

THEORY & **O**BJECTIVE

BUILDING MATERIAL

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BRICKS

THEORY

- ❖ A brick is rectangular in shape and 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:

$$\text{Length of brick} = 2 \times \text{width of brick} + \text{thickness of mortar}$$

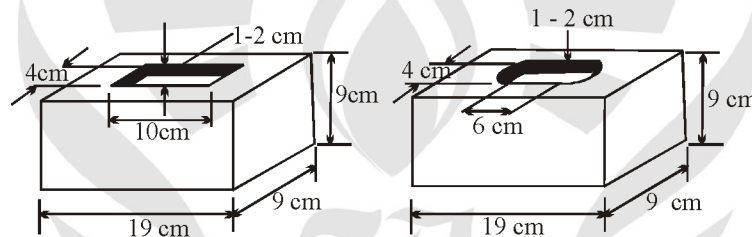
$$\text{Height of brick} = \text{width of brick}$$

Size of a standard brick (also known as modular brick) should be

$$19 \times 9 \times 9 \text{ cm and } 19 \times 9 \times 4 \text{ cm.}$$

When brick placed with mortar then

size of brick $20 \times 10 \times 10 \text{ cm}$



Bricks

- ❖ An indent called frog, 1–2 cm deep, as shown in figure, is provided for 9 cm high bricks. The size of frog should be $10 \times 4 \times 1 \text{ cm}$. 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

- ❖ Clay bricks are classified as first class, second class, third class and fourth class based on their Physical and mechanical properties.

First Class Bricks

- ⊛ These are thoroughly burnt and are of deep red, cherry or copper colour.
- ⊛ The surface should be smooth and rectangular, with parallel, sharp and straight edges and square corners.
- ⊛ These should be free from flaws, cracks and stones.
- ⊛ These should have uniform texture.
- ⊛ No impression should be left on the brick when a scratch is made by a finger nail.
- ⊛ The fractured surface of the brick should not show lumps of lime.
- ⊛ A metallic or ringing sound should come when two bricks are struck against each other.
- ⊛ Water absorption should not be more than 20% of its dry weight when immersed in cold water for 24 hours.
- ⊛ The crushing strength of the brick should not be less than 10 N/mm^2 .

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

↪ **Second Class Bricks :**

- ❖ Small cracks and distortions are permitted.
- ❖ A little higher water absorption of about 22.5 % of its dry weight is allowed.
- ❖ The crushing strength should not be less than 7.0 N/mm².
- ❖ Second class bricks are recommended for all important or unimportant hidden masonry works and centering of reinforced brick and reinforced cement concrete (RCC) structures.

↪ **Third Class Bricks :**

- ❖ **These 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. The crushing strength should not be less than 5.0 N/mm².
- ❖ It is used for building temporary structures.

Classification of Bricks on The Basis of 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	35	30	25	20	17.5	15	12.5	10	7.5	5	3.5
Average Compressive Strength not less than (N/mm²)	35.0	30.0	25.0	20.0	17.5	15.0	12.5	10.0	7.5	5.0	3.5

Note: The burnt clay bricks having compressive strength more than 40 N/mm² are known as heavy duty bricks and are used for heavy duty structures such as bridges, foundation for industrial building and multi-storey buildings.

↪ **Characteristics of Good Bricks:**

- ❖ The essential requirements for building bricks are sufficient strength in crushing, regularity in size, a proper suction rate, and a pleasing appearance when exposed to view.
 - ❖ **Size and shape:**
- ❖ The bricks should have uniform size and plane, rectangular surfaces with parallel sides and sharp straight edges.
 - ❖ **Colour:**
- ❖ The brick should have a uniform deep red or cherry colour as indicative of uniformity in chemical composition and thoroughness in the burning of the brick.
 - ❖ **Texture and compactness:**
- ❖ The surfaces should not be too smooth to cause slipping of mortar. The brick should have pre compact and uniform texture. A fractured surface should not show fissures, holes grits or lumps of lime.
 - ❖ **Hardness and soundness:**
- ❖ The brick should be so hard that when scratched by a finger nail no impression is made. When two bricks are struck together, a metallic sound should be produced.
 - ❖ **Water absorption** should not exceed 20 per cent of its dry weight when kept immersed in water for 24 hours.
 - ❖ **Crushing strength** should not be less than 10 N/mm².

