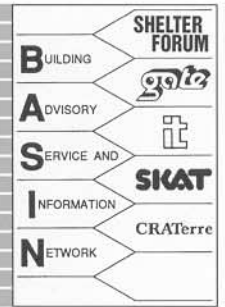




Wall Building

Case Study



Igloo Type Brick Kilns in Zimbabwe

Introduction

Igloo or beehive kilns (as they are generally known in Zimbabwe) derive their name from the shape of the kiln. In the majority of cases, igloo kilns in Zimbabwe are used for firing refractory, face, industrial bricks, pavers, window sills, glazed earthenware sewer pipes, and, in some cases, pottery.

However, this document focusses on the use of igloo kilns specifically in brick production and is based on the study of three different production plants.

The major source of energy used for firing bricks in igloo/beehive kilns in Zimbabwe

is coal, and the coal is manually fed in the majority of cases. The coal used is generally in the form of large pieces averaging about 120 mm in diameter. The size of coal is referred to as “rounds” in the brick production industry and these pieces glow or burn for a relatively long duration.

Generic classification of igloo kilns, according to the mode of operation

An igloo/beehive kiln is essentially an intermittent down-draught kiln, where heat from the fire boxes in the form of a “heat wave” is deflected upwards by buffer walls to the roof of the dome shaped kiln and

drawn down through the brick setting by means of a chimney away via the perforated floor, side flue channels, and the main flue duct. There is no direct contact between the fuel and the bricks.

Construction aspects

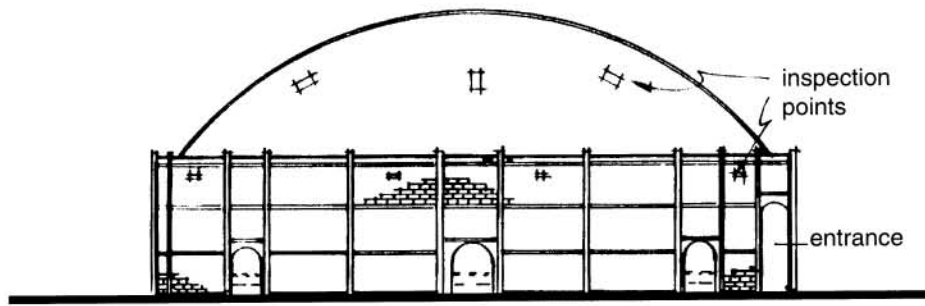
The diameters of igloo kilns vary from 5 to 10 metres, with capacities varying from 20,000 to 35,000 bricks per cycle.

The igloo kiln wall is normally a massive structure being about four brick lengths in thickness for insulation purposes. The footing is executed using either concrete or

