



# BPSC - AE

← ASSISTANT ENGINEER →

Civil Engineering

**Bihar Public Service Commission**

**Volume - 1**

**Building Materials**



# Table of Content

S No.	Chapter Title	Page No.
1	Bricks	1
2	Cement	17
3	Mortar	35
4	Concerete	44
5	Timber	60
6	Lime	81
7	Water and Aggregates	85
8	Stone	91
9	Paint and Varnish	96
10	Practice Sheet	99

# 1 CHAPTER

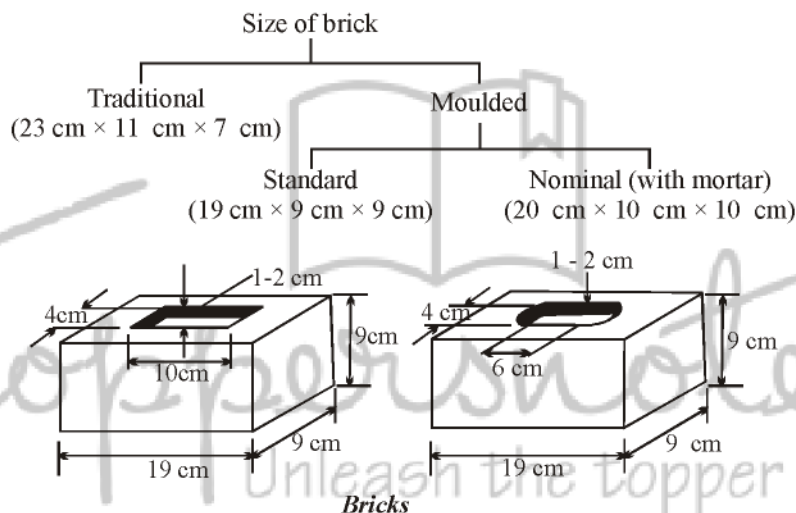
## Bricks

### 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:

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

Height of brick = width of brick



- ❖ 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 According to IS 1077 →

- ❖ Clay bricks are classified as first class, second class, third 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 water for 24 hours.
- ☼ The crushing strength of the brick should not be less than 10.5 Mpa.

**First class bricks two types:**

- A grade first class – strength 10.5 Mpa to 14 Mpa.
  - AA grade first class – strength above 14 MPa.
- ❖ 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 % of its dry weight is allowed.
  - ☼ The crushing strength should not be less than 7.0 N/mm<sup>2</sup>.
- ❖ Second class bricks are recommended for all important or unimportant hidden masonry works and cantering 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 24 per cent of dry weight. The crushing strength should not be less than 5.0 N/mm<sup>2</sup>.
- ❖ 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/mm <sup>2</sup> )	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/mm<sup>2</sup> 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/mm<sup>2</sup>.

#### 📌 **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	< 4%
❖ Other material	< 8%

### **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.

### **HARMFUL INGREDIENTS IN BRICK EARTH:**

- ❖ Following are the ingredients which are undesirable in the brick earth :

#### ✍ **Lime :**

- ❖ Excess of lime cause the bricks to melt and hence its shape is lost.

#### ✍ **Iron pyrites :**

- ❖ If iron pyrites are present in brick earth, the bricks are crystallized and disintegrated during burning because of the oxidation of the iron pyrites.

#### ✍ **Alkalies :**

- ❖ These are mainly in the form of soda and potash. These alkalies lead to efflorescence and straining in the bricks.

#### **Types of Efflorescence:**

- Low efflorescence – If area of efflorescence less than 10% than its called low efflorescence.
- Medium efflorescence – If area of efflorescence 10% – 50% than its called medium efflorescence.
- High efflorescence – If area of efflorescence above 50% than its called high efflorescence.

High efflorescence brick not uses in masonry wall.

#### ✍ **Pebbles:**

- ❖ The presence of pebbles or grits of any kind is undesirable in bricks earth because it will not allow the clay to be mixed uniformly and thoroughly which will result in weak and porous bricks. Also, the brick containing pebbles will not break regularly as desired.

#### ✍ **Vegetation and organic matter :**

- ❖ The presence of vegetation and organic matter in brick earth assists in burning. But if such matter is not completely burnt, the bricks become porous.
- ❖ This is due to the fact that the gases will be evolved during the burning of the carbonaceous matter and it will result in the formation of small pores.
- ❖ Hence it is necessary to see that all these gases are removed during the process of burning for getting bricks of good quality.

### **MANUFACTURING OF BRICKS**

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

- ✳ Preparation of clay
- ✳ Moulding
- ✳ Drying
- ✳ Burning.

