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3. THESIS: PROPOSAL FOR RAMMED EARTH SOUND BARRIER

The success of the rammed earth wall, which proved that the technique could be used in New England, led me to look for other places that rammed earth could be used as a replacement for concrete. Sound barriers along highways was one such area. There is a growing need for sound barriers, and engaging with the state infrastructure offers a chance to make a real impact on construction practices. During the winter I set up meetings with sate and federal highway officials to discuss the possibility of building a rammed earth sound barrier on a stretch of highway on Interstate 93.

The priorities expressed by the officials with whom I met stressed the need for quality control and worker efficiency. High labor rates and a desire to keep workers off the highway meant that methods used to build sound barriers had to be very efficient with regard to time. This need for quality control can be stated as a desire for predictability, which we had run into already on the rammed earth wall at MIT, where we had imported sand to mix with the clay instead of using the site soil, which had a great deal of debris mixed in with it. The rammed earth sound barrier required moving more in the direction of standardization of the material.

Hypothesis

Rammed earth must be standardized for widespread use. Mechanization will allow for large-scale infrastructural works at significant reduction of natural resources.

Investigation

A proposal for 1560' long rammed earth sound barrier along I93 in Dorchester. It included conceptual and physical modeling of mechanization

~~The~~ Mass Highways ~~plans on~~ presently plans to ~~construct~~ ~~sound~~ in the next 5 years & has prepared to build 58 sites along the Turnpike

Rammed Earth OpEd

The time has come to explore environmentally sustainable alternatives to existing methods of sound attenuation along the Massachusetts Turnpike. There is a growing need for sound barriers along the ~~Pike,~~ Massachusetts ~~as well as many other Interstate Highways~~, owing to increasing population density along this important transportation corridor. ~~Housing and commercial development built close to major transportation routes reduce local traffic and are environmentally desireable, as well as economically beneficial.~~ Taking advantage of proximity to highway systems calls for an effective method of diminishing highway noise while preserving appearances on both sides of the wall. Rammed earth, a technique whose origins go back thousands of years but has been updated for use in contemporary construction, may hold the most promise for a natural, environmentally-friendly technique for building effective, durable, and beautiful sound barriers along the Massachusetts Turnpike.

Published surveys show residents of communities in which the walls are erected prefer natural materials to concrete barriers (Cohn and Bowlby, 539). Timber is the most popular material ~~The majority of~~ the sound walls along the Massachusetts Turnpike, ~~are currently being constructed of timber, which, of existing methods~~, offers the most natural appearance. However, the natural appearance ~~natural look~~ of these walls comes at considerable economic and environmental cost. The life-expectancy of sound barriers constructed of timber is estimated at 15-25 years by the Forest Products Laboratory, a government agency promoting the use of timber in construction. This short life span, after which the walls must be disposed of and replaced, is achieved only by treating the wood with toxic preservatives such as arsenic, chromium, and copper (3), ~~This is~~ a considerable dose of chemicals for walls whose purpose is to appear "natural." Moreover, the higher maintenance costs of the wood walls results in an end ~~a~~ price ~~that in the long run is~~ virtually the same as concrete, whose acoustic performance and durability (though not its appearance) is superior to that of timber. Data from testing indicates that the acoustic performance of most timber barriers is barely acceptable weeks after they are installed. Tests have suggested that this initial performance generally declines as the wooden walls age, due to weathering, cracking and settlement.

Why use rammed earth for sound barriers alongside Massachusetts highways? In contrast to concrete and preserved timber, rammed earth is a minimally-processed natural material that harmonizes with its surroundings without requiring the use of chemicals or energy-intensive processes. In rammed earth construction, natural soil is moistened and compacted in layers within formwork ~~removed~~ which is removed at the end of construct ~~built on-site~~. Walls constructed of rammed earth reflect the beauty of their surroundings, because the material is drawn from the

MIT ACOUSTICAL SURVEY
Savin Hill, MA

Date of Interview:
Time of interview: 6 pm
Name: (Optional)

Address: (Optional) 6 ~~SHAD~~ HUBBARDSTON ST APT C

Questions

1. Do you live in Savin Hill, Dorchester? Y N

2. How long have you lived at the present address? 0-1 year 1-3 years 4-10 years over 10years (30)

3. Are you aware of the noise when you are outside your house? Y N

4. Are you aware of the noise from the highway when inside your house? Y N

5. Is there a particular time when the noise from the highway is especially loud?
6-10 AM 10-2pm 2-5pm 5-8pm 8-12am 12-6am

other__________

6. Is there a particular time when the noise from the highway is especially quiet?
6-10 AM 10-2pm 2-5pm 5-8pm 8-12am 12-6am

other weekends

7. When ~~does~~ the noise from the highway bother you the most?
6-10 AM 10-2pm 2-5pm 5-8pm 8-12am 12-6am

other get used to it

8. When, if ever, does the noise from the highway not bother you?
6-10 AM 10-2pm 2-5pm 5-8pm 8-12am 12-6am

other__________

9. Would you be in favor of a wall built to block the sound in the neighborhood? Y N
Depends

10. Would you help build a sound barrier wall if someone else paid for the materials?
blend in => NOT fiberglass

11. If you had a choice, what ~~sort~~ of materials would such a wall be made of?
wood concrete earth strawbales steel recycled materials

12. What negative effects do you think could result from a sound barrier wall?
Loss of View

Contact
Joe Dahmen
354 Congress ST
5th Floor
Boston MA
02210
jdahmen@mit.edu

Savin Hill Sound Barrier

Overview

Savin Hill Sound Barrier is a proposal to build a sound barrier on land owned by the Massachusetts Department of Transportation along Savin Hill Avenue. The goal of the project is to protect homes in the neighborhood from highway noise created by traffic on Interstate 93. The project is a joint venture between students of the School of Architecture at MIT and the residents of the Savin Hill neighborhood, and will use local labor and materials for construction of the wall.

The proposed sound wall would protect the street, yards, and first floors of homes, creating jobs for the community while improving the quality of indoor and outdoor spaces and raising the value of the homes along the highway. In addition, the wall will provide an opportunity to investigate environmentally friendly sound barrier techniques and provide valuable evidence about the longevity and durability of these techniques.

What is Environmental Sustainability?

Environmental sustainability, also known as green building, is a set of construction practices that seeks to minimize the use of nonrenewable resources. The rising cost of energy and the amount of pollution has caused recent gains in popularity of these methods in the United States today. *Savin Hill Sound Barrier* intends to construct the first environmentally sustainable sound barrier in New England in Savin Hill, Dorchester.

Funding

Initial funding is in place from Boston Society of Architects. Savin Hill Sound Barrier is currently seeking funding from local, state, and federal sources to meet labor and equipment costs necessary to construct an environmentally-friendly sound barrier using local labor and materials along Savin Hill Avenue.

