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User Manual for Brick Kiln Workers

NB Institute for Rural Technology

User Manual for Brick Kiln Workers

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Contents

Clay-mixture Preparation 1

To make good quality, free from defects and consistent bricks, the clay-mixture used must be suitable and uniform in nature.

Important instructions to follow:

1. Discard unsuitable hard lumps of soil, roots, dead vegetation, stones, limestone nodules etc. from the dried clay to avoid cracking of bricks during drying or firing.

2. Crush large lumps of soil to small sizes. Small size lumps (Fig. 1.1) helps in ready absorption of water and preparation of clay-mixture.

Figure 1.1: Crushing machine

3. Crushed soil must be sieved (Fig. 1.2) to ensure that the over-size pieces are not used. Machines (Fig. 1.3) are also used for sieving of soil.

Figure 1.2: Sieving of clay

Figure 1.3: Sieving of clay using machine

4. If proportion of clay content is high in the clay-mixture, green-bricks could crack during drying. To mitigate this problem increase the amount of sand in clay-mixture.

5. To obtain the correct proportion of clay-mixture, the mixing of clay and sand must be undertaken after crushing and sieving.

6. Mix appropriate amount of water in the clay-mixture. Excess water content makes the clay-mixture too soft and after moulding, bricks get misshaped.

7. Extracted dry soil is filled into a pit where appropriate amount is water is added to it. This pit is called *tempering tank* (Fig. 1.4).

Figure 1.4: Tempering tank

8. Several layers of clay-mixture are laid in the tempering tank. While laying each layer, clay-mixture and appropriate amount of water are mixed properly so as to ensure uniformity of moisture in the pit. After filling, pit must be covered with plastic sheet or sand to prevent evaporation and premature drying.

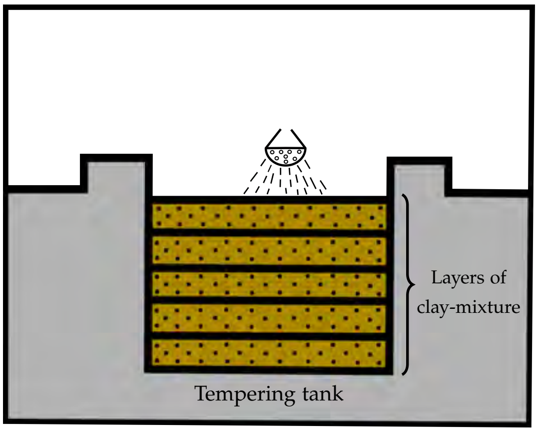

Figure 1.5: Mixture of soil and water

9. Piled up clay-mixture must be left in the tempering pit for one to five days. Due to breaking of softened soil into small lumps and chemical changes takes place in the clay-mixture, its moulding characteristics improves.

10. Soil extracted from tempering pit is mixed and kneaded well by foot-treading (Fig. 1.6) or by Pug-mill (Fig. 1.7) machine to make the clay-mixture suitable for moulding.

Figure 1.6: Foot-treading of clay-mixture

Figure 1.7: Clay-mixture prepared by Pug-mill machine

Moulding

2

A moulding system must be able to produce accurately shaped and sized bricks as they are good to handle, transport, stack, fire and build into a good quality wall. Cost of wall constructed using good quality bricks is also less. Moulding of bricks is done manually or using various machines. Machines are selected according to desired shape and type of brick.

Important instructions to follow:

1. Clay-mixture ready for moulding must be kept on a plastic sheet (Fig. 2.1) and the pile should be covered from all sides with plastic sheet to prevent early drying due to wind and sun.

Figure 2.1: Clay-mixture must be kept on a plastic sheet

2. The moulding area must be levelled with the help of levelling ring (Fig. 2.2) or flat metal blade. Levelling of area must be done after every 4 – 5 mouldings.

Figure 2.2: Levelling of moulding area

3. After dusting the inside of the mould with sand, knock the mould on the ground to shake off any loose sand from the internal surfaces of the mould. Failing to do so leads to production of irregular edged bricks.

4. While throwing the clay-clot into the mould box ensure that its joint (Fig. 2.3) remains at the top so that the joint can be removed while scrapping the excess soil from the top of the mould. Joint left inside the clot leads to formation of deep crack in the brick.

Figure 2.3: Formation of joint in the clot

5. Do not throw the clot into the mould such that it touches the side wall of the mould first (Fig. 2.4) as this will cut-off the sand from the side wall and brick will not slide out of mould easily.

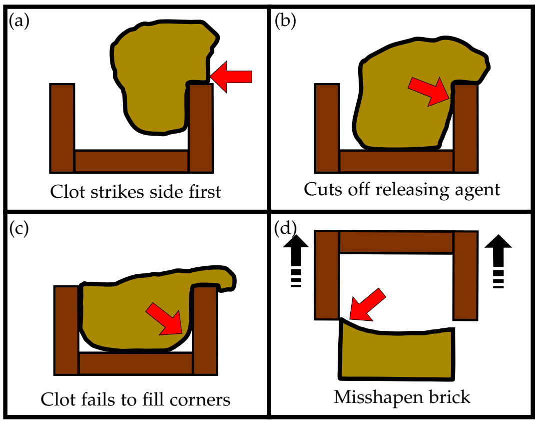

Figure 2.4: Incorrect way of throwing clot into the mould

6. Throw the clot into the mould such that it touches the bottom (Fig. 2.5) of the mould first so that the correctly shaped brick can slide out of the mould easily.

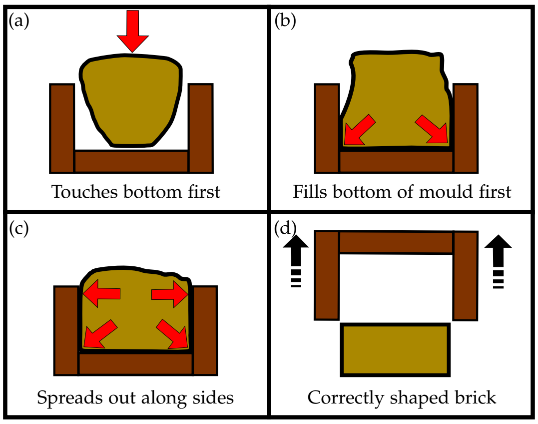

Figure 2.5: Correct way of throwing clot into the mould

7. After throwing the clot into the mould, compact it by the heel of the hand at one end of the mould (Fig. 2.6); then compact the remaining clot by pressing with both hands while moving towards the other end of the mould. Mould must be knocked on the floor to ensure that the clay-mixture fill it completely.

