Unit 1

Stones- Types of Stones, Requirements of Good Building Stones, Dressing of stones, Deterioration and Preservation of Stone Work.
Bricks- Classification, Manufacturing of Clay Bricks, Requirements of Good Bricks.
Alternative bricks (fly ash bricks, AAC blocks)
Lime- Classification, Properties.

Stones

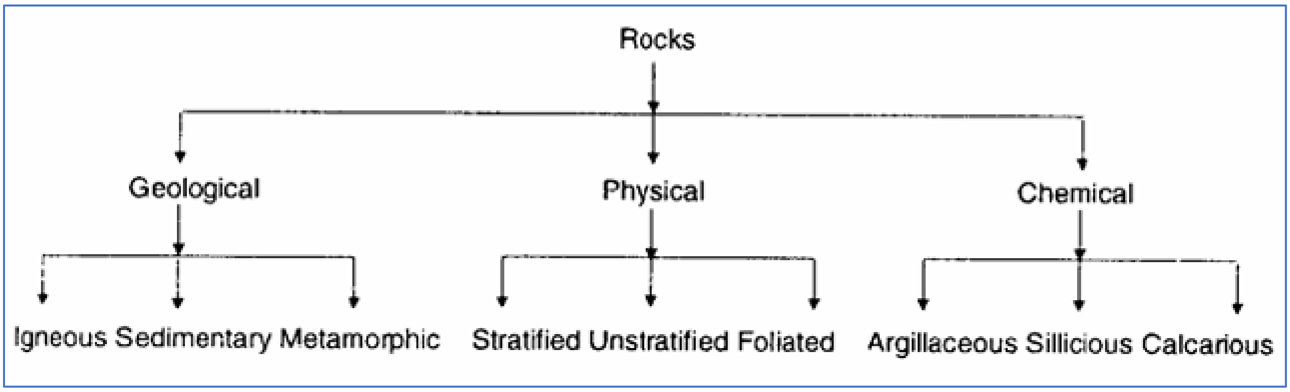
Introduction

All the building structures are composed of different types of materials. These materials are either called building materials or materials of construction. It is very essential for a builder, may be an architecture or engineer or contractor, to become conversant thoroughly with these building materials. The knowledge of different types of material, their properties and uses for different purposes provides an important tool in the hands of the builders in achieving economy in material cost. The material cost in a building range 30 to 50 percent cost of total cost construction. In addition to material economy, the correct use of material results in better structural strength, functional efficiency and aesthetic appearance

Types of Stones

Building stones are obtained from rocks occurring in nature and classified in three ways.

1. Geological classification
2. Physical classification
3. Chemical classification



1. Geological classification

According to the process of formation, rocks are classified into three types:

A. Igneous rocks.
B. Sedimentary rocks, and
C. Metamorphic rocks.

A. Igneous rocks

Rocks that are formed by cooling of Magana (molten or pasty rocky material) are known as igneous rocks. These rocks are strong and durable.

Igneous rocks also known as primary, unstratified or eruptive rocks are of volcanic origin and are formed as a result of solidification of molten mass lying below or above the earth's surface. The inner layers of the earth are at a very high temperature causing the masses of silicates to melt. This molten mass called magma is forced up as volcanic eruptions and spreads over the surface of earth where it solidifies forming basalt and trap. These are known as effusive rocks. If the magma solidifies below the earth's surface itself, the solid crystalline rock is termed as deep-seated plutonic rock. The examples are granite, syenite, diorite and gabbro. If the magma solidifies at a relatively shallow depth, the resultant rock possesses a finely grained crystalline structure—and is termed as hypabyssal. Dolerite is such a rock. The principal constituents of magma are quartz, mica and felspar. The texture of the rock is greatly influenced by the rate of cooling of the magma.

They are further classified as:

a. Volcanic rocks
b. Hypabyssal rocks
c. Plutonic rocks

a. Volcanic rocks

Cooling of magma at earth's surface – extremely fine grained and glossy.

Examples: Basalt and trap.

b. Hypabyssal rocks

Cooling of magma at shallow depth – fine grained crystallized structure.

Examples: Quartz, dolerite and gneiss.

c. Plutonic rocks

Cooling of magma at considerable depth – very strong and crystalline structure.

Examples: Granite and dolerite.

B. Sedimentary rocks

These rocks are formed by the deposition of production of weathering on the pre-existing rocks.

Disintegrated rock material is carried by flowing water and deposited elsewhere. Year after year new layers of materials is deposited and consolidated under pressure, heat and chemical action. Hence, the rocks so formed are uniform, fine grained and bedded.

Sedimentary rocks are also known as aqueous or stratified rocks. The various weathering agencies, e.g. rain, sun, air, frost, etc. break up the surface of earth. Rain water carries down these broken pieces to the rivers. As the rivers descend down to the plains, the velocity decreases gradually and the sediments (disintegrated rock pieces, sand, silt, clay, debris, etc.) in the water settle. Due to the seasonal variation, sedimentation takes place in layers. With time, the sediments get consolidated in horizontal beds due to the pressure exerted by overlying material.

The properties of the sedimentary rocks vary considerably depending upon the nature of the sediment and type of bond between the sediment and grains. Usually, the rocks are well stratified and show well defined bedding planes. The rocks are soft and can be easily split up along the bedding as well as normal planes. The examples of sedimentary rocks resulting from the precipitation of salts in drying water basin (chemical deposits) are gypsum, anhydrite, magnesite, dolomite, lime tufas. Sedimentary rocks resulting from the accumulation of plant or animal remains (organogenous rocks) are limestone, shale, chalk, diatomite and tripoli. The examples of rocks resulting from the deterioration of massive magmatic or sedimentary rocks (fragmental rocks) are sandstone, sand, gravel, carbonate conglomerate and breccia.

Examples: Sandstone, Mudstone, Limestone, Gravel, Gypsum, Lignite, etc.

C. Metamorphic rocks

These rocks are formed by the change in character of the pre-existing rocks. Igneous as well as sedimentary rocks are changed in character when they are subject to great heat and pressure. Known as metamorphism rocks.
These are the rocks formed after igneous rocks and sedimentary rocks undergo changes due to pressure, heat and chemical actions. These rocks have foliated structure.

Metamorphic rocks are formed from igneous or sedimentary rocks as a result of the action of the earth movements, temperature changes, liquid pressures, etc. The resultant mass may have a foliated structure, e
Examples: Quartzite, Schist, Slate, Marble and Gneisses.

- Granite becomes gneiss.
- Basalt changes to schist and laterite
- Limestone changes to marble
- Mudstone becomes slate.

2. Physical classification

Based on the general structure of rocks are divided into three types:

A. Stratified Rocks
B. Unstratified Rocks
C. Foliated Rocks

A. Stratified rocks

These rocks possess planes of stratification or cleavage and such rocks can be easily split along these planes. They have layered structure.
Examples: Sandstones, Limestones, Mudstones (Sedimentary rocks)

B. Unstratified rocks

The structure may be crystalline granular or compact granular, and the rocks are often affected by movements of the Earth.
Examples: Granite, Trap, Marble.

C. Foliated Rocks

These rocks have a tendency to split up in a definite direction only. They have foliated structure. Along the planes of foliation, they split easily. These planes are not parallel to each other.
Examples: Metamorphic rocks.

3. Chemical classification

According to this classification rocks are classified into three types.

