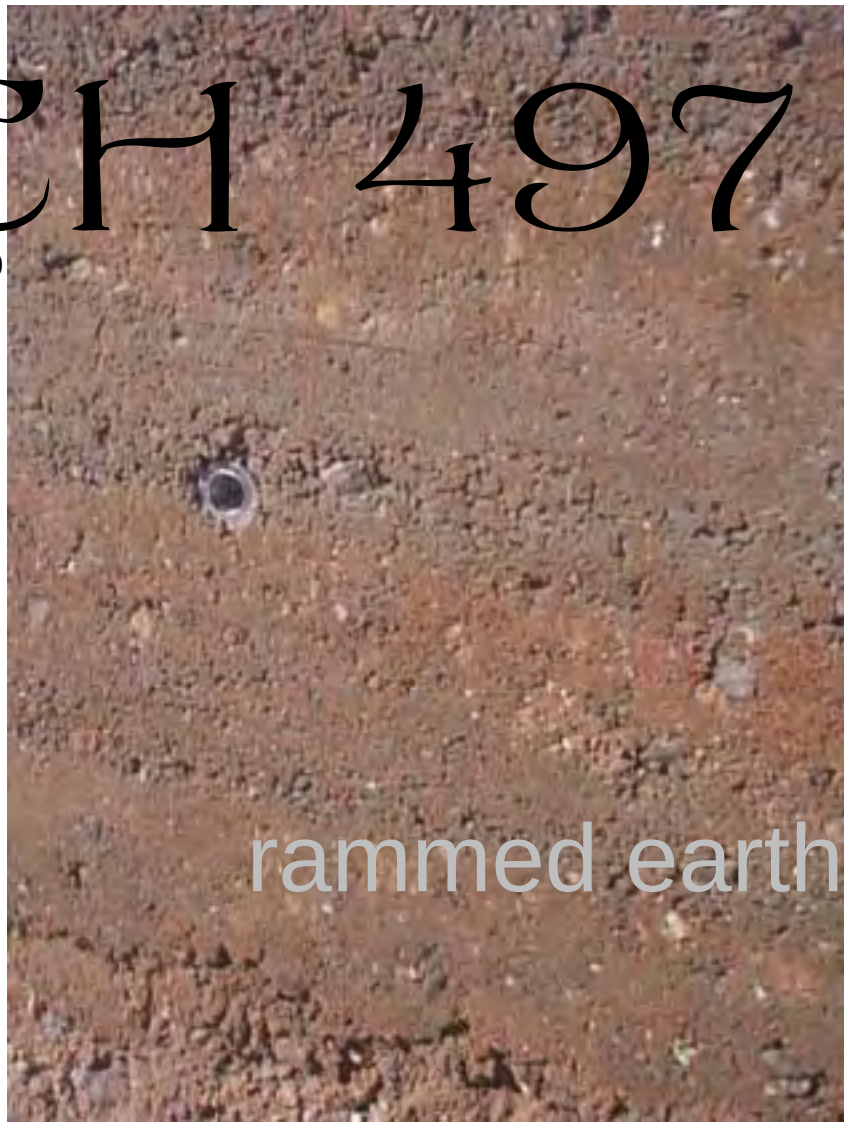
ARCH 497

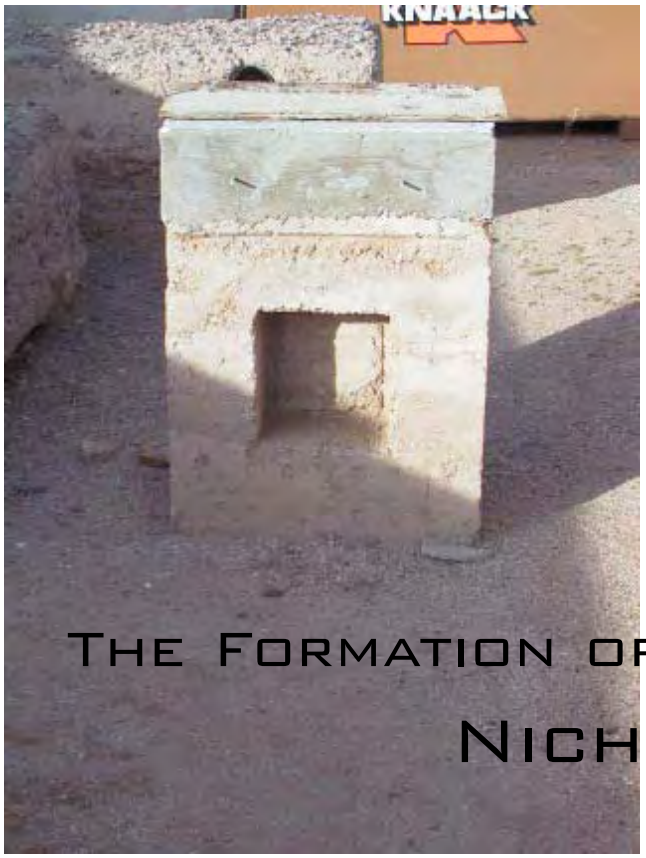
Construction Laboratory, Fall 2000



To discover special shapes, bevels, chamfers and revials that can be achieved in the rammed earth

This project entails building small forms (24”x12”x24” perhaps) and experimenting with how subtracitons can be made in the surface of rammed earth. Issues will be the angle of repose posible, the tolerance for sharp edges, complexity of shapes, the sequence and difficulty of removing forms.

VOIDS



The Formation of Voids and Niches in Ramed Earth

Prof. Mary Hardin

Arch 497

Fall 2000

Group: Alicia Barnes
Julia Nugroho
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Goals for experimentation:

* Attempt a Horizontal niche to help with the placement of the bond beam
* Form vertical Niches to be used for aesthetics
* Experiment with the forms in order to create a void in the wall to be used as a shelf

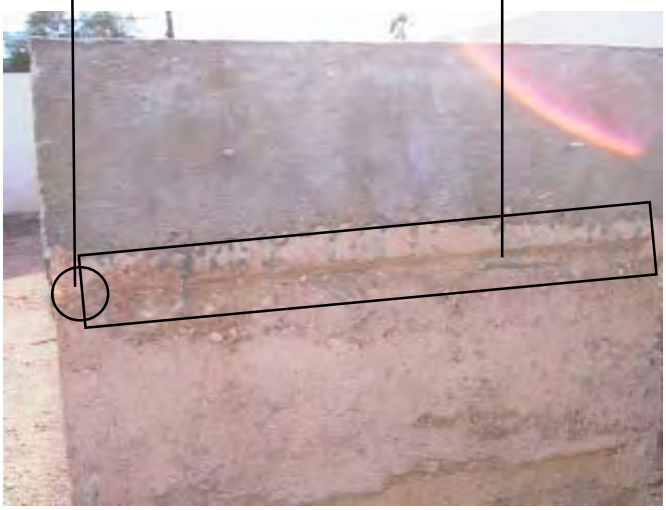
Horizontal Voids

Our first attempts were with PVC pipe 3-4 inches in diameter. We cut them in half and screwed them to the form work. The first trial we tamped was not very successful. We placed both horizontal and vertical pieces. Our earth mixture was a little dry which is why we think there was so much crumbling after it dried. It was also diffucult for us to determine how much we should tamp. All of our trials were done by hand tamping. The Vertical PVC voids turned out better due to the ability to tamp around the form. We found it difficult to avoid tamping, thus deforming, the horizontal pieces.

