Woodfire Kiln Building 2007-2008

Honors Project
In fulfillment of the Requirement for
The Esther G. Maynor Honors College
University of North Carolina at Pembroke

By

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Art with a Concentration in Ceramics
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Date: 4/17/08

ABSTRACT

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By
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May 2008

In the Summer of 2007 Stephen Robison and Rachel Oke determined that there was a need for a wood fire kiln in the University of North Carolina at Pembroke Art Department. The reason for this was that the current facilities did not provide students with a well-rounded experience of firing their pottery. Firing ceramics in a wood fired kiln is a time-honored method of firing pieces that date back to the roots of ceramics. Although gas and electric kilns were readily available for firing there were no traditional kilns, such as a wood fire kiln, available for student usage. It was decided that a Train Kiln, developed by John Neely, would be the most efficient design, a budget was settled on and construction was begun in Summer Session II of 2007. Construction was complete in the fall of 2007 and the kiln was cured and fired on November 1st 2007. The UNCP Train Kiln is now available for student usage in the sculpture yard of the UNCP Art Department.

I wish to extend a word of thanks to the University of North Carolina at Pembroke for their financial support, as well as to Jesse Peters who allowed me to carry out this project. Special thanks especially to Stephen Robison for without his ambition, humor, and signature this project never would have made it off the ground. Thank you.

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I. Introduction

Kilns are an essential part of work as a potter. Whether they are electric, gas, dug into a pit, high fire, low fire, built from bricks, one thousand years old, one hundred years old or less than one year old they all lend their own charm and effect to the finished work of a potter. In a way, the choice of kiln for firing is as important as the construction of a piece. At the University of North Carolina at Pembroke the choices for firing methods were limited. The only available kilns were electric or gas. Though these have a character of their own there is nothing to compare to the effect of a more traditional kiln, wood fire. It was important that students today have the opportunity to learn about wood fire kilns as they have a history dating back to the birth of ceramics. Before gas or electricity could fuel a kiln, the only available heat source was wood.

In order to broaden the horizons of future ceramics students at UNCP, I set out to construct a wood fire kiln for use in the Locklear Hall sculpture yard. My advisor, Stephen Robison and I, originally set out to construct an anagama or "Dragon Kiln". This is the most traditional form of wood kiln but requires a complex and exhaustive firing schedule. Learning the intricacies of loading and firing and anagama can take many years to learn. As students generally have two to four years to enjoy access to school facilities it was determined that a more streamlined and student friendly form of wood fire kiln would be more practical. To this end we endeavored to construct a Train Kiln. The Train Kiln was developed by John Neely and has been constructed on thousands of campuses across the United States. Unlike the anagama the Train Kiln sacrifices form for function. Where the anagama is constructed of beautifully undulating chambers. The Train Kiln lives up to its name and resembles a locomotive with its firebox opposite a taller chimney

and a long rectangular chamber in between. The firing schedule is less rigorous, requiring only approximately thirty-six hours of attention. It also consumes less wood than the long firing anagama; a major concern in the already space restricted sculpture yard.

Once it was determined that a Train Kiln was the form to be constructed a class was created for the summer session II semester. Art 499, an independent study course directed towards kiln construction, could be taken as either a one hour or a three hour credit and ran from June 27th through August 1st. eight people enrolled in the course. Meeting two days a week for three hours or more the class was able to complete the majority of construction of the kiln. Stephen Robison, and myself completed the final construction of the UNCP Train Kiln after the start of the fall semester of 2008.

The kiln was fired for the first time on the 1st of November 2007. It took 36 hours of stoking and attention to fire the Train Kiln but the results were worth it. The Train Kiln is now complete and available for ceramics students to use. Now students at the University of North Carolina at Pembroke will have the opportunity to experience what it is like to fire ones work in a wood fire kiln. The effect of wood fire on the surface of pots is unlike any other technique previously available. It will continue to be available for students indefinitely so long as it is treated with the proper care.

II. Construction

In order to construct the Train kiln a location was selected and materials purchased [Table 1].Once materials were purchased and the sculpture yard was selected as location it was time to begin construction. The base of kiln is of the utmost importance. Not only does it have to support the weight of the bricks above it but it must also stand up under the extreme heat of firing. The Train Kiln is typically fired to Cone 10 or 12. Cones are a small cone shaped object made from a mix of glaze and clay that melt at a very specific temperature. Potters use cones to gauge the temperature inside a kiln. When the cone begins to melt it tips forward. Once it tips the kiln is said to have "reached" that cone. Cone 10 is approximately 2300 degrees Fahrenheit. Cone twelve is almost 2500 degrees. One must keep this in mind when constructing the base as normal concrete or asphalt may not be able to withstand the repeated extreme temperatures and may break down in time.

For the base of the UNCP Train Kiln one first had to level the construction site. To do this, the class constructed a frame out of two by fours the exact size of the completed base and filled the frame with self-leveling concrete. Once that was allowed to set the class put down a layer of firebrick. Firebrick is a dense material that is generally used to construct boilers or line fireplaces because of its high refractory properties. Being highly refractory means that a material is able to remain structurally sound at high temperatures and can be heated repeatedly to extreme temperatures without breaking down. It was important to use firebrick in the construction of the kiln because of the high temperature required to fire ceramics. Normal red house brick would not be able to withstand the punishing heat of Cone 12.

Following the solid layer of firebrick was a layer of soft brick with firebrick around the outside edge. Soft brick is a lightweight brick made from diatomaceous material. The diatoms or hollowed shells of dead microscopic sea creatures make the bricks incredibly porous. They are excellent at insulating but crumble easily if hit. For this reason a layer of firebrick was used as facing to ensure that the soft brick would not be broken down by careless treatment in the future. The soft brick served as the insulating layer between the heat of the kiln and concrete beneath. The plans used in construction [Table 3] called for multiple layers of soft bricks but because the budget was limited and soft brick is so expensive the additional layers as well as the majority of soft brick usage in the rest of the plans was eliminated. The soft brick layer that was laid was more than sufficient to insulate the base of the kiln.

After the insulating layer of soft brick was laid another course of firebricks. With this the base was completed. The next step was to begin construction of the walls. To ensure that the kiln was well insulated the walls were two bricks wide. In constructing a kiln it is important to cross brick seams so that as much heat as possible is kept in the kiln. To this end we added several header courses. Header courses are when a brick is laid so that the narrow end is facing outward rather than the long side. The kiln was constructed in layers with each figure on the plans representing a single layer to be place on top of the last. When it was time to construct the throat arch it was determined that a castable material would be the best choice for long-term stability and ease of construction.

Steven Robison and the visiting artist Dan Murphy constructed a mold out of wood in the exact size that we would need. They then fit that mold into the kiln where the

arch was to be placed and made sure it was secure. A castable material was mixed a single bag at a time and taken out to be poured into the mold. Several students tamped the material into place and made sure it was sufficiently compressed with no lingering air bubbles. Once the mold was full it was left to cure.

When the castable material was fully cured it was time to remove the wooden mold. The mold was dismantled and taken out of the kiln piece by piece, leaving the throat arch to stand on its own. Once that was completed it was time to work on the firebox and finish the chimney.

The train kiln design uses a firebox on one end and a chimney on the other to draft heat through the kiln. The wood is loaded into an elevated chamber where it burns and the coals fall through grate bars to build up a coal bed beneath the firebox. This concept is unique for wood burning kilns because it allows the wood to burn from the bottom up, this prevents the wood from choking the kiln and makes for a more stress-free firing process. The flame and heat from the upper fire chamber is drafted down and through the kiln then out of the chimney; the taller the chimney the stronger the draft. For the UNCP train kiln the chimney is more than twice the height of the firebox. This height is more than sufficient for drafting heat.

The plans were followed as closely as possible until the chamber, firebox and chimney were all at the desired height. On the top of the main chamber and on the fire box a sprung arch was used for aesthetic purposes as well as for strength. The opening into the firebox where wood would be loaded was toped with a sprung arch. The fire chamber itself also had an arched roof. The main chamber into which work is loaded also features an arched roof over part of the chamber. This not only serves an aesthetic

purpose but it also ensures that the removable lid over the remainder of the loading chamber is easily removable.