Sound Barrier Specfications

Materials for 1560’ x 12’x 2’ sound barrier wall along I93 from Boston Globe to Savin Hill Avenue Bridge

1386 cubic yards of soil compacted
416 cubic yards of blue clay
1553 cubic yards of ¾"- aggregate
1025 cubic yards of sand
890 cubic yards of reinforced concrete for foundation and cap

BUDGET FOR 1560’ SOUND BARRIER WALL 12’ HIGH
FROM BOSTON GLOBE TO SAVIN HILL AVENUE, DORCHESTER

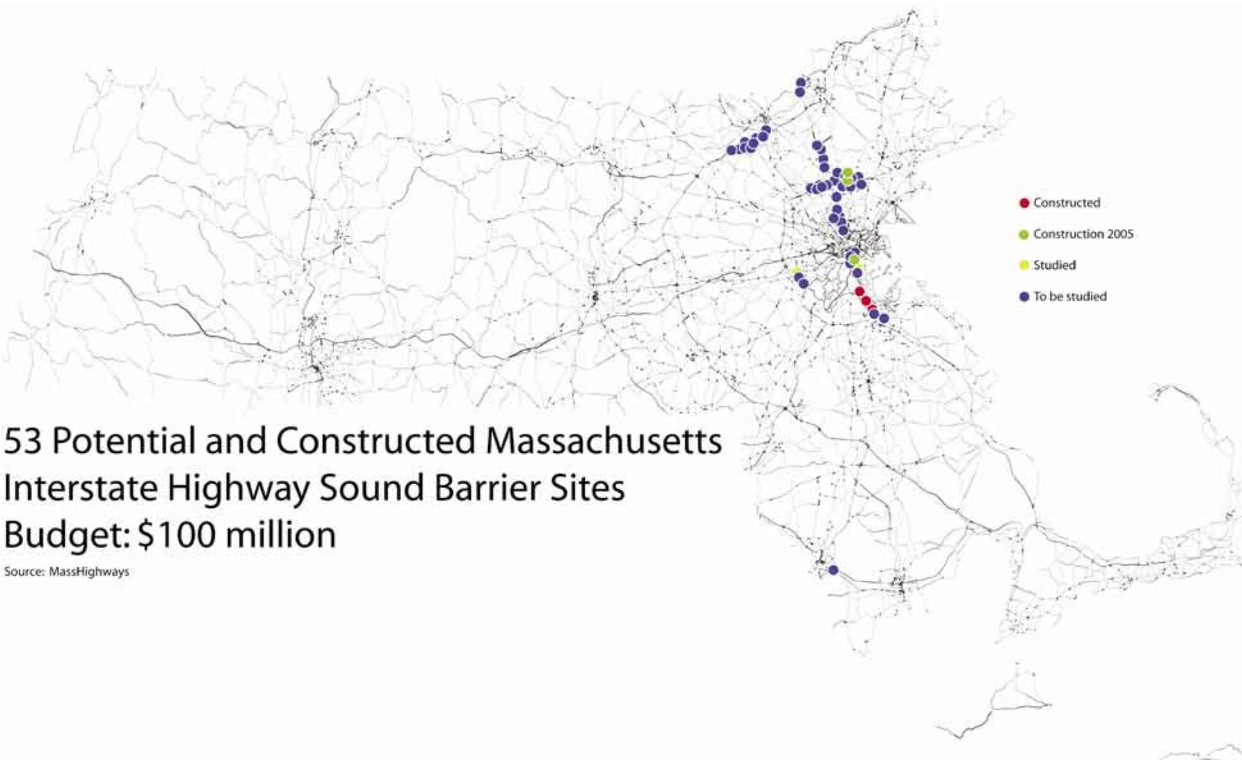
MATERIALS	
Clay	Free
Sand	
27,676 c/f $24 per ton	$31,968
Gravel	
14,257 cf 3/4" minus crushed stone	$13,200
Trucking	
1.7 million tons of clay trucked from downtown construction sites to Savin Hill, Dorchester	$50,000
Formwork:	$8,000
Foundation $40/ft	$62,000
Cap $40,000	
15 % Overhead	$30,775
MATERIALS TOTAL	**$236,000**

LABOR
Earth rammed at 1.5 sf per man hour
18,720 sf of wall 12,480 hr total x $20 p/hr = $249,600

4 people employed for 390 days at $20 p/h
10 people employed for 156 days at $20 p/h
50 people employed 31 days at $20 p/h
310 people empoyed for one day at $20 p/h.
Or 100 people for 39 days at $8 per hour

LABOR TOTAL	**$249,600**
TOTAL COST CALCULATED AT $40 PFF	**$655,200**

These calculations leave $170,000 for cost overruns



53 Potential and Constructed Massachusetts Interstate Highway Sound Barrier Sites
Budget: $100 million
Source: MassHighways

strategy and form, and meetings with civil engineers and other officials of Massachusetts Department of Transportation (MassHighways) and Federal Highway Administration to discuss rammed earth sound barriers. The appeal of infrastructure to the architect is the massive change that can be effected through these means.

Overview

This section of the thesis is based on the assumption that population density in the United States will continue to rise along major transportation corridors, bringing increasing numbers of citizens into close proximity with limited access highways. I propose a sound barrier built of rammed earth along a stretch of Interstate 93 in the Savin Hill neighborhood of Dorchester. I choose this neighborhood because it suffers from unreasonably loud highway noise from the Boston Globe to Savin Hill Avenue. As one of the oldest neighborhoods in Boston, it is worth protecting.

MEETINGS

March 8, 2006
Flew to DC and back today for meeting at Turner Fairbank Highway Research Center at Langley, Virginia. Rented a car to get from Dulles to TFHRC. Irony of it all was that all they had in the lot was a Nissan Pathfinder, so I arrived at the meeting in an SUV. TFHRC in Langley, VA, and shares an entrance with the CIA. Seven staff members in attendance at the meeting: always surprising that people will come to hear anyone talk about a wall of dirt. Productive meeting. TFHRC has a device adapted from a plane-launching catapult on aircraft carriers to launch cars at construction elements to see how they hold up under the impact. Unfortunately no one was using the machine n the day of my visit. Also saw some advanced structural testing in huge indoor laboratory and testing space. Interesting Pi-shaped experimental fiber reinforced beams. All in all a good visit.

PRESENT CONCERNS

Overview

Background research on the history of the highway in America ~~shows~~ suggests that using rammed earth to make a sound barrier was a foregone conclusion that ignores larger situational issues. Rethinking orientation of project to address larger issues.

I) Separation problem: Questioning the impulse to create an~~d~~ absolute separation of transportation corridors from residential and other built areas. This separation has ~~also~~ been a foregone conclusion for the most part in highway construction in America.
   A. Elevated expressways (Boston, Knoxville).
   B. Buried expressways (Boston), putting them completetly out of sight and thus hiding a fact of everyday life. Also the experience of the driver is reduced to a narrow tunnel in which aesthetics have played virtually no role.
   C. Walled Expressways: barriers cutting off views and attempting absolute separation
   D. Seems that perhaps the barrier should engage the paradox of hiding transport corridors rather than attemtping a complete division of these two things. permit and bring about connection between two experiences.

   E. Possible that rammed earth is not the best material with which to achieve aims of
      1) material should arise out conditions of the site and goals of the intervention
      2) use of rammed earth was decided in advance.
      3) Question: how to engage in this sort of thinking without reverting to square 1 in the project?

II) Built vs. Proposed: considering the life of a proposal beyond its immediate context.
   A. Rammed Earth Sound Barrier: In order to build 100'long example project along a highway would cost approximately $50,000 and require approximately 8 weeks of construction time for completion. On site work would need to be started March 15, 2006 at the latest. Know better after meeting with FHWA next week.
   B. This route could require rushing through design in favor of construction, possibly compromising research and educational values
   C. Considering the possiblity of multiphase approach
      1) Stage 1: Thesis investigating relationship of highways to built areas
         a) Deliverables:
            i) infrasturctural plan defining new relationship of major transport corridors to built fabrics in specific location
            ii) Documentation with communication with FHWA and all outdie contractors, including cost estimates for work
            iii) Written document summarizing design and key findings

Meeting at Turner Fairbank Highway Research Center
Langley, VA
March 8, 2006

Attending the meeting
Ian M. Friedland, P.E.
FhwA Office of Infrastructure R&D
Technical Director, Bridge and Structures R&D
Chris Corbisier, Civil Engineer (Noise Specialist)
FHwA Planning and Environment
Office of the Natural Environment
Mark Ferroni, Noise Team Leader
FHwA Office of Planning, Environment, and Realty,
Office of Natural and Human Environment
Mike Adams, Geotechnical Research Engineer
FhwA Office of Infrastructure R&D
Carl Early, Geotechnical Research Engineer
FhwA Office of Infrastructure R&D
One Other TFHRC Researchers who Appeared to be a Civil Engineer

Purpose of meeting
Solicit feedback and advice from leading civil engineering experts on highway infrastructure on feasibility and research objectives to develop an environmentally-friendly sound barrier constructed of rammed earth.

