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This publication is attributed to the work done by several players.

⇒ The initial work on firewood saving rocket ovens in Uganda was done through the Energy Advisory Project (EAP) in the Ministry of Energy and Mineral Development (MEMD), supported by the German Technical Cooperation (GTZ).

⇒ The rocket – elbow combustion chamber was invented by Dr. Larry Winiarsky at Aprovecho Research Center, Oregon, USA. Peter Scott of Aprovecho cooperated with GTZ-EAP to introduce it in Uganda in 2003.

⇒ Through the cooperation between the Ministry of Energy and Mineral Development and the Uganda Industrial Research Institute (UIRI), the prototype rocket baking ovens were developed and tested at the premises of UIRI in 2003 – 2005.

⇒ This revised edition of the rocket baking oven construction manual has been published with the support of the GTZ – Promotion of Renewable Energy and Energy Efficiency Programme (PREEEP), for use as a training tool for oven artisans.

Introduction

Uganda faces a biomass energy crisis marked by an increasing imbalance between the supply and the demand for the firewood by households, institutions and commercial industries. One of the strategies to sustainably contribute towards the reduction of this problem is through an extensive dissemination and use of biomass energy efficient technologies.

The biomass energy efficient technologies have been developed to improve efficiency in energy use for households, institutional and small and medium scale enterprises. These technologies include the domestic and institutional firewood stoves and the firewood baking ovens. The rocket baking ovens have overall efficiency of over 80% (average) compared to the traditional baking ovens.

Likewise these ovens help users to have financial savings of at least 80 % when compared to the traditional bread baking ovens. This implies that the amount of money spent on firewood by a baker in one week using a traditional baking oven could be used for at least 8 weeks with the rocket baking ovens. Another advantage of using the rocket baking ovens is the fact that the money spent to invest in oven construction can be recovered in a relatively short time through money saved from firewood savings.

The purpose of this manual is to give to oven building artisans a practical tool for use in the construction of rocket baking ovens of various sizes.

The Technical Modifications in the Rocket baking oven Design

Following the impressive performance of the prototype rocket bread baking ovens in comparison with the traditional ovens, the Ministry of Energy and Mineral Development (MEMD) through the GTZ-Energy Project (PREEEP), has supported private producers to disseminate rocket baking ovens for use in several institutions. A survey across selected bakeries using improved rocket baking ovens, covering both the entrepreneurs and the bakery workers, reported significant benefits that include:

- Increased efficiency in firewood use through the adoption and optimum utilisation of the rocket baking ovens.
- Improved working conditions of the bakery staff that were previously exposed to the dangerous smoke and intense heat emission from the traditional baking ovens.
- Reduction in baking time
- Better quality products (bread and cakes).
- Reduction in indoor air and environmental pollution because of reduced smoke emission.

However it was also noted that several pioneer rocket ovens did not perform optimally due to the short life span of the firewood shelves which are susceptible to the strong fire generated by the rocket combustion chamber. The other challenge was that several of the oven boxes (baking chamber) would get perforated at the bottom centre due to direct bombardment of the strong fire from the combustion chamber beneath.

During the GTZ regional workshop on household energy[1] held at Mulanje, Malawi in March 2007, several technical aspects were highlighted that required a design review in order to enhance oven performance, durability and user satisfaction.
The proposed modifications included:

- Introducing a separate bypass air inlet for the combustion chamber to simulate the function of the firewood shelf which was easily destroyed by the fire
- Incorporating a grate in the combustion chamber to trap the large burning coals to enhance their combustion prior to becoming ash.
- Fitting a protective material beneath the centre of the baking box to protect it from direct bombardment of the strong fire from the combustion chamber.
- Sealing the oven top with removable insulated laminated tops with provisions for letting out the exhaust gases to minimise the indoor air pollution and to allow for oven cleaning during maintenance and to prevent clogging.
- Installing the oven through assembling of parts for easier maintenance and repair.

It was concluded that for improved performance, the rocket baking ovens should henceforth be disseminated with the features described above. It is recommended that such ovens are constructed by qualified technicians who have considerable experience in the technical specialities of masonry / building construction, metal fabrication and industrial ceramics.

This revised rocket baking oven manual (November 2008 edition) describes the step-by-step construction procedure of the rocket baking oven.

[1] GTZ Report : GTZ Workshop on Household Energy, Mulanje, Malawi, 8 – 13th March 2007

Disclaimer

Whereas relative to the traditional bread baking oven the rocket baking ovens are believed to offer significant benefits to the user(s) including firewood savings, reduced baking time and reduced indoor air pollution and whereas this oven construction manual is believed to be a useful tool for instruction in the procedure for the construction of rocket baking ovens, neither the Uganda Ministry of Energy and Mineral Development nor the German Technical Cooperation assumes responsibility for the completeness or usefulness of the information herein. Additionally neither the Uganda Ministry of Energy and Mineral Development nor the German Technical Cooperation assumes liability in respect of any claim(s) that may arise in the event of any injuries and / or damages that may occur during the design, construction, use, misuse, maintenance and / or malfunction of any ovens that may be constructed on the basis of the design or procedure described herein.

BASIC FACTS ABOUT THE ROCKET BAKING OVENS

The rocket baking ovens are able to achieve maximum transfer of heat to the baking products because they heat at least 90% of the baking box surface area and have thermal insulation around the combustion chamber and fire passages.

Advantages of using the rocket baking ovens

1. Saves money: A baker who previously used 100,000/= worth of firewood with the traditional oven can now use only 10,000/= with the rocket baking oven per week.

2. Time saving: The ovens require about 30-45 minutes for preheating and only 15 minutes for actual baking of buns. This is unlike the traditional baking ovens which require 4 hours for preheating.

3. Less smoke: Because of their design, the rocket ovens generally produce very little smoke. Only a little smoke is produced during the lighting process or when wet wood is used. The baked products are not contaminated with smoke and other effluents of combustion such as ash.

4. Safe and Easy to use: Once lit, the rocket oven fire will not go out unless the user stops feeding firewood to the fire. There is also *no need* to blow at the flame to keep the fire burning. Rocket ovens are safer to use because the fire is shielded. There is less likelihood of accidents or burns to the baker.

5. Good Heat Distribution: The rocket oven evenly distributes heat around the baking chamber thereby producing better quality products.

6. Environmentally Friendly: The rocket baking ovens use less firewood and therefore contribute to a reduction in the rate of deforestation. They offer less pollution to the environment because of their almost smokeless operation.

HOW THE OVEN WORKS

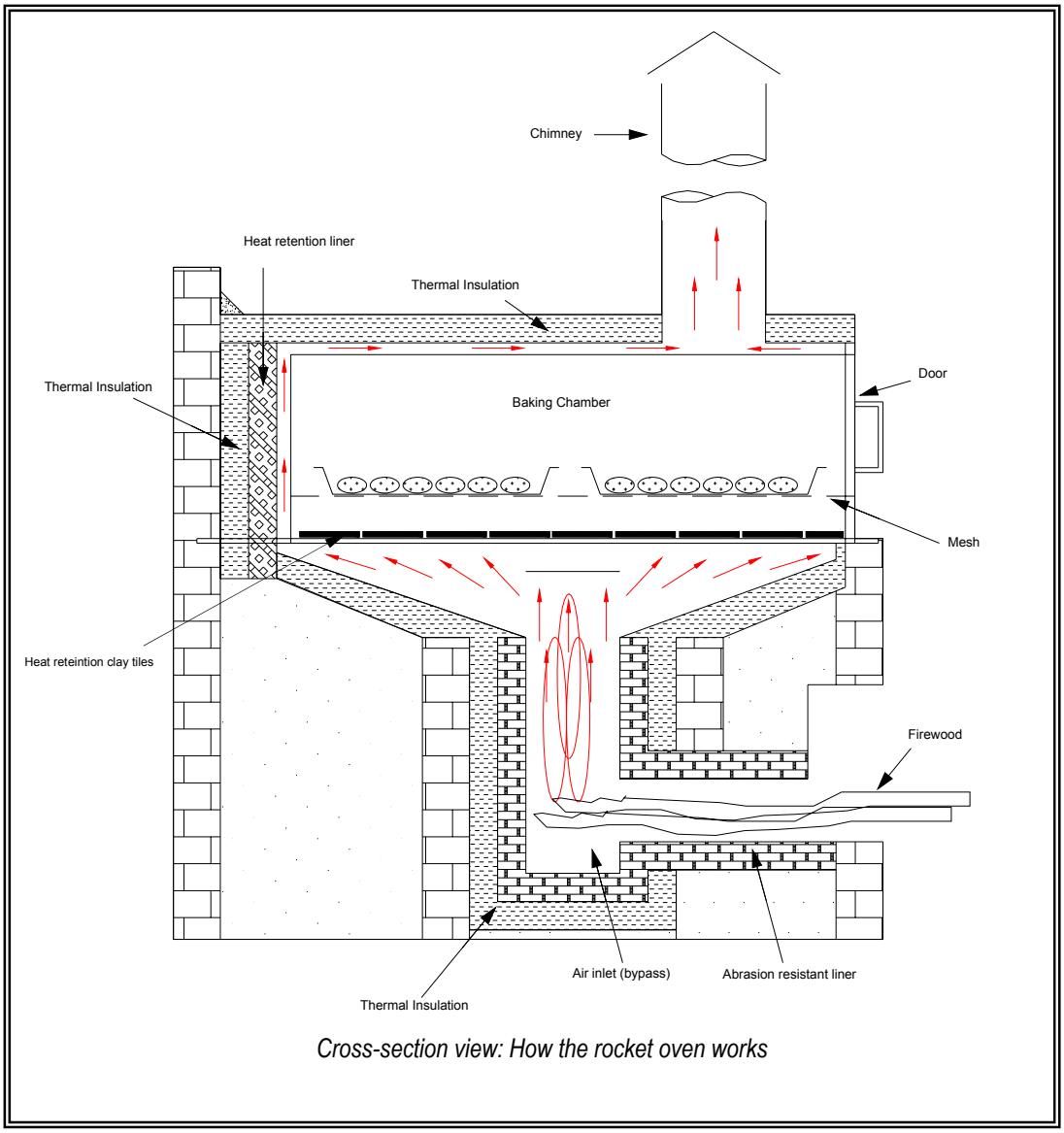
Fig: 1 below shows a sectioned front view of the oven and how it is intended to function.

The bread is enclosed in a metal box / baking chamber which prevents it from getting contaminated with smoke, ash and other effluents of combustion.

The bottom, sides and top of the baking chamber are exposed to the fire, which result into increased heat transfer.

The fired clay tiles are used for heat retention.

The tray rests on the mesh so that heat is not directly transferred to the baking products through conduction thus minimising the risk of burning.



Cross-section view: How the rocket oven works

Diagram 1

2.0 Things to Consider Before Constructing the Rocket Baking Oven

SHELTER
Ensure that shelter is in place to house and protect the baking oven from intrusion and extreme weather like rain.

TOOLS
The rocket baking oven has two major parts: -

i. The brickwork
ii. The metallic baking chamber

The common building construction tools are required for constructing the brickwork while metal fabrication tools are required for fabricating the metal box (baking chamber) and chimney.

Table 1: Common building construction tools for the brick work

	Brickwork tools	**Purpose**
1	Hoe	Digging foundation base and mixing ingredients
2	Pickaxe	Digging foundation base
3	Shovel or Spade	Extract soil from foundation base and mixing ingredients
4	Jerry can	Fetching water
5	Sieve	Sifting ingredients
6	Trough *(karaayi)*	Measuring materials by volume and carrying mixtures
7	Trowel	Placing mortar and smoothing plaster
8	Measuring Tape	Taking measurements
9	Spirit level	Inspecting horizontal level for laid bricks
10	Plumb line	Inspecting vertical alignment for laid bricks / walls
11	Try Square	Inspecting right angled corners
12	Building line	Inspecting the level of brick layers
13	Wooden float	Smoothing plaster
14	Claw Hammer	Driving and removal of nails
15	Sledge Hammer	Driving foundation pegs into the ground
16	Wall Chisel	Split, cut into, notch bricks and walls
17	Bow Saw	Slicing pumice into regular shaped blocks

Table 2: Common metal fabrication tools required for the metal box chamber

	Metal fabrication tools	**Purpose**
1	Hacksaw	Cutting sections to length
2	Vice	Holding sections when being cut to length
3	Hammer	Driving chisel, removal of slag
4	Chisel	Cutting metal sheet
5	File	Smoothing metal edges
6	Measuring Tape	Taking measurements
7	Try Square	Inspecting right angled corners
8	Anvil (or equivalent)	Base for hammering
9	Arc welding set	Joining metal pieces
10	Pick hammer	Removes slag from welded metal parts

Table 3: Safety Gear[2] recommended for use where available

	Device	Purpose
1	Eye Shield	Protection of eyes against radiation during welding
2	Leather gloves	Protection of hands from fire during welding
3	Leather apron	Protection of body and clothes during welding
4	Nose Mask	Protection against inhaling dust and toxic welding fumes
5	Industrial boots	Protection of feet
6	Helmet	Protection of the head
7	Overalls	Protection of clothes during work
8	First Aid Kit[3]	Treatment for injuries

[2] Recommended for use where available.
[3] Professional workshop practice recommends that a First Aid kit should be in place.

PART 1

SINGLE DECK ROCKET BAKING OVEN

3.0 Oven Construction Materials

This oven has a capacity of baking 28 loaves of bread of 1kg each*

3.1 Brickwork

Table 4: Brickwork specifications and quantity for the single deck rocket oven

	ITEM	SPECIFICATION	QUANTITY
	Brick Structure		
1	Bricks	12 x 12 x 22 cm, Kiln Fired	800
2	Sand	River / Plaster Sand	1 Trip (1ton)
3	Cement	Portland	7 Bags @ 50Kg
4	Water		30 Jerry cans (20l each)
	Heat Insulation & Ceramics		
1	Pumice	Porous	4 bags (@ 100l volume)
2	Grog	High temperature mixture	7 bags @ 50Kg
3	Vermiculite	Exfoliated	4 Bags (@100l)
4	Clay Tiles	5" x 10 " x 1" kiln fired	70 Pcs
5	Quarry tile	8'' x 12'' x 1.5''	20 Pcs

* Suitable for small and medium scale baking.

