will enable the rural mason to:

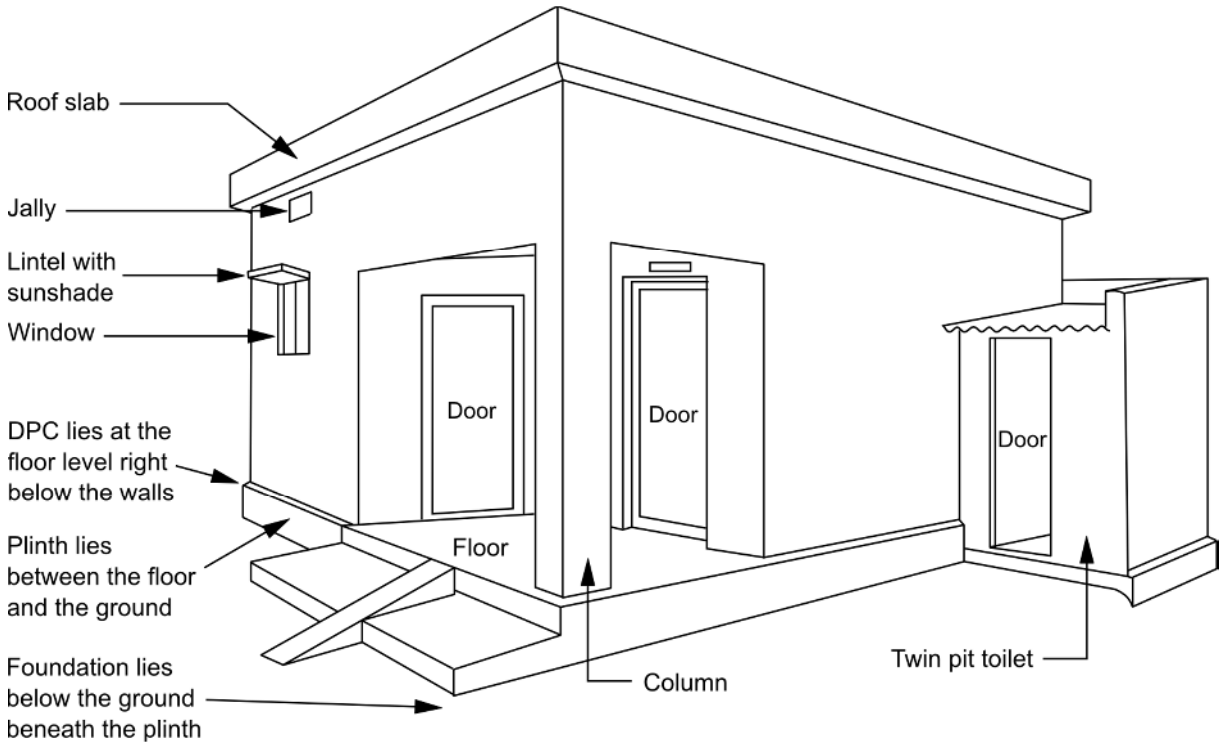
- Explain the general types and layout of rural houses;
- Describe a rural house with all the important structural features.

1.2.1 Layout

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

The particular design and specifications of rural houses depend on the local conditions, e.g. available materials, climate and topography, and also on the specific standards of the respective state governments.

1.2.2 Structural features



The following table describes the different building elements and provides references to the related learning modules:

Foundation

A foundation is required to evenly distribute the load of the building onto the soil to avoid settlements that cause damages to the house. The foundations should be constructed on hard soils.

The construction details are explained in Learning Unit *3 Masonry.*

Plinth

A plinth is constructed immediately above the ground level on top of the foundation. It raises the ground floor to a level where surface water cannot enter the building.

The construction details are explained in Learning Unit *3 Masonry.*

Damp proof course (DPC)

The damp proof course hinders surface water to rise into the walls. The DPC can be constructed using cement concrete 1:2:4 with an aqua-proof compound.
A DPC is not required where a plinth beam is constructed, as this already performs like a DPC.

The construction details are explained in Learning Unit *3 Masonry.*

Plinth beam

A plinth beam is constructed depending on the type of building and nature of soil. It gives additional stability to the building. Plinth beams are constructed using reinforced concrete.