Vertical PVC

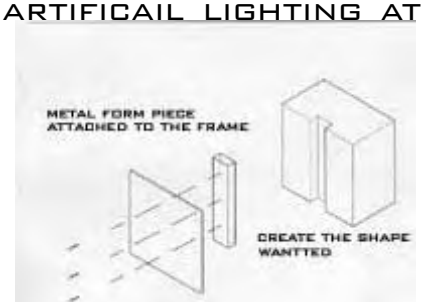
Horizontal PVC

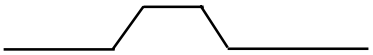
We decided an angled metal bar would work better for registering the bond beam guide. We tried it on a small test piece and it worked well. We also used snap ties to help hold the concrete form work together.



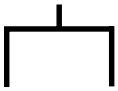
Vertical voids

The vertical voids we attempted were all formed with steel and motor oil was used as the form release. They both turned out well yet there is great possiblities for crumbling at the corners. a chamfered edge would most likely work better and still provide close to the same aesthitics. We thought that a vertical niche could be incorporated into a facade providing an intresting lighting affect with shadows during the day and artificail lighting at night.





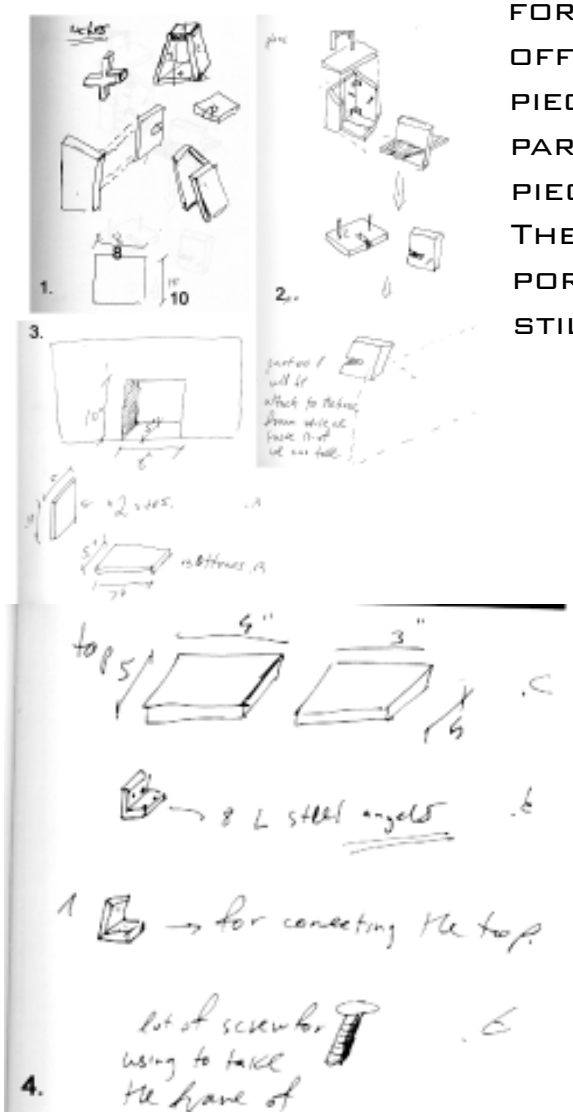
chamfered edge plan

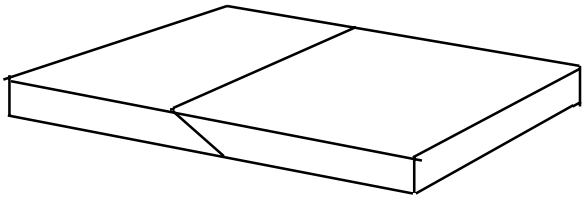


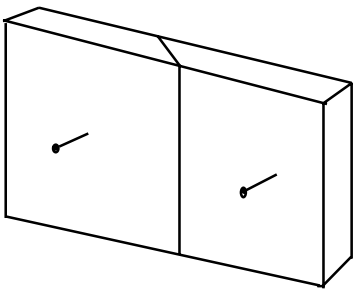
plan view of niche form work

Shelf Void

The thickness of the rammed earth wall allows for some experimentation within that depth. There is a lot of planning involved with putting in a void becuase the intensity of tamping and the suction of the wet earth makes it difficult to remove the form after tamping, although the result is very rewarding. first, we designed the form of the niche by creating a box that could be dismantled after the earth is tamped. the box was 10" X 8" X 5" cube. Next, the box needed to be attached to the form in order to hold it in place. to support the box, we screwed l steel angle in the inside of the box so it could take the load of the tammping. finally, the process of the disassembling the box was; we took of the vertical pieces (the top part then the bottom part) by pulling the hooks we screwed in just for this reason. after that, we took off the horizontal parts, the top piece of the box and then the bottom part. Note that the joints of the top piece are not butt joints, but mitred. The idea is that the angle would support the vertical load and could still slide when disassembled.







Conclusion

after experimenting with two walls intended for trials of creating shapes, we learn that we needed to have a better mix of earth or possibly more water.
the first wall was a good trial to create vertical shapes. Yet, the second wall was not as successful. It turned out that horizontal shapes cannot be placed layered because of the difficulties of tamping the in-between spaces. The mix was still not wet enough in the second trial because after a week of drying the earth started to chip off very easily.
As a result, we put more thought into our third trial and it was a good product. We managed to make the niche and it took little time to dismantle the form. The vertical shape created on the side of the wall came out very nice with clean edges, created by a more simple rectangular metal form. We also used the horizontal channel for a bond beam trial.

final test

To determine pigment additives that will achieve desired colors for earth walls

This project involves experimentation with colors that can be achieved in rammed earth mixtures and also how various color layers can be compacted for particular visual effects. Small forms (12”x12”x12”) will be necessary to allow many iterations of the mixing and tamping process

COLOR

Rammed Earth Pigment Study
Jen Leach
Alisa Brockman
Lisa Bahti
Jeffrey Lavy

Sept. 12
Test Block (no pigment)
120# soil
5.2# cement (4%)

