TARA

VERTICAL SHAFT BRICK KILN

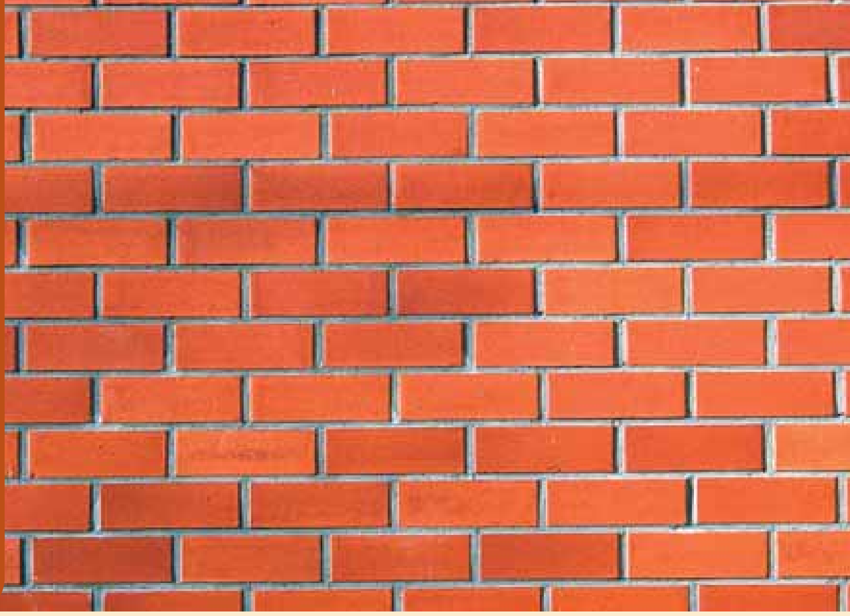
DESIGN MANUAL

Knowledge Partnership Programme

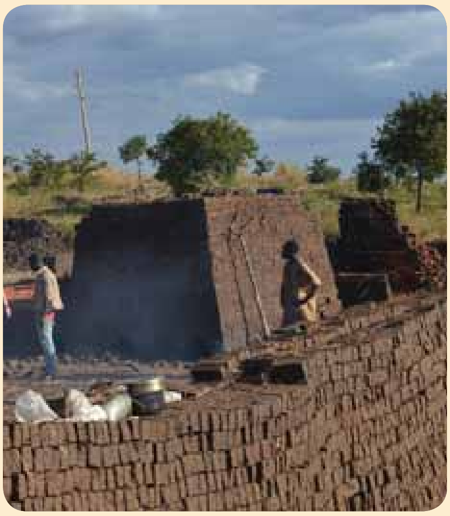
IPE GLOBAL
Expanding Horizons. Enriching Lives.

A Practical Guide
On how to design a Vertical Shaft Brick Kiln

Contact Details:
Technology and Action for Rural Advancement
B-32, TARA Crescent,
Qutub Institutional Area,
New Delhi-110016
Phone Number: 011-26544100
Email: smaity@devalt.org, knagrath@devalt.org



Preface



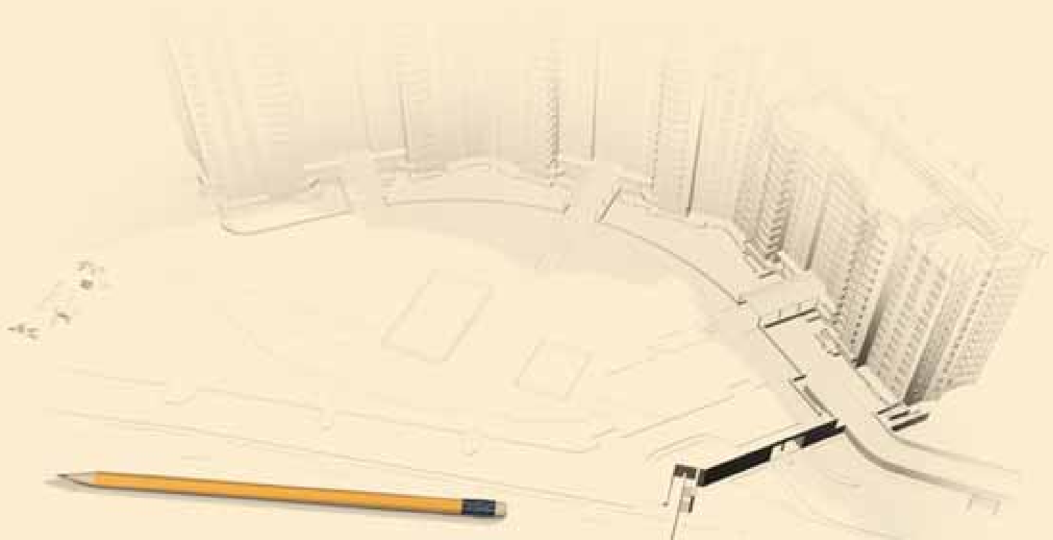
This manual aims at understanding and describing the needs for design methods that have arisen in response to interest in Malawi for the energy efficient and environment friendly brick firing technology i.e. the Vertical Shaft Brick Kiln (VSBK) technology.

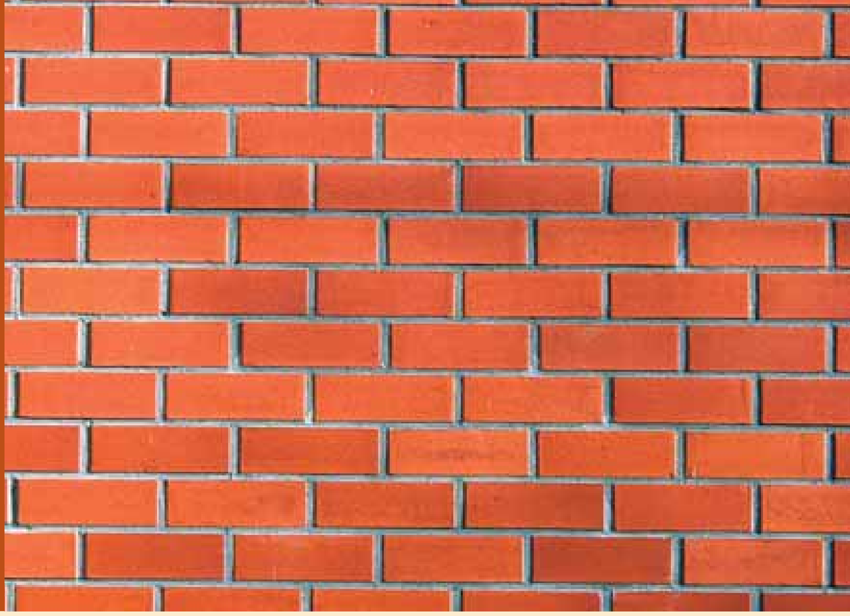
Generally it is understood that designing is done in order to produce drawings needed by clients and construction experts. However, in recent times with the interest in VSBK in Malawi, there has been a need to write down a standard method or recipe that can be relied upon for designing a VSBK. These design aspects are also country specific, since they depend on technical, social and geographical conditions particular to that country. Thus, the need to develop a design manual, specific to Malawi conditions was necessary.

