RADICAL REUSE: FROM THE SUPERFLUOUS TO THE EXQUISITE

By Marco Marraccini
Bachelor of Science in Architecture
University of Virginia, 1999

Submitted to the Department of Architecture in Partial Fulfillment of the Requirements for the Degree of Master of Architecture at the Massachusetts Institute of Technology.

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Signature of Author:

Department of Architecture
January 20, 2006

Certified by:

Associate Professor of Architecture **Ann Pendleton-Jullian**
Thesis Supervisor

Accepted by:

Associate Professor of Architecture **Ann Pendleton-Jullian**
Chair, Department Committee on Graduate Students

Thesis Committee

Thesis Supervisor:
Ann Pendleton-Jullian
Associate Professor of Architecture

Thesis Readers:
Yung Ho Chang
Professor of Architecture and Head of the Department of Architecture

John A. Ochsendorf
Assistant Professor in Building Technology

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Abstract

This thesis focuses on the systematic possibilities for the intricate architectural reuse and reconfiguration of the radial tire and the PET plastic bottle. Both waste products demonstrate significant structural and phenomenological potential and are abundantly available at the global scale. Through the specific exploration of these systems, reuse will be introduced to America's high-end architectural client base. Work in this well-established field has been typically associated with squatter settlements, ecological housing, and low-income developments. The objective is to demonstrate the elegance and sophistication that this strategy can yield. It is through the attention to the detail and the specific aggregation of waste materials that the exquisite and desirable can be created out of the unwanted, thus demonstrating the possibilities for future reuse in the larger construction market.

Thesis Supervisor: Ann Pendleton-Jullian
Title: Associate Professor of Architecture

ACKNOWLEDGEMENTS

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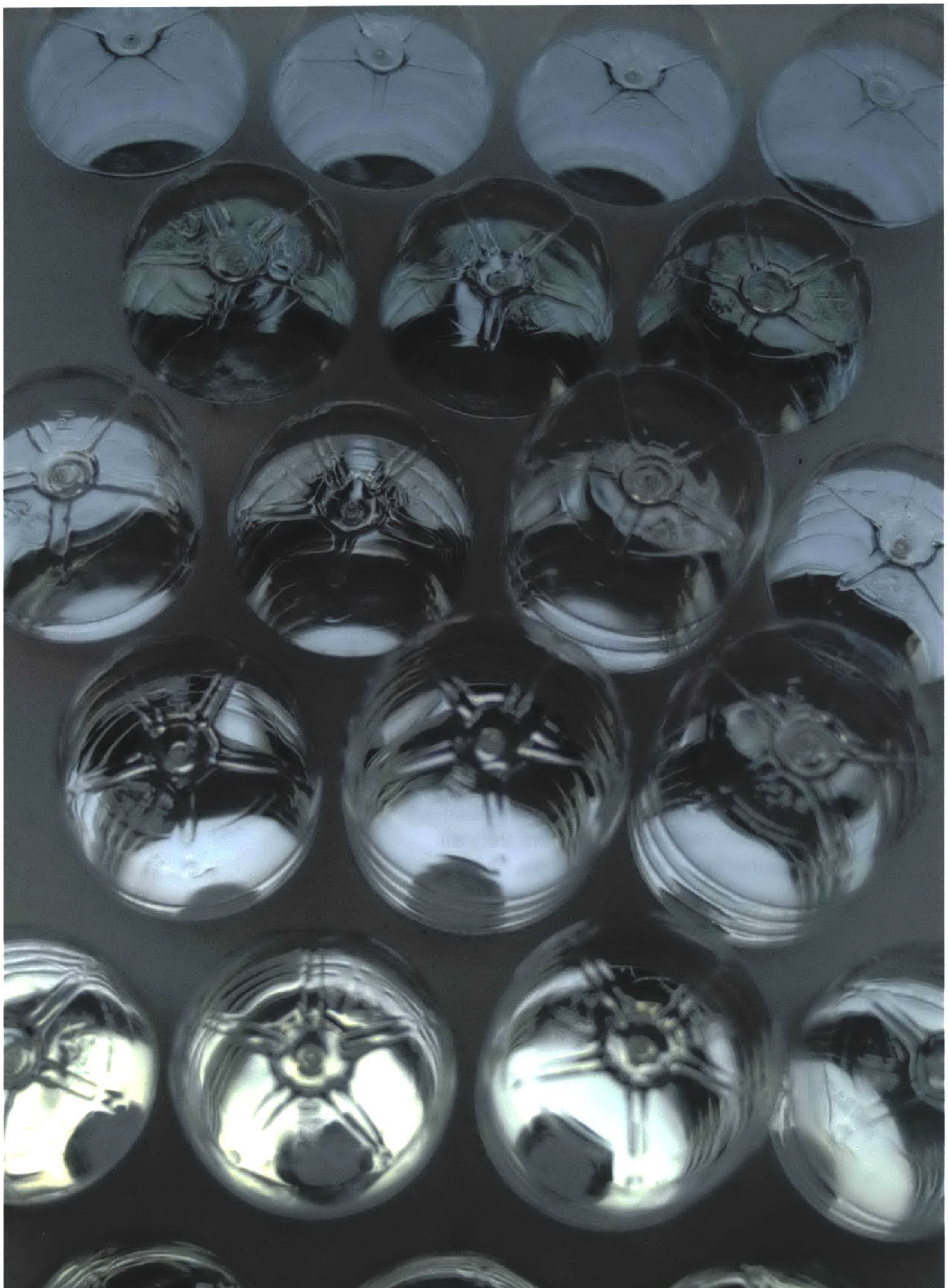
To my readers **John Ochsendorf and Yung Ho Chang - your advice and criticism challenged and informed this work.**

To my advisor **Ann Pendleton-Jullian - your guidance, encouragement, and poignant criticism were instrumental in pushing this project forward. I really appreciate your commitment to this project.**

To my family **Mom, Dad, and Marisa you have supported me with unconditional love and confidence. You are truly an inspiration in everything I do.**

Most of all, to my amazing wife Grace... I could not be more grateful. Your relentless devotion and support has made this work possible. Thank you for your sacrifices and unwavering exuberance.



BOTTLE CEILING (FIG. 01)

Contents

INTRODUCTION

"We in the West have come to identify the termination of one use with the termination of all usefulness, and we carry this simple idea through ruthlessly, in our own treatment of the old as much as our treatment of the waste products our society generates in such profusion... While waste remains valueless it will be wasted: and this valuelessness is a consequence of the tunnel vision from which we in the West all suffer."

-Martin Pawley - Garbage Housing

Wastefulness is a substantial problem that is fully embedded in our society. Little progress has been made to alter this fact. This thesis is about potential. It is not a solution to this massive problem, yet it is an attempt to bring value to what we consider garbage. It is a kind of opportunism - to take advantage of certain waste products' potential and to create something exquisite.

The design work is specifically focused on the various possibilities that the tire and the PET plastic bottle yield. Both waste products demonstrate significant structural and phenomenological potential and are abundantly available at the global scale. Various surface and structural systems are investigated through the understanding of their construction and material properties. The systems reflect a potential for a complex and intricate architecture.

Work in the well-established field of architectural reuse has been typically associated with squatter settlements, ecological housing, and low-income developments. This thesis focuses on the introduction of direct reuse to the high-end construction industry through the implementation of the PET bottle and tire systems. It is this clientele that has the initial financial capacity to implement what could eventually become a cost-effective and desirable means of construction.

The program of a high-end resort hotel is initiated in order to challenge and provide specific programmatic and spatial input for the development of the waste material systems. The hypothetical hotel helps define these systems' limitations. The project is situated on an abandoned garbage dump, Spectacle Island, located in Boston Harbor. The island has been recently covered with 6.3 million tons of fill from Boston, Massachusetts' historic Big Dig in order to contain the garbage beneath. It is slated to become a significant recreational destination within the greater Boston Harbor Islands park system.

MATERIAL WASTE CYCLES

America's material, resource, and energy consumption is mostly invisible to the average consumer. Each American citizen discards 4 lbs of trash per day or 1 ton per year. However, this number is dwarfed by the amount of natural resources (120 lbs) an average American consumes each day. This massive number is indicative of the extensive production cycle that it takes to make our everyday products. The product stream is mostly hidden from our daily lives. The plants, mines, and farmlands are suppressed to far off countries and industrial parks.[1] It is important for us to understand the extent of the production cycle to truly comprehend the effect our consumption has on the world's resources and its people.

In an effort to demonstrate this impact, I have decided to research three of our most universal waste products: tires, plastic (PET) bottles, and paper. Each of these items has extensive production cycles that reach many corners of the world. The plastic bottle, of which Americans throw away 2.5 million every hour, presents a simple example.[2] It is in our possession for an hour or two; however this is only a small fragment of its life cycle. The virgin PET pellets are chemically fabricated in Italy and then shipped to a bottle manufacturer in Virginia. The bottles are blow-molded and trucked all over the eastern coast of the United States to be filled with product and labeled. Imagine: billions of bottles full of air traveling thousands of miles in gas-guzzling eighteen-wheelers. This simple fact negates all of the effort made in designing a materially efficient bottle. Examples like this are commonplace in the manufacturing of everyday products.

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1 Ryan, John C, Stuff: The Secret Lives of Everyday Things (Seattle, Wa: Northwest Environment Watch, 1997)
2 Royte, Elizabeth, Garbage Land: On the Secret Trail of Trash (New York, New York: Brown Little, 2005).

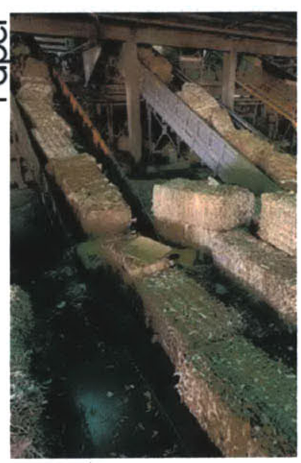
"We're reminded a hundred times a day to buy things, but we're not reminded to take care of them, repair them, reuse them, or give them away."

-Michael Jacobson, Center for the Study of Commercialism

Pet Bottle

(FIG. 02)

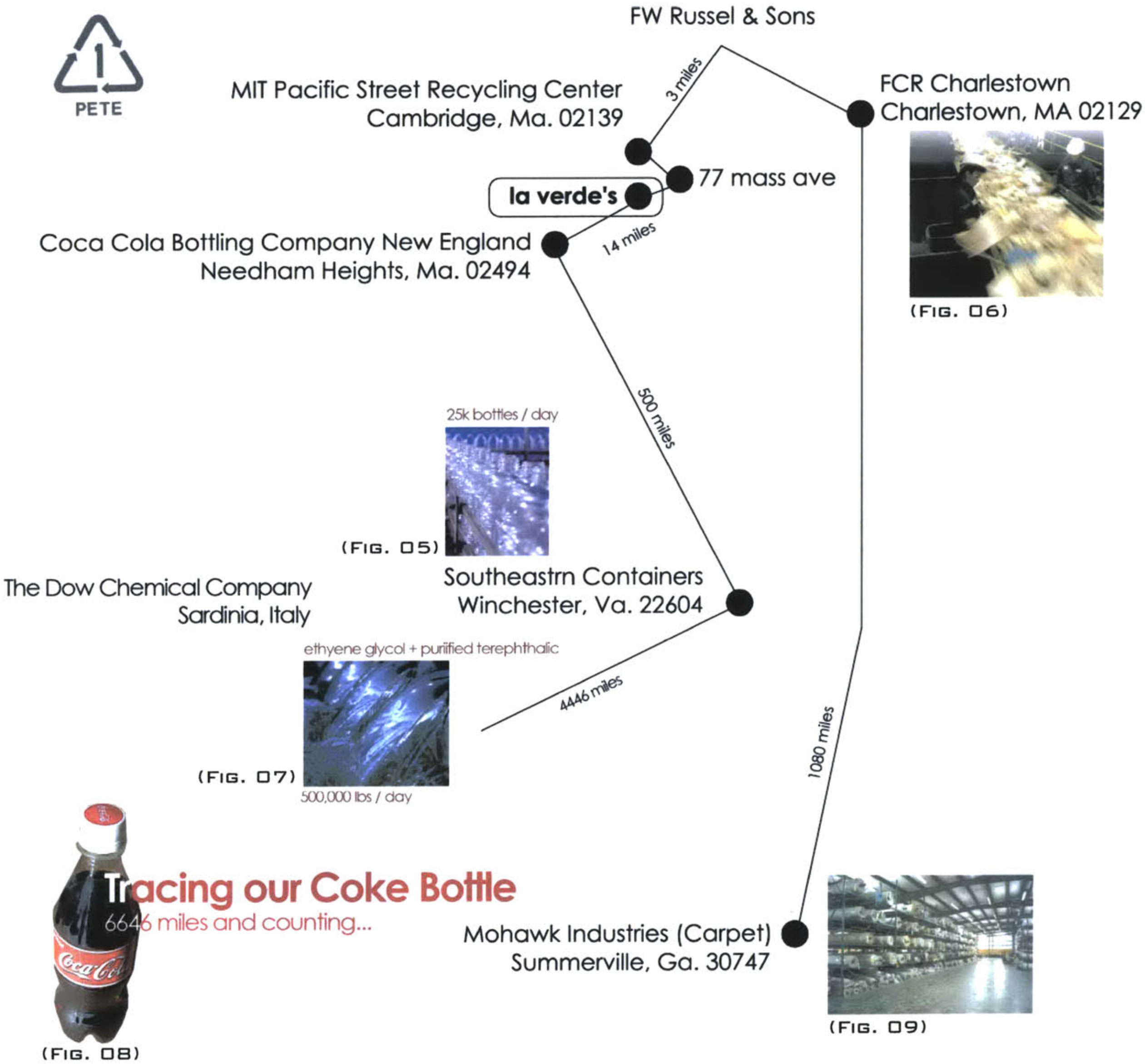
Paper



(FIG. 03)

Tires

(FIG. 04)

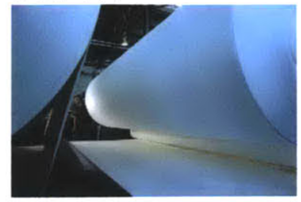

FW Russel & Sons
3 miles
MIT Pacific Street Recycling Center
Cambridge, Ma. 02139
FCR Charlestown
Charlestown, MA 02129
PETE
77 mass ave
la verde's
Coca Cola Bottling Company New England
Needham Heights, Ma. 02494
14 miles
(Fig. 06)
500 miles
25k bottles / day
(Fig. 05)
Southeastrn Containers
Winchester, Va. 22604
The Dow Chemical Company
Sardinia, Italy
ethyene glycol + puriified terephthalic
4446 miles
1080 miles
(Fig. 07)
500,000 lbs / day
Tracing our Coke Bottle
6646 miles and counting...
Mohawk Industries (Carpet)
Summerville, Ga. 30747
(Fig. 09)
(Fig. 08)

(FIG. 10)

MeadWestvaco Tree farm
Kennebunk, ME

98 miles

(FIG. 11)



Mead Paper
Rumford, ME

200 miles

FCR Charlestown
Charlestown, MA 02129

3 miles
FW Russel & Sons

MIT Pacific Street Recycling Center
Cambridge, Ma. 02139

77 mass ave

(FIG. 13)

(FIG. 12)

19 miles

Staples Fulfillment Center
Framingham, MA

6800 miles

(FIG. 14)

Tracing our Mead Office Paper

7120 miles and counting...

(FIG. 15)

KC International (Paper)
South Korea


(FIG. 16)

Mainline Tire Recycling Co Inc.
New Bedford, MA

155 miles

Hamilton Elementary School
Sommersworth, NH


(FIG. 17)

Licensed Tire Hauler 58 miles


(FIG. 18)

Goodyear Tire Auto Service Center
Boston, MA 02215

tire miles


(FIG. 19)

Goodyear Tire Auto Service Center
Boston, MA 02215

1494 miles

Goodyear Tire & Rubber Global Distr. Center
Lincoln, NE 68524


(FIG. 20)

11 miles

Goodyear Tire & Rubber Co. Plant
Lincoln, NE 68504


(FIG. 21)

9630 miles

(FIG. 22)

Tracing our Goodyear Tire

11,358 miles and counting...

Goodyear Sumatra Plantation
Indonesia


(FIG. 23)


(FIG. 24)

Contemporary Reuse

"If life feeds on wasting, and life is what we value, then wasting is wasteful when it fails to support life."

-Kevin Lynch- Wasting Away

American landfills are overflowing at a staggering rate. Of the 5,499 landfills operating today, 4,265 of them will close in just 18 years. Recent acceleration of recycling programs has helped, but America's waste production continues to grow. The National Recycling Coalition's motto of "Reduce, Reuse, and Recycle" provides a response to this problem by focusing attention on the reduction of waste as well as the reuse of it. Recycling is really only slightly better than trash, due to the high levels of energy it takes to physically sort, break down and recycle material. The concept behind direct reuse comes out of the material properties themselves. By grinding down and recycling a material, the material loses its structural integrity. For example a car windshield melted down can only hope to one day become a bottle; thus it is advantageous to explore new options for the windshield in its original form.