3.2 Metal Oven Box Fabrication

Table 5: Requirements for metal fabrication in specification and quantity (Single deck oven)

	ITEM	SPECIFICATION	QUANTITY
1	M.S. Plate	4' x 8' x 4mm (1220 x 2440 x 4 mm)	1 Pc
2	M.S. Plate	4' x 8' x 2 mm (1220 x 2440 x 2 mm)	1 Pc
3	M.S Plate for oven door	4' x 8' x 1.2 mm (1220 x 2440 x 1.2 mm)	1 Plate
4	M.S. Plate	15'' x 15'' x 8 mm (381 x 381 x 8 mm)	1 Plate
5	Angle bar	40 x 4 x 6000 mm	2 Pcs
6	Angle bar	25 x 4 x 6000 mm	2 Pcs
7	Hollow Sections	Sq. 2.5 cm x 2 mm x 6000 mm	3 Pcs
8	Hinges (for oven door)	Bullet (standard)	1 Pair
9	Firewood grate	Steel Fabricated / reinforced High temperature clay piece.	1 Pc
10	Welding rods (1 pack)	G.10	1 Packet
11	Wire mesh	Sq. 6 cm (Size 118 x 118 cm)	1
12	Flat sections	50 x 6000 x 4mm	1
13	C - Section	3'' x 2'' x 4mm x 6000 mm	1

4. Materials Purchase and delivery

Purchase the oven brick work construction materials and deliver them to the store at the oven construction site.

Caution:

1. Materials like vermiculite, pumice, cement, and wall tiles are expensive and should be stored in a secure room.
2. Cement, vermiculite, pumice should be kept in a dry place

4.1 The Firewood Rocket Oven Drawing (Single deck)

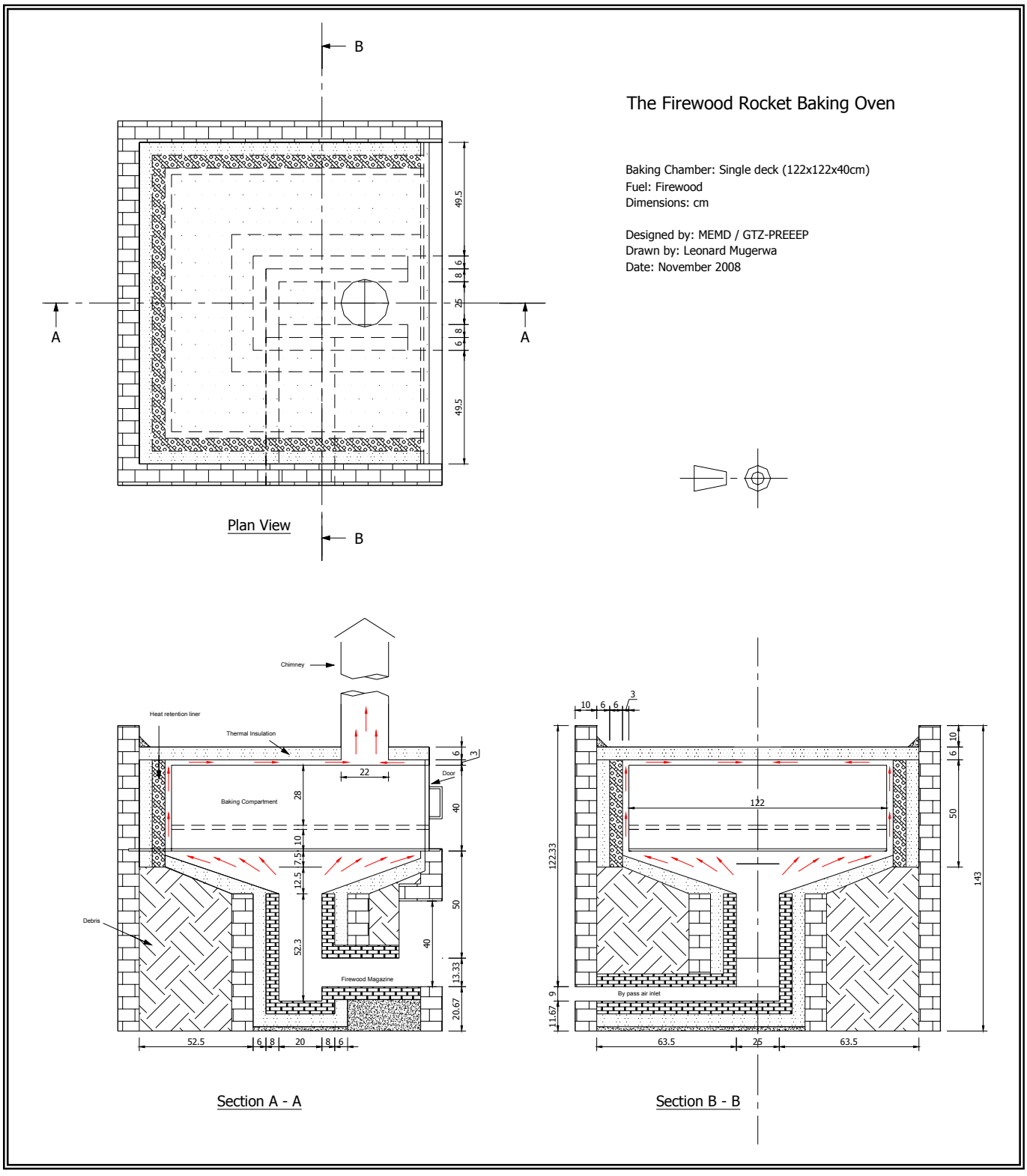


Diagram 2: Technical Drawing of the single deck Rocket Firewood baking oven

5.0 THE BRICK WORK

5.1 Determining the size of the oven base

When building a single deck baking oven of baking chamber size 120 x 120 x 40 cm, its overall size will be as described in the technical drawing shown on the previous page. The reader is advised to make reference to this drawing for guidance when reading through the subsequent part of this book.

The outside dimensions of the drawing have not been included in the technical drawing because the sizes of the bricks that are available on the market in various regions are not of the same size. The size of bricks depends on the size of the mould that was used by the brick maker[4]. Therefore in this publication it has been preferred to specify the inside dimensions of the oven while the outer dimensions will depend on the size of the bricks to be used.

[4] This book has been published at a time when there are generally no standard sizes for bricks in Uganda. Brick sizes vary according to the building construction practices or preferences of a region.

5.2 Determining the combustion chamber position and size

A combustion chamber of rectangular cross section equivalent to 25cm x 20cm is used for the single deck rocket oven.

- Draw the outline of the oven base on paper with dimensions clearly marked,
- Following these drawings, make a floor plan where the oven is to be built.
- With reference to the technical drawing in diagram 2, locate the position of the combustion chamber and air inlet.
- Draw projection lines from the combustion chamber outwards of the central box in perpendicular direction to mark the position of;
    a) Fuel Magazine
    b) By pass Air inlet

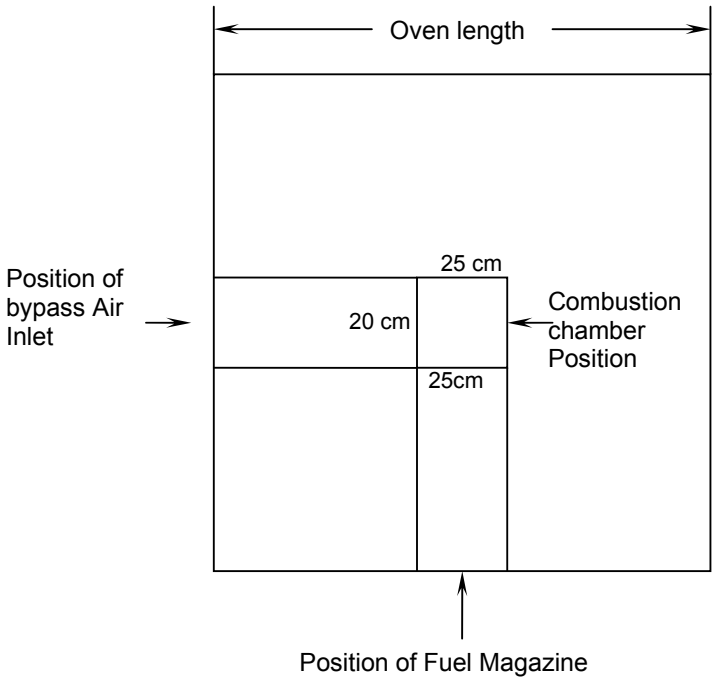


Diagram 3: Positioning the fuel magazine and Bypass air inlet

5.3 With reference to diagram 2 above, map the oven foundation base on the ground and use wooden pegs to fasten building lines to aid the excavation as shown in figure 1.

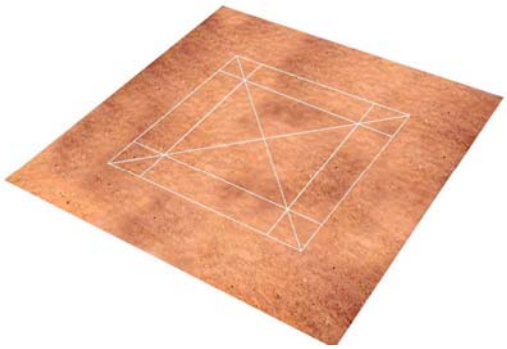


Fig. 1

5.4 Use a pickaxe and a hoe to dig the foundation base within the bounds of the building lines. Use a spade or shovel to remove the soil from the foundation base. At the position of the combustion chamber, dig a recess of approximately 10cm deep as shown in figure 2.

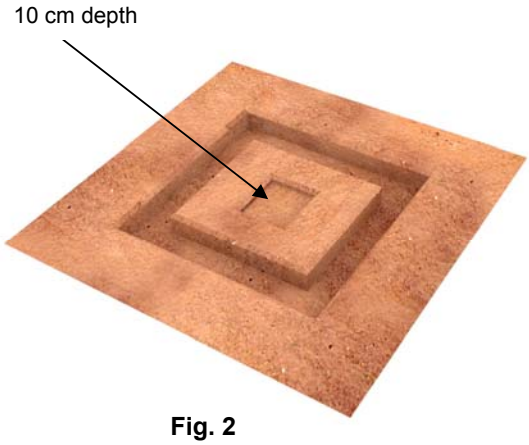


Fig. 2

5.5 Mix portland cement and sand in a volumetric ratio 1:3. Add water and appropriately blend the mortar as shown in picture 1.

Also mix insulation fire resistant mortar of cement and grog in a volumetric ratio 1:2. with water.

Next, use a bow saw to slice the pumice into slabs of thickness 6 cm.

Picture 1

5.6 Lay insulative pumice slabs at the centre as shown in the figure 3. Bond and cover the pumice blocks with fire resistant mortar to form a smooth surface.
Concurrently, lay the foundation bricks in a header style as shown after placing a layer of mortar below.
The mortar should also be placed between the bricks for effective bonding just as it is usually done in building construction.

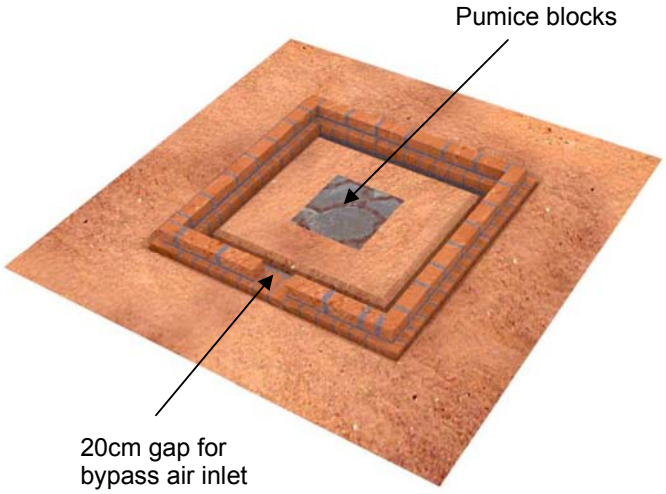


Fig. 3

After constructing at least 2 layers of bricks for the foundation, in the header style depending on the strength of the ground, start to build the walls of the oven.

The bricks forming the walls may be laid in the stretcher style as shown in figure 3.

Leave a 20 cm gap for the bypass air inlet centred on one of the walls as shown in figure 3.

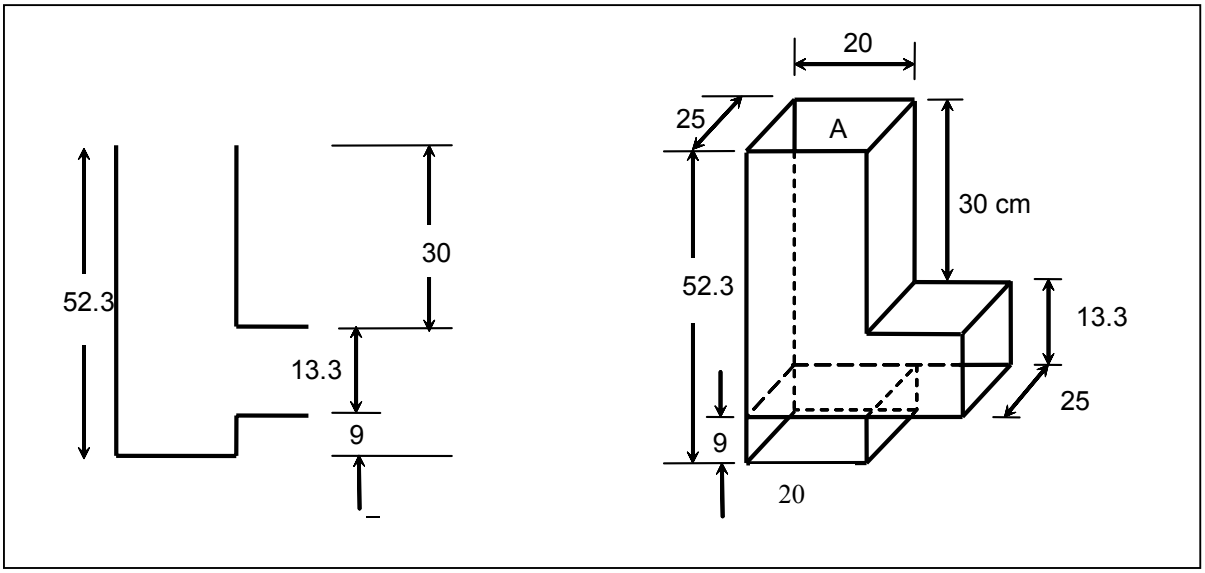


Diagram 4: Details of the combustion chamber size (Dimensions in centimeters).

5.7 Using fire resistant mortar and special firebricks/ clay liners, lay the combustion chamber foundation as shown in figure 4. Providing for the bypass air inlet and firewood magazine.

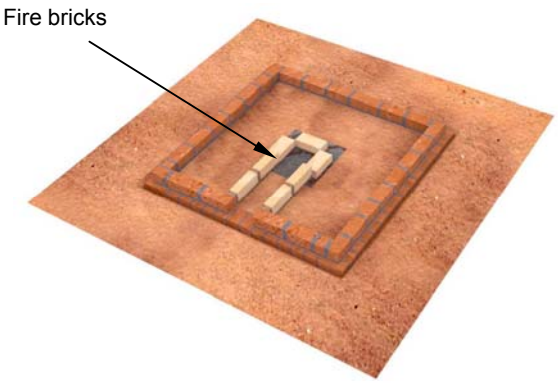


Fig. 4

Also build a foundation for the firewood inlet in a perpendicular direction beginning from the centre outwards using firebricks. Using ordinary bricks build a reinforcement wall directly opposite the firewood inlet as illustrated in figure 5.