Ingredients of Good Bricks :

The proportions of various ingredients are as follows:

☼ Silica	50–60%
☼ Alumina	20–30%
☼ Lime	10%
☼ Magnesia	< 1%
☼ Ferric oxide	< 7%
☼ Alkalis	< 10%
☼ Carbon dioxide, Sulphur trioxide and Water:	- very small amount

COMPOSITION BRICK EARTH

Following are the constituents brick earth :

ALUMINA : (20-30%)

- 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 quantity of sand, the raw bricks shrink and warp during drying and burning and become too hard when burnt.

SILICA :

- It exists in clay either as free or combined. As free sand, it is mechanically mixed with clay and in combined form, it exists in chemical composition with alumina. A good brick earth should contain about 50 percent to 60 per cent of silica.
- The presence of this constituent prevents 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 particles and the bricks become brittle.

LIME :

- A small quantity of lime not exceeding 5 per cent 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 shrinkage of row bricks. The sand alone is infusible. But it slightly fuses at kiln temperature in presence of lime. Such fused sand works as a hard cementing material for brick particles.
- The excess of lime causes the brick to melt and hence its shape is lost. The lumps of lime are converted into quick lime after burning and this quick lime slakes and expands in presence of moisture. Such an action results in splitting of bricks into pieces.

OXIDE OF IRON :

- A small quantity of oxide of iron to the extent of about 5 to 6 per cent 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 blackish. If on the other hand, the quantity of iron oxide is comparatively less, the bricks will be yellowish in colour.

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.



CEMENT

THEORY

- ❖ Cements in a general sense are adhesive and cohesive materials which are capable of bonding together particles of solid matter into a compact durable mass.
- ❖ Cements used in construction industry may be classified as hydraulic and non-hydraulic. The latter does not set and harden in water such as non-hydraulic lime or which are unstable in water, e.g. Plaster of Paris.
- ❖ The hydraulic cement set and harden in water and give a product which is stable. E.g. Portland cement.

PORTLAND CEMENT

- ❖ It is a cementing material resembling a natural stone quarried from Portland in U.K. Portland cement may be defined as a product obtained by finely pulverizing clinker produced by calcining to incipient fusion, an intimate and properly proportioned mixture of argillaceous and calcareous materials.
- ❖ The ordinary Portland cement has been classified as 33 Grade (IS269:1989), 43 Grade (IS 8112:1989), and 53 Grade (IS 12669-1987). The physical requirements of all these three types of cement are almost same except for compressive strength and are as follows:

Physical Requirement	Method of Testing	Grade		
		33	43	53
Fineness (Sp. Surface in cm ² /gm)	Blaine's air permeability	2250	2250	2250
Soundness from lime	Le Chatelier	10mm	10mm	10mm
Soundness from magnesia	Autoclave	0.8%	0.8%	0.8%
Setting time in minutes initial (min)	Vicat apparatus	30	30	30
Final (max)		600	600	600
Compressive strength	UTM machine			
72 ± 1 hour	(70.6 × 70.6 × 70.6) mm	16	23	27
168 ± 2 hour		22	33	37
672 ± 4 hour		33	43	53

Chemical Composition of Raw Material :

- ❖ The three constituents of hydraulic cements are lime, silica and alumina. In addition, most cements contain small proportions of iron oxide, magnesia, sulphur trioxide and alkalis.
- ❖ An increase in lime content beyond a certain value makes it difficult to combine completely with other compounds. Consequently, free lime will exist in the clinker and will result in an unsound cement.
- ❖ An increase in silica content at the expense of alumina and ferric oxide makes the cement difficult to fuse and form clinker.

