SOM PRIZE AND TRAVEL FELLOWSHIP **2011**

PORTFOLIO ID # **11**

Abstract and Itinerary:
Temporary and Transitional Spaces, Architecture and Mobility

Background:

Historically nomadic cultures used lightweight, flexible, and portable materials such as tapestries, animal hides, and thin-wood components to quickly assemble and disassemble communal and private, temporary and transitional spaces. Advancements in technology since 1950 have enhanced the durability and strength of these spaces using plastic and membrane construction methods. Global events such as the World Cup, The World Expo and The Olympics all require multiple transitional and temporary spaces that support human activities in a safe, sustainable way. Global disasters mandate that transitional spaces be quickly assembled with consideration of local, cultural, and economic needs. From airports to temporary event structures, plastic and membrane construction methods continue to set precedents for how architecture can inspire, shelter, and support humanity. By studying precedents and collaborating with colleagues in various disciplines, we can develop ideas that establish new techniques, modes, and models that respond to evolving demands for temporary and transitional spaces.

Built in 1981, The Hajj Terminal, a pioneering tensile-fabric roofed structure in Jeddah, Saudi Arabia, designed by Skidmore, Owings & Merrill (SOM) won the 2010 AIA Twenty-Five Year Award for outstanding performance. This 2.8 million square foot transitional space accommodates 2.4 million Islamic pilgrims on their way to Mecca for two months of the year. A large array of roof-membrane cones, open at the top, naturally ventilate and cool the terminal amidst the burning desert climate while saving energy; because of its temporary use, air conditioning was unrealistic. In a recent interview, John Zils, Senior Structural Engineer on the Hajj project affirmed to me that membrane construction methods of fabric are under-utilized in contemporary practice. In search for structural efficiency, Buckminster Fuller asked the question "How much does your building weigh" and developed geodesic and tensegrity principles that have influenced membrane construction. With the support of the SOM Foundation, I will travel, research, and analyze the tectonic, spatial, and structural methods of architecture that uses Geodesic Typologies and/or Membrane Construction Methods. With that knowledge and experience, I will collaborate with diverse professionals to design transitional and temporary spaces for communities in need and events like the 2014 World Cup, in Brazil.

Research + Analysis:

From large multinational events to emergency response shelters, membrane structures make up only a small sector of current architecture and merit exploration, analysis, and new application. I propose to research historic, recently completed, and current projects that implement membrane construction methods and/or geodesic typologies. I will travel to diverse locations to investigate vernacular, historic, and contemporary transitional and temporary spaces that have established new standards in architecture. For example, The Eden Project in Cornwall, England, by Grimshaw Architects, combines geodesic typologies with membrane construction methods into an organic and flexible form. Zaha Hadid's Chanel Mobile Art Pavilion is an example of a temporary traveling art space that uses membrane construction methods. I will develop a qualitative analysis with writings, sketches, and photographs of the architectural details and spaces. I have contacted SOM, Birdair, Knippers Helbig, Foster and Partners, and FTL Design and Engineering Studio, all firms involved in the design and construction of the architecture I will be researching. They are willing to support my project, providing interviews and drawings for publication and reference. I have also contacted several other firms and anticipate their response. Throughout my research, I will be writing articles for Fabric Architecture Magazine, organizing data collected for later publication.

Stuttgart, Germany will be where I finalize my research and analysis. German architects and engineers such as Frei Otto have and continue to significantly contribute to the knowledge base of membrane structures. A large majority of the contemporary and historic structures I wish to study are in Germany. I will consult with Knippers Helbig and Julian Lienhard, co-authors of Plastics + Membranes Construction Manual (to be released August 2011). Mr. Lienhard has offered me a workspace and access to form-finding software. The combination of geodesic technology with plastic and membrane construction methods will be used tectonically, spatially, and structurally to develop ideas for application. Analyzing my research information from previous months, I will compare and contrast projects, and consider their programmatic and environmental context and their application as transitional and temporary spaces in preparation for publication and application.

Application:

I will collaborate with Paul Casson, one of the finalists for the "2007" Buckminster Fuller Challenge Award, to produce a Corporate Social Responsibility Proposal for the 2014 World Cup, in Brazil. I had the privilege of living in Brasilia, Brazil for a year, which allowed me to become fluent in Portuguese and explore the diverse cultures. I wish to contribute to Brazil's up-and-coming World Cup and Olympic events, using the skill I acquire. Conferring with Mr. Casson and using my research and analysis, I will develop a design concept of temporary and transitional spaces to be used in each city, by a corporate sponsor. With multiple games in twelve cities over thirty days, transitional and temporary structures are ideal because of their inexpensive, re-configurable, and re-usable design. A result of this proposal would be that local workers would be trained in these new building methods. After the event, the structures will be donated to need-based organizations such as schools, wild life preserves, and other non-profits in Brazil, to be used for disaster relief shelters and other purposes. The final proposal will be presented to a corporate sponsor that we are currently investigating, for approval and funding.

Architectural path:

As a student, I lived a nomadic lifestyle, traveling and experiencing architecture. My instructors encouraged me to visit significant buildings and places, nationally and internationally, initiating a path of discovery, which I thoughtfully applied to my projects. Temporary and transitional spaces along with membrane construction methods were central to my education and provided a focus for architectural my aspirations. There is no greater lesson than learning from master works and practicing professionals; architecture is a journey of lifelong learning and the reflection of accumulated knowledge and experience. Consulting with diverse professionals, I endeavor to analyze architecture, concepts, models, and prototypes that integrate membrane and geodesic technologies (externally and internally). I am interested in performing and applying research, collaborating with engineers, clients, architects, and occupants to create responsive, resilient, inexpensive, and re-purposable structures. Transitional and temporary spaces, permanent or impermanent, must be diverse, flexible, and impressionable. Therefore, they deserve special attention and merit research and development. With the help of the Skidmore, Owings & Merrill Foundation, I intend to make the places I travel, my school, office, and home, by "living architecture" and contributing to the global community.

SOM 1

Itinerary:

USA:
- Pier Six Concert Pavilion (1991), Baltimore, Maryland, FTL, International Fabric Associated Industries Expo Oct 25-27, 2011
- The Smithsonian Institution (2007), Washington, DC, Foster and Partners, Smith Group Inc.
- UN Interim Canopy (2009), New York, New York, HLW International, FTL
- The Central Park (2011), San Clemente, California, Michael Maltzan Architects
- San Diego Convention Center (1989), San Diego, California, (1989) Arthur Erickson, Horst Berger, Birdair
- Cavalia Show Tent (1998), Traveling Performance, FTL

Japan:
- Shenzhen East Huaqiao Water Park (2009), Shenzhen, Japan, Taiyo Kogyo Co. Birdair
- Komatsu Dome (1997), Komatsu, Japan, Birdair
- Lounge Facility, Edo Tokyo Museum (1995), Ryogoku, Japan, Hightex
- Morique Building (1992), Osaka, Japan, Keizo Sataka, Taiyo Kogyo Co. Birdair
- Paper Art Museum (2002), Mishima, shizouka, Japan, Shigeru Ban, Hishino Arch. & Eng., Obayashi Co.
- Paper Church (1998), Masuba, Gifu, Japan, Shigeru Ban

China:
- Expo Boulevard Shanghai (2010), Shanghai, China, Knippers Helbig, SBA Design
- Noregian Shanghai Pavilion 2010 Expo, Shanghai, China, Knippers Heilbig, Helen & Hard AS
- Beijing Olympic Water Cube (2008), Beijing, China, PTW Architects
- Beijing National Stadium (2008), Beijing, China, Herzog & de Meuron

Saudi Arabia:
- Hajj Terminal, Jeddah Intl Airport, Jeddah, Saudi Arabia (1981) SOM/Geiger Berger, Birdair
- Ministry Of Municipal And Rural Affairs (1980s), Riyadh, Saudi Arabia, FTL
- King Fahd Stadium (1986), Riyadh, Saudia Arabia, Ian Fraser, John Roberts & Partners, Geiger Berger

South Africa:
- Green Point Stadium/Cape Town Stadium (2010), Cape Town, GMP, Birdair, Louis Karol/Point Architects
- Soccer City Stadium (2010), Johannesburg, Hightex, Boogertman Urban Edge & Partners
- Durban Stadium (2010), Durban, GMP, Schalkich-Bergermann & Partners, Birdair
- Nelson Mandela Bay Stadium (2010), Port Elizabeth, Architectural Design Assoc. & Dominic Bonnesse, Birdair