Possibilities for reuse are abundant, but the more significant question is what type of architecture can come from it? Traditionally, architecture built from waste materials has been associated with low-cost housing, squatter settlements, and as a desirable option for environmentalists. The New York-based architecture firm, Specht Harpman has attempted to break this barrier with their unrealized designs for a Prada boutique. The concept integrates a backlit array of Coke crates that form a backdrop for Prada clothing. The combined crates act as a decorative Arabesque. In this proposal for Prada, Specht Harpman challenges the way the reuse of waste is viewed by the public.[1] It is an attempted transformation of the unwanted to the fashionable. It is in this practically untapped realm that the largest impact can be made. If reuse can become an established and attractive alternative for the wealthy, the rest of the country will begin to see it in a different light. Instead of reusing materials because of financial necessity or the fact that you feel obligated to do so, it could feasibly grow to be a desired option within the larger field of architecture.

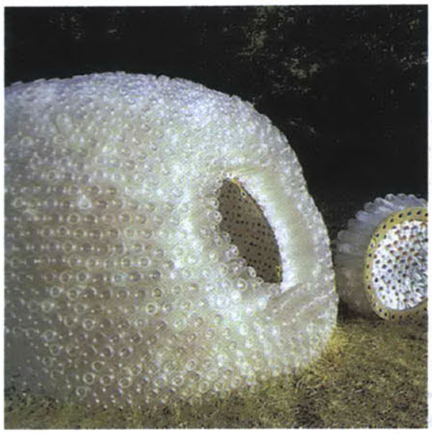
1 Praxis: Journal of writing + Building 2003, No. 5 (Cambridge, Ma: Praxis Publications, 2003).

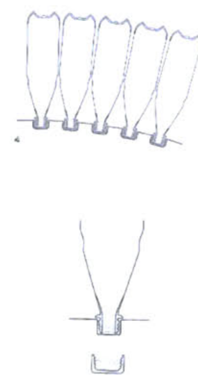
To make the exquisite and desirable out of waste products, there must be a significant transformation that occurs. The materials can be cut, cast, reconfigured, and reoriented to make something original. There is a certain degree of decorum that must be attained to get the larger public interested. This can be achieved by an intensive investigation into the detailing and crafting of these materials. CNC and Craft techniques traditionally reserved for high-end virgin materials will facilitate this transformation. Through the combination of reused or recycled secondary materials (scrap metal, reclaimed lumber, fabric, cable, wire mesh, etc...) an entirely new effect can be produced. A successful example of this strategy is seen in the work of students at the Technical University in Berlin. They have constructed an elegant and sophisticated space by maximizing the potential of the PET bottle. A translucent plastic skin is sandwiched between the cap and the screw top of the bottle. The form is determined by the arrangement of the bottles.[1] The introduction of the plastic skin and the innovative use of the existing cap bring new formal possibilities. The light transmission through the spherical arrangement of bottles makes the project truly exquisite. It is this type of structural ingenuity that is lacking from Specht Harpman's proposal for Prada. When working with reused materials, it is important to capitalize on the structural, aesthetic, and phenomenological properties inherent in the materials.

The exploitation and reconfiguration of waste materials can produce something truly unique and desirable for a wide spectrum of the American public. The following examples demonstrate many of the principles necessary for successful reuse.

1 Schittich, Christian, Building Skins: Concepts, Layers, Materials (Boston, MA: Birkhauser, 2001).

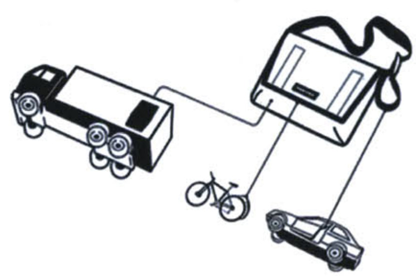
A Summer Space: Johl, Jozwaik, Ruppel (Fig. 25,26,27)





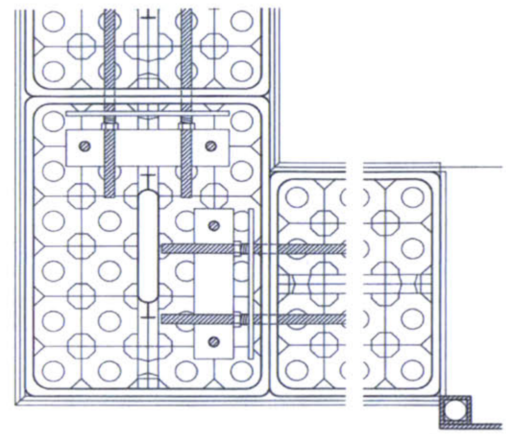
Students at the Technical University in Berlin have constructed an elegant and sophisticated space by maximizing the potential of the PET bottle. A translucent plastic skin is sandwiched between the cap and the screw top of the bottle. The form is determined by the arrangement of the bottles. A spherical vault of refracted light is created by the configuration of PET bottles. This project demonstrates the potential of a single product type as it interacts with a secondary material (plastic sheet). The combination of the two translates into something truly unique.

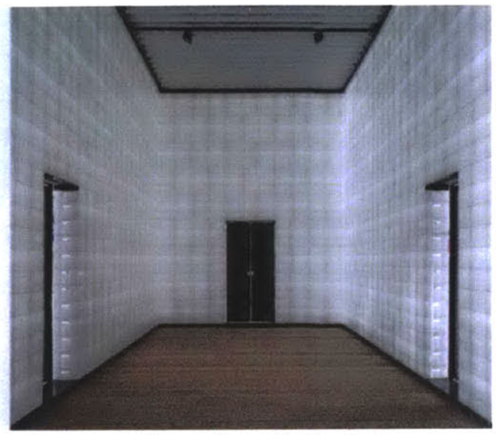
Freitag: Zürich (Fig. 28,29)



Daniel and Markus Freitag, of Switzerland, design bags made of vinyl tarps reclaimed from freight trucks. These vinyl tarps are typically multicolored and clad in graphics. The graphics and patterns are abstracted when the vinyl is cut down to the scale of a bag. Therefore, each bag is unique. Discarded bicycle tubes and seat belts are also used in the construction of the bags. The Freitag bags are sold for $200 and have become extremely popular in Europe and the United States, demonstrating the possibilities for successful high-end products made of waste.

MUSEUM PAVILION: **ATELIER KEMPE THILL, ROTTERDAM (FIG. 30,31)**



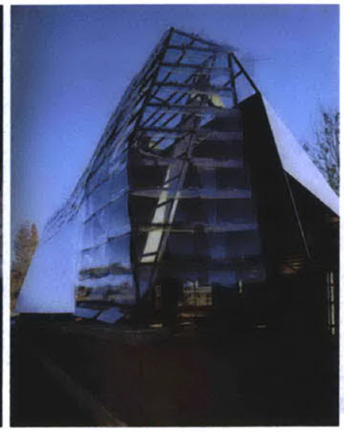


Architects Atelier Kempe Thill built this museum pavilion out of translucent plastic beer crates. Light is filtered into the interior through the grid of stacked beer crates. The modules are through-bolted in the horizontal and vertical direction and held in tension to the floor plates.

2012 ARCHITECTS: **ROTTERDAM (FIG. 32)**

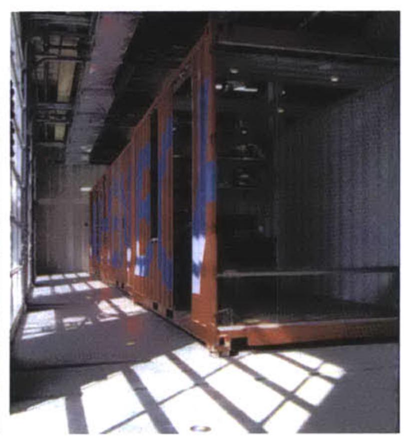
2012 Architects search aggressively for materials suitable to a creative architecture of reuse or more specifically Radical Reuse. Their offices epitomize this agenda. Every desk, computer, and construction material has been reclaimed. Their built projects range from a futuristic installation made of washing machines to a shoe store built of recycled wood and car windshields. 2012's most significant project is the formation of the reuse web site, Recyclicity.net, which helps put architects in contact with organizations that specialize in reuse.

RURAL STUDIO: AUBURN UNIVERSITY (FIG. 33,34,35)



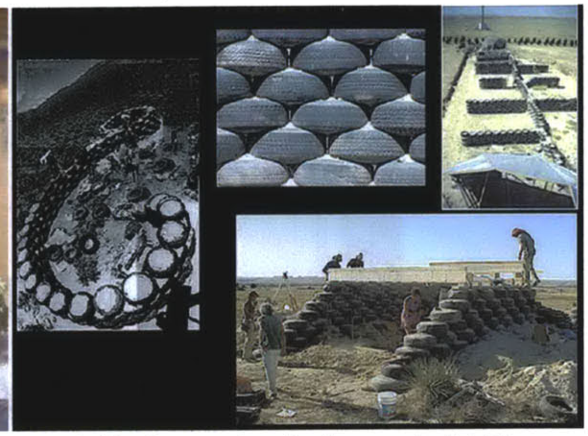
Students at the design-build Rural Studio in rural Alabama use inventive techniques for the reuse of waste material. Bales of aluminum and stacked shipping pallets make up an exhibit in Barcelona, while one student focused his thesis on the construction of a student dorm room built of load bearing paper bales. Stacked carpet tiles make up the exterior walls of the Lucy House, while reclaimed car windshields act as an elegant curtain wall at an open-air community center. License plates are tiled on the exterior of plywood sheathing to act as a weather barrier. The Yancey Chapel is built of rammed earth tires covered in stucco.

LOT/EK: NEW YORK, NY (FIG. 36,37)



LOT/EK works almost exclusively with reused shipping containers. Proposed work ranges from large scale apartment buildings to portable units to temporary exhibits. They also offer a "Container Home Kit" for a variety of living spaces.

EARTH SHIPS: **SOUTHWESTERN US** (FIG. 38,39)

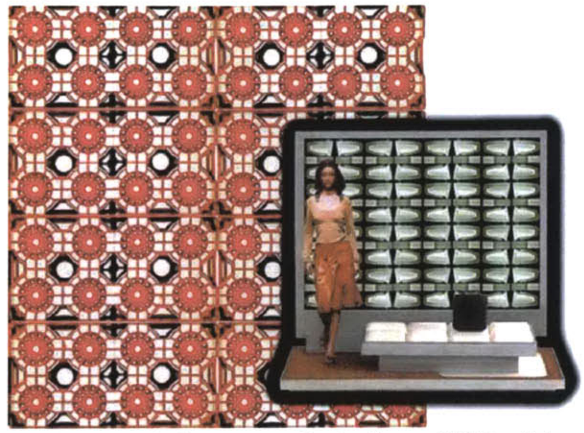



Earthships are sustainable passive solar homes built of natural and refuse material. The company sells instructional videos to help spread the knowledge of tire home construction. They also sell existing Earthships on their websites.

TIRE RETAINING WALL: **TIJUANA** (FIG. 40,41)


In Mexico, large scale retaining walls are built of inverted tire treads cast in place with concrete. The inversion puts the tire in greater tension allowing for a higher degree of strength. The tread on the inside provides for better adhesion to the concrete. The effect is a beautiful aggregation of texture and pattern.

SPECHT HARPMAN: **NEW YORK, NY (FIG. 42)**



Specht Harpman looks at possible aesthetic and phenomenological possibilities inherent in industrial materials. They are pushing industrial and waste materials into the arena of high fashion and design with their proposal for Prada. The concept integrates a backlit array of Coke crates that forms a backdrop for Prada clothing. The combined crates act as a decorative Arabesque.

SHIGERU BAN: **PAPER EMERGENCY SHELTERS (FIG. 43)**

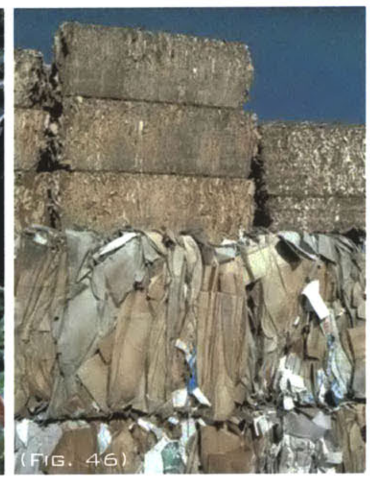
Shigeru Ban designed these emergency shelters to be built by members of the communities affected by disasters. The homes are constructed of recycled paper tubes, plywood, beer crates, and vinyl truck tarps. Waste paper is stuffed inside the tubes to increase insulating properties.

Material Research: The Potential of Waste

The value of waste materials is determined by their potential for reuse or recycling. Reclaimed lumber and metal have a relatively high resale value because they are more easily reintegrated into new construction due to their physical and aesthetic durability. However, value for used tires and plastic bottles is currently limited because of the extensive reprocessing that must occur before they are again a 'usable' commodity. This method allows for the production of a wide variety of products but not without substantial energy and monetary cost.


(Fig. 44)


(Fig. 45)


(Fig. 46)


(Fig. 47)


(Fig. 48)


(Fig. 49)


(Fig. 50)


(Fig. 51)

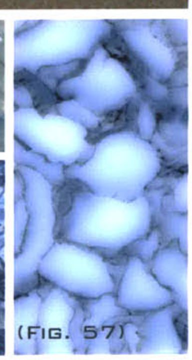

(Fig. 52)


(Fig. 53)


(Fig. 54)


(Fig. 55)


(Fig. 56)


(Fig. 57)

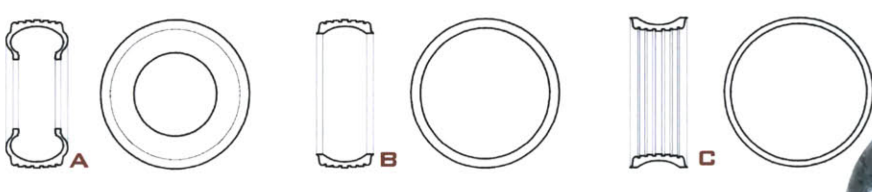

(Fig. 58)


(Fig. 59)

MATERIAL SYSTEMS: THE TIRE

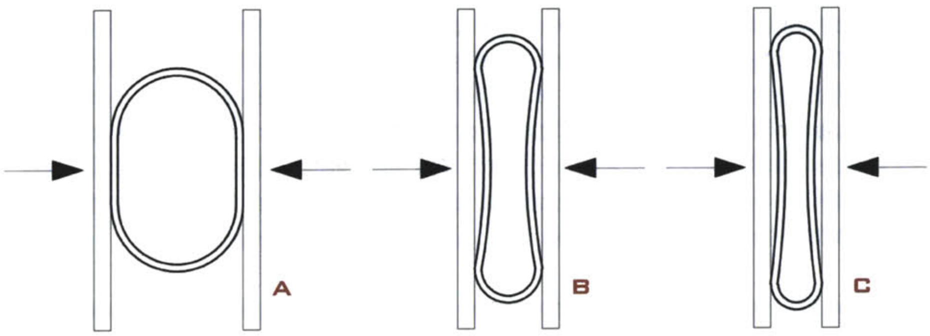
The standard automotive radial tire is built of two components: the tread and the sidewalls. The tread is composed of thirty types of synthetic rubber (5lbs), eight types of natural rubber (4lbs), eight types of carbon black (5lbs), one pound of steel cord, one pound of polyester, one pound of steel bead wire, and forty different kinds of chemicals, waxes, oils, and pigments (3lbs). *Texas Natural Resources Conservation Commission* The sidewalls are composed of a combination of synthetic and natural rubbers. They are built together to form a working tire. The sidewalls hold the tire's shape and define its lateral stability. The sidewalls can easily be separated from the tread with the use of a utility blade. Machinery has even been developed for tire dealers to more accurately and efficiently cut off the sidewalls. This is a crucial step from their perspective because it decreases the spatial volume by fifty percent. It is at this stage where the tire begins to have unique potential for reuse.

The tire tread alone can act as a flexible form for a cast masonry system because it is no longer restrained by the sidewalls. The flexibility inherent in the steel and rubber constructed tread allows for the simple creation of a range of shapes and proportions. A 24in diameter tire can be compressed into a unit that is 4" x 56". An inverted tire is held into shape by a viselike form, while a waste plastic-based concrete is cast into the tread. The inversion of the tread allows for a greater bond between the tire and the concrete and helps to distance one's immediate association with the tire. The black rubber tread and the light grey cast concrete combine to create an elegant aesthetic.

