Clay Products

Building Construction Material

Introduction

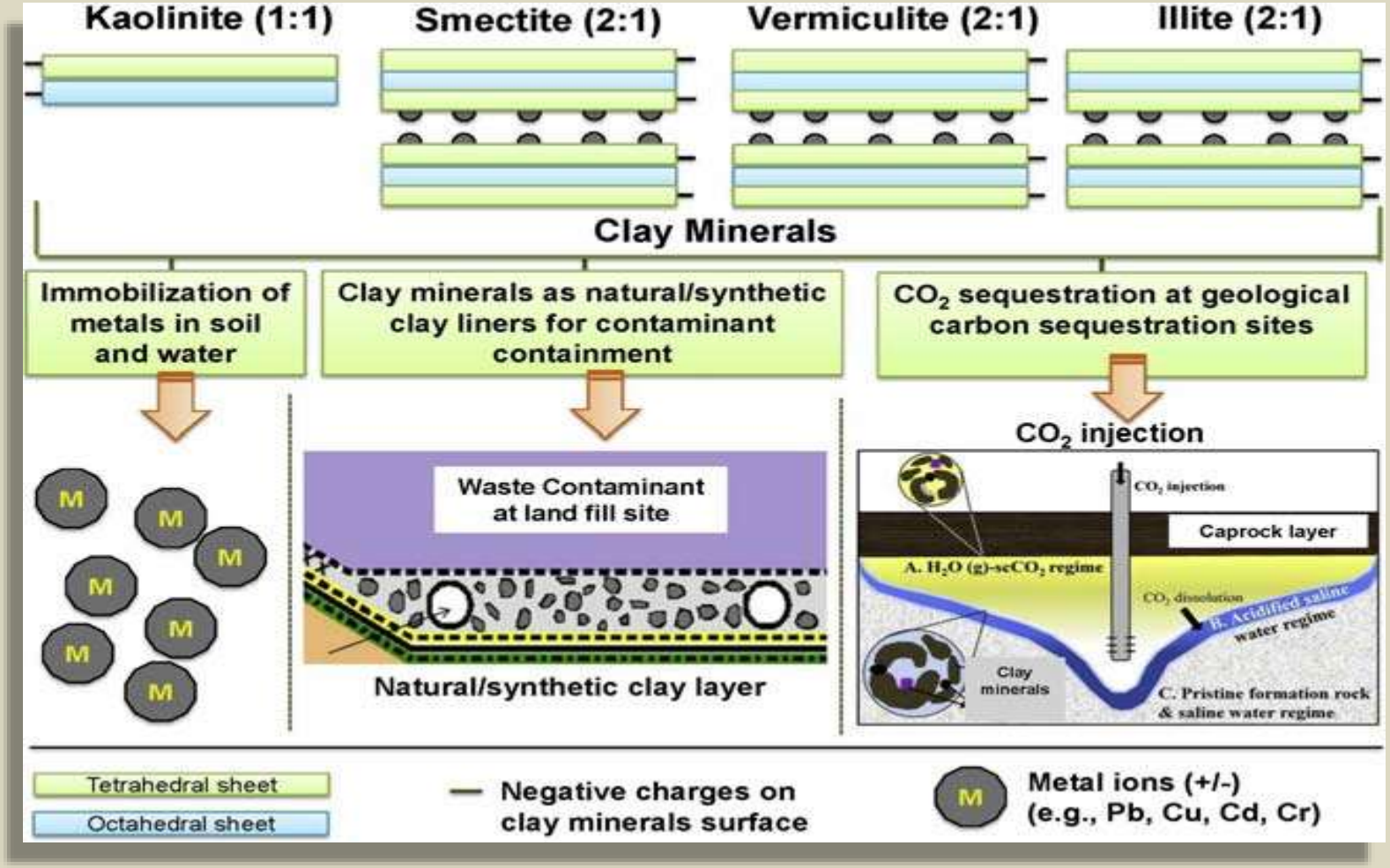
- **Clay is naturally occurring mineral that is found almost every where on the surface of the earth** making the soil cover or the soft ground.
- **It is so widespread in its occurrence that in common language it is often referred as earth**.

Introduction

Introduction

- **Miner logically pure clay may be composed of one or more minerals of clay group** such as **Kaolinite, Montmorillonite, illite, vermiculite and Allohane, etc.** Kaolite is the most important mineral component of common clays.
- **Clay occurs universally. Man has used them since ancient times for making earthware of great variety.**

minerals of clay group



Classification of Clays

- **Clays are classified in two ways: Genesis or their mode of formation and their dominant characteristics.**
- All clays are classified in two ways:
- Genesis or their mode of formation and their dominant characteristics
- **The Residual Clays**
- **The Transported Clays**

The Residual Clays

Classification of Clays

- **The Residual Clay includes all varieties of clays that are found covering the rocks from which they are formed by natural processes.** Such clays are pure in their chemical composition that is related broadly to the parent rock. **China Clay is the best example of residual Clay.**

Residual Clay

Classification of Clays

The Transported Clays.

- **These are the most common clays spread on the earth. They are formed by the disintegration and decomposition of the pre-existing rocks by the natural agencies followed by removal and transportation of broken pieces to far off places where they are finally deposited.** Hence any such deposit of transported clay will have all the particles transported from many places and different source materials. The transported clay are, therefore quite heterogeneous in mineralogical and chemical composition.

The Transported Clays.

Classification of Clays

- **The transported clays are sometimes further distinguished into glacial clays, marine clays, alluvial clays and lacustarine clay when glaciers, seas, rivers, and lakes respectively** have played dominant roles in their formation.

Classification of Clays

- **On the Basis of their dominant Characteristics**, Clays are classified as into four groups:
- **China Clay**
- **Fire Clay**
- **Vitrifying Clay**
- **And Brick Clay**

Classification of Clays

China Clay

- **It is the purest type of clay containing very high percentage of mineral Kaolinite or Kaolin $Al_2Si_2O_5(OH)_4$.** It is Considered high Grade clay and is used for the manufacturing of crockery and other proclain ware

China Clay

Classification of Clays

Fire Clay

- **They are also called refractory clay and contain, besides Kaolinite, Silica and alumina in very high temperature without suffering any deformation off shape** given to them at the time of moulding.
- **They are mainly used in manufacturing of refractory bricks that are of great importance in many metallurgical, mechanical and chemical operations**

Fire Clay

Classification of Clays

Vitrified Clays

- **These clays are rich in fluxing compounds like iron oxide and carbonates of calcium and magnesium. These are easily fusible. i.e. cannot withstand high temperatures above 1100 ^{0} C the fluxes get softened and form glass like material that acts as a strong bonding agent between the other clay particles**. This results in the formation of a smooth surfaced hard burnt clay products.
- **The Vitrifying clays called hard burnt clay are specially used for manufacturing of facing brick, flooring tiles, sewer pipe and other similar ornamental and dense clay products**.

Vitrified Clays

Classification of Clays

The Brick Clays

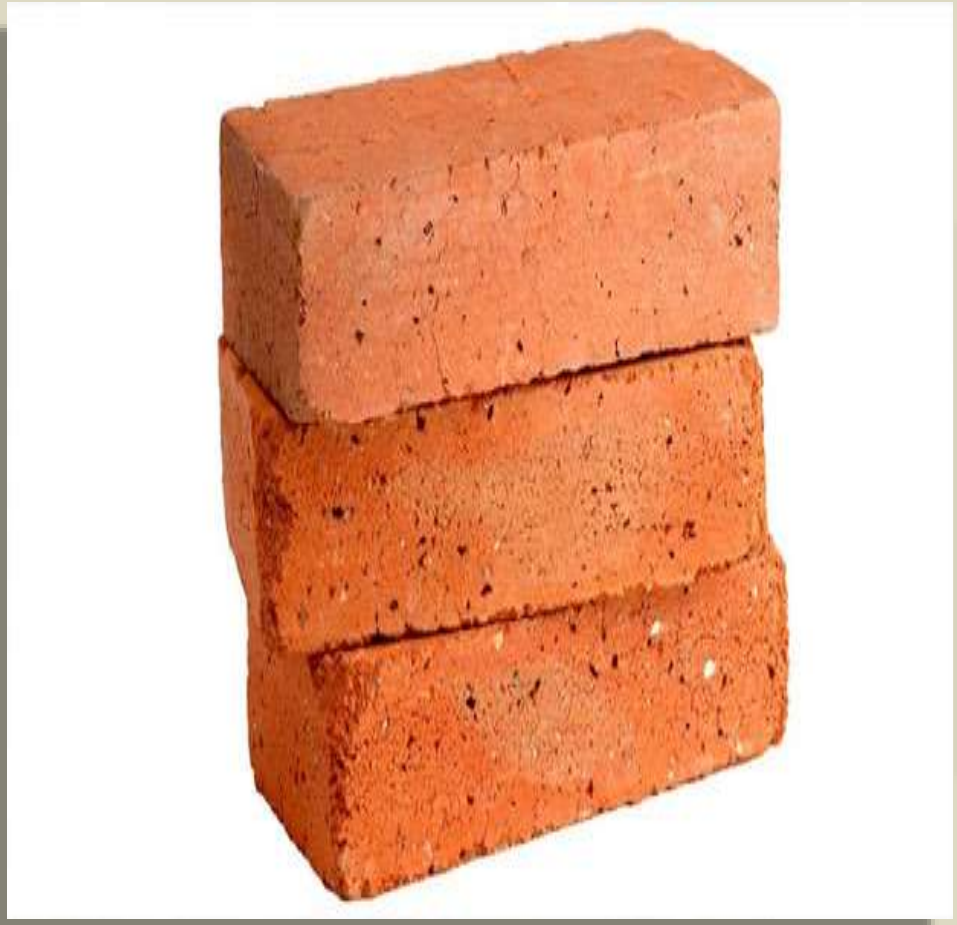
- **These are low grade clays used most for the manufacturing of building bricks and similar clay products. Brick clay are rich in silica, alumina, oxide of iron, calcium, magnesium and organic matter. It is mutual proportion of these components that define their suitability or otherwise for making good quality bricks for building construction.**
- The oxides of iron, calcium and magnesium act as fluxes that fuse easily at brick-making temperature and bind the alumina and silica particles thoroughly giving the brick desired properties of cohesion and strength.

The Brick Clays

Bricks

- **Building bricks may be defined as "Structural units of rectangular shape and convenient size that are made of suitable clays** by different processes involving moulding, drying, and burning.

Bricks



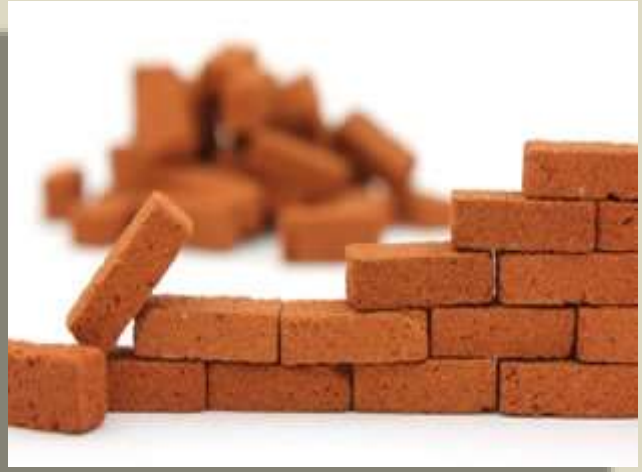
Bricks

- **It is now established that even in remote ancient civilizations bricks were common material of construction.** It is believed that it was in Egypt that bricks were used some 6000 years ago. **Excavation in prehistoric sites in our country has revealed that bricks were used abundantly in Indus valley civilization at Mohan jo daro and Harappa.**

Bricks

Bricks

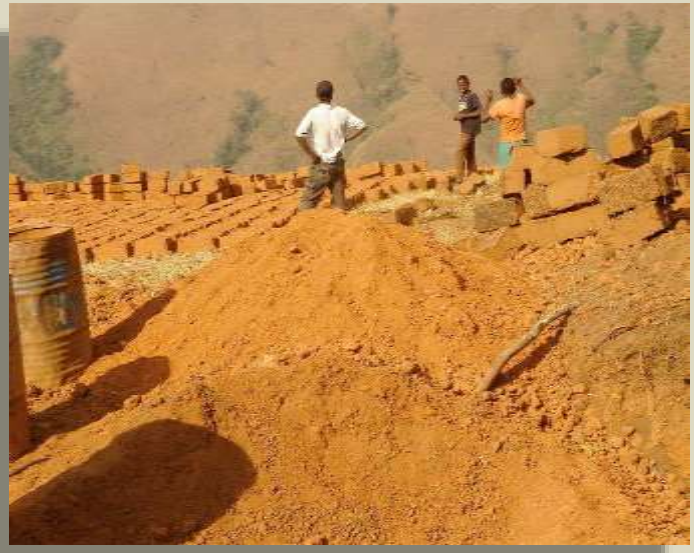
- **Even at present bricks is the most basic and favorable material for common construction throughout the world.** This may be attributed to no of factors:



Bricks

Availability of clay

- **Clay suitable for making bricks are available almost universally. Hence brick making can be adopted anywhere in the world.** This is not true either for stones or for concrete that are material which compete with clay.

