

EARTH, WATER, AIR & FIRE:
THE ROMANTICALLY ROOTED JOURNEY OF
ARCHITECT NADER KHALILI AND HIS HUMANISTIC,
ECOLOGICALLY CENTERED DESIGN

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Superadobe construction is a form of place-based earth architecture. The source of this deeply and intricately context-connected building method grew from the passion of one poetic man, Nader Khalili. He was an architect with a humanistic aspiration, and strove to follow this aspiration, designing and building to benefit the impoverished population of the world. He skillfully incorporated both his traditional building culture and technical background to form various earth-based forms, forms that fit their context, were built with the health of the environment and people in mind and formed a bridge between Eastern and Western building culture. Khalili began building with the earth in his native Iran, and carried these earth structures to the United States. Today various projects worldwide have taken his designs and implemented them in a variety of environmental and socio-cultural locations. In this thesis the romantic and poetic roots of Khalili will be unearthed, and past and present relief and education efforts utilizing Khalili's designs will be highlighted and evaluated in light of his design philosophy.

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I was ecstatic about the opportunity to work with this place-based alternative earth building technique, one that at the time was completely new to me. I had no idea that this experience would inspire me to venture beyond those four weeks, and build my senior thesis project from the groundwork of this internship. During my time working on the retaining wall I established fervent connections with both the people involved in this project and the place. I grasped a deeper understanding of the components of the soil, the topography of the land, the moisture, the tropical seasons, and the beautiful power creating something with others. I felt equally emotionally connected to our finished wall and the people whose hands molded and shaped it, more so than during anything I had worked on in my life.

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Preface

I fell in love with a building method, a communal experience working with my hands in the rich earth to create something physical, beautiful, functional and expressive.

I was first introduced to the Superadobe method about a year ago while living in Monteverde, Costa Rica working on a month long internship in the midst of an environmental studies-centered study abroad program. During this internship I worked with an environmental engineering student from the University of Colorado-Boulder, Michelle Sadeghy, and together with her technical background and my design background we designed and constructed a Superadobe retaining wall adjacent to our study center. We worked long hours, often into the night under the guidance of Ayal Bryant, an Industrial Design Engineer from San Jose with past experience working with earth construction. During this internship we were not allowed to call the earth dirt. We were challenged to create something lasting, strong and beautiful, primarily from the earth below our feet, fostering a connection to our place and the resources available at our site.

At the time I knew little about the origin of the design, but after diving into this thesis project I quickly discovered the finer poetic details entangled in the history of these structures. Nader Khalili was a dreamer, dedicating a large portion of his life to transform his vision into reality. I hope this thesis accurately expresses his dreams and functions to further spread Khaili's imagined earth forms into practical use, inspiring more to not only build in the same, or a similar fashion, but also to live their life with passion for the wellbeing of their community and greater ecosystem. Khalili describes in his book *Sidewalks to the Moon* how his quest was to find "ways to put technology into the service of humanity, and at the same time satisfying my heart and my inner fire to create, to create something meaningful" (301). My aspirations for this

thesis are identical, ideally creating a meaningful document to share these inspirational ideas to benefit both humanity and the environment.

CH 1: An Introduction to Nader Khalili's Earth Architecture

“Your imagination my friend flies away then pulls you as a follower. Surpass the imagination and like fate itself arrive ahead of yourself.”

-Rumi

The Iranian-American architect Nader Khalili (1936-2008), was well known for his visionary architectural ideas. Khalili began his work as a conventional architect, designing skyscrapers in the United States and Iran, yet his most influential work came later in his life. Khalili left his career as a professional architect in the United States and rode a motorcycle into the Iranian desert, spending five years in his homeland of Iran following his dream to seek solutions to shelter the world's poor. It was there, in the desert, where Khalili described that he was racing alone to develop his own delicately tailored vernacular earth-based building form.

As well as from historical forms of earth architecture, Khalili was also deeply inspired by the 13th century Persian poet Rumi. The groundwork of his architecture was derived from the simplicity of the four elements of earth, air, water and fire described in Rumi's poetry and the timeless curved dome and arch form indigenous to this part of the world. Khalili desired to empower people, enabling them to build from the earth under their own feet and establish a strong connection to their home environment. He established his own form of earth-based building, one that could be molded to function in a variety of socio-cultural and environmental contexts. He began with his *Gelfaftan* system, intertwining earth architecture and ceramics, and this eventually evolved into the method he coined, Superadobe. In Khalili's second book,

Sidewalks on the Moon, a quote from his wife Marion eloquently captures his overall dreams and aspirations.

His dream is to create an architecture at once contemporary in form and function and brimming with the traditions. An architecture to shelter the poor, yet be desired by the rich. A bridge between the East and the West, the old and the modern. Something that springs from his native culture, but flows beyond its borders. Not a copy of the past, but a shooting star to light the future (65).

The Superadobe method of building with earth dug from the foundation of the constructing-site has been molded to function as an emergency relief shelter strategy, as well as a technique for building permanent structures. Superadobe is an alternative building method that is not resource intensive, yet rapid and feasible for those with little to no previous construction or design experience. To build these structures, the only materials one needs include earth, water, lime or cement, bags and a few simple and basic tools.

Superadobe is place-based design that falls under the eco-centric, eco-cultural, as well as eco-social logics of sustainable architecture, as articulated by Simon Guy and Graham Farmer in their article *Reinterpreting Sustainable Architecture: The Place of Technology*. Superadobe is eco-centric as a simple form of building with a small ecological footprint, eco-cultural in that it can adapt and mold to specific cultural and bioregional physical characteristics, and eco-social because Superadobe is constructed successfully with the cohesive work of a small community. Khalili's architecture intertwines tradition and technology, utilizing the compressive structural strength of the arch and dome form with barbed wire as a tensile reinforcement. The earthen walls of Superadobe function as a thermal mass, experiencing a temperature fluctuation, known as the "thermal flywheel effect," absorbing and storing warmth and re-radiating this warmth into the living space as the mass cools, therefore during the hottest

parts of the day, the inside of the structure is coolest, and vice versa during the coolest time of day (Hunter 3).

Nader Khalili thoughtfully crafted a method of building that intertwined his cultural roots with his contemporary building skills, with the empowerment of people at the foundation. A breakdown of the strengths of Khalili's building style and philosophy includes the following tenets:

- ❖ The structures consist of simple, aesthetically pleasing, inexpensive and rapidly constructed design that is not resource intensive yet creates strong, lasting, and technically sound structures.
- ❖ The design is accessible to those with no previous design, architecture, or engineering skills; yet it takes a community of people to build and the success of the structure is derived from interpersonal cooperation and connections.
- ❖ The buildings are connected to their context and the earth and function in a variety of environmental, social and cultural contexts.
- ❖ The design is ideal for hot and arid climates, yet can also be molded to cope with a range of climatic conditions and was fundamentally designed to be structurally sound in earthquake conditions.

These characteristics of Khalili's earth buildings are prominent in the success of his structures, yet a deeper analysis of the inspirational origin and story behind the design reveals why these characteristics naturally form a deep connection between Khalili's earth buildings and those who construct them. I believe this is because the design was foundationally inspired

and crafted from poetic and romantic roots, specifically the poetic and romantic roots of physical, cultural and spiritual journey of the architect Nader Khalili. A multitude of low cost building methods exist, but this one stands apart due to the richly romantic life of the man who formed these structures based on a humanitarian philosophy. Buildings are not just physical structures to Khalili, but an opportunity to link and passionately connect humans to their environment. Khalili's romantic and poetic roots are a beneficial analytical lens to grasp an understanding of these earth structures' potential to benefit humanity and the environment into the future.

This building method has taken a life beyond the life of Khalili. The goal of this thesis is to not only to explore Khalili's path of discovery and work building earth structures, but also to analyze if the current projects utilizing his designs are holding true to his values and humanistic intentions.

CH 2: Racing Alone: The Story of the Architect Nader Khalili's Journey to the East

I have built a wall in the desert.

A tall wall.

A wall five knees high.

It is casting a cool shadow on the scorching land.

The walls grow much faster than trees here and give better shade for less water.

With a thousand buckets of water I can build a tall wall to give me shade for a thousand years. Each bucket of water in exchange for a year of shade.

And the earth of the wall is the token of land.

(Poem by Nader Khalili, *Racing Alone* 1)

Khalili rested in the cool shadow of a wall, holding wet clay in his hands as his body calmed from the long dusty ride. He had recently left his professional career as an architect in the United States in 1975 and spontaneously rode into the vast desert of his homeland, Iran, to follow a dream. This journey in Iran would last for five years, establishing a new path for Khalili and transitioning from designing conventional skyscrapers to a life dedicated to humanitarian work. The pivotal moment that influenced this drastic life change unfolded in a memorable moment with his four-year old son, Daston.

Khalili and Daston were playing in a park in their hometown in the United States. Daston was racing with a group of other children and Khalili describes how his son was the smallest and the slowest. After Daston came in last after the fourth round, he stated, “Baba, baba, I want to race alone” (Swan 272).

Khalili drew a line on the ground for him and counted one, two three. Khalili describes how his son “ran and came in even later than before, but he brought a leaf with him, and next time he found a flower, he was enjoying his race alone” (Swan 272). Khalili realized that at the same time his son joyfully raced, he was always coming in first. This simple phrase uttered by his young son would have lasting impact on Khalili. He took these words to heart and decided it was time for him to race alone as well. Less than a year later, Khalili closed his architecture office and began his own solitary journey (Architecture for Humanity 106).

In the beginning of Khalili’s first book, *Racing Alone*, he compares this newfound concept of racing alone to the pace of nature. He states, “Horses don’t race on their own; we make them race. They simply gallop to the speed of the wind when free and exalted.” Khalili links the pace of nature to humans, expressing that “we too are created not as masses to race, but as individuals to live and transcend” (vii-viii). Khalili recognizes that he was previously active in the Iranian race with the United States and other developed nations of the world to achieve modernization. Iran felt as a country they were lagging behind other Western nations.

Khalili describes how “up to thirty thousand Americans were living there and doing projects,” including erecting monstrous high-rise buildings within the Iranian cities (Swan 272). Khalili admits that he was equally a part of this race, “digging for gold in the middle of the Shah’s building boom gold-rush”, by maintaining an architectural office in Iran focused on the building of skyscrapers (Khalili, *Sidewalks* 107).

Here in the desert Khalili began his search for an alternative. He unearthed his joy of discovery, ecstasy of creating, and great potential for coping with struggles. He realized the augmented value of personal goals which function to meet the needs of others. When resting below the tall wall described in Khalili’s poetry above, it is clear that he knew this rich, abundant earth held the key to fulfilling his dream. It was at this moment that Khalili first toyed with the concept of utilizing ceramics in building. He realized that he could build a house from indigenous clay and set it on fire to bake it into a “giant hollow brick, like a giant hollow rock” (Khalili, *Racing Alone* 2).

During this period Khalili reflected on the poetry of the 13th century mystic Persian poet Rumi, whom he had read throughout his life. Rumi was a culturally significant Persian figure, whose most distinguished work includes the six poetry books of the *Masnawi* and his prose, *The Discourses*, *The Letters*, and *The Seven Sermons*. Later in Khalili’s life he spent time translating the poetry of Rumi, specifically Rumi’s *Fountain of Fire* and *Dancing the Flame*. When in the Iranian desert Khalili reflected on the four elements of the world, present in much of Rumi’s work and stated, “my dreams were of a simple house, built with human hands out of the simple materials of this world: the elements--- Earth, Water, Air and Fire” (Khalili, *Racing Alone* vii). In Khalili’s second book, *Sidewalks on the Moon*, he provides some insight into the immense influence of Rumi on his life and designs, comparing Rumi’s poetry to architecture and the creation of spaces.

Rumi was the poet I graduated to later on in life. I grew from Saadi, and Hafiz, to Rumi. He is the architect of poets. He overflows with dances, rhymes, flute, and drum. He creates structures, indestructible. He forms spaces, infinite with sacred geometry and colors, designs landscapes where rocks bloom as flowers, perspectives end without vanishing points, horizons end in fantasia, and God changes to mirrors. He is always burning with an eternal fire, and he is very happy to house the fire, to be a kiln. Rumi is the tongue I could not have. And he utters the words I could not utter (69).

Khalili described Rumi as “the great source of my inspirations” (Khalili, *Sidewalks* 70). Rumi’s elements—earth, air, wind and fire—remained at the core of Khalili’s thoughts, exploration and eventually implemented designs. Beyond Persian poetry Khalili also discovered much inspiration in the forms and textures of ancient Iranian architecture. He pondered the “unending curved forms of mud roofs in Yazd, the ancient town made of earth, at the edge of the great desert” and thought about how to apply these spaces to building with earth and incorporating ceramic art (Khalili, *Racing Alone* 2).

