

## RESEARCH AS ETHICAL PRACTICE: ACADEMIC GOALS ALIGNED WITH COMMUNITY NEEDS

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### Abstract

*Finding a relationship between the necessarily narrow and often arcane topics that are the focus of faculty research efforts, and the more general format of problems given to their design studios can be a challenge for educators at any level in an architectural program. To then reframe the research for exploration in the community proves especially difficult. This paper illustrates a fortuitous trio of collaborations leading from a research idea to full-scale improvisation in a design/build studio and then to significant applications in impoverished Native American and Latino communities. The opportunities for interweaving research, teaching and community service are acknowledged, as well as the concomitant instances of ethical conflict. Viewing these projects holistically, the research agenda is identified as a thread connecting the various projects in a way that adds value to them other than their immediate contribution to the community or to the students involved. Out of several years of residential design-build projects in low-income communities grew a research agenda, independent of any one project but linking all of them, focused on the evolution of low-cost methods of building with rammed earth.*

Finding a relationship between the necessarily narrow and often arcane topics that are the focus of faculty research efforts, and the more general format of problems given to their design studios can be a challenge for educators at any level in an architectural program. To then reframe the research for exploration in the community proves especially difficult. This chapter illustrates a fortuitous trio of collaborations leading from a research idea to full-scale improvisation in a design/build studio and then to significant applications in impoverished Native American and Latino communities. While celebrating the opportunities for interweaving research, teaching and community service, however, the concomitant instances of ethical conflict must be acknowledged.

In each of the following projects, different priorities exist for the researcher, the students and the community being served. An examination of the projects from each of these priority systems allows the tracing of a research idea from its inception to its current incarnation, as well as a discussion of ethical questions that arise when multiple agenda are superimposed. Viewing these projects holistically, the research agenda is identified as a thread connecting the various projects in a way that adds value to them other than their immediate contribution to the community or to the students involved. Out of several years of residential design-build projects in low-income communities grew a research agenda, independent of any one project but linking all of them, focused on the evolution of low-cost methods of building with rammed earth.

This agenda included: determination of an affordable system of forming rammed earth; refinement of a reliable earth/cement mixture to meet performance-based building codes, and optimization of the use of rammed earth with respect to solar orientation. In short, the goal of the research was to discover a way of building inexpensively with this beautiful and environmentally correct material.

The service-learning projects themselves gave rise to the research goal as the author sought to use rammed earth for affordable buildings because of its positive environmental attributes, and then provided vehicles for empirical investigations in a way that no university laboratory could have. The service-learning projects initiated and fueled the process; shaped the research and were shaped by it. Tangential research topics spun off as necessary sidebars and then rejoined the primary investigation. Publications, conferences, and grant funding were all results of efforts to disseminate this research and, in turn, gave the academic payback needed to offset the enormous expenditure of time and energy on service-learning projects.

## Background

Rammed-earth construction was once a technique widely practiced by the indigenous peoples of the Sonoran Desert. (Gregonis, 1979) This load-bearing wall system was achieved by packing an earth/clay mixture between forms made of wood or cactus ribs. As with many populations dwelling in arid regions of the world, natives of Sonora built with earth because of its relative availability, ease of transport, and durability, as well as its potential for maintaining a comfortable interior environment. The system required wall thicknesses of 12 to 24 inches that tapered in section from base to top. Having almost no insulation value, rammed earth walls served instead as thermal mass, which slowed down the transfer of heat from exterior to interior spaces during the day (and performed the opposite function at night).

The rate of heat transfer through a rammed earth wall is about one inch per hour. In the desert climate, this means that the sun's heat works its way towards the interior spaces, but due to the wall thickness, does not complete the transfer before nightfall. The substantial drop in air temperature at night causes the walls to cool off again before sunrise, as their heat radiates back out into the desert sky. As a result, the indoor temperature fluctuates only 7°F to 8°F in twenty-four hours. The possibility of gleaning most of the construction material from the site also makes rammed earth an economical and environmentally conscious choice of building construction. Rammed-earth construction faded from use in the U.S. for hundreds of years and is recently being revived as an alternative for custom homes. Since the mid-1990's rammed earth construction has undergone a renaissance in the southwestern states, primarily in California and Arizona.