Figure 2.6: Correct way to press the clot into the mould

8. Moulding can also be done while standing (Fig. 2.7). Bricks are moulded atop a table. A special type of mould-table (Fig. 2.8) has also been developed in which foot pedal is used to eject the brick from the mould box.

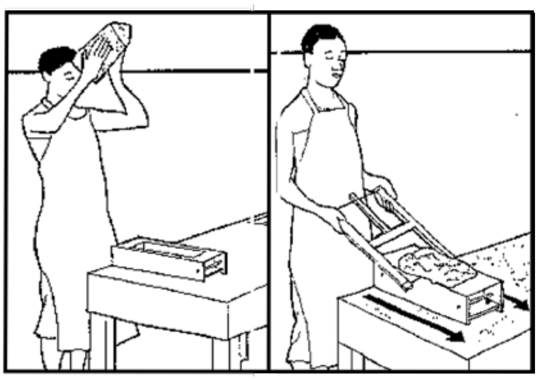

Figure 2.7: Moulding being done while standing

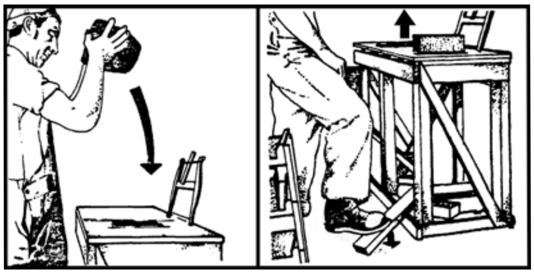

Figure 2.8: Advanced method of moulding

9. Check the mould regularly for any lump of clay sticking inside it especially, at the corners. After shaping of 10 – 15 bricks, scratch the inside of mould properly with flat metal blade.

10. Moulding can also be done using machines. *Soft mud moulding* and *Extrusion* machines are mainly used for production of bricks.

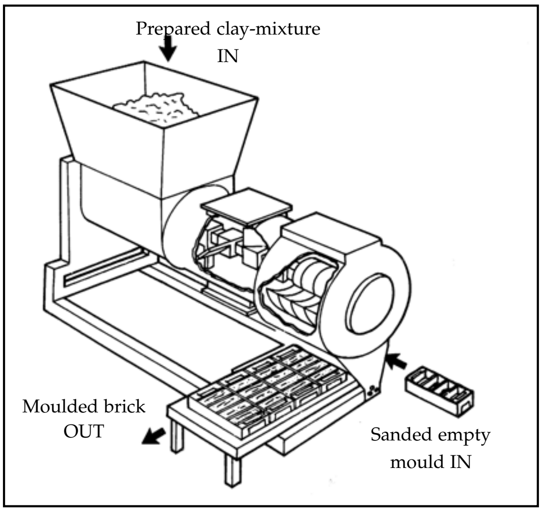

Figure 2.9: Soft mud moulding machine

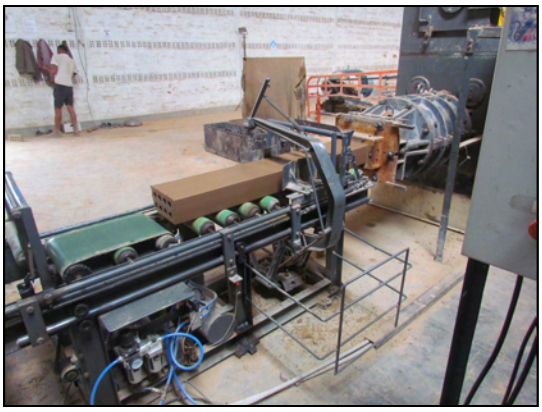

Figure 2.10: Extrusion machine

3 Drying

Thorough drying of green-bricks is vital because then they are acceptably shrunk and sufficiently rigid and, strong for handling and stacking; thus will not crush under the weight of those piled on the top. Drying removes most of the moisture from the bricks which otherwise during firing will either rupture the brick by converting into steam or will evaporate and condense on cold bricks. These cold bricks will then absorb the water and get spoiled. Also, fuel will be saved during firing if maximum possible amount of water is removed during drying. Bricks are dried by natural and artificial means.

Important instructions to follow:

1. The ground to be used for drying and stacking must be swept free of loose debris and, it should be as flat as possible and free from dents.

2. After de-moulding the green-bricks are laid flat on the surface. After 1 – 2 days, turn them from flat position (Fig. 3.1) to the upright position to allow the bottom face to dry

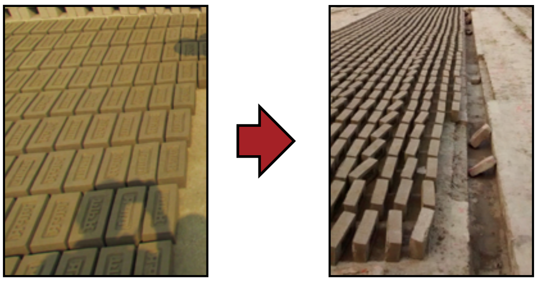

Figure 3.1: Stages of drying

3. After letting the bricks dry in upright position for approximately 3 – 4 days, stack them in hacks (Fig. 3.2). During winters, the open walls can consist of 5 – 6 layers of upright bricks whereas during summers, the walls can be 10 – 12 bricks high.

Figure 3.2: Drying bricks in hacks

4. Build the hacks upon a single layer of burnt-bricks (Fig. 3.3) to aid in fast drying of bottom course of green-bricks and, to prevent spoiling of bricks during rainfall.