It was here, under the tall wall in the desert, that Khalili contemplated catering structures to the Iranian physical environment, with its freezing winters, scorching summer sun, rain and snow and the possibility of earthquakes. He considered glazing and firing earth structures as a viable solution. He visualized this dream in the form of a house and expressed in *Racing Alone*, “Oh yes, when the house is built, when the house is glazed and fired to a solid structure, then no heat of the sun can penetrate it easily, no cold of the winter can enter it fast, no rain or flood can wash it away, and no earthquake can destroy it” (3). While mulling over these preliminary design ideas Khalili expressed that the core function of this work must be to build resistance into houses for the poor, and specifically in a manner that can cope with earthquakes.

At the beginning of his journey, Khalili was living in a village with a population of six. These six consisted of one family, a farmer, his wife, and three children. Khalili built his first design and build workshop on this farmer's land, calling it "Lot 4." He began with exploration of clay and traditional brick making methods. Clay is something that, Khalili asserted, has been used since the dawn of civilization, but today most humans are disconnected from this element. He argues that today we may know more technological characteristics of clay, but ultimately "we have lost the feel for it" (Khalili, *Racing Alone* 10). Khalili is concerned with technological impacts on society, stating that in this techno-centered age of building we are disconnected from the materials that exist outside, below our very feet and only know building materials based as a "substance in a test tube" (*Racing Alone* 9). Khalili blames the rush towards industrialization: "the coming of industrialism with its spangles has thoroughly blinded the human creature to the soul that is alive in clay." According to Khalili clay can "so beautifully mold imagination into form and space", yet today no industry "would use the material were it not cheaper than plastic" (*Racing Alone* 7). He ponders how humans used to create beautiful structures and spaces out of clay, but stopped despite increased technological knowledge of clay's strength. He notes that no contemporary architect or engineer has dared to build a mud vault with greater than a three-meter span when far greater vault spans were built hundreds of years ago, in ancient Iranian cities Yazd and Kashan (*Racing Alone* 9-10).

Despite these observations, Khalili believed that technology is something he could potentially wield to his advantage. To reinforce the many unstable structures in impoverished Iranian villages, technological building concepts could be manifested in a form to function with traditional building materials. Khalili notes the rural houses in Asia built from clay that are easy prey for earthquakes, and brainstorms solutions to low cost housing built in earthquake prone regions. Instead of building foundations connected to the ground he speculates about working with the movement of the earth. He suggests that it might be beneficial to "build separate from

Mother Earth”, with the foundation dug in the ground but the foundational structure of the house unattached to the ground (Khalili, *Racing Alone* 27-28). With the dome and vault form as models, Khalili saw great potential for designing with the freedom of strips of material to create a dome, curve, arch, apse, cocoon, or caterpillar form. At this point he was simply playing with these ideas in his head, striving to create designs that would eventually lead to physical manifestations of his design aspirations.

Khalili’s first officially coined design form the “Cocoon House,” was born amidst these initial ideas of an earthquake resistant home. After seven months in Iran Khalili was finally ready to experiment with the building, firing and glazing of his first structure come springtime. He could not build during the winter and described how the cold winter months were time for “the whole desert to go to sleep and heal its scorched skin” (Khalili, *Racing Alone* 32). The “Cocoon House” was focused on incorporating the technical qualities of an earthquake resistant house, but also was designed to function as a means to heal those in need of rebuilding their homes, and lives, post disaster. Khalili was inspired by the cocoon form created by silkworms and described how “we build walls around our houses for the same reason, as silkworms weave cocoons around themselves, to create a new form of life” (*Racing Alone* 32). Khalili molded a design for humans to form a new life as well. The cocoon design process consisted of first placing a nail in the center with an attached rope to create a rudimentary compass measuring the exterior circular form (the first cocoon experiment was U-shaped). Then one laid down plastic with one half finger’s depth of sand on top, to separate the structure from the foundation in case of earthquakes. Wooden dowels are then placed 30 cm apart around the exterior perimeter to be removed when the structure is complete. When fired from within, the flames can pass through the holes and harden the exterior facade as well. A clay wall base is first constructed and the shelves and conical windows of the house are built by hand with clay within the structure of the walls, using a mix of clay and sand, forty parts clay to ten parts sand.

Khalili's experimental U-shaped cocoon house stood successfully for a few days, until it was destroyed one night by the farmer's animals of Lot 4. After the prototype was destroyed Khalili noticed a single blade of green grass that had grown within the rubble. He expressed how it was fitting in light of the aspiration of this design, as new life was born out of destruction (Khalili, *Racing Alone* 65). During this building process Khalili also experienced a taste of the tradition and cultural ceremony aligned with the traditional Iranian building culture. The farmer's wife insisted on bringing incense to the cocoon house after it was built to bring luck to the structure. Khalili described this as a "touch of deep-rooted culture" (Khalili, *Racing Alone* 56).

At this point in his journey Khalili decided that it would be wise to dedicate more time to learn from the clay masters around the city of Tehran. Eventually he befriended a clay bread-oven maker with experience working closely with clay and fire. He visited this man and marveled at his finished smooth crack free ovens, created from a mixture of clay and straw.

The oven maker, Ali Aga, is someone who continues to be a pertinent character in Khalili's work with earth building. After years of building large material intensive buildings, Khalili delved into traditional brick making, experiencing difficulties while trying to incorporate traditional aspects of the culture with his more modern design plans. He was inspired by the simplicity of this traditional process, one that he believed anyone could master, but was perplexed by how mold this traditional technique to fit with his contemporary additions. Ali Aga built seven-foot ovens in diameter, and Khalili asked if it was possible to structurally enlarge these forms to say, twenty feet in diameter, to form a dome the size of a small house. Ali Aga said that he will not abandon his traditional size to aid Khalili at this time, but says he may be able to do this in the spring. Khalili believed this brick oven-master was simply stalling, hope Khalili would move on beyond these crazy ideas (Khalili, *Racing Alone* 73-74). At this point Khalili expressed frustration in this slow and difficult process and cultural clash, stating

his wish to be both in Iran and the United States at the same time, “because here, in this land, lies a wealth of clay culture that I need to touch, and over there lies a wealth of ease to work on dreams” (Khalili, *Racing Alone* 75). At this point Khalili decided to briefly travel back to America to recruit support for his project because he was unable to tangibly move forward in Iran, entering a period of his journey he described as, “active tongue but dormant mind” (Khalili, *Racing Alone* 102).

After this visit to the United States Khalili returned to Iran with a new strategy. In order to begin work with earth building and the firing of structures within the Iranian community Khalili believed the support of the Iranian government and blessing of the Shah would move the process forward. During his devising of a presentation for Her Imperial Majesty, the Shah’s wife, Khalili came up with the term *Geltaftan* while searching for a name for his design. He became lost in the rich pages of the *Dehkhoda*, the Persian equivalent of Webster’s Dictionary, attempting to illustrate the meaning of the word clay, a word included within hundreds of Persian poems and strongly present in Iranian culture (Khalili, *Racing Alone* 103). Finally, Khalili stumbled upon the composite word, “Geltaftan”, *gel* commonly meaning clay and *taftan* meaning “firing, baking and weaving” (*Racing Alone* 104). This word fit like a glove to describe his proposed building process of firing and baking clay to form a strong and lasting dome. He had discovered his word.

Although the Queen agreed to support Khalili’s idea, he still ran into issues within the bureaucratic system in Iran. Khalili did not receive support from the Iranian Minister of Housing and entered into a nine month period of eleven full presentations, dozens of meetings, and hundreds of phone calls within the channels of the bureaucracy. With frustration Khalili described the system as “bureaucratic channels that are infested with hypocrisy, corruption, and decayed files”, and compared the experience to sinking in quicksand. He wrote, “once you fall into it, the more you move about, the lower you go; and the deeper you get, the closer you are to

being choked” (Khalili, *Racing Alone* 114). Heading back into the desert to Lot 4 with little hope of building and firing in the immediate future Khalili re-thought his plan of action once again.

Tabas: The Earthquake and Pre-Fabricated Relief

A devastating earthquake in the Iranian city of Tabas re-connected Khalili to the humanitarian function of his work. The pivotal role of his architecture was to provide revolutionary cheap and suitable housing for impoverished people, particularly those who had lost their homes to a natural disaster. Tabas is located at the edge of a great salt lake, and is similar architecturally to Kashan and Yazd, the ancient cities with clay-built architectural traditions. Khalili referred to Tabas as a city in the spirit of genuine Persian architecture, in tune with nature and with no intention of dominating it. The architecture was “created from the earth and, over the centuries, learned to live with the desert, to fend off the sun with its thick walls and long shadows, and to break the hostile winds by labyrinth streets and wind catchers” (Khalili, *Racing Alone* 120). The wind catchers of this town had their back to the strong wind gusts but inhaled gentle cooling breezes. The city was intertwined with an indigenous Persian irrigation system called *qanats*, which allowed underground water to ingeniously flow to the surface for use by its people.

At 7:38 p.m. on September 16, 1978 a 7.7 seismic magnitude earthquake shattered this ancient earth city. The city was leveled, bringing the clay structures back to the earth in one single tremor and leaving 12,000 dead. Khalili traveled to Tabas in the aftermath with other architects, engineers and relief organizations. Khalili predicted that with this relief effort would come typical modern prefabricated systems and structures. He traveled to Tabas with hope that his designs could provide an alternative for these people whose buildings had been so fervently

connected to their context. Khalili observed a relief housing effort undermining a traditional building culture.

Surrounded by “the dust of the ruins, the smell of the corpses” (Khalili, *Racing Alone* 122) the petite elderly mayor of the town, who just lost both his city and his family, expressed his primary needs to the relief organizations. He noted that they must fix the main water channel, dig out the rest of the corpses, and most importantly save the trees. The mayor noted that the many orange and palm trees bring life and growth into the city. The head architect for the relief project failed to listen to this wounded man and responded, “we will build you a new town, a modern prefab system, it takes only a few weeks” (*Racing Alone* 122). The architects and engineers then fled Tabas, a mere two hours after landing. Khalili remained with the ruins and reflected on the strong disconnect he had just witnessed between the expressed needs of the people and the short and detached reaction of the head architect.

Khalili witnessed the importance of built structures to this population’s identity, spirituality and process of mourning as the survivors laid out the bodies of the dead on the doors of their fallen homes. They used these doors to ceremoniously carry the lost to the cemetery and Khalili witnessed the hundreds of doors that lined the graveyard. These were doors of all kind, from rich men’s intricately carved house doors to poor men’s stable doors. Khalili also perceived the population’s connection to the natural materials of their environment. He watched a man pray, touching his head, lips and cheek to a piece of dried clay, using the earth in the absence of water, as a religious healing and cleansing material post-disaster. Another man took the dust from the dried ground and rubbed it on his face and the back of his wrists (Khalili, *Racing Alone* 124-126).

The interactions between Khalili and the people of Tabas continue to shed light on the true needs of this town. For example, Khalili spoke to a man who had just lost his wife and children to the quake while this man carefully watered a palm tree within the rubble of his

former home, a home that had been in his family for generations. Khalili asked him about where he would like to rebuild his home. He answered, “of course, here—where else?” as he nurtured the only surviving remnant of his former life (Khalili, *Racing Alone* 127). Khalili knew that the relief architects and engineers planned to place their “prefabricated boxes” on the other end of town, reinforcing the inadequacy of this relief plan to the earthquake victims emotional, spiritual and cultural needs.

Ostad Hasan, another resident of Tabas reinforced these notions of the inadequacy of modern relief housing. Ostad explicitly expressed to Khalili, when he shared that he was an architect, “I hope you are not going to build those cement houses they built in Bueen Zahra after their earthquakes. People use them for their animals. They were built for animals and no one could last inside them. Boiling during the summer and freezing during the winter” (Khalili, *Racing Alone* 128). He went on to explain that he had a cousin in Bueen Zahra and when they went to visit his relief cement home they didn’t know where to take off their shoes and felt like cattle crammed into this space. His cousin then built a home with adobe and clay on the other side of the yard and gave this structure to his goats (*Racing Alone* 129). Ostad and Khalili walked together around the ruins of Tabas and observed a few recently built “modern” buildings erected from steel and concrete, all of which failed to survive the tremor, Khalili believed due to an improperly executed and unstably built construction process. Ostad described how the concrete was not as strong as a material he called *shefteh*, a mixture of lime and earth. The wheels in Khalili’s mind turned. In contrast to the destroyed concrete and steel structures many of the simple clay and adobe domes of the city survived, “hugging each other uncollapsed” (*Racing Alone* 131).