Materials
Slide presentation of RE research carried out so far and future RESB research objectives
6 page report summarizing preliminary research findings on Rammed Earth
Research objectives for RESB
Resume

Duration
2 hours.

print 5 copies

Joe Dahmen
Prepared for meeting at Turner Fairbanks Highway Research Center
March 5, 2006

PURPOSE OF MEETING

1. Evaluate feasibility of constructing environmentally sustainable sound barriers on limited access highways

2. Ensure rammed earth sound barrier research objectives are relevant to FHwA

RAMMED EARTH SOUND BARRIER RESEARCH OBJECTIVES

Immediate Objectives
Mechanize rammed earth construction process

1. **Objective** bring price of rammed earth within FHwA construction cost guidelines

2. **Test acoustic performance of wall**
Objective ensure that rammed earth fulfills basic acoustic criteria for Category I and II sound barriers

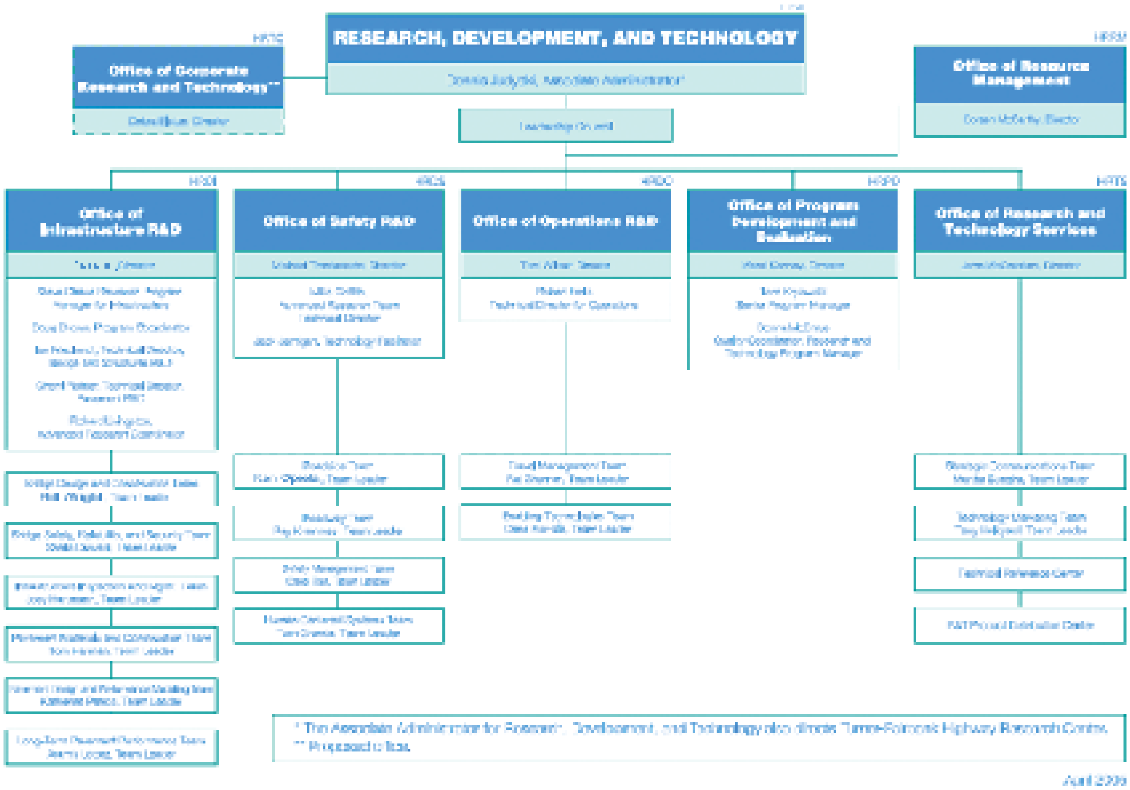
3. **Develop appropriate foundation details**
Objective generate foundation details in accordance with current standards of FHwA

Longer Term Objectives

1. **Investigate steel and/or fabric reinforcement**
Objective ensure compliance with state and federal building code and investigate possibility of using rammed earth in areas of seismic activity

2. **Identify regional sources of clay**
Objective explore the applicability of rammed earth to various regions of the US

3. **Investigate natural coverings**
Objective investigate hardy plant species that might be grown on surface faces of wall to improve acoustic and visual performance



Transcribed notes from the meeting at TFHRC

Many present registered concern about the height restrictions of RE; often SB walls are 20-30 feet high, subjecting them to large wind forces. Can RE withstand that? Also reinforcement was brought up: will the wall meet seismic codes? Possibility of adding short nylon fibers (possibly recycled carpet fibers or other short polypro fibers) was discussed to help with the tensile performance and it was acknowledged that such research could take a long time.

General sense was that the way to get the product out there was to corner a particular segment or niche in the market: i.e. perhaps not all walls, but rather SB under 10 feet or some such. Maybe the "product" (as they referred to the RE wall throughout the meeting, with the general sense that I was trying to bring a product to market, which I suppose is the truth—maybe this answers why I am flying all over the place meeting with these suits) would go over better in the southwest, or on National Park Service lands, where aesthetics are one of the prime concerns.

Suggested That at $25 per face foot (i.e. in elevation) would guarantee me a market for RESB nearly anywhere. Prefab and sitecast concrete can run between $40-100 psff (very rough estimate that I do not trust)

Structural Factors of Sound Barrier Design:

1. Wall's own weight
2. Wind load
3. Seismic load
4. Acoustic Performance

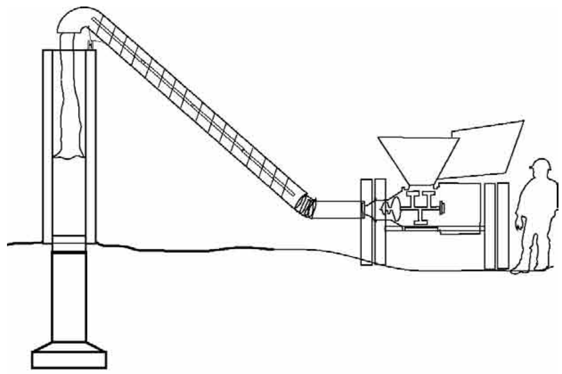
Must be able to validate that system works according to the above.

Acknowledged that precast concrete panels can be made to look like just about anything, which is tough to fight against (although I have yet to see a single precast concrete panel that actually looks good). Other advantage to precast panels are that they diminish time on site, which in the case of HSB is fairly hazardous: it is considered advantageous to keep the amount of worker hours on the site to a minimum. Look at stretch of road

Friedland, Ian wrote:

> Mr. Dahmen,
>
> I'm afraid that we would need more lead time than a few days to organize a meeting and presentation, and check on the availability of staff, as many of us book up our calendars weeks and months in advance. For example, I am fully committed all next week to meetings and travel and have no free time. Can I suggest that you look at the time period between March 1 and 10 and see if any dates might work for you, and we'll then see what works best for the folks here?
>
> Best regards,
> Ian Friedland
>
> -----Original Message-----
> From: Joe Dahmen [mailto:jdahmen@MIT.EDU]
> Sent: Thursday, February 09, 2006 9:00 AM
> To: Friedland, Ian
> Cc: Richter, Cheryl; McCracken, John; Judycki, Dennis; Henderson, Gary; sussman@MIT.EDU; Wright, Bill; Adams, Mike; jgermaine@MIT.EDU; Yung Ho Chang
> Subject: Re: MIT Rammed Earth Highway Sound Barrier
>
> Dear Mr. Friedland,
>
> Many thanks for the opportunity to present my research on rammed earth construction to the Turner-Fairbank Highway Research Center.
>
> I could come to McLean either Tuesday or Wednesday of next week to present my research on rammed earth barriers if that is convenient for you. Is there a particular time on either of those days that will work for you and the relevant TFHRC staff?
>
> I will pass along your regards to prof. Sussman the next time I see him.
>
> Best,
> Joe Dahmen

