CHAPTER-II

PROCESS AND TECHNOLOGY OF BRICK MAKING

SECTION-A

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2.1. Process of Brick Making

2.1.1. Introduction:

Brick making is one of the traditional industries practiced by human being for a long time past. It is an unorganized industry and mainly concentrated on rural and semi urban areas. It creates huge job opportunity and employed millions of people. Even in the advancement of mechanization the most of the brick kilns follows traditional way of brick making processes in the developing countries. Manufacturing processes of bricks involve several phases. These are discussed in the following manner.

2.1.2. Soil Quarrying:

Brick making processes start from the collecting the raw material. A good quality of soil is one of the most important ingredients of raw material. Soil is collected or dug up from the quarry. So management of soil quarry is important. A quick and easy access to the quarry from the kiln area is necessary. For minimizing the effort, time, transportation cost and supervision of the pit, a good transportation facility is needed. So a good or motorable road is needed to construct for carrying soil to the kiln. At the time of quarrying the soil it should be ensured that the unwanted materials like grass, tree root, pebbles removed properly.

At this stage proper management of the quarry is also maintained. There are two options of collection of soil: one is pit of the owner of the kiln and another is the purchase of top soil from farmers. The second option is now more popular in the study area as the owner's land has become lowered. So owners mainly rely on the local contractor for supplying the soil. Some owner has provided their mould to the farmers and asks them to prepare green bricks. The owners buy these bricks at the rate Rs.2000/- per 1000 bricks. However, it should be instructed to the workers or farmers or local contractors to remove plant roots, stones, clay nodules at the time of digging process.

2.1.3. Winning the Clay:

The winning is the method of collecting raw material i.e. good quality soil from the quarry. Winning process consists of two methods-

2.1.3.1. Mechanical Winning:

It is mainly used in developed countries where labour supply is limited and technological advancement is very high. Bulldozer is used for mechanical winning. The bulldozer is hired by owner of the kiln and by the personnel of local syndicate.

2.1.3.2. Hand Digging:

Hand digging is most common practices for winning the clay in most of the developing countries. Iron made spade and shovel are used for hand digging. Hoe and mattock are also used for winning clay.

2.1.4. Transportation of Clay to the Site:

After winning or digging the clay, the syndicate proprietors send the clay by Tractor. An extra trolley is attached to the tractor. As it is an off season, the farmers rent the tractors to the syndicate member. The brick kiln owner who has taken agricultural land for 4 to 5 years uses truck for carrying the clay.

2.1.5. Preparation of Clay:

One of the most important parts of the brick manufacturing processes is preparation of clay. Quality of bricks mainly relies on the availability of good quality of clay soil with uniform nature. Suitable clay is hardly be derived directly from the top soil or on the pit. Clay preparation and pre-processing is very much needed to redundant materials or add some materials for homogeneity of the clay. High concentration of clay may cause cracking on the green bricks. So some sand and salt is added to the clay to prevent cracking. A study reveals that in India 15kg NaCl is added to clay per 1000 bricks to minimize the effect of lime on soil.

The clay preparation stages follow the 4 major steps-

2.5.1. Sorting and Cleaning

2.5.2. Crushing and Grinding

2.5.3. Sieving and Blending

2.5.4. Wetting, Tampering and Mixing

2.5.4.1. Foot Treading

2.5.4.2. Pug mill

2.1.5.1. Sorting and Cleaning:

It is the essential part of clay preparation. At the time of digging or quarrying soil either from the pit or from the agricultural land various impurities such as plant roots, stones, nodules etc. are sorted out. It may include removal of at least 2cm top layer of soil. This may be done by visual inspection. Then the clay is washed by removing unwanted materials.

2.1.5.2. Crushing and Grinding:

The soil used for brick making characterized by high content of plasticity. The piled soil will become dry and hardened and make it difficult to wet and softened. So the cleaned clay is leaved uncover to the open air for a few days for softening. At this time water is added to make the process easier. Thus soil is collected and stored just before the rainy season or just after the rainy season. Some brick kiln owner stocked clay soil from the previous year so that they can start the process of brick making just after the rainy season.

Crushing of clay soil is done manually or by motor driven crusher. Crushing makes the lumps of soil broken and powdered.

Hammer or hammer hoe is used for manual crushing. It plays a dual role such as cutting or digging the soil and mixing or breaking the lumps.