Leaving Tabas, Khalili reflected less on the severe damage of the earthquake but more on the severe damage of the outside relief efforts. He wrote, “every time a quake hits, it becomes happy days for the technocrats, the housing minister’s advisors, and the cement and

steel merchants” who “keep attacking the traditional architecture” and take power from the local knowledge of the people. Khalili was infuriated and believed that “the whole work is nothing but a mockery for a culture that has boasted of the ingenuity of its native architects for centuries” (*Racing Alone* 136). He felt that these architects and engineers had good intentions, yet failed to invest the time, money and communication necessary to implement these relief structures with the long-term needs of the land and people as the primary concern. He saw these architectural efforts as short-term, disconnected, temporary solutions for people in need of longer-term solutions fostering healing, re-connectivity and re-building of their communities and city. Khalili concluded, “it is amazing how blind these specialists and government advisors are to seeing that every time a large quake hits, all their “modern” buildings are leveled as well, and all that is left, if there is anything, are domed clay or brick traditional buildings, more of which will last if some improvements are made on their materials and techniques” (*Racing Alone* 138).

In the leveled ancient Iranian city of Tabas, on the path to be re-built with prefabricated concrete boxes, Khalili uncovered the first potential application of his *Geltaftan* design. He did not feel ready to implement his designs on disaster-stricken people at this point, yet saw the great potential for his building system to function as housing for the re-building and relief housing process. Tabas was direly in need of housing that is inexpensive, can be quickly constructed, is not resource intensive, or can function using the resources at the build-site and creates strong, lasting structures that stand a chance against earthquakes. The people also need housing that can be built by people with little past building experience, and that are environmentally, culturally and spiritually connected to their context. Even Khalili’s fundamental and experimental *Geltaftan* design included these key characteristics.

Iranian Revolution, Ghaleh Mofid Project

In 1979 the focus of Khalili's journey shifted from earthquake-stricken Tabas to the Iranian Revolution, providing the context for Khalili to first experiment with the *Geltaftan* method. During the Iranian Revolution Iran was transformed from a pro-Western monarchy led by Shah Mohammad Reza Pahlavi to an Islamic Republic under the rule of Ayatollah Ruhollah Khomeini (Architecture for Humanity 106). Khalili was not politically involved in the revolution but believed that within the context of the revolution "hopes are high for villages to find their real values again" and "for the culture to find breathing space" (Khalili, *Racing Alone* 152). A revolution that many in the west saw as a return to fundamentalist values was seen by Khalili as a potential opportunity to make a creative break with western modernism, and as a time when he might better be able to exploit the return to traditional values as embodied in the architecture. This freedom left room for Khalili's designs that celebrate and honor the traditional building culture of the region (Khalili, *Racing Alone* 152). Khalili expressed the idea that "the revolution helped my work a lot because it created a crack in the system" with no ministries or building departments and the availability of many students desiring to help (Architecture for Humanity 106). Post-Revolution Khalili began to view the whole country of Iran as his workshop. He saw great potential in firing existing clay and adobe houses in the villages of Iran that were in danger of destruction from climatic conditions like excessive rain and snow. He said that he desired to help "the clients who can only afford their own labor and earth around them" (Khalili, *Racing Alone* 152).

Khalili once again reflected on the simple ingenuity of Iranian Architecture and established three principles based on this traditional architecture to respect and follow when doing his work. He described how architecture is simple, laid out before you by your environment, and evolved around the need of people to live in harmony with their surroundings. In this section of his journey in his book *Racing Alone* he reflected deeply on the natural orientation of a traditional Iranian house and notions of division of space.

All buildings are supposed to face toward Mecca or the sun, which are in the same southern direction...And in the desert your orientation is simple and decided for you: back your wind catchers to the hot wind, face it to the breeze, give sun direction to your rooms, have your court designed for the seasonal movement of the sun. Live on this side of the courtyard in the winter to warm with the sun; and live on the other side in the summer to cool in the shade (154).

Khalili reflected on the typical division of space in a home to fit varying functions and expressed that “all rooms are for living, playing, dining, sleeping” and forms should not determine the functions of a space but instead “forms are eternal; they stand as arches, domes, and vaults, and you build them smaller or bigger” (Khalili, *Racing Alone* 154). From this notion Khalili established three eternal principles in relation to the creation of these curved building forms.

- The principle of resisting the pull of gravity by compression.
- The principle of resisting the heat of the sun by creating a sun-and-shade zone and thus air currents.
- The principle of fighting the earthquake by sharing the forces equally, and of fighting the wind by softening its harsh blow on the curved surfaces.

With respect to these three principles Khalili was determined to focus his work in Iran to find old adobe and clay buildings and strengthen them with fire, as well as construct new buildings in line with the three principles (*Racing Alone* 154-155).

Khalili set out from the city of Tehran to find a rural village for this first firing work.

He desired to find “a real village that represents most of the 65,000 poor, deprived, and forgotten villages” (Khalili, *Racing Alone* 157). He found the village Ghaleh Mofid. Sixty families used to live in this location and only twelve remained. Many of the vaulted roofs of the houses had collapsed from rain and snow and the village suffered from no potable drinking water.

Khalili took clay-adobe samples from this village and traveled back to a brick kiln in Yazd where he had originally tested samples and found that the clay-adobe from this village transformed to quality, strong brick. He traveled back to the village with excitement about the potential to renovate this suffering city but found skepticism was flowing through the veins of the village. Despite political change brought on by the Islamic Revolution the villagers were still enamored with the promises of western modernism. The villagers worried that more roofs would collapse in the coming rain, and that steel and cement were the only ways to fix them. Khalili realized that “the greatest problem in rehabilitating the villages is not the money, the manpower, or the material, it is the rehabilitation from an imported culture shock.” “To reverse all this fatal propaganda that results in the blind copying of the ways of the capital city and in losing respect for their own values will need a revolution by itself” (Khalili, *Racing Alone* 174). Reeducating the villages of the value of tradition proved to be essential to make Khalili’s dream a reality.

Khalili was determined to show the villagers a physical example of what their houses could become. He discovered an ideal example in an old abandoned dome-shaped room used as a kiln to fire clay pipes. This old-kiln, that had been repeatedly fired from the inside, stood in excellent condition adjacent to non-fired buildings that had crumbled through time. The villagers began to show some glimpse of understanding and interest and agreed to allow Khalili to fire a home in their village (Khalili, *Racing Alone* 179).

To do this Khalili returned to his old friend Ali Aga, the man who he said “can speak to fire” (Khalili, *Racing Alone* 193), and asked for his help. After seventeen hours of fire, \$850, and the involvement of the entire small village, the first building was successfully transformed from clay-adobe to strong brick with flame. The entire building, with windows and doors closed with bricks and adobe, was set on fire from the inside out, just like kiln. The same community that has expressed intense skepticism actively participated in the process by performing a ceremony of communal chanting and the burning of *esfand* seeds to bring the structure luck. The children of the village created small statues and pots to be fired inside the building along with bricks and the women utilized the fire during those seventeen hours to do their cooking. Khalili expressed that “we couldn’t deny the excitement that it created for them and the life it brought to the village” as all participated in some shape or form during the firing (Khalili, *Racing Alone* 213). This trial demonstrated how traditional architecture connected with ease to other forms of Iranian culture, tradition and community in a contemporary setting.

The most prominent form of the villager’s acceptance came the following morning after a stormy night. Khalili and Ali Aga came back to the fired house in the morning to find wounds in the wall, notches in the ceiling, and the clay clothing racks Khalili carefully crafted torn off and missing. Both were heartbroken in the aftermath of the successful experience of firing their first house. Later that day, it was revealed that seven of the villagers had slept in the fired house the previous night in fear that their roofs were going to collapse under the fierce storm. They tested the stability of the fired house by attempting to damage it. With all of their strength they attempted to deeply wound the structure of the hard fired surface, but could not do so. Children took the clay coat racks as souvenirs. Khalili was initially infuriated, but after discovering the motivation for the house damage he realized that this was a true test and the best way to show that the people had accepted his work. According to Khalili “the greatest single problem with all housing projects in rural areas of this land has been the villagers’ acceptance” (Khalili, *Racing*

Alone 218). As he had learned in Tabas many of the prefab dwellings are occupied by the villager's animals or left useless. The answer to the success of their work was laid before them. Khalili expressed this stating, "they have tested, accepted, and dwelled in it before we have even permitted them to do so" (*Racing Alone* 219). In particular, many of the villagers particularly liked that the *Geltaftan* system of firing created clean spaces, as well as spaces that were structurally sound. One farmer conveyed that "not a single mouse, tick, or roach is around here. I like this most of all, myself" (*Racing Alone* 219).

A robust sense of community was built and fostered through this experience, from the ceremonies centered on the structure to the inclusion of all members of the community in its creation. The villagers not only strengthened their community but also gained accessible building skills and knowledge, and an empowering and healing experience in the middle of an economically depressed period within the context of the Iranian Revolution. The following day all of the villagers took the day off to hold a ceremony in celebration of the house. They threw *esfand* incense into a charcoal fire in honor of all who contributed, throwing seeds in for nearly every person present. Afterwards they began to discuss the next firing with difficulty; everyone wanted their house to be fired next (Khalili, *Racing Alone* 221-222). Khalili's first *Geltaftan* experiment had been a success.

Despite the cheaper cost of importing glaze, Khalili convinced Ali Aga to make his own glaze to put the finishing touches on the house. They utilized the poison sprayers the farmer's already possessed to spray the traditionally made ceramic glaze. On the walls of the building Khalili wrote a line from one of his favorite poets Ferdousi, "seek knowledge from cradle to grave," below that a line from the Quaran saying "he has created you from clay" and finally the words earth, water, air and fire inspired by Rumi and underneath the word *Geltaftan* (Khalili, *Racing Alone* 230). The villagers all wrote their names on the wall in glaze as well, completing the first *Geltaftan* structure. The room was then re-fired to solidify the glaze and the villagers

took turns peeping through a hole in the structure to see if their names were still there within the flames. Khalili described this moment, watching the flames light up his first successful house, as the greatest moment thus far in his life.

From 1979 to 1980 eight adobe and clay houses were rehabilitated using the *Geltaftan* system in the village of Ghaleh Mofid, with several of the rooms within these houses covered with native ceramic glaze and fired. Khalili and Ali Aga decided that their next step was to construct and fire a new school building (Khalili, *Racing Alone* 232).

Javadabad Elementary School

In 1980 a team of seven began the construction of a *Geltaftan* school building in the village of Javadabad, located in the Tehran province of Iran. The full team who worked to construct and fire this elementary school consisted of Khalili as the head architect, Manouchehr Sedehi, a man with experience in rural development and engineering, Ali Aga the kiln man, two architecture students, Mahmoud Hejazi and Ezzat o Allah Salmanzadeh, and Khalili's sister Fatemeh Nahid Khalili. All worked without pay, along with much aid from the village mason, Ostad Asghar. Javadabad is a low-income village located 90 km east of Tehran, near the desert. The villagers donated the land at the center of the village for the school construction site ("Aga Khan Awards 2004"). The design plan was to construct a ten-classroom school, built with sun-dried mud bricks and then fire the school like a kiln, a few rooms at a time. The school was originally designed as a place of education for both boys and girls, but the existing facilities house solely a girl's secondary school. The total cost of the project was US\$42,000, or \$84 per square meter, with 20% of the cost delegated to materials and 80% to labor costs (Khalili, *Project Summary*).

The team's hope was that this fired school would sustain though rain and snow and that this project would fuel and inspire the people of tens of thousands of similar mud villages

in Iran to take advantage of the benefits of the *Geltaftan* system. Khalili strongly affirmed that this system would improve the structural weakness of some forms of indigenous architecture, would improve the structures resistance to climatic and seismograph conditions, and would increase the hygienic conditions of earthen structures through the firing process. This method provided an alternative to diverging away from more traditional forms of architecture with imported materials and building methods and provided a sense of continuity with the architecture that has existed in Iran for centuries. The foundation of the adobe structure consisted of clay-based earth stabilized with lime and adobe bricks. To fire the structure bricks were loosely placed on a layer of clay and straw, doors and windows were temporarily blocked, and the interior was baked by a torch located in a hole in the center of the room at a temperature of approximately 1000 degrees C. Once the structure had cooled, the school facade was finished with a gypsum plaster (Khalili, *Project Summary*).