A. Siliceous rocks
B. Argillaceous rocks
C. Calcareous rocks

A. Siliceous rocks

In these rocks, silica predominates (silica SiO_2 is main constituent is)) i,e sand. The rocks are very hard and durable and not easily effected by weathering agencies.
Example: Granite, Quartzite, Basalt, Trap, Gneiss, Syenite, etc

B. Argillaceous rocks

In these rocks, clay predominates (clay Al_2O_3 is the main constituent. These rocks are brittle. They cannot withstand shock. The rocks may be dense and compact or may be soft.
Example: Slates, Laterites etc.

C. Calcareous rocks

In these rocks, calcium carbonate predominates (Calcium carbonate is the main constituent). The durability to these rocks will depend upon the constituents present in surrounding atmosphere.
Examples: Limestone, marble.

Characteristics of Good Building Stones

A good building stone should have the following qualities.

1. **Appearance:** For face work it should have fine, compact texture; light-coloured stone is preferred as dark colours are likely to fade out in due course of time.
2. **Structure:** A broken stone should not be dull in appearance and should have uniform texture free from cavities, cracks, and patches of loose or soft material. Stratifications should not be visible to naked eye.
3. **Strength:** A stone should be strong and durable to withstand the disintegrating action of weather. Compressive strength of building stones in practice range between 60 to 200 N/mm^2.
4. **Weight:** It is an indication of the porosity and density. For stability of structures such as dams, retaining walls, etc. heavier stones are required, whereas for arches, vaults, domes, etc. light stones may be the choice.
5. **Hardness:** This property is important for floors, pavements, aprons of bridges, etc. The hardness is determined by the Mohs scale (Section 3.2).
6. **Toughness:** The measure of impact that a stone can withstand is defined as toughness. The stone used should be tough when vibratory or moving loads are anticipated.
7. **Porosity and Absorption:** Porosity depends on the mineral constituents, cooling time and structural formation. A porous stone disintegrates as the absorbed rain water freezes, expands, and causes cracking. Permissible water absorption for some of the stones is given below.

Sr. No.	Types of Stones	Water absorption (% not greater than)
1	Sandstone	10
2	Limestone	10
3	Granite	1
4	Trap	6
5	Shale	10
6	Gneiss	1
7	Slate	1
8	Quartzite	3

8. **Seasoning:** The stone should be well seasoned.
9. **Weathering:** The resistance of stone against the wear and tear due to natural agencies should be high.
10. **Workability:** Stone should be workable so that cutting, dressing and bringing it out in the required shape and size may not be uneconomical.

11. Fire Resistance: Stones should be free from calcium carbonate, oxides of iron, and minerals having different coefficients of thermal expansion. Igneous rocks 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.

12. Specific Gravity: The specific gravity of most of the stones lies between 2.3 to 2.5.

13. Thermal Movement: Thermal movements alone are usually not troublesome. However, joints in coping and parapets open out, in letting the rain water causing trouble. Marble slabs show a distinct distortion when subjected to heat. An exposure of one side of marble slab to heat may cause that side to expand and the slab warps. On cooling, the slab does not go back to its original shape.

Characteristics of stones

In order to ensure suitable selection of stone of particular work, one must be conversant with its composition, characteristics, uses and place of availability.

1) Granite

a. Igneous rock
b. Composed of quart, felspar and mica and minerals
c. Available in grey, green, brown and pink and red
d. Hard and durable
e. High resistance to weathering
f. The texture varies with its quality
g. Specify gravity 2.7 and compressive strength 700 to 1300 kg/cm2
h. Used for ornamental, road metal, railway ballast, aggregate for concrete; for construction of bridges, piers and marine works etc.

2) Balast

a. Igneous rock
b. It is compact, hard and heavy
c. Available in red, yellow grey, blue and greenish black colour
d. Specific gravity is 3 and compressive strength varies 1530 to 1890 kg/cm^2.
e. Used for ornamental, rail road ballast, aggregates for concrete etc.

3) Sand Stone

a. Sedimentary rock
b. It is available in variety of formations fine grained, coarse grained compact or porous
c. Available in white, green, blue, black, red and yellow.
d. Specific gravity 2.65 to 2.95
e. Compressive strength is 650kgs / cm^2
f. Used for ashlar works

4) Lime Stone:

I. **Sedimentary rock:** It is available in a variety of forms which differ from one another in colour Compaction, texture, hardness and durable

a. Compact lime stone
b. Granular lime stone
c. Magnesia lime stone
d. Kanker lime stone
e. Used for paving, road metal, etc

5) Marble

I. Metamorphic rock

a. Available in white, blue, green, yellow black and red colour
b. High compactness,
c. Suitable for decorative works, wall lining columns, pile, table slabs, hearths, tiled floors, steps of stair case etc.

6) Slate:

a. Metamorphic rock
b. Non absorbent, compact fine grained and produce metallic ringing sound when struck
c. Available in black, dark blue, grey, reddish brown etc.
d. Used for providing damp proof course, paving dados etc

Dressing of Stones

A quarried stone has rough surfaces, which are dressed to obtain a definite and regular shape. Dressing of stones is done immediately after quarrying and before seasoning to achieve less weight for transportation. Dressing of stone provides pleasing appearance, proper bedding with good mortar joints, special shapes for arches, copings, pillars, etc.

Deterioration of Stones of Stones Work

The various natural agents such as rain, heat, etc. and chemicals deteriorate the stones with time.

Rain: Rain water acts both physically and chemically on stones. The physical action is due to the erosive and transportation powers and the latter due to the decomposition, oxidation and hydration of the minerals present in the stones.

Physical Action: Alternate wetting by rain and drying by sun causes internal stresses in the stones and consequent disintegration.

Chemical Action: In industrial areas the acidic rain water reacts with the constituents of stones leading to its deterioration.

Decomposition: The disintegration of alkaline silicate of alumina in stones is mainly because of the action of chemically active water. The hydrated silicate and the carbonate forms of the alkaline materials are very soluble in water and are removed in solution leaving behind a hydrated silicate of alumina (Kaolinite). The decomposition of felspar is represented as

$$K_2Al_2O_3.6H_2O + CO_2 + nH_2O = K_2CO_3 + Al_2O_3.2SiO_2.2H_2O + 4SiO_2.nH_2O$$

(Orthoclase) (Alkaline carbonate) (Kaolinite) (Hydrated silicate)

Oxidation and Hydration: Rock containing iron compounds in the forms of peroxide, sulphide and carbonate are oxidised and hydrated when acted upon by aciduated rain water. As an example, the peroxide—FeO is converted into ferric oxide—Fe_2O_3 which combines with water to form $FeO.nH_2O$. This chemical change is accompanied by an increase in volume and results in a physical change manifested by the liberation of the neighbouring minerals composing the rocks. As another example iron sulphide and siderite readily oxidize to limonite and liberates sulphur, which combines with water and oxygen to form sulphuric acid and finally to sulphates.

Frost: In cold places frost pierces the pores of the stones where it freezes, expands and creates cracks.

Wind: Since wind carries dust particles, the abrasion caused by these deteriorates the stones.

Temperature Changes: Expansion and contraction due to frequent temperature changes cause stone to deteriorate especially if a rock is composed of several minerals with different coefficients of linear expansion.

Vegetables Growth: Roots of trees and weeds that grow in the masonry joints keep the stones damp and also secrete organic and acidic matters which cause the stones to deteriorate. Dust particles of organic or nonorganic origin may also settle on the surface and penetrate into the pores of stones. When these come in contact with moisture or rain water, bacteriological process starts and the resultant micro-organism producing acids attack stones which cause decay.

