TECHNOLOGY AND THE STUDIO

Bridging the Gap Between Design and Technology

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Many architecture schools maintain a conceptual gap between so-called "support" courses (such as structures and building systems) and "design" courses. This gap is difficult to bridge for many reasons:

1. Often, the faculty teaching the two types of courses is entirely separate.
2. Sometimes the perception is that the subject matter is somehow significantly different in the two types of classes (that the gap justifiably—maybe even necessarily—exists).
3. The material from other courses, particularly technical courses, is often too abstract and difficult to apply. It is difficult to make this knowledge relevant.
4. The perception often exists that studio is somehow more ***important*** than the other courses [1]. It meets more hours in a week, is generally worth more credit, and is offered every semester of the typical degree program. Studio is what architecture school is ***about***. So design studio becomes all-important, and, for many students, the "support" courses are something to be suffered through. When such an attitude persists, "aesthetic" concerns and "technical" concerns appear to have no meaningful relationship with each other.

I teach both design and a "support" course (like many architecture faculty), and have sought the last few years to collapse the gap between my subject matters—design and building technology. I believe this is essential; my experience as a working architect, prior to my career in teaching, taught me that the gap between matters of technology and matters of design is much smaller than the way it's often treated in school. Additionally, study of vernacular buildings has taught me that in those buildings—many of which are extraordinary pieces of architecture—***there is very little difference between decisions about design and decisions about construction.*** [2] I am interested in collapsing this gap between decisions about design and decisions about construction.

This paper describes an on-going project that I have used in my "support" course, ***Materials***, and in a Third-year design studio. In both cases the aim of the project is to make connections between aesthetic and technical issues. Consider the following quotation from Kenneth Frampton: ***What all of these works demonstrate in different ways is a mastery over the means of production and an ability to break down the construction of a building into its constituent parts and to use this articulation as a stratagem bestowing an appropriate character on the work in hand.*** [3] ***(Emphasis added)*** Simply put, Frampton seems to be saying, "buildings look the way they do because they are built that way." He makes a direct connection between the way buildings are constructed (production & articulation) and the way they end up being (character). If you alter the construction of a building, you will necessarily change its character. This idea has given me a way to help students bridge the gap between technology and design. By making technological issues directly applicable to design problems in design studio, and aesthetic issues directly related to technical matter in Materials class.

Making Bricks in the Materials Class

The ***Materials*** class is for 44 sophomore undergraduates in a 5 year BArch. degree program. [4] This class is the second course in the "technology sequence" at the school. Prior to this they have a class called ***Passive Systems***, which introduces them to the natural forces—thermal, acoustic, light, etc.—at work on buildings which

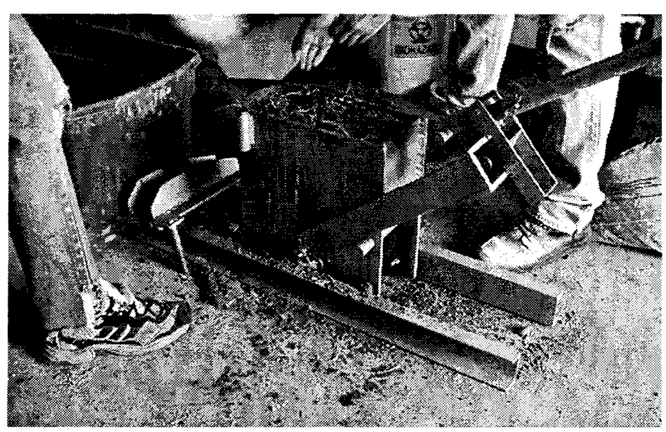
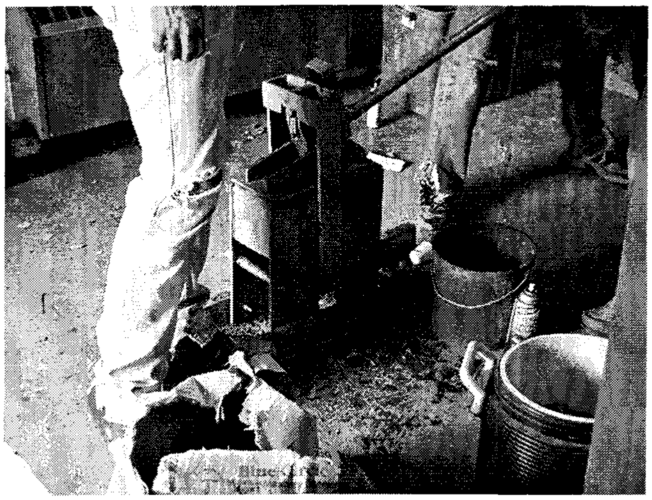


