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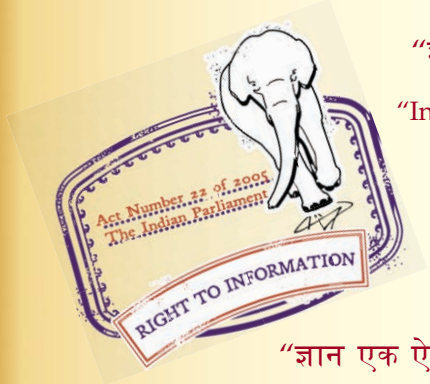
IS 11650 (1991): Guide for manufacture of common burnt clay building bricks by semi-mechanized process [CED 30: Clay and Stabilized Soil Products for Construction]



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Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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IS 11650 : 1991
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(पहला पुनरीक्षण)

Indian Standard

GUIDE FOR MANUFACTURE OF COMMON BURNT CLAY BUILDING BRICKS BY SEMI-MECHANIZED PROCESS

(First Revision)

UDC 691·421 - 431 : 006·76

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

July 1991

Price Group 4

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Clay Products for Building Sectional Committee had been approved by the Civil Engineering Division Council.

In recent years the brick industry has been facing an acute shortage of skilled moulders, kiln setters, firemen, etc, which resulted in a fall in production and deterioration in quality of bricks. Therefore the necessity of adopting some mechanized means of shaping the bricks so as to make the process independent of individual skill was realized. Simple brick making plants in which only the shaping process is mechanized can be based on soft-mud, extrusion or semi-dry process. At present only the extrusion machines are produced indigenously and some expertise in the manufacture of bricks by extrusion process already exists in the country. Therefore, the need of unifying the practice being followed at present was also felt. Moreover, in view of the growing energy crisis there is also the necessity of introducing kiln of higher thermal efficiency fulfilling the requirement of kiln for semi-mechanized brick making process. With a view to improve the manufacturing operations and utilizing the existing knowledge and experience, this standard has been prepared to unify the practice followed.

This standard was first published in 1986. This revision has been prepared to include such of the data which have been established since it was last revised, like manufacturing bricks with various additions as fly ash, sandy beam, rice husk, basalt stone dust, etc, details of firing process, besides making other contents up to date.

Indian Standard

GUIDE FOR MANUFACTURE OF COMMON BURNT CLAY BUILDING BRICKS BY SEMI-MECHANIZED PROCESS

(First Revision)

1 SCOPE

1.1 This standard (First Revision) covers the selection of raw materials, requirement of semi-mechanized plant and method of manufacture of common burnt clay building bricks by semi-mechanized process.

2 REFERENCES

2.1 The Indian standards listed in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

3.1 For the purpose of this standard, definitions given in IS 2248 : 1981 shall apply.

4 SELECTION OF SITE

4.1 In selecting the site for a semi-mechanized brickworks due considerations should be given to the following factors:

a) Availability of an ample reserve of clay or clays of the required quality at the site or within economically short distances of it;
b) Abundant supply of potable water;
c) Good communications;
d) Proximity to a market for the products:
e) Easy availability of labour, power and fuel; and
f) Low level of sub-soil water in all seasons (preferably below 3 m).

4.2 The selected site shall also conform to the prevailing town-planning regulations, specially with regard to the depth and extent of the large pits that would invariably be created as a result of excavation of clay.

5 SELECTION OF RAW MATERIALS

5.1 Selection of Clay

5.1.1 For the manufacture of wire-cut bricks, alluvial clays conforming to the range of mechanical compositions shown below shall be selected:

Clay (0·002 mm)	20 to 40 percent
Silt (0·02 - 0·002 mm)	30 to 50 percent
Sand (0·02 - 0·2 mm)	40 to 60 percent

5.1.2 The total fines (clay + silt) shall not be less than 50 percent by weight. The clay shall be free from stones, gravel, coarse sand and modular lime.

NOTES

1 The limits for particle size grading (*see* **5.1.1**) are not applicable to black cotton and lateritic soils.

2 River silts and silts collected from natural ponds and settling tanks of waterworks are also suitable materials for brick making.