Oct. 3
120# soil
5#, 3 oz. cement (4%)
18 c. water
2 oz. kahlua pigment

Oct. 24
129# soil
7#, 2 oz. Cement (6%)
2 oz. kahlua pigment

Nov. 6
129# soil
7#, 8 oz. cement (6%)
4.8 oz. terra cotta pigment

129# soil
7#, 8 oz. cement (6%)
2 packets of ice blue raspberry lemonade

Nov. 7
80# soil
5#, 3 oz. cement (6%)
Gradation:
One block each (kahlua & terra cotta).
First layer=no pigment
½oz. pigment added to each subsequent layer (6 layers total=2.5 oz total)

Kahlua gradation

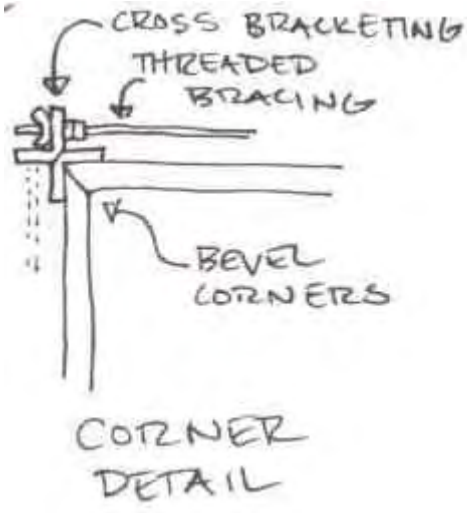
Remaining soil layered together.

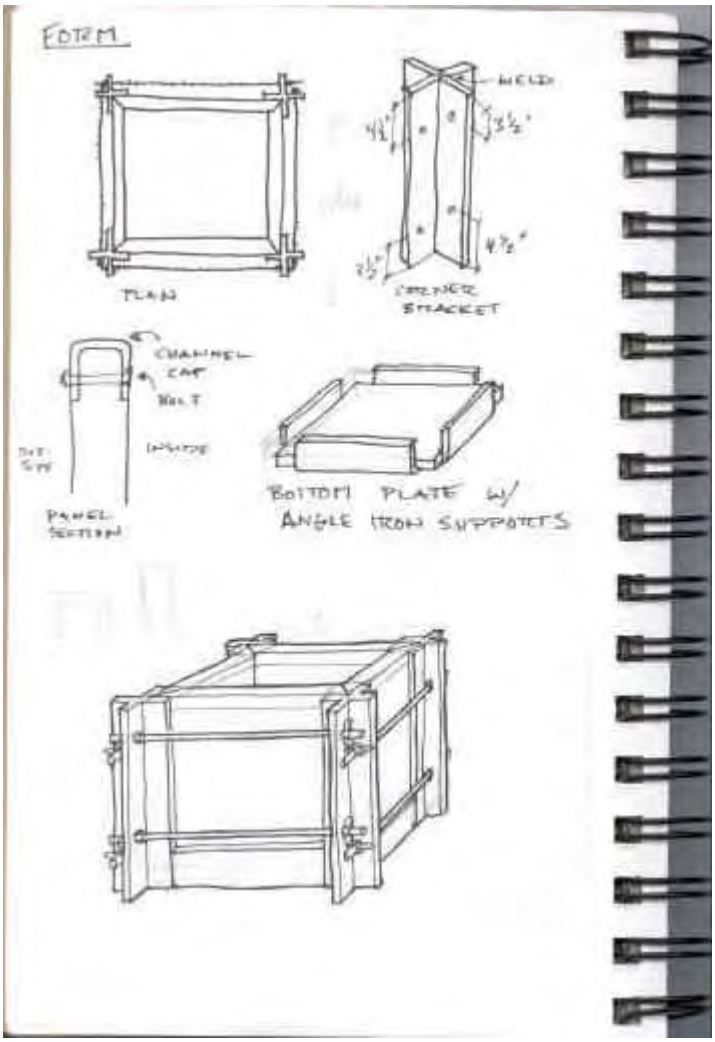
Nov. 16
Attempt to match site sample
80# soil
5#, 3 oz. cement (6%)
4 oz. terra cotta
3 oz. kahlua

Site Sample

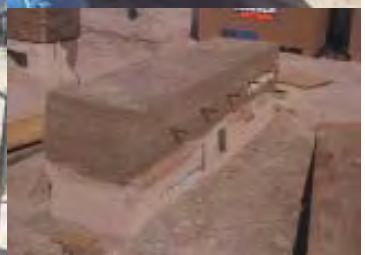
Conclusion:
General preference is for the test samples with higher levels of pigment. However, since this is a low-income project the limiting factor for the amount of pigment used will be the allotted budget. The site material has a predominately reddish color to it lending it towards the terra cotta pigment, but the kahlua seems to tone down the brightness of the terra cotta.

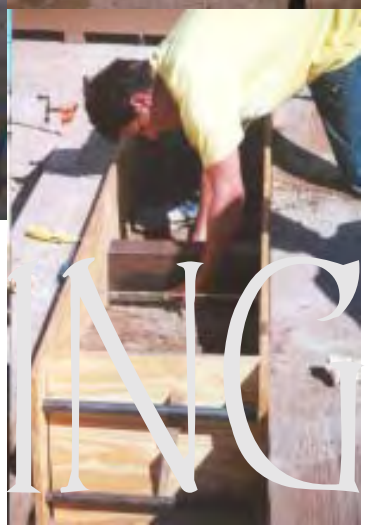
Note:
A one cubic foot form was designed in order to create multiple trials of various pigment proportions.