- ✍ **Preparation of clay :** The clay for bricks is prepared in the following order :

- ✳ Unsoiling
- ✳ Weathering

❖ Digging

❖ Blending

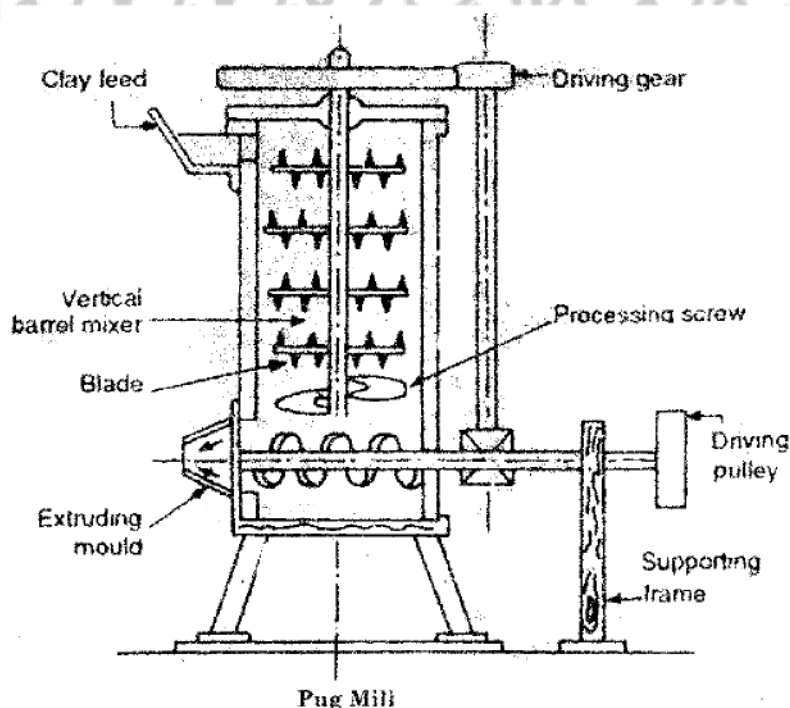
❖ Cleaning

❖ Tempering.

- ❖ **Unsoiling** : The top layer of soil, about 200 mm in depth, is taken out and thrown away. The clay in top soil is full of impurities and hence it is to be rejected for the purpose of preparing bricks.
- ❖ **Digging** : The clay is then dug out from the ground. It is spread on the levelled ground, just a little deeper than the general level of ground. The height of heaps of clay is about 600 mm to 1200 mm.
- ❖ **Cleaning** : The clay, as obtained in the process of digging, should be cleaned of stones, pebbles, vegetable matter, etc. If these particles are in excess, the clay is to be washed and screened. Such a process naturally will prove to be troublesome and expensive. The lumps of clay should be converted into powder form in the earth crushing roller.
- ❖ **Weathering** : The clay is then exposed to atmosphere for softening or mellowing. The period of exposure varies from few weeks to full season. For a large project, the clay is dug out just before the monsoon and it is allowed to weather throughout the monsoon.
- ❖ **Blending** : The clay is made loose and any ingredient to be added to it, is spread out at its top. The blending indicates intimate or harmonious mixing. It is carried out by taking small portion of clay every time and by turning it up and down in vertical direction. The blending makes clay fit for the next stage of tempering.
- ❖ **Tempering** : 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. The water in required quantity is added to clay and the whole mass is kneaded or pressed under the feet of men or cattle. The tempering should be done exhaustively to obtain homogeneous mass of clay of uniform character.

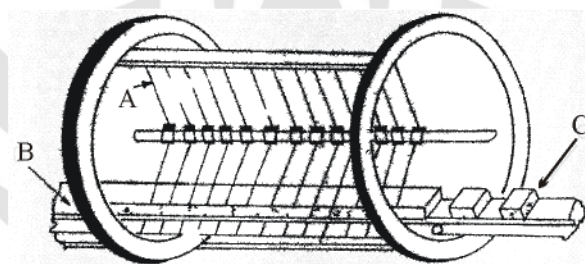
The tempering is generally done in pug-mill. Which may be operated mechanically or with the help of animal.

❖ Capacity – 15000 brick earth/day



➤ **Moulding :** Following are the two ways of moulding :

- ✧ Hand moulding
  - ✧ Machine moulding.
- ❖ **Hand moulding :** In hand moulding, the bricks are moulded by hand i.e., manually. It is adopted where manpower is cheap and is readily available for the manufacturing process of bricks on a small scale. The moulds are rectangular boxes which are open at top and bottom.
- ❖ The bricks prepared by hand moulding are of two types :
- ✧ Ground-moulded bricks
  - ✧ Table-moulded bricks.
- ❖ The lower faces of ground moulded bricks are rough and it is not possible to place frog on such bricks. A frog is a mark of depth about 10 mm to 20 mm which is placed on raw brick during moulding. It serves two purposes :
- ✧ It indicates the trade name of the manufacturer.
  - ✧ In brickwork, the bricks are laid with frog uppermost. It thus affords a key for mortar when the next brick is placed over it.
- ❖ **Machine Moulding :** In machine moulding, the bricks are moulded by machine. It proves to be economical when bricks in huge quantity are to be manufactured at the same spot in a short time