The construction details are explained in Learning Unit *4 Concrete Works.*

Floor

The floor should prevent dampness from rising to the surface. It needs a firm and smooth top that can easily be kept clean.
The ground below needs to be well compacted. The Indian Patent Stone (IPS) flooring is commonly used consisting of a concrete base topped with mortar and finished with a cement slurry.
Building a floor is explained in detail in Learning Unit *3 Masonry.*

Walls

Walls can be built from a variety of materials. They need to be strong enough to carry the roof, to provide protection from 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 for additional support for the roof.

How to build walls is explained in detail in Learning Unit *3 Masonry.*

Openings

Openings in the walls are usually provided for doors, windows and ventilation. Window and door frames can be of timber or metal and have to be securely fixed into the wall.

The construction details are explained in Learning Unit *3 Masonry.*

Lintels

Lintels are constructed above the openings and usually consist of a reinforced concrete beam or slab. Also stone slabs can be used if available and the load above the opening is not huge.

The construction details are explained in Learning Units *3 Masonry and 4 Concrete Works.*

Roof slab

The roof provides protection for the building and the people living in it. The slab is constructed using reinforced concrete and has to be properly connected with the walls on which it rests. The roof slab should be watertight to ensure rainwater does not enter the building.

The construction details are explained in Learning Unit *4 Concrete Works.*

Toilet

Every home needs a toilet. Generally, pour flush twin pit toilets are being taken up under the rural housing programme.

The construction of toilets is described in Learning Unit 5.

1.3 Construction activities and their sequence

This section will enable the rural mason to *describe step-by-step the activities required to construct a typical rural house in the correct sequence.*

Construction activities for rural houses

The construction of a house has to follow a logical path. It is important that a Rural Mason is fully aware of the exact sequence of construction activities as shown in the following list:

(i) Cleaning and levelling the ground before setting out works
(ii) Determining the position of the foundations using centre-line pedestals
(iii) Excavating trenches for foundations
(iv) Constructing foundations from concrete or masonry
(v) Plinth construction using stone masonry
(vi) Laying a damp proof course (DPC)
(vii) Reinforced concrete plinth beam (though usually not required)
(viii) Building walls using bricks, blocks or stones
(ix) Constructing lintels and sunshades
(x) Installing window and door frames
(xi) Laying a roof slab including shuttering, reinforcement and concrete works
(xii) Plastering walls
(xiii) Building a floor
(xiv) Constructing a twin pit toilet
(xv) Painting or white washing

1.4 Tools for masonry works

This section will enable the rural mason to:

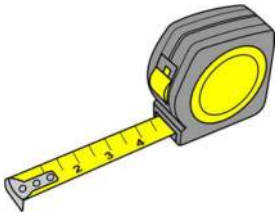
- ✓ Identify and describe the tools used for setting out, measuring and checking the precision of works.
- ✓ Identify and describe the mason tools required for the construction of rural houses.
- ✓ Apply the tools correctly and efficiently for practical masonry works.

1.4.1 Measuring tools for masons

Each mason needs a standard set of appropriate tools to be able to set out and measure works as well as to continuously check the precision of the work under progress. It is important to always keep these in good order and clean.

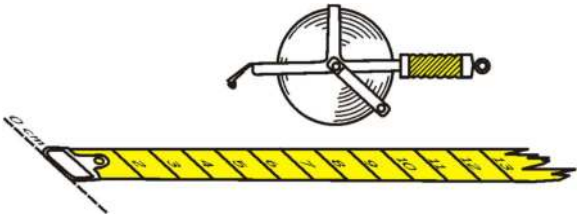
Steel tape (3 metres)

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.



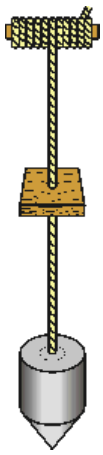
Measuring tape

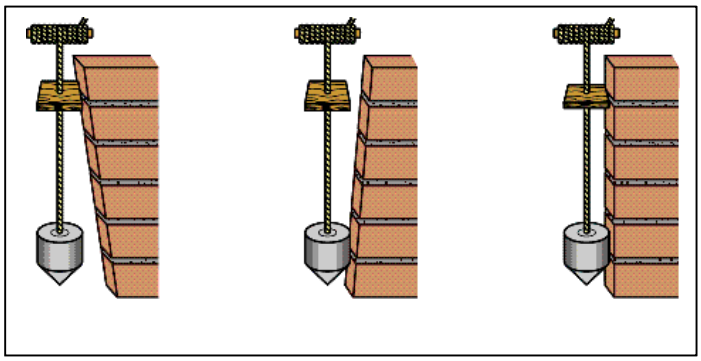
Longer measuring tape can be of different lengths ranging from 10 metres to 30 metres. Care must be taken not to damage the ring at the end of the tape where the 0-point is.