Khalili and his team encountered many impediments in their journey to bring this school to life. Originally many of the villagers of Javadabad were unhappy with the construction, believing it was taking money away from the revolution, and not understanding the team's humanistic intent. The town mason told Khalili's team that he had not built with adobe in fifteen years and only builds "modern houses with steel roof members, concrete foundations, and factory-fired brick" (Khalili, *Sidewalks* 93). Yet, the mason did shed light on his inter-generational knowledge, passed down from his father. He knew how to build arches, domes and vaults from adobe. He simply did not believe that people wanted these kinds of buildings anymore. After speaking with Khalili and visiting the old town kiln, the mason gained an understanding of their vision and agreed to unearth his traditional building skills and aid with the adobe structure before firing (Khalili, *Sidewalks* 94).

In the context of the Islamic Revolution and the dissolution of the previous government's bureaucracy Khalili was able to receive approval and funding from the governor

of the Tehran Province. Khalili articulated that this revealed the crack the revolution had created in the previous government bureaucracy (Khalili, *Sidewalks* 95). The team had proper funding, help from the local mason, and eventually approval from the villagers, but then faced an exterior challenge far beyond their control. Iran and Iraq had declared war.

In an interview with Khalili in *Design Like You Give a Damn* he stated, “Iraq was bombing Iran, I was firing a school, and we were not supposed to have any light at night because of air raids. But I had absolutely no fear. At the time I understood what passionate means...When you are burning inside, outside fire means nothing. The heart becomes a kiln” (106).

Despite Khalili’s passionate ferocity they had to cope with the possibility of bombing threats every night and took practical safety steps like dispersing people away from the central school and turning off all light sources every night. These safety measures directly contradicted the *Gelftaftan* method. Khalili described how the village was in the flight route of the Iraqi fighter plane’s attack route to the capital city of Tehran “and since we need to keep our fires on for three days and nights during the process of baking the school rooms—and the flames will rise over the flue stack to above a knee-high elevation—we are always in danger of being attacked” (Khalili, *Sidewalks* 100). During their time in Javadabad a village fifteen minutes away was destroyed by bombs, therefore during the whole process they were very conscious of this risk.

As the Iranian Revolution and conflict between Iran and Iraq persisted Khalili continued to encounter roadblocks and issues impeding his work, eventually leading him to flee his troubled homeland and seek opportunities to fulfill his dreams in the United States. Khalili described how in the context of the Revolution music, dance and the arts had to

consistently fight for their life, and he knew his work was in danger. Khalili received a letter from the Building Research Center of Iran saying that he was a “corrupt, satanic, anti-Islamic who is abusing the blood of all the martyrs of the revolution with fraudulent ways of making lots of money” claiming to build houses for the poor. Yet these “buildings are weak and will crumble against wind, rain and any load applied vertically or horizontally” (Khalili, *Sidewalks* 128). This letter was signed by Samad M., the chief engineer who had approved the loading test on their fired building, granting them official permission to build and proving the structural soundness of the building’s design. The letter additionally explained that they were actively warning all the officials of all regions and cities of the danger of Khalili’s work (*Sidewalks* 129).

Despite the Revolution’s purported return to traditional values and Khalili’s rejection of modernist techniques, in this confused political period he was attacked. Khalili, his team, and the community in Javadabad expressed their confusion in regards to this contradictory letter filled with fraudulent technical jargon. At this point Khalili had traveled to many parts of country working with his low-cost, community fueled building program, had met with the first president of Iran, Dr. Bani Sadr and discussed working in the flood and war ravaged Dezful and Ahvaz regions. He had trained students to travel to the border towns near Afghanistan and Pakistan to disseminate his building method, and had evolved his *Gelftaftan* system of firing and glazing. Despite this progress Khalili urged his team to pull out of the work for their safety but they refused and stated that they had to finish the school (Khalili, *Sidewalks* 131-132). The school was completed in September of 1980 and was occupied in the winter of 1980 (Khalili, *Project Summary*). As the revolution and war continued to accelerate and the strong accusations against Khalili and his work had little hope of diminishing he decided it was time to leave Iran and headed to California. Once again, Khalili reflected on the influence of Rumi in his life. He articulated, “any time I come to a dead end in the analytical process of acquiring knowledge

then I follow another path, the way of visions, dreams, mysticism, and the quest for seeing instead of learning” (*Sidewalks* 155). With this Khalili followed a new path, one that he described as a path that crossed the bridge between logic and insight, material and spirit, and dream and reality, to fully explore the potential of his work in the United States (*Sidewalks* 156).

Khalili’s passionate work in Iran, from first exploring traditional brick making to constructing and firing an elementary school, is brimming with his humanistic and ecologically centered philosophy. A journey back to his homeland held the spark to light the flame within this architect. There exists unwavering evidence that Khalili deeply desired to help people. He provided many with building experience, as well as strove to intertwine them to their culture, community and environment. The same altruistic characteristics can be seen as Khalili transitioned his work back to the United States.

CH 3: Gelfaftan to Superadobe

-Aab kam joo teshnegi aavar bedast—

Seek not water, seek thirst.

-Rumi

Khalili described this phase of his life as a period of thirst; thirst for knowledge and for pushing the boundaries of creativity (Khalili, *Sidewalks* 197). During construction of the Javadabad school one of the villagers told Khalili that he should fire adobe buildings like this in the city of Tehran if he wants smaller villagers to adopt the method because “we only copy them (Tehran) because they know how to copy the foreign countries” (Khalili, *Sidewalks* 199). This statement deeply impacted Khalili and he described how the West, particularly the U.S., “is the fountainhead of the media and of most things called modern—which the rest of the

world copies blindly—then it is here that ideas must first be effective before they get to the masses” (*Sidewalks* 200). This sheds light on Khalili’s possible motivation to transition to working with earth building in the United States, beyond the difficulty of working in Iran during the Revolution and Iraqi/Iranian conflict.

Soon after leaving Iran Khalili’s work with earth architecture began to evolve and transform. In the United States he crafted a new form of building, building solely with earth. Khalili’s personal challenge was to develop a means for anyone, despite their educational or socioeconomic background, to build with what they already had, the soil underneath their feet. The *Gelfaftan* method was relatively cheap, but still not feasibly affordable for all (Katauskas). Soil is abundant and accessible worldwide and Khalili desired to design a building method that could function with all types of earth, from dense clay to sand.

In 1984 Khalili was invited to submit a one-page abstract of a paper presenting ideas for moon construction. He began to dabble with the design that would eventually evolve into Superadobe. NASA accepted his proposal and asked him to present his ideas at the NASA sponsored symposium for “Lunar Bases and Space Activities of the 21st Century.” Khalili described how this “set my thirst aflame” (*Sidewalks* 197). Khalili was inspired by the characteristics of molten lava, which forms a hard crust or rock when it comes in contact with air, creating caves, domes and arches naturally. In his speech at the Lunar symposium Khalili discussed these natural magma formations, as well as reflected on how buildings have been historically built in harsh climates with earth and rock. He spoke of the value of utilizing arches, domes and vaults, natural material, gravity and angles of repose to form structures. These “principles and techniques,” he argued, “are the inventions of the genius of human minds in the last 4000 years” (*Sidewalks* 217). One of Khalili’s specific design proposals consisted of the creation of fused-adobe blocks to form arches, domes and vaults with dry-packing, corbelling and leaning arch techniques. The symposium audience loved Khalili’s presentation and he was

invited to speak again at the Los Alamos National Laboratory. An excerpt from Khalili's poetry about his lunar designs follows.

sidewalks on the moon

I build my home on the moon

hunting space in cocoon

lunar dust and solar rays

are my substance every phase

craters I pick for the site

since they're made by meteorite

lay my house in evershade

where the shadows never fade

neighbor with the solar zone

where the sun forever shone

(Sidewalks 224)

Khalili's lunar designs consisted of the same unwavering consciousness for humanistic and environmentally friendly construction, founded on poetic notions. He wrote in his typical poetic language "to leave the moon free from blinding shiny faces of steel and titanium, and to walk on it with gentle and kind steps is to respect the souls of our fathers and mothers whose dreams have come to us in the gentleness of silken poetry and mystic music" (Khalili, *Sidewalks* 225). Khalili was invited to create NASA prototypes, funded by NASA and the Los Alamos

National Laboratory. In his text, he concluded a section of the story of his work for NASA with an ancient Persian story by Rumi. This story describes a flock of birds that go on a long journey only to find a mirror at the end. Khalili reflected on how his journey mirrored this ancient story; he had been searching his whole life for meaning and the most meaningful work and ideas had been lying deep within him from the beginning (Khalili, *Sidewalks* 317).

Khalili's final lunar design, coined "Velcro-adobe", consisted of Velcro bags filled with earth and stuck together. Khalili described how "in the very low gravity you don't need anything else...they are heavy, since you need at least 15 feet of soil on top of any structure you build on the moon to keep out the radiation, thermal extremes, and the impact of meteorites—then sandbags can be the structure as well as the shielding" (Swan 273). This very design transformed into Khalili's Superadobe method.

Development of Sandbag Shelters

Every man and woman is a doctor and a builder to heal and shelter themselves.

-Nader Khalili

The lunar design remained conceptual but served as a foundation for Khalili's implemented sandbag shelter design. In Khalili's manual, *Sandbag Shelter and Eco-Village*, he asserted that the function of the book was to empower people to form the materials of war into safe shelters. These shelters utilize primary war materials, sandbags and barbed wire. The materials could be utilized to communally create small homes in the context of displacement due primarily to conflict or natural disasters (Khalili, *Emergency Sandbag Shelter* 9). In keeping with his worldview of seeing architecture poetically, Khalili fervently believed in symbolically utilizing the materials of war to build instead of destroy. He worked to integrate traditional earth

architecture with contemporary global safety requirements, to design a shelter that combined maximum safety with minimum environmental impact (“Aga Khan Awards 2004).

These sandbag shelters consist of standard sandbags filled with a stabilized earth mixture. Local earth material functions as its primary construction resource, exemplifying a place-based alternative building method. The earth is stabilized with varying mixtures of earth, lime, cement or asphalt emulsion and water. The stabilization of the earth within the bags allows for a wide range of soil options and the use of a stabilizer within the soil mix functions to resist water absorption, extending earth construction to areas where earth building is not typically used, like colder and moist climates (Hunter).

The sandbags are then stacked into arches, the arches are staggered into vaults forming a dome form and the sandbags are held together with barbed wire. The barbed wire replaced the concept of Velcro attachments in his lunar design, acting as both a mortar and reinforcement creating tension and friction between the bags. Dependent on the available materials at the build site the sandbags can be filled with a wide range of materials, from pure earth, to pure concrete, to stabilized earth, to recycled materials, creating flexibility and adaptability in the design based on the particular context. These shelters cost a few hundred dollars to build and are designed to function primarily as a temporary shelter (Khalili, *Emergency Sandbag Shelter 14*).

Development of Superadobe

To transform his temporary emergency shelter design into a structure that possessed greater permanence Khalili made a few simple changes in the overall design. He replaced the sandbags with long polypropylene sacs formed into “earth coils” to create the same dome form. Khalili calls this process “corbelling,” named after the ancient method for creating curved roofs, coiling layers of earth filled sacs on top of each other placed gradually inward to produce the conical shape (Khalili, *Emergency Sandbag Shelter 16*). The longer sacs are once again filled

with available material, yet ideally filled with stabilized earth to create the most structurally sound dome. The filled sacs are compressed and held together with a layer of barbed wire and the exterior facade is plastered to complete the structure. The layers of coils function as a low-tech form of compression, where the barbed wire functions as a high-tech form of tension for the structure. Smaller versions of this design cost approximately the same as the sandbag shelters, yet more complex designs can reach around a thousand dollars to construct. Khalili named this design the “Eco-Dome” (Khalili, *Emergency Sandbag Shelter* 14).

Khalili designed the Superadobe structure with desert landscapes in mind, where thick packed earth forms function to reduce internal heat gain during the day and heat loss at night. In these regions earth is more abundant in comparison to other building materials like timber or stone, providing additional validity for this design in a desert environment. It is not clear whether this was an objective of Khalili’s, but he also simultaneously developed a system that has the potential to function successfully beyond dry and arid climates. In Monteverde, Costa Rica we explored this building method’s potential in a tropical climate through the construction of a retaining wall built to alleviate the degradation of an eroding slope adjacent to the CIEE study center. The finer details of Superadobe will be articulated through this experience, supplemented with additional information needed to construct the full dome from Khalili’s manual, *Emergency Sandbag Shelter and Eco-Village*.

Description of the Superadobe Process in Detail: Conservation and Sustainability Internship

Monteverde, Costa Rica

Methods

The creation of our Superadobe retaining wall consisted of a three-part approach, a one week long analysis and design phase and three week long construction phase.

We began our analysis phase with basic research on the essential components of a retaining wall, exploring both the basics of the Superadobe building technique and other retaining wall building techniques, for example tire-based or cement retaining walls. We also watched a film by Cal-Earth, Khalili's school of earth architecture, to further enhance our background knowledge and learned much from our internship advisor, Ayal Bryant, who had background experience with earth construction.