Contemporary construction methods for rammed-earth employ the stabilizing additive of Portland cement, pneumatic backfill tampers to compact the earth mix, and forms fabricated for cast-in-place concrete construction. The high cost of forms and labor take it out of the realm of affordability for most people. However, its positive thermal and environmental attributes make it an alternative that would reduce housing costs in the desert southwest if the construction methods could be made less expensive and the field practices made more reliable.

The Design/Build faculty and staff of the School of Architecture were interested in learning the parameters, limits, and potentials of building with this construction method that had very recently been adopted into the municipal building code. As is common with building codes, the text devoted to rammed earth defines performance criteria but provides no recipes. Without a body of knowledge to turn to for instruction, or experienced local tradesmen with whom to apprentice, novices are left with the need for full-scale experimentation. Questions about soil composition, forming methods, strength and plastic tolerance began to shape a research agenda. To blossom into an applied research project, however, the interest had to be cultivated within an opportunity to actually build.

## The Research

### *Origin of the Research Idea - A Classroom Off the Grid*

The first project involving rammed earth construction was self-contained in terms of research – the professors and students learned about the material in order to construct the building. This initial

collaboration developed in 1996 when the University of Arizona's Athletics and Recreation Department contacted the School of Architecture with a request for assistance with the design of a new classroom facility. One professor in the School, Richard Brittain, responded with an offer of a design/build project and a partnership of two years duration was formed. His fourth year design studio took up the challenge to design an environmentally conscious, low cost classroom facility that could be built by novices. A second semester of design development and construction documents readied the project for ground breaking.

Professors Brittain and Hardin, who would lead students through the construction of the chosen scheme (a structure of rammed earth and insulated concrete block) began to face the realities of functioning as building contractors with little budget for equipment and overhead. An obstacle looming very large in the path of the classroom facility -the need to accomplish rammed earth work without investing in the expensive commercial formwork used in contemporary projects- led to a research goal that would eventually affect the community beyond the campus itself.

Rammed earth construction is currently a high-cost choice for wall systems, as the necessary formwork constitutes a major investment and the labor is specialized. Contractors who focus on rammed earth construction form the entire building at once with many sets of steel reinforced forms that are bolted together, and then tamp the earth/cement mixture in a brief, intensive period. (fig.1) An alternative method of forming walls incrementally, with formwork that could be managed by two or three people and then reused, was necessary for low cost efforts. The efficiency of the large scale forming could be traded for the manageable system, if labor was plentiful and cheap. The problem of developing a low cost forming system for the Design/Build studio was the same as the challenge of bringing rammed earth into the affordable housing arena.

Research into ancient forming methods, soil composition, and wall dimensions led to speculation about a contemporary construction system, simpler and less expensive, that could once again be employed in the vernacular architecture of the region. The specific challenge of designing formwork for the University classroom facility had implications for further, and ultimately more significant research. Several rounds of formwork design and test walls prefaced the actual construction. Before construction began on the classroom facility, formwork designs focused on the goals of mobility and reassembly. Ancient and contemporary Chinese, Moroccan, Australian, and Californian (Easton, D., 1996) precedents for ramming walls in increments led to the use of plywood walls, pipe clamps, and stiffening boards in a simple configuration. After a few test runs with the revised formwork, fine tuning of pipe spacing and placement allowed the building construction to begin.



Figure 2. Incremental rammed earth forms assembled using simple elements.