UK:
- Wimbledon Centre Court Retractable Roof (2009), London, UK, Hightex, Tony Hogg Design
- Inland Revenue Centre Amenity Complex (1994), Nottingham, UK, Hightex, Hopkins Architects
- SAGA Headquarters Amenity Building Folkestone (1998), UK, Hightex Hopkins Architects
- Oasis 1, Brandon House Hotel (2007), New Ross, Ireland, UK, Hightex, Tensys
- Schlumberger Cambridge Research Centre (1985), Cambridge, UK, Hopkins Architects, Arup
- Millennium Dome (1999), London, UK, Richard Rogers Partnership, Buro Happold, Birdair
- Eden Center (2001), Cornwall, UK, Grimshaw & Partners, ARUP
- Dynamic Earth Center (1999), Edinburgh, UK, Hopkins Architects, Aurp

France:
- The Pompidou-Metz Museum (2010), Metz, France, Shigeru Ban, Jean de Gastines
- Nuage Léger Grande Arche (1998), Paris, France, Hightex, Johann Otto von Spreckelsen, Arup
- Chanel Mobile Art Pavilion (2008), L'Institut du Monde Araba, Paris, France, Zaha Hadid Architects

Germany:
- Gottlieb Daimler Stadium (1993), Stuttgart, Germany, Hightex, Seigel & Partner, Schlaich Bergermann & Partner
- Stuttgart Main Station (under construction), Stuttgart, Germany, Ingenhoven Overdiek Architecten
- The Allianz Arena (2005), Munich, Germany, Herzon & De Meuron, Ingenieurburo R + R
- Munich Olympic Stadium (1972), Munich, Germany, Frei Otto
- Munich Airport (1999), Munich, Germany, Hightex, Murphy Jahn
- Oktoberfest U-Bahn Entrance Theresienwiese (1990), Munich, Germany, Hightex, Stadtwerke
- Ice Skating Rink, Munich, Germany (1983), Kurt Ackermann & Partner, Schlaich Bergermann & Partner
- Bad Klosterlausnitz Leisure Pool (1996), Bad klosterlausnitz, Germany, Hightex, David & Strobilious
- Central Bus Station (2002), Dingelstadt, Germany, Hightex, Ing. Büro Herrmann, Schmalalden
- Hermes Umbrellas Expo 2000 Hanover, Germany, Hightex, Herzog & Partner
- ZDF Television Centre (1997), Mainz, Germany, Hightex, Alfred Speer & Partners
- Wolfgang Meyer Sportanlage Stadium (1994), Hamburg, Germany, Hightex, Silcher, Werner & Partner
- Dresden Main Station (2006), Dresden, Germany, Foster & Partners, Buro Happold
- The Sony Center (2000), Berlin, Germany, Murphy Jahn, Arup, Birdair
- Dept. Store Peek and Cloppenburg (2005), Cologne, Germany, Renzo Piano, Knippers Helbig

ID # 11

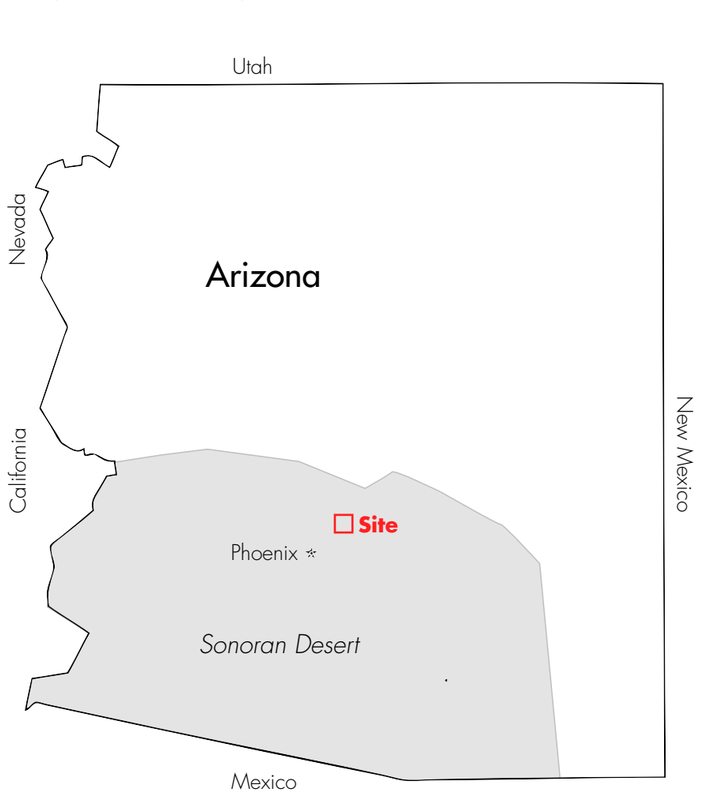
Brittlebush: Design + Build

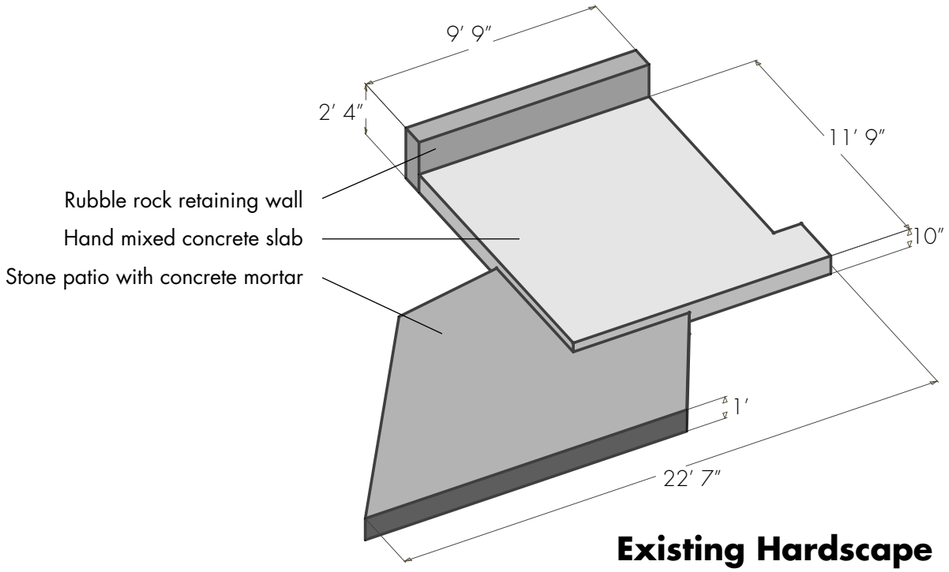
Arizona: A Sonoran desert dwelling

Situated in the Sonoran Desert, the most bio-diverse desert in North America, *Brittlebush* is named after a vital plant in the desert. The brittlebush plant is known as the nurse plant of the desert because its is common that all the other plants set root underneath is leaves, protected from the harsh environment. The design intent behind this project was to emulate the metaphor of the brittlebush's open and gentle protection combined with the idea of a symbiotic relationship between the inhabitants of the desert, including the dwelling and dweller. The desert is limited in resources and yet the Phoenix Metropolitan area grew to 4.1 million by 2010. *Brittlebush* is an experiment in materials asking its inhabitants to question their boundaries between themselves and nature. What does it mean to dwell in this growing mechanized civilization and yet remain close to nature?

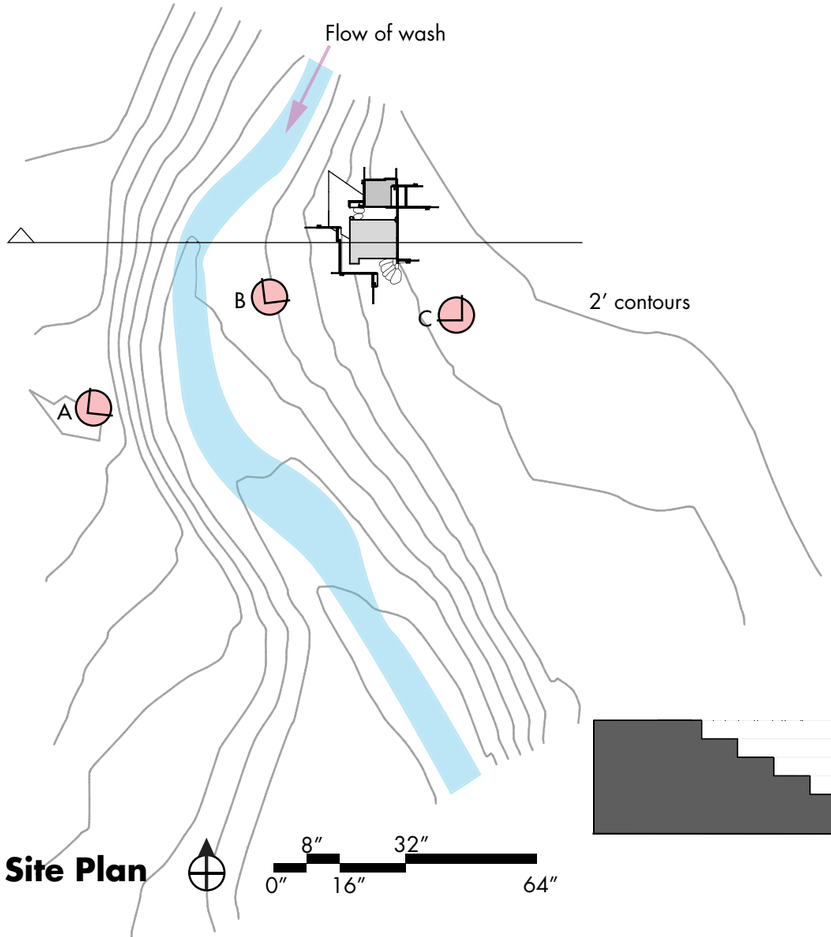
The desert dwelling as a design + build educational path was a rare opportunity to construct an architectural idea unique to my interests and sensibilities. I was the client, architect, and builder. I sought to find solutions to the contradictory aspects among these roles. In this two-year project the architectural process began to reveal some of its nuances and challenges. Resources, cost, and timing are all critical elements that need to be balanced in any project to create functionally and formally, spatial quality. The site and design had to be approved by the school administration, which required an ecologically conscious construction plan that minimized the impact on the desert and remained within the budget limit of $2000.