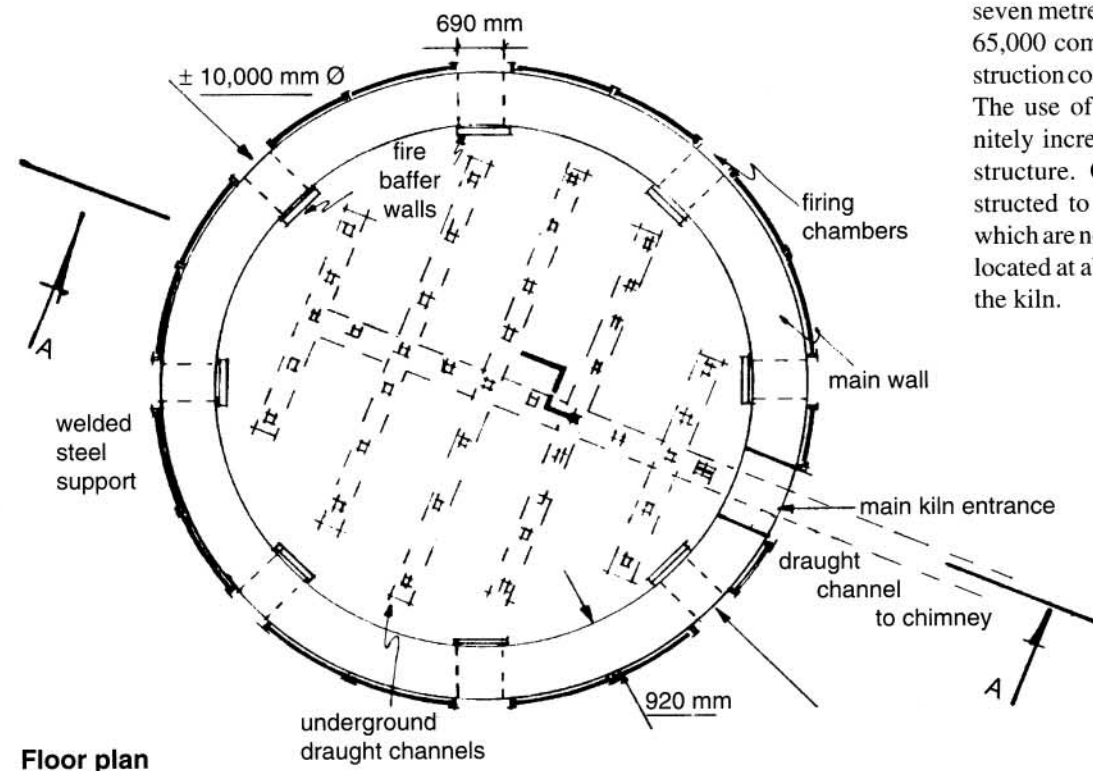
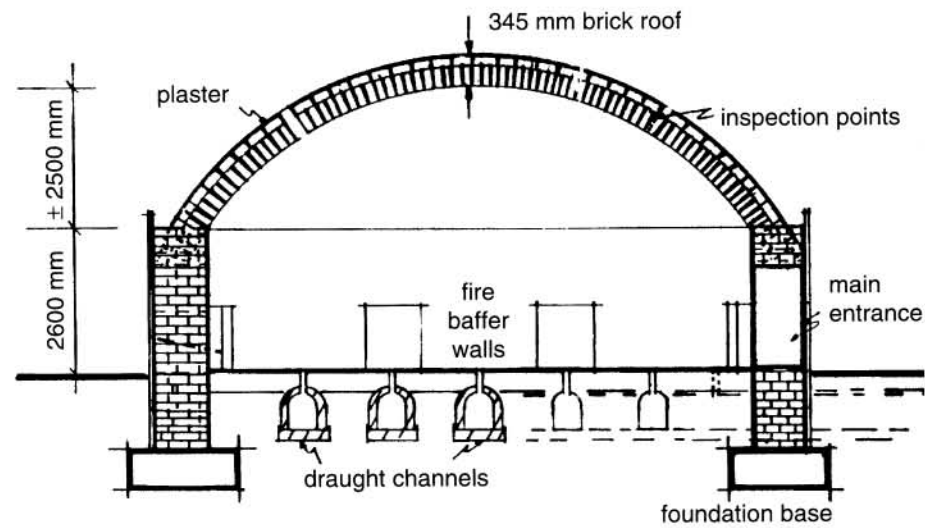


Figure 1 View of an igloo (or beehive) kiln and chimney

Elevation



Section A - A



Floor plan

ordinary brickwork. Alternatively, the footing can be made as an integral part of the bottom slab executed from ordinary bricks.

Side flue channels are inclined into the main flue channel to allow for drainage.

For the construction of the kiln, use is made of either strong common bricks or industrial bricks. In some cases, refractory bricks are used for the lining. For the mortar, either clay mortar or refractory cement mortar is used. In some instances, the clay mortar is blended with ordinary salt, ostensibly to improve its strength.

The dome shape of the roof is formed by the use of dome bricks or arch bricks at certain intervals (starting with the first course of the roof) during the construction of the kiln. Headers form the inside part of the roof and stretchers form the outer cover, which is in turn plastered with cement mortar. Provision is made both within the wall and the roof for inspection holes which are spaced evenly around the kiln.

In the majority of the cases there is one opening/entrance for both loading and discharging of the kiln. However, in rare cases, two opposite openings are provided. Firing chambers with an arched roof are evenly spaced around the kiln wall. The number of firing chambers within one kiln ranges from 8 to 13.

A kiln with an inside diameter of about seven metres would require approximately 65,000 common bricks and the total construction costs would be roughly US\$ 8,000. The use of refractory bricks would definitely increase the investment cost of the structure. Chimneys are normally constructed to serve 3 to 4 kilns. Chimneys which are normally 13 to 15 metres high are located at about 30 to 50 metres away from the kiln.