Figure 3.3: Green-bricks stacked on the top of burnt-brick layer

5. The hack pattern can be either *Cross stacking* or *Herringbone stacking* (Fig. 3.4). Cross stacking pattern is structurally stable but Herringbone pattern is more efficient since it allows for faster and even drying.

Figure 3.4: Stacking patterns for drying

6. Cross stacking can be made more efficient by increasing the number of gaps between bricks. Stack is made more structurally stable by the use of 'tie-brick', which is used to key one vertical column of brick into the one adjoining it (Fig. 3.5). Ample gaps left between bricks ensure proper and uniform airflow through them.

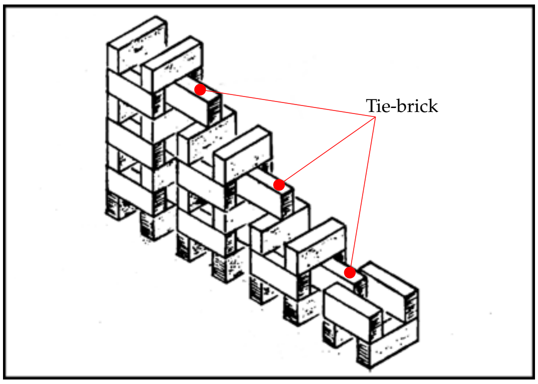

Figure 3.5: Cross stacking pattern with tie-bricks

7. Due to intensive sunshine, high wind speed or dry weather conditions rate of drying becomes high which causes cracking of bricks. To avoid this, hacks should be covered (Fig. 3.6) with wet cloth, leaves/grass or plastic sheet.

Figure 3.6: Hacks are covered with sheets to prevent cracking during adverse weather conditions

8. During high humid weather conditions cover the hacks with plastic sheet at night to avoid absorption of water due to condensation.

9. To control the rate of drying during adverse weather conditions hacks are build under the sheds (Fig. 3.7). Cloth or plastic coverings act as temporary walls of these sheds which shield the bricks from high speed wind, rain or sunshine thereby maintaining favourable humidity conditions under the shed.

Figure 3.7: Drying of bricks under the shed

10. For artificial drying hot gases coming out of the kiln or high speed air (using fans) is passed through the bricks (Fig. 3.8).

Figure 3.8: Artificial drying of bricks

11. In a thoroughly dried brick, there would be no colour differential between the outer skin and inside core of the brick.

12. Hollow clay bricks will dry much faster than solid bricks due to larger surface area available for evaporation of water.

4 Brick Setting in A Natural-draft Zigzag Kiln

Setting of green-bricks depends on the type of kiln. In a Zigzag kiln bricks are arranged in 'chamber-type' setting. Contrary to traditional oval-shaped Bull's trench kiln, Zigzag kiln is rectangular in shape.

With respect to arrangement of bricks, Zigzag kiln is divided into four regions (Fig. 4.1). 'A' and 'B' are the regions situated at the corners of the kiln where fire or hot gases change direction. Arrangement of bricks in these regions is called 'big-chamber'. In the long straight sections of the kilns, referred as 'C', number of chambers are made by stacking green-bricks thereby, forcing the air/hot gases to flow in a *Zig-zag* manner. The short straight sections, referred as 'D', constitute *Gali* regions of the kiln. In these regions, generally, bricks are stacked in such a manner that most of the flow of air/hot gases is along a straight line. This arrangement is similar to brick settings in a fixed chimney Bull's trench kiln (FCBTK).