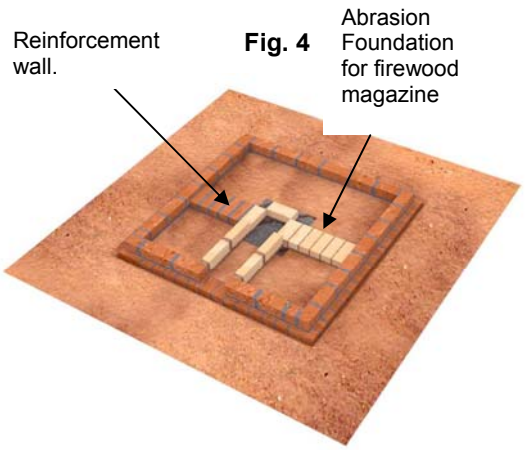


Fig. 5

5.8 In the centre of the combustion chamber at a height 9 cm from the ground level, insert a metallic grate such that it is supported by fire bricks as shown in figure 6.

All the joints between the firebricks should be filled with fire resistant mortar, comprising of cement : grog mixture (volumetric ratio 1: 2).

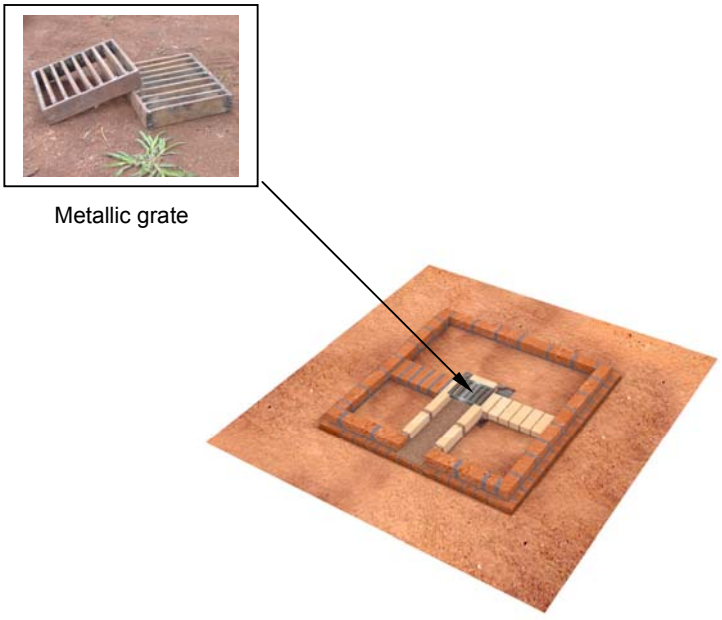


Fig. 6

5.9 After inserting the grate, use quarry tiles to construct a bridge over the bypass air inlet.

The top level of this air inlet bridge should align (flush) with the base of the firewood inlet as shown in fig 7.

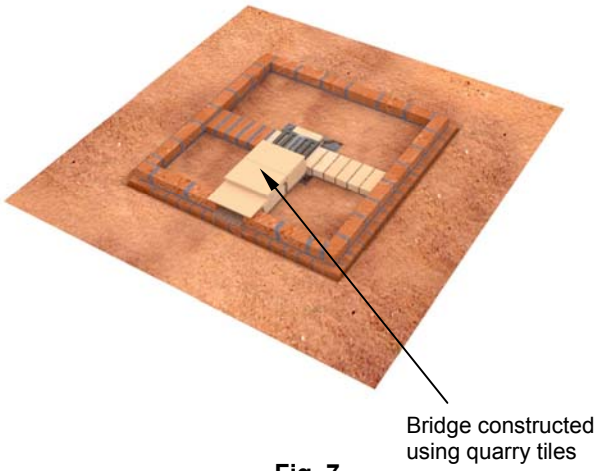


Fig. 7

5.10 Continue constructing the walls of the combustion chamber. At the level of the firewood grate (flush), construct a tunnel like structure of height 13.3 cm and 25 cm wide to form the firewood inlet (firewood magazine).
Similar to the air inlet use quarry tiles to construct a bridge over the firewood magazine.

Use a tri-square, plumb-line and spirit level to inspect and ensure that the structure is vertically upright and the brick levels are horizontally aligned. Do the same for the external walls.

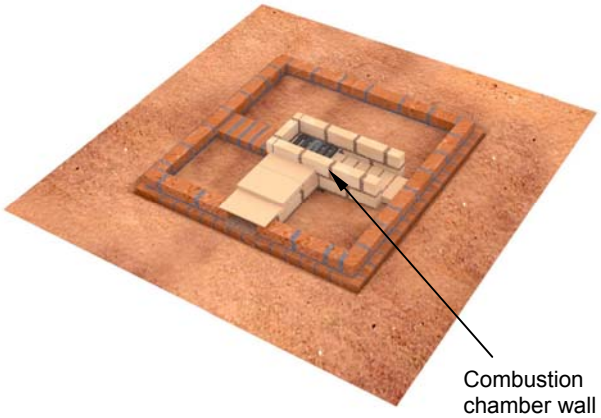


Fig. 8

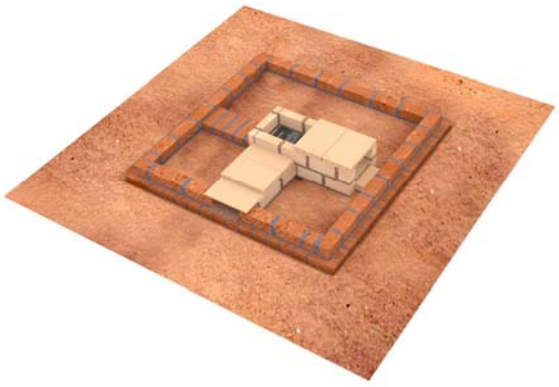


Fig. 9

5.11 Proceed by raising the combustion chamber walls using firebricks and high temperature mortar to the recommended height shown in the technical drawing (diagram 2).

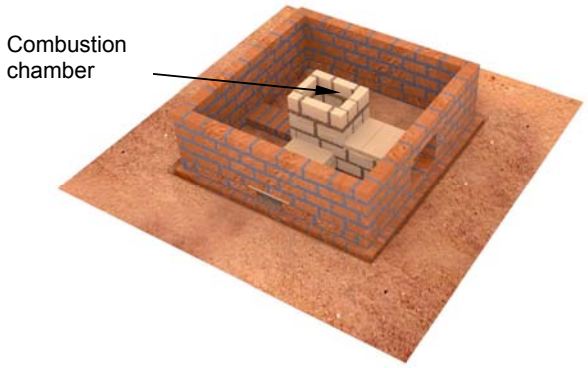


Fig. 10

5.12 Also, continue to build the combustion chamber support walls using ordinary bricks and mortar, leaving a 6 – 7 cm gap to be filled later with thermal insulation e.g pumice, as shown in figure 11. The mortar for the support wall is cement – sand mixture (volumetric ration 1 : 3).

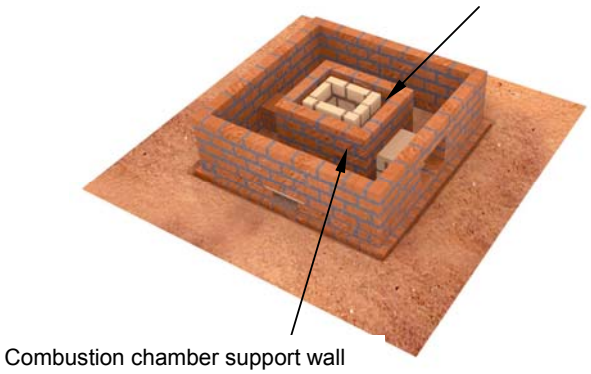


Fig. 11

Regularly use the try square to inspect to ensure that walls are right angled at the corners.
Use the building line and spirit level to ensure that bricks in each layer are horizontally aligned.

5.13 Use the bow saw to slice the pumice into several slabs each of minimum thickness 5 - 6cm.

The pumice slabs will be used for thermal insulation in the gaps around the combustion chamber and the fire passages.

5.14 Insert the pumice slabs in the gap between the combustion chamber and the support walls as shown in fig 12. This will form thermal insulation around the combustion chamber.

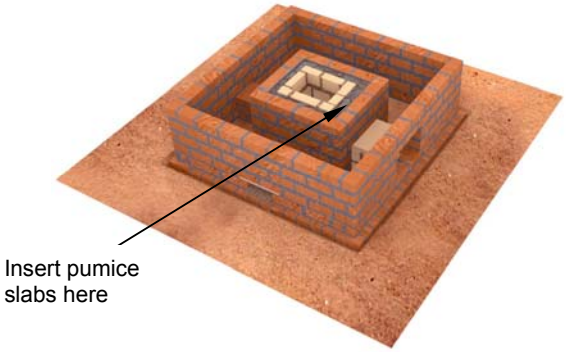


Fig 12

5.15 Fill the gap between the oven outer walls and the combustion chamber support walls with debris.

The top level of the debris should be laid to provide a base that inclines outwards from the combustion chamber.

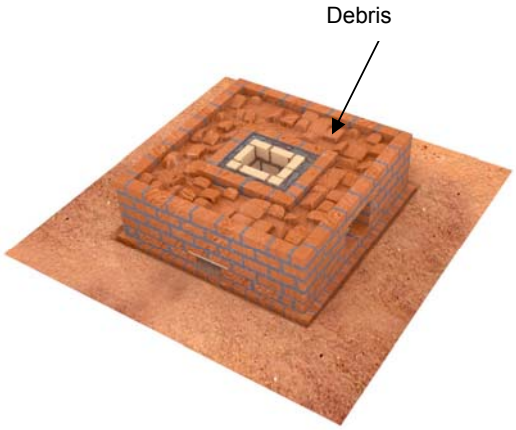


Fig 13

Continue to build the oven walls to about another 32 cm in order to give support for the slanting thermal insulation layer at the shoulders of the combustion chamber as shown in fig 14. Chisel 2 holes in the vertical insulation at the backside to be used to hold the metal box support angle bars.

Fig 14

5.16 Using a mixture of cement and sand build a slanting layer of on top of the debris to form a primary foundation for the insulation layer to be built in the next stage. The ratio of sand to cement applied at this section should be 3:1. Start to shape the slant according to the technical drawing (diagram 2).

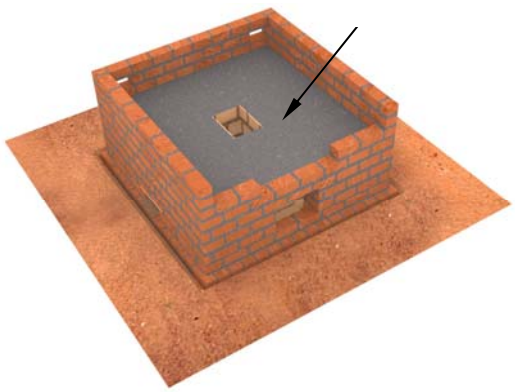


Fig 15

5.17 Erect 4 supports for the box using bricks on the slanting surfaces spaced at approximately 80 cm from each other.

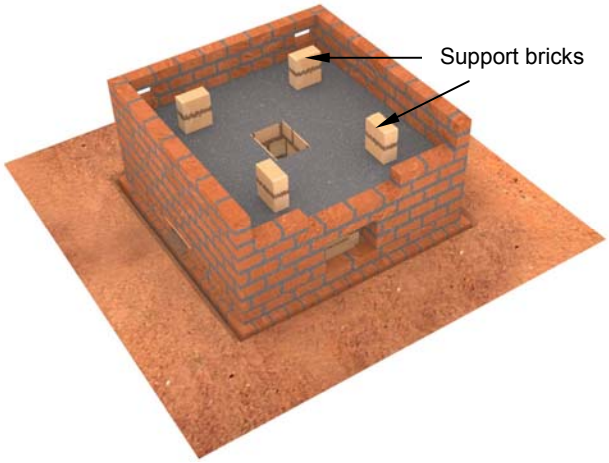


Fig 16

5.18 Lay pumice slabs along the slant to form thermal insulation as shown in figure 17. Use the insulation mortar to bond the pumice slabs.

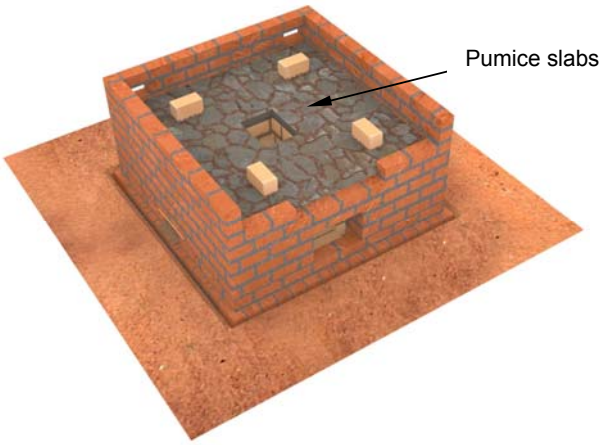


Fig 17

Use the insulation mortar to plaster and make the slant surfaces smooth as shown in figure 18.

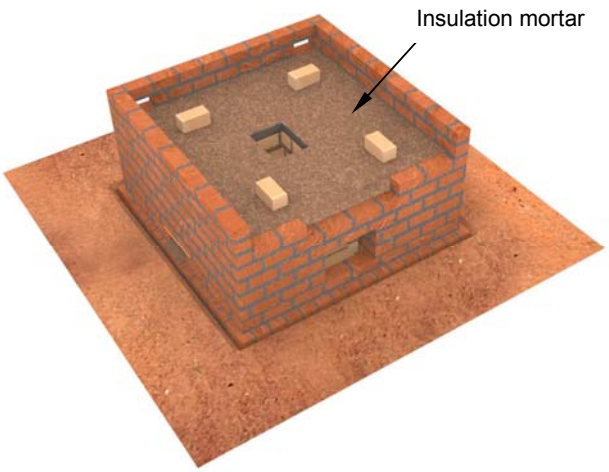


Fig 18

5.19 Continue to build the oven walls upwards to a further height of approximately 70cm using ordinary bricks and ordinary cement and sand mixture leaving the front side open as provision for the insertion of the metallic baking box at a later stage.