Mutual Decay: When different types of stones are used together mutual decay takes place. For example when sandstone is used under limestone, the chemicals brought down from limestone by rain water to the sandstone will deteriorate it.

Chemical Agent: Smokes, fumes, acids and acid fumes present in the atmosphere deteriorate the stones. Stones containing $CaCO_3$, $MgCO_3$ are affected badly.

Lichens: These destroy limestone but act as protective coats for other stones. Molluses gradually weaken and ultimately destroy the stone by making a series of parallel vertical holes in limestones and sandstones.

Preservation of Stone

Preservation of stone is essential to prevent its decay. Different types of stones require different treatments. But in general stones should be made dry with the help of blow lamp and then a coating of paraffin, linseed oil, light paint, etc. is applied over the surface. This makes a protective coating over the stone. However, this treatment is periodic and not permanent. When treatment is done with the linseed oil, it is boiled and applied in three coats over the stone. Thereafter, a coat of dilute ammonia in warm water is applied.

The structure to be preserved should be maintained by washing stones frequently with water and steam so that dirt and salts deposited are removed from time to time. However, the best way is to apply preservatives. Stones are washed with thin solution of silicate of soda or potash. Then, on drying a solution of $CaCl_2$ is applied over it. These two solutions called Szerelmy's liquid, combine to form silicate of lime which fills the pores in stones. The common salt formed in this process is washed afterwards. The silicate of lime forms an insoluble film which helps to protect the stones.

In industrial towns, stones are preserved by application of solution of baryta, $Ba(OH)_2$ - Barium hydrate. The sulphur dioxide present in acid reacts on the calcium contents of stones to form calcium sulphate. Soot and dust present in the atmosphere adhere to the calcium sulphate and form a hard skin. In due course of time, the calcium sulphate so formed flakes off and exposes fresh stone surface for further attack. Barium hydrate. The sulphur dioxide present in acid reacts on the calcium contents of stones to form calcium sulphate. Soot and dust present in the atmosphere adhere to the calcium sulphate and form a hard skin. In due course of time, the calcium sulphate so formed flakes off and exposes fresh stone surface for further attack. This is known as sulphate attack. Baryta reacts with calcium sulphate deposited on the stones and forms insoluble barium sulphate and calcium hydroxide. The calcium hydroxide absorbs carbon dioxide from the air to form calcium carbonate.

$$Ba(OH)_2 + CaSO_4 \longrightarrow \underset{\text{(Barium sulphate)}}{BaSO_4} + \underset{\text{(Calcium hydroxide)}}{Ca(OH)_2}$$

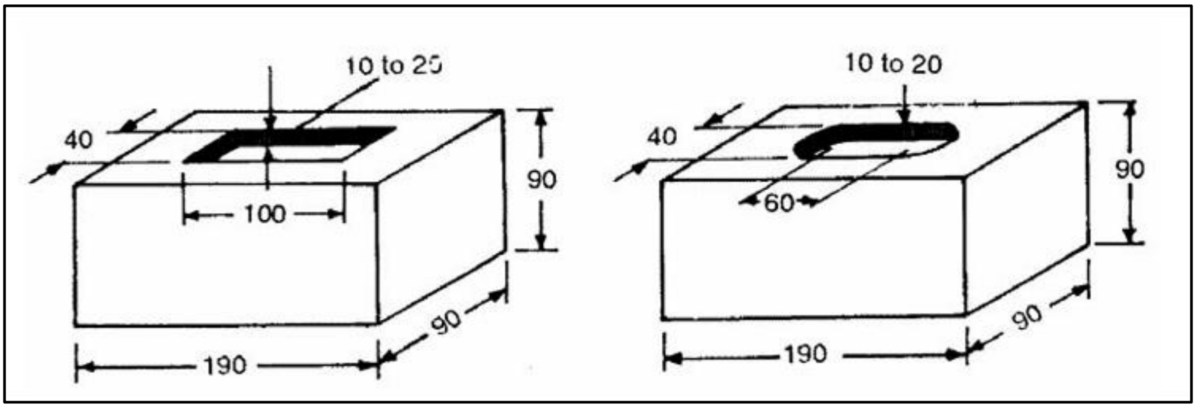
Bricks

One of the oldest building material bricks continues to be a most popular and leading construction material because of being cheap, durable and easy to handle and work with. Clay bricks are used for building-up exterior and interior walls, partitions, piers, footings and other load bearing structures.
A brick is rectangular in shape and of size that can be conveniently handled with one hand. Brick may be made of burnt clay or mixture of sand and lime or of Portland cement concrete. Clay bricks are commonly used since these are economical and easily available. The length, width and height of a brick are interrelated as below:

Length of brick = 2 × width of brick + thickness of mortar

Height of brick = width of brick

Size of a standard brick (also known as modular brick) should be 19 × 9 × 9 cm and 19 × 9 × 4 cm. When placed in masonry the 19 × 9 × 9 cm brick with mortar becomes 20 × 10 × 10 cm.
However, the bricks available in most part of the country still are 9" × 4 1/ 2 " × 3" and are known as field bricks. Weight of such a brick is 3.0 kg. An indent called frog, 1–2 cm deep, as shown in Fig below is provided for 9 cm high bricks. The size of frog should be 10 × 4 × 1 cm. The purpose of providing frog is to form a key for holding the mortar and therefore, the bricks are laid with frogs on top. Frog is not provided in 4 cm high bricks and extruded bricks.



Classification of Bricks

A. On Field Practice
B. On Strength
C. On the Basis on Use
D. On the Basis of Finish
E. On the basis of Manufacture
F. On the Basis of Burning
G. On the Basis of Types

A. On Field Practice

Based on their physical and mechanical properties Clay bricks are classified as

1. First class,
2. Second class,
3. Third class and
4. Fourth

1. First Class Bricks

1. These are thoroughly burnt and are of deep red, cherry or copper colour.

2. The surface should be smooth and rectangular, with parallel, sharp and straight edges and square corners.
3. These should be free from flaws, cracks and stones.
4. These should have uniform texture.
5. No impression should be left on the brick when a scratch is made by a finger nail.
6. The fractured surface of the brick should not show lumps of lime.
7. A metallic or ringing sound should come when two bricks are struck against each other.
8. Water absorption should be 12–15% of its dry weight when immersed in cold water for 24 hours.
9. The crushing strength of the brick should not be less than 10 N/mm2. This limit varies with different Government organizations around the country.

Uses: First class bricks are recommended for pointing, exposed face work in masonry structures, flooring and reinforced brick work.

2. Second Class Bricks

Second Class Bricks are supposed to have the same requirements as the first class ones except that

1. Small cracks and distortions are permitted.
2. A little higher water absorption of about 16–20% of its dry weight is allowed.
3. The crushing strength should not be less than 7.0 N/mm2.

Uses: Second class bricks are recommended for all important or unimportant hidden masonry works and centering of reinforced brick and reinforced cement concrete (RCC) structures.

3. Third Class Bricks

Third Class Bricks are underburnt. They are soft and light-coloured producing a dull sound when struck against each other. Water absorption is about 25 per cent of dry weight.

Uses: It is used for building temporary structures.

4. Fourt Class Bricks

Fourth Class Bricks are overburnt and badly distorted in shape and size and are brittle in nature.