The removable lid was made from corrugated steel and a spun kaolin blanket. Kaolin is the main ingredient in clay and is a highly refractory material. It can be spun into thick blankets that function as an insulation material. The corrugated steel was welded to an angled steel frame in an arch roughly the same rise as the arch over the loading chamber. The kaolin blanket was attached with buttons made from fire clay and wire salvaged from an electric kiln coil. Fire clay is a type of clay body that is highly refractory and can withstand repeated heating and cooling.

Each layer of blanket was attached separately one on top of the other. A single layer was laid on the corrugated steel and wire was passed through the two holes in the fire clay buttons then secured on the back of the lid. This was repeated for each subsequent layer until there was sufficient insulation on the lid.

Before the kiln could be fired it required a steel exoskeleton to ensure maximum stability. A frame was welded around the kiln, fire box, and chimney with room for the kiln expanding as it is fired. A track was then added to the top and bottom of the firebox so that a door to the fire chamber and the lower chamber could be put on pulley wheels and run along the track. This ensured that the heavy steel and soft brick doors could be moved back and forth with ease.

III. Usage

The Kiln was completed in the fall semester of 2007 was fired on November 1st. Firing began at approximately 12:00 in the afternoon on the 1st and continued into the night of the 2nd. Shifts were divided between Stephen Robison and myself so that one could rest while the other tended the kiln. To start the kiln a small fire is build in the lower chamber of the firebox. This is referred to as candling the kiln. It allows the heat in the kiln to build gradually and removes any remaining moisture from the kiln. After several hours the fire is moved to the upper firebox. From this point on the goal is keep the temperature building steadily at about 100 degrees an hour. The kiln log for the first firing is as follows in [Table 1]. The log references a tool called a Cone pack. This is a wad of clay with Cones inserted into it and left to dry. When a kiln is fired the Cone pack is placed in special areas of the kiln called Peeps. Here a brick is left removable so that during a firing the kiln attendant can remove the brick and see which Cones are down. Because each number Cone melts at a predictable temperature Cone packs are used to check the status of the kiln. Once the target cone is down, in this case Cone 12, the kiln has been "fired off" and can be closed and let cool. The kiln is closed at the completion of the firing to keep the work from re-oxidizing.

During the firing the ash from the wood drifts through the kiln and lands on the pieces. Because of the extreme heat inside the kiln the ash melts and turns to glass. Because of this it is unnecessary to glaze the outside of any piece fired in a wood kiln. The wood itself provides the glaze material. The colors and variations in the ash glaze depend on where the wood was grown, what type, etc. The kiln is fired in a primarily reduction atmosphere. When wood is added to the kiln the fire is not allowed enough oxygen from the outside so it takes the oxygen molecules from the work inside the kiln.

This turns the ash glaze a deeper reddish color. Oxidized glaze is pasty in color and not as attractive as a glaze that has gone through reduction. Because of this the kiln must be sealed to prevent oxygen from entering the kiln and reoxidizing the work.

After the kiln is fired and sealed it is allowed to cool for several days. Once cool enough the lid can be removed and work unloaded. The results are always a source of excitement.

Appendix A: Tables

[Table 1] Budget

Description	Estimated Number	Approximate Cost
Cinder Block Splits	55 at $1.12 a piece	$61.60
Shipping of Brick	Local Delivery	$75.00
High Density Firebrick	1500 at $3.35	$5025.00
Castable	10 57lb bags at $31.35	$313.50
Steel: Angle iron, channel iron, expanded mesh	2"x2"x1/4" angle ($1.62) 4" channel ($2.94 per ft) ½" expanded mesh ($1.83 sq. ft)	$516.60
Ceramic fiber blanker	50 sq feet at $53.00	$216.00
Misc. Materials: lumber, concrete, sand, fireclay		$200.00
Total		$6407.7

[Table 2] Firing Log

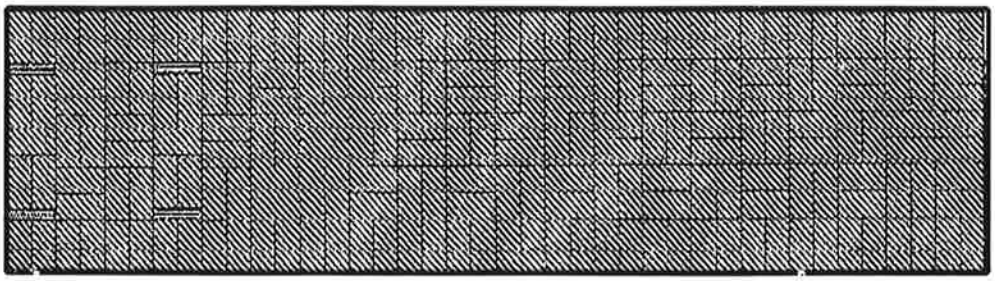
T8ty Woodfire Kiln Firing
Date: November 1st 2007
Of Cone Packs__3_ Cones used 010 4 6 9 10 11 12
Extra: 10 12

Time 12:45	Temperature Fire in bottom box	Notes
3:00 4:00 5:00 6:00 7:00	500 700 800 1000 1100	Apx. 100 degrees an hour climb. Fire still in bottom box.
8:00 9:00 10:00 11:00 12:00	1100-1200 1300 1450 1600 1650	Transition fire to the top box. Five hours into firing. If temperature drops, that's normal.
1:00 2:00 3:00 4:00	1700 1800 2000	Continue at 100 degrees an hour. At 2000 begin backstoking every five minutes. Front cone pack, 010 down
5:00	1900-2100	Cone 9 bending in front pack
6:00	Holding at 2100-2200	Back cone pack, cone 6 is going down.
7:00 10:00		Holding at cone 10 front, cone 6 down in back with 9 tipping. Front 10 down, 12 tipping, back 9 almost down, 10 tipping. Side stoke every 5 min.

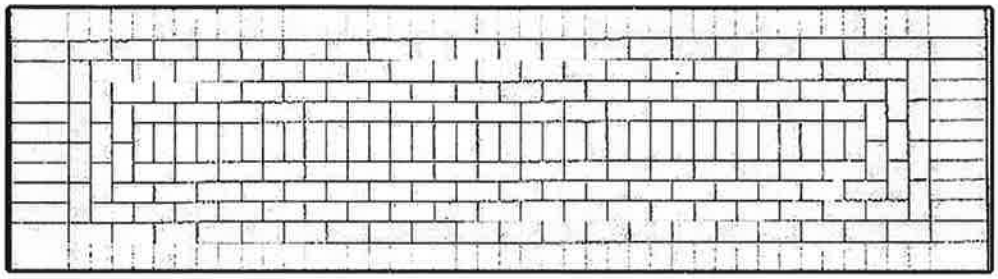
Time 12:00	Temperature	Notes Cone 9 still almost down in back
2:30		Cone 9 down in back
3:30		Front, cone 11 curling backwards against flame, back 10 bending back with flame.
4:00		Cone 11 in front flat, 12 tipping. Cone 10 and 11 down in back pack
5:00		
8:00		Cone 12 in front and back flat. Clamed kiln. (Use slop and newpaper around all dampers.) Close chimney damper.
		Note: Continue side stoking throughout. Leave open side stoke with wood to bring up temp in back.

Layer One: Self Leveling Concrete

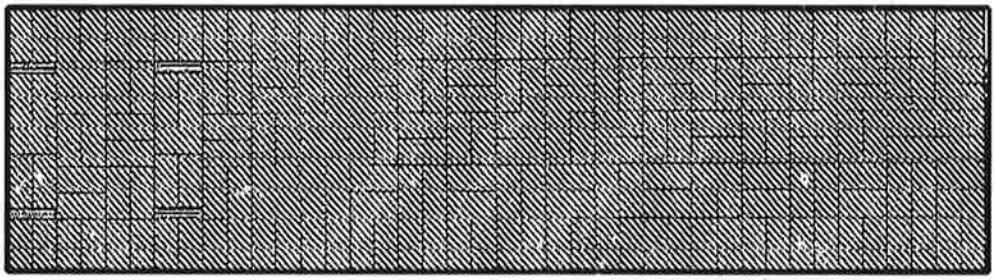
Level 2: Fire Brick in pattern below



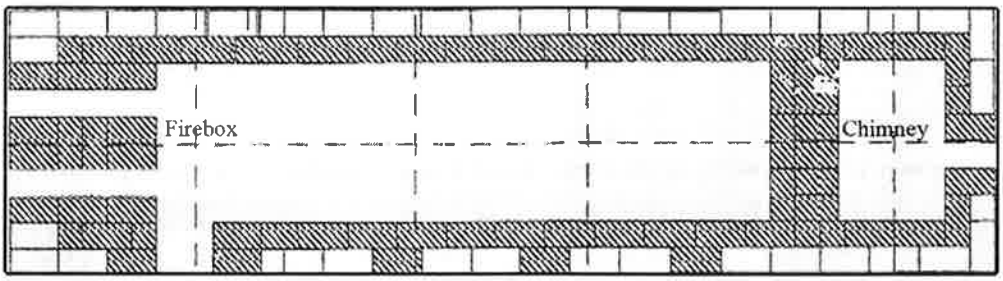
Level 3: Soft Brick add fire brick around the edge for added durability