This design manual specific to Malawi conditions is based on more than a decade long practical working experience in India and Nepal. This design manual is expected to serve as a basic tool for construction engineers and supervisors to delineate the essential parameters for the construction of a VSBK.

This design manual does not claim to be complete or perfect. It is in the hands of the users to utilise it fully by using it as a reference guide for further improvement. The VSBK authors would appreciate if you could share your ideas and work experiences to further improve this design manual.

Society for Technology & Action for Rural Advancement, India





Acknowledgement

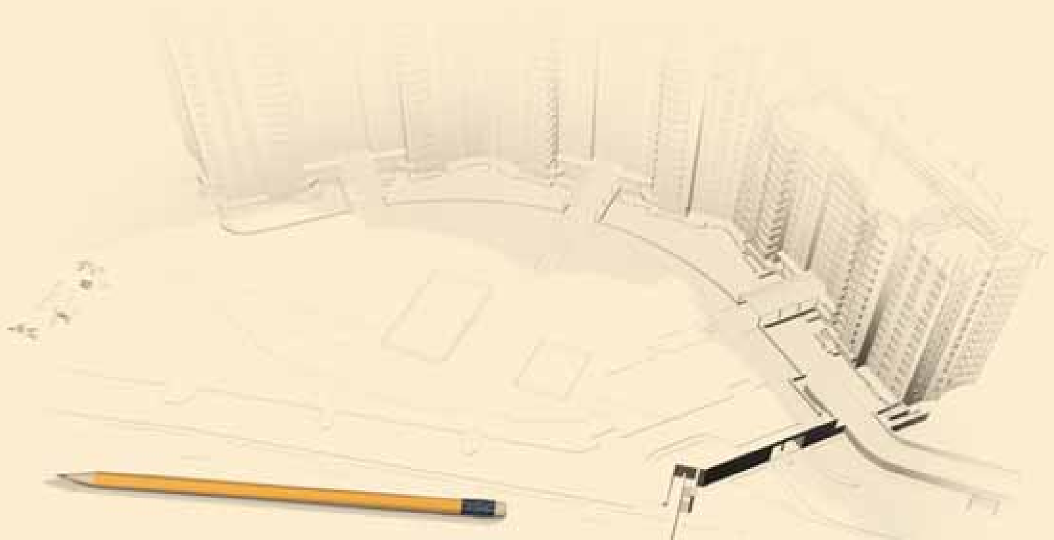
During the course of developing this manual, every effort was made to include the existing knowledge base, along with interactions between personnel associated with the VSBK technology.

We would like to acknowledge the support of various organizations, The Swiss Agency for Development and Cooperation, India; TARA Machines and Tech. Services Pvt. Ltd., India; Centre for Community Organization and Development (CCODE), Lilongwe, Malawi; Eco bricks Limited, Lilongwe, Malawi, TARA Machines and Tech. Services Pvt. Ltd. and IPE Global, New Delhi; who have whole heartedly contributed towards developing the same.

Our sincere thanks to various individuals, whose views have been accessed personally, through one-to-one interactions, the internet and printed documents. Special thank to Heini Muller, Skat Nepal for developing the first manuals. His inspirations and guidance were invaluable in designing many more.

The research efforts captured in this manual would not have been possible without the institutional support given to the project organisations by Deutsche Gesellschalt fur Internationale Zusammenarbeit(GIZ) GmbH and the Knowledge Partnership Programme (KPP) of the Department of International Development (DFID), India. Managed and supported by IPE Global, the KPP aims to step up collaboration around ideas, knowledge, evidence, accountability, technology and innovation, impacting the delivery of global public goods and services and leverage Indian experiences to reduce poverty in LDCs.

Society for Technology & Action for Rural Advancement, India



Contents

Figures

Chapter 1

Introduction

The design of VSBK is the result of efforts and processes developed in the past and the practical experiences of VSBK's performances in different countries. The design of the shaft size is the most important part of VSBK because it determines the dimensions of the entire VSBK structure. The shaft design also plays an important role in the performance of VSBK. **Any fault in the design of shaft can lead to failure of the kiln.** Also, once designed and constructed, the shaft size cannot be changed (Refer Figure 1).

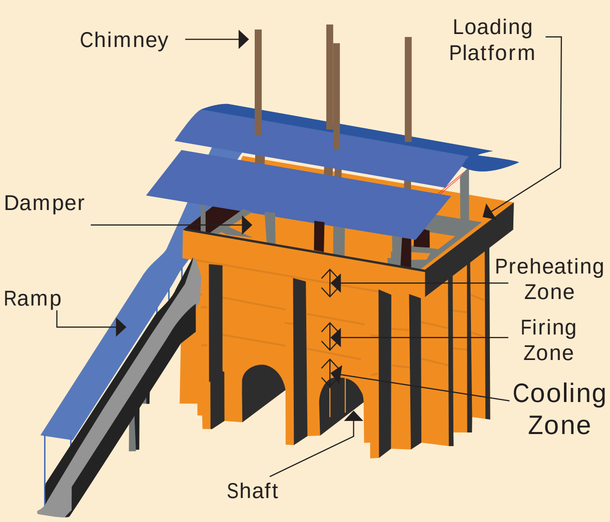


Figure 1: Schematic Diagram of a VSBK

Design Principles

The following criteria are derived from design aims and errors applicable to the present issue of developing the same for a Vertical Shaft Brick Kiln system and limited not only to the final civil superstructure.

1. Identification and review of critical decisions

Every decision which carries a high penalty must be identified as early as possible. Such decisions should be taken only tentatively at first and should be reversible if they are later found to be conflicting with reliable evidences or with informed opinions.

2. Relating the cost of research to the penalties for taking wrong decisions

The penalty for not knowing must exceed the cost for finding out if it is worth using expensive design efforts to answer any questions. The first requirement in evaluating a proposed action is to identify the questions to which the action will provide answers.

3. Matching design activities to the implementation team

The design team members must be confident of their actions. They should have the capabilities and the motivation to carry out these actions. This must also match the capability of the implementation team and therefore be within their reach and understanding.

4. Identifying usable sources of information

Information should be sought from all the major sources of stability or instability to ensure their compatibility with the designs. The reliability of alternative sources of information should be assessed independently before undertaking the design exercise.

A Two Shaft VSBK with Closed Cooling Chamber

The Vertical Shaft Brick Kiln

The VSBK is an energy-efficient and environment-friendly firing technology for producing burnt red-clay bricks. The VSBK technology was originally developed in China in the 1950's and perfected in India during the 1990's. Thereafter it has been implemented in many countries, based on standardised conditions, by adapting and making required modifications as per the local conditions, but keeping the basic principles similar.

