CHAPTER 1: MANUFACTURING MASONRY UNITS

Unit of learning code CON/CU/BUT/CR/03/6

Related Unit of Competency in Occupational Standard Manufacture Masonry Units

1.1 Introduction to the unit of learning

This unit describes the competences required to manufacture masonry units. It involves producing masonry bricks, preparing concrete and clay products and dressing building stones

1.2 Summary of Learning Outcomes

1. Produce Masonry Bricks
2. Prepare concrete products
3. Dress building stones
4. Prepare clay products

1.2.1 Learning Outcome 1:

Produce Masonry Bricks

1.2.1.1 Introduction to the learning outcome

This learning outcome specifies the content of competencies required to produce masonry bricks. It includes definition of terms related to bricks, safety requirement in the workshop, manufacturing of masonry bricks, types of bricks, masonry hand tools, and maintenance of masonry tools.

1.2.1.2 Performance Standard

1.1 Safety requirements in the workshop environment are identified
1.2 Masonry hand tools are used appropriately to perform tasks in masonry workshop
1.3 Masonry machine tools are used appropriately to perform tasks in masonry workshop
1.4 Masonry tools used in construction works are maintained as per manufacturer's specifications

1.2.1.3 Information Sheet

1. Definitions of terms

- A ***brick*** is a type of block used to build walls, pavements and other elements in masonry construction

- ***Block*** is a similar term referring to a rectangular building unit composed of similar materials, but is usually larger than a brick. Lightweight bricks (also called lightweight blocks) are made from expanded clay aggregate
- ***Kiln*** is a thermally insulated chamber, a type of oven that produces temperatures sufficient to complete some process, such as hardening, drying, or chemical changes. **Kilns** have been used for millennia to turn objects made from clay into pottery, tiles and bricks
- ***Mortar*** is a workable paste which hardens to bind building blocks such as stones, bricks, and concrete masonry units, to fill and seal the irregular gaps between them, spread the weight of them evenly, and sometimes to add decorative colors or patterns to masonry walls.

2. Workshop rules and safety considerations

Workshop safety is everyone's responsibility, the following rules have been put in place to ensure the safety of all students and staff. Please read the safety rules carefully before entering the workshop.

Workshop rules

- Notify the workshop staff of your arrival
- No food or drink in the workshop
- Wear the correct protective equipment for the tools you are using – ask if in doubt
- Immediately notify the workshop supervisor of any faulty or broken equipment
- Ask how to use the tools safely
- Make sure your work piece is fixed securely before work commences
- Keep leads up off the floor
- Keep clear of any person operating tools and machinery (bumping an operator or get tangled in the lead could cause serious injury to you or the operator)
- Do not talk to anyone operating electrical equipment and machinery
- Keep your work area tidy
- Clean up any spills immediately
- Wash hands after using equipment and materials

First Aid

- All accidents, cuts and abrasions must be reported before leaving the workshop. If an accident does happen, no matter how small, it must be reported to the workshop staff and an Accident Report Form filled out. Filling out this form is imperative for any future complications resulting from an accident.

Fires or other emergencies

- Think before reacting to any emergency in the workshop, ensure you are reacting safely before you assist in an emergency. Do not attempt to fight any fire unless you have been trained to do so.

Machinery usage

When students are operating machinery all other students are to stay clear and not to talk to the operator. If you feel uneasy or unsafe operating any tools or machinery in the workshop, inform the workshop supervisor and help will be provided.

3. Manufacturing of masonry bricks

MANUFACTURING

Manufacturing of bricks constitutes four stages i.e., preparation of soil, moulding, drying and burning.

Preparation of Soil

Removal of Top Soil: The removal of top soil involves the loose materials present at the top of the soil for a depth of about 200 mm. These materials should be removed as they contain a lot of **impurities** and are not used in the preparation of bricks.

Digging and Spreading: After digging the soil for about 200 mm, the soil is spread on the level ground, and the heaps of clay are about 600 to 1200 mm.

Figure 1 digging and spreading
Reference: https://www.buildersmart.in/blogs/manufacturing-of-bricks

Cleaning: After spreading the soil on the ground, it should be cleaned of stones, vegetable matter, pebbles, etc... If excess non-clay materials are present, the clay should be washed and screened. This whole process will become expensive and clumsy. The lumps in soil should be crushed into a powder form.

Weathering: The soil is then exposed to the atmosphere for softening for a few weeks depending on the nature of the soil, which imparts plasticity and strength to the soil.

Blending: To increase the quality of soil, additionally, sandy or calcareous clays may be added in suitable proportions along with coal, ash, etc. and the whole mass is mixed uniformly with water.

Tempering: After adding the sufficient quantity of water, the soil is kneaded under the feet of men or cattle to make it stiff and homogeneous. In general, for handmade bricks, the soft plastic

clay could be prepared by using about 25 to 30 per cent water. For making superior bricks on a large scale of about 20,000, the earth is tempered in a pug mill.

Moulding of Bricks

A brick mould is a rectangular box of steel or wood, which is open at the top and bottom of the box and inside dimensions of the mould are 20cm X 10cm X 10cm. Moulding of bricks can be done using either hand or machine.

Hand Moulding

There are two types in hand moulding, i.e. ground moulding and table moulding. In this type, bricks are moulded manually and preferred where only a small quantity of bricks is needed.

Ground Moulding: The process of moulding bricks on the ground manually by labour is called ground moulding. On an average, a moulder can mould about 750 bricks per day. When the bricks have dried sufficiently, they are moved to the drying shed and placed in an orderly manner.