Developing a working method with the rammed earth forms and earth mixing equipment required moving through a steep learning curve. Initial setting of forms and squaring, plumbing, and clamping

was tedious until a logical sequence became obvious. Incorporation of small chamfer strips to create reveals between the rammed earth and concrete was very time consuming and caused logistics problems. The earth mixing had to be done by hand, as no earth moving equipment was available, and this slowed down the tamping progress. While the students manning the tampers waited for delivery of earth by way of bucket brigade, they continued to tamp each layer in the forms beyond the compaction limits of the soil. This caused some wall sections to be over-tamped, resulting in a rough, muddy finish texture. But, as the construction proceeded, the students developed a rhythm for the work and synchronized the mixing of earth batches, the moving of scaffolding and forms, and the tamping. Eventually, they were able to understand the process and make suggestions for revised formwork, details, and earth mixing techniques. The two-person system of incremental forming became a reliable system with an investment of about \$300 in plywood. As the students honed their expertise with this system, they also identified the main challenges of working with rammed earth: *formwork design* and *reliability of field practices* of mixing earth with cement and water.



Figure 3. Forms are staggered to allow tamping at several locations simultaneously.



Figure 4. Rammed earth walls completed.

#### *Continuation of a Research Idea - Gila River Residence*

Even as students shaped the classroom facility, the instructors realized the implications of the new forming system for the impoverished communities of the region. Professor Hardin wrote a grant proposal for an educational partnership between the School of Architecture and a Native American community that was in dire need of additional housing. The Gila/Pima community had rejected government-built housing that bore no affinity for their traditional building methods, and much HUD housing on the reservation had been abandoned or vandalized. Desperate for ideas, representatives of the tribal Housing Committee had attended student presentations of environmentally sensitive housing proposals, and had already requested assistance from the School of Architecture. The tribal Housing Committee was enthused about the notion of a partnership that would train members of the

community to build rammed earth houses with a low cost system of formwork and indigenous building materials. When the Kellogg Foundation funded the grant, a new collaboration was formed.

Rammed earth was originally a building technique of Native Americans of this region, as was wattle and daub (Easton, R., 1989). Both have been replaced in this century by a composite wall system of wood and packed mud. Houses built with this system on the Gila /Pima reservation are referred to in English as “sandwich” houses (Van Willigen, 1970). Most residents of the reservation live in a sandwich house, or grew up in one. While these houses require constant patching and replacement of the mud, they are valued by tenants for their maintenance of a fairly stable interior temperature in spite of the wide diurnal temperature swings of the Sonoran desert. They also hold considerable cultural value because they are a local tradition and are built by their tenants with found materials from the landscape (cactus ribs, plant stalks, earth) that remain part of the landscape when the houses deteriorate. Sandwich houses are still the most common dwelling type found on the Gila River reservation and new ones are constructed as a matter of preference and also economy.

While contemporary rammed earth techniques differ due to available technology and requirements of building codes, the genealogy remains obvious. The reliance on the earth from the site, the intensity of the labor required, and the uncomplicated techniques involved make it an easy fit in the arid regions of the southwest, with their housing shortages and ready supplies of unskilled labor.

As Professor Hardin worked with the next generation of students on the design of a dwelling for Della Hughes’ family on the Gila River Indian Reservation, new considerations arose. The soil mixture had to be re-designed in order to make best use of the very silty soil found on the site, and the family had preferences for integrating other traditional materials, such as cactus ribs and arrowweed thatch, into the house. Also, Hardin saw the need to revise the formwork to make fewer breakdown and set-up periods necessary, as those took more time and labor than the tamping. A period of design and testing followed, until the 1999 Design/Build Studio felt prepared to begin new construction.

The configuration of the dwelling was a simple rectangular plan (similar to the typical sandwich house) on an eight-foot module to correspond with the form dimensions; adapted to the family’s preferences for orientation, view, and outdoor living practices. This process of configuration, which was informed by discussions of space usage, indoor vs. outdoor plumbing, indoor and/or outdoor cooking, cooling and heating systems, the use of electricity and the re-use of household water, will not be outlined here as it is a study in itself, of a different sort. The considerations that directly affected the construction practices, however, have a place in this text.