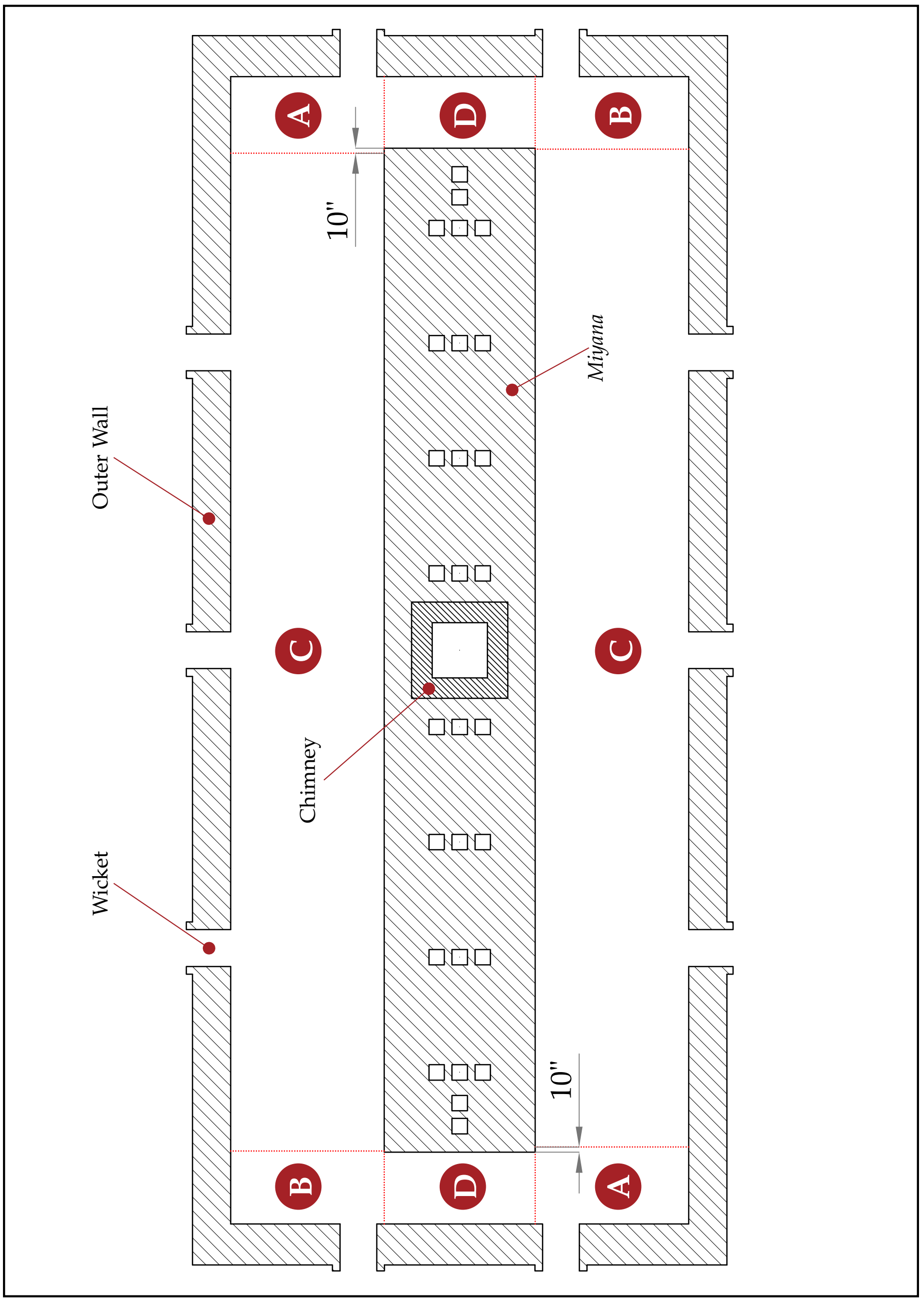

Figure 4.1: General arrangement of a Zigzag kiln

Important instructions to follow:

1. While stacking green-bricks in layers they must be placed on edge (Fig. 4.2) and not on their flat sides because they are stronger in this position.

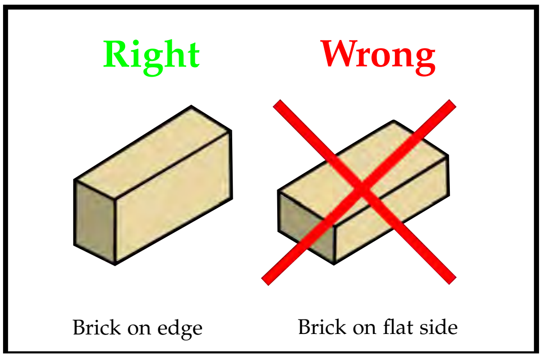

Figure 4.2: Correct way stacking green-brick

2. Before stacking green-bricks, the kiln floor must be levelled and a layer of fired-bricks (placed on their edge) (Fig. 4.3) be put on it to provide stability to the brick setting.

Figure 4.3: Kiln floor laid with fired-bricks

3. Bricks are stacked in rows inside the trench; each row having straight vertical columns (*Paaya*) made by piling up several layers of bricks. Column width depends on number of bricks used in a layer. Number of bricks used per layer can vary from 4 – 10 bricks (Fig. 4.4). Depth of column is equal to length (L) of a brick.

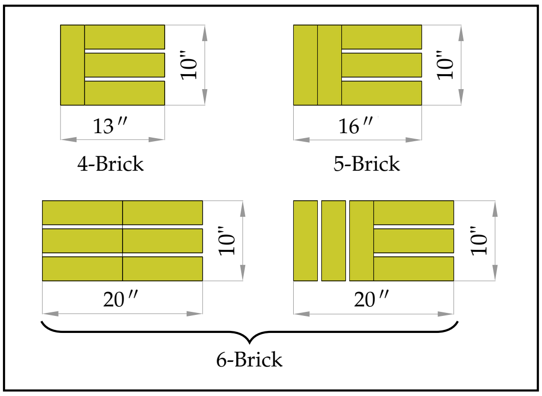

Figure 4.4: Different sized columns

4. A chamber consists of five rows (Fig. 4.5), each containing several brick columns (*Paaya*), the number of which depends on trench width.

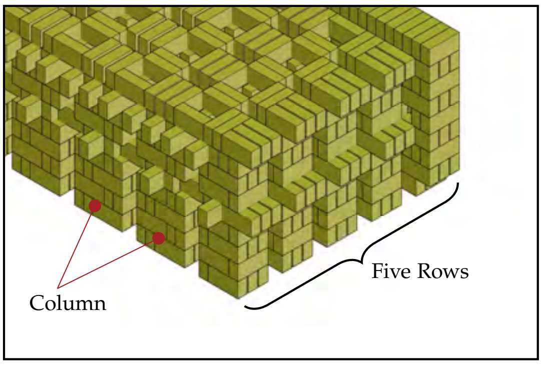

Figure 4.5: Brick setting in a chamber

5. To mark the span of length and width of a chamber iron rod and rope are used respectively (Fig. 4.6). Brick sets are placed along them to lay the bottom course of chamber.

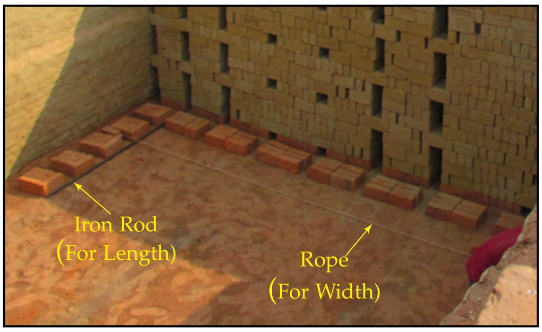

Figure 4.6: Bottom course of chamber

6. Maintain a gap (*Jhiri*) of about 5" (half of brick length) between two consecutive brick columns and rows (Fig. 4.7).

The same amount of space must be left between outer wall or *Miyana* wall and brick columns.