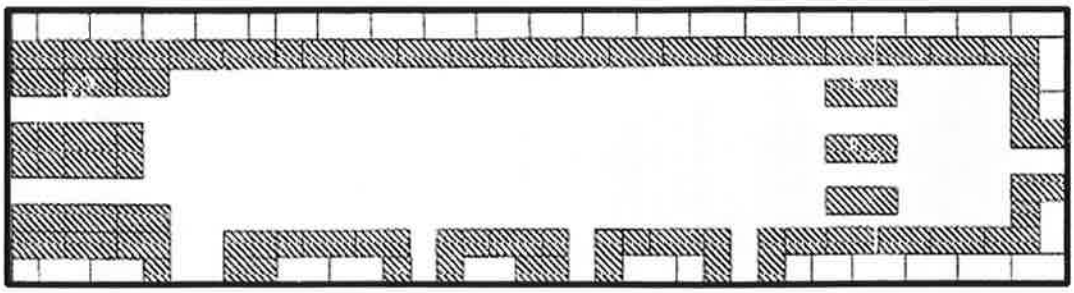
Level 4: Repeat hard brick layer



Level 5: Begin wall construction

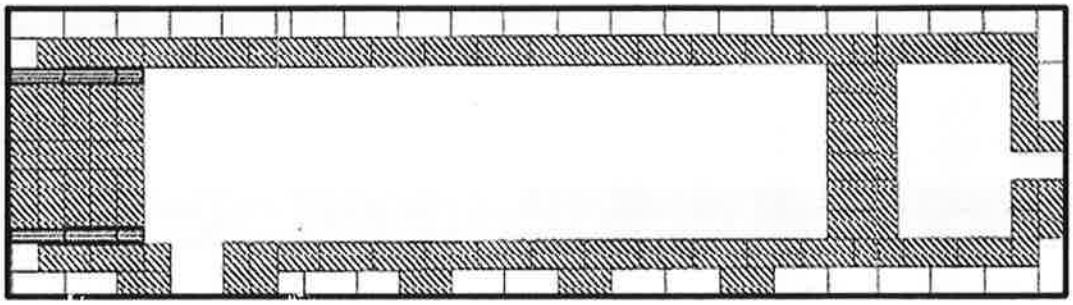


Level 6: Walls Continued



Kiln Peeps * * *

Level 7



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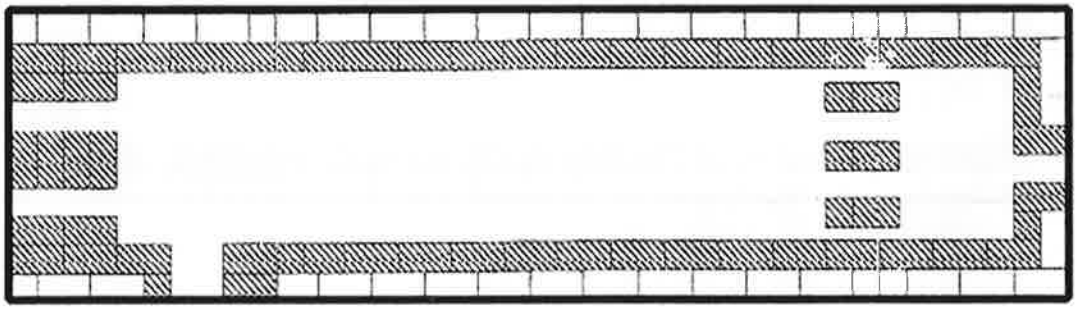

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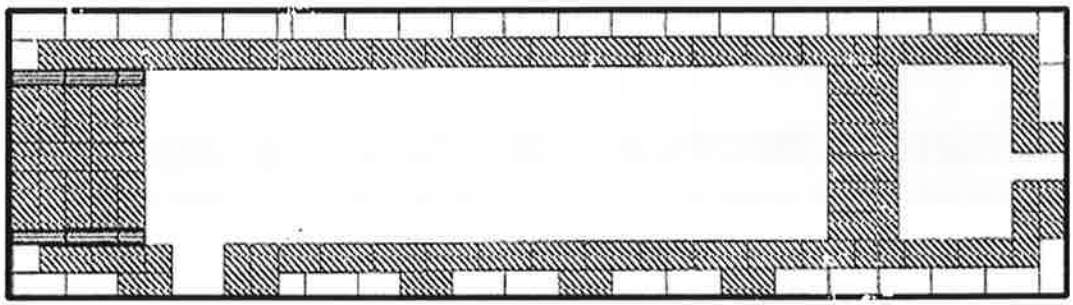
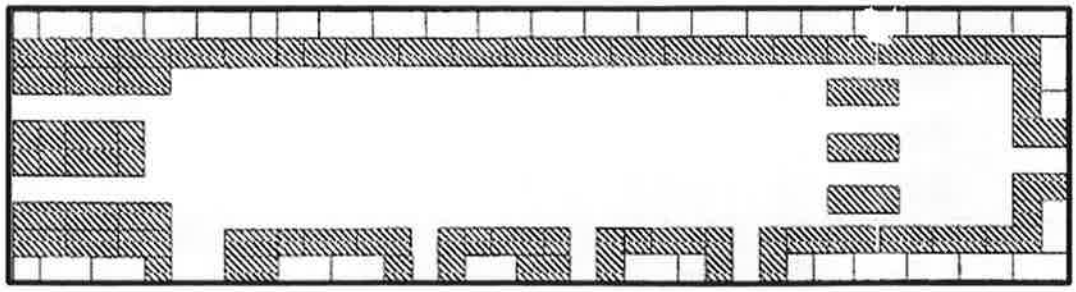


Level 10:Walls Continued



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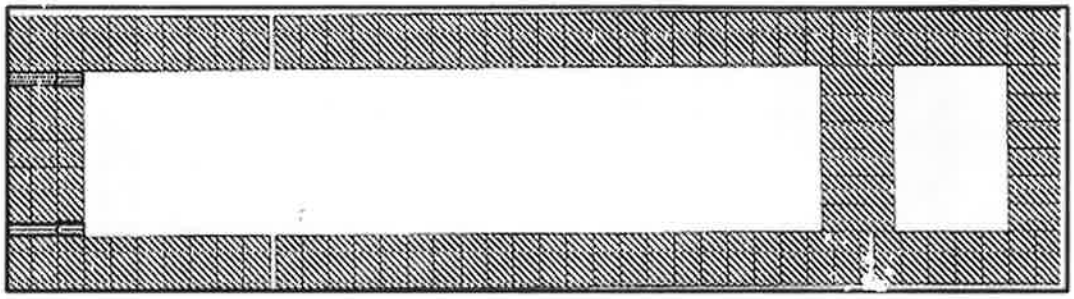

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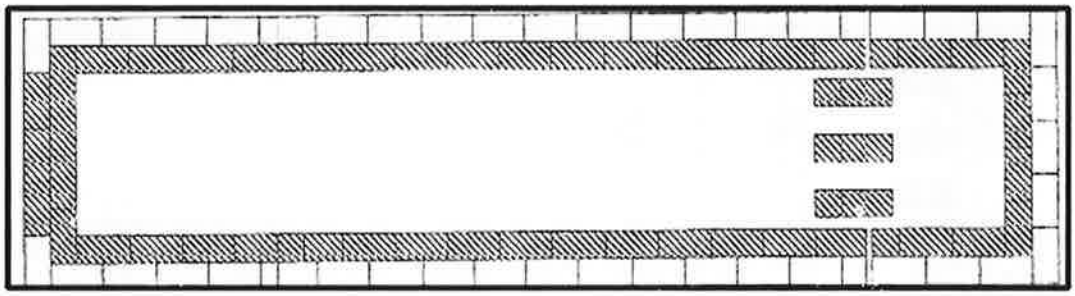

