

How to Build a Kiln

Photo Journal of Kiln Construction



Resource Development International – Cambodia
and Engineers Without Borders Australia

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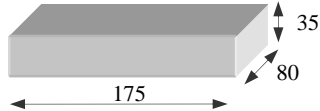
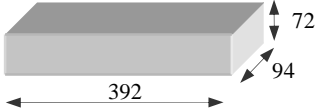
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Introduction

The ceramic water filters produced by Resource Development International - Cambodia (RDIC) are fired in kilns on the factory site. This document provides a photo journal of the manufacturing steps used to construct one of the kilns at RDIC.

RDIC's kilns are simple in design and operation. Ceramic filters are produced in a batch process. The kilns are loaded with 96 filters, slowly heated to an initial 100°C, to evaporate the water content, then up to 866°C at which temperature the clay vitrifies and ground rice husks burn out. The kilns are heated using two 'fire chambers' under the kiln chamber, in which timber fuel is combusted (see Figure 1). Hot gases, smoke, and heat rise into the kiln chamber via two internal chimneys, pass around the filters, and exit through a central exhaust slot in the floor before rising out the chimney in the rear of the kiln (see Figure 2).

RDIC currently has 5 kilns installed. These are generally operated in pairs to maximise time and labour efficiencies. The kilns are all housed within a larger roofed shed to protect the brick body of the kilns from rain. The exhaust chimney of each kiln passes through the roof to release smoke and heat above the building. Further information about RDIC's filter manufacture process can be found in the RDIC Ceramic Water Filter Manual 2008. The raw materials used in the furnace construction include:

<p>1. Clay Bricks</p>  <p>Average size of bricks (dimensions in mm). Produced at local brick factory.</p> <p>2. Loose Clay Bricks</p>  <p>Large loose bricks, internally reinforced with steel, are used in the kiln floor to cover the fire chambers and exhaust chute allowing opening sizes to be adjusted and access into the chambers below. Produced at RDIC.</p>	<p>3. Mortar</p> <p>RDIC uses mortar made in the following proportions by volume</p> <p>5 clay : 3 rice ash : 2 sand : water as required for a good consistency</p> <p>Normal construction cement cannot be used for kiln construction as it will crack at the high firing temperatures.</p>
<p>4. Steel Bars</p> <p>Steel bars are used to raise the fuel source and improve oxygen circulation. RDIC uses bars of approximately 28mm diameter.</p>	<p>5. Steel beams and rods</p> <p>Steel beams and rods are used to support the kiln structure. RDI uses:</p> <ul style="list-style-type: none"> • 40mm x 40mm L-shaped cross section, steel 3 mm thick. • Steel rods 8 mm diameter

The construction process is relatively simple, and can be completed using relatively unskilled labour and simple tools. There are four core steps in the process:

1. Foundation
2. Fire chambers and exhaust chute
3. Kiln chamber and chimney
4. Arched kiln roof. Additional features are also described.