Uses: The ballast of such bricks is used for foundation and floors in lime concrete and road metal.

B. On Strength

The Bureau of Indian Standards (BIS) has classified the bricks on the basis of compressive strength and is as given in Table below.

Class	Average Compressive Strength not less than (N/mm²)
35	35
30	30
25	25
20	20
17.5	17.5
15	15
12.5	12.5
10	10
7.5	7.5
5	5

3.5	3.5

Classification of Bricks based on Compressive Strength (IS: 1077)

1. The burnt clay bricks having compressive strength more than 40.0 N/mm² are known as heavy duty bricks and are used for heavy duty structures such as bridges, foundations for industrial buildings, multistorey buildings, etc. The water absorption of these bricks is limited to 5 per cent.
2. Each class of bricks as specified above is further divided into subclasses A and B based on tolerances and shape. Subclass-A bricks should have smooth rectangular faces with sharp corners and uniform colour. Subclass-B bricks may have slightly distorted and round edges.

C. On the Basis on Use

1. Common Bricks
2. Facing Bricks
3. Engineering Bricks

1. Common Bricks

Common Bricks is a general multi-purpose unit manufactured economically without special reference to appearance. These may vary greatly in strength and durability and are used for filling, backing and in walls where appearance is of no consequence.

2. Facing Bricks

Facing Bricks are made primarily with a view to have good appearance, either of colour or texture or both. These are durable under severe exposure and are used in fronts of building walls for which a pleasing appearance is desired.

3. Engineering Bricks

Engineering Bricks are strong, impermeable, smooth, table moulded, hard and conform to defined limits of absorption and strength. These are used for all load bearing structures.

D. On the Basis of Finish

1. Sand-faced Bricks
2. Rustic Bricks

1. Sand-faced Bricks

Sand-Faced Bricks has textured surface manufactured by sprinkling sand on the inner surfaces of the mould.

2. Rustic Bricks

Rustic Bricks has mechanically textured finish, varying in pattern.

E. On the basis of Manufacture

1. Hand-made
2. Machine-made

1. Hand-made

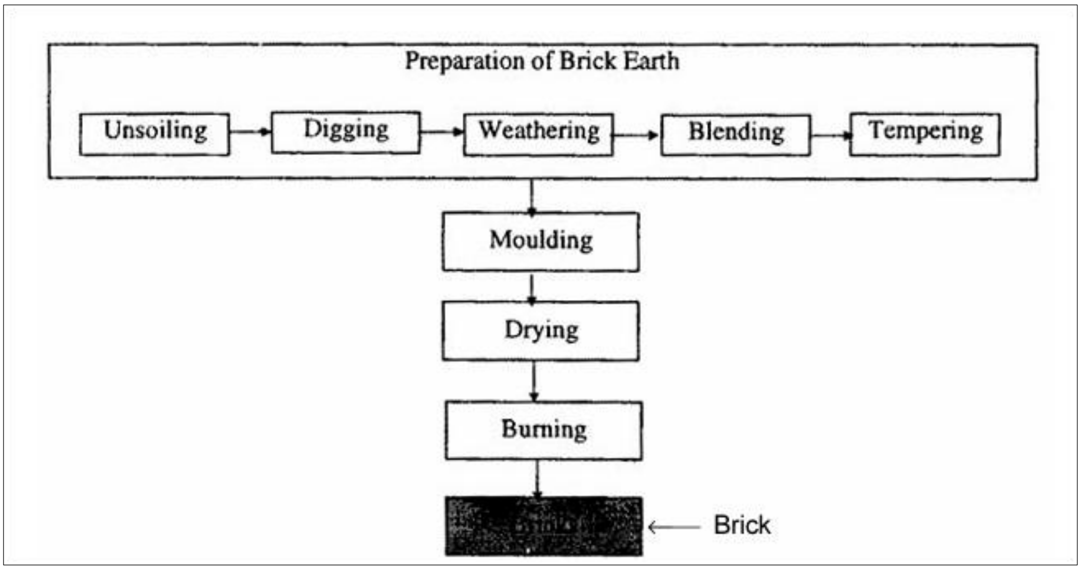
Hand-made bricks are hand moulded

2. Machine-made

Machine made depending upon upon mechanical arrangement, bricks are known as wire-cut bricks—bricks cut from clay extruded in a column and cut off into brick sizes by wires; pressed bricks—when bricks are manufactured from stiff plastic or semi-dry clay and pressed into moulds; moulded bricks—when bricks are moulded by machines imitating hand mixing.

F. On the Basis of Burning
G. On the Basis of Types

Manufacturing of Clay Bricks



Preparation of Bricks Earth/Clay Bricks

1. Unsoiling: The soil used for making building bricks should be processed so as to be free of gravel, coarse sand (practical size more than 2 mm), lime and kankar particles, organic matter, etc. About 20 cm of the top layer of the earth, normally containing stones, pebbles, gravel, roots, etc., is removed after clearing the trees and vegetation.

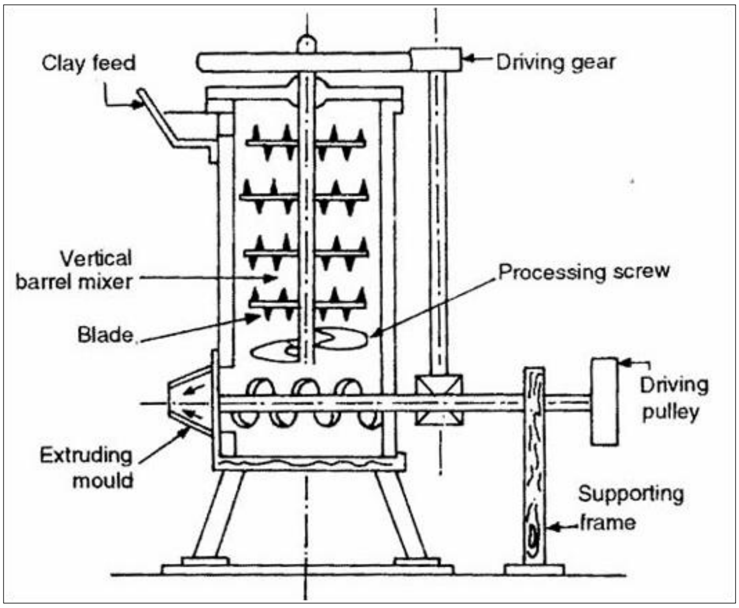
2. Digging:
After removing the top layer of the earth, proportions of additives such as fly ash, sandy loam, rice husk ash, stone dust, etc. should be spread over the plane ground surface on volume basis. The soil mass is then manually excavated, puddled, watered and left over for weathering and subsequent processing. The digging operation should be done before rains.

3. Weathering: Stones, gravels, pebbles, roots, etc. are removed from the dug earth and the soil is heaped on level ground in layers of 60–120 cm. The soil is left in heaps and exposed to weather for at least one month in cases where such weathering is considered necessary for the soil. This is done to develop homogeneity in the mass of soil, particularly if they are from different sources, and also to eliminate the impurities which get oxidized. Soluble salts in the clay would also be eroded by rain to some extent, which otherwise could have caused scumming at the time of burning of the bricks in the kiln. The soil should be turned over at least twice and it should be ensured that the entire soil is wet throughout the period of weathering. In order to keep it wet, water may be sprayed as often as necessary. The plasticity and strength of the clay are improved by exposing the clay to weather.

