# Chapter 3

# Bricks and Mortar

**CHAPTER HIGHLIGHTS**

- *Bricks*
- *Mortar*

## Bricks

Bricks are obtained by moulding clay in rectangular blocks of uniform size and, then by drying and burning these blocks. They are of uniform size and can be properly arranged and further, as they are light in weight, no lifting appliance is required for them.

### Composition of Good Brick Earth

The following are the constituents of good brick earth:

1. **Alumina:** It is the prime constituent of every type of clay. A good brick earth should contain 20–30% of alumina. This provides plasticity. Excess alumina makes raw bricks shrink and warp during drying and burning.
2. **Silica:** It can be free or combined. Good brick should contain 50–60% of silica. This gives uniform shape to bricks. Excess Silica makes bricks brittle.
3. **Lime:** A small quantity of less than 5% of lime is desirable for good brick. The lime quantity prevents shrinkage of raw bricks. Excess of lime causes the brick to melt and, hence the shape is lost. The lime converts to quick lime which results in splitting of bricks into pieces.
4. **Oxide of iron:** Ideally, 5–6% of iron is desirable for good quality bricks. It gives red colour to bricks. Excess of oxide of iron gives dark blue or black colour to bricks. On the other hand, if the quantity of iron oxide is less, the bricks become yellow in colour.
5. **Magnesia:** A small quantity of magnesia present in bricks gives yellow tint and reduces shrinkage. But an excess amount of magnesia leads to decay of bricks.

### Harmful Ingredients in Brick Earth

1. **Iron pyrites:** Bricks are crystallized and disintegrated during burning due to the oxidation of iron pyrites.
2. **Alkalies:** These are the mixture of soda and potash. When bricks are used in masonry, the alkalis present in bricks absorb moisture from the atmosphere.
3. **Pebbles:** Pebbles prevent the clay from thoroughly mixing. If, for any reason, pebbles are thoroughly mixed, the bricks produced are found to be weak and porous.
4. **Vegetable and organic matter:** If the organic matter is not completely burnt, then the bricks become porous.

### Manufacture of Bricks

The manufacture process of bricks involves four distinct operations:

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

## Preparation of Clay

The preparation of clay involves:

1. **Unsoiling:** The top layer of soil, which is about 200 mm in depth, is taken and thrown away as it contains excessive impurities.
2. **Digging:** The clay is then dug out and spread in the form of heaps of clay of about 600–1200 mm.
3. **Cleaning:** The clay obtained by this process, is cleaned of stones, pebbles, vegetable matter, etc.
4. **Weathering:** The clay is then exposed to the atmosphere for softening or mellowing.
5. **Blending:** The clay is made loose and any ingredient to be added to it is spread out at its top. It is carried out by taking a small portion of clay every time and by turning it up and down in vertical direction.
6. **Tampering:** The clay is brought to an optimum degree of hardness and made ready for moulding.
7. **Pugging:** The process of grinding clay with water and making it plastic is known as pugging. The pugmill consists of conical iron tub with cover at its top. The diameter of a pugmill at the bottom is about 800 mm, 1 metre at the top.

## Moulding

The clay prepared is sent for next stage of processing called 'moulding'. Clay moulding is done in two ways:

1. **Hand moulding:**
   - Ground-moulded bricks
   - Table-moulded bricks
2. **Machine moulding:**
   - The excess clay is removed either by a sharp edged wooden or metallic plate known as strike.
   - A mark of depth 10–20 mm which is placed on raw brick during moulding is called 'frog'.
   - The wooden block in which the moulding is done is known as moulding block.

## Drying

Damp bricks are likely to be cracked and distorted. Hence, the moulded bricks are, therefore, dried before next operation.

## Burning

This gives hardness and strength to the bricks and makes them dense and durable. Brick should be burnt properly, if they are over burnt they become brittle and can break easily. Burning of bricks is done in clamps or kilns.

Kilns are of two types:

1. Intermittent kiln: The bricks are loaded, fired, cooled and unloaded. They are rectangular or circular.
2. Continuous kiln: The bricks are loaded, fired, cooled and unloaded simultaneously; this can be done in three ways:
   (a) Bull trench kiln
   (b) Hoffman kiln
   (c) Tunnel kiln.