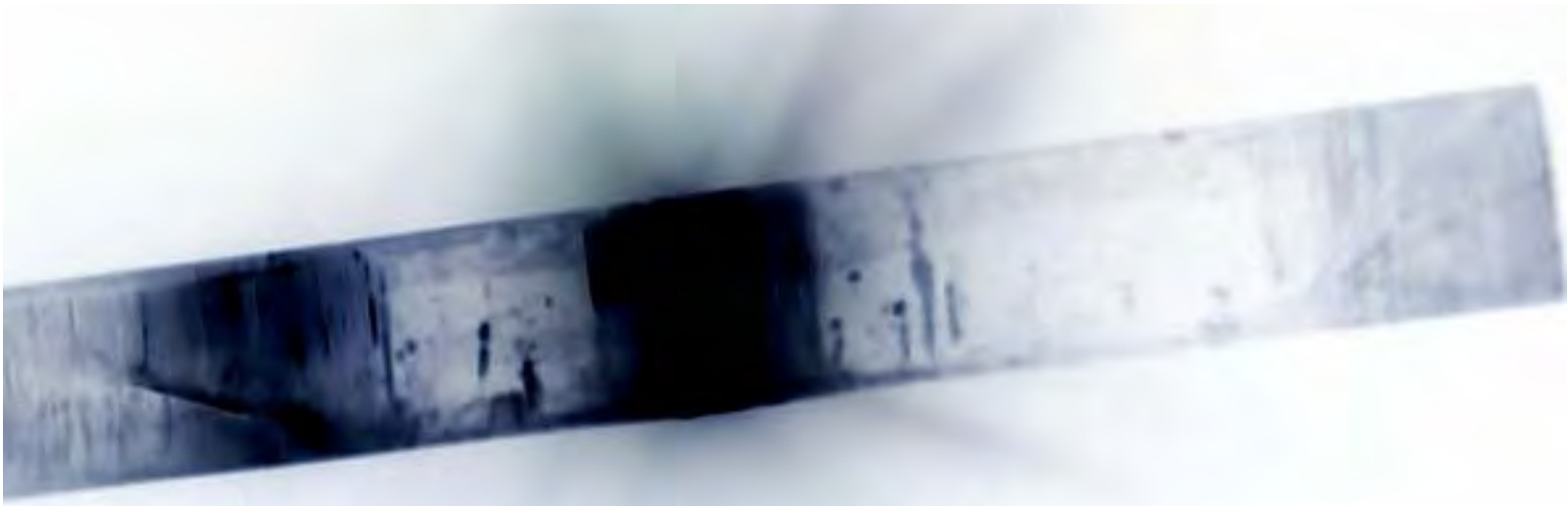
To discover how objects might be embedded and revealed in surface of earth walls





This project necessitates building small forms to enable investigation into the sorts of objects that might be embedded into rammed earth to articulate the surface, create new textures, allow light to pass through, form storage niches, etc. Issues will be the fragility of materials subjected to tamping, the drying time of rammed earth, methods of anchoring objects into the earth mix.

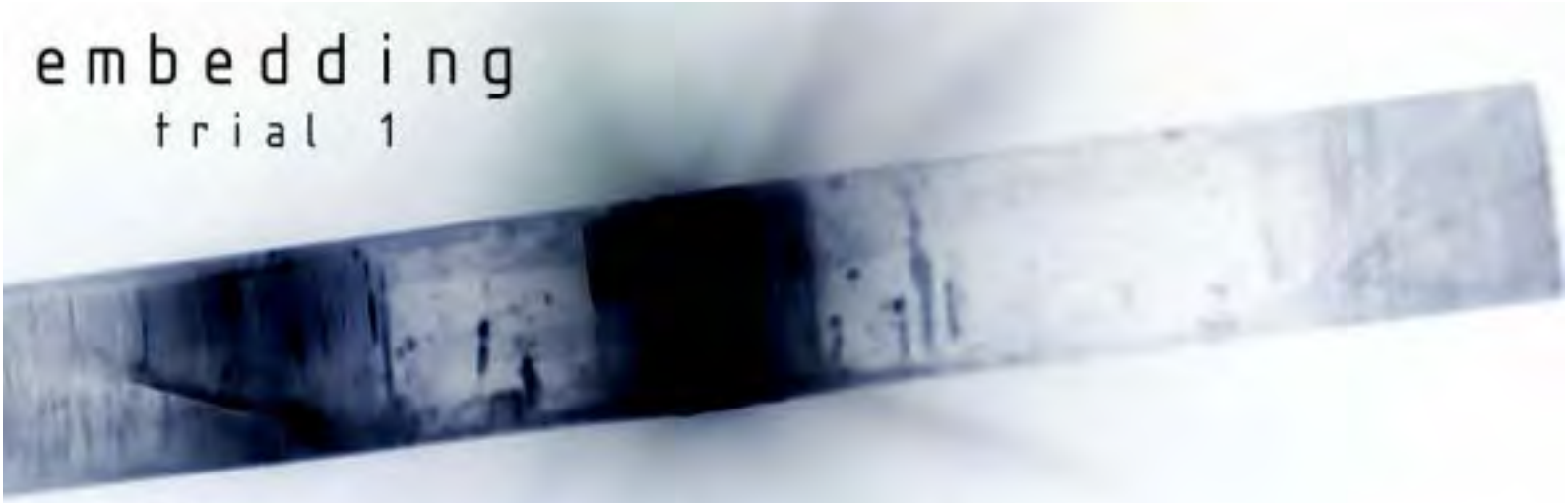
EMBEDDING



arch / 497f
dallas green
bryan bethem
nikki rittenour

explorations into the application of rammed earth
an explanation of a series of two rammings

embedding
trial 1



needs

a- to explore differant methods for allowing light to penetrate the earth walls.

b- to experiment with the embedding of materials for structural use.

c- to create void which could be used for the passing of materials through the wall.

goals

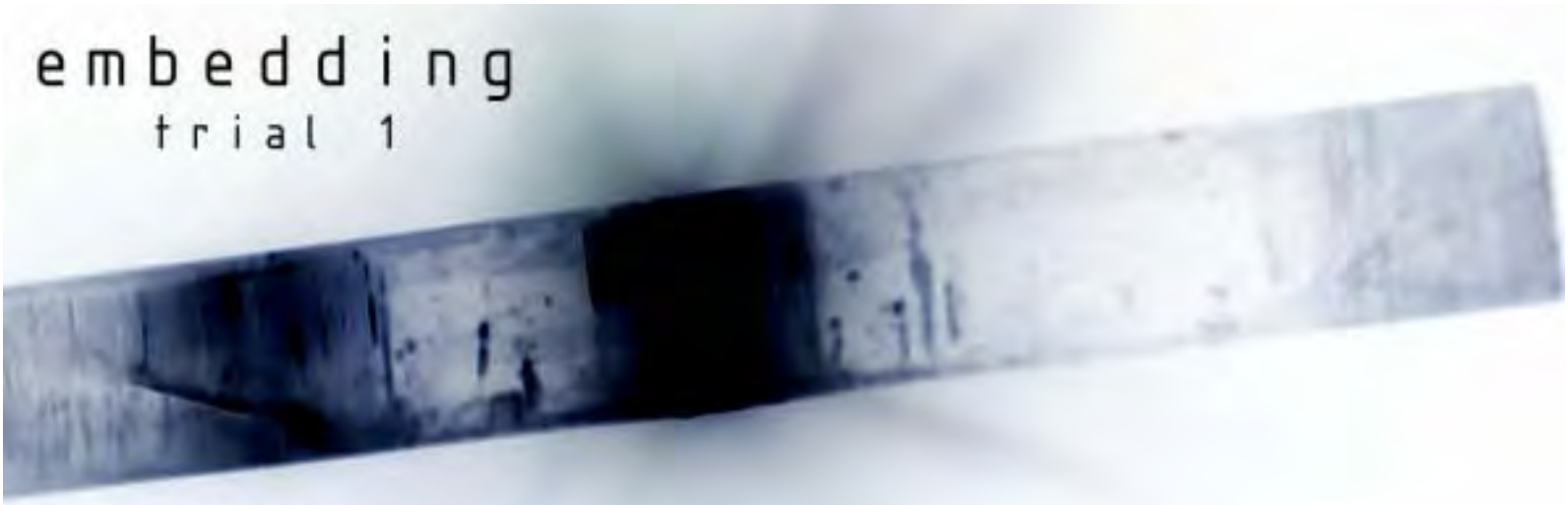
a- embed - 1 - 2 pieces of 3/4" x 12" x 18" plexiglass (1 vertical and 1 horizontal)
- 2 - 1 piece of 3/8" x 3/8" x 20" plexiglass rod
- 3 - fragmented glass (approximately 3/4" deep and 12" wide across the width of the wall)
- 4 - 1 small box made of approximately 1/32" steel, 3" x 8" x 18"
- 5 - 3/4" conduit, 2' in length
- 6 - 1 piece 1/8" thick angle iron, 1" x 6"

