Building Materials

BUILDING MATERIALS

Specific gravity of good building stones should lie between 2.4 to 2.8.

Suitability of stones for various types of construction

Type of structure	**Type of stone**
1. Piers, bridge abutments, light house and weirs	Good quality granite, Good or stratified granite
2. Road pavements and Railway ballast	Interior quality of granite and Gneiss
3. Road metalling paving	Basalt and trap.
4. Cement concrete	Basalt and trap.
5. Ornamental work in building	Red and yellow types of basalt and trap.
6. Roof covering and flooring	Slate
7. Damp proofing and sills of windows	Slate
8. Partitions in urinal and bath rooms	Slate
9. Ornamental buildings, monuments, statues and carved work	Marble
10. Building construction	Laterite
11. Interior decoration in superior building	Serpentine

S.No	Typesof bricks (classification)	Properties	Where to use
1.	First class bricks	These bricks are well burnt, having smooth and even surface, with perfect rectangular shape and uniform reddish colour. When struck with other brick, these given a metallic ringing sound. These should not leave any mark when scrached by finger nail. These should not absorb water more than 20% of its weight when immersed in cold water for 24 hours. When broken into two pieces these should show a uniform compact structure. These show slight eflorescence.	These are used for good structures such as outer walls and facing work when no plastering is done. These are also used in floors and reinforced bricks slabs. Such bricks should be laid in rich mortar.
2.	Second class bricks	These are not perfectly rectangular in shape and are having rough surface, but are hard, slightly over-burnt and uniform in colour. These give ringing sound when struck with each other. Water absorption should not be more than 22% by wt. when immersed in water for 24 hours. These show slight eflorescence.	These are used for internal walls, not exposed to atmosphere, these are used in facing work, which should be plastered. These cannot be sued for R.B. work. Such bricks are laid in mud or lime mortar.

3.	Third class or pila bricks	These bricks are not burnt properly in the kilns and may be slightly under/over burnt, hence these are soft and can be easily broken. These are light red in colour, with yellowish tinge. On striking these do not give a ringing sound. These should not absorb more than 25% of water by weight when placed in cold water for 24 hours. Efflorescence in these bricks in moderate.	These are used for interior construction works, or at places where there is less rainfall or presence of dampness.
4.	Jhama or overburnt bricks	Due to excess fusion and temprature bricks get over-burnt, loose their shape and get twisted. These bricks are durk bluish in colour.	These bricks are not used in building construction work. In the form of broken pieces these may be used as road metal, also in foundations and floors as soling materials.

Classification and Characteristics of Bricks as per Indian Standard Institution (IS 1077-1973)

Tests for the acceptance of bricks for building construction

1. Dimension and tolerance test
2. Compressive strength test
3. Water absorption test
4. Efflorescence test

1. **Dimension and Tolerance Test:** Take 20 bricks out of given sample. The dimensions of 20 bricks should be within the following limits

Class	Length	Width	Height
	12 – 380 + 12	6-180 + 6	
Class A	368 to 392 cm	172 to 186 cm	174 to 186 cm
	30 – 380 + 80	15 - 180 + 15	
Class B	350 to 410 cm	165 to 195 cm	165 to 195 cm

2. **Compressive Strength Test:** Proceed as under :
   (*i*) Take five bricks out of the sample at random.
   (*ii*) Immerse the bricks in water at room temperature for 24 hours.
   (*iii*) Fill the frags and all voids in the bed and face with cement mortar 1:1.
   (*iv*) Store the bricks under damp gunny bags for 24 hours and thereafter immerse them in water for 72 hours.
   (*v*) Place compression testing machine
   (*vi*) Apply the load of a uniform rate of 140 kg/cm^2 per minute till the brick foils
   (*vii*) Take the average value of the comp. strenghts of the five bricks.
   (*viii*) The Compressive strength of a common brick should be 50 kg/cm^2.
3. **Water Absorption Test :** If the water absorption capacity of a brick is more, its strength will be comparatively low.

Procedure:

(*i*) Select five bricks at random out of the given sample.

(*ii*) Dry them in a ventilated oven at 105° to 110°C till they attain practically constant weight.