## Qualities of Good Bricks

1. The bricks should be copper coloured and the colour should be uniform and bright.
2. The bricks should be uniform in shape and should be of standard size.
3. The bricks, when struck with each other, should produce a metallic ringing sound.
4. The bricks should not absorb water more than 20 percent by weight for first-class bricks and 22 percent by weight for second-class bricks, when soaked in cold water for 24 hours.
5. The bricks should not break into pieces when dropped flat on hard ground from a height of about one metre.
6. The bricks should have low thermal conductivity and they should be sound proof.
7. No brick should have the crushing strength below 5.5 $N/mm^2$.
   - Average crushing strength and tensile strength of hand-moulded bricks are 60000 $kN/m^2$. The shear strength of bricks is $\frac{1}{10}$ of the crushing strength.

## Tests on Bricks

1. **Absorption:** A brick is taken and weighed dry, then immersed into water for 16 hours. It is weighed again, and the difference in weight indicates the amount of water it absorbed. In any condition, it should not exceed 20% of the weight of dry brick.
2. **Crushing strength:** The minimum crushing strength of bricks is 3.5 $N/mm^2$. The bricks with crushing strength of 7–14 $N/mm^2$ are graded as 'AA'.
3. **Hardness:** In this test, a scratch is made on the brick surface with a finger nail. If no impression is left on the surface, the bricks are considered as hard.
4. **Presence of soluble salts:** A brick is immersed into water for 24 hours. It is then taken out and allowed to dry in shade. The absence of grey or white deposits on its surface indicates absence of soluble salts.
5. **Shape and size:** For good quality bricks, the dimensions of permissible limits are (for 20 bricks):
   Length: 3680–3920 mm
   Width: 1740–1860 mm
   Height: 1740–1860 mm
6. **Soundness:** Two bricks are taken and struck with each other. If the bricks do not break, then those are superior quality bricks.

7. **Structure:** A brick is broken and the structure of broken brick should be homogeneous, compact and free from any defects, i.e., holes, lumps, etc.

## Classification of Bricks

| Type of Brick | Characteristics |
|---|---|
| First class bricks | • Table moulded and of standard shape.<br>• Burnt in kilns.<br>• Used for superior work of permanent nature. |
| Second class bricks | • Ground moulded and shape is slightly irregular with hairline cracks.<br>• Used at places where brickwork is to be provided with coats of plaster. |
| Third class bricks | • Ground moulded and shape is irregular and distorted at the edges.<br>• They are used for temporary structures at places where rainfall is not heavy. |
| Fourth class bricks | • These are over-burnt bricks and irregular in shape.<br>• These are generally used in foundations, floors and roads, etc. |

## Colours of Bricks

| Colour | Constituent Present in Clay |
|---|---|
| Black | Manganese and large quantity of iron |
| Bluish green | Alkalies |
| Bright red, dark blue, purple | Large amount of iron oxide |
| Brown | Lime in excess |
| Cream | Iron and little lime |
| Red | Iron in excess |
| White | Pure clay |
| Yellow | Iron and magnesia. |

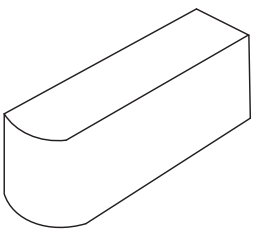
**NOTE**

The weight of 1 $m^3$ of normal size brick is 18 kN. The average weight of brick will be about –35 N.

## Shape of Bricks

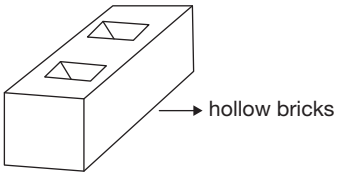
Depending on the type of construction, the shape of bricks can be classified to different types. They are:

1. **Bullnose bricks:**

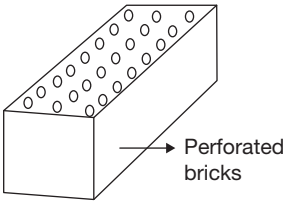


Bullnose bricks are the bricks with one rounded angle. The connection which is formed when a wall takes a turn is known as 'quoin'.