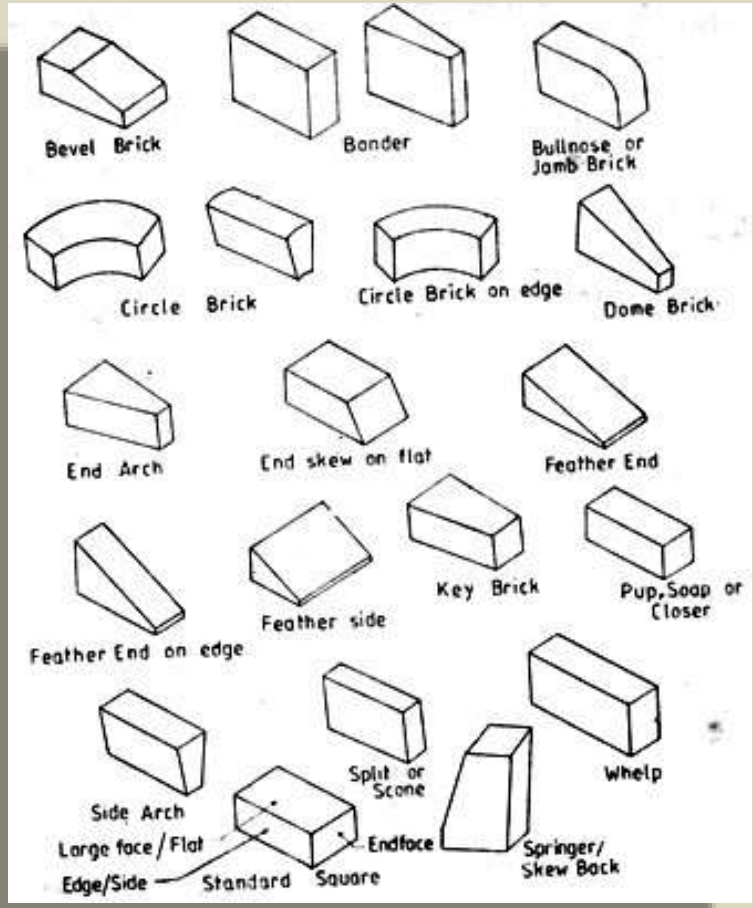


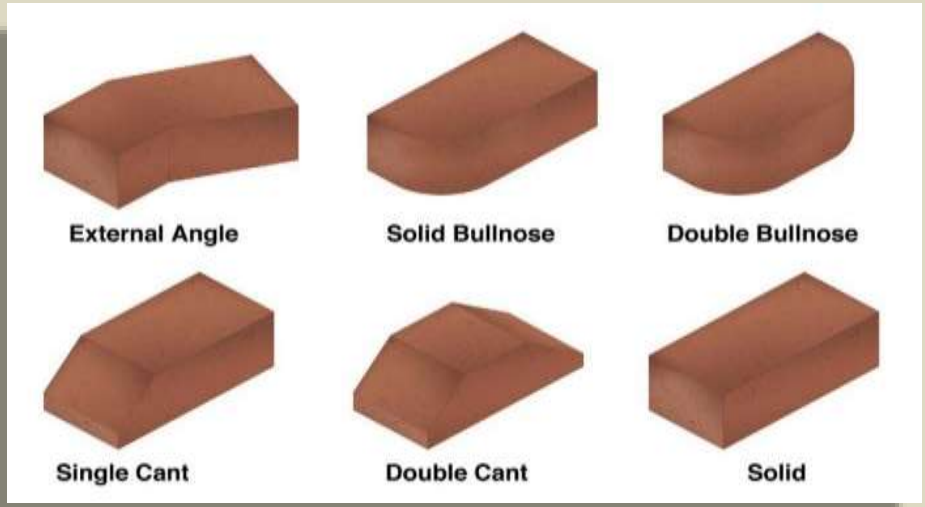
Bricks

Size Shape and handling

- **Bricks are made in ready –to-use sizes and shapes. This affords very convenient handling and use. For stones, however, some dressing is absolutely essential.** In case of concrete, an elaborate formwork and shuttering are basic requirements. Moreover transporting and lying of concrete also requires great care, caution and expertise.

Bricks


Bevel Brick
Bonder
Bullnose or Jamb Brick
Circle
Brick
Circle Brick on edge
Dome Brick
End Arch
End skew on flat
Feather End
Feather End on edge
Feather side
Key Brick
Pup, Soap or Closer
Side Arch
Split or Scone
Whelp
Large face / Flat
Edge/Side
Standard
Square
Endface
Springer/ Skew Back


External Angle
Solid Bullnose
Double Bullnose
Single Cant
Double Cant
Solid

Bricks

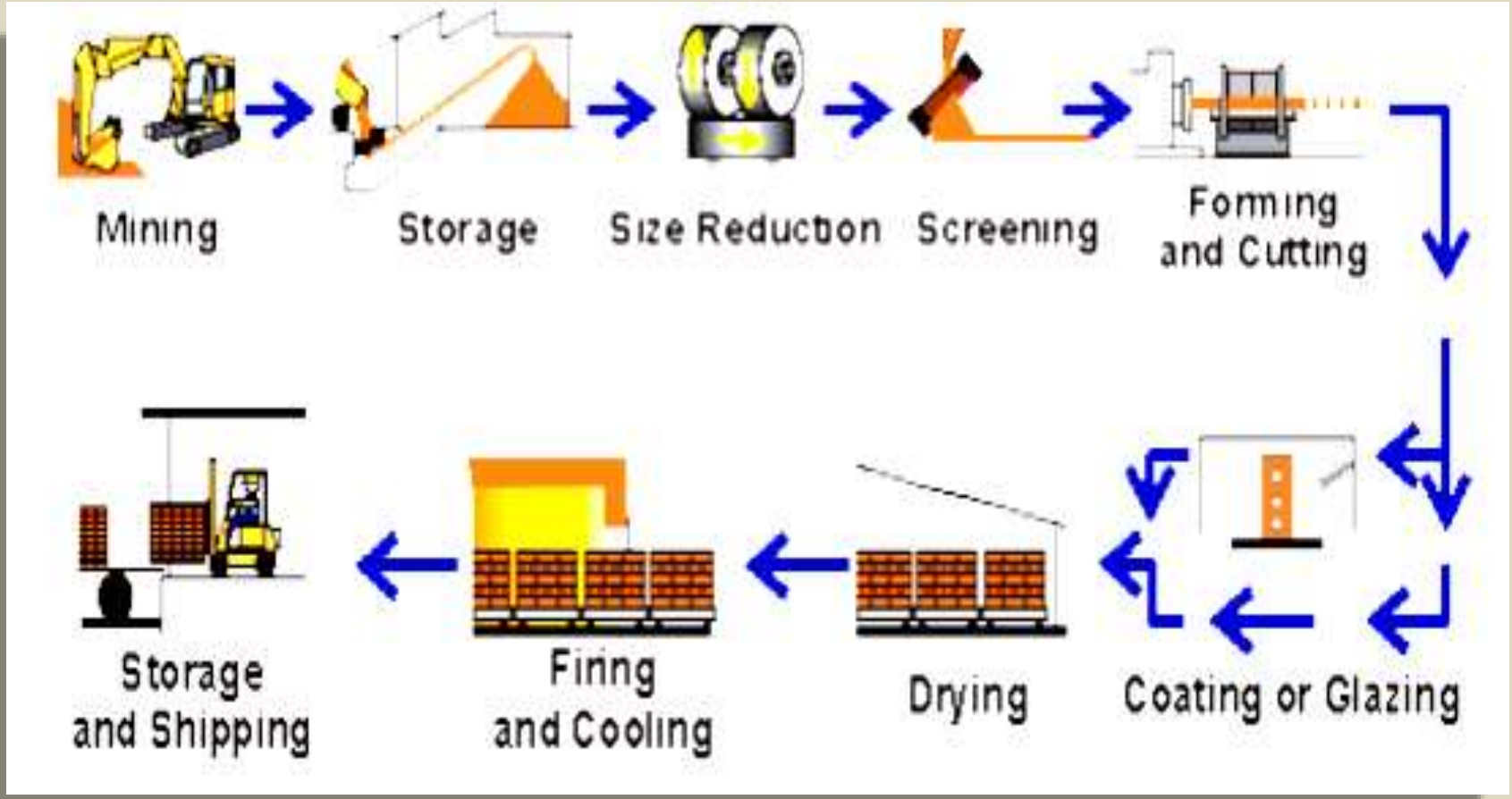
Cost

- **Bricks as also brickwork are cheaper compared to stone masonry and construction with concrete in most cases.** This is because of the factors mentioned under availability. Size and shape and construction methods

Manufacturing of Bricks

- **The process of manufacturing of bricks is carried out in number of stages It Is essential a sequential process.** That is, next stage is reached only when the previous stages have been completed in all respect. **No jumping over or omission of stage is possible. Each stage has its own significance in the process.**

Manufacturing of Bricks



Manufacturing of Bricks

The Stages are listed below:

- Selection of suitable type of clay
- Preparation and tempering of mud
- Moulding of brick units
- Drying of moulded bricks
- Loading of dried bricks in kilns;
- Firing or burning of dried bricks;
- Cooling of the units;
- Unloading of the kiln;

Selection of Suitable Brick Earth

- **A good type of bricks cannot be made from every type of clay.** A suitable brick earth should have the following composition in the desired proportions:
- **1) Alumina (20- 30 %)** All clays are chemically hydrous aluminum silicates. The alumina content is responsible for giving the plastic character to the clay in wet conditions. When alumina content is higher than 30 % the bricks becomes more plastic and also shrink on drying. **But if Alumina Content is Less than 20 %, clay may be difficult to mould to proper shapes. Hence desired content of Alumina is about 20 – 30 %.**

Alumina (20- 30 %)

Selection of Suitable Brick Earth

- **Silica (50- 60 %)**
- **Silica present in Ideal Proportion i.e. 50-60% imparts the qualities of hardness and strength to the bricks.** It is also responsible for resistance against shrinkage and durability of the brick to weather. **However while the proportion of silica are exceptionally high in the clay such bricks when burnt would be quite brittle and porous.**

Selection of Suitable Brick Earth

Selection of Suitable Brick Earth

- **Iron Oxide (4-6%)**
- **This Oxide act as a flux, i.e. it lowers down Softening temperature of Silica and other clay components during firing.** Further, The Iron Oxide in the clays may make their burning difficult and give them yellowish appearance.

Iron Oxide

Selection of Suitable Brick Earth

- **Lime (4-6 %)**
- **This Components make the burning of bricks quicker. Provided,**
- It should not be more than 4 %, because in this case may result in excessive softening of the clay on heating.
- **It must be present only in fine powder form otherwise it may give rise to slaking, which is harmful and may cause slow disintegration of bricks.**

Lime

Selection of Suitable Brick Earth

- **Magnesia**
- Which is invariably associated with lime, has similar effect

Constituents & Desirable quantity	Significance	Effects if Excess quantity	Effects if lesser quantity
Alumina (Al_2O_3) (20-30 %):	plastic character to the clays in wet conditions and resistance against shrinkage on drying	more plastic and shrink more on drying, which may develop cracks in on drying.	clay may be difficult to mould in proper shape
Silica (SiO_2) (50-60 %) free or combined form	Impart hardness and strength to the brick. Prevents the shrinkage, cracking and warping of raw bricks, so imparts uniform shape to the bricks. Durability - depends upon proper composition of silica.	not be mouldable easily and may not burn easily. If burnt, would be quite brittle and porous.	-
Iron oxides ($CaCO_3$) (4-6%)	Acts as flux. Red colour to the burnt bricks	causes brick too soft during the burning stage, so shape is lost	cause burning difficult and also gives yellowish appearance
Lime (Fe_2O_3) (4-6%):	Makes burning and hardening of the bricks quicker. It must be present only in powdered and thoroughly dispersed form. If lime is present as nodules, it may give rise to slaking when brick comes in contact with moisture.	not be more than 5%, because it may result in excessive softening of clay on heating	-
Magnesia (1% or less)	Similar effect like lime so total percentage should be consider, provides a yellow tint to the bricks	-	-

Undesirable Components

brick clay should be free from the following components:

The lime modules:

- **obstruct the proper burning, when bricks are placed in kiln.**
- **If it present, then burnt bricks** are likely to **cause disintegration of bricks** by their slaking action.