Table Moulding: This moulding is done on a table of size 2m X 1m X 0.7m instead of on the ground. This table moulding process is almost similar to ground moulding expect for some minor changes.

Machine Moulding

Plastic Method: In this method, pugged earth is used, which is placed in the machine that contains a rectangular shape of size equal to the length and width of the brick. A beam of the moulded earth comes out of it and is cut into strips by wires fixed in the frames. These bricks are also called wire-cut bricks.

Figure 2 plastic method
Reference: https://www.buildersmart.in/blogs/manufacturing-of-bricks

Dry Method: In this method, the machine first converts the hard earth into a powder form and a small quantity of water is added to the powder to make it a stiff plastic paste. This paste is placed in the mould and pressed by the machine to form hard and correct-shaped bricks. These bricks

are known as pressed bricks, which do not require any drying and can be sent directly to the burning section.

Drying of Bricks

Moulded bricks cannot be burnt directly, as they may get damaged. So before burning they should be dried either naturally or artificially for about two weeks.

Natural Drying: It is also called hack drying, which comprises placing moulded bricks in rows on their edges, slightly above the ground called a hack. These bricks are air and sun-dried that is strong enough to use for the construction of small structures.

Figure 3 natural drying
Reference: https://www.buildersmart.in/blogs/manufacturing-of-bricks

Artificial Drying: When bricks are needed to dry on a large scale, then this artificial drying is preferred. They are dried in special dryers which receive heat from specially made furnaces for artificial drying.

Burning of Bricks

After the process of moulding and drying, bricks are burnt in kilns to impart hardness, strength and to increase the density of the brick. Some physical and chemical changes take place in the burning of bricks. Heating brick to about 640°C produces only physical changes. If a brick is heated up to 700-1,000°C, it undergoes chemical changes. During this reaction, the materials present in brick alumina and silica fuse together to make the brick strong and stable to prevent from cracking and crumbling.

The types of Kilns used for burning purposes are
Clamp or Open Kiln: This is a temporary structure with some advantages like low initial cost, low fuel cost and a few skilled labourers are sufficient to complete the process. The disadvantage is only a small quantity of bricks is manufactured at a time and in that only **60% are good quality bricks**.

Intermittent Kiln: When a large number of good quality bricks are needed, intermittent or continuous kilns are preferred. In this kilns, the process of burning is discontinuous.

Continuous Kilns: In this process, the burning is continuous and they are of three types

To get a good quality brick it has to be heated to the required temperature. The bricks begin to lose their shape and materials get vitrified if heating of brick earth goes beyond 1,300°C

Types of bricks by use

Common or building – A brick not intended to be visible, used for internal structure

- Face – A brick used on exterior surfaces to present a clean appearance
- Hollow – not solid, the holes are less than 25% of the brick volume
- Perforated – holes greater than 25% of the brick volume
- Keyed – indentations in at least one face and end to be used with rendering and plastering
- Paving – brick intended to be in ground contact as a walkway or roadway
- Thin – brick with normal height and length but thin width to be used as a veneer

Masonry hand tools

Brick & Masonry Hand Tools

- Tuck Point/Caulking **Trowels**.
- Margin & Other Misc. **Trowels**.
- Brick & Block **Jointers**.
- Brick & Block **Trowels**.
- Masons Line.
- Mortar Tubs.
- Brick Tongs.
- Line Stretchers.

Maintenance of masonry tools

The following video assist in understanding maintenance of masonry tools

https://www.youtube.com/watch?v=jkfs1efGCpI

All masonry tools should be washed and inspected later be stored in their respective place in the store.

1.2.1.4 Learning Activities

Practical

Task 1Carrying out bricklaying activities

Build a block wall with return, junction and stopped end

1.2.1.5 Self-Assessment

1. Explain the personal safety requirements in a workshop.

2. In which bond brick is laid with its length in the direction of a wall?
   a) Header
   b) Flemish
   c) Stretcher
   d) English
3. ---------- avoided in brick masonry
4. The bricks used for corners of walls of a structure are called:
5. Explain two machines used in brickwork

1.2.1.6 Tools, Equipment, Supplies and Materials

Tools and equipment

- Carpentry tools
- Soil testing tools and kits
- Masonry tools

Materials and supplies

- Clay
- Concrete constituents
- Water
- Packaging materials

1.2.1.7 References

1. Ash, Ahmed (20 November 2014). *Materials science in construction: an introduction*. Sturges, John. Abingdon, Oxon. ISBN 9781135138417. OCLC 896794727
2. Interlocking bricks used in Nepal
3. "Henry Clayton". *Retrieved 17 December 2012*
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5. *Khan, Aurangzeb; Lemmen, Carsten (2013), Bricks and urbanism in the Indus* Valley rise and decline
6. Neil Jackson and Ravindra K Dhir fifth edition *Civil Engineering Materials*
7. The Mechanics Magazine and Journal of Engineering, Agricultural Machinery, Manufactures and Shipbuilding. 1859. p. 361.
8. https://www.studocu.com/my/document/universiti-sains-malaysia/engineering-materials/lecture-notes/5-structural-clay-products-edit/4002506/view clay bricks
9. https://www.buildersmart.in/blogs/manufacturing-of-bricks

1.2.2 Learning Outcome 2
Prepare concrete products

1.2.2.1Introduction to the learning outcome

This learning outcome specifies the content of competencies required to prepare concrete products. It includes definition of terms concrete products, concrete moulds, concrete constituents, batching methods, methods of curing concrete, and maintenance of masonry tools

1.2.2.2 Performance Standard

2.1Concrete moulds are prepared as per the customer specifications.