The construction plan was to build outward from within by using the existing hardscape as the construction staging site to prevent any unnecessary damage to the surrounding vegetation. This required the builder to keep a clean and organized building site. All materials were transported to the site by foot, wheelbarrow, or zip-line.





Existing Hardscape

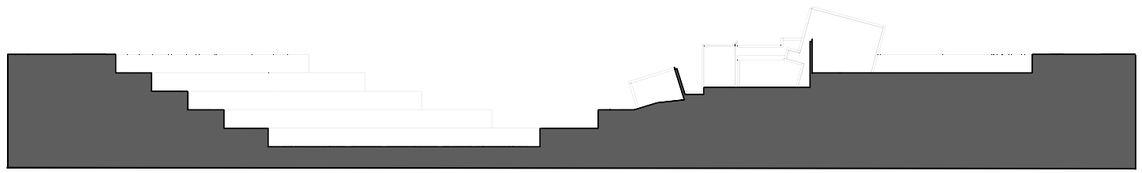


Site Plan

A: View across the wash to the northeast

B: View from inside the wash to the northeast

C: Existing hardscape looking to the northwest



Site Section

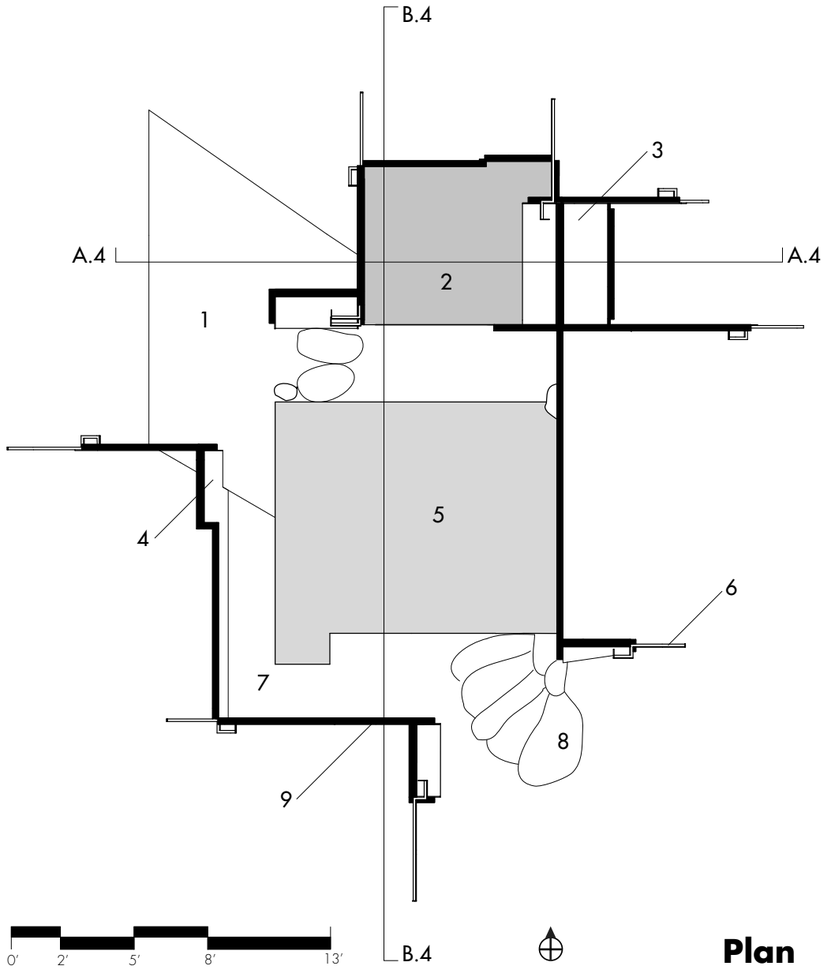
Brittlebush: Design + Build

Thinning and folding rammed-earth walls

The design integrates a fabric roof-membrane, 3"x 3" steel-angle, and rammed-earth into an open-air shade pavilion with a patio, bed, and fireplace. Approximately 90% of the steel in weight was recycled from the school scrap yard. The earth and crushed granite were collected from another site on the school property, as a remediation project keeping a symbiotic relationship with the desert. Commonly rammed-earth walls are roughly 16" thick, to provide structural support. However, due to the dynamic structural needs of the roof-membrane, rammed-earth acts as deadweight against uplift in high winds, as the steel provides an integral armature for balancing the tensions of the roof-membrane. This allowed me to propose a thinner version of a rammed-earth wall with rebar reinforcement and fiber-mesh to tie everything together. All of the steel was pre-cut and welded in place allowing for adjustments to be made on site and keeping loads light. All the steel was anchored into the ground with 12" footings. A small retaining wall was built with CMU blocks and a French drain was added to help prevent erosion in the walls on the east side. I performed 85% of the labor while the remaining 15% came from assistance of students and friends.

Elevated 3.5' from the ground, the bed platform sits above the fireplace and is sheltered on the east side by the chimney. The concrete bed platform and rammed-earth chimney are protected from direct fire but gain thermal heat to passively warm the dweller on colder nights. The soirée patio is a gathering space with three chairs that comfortably accommodate a small group of visitors or just one pensive student needing some quiet time to read or rest.

1. Stone front entry patio
2. Bed with fireplace below
3. Chimney
4. 3" rammed-earth wall typ.
5. Soirée patio
6. Anchor point for fabric typ.
7. Zen garden, crushed granite
8. Stone steps, back entry
9. 3"x 3" steel angle frame typ.



Plan

Rendering of the steel armature and 3" thick rammed-earth wall system

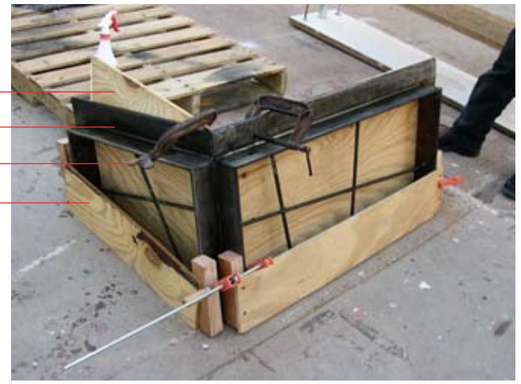
Steel armature, project 25% complete

Brittlebush: Design + Build

Contemplating and testing to refine the details

Once the steel-armature was welded and anchored to the ground, it was critical to test the soil and establish the appropriate proportions of earth, concrete, lime, and colorant. Rammed-earth mixes vary depending on the content of the earth available. Because the contents of local earth didn't have clay or lime, I had to make a variety of mixes and weather-test them for durability. Once I established a formula, I built a small mockup of the wall and tested the construction method and ramming tools, which helped me adjust and alleviate errors on the main walls. I began to fill the walls with the rammed earth material using salvaged 3/4" plywood from local construction waste to build the formwork. Simultaneously, I worked with my original concept sketch and various form finding techniques, seeking to find the most appropriate shape, pattern, and material for the fabric roof-membrane. I also specified the hardware and designed the extensions to the main armature to which the fabric was anchored. Every decision was contemplated, tested, calculated, and adjusted to provide a consistent approach to the design.