5.1.2.1 The total lime (CaO) and magnesia (Mgo) in the case of alluvial clays shall not be more than one percent and in other cases, shall not preferably be more than 15 percent. The lime shall be in finely subdivided form. The total water soluble salts shall not be more than one percent by weight.

5.1.2.2 The chemical analysis of the clays shall be conducted in accordance with IS 1727 : 1967 and IS 2720 (Part 21) : 1977.

5.1.3 The plastic properties of the clay shall be determined by determining the plasticity index (PI) by the method given in IS 2720 (Part 5) : 1985. The range of plasticity index will be 15 to 30.

5.1.4 The extrusion characteristics of the clay shall be determined in a laboratory equipped with a clay extruder. The clay should extrude faultlessly from a water/oil lubricated die. The wire-cut bricks shall be dried on a well-sanded drying floor. The bricks shall be tested both for sun and shade drying under natural conditions. After drying, the bricks shall be fired in a laboratory kiln/furnace at 950 — 1 000°C and tested for cracking, warpage, water absorption, crushing strength and efflorescence according to the procedures laid down in IS 3495 (Parts 1 to 4) : 1976.

5.2 Additives

Certain additives such as fly ashes, sandy loam, rice husk ash, basalt stone dust, etc, are often required not only to modify the shaping, drying and firing behaviour of clay mass but are helpful in the conservation of agricultural land and utilisation of waste material available in large quantities. These additives should have a desirable level of physical and chemical characteristics so as to modify behaviour of clay mass within the optimum range without any adverse effect on the performance and durability of finished products. Some of the basic physico-chemical requirements of conventional additives are as under.

5.2.1 *Fly ash*

Fly ash is a waste material available in large quantities from thermal power plants and can be mixed to the brick earths as alluvial, red, black, marine clays, etc, used for brick making.

The fly ash should preferably be fine textured, free from bottom ash, coarser and other extraneous material, with a fineness varying in the range of 2 000 — 3 000 cm^2/gm. The total water solubles in fly ash should be less than 0·1 percent and unburnt carbon preferably below 15 percent. The Indian fly ashes contain amorphous glassy material, mullite, haematite, magnetite, etc, and

show a chemical composition similar to that of brick earths. These silicates also help towards strength development in clay bodies on firing when mixed in optimum proportion depending on the physico-chemical and plastic properties of soils to be used for brick making.

The proportion of fly ash mixed as an additive to the brick earth should be optimum to reduce drying shrinkage, check drying losses and to develop strength on firing without bloating or black coring in fired product. The crystallites present in the fly ash should comply with the resultant high temperature phases in the finished product. The desirable characteristics of fly ash which could be used as an additive to the soil mass are given below:

Characteristics of fly ash for use as an admixture with brick earths

Characteristics	*Desired Level*
1. Texture	Fine
2. Coarser material (+1 mm)	Below 0·5 percent
3. Unburnt carbon	Below 15 percent

5.2.2 *Sandy Loam*

Addition of sandy loam is often found effective in controlling the drying behaviour of highly plastic soil mass containing expanding group of clay materials. Sandy loam should preferably have mechanical composition as under:

Clay	< 2 micron	8 to 10 percent
Silt	2-20 micron	30 to 50 percent
Sand	>20 micron	40 to 60 percent

The material should however meet the other requirements as specified under 5.

5.2.3 *Rice Husk Ash*

The ash should preferably have unburnt carbon content in the range of 3-5 percent (Determined as LOI) and shall be free from extraneous materials, can be used with plastic black and red soils showing excessive shrinkages.

5.2.4 *Basalt Stone Dust*

Basalt stone occurs underneath the black cotton soil and its dust is a waste material available in large quantities from stone crushers. The finer fraction from basalt stone crushing units can suitably be mixed with soil mass to modify the shaping, drying and firing behaviour of the bricks. The dust recommended for use as an additive with brick earth should be fine (pass 1 mm screen), free from coarse materials or mica flakes and should be of non-calcitic or dolomitic origin.