> Friedland, Ian wrote:
>
>> Mr. Dahmen
>>
>> Your email to Associate Administrator Judycki was forwarded to me for information. We would be very interested in learning about your research and the sound barrier construction technology that you are working on. We might also be able to provide some input on factors and considerations that should be addressed during the course of the research and field demonstrations, should the research proceed to that stage.
>>
>> Please let me know an approximate time-frame that you would be able to meet with us at Turner-Fairbank Highway Research Center (we are located in McLean, Virginia, about 10 minutes from downtown DC), and I will check on availability of the appropriate FHWA staff
>> Best regards,
Ian Friedland
>>
>> p.s. -- please give my regards to Professor Sussman
>>
>>
>> **
>> Ian M. Friedland, P.E.
>> Technical Director, Bridge & Structures R&D
>> Federal Highway Administration
>> Office of Infrastructure R&D
>> HRDI-03, Room F-211
>> 6300 Georgetown Pike
>> McLean, VA 22101
>> ph 202-493-3023 / fax 202-493-3086
>> em ian.friedland@fhwa.dot.gov
>> **



from Buffalo to Toronto (Route 401?) just as it enters Toronto for a test wall of many different finishes.

Possible to suggest the RESB in New Mexico, where the Native Americans are concerned about aesthetics of barrier walls (!). Also many opportunities on park service land

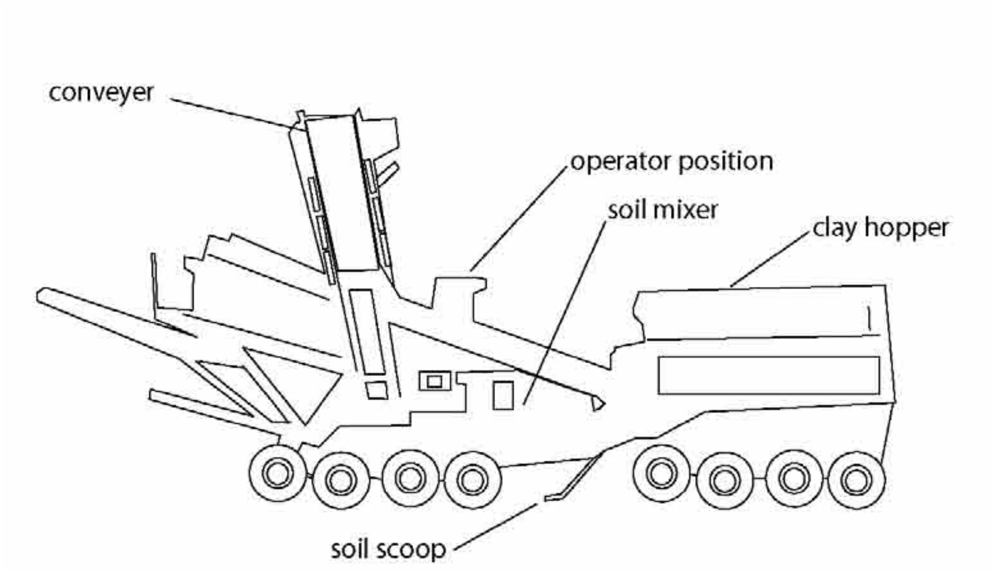
May be necessary to do impact testing: crash test objectives are generally to make products that return vehicles to roadway with minimal damage. Walls that disintegrate under impact, sometimes on the drivers that crash into them, are generally undesirable. Unclear whether impact testing would be a necessity for implementation. (Perhaps the catapult at TFHRC could be used to fire a Buick at a RESB section at some point in the future?) General sense is that requirements for SB implementation, or even standards beyond minimal ones specified by Federal mandate, vary considerably from state to state due to climatic and site conditions.

Quality control of the final product was raised as a pertinent issue: how to ensure that the clay content, aggregate and so forth were present in the necessary quantities. Also need a range of values within which construction can fall and still pass: i.e. not simply an optimal moisture content for compaction, but two values between which compaction will be acceptable, and a method for testing that.

T at top of roof is generally considered to be worth two extra feet of sound barrier, and in the field it is often suggested to simply build two extra feet higher rather than building a T section unless one is desirable aesthetically.

Maintenance, with graffiti was raised as a concern.

GRS (Geotextile Reinforced Soil) is often used as a rockfall barrier along highways. This is being investigated at TFHRC in the geotechnical engineering research group. Basically, layers of a geotextile (woven polypropylene) are laid down and lifts of soil compacted on top of them to around



95% compaction. The wall is faced with CMU on both sides, largely for aesthetic proposes (!) Could not tell whether they build the CMU walls then compact the soil, or vice versa, but it sounded like the latter.

Ian Friedland repeatedly suggested the possibility of pursuing RESB at the state level with Mass DPW (under which MassHighways is a division). He suggested that Professor Sussman at MIT has links with organization within Mass Highways, especially perhaps the director of research. Believe this to be the same one from whom I have recently received a response (or perhaps his underling) but must check on this.

Possible sources of funding:
TFHRC is a research facility that gets its money from the FhwA, and is recently under increased congressional control as to how it spends it. But oversight notwithstanding, TFHRC is in a similar boat to me: it carries out research , and gets money to do it. It is not so much in the business of handing out money, or supporting research outside of its facility. The products that it produces are spread around through

1. Publications
2. Training sessions
3. Information packages

Gradually the picture emerges: research is done that is implemented, if at all, by private contractors who actually get the road and infrastructure contracts from the Gov't. So it is sort of weird, but a model not dissimilar to a research university, without the students, supported by taxpayers.

Federal Lands
Park Service
Federal Lands Highway: consultants for NPS, US Forest Service, and sometimes the Department of Defense(!). Seem to operate out of FhwA budget (?) but not sure. Seem to advice other government agencies when they have road building needs on their own land. This is as opposed to the interstates themselves, which are not owned by the Federal

-----Original Message-----
From: Joe Dahmen [mailto:jdahmen@mit.edu]
Sent: Monday, March 06, 2006 12:29 AM
To: Fallon, John (MHD)
Subject: Rammed Earth Sound Barrier

Dear Mr. Fallon,

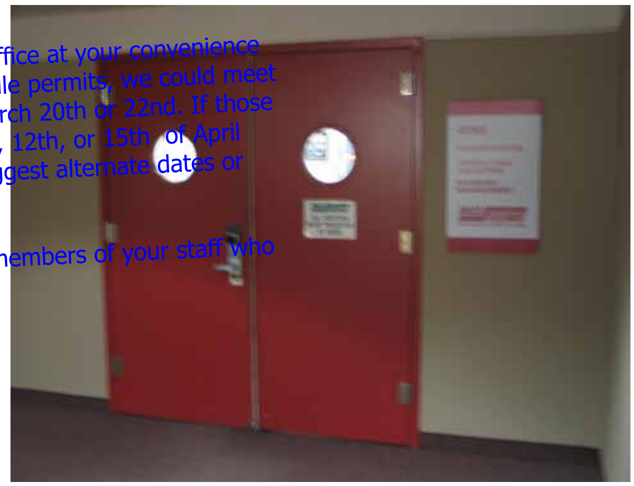
Thank you for your interest in the research that we are doing on rammed earth sound barriers within the Building Technology Research Group at MIT. It would be very useful to meet with appropriate staff in your office to ensure that future research is relevant to practical concerns of the Massachusetts Highway Department.