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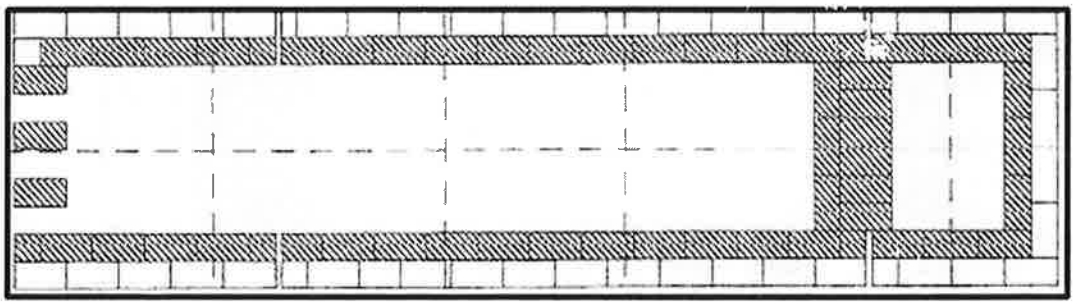

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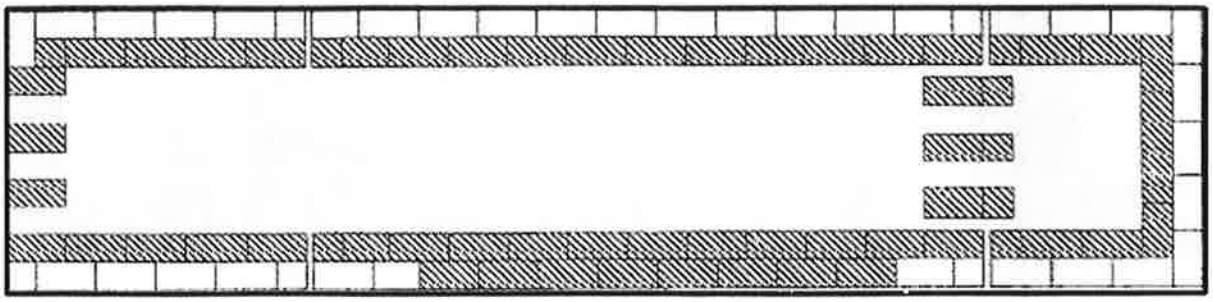

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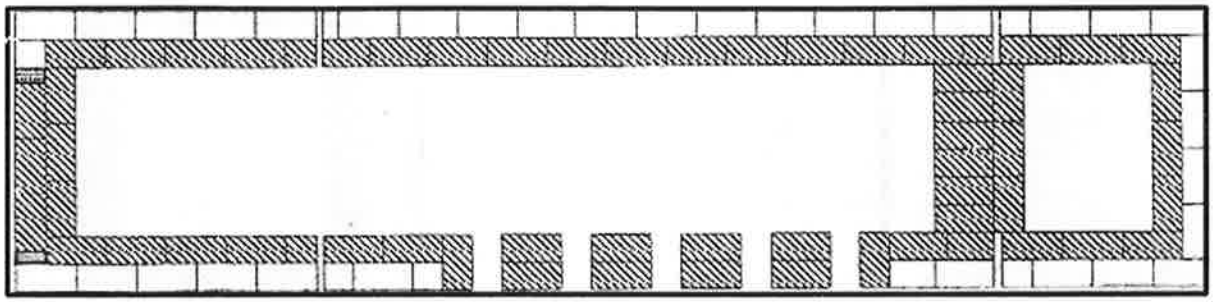

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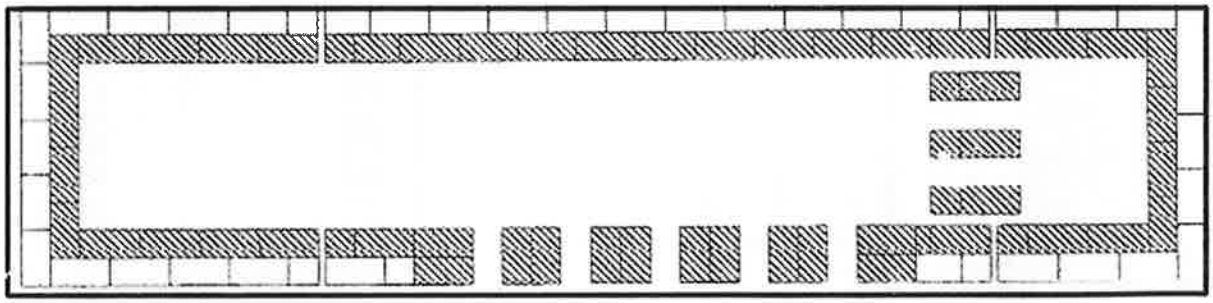

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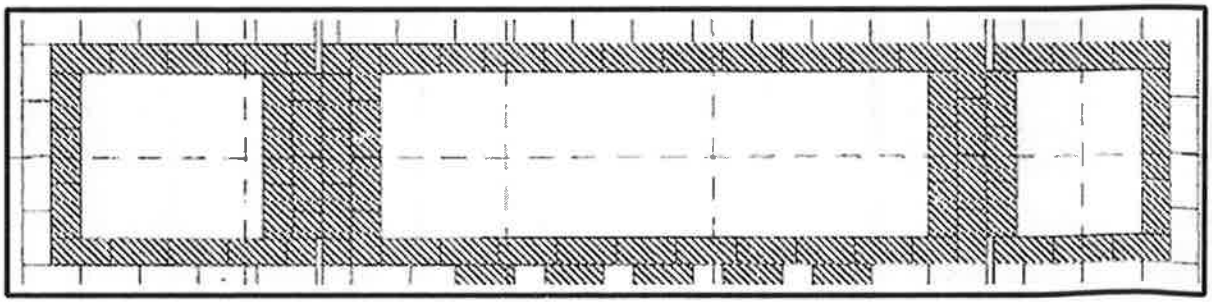

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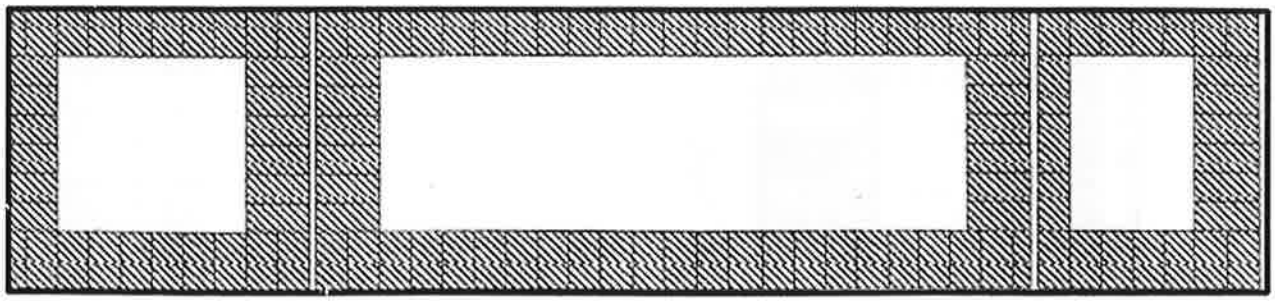

Firebox

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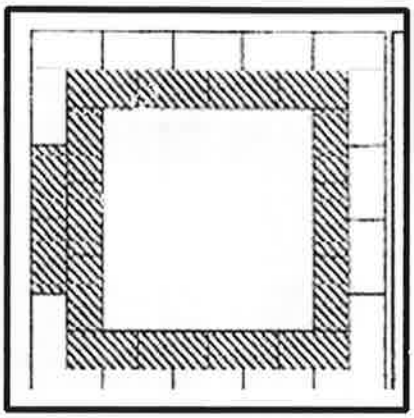

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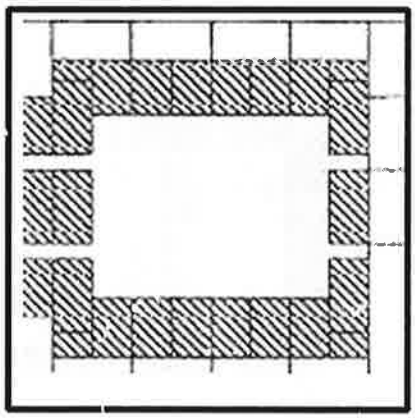