6 SELECTION OF PLANT AND MACHINERY

The semi-mechanized plant for producing wire-cut bricks shall comprise:

a) a double-deck extrusion machine;
b) hand-operated cutting table;
c) sheds for natural drying of bricks on floors/racks;
d) an archless, top-fed zig-zag kiln operating on fan draught;
e) a coal crusher;
f) accessory equipment for manual excavation of clay, materials handling, water and power supply, kiln firing, etc; and
g) control instruments like thermocouples, pyrometers, draught gauge, etc.

7 PROCESS FLOW

The process flow diagram and the layout of the plant are shown in Fig. 1 and 2.

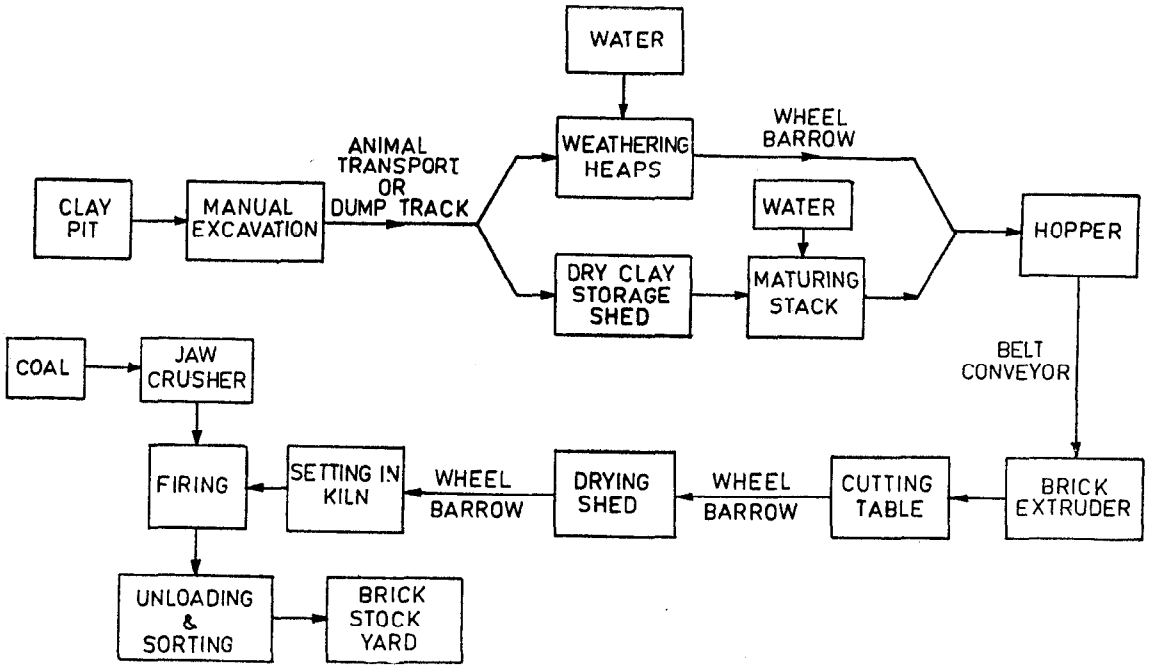
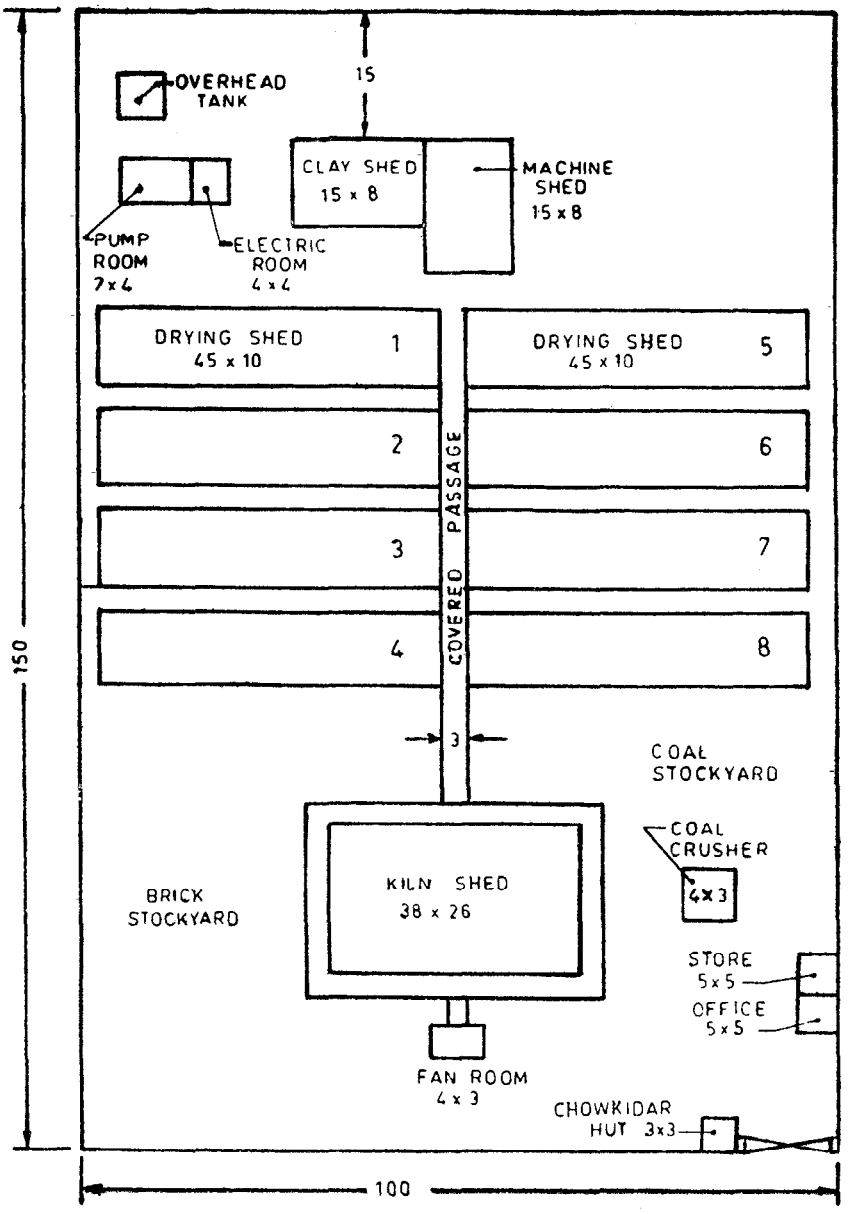