Fig. 1.



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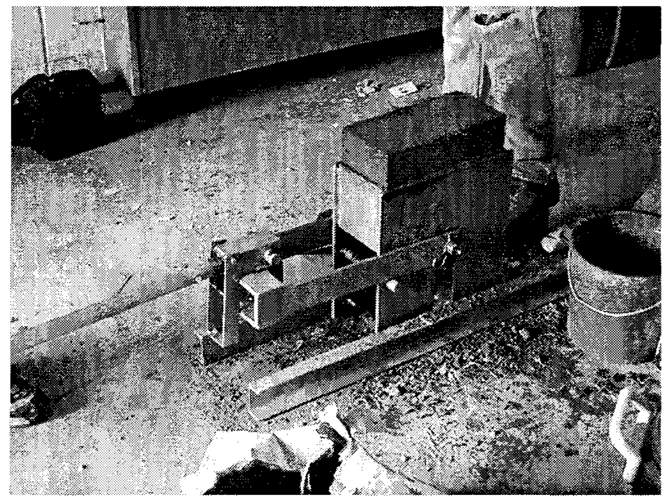

Fig. 3.

affect our comfort and well-being as inhabitants of buildings. I have designed the Materials course to follow up on the Passives course with the following thesis as a guiding principle: That we select **materials** in response to **natural forces**, and in service **of architectural ideas**. I see a triangular relationship between the 3 main parts of the thesis, Materials, Natural Forces and Architectural Ideas. Alter one leg of the triangle and you've necessarily altered the balance between the other two as well.

For a unit on masonry, I developed a lab activity that I believed would incorporate both the experiential and conceptual modes of thinking and learning. The intention of the project was to introduce students to principles of masonry construction, including the material constituents of concrete masonry, methods of manufacture, natural forces which masonry systems must resist, and principles inherent in the development of masonry systems. I thought it would be a valuable experience to attempt to make masonry units from scratch, so the student would gain familiarity with the constituents of the masonry unit, experiment with different mixes, make some blocks, and speculate on how the design of a particular unit would have an impact on architectural ideas such as aesthetics, constructibility and strength.

I chose to use a block-making device called a Cinva-Ram as a vehicle for learning about masonry systems because of its "low-tech/high-touch"[5] nature. The Cinva-Ram is a manual block-making machine developed by Raul Ramirez of the Inter-American Housing Center (CINVA) in Bogota, Colombia. (Fig. 1) It uses the principle of compression in making building blocks and tiles from a number of materials, including common soil. The Cinva-Ram is essentially a steel box with a bottom that moves up and down. A damp mix is placed in the box, and a steel lid is placed on top. A lever is pulled to one side and the bottom moves up, compressing the mix against the fixed top. (Fig. 2) The lever is released, the top removed, and as the lever is pushed into the opposite direction, the bottom moves even further up, and the block is ejected. (Fig. 3) The fresh blocks are set aside to cure for a few days before using them in construction. Using inserts in the press can allow one to transform the rectangular volume for specific purposes, i.e. holes for reinforcing, patterns for decoration, grooves for attaching other systems, a hollow interior to reduce material volume and weight. One person, alone, can operate it, although a more efficient operation would be achieved by a team of four or five people. Production is reported to be as high as 500 blocks a day with such a team. I bought the plans for the machine from a source I found on the Web and built it in our school's shop. Most of the steel was on hand (or scavenged from one of the