Concept Sketch



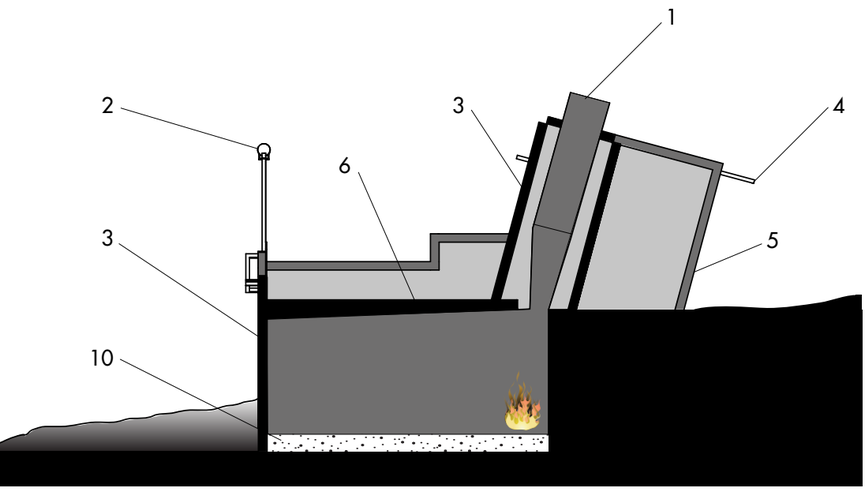
Mockup to test construction method

13 test bricks of rammed-earth, 8"x 8"x 3"

Cost of Materials

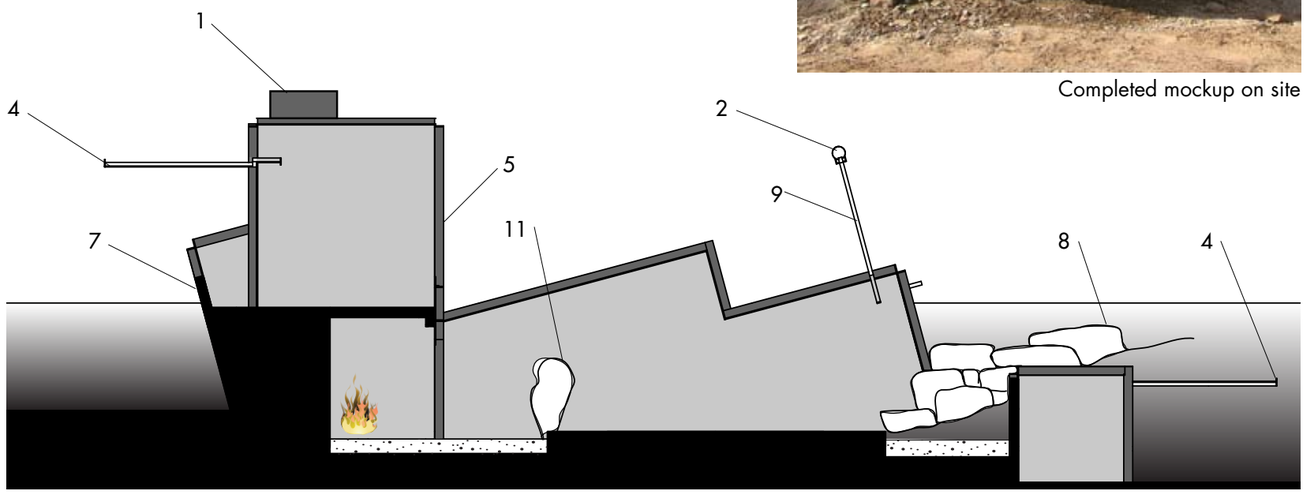
Material	Purchased	Recycled	Cost
3"x3"x3/8" Steel angle	30 Linear feet	210 Linear feet (88%)	$ 215.00
1 1/4"x1 1/4"x1/8" Tube-steel	40 Linear feet	20 Linear feet (33%)	$ 90.00
1"x1"x1/8" Steel angle	60 Linear feet	–	$ 45.00
1 1/2"x2"x1/8" Steel angle	24 Linear feet	–	$ 35.00
1 1/4"x1/4" Steel Flat bar	12 Linear feet	–	$ 15.00
2"x1/4" Steel plate	–	90 Linear feet (100%)	$ -
8"x1/4" Steel plate	–	120 Linear feet (100%)	$ -
3/8" Rebar	430 Linear Feet	40 Linear feet (9%)	$ 180.00
8"x8"x16 CMU block	100units	–	$ 130.00
Local Earth	–	100 Cubic feet from the property	$ -
Local Gravel	–	25 Cubic feet from the property	$ -
Local Stones	–	100 % Gathered from the property	$ -
Cement, Lime, Pigment and Fibermesh	100%	–	$ 360.00
Synthesis Shade Cloth Commercial 95	1,291 sq. ft.	–	Donation
Wood for the formwork	–	100% local construction waste	$ -
Hardware and Miscellaneous Supplies	90%	10%	$ 925.00
		Total	**$ 1,995.00**

Completed mockup on site



1. Chimney
2. Acrylic orb
3. 3" rammed-earth wall
4. Anchor Point
5. 3"x 3" steel angle
6. Concrete bed platform
7. 15 deg. slanted walls
8. Back entry stone steps
9. Tube-steel mast
10. Crushed granite
11. Stone embeded into wall

Section - A.4



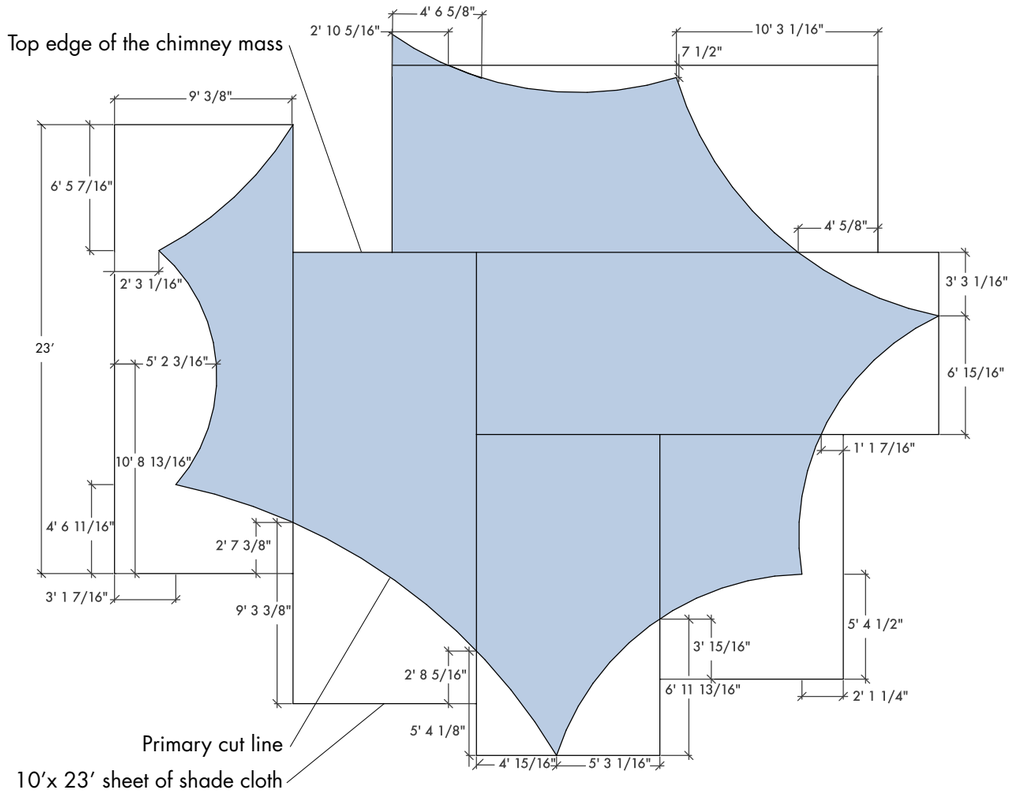
Section - B.4

Brittlebush: Design + Build

Sewing an interchangeable roof-membrane

Fabric membrane structures are generally erected under the design + build model because each fabric responds differently and requires on site measurements and adjustments to ensure a quality product. Finding the best shape for the fabric is one of the most challenging parts of the design process. Once the main structure is established, the general shape is known, but it takes further measurements and analysis of the actual structure to ensure a precise fit. This structure was designed to have an interchangeable roof of two types of material, a PVC vinyl for the rainy season and a poly-mesh shade-cloth for the sunny season. Due to limited availability of material, only the shade-cloth roof was cut and sewn. With everything in place, the other roof would be produced very simply in two weeks. After two years, a final product was available to dwell in, contemplate, and study its ability to stand the test of time. *Brittlebush* has received significant attention from several architecture blogs, three national publications, three international magazines, and one book. "Learning by doing" is an irreplaceable educational model that has improved my ability to see and appreciate the details of my surroundings as I aspire to do more.