A. Wire; B. Column of pressed clay passing through die; C. Wire cut brick  
Brick cutting wire machine

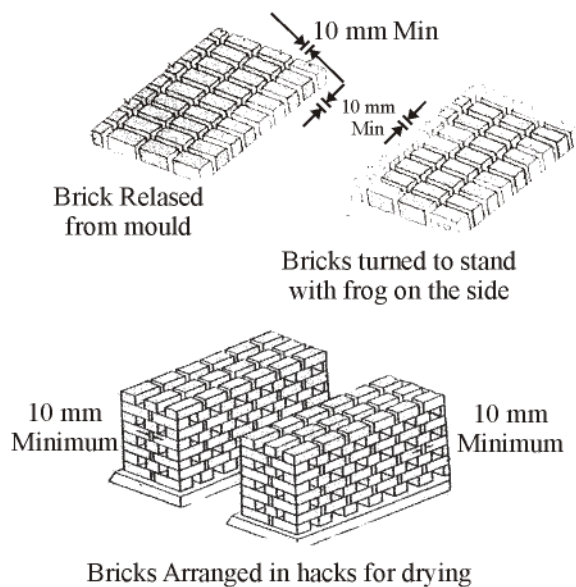
➤ **Drying :**

- ✧ Artificial drying
- ✧ Circulation of air
- ✧ Drying yard
- ✧ Period for drying
- ✧ Screens

**Note:**

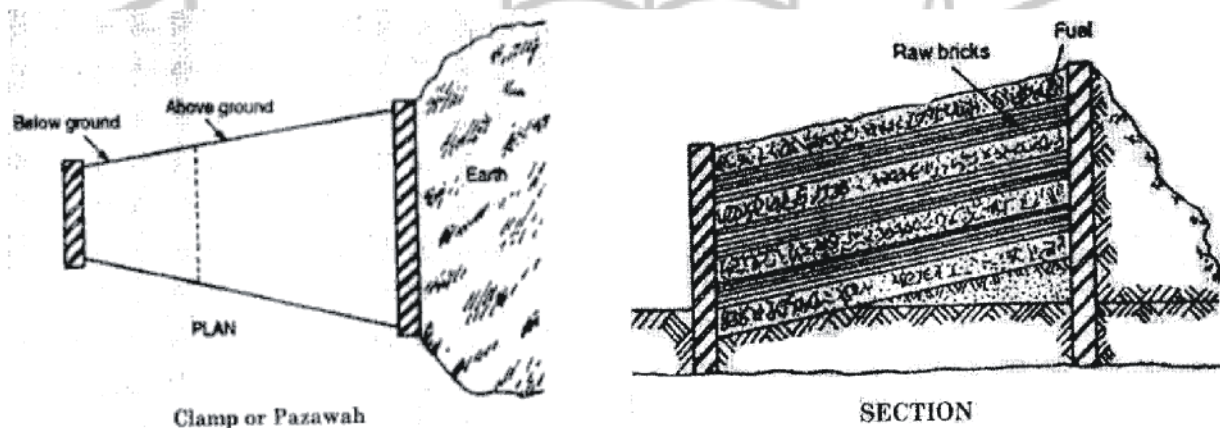
1. After moulding remain moisture content 7% to 30%.
2. After drying remain moisture content 2% – 3%.





### ✍ Burning :

- ❖ This is a very important operation in the manufacturing of bricks. It imparts hardness and strength to the bricks and makes them dense and durable. The bricks should be burnt properly.
- ❖ If bricks are overburnt, they will be brittle and hence break easily. If they are underburnt, they will be soft and hence cannot carry loads.



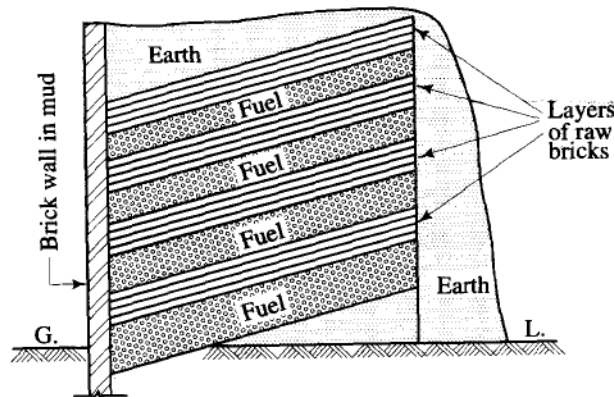
## BURNING OF BRICKS IS DONE IN CLAMPS AND KILNS

### Clamps

✍ **Procedure :** A typical clamp is shown in Fig. Following procedure is adopted in construction of clamp :

- ⊕ A piece of ground is selected. Its shape in plan is generally trapezoidal. The floor of clamp is prepared in such a way that short end is slightly in the excavation and wider end is raised at an angle of about  $15^\circ$  from ground level.