FIG. 1 PROCESS FLOW DIAGRAM OF A SEMI-MECHANIZED BRICK PLANT



All dimensions in metres.

FIG. 2 LAYOUT OF A SEMI-MECHANIZED BRICK PLANT

8 THE MANUFACTURING PROCESS

8.1 Preparation of Clay/Clay Admixtures

8.1.1 *Addition of Opening Material* (such as fly ash, sandy loam, rice husk ash, stone dust, etc).

Requisite predetermined proportions of additives as indicated above should be spread over the plain ground surface on volume basis. The soil is then manually excavated.

8.1.2 In excavating clay, care shall be taken to expose the entire clay profile reaching up to the maximum depth (usually 3 m or so) to which clay occurs. Clay shall be dug from the top to the bottom of the exposed face so that clays in all the intermediate strata get mixed up in the process.

8.2 The excavated clay is transported by pack animals or by a dumper truck to the weathering heaps built up around the brick machine shed. The clay in the weathering heaps is maintained at a moisture content of 15 to 20 percent by frequent spray of water. A stock of dry clay is stored in a storage shed for maintaining production through the wet season.

8.2.1 Weathering of wet clay should be continued for at least one month or longer, if necessary.

NOTE — In the case of black cotton soils contaminated with nodular (kanker) lime, dry soil should be pulverized in a suitable machine to reduce the size of the lime particles to below 1 mm. Alternatively, the soil can be mixed with water to a thin slurry in a blunger and washed free of lime by wet sieving. The washed slurry is treated further as described in 7 of IS 2117 : 1991.