2.2 concrete constituents are gathered as per concrete mix design

2.3Concrete constituent are batched as per batching methods

2.4 Concrete ingredients are mixed as per ASTM standards

2.5 Concrete mix is placed in moulds as per placing convections

2.6 Concrete is cured as per laid down procedures

2.7 Moulds are dismantled and stored as per laid down procedures.

1.2.2.3Information Sheet

Definitions of terms

- ***Concrete*** is a mixture of cement as a paste, aggregates (fine and course aggregate) and water. The mixture is according to a given design mix such as 1:2:3 ratio.
- ***Beam*** is a structural element that primarily resists loads applied laterally to the beam's axis. Its mode of deflection is primarily by bending.

In engineering, beams are of several types

1. Simply supported – a beam supported on the ends which are free to rotate and have no moment resistance.
2. Fixed or Encastre – a beam supported on both ends and restrained from rotation.
3. Over hanging – a simple beam extending beyond its support on one end.
4. Continuous – a beam extending over more than two supports.
5. Cantilever – a projecting beam fixed only at one end.

- ***Column*** is a structural element that transmits, through compression, the weight of the structure above to other structural elements below
- ***Slab*** is a common structural element of modern buildings, consisting of a flat, horizontal surface made of cast concrete. Steel-reinforced slabs, typically between 100 and 500 mm thick, are most often used to construct floors and ceilings

- ***Mould*** is generally referred to in the industry as “forms” or “formwork”. They’re made from a variety of materials, from wood and fiberglass on the jobsite to sheet steel in the casting yards.
- ***Batching*** is the process of measuring concrete mix ingredients either by volume or by mass and introducing them into the mixture
- ***Precast concrete*** is a construction product produced by casting concrete in a reusable mold or "form" which is then cured in a controlled environment, transported to the construction site and lifted into place

Constituents of concrete

- Fine Aggregates are small size filler materials in construction. Its particles pass through 4.75 mm sieve and retain on 0.075 mm sieve.
- Coarse Aggregates are larger size filler materials in construction. The particles that retain on 4.75 mm sieve.
- Cement. This is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together.

Water. It should be clean drinkable water to produce a clean and durable concrete.

Concrete batching methods

Batching: The measurement of materials for making concrete is known as batching.
The following two methods of batching is practiced:
(a) Volume batching
(b) Weight batching.

(a) Volume Batching:

In this method cement, sand and concrete are batched by volume. A gauge box is made with wooden plates, its volume being equal to that of one bag of cement. One bag of cement has volume of 35 litres. The required amount of sand and coarse aggregate is added by measuring on to the gauge box. The quantity of water required for making concrete is found after deciding water cement ratio. For example, if water cement ratio is 0.5, for one bag of cement (50 kg), water required is $0.5 \times 50 = 25$ kg, which is equal to 25 litres. Suitable measure is used to select required quantity of water. Volume batching is not ideal method of batching. Wet sand has higher volume for the same weight of dry sand. It is called bulking of sand. Hence it upsets the calculated volume required.

(b) Weight Batching:

This is the recommended method of batching. A weighing platform is used in the field to pick up correct proportion of sand and coarse aggregates. Large weigh batching plants have automatic weighing equipments.
The video below explains more on how batching is done on the two methods.

https://www.youtube.com/watch?v=G7h8kcSNAh8

Mixing: To produce uniform and good concrete, it is necessary to mix cement, sand and coarse aggregate, first in dry condition and then in wet condition after adding water.
The following methods are practiced:
(a) Hand Mixing
(b) Machine Mixing.

Transporting and Placing of Concrete

After mixing concrete should be transported to the final position. In small works it is transported in iron pans from hand to hand of a set of workers. Wheel barrow and hand carts also may be employed. In large scale concreting chutes and belt conveyors or pipes with pumps are employed. In transporting care should be taken to see that seggregation of aggregate from matrix of cement do not take place.

Concrete is placed on form works. The form works should be cleaned and properly oiled.

If concrete is to be placed for foundation, the soil bed should be compacted well and is made free from loose soil.Concrete should be dropped on its final position as closely as possible. If it is dropped from a height, the coarse aggregates fall early and then mortar matrix. This segregation results into weaker concrete.

The following video explains more on placing of concrete in any place of construction or product that is being produced https://www.youtube.com/watch?v=bXj_9vpfedE

Concrete curing

Concrete curing is the process of maintaining adequate moisture in concrete within a proper temperature range in order to aid cement hydration at early ages. Hydration is the chemical reaction between cement and water that results in the formation of various chemicals contributing to setting and hardening. The hydration process is affected by the initial concrete temperature, the ambient air temperature, the dimensions of the concrete, and mix design. Therefore, for this process to progress well, in-situ concrete must have sufficient moisture and a temperature that favours this chemical reaction at a rapid and continuous rate.