The experiences of the classroom facility construction led to changes in the forming system that included: eliminating the use of plywood piers to support the forms (making them freestanding spared a great deal of plywood); doubling the height of the forms (cutting in half the number of breakdown and reassembly activities); and reducing the number of pipe clamps and stiffening boards (again saving materials and handling time). (fig.5) The revised rammed earth formwork proved to be manageable by two people, although a third person was useful in tightening the clamps and checking for level and plumb. The walls of the Gila residence were built in nine days with the participation of members of the Gila River Community construction crew. Gila tribe members formed and poured the footings for the rammed earth walls. Four to six of the crew worked with the students each day and continued the work after the semester ended. During the first two days of wall building, the Gila crew mixed earth and cement, and observed the forming process. By the third day they were engaged in the forming and eventually adapted it for unique situations brought upon the project suddenly, such as the building inspector’s request for a recess to contain the electrical panel box. The last two days of wall building were done entirely by the Gila crew, as the Design/Build studio turned to the challenge of forming for the concrete bond beam.



The new problem revealed in this iteration of building was the difficulty of rebuilding “flying” formwork at the top of the walls in order to pour the bond beam required by the building code. The tops of the rammed earth walls were not level, and it was challenging to find a method of leveling and securing the formwork for the concrete pour. Plywood strips were cut from wall formwork and clamped to the rammed earth walls with snap ties used in concrete construction. 2x4 braces were used to keep the forms a uniform distance from the wall footings, but the system was cumbersome and tedious to construct. Holes left in walls where pipe clamps had passed through turned out to be the most useful points for supporting the forms. This discovery led to the further refinement of the form design for the third iteration of building.



Figure 6. “Flying formwork” for the bond beam was difficult to support and level.

#### *Refinement of the Research Agenda - “A” Mountain Rammed Earth Residence*

A third collaboration formed between Professor Hardin, Dr. Scott Merry (a UA professor of Civil Engineering), and the local affiliate of Habitat for Humanity. Professor Hardin and her students designed and constructed a rammed earth house for Habitat for Humanity Tucson, to house Maria Felix, her five children, and their grandfather. Habitat for Humanity accepted the suggestion of an experimental rammed earth residence from its own Design and Technology Committee, which was advocating “green” building techniques. Professor Hardin was invited to lecture to the committee about rammed earth and straw bale construction, thus having a direct influence on its final choices.

In the pre-building phase of the project, Hardin and her students mixed small batches of rammed earth and broke test cylinders to ascertain compressive strength and other attributes necessary for obtaining a building permit. There is no accessible body of knowledge about other material properties of rammed earth mixtures, including stiffness and shrinkage potential. The composition of a mixture and the compaction is an inexact science, based on rules of thumb and the experience of the work force. Needing more expertise about soils properties, Hardin sought the advice of Dr. Merry. Together with a third crop of Design/Build students and a research assistant in Civil Engineering, they engineered a consistent earth and cement mix with constant water content and sufficient compaction. This involved creating tests and testing equipment in the University’s Soils Lab to evaluate the relationship between the compacted dry density, water content, compaction energy, cement content, and compressive strength of the product (Fritz, 2001). This research led to the next goal; to find ways of controlling the field practices of rammed earth construction in order to parallel the ideal practices established in the laboratory setting. Upcoming experiments will include translating the energy input to the miniature test lab cylinders to a time and area equation for ramming earth with pneumatic tampers in the field, as well as the use of a field kit for measuring water content of a dirt pile by noting the reaction of earth and water with a bicarbonate powder in a closed container equipped with an pressure gauge.