- ✧ The brick wall in mud is constructed on the short end and a layer of fuel is laid on the prepared floor. The fuel may consist of grass, cow dung, litter, husks of rice or ground nuts, etc. The thickness of this layer is about 700 mm to 800 mm. The wood or coal dust may also be used as fuel.



*Clamp*

- ✧ A layer, consisting of 4 or 5 courses of raw bricks, is then put up. The bricks are laid on edges with small spaces between them for the circulation of air.
- ✧ A second layer of fuel is then placed and over it, another layer of raw bricks is put up. Thus alternate layers of fuel and raw bricks are formed. The thickness of fuel layer gradually decreases as the height of clamp increases.
- ✧ The total height of a clamp is about 3 m to 4 m. When nearly one-third height is reached, the lower portion of the clamp is ignited. The object for such an action is to burn the bricks in lower part when the construction of upper part of clamp is in progress.
- ✧ When clamp is completely constructed, it is plastered with mud on sides and top and filled with earth to prevent the escape of heat. If there is any sudden and violent outburst of fire, it is put down by throwing earth or ashes.
- ✧ The clamp is allowed to burn for a period of about one to two months.
- ✧ It is then allowed to cool for more or less the same period as burning.
- ✧ The burnt bricks are then taken out from the clamp.

➤ **Advantages of clamp burning :** Following are the advantages of clamp burning :

- ✧ The burning and colling of bricks are gradual in clamps. Hence the bricks produced are tough and strong.
- ✧ The burning of bricks by clamps proves to be cheap and economical.
- ✧ No skilled labour and supervision are required for the construction and working of clamps.
- ✧ The clamp is not liable to injury from high wind or rain.
- ✧ There is considerable saving of fuel.

➤ **Disadvantages of clamp burning :** Following are the disadvantages of clamp burning :

- ✧ The bricks are not of regular shape. This may be due to the settlement of bricks when fuel near bottom is burnt and turned to ashes.
- ✧ It is a very slow process.

- ✧ It is not possible to regulate fire in a clamp once it starts burning and the bricks are liable to uneven burning.
- ✧ The quality of bricks is not uniform. The bricks near the bottom are overburnt and those near sides and top are underburnt.

## KILNS

- ❖ A kiln is a large oven which is used to burn bricks. The kilns which are used in the manufacture of bricks are of the following two types :

- ✧ Intermittent kilns
- ✧ Continuous kilns.

### ↗ Intermittent kilns :

- ❖ These kilns are intermittent in operation which means that they are loaded, fired, cooled and unloaded. Such kilns may be either rectangular or circular in plan. They may be over ground or underground. They are classified in two ways :

- ✧ Intermittent up-draught kilns
- ✧ Intermittent down-draught kilns.

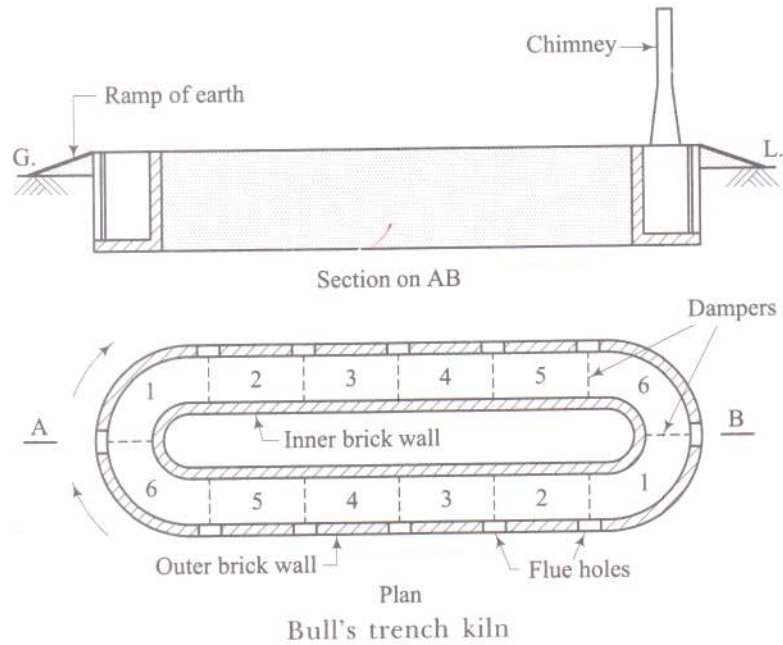
### ↗ Continuous kilns :

- ❖ These kilns are continuous in operation. This means that loading, firing, cooling and unloading are carried out simultaneously in these kilns. There are various types of the continuous kilns.