4. Blending: The earth is then mixed with sandy-earth and calcareous-earth in suitable proportions to modify the composition of soil. Moderate amount of water is mixed so as to obtain the right consistency for moulding. The mass is then mixed uniformly with spades. Addition of water to the soil at the dumps is necessary for the easy mixing and workability, but the addition of water should be controlled in such a way that it may not create a problem in moulding and drying. Excessive moisture content may effect the size and shape of the finished brick.

5. Tempering: Tempering consists of kneading the earth with feet so as to make the mass stiff and plastics (by plasticity, we mean the property which wet clay has of being permanently deformed without cracking). It should preferably be carried out by storing the soil in a cool place in layers of about 30 cm thickness for not less than 36 hours. This will ensure homogeneity in the mass of clay for subsequent processing. For manufacturing good brick, tempering is done in pug mills and the operation is called pugging.

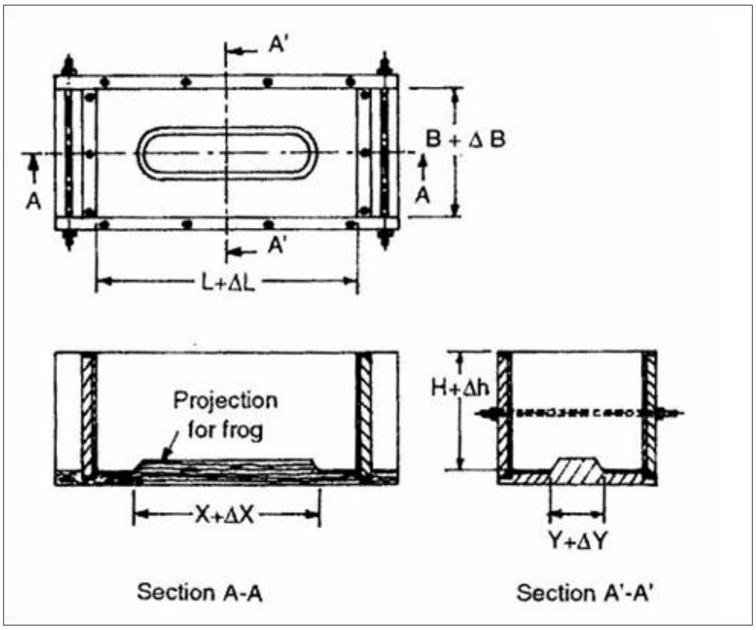
Pug mill consists of a conical iron tube as shown in Fig. The mill is sunk 60 cm into the earth. A vertical shaft, with a number of horizontal arms fitted with knives, is provided at the centre of the tube. This centralshaft is rotated with the help of bullocks yoked at the end of long arms. However, steam, diesel or electric power may be used for this purpose. Blended earth along with required water, is fed into the pug mill from the top. The knives cut through the clay and break all the clods or lump-clays when the shaft rotates. The thoroughly pugged clay is then taken out from opening provided in the side near the bottom. The yield from a pug mill is about 1500 bricks.



Plug Mil

6. Moulding: It is a process of giving a required shape to the brick from the prepared brick earth. Moulding may be carried out by hand or by machines. The process of moulding of bricks may be the soft-mud (hand moulding), the stiff-mud (machine moulding) or the dry press process (moulding using maximum 10 per cent water and forming bricks at higher pressures). Fire-brick is made by the soft mud process. Roofing, floor and wall tiles are made by dry-press method. However, the stiff-mud process is used for making all the structural clay products.

Hand Moulding: A typical mould is shown in Fig. Hand moulding is further classified as ground moulding and table moulding.



Ground Moulding: In this process, the ground is levelled and sand is sprinkled on it. The moulded bricks are left on the ground for drying. Such bricks do not have frog and the lower brick surface becomes too rough. To overcome these defects, moulding blocks or boards are used at the base of the mould. The process consists of shaping in hands a lump of well pugged earth, slightly more than that of the brick volume. It is then rolled into the sand and with a jerk it is dashed into the mould. The moulder then gives blows with his fists and presses the earth properly in the corners of the mould with his thumb. The surplus clay on the top surface is removed with a sharp edge metal plate called strike (Fig Below) or with a thin wire stretched over the mould. After this the mould is given a gentle slope and is lifted leaving the brick on the ground to dry.

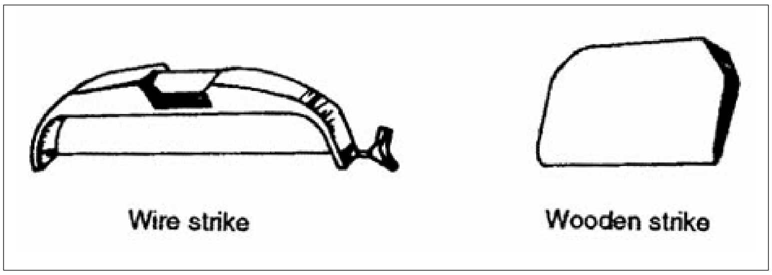
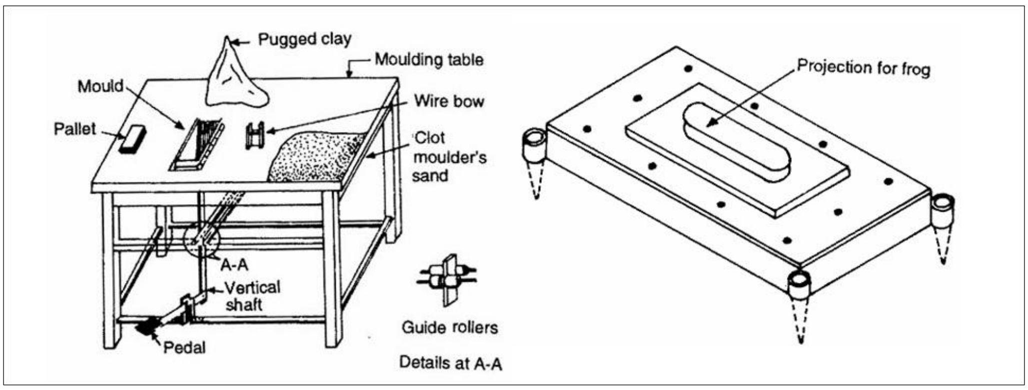
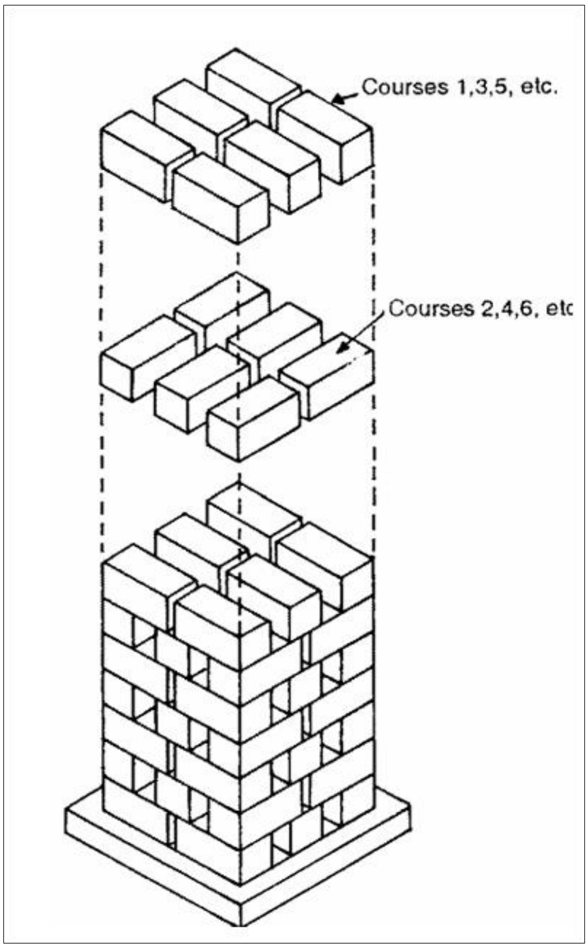


Table Moulding: The bricks are moulded on stock boards nailed on the moulding table (Fig.). Stock boards have the projection for forming the frog. The process of filling clay in the mould is the same as explained above. After this, a thin board called pallet is placed over the mould. The mould containing the brick is then smartly lifted off the stock board and inverted so that the moulded clay along with the mould rests on the pallet. The mould is then removed as explained before and the brick is carried to the drying site.