After the achievement of a workable earth mix, the construction of the residence allowed another round of formwork refinement. This time, extra pipe clamps were purposefully run through the top of

each wall to establish a set of holes all the way around the building at the same level relative to the wall footings. Once the walls were completed, pipe clamps could be reinserted into the holes, establishing an armature for the placement of the bond beam formwork. The forms could be rested on the pipe clamps, then fitted with snap ties and carefully leveled as they were tightened. This eliminated the need for bracing below, and made the leveling a fine-tuning procedure rather than a struggle. Even though this refinement proved clear and logical, another improvement became obvious. If a method of pouring an incremental bond beam could be developed, the need for separate “flying” forms for the bond beam would be wholly unnecessary. The required four-inch bond beam could be poured into the top of each eight-foot wall section while the rammed earth forms were still erect. The building code requires a continuous bond beam for lateral support of the walls, but does allow for separate concrete pours if the reinforcing steel is continuous. The next trial will attempt to reconsider the forms to allow the passage of continuous steel through the end boards of the forms and to control the aesthetic detailing of the inevitable cold joints of the consecutive concrete pours.

### Dissemination of the Research

As the research goals of discovering and refining a method of building inexpensively with rammed earth were realized, results of the service-learning projects were disseminated in ways that brought academic recognition to the participants and led directly to additional resources and opportunities. By concentrating on separate issues of technological innovations, pedagogical strategies, community outreach, design quality, and history of the local vernacular architecture, Professor Hardin was able to gain broad exposure for the series of three projects.

The classroom building was honored with a “Sports Facility of the Year Award”, given by the National Intramural Recreational Sports Association in 2001. Technological and pedagogical aspects of its construction were the subjects of five peer-reviewed publications (three volumes of proceedings from conferences on technological innovations in architecture and two volumes of proceedings from conferences relating vernacular architecture to technological issues) as well as six scholarly presentations from 2000-2003. A video production recording the construction process and expanding the documentation with background information about rammed earth was funded by a grant from the College of Agriculture at the University of Arizona, with the intent of distributing it from the agriculture extension sites throughout the state. Professors Brittain and Hardin were named as winners of the Daryl Dobras Award for Excellence in the College of Architecture and Landscape Architecture due to their efforts in the service-learning project. The experience and success with this building was fundamental in the acquisition of two grants (one substantial grant from the Kellogg Foundation and one smaller one from the U of A) for building the Gila River residence in partnership with the Gila River Indian Community.

The results of further research in the Gila project were included in four of the five publications mentioned above, as well as in three additional publications (one scholarly journal article, one other peer-reviewed publication and two invited publications) and an additional scholarly presentation. The residence itself was honored by its selection in a peer-reviewed competition for inclusion in the national Design Matters: Best Practices in Affordable Housing catalog. Participation in the project garnered awards for Professor Hardin as well: in 2000 she won an *Honorable Mention* from the Design-Build Institute of America for “demonstrated leadership in the advancement of best design-build practices and of design-build as the project delivery method”, and an Academy Teaching Award from the School of Architecture. The Gila project was featured as the cover story in the Outreach UA magazine in 2000, generating city-wide interest in the service-learning approach and opening doors for the collaboration between Habitat for humanity and the school of Architecture.

The Felix residence allowed a focus on the earth mixture, opening the door for an interdisciplinary partnership between professor Hardin and Dr. Merry of the UA Civil Engineering Department. The questions about compressive strength, plasticity, and ideal water content piqued the interest of

Wolfgang Fritz, a research assistant to Dr. Merry, who adopted the issues as the topics of his doctor dissertation. His initial laboratory findings became the subject of a jointly authored paper (Fritz, Merry, Hardin 2001) presented at a national conference on thermal envelopes, and fodder for another collaborative paper (Hardin, Merry, Fritz 2003) published in the proceedings and chosen for presentation at an international conference on passive and low energy architecture. The series of three projects, when presented as a related trio, brought recognition to Professor Hardin in the form of the 2001 ACSA Collaborative Practice Award, a national award for the best collaboration of professional practice, teaching, and community service.

This litany of publications, grants and awards is meant to show how a research agenda can come to fruition within service-learning projects. The research, running parallel to the service-learning projects, must have a coherent trajectory of its own. Research interests can begin to define the nature of the service-learning projects and courses; suggesting future projects while creating a basis of support for them. In this way, the service-learning projects can be made to do double duty for faculty who are pressed for time to accomplish publications and other peer-reviewed activities toward promotion and tenure.