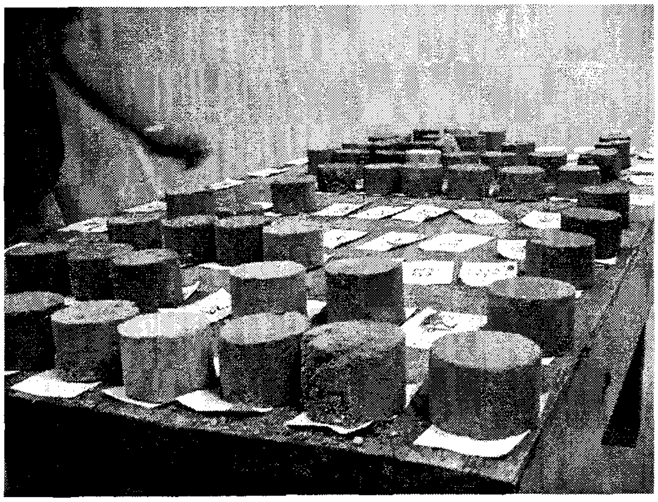

Fig. 4.

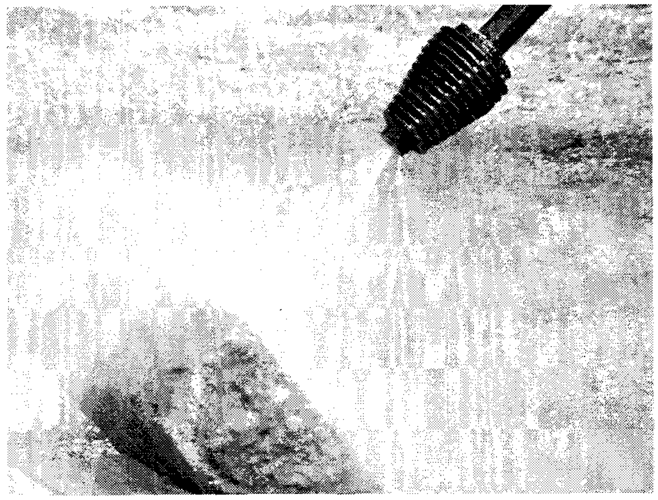

Fig. 5.

Agriculture shops on campus) and essentially cost nothing but about 16 hours of my time. Making it was an enjoyable challenge for me.

The project occupied about 6 weeks of calendar time, and consisted of the following lab activities:

Acquiring Materials: the students were divided into twenty-two teams of two students, and were assigned the responsibility of acquiring materials to begin our tests. They collected Portland cement, mason's cement, concrete (coarse) sand, fine sand, pea gravel, coarse gravel, vermiculite and "red sand" (red sand is a slightly clayey sand used for good compaction and fill in the South).

Making Test Cylinders: I systematically came up with 110 different mixes of some or all of the materials above. Each team was asked to make test cylinders using removable molds (of 4"PVC pipe couplings and hose clamps) and a hydraulic soil testing press we have in our school. (Fig. 4) After curing for two weeks, we measured the mass of each cylinder, and calculated the volume of each cylinder using the water displacement method. The compressive strength was then found by crushing the cylinders in the soil test press. All of these data, including pictures of the cylinders, were posted on a class website for sharing.

Analyzing Results: I asked the students to compile a spreadsheet with all of the data from our 110 test cylinders, and then to interpolate the data to arrive at the following: the "strongest" mix, the "lightest" mix, the "strongest" mix with the "best" finish, the "lightest" mix with the "best" finish, the "strongest/lightest" mix with the "best" finish, and the "strongest/lightest" mix with the "best" finish in 3 different colors. (I am using quotes around these adjectives due to their subjective nature.) The point of this exercise is to understand the trade-offs between these various criteria.

Making Cinva Blocks, (trial run): we selected about a dozen of the most promising mixes and spent a lab session making a trial run of blocks in the machine. By doing this as a group, we became familiar with the operation of the machine, got a feel for the dampness of the mix, and developed techniques for delivering the blocks out of the machine. These blocks were allowed to cure for 2 weeks and then were each broken into two pieces. One half of each block was tested for compressive strength, and the other half was subjected to a "water-blast" from a household pressure washer to test the erodability of the block. (Fig. 5) These data were then posted to the web for universal access.