If the clay is hard and full of lumps, it is grind into powder by passing between cast iron or stone rollers set sufficiently close together. The rollers may be rotated mechanically. For large scale manufacturing pendulum crusher either manually or by power is used to make the hard clay to be powdered.

2.1.5.3. Sieving and Blending:

Sieving is essential stage for removing large sized clay nodules. The nodules present in the soil should be removed. The clay should be passed 5mm sieve for betterment of brick. Sieve is made by wire mesh.

Blending is a process involved with field test of clay whether it is deficient in constituents or not. At this stage, one should test what amount of ingredient is to be added. To test the clay, some clay is taken into hands and tuning it up and down in vertical direction. This process is termed as blending of clay.

2.1.5.4. Wetting, Tampering and Mixing:

Tampering is the process of adding adequate water to the clay. In this stage sufficient water is added to clay to make the mixing processes easier. This watered clay is kneaded well by feet of men or cattle until it becomes homogeneous mass. At this stage sand *gorg* etc. are mixed to the clay. The process of kneading the brick earth by adding water to get homogeneous mass and required plasticity is known as tampering or pugging or souring. It is a long term process. It allows chemical and physical changes of clay and makes the clay for moulding.

Photo Plate- 2.1. Wetting of Clay

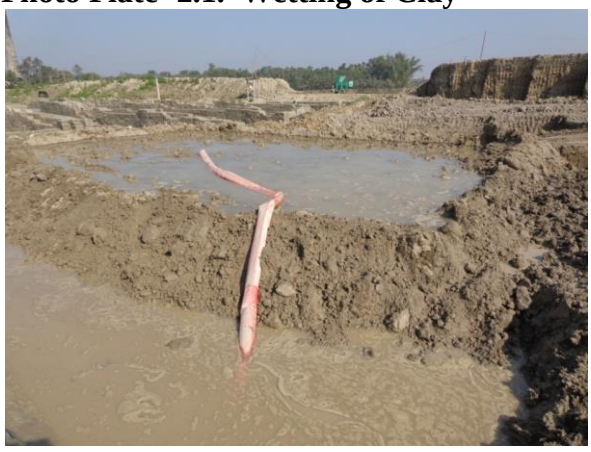


Photo Plate- 2.2. Foot Treading of Clay

Tampering or mixing is carried by human feet or animal driven pug mill. Now-a-days, electric or diesel powered pug mills are used for kneading the clay. So there are three methods of mixing clay-

2.1.5.4.1. Foot Treading:

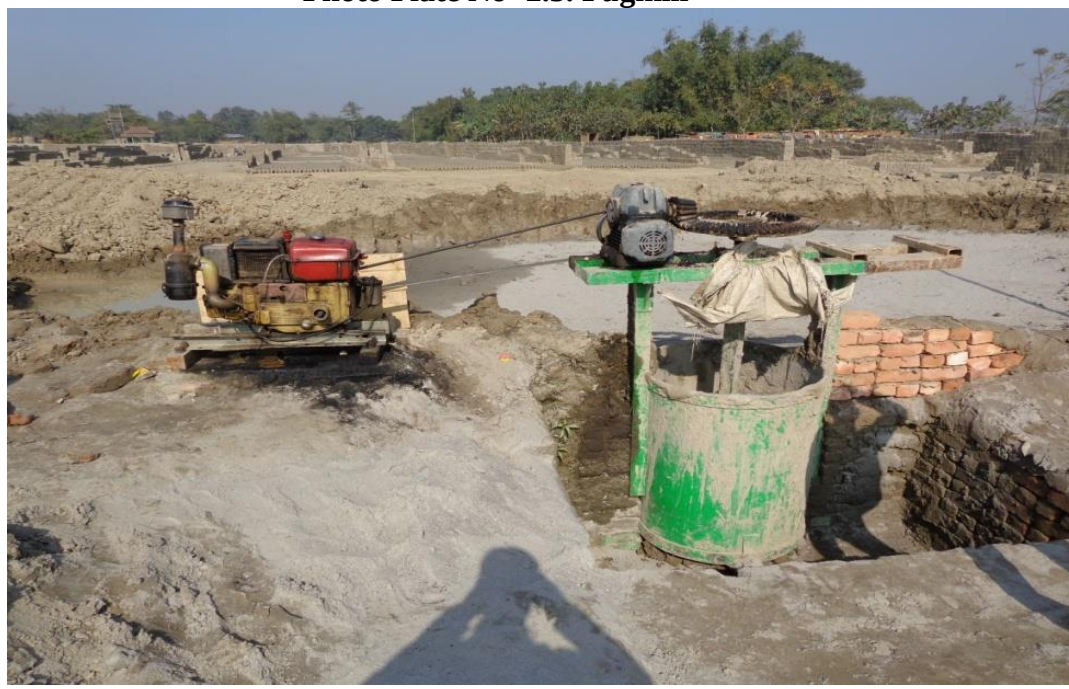
It is a labour intensive method for kneading the clay. At first the sieving or blending clay soil is carried to a plain area and spread over it in circular way. The clay is then wetted and mixed by hoes or spades and left over 1 to 2 days for tampering. Finally, the labours paddle and tread it by feet. This process of mixing is now obsolete as it is very much trouble some. Care