(*iii*) Remove the bricks from the oven and cool them to room temperature.

(*iv*) Weight the bricks in a balance. Let it be W_1 kg.

(*v*) Immerse the five bricks in water completely at 27° ± 2C for 24 hours.

(*vi*) Remove one brick from water and wipe off its surfaces with a damp cloth.

(*vii*) Weight the brick within three minutes after its removal from water. Let its weight be W_2 kg.

(*viii*) Water absorption capacity = $\dfrac{W_2 - W_1}{W_1} \times 100$

(*ix*) Take the average value of the water absorption capacities of the five bricks.

(*x*) For 1st class bricks, the water absorption capacity should not be more than 20% by wt.

4. **Efflorescence Test :** This test is performed to know the presence of any alkaline malter in the bricks.

Procedure:

(*i*) Take five bricks at random from the given sample.

(*ii*) Place each brick on end in a dish containing distilled water ensuring depth immersion at least 2.5 cm.

(*iii*) Keep the dish in a ventilated room (temp 20° to 30°C) till the whole of distilled water in the dish evaporates.

(*iv*) Again pore 2.5 cm depth of distilled water in the dish and keep it till whole of water gets evaporated.

(*v*) Now, examine the bricks for efflorescence as detailed below :

Observation	Result
(*i*) No perceptible deposit	Nil - efflorescence
(*ii*) 10% area covered with deposit of salts	Slight - efflorescence
(*iii*) 50% area covered with deposit of salts without any powdering or flaking surface	Moderate - efflorescence
(*iv*) 50% area covered with deposit of salts accompanied by flaking of surface	Heavy - efflorescence
(*v*) Heavy deposits of salts accompanied by flaking of the surface	Serious - efflorescence

Terra Cotca made from a mixture of fine clay 60%, crushed pottery 20%, while sand 14% and powdered glass 6% with a quantity of desired colouring sbustance. It is baked earth of superior variety of clay. Terra-cotta is used for architectural and ornamental parts of superior building as a substitute for stones. It is used as sound proof material and its hollow blocks prevent dampness in the structure.

STONES

Classification of Rocks:

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

1.

Geological Classification
- Igneous rocks
  - Plutonic rock
  - Hypabyssal rocks
  - Volcanic rocks
- Sedimentary rocks
- Metamorphic rocks

The rock which are formed by cooling of magma are known as the igneous rocks.

- Plutonic rocks are formed due to cooling of magma at a considerable depth from earth's surface. The igneous rocks commonly used in building industry are of plutonic type. Granite is the leading example of this type of rock.
- Hypabyssal rocks are formed due to cooling of magma at a relatively shallow depth from earth's surface. The cooling is quick and hence, these rocks possess finely grained crystalline structure, e.g. Dolerite.
- Voleanic rocks are formed due to pouring of magma at earth's surface. These rocks are extremely find grained in structure, e.g. Basalt.

(*ii*) **Sedimentary Rocks:** These are formed by the deposition of products of weathering on the pre-existing rocks.

Following four types of deposits occurs:

(*a*) Residual deposits

(*b*) Sedimentary deposit

(*c*) Chemical deposit

(*d*) Organic deposit

e.g. Gravel, sandstone, limestone, gypsum, lignite, etc.

(*iii*) **Metamorphic rocks :** These arocks are formed by the change in character of the pre-existing rocks. The igneous as well as sedimentary rocks are changed in character when they are subjected to great heat and pressure. The process of change is known as the metamorphism.

There are three agents of metamorphism, namely, heat, pressures and chemicaly acting fluids.

2. Physical Classification

(*i*) Stratified rocks (e.g. Sedimentary rocks)

(*ii*) Unstratified rocks (e.g. Igneous rocks)

(*iii*) Foliated rocks (e.g. Metamorphic rocks)

3. Chemical Classification:

Chemical classification known as scientific or engineering classification.

(*i*) Silicious rocks (e.g. Granites, quartrite)

(*ii*) Argillaceous rocks (e.g. Slates, laterites)

(*iii*) Calcareous rocks (e.g. Limestones, marsles)

SOURCES OF STONES

The stones are obtained from rocks. Qartz sand, chemically pure gypsum, magnesite etc. are monomineralic rocks and basalt, granite etc. are polymineralic rocks.