The organic matter:

- **Roots of grasses, leaves and other organic matter, which produces carbon** on burning within the body of brick.
- **Brick darker in appearance and too porous in nature**, remove in preparation stage.

Undesirable Components

Sulphides and sulphates:

- **Iron sulphide in form of pyrite and alkalkies in form of potash and soda are often present in some clays.**
- Iron sulphide causes disintegration of the brick during burning stage itself.

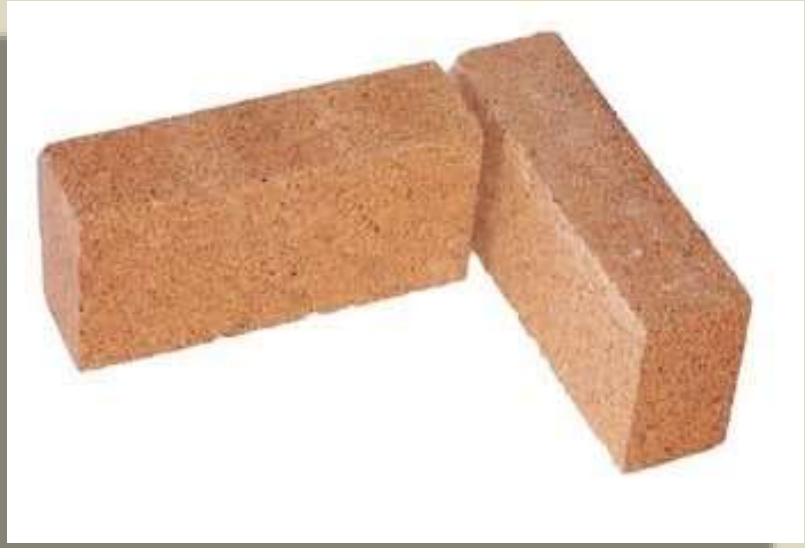
The alkali salts:

- **Act as fluxes during burning and create additional softening**.
- **If it is present in burnt bricks, it absorbs the moisture from the atmosphere** and form the solution within the body of brick.
- On evaporation, these solution form white patches. This effect is called efflorescence.

Field Tests For Brick Earth

- **When the manufacture of brick is on large scale, it is always advisable to go through survey of deposits of clays which include mapping of area** for considerable depth Analysis of chemical composition testing the engineering properties of the specimen made from such earth.
- **Such survey assure the total quantity and quality of the clay.**

Field Tests For Brick Earth



Field Tests For Brick Earth

Test for consistency

- **Small sized balls are made from the soils** by mixing it with appropriate quantities of sand and water.
- **Balls are allowed to air dry under a shaded place.**
- **When they are completely dry, each ball is observed for its shape, size and appearance of any cracks.**
- **If soil is of suitable type, it will not show any deformation or crack in them.**
- **If some shrinkage is there, we may vary the mutual proportions of soil, sand and water and observed again.**
- **By varying these proportion, a right proportion is found for making good quality bricks.**
- **If negative results are obtained in all the trials, it means the brick clay is not suitable.**

Test For Consistency

Test For Moulding Properties

- **Test is performed on the soil which have passed the consistency test.**
- **Soil is thoroughly mixed after adding some more water for preparing homogeneous mud.**
- **Thin threads, about 3-4 mm thick are made by rolling between the palms of two hands from small amount of mud paste.**
- **Length of such threads indicates good plastic nature of the soil.**
- **Longer and thinner the threads, the soil is of good plasticity and threads break quickly on rolling in non-plastic type of clays.**
- **Test bricks are made from such paste and allowed to dry. If the corners, edges and surface shape remain intact even after drying, then clay is described as satisfactory.**

Field Tests For Brick Earth

Test to determine deformation on burning

- **Test helps in finding out approximate ratio of fluxes in the clays.**
- Test bricks are made from the mud prepared in first two cases.
- This bricks are air-dried.
- Burnt in a potter's kiln for three to five days and cooled in air
- The clays are of satisfactory quality when bricks show
  - ***Typical red colour***
  - ***Have maintained their dimensions at corners and edges***
  - ***Have burnt uniformly***
- **If burnt bricks shows defects like warping of surfaces, twisting at edges and swelling at places, the brick clay is considered defective and unsuitable for making good bricks.**

Test to determine deformation on burning

Field Tests For Brick Earth

Strength tests:

- If clays passes above all the tests, then only this test is carried out.
- Field test involves dropping the properly burnt bricks, one by one, from a height of 2-3 meters on hard dry ground below.
- If brick is of good quality, then it should easily withstand this shock without breaking.
- If brick is of poor quality, then it break easily on falling from such heights.

Strength tests

Preparation Of Mud

Winning:

- **Obtain brick earth from its natural deposit**.
- **Clear off from vegetation**, pebbles and other organic matter.
- **Manual digging or mechanical excavation** are used to obtain dry soil or brick matter.
- **Clay is spread on even ground for seasoning** so that clay is exposed to atmosphere for good time.
- **At this stage, earth is further cleaned off any pebbles**, stones lime nodules and visible organic matter.
- **The seasoned clay is ready for making mud** by mixing with adequate amount of water.

Winning

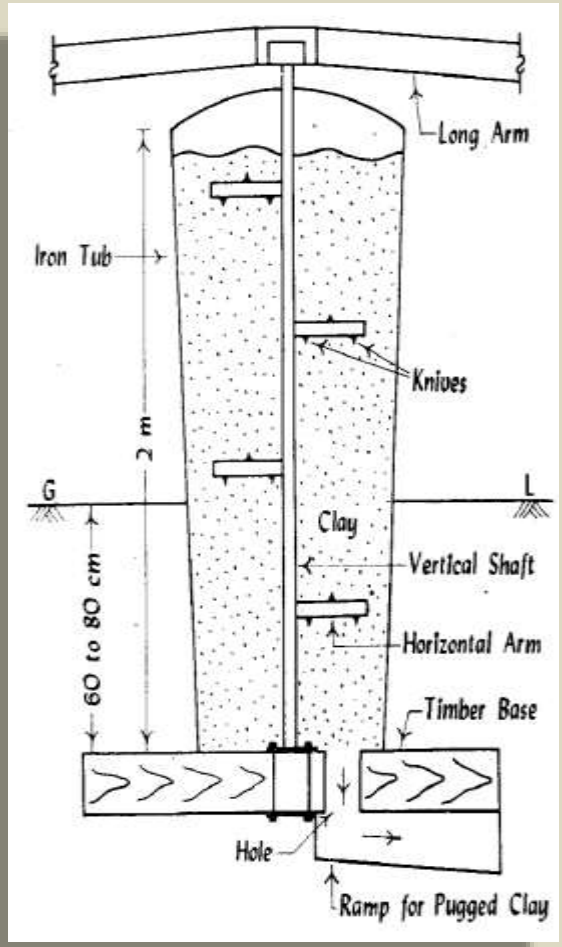
Preparation Of Mud

- **Tempering**: Converting the brick earth to mud of proper consistency by thoroughly mixing with desired quantities of water.
- **Manual tempering:** Clay is spread on a platform and thoroughly mixed under feet of either man or cattle.
- Water is added gradually in small quantities till desired homogeneity and plasticity are obtained.
- **Pug mill tempering (pugging):** mechanical device called pug mill.

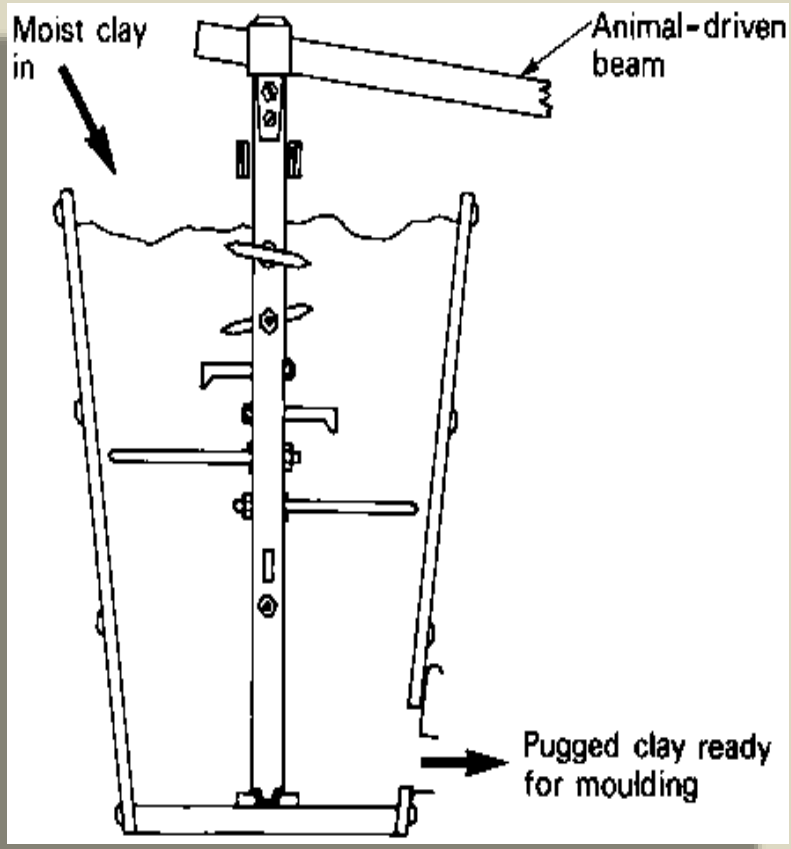
Manual Tempering

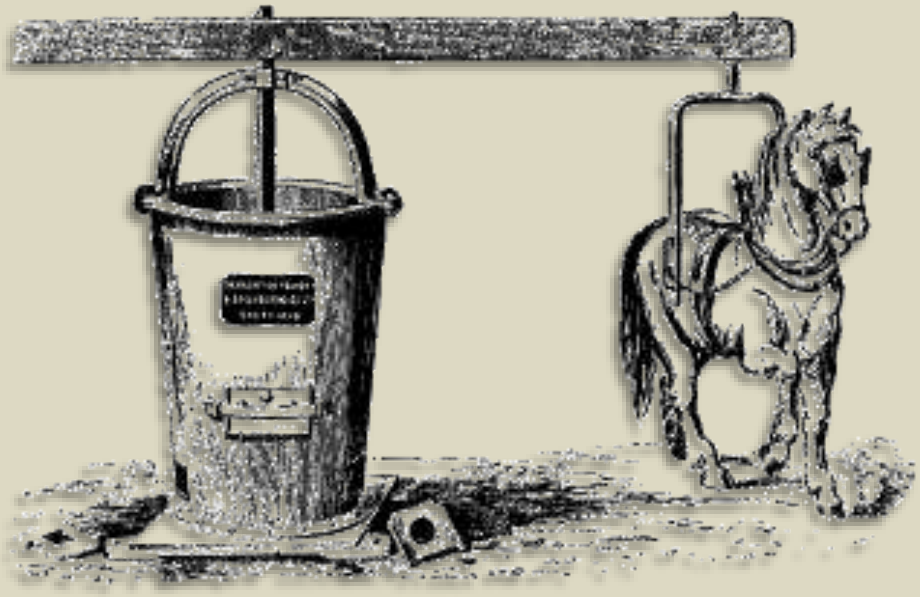
Pug Mill Tempering

- **A simple pug mill** consist of steel cylinder covered at top and hole at or near the bottom.
- **Most important part of pug mill is a central vertical shaft provided at the base** which can be rotated with the help of long arm through animal or motor power.
- **Central shaft is attached with the horizontal blades, each carries some knives.**
- **Seasoned clay and water are added from an opening provided at the top.**
- **The churning effect to the clay-water mixture, that is converted into mud of desired plasticity and consistency.**
- The mud is then taken out from the hole at the base and new charge is field.



Pug Mill Tempering





Moulding Of Bricks

- **Moulding:** is the process of making green bricks of proper shape and size from thoroughly tempered clay.
- **Two Main Methods**: hand moulding and machine moulding.