In order to balance the faculty member's interest in conducting academic research as a part of service-learning courses with the learning objectives of the students and the needs of the community, it is useful to examine projects from each of those perspectives. The three rammed earth projects are briefly reviewed here (retrospectively) to highlight some of the student and community considerations.

### **The Students' Perspective**

For the architecture students, a new type of learning takes place once the construction phase begins in any design-build project.. Twenty-eight 4<sup>th</sup> year and graduate students registered for the 1997 Design/Build Studio that constructed the classroom facility. Several teams formed to produce shop drawings for each wall and roof plane. Students organized and placed materials orders, met deliveries, and practiced skills such as welding, mixing mortar, and laying block. Carefully dimensioned sketches filled notebooks as students planned and prepared for each day's exertions. Tool belts lost their sheen, thumbs wore bandages, and vocabularies grew. Faculty and students from the Recreation Department joined the effort, shoveling dirt and steering pneumatic tampers. The entire crew was energized by the participation of the clients. As the walls rose, the forming system was rethought, revised, and constantly improved until results became consistent.

As the students honed their expertise with this system, they also became more confident with solving construction problems in the field, trying innovative solutions, imagining how materials assemblies came together, drawing their ideas in their sketchbooks, and relying upon their intuition about physical problems. The impact on their design thinking was immediate and tangible. For many of them, the palpable sense of material properties and the particularity of connections between materials gained in the design-build experience were reflected in their final Capstone and thesis projects the following year.

As with the previous design-build studio project, the new group of students who constructed the Gila River Residence learned in an experiential way that cemented knowledge previously held as an abstraction. The study of materials and methods of construction, traditionally organized into a lecture format, expanded to include all of the realizations and innovations that happen only in the field. Working alongside the Gila tribe members contributed to their learning in ways they had not anticipated.

In spite of her obvious scarcity of means, Della Hughes invited the students and several tribe members to join her and her four children for a meal every day the class worked on her house. She built a wood fire, prepared handmade fry bread, and cooked beans and meat for tacos for each noon



repast. The time and resources invested in her generous offerings made a strong impression on the group who gathered under her thatched ramada. In this situation, students talked to the Gila individuals about their jobs, pastimes, schooling and career plans. On the final course evaluations, several students reported a positive change of attitude about those on the receiving end of community service projects. While not explicitly on the course syllabus, examination of previously held beliefs about ethnic and socio-economic differences and confirmation of an ethic of community service are welcome learning objectives.

The Gila family holds a strong affection for their first home, although it is very small and in poor repair. Built by the late grandfather of the family over 70 years ago, it would remain standing as a storage building or guest quarters upon completion of their new house. The appearance of the mud and saguaro rib walls is a desirable attribute for this family, who asked for a similar appearance in some location of their new home. The challenge to incorporate saguaro ribs into the formwork and earth tamping system of rammed earth led to several experiments with strips of milled lumber and cactus ribs and different methods of embedding them into the earth or attaching them to the formwork. The desired end result was finally accomplished by laying the ribs against the formwork one by one as the tamping progressed, anchoring them into the rammed earth with 3-inch drywall screws, and brushing them with a wire brush to subtract the covering surface once the forms were removed.

The experimentation necessary for the addition of cactus ribs to the earthen walls created the opportunity for a lengthy discussion of professional ethics in the studio. Students resisted using materials in a way they considered gratuitous – unless they served a structural purpose, the cactus ribs were seen as ornamental, and therefore lacking in structural integrity. Responding to solid modernist training, they insisted that the ribs be present only if they achieved a span, bore weight, or transferred loads. However, the saguaro ribs did none of these tasks. After several days in the company of tribe members, student opinions softened. The consensual decision was made to use the ribs, but to set them in 12 inches from the end of the form, which allowed the visual understanding that they served an ornamental rather than structural purpose. The students found an ethical compromise wherein they acknowledged cherished doctrine (a construct of their own educational culture) while pleasing their clients.