Plumb bob

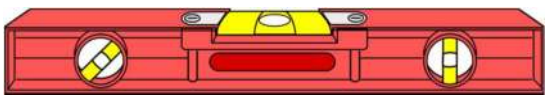
The plumb bob is used to check whether a surface is vertical. The string is held between two fingers, with a distance plate square against the surface to be checked. Whether a wall is vertical is established by comparing the surface of the wall with the plumb bob string.





Spirit level

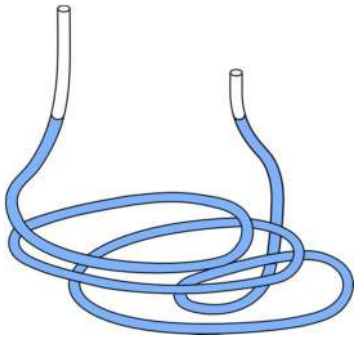
The spirit level is used to check both horizontal and vertical surfaces. Using a spirit level for vertical surfaces can be more efficient than using a plumb bob. The vials of the level indicate the horizontality or verticality of a surface depending on the position of the air bubbles inside.



Water tube level

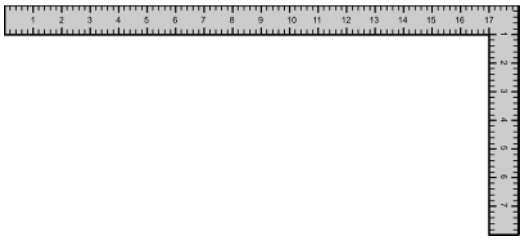
The water tube level (or pipe level) is an ideal instrument to transfer levels on a building site. It can also be used around corners where there is no direct sight.

The level is made of a transparent pipe filled with water. Scale markings can be made on staffs to allow for level readings.



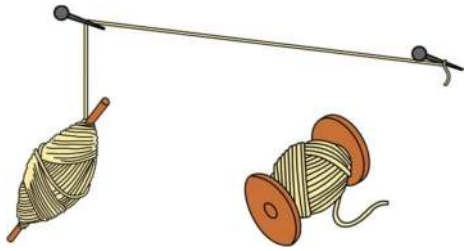
Mason's square

The square is used to measure right angles. The mason's square is made of steel and is used to check right angles of walls. It is also useful for checking whether dressed stones are of rectangular shape.



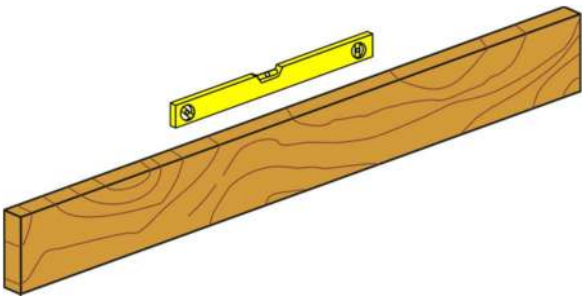
String with pegs (mason's line)

A string, stretched between two pegs, guides the mason to follow a horizontal line when laying bricks, blocks or stones. When digging foundation trenches, the thread indicates the exact location of the trench.



Straight edge

The straight edge is used to transfer levels over a short distance, to level surfaces and to check the evenness of surfaces. Straight edges can be of wood (a 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 to check that a wall is vertical.



1.4.2 Standard mason's tools

Each mason needs to be equipped with a standard set of good quality masonry tools. It is important to keep these clean and in good order.

Mortar pan

Mortar pans are made of steel or plastic and used to hold mortar, ready for use, within the reach of the mason.

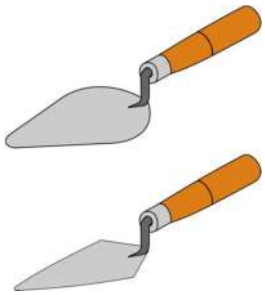
The mortar pan needs to be cleaned out, washed and dried after each use.