Moulding Of Bricks

- **Hand Moulding:** Using skilled manpower.
- Most common method in India.
- The quality of tempered clay is kept soft.
- More water content (18-25% by weight). So, we can call this method as soft mud process.
- **Ground moulding**: bricks are shaped from such a soft mud by hand on a specially prepared ground.
- **Table moulding**: bricks are shaped from such a soft mud by hand on a specially designed table.

Moulding Of Bricks

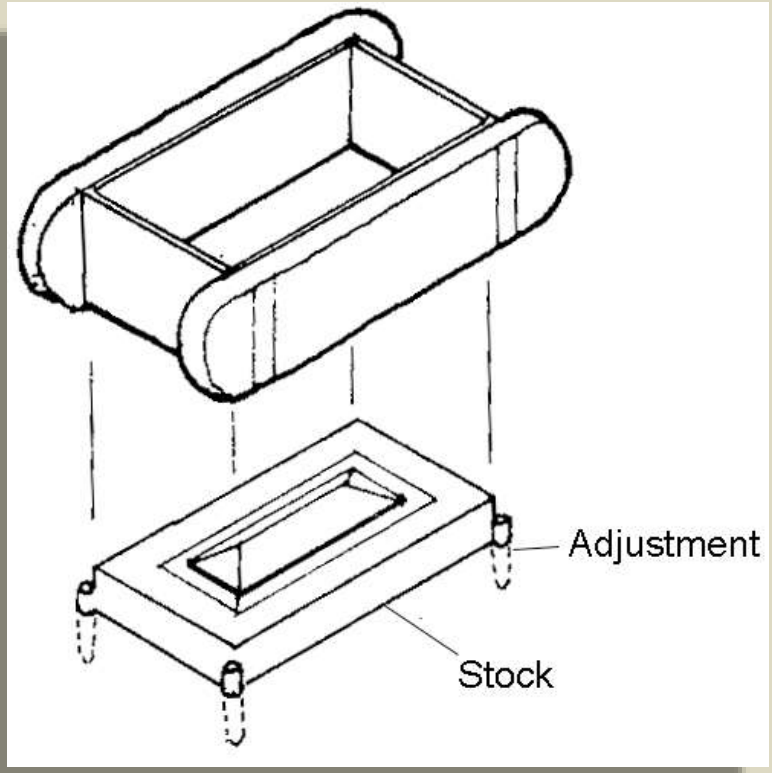
Table Moulding

Tools For Hand Moulding

- **A brick mould:**
  - **wood or steel.**
  - **Its inside dimensions are kept slightly bigger than the desired dimensions of finished brick** because bricks on drying are liable to shrink in size.
  - It may be a single unit or a multiple unit type.
- **The stock board (moulding board):**
  - **Small wooden board with raised central projection carrying the identification marks (frog)** of the manufacturer.

A Brick Mould

The Stock Board (Moulding Board)



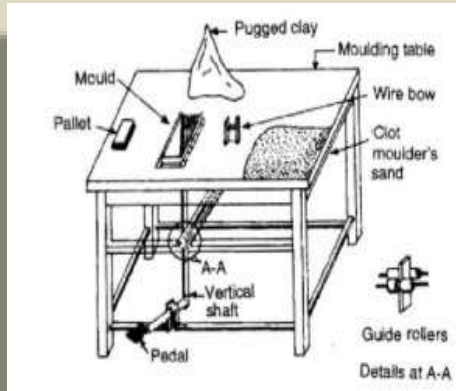


Fig. 9(a) Brick Moulding Table

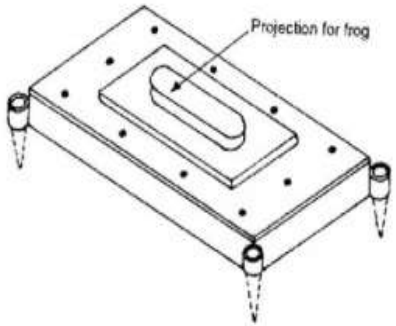


Fig. 9(b) Stock Board

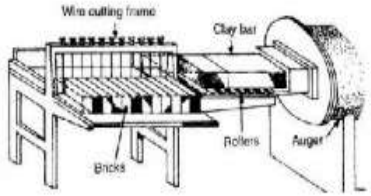
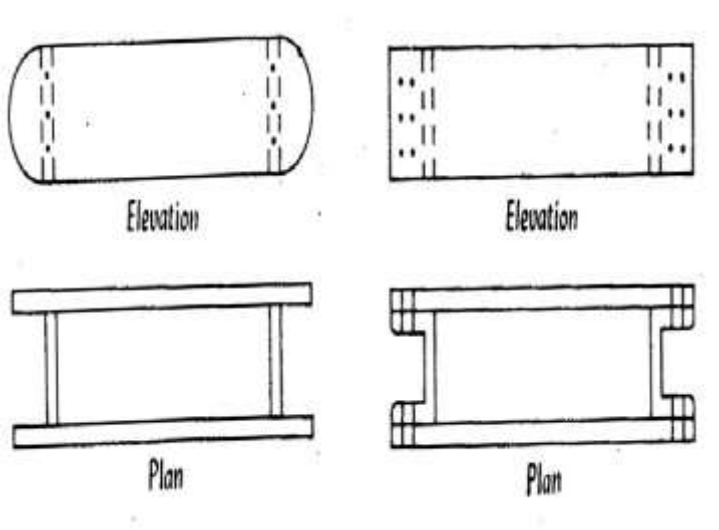


Fig. 10 Plastic Moulding

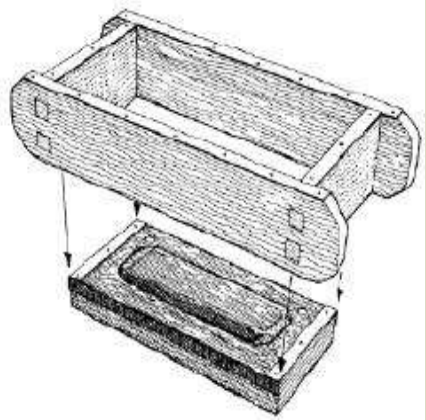
Tools For Hand Moulding

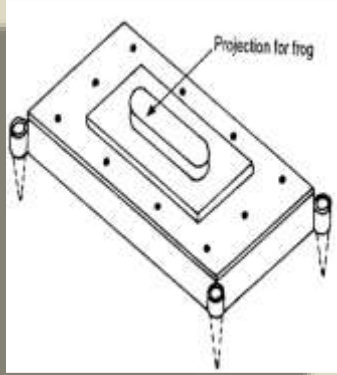
- **The Pallets:**
  - **Thin wooden plates used for handling the green bricks from the moulding boards to the drying field.**
- **The Strike:**
  - Wood or metal
  - **Has its one edge quite thin to slash surplus mud from the top of the moulded brick, while it is in the mould.**
  - Sometimes a thin wire strung in a wooden block for holding is used for the same purpose, it is called cutting wire.

Tools For Hand Moulding

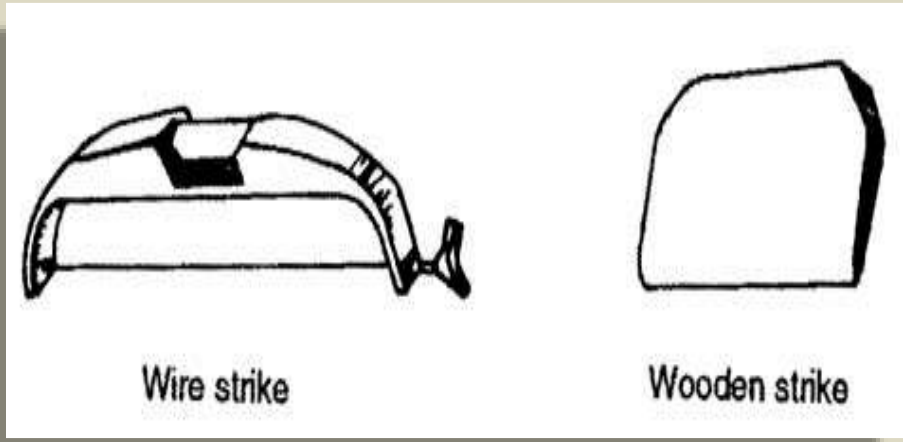


Wooden mould & Steel mould





Stock board



Ground Moulding

- **Common method of moulding bricks in India**
- A stretch of land is first flattened, levelling and cleaned and made smooth by mud plastering.
- Some sand is sprinkled uniformly over it to make it non-sticky.

Ground Moulding

Ground Moulding

(a) For making ordinary bricks:

- **Mould is either dipped in water (slop moulding) or some sand is sprinkled on its inside surface (sand moulding).**
- Mould is placed on the ground at desired spot.
- **Lump of mud is dashed into the mould by hand. Mud should reaches to the sides and corners of the mould.**
- **Any surplus mud is removed by using the strike or the cutting wire.**
- **The mould is then lifted up with a jerk and leaves behind the moulded brick** on the ground below.

Ground Moulding

- **Moulding bricks with frog (pallet moulding)**
  - **By using a stock board and pallets.**
  - **The stock board is provided with a raised projection carrying the identification mark.**
  - **The mould is placed on the stock board (instead of ground) and a brick is moulded.**
  - The brick is then taken away using two pallet to the drying field.

Ground Moulding

- **Frog: an identification mark during the moulding stage with the help of a stock board.** It serves following purposes:
  - The name of the manufacture of the brick is easily found and can be known for the quality of the brick.
  - **The frog-faced side is placed upward during use, which accommodates some extra mortar, which develops structural grip between upper and lower brick.**

Frog

Table Moulding

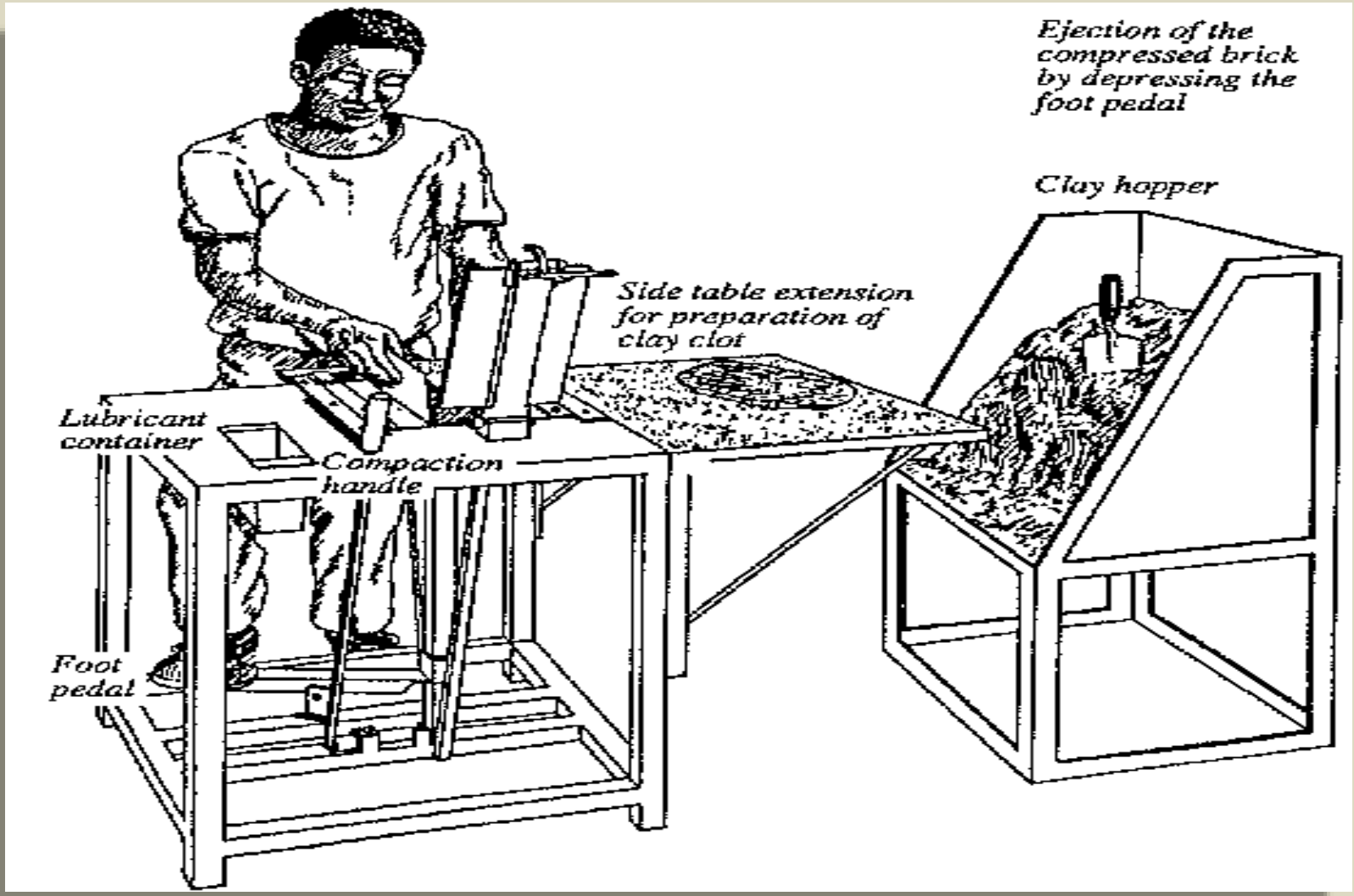
- **The skilled worker – moulder carries out all the moulding operations on a specially designed table of suitable dimensions.**
- **Table is large enough to accommodate all the materials required in hand moulding such as stock board, moulds, cutting edge, water, sand and tempered mud.**