The location of the studio project, necessitated by the circumstances of the research grant and tribal partnership, required students to drive 184 miles round trip. While the strides made in the rammed earth form design and earth mix components represented progress for the professor's research agenda and for the larger goal of achieving affordable housing with indigenous materials, some hardship fell upon the students. The time commitment was greater than usual, compromising other activities, and the learning sequence was episodic, interrupted by the long periods in between construction trips and by delays in the delivery of materials and scheduling of tribal workers. Because of the terms of the grant, travel was funded only for the rammed earth and concrete construction; the remainder was left to the Gila construction crew who were to become self-sufficient home-builders. The students did not witness the subsequent stages of construction or the completion of the residence. Given the parameters of the funding and time frame, the students' learning was bracketed by the framework of the overarching research project. In this case, the learning objectives were secondary to the logistics of the endeavor, an ethical dilemma for the architectural educator.

For the duration of the Rammed Earth Residence for Habitat project, the proximity of the site to the campus and the engagement of students in the entire spectrum of construction processes helped to ensure a powerful learning experience. The availability of lab facilities at the School of Architecture allowed for expansion of fabrication opportunities and less reliance on off-the-shelf products. Students welded and riveted steel doors, bent perforated steel eave vents, and inlaid concrete window sills with colored glass or finished hardwoods. The final product was a well-crafted object of pride. Several

weeks after the end of the semester, however, a volunteer paint crew from Habitat for Humanity arrived on site and covered the sealed, natural rammed earth walls with mint green paint.

This action was the result of a lapse in communication between Habitat for Humanity and the professor, who was not consulted or notified of the intention of the president of HFH Board of Directors to paint the house to cause it to “blend in” with others in the neighborhood. The incident illustrates tone of the difficulties in working with an institutional client. The institution has priorities that are defined by general policies and does not respond in an agile manner to the particular circumstances of an unusual, individual project. In this instance, the irreversible painting was viewed as a tragedy by the students who labored for a year to create a unique residence of all-natural materials with no painted, carpeted, or veneered surfaces. One act transformed the learning experience into a bitter perception of futility for many, potentially souring them on community service work in the future.

### **The Community’s Perspective**

At the 1999 dedication ceremony for the rammed earth classroom facility, Richard Ramirez, Director of the Recreation Department, praised the final product as being “much, much more than the metal shed we would have settled for”. When the classroom building was honored with one of the “Sports Facilities of the Year” awards by the National Intramural Recreational Sports Association magazine, it became clear that from the standpoint of the university that the goals of the project had been met. A low cost, functional building broke new ground in terms of energy conservation and materials exploration. Nevertheless, there were ethical decisions made along the way that can be questioned in retrospect.

When the students in the original design studio proposed a building constructed of rammed earth, they had no experience with the material or the necessary construction methods. In design review sessions, they educated the clients with regard to the thermal and aesthetic benefits of the material (thus steering the decision in this direction) but could not speak to the actual costs and technical requirements of the construction. Leaving these difficult issues to the professors and next generation of students (the builders) is not a behavior one would encourage in professional practice. Most often this leads to adequate technical solutions with poor design resolution in the hands of the builder, with associated cost overruns. However, the lead professor was confident that novice builders could successfully address construction and cost issues after a period of research. In the end, the research did result in a commendable process and product, and the award-winning end seems to justify the risky means.

The reaction of the Gila family, their neighbors and the construction crew to the completed Gila River residence has been strong and positive because of the resemblance to their traditional sandwich houses, in appearance, solidity, smell, and surface temperature. The second rammed earth house is already scheduled for construction by the trained crew, using the same soil mix and forms. In this case, the community actively sought an earthen technology for home building, and were willing research subjects. The many arguments for use of rammed earth on the Gila reservation (plentiful materials, no need for importation or transportation of earth, good fit within earth building tradition, low skill labor requirement, high thermal value) underscore an ethical partnership between research and service. This instance, however, may be contrasted with the circumstances of the third project.