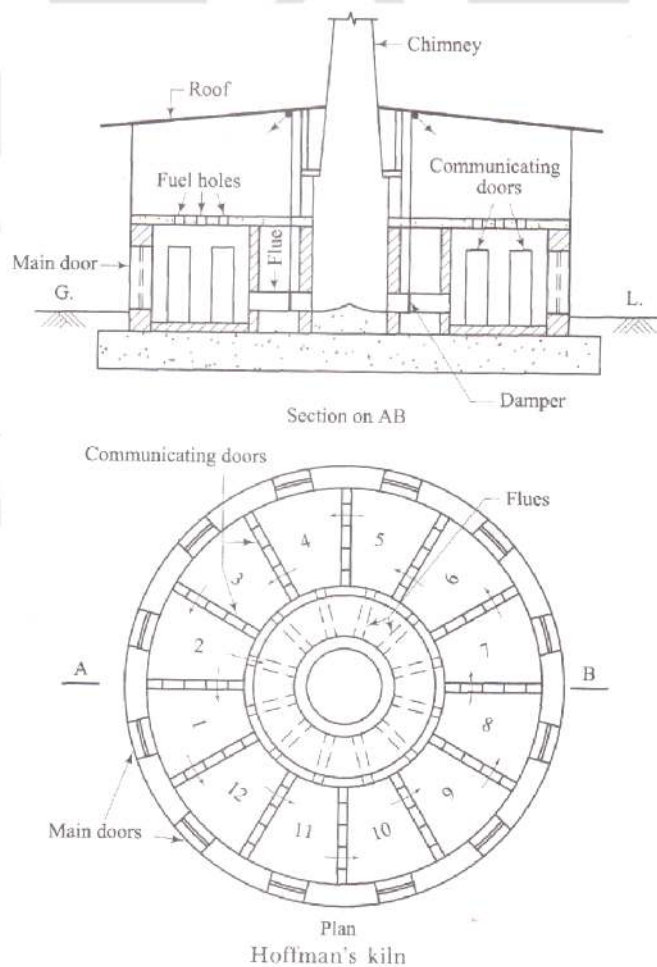
- ✧ Bull's trench kiln
- ✧ Hoffman's kiln
- ✧ Tunnel kiln.

- (i) **Bull's trench kiln** : This kiln may be of rectangular circular or oval shape in plan. As the name suggests the kiln is constructed in a trench excavated in ground. It may be fully underground or partly projecting above ground.

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



(ii) **Hoffman's kiln:** This kiln is constructed overground and hence it is sometimes known as the flame kiln. Its shape is circular in plan and it is divided into a number of compartments or chambers. As a permanent roof is provided, the kiln can even function during rainy season.



Chamber	Arrangement
1	Loading
2 to 5	Drying and pre heating
6 and 7	Burning
8 to 11	Cooling
12	Unloading

(iii) **Tunnel kiln:** This type of kiln is in the form of tunnel which may be straight, circular or oval in plan.

#### **COMPARISON BETWEEN BULL'S TRENCH KILN AND HOFFMAN'S KILN**

S.no.	Item	Bull's trench kiln	Hoffman's kiln
1.	Burning capacity	About 3 lakhs in 12 days.	About 40 lakhs in one season.
2.	Continuity or working	It stops functioning during monsoon as it is not provided with a permanent roof	It functions all the year round as it is provided with a permanent roof.
3.	Initial cost	Low	High
4.	Nature	It is semi continuous in loose sense.	It is perfectly continuous.
5.	Cost of fuel	High as consumption of fuel is more.	Low as consumption of fuel is less.
6.	Drying space	More space	Less space.
7.	Popularity	More popular because of less initial cost.	Less popular because of high initial cost.
8.	Quality of bricks	Percentage of good quality bricks is small	Percentage of good quality bricks is more.
9.	Suitability	Suitable when demand of bricks in monsoon is not substantial	Suitable when demand of bricks is throughout the year

#### **COMPARISON BETWEEN CLAMP-BURNING AND KILN-BURNING**

- ❖ In order to bring out points of differences between similar items of clamp burning and kiln-burning of bricks, a table is prepared.

#### **COMPARISON BETWEEN CLAMP-BURNING AND KILN-BURNING**

No.	Item	Clamp-burning	Kiln-burning
1.	Capacity	About 20000 to 100000 bricks can be prepared at a time.	Average 25000 bricks can be prepared per day.
2.	Cost of fuel	Low as grass, cow dung, litter, etc. may be used.	Generally high as coal dust is to be used.
3.	Initial cost	Very low as no structures are to be built.	More as permanent structures are to be constructed.
4.	Quality of bricks	The percentage of good quality bricks is small about 60% or so.	The percentage of good quality bricks is more about 90% or so.
5.	Regulation of fire	It is not possible to control or regulate fire during the process of burning.	The fire is under control throughout the process of burning.