OXIDE	FUNCTION	COMPOSITION (%)
CaO	Controls strength and soundness. Its deficiency reduces strength and setting time	60 – 65
SiO ₂	Gives strength. Excess of it causes slow setting.	17 – 25
Al ₂ O ₃	Responsible for quick setting, if in excess, it lowers the strength.	3 – 8
Fe ₂ O ₃	Gives colour and helps in fusion of different ingredients	0.5 – 6
MgO	Imparts colour and hardness. If in excess, it causes cracks in mortar and concrete and unsoundness.	0.5 – 4
Na ₂ O + K ₂ O	These are residues, and if in excess cause efflorescence and cracking	0.5 – 1.3
TiO ₂		0.1 – 0.4
P ₂ O ₅		0.1 – 0.2
SO ₃	Makes cement sound	1 – 2

Composition of Cement Clinker :

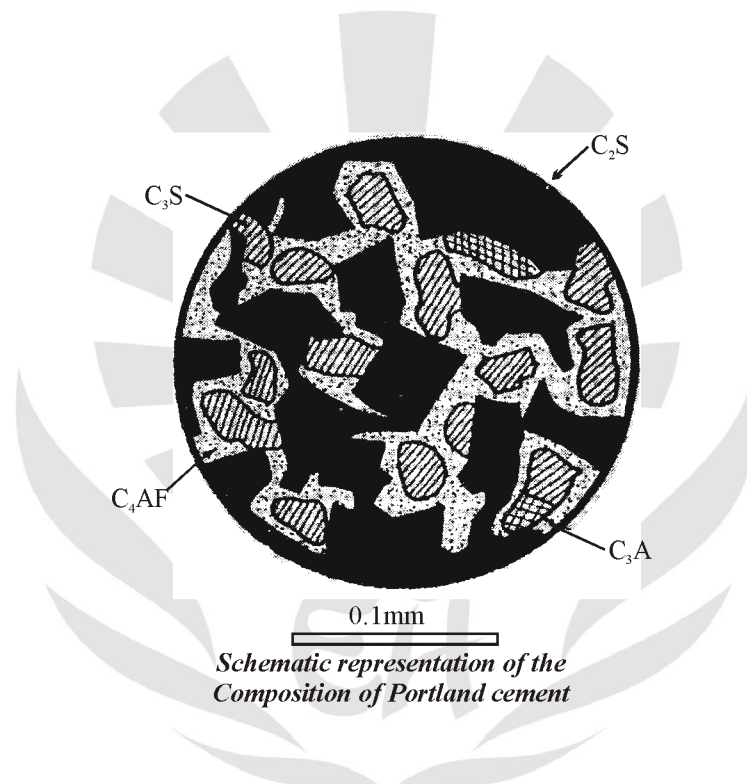
- ❖ The various constituents combine in burning and form cement clinker. The compounds formed in the burning process have the properties of setting and hardening in the presence of water.
- ❖ They are known as *Bogue compounds* after the name of Bogue who identified them. Le-Chatelier and Tornebohm have referred these compounds as Alite (C₃S), Belite (C₂S), Celite (C₃A) and Felite (C₄AF). The following Bogue compounds are formed during clinkering process.

The principal mineral compounds in Portland Cement	Formula	Name	Symbol
Tricalcium silicate	3CaO.SiO ₂	Alite	C ₃ S
Dicalcium silicate	2CaO.SiO ₂	Belite	C ₂ S
Tricalcium aluminate	CaO.Al ₂ O ₃	Celite	C ₃ A
Tetracalcium alumino ferrite	4CaO.Al ₂ O ₃ .Fe ₂ O ₃	Felite	C ₄ AF

Functions of Bogue's Compound

- ↻ **Tricalcium silicate** is supposed to be the best cementing material and is well burnt cement. It is about 25-50% (normally about 40 per cent) of cement. It renders the clinker easier to grind, increases resistance to freezing and thawing, hydrates rapidly generating high heat and develops an early hardness and strength.
- ❖ However, raising of C₃S content beyond the specified limits increases the heat of hydration and solubility of cement in water. The hydrolysis of C₃S is mainly responsible for 7 day strength and hardness. The rate of hydrolysis of C₃S and the character of gel developed are the main causes of the hardness and early strength of cement paste. The heat of hydration is 500 J/g.
- ↻ **Dicalcium silicate** is about 25-40% (normally about 32 per cent) of cement. It hydrates and hardens slowly and takes long time to add to the strength (after a year or more). It imparts resistance to chemical attack.
- ❖ Raising of C₂S content renders clinker harder to grind, reduces early strength, decreases resistance to freezing and thawing at early ages and decreases heat of hydration. The hydrolysis of C₂S proceeds slowly.
- ❖ At early ages, less than a month, C₂S has little influence on strength and hardness. While after one year, its contribution to the strength and hardness is proportionately almost equal to C₃S. The heat of hydration is 260 J/g.