Figure 1: Aerial View of Kiln Chambers

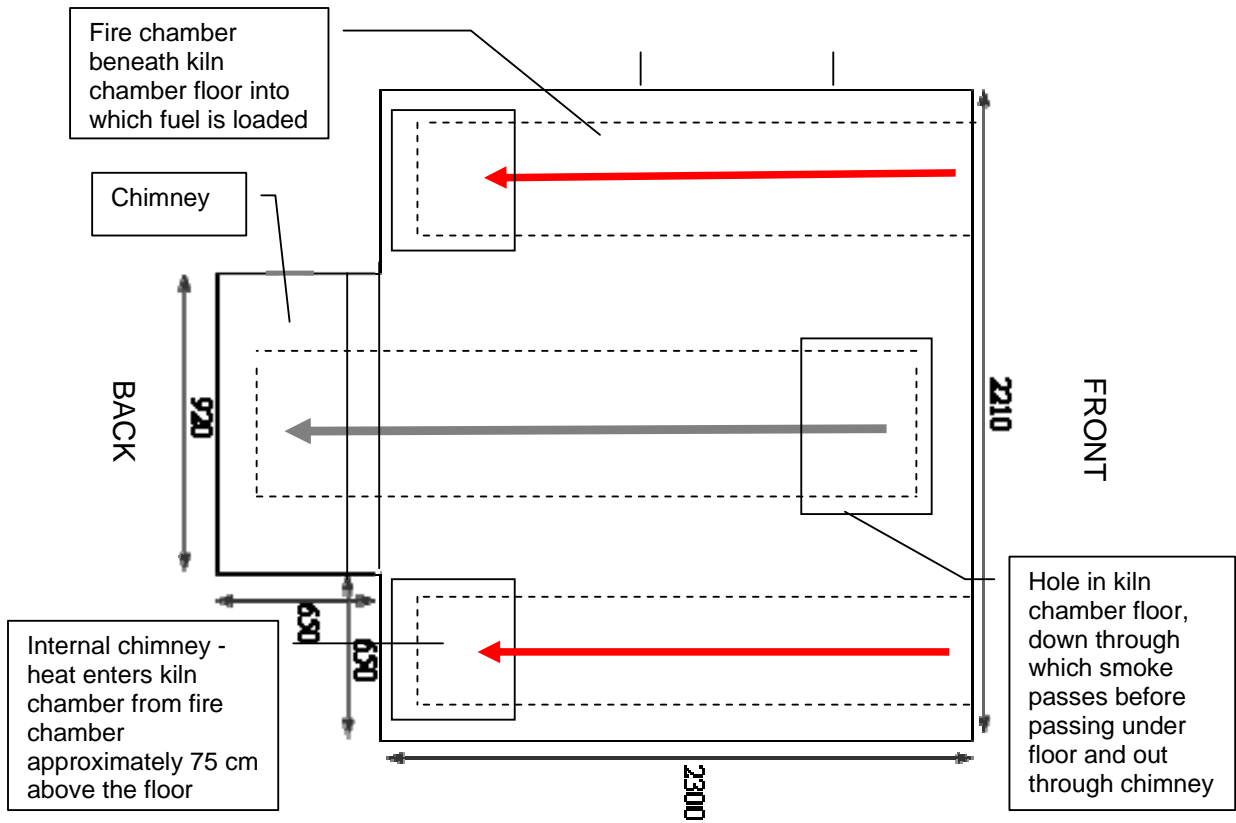
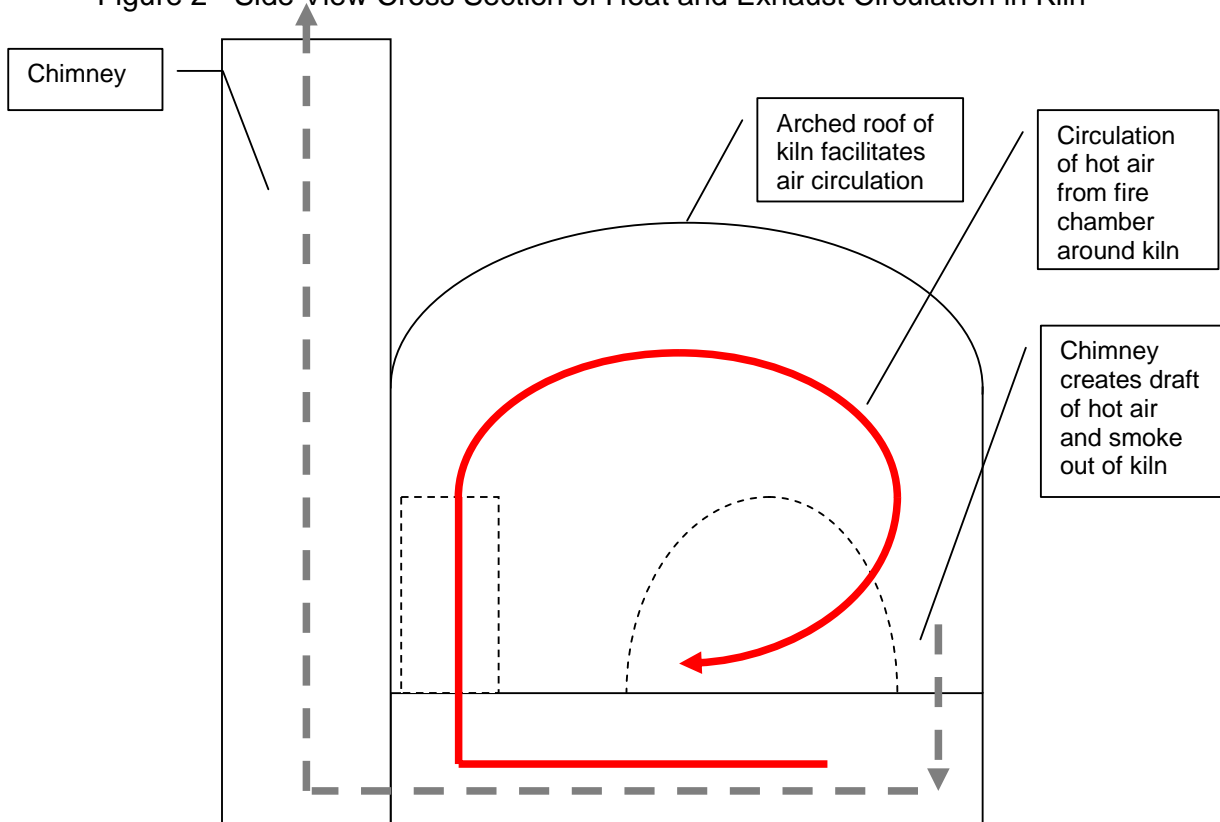