We took this background research and applied it to the necessary functional, environmental and aesthetic considerations for our site. Monteverde is a small town located on the continental divide in the mountainous region of Costa Rica. The dominant weather pattern consists of a dry season typically from January to May, and a wet season from May to December. Some of our main functional and environmental concerns consisted of preventing further erosion and increased sedimentation into the adjacent stream, mitigating a potential future landslide of the degrading bank, and providing drainage for excess water during the rainy season. Aesthetically we were challenged to create a wall that blended into its natural context, create the potential for a vertical garden within the wall, and create an additional social outdoor space for the adjacent CIEE study center.

The foundational concept of Superadobe is to utilize the soil at your own site to create a stable mix to fill the sacs, so we conducted soil tests to determine our best possible mix for our site. By taking a sample of our site soil and placing it in a jar of water, letting the various particles settle with time, we discovered high clay content in our on-site soil. We conducted stability and humidity tests with different mix concentrations of soil, lime, and water and also soil, cement and water. Our soil tests were very similar to the tests Khalili described conducting in Ghaleh Mofid, where he described taking portions of his fired adobe and fully encompassing it in water then, testing the samples ability to hold its shape and form (Khalili, *Racing Alone*

220). Due to monetary and time issues, as well as the stability success of the cement mixtures, we decided to utilize a ten to one, soil to cement ratio for our fill mixture.

After soil testing we did an overall site analysis (Figure 1) of the corresponding study center back and side yard, focusing on main areas of rainwater drainage, particularly of the slope directly above the planned wall site. After this site analysis we began brainstorming both the technical (Figure 2) and artistic (Figure 3) designs of our wall and created hand-drawn drafts of our design ideas and site analysis as seen in the attached figures.

Once our designs were approved we began the three weeklong construction phase. The construction phase consisted of three major steps, creating the foundational technical structure, plastering the exterior, and adding the aesthetic finishing touches. Our first step before wall construction was to shave off a large portion of the overhanging eroding slope and collect this earth to use later as bag fill. We also dug out a large portion of earth at the base of the wall, attempting to even out the existing hillside, forming more of a ninety-degree angle between the ground and the vertical slope. We then dug a large trench to form the wall foundation, adding additional earth to our supply for bag fill. Within the trench dug below the ground we first placed a layer of black plastic and then a thin layer of gravel for drainage purposes. Then, in a slightly curved formation to match the natural curve of the slope, we laid three layers of double bags in the trench below ground, nine layers of double bags above the ground, and four single layers of bags at the top. The length of the 14-inch wide bags was measured by counting the number of foot lengths and adding a few extra to account for excess bag needed to close the ends of each coil and expansion room when filled with the earth mix.

The bag laying process required much physical work, consisting of mixing the cement, earth and water mix in a wheelbarrow with a large shovel (as seen in Figure 4) filling polypropylene bags with this earth mix utilizing a small container (as seen in Figure 5), and compressing the filled bag with a metal tamp using a mechanism called "tamping" (as seen in

Figure 6). The work was most efficient with two people mixing in two wheelbarrows, two people taking the mixed earth and filling the long polypropylene bag held by the fifth team member. Khalili describes in his manual, *Emergency Sandbag Shelter and Eco-Village* that one must conduct a 'hand moisture test' to determine if the earth mix is adequate. Under the instruction of our internship leader Ayal we conducted this identical test, squeezing the mix in our hands, and gauging its strength if the mix formed a ball that neither fell apart nor dripped excess water.

To begin laying a bag the team member holding the bag would first take an extra foot of bag material and fold it underneath. They would then step on this piece and then use their shin to hold up the bag as it was filled, compressing the earth mix with their body weight as the bag was filled and slowly laying it down in proper place. Twisting the bag as it was filled aided with filling the complete potential volume of the bag. When the full length of the bag was tightly filled a team member sat on the end of the bag, compressed the end with a brick or rock, and then would fold the excess bag underneath, laying the tightly filled end over the fold. The full bag was then repeatedly "tamped" with a tool we constructed out of a long metal pipe and metal plate, until the filled bag made a clear ringing sound upon contact with the tamp.

As we constructed bag layers we angled the wall slightly towards the hillside to cope with the lateral pressure of the soil at our determined angle of repose. In Nader Khalili's manual, *Emergency Sandbag Shelter and Eco-Village* he provides an explanation of the angle of repose stating, "when earth is piled up it naturally forms a cone, the shape of a mountain. The conical or domed shape is the natural structure of earthen material in harmony with gravity. And its slope is called the earth's angle of repose" (24). Interwoven between each layer of bag we attached a curving layer of barbed wire for the double layers and a straight line of barbed wire for the single upper wall layers to add additional structural support. Between the double layers we incorporated three layers of 6" diameter pipes, extending from the backfill to the front of the

wall, for water drainage. The backfill, encompassing the empty space between the wall and the natural hillside, was first filled with gravel and large rocks for additional drainage, and then with soil on top to eventually plant in, to augment the stability of the cohesive system of our wall and the hillside with the strength of plant roots. Two side buttresses were constructed with three short single bag layers for additional structural support and outdoor seating.

After the structure of wall was complete we coated the exterior of the bags with a tar-emulsion, a waterproofing agent to help cope with our particularly wet tropical climate. When the tar was dry we began our plastering process, as seen in Figure 7. We used an initial thick layer of plaster as a base coat to fill in the larger spaces in between bag-layers. This first layer of plaster consisted of cement, fine sifted soil, and a much higher concentration of water. After this initial layer was applied and smoothed, we applied a topcoat plaster layer of a mixture of cow manure, cement, fine soil and water.

Simultaneously throughout the plastering process we began to implement the aesthetic elements of our design, just as Khalili in his earliest experiments in Iran included aesthetic touches. We used recycled aluminum cans, peanut cans and plastic flowerpots, placed them within the wet plaster base coat near the top of the wall to begin our tree design. We plastered around these pots, fully incorporating them into the wall and smoothed all surfaces. Within the top plaster coat we added leaf and vine mosaic designs between the pots with broken recycled green glass. Figure 8 illustrates the planter and glass mosaic design elements. After the wall was fully plastered, with both base and topcoat, we mixed a different plaster mix, with a higher concentration of manure, to use a method called “reptiling” to form the tree trunk and branch design. “Reptiling”, a technique described by Khalili, consisted of molding the plaster into small balls and gently throwing them onto the wall in the design we desired. The balls formed scale-like looking details that we used to connect the tree trunk to the pots as branches. The “reptiling” technique can be seen in Figure 9.

Results/Final Product

Our preliminary products consisted of a series of drawings illustrating our site analysis, initial technical and aesthetic design, and a final structural/technical design. We proposed two trenches to be dug parallel to the slope above our wall site to help alleviate the pressure of water flow during the rainy season in Monteverde, and instead divert this water to the adjacent stream. During the construction phase we did end up digging these water diversion trenches, and used this additional earth to fill bags.

We planned to use a technique called “retiling” to create the organic tree design and implement planters within the wall to imitate the natural look of a tree’s leaves. Along with the “retiling” design forming a tree trunk form we also initially planned to construct a bench in front of the wall. This bench was designed to function as an additional support structure as well as a portion of the wall functioning as a comfortable outdoor patio space. Due to time constraints we could not complete the bench part of the aesthetic design but successfully completed the tree on the facade. The finished technical structure of the completed retaining wall can be seen in Figure 10, with a height of approximately 1.3 meters, length of 5 meters, and width of 1 meter.

The final product of our month long internship was a fully constructed retaining wall that fulfilled our desired fundamental technical, environmental, and aesthetic characteristics. We successfully implemented the basic Superadobe structure to create a structurally sound wall that also blends naturally into its context, as seen in the fully completed wall in Figure 11. We constructed the wall during the end of the dry season in Monteverde. According to the program’s onsite director, the wall remained strong through its first rainy season and flourished with green growth. An image of the evolution of the Superadobe wall post-wet season can be seen in Figure 12.

From Retaining Wall to Superadobe Dome

The dome-construction process consists of the same fundamental bag laying technique we utilized when creating a retaining wall with a few additional details to complete the full dome form. A single dome with an 8' to 12' diameter uses the same 14"-16" polypropylene bags used for the retaining wall and can be built in 1-7 days by a team of 3-7 people, with at least one person with previous training in Superadobe earth construction (Khalili, *Emergency Sandbag Shelter* 32). The orientation of the dome on its site based on topography, climatic conditions, run-off, sun exposure, etc. is pertinent to the potential success of the building.

The first step to building the Superadobe Dome is to draw an interior and exterior circle by placing a center stake on the ground and attaching a chain, stick or rod. This simple tool creates the chain compass which functions to form the symmetrical base circle and dome form (Khalili, *Emergency Sandbag Shelter* 33). Just like a retaining wall, a foundational trench 6-18 inches in depth is dug and leveled, but with the dome trenches for entry buttress walls must also be dug. The bag filling method described in Khalili's manual is identical to the method described above, but for the dome the bag must be constantly checked with the central compass as it is laid around the curve. At the beginning of the dome construction the bag edge should be $\frac{1}{2}$ inch or one finger width beyond the compass line and should be checked pre and post-tamping (Khalili, *Emergency Sandbag Shelter* 37). It is easier to move the filled bag before tamping so aligning the initial bag alignment is key for structurally sound construction. In a dome, the barbed wire functions to resist tension forces, with breaks in the continuity of the wire decreasing its supportive effectiveness. Khalili's manual describes how the "tensile forces are a result of the static forces created by its own shape, and of dynamic forces which result from live-loads and seismic forces" (Khalili, *Emergency Sandbag Shelter* 42).

As the walls of the dome begin to grow one must decide if they are going to leave space open for a door, placing a doorframe in the empty door space, or if the door will be cut out of

the bags post-construction (Khalili, *Emergency Sandbag Shelter* 43). The level where the base of the circular form is complete and the slightly inward-curved dome begins to form is called the “spring line.” Here a second compass is created to form the symmetrical dome shape, called the “height compass”. The height compass is attached to the base of the doorway on the outside of the foundation and the length of the rope/chain/pipe is the same length as the diameter of the dome. The center compass rotates around the center and meets the end of the height compass to determine the placement of the next row. The height compass remains the same length the whole time and the arch created by this compass as it runs perpendicular to the ground determines the shape of the Lancet Arch, or curve of the dome form (Khalili, *Emergency Sandbag Shelter* 54). The bag rows will then begin to corbel inward, with bags placed slightly inward as the rows progress to eventually meet at the top of the dome shape.

An imperative consideration for the construction of the dome is the incorporation of windows, or pipes for ventilation and light. This depends primarily on climatic conditions. Khalili’s manual recommends incorporating many pipes to improve ventilation in tropical climates, a small skylight and pipes at the top of the dome to siphon off hot air in desert climates, and a few lower level window pipes to provide extra light in cold climates. In an emergency situation in areas of conflict Khalili describes how it would be advantageous to use pipe windows compared to larger windows due to security reasons, with angled pipes to deflect bullets. For the addition of large windows “an unreinforced opening must be an arched, circular or triangular shape, because of the nature of earth construction” and it is recommended that 3-4’ of wall space is left between openings in the dome form, utilizing the walls to function as buttresses to support the arched opening. Bags can either be laid directly over pipes, becoming level again after a few rows, or windows and pipe opening can be cut out of the constructed wall with a hand saw or steel wire, but only when the stabilized earth is still wet. In an emergency situation, if no bag-cutting device is available, un-tamped dry earth can be used to

fill small bags to temporarily fill the arch space, to be removed when the dome is complete. If materials are available the easiest way to form arched openings is by using a template of an arch, made out of plywood, metal, or recycled materials, to simplify the process and place in the dome temporarily, laying the wall bags around the arch template (Khalili, *Emergency Sandbag Shelter* 58-61).

As the upper bags begin to corbel inward following the compass curve, tamping with a slight slope towards the outside can be beneficial because the bag will naturally move inward as it is tamped. The very top bags should create a spiral form and the builder can choose whether to completely close the top of the dome or leave a skylight opening for increased daylight and ventilation. Khalili describes how “the beauty of the organic domed form is how completely it works in harmony with nature and gravity”, with its lower wide curved coils transitioning to more self-supported tight upper coils (*Emergency Sandbag Shelter* 77).