A mineral indicates a substance having definite chemical composition and molecular structure. It is formed by natural inorganic process. Such minerals, when combine, form rocks of various types. The properties of rock are then governed by the properties of minerals present in the structure.

Commonly found minerals in the igneous rocks:

1. Augite called pyroxene
2. Chlorite
3. Felspar
4. Homblen de
5. Mica
6. Olirine
7. Plagiclase
8. Quartz
9. Serpentiner

Minerals also contained in sedimentary rocks:

1. Calcite
2. Magnesite
3. Dolomite
4. Glauconite
5. Limonite
6. Gypsum
7. Anhydrate

Texture or Structure of Rock

The arrangement of minerals forming a rock is known as its texture or structure. Following are the different types of textures :

1. Compact Crystalline (e.g. marble, quatrite)
2. Conglomerate
3. Foliated
4. Glassy
5. Granular crystalline (e.g. sandstone, gneiss)
6. Pisolific
7. Porous granular
8. Prophynitic
9. Vesicular

Fracture of a Rock

The types of surface obtained, when a rock is broken, indicates its fracture. Following are different types of fractures of rocks :

1. Conchoidal (e.g. quartz, flint)
2. Earthy (e.g. chalk)
3. Even
4. Fibrous (e.g. asbestos)
5. Hackly
6. Uneven

Use of Stones

1. Structure
2. Face work
3. Paving
4. Basic materials
5. Miscellaneous
   (*i*) ballast for railways,
   (*ii*) plea in blast furnaces

Tests for Stones

1. **Acid Test:** Stone is placed in HCL for 7 days. Its surface is free from powder.
2. **Attrition Test:** This test is done to find out the rate of crear of stones which are used in road constructon. The results of test indicates the resisting power of stones against the grinding action under traffic.
3. **Crushing Test**
4. **Crystallisation Test**
5. **Freezing and Throwing Test**
6. **Hardness Test:** Co-efficient of hardness
   $$= 20 - \frac{\text{loss in weight in gm}}{3}$$
7. **Impact Test :** To determine toughness of a stone
8. **Microscopic Test**
9. **Smith's Test:** This test is performed to find out the presence of soluble matter in sample of stone.
10. **Water Absorption Test**

Quality of Good Building Stone

1. Crushing strength > 100 N/mm^2
2. Appearance
3. Durability
4. Facility of dressing
5. Fracture
6. **Hardness :** Co-efficient of hardness > 17 used for road work
7. **Percentage wear :** for good building stone wear should be $\leq$ 3%
8. Resistence to fire
9. Seasoning (6 to 12 months)
10. **Specific gravity :** for a good building stone sp. gravity > 2.7
11. Texture
12. **Toughness index:** Toughness index < 13 stone is not tough
    Toughness index lies between 13 and 19, the stone is said to be moderately tough Toughness index > 19 high
13. **Water absorption:** For a good stone, percentage absorption by wt. after 24 hours should not exceed 0.60

Stone Quarrying:

The process of taking out stones from natural rock beds is known as the quarrying.

Common building stones of India

1. **Igneous :** Basalt and trap, granite
2. **Sedimentary :** Chalk, kankar, limestone, sandstone
3. **Metamorphic:** Gneiss, laterite, marble, murum, quartrite, slate.

BRICKS

Composition of Good Brick Earth:

1. Alumina (20 to 30%)
2. Silica
3. Lime
4. Oxides of iron
5. Magnesia

1. **Alumina :** It is the chief constituent of every kind of clay. A good brick earth should contain about 20% to 30% of alumina. This constituent imparts plasticity to the earth so that it can be moulded. If alumina is present in excess, with inadequate quality of sand, the raw bricks shrink and warp during drying and burning and become too hard when burnt.
2. **Silica :** It exists in clay either as free or combined. As free sand, it is mechanically mixed with clay and is combined form, it exists in chemical composition with alumina. A good brick earth should contain about 50% to 60% of silica. The presence of this constituent presents cracking, shrinking and warping of raw bricks. It thus imparts uniform shape to the bricks. The durability of bricks depends on the proper proportion of silica in brick earth. The excess of silica destroys the cohesion between and the brick becomes brittle.
3. **Lime :** A small quantity of lime not exceeding 5% is desirable in good brick earth. It should be present in a very finely powdered state because even small particles of the size of a pin-head cause flaking of the bricks. The lime prevents shrinking of raw bricks. The excess of lime causes the brick to melt and hence its shape is lost.
4. **Oxides of Iron :** A small quality of oxide of iron to the extent of about 5 to 6% is desirable in good brick earth. It helps as lime to fuse sand. It also imparts red colour to the bricks. The excess of oxide of iron makes the bricks dark blue or black. If on the other hand, the quality of iron oxide is comparatively less, the brick will be yellowish in colour.
5. **Magnesia :** A small quantity of magnesia in brick earth imparts yellow tint to the bricks and decreases shrinkage. But excess of magnesia leads to the decay of bricks.

Harmful Ingredient in Brick Earth

1. Lime
2. Iron pyrites
3. Alkalies
4. Pebbles
5. Vegetation and organic matter

Classification of Brick Earth :

The brick earth is classified in the following three categories :

1. Loamy, mild sand clay
2. Marls, chalky or calcareous clay
3. Plastic, strong or pure clay

1. A typical analysis of such clay is as follows :

Alumina	–	27%
Silica	–	66%
Lime and Magnesia	–	1%
Oxide of Iron	–	1%
Org. Matter	–	5%
	–	100%

2.

Alumina	–	10%	
Silica	–	35%	
Lime & Magnesia	–	48%	
Oxide of Iron	–	3%	Sand is sometimes added to such clay
Alkalies	–	4%	
		100%	

3.

Alumina	-	39%	
Silica	-	50%	
Lime & Magnesia	-	6%	Such clay is connected by adding sand and ash
Oxide of Iron	-	8%	
Org. Matter	-	2%	

The following two field tests may be carried out to determine the suitability of soil for the purpose of brick manufacture :

1. **First Test :** The soil to be tested in ground to a fine powder and sufficient quantity of water is then mixed. It is then kneaded and converted into a plastic mass of required consistency. Then the balls of about 80 mm dia. are moulded with heads and then balls are allowed to dry in the sun. If the dry balls deform in shape and crumble down easily on pressing, it indicates the excessive said content in the soil. On the other hand, if the said content is deficient, the balls will develop surface cracks and drying.
2. **Second Method :** For plastic soil the bricks of standard size are taken moulded with sharp edges and corners. These bricks are then allowed to dry in the sun for four days and they are examined for cracks developed due to shrinkage.

Manufacture of Bricks:

In the process of manufacturing bricks, the following four distinct operations are involved :

1. Preparation of clay
2. Moulding
3. Drying
4. Burning

1. Preparation of Clay:

(*i*) Unsoiling

(*ii*) Digging

(*iii*) Cleaning

(*iv*) Weathering

(*v*) Blending

(*vi*) Temptering

In the process of tempering, the clay is brought to a proper degree of hardness and it is made fit for the next operation of moulding.

For manufacturing good bricks on a large scale, the tempering is usually done in a pug mill.

The process of grinding clay with water and making it plastic is known as the pugging.

2. Moulding:

Moulding

Hand Moulding → Ground Moulding – 750 bricks per day in 8 hours; Table Moulding bricks

Machine Moulding

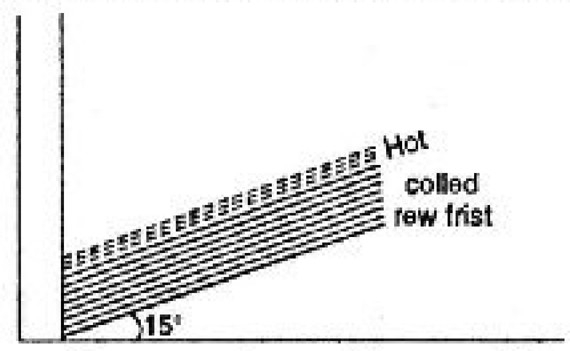
- The moulds are made longer by about 8 to 12% in all directions.
- The bricks prepared by dipping mould in water every time are known as the slop-moulded bricks. The fine sand or ash may be sprinkled on the inside surface of mould instead of dipping mould in water. Such bricks are known as the sand-moulded bricks and they have sharp and straight edges.
- A frog in a mark of depth about 10mm to 20mm which is placed on raw brick during moulding. It serves two purposes:
  1. It indicates the trade name of the manufacturer.
  2. In brickwork, the bricks are laid with frog uppermost. It thus affords a key for mortar when the neat brick is placed over it.

