# #BRICKS:

- Regular size rectangular unit
- Used for most of the building works
- Used as substitute for stone, where stone is not available.

# # INGREDIENT (WITH AVERAGE PROPORTIONS WEIGHT BASIS)

- Silica ($SiO_2$) :55%
- Alumina ($Al_2O_3$) :30%
- Iron Oxide ($Fe_2O_3$) :8%
- Magnesia (MgO) :5%
- Lime (CaO) :1%
- Organic Matter :1%

**-Silica is Sand**
**-Alumina, Iron Oxide& Magnesia constitutes clay**

# # FUNCTION OF CHIEF INGREDIENTS:

- **Alumina :**
  - Main constitute of clay; acts as cementing material in raw brick;
  - Provides plasticity to earth/brick clay so that it can be molded;
  - If it contains in excess amount, brick **shrinks**, **cracks** and **warps on drying and burning** (just like any other cementing material when drying).

- **Silica:**
  - Good Bricks contains 50-60%;
  - Prevents cracking, shrinking & warping of raw bricks;
  - Presence of silica in **e**xcess amount in bricks destroys cohesion between the particles and makes brick brittle and weak.

**Durability of bricks depend largely upon proper proportion of alumina and silica**

- **Lime:**

  - Brick should contain little finely powered lime (1%);

  - It enables silica (of required portion) to melt at furnace temperature (of 1650$^{o}$C) & binds the particles of brick together resulting in strong & durable bricks;

  - At about 1100$^{o}$C, lime acts as catalyst to elevate the furnace temperature to 1650$^{o}$C at which silica fuses;

  - If excess lime presents in brick clay, it makes bricks vitrified, and causes bricks to melt (as more than the required amount of silica will fuse) and hence, the shape of brick will be lost (i.e., disfigured).

- **Iron Oxide:**
  - Should contain a small quantity;

  - Acts as a flux like lime, thus helps to fuse at low temperature;

  - Imparts red color to bricks on burning.

- **Magnesia:**
  - A small proportion of it decrease shrinkage & gives yellow tint to the bricks;

  - Excess amount causes bricks to decay.

## #HARMFUL INGREDIENTS

- **Lime:**

  - Excess lime melts the bricks and disfigures it;

  - If $CaCO_3$ exists (in purest form, i.e., if it contains at least 95% CaO) in lime-lump in brick clay, it converts into quick lime on burning. When these bricks come in contacts with water, **quick lime** **slakes** and expands and hence causes disintegration of brick.

- **Alkalis:**
  - Mainly salt of Na & K;

  - Acts as a flux in the kiln and causes fusion, warping and twisting of bricks;

  - Alkalis absorbs moisture from atmosphere and causes dampness & efflorescence (because of the presence of hygroscopic salts, e.g., $CaCl_2$, $MgCl_2$, etc.).

- **Pebbles ,Stones & Gravels:**
  - Their presence do not allow thoroughly mixing of earth, thus make bricks weaker.

- **Iron Pyrites (FeS):**
  - Causes crystallization & disintegration of bricks during burning;
  - Discolors bricks in the form of black slag.

- **Organic Matter:**
  - Makes bricks porous resulting in low density and weaker bricks.

# #CHARACTERISTICS OF GOOD BRICKS:

- Uniform color (deep red/cherry)
- Uniform shape (edges sharp, straight & subtends at right angle with other edge);
- Size: standard (i.e., **PWD:** 9.5″x4.5″x2.75″; **BDS 2002:** 24cm x11.5cm x7cm);
- Texture and compactness (fine, dense & compact; across a broken surface);
- Water absorption (≤10% for **S-grade**, ≤15% for **A-grade** and ≤20% for **B-grade** bricks; Grading based on **BDS 2002** specification);
- Crushing strength should be as specified by **BDS 2002** as follows:

| Grade | $\sigma_{mean}$ (kg/cm$^2$) | $\sigma_{min}$ (kg/cm$^2$) |
|---|---|---|
| S | 280 | 245 |
| A | 175 | 154 |
| B | 140 | 105 |

- Hardness: should be hard enough to resist any finger nail impression on brick surface if one tries to do it with thumb nail;
- A good brick should be sound which can be revealed if a brick emits metallic or ringing sound when struck by another similar brick or by a light hammer;
- Free from any kinds of non-homogeneity because of gravel, stones etc.;
- Should be soundproof (as far as possible) and having low thermal conductivity.