The following video assist us in understanding curing more.

https://www.youtube.com/watch?v=T_wqwYPAie4

1.2.2.4 Learning Activities

Practical

1. Batch materials for slump test using 1:2:3 ratio
2. Mix materials
3. Perform a slump test

1.2.2.5 Self-Assessment

1. Distinguish between fine aggregate and course aggregates in terms of
   a. Particles sizes
   b. Source
   c. Surface area and
   d. Uses
2. Explain a posttension concrete

3. Describe two methods of curing concrete
4. Explain two methods of transporting concrete.
5. Describe a beam form work

1.2.2.6 Tools, Equipment, Supplies and Materials

Tools and equipment

- Carpentry tools
- Soil testing tools and kits
- Masonry tools

Materials and supplies

- Clay
- Concrete constituents
- Water
- Packaging materials

1.2.2.7 References

1 Ash, Ahmed (20 November 2014). *Materials science in construction: an introduction*. Sturges, John. Abingdon, Oxon. ISBN 9781135138417. OCLC 896794727

2 Neil Jackson and Ravindra K Dhir fifth edition *Civil Engineering Materials*

1.2.3 Learning Outcome 3:

Dress building stones

1.2.3.1 Introduction to the learning outcome

This learning outcome specifies the content of competencies required to dress building stones. It includes definition of terms building stones, tools for dressing stones and methods of stone dressing.

1.2.3.2 Performance Standard

3.1 Building stones are acquired as per prescribed size and quality.
3.2 Stones surfaces are dressed as per the method and type of dressing.

1.2.3.3 Information Sheet

Building stone

A building stone may be defined as a sound rock that can be safely used in some situation in the construction as a massive dressed or undressed unit.
Granites and marbles used in the form of finely dressed blocks or slabs or columns in monumental and costly buildings are good building stones.

Requirements of good building stones

The following are the quality requirements of good building stones:

Strength
Generally, most of the building stones have a high strength to resist the load coming on it. Compressive strength of building stones generally fall within the range of 60 to 200N/mm2.

Durability
Building stones should be capable of resisting the adverse effects of natural forces like wind, rain and heat. It must be durable and should not deteriorate due to the adverse effects of the above natural forces.

Hardness
When stones are used in floors, pavements or aprons of bridges, they become subjected to wearing and abrasive forces caused by the movement of men or machine over them. So it is required to test the hardness of stone.

Toughness
The toughness of stones means its ability to resist impact forces. Building stones should be tough enough to sustain stresses developed due to vibrations. The vibrations may be due to the machinery mounted over them or due to the loads moving over them. The stone aggregates used in the road constructions should be tough.

Porosity and Absorption

The porosity of building stones depends upon the mineral constituent and structural formation of the parent rock. If stones used in building construction are porous, then rainwater can easily enter into the pore spaces and cause damage to the stones. Therefore building stone should not be porous.
Water absorption of stone is directly proportional to the porosity of the rock. If a stone is more porous, then it will absorb more water and cause more damage to the stone.
In higher altitudes, the freezing of water in pores takes place, and it disintegrates the stone.

Dressing
Giving the required shape to the stone is called dressing. It should be easy to dress so that the cost of dressing is reduced. However, the care should be taken so that, this is not at the cost of the required strength and durability.

Appearance
In case of the stones to be used for face works, where appearance is a primary requirement, its colour and ability to receive polish is an important factor.
Light-coloured stones are more preferred than dark-coloured stones as the colour are likely to fade out with time.

Seasoning
Good stones should be free from the quarry sap. Lateritic stones should not be used for 6 to 12 months after quarrying. They are allowed to get rid of quarry sap by the action of nature. This process of removing quarry sap is called seasoning.

Workability
The stone should be workable. Stone is said to be workable when the work involved in stone working (such as cutting, dressing & shaping) is economical and easy to conduct.

Cost
Cost is an important consideration in selecting a building material. The proximity of the quarry to the building site brings down the cost of transportation and hence the cost of stones comes down.
Looking for stone cutting supplies? Look no further! CMP Stonemason Supplies got you covered

Fire resistance
Stones should be free from calcium carbonate, oxides of iron, and minerals having different coefficients of thermal expansion. Igneous rock show marked disintegration principally because of quartz which disintegrates into small particles at a temperature of about 575°C. Limestone, however, can withstand a little higher temperature; i.e. up to 800°C after which they disintegrate.

Stone dressing

The Dressing of stone is defined as “The process of giving a proper size, shape and finish to the roughly broken stones as obtained from the quarry.”
This is done with the help of hand tools like a pickaxe, chisels, etc., or with the help of machines. This process is done manually or mechanically. A dressed stone is fit for use in a particular situation in a building.

Objectives:

Stones obtained from the quarries are very rough and irregular in shape and quite bulky in size and weight.
Various objectives of dressing are below;

(a) To reduce the size of the big blocks of stones so that they are converted to easily lift-able pieces. This reduction in size is generally carried out at the quarry itself because that saves a lot of transportation costs.

(b) To give a proper shape to the stone. It is known that stones can be used at different places in the building, e.g., in foundations, in walls, in arches, or for flooring, each situation will require a proper shape.
This can be given at the quarry and also at the site of construction.

(c) To obtain an appealing finish. In a residential building, stones are used not only because of their extra strength, hardness, and durability but also because of their aesthetic value.
Stone surfaces can be made very decorative and of appealing appearance, which will last for a considerable time. A stone house has its distinct individuality in a city of concrete structures.

Stages in the Dressing of Stone.
The different stages of dressing of stones are:

1. Sizing:
It is the process of inducing the irregular blocks to the desired dimensions by removing extra portions. It is done with the help of hand hammers and chisels.

2. Shaping:
This follows sizing and involves removing the sharp projections. Many stones are used in common construction after shaping.

3. Planing:
This is rather an advanced type of dressing in which the stone is cleared off all the irregularities from the surface.

4. Finishing:
This is done only in case of specially dressed stones and consists of rubbing of the surface of stones with suitable abrasive materials such as silicon carbide.