3. **Drying :** The bricks are laid longitudinally in stacks of width equal to two bricks. A stack consists of eight or ten tiers.
4. **Burning :** Appropriate temperature for burning of bricks = 1100°C

   The burning of bricks is done either in clamps or in kilns. The clamp are temporary structure and the kilns are permanent structures.

CLAMPS:

Its shape in plan is generally traperoidal. The thickness of fuel layer gradually decreases as the height of clamp increases. Total height is about 3 to 4 m. The clamp is allowed to burn for a period of about one to two months. Same for cooling period.



Time of burning and cooling : Clamp burning requires about 2 to 6 months for burning and cooling of bricks. But for kiln burning time for burning of one chamber is about 24 hours and only about 12 days are required for cooling of bricks.

Kilns :

(*i*) Intermittent kilns

(*ii*) Continuous kilns

These are of three types:

(*a*) Bull's trench kiln

(*b*) Hoffman's kiln

(*c*) Tunnel kiln

(*a*) **Bull's trench kiln:** This may be of rectangular, circular or oval shape in plan. This is the most widely used in India and it gives continuous supply of bricks. Each section requires about one day to burn. A tentative arrangement for different sections may be as follows :

Section 1	–	Loading
Section 2	–	Empty
Section 3	–	Unloading
Section 4	–	Cooling
Section 5	–	Burning
Section 6	–	Heating

(*b*) **Hoffman's kiln :** Constructed overground also known as flame kiln. Its shape is circular in plan. The kiln can even function during rainy seasons.

Chamber 1	–	Loading
Chamber 2 to 5	-	Drying and preheating
Chamber 6 and 7	-	Burning
Chamber 8 to 11	-	Cooling
Chamber 12	-	Unloading

Comparison between Bull's Trench Kiln and Hoffman's Kiln

No.	Item	Bull's trench kiln	Hoffman 's kiln
1.	Burning capacity	About 3 lakhs in 12 days	About 400 lakhs in one season
2.	Continuity of	It stops functioning during monsoon as it is not provided with a permanent roof.	It functions all the year round as it is working provided with a permanent roof.
3.	Cost of fuel	Hight as consumption of fuel is more	Low as consumption of fuel is less
4.	Drying space	It requires more space for drying of of bricks	It requires less space for drying bricks
5.	Initial cost	Low.	High
6.	Popularity	More popular because of less initial cost	Less popular because of high initial cost
7.	Quality of bricks	Percentage of good quality bricks is small	Percentage of good quality bricks is more

Quality of Good Bricks:

1. The bricks should be table-moulded, well-burnt in kilns, copper-coloured, free from cracks and with sharp and square edges. The colour should be uniform and bright.
2. The bricks should give a clear metallic ringing sound when struck with each other.
3. The bricks when broken should show a bright homogeneous and uniform compact structure free from voids.
4. The bricks should not absorb water more than 20% by wt. for first class bricks and 22% by wt. for second class bricks, when soaked in cold water for a period of 24 hours.
5. The bricks should be sufficiently hard. No impression should be left on brick surface, when it is scratched with finger nail.
6. The brick should not break into pieces when dropped flat on hard ground from a height of about one metre.
7. The bricks should have low thermal conductivity and they should be sound proof.
8. The bricks, when soaked in water for 24 hours, should not show deposits of white salts when allowed to dry in shade.
9. No brick should have crushing strength below 55 kg/cm^2.

Size and Weight of Bricks :

The bricks which are not standardized are known as the traditional bricks.

For India, a brick of standard size 19 cm × 9 cm × 9 cm is recommended by the BIS. With mortar thickness the size of such a brick becomes 20 cm × 10 cm × 10 cm and it is known as the nominal size of the modular brick. Thus, the nominal size of brick includes the mortar thickness.