Final Blocks: The final assignment was for each team to make a total of ten blocks which satisfied the following design criteria: 1. **Strength**. Make two identical blocks which are capable of withstanding high compressive strength. 2. **Looks**. Make two identical blocks which have the smoothest finish and the best overall looks. (no broken corners, chipped edges, etc.) 3. **Color/Finish**. Make two identical blocks which have a color/finish substantially different than the body on one face. 4. **Assembly**. Make two identical blocks which would simplify the assembly of a wall. (For instance, think about how indentations could be cast into the surface which would "lock" together individual blocks.) 5. **Reinforcing**. Make two identical blocks which will allow the introduction of steel and grout to permit a reinforced wall. It was theoretically possible to make ten identical blocks all of which satisfied all of these criteria (but no one rose to the challenge!) That is to say, there is nothing mutually exclusive about these criteria, but there may be some trade-offs. (Figs. 6 & 7)

This project showed, in a synthetic way, the triangular relationship between materials, forces and architectural ideas, and more importantly, demonstrated that we have the ability to rigorously test and analyze some of these criteria in comparison to each other.

Making Bricks and Designing Buildings in Studio

After this experience in Materials class, I decided to use stabilized earth block construction in a third-year design studio of thirteen students[6]. My idea was to have students start learning about the basic material qualities of soil, through testing and research; then they made blocks in the Cinva-ram. Following these activities, the students designed a building using stabilized earth blocks as the primary material. My sense is that this procedure is the opposite of the typical design studio, where students first design the building, then try to select materials which support the design intentions. My project asked the students to understand a material, in a through, direct way, then to design a building which supported the material qualities.

\There happens to be a stabilized earth building on our campus, directly behind the architecture school. It was built in 1942 as an engineering experiment. Sixty years later we find, by examining this building, that stabilized earth is a perfectly suitable material for construction in the extreme climate found in the Midwest. Having this building in our backyard legitimized the activities of the studio in the eyes of the students, who were admittedly skeptical of the premise of earth construction. (Fig. 8)

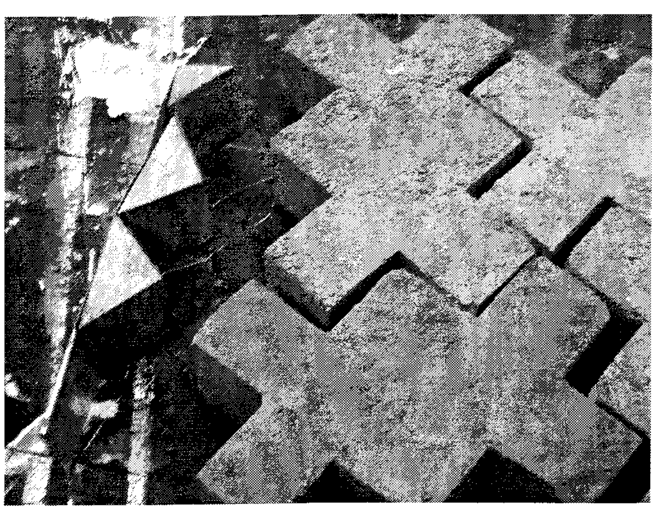

Fig. 6.

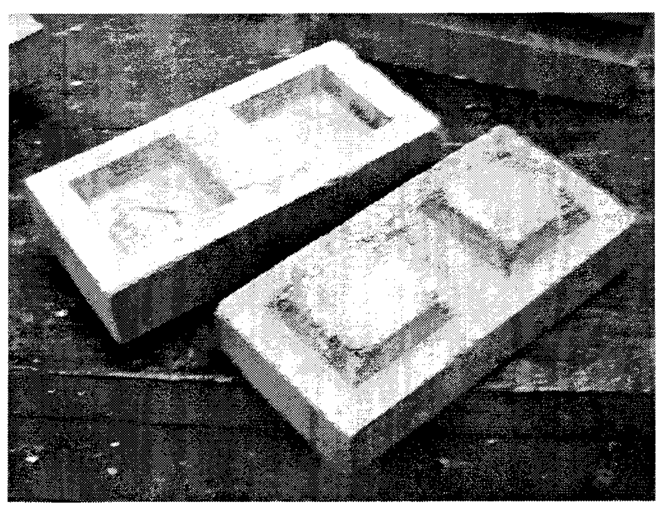

Fig. 7.