actions

forms were made of 1/2" plywood 18" deep, 18" wide, and 5' in length. the soil used was 50% chippy-fill and 50% adobe with cement added at 4% of the soil weight. mixing and tamping were done with standard procedures. no hydraulic tamps were used.

embedding- after first tamping a base of approximately 6" the metal box and conduit were added. next, the fractured glass and vertical plexiglass pieces were added.
NOTE: a small relief was cut into the forms for each end of each piece of plexiglass to be placed, to hold the glass in position.
as each element was added earth was placed around the object and carefully tamped. this worked well in all cases except the 3/8" plexiglass rod that was placed an angle, this piece was difficult to tamp around.
the final object added was the angle iron.

embedding
trial 1



actions

embedding (cont)

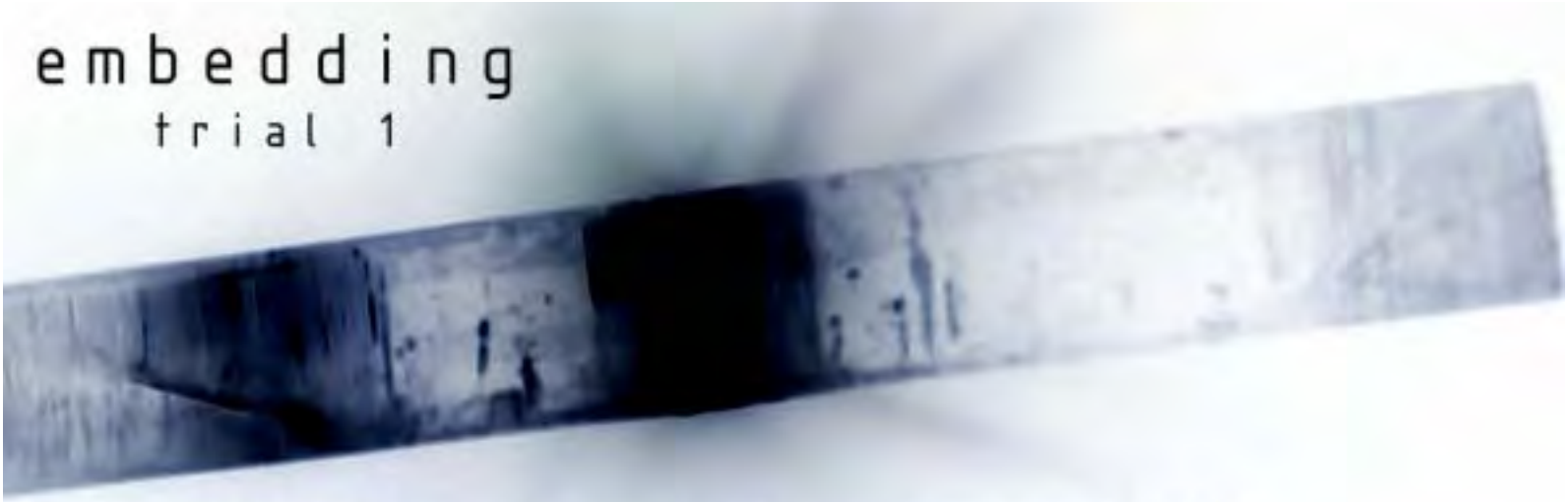
the form was notched to hold the angle iron in place and to ensure that the object would protrude from the rest of the wall when complete. the form was then filled to a depth of approximately 12".

results

b- embed - 1 - both the vertical and horizontal pieces successfully transmitted light through the wall. the vertical piece was easier to place (because of less fear of breakage) and to compact earth around.

- 2 - the rod also transmitted light successfully, but is so small that it is hardly noticable compared to to the larger pieces. without enclosing space around one of the ends it is difficult to measure the success of placing this piece at an angle.
- 3 - the fractured glass transmitted a small amount of light, but was very problematic. it would require some way of being sealed to prevent falling out and allowing in moisture.
- 4 - "the mailbox" was successful in creating a void through the wall, but needs either more reinforcing or to be made of a stronger material, it deformed under the pressure of the rammed earth.
- 5 - the conduit was used to provide a chase for power to the mailbox. This was successful, but very hard to keep in place while tamping.
- 6 - the angle iron protruded out of the earth and feels very secure, but has not been tested for tension strength.

embedding
trial 1



<u>conclusions</u>

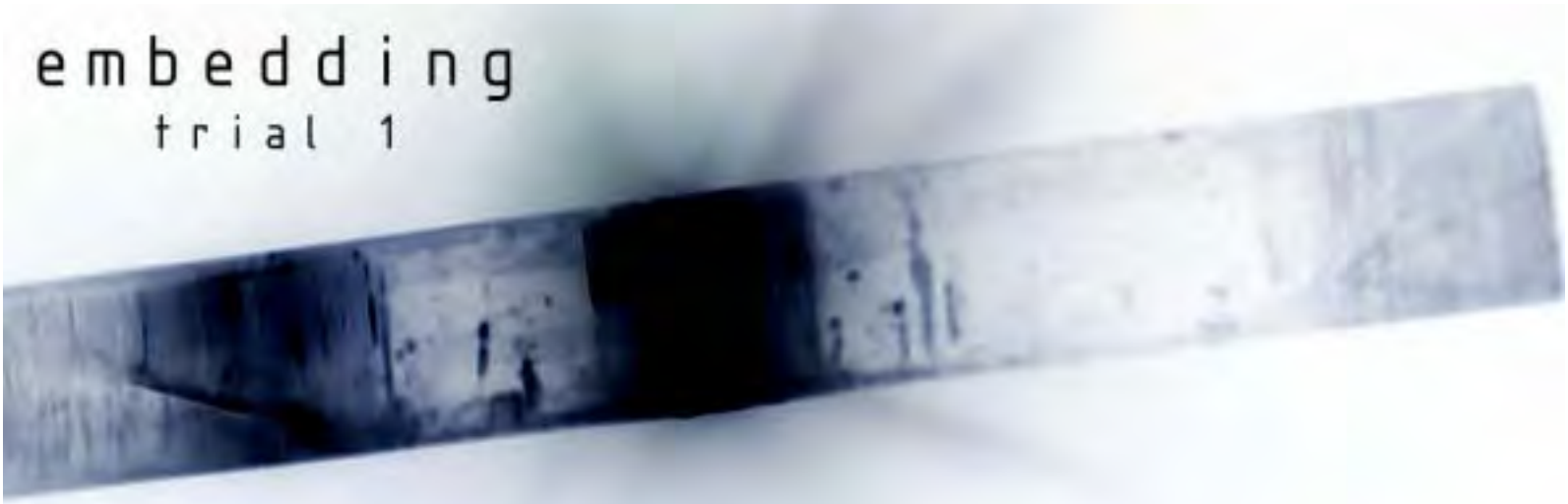
the use of acrylic plexiglass as a method of bringing in light is a viable option, particularly when placed vertical.