Figure 2 - Side View Cross Section of Heat and Exhaust Circulation in Kiln



Stage 1: Foundation

Upon a base of brick and mortar, a foundation of 7 layers of brick is laid for the kiln (including its chimney). Bricks patterns are alternated to ensure no easy crack lines can develop between layers.



Stage 2: Fire Chambers and Exhaust Chute

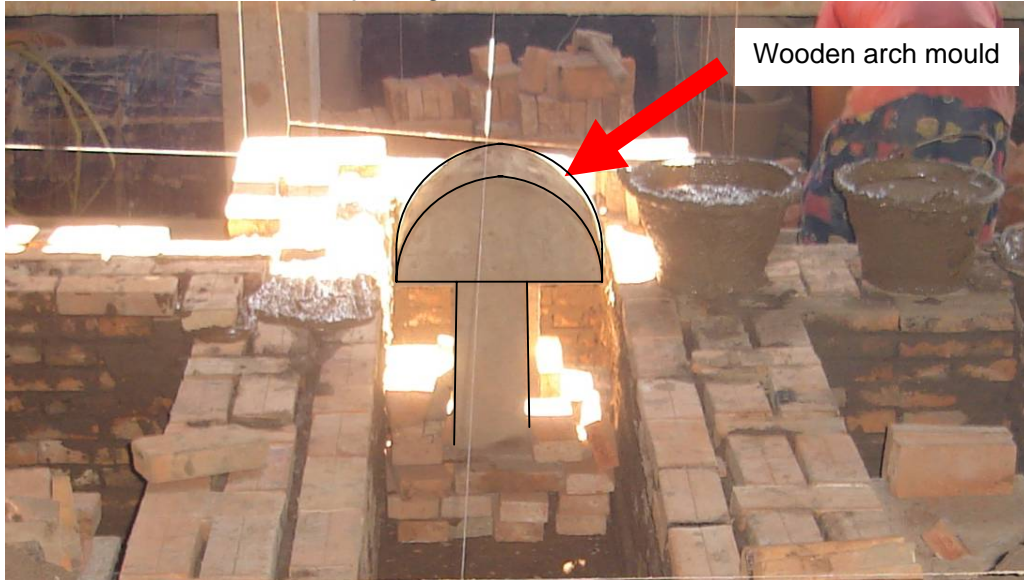
A. Constructing the Walls

Walls for the fire chambers, exhaust chute, and chimney are constructed on top of the foundation. The walls are all 1.5 brick lengths (three brick widths) thick, and are laid using mortar (described on page one) in an alternating pattern to increase strength. The left and right fire chambers are open at the front - to allow fuel to be inserted. The central exhaust chute is closed with 1.5 brick length wall at the front and opens to the chimney at the back.