The VSBK has vertical shaft of rectangular or square cross-section. The gap between shaft wall and the outer kiln wall is filled with insulating materials – broken bricks and burnt coal ash. The kiln works as a counter-current heat exchanger, with heat transfer taking place between the air moving up (continuous flow) and bricks moving down (intermittent movement). Green bricks are loaded in batches from the kiln top. Bricks move down the shaft through brick pre-heating, firing and cooling zones and unloaded from the bottom. The combustion of coal (added along with bricks at the top) takes place in the middle of the shaft. Combustion air enters the shaft from the bottom, gets preheated by hot fired bricks in

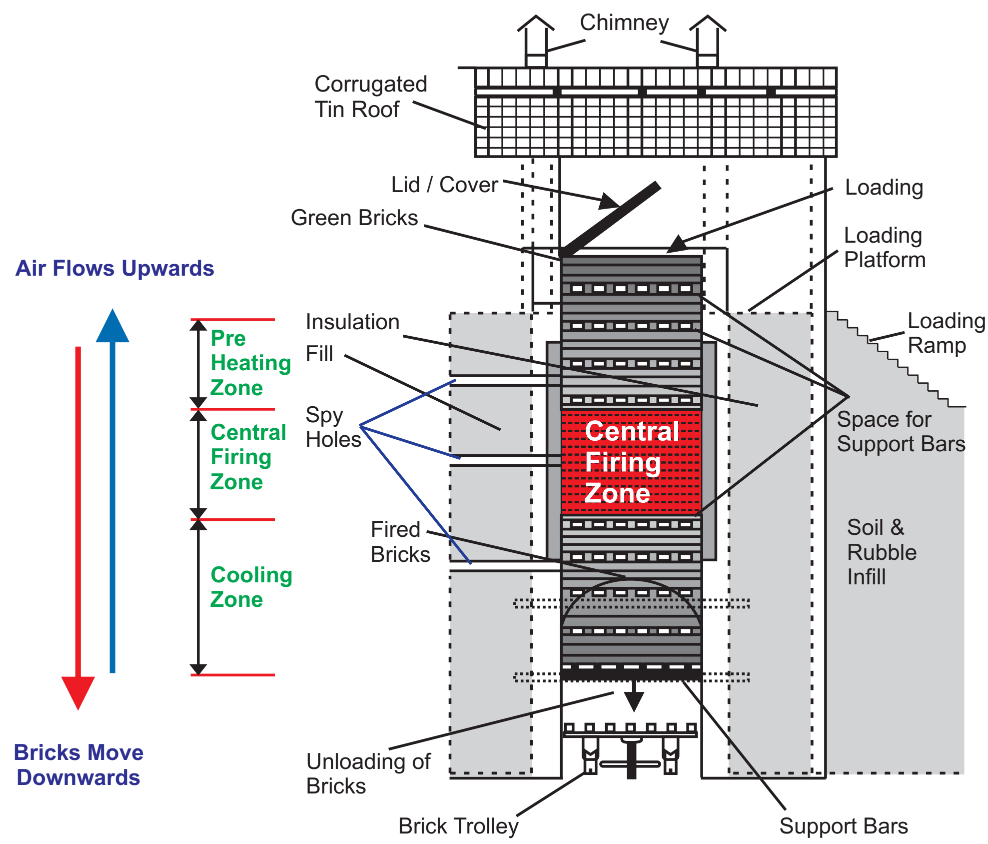
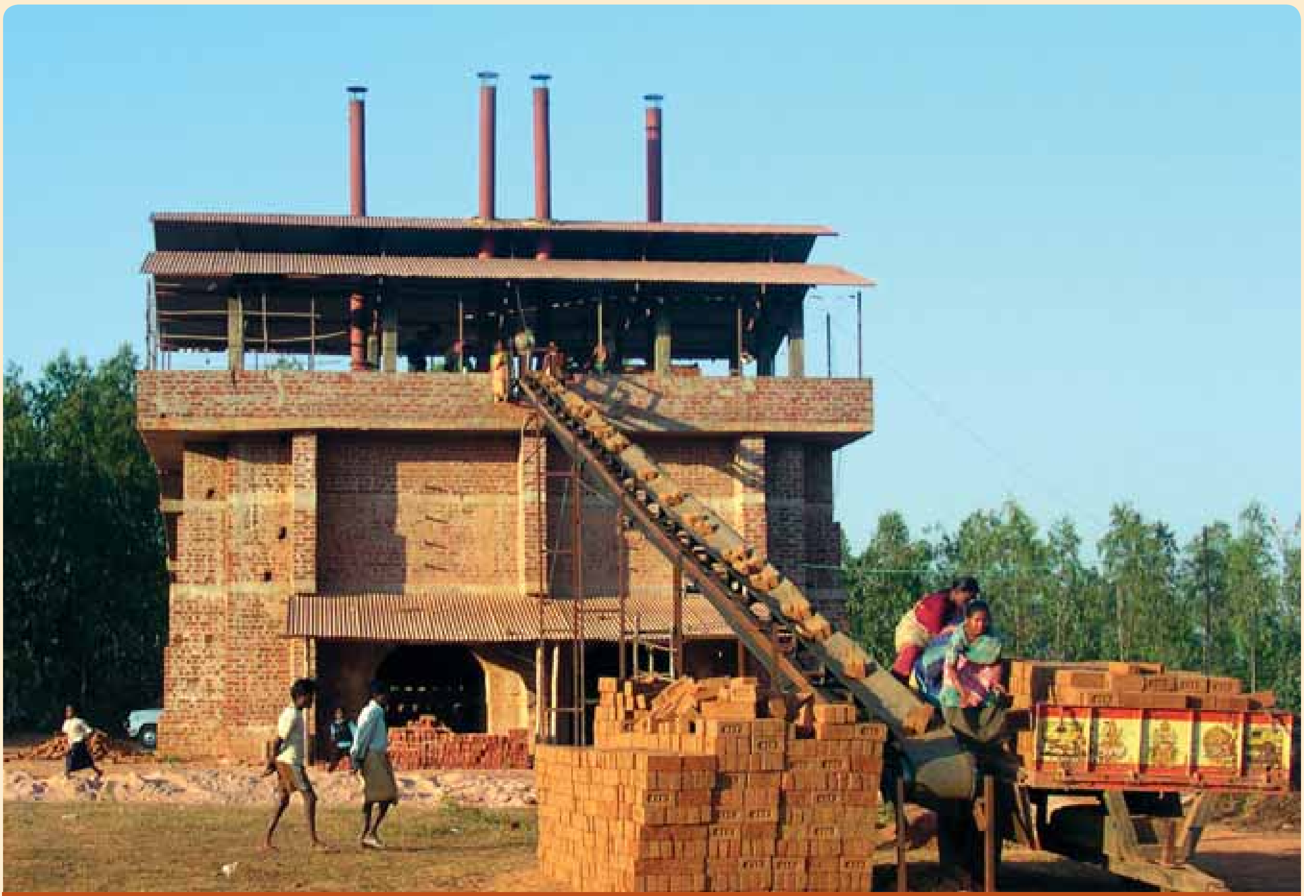


Figure 2: Schematic Diagram of the Firing Zone of the VSBK



A Two Shaft VSBK

the lower portion of the shaft, before reaching the combustion zone. Hot combustion gases preheat green bricks in the upper portion of the shaft, before exiting from the kiln through a shaft or a chimney (Refer Figure 2).

The brick setting in the kiln is kept on support bars at the bottom of the shaft. The unloading of bricks is done from the bottom of the shaft, using a trolley. The trolley is lifted (using single screw mechanism) till the iron beams placed on the trolley touches the bottom of the brick setting and the weight of bricks is transferred on to the trolley. The freed support bars are taken out. The trolley is then lowered by one batch (equivalent to four layers of bricks) – the support bars are again put in place through the holes provided in the brick setting for that purpose. With a slight downward movement, the weight of the brick setting is transferred to the support bars. The trolley (with one batch of fired bricks on it) is further lowered till it touches the ground level and is then pulled out of the kiln on a pair of rails provided for the purpose. In every 2-3 hours, a batch of fired bricks is unloaded at the bottom and a batch of fresh green bricks is loaded at the top simultaneously. At any given time, there are typically 11 to 12 batches in the kiln, depending on the green bricks' quality.