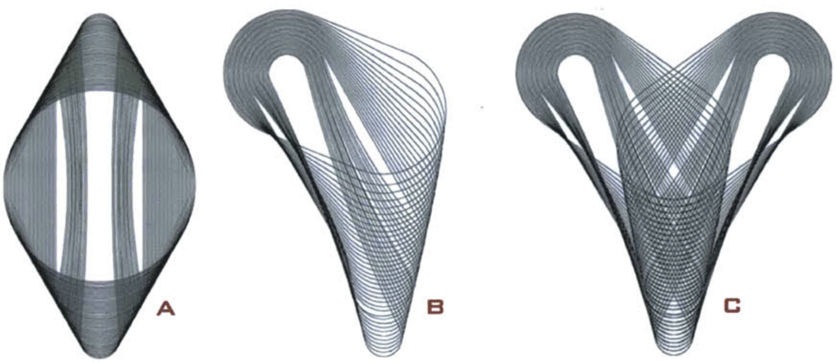


TIRE TRANSFORMATION (FIG. 60)

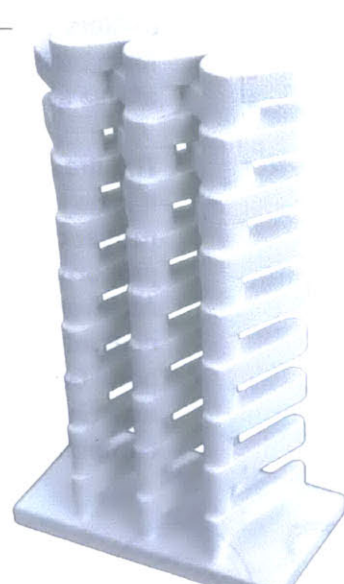
TIRE MASONRY UNIT (FIG. 61)



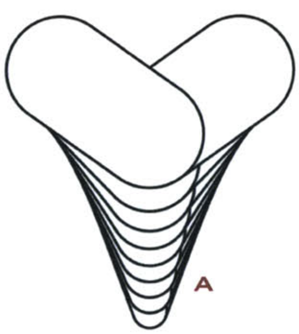
COMPRESSION (FIG. 62)



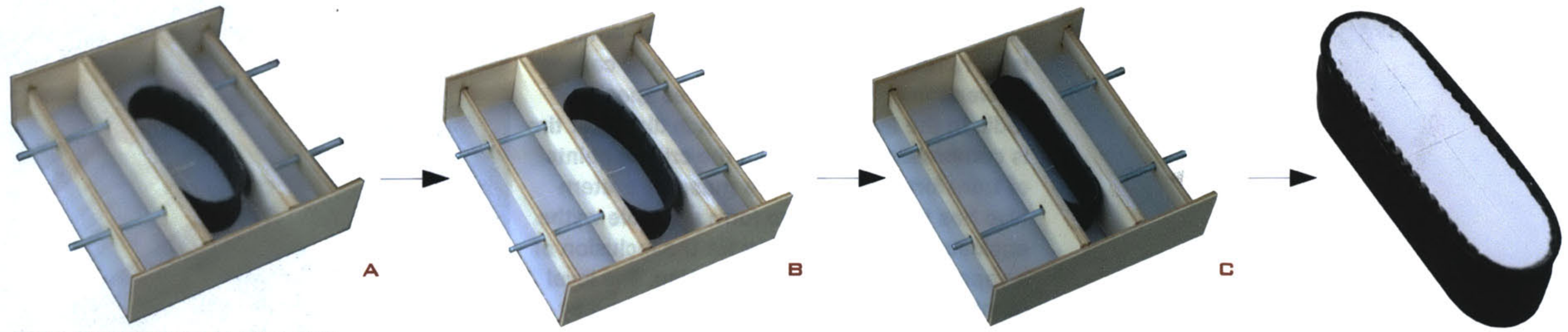
VARIATION + ROTATION (FIG. 63)



Z-CORP PRINT (FIG. 64)

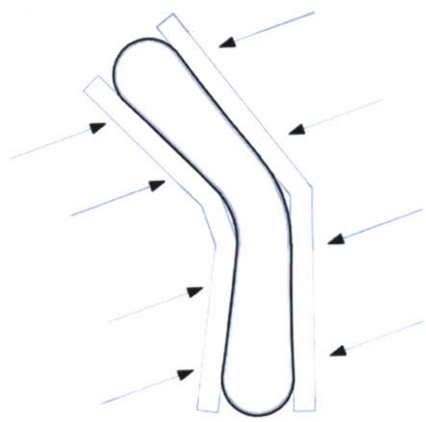


WALL SYSTEM (FIG. 65)

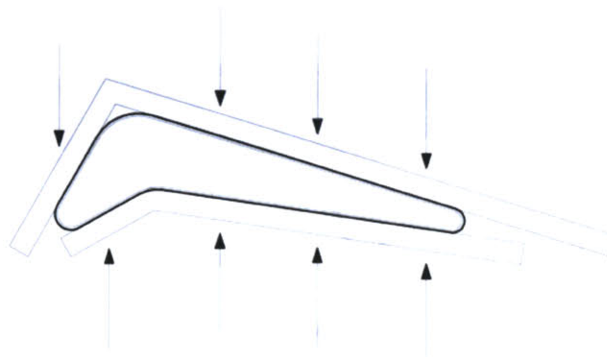


Tire Compressor (Fig. 67)

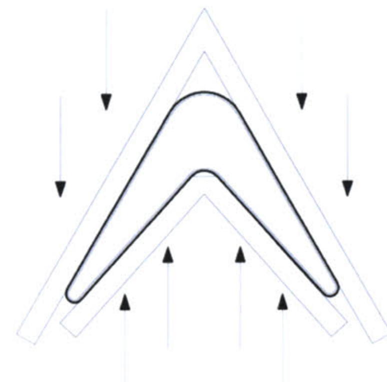
Bent Unit (Fig. 68)



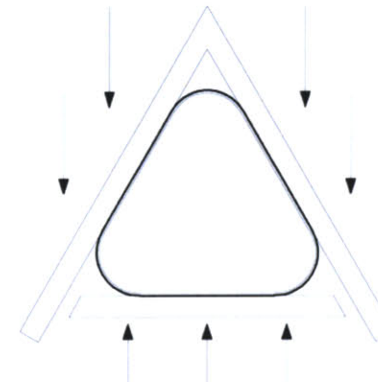
Compression A (Fig. 69)



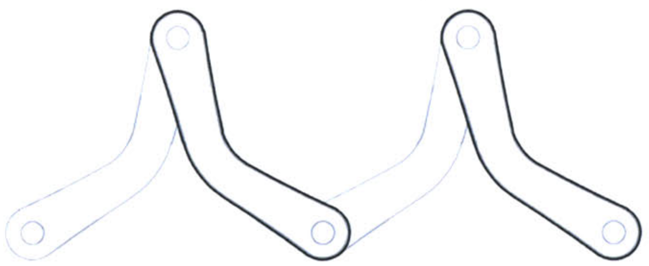
Compression B (Fig. 70)



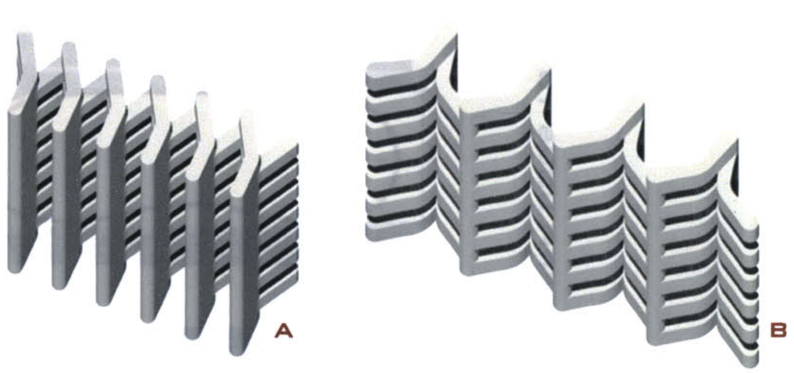
Compression C (Fig. 71)



Compression D (Fig. 72)

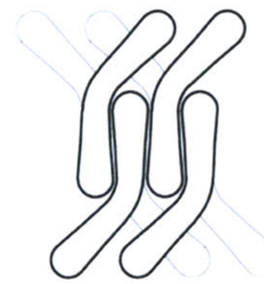


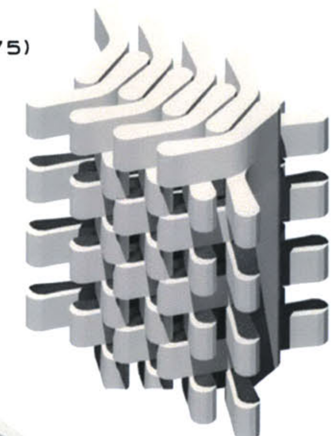
Arrangement A (Fig. 73)



Arrangement B (Fig. 74)

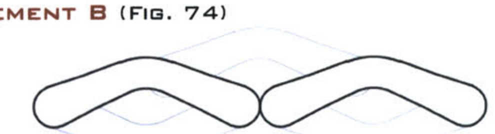
Arrangement C (Fig. 75)



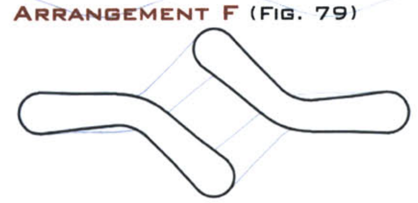


Arrangement D (Fig. 76)

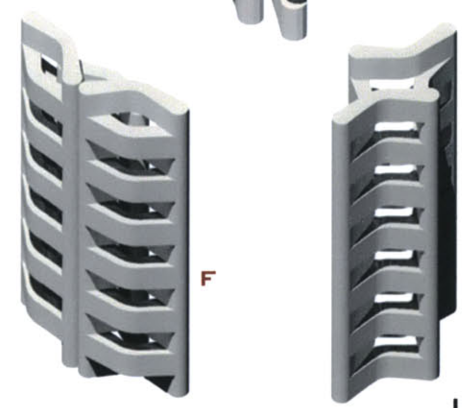
Arrangement E (Fig. 77)

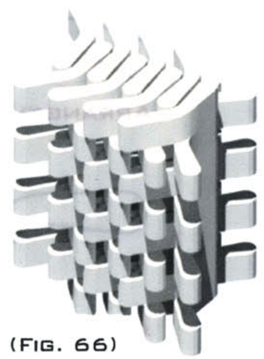


Arrangement F (Fig. 79)

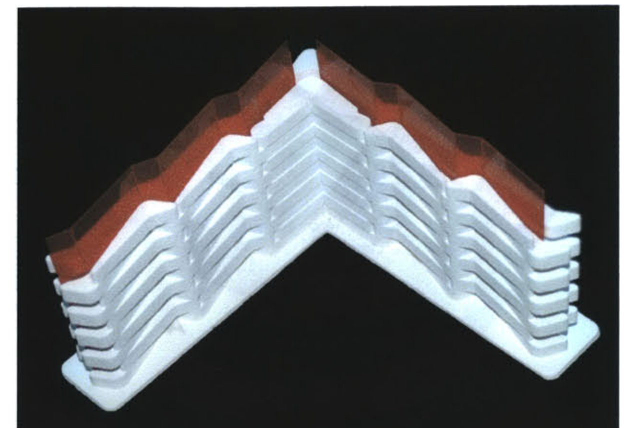


Arrangement G (Fig. 80)

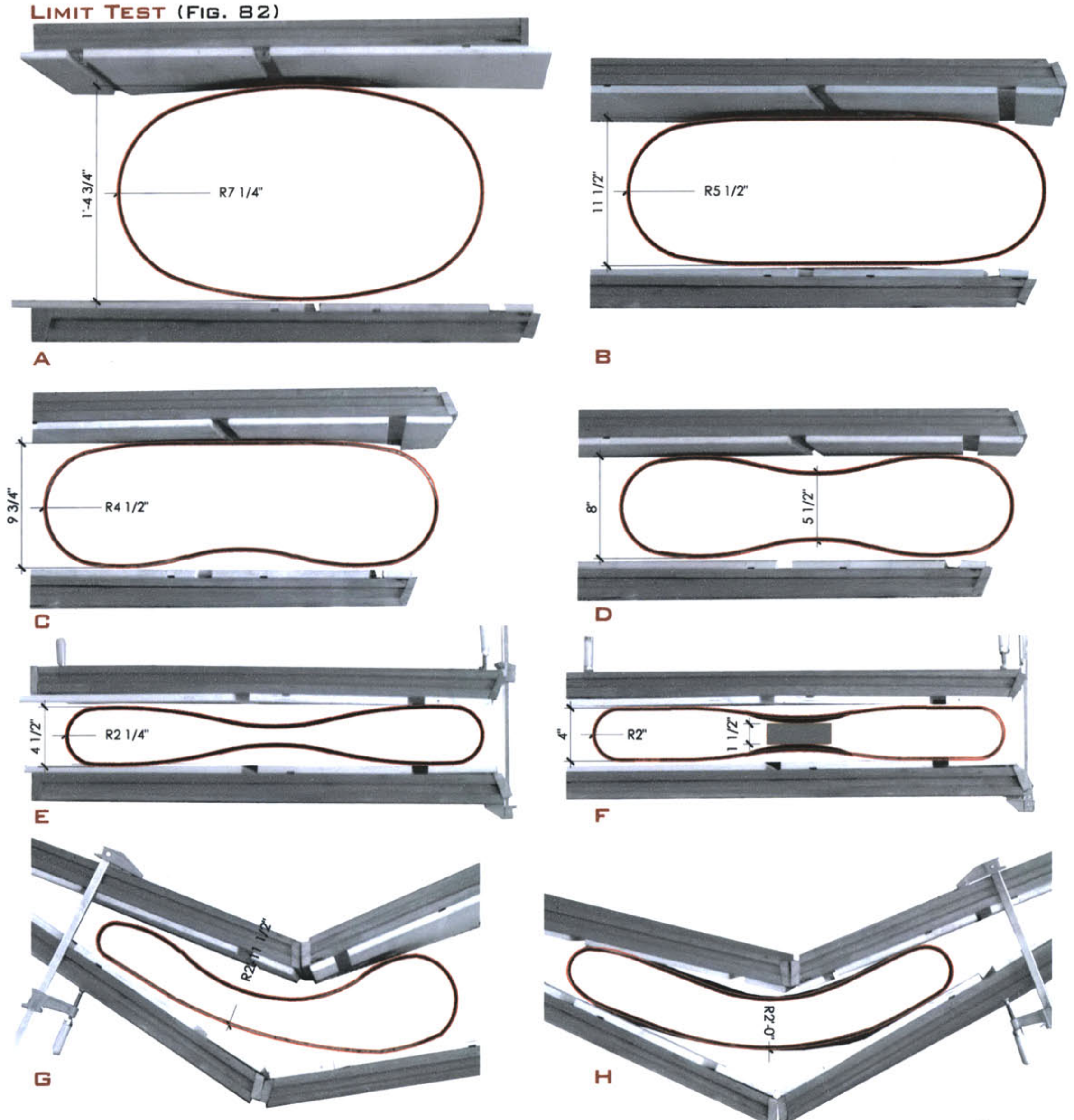


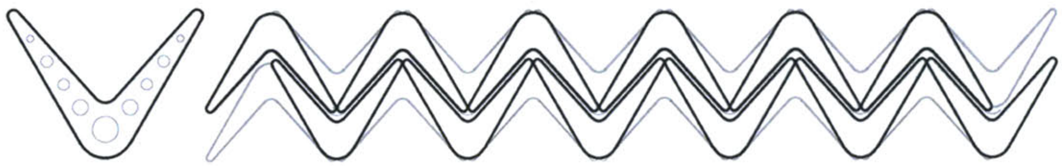

(Fig. 66)

The flexibility of the tire tread is constrained because of its complex construction. When it is compressed, the steel substructure causes conversion in its form and defines specific radii. In the test below, a 48 inch diameter tire is compressed to establish the critical points of transformation. The tire masonry system also has the potential to form a double wythe enclosure wall. This allows for the inclusion of a vapor barrier and rigid insulation. The level of intricacy and patterning is heightened by forming a complex masonry unit and laying it strategically.


Cavity Wall C Z-Corp Print (Fig. 81)

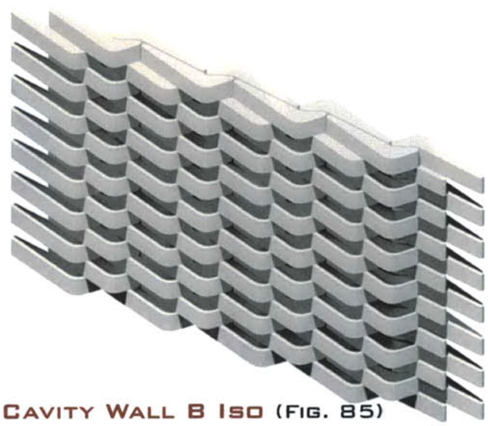
Limit Test (Fig. 82)



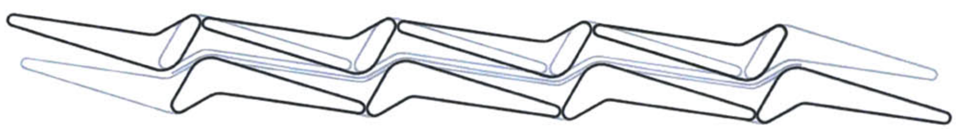


Cavity Wall A (Fig. 83)

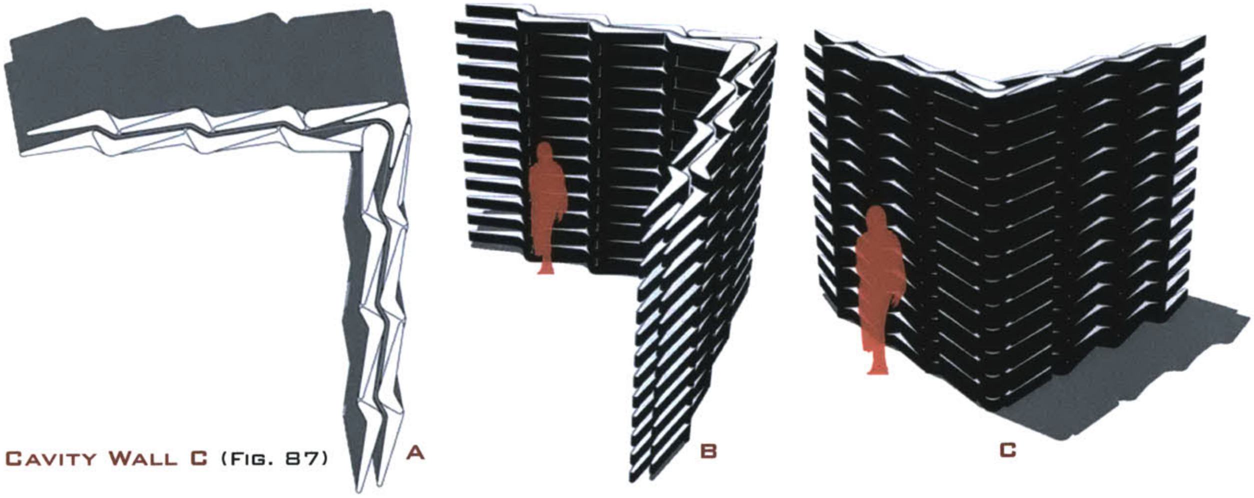
Cavity Wall A Iso (Fig. 84)



Cavity Wall B Iso (Fig. 85)

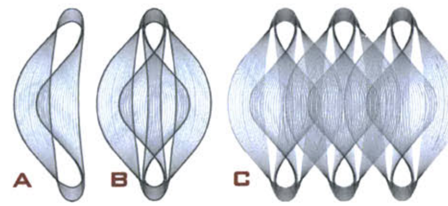


Cavity Wall C Plan (Fig. 86)



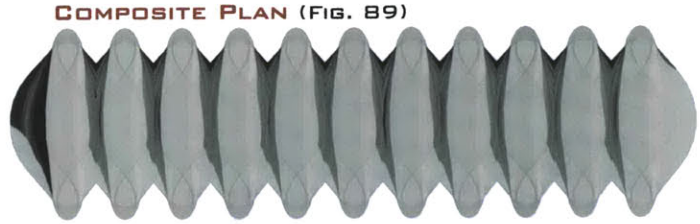
Cavity Wall C (Fig. 87)

The tire masonry unit has the ability to accomplish gradual transformations within its simple flexible form. The form has the ability to bend from a straight unit into a curved unit. The transformation can literally occur within the construction of a wall. In the example below, the unit at the base is curved, mirrored, and overlapped. Each unit is gradually bent less as they are stacked up to form the variegated wall. The result is a wall system that becomes more porous as it gets higher. The wall transitions into a series of piers as the units begin to straighten out.