The average weight of a brick will be about 3 to 3.5 kg. Brick tiles should be 19 cm × 9 cm × 4 cm in size.

Shape of Bricks

1. **Bullnose Brick :** A brick moulded with a *rounded angle* is termed as a bullnose. A connection which is formed when a wall takes a turn is known as a *quoin*.
2. Channel Bricks
3. Coping Bricks
4. **Cownose Bricks :** A brick moulded with a double bullnose on end is known as a cownose.
5. **Curved Sector Bricks :** Used for circular pillar, brick chimneys etc.
6. Hollow Bricks
7. Paring Bricks
8. Perforated Bricks
9. Purpose-made Bricks

Fire Clay : It's constituents are

(*i*) Alumina 25 to 35%

(*ii*) Silica 75 to 65%

The fire-clay is a refractory clay which is capable of resisting a high temperature without being melted or softened.

Fire Bricks : These are made from fire clay. These are of following three types

(*i*) Acidic Bricks

(*ii*) Basic Bricks

(*iii*) Neutral Bricks

Substitutes of Bricks

Classification of bricks as per I.S.I. 1077 – 1971

I	II	III	IV
1. Well burnt	Slightly under burnt or over burnt	Not burnt properly	Over burnt
2. Perfectly rectangular	Not perfectly rectangular	Not perfectly rectangular	Lost its shape
3. Uniform reddish colour	Uniform colour	The light red and yellow colour	Dark colour
4. Having smooth even surface	Rough surface	More rough surface	Hard surface
5. Metallic ringing sound	Ringing sound	Will not give ringing sound	No explanation
6. 20% absorption of water by weight	22% absorption	25%	More than 25%

Colours of Bricks

Colour	Constituent present in clay
1. Black	Manganese and large proportion of iron
2. Red	Iron in excess
3. White	Pure clay
4. Yellow	Iron and magnesia
5. Brown	Lime in excess
6. Bluish green	Alkalies

LIME

Some Definitions:

1. **Calcination :** The heating to redness in contact with air is known as the calcination.
2. **Hydraulicity :** It is the property of lime by which it sets or hardens in damp places, water or thick masonary walls where there is no free circulation of air.
3. **Lime :**

$$\underset{\text{(lime stone)}}{CaCO_3} \xrightarrow[\text{(Moisture \& } CO_2 \text{ are removed)}]{\text{Calcination}} \underset{\text{(lime)}}{CaO} + \underset{\text{(carbon dioxide)}}{CO_2}$$

4. **Quick Lime :** The lime which is obtained by the calcination of comparatively pure limestone is known as the quick lime or caustic lime. The quick lime as it comes out from kiln is known as the *lump lime*.
5. **Setting :** The process of hardening of lime after it has been converted into paste form is known as the setting.
6. **Slaked Lime or Hydrate Lime :** The product obtained by slaking of quick lime is known as the slaked lime.

$$\underset{\text{(quick lime)}}{CaO + H_2O} \xrightarrow{\text{Slacking}} \underset{\text{(Hydrated lime)}}{Ca\,(OH)_2} + \text{Heat}$$

   The rate of slaking is affected by the size of lime lumps and temperature. It accelerates with the rise in temperature.

   The slaked lime should be kept (or used) in a damp place.

7. **Slaking :** When water is added to quick lime in sufficient quantity, a chemical reaction takes place. Due to this chemical reaction, the quick lime cracks swells and falls into a powder form which is the calcium hydroxide $Ca(OH)_2$ and it is known as hydrated lime. This process is known as slaking.

Classification of Binding Materials :

1. **Air Binding Material :** Strength gained only in the presence of air *e.g.* Gypsum, acid-resistant cement, quick lime etc.
2. **Hydraulic Binding Material :** Strength gained air and also in water *e.g.* Portland cement, hydraulic lime, etc.

   Such binding material can be used for constructions above ground, below ground and under water.
3. **Autoclave Binding Material :** *e.g.* Lime-silica, sand, Portland cements.

SOURCES OF LIME

Classification of Limes :

The limes which are obtained by calcination of limestones are broadly classified into the following three categories:

1. Fat lime, high calcium lime, pure lime, rich lime or white lime.
2. Hydraulic lime or water lime
3. Floor lime, impure lime or lean lime. It sets or hardens rely slowly.