The two chimneys, located diagonally, opposite to each other on top of the shaft, remove the flue gases from the kiln. A lid is also provided on the shaft top, which is kept closed during the normal operation.

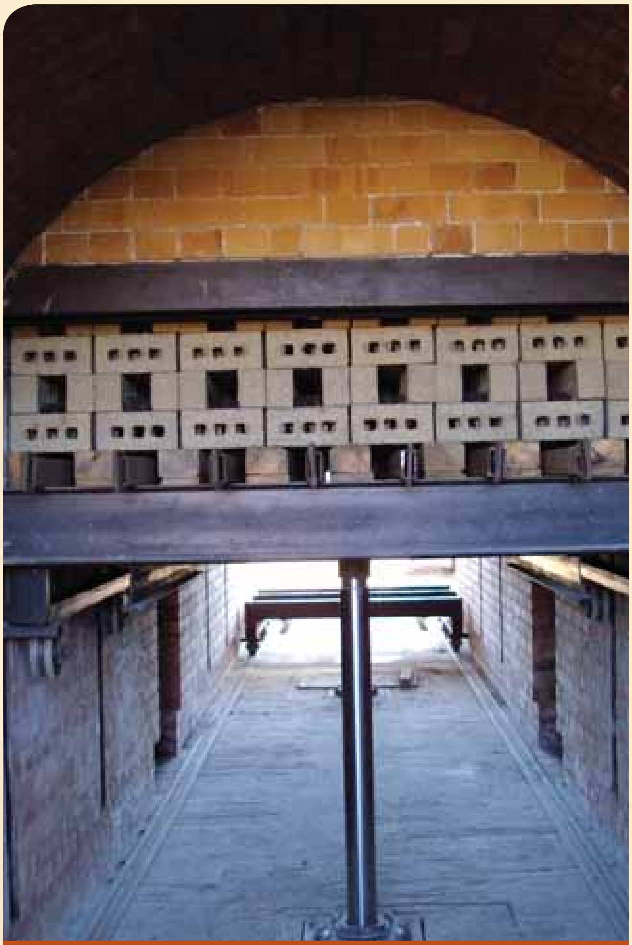
Flue gases are directed to pass through chimneys so that the working area on the kiln top does not get polluted. The provision of shaft lid, better ventilation of working area on kiln top and higher and bigger chimneys are some of the highlights of the VSBK kiln and its related processes.

The heating cycle for the green bricks is raw material specific (pre-heating, vitrification and cooling down) and is normally completed within 24-30 hours. It requires round the clock operations and supervision with special skills. The firing operator needs to maintain a correct balance between:

- **Energy:** Controlled by the amount of coal feeding
- **Airflow:** Controlled by stacking density and damper position
- **Unloading speed:** Controlled by the operator

Comparison of Clamps and VSBK Operation

- In Malawi, only fuelwood is used as a fuel in clamp firing, whereas fuelwood is only required for the initial firing in VSBK.
- A VSBK system uses only coal as a fuel.
- In a clamp, firing can only start after atleast 50,000 to 200,000 bricks are piled up. On the other hand, VSBK requires only 3,500 to 4,500 bricks to start the firing process (depending on the cross-section of the shaft). Thus, VSBK is a low working capital investment firing system.
- In a VSBK, small fireboxes are made at the bottom initial firing. The initial firing from the bottom requires only about 100 kg of fuelwood. Once the fire starts, no additional fuelwood is required. In a Clamp, the fireboxes are much wider and larger in size. Large quantities of Fuelwood is required along with other flammable materials, like saw dust, rubber tyres etc.
- In a VSBK, the fuelwood burns for an initial period of three to four hours for firing initialisation, whereas in a Clamp a minimum of 16 to 20 hours are required for the same result.
- In a VSBK, stable production is achieved within two to three days from start of the initial firing after which saleable bricks are produced. In a Clamp, a gestation period of atleast 15 to 20 days is essential for the production of suitable saleable bricks.
- In a VSBK, fire is stationary at the centre of the shaft and the bricks move from the top to the bottom of the shaft. Whereas in a Clamp, piled bricks are stationary and fire moves around the stationery bricks from bottom to top.
- VSBK is a rapid firing system. It takes just 24-30 hours to fire bricks in VSBK, hence making the technology more demanding when compared to Clamp. The other technology is a slow firing system. It takes 10-15 days to fire bricks in Clamp, hence providing higher firing tolerance.



Hydraulic Unloading Device

Basic Advantages of VSBK

High Energy Efficiency

VSBK has the lowest specific energy consumption (0.7-0.8 MJ/kg of fired bricks), making it the most energy efficient kiln in the world. It also economises on fuel costs, with savings of 30 to 50% when compared to other common brick-firing technologies, such as clamps or Hoffman kilns.

Environment Friendly Operations

If a VSBK is operated as per the recommended conditions, emissions are reduced by approximately 90%, compared to common traditional brick-firing technologies. It has the lowest particulate matter (SPM) emissions.

Economically Viable

Brick production using the VSBK technology is a profitable business and the overall initial investment is low (as compared to Hoffman kiln technology). Since, the energy consumption in a VSBK is 30 to 50% lesser, the working capital required is also less.

Less Land Requirement

The construction of a VSBK requires very little land as compared to most modern technologies. The building of multiple shaft production units further enhances the ratio of land use to production output.

Uniform Quality of Production

It is not possible to achieve uniform quality of fired bricks in any other common brick firing technologies due to heat loss. However, it is possible to achieve 95% uniformness of quality in a VSBK. Compared to clamps, where the brick quality is significantly unconsistent, a VSBK produces mostly first grade bricks. Breakages and wastage can be limited to even less than 5% through stable operation and quality green bricks.

Consistent Quality

As mentioned earlier, VSBK produces high quality bricks, albeit if proper firing practices are followed. The fired bricks show a fine, deep red colour and have a good, metallic ring depending upon the quality of the soil. A compressive strength of upto 200 kg/cm^2 can be achieved using appropriate soil.

Round the year production

The VSBK can be operated all the year round and even during the monsoon time, subject to availability of dried green bricks. Weather has only a minor influence as a roof protects the kiln.