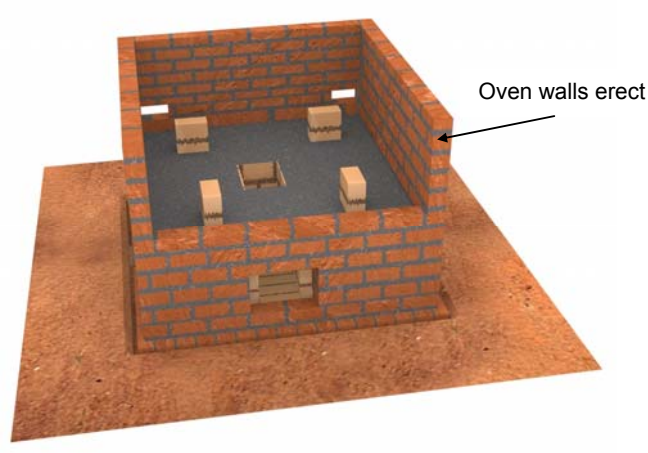


Fig 19

5.20 Using pumice slabs and insulation mortar, build the vertical insulation layer of minimum thickness 6cm. This will help to reduce heat loss through the oven walls in order to enhance heat transfer.

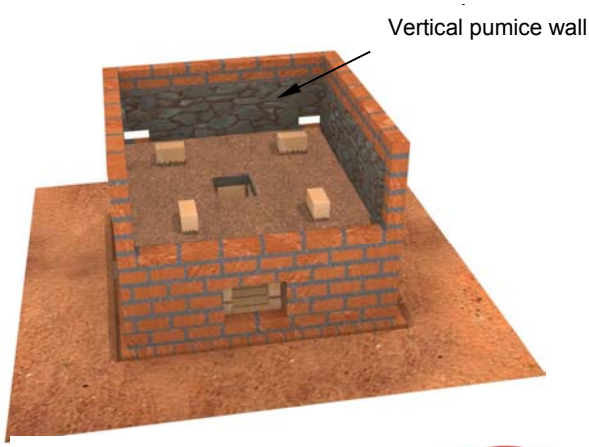


Fig 20

5.21 Construct a vertical heat retention layer of heat retention bricks/tiles of approximate thickness 6cm along the pumice layer.

In practice the heat retention liner is built simultaneously with the pumice insulation liner behind it as shown in figure 21.

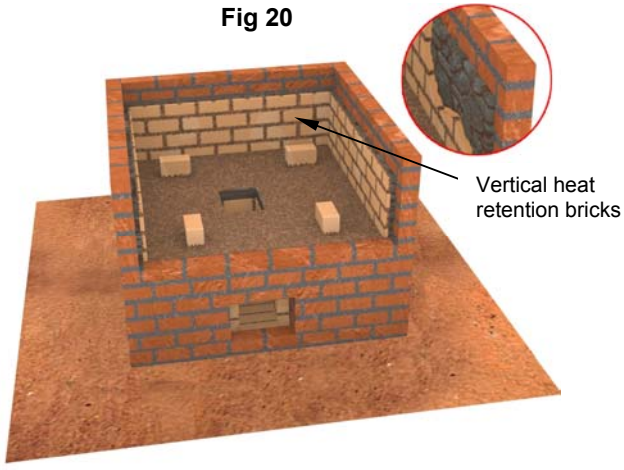


Fig 21

6.0 THE METAL BOX / BAKING CHAMBER

Single deck oven (120 x 120 x 40cm)

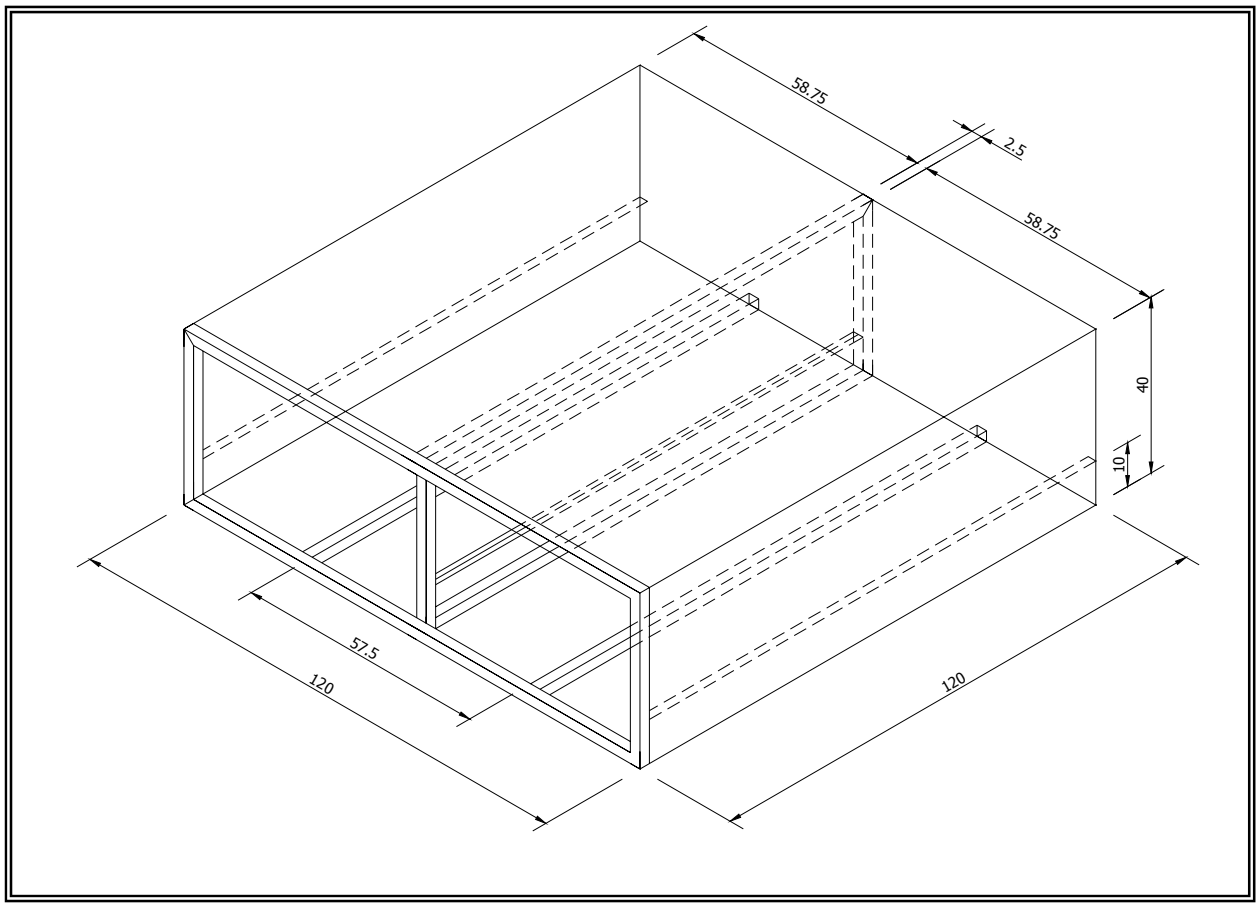


Diagram 5: Illustration of the metal oven box for the single deck oven (120 x 120 x 40cm)

6.1 Fabrication of the metal box (baking chamber) for the Single Deck / 4 trays Oven (Capacity 120 X 120 X 40 cm^3).

When fabricating the 120 X 120 X 40 cm^3 metal baking chamber, usable for small and medium scale baking, the reader is advised to make reference to the technical drawing on the previous page and the subsequent illustrations for guidance when reading through the fabrication procedure.

It is recommended that the bottom and sides of the box be made from the 4 mm thick mild steel (M.S.) plate in order for the oven to last long enough. This is because the fire from the rocket – elbow combustion chamber, is quite hot and could easily wear out M.S. plates of less thickness. The top covers of the box may be fabricated out of the 2 mm thick M.S. plate because the temperature of the hot flue gases (fire) will have fairly reduced at this point. Finally the bottom of the metallic box is protected from direct bombardment of the fire, using a secondary heat protection in form of a slab of approximately 8mm. The slab could be fabricated from sheet metal or an appropriate clay tile.

Lay down on a flat surface the 1220 X 2440 X 4 mm M.S. plate (= 4' X 8' X 4 mm), and then mark it for cutting / bending as shown below in diagram 6.

NOTE: First wear protective gear e.g. eye gurgles and leather gloves.
Then cut the metal sheet with a hammer driven chisel or angle grinder with a steel cutting disc. Alternatively soften the marked lines using hammer driven chisel and then bend through 90° to separate the pieces.

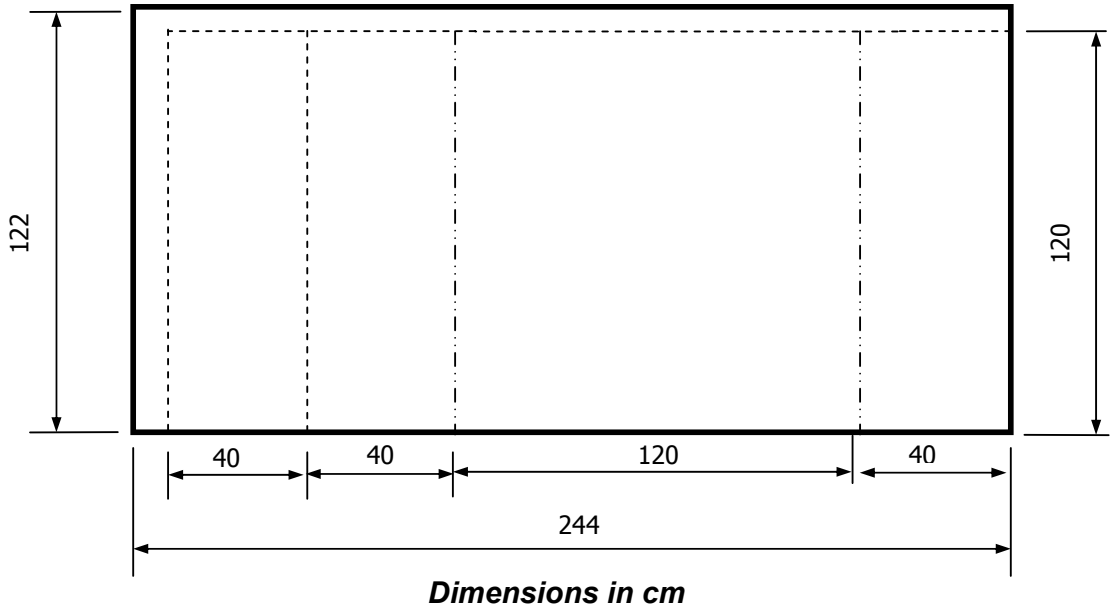


Diagram 6: Partitioning of the 4mm metal sheet to form metal box (Baking chamber)

6.2 Begin assembling the pieces that have been cut from the M.S. plate 1220 X 2440 X 4 mm (= 4' X 8' X 4 mm) to obtain U-shaped piece shown in figure 22. Skilfully use arc welding to join the pieces. The welding should be continuous to ensue that the edges of the box are air tight.

Fig 22

6.3 Use arc welding to attach the 40 X 120 cm piece that has been cut from the M.S. plate 1220 X 2440 X 4 mm (= 4' X 8' X 4 mm) to the back side of the U – shaped piece. The edges should be given a full (continuous) weld to prevent the flue gases, smoke etc, from entering the baking chamber.

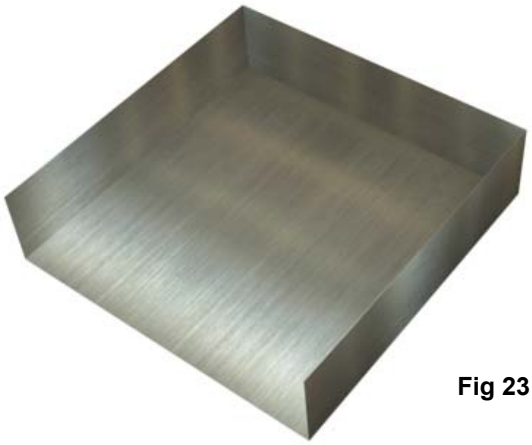
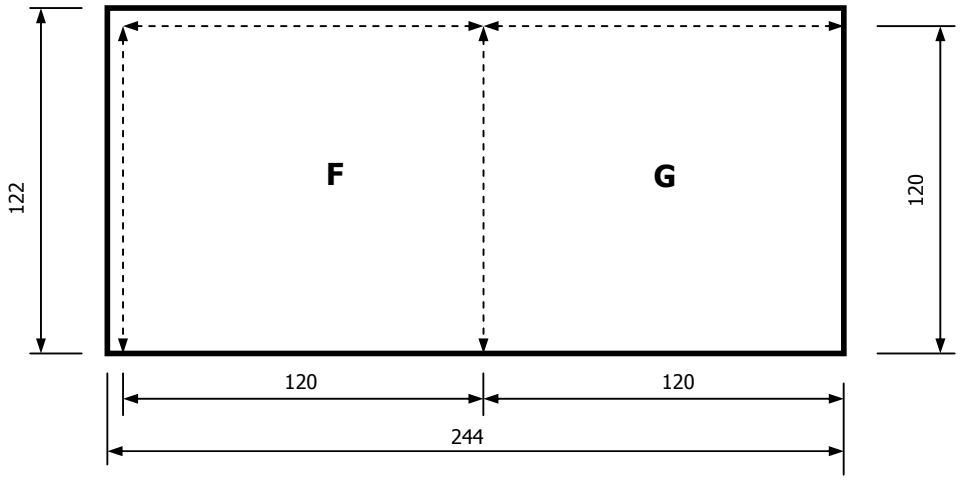


Fig 23

6.4 Lay down on a flat surface the 1220 x 2440 x 2mm MS plate (= 4' X 8' X 2 mm), and then mark it for cutting as shown below.

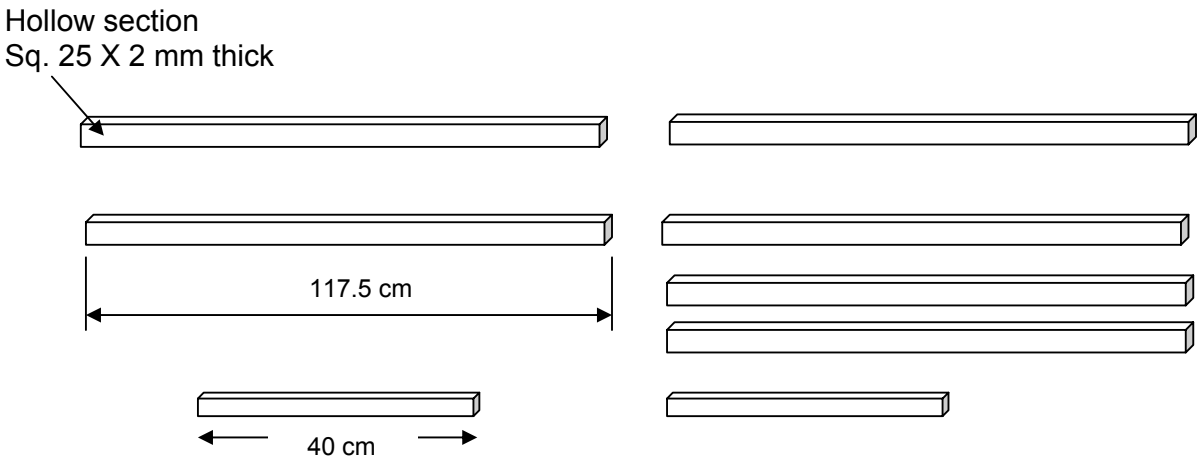
KEY: Cut with hammer driven chisel / angle grinder with steel cutting disc.