Full scale form finding process, using multiple pieces of spandex fabric



Fabric Pattern

Sewing the roof-membrane

Mockup of fabric connection to the chimney mass

Rammed-earth and landscaping finished, project 85% complete

Brittlebush: Design + Build
Learning by doing and doing more

Soirée patio with three chairs look at the back entry

Acrylic orb lifting the fabric

Patio with fireplace behind and bed above

View from across the wash

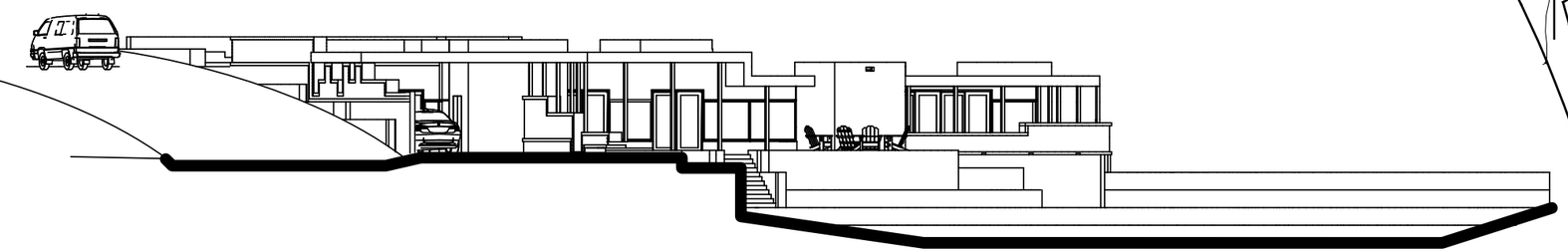
Coyote Residence: Santa Fe, New Mexico

How does a building become part of the landscape?

The Coyote Residence was designed for a property located in the lower northern foothills of Santa Fe, New Mexico. As the capital of the state with a population of 76,000 people, there are many challenging regulations that influenced architectural decisions. Santa Fe is located in a high desert mountain climate limited in water, which made it essential to integrate a water collection system into the roof design.

Due to the lack of distant views, a wash running through the property, and the regulations limiting ridge-top construction on the east side of the site, locating the building envelope was a complicated problem. The final decision was to stay on the northwest corner of the property to eliminate the need to build a culvert across the wash, allowing those funds to be used on other areas of the construction cost. This decision also reduced the cost to connect to the utilities and made it easier to integrate passive solar concepts into the design. Some drainage mitigation still needed to be designed into the landscaping and foundation within the drainage easement. Another advantage of placing the home in this location is that the property across the wash remained untouched, providing an intimate view of nature and the changing sky. Owned by the residents, the two acres of land across the wash became a micro-view of the high mountain desert and provide a peaceful retreat for a small stroll.

The greatest challenge of this residence was to provide an integrated connection to nature for the residents and the building while keeping within current building practices. The property is low in the landscape surrounded by the foothills. The House needed to take on that feature by sitting into the hillside on the northwest side, sinking down and away from the road. The site section below describes how local traffic quickly rises above the residence sending most of the vehicle noise over the house.



Site Section

Site Plan

A: View from building site looking south

B: View from building site looking northeast

C: View from across the wash

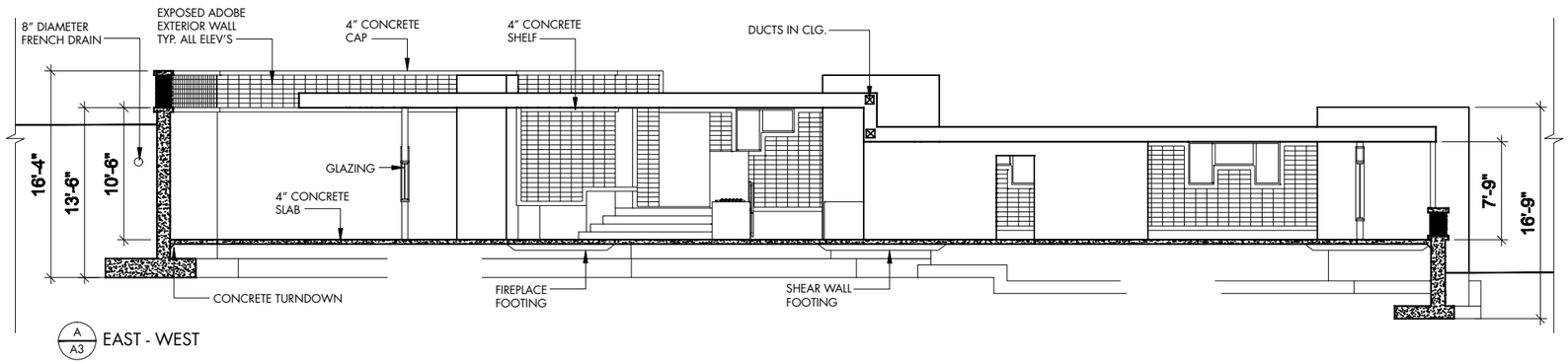
ID # 11

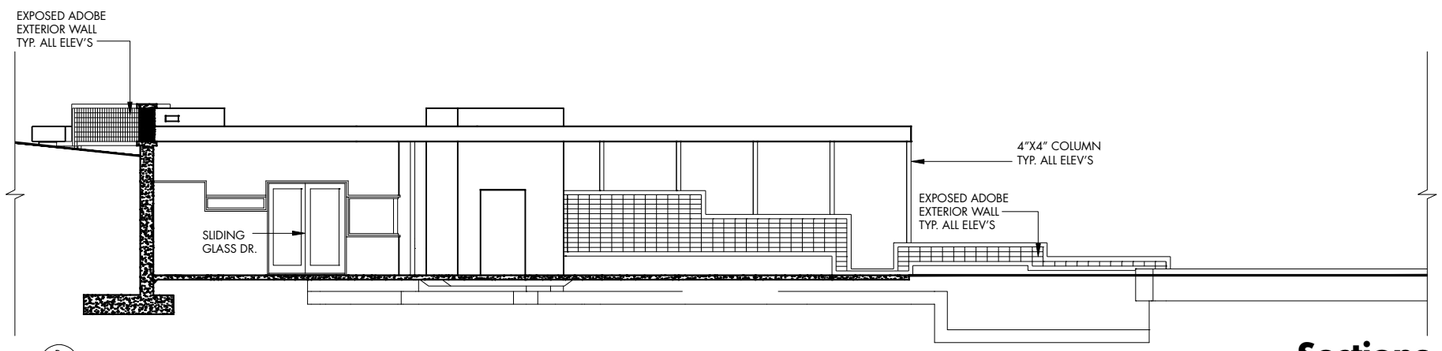
Coyote Residence: Santa Fe, New Mexico

Integrating knowledge and knowing when and where to look for support

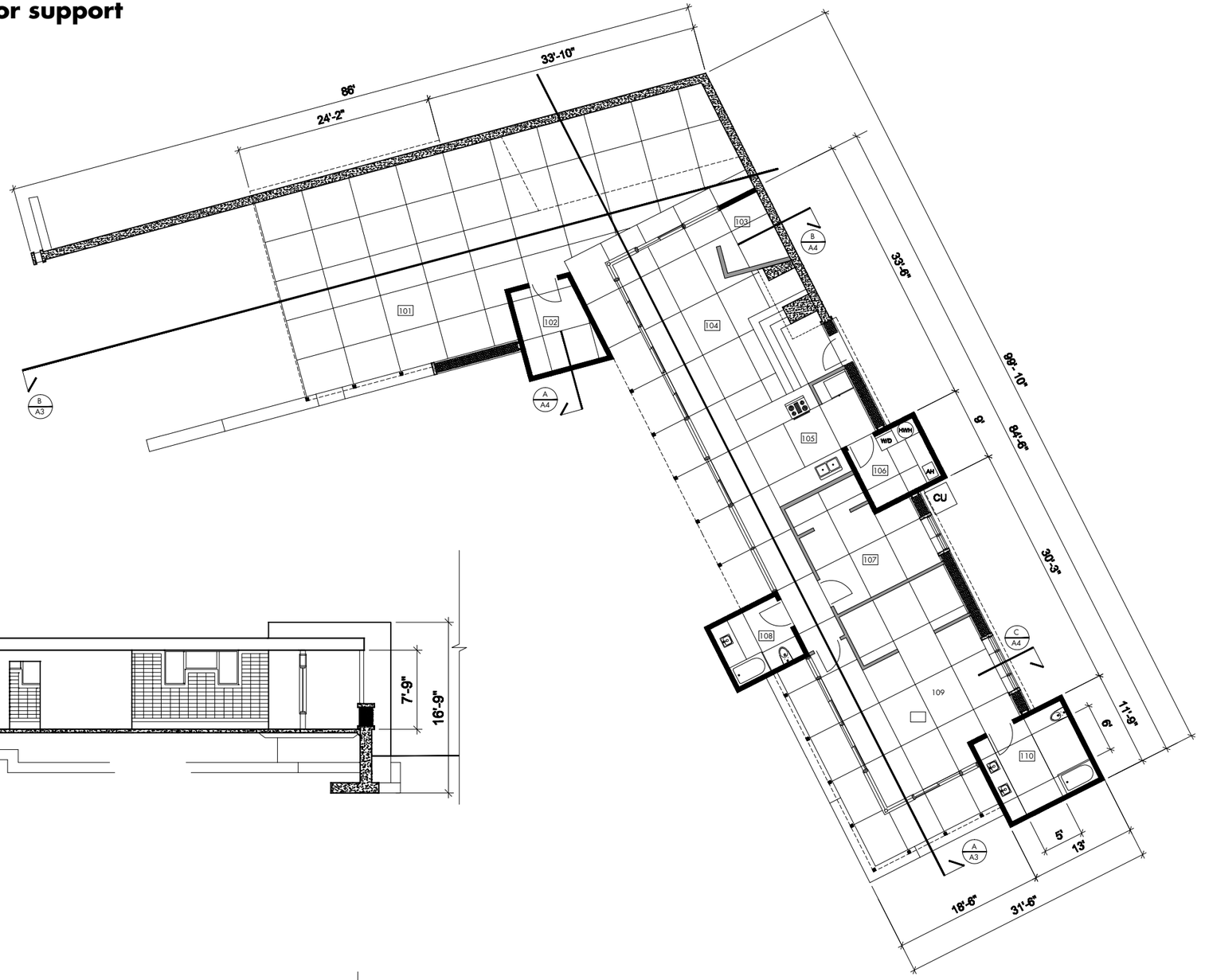
As part of my final design project, I had a goal to reach design development drawings while integrating several of the techniques I had learned in design, rendering, and construction methods and materials. Door and finish schedules, structural calculations, and legal contracts were drafted for this project. To synthesize these various skills it was essential to test my knowledge and know when to ask for assistance or look for reference.