Table Moulding

Table Moulding

- **Process is similar to pallet moulding on ground.**
- **The moulder is placed on the stock board and then sprinkles some sand inside the surface of mould.**
- **Dashes a lump of mud into it, press it thoroughly and skillfully.**
- Cuts away any surplus mud with the strike or the cutting edge.
- Places a pallet over the mould and turn it over.
- The moulded brick is transferred to the pallet, which is carried away by a helper.
- **This process is repeated for each brick.**
- **Initial cost is slightly higher than ground moulding but more efficient and economical in the long run because production is better in quality and quantity.**

Table Moulding



Machine Moulding

- **Essential process in all mechanized brick making plants.**
- **Cheaper in longer run and gives uniform quality brick.**
- **Main two methods: Stiff mud method and Dry process method.**
- **Stiff mud method:** Small quantity of water (8-12 % by volume) is added to the clay to create plasticity.
- This stiff mix is made to pass out under pressure from moulding machine.

Machine Moulding

Machine Moulding

- Two versions of machines can be used such as:
  - **Worm gear moulding machine**
  - **A vacuum press for brick moulding.**

Worm gear moulding machine: consists of

- **A feeding chamber provided with a worm gear to apply pressure.**
- **A hopper at the top to receive the clay mix from the pug mill**
- A fixed die provided at the front narrow end
- A conveyor belt on a set of rollers
- Cutting wire device adjusted in front of the die

Worm Gear Moulding Machine

The operation steps on machine consist of

- Feeding the properly mixed stiff mud into the chamber through the hopper
- Forcing forward the mud charge using the worm gear.

The pressed mud comes out through the die in the form of continuous rectangular ribbon having the height and width of the bricks.

This ribbon gets cut into brick lengths by pressing down the cutting wire device, when the conveyor belt is under the device.

Capacity of machine: 1000 – 2000 units per hour or more depending upon the machine.

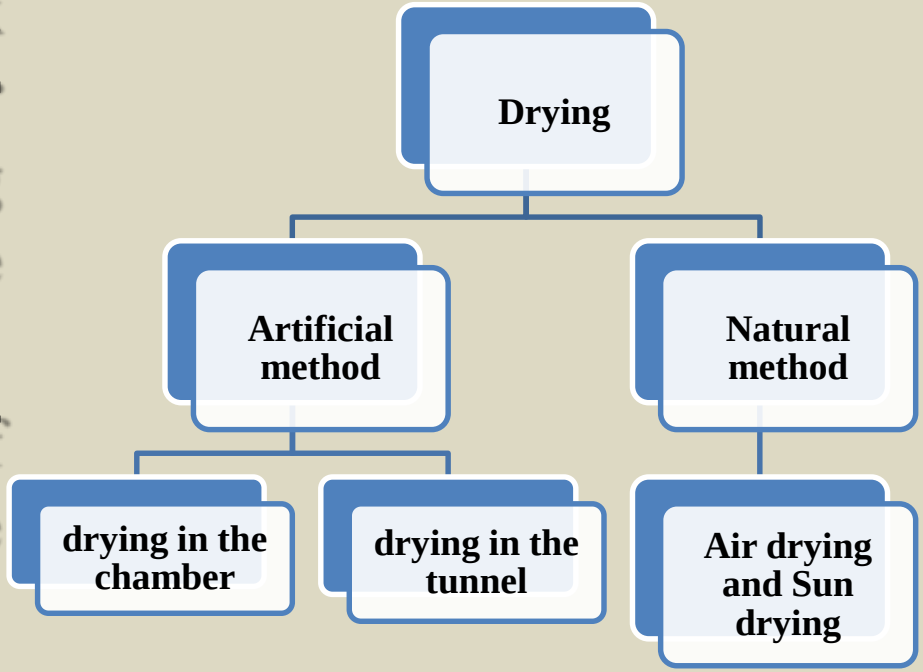
Worm Gear Moulding Machine

Machine Moulding

- **Dry press process: a very small quantity of water is added to finely crushed and thoroughly cleaned batch of clay.**
- Mix is almost dry, at best damp.
- **Such damp clay is fed through hoppers to special brick** moulds.
- **Pressure - 50-150 Kg/cm^2 through hydraulic presses.**
- **This pressure is sufficient enough to convert the loose damp clay mass into dense and very compact** brick unit.
- Brick is removed from the mould.
- These bricks are having perfect shapes on all the sides, edges and corners.
- Such bricks are also called as **pressed bricks.**

Drying Of Bricks

- **Reasons To Dry The Green Bricks:**
  - **To Make Green Brick Strong Enough To Bear Rough Handling During Stacking In The Kiln For Burning.**
  - To Allow Loss Of Moisture At A Slow Rate To Avoid Disintegration.
  - To Save Fuel During Burning Stage.



Drying Of Bricks

Drying Of Bricks

- **Natural method (stacking method): there are two different stages involved in the drying process such as:**

1) **Pre stacking stage:** Moulded bricks are laid sidewise and flat wise for 2 – 3 days in the drying fields. **So, that they become hard enough to handle for stacking in heaps.**
2) **Stacking stage:** Bricks are arranged in the layers (100 cm wide and 10 brick layer height) by skilled workers.

- **Staking is done in specially prepared drying ground.**
- **Enough space is left in between the individual bricks and between layers.**

Natural method (stacking method)

Drying Of Bricks

- **Artificial drying: essential in mechanized brick making unit.**
- Independent of weather condition.

Chamber Drying:

- **Arrange in stacks in drying chamber by keeping sufficient spaces for free circulation of hot air around them.**
- **Hot air is circulated under control condition of temperature and humidity.**
- **2 – 4 days or more, and then next batch is stacked.**

Chamber Drying

Drying Of Bricks

Tunnel drying:

- **Bricks are stacked on mobile cars that are made on travel** on rails within a specially designed drying tunnel.
- **The tunnel is divided into compartments and each car is made to stay in a particular compartment** for pre-fixed duration.
- The cars come out from other end.
- **2 – 3 days for a car load of bricks to dry to desired extent.**

Tunnel Drying

Burning Of Bricks

- **Absolutely essential to develop in brick making the desired building properties such as sufficient strength, hardness, durability and resistance to decay and disintegration.**

Burning Of Bricks

Burning Of Bricks

- **3 chemical changes take place during burning process**:
- **Dehydration:** complete removal of water from the pores of the bricks.
  - **Completed at the temperature range of 425 – 765^{0}C.**
  - Losses all the free water.

Burning Of Bricks

- **Oxidation:** it start taking place during heating of the bricks at the **above temperature and gets completed at about 650^0C-900^0C.**
  - **All the organic matter in the brick earth gets oxidized. Carbon and sulphur are eliminated as oxides.**
  - Fluxes (lime, magnesia, iron) become reactive at these temperature.
  - Brick acquires the red colour due to the oxidation of iron in the clay.

Burning Of Bricks

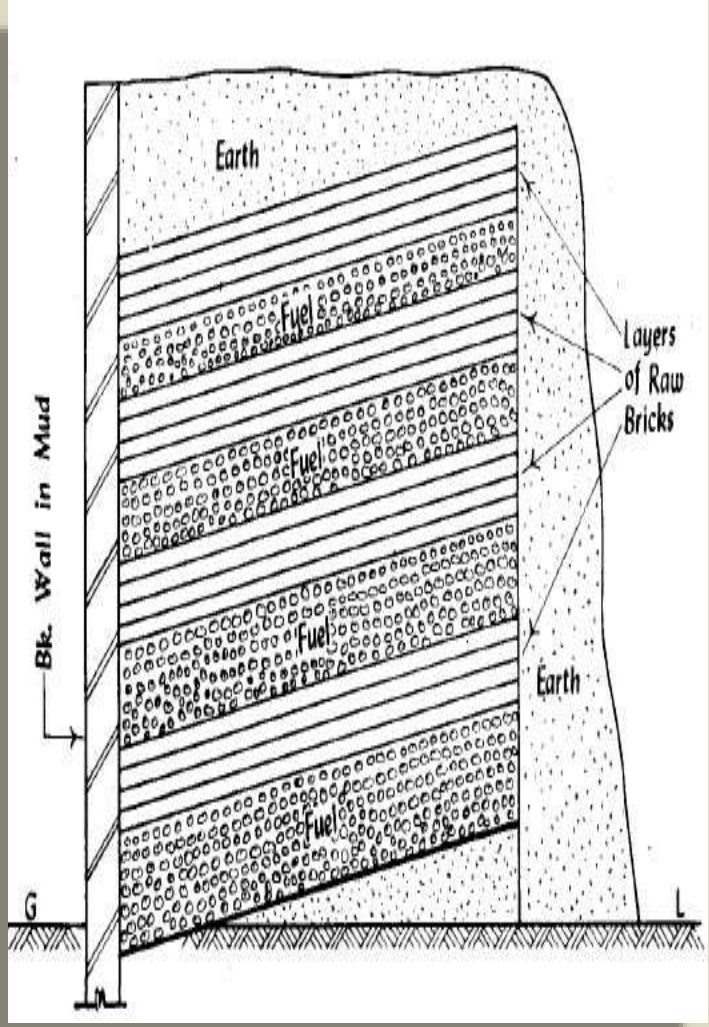
- **Vitrification**: last reaction takes place at temperature **range of 900^0C to 1100^0C.**
  - **The alumina and silica start softening in the presence of the fluxing compounds.**
  - **The constituent grains get bound firmly.**

Burning Of Bricks

- **Bricks can be burnt using the following methods:**

(a) Clamp Burning

(b) Kiln Burning

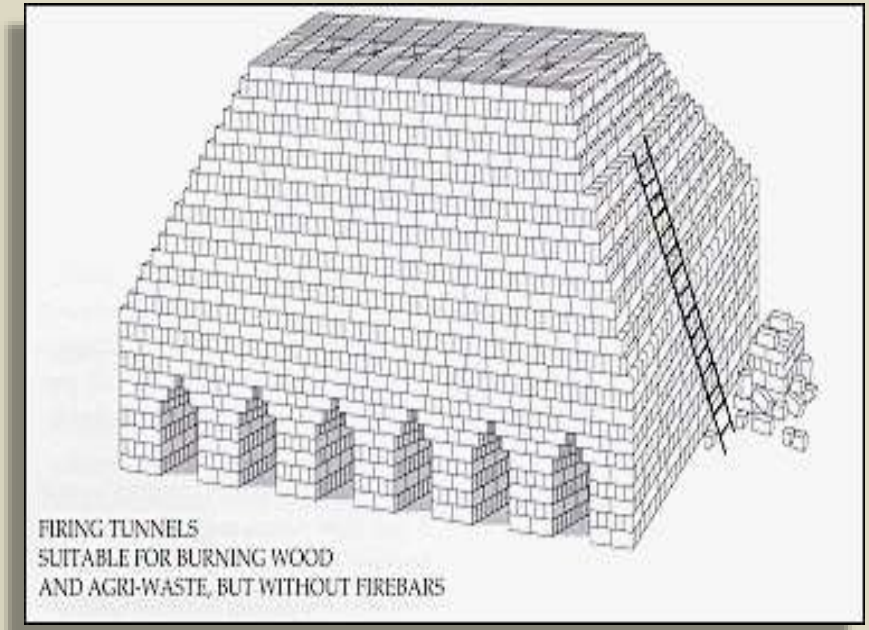


Burning Of Bricks

Clamp Burning:

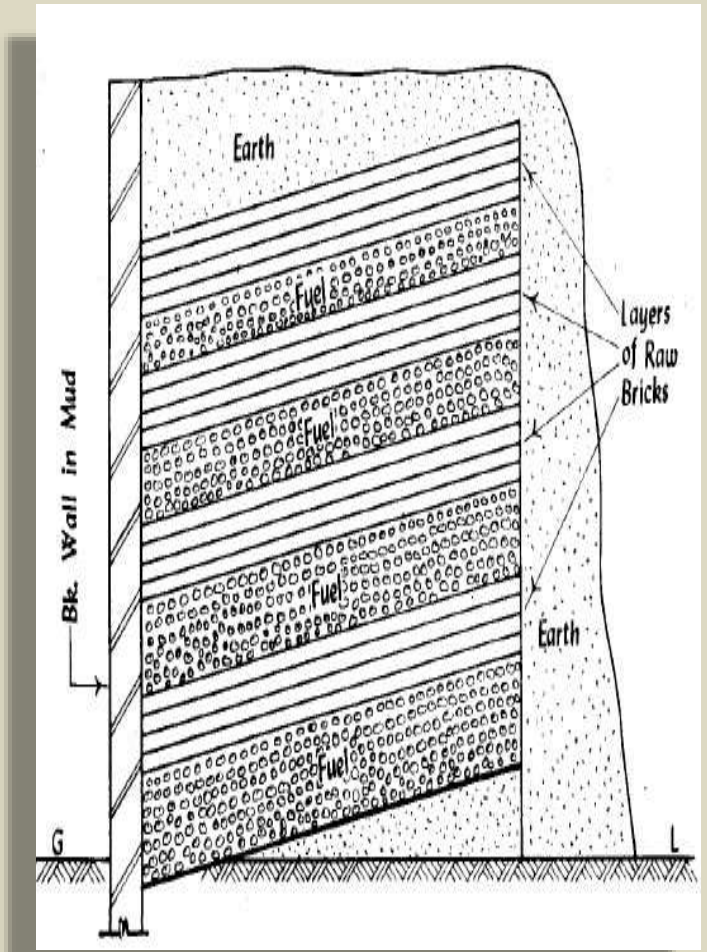
- **(Open kiln or Pazawah)**
  - **Temporary structure, constructed over the ground**
  - **Height - about 4 to 6 m.**
  - Used for lower scale bricks, not suitable in monsoon season.
  - **Trapezoidal in plan, whose shorter edge among the parallel sides is below the ground and slope angle of about 15^{0}**
  - **A vertical brick and mud wall is constructed at the lower edge to support the stack of the brick.**

Clamp Burning



Burning Of Bricks

- **Clamp Burning:**
- **(Open kiln or Pazawah)**
  - **First layer - fuel is laid as the bottom most layer with the coal, wood and other locally available material like cow dung and husk.**
  - Another layer - 4 to 5 rows of bricks
  - Then again a fuel layer is laid over it.
  - Thickness of the fuel layer decreases with the height of the clamp.
  - Top surface - covered with the mud so as to preserve the heat.
  - Fire is ignited at the bottom, once fire is started **it is kept under fire by itself for one or two months and same time period is needed for the cooling of the bricks.**
  - **In a clamp of 10 m * 7.5 m sides, about one-lakh bricks can be burnt in two months.**



Burning Of Bricks

- **Advantages of Clamp Burning:**
  - **Easy to erect and operate**
  - **Any type of fuel can be used**
  - Not requires skilled labour and least supervision after burning
  - **Economical**
  - **Clamp is not liable to injury from high wind or rain**

Burning Of Bricks

- **Disadvantages of Clamp Burning:**
  - **Burning of bricks is not uniform**, such as bricks at the bottom are over-burnt while at the top are under-burnt.
  - **Bricks loose their shape**, and reason may be their descending downward once the fuel layer is burnt.
  - **This method can not employed for the manufacturing of large number of bricks** and it is costly in terms of fuel because large amount of heat is wasted.
  - **It can not be employed in monsoon season.**
  - **Time required for burning is too long.**
  - **No possibility to regulate heat, once it start burning.**

Burning Of Bricks (Kiln Burning)

- **Kilns are permanent structures, used for burning.**
- **Fuel - Coal and other locally available materials like wood, cow dung etc.**
- **Two types based on their principle of construction:**

Burning Of Bricks (Kiln Burning)

Intermittent Kilns: periodic kilns, only one process can take place at one time.

- **The brick supply from such kilns is intermittent and not continuous.**
- **e.g. The Allahabad kiln**

Continuous Kilns: **possible to get supply of bricks almost continuously**.

- **Used when the bricks are demanded in larger scale and in short time.**
- Operations in these chambers are so controlled that at any given time, when one chamber is in the loading process, another chamber may be in burning stage, third chamber in the preheating stage, fourth chamber in the cooling stage and fifth chamber in the unloading or supply stage.
- **e.g. The Bull's trench kiln, The Hoffman's continuous kiln, The Tunnel kiln.**

Burning Of Bricks
(Kiln Burning)

Intermittent Kiln

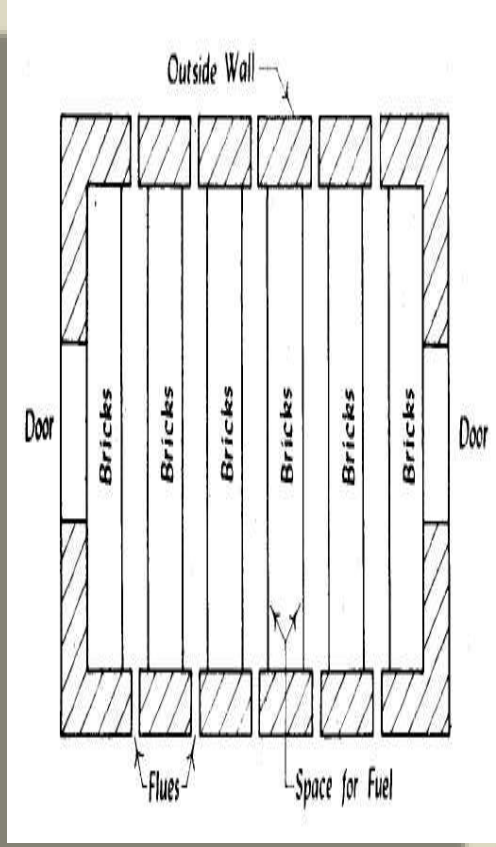
- **Rectangular, Four Permanent Walls.**
- **Totally Underground Or Partly Underground And Partly Over Ground.**
- **The Longer Walls Are Raised Perpendicular To The Direction Of Prevailing Winds.**
- Provided With Number Of Opening Called Flues (F), Exactly Opposite To Each Other For Charging Fuels And Controlling Air.
- Openings Are Provided With Door Sheets, Which Can Be Raised Or Lowered.
- The Shorter Walls Are Provided With Doors For Loading And Unloading The Bricks.
- There Are Four Stages In The Working Of Kiln:
  - **Loading**
  - **Firing**
  - **Cooling**
  - **Unloading**

Intermittent Kiln

Burning Of Bricks (Kiln Burning)

Loading: dried bricks are laid in rows on the raised portions.

- **Each row - two to three brick thick.**
- **Height - 8 to 10 brick layers.**
- **Brick laying in such a manner that make arch-shaped opening for,**
  a) supply of fuel b) supply of air
- While staking, some space is provided between individual bricks for circulation of air around each brick.
- Top layer - covered with thick layer of dry earth, which helps in preventing escape of heat from the kiln during the burning process.



Burning Of Bricks
(Kiln Burning)

Firing: After loading, fuel is supplied in the opening at the base, is fired through the arch shaped opening provided for this purpose.

- Low fires: 1 – 2 days for removing moisture left in the brick during the process of drying.
- **Firing is brought to full strength.**
- **The flames spread upward baking and burning the bricks stacked within the body of the kiln in 2 – 3 days time.**

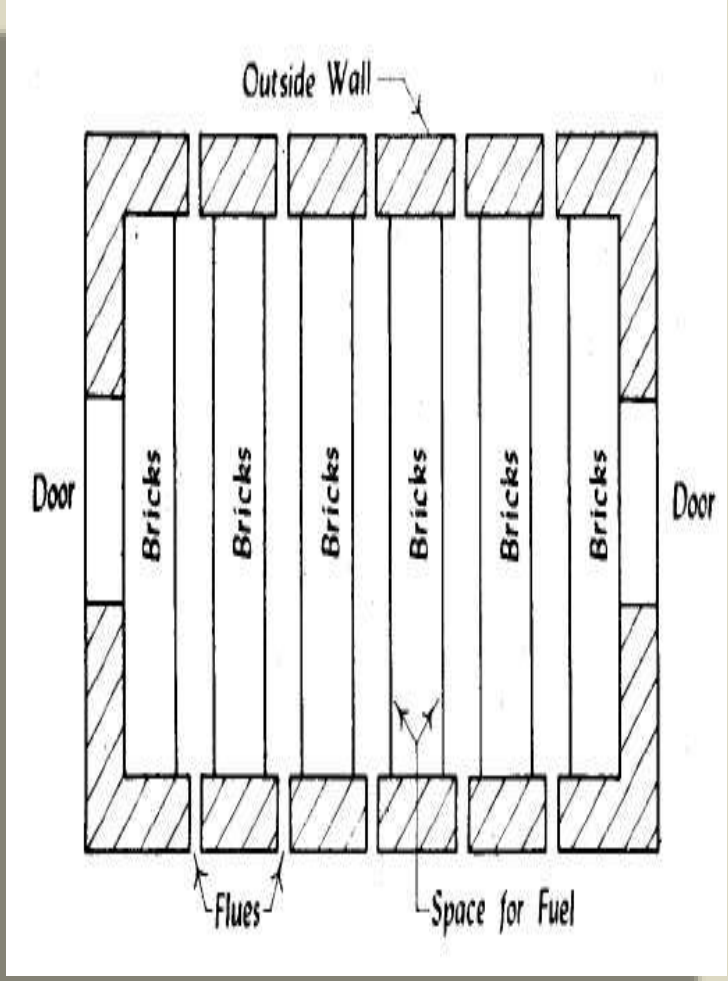
Burning Of Bricks (Kiln Burning)

Cooling: After visual inspection and ensuring that all the fuel has been burnt, the kiln openings are closed for 7 – 10 days, which helps in natural slow cooling of the burnt lot of bricks.

- **Slow cooling is essential for avoiding development of cracks in the cooling bricks.**
- **If cooling at fast rate, cracks are likely to occur and spoil the brick.**

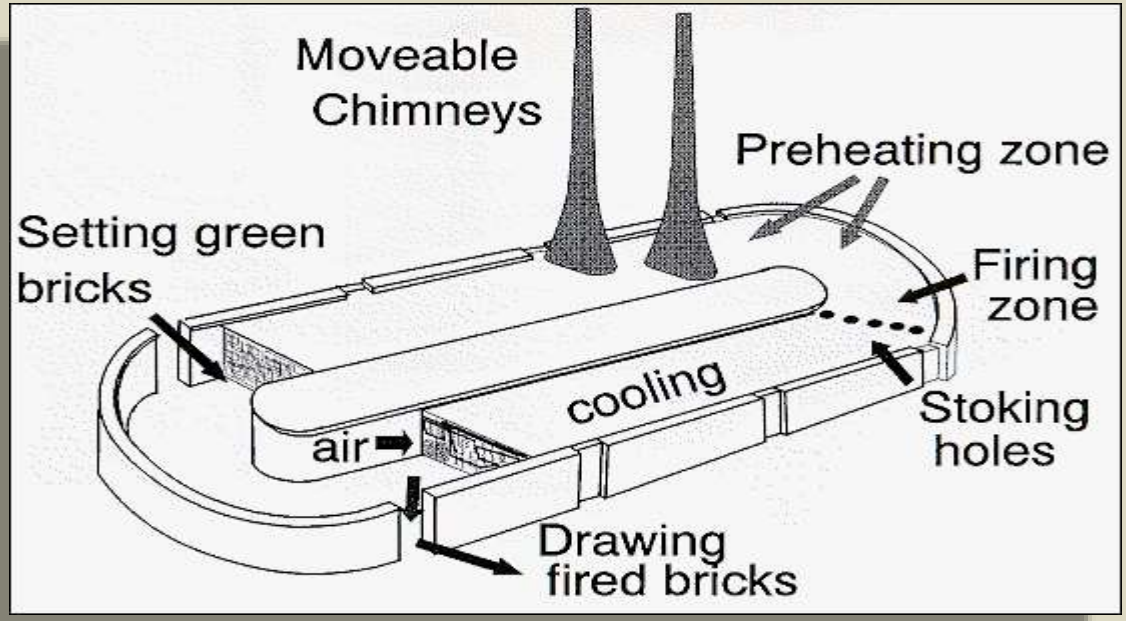
Unloading: after sufficient cooling, the top layer of the dust is removed.