should be taken that the mixed clay neither very hard or dry nor very much wetted. Both will hamper for moulding.

2.1.5.4.2. Pug mill:

A pug mill is a machine either by animal driven or by diesel or electric powered machine for tampering and mixing of clay ready for moulding. The pug mill has provisions made both at the top and bottom to feed and collect the clay. Mixed and wetted clay is fed to the pug mill from the top. At the time of rotating the shaft the clay has cut through by the blades, broken up all the clods and kneaded thoroughly. The pugged or kneaded clay is taken out through the opening slit at the bottom of the pug mill. The capacity of a single pug mill is to yield clay about 10000 to 15000 brick per day. An animal powered pug mill consists of a conical iron tub which has a height of 1.2m to 1.8m. Diameter of the top opening is 0.75m to 0.80m and bottom opening is 1.2m to 1.3m. The tub is dug 0.6m below the ground level. A vertical shaft is fitted at the centre with a number of horizontal arms fixed to the vertical shaft. Each horizontal arm contains a number of knives or cutting blades. A long wooden arm is fitted on the vertical shaft. It is used to rotate the shaft by animal or mechine.

Photo Plate No- 2.3. Pugmill



2.1.6. Moulding of Clay:

Moulding is defined as the process of preparing brick with proper size and shape. For this wooden mould or steel moulds are used. Moulding is done by three methods-

2.6.1. Hand Moulding, 2.6.2. Machine Moulding and 2.6.3. Turnover Moulding

2.1.6.1. Hand Moulding:

Hand moulding is a labour intensive process. Availability of man power is essential for hand moulding. Hand moulding is done by two ways-

2.6.1.1. Ground Moulding and 2.6.1.2. Table Moulding

2.1.6.1.1. Ground Moulding:

The following steps are followed in case of ground moulding

- For this process sufficiently leveled, sweeped and plastered ground is needed. The ground is spread by sand or ash.
- The wooden or steel mould is placed on the ground and filled with tampered lumps of clay and pressed enough so that all corners are filled with clay. The excess clay is scraped off and top surface is leveled with the help of a metal strike or wood strike or by a wire.
- The mould is then lifted up leaving the moulded brick on the ground to dry. Next, moulder is placed adjacent to the previous brick to mould another brick. The process continues up to the day's end and moulded raw bricks lie on the ground in a systematic way. A brick moulder can mould about 600 to 800 bricks in a day of 8 to 10 hrs working period.
- A frog mark of depth 10-20mm is set up on raw bricks at the time of moulding process. This frog mark is used to demarcate the trademark of the manufacturing company and during construction; bricks are placed with frog upper side. It allows storing mortar when the next brick is placed over it.
- As the plastic tampered clay is used for moulding the mould surface may be sticky and it is difficult to lay off the moulded bricks on ground. To eliminate this drawback some lubricant like materials is used. If sand is spread on the inner sides of the mould,

the process is known as sand moulding. This method yields regular shaped and well finished bricks. If the mould is wetted by water in each time before moulding, the process is termed as slop moulding.

2.1.6.1.2. Table Moulding:

Table moulding process is similar to ground moulding process. These bricks are moulded on a table with dimension of 1m high and 2m long. In this method the clay, mould, water pots, stock board, thin wire or strike and pallets are placed on the table.