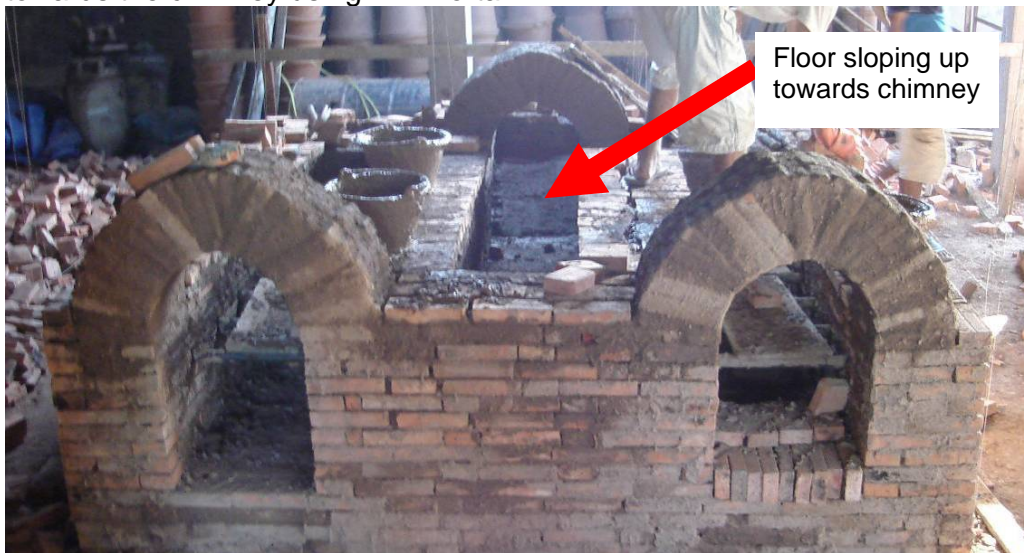


Constructing the Arches

A wooden arch mould is used to guide the construction of arches above the openings to the fire chambers and exhaust chute. Arches are used to support the walls built above the openings.

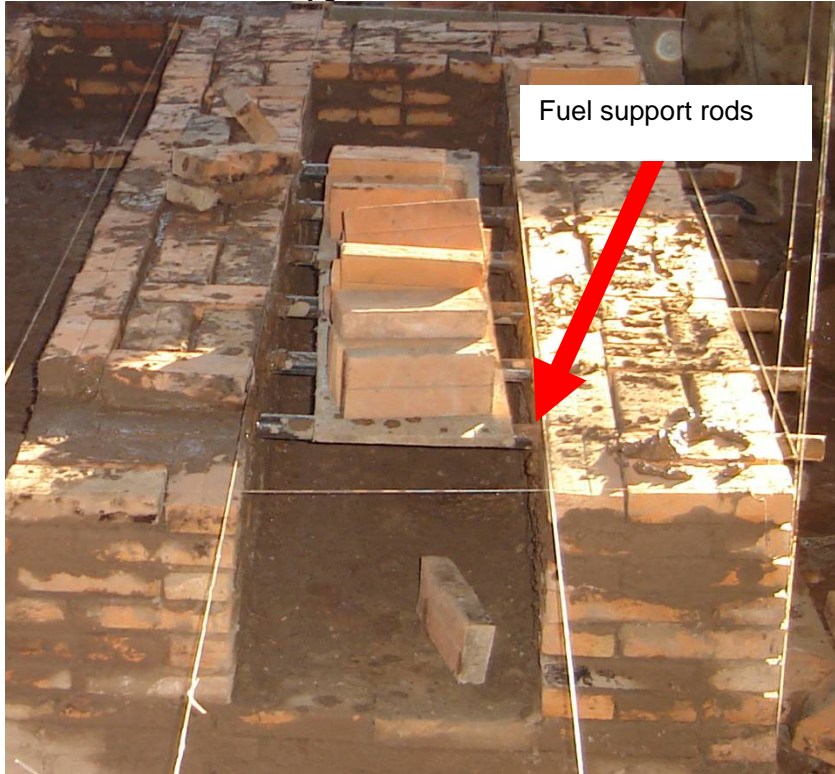


Completed fire box and exhaust box arches are shown. From half way along the length of the exhaust chute, the floor is also gently sloped upwards towards the chimney using kiln mortar.



B. Fuel Support Rods

On the 6th layer of bricks above the foundation, spaces are left between the bricks for the installation of 5 removable fuel support rods. Fuel rods support the kiln fuel to allow oxygen to flow under the fuel and feed the fire.



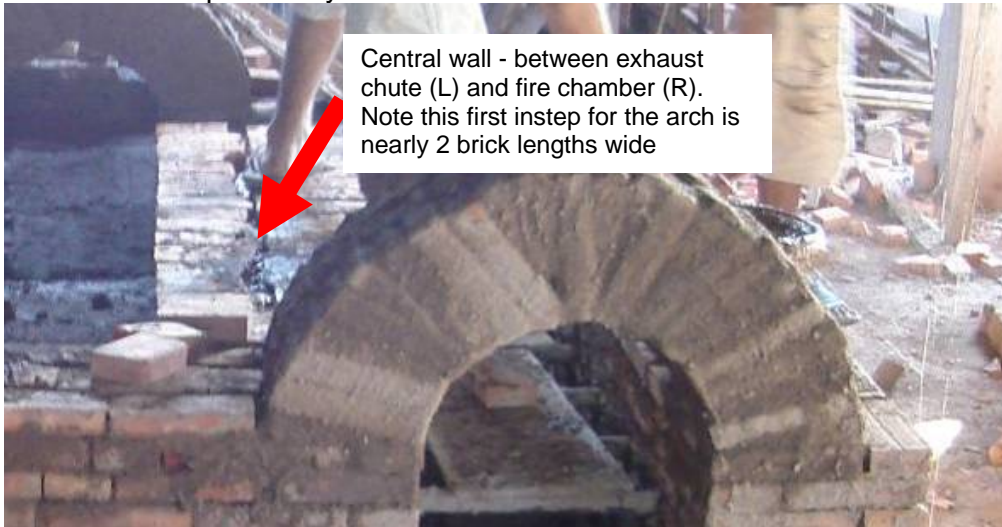
Fuel support rods installed in a completed kiln.