2. **Channel bricks:** These bricks are moulded in the shape of gutter or a channel. They are used to function as drains.
3. **Coping bricks:** Bricks which are made to suit the thickness of wall on which coping is to be provided.
4. **Cownose bricks:** Bricks which are moulded with double bull-nose on ends is known as the cownose bricks.
5. **Curved sector bricks:** These are in the form of curved sector and used in the construction of circular pillars.
6. **Hollow bricks:** These are known as cellular or cavity bricks. These bricks comes with a wall thickness of 20–25mm.




7. **Perforated bricks:** Bricks of this type contains cylindrical holes throughout the thickness. These bricks are light in weight and require less quantity of clay for production. Bricks with 30–45 percent of total area of corresponding face of brick would offer adequate thermal insulation property.




Based on the type of materials used for production, bricks can be classified as:

(a) Concrete blocks

(b) Fly ash bricks

(c) Calcium silicate bricks

# Mortar

Mortar is the term 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.

## Classification of Mortars

The mortars can be classified based on the following:

1. Bulk density
2. Kind of binding material
3. Nature of application

### Bulk Density: 2 Types of Mortars

1. Heavy mortars: Mortars having bulk density of 15 kN/m$^3$
2. Light weight mortars: Having bulk density less than 15 kN/m$^3$

### Kind of Binding Material

1. **Lime mortar:**
   - Lime is used as binding material, may be fat lime or hydraulic lime.
   - Mortar prepared from fat lime is not suitable for water-logged areas and in damp conditions.
   - Lime mortar has a high plasticity, possesses good cohesiveness and shrinks very little.
   - Sufficiently durable, but hardens slowly.
   - Generally used for lightly loaded above the ground parts of buildings.
2. **Surkhi mortar:**
   - Prepared by using surkhi instead of sand.
   - Used for ordinary masonary work of all types in foundations and super structures.
   - Cannot be used for plastering or pointing, since it is likely to disintegrate with time.
3. **Cement mortar:**
   - Depends upon strength requirements and importance of work; proportions of cement to sand by volume varies between 1 : 2 to 1 : 6, or more.
   - Surkhi and cinders should not be used to prepare cement mortar; only sand can be used.
   - Used for underground constructions, water saturated soils, and in case of requirements of high strength and water-resisting properties.
4. **Gauged mortar:**
   - Also known as the composite mortar or lime-cement mortar.
   - Usual proportions of cement to lime by volume is about 1 : 6 to 1 : 8.
   - Used for bedding and for thick brick walls.
5. **Gypsum mortar:**
   - Prepared from gypsum binding materials, such as building gypsum and anhydrite binding materials.

## Nature of Application

1. **Brick laying mortars:** Intended to be used for brickwork and walls.
2. **Finishing mortars:** Intended for common plastering, architectural and ornamental works.

## Selection of Mortar

Table following table reflects the types of mortars to be used for various civil engineering works.

| Nature of Work | Type of Mortar |
|---|---|
| Construction work in water-logged areas and exposed positions | Cement or lime mortar proportion 1 : 3, lime being eminently hydraulic lime. |
| Damp-proof courses and cement concrete roads | Cement mortar proportion 1 : 2. |
| General RCC work, such as lintels, pillars, slabs, stairs | Cement mortar proportion 1 : 3, the concrete mix being 1 : 2 : 4. |
| Internal walls and surfaces of less importance | Lime cinder mortar proportion being 1 : 3. Sand is replaced by ashes or cinder. |
| Mortar for laying fire-bricks | Fire-resisting mortar consisting of 1 part of aluminous cement to 2 parts of finely crushed powder of fire-bricks. |
| Partition walls and parapet walls. | Cement mortar proportion 1 : 3 or lime mortar proportion 1 : 1. Lime should be moderately hydraulic lime. |
| Plaster work | Cement mortar proportion 1 : 3 to 1 : 4 or lime mortar proportion 1 : 2. |
| Pointing work | Cement mortar proportion 1 : 1 to 1 : 2. |
| Reinforced brickwork | Cement mortar proportion 1 : 3. |
| Stone masonry with best varieties of stones. | Lime mortar proportion 1 : 2, lime being eminently hydraulic lime. |
| Stone masonry with ordinary stones, brickwork, foundations, etc | Lime mortar proportion 1 : 2 or cement mortar proportion 1 : 6. Lime should be eminently hydraulic lime or moderately hydraulic lime. |
| Thin joints in brickwork | Lime mortar proportion 1 : 3, lime being fat lime. |

## Lime Mortar

### Introduction

Lime is a cementing material which is made since Egyptian and Roman times. At present, cement has been replaced by lime to a great extent.