8.3 Extrusion and Wire-Cutting

8.3.1 The weathered clay is brought in trolley-loads to the clay storage space provided around the hopper located at the feeding end of the belt conveyor which carries clay to the brick machine. When the belt is running, clay is manually fed into the hopper by dragging it forward by a 'phowrah'. The feed is maintained at more or less uniform rate by practice and also by controlling the movement of the belt by a switch controlled by the brick machine operator.

8.3.2 The conveyor delivers the clay at the feed-end of the top deck of the machine which comprises the mixer section where two shafts carrying a number of blades rotate in opposite directions which mix the clay with further quantities of water and pug it into a stiff paste which is propelled forward and dropped into the lower deck of the machine. The quantity of water added to the clay in the mixer is controlled manually. The total water content of the clay varies generally between 20 to 25 percent, depending on the plastic properties of the clay.

8.3.3 The bottom of the machine comprises the lower box, a barrel, the spacer and the die. The box and the barrel enclose the main auger which propells, compacts and extrudes the clay through the die.

8.3.4 The die used for making modular bricks will have a front opening whose dimensions are shown in Fig. 3. The lengths $\triangle C$ and $\triangle B$ are the allowances for total linear shrinkages of the clay so that the fired bricks will have a length of 19 cm and breadth of 9 cm. The rear opening of the die is larger and matches with the delivery end of the spaces. The die may be of wood or cast iron and is lined internally with GI sheet. It also has provision for water or oil lubrication on all the four interior faces and corners.

8.3.5 The extruding column of clay travels over the top plate of the cutting table. This plate is also oil or water lubricated. The cutter operator cuts off three bricks at a time. This is accomplished by pushing down three taut wires fixed to a wire frame through the clay column. The wire frame can be rotated through 180° in the vertical plane.

8.3.6 The spacing between the three cutting wires is $9+\triangle t$ cm where $\triangle t$ is the linear shrinkage of the clay.

9 DRYING OF BRICKS

9.1 After putting off three bricks the cutter operator pushes them on to the delivery table from where bricks are loaded on a 3-mm thick steel pallet measuring 60×20 cm so that each pallet can hold five modular bricks. Each pallet is provided with two handles for lifting it off the cutting table and placing it on a wheel barrow. Each wheel barrow can carry four pallets loaded with 20 bricks in each trip to the drying shed.

9.1.1 The wheel barrow runs on a single solid rubber-tyred wheel and its top deck is spring loaded. The barrow is pushed by one man.

9.2 On arrival at the drying shed, the loaded pallets are lowered on the floor. The bricks are then manually slid on to the drying floor which is covered with a 12-mm layer of fine sand. The empty pallets are returned to the cutting table.

9.2.1 Bricks are left to dry on the floor for 3 to 4 days and are arranged in hacks in the same pattern of setting recommended in IS 2117 : 1975. Bricks dry in hacks for a further period of 7 to 15 days till the moisture content is reduced to 5 to 7 percent approximately.

9.2.2 Bricks made out of clays highly sensitive to drying stresses should be protected against exposure to high winds in the initial stages of drying particularly in the summer months. This is secured by covering the sides of the drying sheds with gunny-cloth screens.

NOTE — Bricks can also be naturally dried on wooden pallets placed on racks in several tiers.

9.3 Dry bricks are transported to the kiln in box or platform type wheel barrows running on two or more solid rubber tyred wheels. Each barrow may carry 30 to 40 bricks.

10 KILN SETTING AND FIRING

10.1 The pattern of setting of dry modular bricks in the high draught kiln* and the method of firing are described in **10.2** and **10.3**.

*Design Drawings and other technical particulars of high draught kiln can be obtained from the Central Building Research Institute.