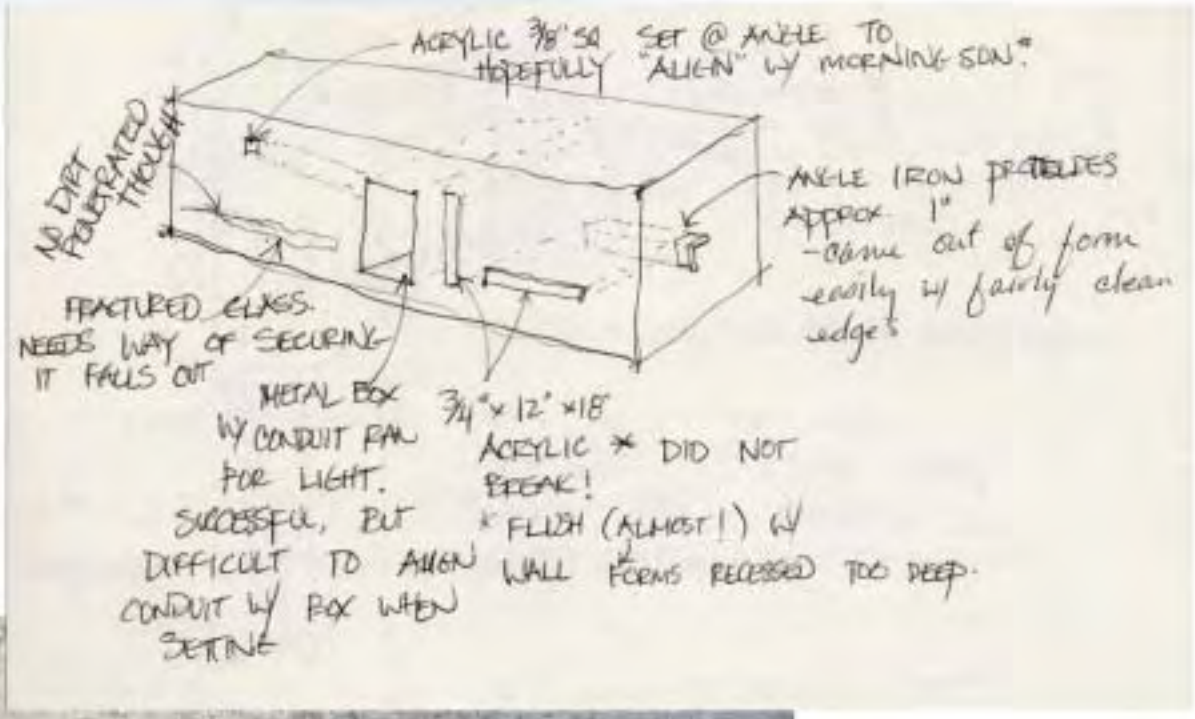
the fractured glass does not transmit enough light to justify being used for this purpose.

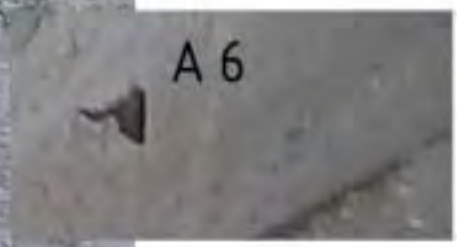
"the mailbox" would make an interesting detail,
but needs to be substantial enough to withstand tamping.

the angle iron represents some good possibilities, but would need to protrude farther to be useful.

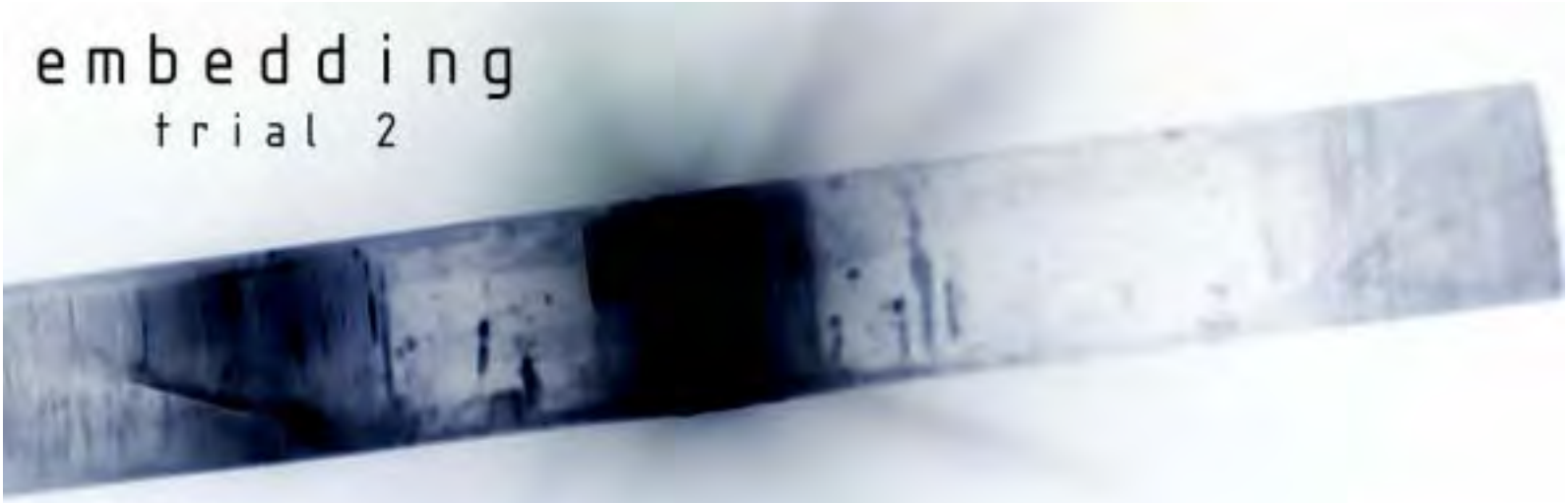
embedding
trial 1







embedding
trial 2



needs

a- explore ways of hanging objects on/from the rammed earth walls

b- explore ideas of embellishing and/or creating variation

goals

a- embed - 1 - wood nailing strip
- 2 - metal anchors
- 3 - bolt receptor

b- insert - 1 - glass fragments
extrude- 2 - rammed earth

actions (mix make-up was identical to trial 1- was drier and tamped more thoroughly)