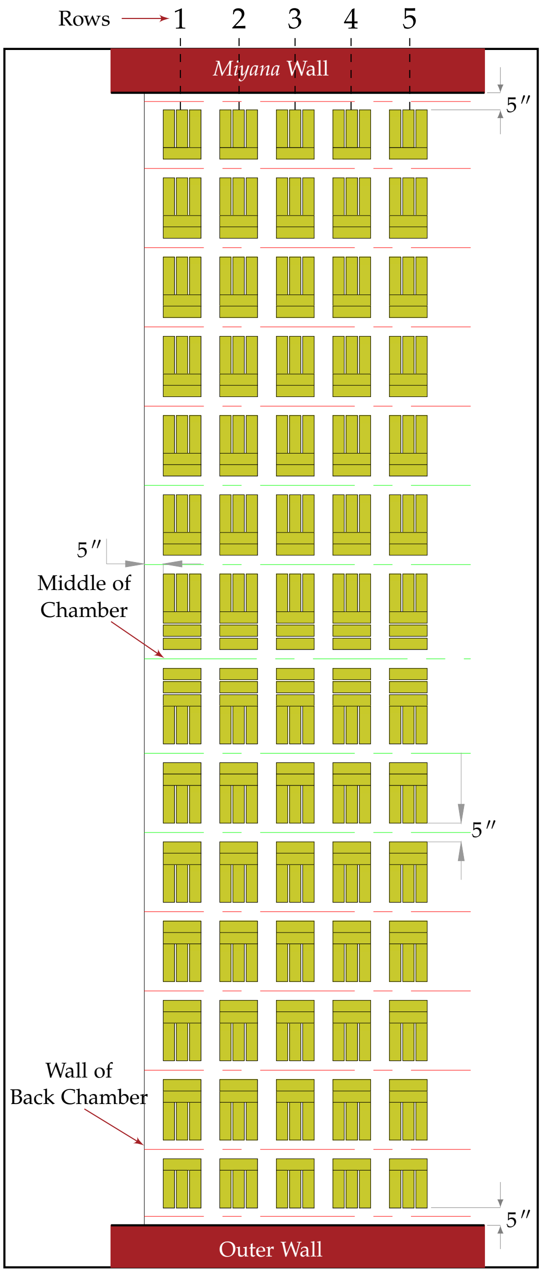

Figure 4.7: Bottom course of a chamber

7. Total number of columns (*Paaya*) to be set in a row of brick setting must be even.

8. Trench width is decided by green-brick size, number of brick columns in a row and production capacity. Chamber width is same as trench width (Fig. 4.8). Length of chamber is calculated as ≡ 5(Number of gaps) × 5" + 5(Number of rows) × 10" = 6'3".

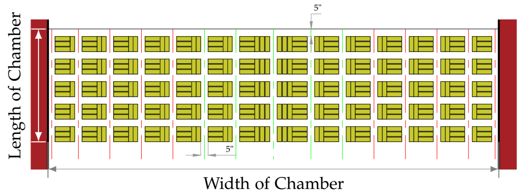

Figure 4.8: Span of a chamber

9. As shown in Fig. 4.9 first chamber of region-C is set at a distance of 10" form the corner of *Miyana* wall. This space is utilized to put the last row of *Big-chamber* of region-A.

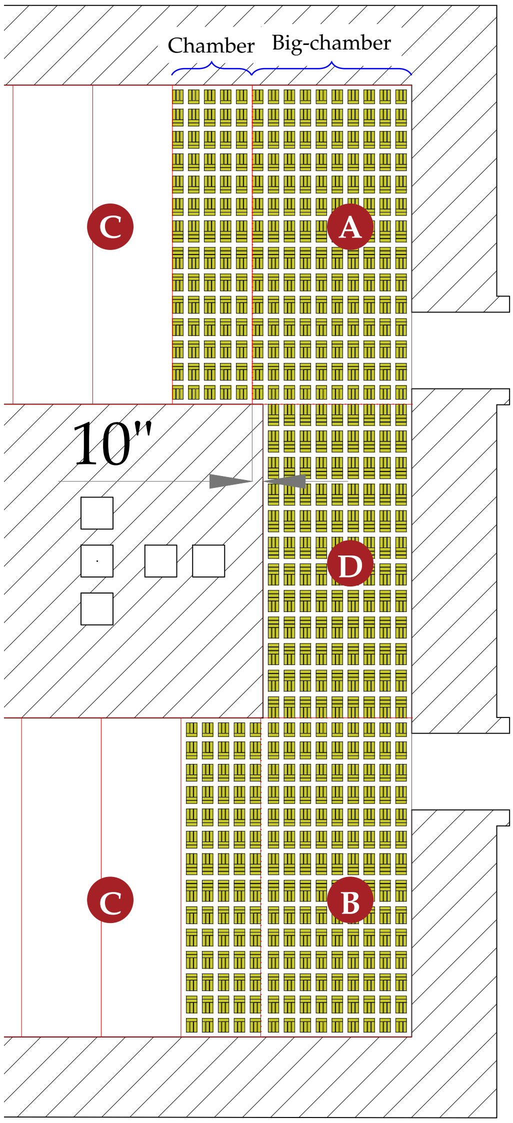

Figure 4.9: Brick setting in different regions of a Zigzag kiln

10. Total number of chambers to be set in the longer sections (region-C) of the trench must be even.

11. Length of *Miyana* is calculated as $\equiv$ (Number of chambers $\times$ Length of chamber) $+$ 10".

12. In *Gali* region, along the width of *Miyana*, it is advised to set columns (preferably, all five to eight-brick columns) starting from one edge up to the other edge of *Miyana* (Fig. 4.9).

13. Along the width of *Gali* columns must be placed in such a way that a spacing of 5" (half the length of green-brick) is left between consecutive columns and, between *Miyana* or outer wall and column.

14. Width of *Gali* is taken to be a number which is a multiple of – [length of a brick(10") + width of a gap(5") = 15"] and also, nearest to half of the trench width.

15. To provide spaces for coal particles to settle, ledges (*Jodi*) are provided (Fig. 4.10) in some particular courses at different heights of brick setting. Additional structural stability to the brick setting is provided by putting bricks, called *Bandhan*, between rows.

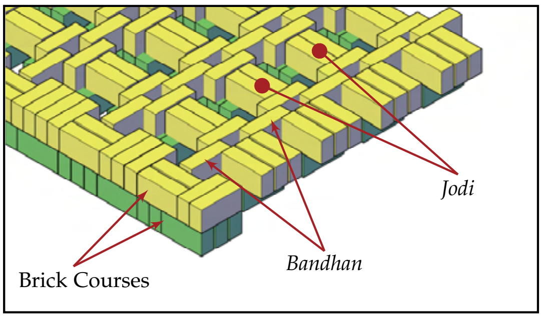

Figure 4.10: Courses of a chamber

16. A ledge (*Jodi*) can be placed either at the space between two adjacent columns (*Paaya*) of a row (Fig. 4.11) or, at the space (*Jhiri*) between two adjacent rows (Fig. 4.12) of the brick setting.