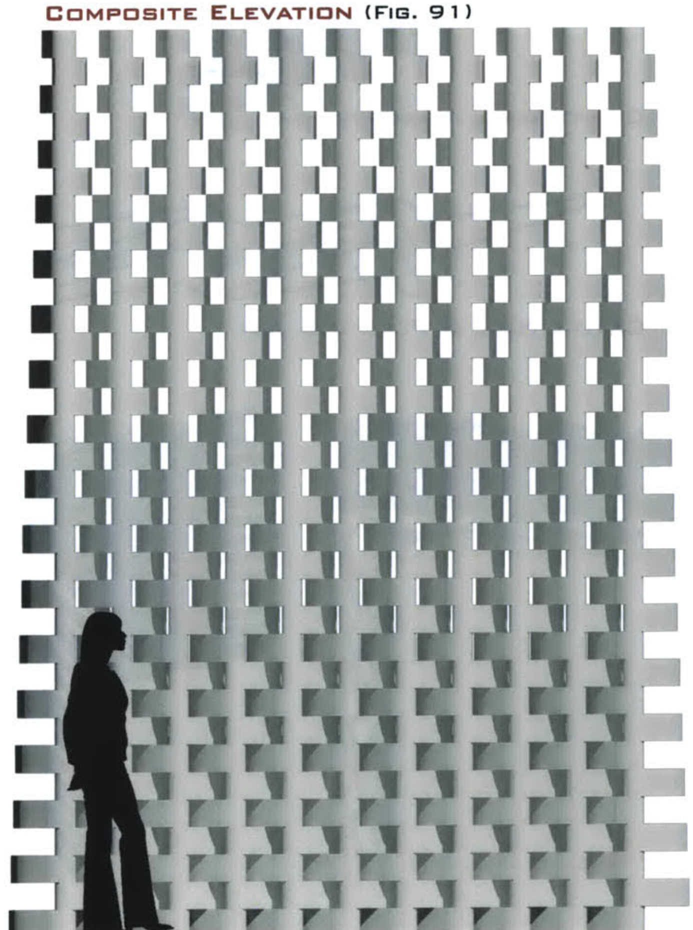


PLAN DEVELOPMENT (FIG. 88)

COMPOSITE PLAN (FIG. 89)

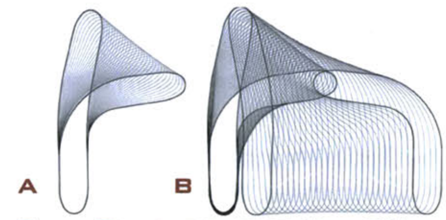


COMPOSITE ELEVATION (FIG. 91)



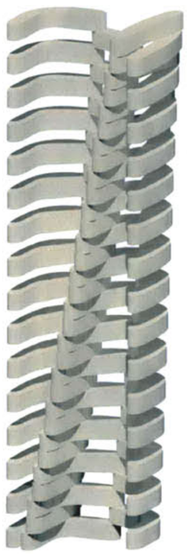
ISOMETRIC (FIG. 90)

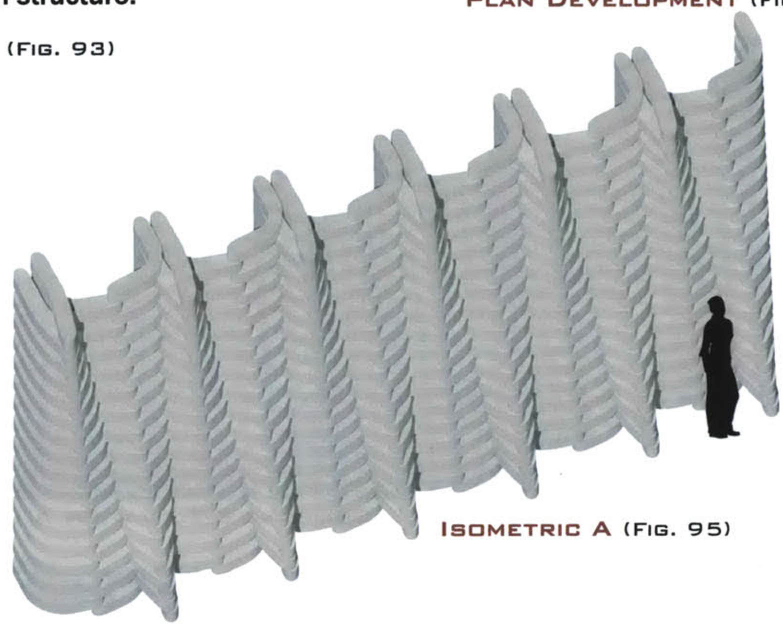
Following the same logic as the previous example, these two wall systems use a unit that is gradually bent or curved. The wall variation B (fig. 96,97) becomes more transparent as it moves from left to right. The units bend more and the openings get larger. The wall system variation A (fig. 93-95) literally stacks each block as it bends to create an intricately woven structure.



PLAN DEVELOPMENT (FIG. 92)

VARIATION A COMPONENT (FIG. 93)



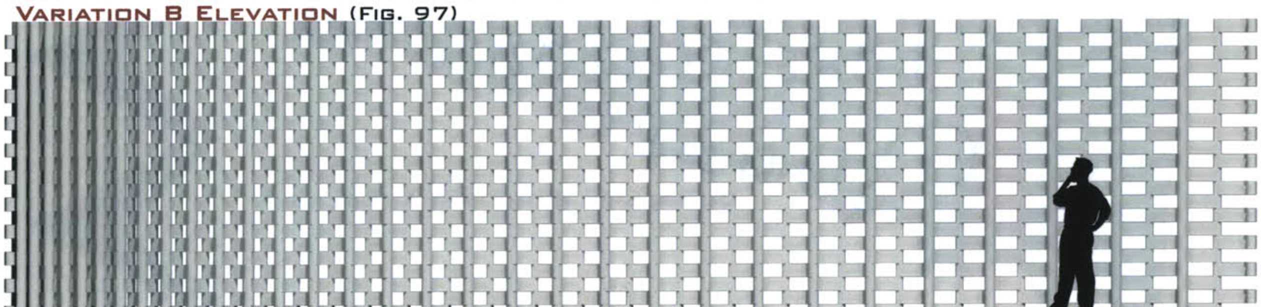


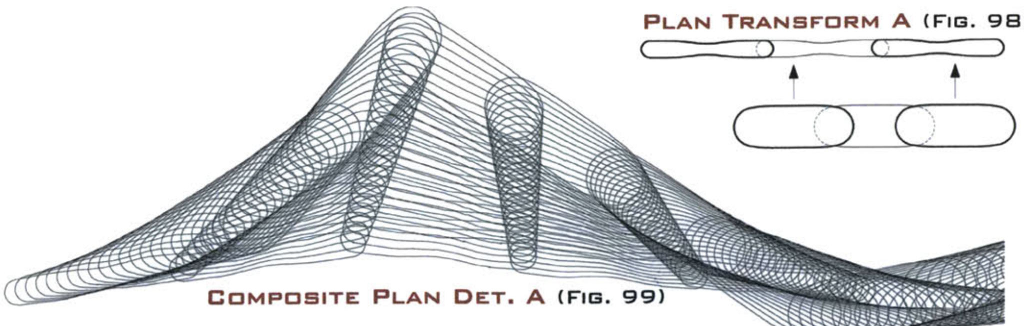
ISOMETRIC A (FIG. 95)

VARIATION A PLAN (FIG. 94)

VARIATION B PLAN (FIG. 96)

VARIATION B ELEVATION (FIG. 97)



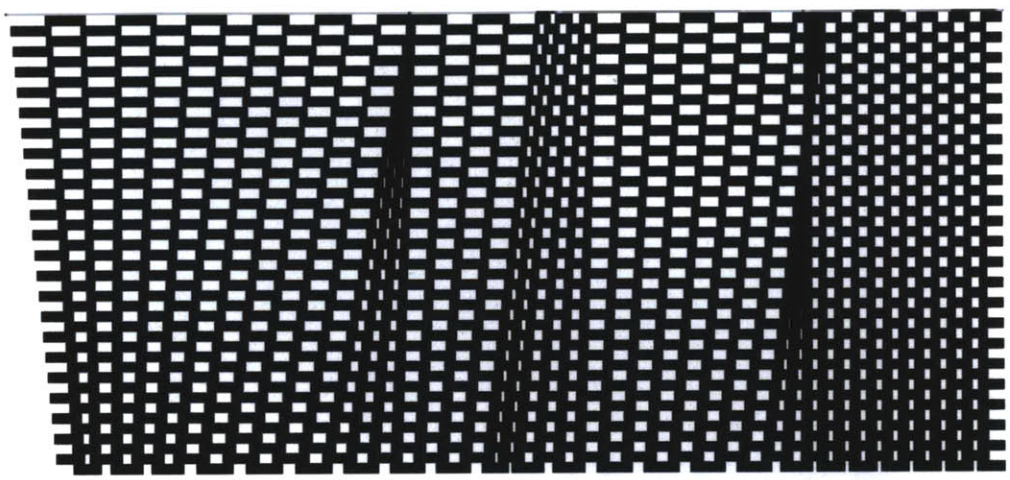


Plan Transform A (Fig. 98)

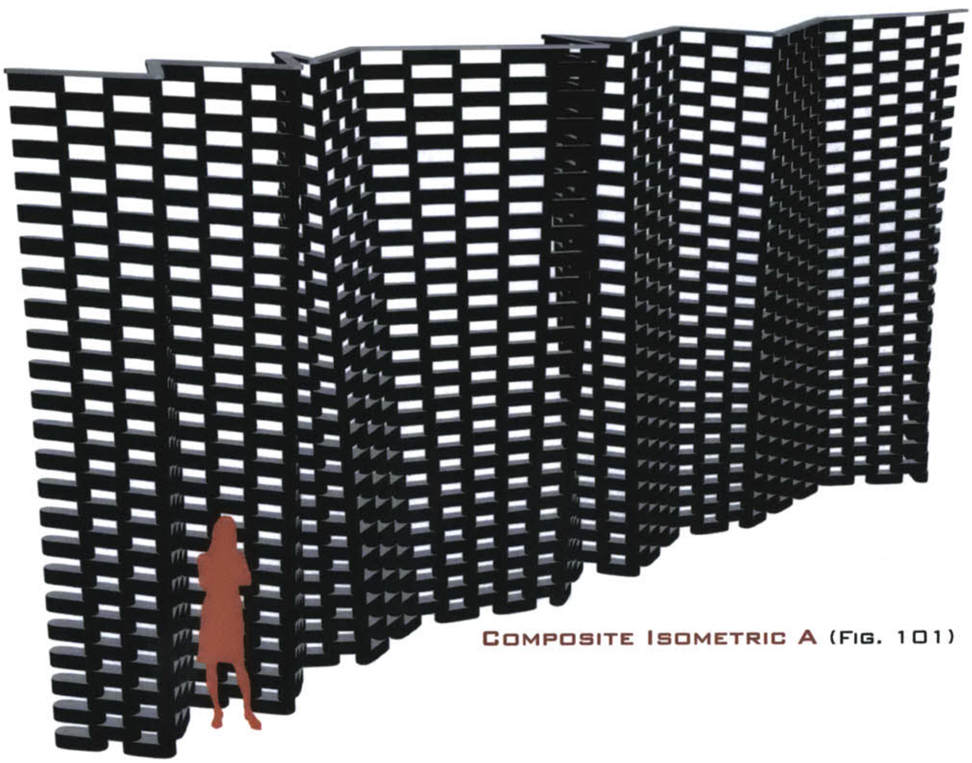
Composite Plan Det. A (Fig. 99)

Composite Plan A (Fig. 102)

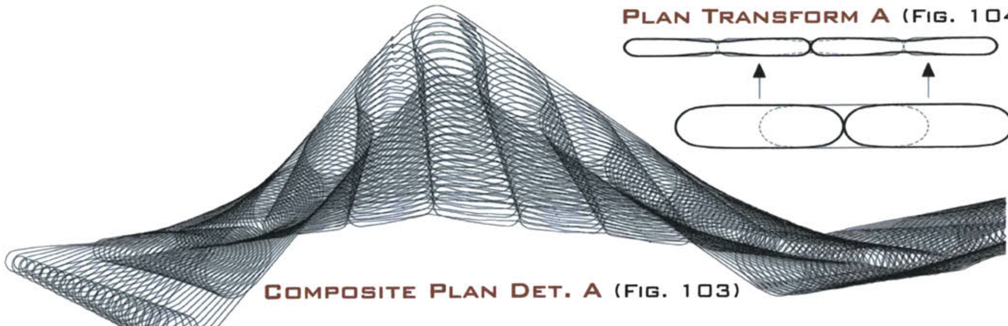
The flexibility inherent in the tire brick module allows for a level of complexity in construction. By rotating and gradually varying the size of the bricks at each level, it is possible to create uniformly spaced wave like walls.



Composite Elevation A (Fig. 100)



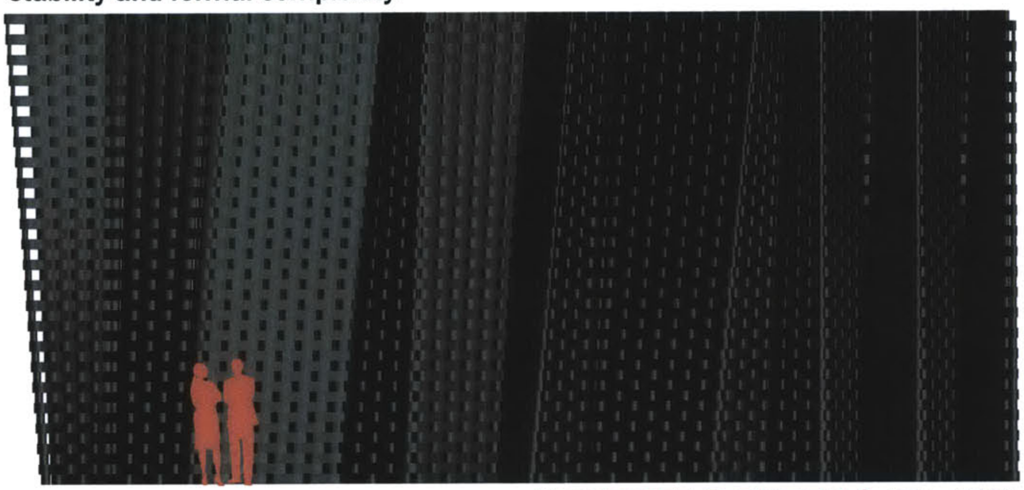
Composite Isometric A (Fig. 101)



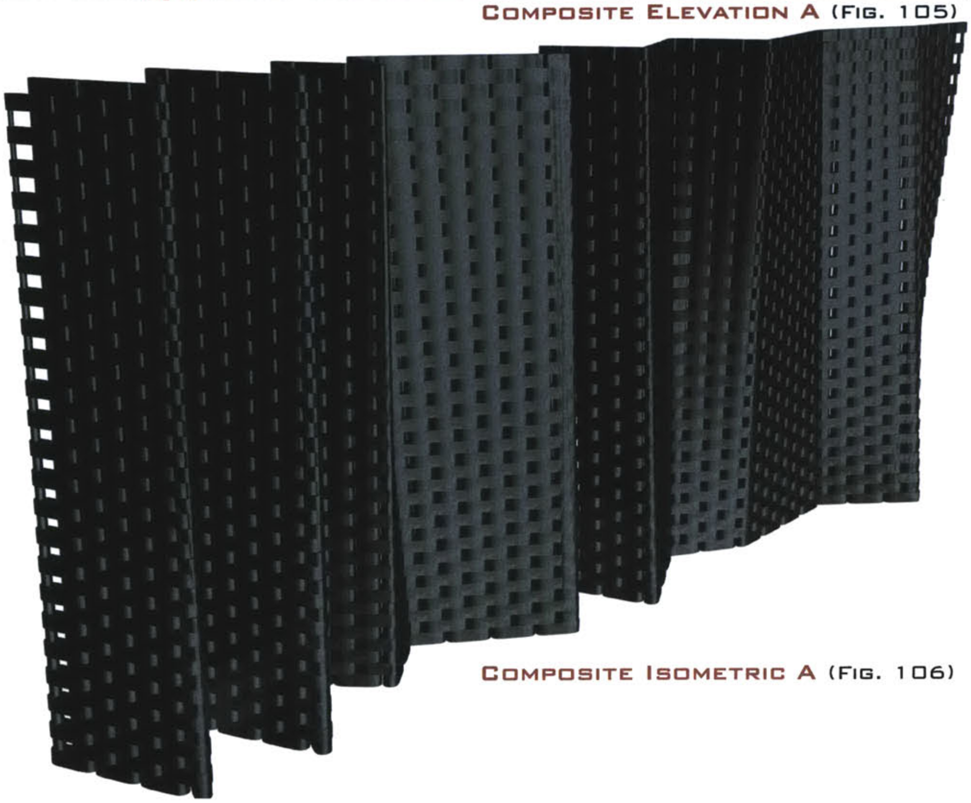
PLAN TRANSFORM A (FIG. 104)

COMPOSITE PLAN DET. A (FIG. 103)

The variable tire masonry unit also allows for a similar effect in a closed wall system. The tire units at the base are wider to allow for greater structural stability and formal complexity.