Drying: Green bricks contain about 7–30% moisture depending upon the method of manufacture. The object of drying is to remove the moistre to control the shrinkage and save fuel and time during burning. The drying shrinkage is dependent upon pore spaces within the clay and the mixing water. The addition of sand or ground burnt clay reduces shrinkage, increases porosity and facilities drying. The moisture content is brought down to about 3 per cent under exposed conditions within three to four days. Thus, the strength of the green bricks is increased and the bricks can be handled safely. Clay products can be dried in open air driers or in artificial driers. The artificial driers are of two types, the hot floor drier and the tunnel drier. In the former, heat is applied by a furnance placed at one end of the drier or by exhaust steam from the engine used to furnish power and is used for fire bricks, clay pipes and terracotta. Tunnel driers are heated by fuels underneath, by steam pipes, or by hot air from cooling kilns. They are more economical than floor driers. In artificial driers, temperature rarely exceeds 120°C. The time varies from one to three days. In developing countries, bricks are normally dried in natural open-air driers (Fig.). They are stacked on raised ground and are protected from bad weather and direct sunlight. A gap of about 1.0 m is left in the adjacent layers of the stacks so as to allow free movement for the workers.



Requirements of Good Bricks.

Size: The size of the brick should be uniform and must be of standard size. As per IS 1077(1992) the standard size of brick is 190 mm x 90 mm x 90 mm (or) 190 mm x 90 mm x 40mm.

Shape: The brick must be of rectangular shape. The sides of the brick should be parallel Also; the edges of brick must be sharp and straight.

Color: Good brick must possess uniform color which may be either deep red or cherry. The uniformity in color of bricks represents uniformity in chemical composition and homogeneous burning of brick.

Texture: The surface of the brick must not be too smooth. Excess smoothness of the bricks result in slipping of mortar.

Compactness: The fractured surface of brick should not show fissures, holes or lumps.

Compressive strength: The crushing strength of the brick must not be less than 3.5 N/mm2. The compressive strength test of brick is determined using Compression Testing Machine.

Hardness: Scratch the brick with a finer nail. The quality of the brick is considered as good when no impression is to be left on its surface.

Soundness: Strike two bricks against each other. If a metallic ringing sound is produced, then the bricks are of good quality. A good quality brick must be able withstand severe weather condition.

Toughness: The brick should not break into pieces when dropped flat on hard ground from a height of about 1 m or 1.2 m.

Water absorption: Water absorption of brick must be limited to 20% or 1/5 of the weight of the brick, whichever is lesser. Determine the water absorption of brick by either 24 hours immersion cold water test or 5 hours boiling water test.

Expansion: When wetted with water, the bricks should undergo minimum change in volume.

Extent of burning during manufacturing: The bricks should neither be under burnt nor be over burnt.

Thermal conductivity: The thermal conductivity of the bricks must be low so that houses constructed using them are cool in summer and hot in winter.

Efflorescence: Soak the brick in water for 24 hours and dry it in shade. The absence of white patches on brick surface indicates that the quality of brick is good. The formation of white patches is due to the presence of excess soluble salts (like sulphates of sodium, magnesium, calcium, potassium, etc.,). Determine the formation of white patches by using Efflorescence Test.

Brick affected by Efflorescence

Good Brick Earth: The earth used for manufacturing brick must be free from pebbles, stones, organic matter and harmful chemicals.

Other properties: A good brick should be sound proof, inflammable and incombustible.

Alternative bricks (fly ash bricks, AAC blocks)

Fly Ash Bricks: Fly ash bricks are a modern and eco-friendly building material made from waste produced by thermal power plants. Instead of using clay and burning it in kilns, these bricks are made using fly ash, sand, lime, and cement, then pressed and cured. This process saves energy and protects the environment.

They are becoming popular in construction because they are strong, lightweight, cost-effective, and help reduce pollution. More builders and homeowners are choosing fly ash bricks for homes, offices, and even big buildings.

Advantages of Fly Ash Bricks

Less Water Absorption: Fly ash bricks have lower water absorption rates compared to clay bricks. This property makes them less susceptible to damage from moisture, resulting in improved structural integrity and longevity.

Strength and Durability: Fly ash bricks are known for their high compressive strength and durability. They are capable of withstanding heavy loads and adverse weather conditions, making them ideal for a wide range of construction applications.

Fire Resistance: Fly ash bricks exhibit excellent fire resistance properties, making them a safer choice for construction in areas prone to fire hazards. They have a high melting point and do not release toxic gases when exposed to fire, contributing to enhanced building safety.

High strength and Durability: Fly ash bricks are known for their exceptional strength. They can achieve compressive strengths of 7.5 MPa or higher, making them suitable for both load-bearing and non-load-bearing walls. Their uniformity in size and shape also reduces plaster thickness, resulting in savings on cement and labor. Unlike clay bricks, fly ash bricks do not crack easily and maintain their form over time.

Lightweight and easy to handle: These bricks weigh less than traditional red bricks, which helps reduce the overall dead load on a building's structure. This feature is especially beneficial for multi-storey constructions, as it minimizes the load on beams and columns. Lightweight bricks are also easier to transport, lift, and lay speeding up the construction process.

Better thermal insulation: Fly ash bricks offer better insulation properties, helping regulate indoor temperatures more effectively. This results in energy savings as buildings require less heating or cooling. For both residential and commercial buildings, this means lower electricity bills and improved living comfort throughout the year.

Eco-friendly uses industrial waste: The main ingredient, fly ash, is a by-product of thermal power plants. Instead of being dumped and causing environmental issues, it's reused in the brick-making process. This not only reduces landfill waste but also limits the carbon emissions associated with clay brick manufacturing, which involves topsoil excavation and burning.

Reduces load on structural members: Because of their light weight and high strength, fly ash bricks exert less pressure on foundations and supporting structures. This allows for more economical designs and contributes to long-term safety. Builders and engineers often prefer them in earthquake-prone areas for their superior performance under stress.

Disadvantages / Limitations of Fly Ash Bricks

Not suitable for water-logged areas: One of the main limitations of fly ash bricks is their low water absorption capacity. While this is generally an advantage for moisture resistance, it becomes a drawback in areas with continuous water exposure or high groundwater levels. In such conditions, these bricks may not perform well unless proper waterproofing and protective coatings are applied.