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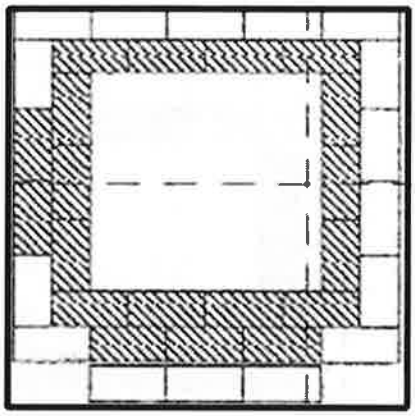

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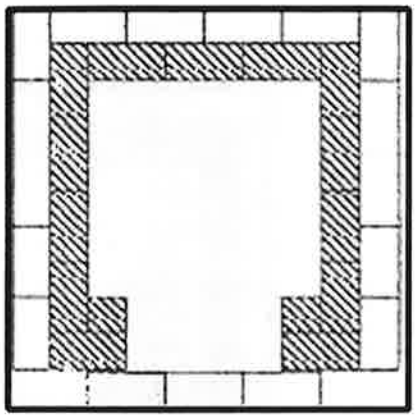

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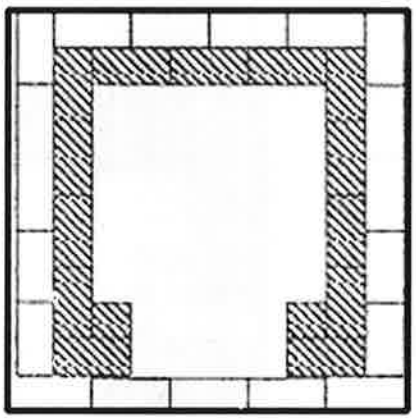

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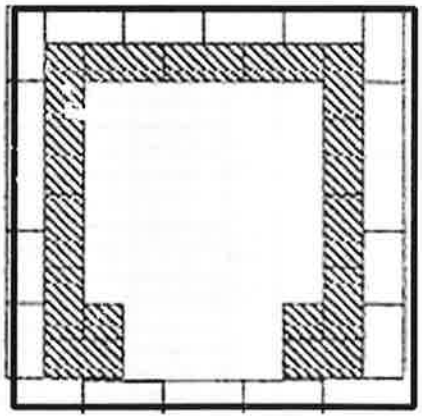

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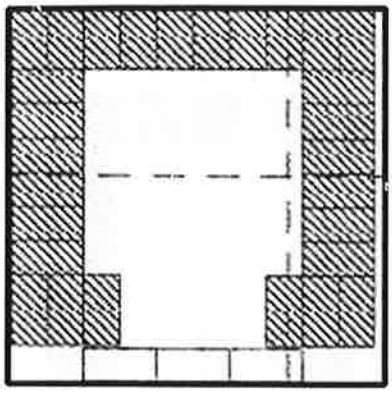

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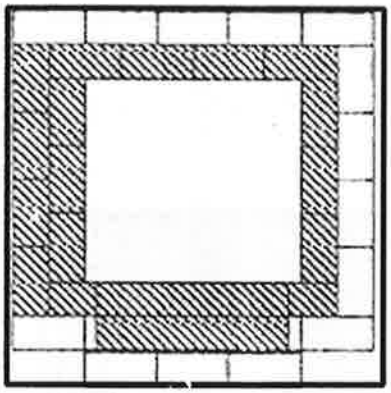

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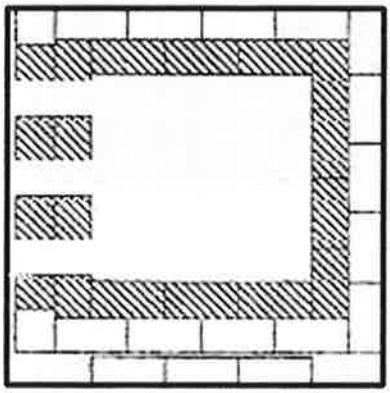

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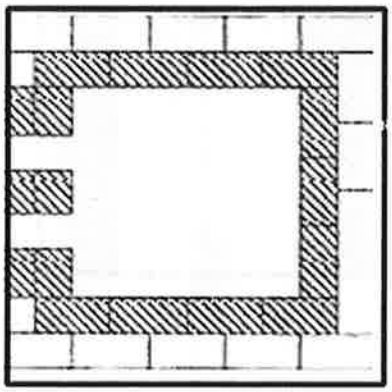

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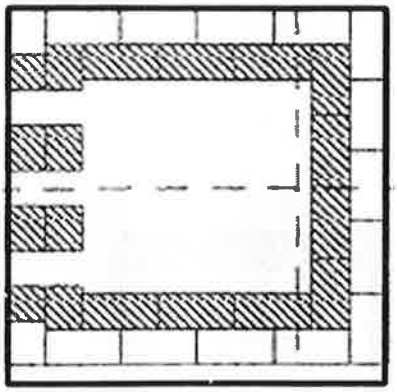

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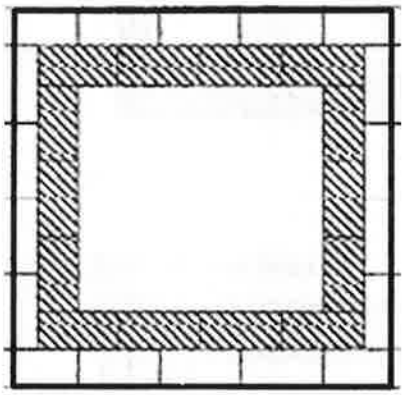

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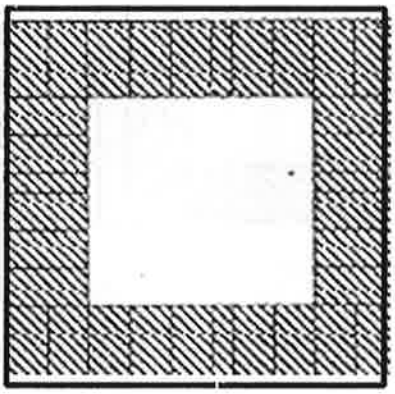

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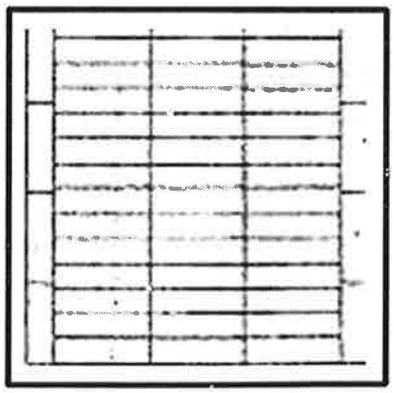
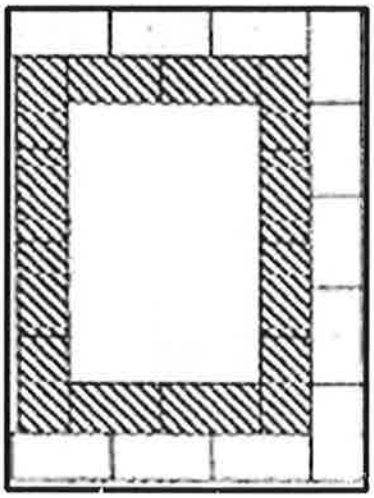
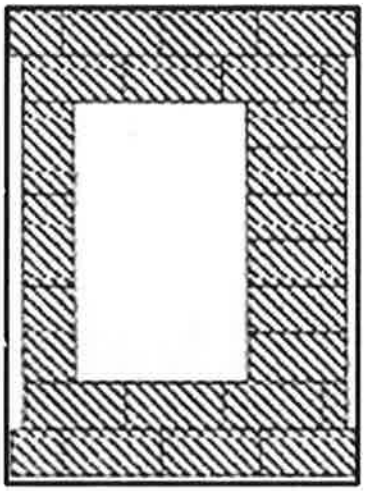


Sprung arch roof on Firebox

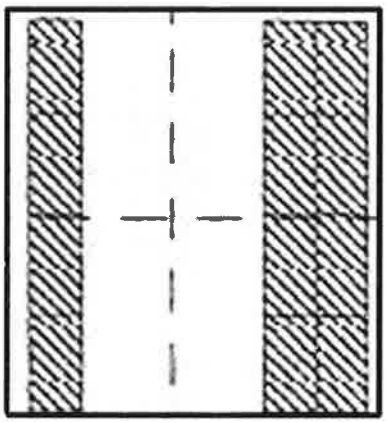
1. Chimney



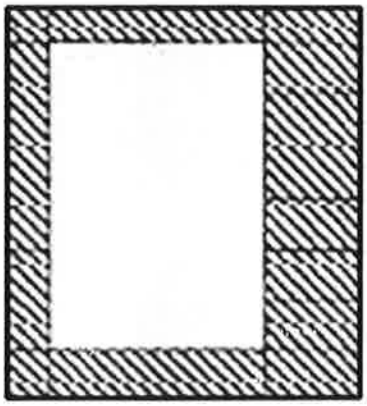
2.