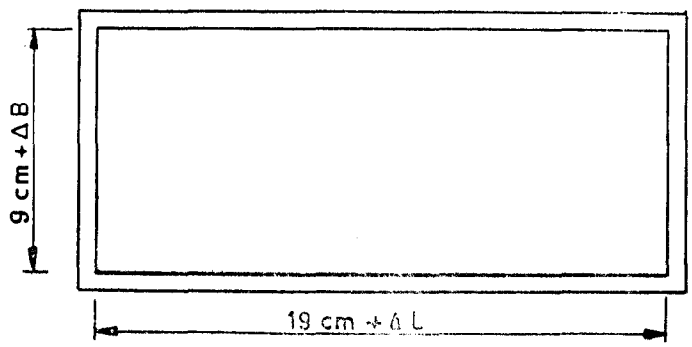


FIG. 3 BRICK DIE

10.2 Setting of Bricks

The plan of the kiln showing the partition walls of the 24 chambers and the position of the 18 flues and their corresponding dampers is shown in Fig. 4. The partition walls are built with dry bricks without any mortar but one face is given a thin mud plaster.

10.2.1 Cross sections of the pattern of setting of bricks in a chamber is shown in Fig. 5.

NOTES

1 The kiln should be constructed on dry ground as far away from pools, streams, river banks, etc, as possible. The ground/sub-soil water level should remain at least 3 m below the kiln floor during the monsoon period. The level of the ground should be such that rain water naturally drains away from all sides of the kiln.

2 All round the kiln sufficient PUCCA drainage should be provided to avoid formation of pools during rain anywhere near the kiln.

3 For all-weather operation, the kiln should be protected by a shed.

4 A stand-by diesel engine-generator of adequate capacity should be provided to take care of any interruption in power supply.

10.3 Initiation of Fire and Control of Firing

10.3.1 At least 20 chambers of the kiln should be loaded before starting the fire. While loading, one face of each partition wall should be plastered with mud. The wickets of all the loaded chambers should be closed by temporary brick walls and plastered over with mud. Preferably this wall shall be of cavity construction and the cavity shall be filled with fine ash obtained as kiln waste.

10.3.2 Firing should be started in one of the end chambers which has the end wall of the kiln as one of its longer sides (Chamber No. 1 in Fig. 4. Alternatively chambers 12, 13 or 24 of Fig. 4 can also be used). A temporary wall with three furnaces at its bottom is constructed about 25 cm ahead of the first row of bricks set in the kiln. 25 mm square mild steel bars are then placed in furnaces to serve as grates. The open space between the top of the temporary wall and the main setting is closed up by corbelling a row of bricks on either side and covering with a layer of ash as in the main setting.

10.3.3 The Chamber Damper No. 3 is partly opened and No. 5 shall be full open at the time of starting the fan. A draught of about 5 to 6 mm shall be maintained by partially lowering the plate damper in the main flue connecting the kiln with the fan. A galvanized steel sheet damper shall be temporarily placed across the gap in the partition wall between Chamber 8 and Chamber 9.

10.3.4 Fire shall be lit in temporary furnaces in which rubble coal (steam coal) is burnt. When coal starts burning vigorously long tongues of flame are seen entering the first chamber. Coal shall be fed to the grates every 20-30 minutes. After each feed, the furnaces shall be closed with temporary doors or shutters to prevent entry of excessive amounts of cold air.