1. Fat Lime

Comparison between Fat Lime and Hydraulic Lime

No.	Item	Fat lime	Hydraulic Lime
1.	Composition	It is obtained from comparatively pure carbonates of lime containing only 5% of clay impurities	It is obtained from lime stones containing clay to the extent of about 5 to 30% and some amount of ferrous oxide.
2.	Slaking action	It slakes vigorously. Its volume is increased to about 2 to $2\frac{1}{2}$ times the weight of quick lime. The slaking is accompanied by sound and heat	It slakes slowly. Its volume is slightly increased. The slaking is not accompanied by sound and heat.
3.	Setting action	It sets slowly in presence of air. It absorbs CO_2 from atm. and forms $CaCO_3$	It sets easily under water. It combines with water and forms crystals
4.	Hydraulicity	It does not possess hydraulic properly.	It possesses hydraulic properly
5.	Colour	It is perfectly white in colour	Its colour is not so white as fat lime
6.	Strength	It is not very strong. Hence it cannot be used where strength is required	It is strong and can, therefore, be adopted where strength is required,
7.	Uses	It is used for plastering, white washing, etc. and for preparing mortar with sand or surkhi	It is used for preparing mortar for thick walls, damp places, etc.

If clay content increases setting time decreases in water and hydraulicity increases.

Uses of Lime

1. It is used as chemical raw material in the purification of water and for sewage treatment.
2. It is used as a flux in the metallurgical industry.
3. It is used as a matrix for concrete and mortar.
4. It is used in the production of glass.
5. It is used for making mortar for masonry work.
6. It is used for plastering of walls and ceilings.
7. It is used for the soil stabilization and for improving soil for agricultural purposes
8. It is used for white washing and for serving as a base coat for distemper.

Properties of the Fat Lime

1. It hardens very slowly.
2. It sets slowly in presence of air.
3. It slakes vigorously.
4. Its colour is perfectly white.
5. It has a high degree of plasticity.
6. It is soluble in water which is changed frequently.

SILICATES BASED MATERILS

Silica, quartz and silicate materials include fused silica, quartz, kaolin or clay-based materials, cordierite, steatite, forsterite, sillimanite, zircon, porcelain, and fireclay. They are based on silicon dioxide and various chemical variations.

Processing and Production

Silica and silicate materials are fused or cast with aluminum, calcium, sodium, and magnesium oxide additions to modify specific properties and impart various processing characteristics. Quartz is a hard, crystalline mineral that is the second most abundant mineral in Earth's crust. It is often colored by impurities, but also contains silicon dioxide.

Chemical variations and different processing techniques can be used to improve the clarity, transparency, and dielectric properties of silica and silicate materials. These various methods are used to produce aluminum silicate, calcium silicate, clay, cordierite, fireclay, forsterite, and kaolin.

Material Types

Aluminum silicate is insoluble and often used as a refractory in glassmaking. Categories include sillimanite, fibrolite, and mica (muscovite, biotite, and phlogopite). Mica is fireproof and non-fusing, has low heat conductivity, excellent thermal stability, and good dielectric or electrical insulation properties.

Cordierite has a low coefficient of thermal expansion, high mechanical strength, low dielectric loss, and excellent thermal-shock resistance. It can withstand a red heat to ice water quench, and then be returned to red heat. Cordierite is often fabricated into an insulator or insulating substrate because of its good dielectric properties.

Fireclay is a heat-resistant, secondary clay or clay-based mixture useful for elevated temperature or refractory bond applications. Fireclay-based refractories or ceramics use natural clay or a mixture of clay and other ceramics such as alumina, calcium aluminate, or silicon carbide.

Forsterite is a stoichiometric magnesium orthosilicate (Mg_2SiO_4) used in applications that require a high coefficient of thermal expansion. Forsterite has desirable electrical insulation properties and is used as a layer on transformer steel sheets.

Fused silica is a compound of silicon and oxygen. High purity, amorphous, fused silica is a high-performance ceramic with very low expansion, remarkable thermal shock resistance, low thermal conductivity, excellent electrical insulation up to 1000□ C, and excellent resistance to corrosion from molten metal and glass.