Figure 2 Plan, section and elevation of an igloo kiln

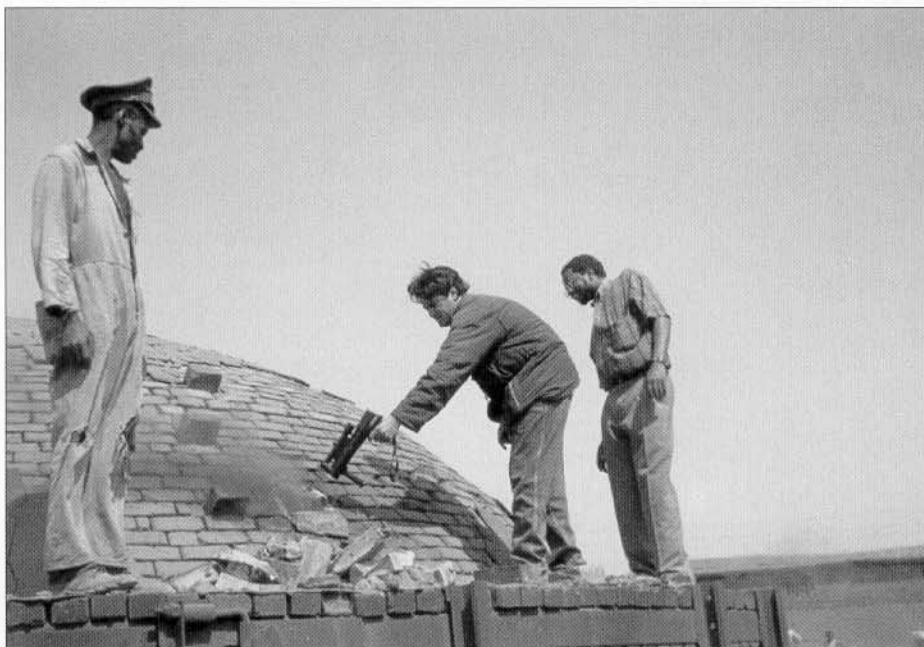


Figure 3 Monitoring the state and colour of the bricks through an inspection hole

Setting of bricks inside the igloo kiln

In an igloo kiln, brick setting density is generally lower than brick setting density in a field clamp.

Face bricks are arranged inside the kiln in such a manner that at least both stretcher faces will be exposed to the heat, and there will be adequate space for the flow of heat without undue restriction from the top of the kiln to the floor, and out into the chimney. Enough space is left as well between the kiln wall or roof and the brick setting for specifically the same reason.

For face bricks, normally a pattern known as "Pillar Setting" is employed and in this pattern bricks are laid on their bed faces. Bricks are arranged in the form of pillars, which are then linked together, as shown in Figure 6.

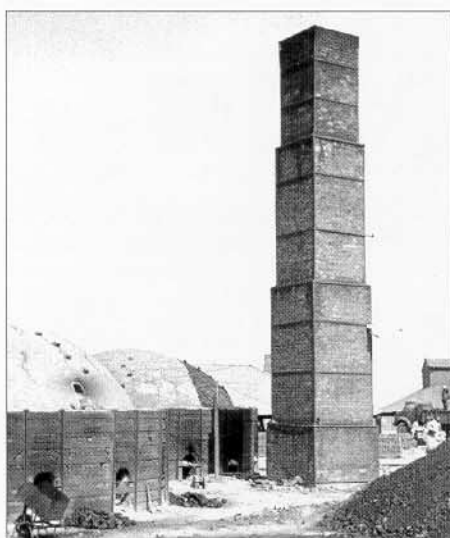


Figure 4 One chimney serving several igloo kilns

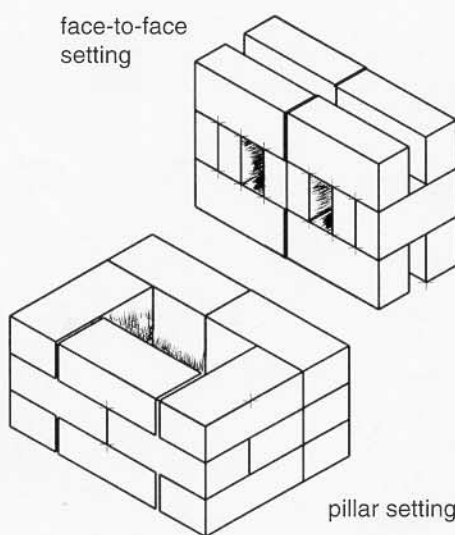


Figure 5 Methods of setting bricks for firing

For industrial/engineering bricks, a pattern called "face to face setting" is normally employed, and the bricks are laid on their edges/stretcher faces. "Face to face" setting produces a much denser packing than the "pillar" setting.