Once the full structure is complete, with the exception of building in a dry desert climate, the exterior must be waterproofed. Khalili describes various waterproofing techniques, both for rapid emergency construction to long-term permanent building, but states that overall “as a general rule, waterproofing layers must follow available local waterproofing methods that have proven themselves over time” (*Emergency Sandbag Shelter* 169). For short-term emergency waterproofing a tarp or plastic sheet can be placed over the dome, attached via short wires or embedded attachments such as small pipes and rope. Long-term waterproofing finishes consist of membrane type waterproofing, like a coat of asphalt emulsion, or discrete elements, like metal or ceramic tile, to cover the exterior and protect it from moisture (Khalili, *Emergency Sandbag Shelter* 83-85).

After waterproofing the dome must be plastered. In Khalili’s manual the plastering process is identical to the plastering method described previously for the retaining wall. Builders should begin by spraying the surface of the dome, then apply the base plaster layer,

called the “brown coat” in Khalili’s manual, and then apply the exterior plaster coat, referred to as the “finish coat” (*Emergency Sandbag Shelter* 132). Various aesthetic finishes can be used to decorate the façade of the dome, including the “reptiling” method previously mentioned, smoothing the exterior with a damp sponge for a clean finish, painting the surface, decorating with tile, or using white stucco to highlight features of the structure, like outlining doors and windows. With a full dome the interior walls can also be plastered using a stabilized earth plaster, particularly if dampness is a concern. Khalili also mentions the option of using a traditional mud-straw plaster, kneading the plaster by foot. This type of plaster may be ideal in a location where there is no access to a stabilizer, like lime or cement (*Emergency Sandbag Shelter* 169). Additional climatic considerations determine the ideal plastering materials. In wet and cold climates it is advised “porous, breathable surfaces, such as lime-sand plaster, are traditionally used to resist frost better than denser ones, since denser materials will hold water for longer periods of time” (*Emergency Sandbag Shelter* 173). In dry climates a thick clay-straw plaster with crack-resistant finish plaster on top, either reptiling or lime-based plaster, is ideal.

Throughout Khalili’s manual he provides both a permanent dome building technique, as well as a rapid emergency application, expanding the function of this building form to fit the needs of various demographics of people. For those who do not have access to this manual, but do have access to a computer, the entire manual is summarized into four pages and placed on the Cal-Earth website for instant and free global access.

In The United States Khalili was able to transform his dreams successfully into reality. He took the lessons learned from exploring the desert of Iran and crafted these place-based experiences to tangibly augment his design. Khalili pushed his boundaries as an architect, dabbling with lunar design and with this created the preliminary method that would later be implemented worldwide for the benefit of humanity. From “Velcro-adobe” to Superadobe Khalili challenged alternative earth design. He intertwined tradition and technology to form

buildings crafted initially for the desert, but also a design that possessed promise to function in a variety of climatic conditions.

CH 4: Applications of the Superadobe Method

A Place for Building Education: Cal-Earth

“It takes students to draw out the milk of knowledge from the teacher.”

-Rumi

The information from Khalili’s building manual, *Emergency Sandbag Shelter and Eco-Dome*, was the product of a non-profit research organization and school of Architecture located in Hesperia, California. This school was established in 1991 by Khalili and given the name Cal-Earth, The California Institute of Earth Art and Architecture. Khalili chose this desert site due to its ideal climatic conditions as well as strict California building codes, to test the potential strength of his prototypes, and to create an educational space for those interested in earth architecture.

Khalili expressed that natural ideal test conditions existed in Hesperia, located within the context of the harsh Mojave desert, the nearby San Andreas fault, desert thunderstorms with flash floods, high summer temperatures reaching above 100 degrees fahrenheit, below freezing winter nights and snow, high speed wind and sand storms. The location even stood the test of two major earthquakes, one in 1992 and another in 1999 (Khalili, *Emergency Sandbag Shelter* 272).

The philosophy of Cal-Earth is seeped with the influence of Rumi. Their mission statement articulates, Cal-Earth’s “philosophy is based on the equilibrium of the natural

elements of earth, water, air, fire, and their Unity at the service of arts and humanity.” The objective of this non-profit is described as being guided by three primary principles (*Cal-Earth*).

1. shelter is a basic human right
2. every human being should be able to build a house for him or herself
3. the best way to provide shelter for the exponentially increasing human population is by building with earth

With these three principles in mind those working with Khalili at Cal-Earth formed prototype earth structures in a symbiosis of tradition and technology. The early prototypes consisted of domes built with small-standard sandbags, including the first full dome prototype, completed in 1992. Following these experiments Cal-Earth began to utilize barbed wire between un-stabilized earth-filled bag layers, forming larger structures (“Aga Khan Awards 2004”). The first use of stabilized earth was the use of stabilized earth slabs anchored to the walls of an unstabilized earth-bag vault with 2’ long steel reinforcing bars, connected to a sandbag dome. The 20’ diameter brick “Rumi dome” was also an early prototype (Khalili, *Emergency Sandbag Shelter* 271).

Three design modifications tremendously increased the safety of the later Superadobe prototypes: building with accurate curvature, stabilizing the earth mix, and adding 4-point barbed wire (Khalili, *Emergency Sandbag Shelter* 272). The load-bearing or compression form of the symmetrical dome with the addition of barbed wire as a tensile element, acting as a mortar or reinforcement between the stabilized-earth bag layers, completed the final earthquake proof Superadobe design.

This design was utilized to create the prototypes tested for expected stresses during an earthquake. The design plans and engineering calculations were submitted to the city building

department and after years of dialogue and successful field tests the Hesperia Building and Safety Department, in consultation with ICBO (International Conference of Building Officials) issued Cal-Earth permits for construction of a museum and housing in 1995 and construction of the Hesperia Museum and Nature Center began in 1996 (Khalili, *Emergency Sandbag Shelter* 272).

Single dome prototypes, to the small 40 square meter clover leaf home design, the final "Eco-Dome", to two and four bedroom vaulted model house plans, called "Earth One", were constructed over the next few years. All structures built at Cal-Earth were observed and documented thoroughly over a period of five years, and most are still under observation and documentation today to continue monitoring the longevity of the structures. Over the five-year period of observation and documentation Cal-Earth came to the conclusion that it is essential to ensure the prolonged symmetry of the dome, especially for the domes without stabilized earth. Barbed wire can help compensate for asymmetry. Concerns about oxidation of the barbed wire were alleviated as long as the barbed wire remained placed between bags and not exposed to the outside, and buttressing was essential for large openings and support for structures larger than 10' in diameter. They also concluded that small sandbags, when built symmetrically with buttressing and barbed wire, were as effective structurally as the long bags, un-stabilized earth structures lasted as long as they were plastered and waterproofed, most standard sandbags began to disintegrate after 300 hours of exposure to ultraviolet light, and finally demolition of a dome, due mainly to the barbed wire, proved very difficult, even with a bulldozer (Khalili, *Emergency Sandbag Shelter* 274-275).

Cal-Earth continued to expand, focusing not only on prototype buildings, but environmental and earth construction education, holding true to Khalili's dream to enable people from all walks of life to build independently with their native soils. Khalili believed that the only missing link was the education of people to use these timeless building techniques,

molding them to fit their own culture and environment. The researchers at Cal-Earth strive to do this, focusing on holistic teaching methods, offering learning opportunities from free Saturday open houses, site visits and tours, four day to one week long workshops, children's field trips, international workshops, to one to four month long apprenticeship programs. The organization also sells the polypropylene bag material in various sizes, and books and films to aid with independent building projects. The Superadobe building system is not a copyrighted design, but one that Cal-Earth describes as "freely put at the service of humanity and the environment" (*Cal-Earth*). Although, Cal-Earth does express that licensing is required for commercial use. Nader Khalili, who passed away in 2008, played an active role in developing Cal-Earth to the end of his life. Currently members of his family have stepped up to continue Khalili's legacy and strive to spread his dreams and humanistic and environmentally conscious philosophy.

Superadobe Projects formed from Cal-Earth

In 2007, an estimated 5 million people from all corners of the world became homeless due to either natural or human-induced disasters. Today it is estimated that 40 million people are considered refugees or internally displaced (UN Habitat, iv).

This thesis is not striving to provide a doomsday image of the millions of displaced people worldwide, but instead to shed light on a building solution that could help alleviate this issue where culturally and geographically appropriate. The scale of needed emergency, transition, and permanent housing around the world is inarguably quite daunting, yet the building solutions do exist. The following pages include examples of Nader Khalili's Superadobe designs in action, used to house refugees, re-build communities, protect against natural disasters, and provide safe and inspiring locations for education.

“Earth turns to gold in the hands of the wise.”

-Rumi

Baninajar Refugee Camp

In 1994 the UNDP (United Nations Development Program) and UNHCR (United Nations High Commissioner for Refugees) commissioned Cal-Earth to implement their emergency dome design for the Baninajar Refugee Camp in the Khuzestan province of Iran (Khalili, *Emergency Sandbag Shelter* 300). In 1995 Iraqi refugees, under guidance of the design team of Nader Khalili and Hamid Irani (the supervising UNDP architect), worked to construct the very first Superadobe domes used for relief housing. Refugees from the Persian Gulf War, or Iraq-Kuwait war, were streaming into Iran, creating a dire need for rapid housing (Architecture for Humanity 104). Khalili responded to this request from the UN, traveling back again to his homeland of Iran to carry out his prototype cluster camp design. For the first time Khalili saw the materials of war implemented to re-build the war victims instead of breaking them down.

The UN was required to construct a prototype in the building research center of the ministry of housing in Iran, to approve and test the design before working with the refugees in the camp (Architecture for Humanity 110). Cal-Earth functioned as the official design firm for the project with P.J. Vittore, Ltd. as the structural engineer. The domes constructed by the refugees were 5 meters in diameter and cost \$625 to build each. Fourteen total shelters were constructed in a three-week long period, averaging one shelter every six days (Khalili, *Emergency Sandbag Shelter* 223).

In contrast to the typical concrete block and corrugated sheeting and tents, these Superadobe shelters were better insulated against cold and heat. Local materials were used, and some upgrades were added to the basic dome form, including various finishes/plaster, doors,

flooring, electricity infrastructure, a wind-catcher and fireplace. The UN expressed one of the primary motives for choosing the Superadobe design was its ability to function as a temporary shelter but with the potential for permanence. Khalili thought that the camp was designed to be temporary primarily because “host countries never like to have permanent architecture for refugee camps” (Architecture for Humanity 112). The camp was inhabited for at least two years before it was dismantled by the Iranian government (Khalili, *Emergency Sandbag Shelter* 223).

Khalili did not stay on site in Iran during the entire building process, but went back and forth a few times and left Hamid Irani, who had been trained in the Superadobe technique at Cal-Earth, in primary control of aiding the refugees. In a UN report from 1996 on the Baninajar refugee camp a year after the dome construction it was reported that the refugees were not accustomed to a communal living space for both sexes, therefore two smaller connecting domes would have better fit the cultural living customs of the population. Yet, overall the UN concluded that this relief design was a success and stated, “it may succeed as a strategy for housing refugees in Iran.” The dome shape functioned effectively to circulate warm air to the top of the tall designed domes, leaving the base cooler, and receive the sun’s rays on one side of the dome, resulting in a cooler exterior side as well. The refugees had no previous experience with Superadobe, but all were able to participate and construct their own homes under the guidance of Khalili and Hamid Irani (Khalili, *Emergency Sandbag Shelter* 224).

Khalili took this first relief project as an experience to further guide him to augment the quality of his designs at Cal-Earth. The Cal-Earth team began to work with more space division, instead of one simple dome, and began to use long tubular bags instead of many small standard sandbags. Overall, according to Khalili’s foundational design philosophy, this relief project fulfilled his core aspirations. The structures were simple, low-cost, quickly constructed, used local resources, fit their desert context in Iran, were structurally sound and aesthetically

pleasing, were built communally by those with no little to no previous experience, and functioned to dignify and empower a vulnerable population to fulfill their own basic needs.

Cal-Earth Pakistan

In 2005, the same year that Khalili was awarded the Aga Khan award for architecture, the refined Superadobe relief design was implemented once again. In response to the Central Asian earthquake that struck the mountainous region of Pakistan on October 8th, 2005, Cal-Earth Pakistan was established to aid the victims of this devastating natural disaster and specifically train them in reconstruction (Fazly). An estimated 74,000 people were killed and 3.5 million others were left to face the coming winter with either damaged or entirely destroyed homes (UN Habitat 54). This relief project involved collaboration between Cal-Earth and the SASI (Strategic Actions Social Impact) foundation. At this point all Superadobe structural systems had passed California building codes, therefore the Pakistani governing authorities approved the shelters. This relief project was the largest organized relief effort utilizing Superadobe, with two major training and prototype sites in Islamabad and Rawalpindi (Fazly). It involved the hands-on training of hundreds of refugees (referred to by Cal-Earth as “effectees”) as well as the training of students, members of the military, NGO representatives and interested volunteers (Fazly).