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 a wooden handle.

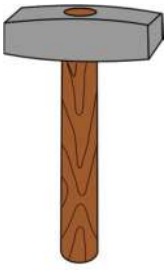
The pointing trowel has a narrow pointed steel blade for placing mortar where a regular trowel is too large. It is also used in jointing work for pressing mortar into joints.



Stone and mason's hammers

Stone and mason's hammers are essential tools to cut and shape stone, bricks and blocks. The mason's hammer has a sharp end to cut bricks and blocks. It needs to be sharpened from time to time.

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

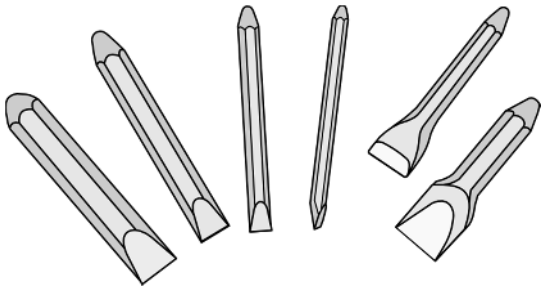


Club hammer

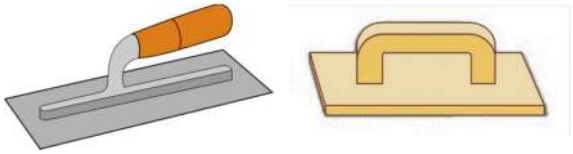
Mason's hammer

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.



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 plaster, etc.



Brooms, brushes, buckets and sponges

The work area 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. Bricks and stones are somewhat porous, so before they are placed, they are dampened with water to avoid drawing moisture from the mortar. A sponge is useful for the final cleaning of completed walls.

Jointer

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

1.4.3 Common construction tools

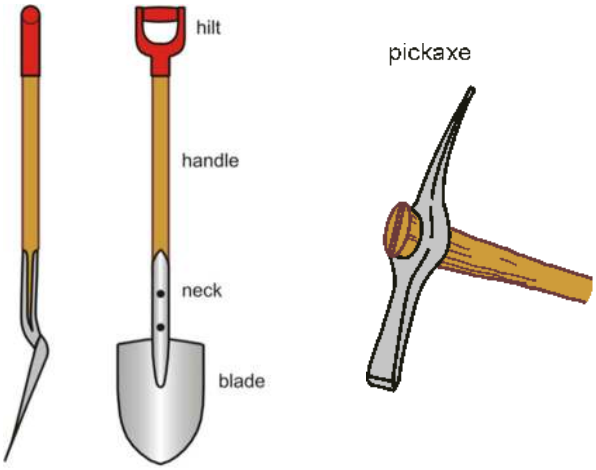
Besides the specialised mason's tools there are also some other hand tools that are required on site, for activities such as excavation work, mixing of mortar and concrete, preparing formwork, etc.

COMMON CONSTRUCTION TOOLS

Shovel and pickaxe

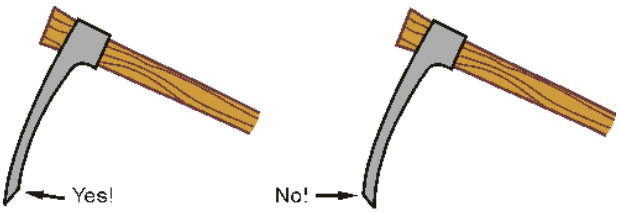
A commonly used *shovel* has a round mouth blade and a wooden handle with a cross-grip at its end. A shovel to be used for construction works should be heavy duty.

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.

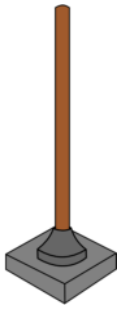


Hoe

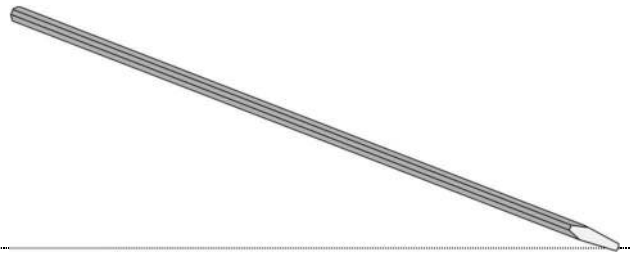
The hoe is a common tool for excavating soft and medium-hard soil. It is basically an agricultural tool but also used on construction sites. The blade should be of hardened steel and has to be sharpened after extensive use. The handles should be of smoothened hard wood and securely fixed to the blade.