I would consider it an honor to come to your office at your convenience to present the research thus far. If your schedule permits, we could meet in the afternoon on Monday or Wednesday, March 20th or 22nd. If those dates are too soon, the afternoons of the 10th, 12th, or 15th of April would work fine as well. Please feel free to suggest alternate dates or times if these are not convenient for you.

I look forward to meeting you and any other members of your staff who might find the research relevant.

Best regards,
Joe Dahmen

Joseph Dahmen
jdahmen@mit.edu



Government, but rather the states that maintain them.

National Highway Institute: Offers 2-3000 courses and training
Ian Friedland suggested the following funding sources:

Transport Research Board

Notes from the meeting with Massachusetts Highway Department
Boston, MA
March 10, 2006

Type 1 Sound Barrier Construction: new roadway or new lanes on existing roadway.
Sound barrier required in MA when sound levels will exceed 67 dB overall or cause a 10dB increase over ambient sound levels.

Goal of Sound barriers is to effect 10dB minimum decrease at first row of houses from the highway.

Type II sound barriers along existing highways are on a "voluntary" basis.

Sound barriers must accord with published Aashto certifications, available on the web.

New standards are generic designs-- set of parameters that can be deployed in a range of circumstances. Cost of these in Massachusetts is between $40-$50 per face foot. This price is expected to fall in the near future as it is much higher than the $25 or so that used to be the norm during the mid 90's, before the adoption of the new generic designs.

Wind loading is the major factor in design strength. Have experienced problems with panels popping out due to excessive deflections of tall walls using existing designs.

24' is the maximum height of sound barriers built in Massachusetts.
Sound is a product of tires on the road, engine

-----Original Message-----
From: Fallon, John (MHD)
Sent: Thursday , March 10, 2006 12:29 AM
To: Joe Dahmen [mailto:jdahmen@mit.edu]

Subject: Rammed Earth Sound Barrier

Joe
Nice job today. Very interesting was the consensus. I will be mailing info to you as I come across extra copies pertinent documents. Sorry for the half hazard manner.
The following persons were at today's presentations

Lou Rabito P.E. – Highway Design
Carrie Strassfeld – Highway Design
Matthew DeSorbo –Environmental Section
Larry Cash P.E. – Project Manager
Pete Connors – Geotech Section
Nabil Hourani – Geotech Section
German Neito – Highway Design
Maliha Akhtar – highway design
Melissa Migue -l GeotechJemal Ali – Highway Design

noise, and exhaust stack. Average stack height figured to be 12' in Massachusetts, so most sound walls must be at least this tall. Also embankments often slope away from the road , meaning sound walls must be considerably taller than 12' to reach effective target height.

Various engineers suggested pursuing RE sound barriers in Southwestern states, where the technique is already in use to build homes etc. in addition to New England.

Quality control of the material is a large issue. Preferred scenario two, where clay is stockpiled and dried and pulverized prior to re hydration and use, to scenario 1, where clay is used directly from the truck that brings it wet from the site for quality control reasons. Best of all would be to use prefabricated sections in order to minimize construction time along highway. Although in type I construction, when job site will be ongoing, this is less of an issue. There is an initiative to install sound barriers prior to road construction so that it limits the noise associated with that activity.

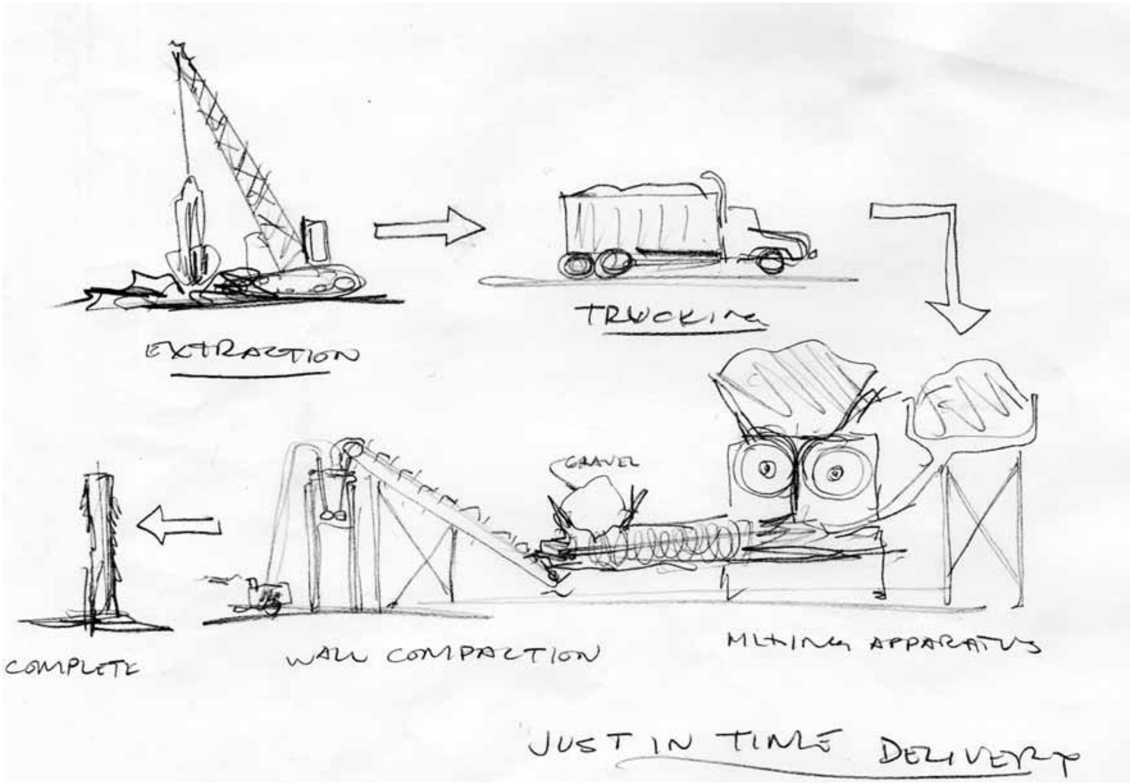
Design of material must keep construction in mind.

They get proposals from contractors frequently wanting to build test walls out of sustainable materials(!) but there is no formal process set up to bring this about.

Suggested building a rammed earth wall at a rest area might be a good place to test the technique. Time less of a constraint and people could see it. Less bad if it fails there.

Perhaps the best way would be to try to set up a research link with Mass Highways. This implies perhaps that they might do the building?

Easiest way possible to set up a research link with MIT would be through state schools with whom MassHighways and other government agencies already collaborate.
Masshighways would have to submit RFP (request



for proposals) which would then be answered by a specific professor at MIT)(?) John Fallon seemed somewhat excited by the prospect of setting up research links with MIT but did not seem sure how this would happen and seemed as though the decision was somewhat over his head. Easiest way methodologically might be to find someone doing this sort of research at UMass and partner with them, as the infrastructure is more or less in place to set this up now.

Must be able to write specifications for allowable soil types, including gradation of particle sizes, allowable amounts of clay, reinforcement required, etc. Most of the specs for sound barriers are available as Aashto standards.

Savin Hill SB north of Boston Globe will be built with steel H piles with prefabricated concrete slats inserted between the piles. Contract awarded earlier n the month. Probably cost between $40-50 pff. Wall will be 400' long located north of Boston Globe. There may not be drawings of this wall, only a text description.