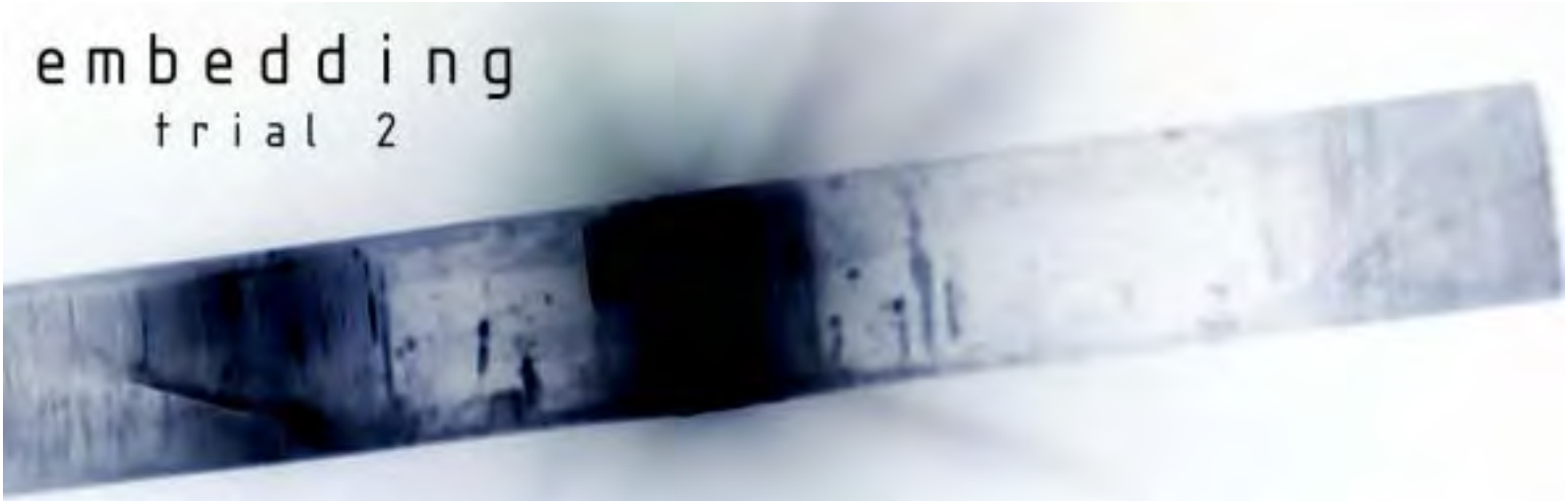
a- embed - 1 - a baltic birch 3"x24" piece was laid against the form with screws attached to the earth side (not the form) to anchor it
- 2 - metal rods were fashioned with anchoring plates which were inserted in holes in the forms. they extended 3" out of the form leaving 8" inside
- 3 - a female threaded bolt receptor was laid in the form against the plywood

b- insert - 1 - glass fragments were placed in the form against the plywood
extrude- 2 - a hole was cut in the form and additional formwork was attached expanding the area by 1-1/2"

results

a- embed - 1 - the nailing strip was flush with the wall and in general turned out well
- 2 - the metal rods seemed secure and further trials will explore welding onto them
- 3 - the receptor was flush with the wall and the eyelet screwed in smoothly

embedding
trial 2



results (cont.)

b- insert - 1 - the glass fragments were spaced and layered to allow the earth to secure them

extrude- 2 - the extrusion was not clear but rather crumbled (possible causes un-oiled forms & normal tamping)

b-1 glass fragments

a-1 nailing strip
a-2 metal anchors

trial 1 vs trial 2

b-2 extrusion

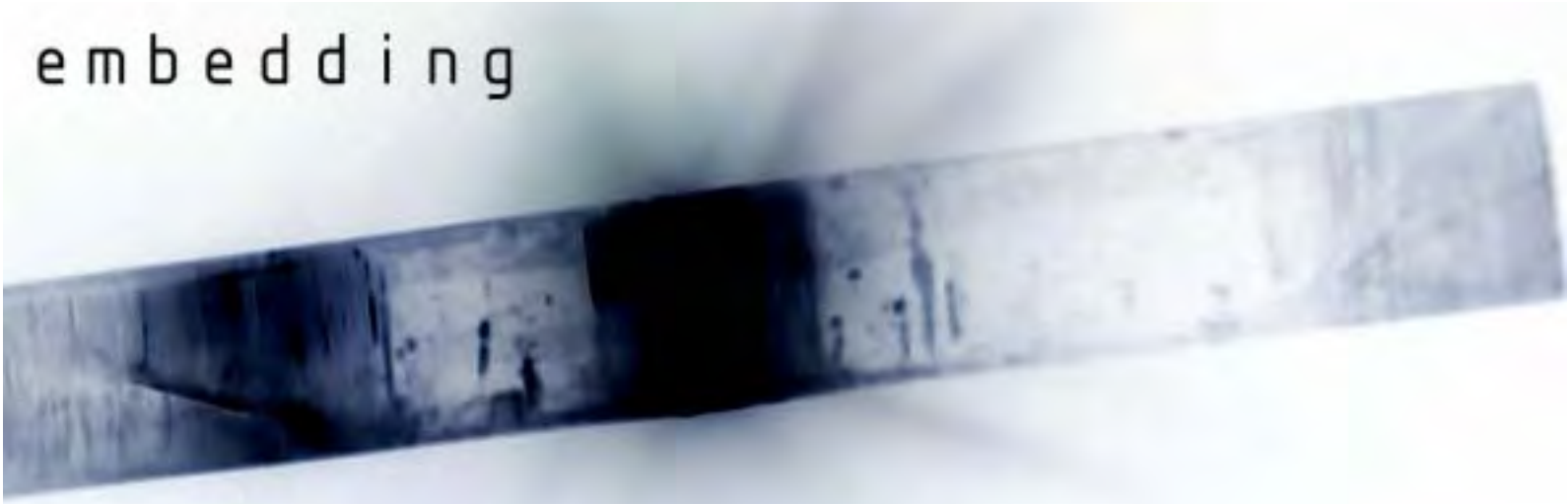
a-3 receptor

conclusions

In general our experiments in trial 2 were successful. Refinements from trial 1 were made in that the glass fragments were held in place by the earth creating a decorative strata. Other, more proven ideas were explored, for example the nailing strip. We also decide to explore some new ways to solve the same problem by using the receptor and metal anchors. In addition, some established ideas were thought of "in reverse". Instead of creating voids we experimented with creating extrusions.