5. Polishing:
This is the last stage in dressing and is only done on marbles, limestone, and granite.

The video below shows a stone is dressed and how tools are handled.
https://youtu.be/VCwkbbM6hXI

Table 2 Tools used for stone dressing

1	Spall Hammer	Used for rough dressing of stones
2.	Scrabbling hammer	Used for removing irregular bushings
3.	Mash hammer	Used for rough dressing
4.	Waller hammer	Used for removing spalls
5.	Club hammers	Used to strike narrow-headed chisels
6.	Mallet	Used to strike mallet headed chisels
7.	Dummy	Used for striking chisels for carving work
8.	Gad	Used to split stones
9.	Drag	Used to give drag finish
10.	Hand saw	Used to cut soft stones
11.	Cross-cut saw	Used to cut hard stones
12.	Frame saw	Used to cut large blocks of stones
13.	Pitching tool	Used to make stones of required size
14.	Square	Used to set edges at right angles
15.	Boaster	Used to cut soft stones
16.	Punch	Used for rough dressing
17.	Point	Used for rough dressing of hard stones
18.	Gouge	Used to dress stones for cornices, string courses etc
19.	Broad Tool (nicker**)**	Used to form chisel lines on stone surface
20.	Wood handled chisel	Used to dress soft stones
21.	Claw chisel	Used to dress hard stones
22.	Tooth chisel	Used to dress hard stones
23.	Drafting chisel	Used for fine dressing

1.2.3.4 Learning Activities

Task 1
Identify and group the given pieces of rocks in their respective groups.

1.2.3.5 Self-Assessment

1. Describe igneous rocks
2. Explain three properties of rocks
3. Explain three objectives of stone dressing
4. Outline four hand tools used in stone dressing
5. Describe two methods of stone dressing

1.2.3.6 Tools, Equipment, Supplies and Materials

Tools and equipment

- Carpentry tools
- Soil testing tools and kits
- Masonry tools

Materials and supplies

- Clay
- Concrete constituents
- Water
- Packaging materials

1.2.3.7 References

1. Neil Jackson and Ravindra K Dhir fifth edition *Civil Engineering Materials*

2. https://civilseek.com/dressing-of-stones/
3. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=25282
4. https://byjus.com/physics/igneous-rocks/#:~:text=Igneous%20rocks%20are%20defined%20as,%2C%20rhyolite%2C%20or%20obsidian

1.2.4 Learning Outcome 4

Prepare clay products

1.2.4.1Introduction to the learning outcome

This learning outcome specifies the content of competencies required to prepare clay products. It includes definition of terms clay products, methods of production of clay products, testing clay products and packaging of clay products.

1.2.4.2 Performance Standard

4.1 Clay products are produced as per manufactures guidelines/specification.
4.2 Clay products are tested as per manufactures standards.
4.3 Clay products are packaged according to type, size, shape, quantity and environmental requirements.

1.2.4.3 Information Sheet

Clay products, ceramic products intended for use in building construction. Typical clay products are building brick, paving brick, terra-cotta facing tile, roofing tile, and drainage pipe. These objects are made from commonly occurring natural materials, which are mixed with water, formed into the desired shape, and fired in a kiln in order to give the clay mixture a permanent bond. Finished structural clay products display such essential properties as load-bearing strength, resistance to wear, resistance to chemical attack, attractive appearance, and an ability to take a decorative finish.

Raw Materials and Processing

Clay products are made from 35 to 55 percent clays or argillaceous (clayey) shales, 25 to 45 percent quartz, and 25 to 55 percent feldspar. As with all traditional ceramic products, the clay portion acts as a former, providing shaping ability; the quartz (silica) serves as a filler, providing strength to the formed object; and the feldspar serves as a fluxing agent, lowering the melting temperatures of the clay and quartz during firing. The proportions cited above are often found directly in shale deposits, so that blending is often not necessary. In addition, little or no beneficiation, or crushing and grinding of the mined material, is employed. Local clays or shales of highly variable composition are used in order to keep transportation costs as low as possible. The colour of the finished product derives from impurities, most notably iron oxides, present in the raw materials. Colours can range from buff and other light shades of brown through red to black, depending upon whether an oxidizing or reducing atmosphere exists in the kiln. In the processing of clay products, stiff-mud plastic-forming operations predominate—for example, pressing operations for brick and extrusion for brick or pipe. Formed objects are usually fired in continuous conveyor belt or railcar operations, with the ware, as it traverses the tunnel kiln, proceeding from room temperature into a hot zone and finally to a cooler zone at the other end.

Properties

The properties exhibited by clay products are determined by particle size, firing temperature, and ultimate microstructure. Compared with finer ceramic products such as whitewares, much coarser filler particles are used, and lower firing temperatures are employed—typically in the range of 1,050° to 1,100° C (approximately 1,925° to 2,000° F). At such low temperatures the filler particles (usually crushed quartz) are normally not affected. Instead, the clay or shale ingredients contain sufficient impurities to melt and form a glass, thus bonding the particles together. As is the case with white wares, crystalline mullite needles grow into this glassy phase. The resulting microstructure consists of large secondary particles embedded in a matrix of fine-grained mullite and glass—all containing a substantial volume of large pores.

Because of the presence of large and small particles in their microstructures, fired clay products have relatively high compressive strengths. This ability to bear relatively heavy loads without fracture is the prime property qualifying these products for structural applications. The size and number of pores is also important. If under fired, structural clay products have low strength and poor resistance to frost and freezing, owing to the presence of many small pores in the clay regions. Over fired ware, on the other hand, has too much glass. It is strong but brittle and is susceptible to failure under mechanical and thermal stress. Furthermore, it is impossible to obtain a good bond when glassy products are used with mortars. Small pores and high glass content are desirable, however, when chemical resistance and imperviousness to water penetration are required.