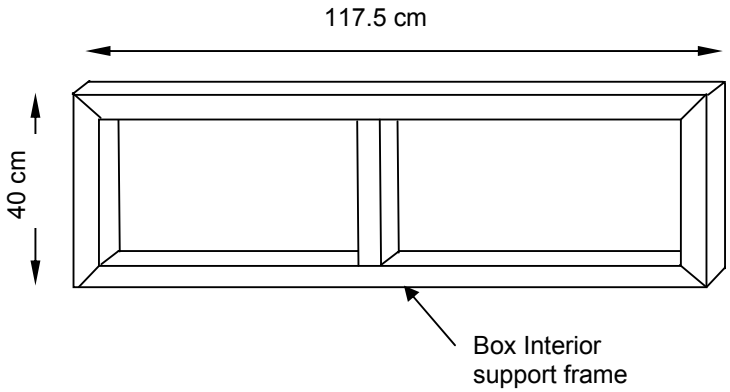
Dimensions in cm

Diagram 7: Partitioning the 2mm MS plate for the metal box top

6.5 From the original hollow section of sq. 25mm x 2mm x 6m, cut segments of 117.5 cm length each.



6.6 Cut the ends of the segments at 45°. Select the appropriate segments and assemble them to form an internal support frame of the oven box as illustrated. This will give vertical support in the middle of the oven baking chamber to check sagging when the oven gets hot during baking.



6.7 Weld two hollow section segments of length 117.5 cm on the M.S. plate assembly, as shown, to increase its structural strength. The spacing between them should be approximately 57.5 cm. (Also refer to the metal box drawing in diagram 5). Position them starting from the back while leaving a 2.5 cm gap towards the front of the box to accommodate the oven door frame to be fitted later.

Fig 24

6.8 Insert the box interior support frame vertically and skilfully weld it in the middle of the MS plate assembly as illustrated in figure 25. Use a pick hammer to remove the slug from the welded joints

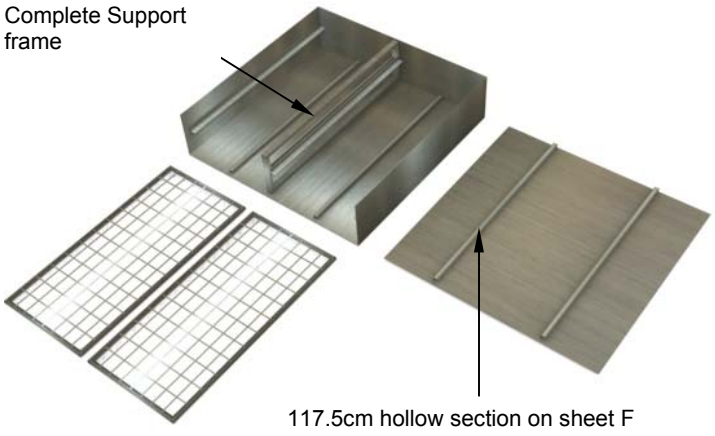


Fig 25

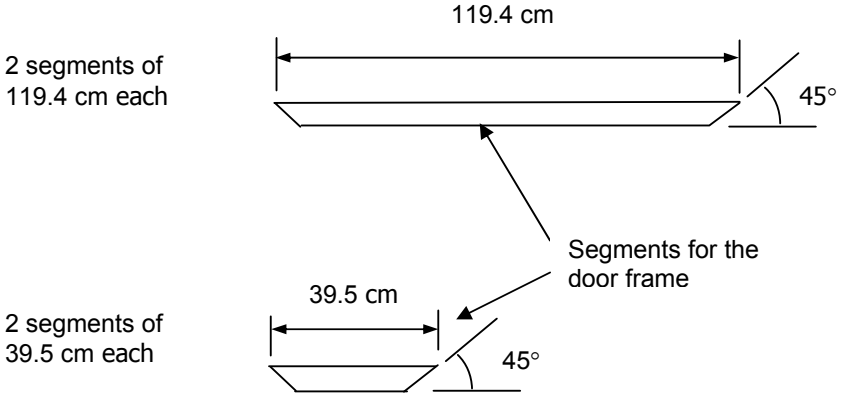
6.9 Weld the remaining 2 segments of hollow sections of length 117.5cm on one of the sheets (say **F** in diagram 7) cut from the 2 mm M.S. plate, as shown, to increase its structural strength. The spacing should be approximately 57.5 cm. (regularly refer to the metal box drawing in diagram 6). Position the hollow sections on sheet **F** starting from the back while leaving 2.5 cm gap towards the front of the sheet as shown in figure 25.

6.10 Invert sheet F that has been welded with the hollow sections to form the top cover for the box and carefully weld it at the edges to form the box as illustrated in figure 26. Ensure that the edges of the box are fully welded to make them airtight. This will be important in preventing flue gases (fire), smoke etc from entering the baking chamber during baking. The result is that baking products (bread, cakes etc) will be clean.

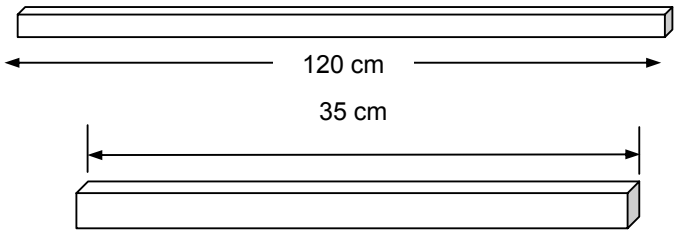
Fig 26

6.11 Prepare the door frame as follows.

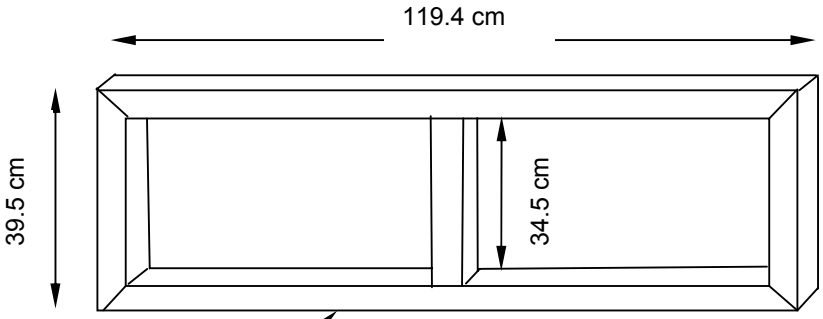
From an original hollow section sq. 25mm x 2mm x 6m cut segments of lengths specified below, at an angle of 45°, as illustrated.



6.12 From the same hollow section as in 6.11 above, cut one segment with right angled edges and length 35 cm, to be used to support the middle of the door frame.



6.13 Weld the 45° angled hollow sections into a rectangular frame together with the central support section. This will be the door frame for the baking chamber.



Weld the rectangular doorframe to the entrance of the metal box as shown in figure 27.

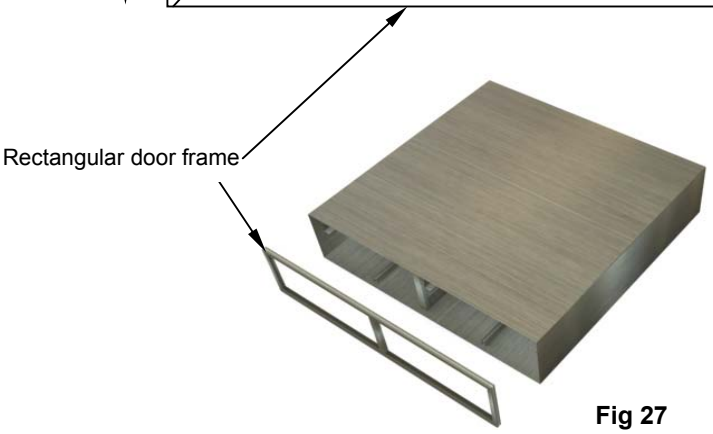
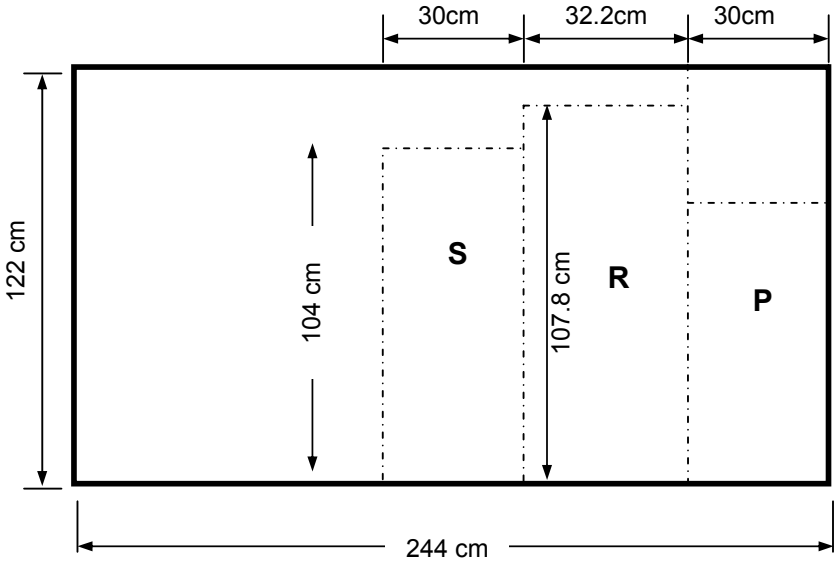


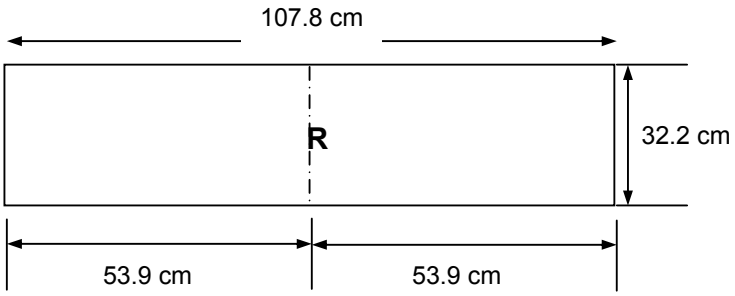
Fig 27

6.14 Fabricate the door shutters for the oven box as follows.

Lay down on a flat surface the 122cm X 244 cm X 0.8 mm thick M.S. plate. Mark it for cutting as shown. Cut it and label the pieces with letters respectively.

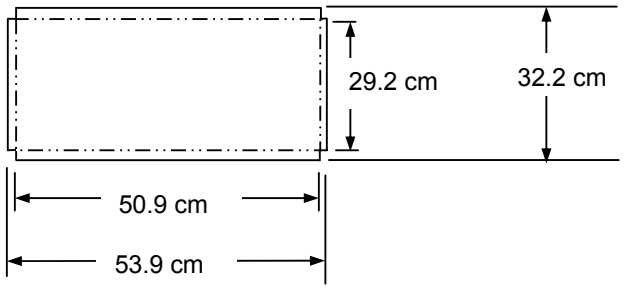


6.15 Cut out segment **R** and divide it into 2 pieces of equal length each of 53.9cm.

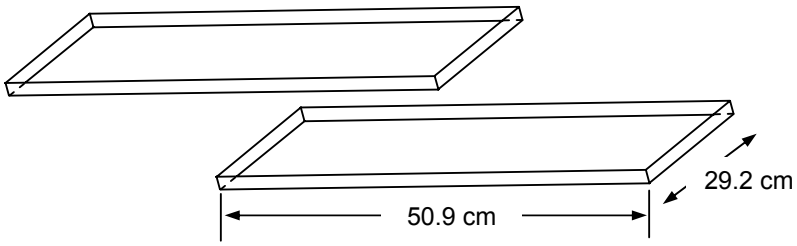


Cut out 1.5 cm squares from the corners of each of the two metal sheets cut from **R**.

Mark dotted lines on the resulting pieces of the two sheets as shown.

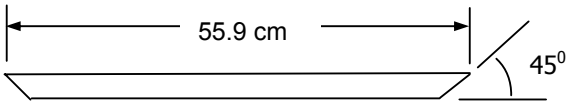


Fold them along the dotted lines through 90° to form two tray – shaped pieces.

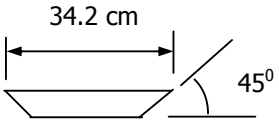


6.16 With the edges at an angle of 45°, cut the hollow section (sq. 25 X 6000 X 2 mm) into segments of the lengths specified below. These will be used to make the 2 door frames.

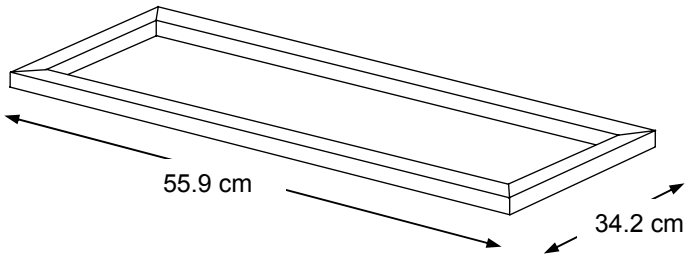
4 segments of 55.9 cm



4 segments of 34.2 cm



6.17 Weld the 45° angled hollow sections into two rectangular frames. These will be the door shutters for the baking chamber



6.18 Use arc weld to fit the tray – shaped pieces into the door shutter frames.
They will then appear like a tray bounded by a hollow section frame. (Figure 28)

Fig 28

6.19 Cut sheet **S** into 2 equal pieces measuring 52cm x 30 cm each.

Fill the tray – shaped pieces with vermiculite to level as in figure 29.

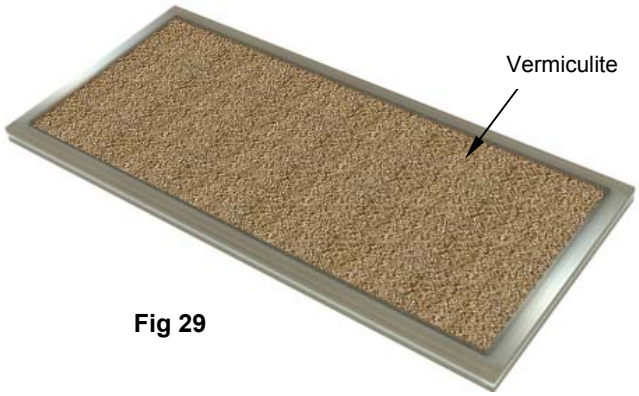


Fig 29

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Cover each of the vermiculite trays with the pieces from sheet **S** and weld them on to the frames.