- **Burnt bricks are removed from the top layer to downwards.**
- **The entire kiln is emptied and thoroughly clean for loading next batch.**



Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)

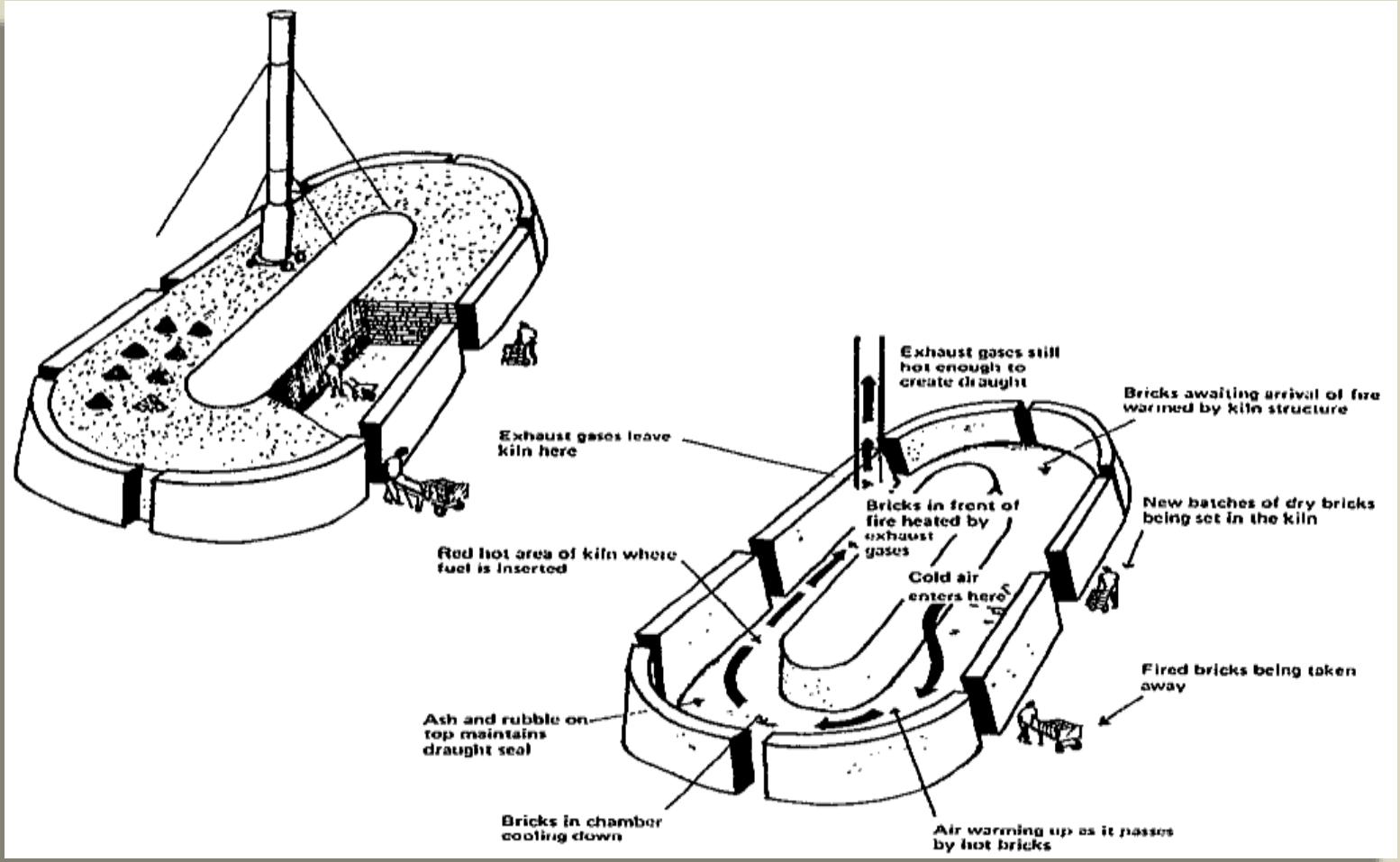
- **Principle**: continuous type of kiln.
- **Number of compartments, which can be operated in sequential process.**
- **Possible to obtain a regular supply of burnt bricks.**



Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)

- **Construction: rectangular, circular or oval shape in the plan.**
- Below the ground level by excavating a trench of the required width for the given capacity of brick manufacturing.
- **Range of dimension of trench depending upon the desired capacity of the bricks:**
  - **Length: 50 – 78m**
  - **Width: 6 – 8 m**
  - **Depth: 1 – 2 m**
- **A typical trench kiln has two walls:**
  - Inner wall - continuous and close contact with the inner land part.
  - Outer wall - number of openings or gates provided with dampers or doors which can be opened or closed.

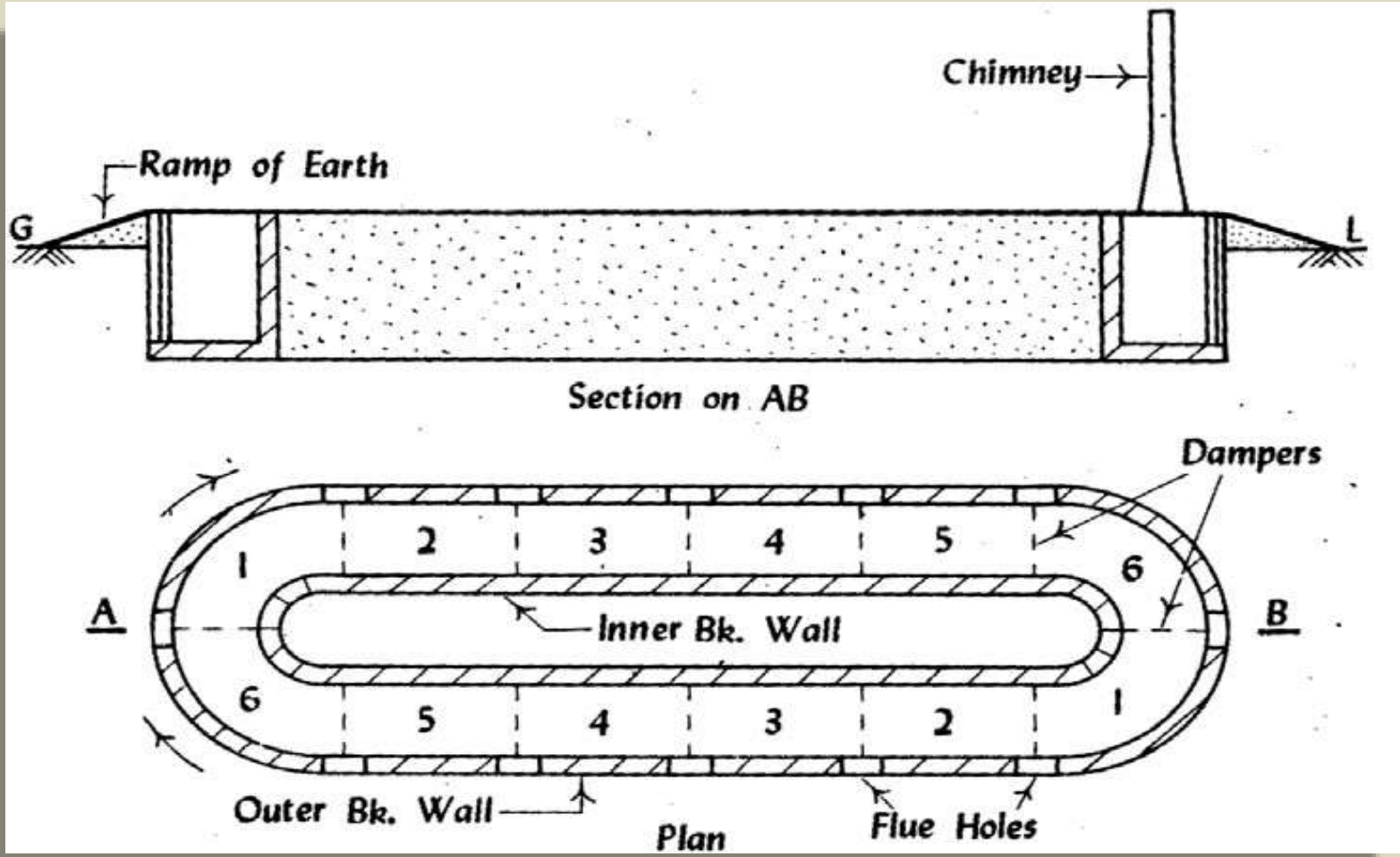
Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)



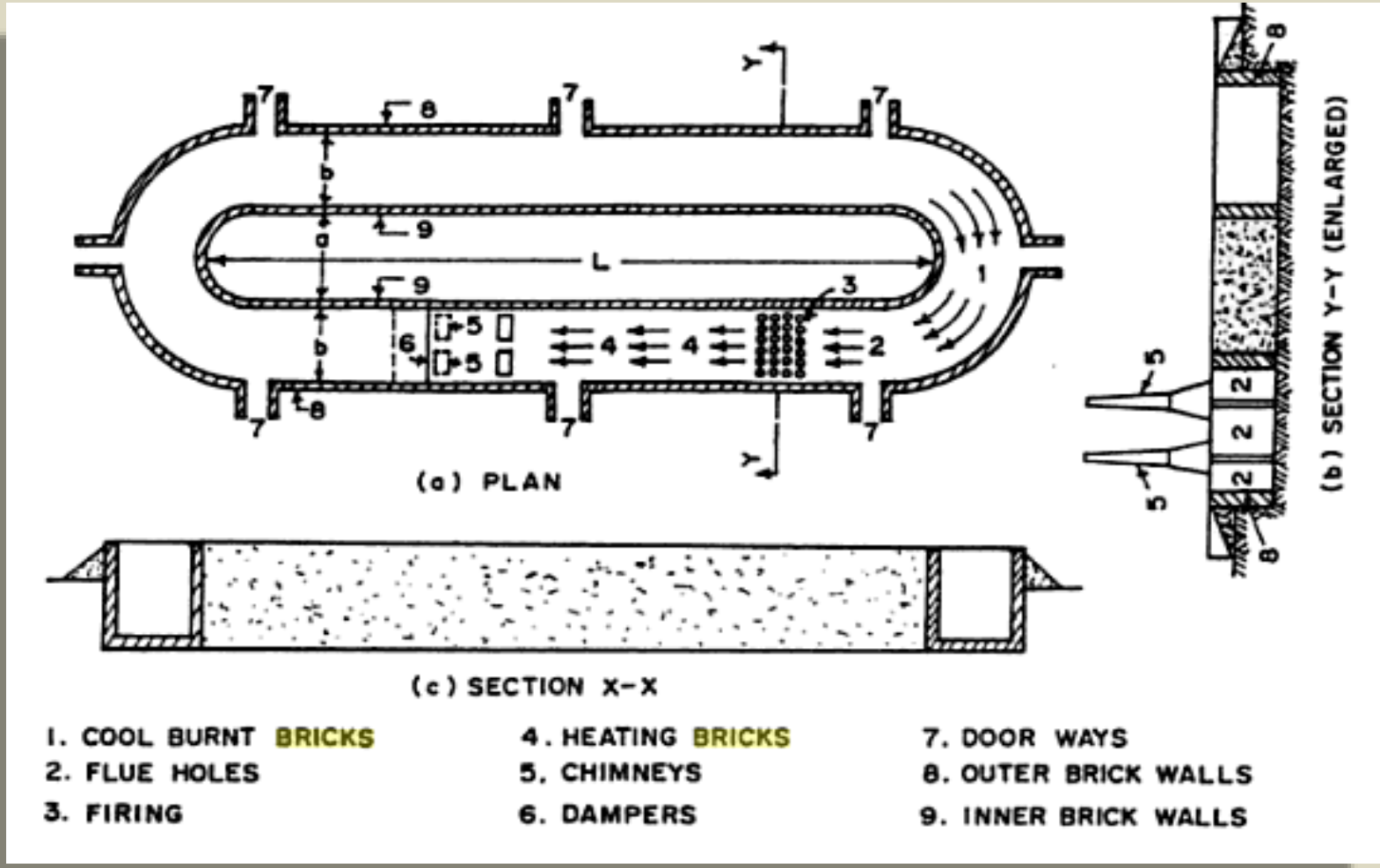
Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)

- **This Trench is divided generally in 12 chambers so that 2 numbers of cycles of brick burning can take place at the same time for the larger production of the bricks.**
- **The structure is under-ground so the heat is conserved to a large extent so it is more efficient.**
- **Once fire is started it constantly travels from one chamber to the other chamber, while other operations like loading, unloading, cooling, burning and preheating** taking place simultaneously.
- Such kilns are generally constructed to have a manufacturing capacity of about 20,000 bricks per day.
- **Drawback:** not a permanent roof, so it is not easy to manufacture the bricks in the monsoon seasons.

Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)



Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)



Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)

- **Working:**
  - **first prepare to keep all compartments of the kiln in operation.**
  - **Each compartment** has to pass through following six stages such as **loading, unloading, cooling, burning, preheating and cleaning.**

Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)

- **Loading:**
  - **stacking of brick is done carefully within the kiln boundaries**
  - **Enough space is left between any two bricks in a layer for free circulation of hot gases.**
  - Fuel galleries are made in the lower regions that are continuous with the flues in the outside wall.
  - Vertical flues (holes) are left connecting the fuel galleries and horizontal flues. These holes should be left at approximately every meter during loading.
  - Arched openings are left at the end for placing the chimney.

Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)

- The top of the loaded section is thoroughly covered with 20 – 30 cm deep layer of ash and dust.
- Metal plates may be placed over them during the operation to cover the top.

Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)

- **Preheating**:
  - **hot and waste gases from a preceding burning chamber are made to pass to the loaded chamber by raising the dampers between the two chambers.**
  - Gases are not very hot.
  - To make the bricks completely dry and make them ready for final burnin**g.**
- **Burning**:
  - **required volume of air is supplied by regulating the opening by raising of the gates provided in the outer wall.**
  - Additional quantities of fuel may be added from the flues provided at the top.
  - 24 – 30 hours for perfect burning.

Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)

- **Cooling**:
  - **All the outer gates are closed by lowering the dampers.**
  - **The interdepartmental gates are opened up for leading the hot gases to the preheating section.**
  - 3 – 4 days to cool down completely before unloading.
- **Unloading**:
  - The top layer of ash and dust are first removed from the top of the section.

Burning Of Bricks
(Kiln Burning - The Bull's Trench Kiln)

- **Advantages :**

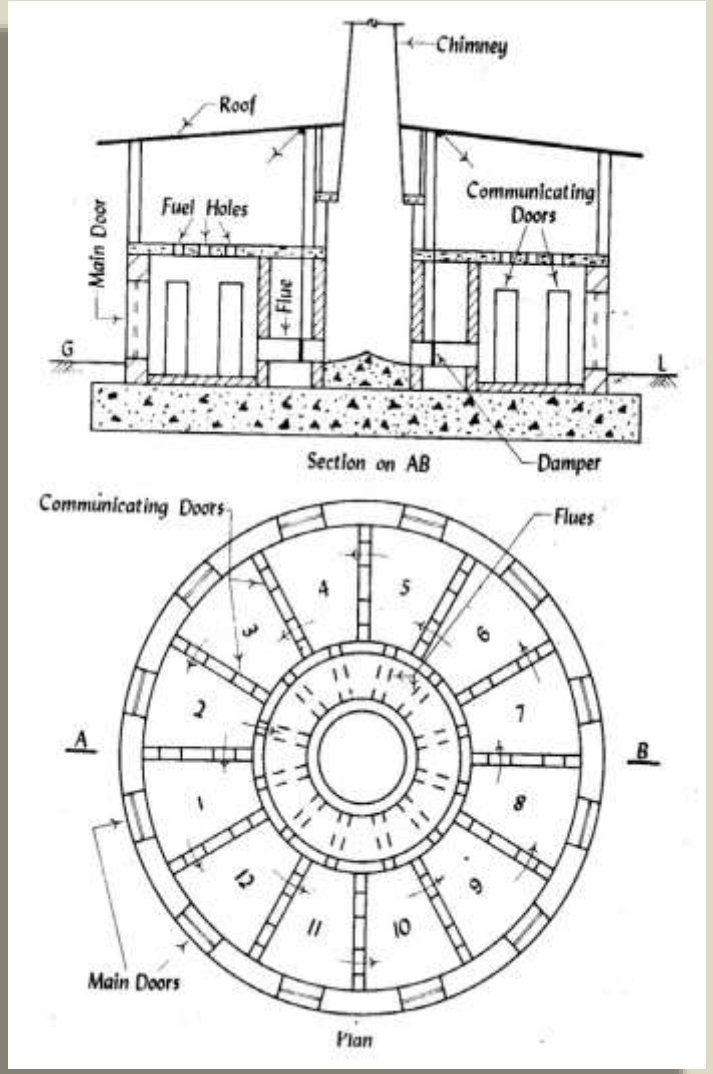
1) Cost of fuel is less as heat of hot gases is fully utilized for pre-heating of bricks
2) Continuous supply
3) High percentage of first class bricks

- **Disadvantages :**

1. High initial cost
2. Constant skilled supervision is essential

Burning of bricks
(Kiln Burning - The Hoffman's continuous kiln)

- **Principle**: modern and more refined type of brick kiln.
  - **For large number of bricks.**
  - **Control condition of temperature.**



Burning of bricks
(Kiln Burning - The Hoffman's continuous kiln)

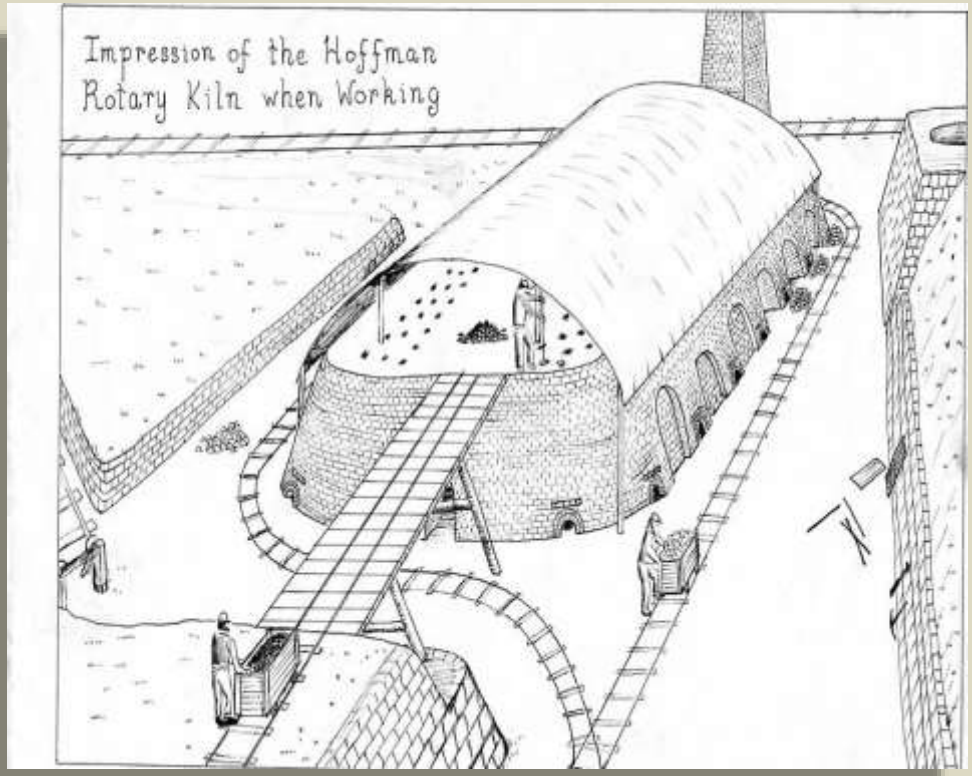
Construction: over ground

- It is sometimes known as flame kiln.
- Circular in plan and it is divided into a 12 number of chambers.
- **Permanent roof - can be worked throughout the year.**
- **The adjacent chambers are inter connected by doors which can be open or closed by raising or lowering dampers.**
- **Central chimney is provided, which is connected to all twelve chamber.**
- **Each chamber is also provided with separate gate in the outer wall through which it can be loaded, unloaded and fired.**

Burning Of Bricks
(Kiln Burning - The Hoffman's Continuous Kiln)

- **Working: at any time, some chambers can be in burning, other in the preheating, still others in cooling and some in the unloading stage.**
- The most important condition for the working is establishment of upward current of air within the kiln, which can be done by closing all the outer gates except of the chamber, which is being unloaded.
- **Natural air enters the kiln through this gates.**

Burning Of Bricks
(Kiln Burning - The Hoffman's Continuous Kiln)



Burning Of Bricks
(Kiln Burning - The Hoffman's Continuous Kiln)

- **It is made to pass through different chambers by opening their interconnecting doors.**
- **The flue at the back of each chamber is kept closed.**
- **The air will do the job of cooling, burning and pre-heating.**
- The air is then enter the chimney for pre-heating stage.
- A scheme of cyclic operation is prepared in advance for working.
- There are many possibilities. Based on time requirement for each stage, we can decide the operation of the kiln.

Burning of bricks
(Kiln Burning - The Hoffman's continuous kiln)

- **Advantages :**

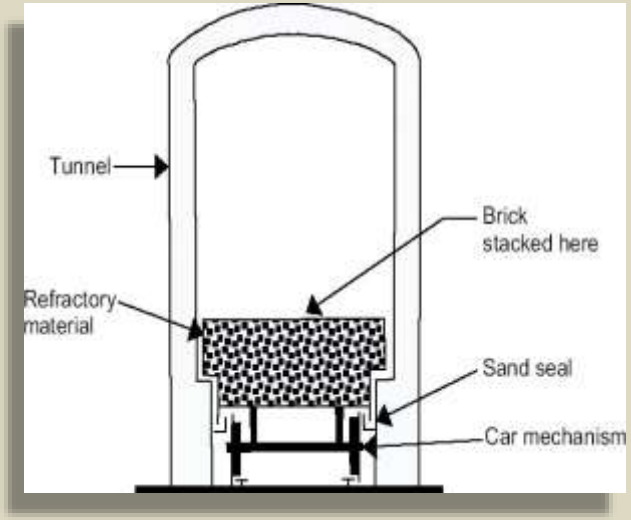
1. High percentage of first class bricks
2. Regular out-turn of bricks
3. Bricks are evenly burnt
4. Economy in fuel as all the heat of combustion is utilized

- **Disadvantages :**

1. High initial cost
2. Constant skilled supervision is essential
3. Economy demands regular consumption of its output, which may not be possible everywhere.

Burning Of Bricks
(Kiln Burning - The Tunnel Kiln)

- **In form of tunnel.**
- **Continuous type and highly efficient.**
- The tunnel is provided with rail tracks for cars.
- **Raw bricks are placed in trolleys which are then moved from one end to the other end of tunnel.**



Burning Of Bricks (Kiln Burning - The Tunnel Kiln)

- **Three sections:** pre-heating section, the burning section and the cooling section.
- **The car loaded with raw bricks is moved into the pre-heating chamber. The bricks are heated by the waste gases coming from the burning section.**
- **After few hours stop, the car is moved into the burning chamber for 20 to 24 hrs.**
- Then the car is moved to the cooling chamber.
- When bricks are sufficiently cooled, they are unloaded.
- **The kiln proves to be economical when the bricks are manufactures on a large scale.**
- **As temperature is under control, uniform bricks of better quality are produced.**

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	Percentage of good quality bricks is small about 60% or so.	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	Fire is under control throughout the process of burning.
6.	Skilled supervision	Not necessary throughout the process of burning.	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.	Hot flue gas is used to dry and pre-heat raw bricks. Hence wastage of heat is the least.

Comparison Between Bull's Trench And Hoffmans Kiln

No.	Item	Bull's Trench kiln	Hoffman's kiln
1.	Continuity	Semi-continuous in strict sense because it has no roof and can not burn bricks during monsoon.	Perfect, because it has a permanent roof and burning operations can be carried out through out the year.
2.	Initial cost	Low, because construction is ordinary type.	High, because construction requires perfect designing and high quality material.
3.	Operating cost	Higher, because quantity of fuel consumed is more and conservation of heat is less.	Lower, because maximum conservation of heat is possible in this type of kiln
4.	Quality of bricks	Ratio of best quality to total bricks is less.	Ratio of best quality to total bricks is quite high.
5	Suitability	Suitable for low investment production of bricks	Most suitable for semi mechanized and mechanized production

References

- **Building Construction :** ***Dr B.C. Punmia***
- **Civil Engineering Material :** ***Prof. Singh***
- **Internet Web Sites**

Thanks…

GHT