Products

By some estimates structural clay products make up as much as 50 percent of the entire ceramics market. The industry is highly conservative, with development aimed primarily at automation and labour minimization rather than the introduction of new products.

There is a wide variety of clay products, broadly classified as facing materials, load-bearing materials, paving materials, roofing tile, and chemically resistant materials. Examples of facing materials are face brick, terra-cotta, brick veneer, sculptured brick, glazed brick and tile, and decorative brick. Building brick, hollow brick, and structural tile for floors and walls are examples of load-bearing materials. Paving materials include light traffic pavers, quarry tile, and paving brick—this last product once in more common use than at present. Roofing tiles are quite common in many parts of the world, red and black colours being of particular note. Chemically resistant materials include sewer pipe, industrial floor brick, drain tile, flue liners, chimney brick, and chemical stoneware.

The manufacture, properties, and uses of brick and tile are covered in detail in the article brick and tile.

Types of Clay Product

In routine construction work, we come across many clay products used in Masonry work, roof coverings, sanitary & drainage works, etc.

- Bricks
- Tiles

• Roofing Tiles

• Flooring Tiles

• Earthen Ware.

• Sanitary Wares.

• Stone Wares.

Refractories.

• Porcelain etc

1.2.4.4 Learning Activities

Practical:

Identify the clay products given

1.2.4.5 Self-Assessment

1. Which of the following is a property of porcelain?
   a) Soft
   b) Absorbent
   c) Vitreous
   d) Expensive
2. Explain five defects of clay products.
3. Outline two test done on clay tiles.
4. Explain four places where clay products are applied.

1.2.4.6 Tools, Equipment, Supplies and Materials

Tools and equipment

- Carpentry tools
- Soil testing tools and kits
- Masonry tools

Materials and supplies

- Clay
- Water
- Packaging materials

1.2.4.7 References

1. https://www.britannica.com/technology/structural-clay-product
2. https://civiljungle.com/clay-product/

Appendix

Answers to the self-assessments test

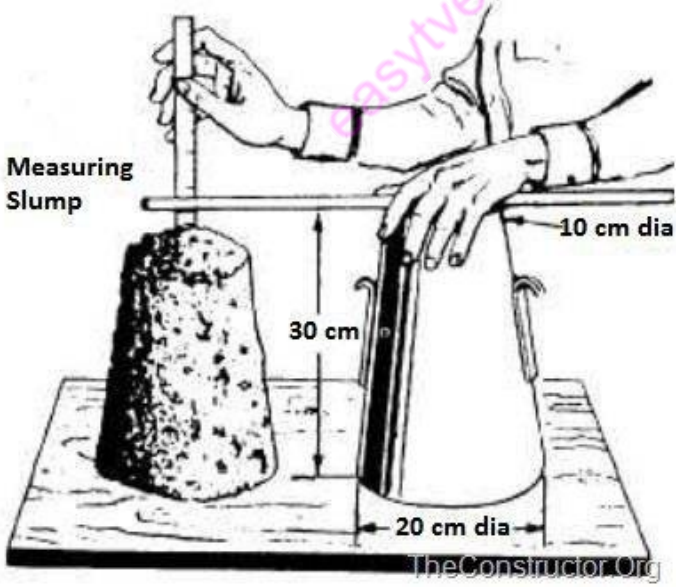
Appendix 1

1. Explain the personal safety requirements in a workshop.
2. In which bond brick is laid with its length in the direction of a wall?
   a) **Header**
   b) Flemish
   c) Stretcher
   d) English
3. **Vertical joint should be** avoided in brick masonry
4. The bricks used for corners of walls of a structure are called:
   Quoins
5. Explain two machines used in brickwork

Appendix 2

Practical

1. Batch materials for slump test using 1:2:3 ratio
2. Mix materials
3. Perform a slump test



The test is carried out using a metal mould in the shape of a conical frustum known as a slump cone that is open at both ends and has attached handles. The tool typically has an internal diameter of 100 millimetres (3.9 in) at the top and of 200 millimetres (7.9 in) at the bottom with a height of 305 millimetres (12.0 in).The cone is placed on a hard non-absorbent surface. This cone is filled with fresh concrete in THREE stages. Each time, each layer is tamped 25 times with a 2 ft (600 mm)-long bullet-nosed metal rod measuring 16 mm in diameter. At the end of

the third stage, the concrete is struck off flush with the top of the mould. The mould is carefully lifted vertically upwards, so as not to disturb the concrete cone.

The concrete then slumps (subsides). The slump of the concrete is measured by measuring the distance from the top of the slumped concrete to the level of the top of the slump cone.