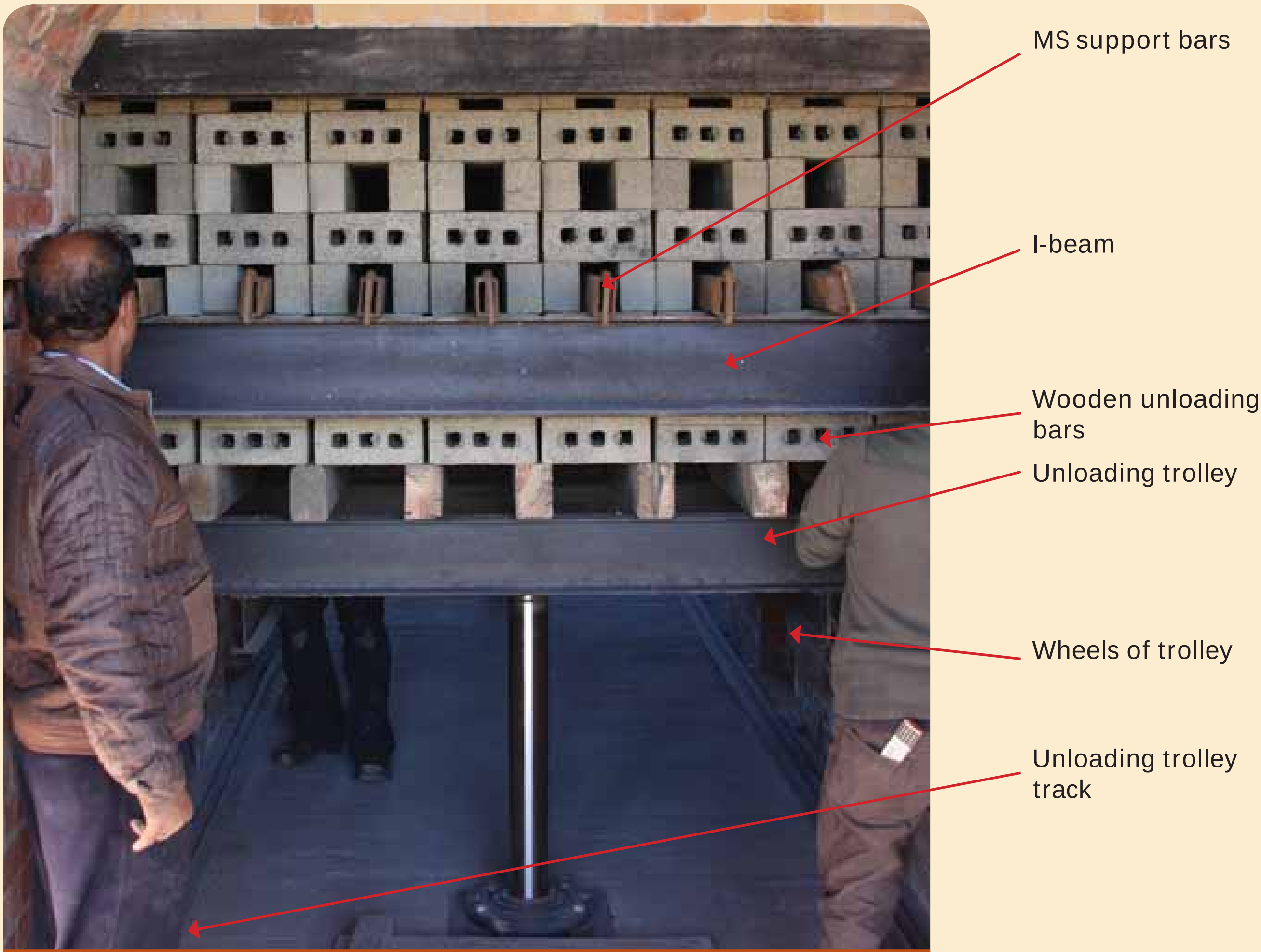
Flexibility in operation

The firing of each shaft is independent from each other, which means it is not necessary to fire or close all shafts togeather. A decision on the number of shafts to operate can vary according to the availability of dried green bricks, market demand etc.

Chapter 2

Terminology used in VSBK Design

Terminology	Description
Brick Supporting I-beam	I-beams are fixed along the two sides of the lower portion of the shaft. The total load of the bricks inside the shaft is supported by means of I-bars.
Flue Ducts	The flue duct is a specially designed structure at the upper most part of the shaft, through which flue gases passes to the chimney.
Green Brick	Green bricks are raw dried bricks, which are ready for firing.
Ground Level	The top of screw supporting the I-beam is taken as ground level (GL+/- 0.00mm).
Loading Platform	A loading platform is at the upper part of the VSBK, where the green bricks are stacked before loading inside the shaft.
Shaft	Shaft is a vertical rectangular or square hollow section, constructed with refractory bricks, where the brick firing takes place. The shaft has designated pre-heating, firing and cooling zones where different stages of firing take place.
Shaft Height	The shaft height is the total height of a shaft, measured from the ground level (+/- 0.00 mm) to the shaft top.
Shaft Size	Size of the shaft is three dimensions of the shaft. It is dependent on the dimensions of dried green bricks.
Support Bars	It is an iron bar of I or square shape. It bears the total load of the bricks in the shaft.
Trolley Guide	Trolley guide is fixed in the lower wall of the shaft. It is used to guide the movement of the trolley or to raise and lower the unloading trolley in a fixed line of motion.
Trolley Track	Trolley track is fixed in unloading tunnel ground. It helps in the movement of the unloading trolley in and out of the tunnel.
Unloading Trolley	A steel structure with four-flanged wheel, which can move along a trolley track carrying the fired bricks on its top. Wooden planks on its top can engage with and lift the stack of bricks in the shaft, when moved vertically by the hydraulic unloading system.



Different Components of Unloading Mechanism

Flue Duct

Chapter 3

VSBK Site Selection Criteria

The quality of bricks produced in a VSBK depends upon the quality of the soil used. Hence, the design of the VSBK begins with the selection of a suitable kiln construction and soil mining site, as well as designing the layout of the entire brick production system. The soil mining site and the kiln construction site might or might not be the same, but both the sites should be within an economical distance. There are various essential factors that need to be evaluated during the site selection, which binds the design and operation of the entire VSBK system.

Bearing Capacity	This is especially applicable for the kiln construction area. The load bearing capacity of the soil determines the type of footing; either mat footing or step masonry footing. The soil bearing capacity should be determined or data should be collected before the designing is initiated.
Drainage	The selected site must be free from any water logging problems. Such areas should be avoided for VSBK, or a well laid drainage system should be designed. Special care should be taken while designing a VSBK in areas where the water table is high.
Electricity	Though VSBK does not require electricity to fire bricks, it is imperative to have a provision for electricity at the site, mainly for the lighting purpose and for using other mechanical devices, like a pugmill, extruder, hydraulic mechanism etc.
Future expansion	There should be enough space for future expansion.
Site Conditions	The site should not have numerous trees and should be distant from a river bank. The site should also be free from boulders.
Soil Quality	The VSBK's brick quality highly depends upon the quality of the soil; hence the site should be selected where suitable soil is available.
Soil Quantity	The soil mining site should have sufficient quantity of soil at least for five years to make it an economically viable business.
Topography	It is a great advantage to have a hillock, elevated (sloping) land, or some high ground next to the kiln. The topography can be used to design the vertical transportation mechanism of the green bricks. Therefore, the cost of the ramp construction can be reduced with proper use of topography.
Transportation	The site should be easily accessible and should be as near as possible to the targeted market for an economically viable business. The location of the soil mining and construction site must be in economical distance to minimise the transportation cost.
Water Availability	The site should have access to sufficient quantity of water for green brick making and other sanitary purposes.