C. Constructing the roof of the fire chambers and exhaust chute

The roof of the fire chambers and the exhaust chute are stepped inwards to form an incomplete arch (top centre remains open slightly to allow kiln modifications in the future). The arches increase the strength of the chamber rooves.

Instep 1: The first three rows of the chamber rooves step inwards only slightly. For the central walls - adjoining the exhaust chute and each of the fire chambers - this is achieved by aligning one row of full length bricks and one row of shortened bricks on top of the central walls (1.5 bricks wide). The side walls instep similarly.



Instep 2: The chamber ceilings arch in further with the next 3 rows. Note the central wall between the central exhaust chute and the two fire chambers is now 2 and a half brick wide. This breadth of wall is also repeated for 2 additional layers.



The remaining openings of the chambers are left open during construction. Large loose bricks are constructed separately and placed over the remaining openings. This allows adjustments to air flow to be moderated at a later time.



Stage 3: Kiln Chamber and Chimney

A. Floor and Walls

Following the completion of the arches, the kiln chamber and chimney walls continue to be built 3 brick widths thick. String lines ensure straight and even walls.



B. Kiln chamber entry door

Kiln chamber entry door under construction:



Kiln chamber entry door in a completed kiln. The arch is constructed similarly to those of the fire chamber openings.



C. Inspection and Thermocouple Holes

Gaps are also formed in the kiln chamber wall (opposite the side with the doorway) for kiln regulation.

An upper hole is one brick wide. It allows inspection of the kiln - including to see the state of pyrometric cones - and can be blocked up with a brick when not in use. A second, smaller, hole allows for the insertion of the thermocouple probe.



D. Chimney construction

Chimney wall construction is conducted in conjunction with the building of the kiln chamber walls. An air intake/inspection hole is left open on the outer wall. Reinforcement bars are inserted through chimney walls at 1/3 and 2/3 the height of the walls providing additional strength to the steel reinforcement frame - further described at E.



E. Steel reinforcing frame

Wall construction is finalised with a steel reinforcing frame for the main furnace structure. Vertical L-shaped beams are attached at each corner of the kiln. To these small L-shaped segments with holes (10mm) drilled in them are attached at 1/3 and 2/3 of the height of the kiln walls. Steel rods are then inserted through the holes and bolted at both ends. Note the angle bar reinforcing beam lying horizontal at the top of the brick work, to be embedded by the roof construction.



Steel reinforcement of kiln chimney.



Stage 4: Arched Kiln Chamber Roof

An arched roof assists in the circulation of hot air within the kiln. A wooden mould is used to guide and support the bricks during construction, and is removed after the bricks are set with mortar. The mould is initially developed to ensure the bricks to be laid over it will fit neatly with its slope and curve. To do this, bricks are taken and laid on the ground in a 'mock' arch. The shape of the 'mock' arch is traced onto several sheets of plywood and cut out. The plywood arches are set up above the kiln chamber, propped by wood supports and a flexible sheet of wood is laid over the top.



Interior bracing during roof construction.



Wooden arches supported inside the kiln with covering of flexible plywood over the top.



Bricks are then placed over the wooden arch and fixed in place with mortar. 2 additional layers of bricks are laid flat and mortared (in alternating patterns) over the top of the initial brick arch.



The roof is then reinforced using steel beams.



Other features

F. Chimney Coverings

RDIC kilns are built within a shed to protect their structure from rain.



G. Interior chimneys in kiln chamber

Interior Chimneys are placed over the end of the fire chamber opening (closest to kiln) while the rest of the length is filled in with the large loose bricks. Use of the chimneys feeds the hot air towards the middle of the kiln to aid circulation (see also Figure 2):



H. Fire chamber doors

Corrugated iron covers are slid over the openings to the fire chambers when in use.