COMPOSITE ELEVATION A (FIG. 105)



COMPOSITE ISOMETRIC A (FIG. 106)

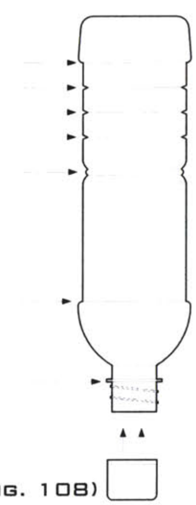
COMPOSITE PLAN A (FIG. 107)

MATERIAL SYSTEMS: THE PET BOTTLE

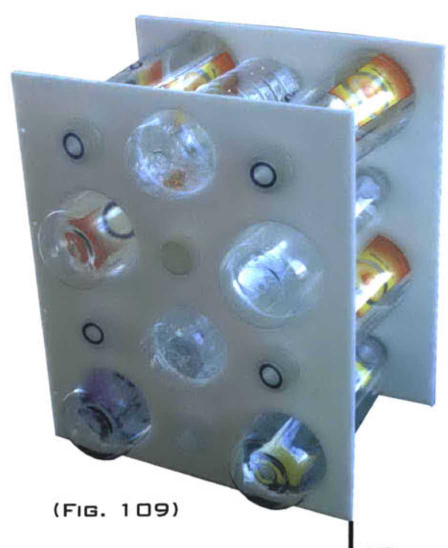
The Polyethylene Terephthalate or PET bottle has become the most prevalent of drink containers because it is strong, lightweight, and shatter-resistant. These properties are also advantageous for architectural reuse. The bottles have a formal elegance due to their intricately blow molded translucent shape. The following material systems take advantage of these traits as well as the specific construction of the bottle itself.

The first two systems act as structural walls. The concept is to take advantage of the bottle's screw cap and molded ridges. With the use of a computer numerically controlled (CNC) machine, exact holes are cut in sheet material that allows for the bottle to be friction fit between two sheets. This system brings lateral stability to the flat sheets. It also allows for the transmission of light. Stability and surface symmetry are enhanced by alternating the orientation of the bottles. (See fig. 109,110,133,134) This same principle can be incorporated in a cast wall as well. In this system, the bottles act as the form ties and structure for the form work. The bottles are so tightly friction fit that the concrete does not seep through the joints. Once the cast is dry the caps are unscrewed and the sheets can be removed. (See fig. 111)

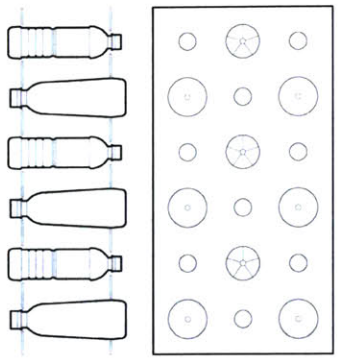
The second two systems are interior treatments with spatial and optical complexity. A luminescent suspended ceiling is formed by cutting an array of holes in a surface material. The bottles are friction fit at different ridges along their body to achieve the effect of a complex variegated surface. Back lighting (white or colored) could also be employed to accentuate this effect. (See fig. 112,141) The final system utilizes a fabric sheet. A flexible surface is created when the fabric is sandwiched between the bottle and its closed cap. Stability is reached when the bottles are held in compression. To create a complex space, rigid ribs would be employed to hold lines of bottles in place. These bottle ribs act to hold the fabric bottle surface in compression. (See fig. 113-118)



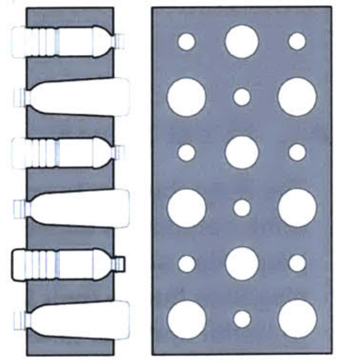
(FIG. 108)



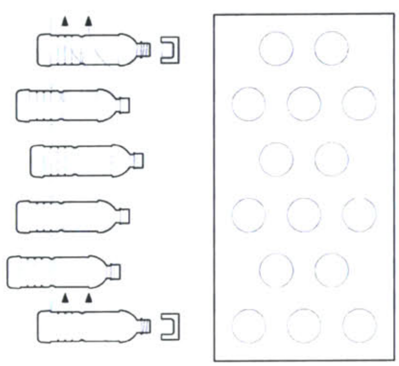
(FIG. 109)



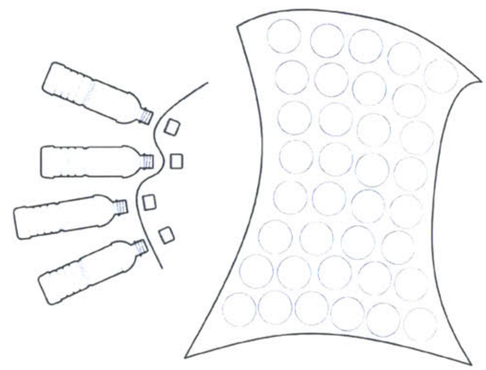
Structural System A (Fig. 110)



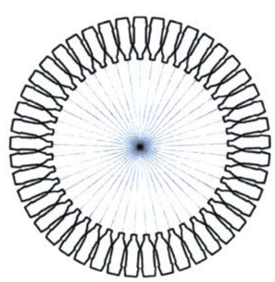
Structural System B (Fig. 111)



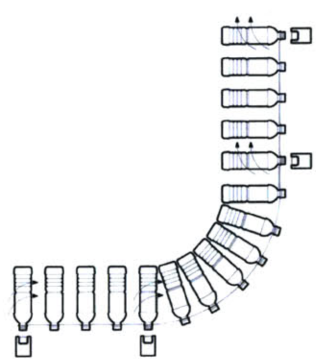
Suspended Ceiling System (Fig. 112)



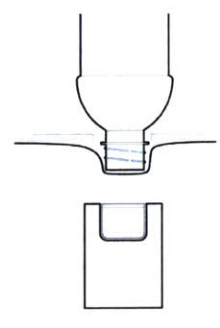
Flexible Surface B (Fig. 113)



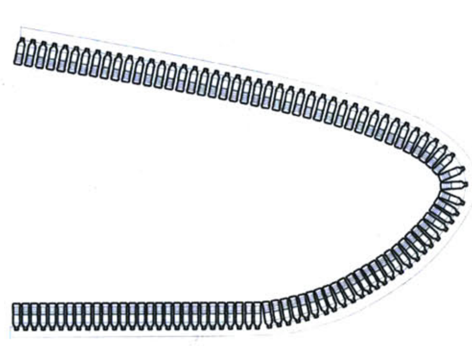
Compression Ring (Fig. 114)



Rib Compression (Fig. 115)

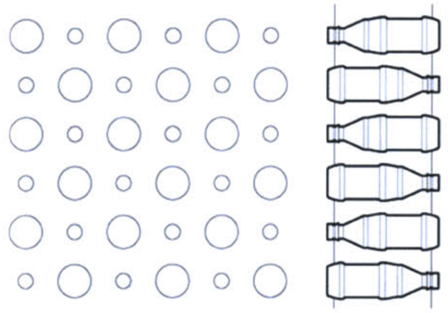


Fabric / Rib Int. (Fig. 116)

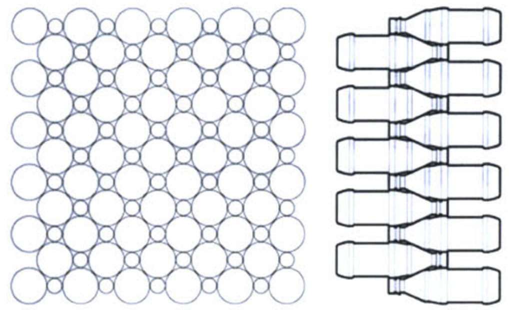


Rib Section (Fig. 117)

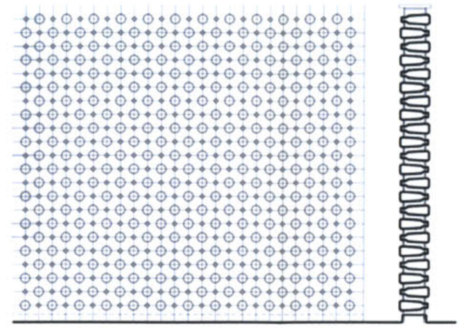
Surface / Rib Isometric (Fig. 118)



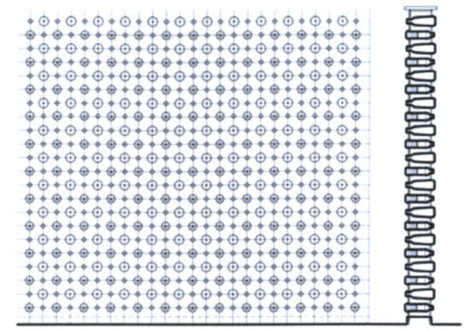
Variation A Detail (Fig. 120)



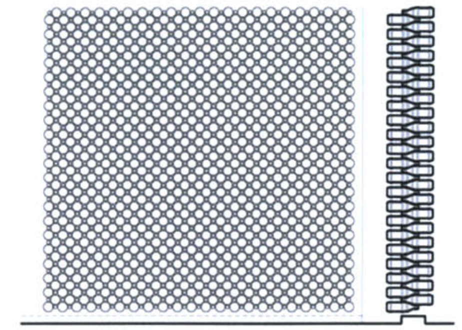
Variation B Detail (Fig. 121)



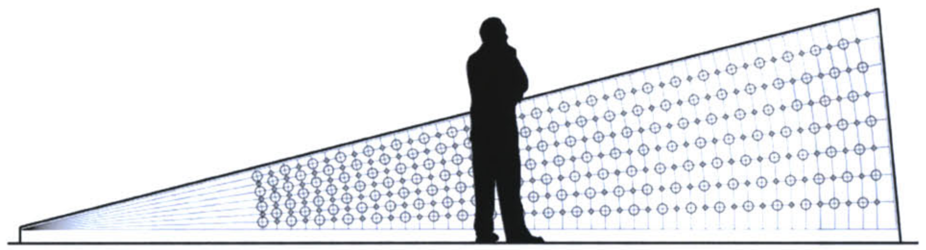
Variation A (Fig. 122)



Variation A2 (Fig. 123)

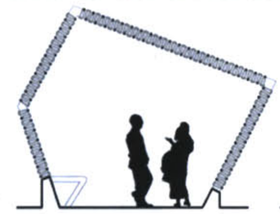


Variation B (Fig. 124)

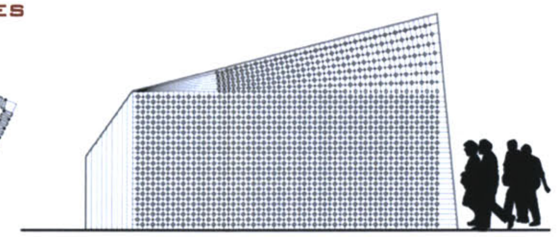


Sloped Edge Condition (Fig. 125)

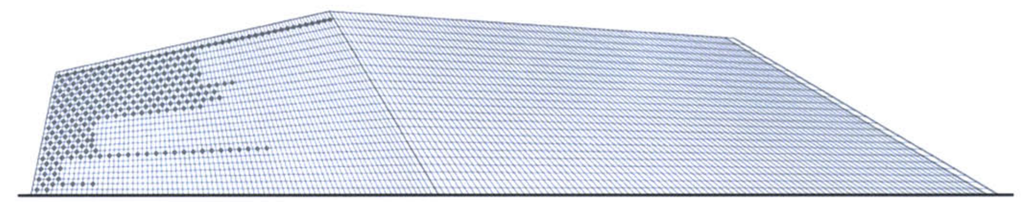
Geometric Studies



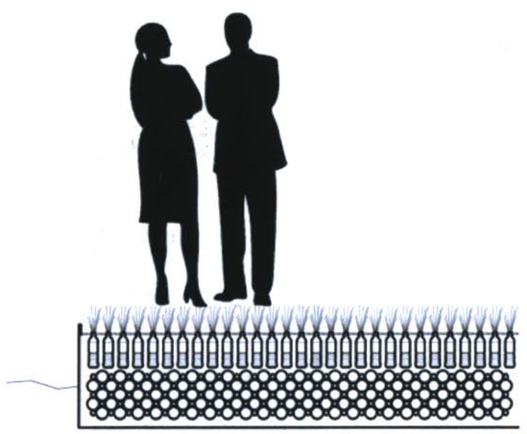
Test A (Fig. 126)



Test B (Fig. 127)

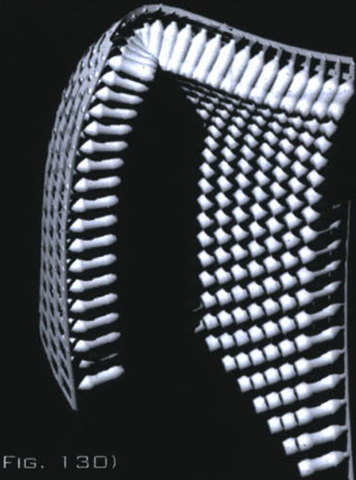


Test C (Fig. 128)



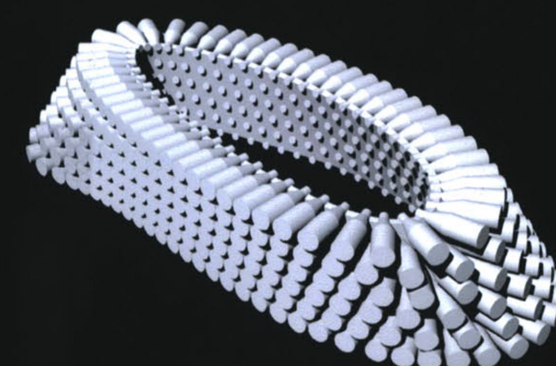
Floating System (Fig. 129)

Complex Bottle Studies

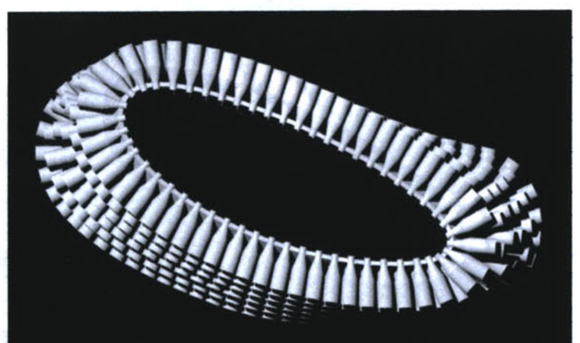


Test A (Fig. 130)

Test B (Fig. 131)



Test C (Fig. 132)

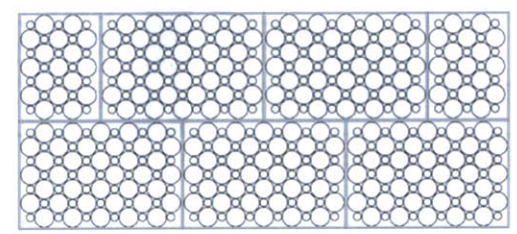


(Fig. 119)

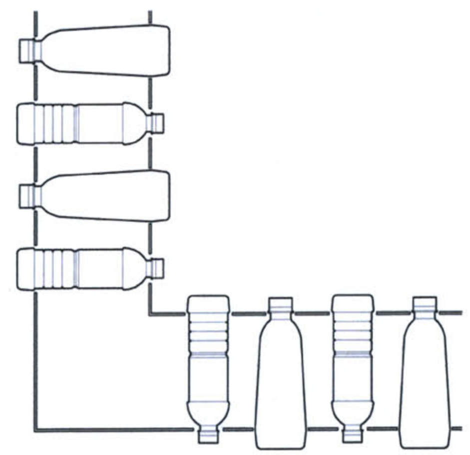
There are other possibilities beyond the four types of bottle systems described in the previous page. One concept is to use the plastic bottle as a container for the growth of plants at a large scale. The bottles are durable containers able to store and release water through encased or covered soil. This would allow for a relatively shallow green roof system. It is also possible to pull tension cables between beams of bottles cast in place. The effect is an alternating trellis.