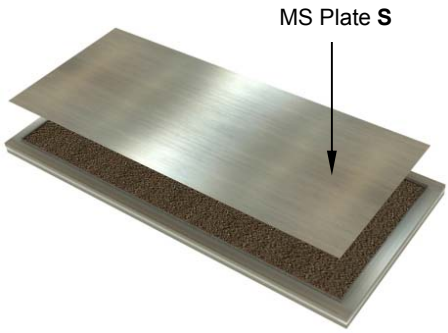


Fig 30

16.20 Ensure that the weld is continuous (full) to appropriately seal the vermiculite in the door frame as illustrated in figure 30.

6.21 Fit hinges to the sides of the door shutters and use arc welding to fix them to the box such that the doors open along a vertical axis.

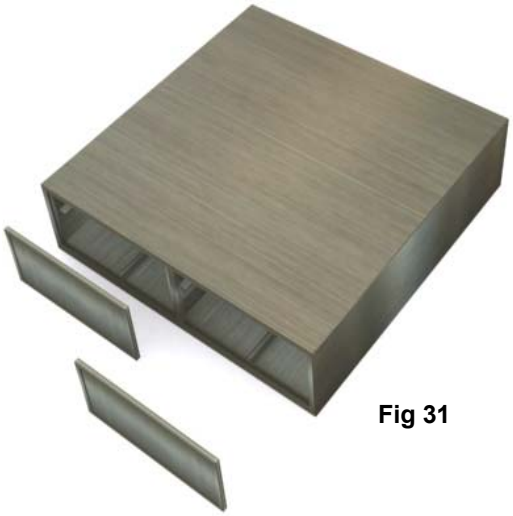


Fig 31

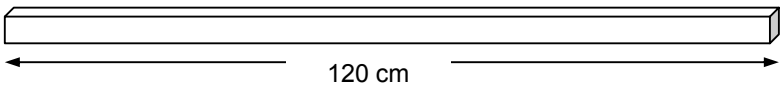
Fit a latch and a handle to the door shutter. Both of them should be thermal insulated to protect the oven user from injury during oven use.

At this stage the box appears as shown in figure 32.

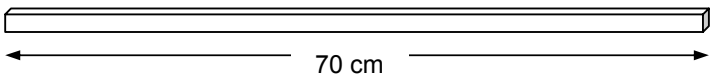
Fig 32

6.22 From a hollow section sq. 30mm X 6000 X 2 mm, cut off segments as described below

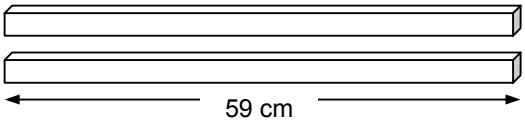
One segment of 120 cm



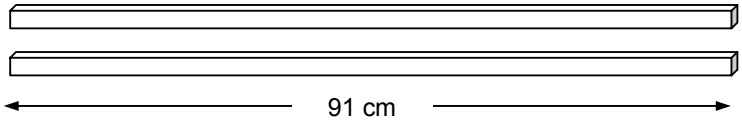
One segment of 70 cm

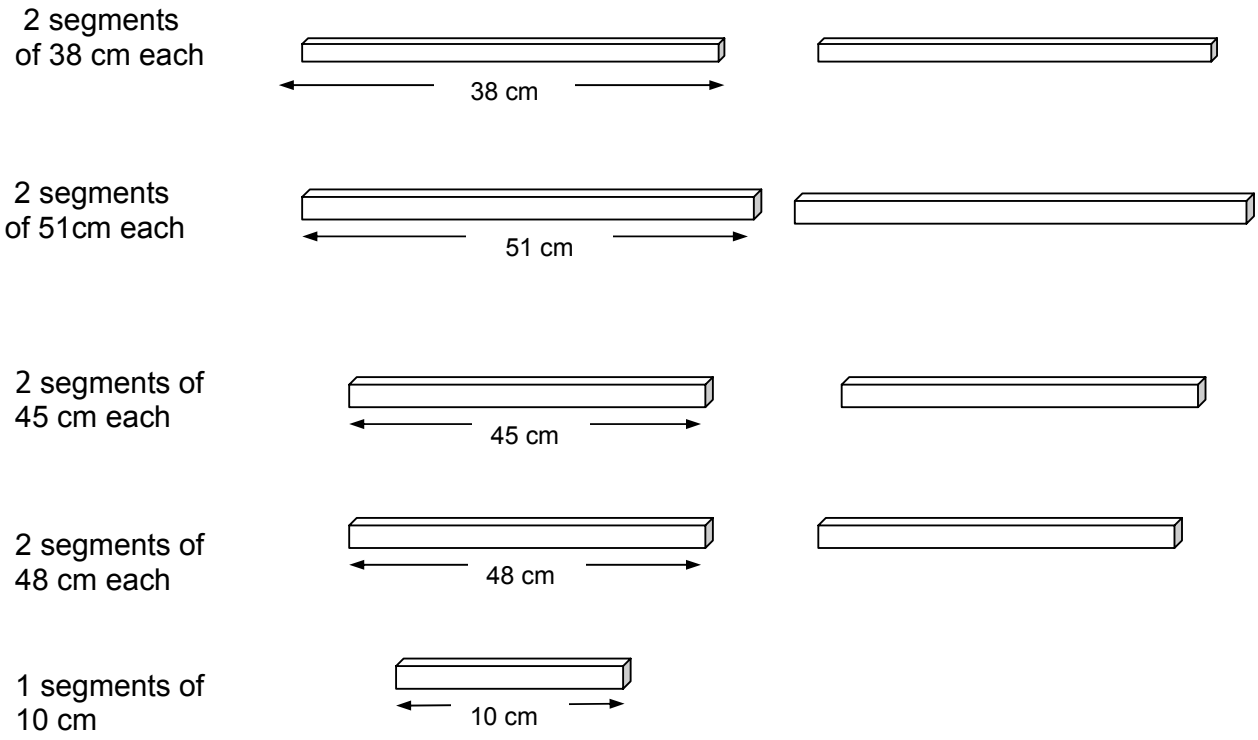


2 segments of 59 cm each

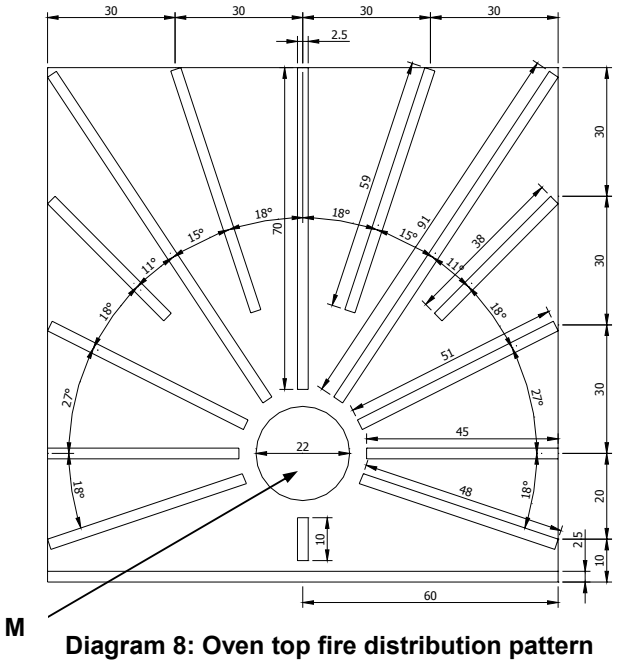


2 segments of 91 cm each





6.23 Position the hollow section segments radially on the top face of the box as shown below. The picture shows the plan (top) view of the box when facing in the direction of the arrow marked F.E. (see Diagram 9). Use arc weld to fix them into position.



M

Diagram 8: Oven top fire distribution pattern

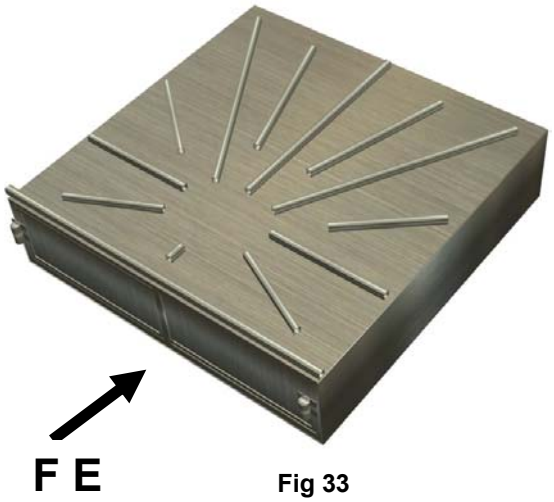


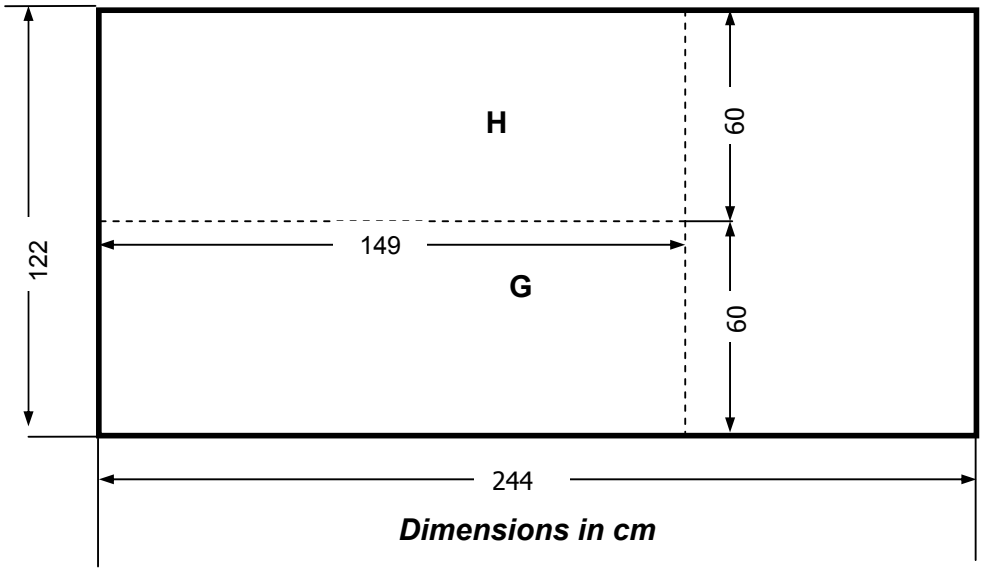
Fig 33

Key

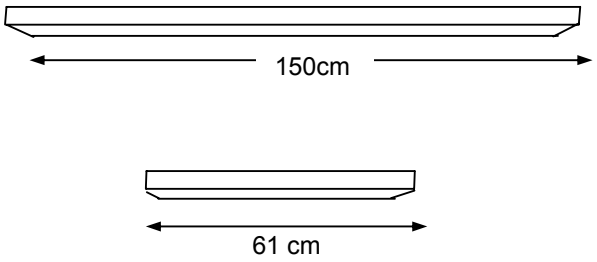
M represents the position to be occupied by the chimney.

Constructing the Oven top cover

6.24 Lay down another MS Plate of 122cm x 244cm x 2mm and mark it for cutting as shown below. Label the sheets **G** and **H** as shown in the diagram.



6.25 Lay down 2 angle bar sections measuring 40 x 4mm x 6m and cut them into 4 segments each of 150 cm length and 4 segments each of 61 cm length. Cut the edges at 45^0.



Weld the angle sections in 6.25 above to form two rectangular frames of sides 150cm x 61cm.

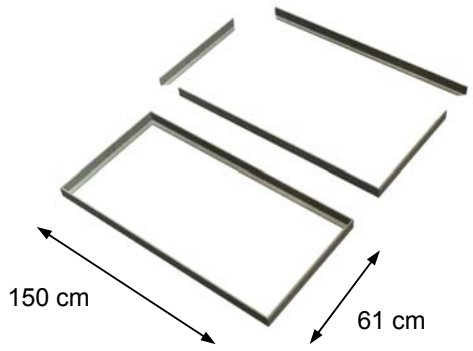


Fig 34

6.26 Lay down and weld the MS plates **G** and **H,** one into each of the frames as shown in figure 35.

Scribe a 22 cm diameter circle at the centre of one of the plates named **G**.

Use a chisel driven hammer to cut along the perimeter of the circle to form a hole to be occupied by the chimney.

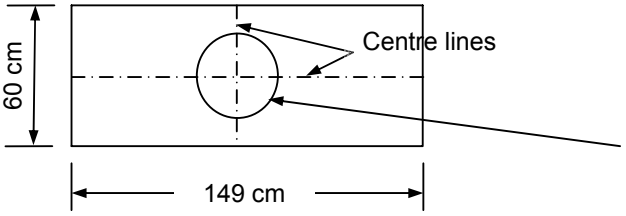
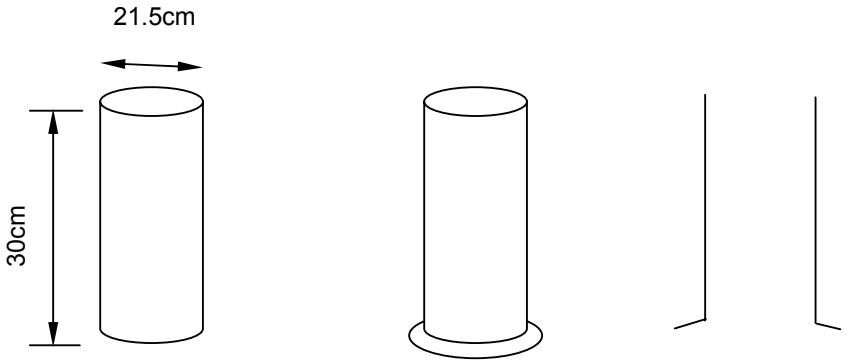


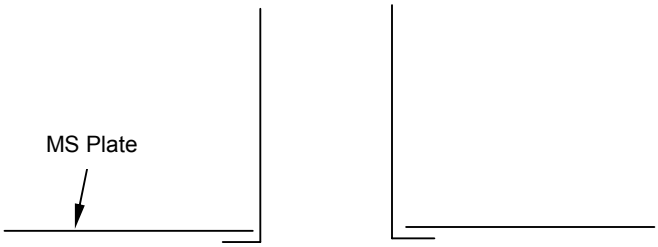
Fig 35

Roll the sheet labelled **P**, cut from the M.S. Plate 122 cm X 244 cm X 0.8 mm, to form a cylindrical shape. Use seaming to join the edges. Note: Taper it at towards the top.



Use the hammer and anvil to spread out the shape of the base. This forms the chimney base.

6.27 Insert the chimney base into the 22 cm hole in the centre of the 2 mm M.S. sheet (sheet **G**). Insert it from below as shown.