Requires proper curing: Unlike clay bricks that are fired in kilns, fly ash bricks rely on a curing process to gain strength. Improper or insufficient curing can lead to weak bricks that may break or crumble over time. Curing must be done consistently for at least 15 to 21 days using clean water and under controlled conditions. This adds to the production timeline and requires space and resources.

Limited availability in remote areas: Although fly ash bricks are gaining popularity in urban regions, their availability in rural or remote locations remains limited. Manufacturing plants are often located near thermal power stations to reduce transportation costs of fly ash. In areas far from such facilities, the logistics of sourcing raw materials or finished bricks can raise the overall cost, making traditional red bricks a more convenient option.

Skilled labor required for handling: Fly ash bricks require precise laying with minimal joints to prevent cracking. Unlike traditional bricks that are more forgiving, these bricks need trained masons familiar with their characteristics. Inexperienced handling may result in misalignment or improper bonding with mortar, affecting the structural integrity.

Color variation: Fly ash bricks may have slight variations in color due to changes in the chemical composition of fly ash, which can affect the final look of exposed walls. While this is not a functional issue, it may concern builders focused on aesthetics.

Applications of Fly Ash Bricks

Residential, commercial, and industrial buildings: Fly ash bricks are widely used across all types of construction residential homes, commercial complexes, and industrial facilities. Their strength and thermal insulation make them ideal for both low-rise and high-rise buildings. Homeowners prefer them for walls and partitions due to their durability and smooth finish, while commercial developers appreciate their speed of installation and cost efficiency. In industrial settings, they are often used in warehouses, factories, and storage units where structural reliability is essential.

Load-bearing and non-load-bearing walls: Thanks to their high compressive strength, fly ash bricks are suitable for load-bearing walls in buildings up to several stories. They efficiently transfer structural loads to the foundation without the need for complex reinforcement in smaller projects. In non-load-bearing applications, these bricks are used in infill walls, facade cladding, and internal partitions, contributing to stability without adding excessive weight to the framework.

Partition walls and infill panels: Fly ash bricks are an excellent choice for partition walls and infill panels in framed structures. Their uniform size and lighter weight help speed up wall construction and make them easy to handle and install. Because they create fewer joints and smoother surfaces, interior walls made with these bricks require less plastering, which improves finishing speed and reduces overall construction costs.

Other specialized uses: In addition to standard wall construction, fly ash bricks are also used in boundary walls, garden structures, compound fencing, and paving blocks. Their resistance to moisture and pests makes them suitable for both indoor and outdoor applications. Some eco conscious builders also use fly ash bricks in green buildings and LEED-certified projects due to their sustainable composition and low environmental impact.

AAC blocks

AAC blocks, or *Autoclaved Aerated Concrete blocks*, boast a lightweight nature. They're about one-fifth the weight of traditional bricks, making them a breeze to handle. Plus, these blocks offer excellent insulation properties and fire resistance, like a superhero for your walls. Studies show that using AAC blocks can reduce energy consumption by up to 30% in buildings.

Strength and Durability: AAC blocks are lightweight superheroes at approximately one-fifth the weight of traditional bricks. They're tough, too, with compressive strengths around 5 to 7 MPa. Traditional bricks strut their durability with a lifespan over 100 years if pampered just right. Fly ash, while not as robust, still brings decent compressive strength but packs a punch with water resistance. Pick your fighter based on lifespan and strength; both have their merits.

Advantages of AAC (Autoclaved Aerated Concrete) Blocks

Lightweight Material: AAC blocks are much lighter than traditional clay bricks. Due to their low density, they significantly reduce the dead load on a building. This helps in designing smaller foundations and structural elements, making the overall structure more economical and safer, especially for multi-storey buildings.

High Strength and Durability: Even though AAC blocks are lightweight, they possess sufficient compressive strength for both load-bearing and non-load-bearing walls. Since they are manufactured in factories under controlled conditions, their quality, strength, and durability remain uniform throughout construction.

Excellent Thermal Insulation: AAC blocks have a porous structure filled with air pockets, which provides very good thermal insulation. This helps maintain comfortable indoor temperatures by keeping buildings cooler in summer and warmer in winter, thereby reducing the need for air conditioning and heating.

Fire Resistance: AAC blocks are non-combustible and offer high fire resistance. Depending on the thickness, they can withstand fire for several hours without losing structural stability. This makes them suitable for residential, commercial, and industrial buildings where fire safety is important.

Sound Insulation: The cellular structure of AAC blocks effectively reduces sound transmission. They help minimize noise from outside and between rooms, making them ideal for homes, hospitals, schools, offices, and hotels.

Earthquake Resistance: Because AAC blocks are lightweight, the seismic load acting on the structure is reduced. This improves the earthquake resistance of buildings and minimizes structural damage during seismic activity.

Faster Construction: AAC blocks are larger in size compared to conventional bricks, which means fewer joints and faster wall construction. They also require less mortar, reducing both construction time and labor cost.

Cost Effective in the Long Run: Although the initial cost of AAC blocks may be higher than clay bricks, they reduce overall construction cost. Savings are achieved through reduced steel usage, thinner plaster, lower mortar consumption, and energy savings due to better insulation.

Smooth Finish and Accurate Shape: AAC blocks are machine-made and have precise dimensions with a smooth surface. This results in uniform walls and reduces the thickness of plaster required, improving the overall finish of the building.

Eco-Friendly and Sustainable: AAC blocks are environmentally friendly as they often use fly ash, an industrial waste product. Their manufacturing process produces less waste and consumes fewer natural resources, reducing the carbon footprint of construction.

Low Water Absorption: AAC blocks absorb less water compared to traditional bricks. This reduces problems related to dampness, seepage, and efflorescence, improving the life of the building.

Disadvantages / Limitations of AAC (Autoclaved Aerated Concrete) Blocks

Higher Initial Cost: AAC blocks are generally more expensive than traditional clay bricks at the time of purchase. This higher material cost can increase the initial construction budget, especially for small-scale projects, even though long-term savings may offset it.

Lower Load-Bearing Capacity Compared to RCC: Although AAC blocks have sufficient strength for wall construction, their load-bearing capacity is lower compared to reinforced concrete. Therefore, they are mainly used for walls and not suitable for heavy structural elements without proper support.

Brittle Nature: AAC blocks are more brittle than clay bricks. They can crack or break easily during handling, transportation, or improper installation, leading to material wastage if not handled carefully.

Requires Skilled Labor: Construction with AAC blocks requires skilled masons familiar with thin-joint mortar and proper laying techniques. Untrained labor may cause poor bonding, cracks, and reduced wall strength.

Limited Availability in Some Areas: AAC blocks may not be easily available in all regions, particularly in rural or remote areas. Transportation from distant manufacturing plants can increase costs and project delays.

Special Mortar Requirement: AAC blocks require thin-bed adhesive mortar instead of conventional cement-sand mortar. This special mortar may not always be readily available and can add to the overall construction cost.

Lower Impact Resistance: AAC blocks have lower impact strength compared to traditional bricks. They may get damaged by heavy impacts, making them less suitable for areas exposed to high mechanical stress.

Moisture Sensitivity if Poorly Finished: If AAC block walls are not properly plastered or waterproofed, they may absorb moisture over time. Poor finishing can lead to dampness and surface cracks.

Fixing Heavy Loads is Difficult: Fixing heavy fixtures such as cupboards, geysers, or wall-mounted equipment requires special anchors or fasteners. Ordinary nails and screws may not hold firmly in AAC blocks.