# #BROAD CLASSIFICATION OF BRICKS:

**Usage:**
- in building of long durability, say 100 years.
- for building exposes to corrosive environment;
- for making coarse agg. of concrete.

- **S-grade** (or 1st Class brick):
  - Standard Size**;** Uniform yellow or red colored;
  - Well brunt; Regular shape; Uniform texture (can be visible across a broken surface);
  - No efflorescence; No pebbles, gravels or organic matter;
  - AC $\leq$ 10%; Crushing strength: $\sigma_{mean}$= 280 kg/cm$^2$; $\sigma_{min}$= 245 kg/cm$^2$; where $\sigma_{mean}$= mean strength for 12-halved bricks and $\sigma_{min}$= minimum strength for 12-halved bricks;
  - Emits metallic sound; No finger nail impression.

**Usage:**
- For the construction of one-storied building, temporary shed, when intended durability is not more than 15 years.

- **A-grade** (or 2nd Class brick):
  - Standard Size**;** Uniform yellow or red colored;
  - Well brunt (slightly over-brunt is acceptable);
  - Regular shape; Efflorescence is not appreciable;
  - 10% <AC $\leq$ 15%; Crushing strength: $\sigma_{mean}$= 175 kg/cm$^2$; $\sigma_{min}$= 154 kg/cm$^2$;
  - Emits metallic sound; No finger nail impression.

- **B-grade** (or 3rd Class brick):
  - Soft and light red colored; Shape and size not regular;
  - Under brunt (slightly over-brunt is acceptable);
  - Extensive efflorescence; Non-uniform texture;
  - 15% <AC $\leq$ 20%; Crushing strength: $\sigma_{mean}$= 140 kg/cm$^2$; $\sigma_{min}$= 105 kg/cm$^2$;
  - Emits dull/blunt sound;
  - Left finger nail impression.

- **Over-brunt or Jhama brick:**
    - Vitrified;
    - Shape distorted (as larger than the required amount of silica gets fused);
    - High AC (absorption capacity);
    - Strength may be higher or equivalent to **S-grade** (or 1st class) brick.

> Used for:
> - lime concrete for foundation
> - coarse agg. In concrete of slab and beam which will not come in contact of water.

- **Under-brunt brick:**
    - Half brunt brick;
    - Yellow colored;
    - Low strength;

> Used as:
> - surki in lime-terracing;
> - Soling under RCC footing or basement.

# #MANUFACTURING OF BRICKS:

Five steps:

- Preparation of clay;
- Pugging or tempering of clay;
- Molding of bricks;
- Drying of bricks;
- Burning of bricks

## 1. Preparation of clay:

- Involves operation like un-soiling the top loose earth, then digging, cleaning weathering and blending of the earth;
- After removing the top unsuitable soil, the clay is dug out and spread it on the leveled ground, and is left exposed to atmosphere for softening.
- Digging the earth before rain is advantageous; the full monsoon can be utilized for weathering the earth;
- After weathering, the earth is chemically analyzed. If any difference of any ingredient from the required amount is observed, it should be added correspondingly.

## 2. Pugging/Tampering of clay:

- Involves breaking up of prepared clay, watering and kneading till earth becomes a homogeneous mass.
- Water is added in the required quantity.
- The whole mass is kneaded manually (under the feet of man or cattle) or mechanically with using Pug-mill.

## 3. Molding of bricks:

- After tempering of clay, bricks should be molded as soon as possible. Otherwise plug clay may become stiff and molding brick may become difficult.
- Moulds are made slightly greater in size than the standard of brick to compensate for shrinking on drying and burning.
- Molding is of two types: hand molding (ground molding and table molding) & machine molding.
- Molding directly on ground has two drawbacks: (i) the lower face is very rough and (ii) bricks cannot have frog marks.