Chapter 4

Limitations in VSBK Designs

Measurement of Width of a Green Brick

The design of a VSBK is bound by certain limitations. The limitations are basically with:

a. Shaft cross-section

b. Shaft height

c. Changing the shaft cross-section

Limitations in Shaft Cross-section

- The size of the dried green brick determines the shaft size.
- The squareness of a nominal cross section of a shaft should not be less than 50%.
- Greater shaft width causes large bending in support bars due to additional load, which limits the width of the shaft.
- Greater the shaft size, greater will be the load inside the shaft, influencing the design of the screw and support bars.

Limitations in Shaft Height

- The shaft height is dependent on the batch number and batch height, which again directly depends on the green brick's breadth and weight.
- The total brick weight in the shaft must also be considered, while determining the shaft height.
- The load carrying the capacity of bricks also influences the design of a shaft height.

Limitation in Changing the Shaft Cross-section

- The shaft design directly depends upon the green brick dimensions. Once the shaft is constructed, it is not possible to change the cross-section, unless the whole shaft is dismantled and reconstructed.

Chapter 5

VSBK Design Parameters

1. Design Brick Dimension

The "Design Green Brick" parameter is referred to the green brick, used for designing the VSBK. The green brick dimension plays a vital role in the designing of the shaft and the VSBK. Once the shaft is constructed, its size cannot be adjusted or changed. Thus the dimensions of a "Design Green Brick" during the design process should be carefully assessed and calculated. The "Design Green Brick's" size is the dimension of the bricks, which is completely dried and ready to be loaded in the shaft during operation. If the loaded brick dimension does not match with the "Design Green Brick", then there might be cases of shaft damage, shaft jamming or excessive heat loss. Hence this is the most important and fixed parameter.

Calculation of "Design Green Brick" dimensions

- Assess the fired brick dimensions commonly used in the market or as desired to be produced by the entrepreneur.

  Thus

  Length = L mm

  Breadth = B mm

  Depth = D mm

- Calculate the total shrinkage (during drying of green bricks and also firing shrinkage) of soil (based on field data)

  Thus,

  Firing shrinkage in length = L_f %

  Firing shrinkage in breadth = B_f %

  Firing shrinkage in depth = D_f %

- Evaluate the "Design Green Brick" dimension using total shrinkage

  Thus,

  Design Green Brick length (L_d) = L / (1-L_f %) mm

  Design Green Brick breadth (B_d) = B / (1-B_f %) mm

  Design Green Brick depth (D_d) = D / (1-D_f %) mm

  OR

If it is an existing brick production unit, then determine the dimensions of green bricks by measuring the dimensions of 30 dried green bricks, which are used in production.

2. Shaft Cross-section

The empirical formula for calculating the shaft size is:

(a) Length

Length of shaft = [L_d x N_{length}] + [10 x (N_{length} +1)]

Note:

- L_d is the calculated or measured "design green brick" length

- N_{length} represents the total number of bricks accommodated in the shaft length

- The value of 10 (expressed in mm) is added for providing airflow gap from both sides of the brick.

- Value 1 inside the inner bracket is provided to adjust total number of gaps between bricks.

Checking the Green Brick Size Lengthwise to Fit in to Shaft

(b) Breadth

Breadth of shaft = $[L_d \times N_{breadth}] + [10 \times (N_{breadth} + 1)]$

Note:

- L_d is the calculated or measured "design green brick" length
- $N_{breadth}$ represents the total number of bricks in shaft breadth.
- The value of 10 (expressed in mm) is added for providing an airflow gap from both the sides of the brick.
- Value 1 inside the inner bracket is provided to adjust total number of gaps between bricks.

3. Batch Height

The empirical formula for calculating batch height is:

Single batch height = [Bd + 4 mm] x 4 layers

Note:

- Bd is the calculated or measured "design green brick" breadth
- 4 (expressed in mm) is the tolerance for variations in breadth.
- 4 (expressed in number) is the number of layers considered in one normal batch.

4. Kiln Height from Ground Level

Shaft height depends on the following given parameters:

4.1. Height up to the base of the I-beam

This is based on the addition of the height of:

4.1.1. Unloading trolley track

4.1.2. Unloading trolley set, including the wheels

4.1.3. Wooden bars on the unloading trolley

4.1.4. Provision of 6 layers (1.5 batches) unloading

4.1.5. Clearance gap between the bricks and the beam

4.2. I-beam height

4.3. Girder operation clearance

4.4. Support bar depth

4.5. Height of first flue duct level

4.6. One flue duct height

4.7. Height from second flue duct top level to shaft top

Total kiln height = [4.1 + 4.2 + 4.3 + 4.4 + 4.5 + 4.6 + 4.7] mm

Chapter 6

Case Study - Malawi

The objective of this chapter is to inform the designers about the calculation procedures required to design the VSBK shaft. This is just an example calculation, based on the preliminary information collected from a brick field in Malawi. This calculation **cannot** and **should not** be applied as a standard design for VSBK construction in Malawi.

The “Design Green Brick” dimensions (as per the data collected from Malawi)

- Length (L_d) = 230 mm
- Breadth (B_d) = 110 mm
- Depth (D_d) = 70 mm

1. Calculations for Shaft Cross-Section

1.1 Length of shaft

$= [L_d \times N_{length}] + [10 \times (N_{length} + 1)]$

$= [230 \times 8] \times [10 \times (8 + 1)]$

$= 1930$ mm

Thus **length of shaft = 1930 mm**

1.2 Breadth of shaft

$= [L_d \times N_{breadth}] + [10 \times (N_{breadth} + 1)]$

$= [230 \times 4] + [10 \times (4+1)]$

$= 970$ mm

Thus **breadth of shaft** = **970 mm**

Shaft size = 1930 mm X 970 mm

Calculation of a Shaft Cross-Section

2. Calculations for Batch Height

2.1 Single batch height = $[B_d + 4] \times 4$

= [110 + 4] x 4

= 456 mm

Thus, **batch height = 456 mm**

3. Calculation of the Shaft Height

3.1. Height up to base of I beam

3.1.1.	Unloading trolley track	= 75 mm
3.1.2.	Unloading trolley	= 440 mm
3.1.3.	Wooden unloading bars	= 100 mm
3.1.4.	6 layer batch height	= 696 mm
3.1.5.	Operational clearance	= 40 mm
	Total	**= 1351 mm**

3.2. I-beam height = 200 mm

3.3. Hydraulic operation clearance = 40 mm

3.4. Support bar depth = 75 mm

3.5. Height upto base of 1st flue duct level (On top of 11th batch height)

= 11 x 456 = 5016 mm

3.6. Height of 1st flue duct

= [(1 refractory brick thickness) x 4 + (refractory brick on edge thickness) + (refractory brick on flat thickness) + (mortar thickness x 6)]

= 75 x 4 + 115 + 75 +3 x 6 = 508 mm

3.7. Height from 2nd flue duct

= (1st flue duct height) + (breadth of one brick) + (thickness of RCC band on top)

= 508 + 110 + 50 = 668 mm

Note:

- Breadth of one dry brick is allowed at the shaft top for tolerance of space required for lid cover operation
- 50 mm is the thickness of the RCC band around the shaft top.