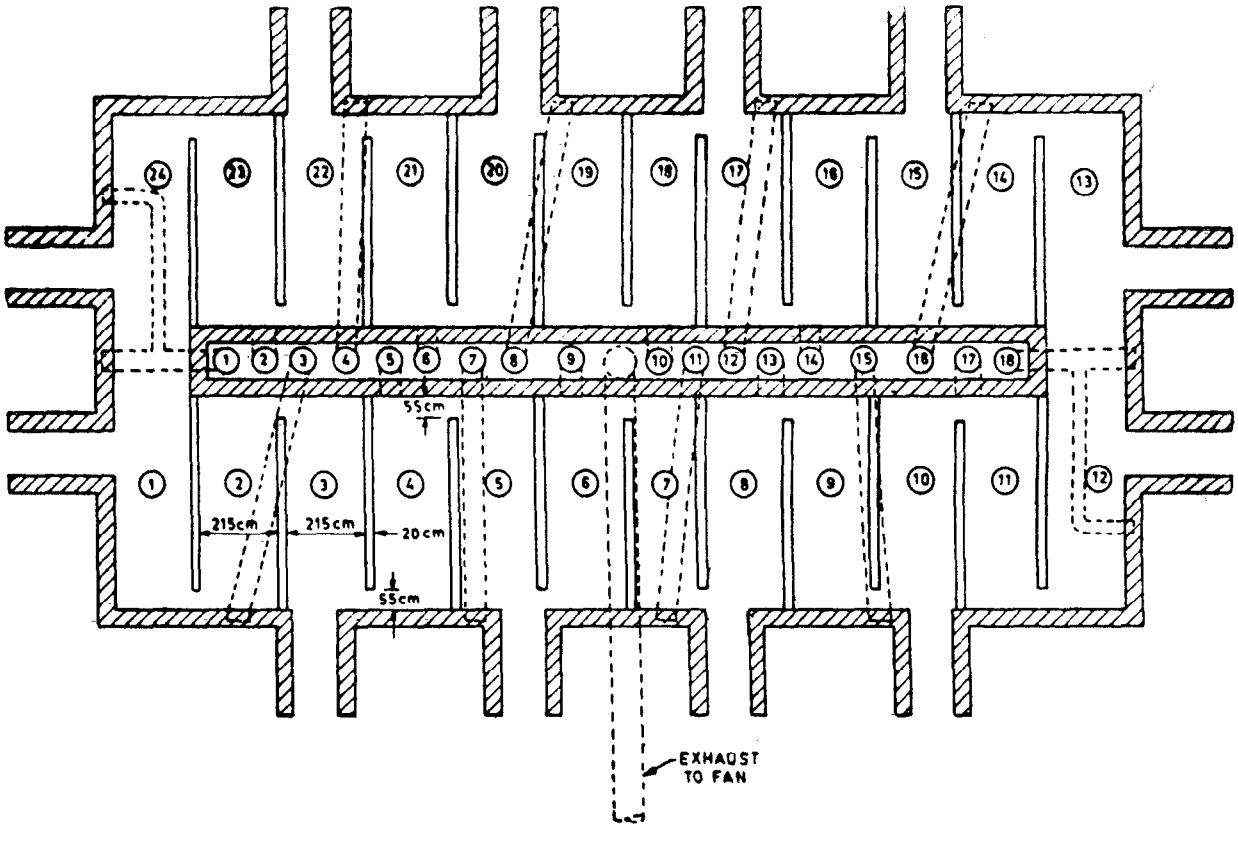


FIG. 4 PLAN OF KILN

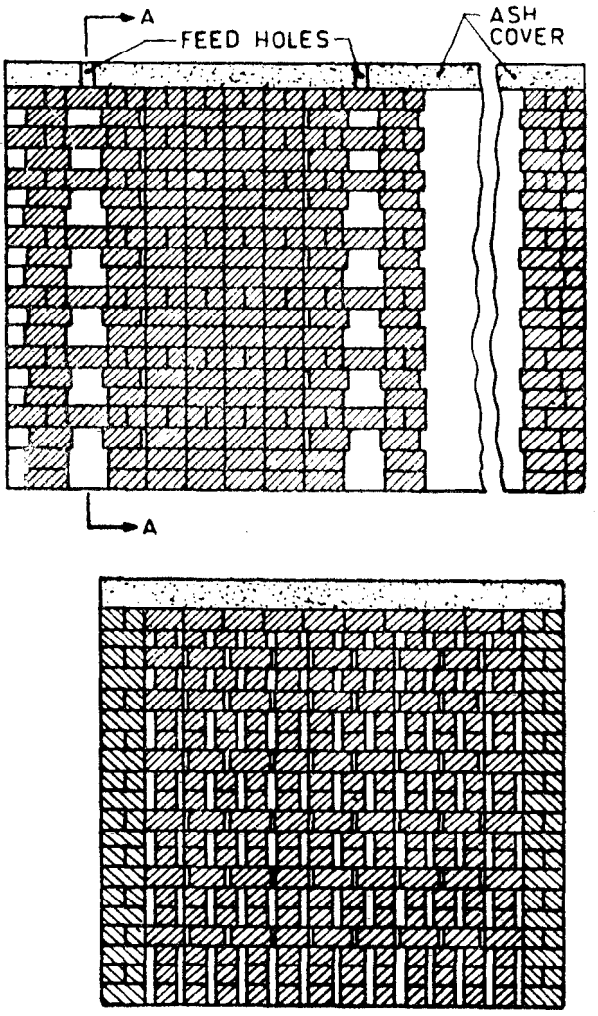
10.3.5 When the bricks in the first chambers as well as its floor are observed to have become red hot, feeding of slack coal crushed below 12 mm shall be started in this chamber through the top feed holes in which the CI feed hole caps have already been fixed. Initially only 1/2 to 1/4 kg of coal shall be fed per feed hole every 20 min. Frequency and quantity of feed shall be increased to 15 min when the chamber temperature goes above 900°C. At this stage Damper No. 3 shall be closed down and exhaust shall be taken only through Damper No. 5.