The recipients of the Habitat Rammed Earth Residence, recent immigrants from Hermosillo Mexico, were pleased with the natural earth appearance and thermal resistance of their home because of their familiarity with adobe construction. They did not choose to paint the interior rammed earth walls after the invasion of the Habitat exterior paint crew. Additionally, they felt the sturdy thick walls were superior to wood frame walls and would better resist fire and termite invasion. But the larger community, Habitat for Humanity staff and volunteers, were uncertain about the propriety of the earthen walls in the context of Styrofoam and stucco construction. Besides the consenting members of

the Design and Technology subcommittee, there were skeptics within the organization. While Professor Hardin was familiar with the construction technology, there was a steep learning curve for the Habitat supervisor and others. The building process demanded the use of some rental equipment that added logistics work for the staff, and the rawness of the finished product puzzled many who were used to the mainstream housing market. The willfulness of this material choice can be questioned in retrospect.

There are several ethical concerns tied to service-learning here. Partnership agreements between educators and community members should carefully describe the responsibilities and rights of both parties to communication and decision-making. Educators should insist on an agreement that protects the work of the students from disrespect or degradation as far as is possible, and should shoulder the responsibility to educate the public about unusual aspects of the student work.

## Conclusions

### At the End of the Day

*Service-learning can be compatible with academic research; in fact, the field experiences offer opportunities to ground research agendas in the exigencies of architectural practice and the most urgent issues of contemporary urban life.*

As an act of ethical professional practice, the refinement of an inexpensive way to use a valuable material in affordable housing is justified. Professional rammed earth contractors in the Phoenix/Tucson metro areas charge \$26 per square foot of wall area for rammed earth construction (including concrete footings and bond beams). With the evolution of an incremental form system, the cost of the rammed earth construction for the third project was \$3.17 per square foot of wall area (including bond beams). With the hours of student labor factored in at minimum wage, the total cost per square foot came to \$8.77. The current cost of a wood stud wall system (with R19 insulation, sheetrock interior, rigid insulation and stucco exterior) is \$7.42 and a concrete masonry unit wall system (with steel reinforcing, sheetrock interior, rigid insulation and stucco exterior) prices at \$11.17 per square foot. (E-Crete 2001) This points to the potential of rammed earth used as a construction material for affordable housing, especially if the long-term reduced costs of utilities and maintenance are figured in. When viewed as an evolution of a long cultural tradition in this place, the incentive for further research and development of this construction methodology gains momentum. The research-driven development of a low-cost method of building high quality housing brings the principles of the architectural profession into alignment with one of society's most pressing problems.

*The tremendous commitment of time required for developing and teaching service-learning problems can be mitigated to some extent by strategic use of the circumstances for "piggybacking" grants, publications, awards, and other forms of peer recognition.*

Many educators involved in service-learning courses testify to the necessity of spending much more preparation time on these courses than on other more traditional ones. The frequent community meetings, constant logistics planning, and individual student debriefings can claim much of the time usually devoted to research, writing, or service on school and university committees. Unless this extra time can yield academic results beyond the teaching objectives, service-learning projects can be viewed as risky activity for tenure-track faculty. But when mined for opportunities for peer recognition, service-learning projects can integrate the three prongs of academia (teaching, research and service) in a way that describes a coherent and compelling case for tenure and promotion.

*A research agenda developed in conjunction with service-learning projects can be effectively combined with pedagogical and social agendas; although managing multiple agendas requires vigilance in order to avoid priority conflicts.*

While all these aspects of a service-learning project are important, one will occasionally take precedence over the others for some time or even for the duration of the project. It is important for the educator to review the project priorities against the objectives for teaching, the research agenda, and the community needs; adjustments may need to be made in the goals and expectations of each party involved in order to fairly balance the outcomes. A research agenda that ties a series of service-learning projects together into an over-arching investigation or field of study ensures that the sum of the endeavors will be more significant than the list of discrete experiences.

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