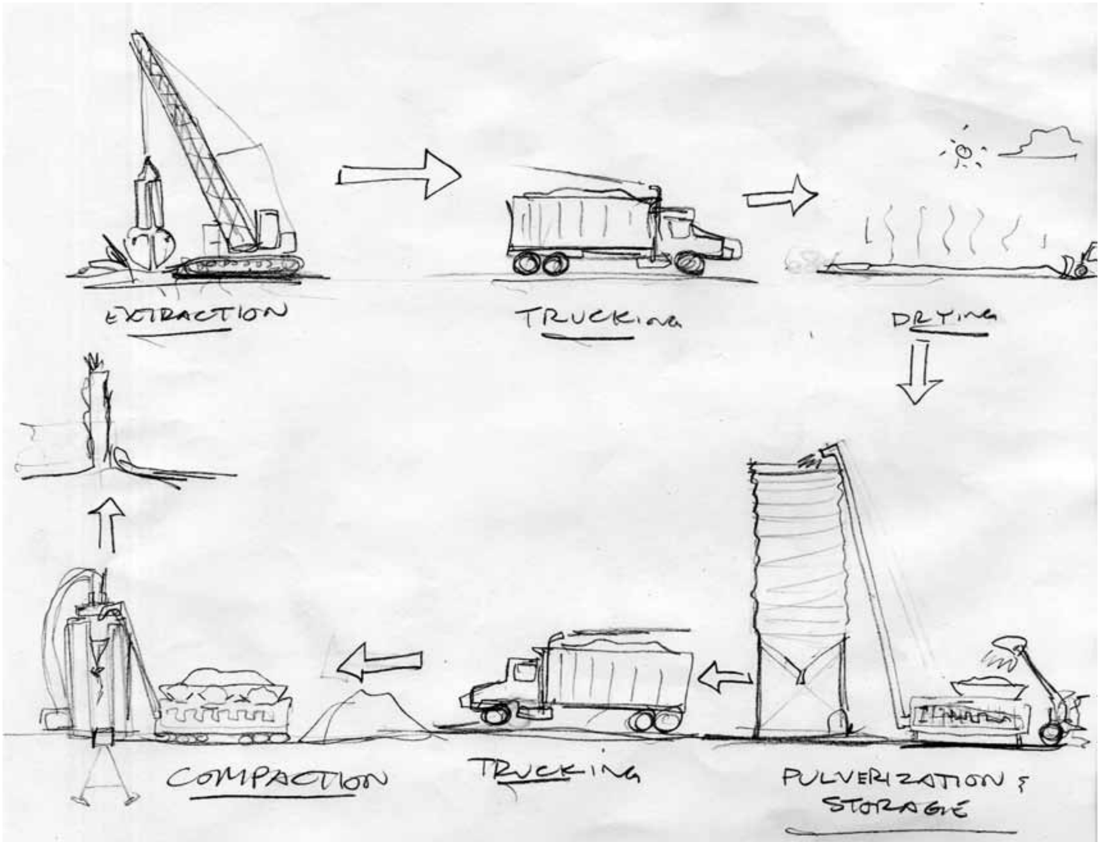
Wind case C and D, Aashto standards(?)

SB required to meet minimum ASTM standard tests for freezing, thaw, spalling requirements for the state of Massachusetts.

Recommend investigating the following agencies:
New England Recycling Center
New Frontiers

Summary

The research and meetings with local and federal highway officials suggest that rammed earth can be adapted for widespread use on infrastructural projects throughout the United States. Mechanization of the construction processes will allow for large-scale infrastructural works at significant reduction of natural



resources. However, state agencies move slowly and cautiously. State highway engineers are very conservative and have little incentive to try new ideas that might cause problems. The central concern raised at the state and federal level is that of quality control. Working within bureaucracy requires establishing extensive specificationsis service of this. Building a rammed earth sound barrier will require a long-term campaign and will likely occur in the southwest where they are more familiar with the method and some standards already exist.

As my research on a rammed earth sound barrier progressed, a paradox emerged about the relationship of standardization to the embodied energy of rammed earth. As rammed earth becomes more standardized, the environmental costs associated with transportation and processing rise. Environmental gains are sacrificed for efficiency and predictability. Thus the initial hypothesis, which claimed that rammed earth must be standardized for widespread use, was valid, but working toward the standardization revealed that time efficiency and resource efficiency are often inversely proportional to each other. This led to the third hypothesis, which compares these two sometimes antithetical forms of efficiency. Material efficiency is explored at the expense of practicality and time efficiency.

4. ANTITHESIS

The meetings with highway officials led to a paradox, expressed as the inversely proportional relationship of time to materials efficiency, which I had come across during the construction of the rammed earth wall at MIT. The construction schedule prevented us from utilizing the site soils for the wall. Instead, we had sand and gravel delivered to the site and mixed it mechanically with the clay, which was also imported. These operations resulted in a very homogenous wall that eliminated all off the idiosyncrasies present in the site soil. This was good for productivity, but represented a large amount of energy in transportation and material processing. These same operations were repeated at a much larger scale in the plans for the rammed earth sound barrier, in which the required quality control necessitated even greater predictability of materials. While importing the materials for the rammed earth wall permitted a great deal of time-efficiency, they resulted in a larger amount of resource use than would have been the case had the site materials been incorporated in the wall.

The exercises in the antithesis section of the thesis seek to reverse this trend of importing predicable material in favor of working only with the materials on a particular site (the bounded operation). This return to a kind of "non-standard" practice also contained within it the seed of its own demise: limiting the material to that which can be found on a particular site, a form of radical site specificity, ultimately constrains formal expression so much that almost no statement can be made. Particularly as this method moved from the exercises in the courtyard out into the marginal spaces along the highway, it became apparent that importing materials was as important for conceptual reasons as physical ones.

A question might be posed about the relevance of learning to work within the severe limitations of found materials and a minimal budget during a time of great financial prosperity. Certainly there were times during the semester when I felt as though the way that I was learning to work might be more suited to say, rural China, than the economic and material prosperity of the

post-industrial United States. Leaving aside for a moment the hunger for limited resources by the construction processes specified by architects, the contention here is that learning to build in a way that requires as little money as possible ensures that when the fortunes of the architect are lifted along with the rest of the economy, the prior training in minimal methods ensure that the architect will use the increased funding to do more interesting things than spending the money needlessly on gold plated fixtures for the bathroom. That alone should provide incentive in learning to work in this way.

Hypothesis
The most materially-efficient approach is bounded by the site.

Investigation
The principal means of investigation for this section is the creation of five building blocks based exclusively on materials that were found on particular sites. These activities introduced the "bounded operation'" in which the activities and materials were wholly circumscribed by a specific location, utilizing no off site material processing, or introduction of outside materials. The blocks created are small in scale, generally measuring no larger than two feet by three feet and formally simple, due to the constraints of the process. The interest in the bounded operation comes from several sources.

Five Projects Investigating the Antithesis

Locations: Fort Point, Building N51 Courtyard, Dog Park Island
Dimensions: variable
Materials: entirely bounded by site
Tools: minimal

Hypothesis: Embodied energy can be diminished by moving away from standardized processes in favor of materials and operations bounded by the site.

These five projects investigate the shortcomings of the rammed earth wall at N51, prioritizing material efficiency over time efficiency and convenience.

Friday March 31, 2005
….Set about making formwork out of the beer cases and other cardboard that had been awaiting the recycler. Using hot glue gun sitting on pavement in lot. Built a box roughly 3 feet by 1 foot by 2.5 feet high. Took old plastic grocery bags and wrapped them around it to keep the boxes from blowing out under pressure of paper slurry I was about to pour in. Whole thing looked tragic. Maybe getting somewhere…. Next attempt with the drill mixer was more successful. 20 minutes reduced the month's paper to a pulpy slurry. Emptied that in the wheelbarrow and threw in some old rammed earth mix that was slumping away in a corner of the yard, a holdover from last summer that had to be disposed of anyway. Tipped that in the wheelbarrow. Put the hoe to it. Mix is strangely lightweight, much easier to work than concrete. Grabbed a handful and made a ball out of it. Unfamiliar feeling…

Tools: Hot Glue gun, knife, drill, steel mixing paddle
Distance driven: 3 miles
Electricity used: 1.1 kWh
CO_2 emitted in construction: 3.6lbs

This block is the result of an investigation into the potential of recycling as a building material. Materials other than flower seeds were those found in pile of recycling for month of March. Binder is paper pulped with water and compressed into box formwork.