## 4. Drying of bricks:

Following are the objective of drying the bricks:

- To remove as much of moisture from bricks as possible, so as to save fuel and time while burning.
- To avoid the chances of cracking and distortion of bricks during burning.
- To increase the mechanical strength of bricks so that they can be handled and stocked without any damage to the raw bricks.

## 5. Burning of bricks:

- Imparts strength and hardness to bricks and makes them dense and durable. At about 1100$^0$C, the two main constitute of bricks, silica and alumina, combines with each other and bricks become dense and strong.
- Kiln is a system to burn bricks in very large number. For burning, intermitted kiln and continuous kiln are used.
- A continuous kiln is used to burn bricks in large quantity.

# #BRICK BURNING:

**Kiln:** is a system to burn the raw bricks in very large numbers.

Two types: Intermitted kiln & continuous kiln.

## Continuous kiln:

1. Bull's trench, 2Hoffman kiln, 3.Tunnel kiln

## Disadvantage of Intermitted kiln:

- Valid for small project.
- Supply of bricks is intermitted on the required basis
- Quantity of burning is non-uniform; near the bottom (i.e., closer to the source of fuel/burning), the bricks are over-burnt and near the top are under-burnt.

## Advantage of Hoffman kiln:

- Better control on heat.
- Supply of burning is continuous.
- Bricks are burnt evenly and hence, bricks of good quantity are produced.

## Disadvantage of Hoffman kiln:

- Initial cost is high.
- Requires regular demand of the bricks, which may not be possible in rural areas.

## Hoffman kiln:

**Description of Hoffman kiln:**

- Circular or oval in plan;
- Chimney is placed at the central point/position;
- Eight/twelve chambers or compartments (namely, 1, 2, 3………..,12) are arranged around the Chimney;
- Each chamber has door (e.g., $O_1$,$O_2$, etc.) in the external wall; it is used for loading and unloading of bricks;
- All the chamber have communication door (namely, $D_1$, $D_2$, …., etc.) in the wall separating each other;
- Each chamber is connected to the chimney with radial flues (namely, $R_1$, $R_2$, ……, etc.);
- Kiln has a permanent roof; fuel holes are provided in the rooftop to drop fuel in the kiln.

**All the chamber are subjected to loading, drying & preheating, burning, cooling and un-loading operations successively. And all the operation is going on simultaneously in the kiln at a given time.**

## #OPERATIONS:

At any instant, all the chamber of the kiln may be functioning as follows:

| | |
|---|---|
| **Chamber 1:** | **Loading** |
| **Chamber 2~5:** | **Drying & Preheating** |
| **Chamber 6,7 :** | **Burning** |
| **Chamber 8~11 :** | **Cooling** |
| **Chamber 12 :** | **Unloading** |

With this arrangement, the circulation of fuel gas will be as follows:

- Cool air enters the kiln through open doors of chambers 1 & 12 (i.e, $O_1$ & $O_{12}$) and pass through chamber 11,10,9,8 (using $D_{11}$,$D_{10}$ etc.) and gets heated while performing cooling of hot brunt bricks in these chambers.

- The heated air or gases enter the burning chamber 7 & 6 (through $D_7$ and $D_6$); Fuel is dropped in these chambers from the top to perform burning.

- Aftermath, the hot gases are led to the chamber 5,4,3,2 to perform drying & preheating of freshly loaded bricks. The communication door of chamber 2 with that of chamber 1 (i.e., $D_1$) is closed and the cool gases are lead to chimney through the radial flue $R_2$.

- Note that this particular arrangement, all the radial flues except of chamber 2 remain closed and the all the communication doors except $D_1$ remain opened. Outer loading and unloading doors remain closed except for two chambers, which are being loaded ($O_1$) and unloaded ($O_{12}$).