### Some Definitions

1. **Calcination:** Heating to redness in contact with air is known as calcination.
2. **Hydraulicity:** It is the property of lime by which it sets or hardens in damp places, water or thick masonry walls where no circulation of air is present.
3. **Lime:** After calcinations, the leftover product from limestone is known as lime.

$$CaCO_3 = CaO + CO_2$$

(Limestone) = (Lime) + (Carbon dioxide)

4. **Quick lime:** The lime which is obtained by the calcination of comparatively pure limestone is known as quick lime.
5. **Slaked lime:** The product obtained by the slaking of quick lime is known as slaked lime or hydrate of lime.

## Constituents of Lime

1. **Clay:** It is responsible for producing hydraulicity in lime. Here, 8–30% of clay is desirable.
2. **Soluble silica:** The silicates of calcium, magnesium and aluminium are responsible for hydraulicity. They become active at high temperature.
3. **Magnesium carbonate:** Presence of this constituent allows lime to slake and set slowly. If the content of carbonate of magnesia is about 30%, the hydraulicity is rendered to lime even in absence of clay.
4. **Alkalies and metallic oxides:** Their presence of 5% develops hydraulicity due to formation of soluble silicates.
5. **Sulphates:** These accelerate the process of setting and reduce slaking action.
6. **Iron:** This develops complex silicate at high temperature.
7. **Pyrites:** These should not be present, and should be rejected always.

**Classification Between Fat Lime and Hydraulic Lime**

| Fat Lime | Hydraulic Lime |
|---|---|
| It is obtained from comparatively pure carbonate of lime containing only 5% of impurities. | It is obtained from limestones containing clay to the extent of about 5–30% and some amount of ferrous oxide. |
| It slakes vigorously. Its volume is increased to about 2–2$\frac{1}{2}$ times the volume of quick lime. | It slakes slowly. Its volume is slightly increased. |
| It sets slowly in presence of air. | It sets under water. |
| It does not possess hydraulic property. | It posses hydraulic properly. |
| It is perfectly white in colour. | It is not as white as fat lime. |
| It is not very strong. | It is very strong. |
| It is used for plastering, whitewashing and for preparing mortar with sand (or) surkhi. | It is used for preparing mortar for thick walls, damp places, etc., |

## IS Classifications of Lime

1. **Class A:** It is used for structural purposes. Its minimum compressive strength with lime sand mortar of proportion (1 : 3) by weight at the end of 14 days and 28 days should be 1.75 N/mm$^2$ and 2.8 N/mm$^2$.
2. **Class B:** It is semi-hydraulic lime, used for mortars for masonry work. Its minimum compressive strength with lime and mortar of proportion 1 : 3 by weight at the end of 14 days and 28 days should be 1.25 N/mm$^2$ and 1.75 N/mm$^2$.
3. **Class C:** It is used for plastering, white washing and with suitable admixture, such as surkhi or any other pozzolonic material to produce artificial hydraulic mortars.
4. **Class D:** It is same as class C lime, but supplied in hydrated (or) quick form.
5. **Class E:** It is supplied in hydrated form only. It is kankar lime.
6. **Class F:** It is siliceous dolomitic lime, used for undercoat and finishing coat of plaster.

## Exercises

1. A mortar for which both cement and lime are mixed is called
   (A) gauged mortar (B) cement mortar
   (C) lime mortar (D) light weight mortar
2. What is the quantity of cement (in kg) and of dry sand (in cubic metre) respectively required for preparing 1 cubic metre of wet cement mortar of 1 : 5 proportion?
   (A) 270 and 1.00 (B) 290 and 1.05
   (C) 290 and 1.00 (D) 310 and 1.05
3. Which of the following ingredients refer to binding materials of mortar?
   Select the correct answer using the code given below:
   I. Cement
   II. Lime
   III. Sand
   IV. Ashes
   (A) I and IV (B) III and IV
   (C) I and I (D) II and III
4. Lime mortar is generally made with
   (A) quick lime
   (B) fat lime
   (C) hydraulic lime
   (D) white lime

**5.** One of the main demerits in the lime mortar is that it
(A) is not durable.
(B) does not set quickly.
(C) swells.
(D) is plastic.