Dimensions: 12x30x30"
Materials: Entirety of one month's recycling: cans, bottles, bags, newspaper, magazines, cardboard boxes, flower seeds, water. Formwork: cardboard boxes, plastic bags, hot glue

Dog Park Island Rammed Earth Block

Dimensions: 36x30x12"
Materials: Clay, sand, and shells found on site
Formwork: mobile rolling reusable
Tools: manual rammer
Distance driven: 12 miles
Electricity used: 0 kWh
CO_2 emitted in construction: 7.8lbs

Dog Park Island (Victory Road Park) was created through illegal dumping of construction debris into Dorchester Bay on a 23 acre site from 1979-1983. The Metropolitan District Commission covered the debris with three feet of Boston Blue Clay to contain the contamination and opened it as a public park in 1986.

354 Congress Rammed Earth Block

Location: cut in asphalt parking lot prior to construction of new building
Dimensions: 36x36x12"
Materials: 90%site soil (broken brick, sand, ash, mixed media) mixed with 10%gypsum plaster, water
Formwork: mobile rolling reusable
Tools: manual rammer
Distance driven: 0 miles
Electricity used: 0 kWh
CO2 emitted in construction: 0lbs

Birdseed Block

Dimensions: 12x24x24"
Materials: Limited to what could be found in courtyard.
  Block: Clay, sand, sticks, plastic bottles, birdseed
  Formwork: recycled lumber from courtyard, screws, clamps
Tools: screwgun, hand saw
Distance driven: 0 miles
Electricity used: .22 kWh
CO2 emitted in construction: .3lbs

Construction Furniture

Dimensions: 12’x4’x3’
Materials: wood sheeting, road sign, salvage lumber from construction site.
Tools: broom
Distance driven: 0 miles
Electricity used: 0kWh
CO2 emitted in construction: 0

Summary

The initial hypothesis about the efficiency of building only with materials present on a given site was proven true, although the limitations of building on a particular site only with the material found there limits the expressive potential of such activity severely. Where a reevaluation of marginal sites is desired, such a reevaluation requires more than the site materials alone can offer. Start with trash—add nothing—end with trash results in a non—statement. Most of the exercises in this section were carried out in the courtyard of MIT, which was a sort of "non-site"-- although the materials were drawn from the site there was no real attempt to make a commentary on the site *as* a site. When I carried the experimentation to sites away from the courtyard, a problem became apparent: the refusal to use any materials that were not drawn from the site resulted in limited expression and a product that was almost indistinguishable from the site itself. In short, it was hard to make pieces that said anything at all about a particular site. This was problematic, as I was working with an eye toward the sites along the highway, to try to draw attention to them as spaces worthy of use, or at least consideration. It was clear that some other way of working was needed.

Reclaiming derelict spaces in a resource-intelligent way requires a hybrid approach toward materials and techniques. Derelict sites often require something more than the materials present on site alone can offer. In contrast, arriving at the site with all new materials results in the statement overpowering the particular character of the site. The condition of derelict spaces determined by a lack of concern, so addressing the shortcomings of the site requires importing something to the site for conceptual as well as practical reasons.


4 SITES ALONG
INTERSTATE 93
IN DORCHESTER
I-93
Equipment Alley
Deadman Alley
Trash Cove
Dog Park Island
Savin Hill
Dorchester Bay
I-93

5. SYNTHESIS

This section contains site experimentation in three distinct locations along Interstate 93 in and around the neighborhood of Savin Hill, Dorchester. This was the area that I studied to propose a rammed earth sound barrier. When it became clear that building the sound barrier was out of the question, I returned to the sites to drawn by the marginal spaces along the highway. I had found the spaces while looking for local resources to use in building the sound barrier; I was beginning to regard the spaces themselves as a sort of wasted resource.

These spaces were often used by marginalized members of society. Equipment Alley was used as an informal park by area residents on Sundays, but was too dangerous to use on the other days of the week because of the truck traffic there. Dead Man Alley, which I named for the homeless man that had died there the week before I built my structure in the alley. DogPark Island was created by the illegal dumping of construction debris into Dorchester Bay but during the 1980's.

My intention was to test some of what I had learned in the previous material experiments on these particular sites. The marginal sites introduced a new challenge: whereas the previous experiments had not taken the site into account except as a source of materials, these projects confront the site as material. Moreover, the temporary occupation of the spaces in question is an attempt to draw attention to them as cast-off spaces that might offer an opportunity for creative reuse. As such, the material strategies had to somehow engage the sites in a more comprehensive way then the previous exercises. I relaxed somewhat my previous restriction to use only material from a site.

The rules for this section are the following:
All tools and materials must be brought to the site in my car, a Ford Escort.
Materials used must be 80% from the site
20% of materials can be imported
No material used can be harmful to the groundwater as it decomposes.

The blue foam from which several of the projects are constructed I found in large chunks along the side of the highway that borders on Dorchester Bay and sawed into planks at the MIT woodshop.

Hypothesis
Reevaluating marginal sites requires a hybrid approach in which the binder is imported.

Description of project
temporary occupation of the marginal spaces along the highway. Considers site as the block of material.

Trash Cove Cottage

Location: Trash Cove
Dimensions: 8'x8'x7'
Materials: found lumber, found polystyrene foam, seagrass, rope, tire
Tools: none
Electricity used: none
Distance driven 14miles
CO2 emitted in construction: 9.1lbs

This structure investigates the relationship of building to site. It was built exclusively with materials found in a cove of Dorchester Bay adjacent to an off ramp of Interstate 93. No building materials were imported to the site; tools were limited to those using no energy other than that of the user.

Sunday, April 2, 8am

...By 4 pm the next day I had picked up nearly all of the timbers at the site that were small enough for me to carry. The structure was high enough that I had to stand on timbers dragged to its edge for the purpose of stacking the last pieces. From inside I could stand straight up and be hidden completely from the road, although the spaces between the timbers meant that the sound was virtually

unchanged from inside. The configuration allowed me to observe the off ramp without being seen.... I gathered armloads of the sea straw that covers the tidal region of the mudflats of Trash Cove, bringing the damp straw past the brambles to the inside of the hut. Stuck the straw into the gaps between pieces of wood to create a more complete enclosure. 15 loads of straw and assorted trash along with it and the inside of the structure was now a mostly continuous surface of hay. Not too good against the weather but nevertheless makes the thing look solid from the outside and creates more of a sense of enclosure on the inside. It was built in roughly the same way as a bird builds a home: sticks intertwined more or less at random but the whole thing forming a more or less contiguous whole. When I shook a timber at the middle of the wall, the whole nest swayed gently, gravity and the intertwined aspect of the all of the planks serving to hold it together in a monolithic manner. I picked up the shovel and the rest of my things and walked the half-mile back to the car.

Blue Foam Construction #1

Location: N51 Courtyard
Dimensions: . 8'x6'x5'
Materials: Structure: salvaged resawn polystyrene foam, hot glue, tape
Tools: electric bandsaw, knife, car
Distance driven: 9.1 miles
Electricity used: 2.2kWh
CO_2 emitted in construction: 9.2lbs

Goals: use minimal means to establish structure. Use car to provide formwork for debris encountered alongside highway on travels to and from site. Create value in debris by adding labor to it. Present familiar material in unfamiliar form.

Thursday April 27th
In the courtyard working on the car structure in the courtyard until 3am. Structure built with hot glue, masking tape and foam from DogPark Island using car as formwork. Construction delayed for several hours while I waited for Dewart to vacate the shop so I could run the barnacled 1x3x4" chunks of blue foam through the bandsaw. Car structure collapsed in stages today. Complete pancake by 1pm. Progressive failure, said Axel, who was there to see it as he was working on his skyscraper. Missed opportunity for video. Oh well. Performed better

than I thought it would. Structure stood from the time I backed the car out form under it to when I left. Glue remains in several spots of windshield of the car






Blue Foam Construction #2

Locations: Equipment Alley, Dog Park Island
Dimensions: . 8x6x5”
Materials: salvaged resawn polystyrene foam, gypsum plaster,
plastic sheeting, water
Tools: trowel, knife, stick, car
Distance driven: 19.1 miles
Electricity used: 0 kWh
CO2 emitted in construction: 12.5lbs
The project consisted of the temporary occupation of an alley adjacent to I93, followed by the transfer of the structure by car three miles to Dog Park Island parking lot, where it underwent catastrophic failure.