In the United Nation report *IASC Emergency Shelter Cluster: Shelter Projects 2008*, an image of the shelter design for this earthquake is displayed in the introduction. A caption under the image stated that “affectees were not involved in the design and it was not used on any scale” (UN Habitat viii). This same report, in the section discussing the relief work post earthquake in Pakistan mentioned on a materials chart that polypropylene sandbags for “transitional housing” were used, but there is no specific evidence of the use of Superadobe design (UN Habitat 58). In contrast to this report from the United Nations, email

correspondence with Hooman Fazly, one of the instructors during the Pakistan training program who currently works for Cal-Earth, provided evidence that Superadobe was utilized in Pakistan. Fazly described in the email that the affectees would come to the training site to learn the Superadobe method and afterward traveled back to their villages. Fazly's information about his experience working in Pakistan is rich with proof of the success of this Superadobe project.

Fazly states, "None took to the work more than the villagers who were brought to our site from the effected areas. Having a number of buildings in various stages of completion allowed them to get the concept within hours of arriving (although we insisted on keeping them at least 36 hours), and they would get very excited about going back to their villages and starting to rebuild for themselves. We would send them off with good wishes and a few rolls of bag. Any skepticism regarding their ability to build on their own was eliminated once pictures started to come back of proud survivors with big smiles standing on and around domes they had built themselves. Not only had they learned, but they had also trained others, and even innovated based on their needs and availability. We trained many groups of villagers and they successfully completed lots of shelters before the first snow that year. Although the magnitude of the disaster was overwhelmingly large, what we accomplished there on the ground was an undeniable testament to the strength of the work and the empowerment it creates. It proved everything that Nader Khalili had always said."

The Earthbag School Project

After Khalili's death in 2008 projects implementing his humanistic designs have continued to spread. A current project in the Philippines is less focused on relief housing, but is a project dedicated to education. Illac Diaz, a young social activist and founder of My Shelter

Foundation, who was trained in earth construction by Khalili himself, is leading this project with his classroom designs, working with Abakada Inc, an NGO of the Philippines focused on the provision of educational facilities in rural areas (Bolido 14). Abakada Inc. was awarded a grant for a proposal they submitted to the Work Bank, "Ibang Klase: Earthbag Classrooms" (One-of-a kind: Earthbag Classrooms) to spearhead this earth school building project. It is called the Earthbag School Project and is utilizing Khalili's earth building designs to build school buildings in rural developing locations without adequate educational facilities. Thus far, one Superadobe structure has been built on the Island of Siargao, in the eastern Mindanao province, and is the first of a series of planned schools to be built throughout the region.

Before the Superadobe school was constructed the 273 students of Day-asan National High School in Siargao had class in "a makeshift hut made of nipa and, beside it, a room that doubles as the barangay's multipurpose hall." Students at the school expressed difficulty learning due to an overcrowded and noisy learning environment, and during the rainy season the school buildings were not adequate shelter from wind and rain, let alone a place to relax and learn. Inadequate infrastructure in the education sector is a widespread issue in the Philippines (*Earthbag School*). Diaz articulated that most classrooms that do exist in the Philippines are hot and dimly lit, creating an uncomfortable environment that he believes is contributing to high student dropout rates countrywide (Bolido 15).

The first school, constructed rapidly in less than a month, consists of three classrooms, with one room to be used as a resource center for the community and a library. The school was constructed with connected vault rooms, made primarily with onsite earth. Blue painted roofs and rusted red window frames add to the aesthetic beauty of the structure. Illac Diaz of My Shelter Foundation reported that the earthbag system cut down the cost by 40% compared to conventional classrooms constructed in the Philippines. This type of construction was not only a cost effective method for the region, but one that augments the health of communities in need of

re-strengthening. This solution also assists with deforestation issues in the area. Dias articulated that the founding philosophy of My Shelter Foundation is to look for “uncommon solutions for common problems” and in the Philippines construction typically uses wood, cane, stones and other forest products (Bolido 14). This is no longer a realistic building method in the context of a country experiencing severe deforestation. Building with earth is Diaz’s solution demonstrating the flexibility of Khalili’s method to meet challenges in variable environments.

Diaz focused on community involvement throughout all phases of this project, believing strongly that rebuilding communities is “about empowerment and using the energies of the people who are the target beneficiaries as the greatest force for their own uplifting”, therefore self-empowerment. Diaz additionally had natural disasters at the forefront of his design aspirations; in this region typhoons as a primary concern. He chose Khalili’s technically sound and extreme weather-resistant design to create a space that could not only serve as an educational space, but also a safe space for shelter if a natural disaster did strike. The classrooms were designed to increase the amount of natural light and ventilation, increasing the comfort of the space for the students (*Earthbag School*). Diaz’s work in the Philippines is precisely the work Khalili would have wished to see, combining care for nature and people in the construction of buildings.

Love & Haiti Project

The Love & Haiti Project is a non-profit project that began in Haiti after the 7.0 magnitude earthquake on January 12th, 2010, focused on empowering the Haitian community to re-build their lives and communities after the destruction, not only through providing services, but by educating, building capacity, and fostering long-term solutions. The team, utilizing permaculture and Superadobe earth construction is striving to support the Haitian population to re-gain self-sufficiency in providing for their own basic needs. Currently, approximately 1.3

million displaced Haitians are living in tent cities and are in need of a means to re-build and heal. One of this projects primary goals is to create safe, transitional sub-permanent housing alternatives through earth building. Even before Haiti was struck by the 2010 earthquake the country was facing issues of nearly complete loss of original forest cover, desertification of once fertile farmland soils, and widespread flooding (*The Love & Haiti Project*). In a short film created by the Konbit Shelter Project, a Haitian resident expressed that even a year after the earthquake, residents of his town of Bigones feared sleeping in their own homes. Swoon (Callie Curry) one of the co-founders of the Konbit Shelter Project stated in this same short film that much of the building culture in Haiti consists of imported cinder block buildings that did not survive the earthquake (*Konbit Shelter: Blog*). The earth construction solution seemed obvious, creating spaces that would not just provide short-term relief but long-term housing that could have a chance to withstand the strength of tremors.

Konbit Shelter, a sustainable building project, is spearheading the Superadobe build portion of the Love & Haiti Project, focusing on the building of earthquake proof earth homes and community spaces. Konbit, in Haitian Creole is defined as a “traditional form of cooperative communal labor”, and this organization is interpreting this definition in a global sense, focusing on cooperation across borders. The Konbit team is quite diverse, consisting of artists, builders, architects and engineers of all ages. They express in their mission statement that, “we are working to build permanent, creatively designed structures which utilize the advantages of earth bag and dome architecture as adapted to the climate and conditions of rural Haiti” (*The Konbit Shelter Project*). Similar to the Superadobe school building project in the Philippines, Haiti was in dire need of a transition in building culture from one using wood in the context of extreme deforestation, to a resource more widely available on-site. Konbit Shelter’s Superadobe buildings use 90% local earth material and only 10% cement for stabilization, providing a solution to this resource issue.

The Konbit team is dedicated to community involvement in the re-building process. They plan to combine their background and skills with those of local artisans, builders, and farmers. During the summer of 2010 Konbit Shelter joined forces with the Mango Grower's Association of Leogane, in the community of Barriere Jeudi, located in the village Bigones, to build their first Superadobe structure, a three connected-dome community center. Due to the large thermal mass of the structure the team chose to add many windows and pipes for ventilation in this hot and humid climate. One of the most distinguished features of the community house is one of these windows, a large clover floral shaped window made from welding five 55 gallon recycled oil barrels together. The design also contained a large drainage pipe for a rainwater collection system. All materials were sourced within Haiti and money was raised to temporarily hire a crew of local Haitian builders from the community, supporting the local economy and spreading valuable building education (*The Konbit Shelter Project*).

The builders discovered that the Haitian Acra Bag Factory could locally supply the polypropylene bags, solving the issue of importing bags from the United States and further supporting the local Haitian economy, yet the team had to cope with tedious bureaucratic details to finally secure the needed bags from this company. The Konbit team was able to find a monetary and bureaucratic-free local source of plaster and fill material. One large issue post-earthquake in Haiti was what to do with the estimated over 20 million cubic meters of rubble that plague the streets of the country. Konbit Shelter decided their design should incorporate this rubble. They devised two rubble solutions: using the large debris as back-fill and the crumbling rubble as a material to incorporate in the stabilized earth plaster. The team used rubble from the site right next door, cleaning an area with a destroyed cement structure and using this very material to construct something beautiful next door. The finished community center was celebrated by over 120 participants in two days of festivity, art workshops, cultural activities and mental wellness programs, run by Konbit Shelter and Ayiti Resurrect. Ayiti

Resurrect is a collaborative group of artists, community builders, mental health specialists, and holistic healers working in Haiti on a project they are calling the “Ayiti Cherie Healing Project.” The community decided that the space would be used as a gallery space to showcase sculpture created by the town - this area is rich in artists who specialize in small sculpture – and as a meeting location for the mango farmers of the region, the Mango Grower’s Association, and possibly as a hub for education regarding alternative building techniques (*Konbit Shelter: Blog*).

The Konbit team returned to Haiti again in December of 2010 to begin constructing single-family Superadobe homes. The first family home design consisted of the primary clover dome structure, but is adorned with personal intricate details including a locally hand-carved breathtaking wood arched doorway, elaborate wind scoops decorating the top of the dome, interior spiral stone steps leading to a lofted space, and exterior paint that highlights the flower-like shape of the structure. The home was designed for a woman named Monique, a mother of two young girls, Bessie and Neika. The interior diameter of the main space is 18.5’, with a 5’ radius conical back room separated by a semi-spiral stepped wall that divides the space, creates a loft reducing some of the natural echo acoustics of the dome shape, and acts as an internal structural buttress (*Konbit Shelter: Blog*). Community involvement and cultural ceremony involving both the Konbit team of volunteers and the Haitian people runs deeply through the documentation of this project, reflecting on the experiences Khalili had building in his native Iran. In the long term, the Konbit Shelter Project aims to develop a sustained family-based building program. This program will bring together one artist, one architect and one Haitian family, to dream, design, and construct an earth-based home. The project will be based in Bigones, but plans to spread into the surrounding rural community (*The Konbit Shelter Project*).

CH 5: Conclusions: Sharpening Pencils and Scratching Paper

Passion is what drives these current Superadobe projects. It is this passion that genuinely reflects the humanistic and environmentally conscientious dreams of Nader Khalili. Khalili's earth-based designs have had a strong life beyond the life of their creator and continue to spread his love, knowledge and philosophy in various parts of the world. Whether they endeavor to provide people with basic shelter, a place for community, or a space for education, the solution that was buried in the earth has now been un-earthed. Khalili uncovered a traditional, vernacular form of building, inspired by his native building culture, and delicately incorporated the technical aspects to create spaces that can cope with a variety of climatic conditions. Using the monolithic structural strength of the arch, vault and dome Khalili's Superadobe and ceramic designs have made their mark in the alternative architecture realm, but their potential to grow is momentous. The poetic story behind the development of Superadobe reveals its strength as not only a low-cost environmentally friendly form of constructing, but one that holds deep emotional connections and fosters bonds between people and their environment through working with the earth. To emphasize the strength of Khalili's design, here again are the primary characteristics that form the Superadobe dome.

- ❖ The structures consist of simple, aesthetically pleasing, inexpensive and rapidly constructed design that is not resource intensive yet creates strong, lasting, and technically sound structures.
- ❖ The design is accessible to those with no previous design, architecture, or engineering skills; yet it takes a community of people to build and the success of the structure is derived from interpersonal cooperation and connections.
- ❖ The buildings are connected to their context and the earth and function in a variety of environmental, social and cultural contexts.
- ❖ The design is ideal for hot and arid climates, yet can also be molded to cope

with a range of climatic conditions and was fundamentally designed to be structurally sound in earthquake conditions.

“If you can cut through the bureaucracy, I have the design.”

—quote by Khalili to U.N. officials Omar Bakhet and Anton Ferreira (*Emergency Sandbag Shelter 220*)

Two primary issues stand in the way of spreading this earth building technique: bureaucracy and lack of education.

When asked what Khalili viewed as the main obstacle to seeing new concepts for emergency housing, like Superadobe domes, he expressed that it is the bureaucracy. He reflected on the fact that organizations like the UN are limited in what they can build, and ultimately the specific request has to be derived from the country (*Architecture for Humanity 112*). Khalili dealt with numerous bureaucratic issues from his more experimental phase in Iran to dealing with California building codes in Hesperia. The Konbit Shelter team, similarly, expressed their issues dealing with obtaining essential materials in Haiti.