Calculation of the total shaft height

Sl. No.	Description	Height (mm)	Remarks
3.1.	Height from ground level to the base of the I-beam	1351	from ± 0.00 level
3.1.1.	Height of the trolley track	75	
3.1.2.	Height of the unloading trolley with wheels	440	
3.1.3.	Height of the wooden support bars	100	
3.1.4.	Six layer batch height	696	
3.1.5.	Operational clearance	40	
3.2.	Height upto top of the I-beam	1551	Add 3.1. + 200 mm for I-beam
3.3.	Height upto MS support bars and bottom of fired brick layer	1666	Add 3.2. + 40 mm + 75 mm
3.4.	Height upto the base of 1st flue duct level	6682	Add 3.3 + 11 batch height
3.5.	Height upto base of 2nd flue duct level	7190	Add 3.4 + 508 mm i.e. 1 flue duct height
3.6.	Top of shaft	7858	Add 3.5 + 508 mm + 110 mm + 50 mm (including RCC band above shaft)

4. Calculation of Flue Duct Level

Base of 1st flue duct level = On top of 11th batch height

= [(height of I-beam top from ground level including MS support bars and clearances) + 11 x 1 batch height

= (1666 + 11 x 456) mm

= 6682 mm

Base of 2nd flue duct level = 1st flue duct level + 508 mm

= 6682 mm + 508 mm

= 7190 mm

Note:

- 508 mm is the flue duct height, inclusive of 3mm mortar in between the 230 mm x 115 mm x 75 mm refractory brick lining.

5. Platform Level

The platform = base of 1st flue duct level = 6682 mm

Thus, **platform height from ground level = 6682 mm**

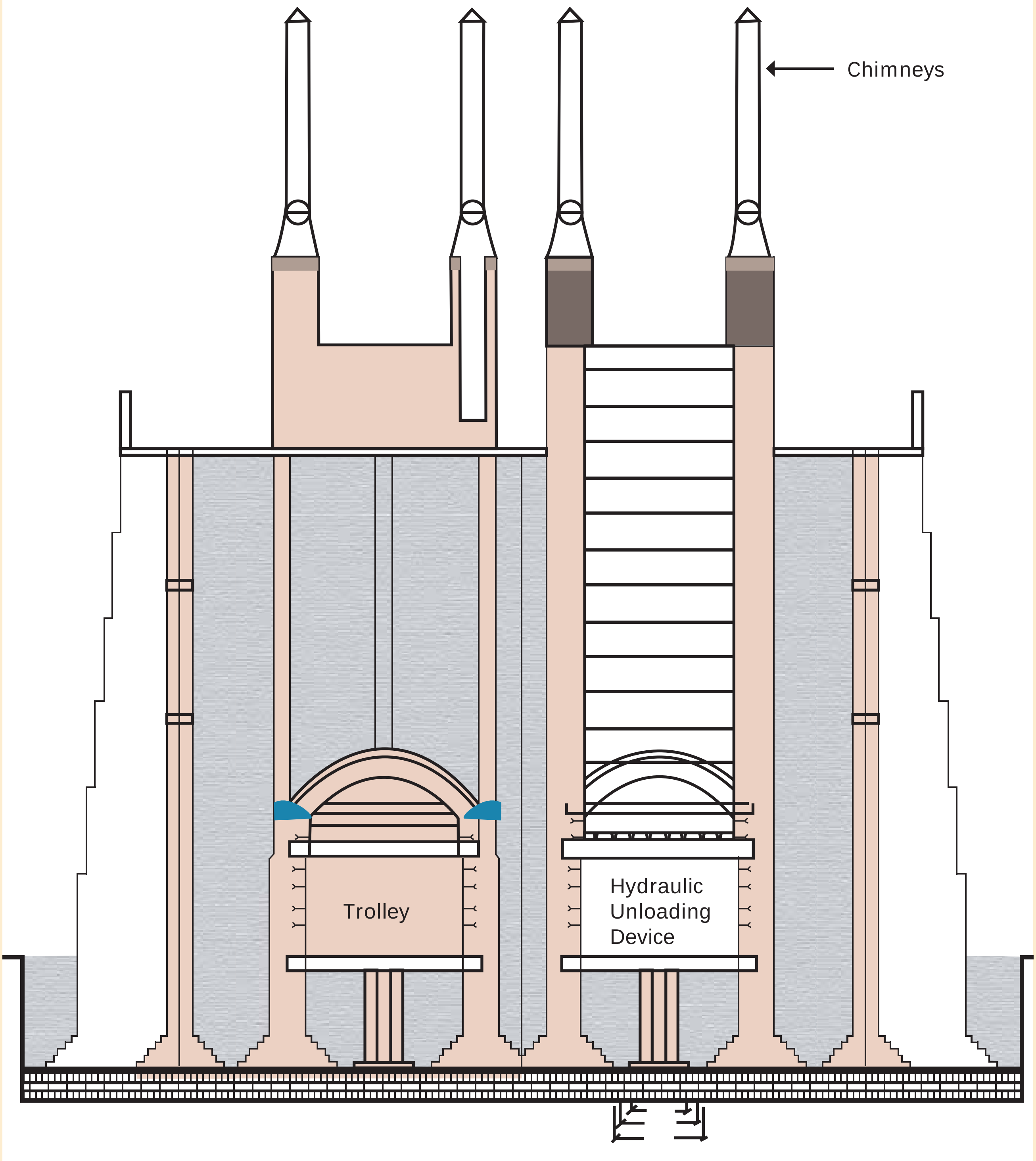


Figure 3: A Typical Cross-Section of a VSBK

Appendix

Bill of Quantities (BoQ) Standard Cost Estimate of a 2 Shaft VSBK

Kiln size: 21.36 m x 8.10 m

Shaft size: 2m x 1m (1966 mm x 998 mm)

Batch height: 11 batches

Sl.	Item	Specification	Quantity	Unit	Rate (MKW)	Cost (MKW)
A	Material					
1	Cement	43 gr. OPC, 50 kg bag	454	bags	7,000	3,178,000
2	Sand	Medium, coarse sand for masonry work, transport inclusive	176	tonnes	4,000	704,000
3	Picket bricks	Over burnt bricks, hard and good in size	21,800	no's	5.00	109,000
4	Bricks	IInd class, 240mm x 115mm x 70mm	139500	no's	5.00	697,500
5	Brick crush		2.45	Cum	450	1,103
6	Burnt brick chips	(10-20) mm size	22	Cum	5	111
7	Refractory bricks	IS:8 230mm x 115mm x 75mm; Al_2O_3 >32%,1300ºC	5600	no's	580	3,245,625
8	Refractory clay	For IS:8 refractory masonry, 50 kg bag	24	bags	1,630	39,120
9	Refractory mortar	High alumina cement, 50 kg bag	12	bags	3,708	44,491