Wall Sample A (Fig. 133)

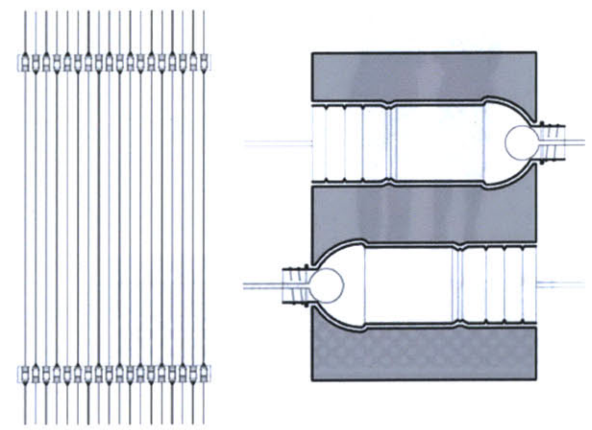
Wall Sample B (Fig. 134)



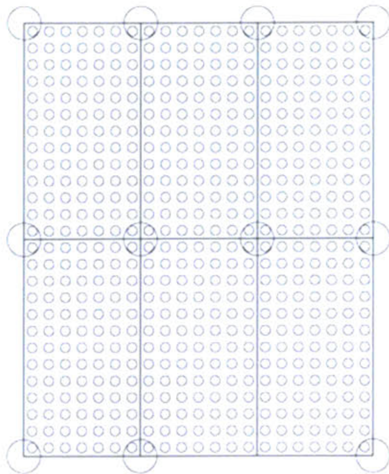
Packed Blocks (Fig. 135)



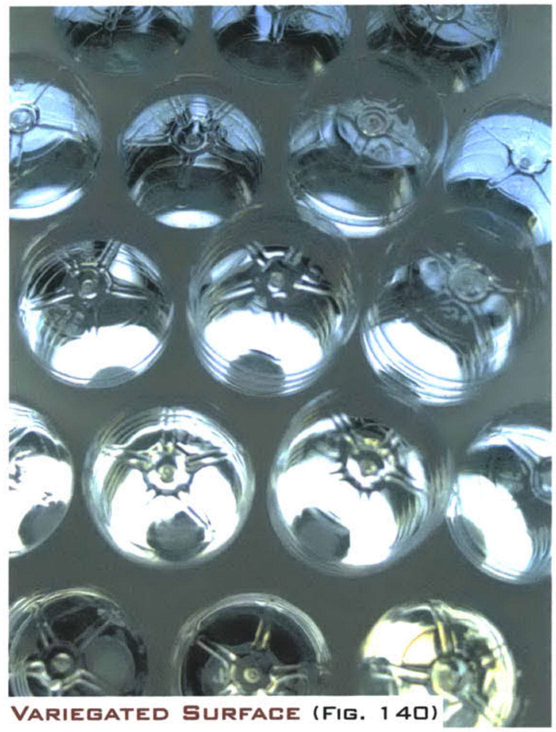
Wall Broken Corner (Fig. 136)



Bike Tube Tensile Trellis (Fig. 137,138)

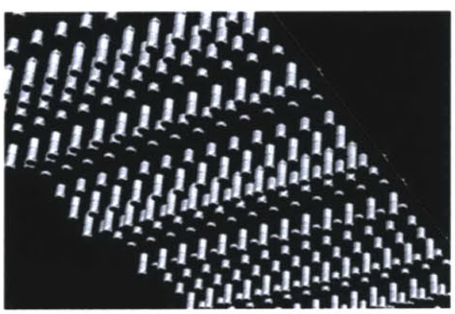


Surface Panels (Fig. 139)

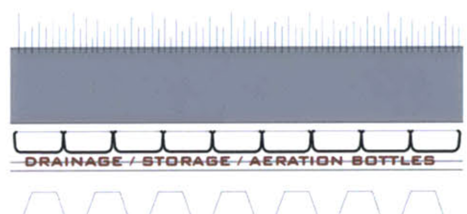


Variegated Surface (Fig. 140)

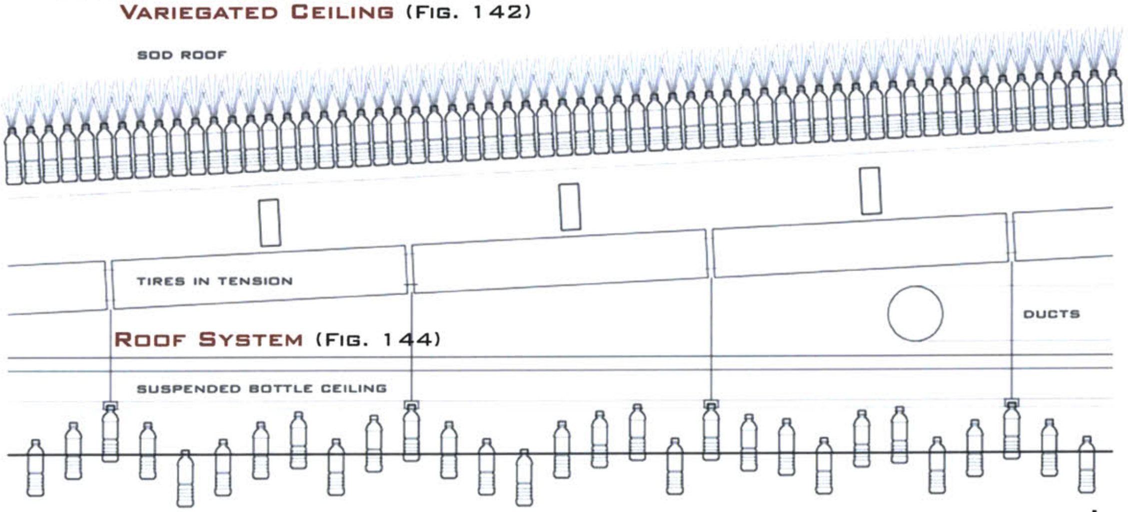
Masonry Block Wall (Fig. 141)



Variegated Ceiling (Fig. 142)

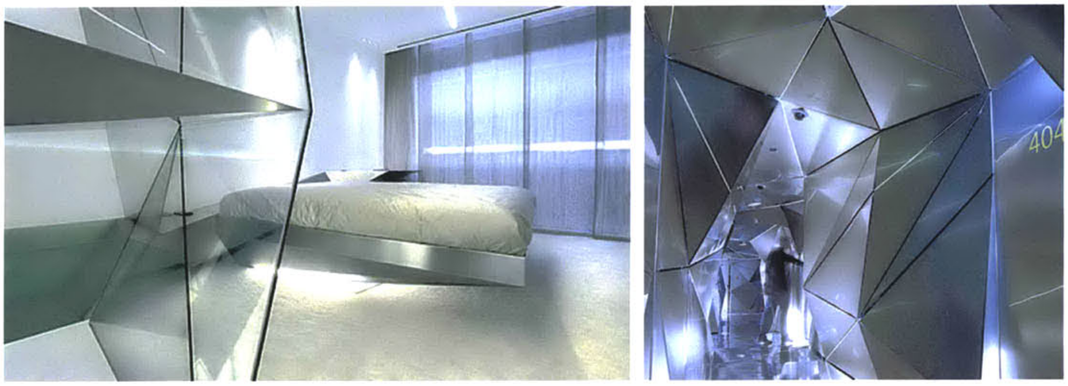


Green Roof System (Fig. 143)



Roof System (Fig. 144)

PROJECT BRIEF



PLASMA STUDIO (FIG. 145)

Historically, hotels have been used to test and introduce new technologies and design concepts to the larger public. They are a place where people can experience new ways of living before making a significant change in their own homes. Manufacturers first tested heating systems and electricity in hotels before introducing them to the housing market.[1] Hotelier Ian Shrager has used his numerous boutique hotels to demonstrate the latest in architectural thought and fashion. His most recent project, Madrid's Hotel Puerta America, combines the work of nineteen of the world's most prominent architects and designers including: Jean Nouvel, Christian Liaigre, Norman Foster, Ron Arad, Richard Gluckman, David Chipperfield, Plasma Studio, and Zaha Hadid. The result is an architectural candy shop for its guests. The visitors are allowed to experience a variety of architectural styles and thought over their many stays at the hotel. It is this combination of laboratory and high design that makes the hotel a perfect project type to present radical reuse to the public.

The proposed hotel will target the high-end traveler while being constructed of reused and recycled materials that are woven into the landscape and the spatial sequence of the architecture. The reconfigured waste materials act as a demonstration of the inherent and extravagant possibilities available in waste products. The material focus will be placed on the plastic bottle and the tire systems. In working with waste material it is important to categorize them based on value. For example there are far more tires thrown away then would ever be needed for TDF, rubber-based asphalt, or playground surfaces. Thus I will think of them as a limitless commodity. The more that is used, the better. This also applies to the use of plastic bottles. Reused materials such as scrap steel and reclaimed lumber are in much higher demand. For this reason, I will utilize these materials strategically and conservatively.

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1 Albrecht, Donald, New Hotels for Global Nomads (London: Merrell Publishers, in Association with, Cooper-Hewitt, National Design Museum, New York, New York, 2002).

Spectacle Island

WEST VIEW (FIG. 146)

Spectacle Island is located in Boston's inner harbor. It is a 121–acre island that has been home to a quarantine hospital, summer hotels, a horse-rendering plant, and most recently a garbage dump. It has been the recipient of 6.3 million tons of fill excavated from the construction of I-90 and I-93. The fill, in conjunction with plantings, rock swales, and rock retaining walls has been used to contain the garbage dump within the island. The Big Dig's excavated fill has helped make the harbor a clean place to swim and has made Spectacle Island a desirable place to visit. The added height has created panoramic views of the city and the harbor from both the 150 foot north drumlin and the 125 foot south drumlin.

The island currently has the largest public dock in the harbor and will eventually become the hub to the entire Harbor Island park system. A visitor center and picnic shelter are currently the only built forms on the island. Trees and shade are lacking due to the relatively sparse quantity of plantings. The existing circulation is all ADA compliant, which makes for a series of circuitous paths around the drumlins. There is presently no direct access between the two drumlins and between the beaches and the drumlins.

BOSTON HARBOR PLAN (FIG. 147)

WEST BEACH (FIG. 148)

BOSTON VIEW (FIG. 149)

SOUTH PATH (FIG. 150)

SITE SECTION (FIG. 151)

VIEW OF SOUTH DRUMLIN (FIG. 152)

The Hotel + The Island

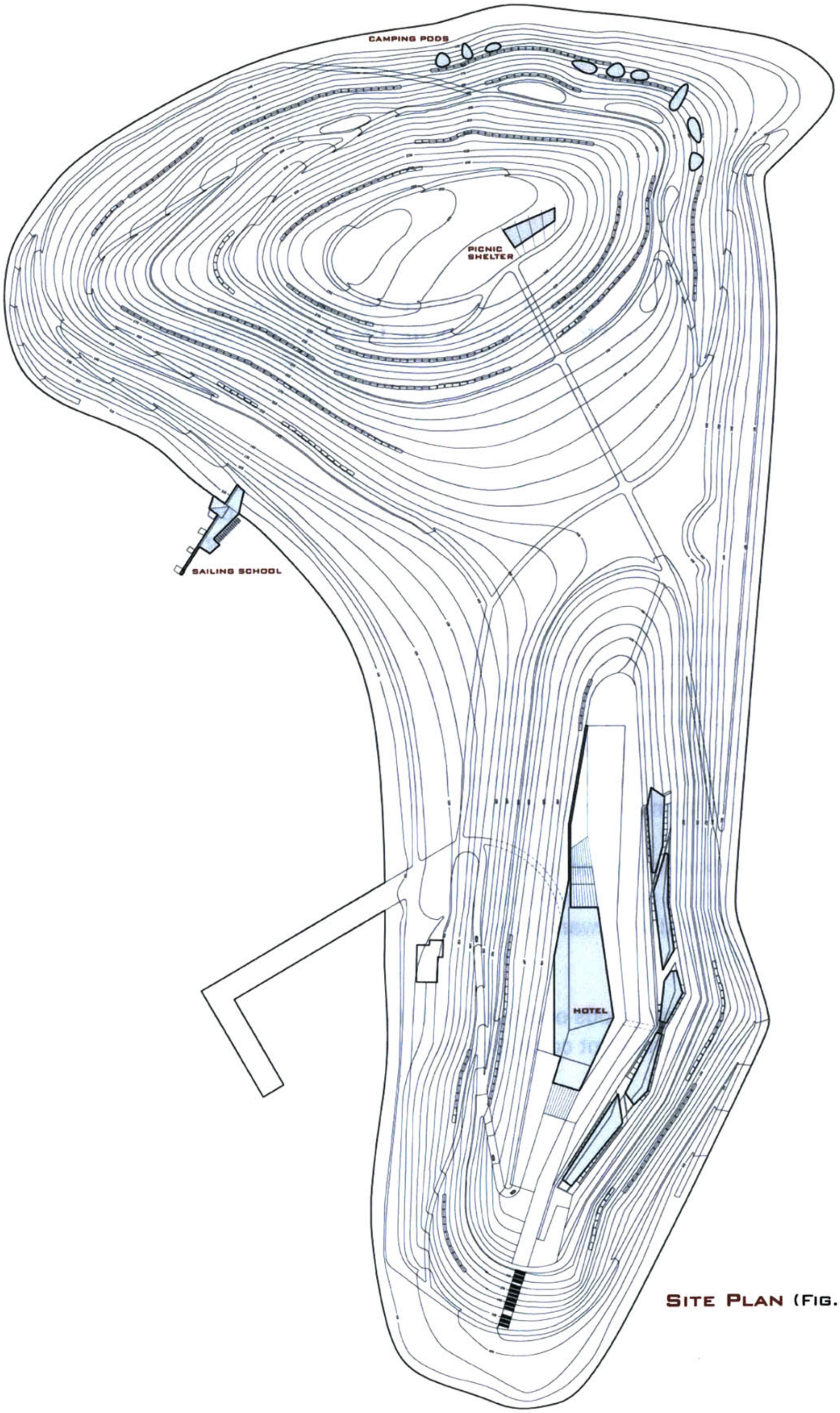
Spectacle Island's significant scale and raw nature combined with the programmatic complexity of a high-end resort hotel provide a challenging scenario to expand and develop the workings of the tire and bottle systems. It is in this context that the building system's limits are tested. For example: How are long spans and short spans addressed? How can the limitations inherent to the tire and bottle systems affect larger design decisions?

The basic site strategy establishes distinct zones on the island defined by new constructions and basic alterations to existing circulation patterns. Due to the introduction of a high-end hotel it is important to make efforts to attract a diverse body of visitors to the island.

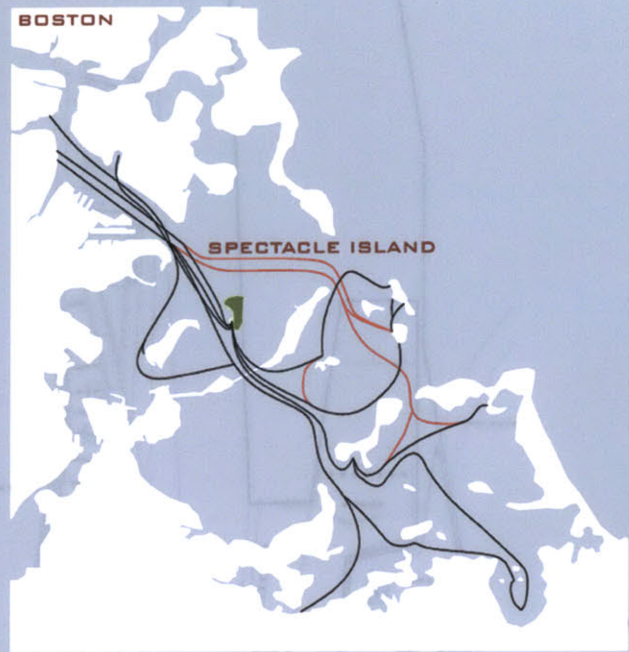
The one hundred thousand square foot resort hotel is situated on the island's south drumlin. A pedestrian and automotive path connects the hotel to the dock. It also links directly to the north drumlin and the south beach via pedestrian paths and stairs. The public front of the hotel occupies the ridge line and houses a restaurant, bar, lounge, and art gallery. The guest rooms are situated along the southeastern slope to take advantage of the prevailing summer winds and to establish a private zone distinct from the mainly public island.

A sailing school is located along the remains of the island's original dock on the western shore. A coordination would occur between this school and the adjacent Thompson Island's Outward Bound program. Children could learn sailing between the two islands.

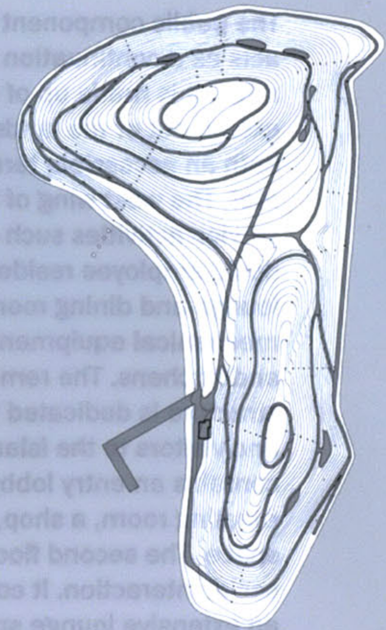
A series of camping pods occupies the hillside along the north east portion of the island. These permanent constructions allow for insulated camping for a majority of the year.