The bricks are moulded on stock board which is similar in size of mould. The stock board is fixed on the table and mould is placed on it. The tampered clay clot is poured on it and pressed. The extra clay is removed by the thin wire. The pallet is placed top on it and removed the raw brick from it. Before starting the process sand is spread on the mould. So this is the process of sand moulding. The moulded bricks are transferred to the page and the workers carry the moulded bricks to the drying shed.

Table moulding is not familiar because it is costly and time consuming.

2.1.6.2. Machine Moulding:

Machine moulding is more efficient in terms of producing large quantities of bricks during a short period of time. It is economical and less labour intensive method. The machine may be represented by mechanically or manually. It produces heavy, strong, durable and finely finished bricks with a minimal shrinkage and less defects. The machine moulding methods are of two types-

2.6.2.1. Plastic Clay Machine and 2.6.2.2. Dry Clay Machine

2.1.6.2.1. Plastic Clay Machine:

It contains a rectangular opening of the similar size of a brick. Plastic pugged or tampered clay is fed into the machine. The clay comes out in the form of clay bar which is cut into the size of brick in the cutting frame. The bricks produced in this method are known as ‘wire cut bricks’. The raw bricks are now transported to the drying place for drying.

2.1.6.2.2. Dry Clay Machine:

Dry clay machine is more efficient in terms of production and performance. This machine uses powdered soil and small amount of water. It pressed the clay to form stiff plastic state and put into the machine. The machine presses the clay and hard and perfectly shaped brick is made. This type of brick is known as pressed brick which is directly used for burning without drying. But burning process should be done carefully because these types of bricks are cracked easily.

The moulding machine is generally used in European developed countries where labour supply is insufficient and the manufacturer can invest more capital for production of bricks. Central Building Research Institute (CBRI) Roorkee has invented hand operated moulding machine. In India moulding machine is not operated because of the following reasons:

i) Initial cost is very high

ii) The recurrent cost is very high

iii) Operational cost is very high

iv) Availability of cheap labour who are moulding bricks manually.

2.1.6.3. Turnover Moulding:

It is one of the locally produced traditional methods of brick moulding. A wooden mould with a steel fixed at the bottom of the mould is used for making the raw bricks. The wooden mould has four sided openable woods which are removed easily after the excess clay is cut off. The four sides are separated and bricks are transferred with pallet to the drying place.

2.1.7. Transportation of Moulded Bricks:

Sand or slop whichever is moulded is called green brick. These moulded bricks are carried to the drying area. This is generally done with the help of a human cart trolley or '*bank'* (a bamboo made stick on which two sides are used to carry load). Sometimes a wheel burrow is used to carry 20-30 bricks to the drying area at a time.

2.1.8. Drying Process:

The moulded bricks may content 10% to 30% moisture. These are called green bricks. The moisture content depends on type of clay used and what type of moulding method is used. Whatever may be the moisture content in the raw bricks, the moulded bricks are to be dried before burning of bricks. The drying process fulfills the following objectives:

- To remove water content, it allows the reduction of time of burning and consumption of fuel.
- To minimize the rapture, cracking and distortion at time of burning of green bricks.
- To increase the strength of green bricks.
- To make the bricks 'leather hard', rigid and strong for handling and stacking.

At the time of drying process, the bricks may shrink and crack ranging from 5% to 10% depending upon the plasticity of the clays. For this reason, the moulded bricks are kept slightly big size than the final required size. Some precautions have been taken into consideration for drying process-

- Drying should be done under shade as direct sunlight can cause the cracking and shrinking.
- Stack height should be 20 bricks height and arranged in such a way that movement of air in between the bricks is free.
- The hack or drying ground should be raised and sanded to allow any rain water to flow off.
- The stack should be protected from rain water.
- Care should be taken to carry or handle the green bricks to minimize the distortion.

The drying of bricks follows two methods:

2.8.1. Natural Drying and 2.8.2. Artificial Drying

2.1.8.1. Natural Drying:

The method of natural drying mainly adopted in Asian and African countries because of availability bright sunshine and low technological advancement. In this method the bricks are spread over in the hack or hack stead in a row. The hack stead is raised and sanded with husk or saw dust so that sudden heavy down pour does not affect the bricks. The bricks are dried 2-3 days to the direct sun to facilitate uniform drying and prevent wrapping or shrinking. Then the bricks are piled in such a manner that there is sufficient air gap along the rows and columns. The piling is done in criss-cross or zig-zag pattern. The height of stack should be 20 bricks high. There should be sufficient gap (about 1m) between the stacks for movement of labours. An arrangement should get ready to protect the stack from sudden rain. For this purpose, polythene sheet is used. This type of drying process generally takes 8-10 days and it depends mainly on weather condition and plasticity of the clay.