Through this project, I consulted with faculty, students, and friends and brought together their insight and knowledge and sought to articulate my interpretation of their ideas in this cohesive design. Architecture is a process of lifelong learning and application. By discovering and rediscovering how to build and how to question what we build, new ideas emerge. By collaborating with others and initiating dialogue we begin to establish new principles and approaches to the work. This process is similar to working with clients, engineers, the city, and neighbors. Architecture is rarely created by one person and requires a good listener, as well as thinker to develop and deliver ideas that make a difference.





Sections



ROOM FINISH SCHEDULE

			WALLS					
NO.	ROOM NAME	FLOOR	NORTH	SOUTH	EAST	WEST	CEILING	HEIGHT
101	CAR PORT	CON	CON/ADB	OPEN	ADB	CON/ADB	DW	10' 6"
102	STORAGE	CON	DW	DW	DW	DW	DW	10' 6"
103	OFFICE	CON	CON/ADB	WOOD	WOOD	CON/ADB	DW	10' 6"
104	LIVING ROOM	CON	CON/ADB	GLASS DR	OPEN	GLASS DR	DW	10' 6"
105	KITCHEN	CON	CON/ADB	GLASS DR	DW	OPEN	DW	10' 6"
106	MECH. & LAUNDRY	CON	DW	DW	DW	DW	DW	10' 6"
107	BEDROOM	WOOD	CON.ADB	DW	DW	DW	DW	7' 9"
108	BATHROOM	TILE	DW	TILE	DW	DW	DW	10' 6"
109	MASTER BEDROOM	WOOD	CON/ADB	GLASS DR	GLASS DR	DW	DW	7' 9"
110	MASTER BATHROOM	TILE	DW	DW	TILE	DW	DW	10' 6"

Plan

Coyote Residence: Santa Fe, New Mexico

Local and contemporary materials in the high desert

These elevation-renderings are intended to give the client a sense of texture, color, and light that is integrated into the design, while the details on the following page are essential to understand the construction methods and materials. Landscaping was also considered by using local species such as the cottonwood commonly found in the lower areas of the foothills.

As the original place of Pueblo and Territorial Style Architecture and one of the oldest cities in the USA, Santa Fe is a rich library of desert vernacular architecture. It is also a challenging context to introduce contemporary ideas and materials because of historic regulations and architectural guidelines. Many current buildings are designed to stylistically mimic adobe architecture but fail to creatively use local materials and resources.

The design of this small 1600 square foot residence called for an investigation into reinterpreting local materials, by using them in different ways. By developing a fresh perspective on local materials, contemporary and vernacular architecture fit together in an integrated palette. Instead of using stucco as the siding on the home I proposed to apply what is locally known as coyote fencing, horizontally. These 1.5" to 2.5" dowels of cedar wood provide a horizontal banding around the home that texturally integrates the structure in with the landscape and the local vernacular. The use of adobe bricks is also integrated and featured in sections of the walls that had less structural demands. The bricks are surrounded by concrete to protect from erosion with the purpose of the contemporary material protecting the local. By blending local and contemporary materials the design stands in the present without forgetting the past.