6.	Skilled supervision	Not necessary throughout the process of burning.	The continuous skilled supervision is necessary.
7.	Structure	Temporary structure.	Permanent structure.
8.	Suitability	Suitable when bricks are to be manufactured on a small scale and when the demand of bricks is not continuous.	Suitable when bricks are to be manufactured on a large scale and when there is continuous demand of bricks.
9.	Time of burning and cooling	It requires about 2 to 6 months for burning and cooling of bricks.	Actual time for burning of one chamber is about 24 hours and only about 12 days are required for cooling of bricks.
10.	Wastage of heat	There is considerable wastage of heat from top and sides and hot flue gas is not properly utilized.	The hot flue gas is used to dry and pre-heat raw bricks. Hence the wastage of heat is the least.

#### FACTORS AFFECTING QUALITY OF BRICKS

- ❖ Following factors affect the quality of bricks :
  - ✱ composition of bricks earth;
  - ✱ preparation of clay and blending of ingredients;
  - ✱ nature of moulding adopted;
  - ✱ care taken in drying and stacking of raw or green bricks;
  - ✱ type of kiln used including type of fuel and its feeding;
  - ✱ burning and cooling processes; and
  - ✱ care taken in unloading.
- ❖ It is thus obvious that not only the bricks of different bricks fields will have different strengths, but in the same brick field, the bricks of the same batch may have different strengths.
- ❖ The average crushing strength and tensile strength of hand moulded bricks are 60000 kN/m<sup>2</sup> and 2000 kN/m<sup>2</sup> respectively. The shearing strength of bricks is about one-tenth of the crushing strength.

#### TESTING OF BRICKS AND QUALITY OF BRICKS

- ❖ The bricks should be well burn.
- ❖ Free from cracks with sharp and square edge.
- ❖ The colour of bricks should be uniform.
- ❖ The bricks should be uniform shape and size.
- ❖ Standard size of the brick is 19 cm × 9 cm × 9 cm
- ❖ The brick should be produce clear mettalic sound. When struck with each other (soundness test).
- ❖ When the bricks as broken if should be homogenous and free from any defect such as holes and lumps (structure test).
- ❖ The bricks when immersed in water for 24 hrs it should not show absorption greater than 20% of its dry weight for first class bricks, 22% for 2<sup>nd</sup> class bricks and 24% for 3<sup>rd</sup> class bricks. (absorption test)

- ❖ The bricks should have sufficient hardness i.e., it should not show any impression when scratch with finger nail over its surface. (Hardness test)
- ❖ The bricks should not break into the pieces when it is drop from 1m height from ground surface (Toughness test)
- ❖ The bricks does not show any sign of efflorescence.
- ❖ The nominal size of the brick is 20 cm × 10 cm × 10 cm.
- ❖ The weight of 1 m<sup>3</sup> bricks is approximately 1800 kg.
- ❖ The number of the brick required for 1 m<sup>3</sup> = 500.
- ❖ Weight of single brick = 3.5 – 3.6 kg.

#### 🔗 **Compressive Strength Test:**

- ⊛ For testing bricks for compressive strength from a sample the two bed faces of bricks are ground to provide smooth, even and parallel faces. The bricks are then immersed in water at room temperature for 24 hours. These are then taken out of water and surplus water on the surfaces is wiped off with cotton or a moist cloth.
- ❖ The frog of the brick is flushed level with cement mortar and the brick is stored under damp jute bags for 24 hours followed by its immersion in water at room temperature for three days. The specimen is placed in the compression testing machine with flat faces horizontal and mortar filled face being upwards.
- ❖ Load is applied at a uniform rate of 14 N/m<sup>2</sup> per minute till failure. The maximum load at failure divided by the average area of bed face gives the compressive strength.

⊛ Compressive strength  $(\text{N/mm}^2) = \frac{\text{maximum load at failure (N)}}{\text{avg area of bed face (mm}^2\text{)}}$

- ❖ The average of results shall be reported. The compressive strength of any individual brick tested in the sample should not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 percent.

#### **FIRE-BRICKS**

- ❖ These bricks are made from fire-clay. The process of manufacture is the same as that of ordinary clay bricks. The burning and colling of fire-bricks are done gradually.
- ❖ These bricks are usually white or yellowish white in colour. The weight of a fire-brick is about 30 to 35 N. The fire-bricks can resist high temperature without softening or melting. Hence they are used for linings of interior surfaces of furnances, chimneys, kilns, ovens, fireplaces, etc.
- ❖ The compressive strength of these bricks varies from 200 to 220 N/mm<sup>2</sup>. The percentage of absorption for these bricks varies from 5 to 10.
- ❖ Following are the *three* varieties of fire-bricks :
  - ⊛ Acidic bricks
  - ⊛ Basic bricks
  - ⊛ Neutral bricks.