Self-Assessment

1. Distinguish between fine aggregate and course aggregates in terms of
   e. Particles sizes
      Fine aggregates are the particles that pass through 4.75 mm sieve and retain on 0.075 mm sieve while coarse aggregates are the particles that retain on 4.75 mm sieve.
   f. Source
      River sand or machine sand, crushed stone sand, crushed gravel sand are the major sources of fine aggregate while Dolomite aggregates, crushed gravel or stone, natural disintegration of rock are the major sources of coarse aggregate
   g. Surface area
      The surface area of fine aggregates is higher while the surface area of coarse aggregate is less than fine aggregates.
   h. Uses
      Fine aggregates are used in mortar, plaster, concrete, filling of road pavement layers, etc while coarse aggregates are mainly used in concrete, railway track ballast, etc
2. Explain a post tension concrete. Post tension is a method of prestressing in which the tendons are **tensioned after** the **concrete** has hardened and the prestressing force is primarily transferred to the **concrete** through the end anchorage
3. Describe two methods of curing concrete

i. Sprinkling of Water

Sprinkling Of Water Continuously on the concrete surface provides an efficient curing. It is mostly used for curing floor slabs. The concrete should be allowed to set sufficiently before sprinkling is started. The spray can be obtained from a perforated plastic box. On small jobs sprinkling of water may be done by hand. Vertical and sloping surfaces can be kept continuously wet by sprinkling water on top surfaces and allowing it to run down between the forms and the concrete. For this method of curing the water requirement is higher.

ii. Ponding Method

This is the best method of curing. It is suitable for curing horizontal surfaces such as floors, roof slabs, road and air field pavements. The horizontal top surfaces of beams can also be ponded. After placing the concrete, its exposed surface is first covered with moist hessian or canvas. After 24 hours, these covers are removed and small ponds of clay or sand are built across and along the pavements. The area is thus divided into a number of rectangles. The water is filled between the ponds. The filling of water in these ponds is done twice or thrice a day, depending upon the atmospheric conditions. Though this method is very efficient, the water requirement is very heavy. Ponds easily break and water flows out. After curing it is difficult to clean the clay.

iii. Membrane curing

The method of curing described above come under the category of moist curing. Another method of curing is to cover the wetted concrete surface by a layer of water proof material, which is kept in contact with the concrete surface of seven days. This method of curing is termed as membrane curing. A membrane will prevent the evaporation of water from the concrete. The membrane can be either in solid or liquid form. They are also known as sealing compounds.

iv. Steam curing

Steam curing and hot water curing is sometimes adopted. With these methods of curing, the strength development of concrete is very rapid.

These methods can best be used in pre-cast concrete work. In steam curing the temperature of steam should be restricted to a maximum of 75^0C as in the absence of proper humidity (about 90%) the concrete may dry too soon. In case of hot water curing, temperature may be raised to any limit, ay 100^0C.

4. Explain two methods of transporting concrete.

   Wheel barrow or hand cart

It is normally used on ground level i.e. road construction and other similar structures. Segregation can occur if transportation is done on rough roads, however this problem can be minimizes if pneumatic tyres are used.

Bucket and ropeway

It is suitable for works in valley, over high piers and long dam sites. Excessive free fall of concrete should be avoided to minimize segregation.

Truck mixer and dumper

It is an improved and better method for long lead concreting. The concrete is covered with tarpaulin if it is transported in open trucks. If long distance is involved, agitators should be used.

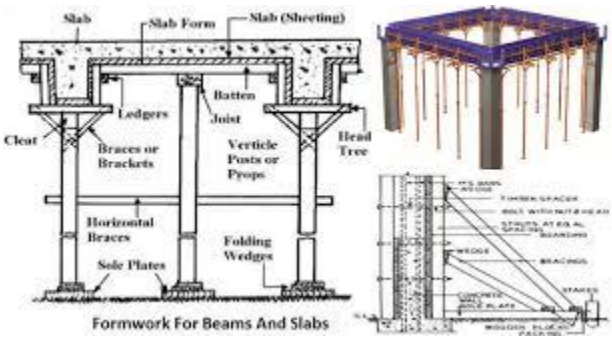
Belt conveyor

It has limited application due to chances of segregation on steep slopes, roller points and changes in direction of belt. It also involves over-exposure of concrete to environment.

Chute

It is generally used for concreting in deep locations. Care should be taken that slope should not be flatter than 1V:2.5H, otherwise concrete will not slide down. But workability should not be changed to suit the delivery by chute. Technically it is not a very good method but it is extensively used in the field.

5. Describe a beam form work



Formwork for beams takes the form of a three-sided box which is supported and propped in the correct position and to the desired level. The removal time for the formwork will vary with air temperature, humidity and consequent curing rate.

Appendix 3

1. Describe igneous rocks

Igneous rocks are defined as types of rocks that are formed when molten rock (rock liquefied by intense heat and pressure) cools to a solid-state.

Lava is molten rock flowing out of fissures or vents at volcanic centers (when cooled they form rocks such as basalt, rhyolite, or obsidian). Pyroclastic deposits are accumulations of fragmented material (e.g. ash, bombs, tuffs, and volcanic breccias) ejected during volcanic eruptions.

Igneous rocks can be easily identified with their texture, density, color, and mineral composition. Its texture depends on the shape, size, time period to cool down and solidify, and the arrangement of crystals in the rock.

Types of Igneous Rocks

Following are the two types of igneous rocks :

Intrusive igneous rock: These rocks crystallize below the earth's surface resulting in large crystals as the cooling takes place slowly. Diorite, granite, pegmatite are examples of intrusive igneous rocks.

Extrusive igneous rock: These rocks erupt onto the surface resulting in small crystals as the cooling takes place quickly. The cooling rate for a few rocks is so quick that they form an amorphous glass. Basalt, tuff, pumice are examples of extrusive igneous rock.

2. Explain three properties of rocks

Strength

Generally, most of the building stones have a high strength to resist the load coming on it. Compressive strength of building stones generally fall within the range of 60 to 200N/mm2.

Durability

Building stones should be capable of resisting the adverse effects of natural forces like wind, rain and heat. It must be durable and should not deteriorate due to the adverse effects of the above natural forces.