- ↗ **Tricalcium aluminate** is about 5-11% (normally about 10.5 per cent) of cement. It rapidly reacts with water and is responsible for flash set of finely grounded clinker.
- ❖ The rapidity of action is regulated by the addition of 2-3% of gypsum at the time of grinding cement. Tricalcium aluminate is responsible for the initial set, high heat of hydration and has greater tendency to volume changes causing cracking.
- ❖ Raising the C_3A content reduces the setting time, weakens resistance to sulphate attack and lowers the ultimate strength, heat of hydration and contraction during air hardening. The heat of hydration is 865 J/g.
- ↗ **Tetra calcium alumina ferrite** is about 8–14% (normally about 9 per cent) of cement. It is responsible for flash set but generates less heat.
- ❖ It has poorest cementing value. Raising the C_4AF content reduces the strength slightly. The heat of hydration is 420 J/g.



HYDRATION OF CEMENT:

- ❖ The chemical reaction between cement and water is known as *hydration* of cement.
- ❖ The reaction of compound C_3A with water is very fast and is responsible for flash setting of cement (stiffening without strength development) and thus it will prevent the hydration of C_3S and C_2S . However, calcium sulphate ($CaSO_4$) present in the clinker dissolves immediately in water and forms insoluble calcium sulphoaluminate.
- ❖ It deposits on the surface of C_3A forming a colloidal membrane and consequently retards the hydration of C_3A . The amount of $CaSO_4$ is adjusted to leave a little excess of C_3A to hydrate directly. This membrane in the process breaks because of the pressure of the compounds formed during hydration and then again C_3A becomes active in the reaction.
- ❖ The hardening of C_3S can be said to be catalysed by C_3A and C_3S becomes solely responsible for gain of strength up to 28 days by growth and interlocking of C-S-H gel. The increase in strength at later age is due to hydration of C_2S .



MORTAR

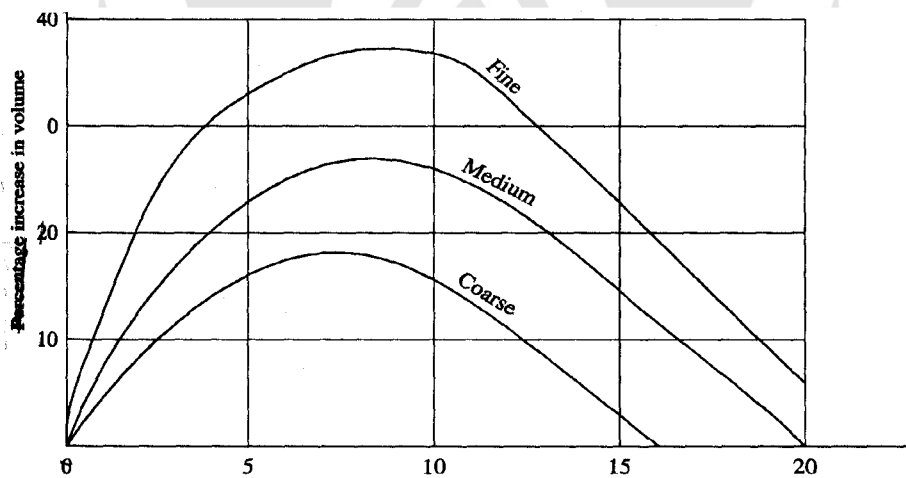
THEORY

GENERAL

- ❖ The term *mortar* is used to indicate a paste prepared by adding required quantity of water to a mixture of binding material like cement or lime and fine aggregate like sand.