- After burning of chambers 6 & 7 completed, the pattern of circulation will be as follows:

| | |
|---|---|
| **Chamber 12:** | **Loading** |
| **Chamber 1~4:** | **Drying & Preheating** |
| **Chamber 5,6 :** | **Burning** |
| **Chamber 7~10 :** | **Cooling** |
| **Chamber 11 :** | **Unloading** |

## #Fire bricks or refractory bricks:

- Manufactured from special designed earth;

- After burning, withstand very high temperature without affecting its shape, size and strength;

- Used for lining of chimney, furnaces, etc. where usual temperature are expected to be very high

## Fire Clay:

- Can resist very high temperature without getting soft or melting;
- Compound of nearly pure hydrated silicate of alumina (25-35%) and high proportion of silica (65-75%), with small percentage of alkalis;
- High % of alkalis (such as lime, magnesia, iron oxide, etc.) reduce the fire resisting capacity of the fire clay. They act as flux and cause fusion of the brick clay (actually silica at high temperature);
- Three category of fire clay depending on the fire resistance capacity. Low duty fire clay resists temperature up to $800^0$C; Medium duty up to $1500^0$C and High duty up to $1650^0$C.

**Example of fire bricks**

- Made from fire clay or refractory earth;
- Ingredient:
  Silica: 60-75%
  Alumina: 20-35%
  Fluxing material: < 10%
- Smaller the % of the fluxing material, higher will be the % of alumina and more fire resisting will be the brick;
- However, the percent of alumina should not be allowed to exceed unnecessarily, otherwise bricks may become alkaline in nature.

# #Laboratory Tests For Bricks:

a. Absorption capacity test

b. Crushing strength test

c. Hardness test

d. Shape & size test

e. Soundness test

f. Soluble salt/ efflorescence test

# #FIELD TEST FOR BRICK:

a. Arrange two bricks so as to form a 'T' and allow free fall from a height of 6 ft (1.5 m) on to level ground. If the brick pair resist breakage, the bricks are good.

b. If it is not possible to impart a finger nail scratch on to the surface of a brick, it's a good brick.

c. If hammered a brick with another of similar kind or a light hammer and if metallic sound emits, the bricks is good.

## Coloring of bricks depends on:

a. Burning temperature of bricks.

b. Type of fuel used for burning.

c. Chemical composition of bricks.

d. Nature of silica used in molding.

e. Degree of dryness achieved during burning.

f. Degree of air admitted to the kiln during burning.

## Efflorescence test:

- Take 5 full bricks from a lot;
- Each brick shall be placed on end in a shallow flat bottom non-absorbent dish keeping clearance of 5 cm between two consecutive bricks;
- Distilled water shall be poured to a depth of 2.54 cm so that it surrounds each bricks by one-inch only;
- The whole arrangement shall be allowed to stand in a well-ventilated room at 15-20$^{o}$C;
- After a few days when the water has been absorbed and the bricks appear to be dry, as similar quantity of water shall again be poured in the dish and further drying period is allowed;

- Tendency to efflorescence shall be reported as nil, slight, moderate and heavy;
- Nil: for no perceptible deposit of efflorescence;
- Slight: Not more than 10% of the area of the bricks covered with a thin deposit of salts;
- Moderate: A heavier deposit than under 'slight' and covering up to 50% of the area of the brick surface but accompanied by powdering of flaking of the surface;
- Heavy: A heavy deposit of salts accompanied by powdering and/or flaking of the surfaces;
- If the observed efflorescence varies in each specimen, the worst affected specimen shall form the basis of the report.

## Blocks instead of bricks:

### Advantages:

- Regular shaped with straight and sharp edges having smooth surfaces;
- Requires minimum mortar for plastering if it is given;
- Sometimes no need for plaster if walls made of blocks;
- Less fuel consumption in manufacturing; it can be denoted as green brick;
- Environmental friendly as no direct fuel consumption is required as it is made of cement mortar; however, brick needs direct fuel (e.g., gas, burning wood, etc.);
- Since hollow block, unit weight is less and hence reduces dead load for partition walls up to 40% (compared to brick usage); thereby reduces foundation and structural cost substantially;
- Since hollow, if constructed by hollow blocks the walls will be soundproof and heatproof.

**Disadvantages:**

- Special provision for anchorage of window and door frame; usually rod is passed through the holes of blocks lopcated at window or door opening edges, which is latter concreted so as to make way for inserting MS angles;
- Special provision is required to hold the service lines in place through the holes of blocks;
- Should be made watertight or provision is necessary to drainout water if enters into the block holes.