The slop moulded bricks should be dried in a single layer as they cannot allow the weight of another bricks. So the drying area should be wide enough to spread the bricks in rows. The sand moulded bricks may stack one or two to each other as they are more leather hard than slop moulded bricks. The green bricks should be flipped off after 2 or 3 days to allow the other face for drying. The drying process will continue for a few days until the bricks become lighter in colour. The ground bricks of the hack stead may remain undried depending on the weather condition. So it is desirable to build the hacks on burnt bricks or wooden planks. Excessive of drying may cause cracking and distortion of the bricks. It is very much difficult to control the exactitude of drying in open air. The bricks may be covered with leaves and grasses which may help to control the exactitude of drying in some extent.

Photo Plate- 2.4. Natural Drying of Green Bricks

2.1.8.2. Artificial Drying:

Moulded bricks can be dried artificially. It is very much useful for large scale brick making. Two types of driers are used for artificial drying-

2.8.2.1. Hot floor drying and 2.8.2.2. Tunnel drying

2.1.8.2.1. Hot floor drying

When the bricks are dried by laying or hacking on a hot floor is called hot floor drying. In this system hot flue gases are passed from a furnace at one end to stack at the other end. In this method bricks are arranged in stacks in the chamber keeping sufficient space for the circulation of hot air under controlled temperature and humidity for a period of 2-4 days.

2.1.8.2.2. Tunnel drying

In the tunnel drying, the moulded bricks are allowed to pass through tunnels. The driers are heated by means of special furnaces or by hot flue gases. The temperature is kept lesser than 120°C and the process of drying of bricks takes about 1-3 days. The tunnel driers are more economical than hot floor driers.

Due to high cost and scarcity of fuel, the artificial drying method is not suitable for tropical developing countries.

Table-2.1. An Estimate Showing the Energy Requirements for Evaporation of one kg of Water

Efficiency of Process	Energy (KJ/Kg Water Evaporated)		
	Hot floor dryer	Chamber dryer	Tunnel dryer
High	7100	3300	3300
Low	12400	8900	7100

Source: Macey (1950)

It is evident from the above table that artificial drying of raw bricks consumes 3000-8000 Mega Joules (MJ) per thousands of bricks. It is also evident that 1 kg of coal produces 29.3 MJ energy. So artificial drying requires 100-270 kg coal for burning process. Hence, artificial drying process is not useful in developing countries like India.

The climatic condition of India is very much favourable for natural drying of bricks, as abundant sunlight is available throughout the year except rainy season. Moreover, brick manufacturing starts after rainy season when intensity of sunlight decreases. This weather condition is suitable for natural drying of bricks. As the study area is located in the tropical region (Latitude 26º 15 / 19//N to 26º 20 / N and Long 89º 32 / 20// E to 89º 39 / 8// E), the manufacturer of bricks prefers natural drying method.

2.1.9. Loading of Bricks to the Dock:

The sun dried green bricks are then transported to the kiln area. The people who carry green sundried bricks to the dock are called Rejin. The Rejin stacks the green bricks inside the kiln or dock in systematic way for proper burning.

2.1.10. Burning/Firing Process:

Burning of green dried bricks is one of the major important operations for brick manufacturing. Firing makes the bricks strong, durable, hard, dense, impervious and converts in red colour. Burning process is done in two steps:

Step. 1: Bricks are brunt at a temperature 650°C. It is called 'Temperature of dull red heat'. It allows the organic matter contained in the green bricks oxidized and water in the crystal form is swept away.

Step.2: Bricks are brunt at a temperature 1100°C. It allows green bricks to bind alumina and sand together. It also changes the chemical properties of the bricks. Bricks become strong and dense at this temperature. Again, at this temperature a small amount of fusible glass is formed and binds the clay particle together.

In the above two steps the clay bricks will vitrify. The temperature should remain constant at this stage for complete vitrification. Temperature more than 1100°c is not desirable as it may cause distortion of bricks. Bricks are generally burnt by two processes:

2.10.1. Clamp Burning and 2.10.2. Kiln Burning

2.1.10.1. Clamp Burning

The clamps are temporary structures and are practiced mainly in developing countries to produce bricks to meet local demands. It is generally performed in small scale brick manufacturing.