Continued on next page

Continued from previous page

Sl.	Item	Specification	Quantity	Unit	Unit Price MK	Total Price MK
10	Lime	Slaked @ 640 Kg/Cum	32	bags	3,500	112,000
11	Burnt coal ash	Good quality	148.42	Cum	854	126,751
12	Brick bats	Good quality	99	Cum	380	37,620
13	MS steel bars:					
	a. 6 mm dia	MS Fe 450,@ 0.222 kg/m	150	kg	1,808	271,200
	b. 10 mm dia for tie beam	MS Fe 450,@ 0.616 kg/m	395	kg	242	95,590
	c. 10 mm dia for loading platform	MS Fe 450,@ 0.616 kg/m	515	kg	242	124,630
	d. 10 mm dia for temp. monitoring slab	MS Fe 450,@ 0.616 kg/m	20	kg	242	4,840
	e. 10 mm dia for chimney grouting	MS Fe 450,@ 0.616 kg/m	30	kg	242	7,260
	f. 12 mm dia for anchor bars	MS Fe 450,@ 0.888 kg/m	60	kg	260	15,600
	g. 12 mm dia for roof columns	MS Fe 450,@ 0.888 kg/m	155	kg	260	40,300
14	Binding wire	8 no	2	kg	450	900
15	Nails	3mm, L= 40mm	8	kg	350	2,800
16	I - Joist:					
	a. Screw support I - beam @ 25.4 kg/m	ISMB 200x100, L= 2690mm (8'-10"), 4 no's	10.76	Rm	5,060	54,446
	b. Brick support I - beam @ 25.4 kg/m	ISMB 200x100, L= 2630mm (8'-8"), 4 no's	11	Rm	5,060	53,231

Continued on next page

Continued from previous page

Sl.	Item	Specification	Quantity	Unit	Unit Price MK	Total Price MK
17	Channel section:					
	a. C- beam @ 12.7 kg/m	ISMC 125x65, L = 2570mm (8'-5.2"), 8 no's	20.56	Rm	3,500	71,960
	b. Trolley guides @ 7.9 kg/m	ISLC 100x50, L = 1141mm (3'-9"), 8 no's	9	Rm	435	3,971
18	MS base plates:					
	a. for screw support I - beam, @ 62.8 kg/m2	350mm x 260mm x 8mm, 4 no's (5.70kg/ plate)	0.364	Sqm	38,000	13,832
	b. Brick support I - beam, @ 62.8 kg/ m2	250mm x 260mm x 8mm, 8 no's (4.00kg/ plate)	0.52	Sqm	38,000	19,760
	c. C- beam, @ 62.8 kg/m2	280mm x 260mm x 8mm, 8 no's (4.60kg/ plate)	1	Sqm	38,000	22,131
19	MS protection plates:					
	a. Against support bar wear and tear, 8 no's	4mm thick, (600 x 250) mm, @ 31.40 kg/m2	1.2	Sqm	27,000	32,400
20	Support bar resting arm					
	a.MS channel, @ 7.9 kg/m	ISLC 100 x 50, L=1700mm (5'-7"), 4 no's	4	Rm	2,200	8,800
	b. MS bush	32mm dia MS (ID) L = 100mm	2	no's	212	424
	c. MS axail @ 6.31 kg/m	32mm dia plain bar, L = 100mm	4	no's	170	680
21	MS peep hole pipes	40mm dia, L = 2680mm (8'-10"), 14 no's	37.52	Rm	1,386	52,003
22	Exhaust system:					
	a. Metal chimney	As per VSBK specifications	2	set	350,000	700,000

Continued on next page

Continued from previous page

Sl.	Item	Specification	Quantity	Unit	Unit Price MK	Total Price MK
	b. MS bolt for grouting, double nut	16mm dia, L= 300mm, 3" threads	40	no's	450	18,000
23	Brick guides	As per VSBK specifications	2	no's	2,170	4,340
24	Girder:					
	a. I - beam	ISMB 200 x 100, L= 1990mm (6'-6.5"), 4no's	8	Rm	5,195	41,352
25	G.I.roof with 600 mm monitor gap	As per requirement				
	a. MS bolt for truss base plate	16mm dia, L= 300mm, 3" threads	40	no's	450	18,000
	b. Base plates for trusses	200mm x 200mm x 6mm, 10 no's (1.90 kg/ plate)	0.4	Sqm	29,800	11,920
	c. Tubler steel trusses:					
	# Tie member	ISA 50mm x 65mm x 5mm, @ 3.80 kg/m, 5 no's truss	35.35	Rm	1,000	35,350
	# Other then tie member	ISA 50mm x 65mm x 5mm, @ 3.80 kg/m, 5 no's truss	100	Rm	1,000	100,000
	d. MS channel for cooling chamber roof	75mm x 40mm MS channel @ 6 kg/m	16	Rm	520	8,216
	e. Purlins	ISA 40mm x 40mm x 5mm, @ 3.00 kg/m	120	Rm	800	96,000
	f. Fibre glass sheet for kiln roof	3600mm x 800mm, 22 gauge	48	no's	2,170	104,160
	g. G.I. Sheet for cooling chamber roof	3600mm x 800mm, 24 gauge	22	no's	2,170	47,740
	h. U bolts with bitumen washer for kiln	5mm dia, L=75mm long, for kiln	120	no's	250	30,000
	i. U bolts & bitumen washer for cooling	5mm dia, L=75mm long, cooling chamber	20	no's	250	5,000

Continued on next page

Continued from previous page

Sl.	Item	Specification	Quantity	Unit	Unit Price MK	Total Price MK
26	Steel door for cooling chember	1200mm x 1800mm	2	no's	27,000	54,000
		Material Cost (MKW)				**10,466,156**
B	**Equipment cost**					
1	Hydraulic unloading device	As per VSBK specifications	2	no's	313,424	626,848
2	Unloading trolley	As per VSBK specifications	4	no's	223,742	894,968
3	Trolley track	As per VSBK specifications	2	set	118,260	236,520
4	Brick support bars	As per VSBK specifications	16	no's	12,414	198,624
5	Conveyer belt	As per VSBK specifications	1	no's	696,640	696,640
6	Transfer trolleys for fired brick stacking	As per VSBK specifications	4	no's	44,332	177,328
7	Coal crusher	As per VSBK specifications	2	no's	390,540	781,080
8	Crow bars	32mm dia, L= 1500mm	2	no's	2,956	5,912
9	Hot brick lifting tong	As per VSBK specification	4	no's	422	1,688
10	Weighing balance, 25 kg	Weights (50gm - 10kg)	2	no's	4,222	8,444
11	Plastic rope	8mm dia	1	Roll	500	500
12	Wooden square bars:					
	a. Hard core wood	1090 (3'-7") x 100mm x 100mm, size	28	no's	1,000	28,000

Continued from previous page

Sl.	Item	Specification	Quantity	Unit	Unit Price MK	Total Price MK
	b. Hard core wood	1090 (3'-7") x 100mm x 50mm, size	8	no's	850	6,800
	c. Plain strips (26 gauge G.I. sheet)	1100 (3'-10") x 200mm, 20 no's	8.8	Sqm	1,920	16,896
	d. Nails	1.5mm, L = 25mm	3	kg	350	1,050
		Equipment Cost (MKW)				**3,681,298**
C	**Labour:**					
1	Mason	Skilled	550	no's	1,000	550,000
2	Helper	Unskilled	1,200	no's	400	480,000
3	Carpenter	Skilled	10	no's	1,500	15,000
4	Barbender	Skilled	10	no's	1,000	10,000
5	Welder with welding plant	Skilled	10	no's	3,000	30,000
		Labour Cost (MKW)				**1,085,000**
D	**Fabrication charges**	**As per requirement**				**1,000,000**
E	**Centering/ shuttering and scaffolding**	**As per requirement**				**500,000**
F	**Transportation charges**	**As per requirement**				**1,500,000**
		Total Cost (MKW)				**18,300,000**

TARA

Registered Office:
B-32, TARA Crescent, Qutab Institutional Area,
New Delhi - 110 016, India