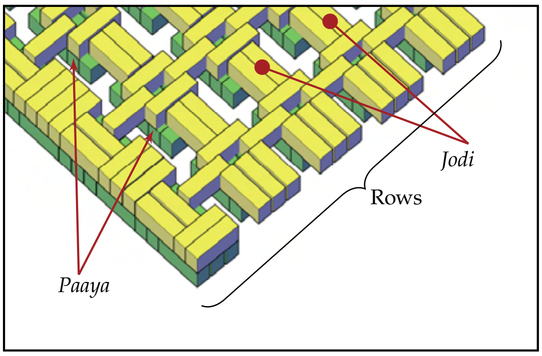

Figure 4.11: Ledges between columns

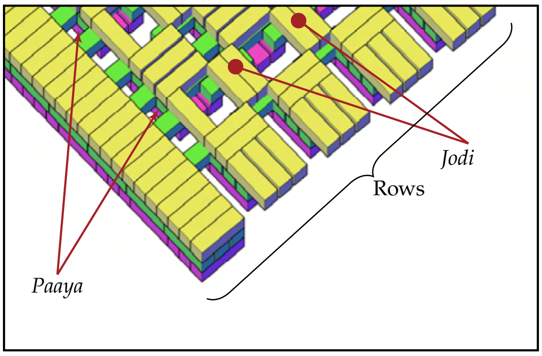

Figure 4.12: Ledges between rows

17. Out of all the courses of the brick setting, only 'five' courses contain ledges in them. In these five courses, ledges are placed alternately at the space between the columns and the space between rows.

18. Courses containing ledges must be separated by at least three regular courses. Depending on number of total courses, any two courses containing ledges can be separated by more than three regular courses to maintain the total number of courses containing ledges as five.

19. On the top of last course containing ledges a lattice (*Jaali*) of green-bricks is made by placing bricks alternately on columns and between rows (Fig. 4.13). This is the topmost course of the green-bricks' stacking.

20. Green-brick setting is covered from the top by a layer of fired-bricks placed on their flat side (Fig. 4.13). Should green-bricks are to be utilized as covering, then it is advisable to use their two layers.

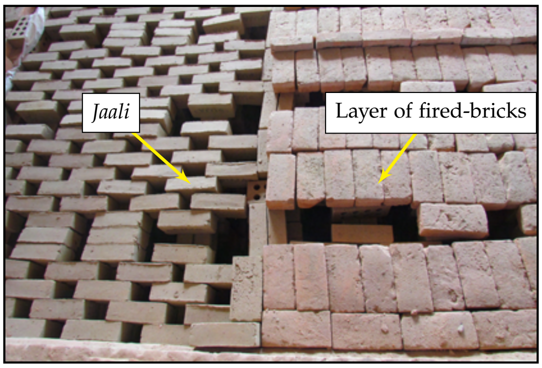

Figure 4.13: Covering the topmost course of green-bricks

21. In all the regions of kiln, feedholes of size (5" × 5") are to made at the topmost layer (Fig. 4.14) of the brick settings. In region-C, these holes are made along the 'first' and 'fourth' rows of a chamber. Hole must be made in such a way that its center aligns with the center of the ledge (*Jodi*) directly below it.

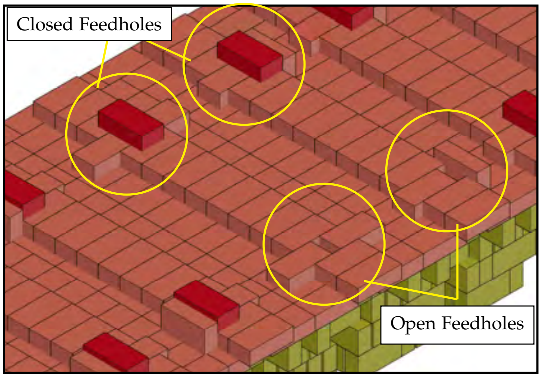

Figure 4.14: Feedholes to drop fuel into the kiln

22. Ash layer of about 6"–7" is spread on the top of flat faced fired-bricks to minimize heat loss from the kiln.

23. In a natural-draught Zigzag kiln, generally, a maximum of 'three' chambers can be fired per day under steady-state kiln operation. Therefore, last row of every 'third' chamber is covered with plastic sheet (Fig. 4.15). This placement of sheet aid in establishing the length of preheating zone of the kiln. Ingress of unwanted cold air from the preheating zone is also prevented by these sheets.

Figure 4.15: Putting plastic sheet on the last row of chamber

24. In a brick setting, ranks of courses in which ledges are to be placed depends on total number of courses in the setting. The following table specifies ranks of courses containing ledges (*Jodi*) for different brick settings.

	Brick Setting			
	21-Course	22-Course	23-Course	24-Course
Ledge – 1 (Between columns)	5th	6th	7th	8th
Ledge – 2 (Between rows)	9th	10th	11th	12th
Ledge – 3 (Between columns)	13th	14th	15th	16th
Ledge – 4 (Between rows)	17th	18th	19th	20th
Ledge – 5 (Between columns)	20th	21st	22nd	23rd
Jaali (Top layer)	21st	22nd	23rd	24th

25. Proper brick setting governs the required supply of air into the kiln which is instrumental in the production of high quality fired-bricks.

Firing of Bricks 5

Firing of bricks is the most important step in the production of burnt-clay bricks. If bricks are fired properly, the process produces high quality bricks – an ideal building material. If the kiln is not fired carefully and cautiously, large amount of soil, fuel, resources, capital and time is wasted. With respect to firing, a kiln can be divided into three zones (Fig. 5.1).