Hardness
When stones are used in floors, pavements or aprons of bridges, they become subjected to wearing and abrasive forces caused by the movement of men or machine over them. So it is required to test the hardness of stone.

Toughness
The toughness of stones means its ability to resist impact forces. Building stones should be tough enough to sustain stresses developed due to vibrations. The vibrations may be due to the machinery mounted over them or due to the loads moving over them. The stone aggregates used in the road constructions should be tough.

3. ***Explain three objectives of stone dressing***

To reduce the size of the big blocks of stones so that they are converted to easily lift-able pieces. This reduction in size is generally carried out at the quarry itself because that saves a lot of transportation costs.

To give a proper shape to the stone. It is known that stones can be used at different places in the building, e.g., in foundations, in walls, in arches, or for flooring, each situation will require a proper shape.
This can be given at the quarry and also at the site of construction.

To obtain an appealing finish. In a residential building, stones are used not only because of their extra strength, hardness, and durability but also because of their aesthetic value.
Stone surfaces can be made very decorative and of appealing appearance, which will last for a considerable time. A stone house has its distinct individuality in a city of concrete structures

4. ***Outline four hand tools used in stone dressing***
    i. Spall Hammer Used for rough dressing of stones
    j. Mash hammer Used for rough dressing
    k. Cross-cut saw Used to cut hard stones
    l. Square Used to set edges at right angles
    m. Boaster Used to cut soft stones
5. ***Describe two methods of stone dressing***

Dressing of stone can be done both manually as well as mechanically.
a. ***Manually***, skilled stone-smiths can work wonders on the suitable type of stones with chisels and hammers and abrasives.
b. ***Mechanically***, machines can cut the stone to any desired size and shape. Their surfaces can be made extra smooth by polishing through machines.

Appendix 4

1 Which of the following is a property of porcelain?
a) Soft
b) Absorbent
c) Vitreous
d) Expensive

2 Explain five defects of clay products

Over-burning of Bricks: Bricks should be burned at temperatures at which incipient, complete and viscous vitrification occur. However, if the bricks are over burnt, a soft molten mass is produced and the bricks loose their shape. Such bricks are not used for construction works.

Under-burning of Bricks: When bricks are not burnt to cause complete vitrification, the clay is not softened because of insufficient heat and the pores are not closed. This results in higher degree of water absorption and less compressive strength. Such bricks are not recommended for construction works.

Bloating: This defect observed as spongy swollen mass over the surface of burned bricks is caused due to the presence of excess carbonaceous matter and sulphur in brick-clay.

Black Core: When brick-clay contains bituminous matter or carbon and they are not completely removed by oxidation, the brick results in black core mainly because of improper burning.

***Efflorescence*:** This defect is caused because of alkalies present in bricks. When bricks come in contact with moisture, water is absorbed and the alkalis crystalise. On drying grey or white powder patches appear on the brick surface. This can be minimised by selecting proper clay materials for brick manufacturing, preventing moisture to come in contact with the masonry, by providing waterproof coping and by using water repellent materials in mortar and by providing damp proof course.

Chuffs: The deformation of the shape of bricks caused by the rain water falling on hot bricks is known as chuffs.

Checks or Cracks: This defect may be because of lumps of lime or excess of water. In case of the former, when bricks come in contact with water, the absorbed water reacts with lime nodules causing expansion and a consequent disintegration of bricks, whereas shrinkage and burning cracks result when excess of water is added during brick manufacturing.

Spots: Iron sulphide, if present in the brick clay, results in dark surface spots on the brick surfaces. Such bricks though not harmful are unsuitable for exposed masonry work.

Blisters: Broken blisters are generally caused on the surface of sewer pipes and drain tiles due to air imprisoned during their moulding.

3 Outline two test done on clay tiles.

Transverse Strength Test (IS: 2690) consists of applying the load along the centre line at right angles to the length of the tile (which has been immersed in water for twenty four

hours) supported on the rounded edges of wood bearers. Six tiles are tested and the average breaking load should not be less than as specified in the code

Water Absorption Test (IS: 2690): Six tiles are dried in oven at 105 ± 5°C and cooled at the room temperature. They are then immersed in water for twenty four hours. Thereafter wiped dry and weighed.

4 Explain four places where clay products are applied.

Wall materials. The examples are common clay brick, perforated clay brick, porous and perforated stiff-mud brick, hollow clay dry-press brick. Perforated plastic moulded ceramic stones and light weight building brick. Clay brick accounts for half of the total output of wall materials. Structural properties of hollow clay products and low heat losses through air-filled voids (particularly at subzero temperatures) provide great possibilities for reducing the thickness and the weight of exterior walls. Ceramic facing tiles remain the chief finishing material for sanitary and many other purposes and are still in great use for external facing of buildings.

Brick for special purposes. The example are curved clay brick, stones for sewage installations (underground sewer pipes) brick for road surface (clinker).

Hollow clay products for floors. The examples are stones for close-ribbed floors (prefabricated or monolithic), stones for reinforced ceramic beams, sub flooring stones (fillers between beams)

Facade decoration. The examples are glazed or non-glazed varieties subdivided in to facing brick and ceramic stones, floor ceramics, small-size ceramic tiles, ceramic plates for facades and window-sill drip stones.

Clay products for interior decoration. The examples are tiles for facing walls, built-in parts, large floor tiles and mosaic floor tiles.

Roof materials. The examples are common clay roof tiles for covering slopes of roofs, ridge tiles for covering ridges and ribs, valley tiles for covering valleys, end tiles ("halves" and “jambs") for closing row of tiles, special tiles.