10.3.6 Both top and bottom firing in Chamber No. 1 shall be continued till fire is observed to have entered Chamber No. 2. When the floor of this chamber also becomes red hot (as viewed through the feed holes) feeding of slack coal shall be started in this chamber also.

10.3.7 By the time coal feeding starts in chamber No. 3, the temperature of bricks in Chambers 1 and 2 should reach around 1 000°C. The draught can then be increased to about 25 mm, Damper No. 5 closed and No. 7 opened. Bottom firing of Chamber No. 1 (through temporary grates) shall be stopped at this stage but top feeding should continue to maintain sufficient back heat. Feeding of coal along the centre row of feed-holes in this chamber should also be stopped at this stage. The openings of the temporary grates are then sealed by bricks leaving only three small air holes at the base.

10.3.8 When fire enters Chamber 4 feed-hole pots from Chamber 1 shall be removed and the holes sealed by bricks and ash. The feed pots shall be inserted in Chamber 4 feed holes. The sheet damper in Chamber 8 shall be shifted to Chamber 12. Damper No. 7 shall be closed and No. 9 or 11 opened. Draught shall now be increased to 40 mm by raising the plate damper near the fan.

10.3.9 The kiln should now be in the regular firing order. Two chambers should normally be burnt every 24 hours.



SECTION A-A

FIG. 5 PATTERN OF SETTING OF MODULAR BRICKS IN KILN

10.3.10 By the time fire enters the 17th or the 18th chamber, bricks in Chamber 1 should be sufficiently cool to permit unloading. Ash from above Chambers 1 and 2 is removed and the wickets pulled down. Unloading of bricks shall then start from these chambers.

10.3.11 Loading of dry bricks in chamber beyond No. 20 may be resumed after placing the MS sheet damper to seal the 'jalli' portion of the partition wall between Chambers 20 and 21.

10.3.12 When regular loading and unloading of chambers have started, the following schedule of firing shall be followed:

	No. of Chambers
Cooling	12
Full fire	2
Preheating and drying	4
Loading	2
Unloading	2
Empty	2
Total	24

NOTES

1 This schedule of firing does not apply rigidly to all kilns but shall be modified according to the nature of the clay and fuel used for burning.

2 Slack coal obtained as run of mine, must be sieved through a 12·5 mm IS Sieve. All large lumps of coal should be crushed in a jaw-crusher to below 10 mm size.

3 At the time of setting, much care is needed to ensure correct alignment of brick blades and trace holes. Any mistake made at the time of setting may seriously affect the propagation of fire and may lead to uneven firing.

4 Before starting the fire, all dampers must be thoroughly checked against leakage. All damper shafts should be correctly aligned and any imbalance in the damper should be corrected.

ANNEX A

(*Clause* 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
1727 : 1967	Methods of test for pozzolanic materials (*first revision*)
2117 : 1991*	Guide for manufacture of hand-made common burnt clay building bricks (*second revision*)
2248 : 1981	Glossary of terms relating to clay products for building (*first revision*)
2720 (Part 5) : 1985	Methods of test for soils : Part 5 Determination of liquid and plastic limits (*second revision*)
2720 (Part 21) : 1977	Methods of test for soils : Part : 21 Determination of total soluble solids (*first revision*)
3495 (Parts 1 to 4) : 1976	Methods of test for burnt clay building bricks (*second revision*)

*Revision under print.

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