#### 🔗 **Acidic bricks :**

- ❖ These bricks are used for acidic lining. Following are the types of acidic bricks :

- ❖ **Ordinary fire-bricks** : These bricks are prepared from natural fire-clay and they provide a good material for acidic refractory lining.
- ❖ **Silica bricks** : These bricks contain a very high percentage of silica to the extent of about 95 to 97 per cent. A small quantity of lime, about 1 to 2 per cent, is added to work as binding material. These bricks are moulded under pressure and burnt at high temperature. The silica bricks can stand a high temperature upto about 2000°C. The compressive strength of such bricks is about 15 N/mm<sup>2</sup>.

#### ➤ **Basic bricks :**

- ❖ These bricks are used for basic lining and basic refractory materials are used in the manufacture of such bricks. The magnesia bricks are prepared from lime and magnesia rocks. The dolomite may also be adopted for the manufacture of these bricks.

#### ➤ **Neutral bricks :**

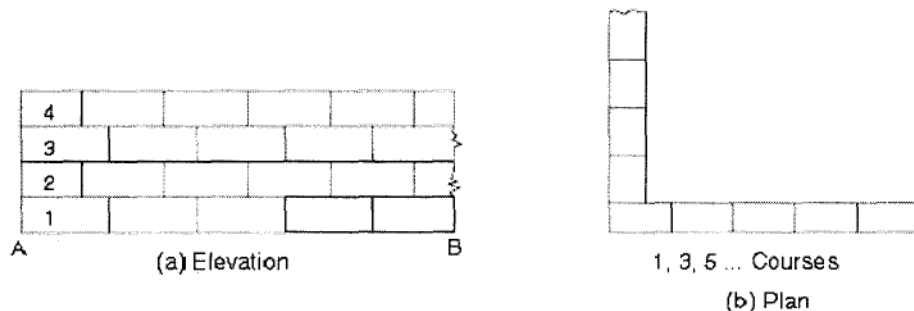
- ❖ These bricks are used for neutral lining. They offer resistance to the corrosive action of slags and acid fumes. As compared to the basic bricks, the neutral bricks are more inert to the slags. Following are the types of neutral bricks :
  - ❖ **Chromite bricks** : These bricks are prepared from a mixture of chrome, iron ore, ferrous oxide, bauxite and silica. Such bricks are unaffected by acidic or basic actions.
  - ❖ **High alumina bricks** : These bricks contain a high percentage of alumina and they are found to be more inert to the slags.

### **BRICK MASONRY**

- ❖ Brick masonry is built with bricks bonded together with mortar. For temporary sheds mud mortar may be used but for all permanent buildings lime or cement mortars are used.
- ❖ The various types of bounds generally used in brick masonry are
  - ❖ Stretcher bond
  - ❖ Header bond
  - ❖ English bond and
  - ❖ Flemish bond.

#### ➤ **Stretcher Bond :**

- ❖ A stretcher is the longer face of the brick as seen in the elevation. In the brick of size 190 mm × 90 mm × 90 mm, 190 mm × 90 mm face is the stretcher. In stretcher bond masonry all the bricks are arranged in stretcher courses as shown in Fig.
- ❖ However care should be taken to break vertical joints. This type of construction is useful for the construction half brick thick partition wall.