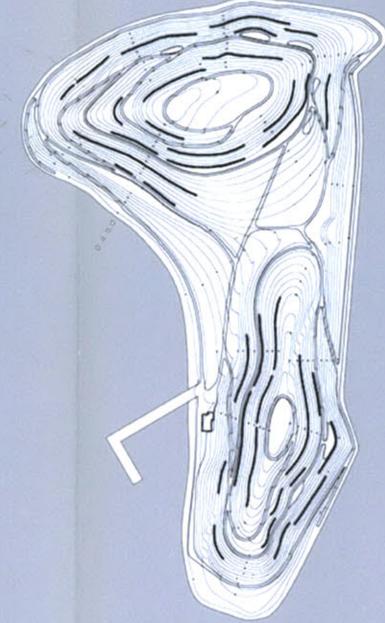


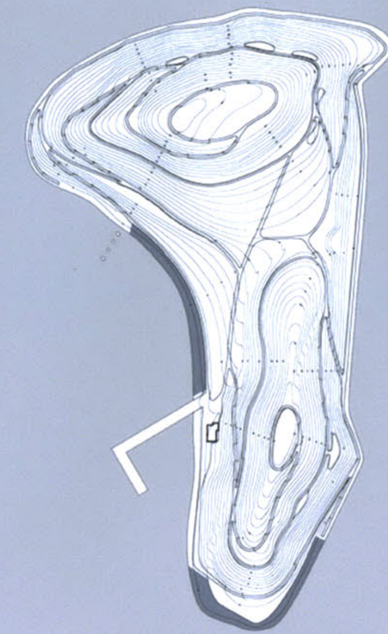
Site Plan (Fig. 153)

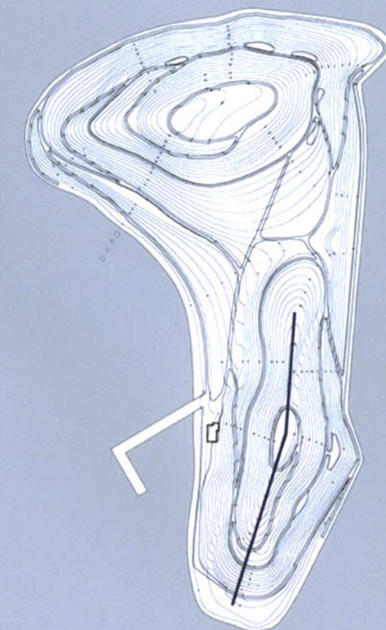


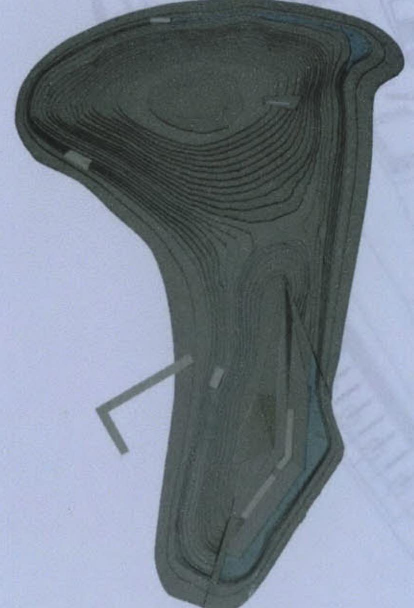
FERRY ROUTES (FIG. 155)

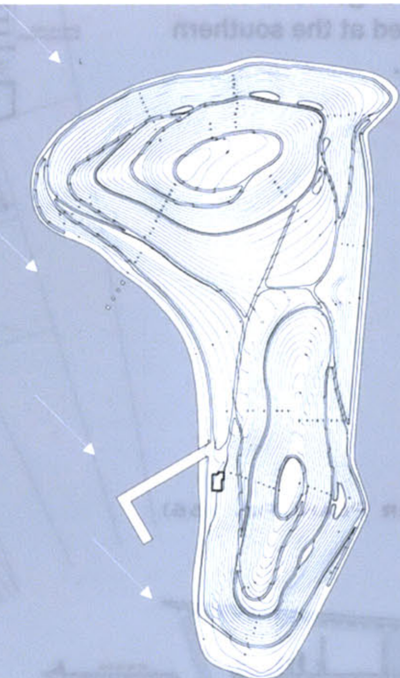

CIRCULATION (FIG. 156)

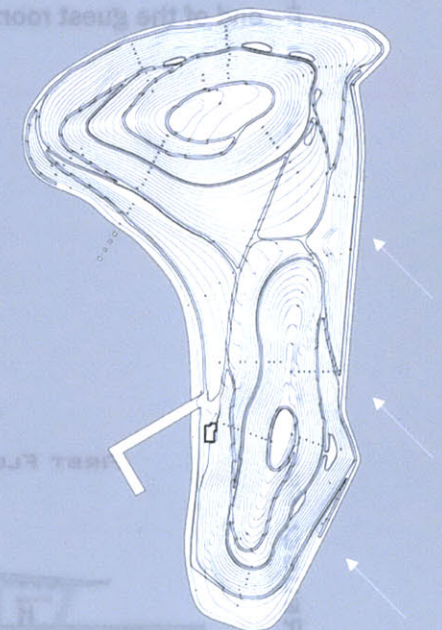

EROSION CONTROL (FIG. 157)

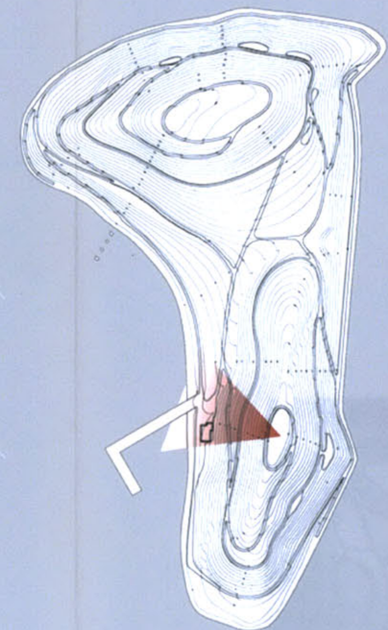

BEACHES (FIG. 158)

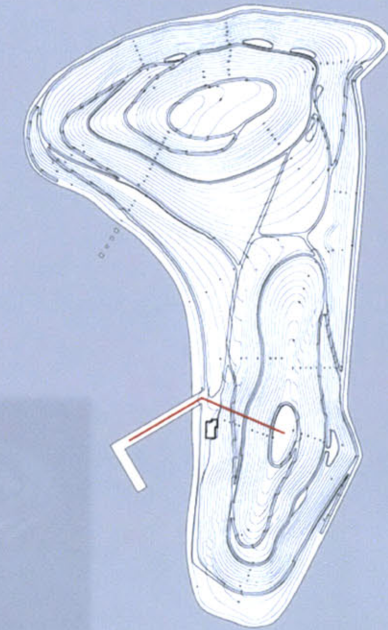

RIDGE LINE (FIG. 159)

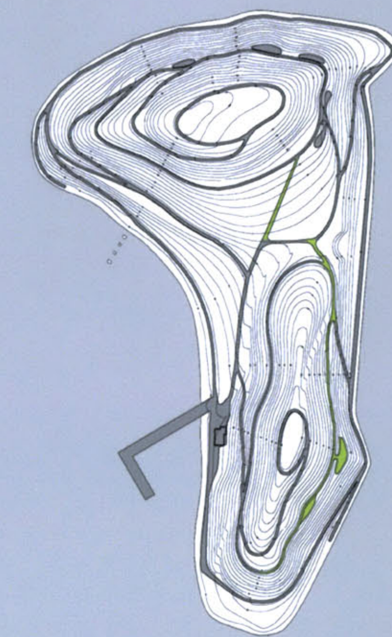

SITE MODEL (FIG. 160)

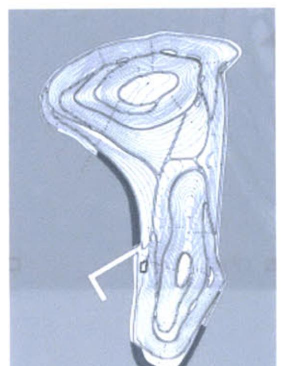

WINTER WINDS (FIG. 161)


SUMMER WINDS (FIG. 162)


BOSTON VIEWS (FIG. 163)


DOCK ACCESS (FIG. 164)

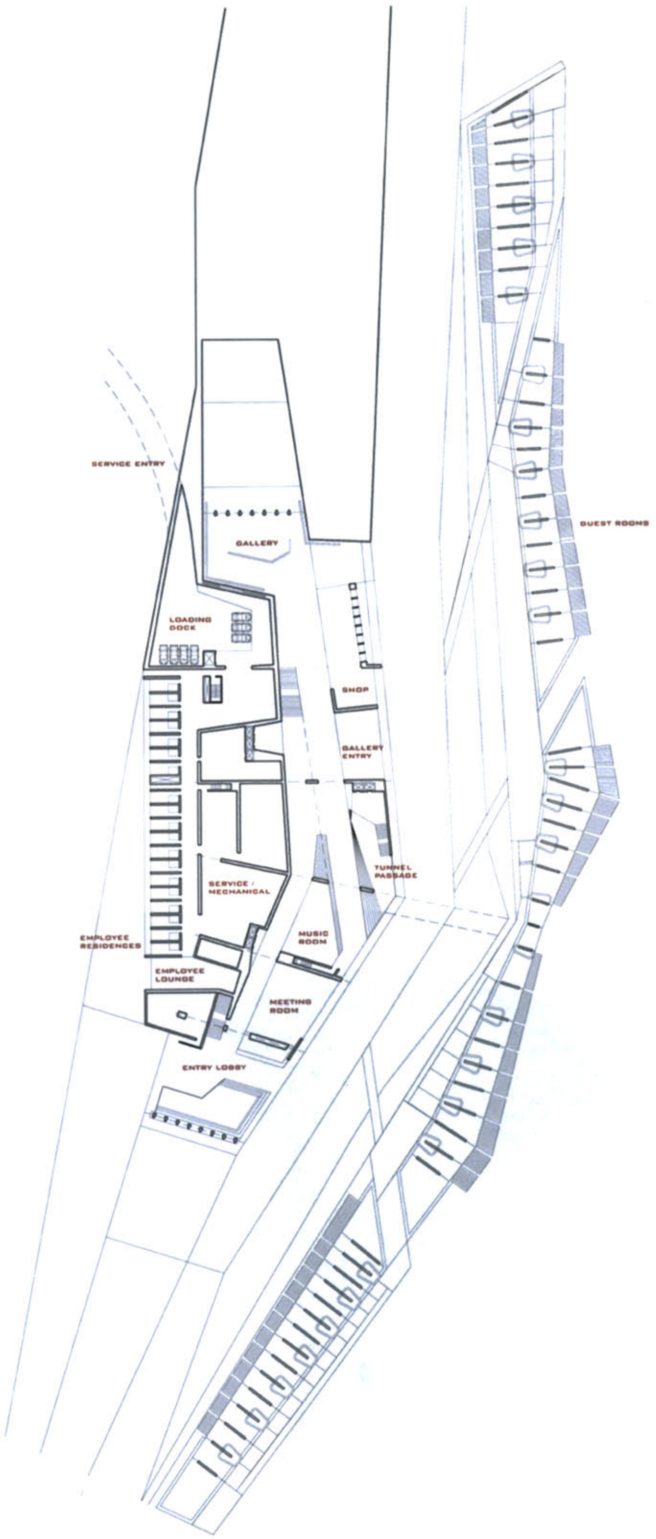

NEW CIRCULATION (FIG. 165)



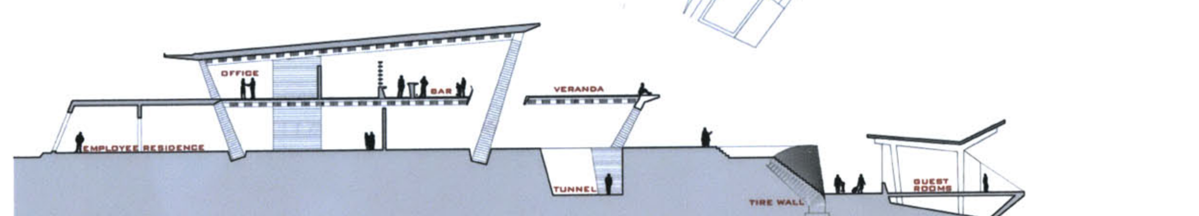
(Fig. 154)

The public component of the hotel acts as a continuation of the existing ridge. It is made up of two stories that extend out of the landscape, creating both an accessible terrace and a green roof. The west wing of the hotel houses service activities such as a loading dock, employee residences, employee lounge and dining room, storage rooms, mechanical equipment rooms, offices, and kitchens. The remainder of the structure is dedicated to hotel guests and visitors to the island. The first floor contains an entry lobby and lounge, a meeting room, a shop, and a gallery space. The second floor is dedicated to social interaction. It contains a restaurant, an extensive lounge space, and a bar.

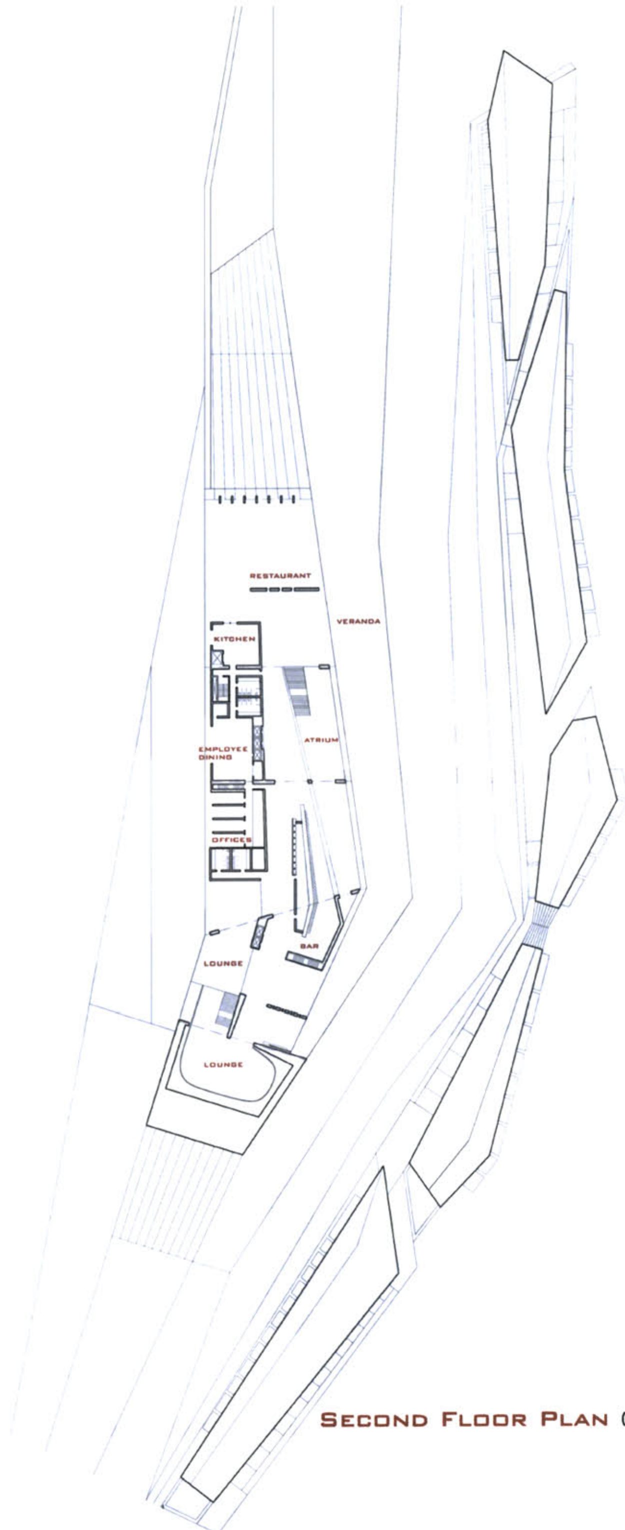
The guest rooms occupy the length of the south drumlin along its eastern hillside. They are defined by a long tire masonry wall that retains the earth and runs parallel to their arrangement. The swimming pool is located at the southern end of the guest rooms.