In would be worth it to note some general difficulties we experienced, for example the mysterious way in which our trials never seemed to be solid enough. this could have resulted from insufficent tamping. Also, the problems with securing the same forms only to the block below (see picture above). This resulted in a very evident distinction between trials.

embedding



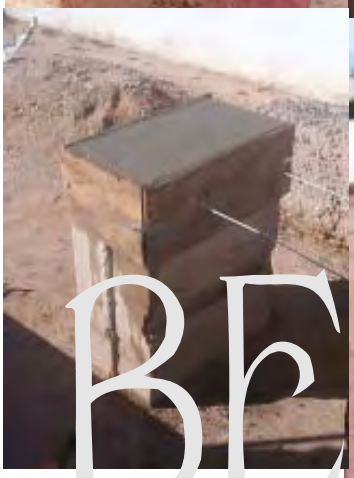
NIGHT PHOTOGRAPHS

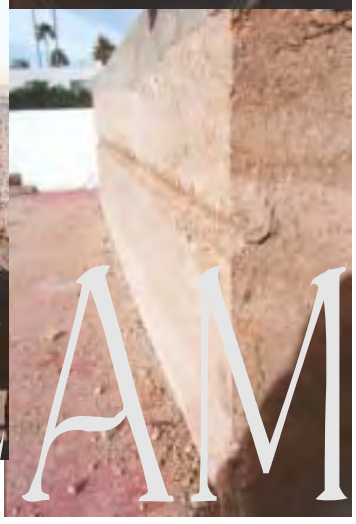
To determine a soil/cement mix that will achieve the compressive strength required by code

This project must happen in three-week cycles, because the building code requires that the earth samples be cured for 14 days before they are crushed to determine compressive strength. Four of five rounds of earth mixing, tamping and crushing will be necessary to determine a reliable mix to use on the rammed earth residence to be guilt in the spring semester of 2001. We will begin with standard mixes purchased from B&R Gravel (adobe mix and engineered fill). From there, we will very the amounts of cement, fill, clay and pigment to learn which elements contribute to or detract from the strength of the mix. We will work with Western Tech Lab and their test cylinders to make sure that we conform to industry standards.

STRENGTH

To invent formwork refinements necessary to allow a discontinuous concrete bond beam to be poured at top of forms or to simplify current continuous bond beam forming process





The house to be built next spring will be constructed with an incremental form system. The forms will be sued and then moved. One important issue is whether the bond beam will be poured in discontinuous batches (but tied together with rebar) using the forms when they are already in place, or poured as one continuous member at the end, requiring all new formwork. This is critical to the planning of the project but requires the most invention. It will take the biggest test forms (18”x12”x6’, perhaps) and require working in stages to simulate the real construction sequence.

BOND BEAM

architecture 497f
construction laboratory
fall 2000 u of a clapa
professor mary hardin

bryan bethem julia nughro
dallas green amir barak

project number 5

To invent formwork refinements necessary to allow a discontinuous concrete bond beam to be poured at top of forms or to simplify current continuous bond beam forming process.

The house to be built next spring will be constructed with an incrimental form system. The forms will be used and then moved. One important issue is whether the bond beam will be poured in discontinuous batches using the forms when they are already in place, or poured as one continuous member at the end, requiring all new formwork.

materials:
a. rammed earth
b. 2-1/2" pvc
c. ready-mix concrete
d. 18" "short" snap-ties
e. 2-1/8" dia. pipe clamps
f. 1/2" plywood form-work
g. pnuematic tampers
h. 1/2" steel angle
i. 1" drywall screws

needs:
a. to explore options of bond beams
b. to establish which system to use
c. to experiment with the means of construction

goals:
a. registering
    1. finding a way to register the bond beam- meaning the ability to level the form work with ease and to use the wall its' self to establish the bond beam level and true.
    2. ease-find an easier way to hold a form for pour

trial one:

plan:

1. using a technique tested in earlier experiments, a triangular niche was cast into the top of the earth wall. the angle used to create that niche was then attached using 5 1" drywall screws @ 12" o.c. to the bond beam form work. the plan requires strict discipline when creating the niche. it needs to be perfectly level.
2. once the angle is attached, the angles are set into the groove, allowing the wall to support the weight of the forms.
3. pipe clamps, as well as snap ties, are used to contain the formwork horizontally.

actions:

1. the groove held its edges without a great deal of degradation. the angles let loose during tamping and the groove took on a curved banana shape.
2. the banana shape could not be reproduced accurately, resulting in a gap between the earth and the form. its ability to be level was dependant upon the niches.
3. three snap ties were used and they held without any problems.



conclusion:

1. the idea was worthy for its ability to use the wall for means of construction. it required a large amount of labor to attach the components. after the attachment was completed, the ability to complete the process of clamping the formwork on and pouring was less than desirable. the entire process was difficult, and relied on things which were easily done incorrectly. a more solid means of registering the formwork is needed, something which will be consistent over the entire structure...trial two.

trial two:

plan:

1. after the first trial, we decided to try a different method for a better leveled bond beam. learning from the imbedding experiment, we could place a pvc pipe in the wall, horizontal and perpendicular to the wall's length, close to the levelness that we desired.
2. utilizing the pvc pipe, we could place a pipe clamp to support the bond beam frame.
3. using the same frame that we used in the first trial, we are going to put two pvc pipes, 8.5" o.c from each end and 3.5" from the top.

actions:

1. we did the usual tamping up until 12 inches high, then we placed the two pvc pipes with pipe clamps inserted in the pipe through the frame, to hold them in place, as we continue tamping the earth.
2. a week later, after the wall dried, we took off the frame. now, we used the same method of constructing the wall, instead of letting the ground support the frame, we used the pipe clamps in the pvc pipes as supports for the bond beam form.

conclusion:

1. after the concrete mix cured, we took off the form and measured the surface of the bond beam pour with a level, it was level.
2. the gap between the frame and earth created some rugged lines on the side of the wall where the concrete leaked out. This was due to the width of the wall being slightly more narrow than the snap ties.
3. the holes created on the wall gave a nice aesthatic to the elevation but a method of capping, possibly precast concrete, could be explored.
4. this appears to be a convienent and reliable system since the pvc/clamp system is already used to form the rammed earth wall.