Steatite ceramics are used for high frequency, low loss, and high voltage insulation. Steatite has good mechanical properties and low loss electrical qualities. It is used in igniters, standoffs, surge arrestors, coil forms, spacers, and spark plugs. Steatite is easily fabricated to close tolerances and much less expensive than alumina ceramic insulators.

Applications

Silica, quartz and silicate materials are used in optical, thermal, chemical, and electrical and electronics applications.

CEMENT

Composition of Ordinary Cement

Lime	CaO	62	62 to 67
Silica	SiO_2	22	17 to 25
Alumina	Al_2O_3	5	3 to 8
Calcium Sulphate	$CaSO_4$	4	3 to 4
Iron Oxide	Fe_2O_3	3	3 to 4
Magnetia	MgO	2	0.1 to 3
Sulphur	S	1	1 to 3
Alkalies		1	0.2 to 1
Total = 100 %			

Properties of Cement

1. It gives strength to masonary.
2. It is an excellent binding material.
3. It is easily workable.
4. It offers good resistance to moisture.
5. It possesses good plasticity.
6. It stiffens or hardens early.

Functions of Cement Ingredients

1. **Lime :** The lime in excess makes cement unsound and causes the cement to expand and disintegrate. On the other hand, if lime is in deficiency, the strength of cement is decreased and it causes cement to set quickly.
2. **Silica (SiO_2) :** It imparts strength to the cement due to the formation of dicalcium and tricalcium silicates. If SiO_2 is present in excess quantity, the strength of cement increases but at the same time, its setting time is prolonged.
3. **Alumina :** It imparts quick selting property to the cement. The Al_2O_3 should not be present in excess amount as it weakens the cement.
4. **Calcium Sulphite :** It is the gypsum and its function is to increase the initial setting time of cement.
5. **Iron Oxide :** It imparts colour, hardness and strength to the cement.
6. **Magnesia :** It imparts hardness and colour to the cement. A high content of magnesia makes the cement unsound.
7. **Sulphur :** A very small amount of sulphur is useful in making sound cement. If it is in excess, it causes cement to become unsound.
8. **Alkalies :** If they are in excess, they cause a number of troubles such as alkali aggregate reaction, efflorescence and staining.

Setting Action of Cement

When water is added to cement, the ingredient of cement react chemically with water and form various.Complicated chemical compounds. The formation of these compounds is not simultaneous. But setting action of cement continues for a long time.

It is found that ordinary cement achieves about 70% of its final strength in 28 days and about 90% of its final strength in one year or so.

Following are the important compounds formed during the setting action of cement:

1. **Tricalcium Aluminate (3 CaO. Al_2O_3):** Formed within about 24 hours after addition of water to the cement.
2. **Tetra-Calcium Alumino-ferrite (4 CaO. Al_2O_3. Fe_2O_3):** This compound is also formed within about 24 hours after addition of water to the cement.
3. **Tricalcium Silicate (3CaO. SiO_2):** This compound is formed within a weak or so after addition of water to the cement and it is mainly responsible for imparting strength to the . cement in early period of selting.
4. **Dicalcium Silicate (2CaO. SiO_2) :** This compound is formed very slowly and hence, it is responsible for giving progressive setting to the cement.

C_3A	4 to 14%	$\left.\right\}$ Celot
C_4AF	10 to 18%	
C_3S	45 to 65%	Alit
C_2S	15 to 35%	Belit

C_3S and C_2S contributes most of the eventual strength.

Initial selting of portland cement is due to the tricalcium aluminate.

Cement having less C_3A will have higher ultimate strength, less evolution of heat and less cracking.

After 28 days, the hydration of C_3S comes practically to an end and the hydration of C_2S only really begins at that time.

Manufacture of Ordinary Cement

The cement mills have electro-static precipitators (ESP) installed to check the dust emission.

Following three distinct operations are involved in the manufacture of normal setting or ordinary or portland cement:

1. Mixing of raw material
   (*i*) Dry process (modern technology)
   (*ii*) Wet process (old technology)
2. Burning
3. Grinding