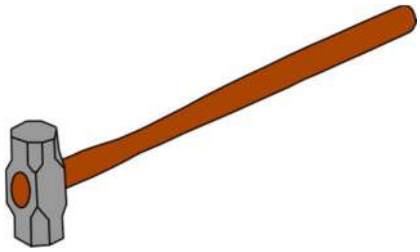
Earth rammer
Earth rammers are used to compact small areas, such as the backfill of foundation trenches. To achieve good compaction, the thickness of the layers of soil should not exceed 8 - 10cm. A good rammer should weigh at least 10kg.



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



Sledgehammer
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. Sledgehammers are used for heavy work, mainly for breaking stone and hammering split wedges into rocks.



1.5 Occupational health and safety on building sites

This Section will enable the rural mason to:

- ✓ Recognise that most on-site-accidents during construction are preventable.
- ✓ List, describe and apply the protection equipment required on construction sites.
- ✓ Understand easy ways of mitigating most accidents on-site.
- ✓ Be informed about how to respond to on-site emergencies.

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 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 therefore 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 stone cutting. 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.

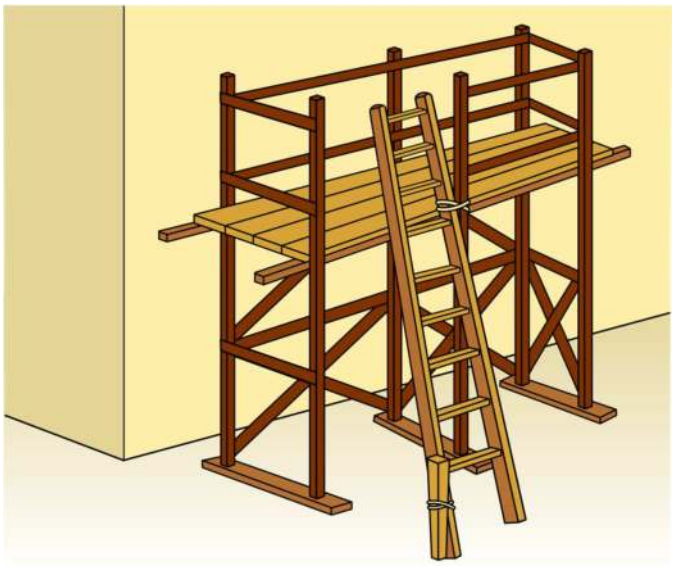
Safety construction boots and gumboots protect against sharp objects penetrating the sole and from falling objects. Sandals or slippers should not be allowed.

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 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. Ensure 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.

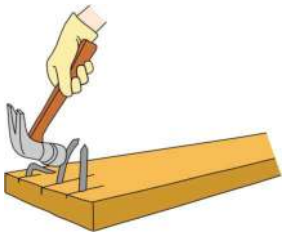
Safe lifting of heavy objects

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

Bend your hips and knees to squat down to your 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 site tidy



Keep the site clean and free of debris. Keep access roads and walk ways 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 to workers and others. 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 operating various types of 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.

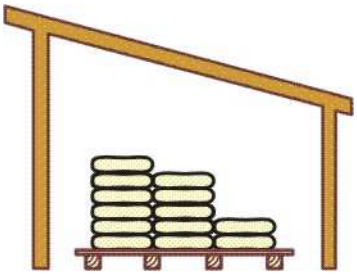
1.6 Building materials, their use and quality

This Section will enable the rural mason to:

- ✓ Describe the purpose and quality of materials commonly used for the construction of simple rural houses.
- ✓ Calculate the quantity of materials to be used for typical masonry works.

The following table describes the most common building materials.

<table>
<tr><th>Material</th><th>Purpose</th><th>Quality</th></tr>
<tr><td>Sand</td><td>Sand is used for mixing mortar and concrete:
• Mortar is a mixture of sand, cement and water.
• Concrete is a mixture of cement, sand, stone and water.</td><td rowspan="2">Sand should be:
• Clean - free from dirt and organic material
• Contain little clay (max 8%)
• Grains 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.
 