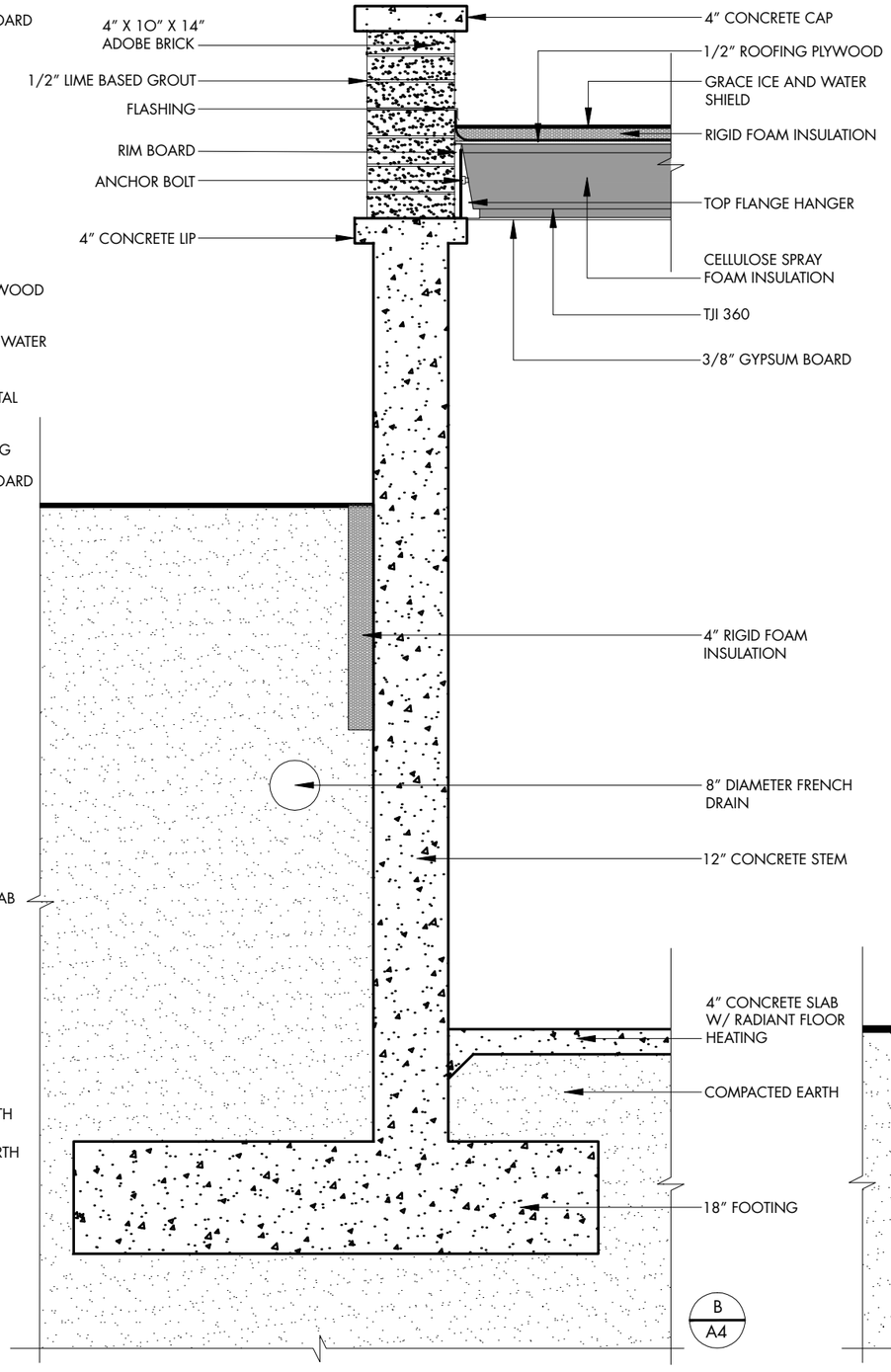
East Elevation

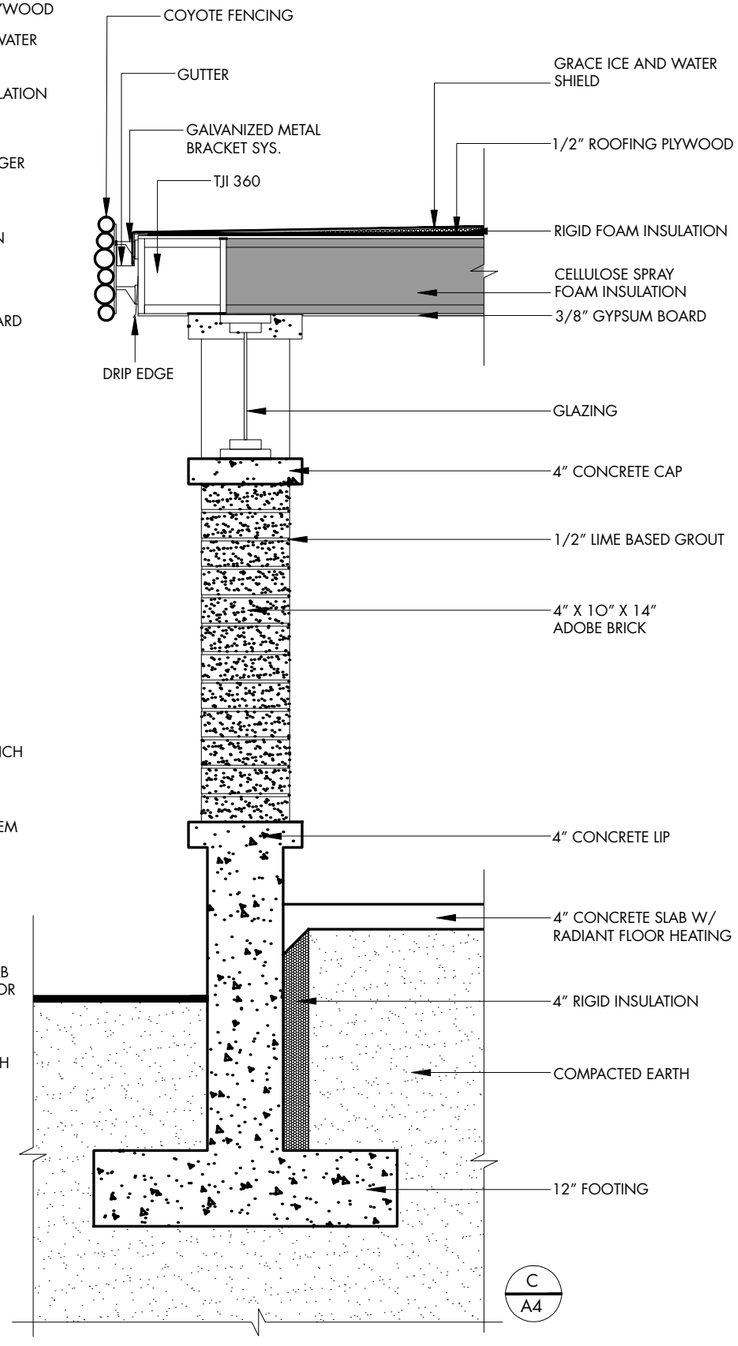
South Elevation

Coyote Residence: Santa Fe, New Mexico

Wall sections: How to assemble ideas

Commonly used as a fence material, Coyote Fencing was proposed to be applied horizontally as siding.





Details **1/2" = 1' 0"**

Coyote Residence: Santa Fe, New Mexico

Integrating the building into the landscape

Western perspective looking down the stone steps toward the front entrance

Southern perspective looking into the central patio

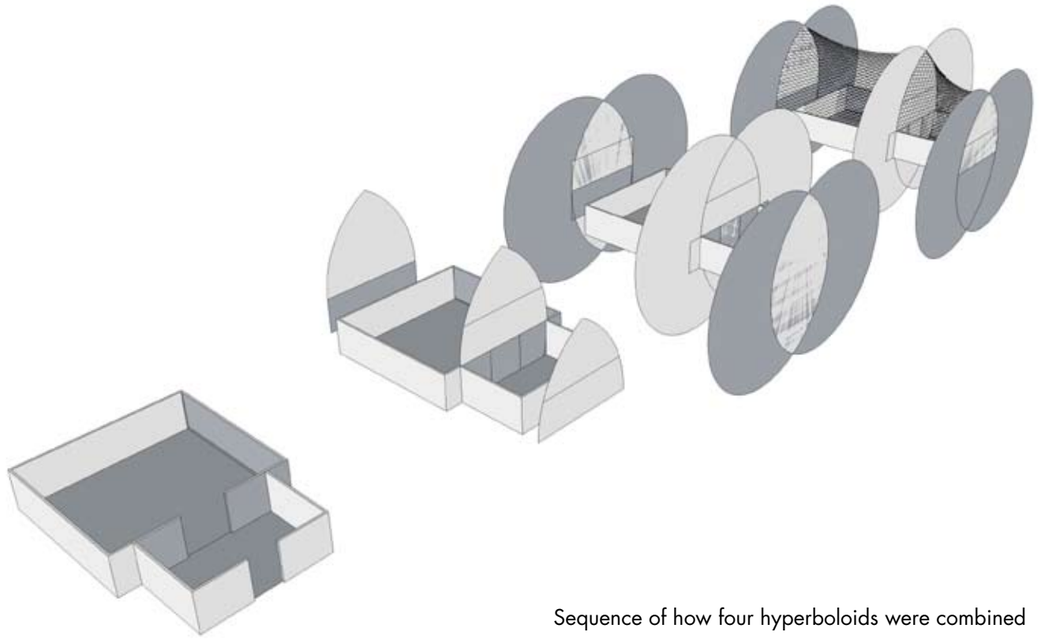
Perspective from the middle of the wash

Thin Shell Concrete:
Creating a curved surface with straight lines

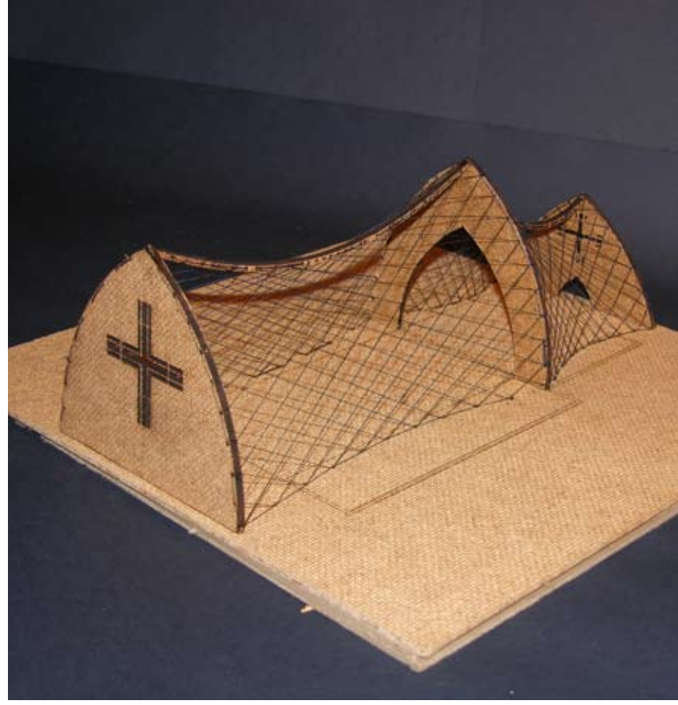
This thin-shell design was an exercise in understanding the structural limits of thin shell concrete paraboloids and hyperboloids. Most of these three-dimensional geometric shapes are created with straight lines that result in a curved surface. There are two types of paraboloids: elliptic and hyperbolic. The elliptic paraboloid cannot be made with straight lines, but is formed by taking half of an ellipse and rotating it on its central axis, creating a shape similar to a satellite dish or half an egg, depending on the depth of the ellipse. The hyperbolic-paraboloid is created with straight lines connecting the opposite sides of a quadrilateral shape with each point at a different height, making a shape similar to a Pringles chip or a saddle. A hyperboloid is formed by taking a cylinder and twisting the two ends in opposite directions generating an hour-glass shape.

I studied the works of architects and engineers that pioneered the current achievements in thin-shell concrete structures: in particular Felix Candela, Eladio Dieste, Oscar Niemeyer, Eduardo Torroja, Pier Luigi Nervi, Kenzon Tange and Robert Mailart. As an exercise, I designed a thin-shell roof for a small chapel measuring 48 feet wide by 72 feet long. After several small concept sketches, I decided to combine the principles of a gothic pointed arch with a hyperboloid, a concept I had not found in my research. Four hyperboloids converged geometrically, to create a pointed barrel arch.