The other impediment is simple. If people do not know about this type of architecture, or do not understand how to build it, or why it is effective, successful implementation is impossible. Cal-Earth, an organization at the heart of this building method, aims to fight this. They not only have been working to perfect the building method, but hold workshops, internships, and tours to spread building skills and knowledge. Numerous independent projects, beyond the two highlighted here in the Philippines and Haiti, are working to disseminate this building education that is universally applicable, but gains strength when implemented to fit its specific social, cultural, and environmental contexts.

The words of the mystic poet Rumi poignantly reflect Khalili’s overall message.

Rumi wrote, “you have two duties in life: to sharpen your pencil and scratch your paper” (Architecture for Humanity 112). Nader Khalili, those at Cal-Earth and others worldwide experimenting with earth building are doing just that, sharpening their pencils and scratching their paper. In applying the Superadobe method to a tropical climate in Monteverde, Costa Rica, unearthing the romantic and poetic roots behind the creation of Khalili’s earth designs, and analyzing a variety of Superadobe relief and education projects worldwide this thesis strives to do the same.

Nader Khalili’s method of construction intertwines and connects people to each other and their environment. By using the most abundant resource worldwide, rich earth, anyone can feasibly build an earth-based structure in a manner that cultivates personal and environmental health. Khalili has proved that worldwide, building with structural integrity and cultural consideration, fostering simplicity, beauty, hope and compassion for community and the earth, is within reach.

ATTACHED FIGURES

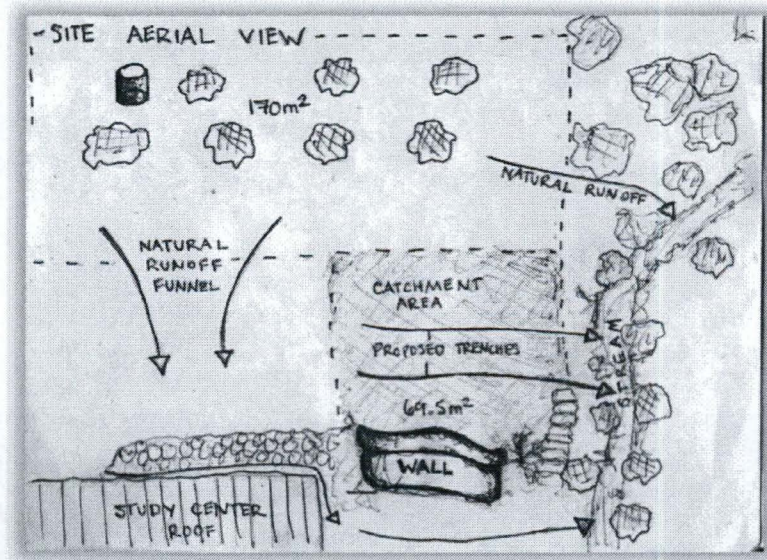


Figure 1: Site Analysis showing the direction of water drainage.

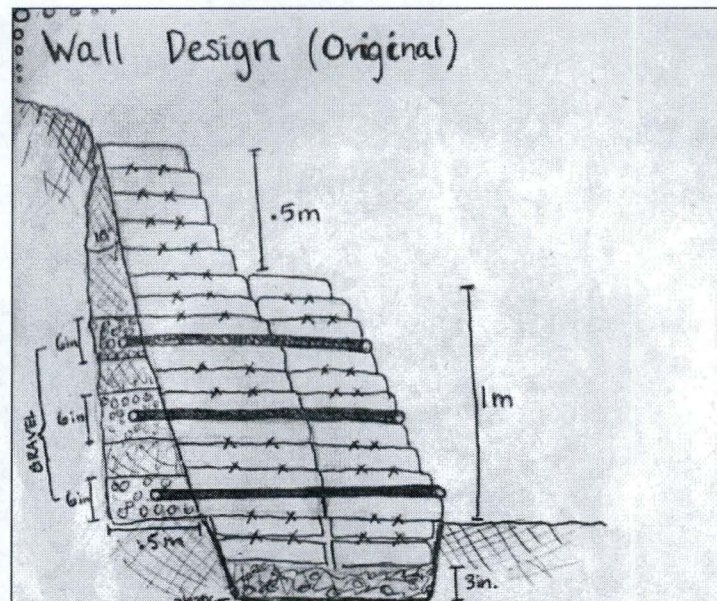


Figure 2: Technical Design showing the structure and size of the proposed wall.

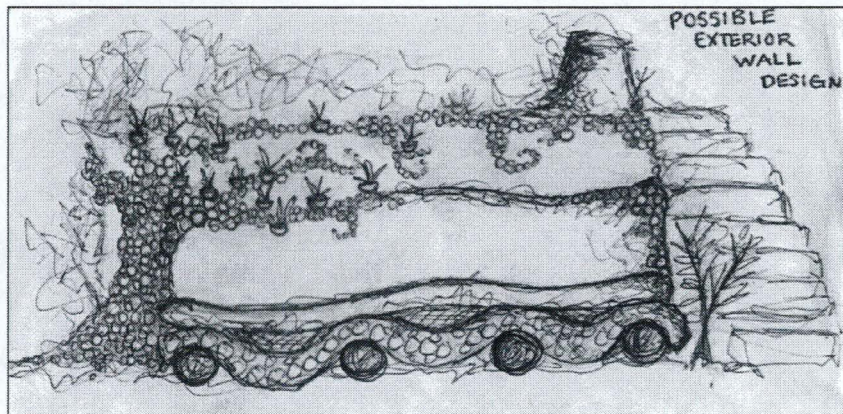


Figure 3: Aesthetic Design

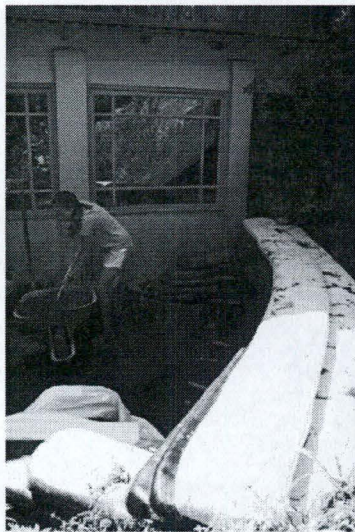


Figure 4: Earth Mixing



Figure 5: Bag Filling



Figure 6: Tamping



Figure 7: Plastering Phase



Figure 8: Planters and Glass Mosaic



Figure 9: Reptiling

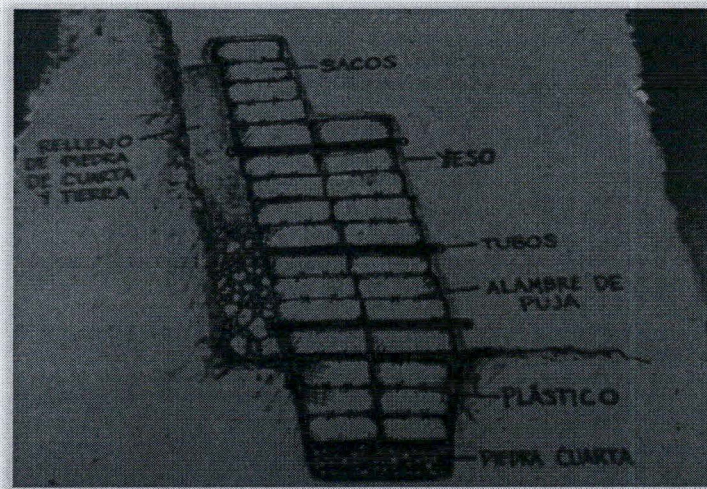


Figure 10: Complete Structure Diagram

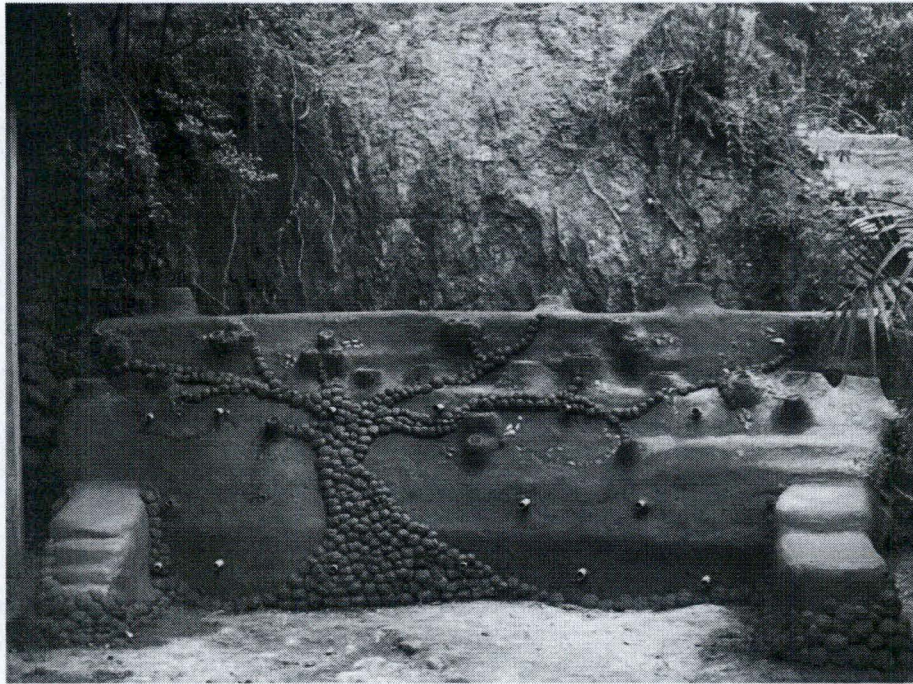


Figure 11: Completed Superadobe Retaining Wall (March 2011)

WORKS CITED

"Aga Khan Awards 2004 - Sandbag Shelter Prototypes - Cal-Earth Institute / Nader Khalili." *The Architectural Review*. 217.1295 (2005): 72. Print.

Architecture for Humanity (Organization). *Design Like You Give a Damn: Architectural Responses to Humanitarian Crises*. New York, NY: Metropolis Books, 2006. Print.

Berge, Bjørn, and Filip Henley. *The Ecology of Building Materials*. Oxford: Architectural Press, 2000. Print.

Bolido, Linda. "The Ceramic House May Solve Filipinos' Problems." *Ecos*. 2005.127 (2005). Print.

Brown, G Z, and Mark DeKay. *Sun, Wind & Light: Architectural Design Strategies*. New York: Wiley, 2001. Print.

Cal-Earth: The California Institute of Earth Art and Architecture. Cal-Earth Inc./ Geltaftan Foundation. 1999-2012. <http://calearth.org/>

Earthquake relief in Pakistan. EarthbagBuilding.com: Sharing information and promoting earthbag building. Kelly Hart and Dr. Owen Geiger. <http://www.earthbagbuilding.com/projects/pakistan.htm>

Earthbag School. EarthbagBuilding.com: Sharing information and promoting earthbag building. Kelly Hart and Dr. Owen Geiger. <http://www.earthbagbuilding.com/projects/school.htm>

Fazly, Hooman. Email Correspondence. April, 20 2012.

Heidegger, Martin. "Building Dwelling Thinking". *Poetry, Language, Thought*. " Translated by Albert Hofstadter. Harper Colophon Books, New York, 1971.

Hunter, Kaki, and Donald Kiffmeyer. "Earthbag Construction." *Mother Earth News*. 2005.212 (2005). Print.

IASC Emergency Shelter Cluster: Shelter Projects 2008. UN Habitat. http://sheltercentre.org/sites/default/files/IASC_shelter_projects_2008.pdf

Katauskas, Ted. *Dirt-Cheap Houses from Elemental Materials*. *Architectural Record*, August 1998. http://www.ArchitectureWeek.com/2000/0517/building_1-2.html

Khalili, Nader, and Iliona Outram. *Emergency Sandbag Shelter and Eco-Village: Manual--how to Build Your Own with Superadobe*. Hesperia, Calif: Cal-Earth Press, 2008. Print.

Khalili, Nader. *Project Summary: Javadabad*, 1986.

Khalili, Nader. *Racing Alone: A Visionary Architect's Quest for Houses Made with Earth and Fire*. San Francisco: Harper & Row, 1983. Print.

Khalili, Nader. *Sidewalks on the Moon: The Journey of a Mystic Architect Through Tradition, Technology, and Transformation*. Los Angeles: Burning Gate Press, 1994. Print.

Konbit Shelter: Blog. November 28, 2011. <http://blog.konbitshelter.org/>

The Konbit Shelter Project. 2010. <http://konbitshelter.org/>

Swan, James A, and Roberta Swan. *Dialogues with the Living Earth: New Ideas on the Spirit of Place from Designers, Architects, & Innovators*. Wheaton, Ill: Theosophical Pub. House, 1996. Print.