Quality Depends on Manufacturer: The performance of AAC blocks depends heavily on manufacturing quality. Poor-quality AAC blocks may have inconsistent density, reduced strength, and higher water absorption.

Applications of AAC (Autoclaved Aerated Concrete) Blocks

Residential Buildings: AAC blocks are widely used in residential construction for both load-bearing and non-load-bearing walls. Their lightweight nature reduces the overall load on the structure, while their thermal and sound insulation properties provide comfortable living conditions in houses and apartments.

Commercial Buildings: In commercial structures such as offices, shopping complexes, and hotels, AAC blocks are used for partition walls and external walls. Their fire resistance, sound insulation, and faster construction speed make them suitable for large-scale commercial projects.

Industrial Buildings: AAC blocks are used in factories, warehouses, and industrial units for wall construction. Their fire resistance and durability help improve safety, while their lightweight property reduces structural stress in industrial buildings.

High-Rise Buildings: Due to their low density, AAC blocks are commonly used in high-rise and multi-storey buildings. They help reduce dead load on the structure, which allows for economical structural design and improved earthquake resistance.

Partition Walls: AAC blocks are ideal for internal partition walls because they are lightweight, easy to cut, and provide good sound insulation. They allow flexible interior layouts and easy modification of spaces.

Load-Bearing Walls (Low-Rise Structures): In low-rise buildings, AAC blocks can be used for load-bearing walls when designed properly. Their adequate compressive strength and uniform quality make them suitable for such applications.

Fire-Resistant Walls: AAC blocks are commonly used in fire-rated walls, staircases, lift shafts, and fire separation walls. Their non-combustible nature helps prevent the spread of fire and enhances building safety.

Thermal Insulation Walls: AAC blocks are used in buildings where thermal efficiency is important, such as residential homes, cold storage facilities, and energy-efficient buildings. They help reduce heat transfer and energy consumption.

Renovation and Extension Works: Due to their lightweight nature, AAC blocks are suitable for renovation and extension of existing structures. They add minimal load to old buildings and can be easily cut and shaped to fit new designs.

Prefabricated and Modular Construction: AAC blocks are used in prefabricated construction systems and modular buildings. Their uniform size, easy handling, and quick installation support fast and efficient construction methods.

Lime- Classification, Properties.

Lime

Introduction

Lime is one of the oldest binding materials used in civil engineering and building construction. It has been used since ancient times in monuments, masonry structures, and plastering works due to its good binding and finishing properties. Lime is obtained by the calcination of calcareous materials such as limestone, chalk, shells, and kankar in a lime kiln at high temperatures. During this process, carbon dioxide is driven off and quicklime (calcium oxide) is formed.

The quicklime thus obtained is not directly suitable for construction purposes. It is first slaked with water, either by sprinkling or immersion, to produce slaked lime (calcium hydroxide). Slaked lime is available in the form of dry powder, lime putty, or lime slurry, depending on the method of slaking. Proper slaking is essential to achieve good workability, strength, and durability of lime.

Lime acts as a cementing material by binding aggregates together in mortars and plasters. When used in construction, lime hardens either by carbonation (in the case of fat lime) or by hydration (in the case of hydraulic lime). Due to its plasticity, lime mortar provides excellent workability and smooth finishing, making it suitable for plastering and pointing works.

Overall, lime is an economical, eco-friendly, and versatile construction material that continues to play an important role in modern as well as traditional civil engineering works.

Classification of Lime

Lime is classified based on its chemical composition and setting characteristics as follows:

A. Fat Lime (Rich Lime / High Calcium Lime)
B. Hydraulic Lime
C. Poor Lime (Lean Lime)

D. Magnesium Lime

A. Fat Lime (Rich Lime / High Calcium Lime)

- Contains about 90–95% calcium oxide (CaO)
- Very small amount of impurities
- Slakes vigorously with water
- High plasticity
- Sets and hardens very slowly

Fat lime is obtained from pure limestone and is free from clay and silica. On adding water, it slakes rapidly with evolution of heat and increases considerably in volume. It hardens only in air by absorbing carbon dioxide (carbonation) and therefore cannot set under water. It is mainly used for whitewashing and plastering works.

B. Hydraulic Lime

- Contains clay and silica along with calcium oxide
- Possesses hydraulic properties
- Can set and harden under water
- Stronger and more durable than fat lime

Hydraulic lime is obtained from limestone containing clay. Due to the presence of silica and alumina, it sets by hydration and can harden even under damp conditions or water. Based on clay content, hydraulic lime is further classified into feebly, moderately, and eminently hydraulic lime.

1. Feebly Hydraulic Lime

- Clay content: 5–10%
- Sets slowly
- Moderate strength
- Used for ordinary masonry work

2. Moderately Hydraulic Lime

- Clay content: 11–20%
- Medium setting time
- Good strength
- Used for masonry and foundation works

3. Eminently Hydraulic Lime

- Clay content: 21–30%
- Sets rapidly
- High strength
- Used for underwater and heavy engineering works

C. Poor Lime (Lean Lime)

- Contains more than 30% impurities
- Low calcium content
- Slakes slowly
- Poor binding property

Poor lime is obtained from impure limestone containing a large amount of clay and sand. It has low plasticity and develops very little strength after setting. Due to its inferior quality, it is used only for temporary and low-grade construction works.

D. Magnesium Lime

- Contains 5–35% magnesium oxide (MgO)
- Slakes slowly
- Moderate plasticity
- Better strength than fat lime

Magnesium lime contains both calcium oxide and magnesium oxide. It slakes slowly and provides moderate strength and durability. It is commonly used in masonry works where moderate strength is required.

Properties of Lime

Slaking: Slaking is the chemical process in which quicklime (CaO) reacts with water to form slaked lime or calcium hydroxide [$Ca(OH)_2$] with the evolution of a large amount of heat. During this reaction, lime swells and breaks down into a fine powder or paste. Fat lime slakes rapidly and vigorously, whereas hydraulic lime slakes slowly due to the presence of clay and impurities. Proper slaking is very important because incomplete slaking may cause expansion and cracking in lime mortar and plaster.

Setting and Hardening: Setting and hardening is the process by which lime changes from a plastic state into a rigid mass. Fat lime sets slowly in air by absorbing carbon dioxide from the atmosphere, a process known as carbonation, and therefore it cannot harden under water. Hydraulic lime sets and hardens by hydration due to the presence of silica and alumina and can harden even in damp or underwater conditions. The setting time of lime mainly depends on the amount of clay present in it.

Plasticity: Plasticity is the ability of lime to be moulded easily without cracking and to retain its shape. High plasticity provides good workability and smooth finishing in plastering works. Fat lime possesses high plasticity and is therefore widely used for plastering and finishing purposes, while poor lime has low plasticity due to the presence of excessive impurities, resulting in poor workability.

Strength: The strength of lime depends upon its type, composition, and method of setting. Fat lime develops low compressive strength as it hardens slowly by carbonation. Hydraulic lime develops higher strength due to the formation of hydraulic compounds during hydration. Among all types, eminently hydraulic lime gives the highest strength and is suitable for structural and load-bearing works.

Durability: Durability is the ability of lime to resist the effects of weathering, moisture, and environmental conditions over a long period. Hydraulic lime is more durable and resistant to moisture compared to fat lime because it can set and harden in the presence of water. Fat lime is less durable in damp conditions and is therefore mainly used in dry locations. Hydraulic lime is preferred for foundations, damp places, and underwater construction works.