BULKING OF SAND

- ❖ The presence of moisture in sand increases the volume of sand. This is due to the fact that moisture causes film of water around sand Particles which results in the increase of volume of sand. For a moisture content of about 5 to 8 per cent, this increase of volume may be as much as 20 to 40 per cent, depending upon the grading of sand.
- ❖ The finer the material, the more will be the increase in volume for a given moisture content. This phenomena is known as the *bulking of sand* and it can be expressed in a graphical way as shown in Fig.



Percentage by weight of moisture Chart showing bulking of sand

FUNCTION OF SAND IN MORTAR

- ❖ The sand is used to mortar and concrete for the following *purpose*:
 - ⊛ **Bulk:** It does not increase the strength of mortar. But it acts as adulterant. Hence the bulk or volume of mortar is increased which results in reduction of cost.
 - ⊛ **Setting:** If building material is fat lime, the carbon dioxide is absorbed through the voids of sand and setting of fat lime occurs effectively.
 - ⊛ **Shrinkage:** It prevents excessive shrinkage of the mortar in the course of drying and hence the cracking of mortar during setting is avoided.
 - ⊛ **Strength:** It helps in the adjustment of strength of mortar or concrete by variation of its proportion with cement or lime. It also increases the resistance of mortar against crushing.

8. Lime mortar is generally made with
 (a) quick lime (b) fat lime
 (c) hydraulic lime (d) white lime
9. The compressive strength of a standard good 1 : 3 portland cement-sand mortar after 3 days of curing should not be less than
 (a) 70 kg/cm² (b) 115 kg/cm²
 (c) 175 kg/cm² (d) 210 kg/cm²
10. The split tensile strength of M 15 grade concrete when expressed as percentage of its compressive strength is
 (a) 10 to 15% (b) 15 to 20%
 (c) 20 to 25% (d) 25 to 30%
11. The approximate ratio between the strengths of cement concrete at 7 days and at 28 days is
 (a) 3/4 (b) 2/3
 (c) 1/2 (d) 1/3
12. Modulus of elasticity of M 25 concrete as determined by formula of IS:456 is
 (a) 1,24,500 MPa (b) 90,125 MPa
 (c) 28,500 MPa (d) 16,667 MPa
13. Match List-I (Metals or alloys) with List-II (Their common use) and select the correct answer using the codes given below the lists:
- | List-I | List-II |
|-------------------|------------------------------|
| A. Steel bars | 1. Water taps |
| B. Zinc | 2. Door Frames |
| C. Aluminium | 3. Reinforcement in concrete |
| D. Brass castings | 4. Corrugated roof sheet |
- Codes : A B C D
- (a) 3 1 4 2
 (b) 3 2 4 1
 (c) 1 3 4 2
 (d) 3 4 2 1
14. The modulus of elasticity of high tensile steel is
 (a) smaller than that of mild steel
 (b) equal to that of mild steel
 (c) larger than that of mild steel
 (d) equal to that of aluminium
15. Yield stress of ordinary mild steel bars after twisting to a pitch of about 9 to 12 diameters
 (a) increases by about 50%
 (b) decreases by about 30%
 (c) increases by about 20%
 (d) decreases by about 10%
16. **Assertion (A)** : Dimensional changes in wood result due to variation in the moisture content of the wood with atmospheric condition.
Reason (R) : The cell walls in wood are highly hygroscopic and when exposed to moisture, absorb large amounts of water and swell.
 (a) Both A and R are true and R is the correct explanation of A
 (b) Both A and R are true but R is not a correct explanation of A
 (c) A is true but R is false
 (d) A is false but R is true
17. **Assertion (A)** : Pozzolana is added to cement to increase early strength.
Reason (R) : It offers greater resistance to the attack of aggressive waters.
 (a) Both A and R are true and R is the correct explanation of A
 (b) Both A and R are true but R is not a correct explanation of A
 (c) A is true but R is false
 (d) A is false but R is true
18. **Assertion (A)** : Use of cement lime mortar is generally preferred to cement mortar.
Reason (R) : Cement-lime mortar has higher workability and water retentivity characteristics than cement mortar.
 (a) Both A and R are true and R is the correct explanation of A
 (b) Both A and R are true but R is not a correct explanation of A
 (c) A is true but R is false
 (d) A is false but R is true