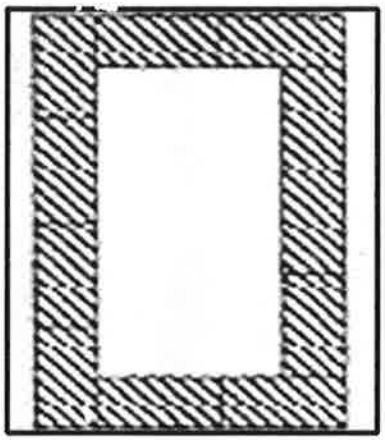
3.



4.



5. Until desired height



In Plans, stripes indicate firebrick, white represents soft brick.

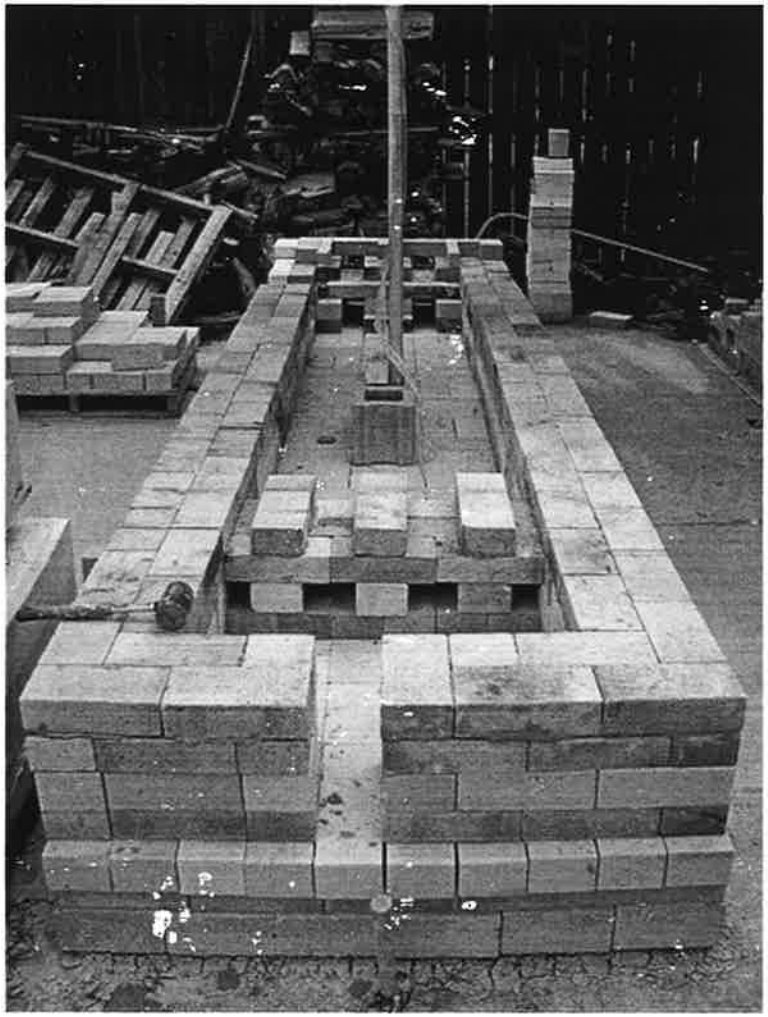
Appendix B: Images

1.The foundation is laid. The class posed behind the mold.

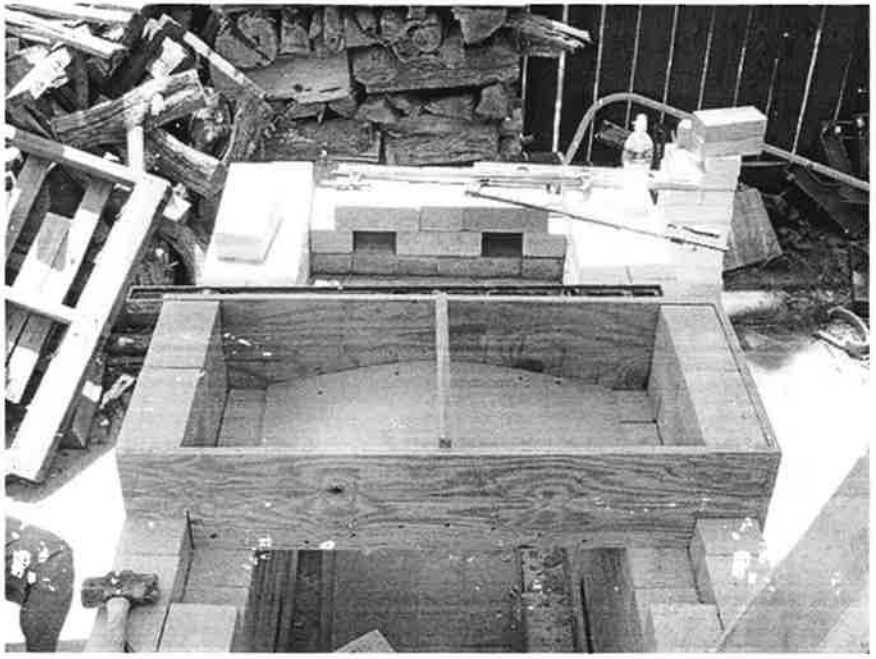
2.Laying the first layer of soft brick.

3. The first layer of firebrick on top of which the soft brick is laid.

4. The walls begin. Two rows of firebrick shown on this layer.



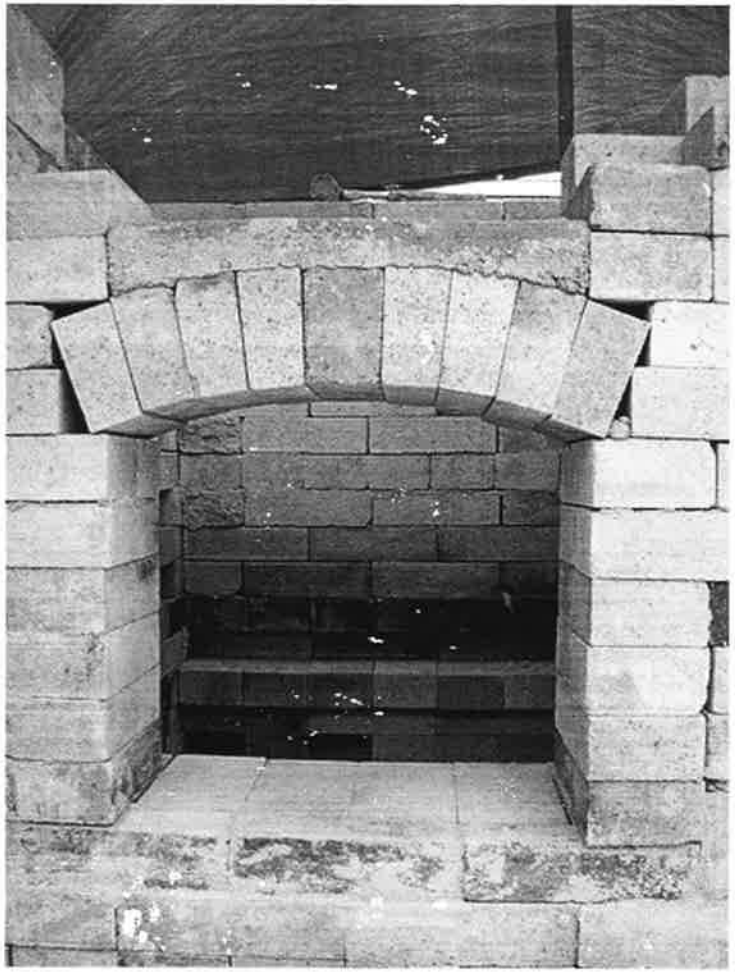
5. Firebox (above) and the chimney (below) begin to take shape.