Sunday April 30, 5:30pm
... After 2 hours or so the cops arrived, followed by two ambulances. Worker at the equipment rental place had called the police, claiming that a pyschotic was iglooing their car in their alley. I was annoyed because I had asked for permission from the rental place prior to building. Cops nodded when I told them it was a disaster housing scenario for an initiative at MIT and asked for my MIT ID, which I handed over. Apparently satisfied as to my sanity, they waved the ambulances away. By six I was ready to drive the car out from under the foam. Several of the workers in the equipment rental place had been taking bets on whether the structure would stand once the car was removed. I handed my camera to man named Joe and he filmed the car driving out from beneath the foam. The

workers returned to their jobs in the office…

Returned to equipment alley at night to remove the structure prior to Monday morning as promised to the Dorchester Police. Thought it would be much easier to just drive off with the thing on the roof of the car rather than demolishing it on the spot... I backed the car back into the shelter and removed the bottom two courses of foam to give it clearance. I secured it with some twine and a stick through the trailer hitch that poked out the back. Then I cut holes for the taillights and unscrewed the licence plate from the front bumper and stuck it to the foam with a couple of sticks. I drove off at 5mph on side streets for Dog Park Island, about 3 miles away....

Wed. May 10th
It was slow going at first. A slow breeze kept knocking over the foam, and the plaster would not kick off very fast due to the wet cold weather. Traffic was loud, moving at 70 mph 30 feet or so from where I was building. Rain stopped and started, stopped and started. Never too heavy. Trying to videotape took extra time, as I had to keep covering the camera in a plastic hood to keep the rain off it. Gradually settled into a rhythm. The quality of this one was much better than previous attempts. Around 3pm a wet man with a dog approached across the playing field on the other side of the chain link fence separating the field from the derelict alley. "Crime scene?" he asked through the fence. I stopped, unsure how to answer his question. My sweatshirt and rain pants were covered in plaster and my sneakers were sopping wet. I still had on my neon construction vest and hard hat to make the enterprise look legitimate from a distance. "Architecture project", I answered. He claimed that a drunk had died in the alley a week before...

Blue Foam Construction #3

Location: Dead Man Alley
Dimensions: . 8x6x5''
Materials: Structure: salvaged resawn polystyrene foam, gypsum plaster, plastic sheeting, water. Seat: salvaged polystyrene foam, hot glue, construction adhesive, automotive epoxy body filler, water
Tools: electric bandsaw, hand tools, trowel, knife, stick, car
Distance driven: 8 miles
Electricity used: 1.1kWh
CO_2 emitted in construction: 6.9lbs

The project consisted of the temporary occupation of an alley adjacent to I93. Structure collapsed immediately when formwork was removed.

Summary

The structures that I built on the marginal spaces along the highway engendered a shift in the thinking of a site as a source of material to a hybrid conception of the site as a material in its own right. The installations seek go beyond the previous exercises, to use the material found on the sites in its expressive potential to draw attention to the marginal spaces. In a physical sense, the pieces were built with aggregate from the site, in the form of salvaged blue foam, stuck together with a binder composed of gyspum plaster. Prior to construction, I brought the foam was from the sites to MIT, where I turned it into tiles with a bandsaw. I returned to the site with the tiles, using fast setting gypsum plaster to stick the tiles together, using the a car that I arrived in as formwork. In some cases the structures stood up when that car was removed; in the last case the structure collapsed as soon as the car was removed. The final installation was made of pieces of this collapse. Relaxing the requirements to allow the importation of a binder to the site was necessary in order to make the installations stand out from the site.

These categories of aggregate and binder, which explain the physical aspect of the constructions, is also useful to talk about the site as material, and my operations on it. The aggregate in this sense is the site conditions to which the installations respond: the noise of the highway, and the derelict nature

of the space there. The binder is the conceptual orientation that makes sense of the operations on the site. That is to say, the attitude with which I arrive (in this case, to draw attention to the unconsidered space of the marginal sites) orients my operations on the site so that they make sense. Any material is a combination of binder and aggregate; in the hybrid operation, the binder is imported and the aggregate comes form the site.

The imported binder, in its conceptual as well as its physical sense, allows the architect to present familiar material (i.e. that drawn from the site) in an unfamiliar form, and hints at the interrelationship of material to form that characterizes architectural operations.

6. CONCLUSION

This thesis is about the relationship of architecture to resources: the composition of materials, the energy that goes into the processing and assembly of them, the time that such activities take, and the space that is created through them. From a certain view, the activities documented in the thesis could be seen as hopelessly out of touch with the contemporary conditions in which architecture occurs. There were certainly times when these thoughts occurred to me during the year. As the saying goes, why reinvent the wheel? Why attempt to build with dirt and trash when we live in a world in which processed materials are so readily available, as close as the nearest lumber yard or Home Depot?

My inspiration for this way of working was informed by an earlier exploration of a much more complicated topic. A decade or so ago at the Media Lab at MIT, John Maeda gathered students together to run through a human simulation of computer calculations. The Human Powered Computer Experiment assigned specific tasks to human actors, who played out their roles in accordance with the basic functions performed by the various elements of the computer. The project was an attempt to gain a greater understanding of what the otherwise invisible electrons are doing at speeds far greater than we can comprehend when we turn on a computer. By engaging with the materials question directly, I hoped to gain a similar appreciation for the often invisible resources that we use in architecture every day often without a second thought. There is nothing like carrying a bag of plaster for a few hundred yards to understand just how much energy is required to transport it.

The result of this process is a way of seeing the world which has changed since beginning the project. I now sense an opportunity when I look at a pile of material almost anywhere, whether on a construction site or a pile of trash at the end of an alley. This is a different place from where I began. During the thesis I imposed limits on what I was doing in order to gain a direct appreciation for the great amounts of resources used in the practice of architecture. An appreciation for the tight interrelationship between these resources is part the outcome of the project. It is impossible to explore the question of the use of resources without pulling in notions about site, context, and the formal concerns that come out of them.

We live during a time when it is possible to get any material from almost anywhere in the world. The ability to use materials from all over the world is generally seen as a positive aspect of contemporary practice by architects, who appreciate the freedom of expression that it offers. However, design is rarely compelling unless it reacts to some limitation, which can be imposed by practical terms or for conceptual reasons. The desire to build in accordance with intelligent use of resources can be one such limit, which is part of what makes the historical schism between sustainable building and good design so difficult to understand. For many years there seemed to be a clearly defined choice between good design and design that took a responsible attitude toward resource use. Certainly in my own explorations I have come up against the difficulty of creative expression within the limits of intelligent use of resources. As I attempted to build using only what I could find on a particular site, I found the means of expression so limited as to render these constructions almost invisible. The blocks of materials had great meaning for me, but to anyone else they were just blocks of material, indistinguishable from the other materials on the site, to which they bore a similarity that was more than passing. I have chosen to accept the minimal use of resources as my limitation, but my desire is to do so in a way that is formally compelling, rather than the preoccupation with resources at the expense of form. Architecture is more than sticking together materials to make form, after all. That much is satisfied by basic construction. Architecture begins when material come together in a way that creates a space challenges or inspires its users: design is about communication of ideas at its core. The challenge that I set for myself in my future work is to use the resource understanding gained through the thesis to engage the highest formal aspirations of architecture.

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All photographs were taken by the author.