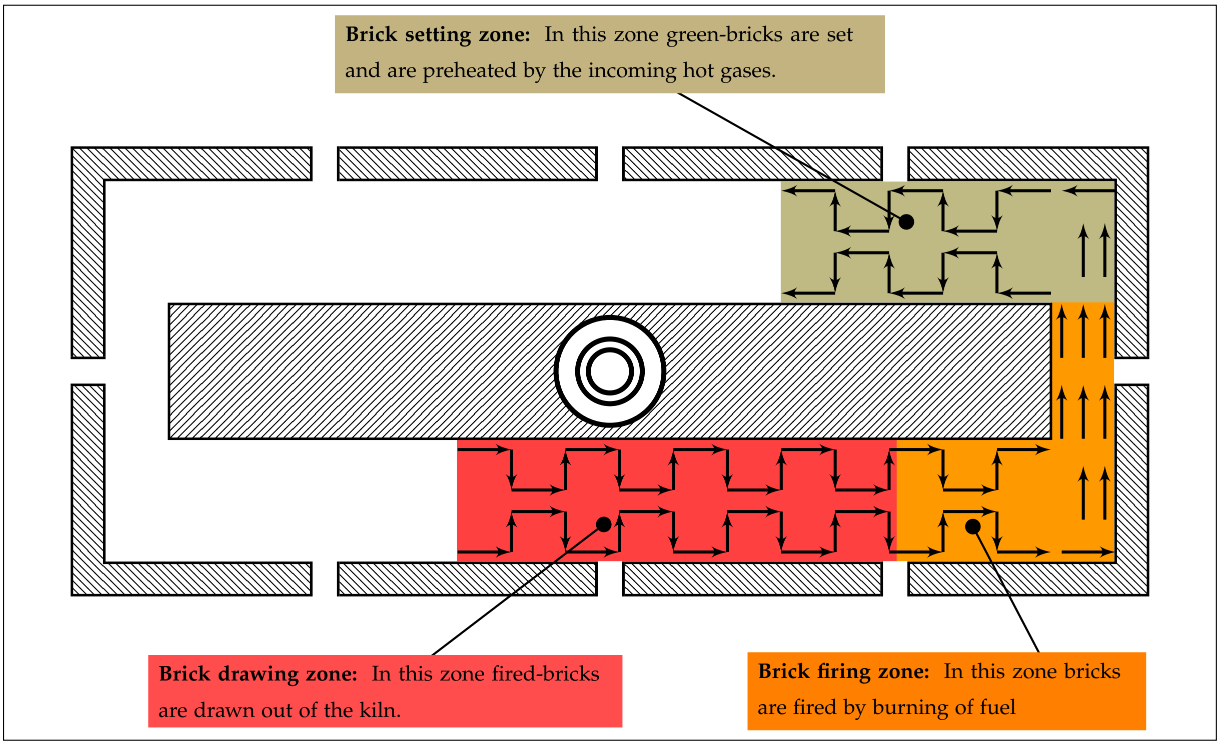

Figure 5.1: Different zones of a kiln

1. Fuel must be stored on a raised concrete flooring with proper drainage system. Mixing of soil or ash with fuel must be avoided.

2. Fuel must be stored inside a shed with proper ventilation, temperature and humidity control.

3. For producing high quality bricks coal should be fed after crushing. Small size particles ignited and burnt easily, thereby supplying heat while falling through the kiln. Big size pieces fall to the floor and supply heat mainly to the bottom of setting.

4. Use crushers to cut the as-received coal. Crushed coal must be sieved before feeding into the kiln.

Figure 5.2: Coal crushing machine

5. Feeding large-sized coal pieces result in production of over-burnt bricks at the bottom of the kiln.

6. Mixing of coal particles with air is better if kiln is fed with small-sized coal resulting in increase of combustion rate.

7. Use small capacity (400 g – 750 g) hand-

shovel (Fig. 5.3) to feed crushed coal into the kiln. Only under special circumstances high capacity shovel should be used to increase the temperature.

Figure 5.3: Small hand-shovel must be used to feed crushed coal

8. Coal of recommended size grading must be fed little and often through the feed-holes into the kiln. Heavy charge of fuel at longer intervals not only wastes fuel but also delays the cooling of bricks and deteriorates the brick quality.

9. Large volume of air is required for combustion of fuel, to bring fire forward, for cooling of fired-bricks and for preheating of green-bricks. With the help of chimney or a fan sufficient draught is created in the kiln to provide the required supply of air.

10. Air required to take the water vapour formed during drying of bricks out of the kiln is supplied by maintaining sufficient draught inside the kiln.

11. Ensure that leakages across the kiln are minimized to maintain the required draught in the kiln else, it will adversely affect the fuel consumption and quality of bricks produced.

12. Wickets must be closed by double layered wall (Fig. 5.4); space between the two layers must be filled with soil to minimize air ingress and heat loss through wickets.

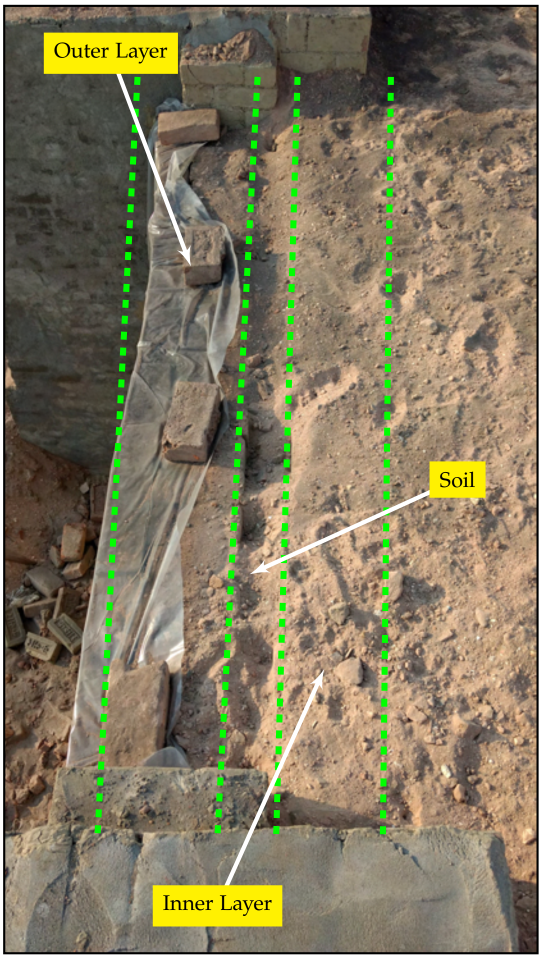

Figure 5.4: Correct way to close a wicket

13. Appropriately put in position ducts' lid and shunts; the sides of lid and shunt must be packed with ash to minimize air ingress and heat loss through them.