Note:
For purposes of clarity, the gaps in the diagram have been made to appear bigger.

6.28 Use arc weld to appropriately fit the chimney base to the 2 mm M.S. sheet (sheet G) as shown in figure 36.

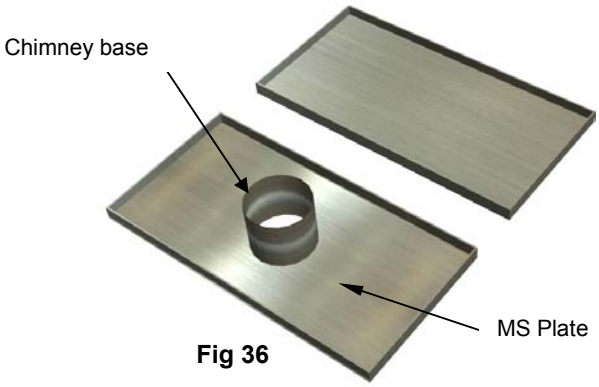


Fig 36

6.29 Fill the top covers with vermiculite as shown in figure 37. This will help to insulate the oven top in order to enhance heat transfer into the oven baking chamber (box) before the exhaust finally exits through the chimney pipe.

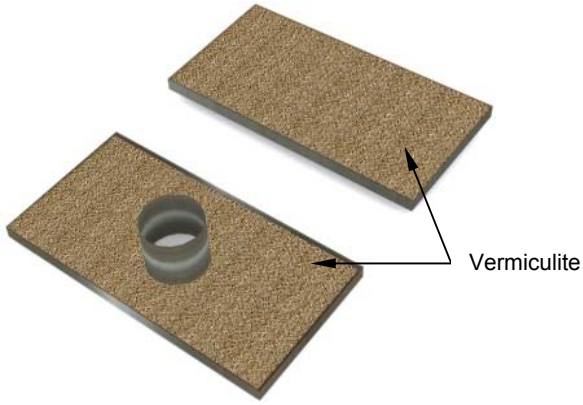


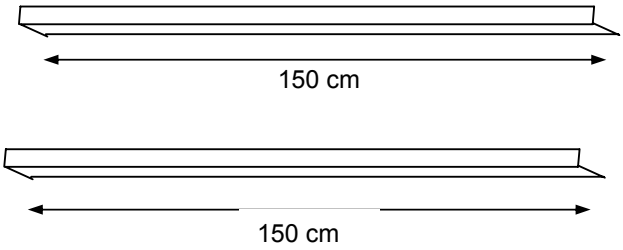
Fig 37

6.30 Repeat step 6.26 to obtain two other M.S. plates measuring 150 x 61 cm each for use to cover the vermiculite in figure 37. Use arc weld to seal these tops in order to prevent any leakages of vermiculite.

6.31 The resulting parts shown in figure 38 will be placed on the radial hollow segments on top of the box assembly.

Fig 38

6.32 Lay down an angle bar measuring 25 x 40mm x 6m and cut it into 2 segments each of 150 cm length.



Using arc weld, attach the angle sections to the top covers as shown in figure 32 in order to align the covers and seal the joints to minimise heat escape during the time of oven operation in future.

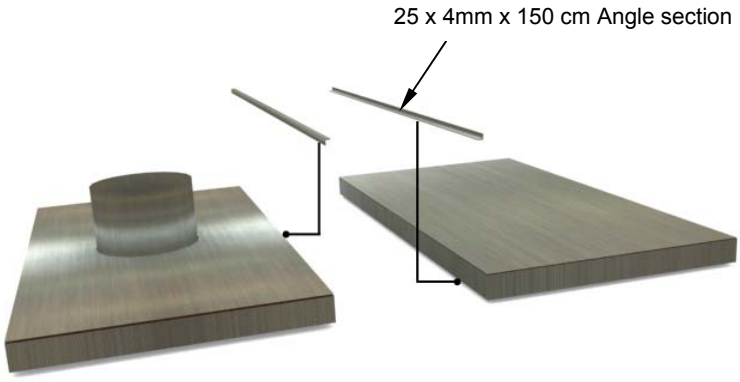


Fig 39

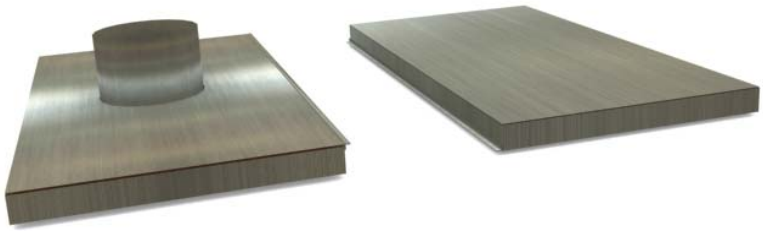


Fig 40

6.33 Fix two suitable handles on each of the top covers as shown in figure 41.

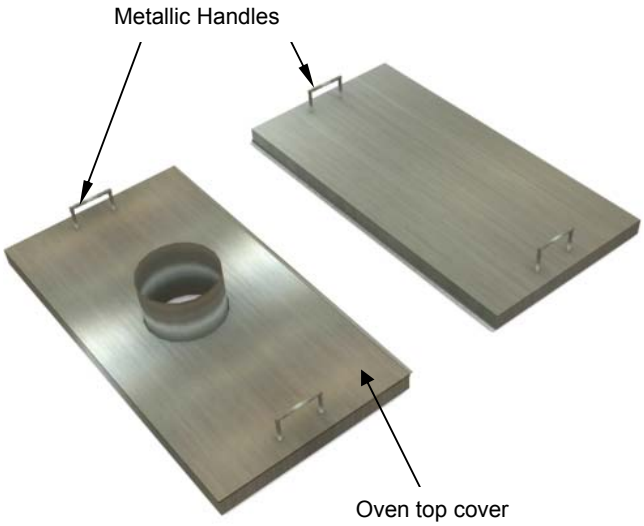
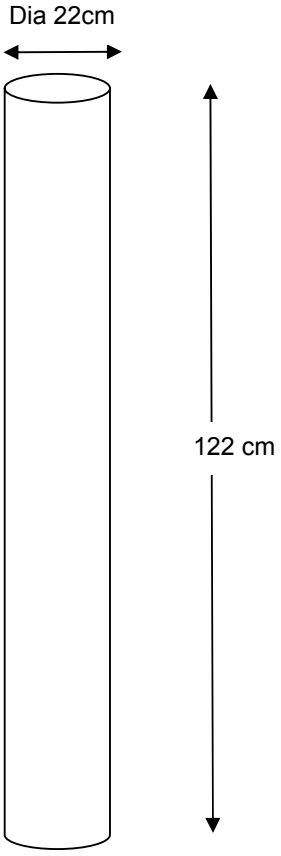
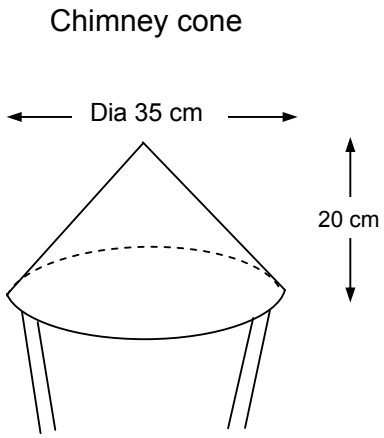


Fig 41

6.34 From a plain galvanised iron sheet of thickness 1.2 cm, cut off a rectangular section of 100cm x 71cm. Roll it into a cylindrical shape to form a chimney. Fasten the edges using the seaming method as was done with the chimney adaptor. Attach a suitable cone at its top. Keep it for use at a later stage.





6.35 Lay down a C – Section measuring 80mm x 40mm x 4mm and cut off three sections each of length 40cm.
Lay down an MS plate of 8 mm thick. Cut off a smaller sheet measuring 40 x 40cm x 8mm.

Use the combination of the C – section segments and the 8 mm MS plate off-cut above to assemble the secondary protection for the oven box against direct bombardment by flames from the combustion chamber which would easily destroy and reduce oven box durability. See figure 42.

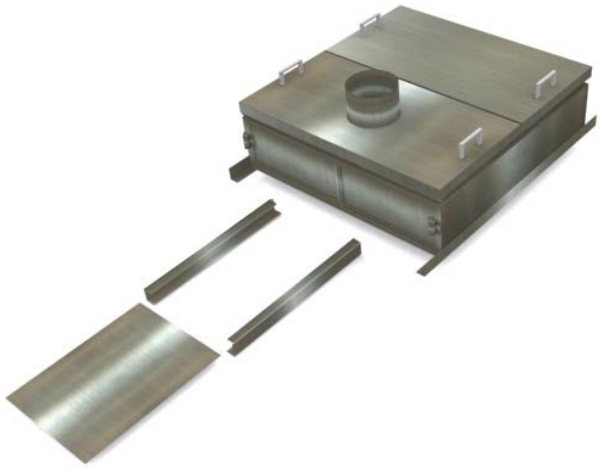


Fig 42

6.36 Use bolts or arc welding to attach the two C-Sections at spacing of 40 cm apart beneath the metallic box in a central position as shown in figure 43.

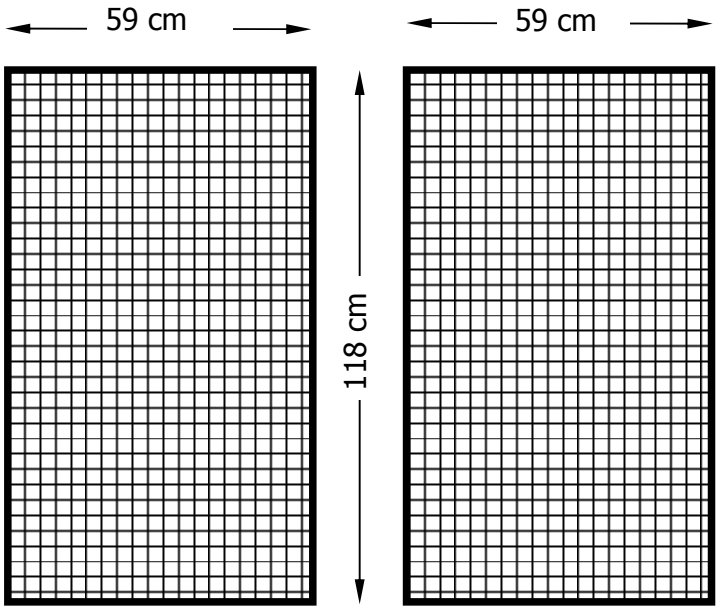
The height of the C – Section automatically provides the space between the oven metallic box and the 8mm plate. It is approximately 7cm maximum.

Fig 43

6.37 Assemble 2 pieces of 6 X 6 cm of a welded mesh onto two 118 X 59 cm rectangular hollow section frames to form the oven shelves.

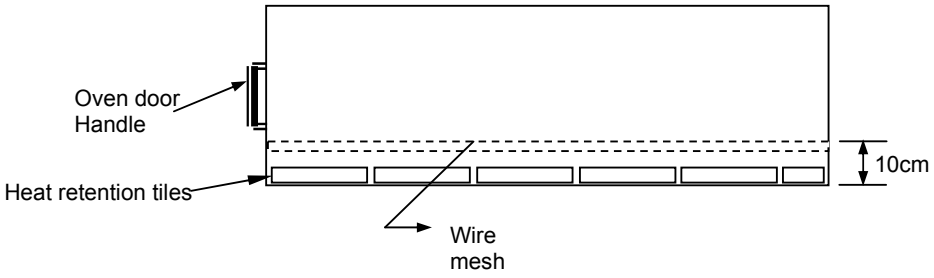
Weld support levels for the mesh frame to support it inside the metal box at 10 cm above its bottom.

This mesh will hold the trays with baking products (bread, cakes etc), during baking and protect them from burning.



6.38 Insert clay tiles (heat retention tiles) on the inside base of the baking chamber.

6.39 Place the oven shelves into the box.



7.0 FITTING METAL BOX ON THE BRICK STRUCTURE

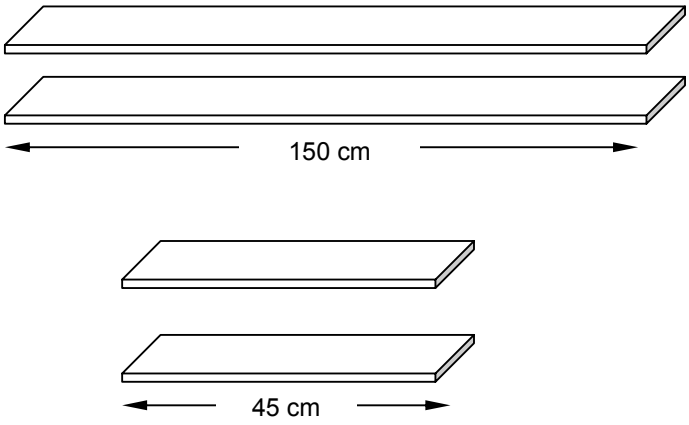
7.1 Fit the box in the brick structure and ensure a 3 cm gap between the box and the vertical insulation (left, back and right). The gaps between the front of the box and the brick structure should be sealed using cement and grog mixture (ratio 1:2) to avoid leakage of fire.

Fig 44

7.2 Cover the top of the oven with the tops fabricated in Fig 41**.** Place them on the radial hollow segments on top of the oven box assembly
They should leave an extension beyond the box of approximately 15 cm on either side across as shown in figure 45.

Fig 45

7.3 Lay down Flat sections (Sq. 50 X 3 X 6000 mm) and cut them into segments to seal the gaps of the oven body and oven box at the front.



7.4 Place the flat sections on the front of the oven body to seal off any escape of heat as shown in figure 46.

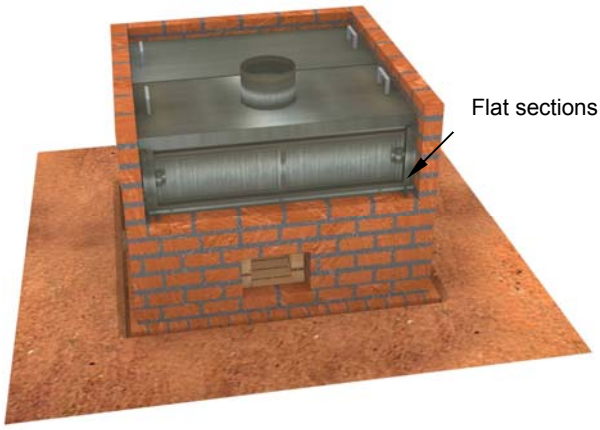


Fig 46

7.5 Use silicon gel to seal the joints to minimise possible flue gas leakages between metal joints. This will enhance heat /energy transfer into the oven box.