**6.** A good brick should not absorb water by weight more than
(A) 10% (B) 20%
(C) 25% (D) 30%

**7.** The most important purpose of frog in a brick is to
(A) emboss manufacturer's name.
(B) reduce the weight of brick.
(C) form keyed joint between brick and mortar.
(D) improve insulation by providing 'hollows'.

**8.** The number of bricks required per cubic metre of brick masonry is
(A) 400
(B) 450
(C) 500
(D) 550

**9.** The minimum compressive strength of first class bricks should be
(A) 5 N/mm$^2$
(B) 7.5 N/mm$^2$
(C) 9 N/mm$^2$
(D) 10 N/mm$^2$

**10.** Match List I (Constituents of bricks) with List II (Corresponding influence) and select the correct answer using the codes given below the lists:

| | List I | | List II |
|---|---|---|---|
| **a.** | Alumina | **1.** | Colour of brick |
| **b.** | Silica | **2.** | Plasticity recovery for moulding |
| **c.** | Magnesia | **3.** | Reacts with silica during burning and causes particles to unite together and development of strength |
| **d.** | Limestone | **4.** | Preserves the form of brick at high temperature and prevents shrinkage |

**Codes:**

| | a | b | c | d | | a | b | c | d |
|---|---|---|---|---|---|---|---|---|---|
| (A) | 2 | 1 | 4 | 3 | (B) | 3 | 4 | 1 | 2 |
| (C) | 2 | 4 | 1 | 3 | (D) | 3 | 1 | 4 | 2 |

**11.** Which one of the following is the nominal size of standard modular brick?
(A) 25 cm × 13 cm × 8 cm
(B) 25 cm × 10 cm × 8 cm
(C) 20 cm × 10 cm × 10 cm
(D) 20 cm × 15 cm × 10 cm

**12.** Why are bricks soaked in water before using the brick masonry?
(A) For removing dust
(B) For reducing air voids
(C) For preventing depletion of moisture from mortar
(D) For reducing efflorescence

**13.** Modular bricks are of nominal size 20 × 10 × 10 cm and 20% of the volume is lost in mortar between joints. Then what is the number of modular bricks required per cubic meter of brickwork?
(A) 520 (B) 500
(C) 485 (D) 470

**14.** Number of bricks required for one cubic meter of brick masonry is _____.
(A) 450 (B) 500
(C) 550 (D) 600

**15.** The relation between the strength of brick masonry $f_w$, the strength of bricks $f_b$, and the strength of mortar $f_m$ is given by (where $k_w$ is coefficient based on layout of the bricks and the joints)
(A) $f_w = \sqrt{k_w \frac{f_b}{f_m}}$ (B) $f_w = k_w \frac{f_b}{f_m}$
(C) $f_w = \sqrt{k_w, f_b f_m}$ (D) $f_w = k_w \sqrt{f_b \cdot f_m}$

**16.** Which of the following ingredients of the brick earth enables the brick to retain its shape?
(A) Alumina (B) Silica
(C) Iron (D) Magnesia

## Previous Years' Questions

**1.** Bull's trench kiln is used in the manufacturing of **[GATE, 2016]**
(A) lime (B) cement
(C) bricks (D) None of these

**2.** As per Indian Standards for bricks, minimum acceptable compressive strength of any class of burnt clay bricks in dry state is **[GATE, 2016]**
(A) 10.0 MPa (B) 7.5 MPa
(C) 5.0 MPa (D) 3.5 MPa

## Answer Keys

### Exercises

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** A | **2.** D | **3.** C | **4.** C | **5.** B | **6.** B | **7.** C | **8.** C | **9.** D | **10.** C |
| **11.** C | **12.** C | **13.** D | **14.** B | **15.** D | **16.** B | | | | |

### Previous Years' Questions

**1.** C **2.** D