  </td></tr>
<tr><td>Quarry dust</td><td>Quarry dust may be used for certain purposes in places where sand is not available, e.g. cement mortar for masonry works.</td></tr>
<tr><td>Stone</td><td>Stone of different sizes is used in concrete.

Concrete consists of a mixture of cement, sand, stone and water.</td><td>Stone should be:
• Clean – free from dirt, organic material, clay and dust
• Two sizes of stones:
- Fine = 12.5mm to 20mm
- Coarse = 25mm to 40mm
  </td></tr>
<tr><td>Cement</td><td>Cement is used as a binder in mortar and concrete.</td><td>• Cement is usually supplied in bags of 25kg or 50kg and should be marked ISI.
• Cement older than three months looses its strength.
• Bags should be carefully handled and be kept dry at all times.
• Bags should be stored dry and well ventilated, avoiding any moisture.
  </td></tr>
</table>

Material	Purpose	Quality
Water	Water is a key ingredient in mortar and concrete. Water is also used for curing mortar and concrete.	• Only use clean water. • Water can be taken from rivers, lakes, wells and from taps. • Salt water (sea or lake), surface run-off water and water with other chemical or organic impurities must not be used. • Dirty water with organic particles can be poured into a drum and used after these particles have settled at the bottom (use only the clean upper part of the water). • Water on site is best kept in drums. 
Bricks	Bricks are used for many different structures. In rural house construction bricks are mainly used for building the walls.	• Bricks are manufactured from burnt clay. • Bricks should be uniform in size, (conventionally 22.5cm x 10.5cm x 7.5cm) but can be different from area to area. All sides should be straight and rectangular to each other.  • Bricks should be free from cracks and should not easily break (for testing drop the 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. • A good brick has a clear ringing sound when two bricks are struck together.
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. 	

Material	Purpose	Quality
Rubble stones	Rubble stones are natural stones, suitable for building foundations, plinths and walls.	Stones to be used in construction should be: • strong, without any cracks • free from dust and dirt • of rectangular shape, which is ideal for masonry work • not too long, too flat or too round → difficult to use in construction. 
Reinfor-cement 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 and columns.	High strength deformed steel bars are commonly used in construction. 
Timber	Timber is commonly used for building scaffolds and formwork and for roof trusses. Frames for doors, windows are often made from hardwood.	• Timber for shuttering and formwork must be plain, clean and without holes. • Frames and doors should preferably be of hardwood, plain and clean. It may be necessary to treat it against termite infestation. 

1.7 Construction measurements and calculations

Most construction activities require setting out and estimating quantities of materials. This requires a sound knowledge of calculating lengths, areas and volumes. This objective of this section is to enable the rural mason to c*alculate lengths, areas and volumes which are commonly used in the construction of rural houses.*

1.7.1 Introduction

The Metric System is a universal system of measurement with standard units for length, weight, time, temperature, etc. This system is commonly referred to as the System International (SI). Some of the most common measurement units are shown in the table below.

As a general rule of thumb, do not mix measurement systems and units. Before making any calculations make sure to use one system and one unit only.

1.7.2 Metric units used in construction works

Rural masons require some skills in the measurement and calculation of geometric shapes, including length, area, volume and weight. In most cases the metric system is used for these calculations. The table below shows various metric units, their common 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 millimetre = 250mm
Area	Square metre	m^2	10 square metres = $10m^2$
Volume	Cubic metre (solids) 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 standard unit for length is the metre (m). For shorter lengths centimetres (1m = 100cm) are used which is again subdivided into millimetres (1cm = 10mm). For longer distances, the kilometre (1km = 1000m) is used. For building works, the common units for measurements are ‘metre’, ‘centimetre’ and ‘millimetre’.

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

1.7.3 Imperial units used in construction works

Besides the metric system of measurement there are also other systems in use, such as the Imperial System. Sometimes measurements are indicated in 'inches', 'feet' and 'yards'. For longer distances, *miles* may be used. Inches and feet are commonly used for building works.

Conversion of lengths in the Imperial System			
Unit	Inches	Feet	Yards
1 Inch	1	0.0833…	0.0277…
1 Foot	12	1	0.333…
1 Yard	36	3	1

Since both measuring systems are used in building works, it is often necessary to convert units of measurements from one system to the other. The table below describes how Metric and Imperial units compare.