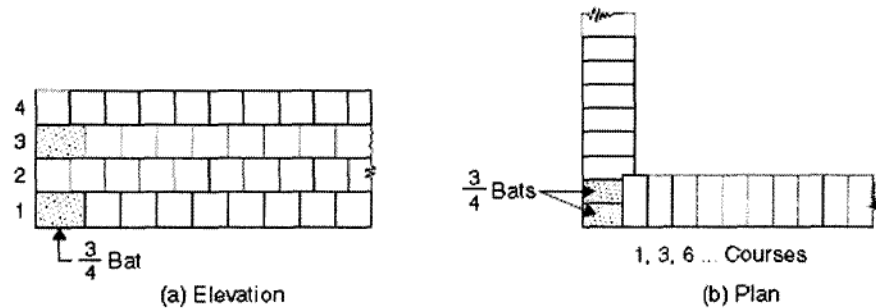


***Stretcher bond***



### Header Bond :

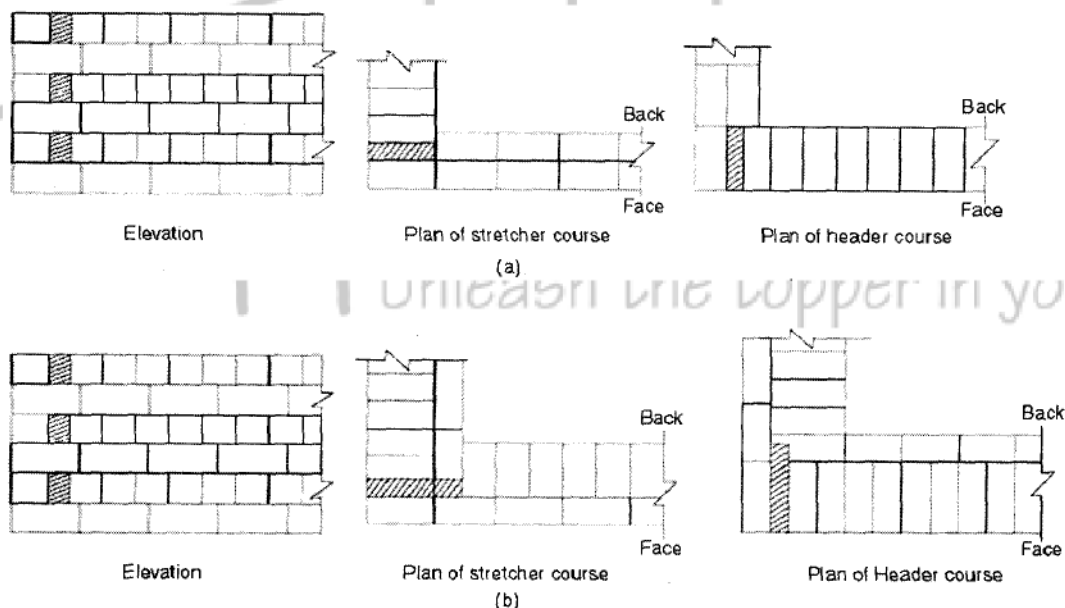
- ❖ A header is the shorter face of the brick as seen in the elevation. In a standard brick it is 90 mm × 90 mm face. In header bond brick masonry all the bricks are arranged in the header courses as shown in Fig. This type of bond is useful for the construction of one brick thick walls.



*Header bond*

### English Bond :

- ❖ In this alternate courses consist of headers and stretchers. This is considered to be the strongest bond. To break continuity of vertical joints a brick is cut lengthwise into two halves and used in the beginning and end of a wall after first header.
- ❖ This is called queen closer. [Ref. Fig.]. Fig. shows typical one brick and one and half brick thick wall with English bond.

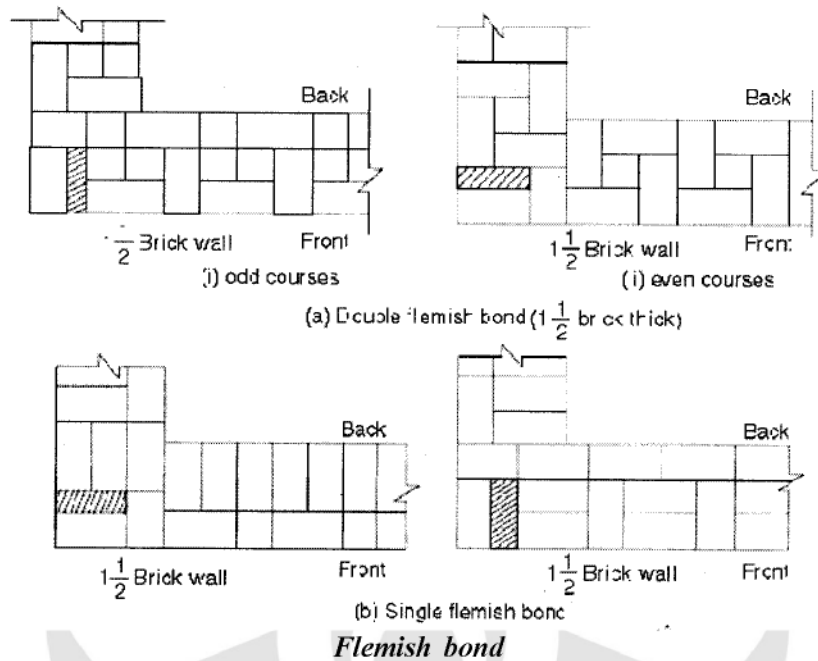


*English bond*

### Flemish Bond :

- ❖ In this type of bond each course comprises of alternate header and stretcher [Fig.]. Alternate courses start with stretcher and header. To break the vertical joints queen closers are required, if a course starts with header. Every header is centrally supported on the stretcher below it.
- ❖ Flemish bonds may be further classified as
  - ⊛ Double Flemish Bond
  - ⊛ Single Flemish Bond.

- ❖ In case of *double flemish bond*, both faces of the wall have flemish look, i.e., each course consist of alternate header and stretcher, whereas *single flemish bond* outer faces of walls have flemish look whereas inner faces have look of English bond [Fig. (a), (b)].
- ❖ Construction of flemish bond needs greater skill. It gives more pleasing appearance. But it is not as strong as English bond. If only pointing is to be used for finished wall, flemish bond may be used to get good aesthetic view. If plastering is going to be used, it is better to use English bond.



**Flemish bond**

○○○