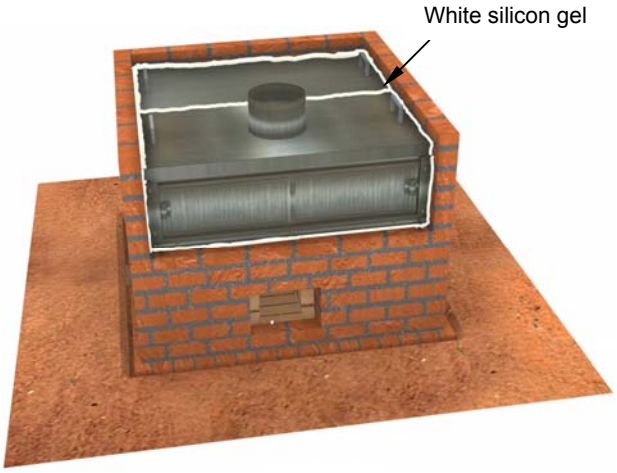


Fig 47

7.6 Plaster the oven walls using an appropriate mix of cement and sand in the ratio 1:3.

7.7 Attach the chimney cone to the chimney pipe and slide it onto the chimney base.

7.8 Allow a period of at least 15 days for the cement to bond and all the oven parts to dry effectively. The oven will be ready for use after this.

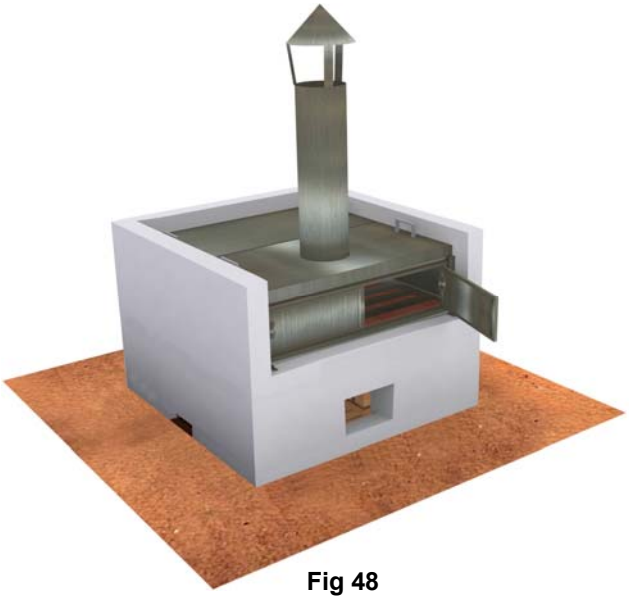


Fig 48

PART 2

Other oven sizes

8.0 DOUBLE DECK ROCKET BAKING OVEN

The double deck rocket baking oven is constructed following a similar procedure as that of the single deck rocket baking oven explained in PART 1 of this manual.

The double deck oven has got two baking shelves with a total baking capacity of approximately 44 loaves each of 1Kg, accommodated on 8 trays at ago.

It offers all the other benefits as mentioned for the case of the single deck rocket baking oven.

The technical drawing (diagram 9) on the next page should be used as a guideline when constructing the double deck oven.

DOUBLE DECK ROCKET BAKING OVEN TECHNICAL DRAWING

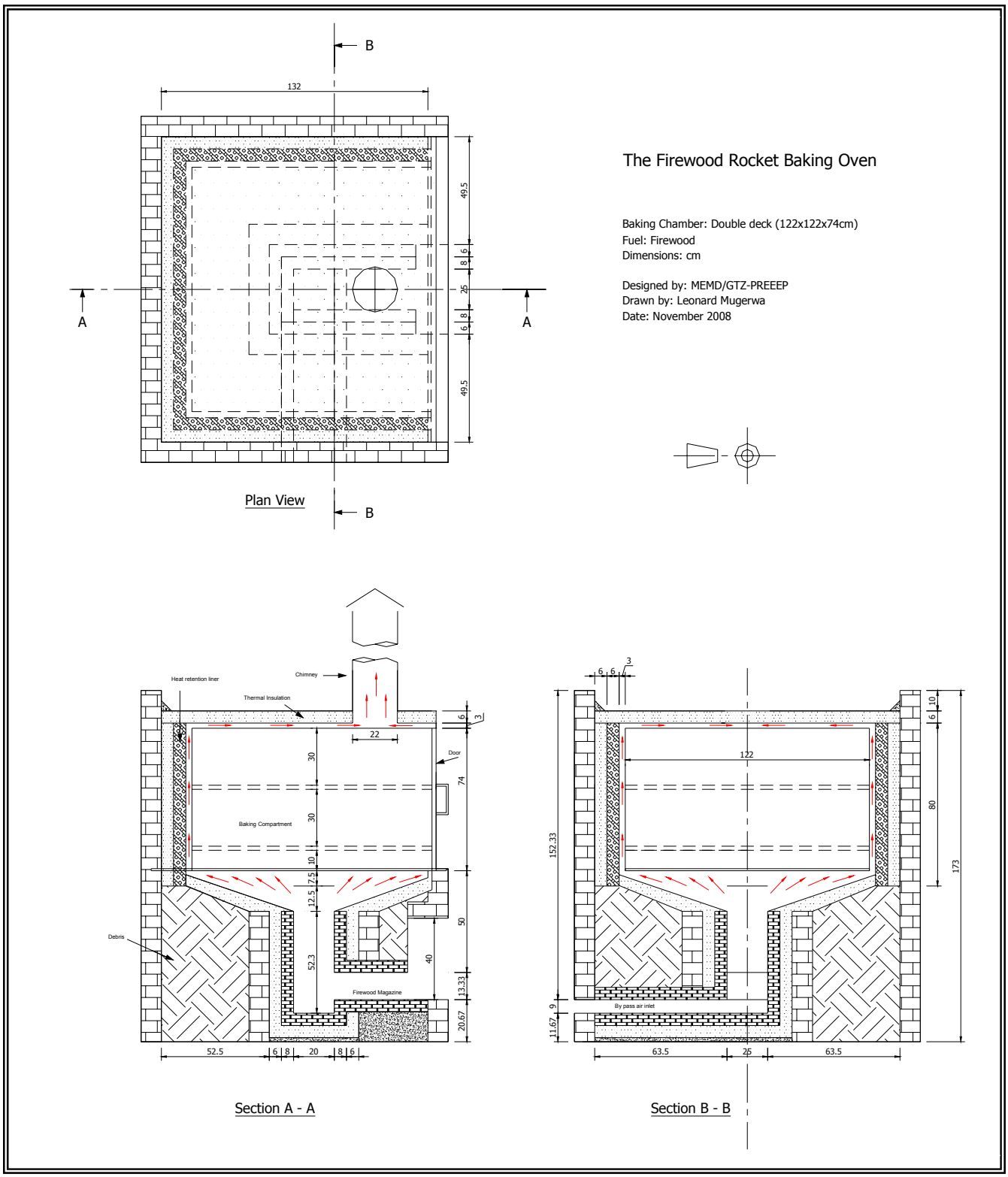


Diagram 9: Technical Drawing of the double deck Rocket Firewood baking oven

9.0 LARGE SCALE - COMMERCIAL ROCKET BAKING OVEN

The large scale - commercial rocket baking oven is constructed as an equivalent of four double deck rocket ovens in a modular format, with four separate baking chambers and four combustion chambers. Each combustion chamber is assigned to heat only one of the baking compartments.

The large scale - commercial rocket baking oven is constructed following a similar procedure as that of the single deck rocket baking oven explained in PART 1 of this manual and the double rocket oven in 8.0.

This oven has got a baking capacity of 256 loaves of 1kg bread and 360 loaves of 500g bread in only one baking shift. It is suitable for large bakery settings where it can be operated on full scale.

The technical drawing (diagram 10) on the next page should be used as a guideline when constructing the large scale – commercial rocket baking oven.

9.1 LARGE SCALE - COMMERCIAL ROCKET BAKING OVEN TECHNICAL DRAWING

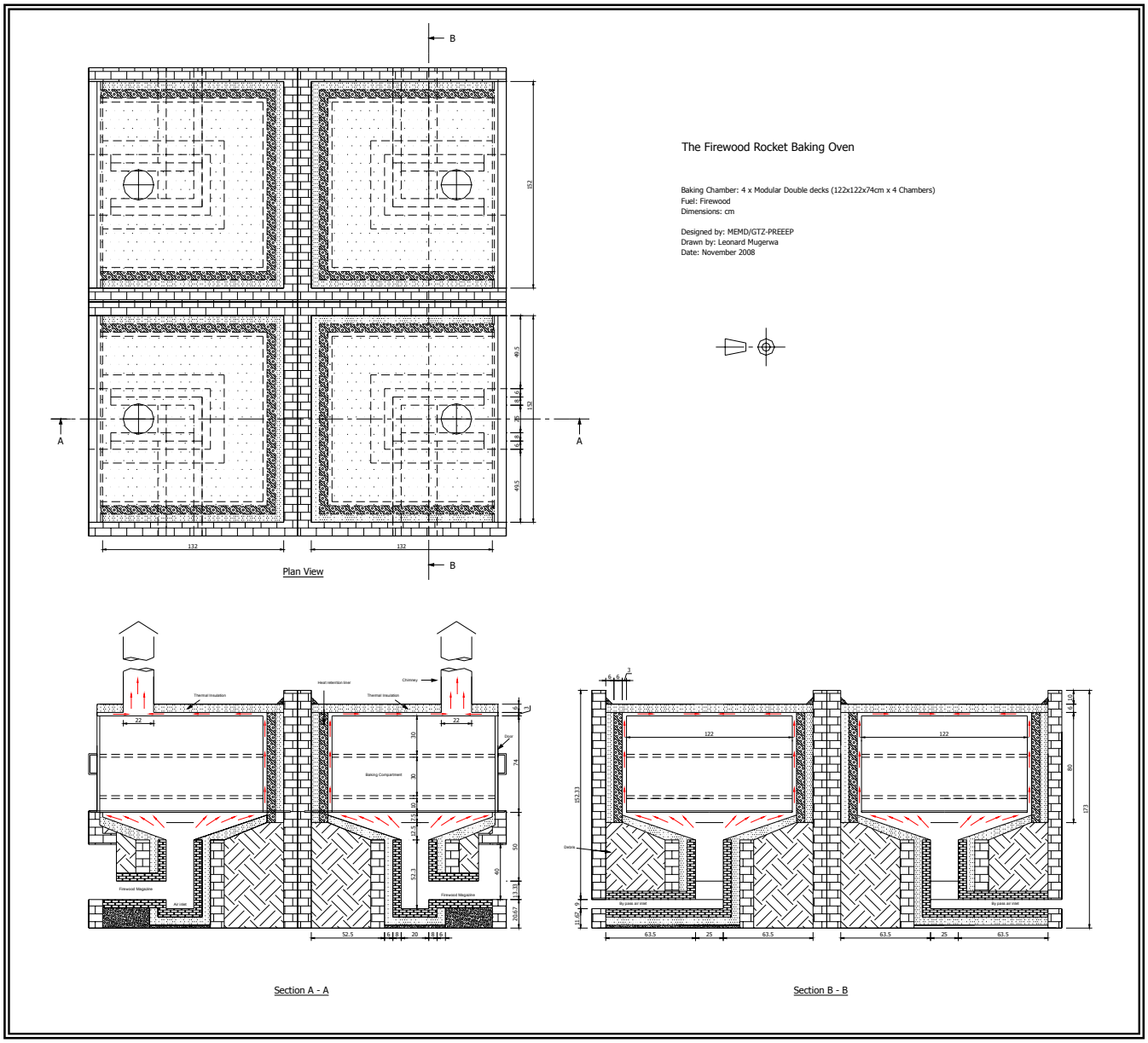


Diagram 10: Technical Drawing of the large scale rocket firewood baking oven

10 USING THE OVEN

After the drying phase, the oven is now ready for use. It is suitable for use in baking all common baking products including bread, cakes, cookies etc. The oven is a multipurpose appliance e.g. it can also be used for grilling

***Note**: This manual has been written for the purpose of technical guidance in oven construction and maintenance only. It is important that the person using this oven for baking should have prior training in baking skills.*

It is recommended that the oven should be supplied with appropriate ash scoops, one for each combustion chamber.

When using the oven it is advisable to use small amounts of dry chopped firewood. It is also important to observe the following recommendations

10.1 Efficient baking practices

- Always use dry firewood split into thin pieces. Wet firewood takes longer to burn and produces a lot of smoke.
- Preheat the oven to the desired temperature before loading it with the dough.
- Avoid feeding too much firewood into the oven. This will waste the fire wood and burn the bread etc.
- Always remove any ash from the combustion chamber before lighting the oven.
- Avoid frequent opening of the oven door as this results in heat loss.
- Prepare your dough beforehand so that it is ready when your oven reaches the right temperature. This helps to save time and firewood.
- Proof and baking times must be synchronized so that both the oven and dough pieces are ready at the proper times.
- For optimal use of the oven it is recommended that you bake a full load each round.

10.2 Cleaning the oven

The oven should be cleaned only when it is not in use (i.e. it should be cold).

- **Baking chamber**
  Open the baking chamber door to clean the baking chamber. This should always be done at least twice a week.

- **Combustion chamber**
  Slide out the firewood shelf and remove the wood ash from the firewood feed chamber. Place back the firewood shelf after removing the ash. This should always be done before lighting the fire.

- **The oven body**
  Use a damp cloth to clean the oven walls and the oven top covers. This should be done at least twice a week to avoid accumulation of dust on the oven.

- **Chimney**
  Lift the chimney off its base. Remove the soot from its inside using a brush with a long handle (or similar tool). Place back the chimney on its base. This should be done twice a month to avoid clogging.

Note: The chimney has been designed so that it can easily be placed (attached) on and lifted (detached) from its 30 cm high base to allow for cleaning. Care should be taken to avoid deforming it and its cone.

Table 6: Summary of cleaning schedule

Oven Part	Frequency of cleaning	Purpose
Baking chamber	At least twice a week	Remove bread crumbs, etc
Chimney	After 4 weeks	Remove soot
Combustion chamber	Always before lighting fire	Remove wood ash
By pass Air inlet	Always before lighting fire	Remove wood ash
The oven body	At least twice a week	Remove dust
Bottom plate	Once in six months	Check for strength
Oven Cavities (flue gaps)	Once in Six months	Remove soot and dust.

10.3 Oven maintenance and repair

It is advisable that a skilled technician performs oven inspection regularly to identify faults and provide the necessary remedy to check further damage.

Table 7: Oven maintenance checklist

Oven Part	Fault to be checked
Baking chamber	Wear and tear
Baking chamber door	Looseness
Chimney	Wear and tear
Combustion chamber insulation	Cracks, wear and tear
Firewood grate	Cracks in tiles, wear and tear
Heat retention tiles	Wear and tear
Oven door latch, handle, hinges	Wear and tear
Oven walls	Cracks, wear and tear
Top insulation	Flu gas leakage, wear and tear
Wire mesh	Wear and tear