Conversion of measurement units between the Metric and Imperial systems
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.

1.7.4 Areas

In the Metric System, a m^2 is a measure of an area and would mean the 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

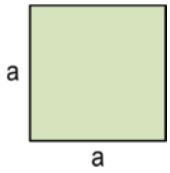
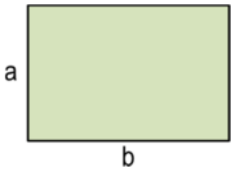
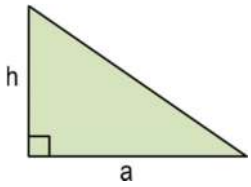
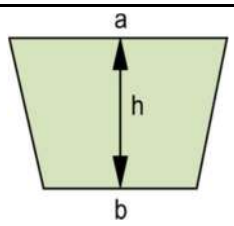
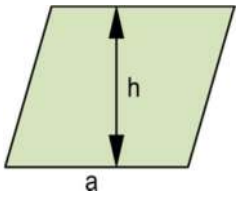
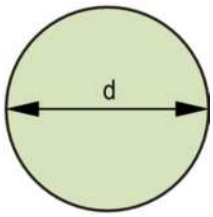
Other special units are:

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.

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

1.7.5 Volumes

Definition

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 infrastructure works are = cm^3 and m^3

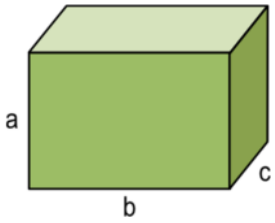
Conversion of volumes			
	cm^3	dm^3 (1 litre)	m^3
$1cm^3$	1	0.001	0.000001
$1dm^3$	1000	1	0.001
$1m^3$	1,000,000	1,000	1

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

Rectangular prism (box)

The calculation of boxes is most common in construction works. For example, it may be necessary to calculate the volume of a gauge box, or the volume of concrete required for a column or a slab.

Calculation formula:



Rectangular prism:

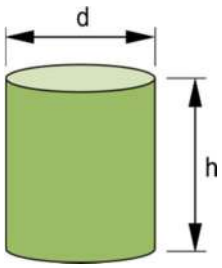
V = a x b x c

Example:

Volume =
3m x 5m x 2m = 30m^3

Cylinder (drum)

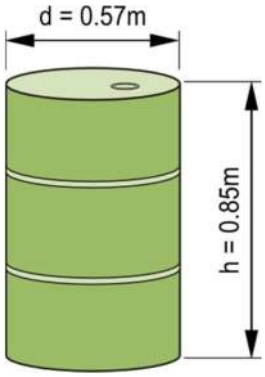
Cylindrical forms are also common in construction. For example most containers containing liquids are cylindrical.



Calculation formula:

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

Example:



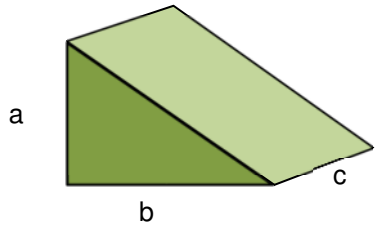
Volume = 22/7 x 0.57^2 / 4 cm^2 x 0.85m = 0.217 m^3

= 217 litres

Triangular prism (wedge)

Excavation works are often done on slopes and thus the volume of soil to be excavated is calculated in the form of a wedge.

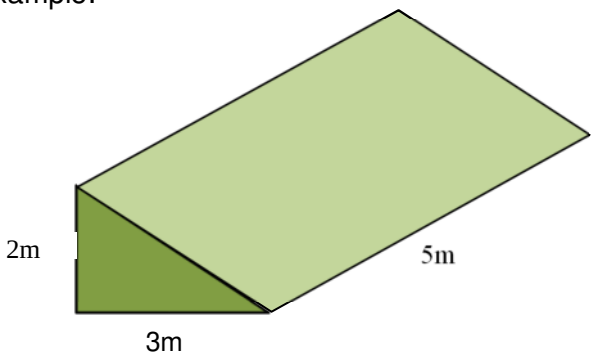
Calculation formula:



Triangular prism:

$$V = \frac{a \times b}{2} \times c$$

Example:



Volume of a prism with equal end areas =

$$V = \frac{2m \times 3m}{2} \times 5m = 15m^3$$