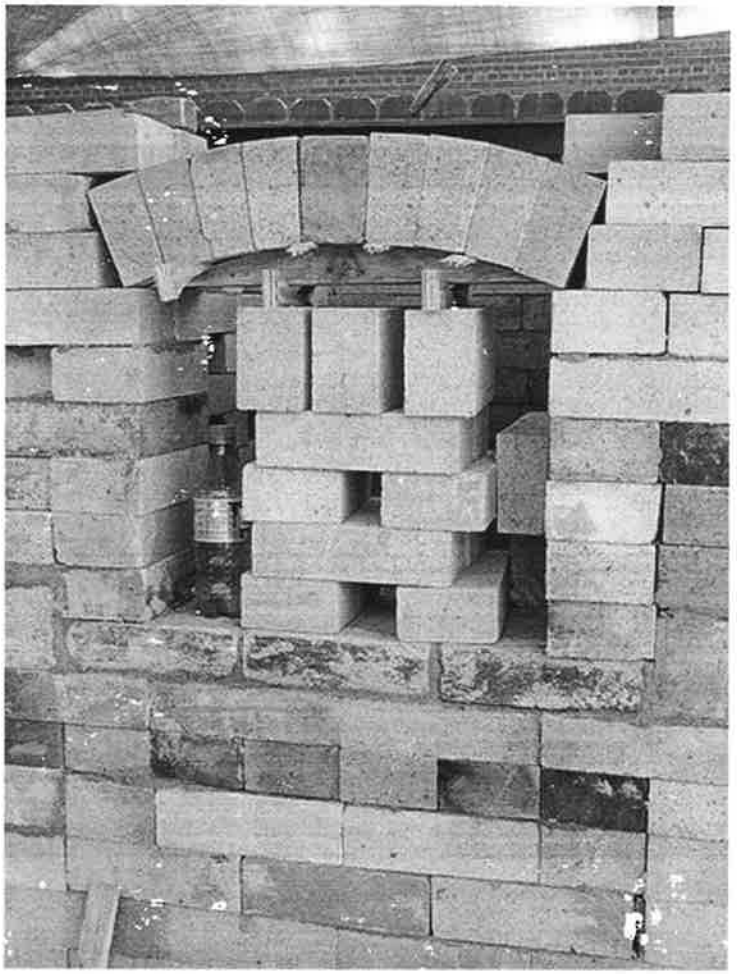
6. The mold is laid in the kiln for the throat arch

7. Castable is poured into the mold and tamped down.

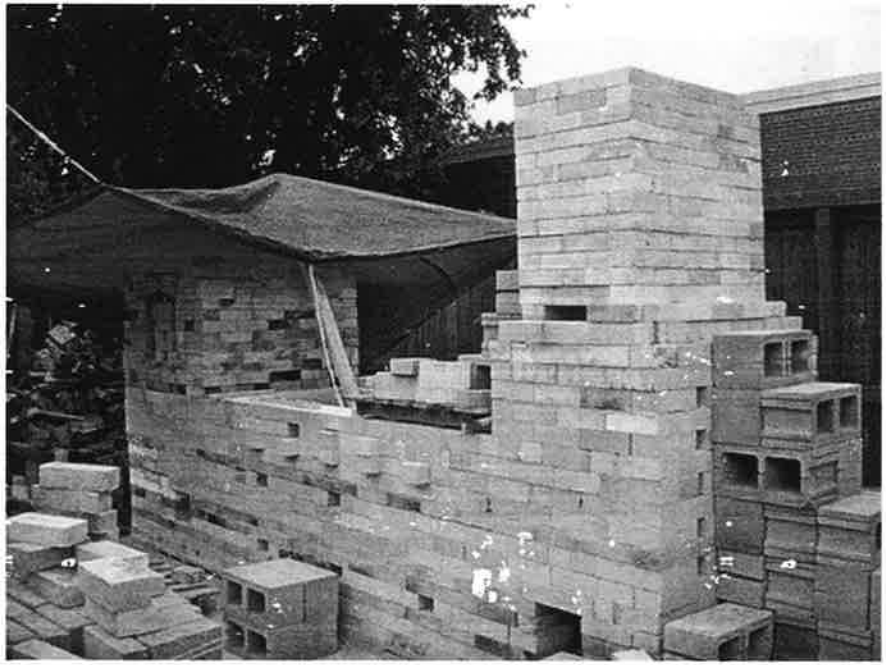
8. Once cured the mold for the castable is dismantled and removed



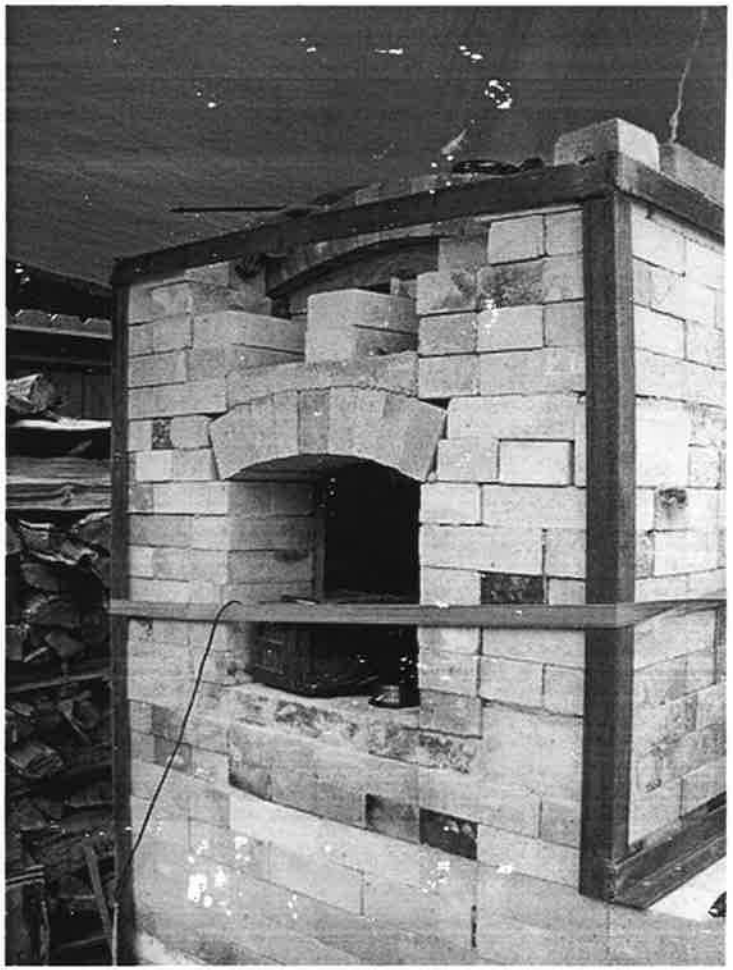
9. The sprung arch over the opening into the firebox through which wood will be loaded