To conclude this short design exercise, I built a model with thread to understand the physical transformation of straight lines generating curved shapes and produced renderings to place the design in a context. This exercise taught me to think about various combinations of three-dimensional geometries. I began to understand how curved surfaces relate to two-dimensional shapes and the structural advantages and limitations of thin shell concrete. By gaining a deeper understanding of how straight lines create three-dimensional curved surfaces, I began to study membrane structures differently. Instead of seeing curved surfaces with anchoring points, I began to see geometric plains connected by lines.

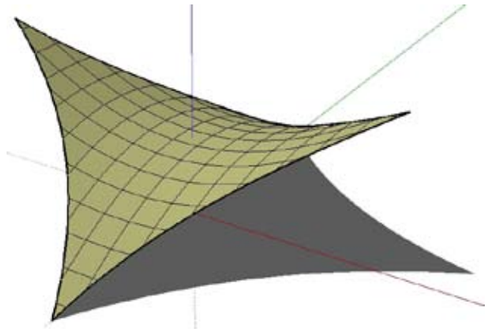


Sequence of how four hyperboloids were combined



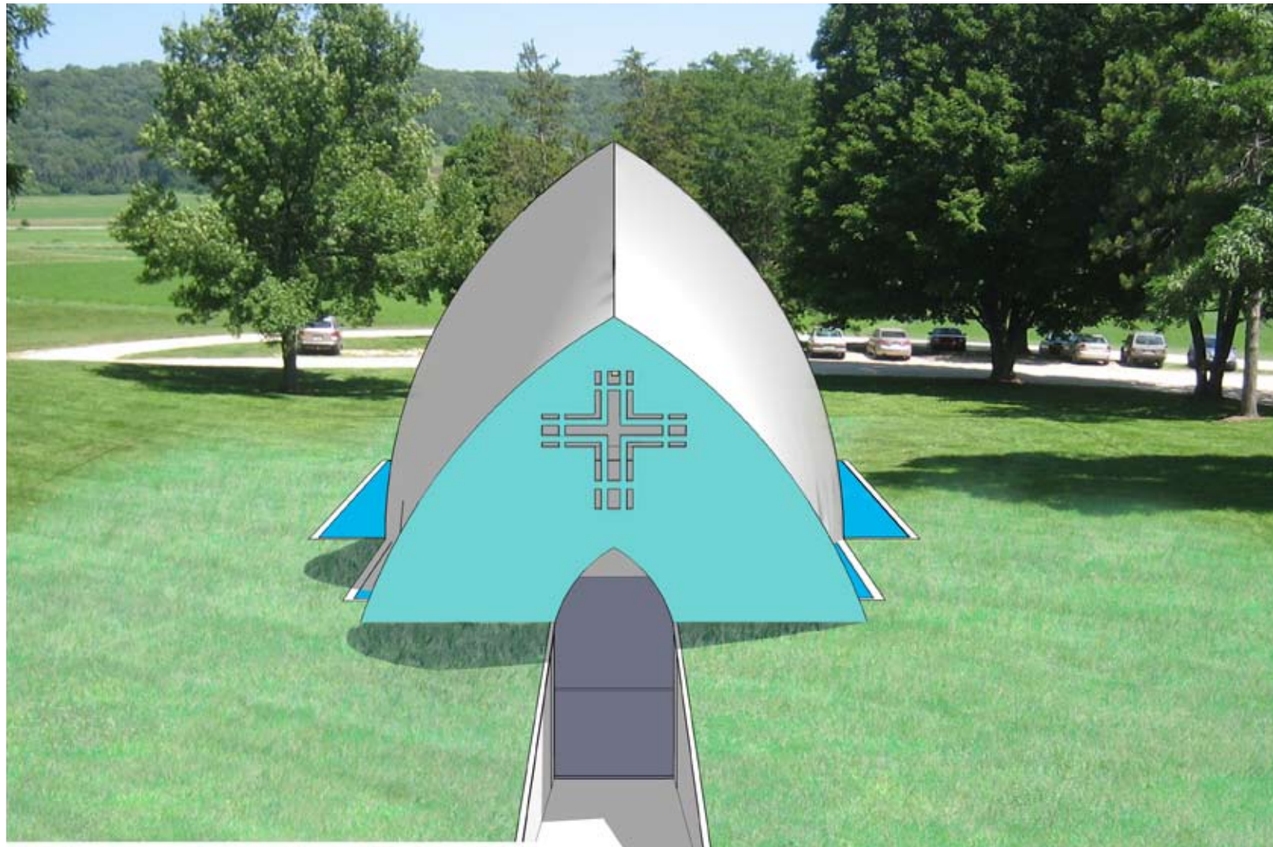
Thread model integrating strait lines to articulate the curved shell

Eliptic-Paraboloid



Hyperbolic-paraboloid

Twisting of a cylinder to produce a hyperboloid



Rendering of front entry

Fabric Shaping Space: Flexibility and Rigidity

Corpocidade (City-body): Dancing with architecture as an art performance

In October 2008 a conference in San Salvador, Bahia, Brazil entitled "Corporcidade: Debates on Urban Aesthetics" was organized by the Federal University of Bahia. They initiated a debate in urban aesthetics between the fields of arts and urbanism, interweaving cultural policies and urban areas. The debates intended to discuss how our understanding of the human body, arts, and urban environment affect our behavior and shape the creation of knowledge in several fields, especially the visual arts, dance, architecture, and urbanism.

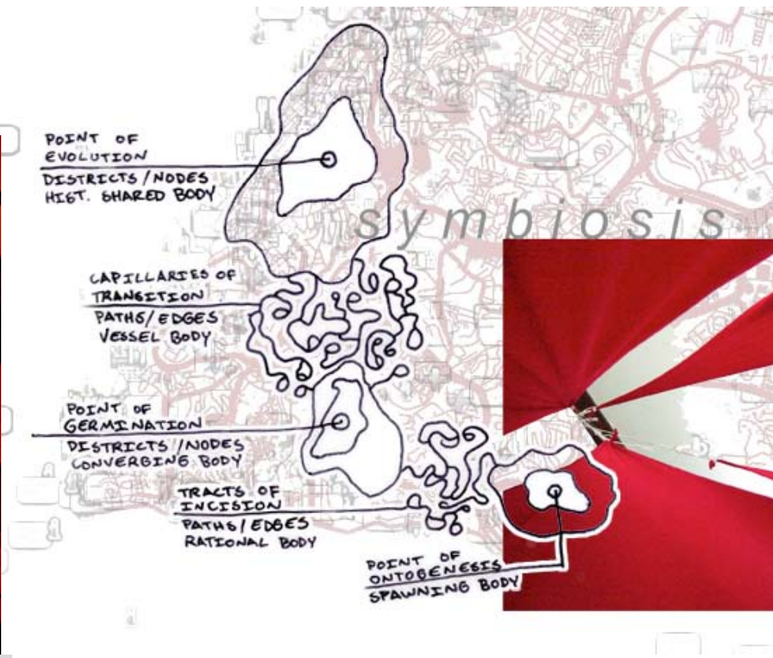
An artist and I, conceived the following project titled *Symbiosis*. It consisted of a movable installation/urban intervention that explored the relationship between the body (individual and collective) with the built environment. Rectangles of fabric, much like hammocks, were to stretch from and fold around corners of buildings, lamp posts, signs and gates, creating pocket-like organisms to be inhabited by the human body – the performer, the viewer, the passer by. These organisms, while inhabited, would act like second skins, protective elements, and connective tissues, invoking conversations about their symbiotic nature with the built environment. While the social organisms are uninhabited, the interdependency between the "actual body" (city and inhabitants) and the "constructed body" (symbiotic organisms and participants) was emphasized by the disembodied space. The public body is an essential element for the vitality of the built environment.

Symbiosis was proposed as a corporeal experience, a splash of color, a collective experiment pulsating, shifting, and migrating through the streets of Salvador, Bahia. *Symbiosis* was to be a collaborative project by two multidisciplinary artists, along with local volunteers, participants, and dancers. *Symbiosis* was a concise metaphor to examine the urban aesthetic by creating a space where the city's infrastructure would be emphasized, inviting the attention and analysis of its inhabitants and spectators. The urban landscape would be essential to the content of these installations and would make each experience unique to Salvador, Bahia in its historic and contemporary life. This migratory experiment would take place over the course of two - three days, exploring the areas between the more historic Pelourinho and the newer Federal University of Bahia campus.

The "actual body" and the "constructed body" connecting to a structure

A sequence of these organisms moving through the landscape

Examples of other school related art, architecture, and dance collaborations.



An abstract map of San Salvador and meandering path of the organisms