The third and final setting arrangement employed is similar to the "face to face" setting, but the bricks are laid on their bed faces and their edges/stretcher faces left exposed.

The bulk density in a seven metre diameter beehive kiln would be about 120 bricks/m³ for face bricks, whilst for industrial engineering bricks it would be 150 bricks/m³.



Figure 6 Pillar setting (packing) inside an igloo kiln

Operating regime for an igloo / beehive kiln

As a matter of importance, these kilns are charged with bricks which are dry enough, ie with a relatively low moisture content.

For a 24,000 face brick capacity kiln, the following would be typical operating regime:

1. Four days are spent on loading the kiln with a team of two setters and four loaders. After loading, the entrance is sealed.
2. Low temperature firing would proceed for three days with one fireman per shift. At the end of these three days, temperatures within the kiln are in the region of 850° to 950° C. The fireman is manually feeding coal into the fire boxes, starting with a low fire to gradu-

ally drive off the moisture content and bring the bricks to the soaking temperatures.

3. With the addition of more coal, the temperatures are elevated to a range of about 1,000° to 1,200°C and roughly maintained within that region. High temperature firing proceeds for about four to five days. The condition of the bricks is constantly monitored by checking the state and colour of the bricks through inspection holes. It is also during this period that salt is added to the fire to achieve various colour shades of the bricks. Dampers are used to regulate draught.
4. Cooling of the kiln takes about four to five days. It is absolutely essential that cooling proceeds in a regulated manner. Cooling can, however, be accelerated after the initial one and half or two days by the use of fans.
5. Finally, off-loading takes about three days.

Fuel consumption and energy efficiency aspects

Fuel consumption in igloo kilns at the brick plants studied (on the basis of quantities of coal utilized) was found to range from 4.375 MJ/kg to 7.08 MJ/kg or from 4,375 kJ/kg to 7,080 kJ/kg

These figures are comparable with experiences elsewhere in the world, where energy consumption figures for similar types of kilns range from 2,160 kJ/kg to 8,500 kJ/kg (Energy use and Efficiency in Building Materials Production, by A. Russel, 1996). Net calorific value of coal used was in the order of 30 MJ/kg.

Thermal efficiencies of the igloo kilns studied, on the basis of a theoretical energy input requirement of 110 kJ/kg and specific heat capacity of clay of 1 kJ/kg degrees Celcius (Ceramic Technology, Volume 9), using formula

$$\eta = \frac{\text{Theoretical energy input requ.} \times 100\%}{\text{Total energy input}}$$

would range from 15 to 25 %, which is definitely low by any standards. If the value of the theoretical energy requirement had been taken as 850 kJ/kg, according to Barringa, et al (1992), the efficiencies would be even lower.

The efficiency of these kilns is affected by the lack of adequate control of the air-to-fuel ratio, as evidenced by dense masses of black smoke during fuel charging. The air-to-fuel ratio is always lean, due to the fact that the high firebed resistance limits the supply of primary air, and limited space above the firebed denies access of secondary air.

The combustion gases emitted from the beehive kilns recorded the following average figures:

• Sulphur dioxide (SO ₂)	0.42	ppm
• Carbon monoxide (CO)	230	ppm
• Carbon dioxide (CO ₂)	2,215	ppm
• Nitrogen oxides (NO _x)	0.153	ppm

Maintenance aspects

Igloo/beehive kilns require regular maintenance of buffer walls, which are often damaged during the firing cycle. Flue channels would also require regular inspection to ensure that there are no blockages.

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Building materials and construction technologies that are appropriate for developing countries, particularly in the low-income sector, are being developed, applied and documented in many parts of the world. This is an important prerequisite for providing safe, decent and affordable buildings for an ever-growing population.

But such new developments can do little to improve the building situation, as long as the information does not reach potential builders. The types and sources of information on standard and innovative building technologies are numerous and very diverse, making access to them difficult.

Thus, in order to remedy this drawback, Shelter Forum, GATE, ITDG, SKAT and CRATerre are co-operating in the Building Advisory Service and Information Network, which covers five principal subject areas and co-ordinates the documentation, evaluation and dissemination of information.

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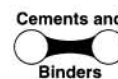
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