Fig. 8.

The general sequence of the studio was as follows:

Soil testing: Stabilized earth construction necessarily begins with soil. Soil properties vary widely within a region, and potentially within the same general site. It is important to do rudimentary testing to determine the suitability of a particular soil sample. I asked each student to bring in a quart of soil, and using simple, direct, sensory tests, try to determine the constituents (clay, silt, sand, organic matter) of the soil. These techniques include rolling out "slabs" and "worms" to experience the plasticity; settling out in water and measuring the stratification of different particle sizes; biting the soil with your teeth to test the grittiness of the soil. [7] We then visited the soils lab in the engineering department to see how the engineers arrive at conclusions about soil.

Making test blocks: I told the class that we would be making test blocks for testing the compressive strength of stabilized earth mixes. The immediate problem was to decide on a technique for making consistent blocks. Students proposed different devices that they could build, and through group discussion[8] of each proposal, consensus was reached on the one they felt was 1) most buildable, and 2) most accurate.

Each student made a set of test blocks using their soil and a range of stabilization (5% cement, 10% cement, 15%cement, etc.) After 2 weeks of curing time, we tested the compressive strength of the blocks in the school's structures lab, collected the data, and got a sense of the effectiveness of cement as a stabilizer. Preliminary conclusions from this round of testing led the students to believe that the soils with a higher clay content withstood the highest loads.

Making test blocks: Students got more samples of their soils and made actual blocks using the Cinva-ram. During the making and after curing, students were able to observe numerous things: 1) the appearance of the blocks, 2) the suitability of a soil to be molded using that device, 3) the amount of shrinkage, 4) the amount of cracking/crumbling. Preliminary conclusions from this round of work led the students to a different conclusion than above: the clayey soils exhibited a lot of shrinkage and cracking, and were pretty ugly. The best looking block was the one with the sandiest soil. It was also the one that shrank the least. How to resolve this apparent contradiction in results from the first two tests?

Understanding assemblies: About this time, we had the opportunity to visit a strawbale house that was under construction near us. I saw this as a chance to 1) see another alternative approach, 2) see the assemblies in the various stages of making. After arriving back in studio, I asked the students to draw wall sections of the strawbale house. In a group discussion of the wall section, I drew out of the students the idea that all wall assemblies have common goals, independent of their material. We expect them to be **strong**; we expect them to keep us **warm**; we expect them to shed **water**; we expect them to be **constructed**; we expect them to **breathe** (humidity); we expect them to **look good**. The class divided into teams and asked the following questions with regard to these subjects:

Strength

- What are the structural forces at work in a single block?
- What are the structural forces at work in an assembly?
- What are the structural implications for the entire system?

Humidity
- What are the humidity/breathability issues at work in a single block?
- What are the humidity control issues in an assembly?

Water Resistance
- How does a system of earth blocks deal with water?
- How does an earth block as a single thing deal with water?

Constructibility
- How do construction systems become integrated at the single block level?
- How does one think about integration at the assembly level?

Thermal Resistance
- What are the thermal issues at work in a single block?
- What are the thermal issues at work in an assembly?

Aesthetics
- How does one develop the aesthetic dimensions of a single earth block?
- What implications does that have for an entire assembly?