14. A natural-draught Zig-zag kiln running at steady-state has twelve chambers in cooling, nine chambers in preheating and six chambers in combustion zone (Fig. 5.5).

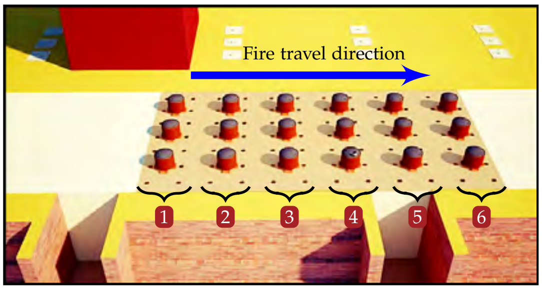

Figure 5.5: Combustion zone of a kiln

15. To maintain different temperatures in chambers of combustion zone, different fuels and their combination are used.

Chamber	Fuel	Temperature
Chamber–1	Sawdust + Coal	800 °C – 845 °C
Chamber–2	Sawdust + Coal or coal	935 °C – 1020 °C
Chamber–3	Coal	1030 °C – 1035 °C
Chamber–4	Coal	970 °C – 1010 °C
Chamber–5	Sawdust + Coal	830 °C – 910 °C
Chamber–6	Sawdust	480 °C – 635 °C

16. In the direction of fire travel, during steady-state operation, the last two chambers of combustion zone are maintained in *upcast* (Fig. 5.6), middle two chambers in *neutral* (Fig. 5.7) and first two chambers in *downcast* (Fig. 5.8) mode of operation.

Figure 5.6: *Chamber*–1 and *Chamber*–2 are maintained in *upcast* mode

Figure 5.7: *Chamber*–3 and *Chamber*–4 are maintained in *neutral* mode

Figure 5.8: *Chamber*–5 and *Chamber*–6 are maintained in *downcast* mode

17. Temperatures must be measured at regular intervals using thermocouples (Fig. 5.9). In a chamber, measurements are done near the bottom, center and top of the kiln so that uniformity of firing across the cross-section can be checked on regular basis.

Figure 5.9: Temperature measurement in a kiln

18. At steady-state operation of the kiln, counting from the first chamber of combustion zone, at sixth and ninth chamber, first and second shunts are put into position respectively.

19. At steady-state operation of the kiln, after every eight hours a new chamber is opened for fuel feeding i.e., three new chambers per day are opened for firing; shunts are also shifted further accordingly.

20. If air flow into the kiln is very high due to increase in draught inside the kiln, by closing the dampers or lid of ducts of cooling zone air flow is regulated.

21. If air flow into the kiln is low, by opening the dampers or lid of ducts of cooling zone air flow is regulated.

22. Excessive length of cooling or preheating zone causes drop in air flow into the kiln thereby adversely affecting the fire travel rate.

23. To burn the coal completely, feeding in the front chamber of combustion zone must be started only when the temperature inside it reaches 650 °C or more (good red colour), otherwise un-burnt fuel would get piled up at the bottom of the kiln (Fig. 5.10, 5.11).

Figure 5.10: Insufficient temperature to burn the coal

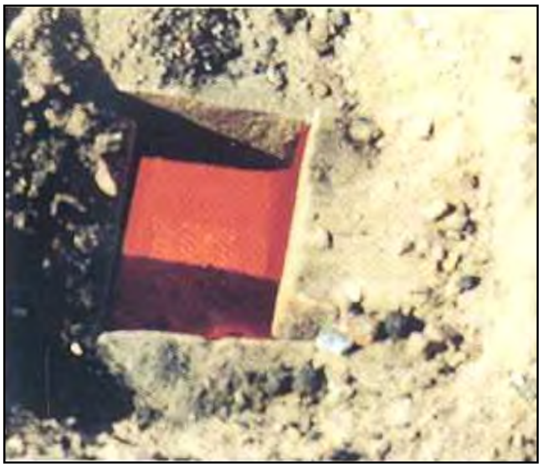

Figure 5.11: Sufficient temperature to burn the coal

24. By looking through the feedholes into the chamber temperature acquired by the bricks can be fairly judged by observing their colour (Fig. 5.12). At 400 °C bricks are black in colour; at about 700 °C bricks will acquire red colour; orange colour of bricks indicates that their surface temperature is about 1100 °C. Flames produced by burning of coal particles are bright yellow in colour.

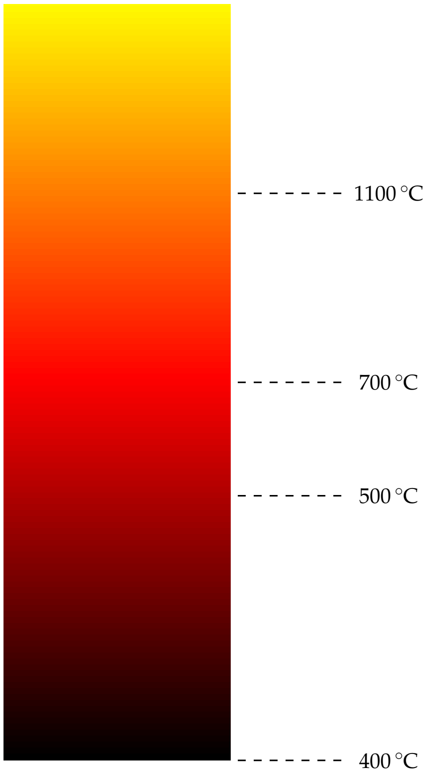

Figure 5.12: Temperature of bricks according to colour attained by them