10. The sprung arch placed on the removable mold to support it until it can be buttressed

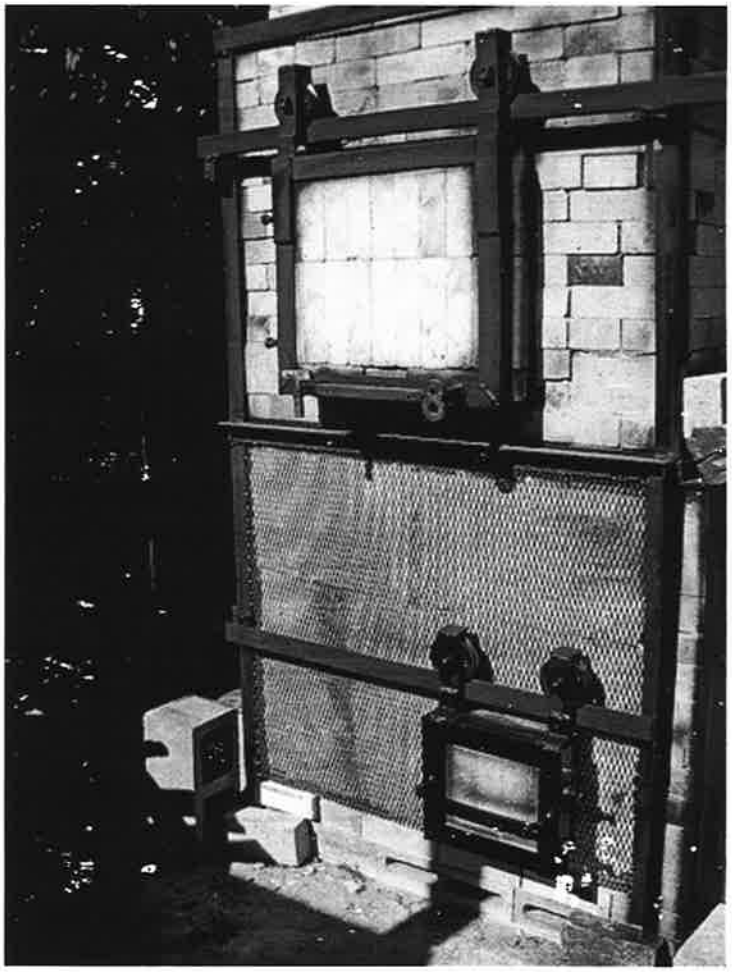


11. The kiln is partially completed and waiting for its steel exoskeleton

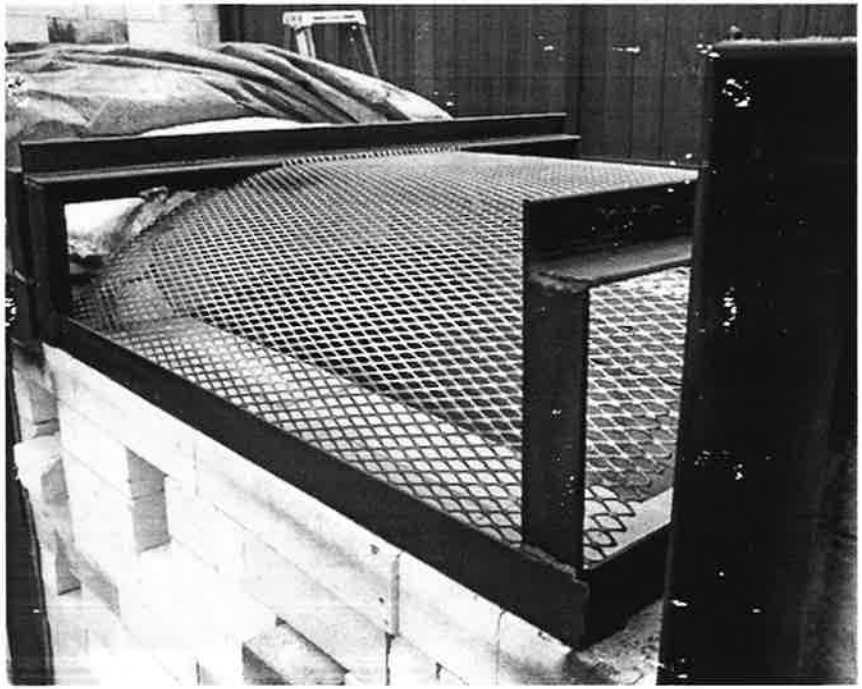


12. The steel frame is braced against the kiln before welding

13. The arch is laid over half of the loading chamber with kaolin insulation over top



14. The upper and lower firebox doors are welded and loaded on angle steel tracks

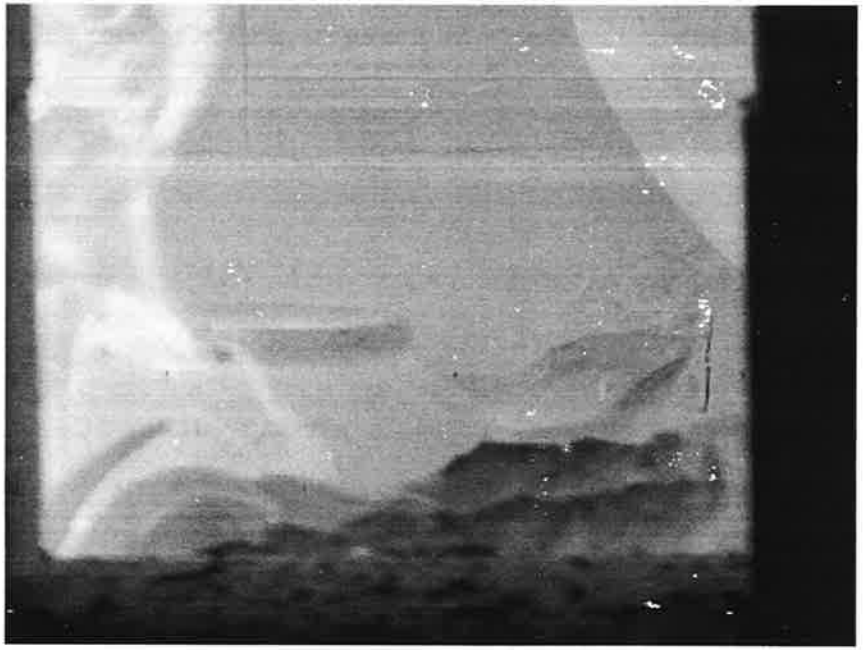


15. The expanded steel lid with handles before the insulation was stitched on

16. The completed kiln, ready to be fired

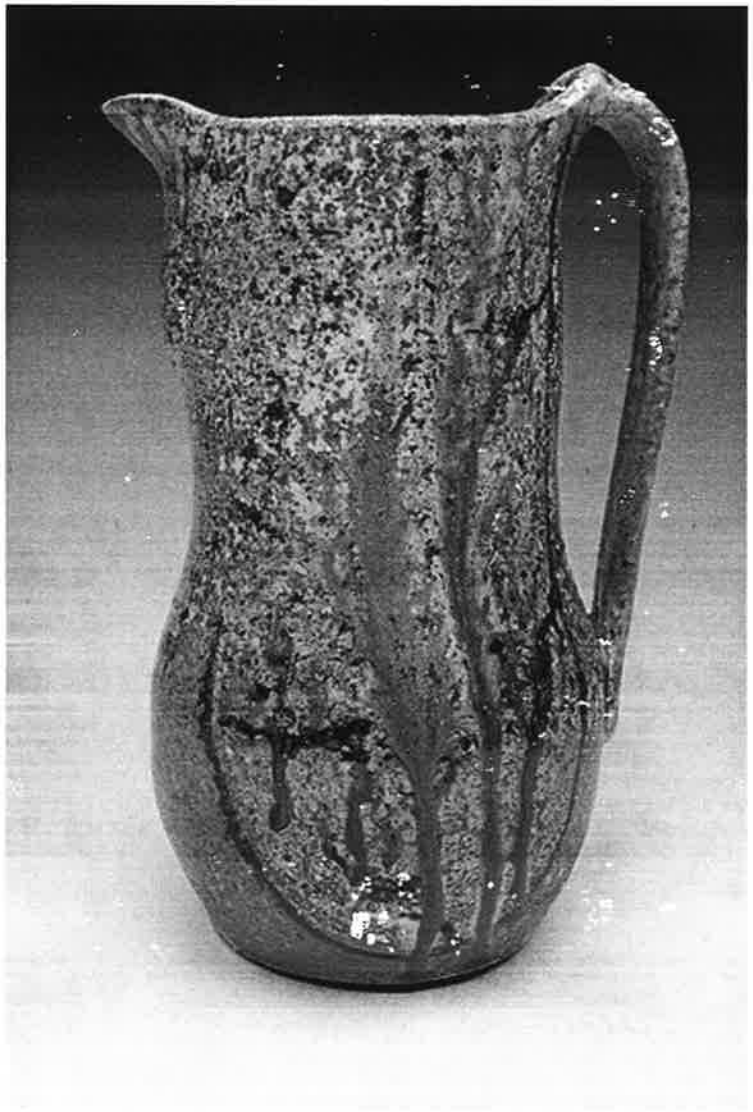
17. The work ready to be loaded

18. Work loaded at the front of the kiln beneath the throat arch. Work loaded here will receive the most punishment from the fire



19. A view inside the kiln while it is being fired

20. The work after it has been fired. All the glaze is from the ashe



Pitchers from the first firing thrown by Stephen Robison

Pictures taken by Stephen Robison used with permission by Rachel Oke for the purpose of this thesis.

References

References

Robison, Steve. Personal Interview. 27 Jun 2007- 15 Mar 2008.