The class agreed to study this information in teams through testing, and to prepare their results for sharing with each other on the class website. This round of work demonstrated that there are often trade-offs between one category and others. For instance, it was easy to imagine that one could design a texture on a block surface that would hinder the block's ability to shed water; or that an attempt to make a block more thermally resistant could hinder its compressive strength. The students learned that there are no easy answers, and that one must deal with this complexity in a critical and careful manner. All of this information was placed on the class website for sharing amongst the class. (Figs. 9 & 10)

Building design: The students were asked to design a university research center for stabilized earth construction on our campus. Through group discussion we easily came up with a plausible program of spaces that such a building would likely have, since they had been studying this material in a variety of ways. The studio became more orthodox for the rest of the term, with students working on their individual design schemes. But the work was not typical: wall sections and ideas about materials and assemblies had a much greater impact on the forms of the buildings than I would expect from third-year students. The discussions in the final juries were much more wide-ranging and specific, embedded with real knowledge about the material itself, with real knowledge about the program, and with more verifiable speculations about the final design proposals.

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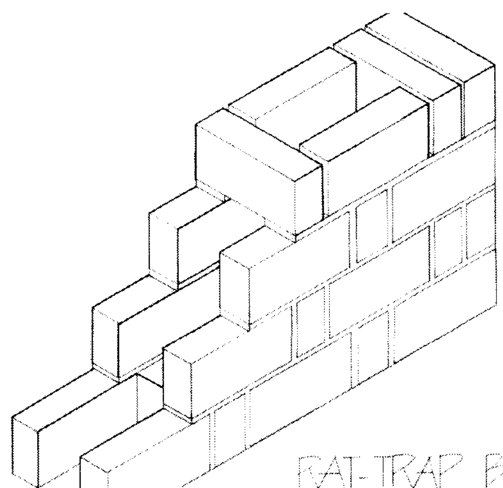

stabilized earth block construction, and making it available on the Web.

Fig. 9.

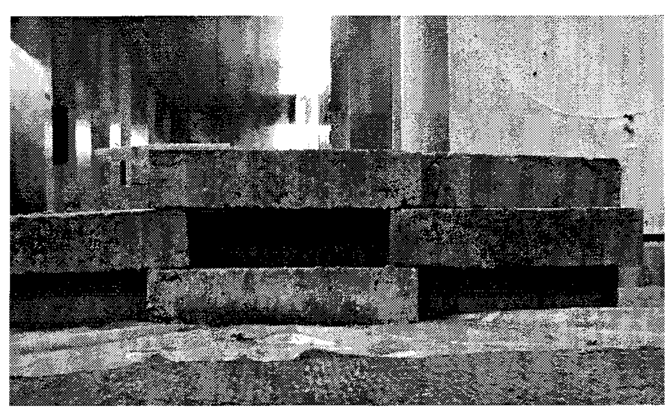

Fig. 10.

The first four bullet points in this list are things the involved students can take away from this for themselves. The last point is useful for the larger world as it discovers our work on the Web. The work of the studio and the course serves as a legitimate body of research which has a use as people in the world engage themselves in learning about alternative construction systems.[9] For more information on this work see *http://www.saud.ku.edu/ngore/nilsweb/cinvablocks/index.html.*

Notes

1 In many ways studio ***is*** more important if you consider it to be the synthesis of all the disparate facts learned in the other courses; as the string that binds them all together.

2 See Howard Davis, ***The Culture of Building***, for a thorough elucidation of this idea. (Oxford University Press, 1999)

3 ***Studies in Tectonic Culture***, (MIT Press, 1995) p.316

4 This class was taught at Mississippi State University.

5 By low-tech/high-touch I mean an activity which is simple to understand at face value (low-tech), and which has a high degree of physical interaction with actual materials (high touch).

6 This work was done at the University of Kansas, so these students knew nothing about my previous work in the ***Materials*** class at Mississippi State.

7 If you bite a small sample of damp soil with your front teeth, and don't get an unpleasant gritty sensation, the sample is largely clay.

8 Group discussion was potentially the single most important element in this studio. Through discussion, the students are able to speculate on certain issues and then talk it out to arrive at conclusions. It provides an excellent opportunity to share information between them, and raises the level of discourse much higher than if students were merely working independently.

9 I receive approximately three e-mails a month from people all over the world who have seen the work on the website and are interested in finding out more about stabilized earth construction.