2.1.10.2. Kiln Burning

On the other hand, kilns are permanent structures which are used to produce bricks at a large scale.

Table -2.2: The Capacity of Firing of Kilns.

Type of Kiln	Capacity of Bricks (in ’000)	Capacity of bricks (’000/ day)
a) Intermittent		
Clamp	10-1000	
Scove	5-100	
Scotch	15-25	
Down drought	10-50	
b) Continuous		
Original Hoffman		10-15
Modern Hoffman		2-24
Bull’s Trench		14-28
Habla		15-30
VSBK		

Source: Bhalla (1984)

Table-2.3: Energy Requirements in Different Types of Kilns

Type of Kiln	Heat Requirement (Mega Joule/1000 bricks)	Equivalent to Coal Burning (kg)	Quantity of fuel required (Tons/1000 bricks)		
			Wood	Coal	Oil
a) Intermittent					
Clamp	7000	239	0.44	0.26	0.16
Scove	16000	546	1.00	0.59	0.36
Scotch	16000	546	1.00	0.59	0.36
Down drought	15500	529	0.97	0.57	0.30
b) Continuous					
Original Hoffman	2000	68	0.13	0.07	0.05
Modern Hoffman	5000	171	0.31	0.19	0.11
Bull’s Trench	4500	154	0.28	0.17	0.10
Habla	3000	102	0.19	0.11	0.07
Tunnel	4000	137	0.25	0.15	0.09
VSBK	800		0	.105	0

Source: Bhalla (1984)

Kiln burning/ firing process follows three major steps:

2.10.2.1. Heating, 2.10.2.2. Soaking and 2.10.2.3. Cooling

2.1.10.2.1. Heating:

Heating is the first and foremost process in firing. It is essential for removing of moisture and carbonaceous material. It allows changing the chemical composition of green bricks and colour change of the green bricks. There are 6 processes of heating which are discussed in the following manner-

- At the time of moulding of bricks a plenty of water is added to the clay. About 3-10% moisture retained in green bricks after drying. This moisture will be removed when the temperature rises 150°C.
- The brick making clay may contain organic matter such as roots and leaves of plant. When the temperature increases and it reaches up to 400°C the combustion of organic matter process starts and it ends at a temperature 650°C.
- Clay mineral contains combined water. Kaoline is one of the important clay mineral and it constitutes Hydroxyl ion (Al_2O_3, $2SiO_2$, $2H_2O$). At a temperature 400-600°C the combined water is removed.
- Brick clay contains silica. When the temperature rises to 573°C the quartz of silica expanded 20% due to the changes of α- Quartz to β- Quartz. When the temperature falls below 573°C, the reverse process occurred. If the temperature is not controlled properly, the expansion and shrinkage cause the bricks deformation with cracking.
- CO_2 and SO_2 released at the temperature 600-800°C.
- During firing process vitrification occurs. It is the partial melting of clay at the contact points. It binds the clay particle with a glassy bond. It depends on temperature of clay mass and duration of heating process. Vitrification starts at a temperature 900°C though it varies from different types of clay. Thus, the whole firing temperature ranges between 1100°C to 1500°C.

2.1.10.2.2. Soaking:

For uniform vitrification the temperature should remain constant for a few hours. This process is termed as soaking.

2.1.10.2.3. Cooling:

The cooling process of brick should be slow to keep away extreme thermal stress in the bricks. A clamp generally takes two weeks to cool.

2.1.11. Unloading of Burnt Brick:

Burnt and cooled bricks are then unloaded from the dock to the stacking place. The people who unload the bricks are called *Paka Bagdar*.

2.1.12. Sorting:

During the unhacking of bricks from the dock the bricks are sorted on the basis of colour. Colour is considered as the level of burning. Bricks are classified as 1st class, 2nd class, 3rd class brick, Jhama or Pila bricks and broken bricks. Again, bricks are also sorted according to the defects. As the price rate of bricks of different classes varies, the bricks are stacked differently.

2.1.13. Dispatch or Sale:

Finally, the bricks are ready for sale. The brick owner has own truck to dispatch the brick to the consumer. Sometimes, the local middlemen buy the bricks at the beginning and store for future business. The rate of bricks to the middlemen is lesser because they invest money at the inception of brick manufacturing season.