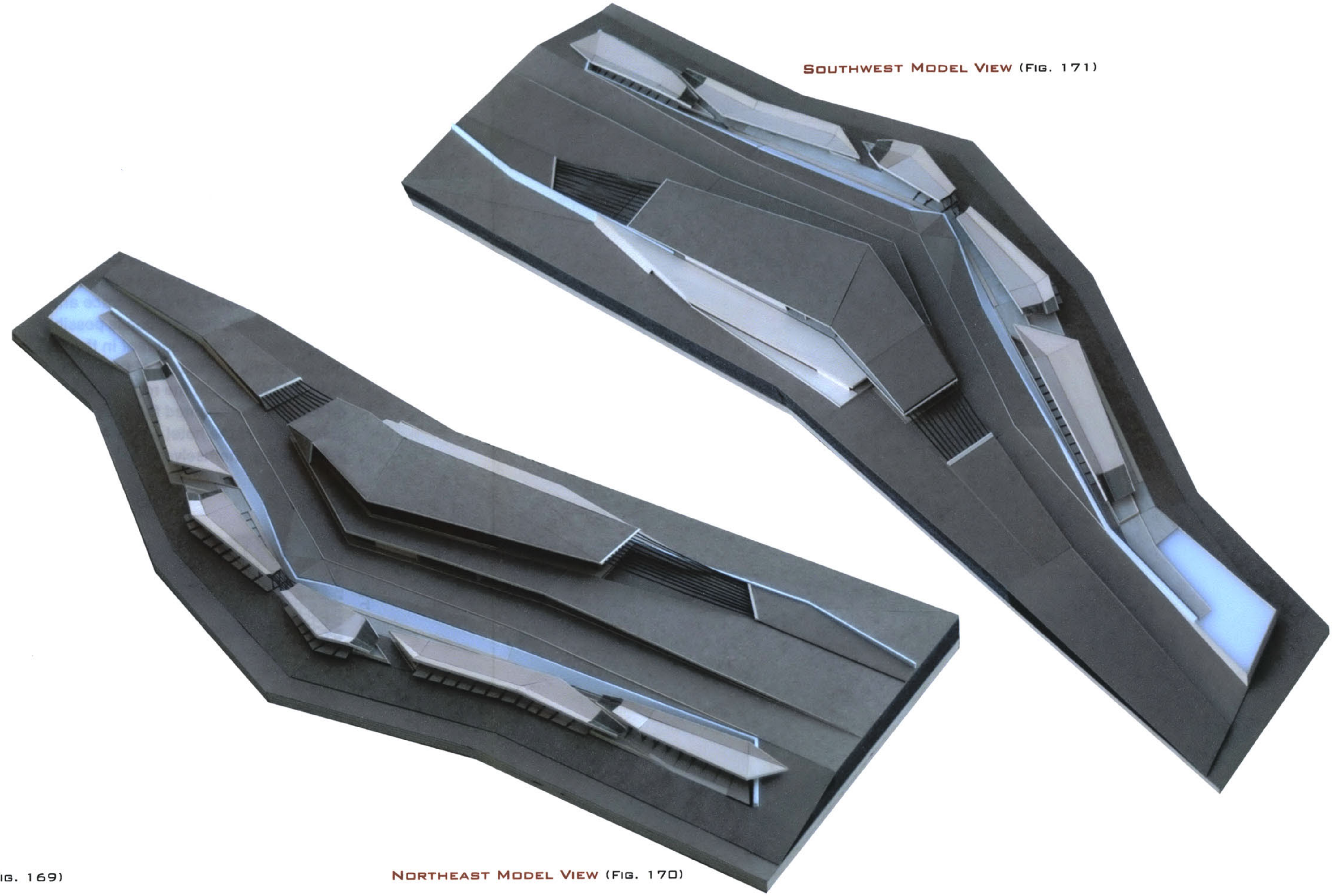
First Floor Plan (Fig. 166)



Transverse Section (Fig. 167)

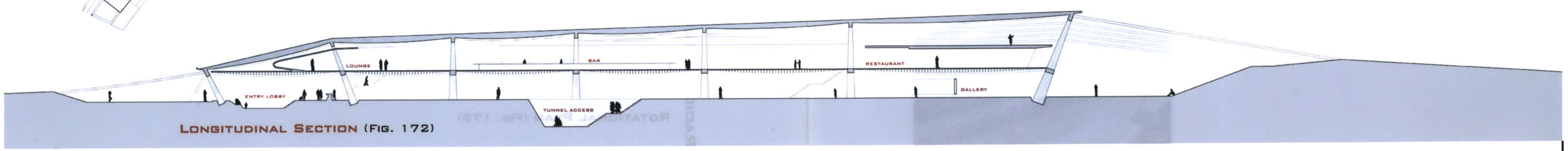


Second Floor Plan (Fig. 169)

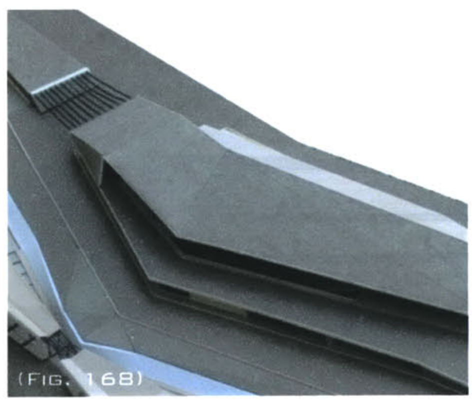


Northeast Model View (Fig. 170)

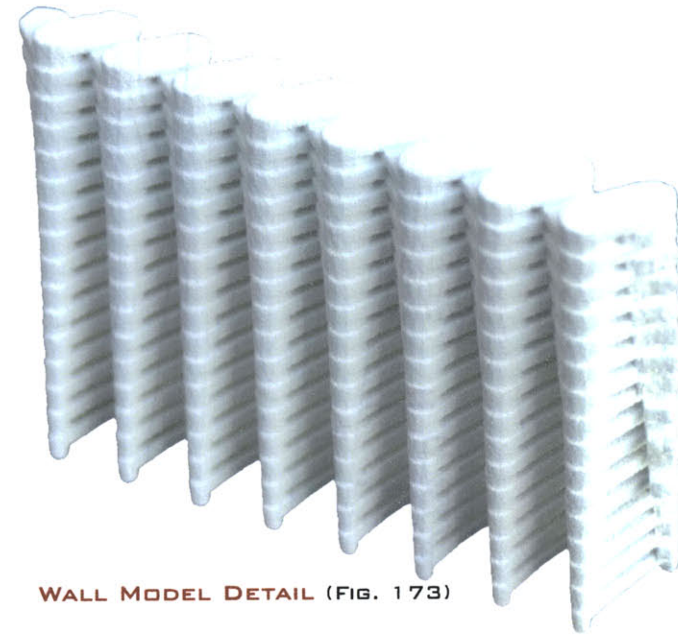
Southwest Model View (Fig. 171)

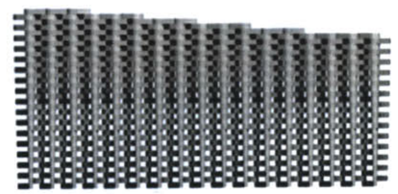


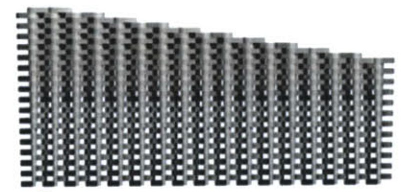
Longitudinal Section (Fig. 172)

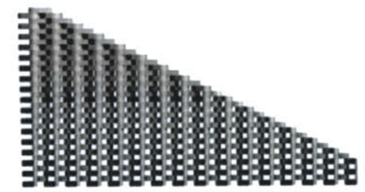

(Fig. 168)

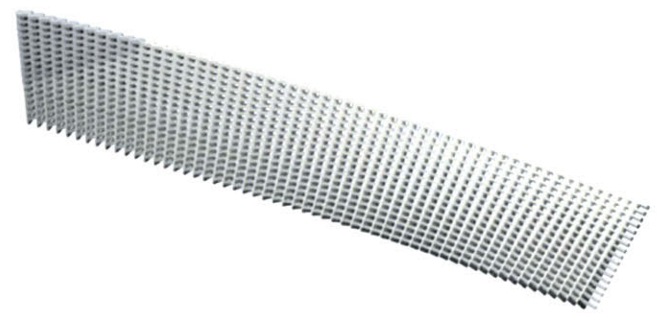
The tire retaining wall located along the east side of the south drumlin provides an opportunity to test the masonry tire wall at a significant scale. The system acts well to simultaneously retain earth and allow for drainage. The wall is able to consistently taper in height at three different slopes. The units are also gradually rotated to the slope of a stair to address the human connection between the hotel's public terrace and the guest room. The rotation is possible due to the tolerance inherent in the mortar joints. The height of the wall is reduced because of the rotation. This difference is accounted for at both the public level of the hotel and within the guest rooms themselves.


Wall Model Detail (Fig. 173)

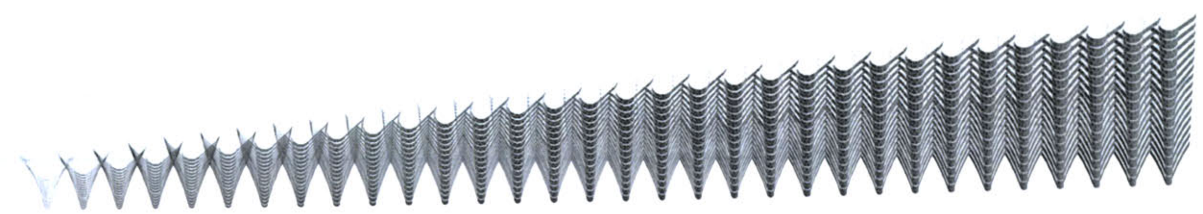

5° Slope (Fig. 174)

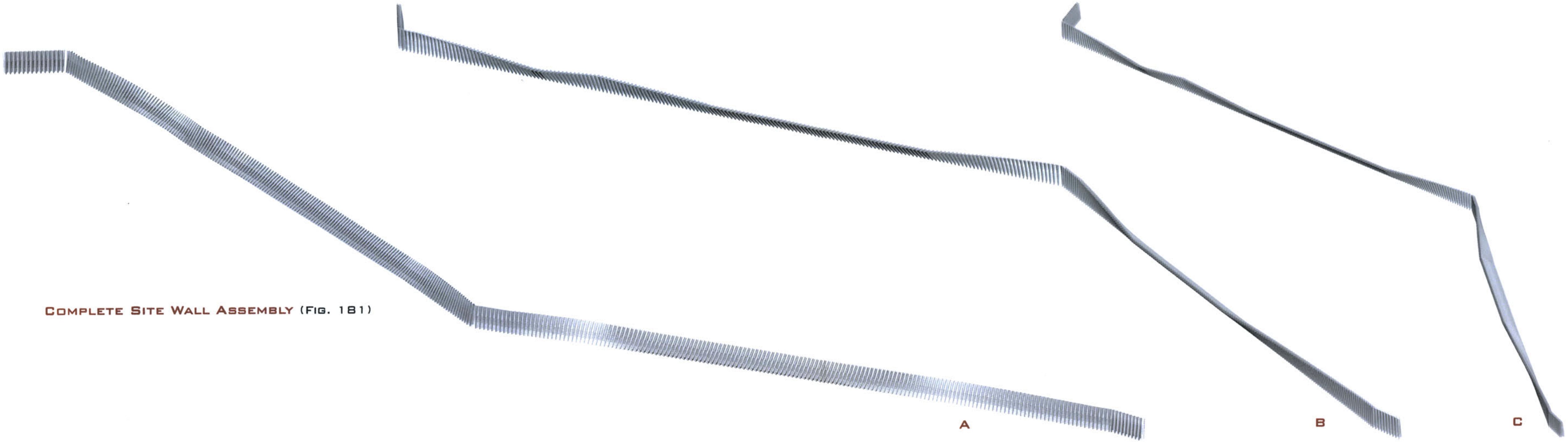

9° Slope (Fig. 175)


26° Slope (Fig. 176)


Gradual Rotation (Fig. 177)

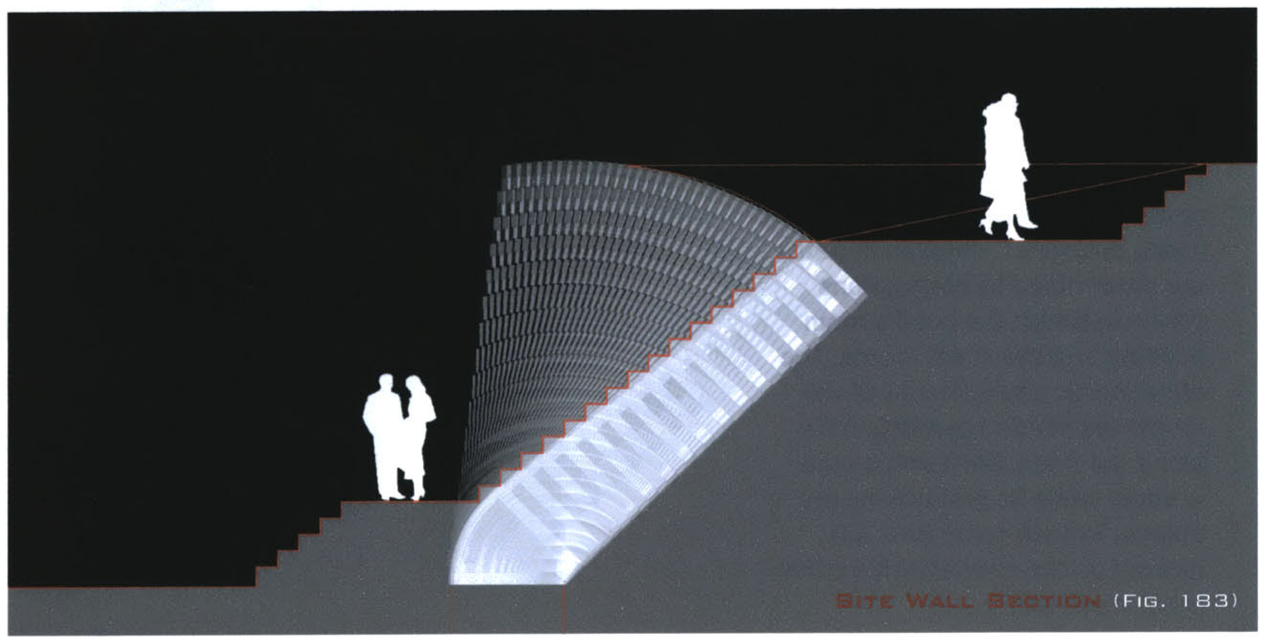

Corner Detail (Fig. 178)


Rotational Plan (Fig. 179)

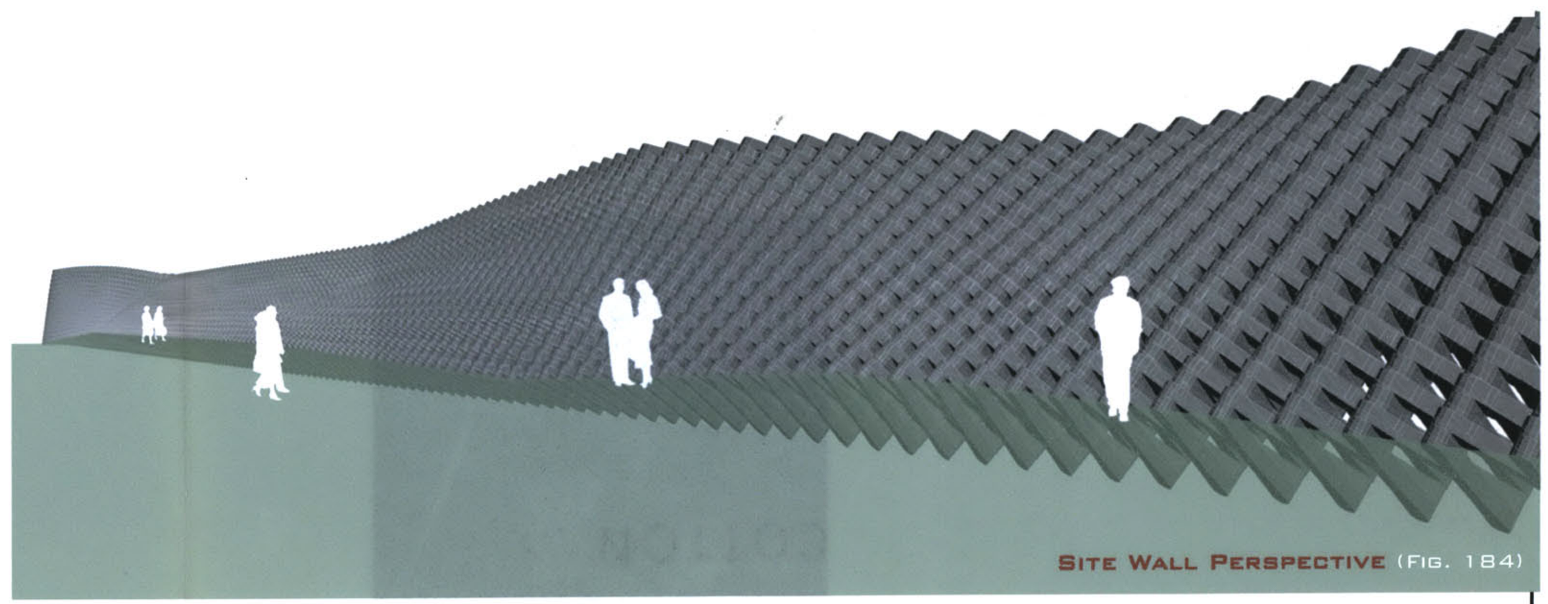


COMPLETE SITE WALL ASSEMBLY (FIG. 181)

COMPLETE SITE WALL ELEVATION (FIG. 182)

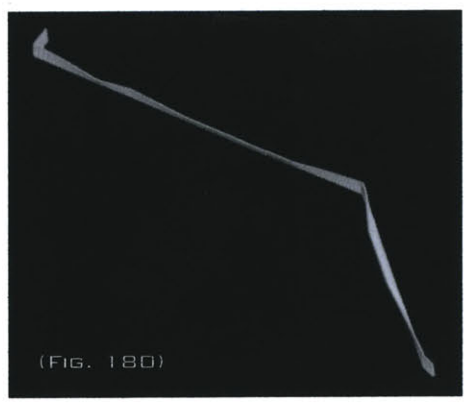


SITE WALL SECTION (FIG. 183)



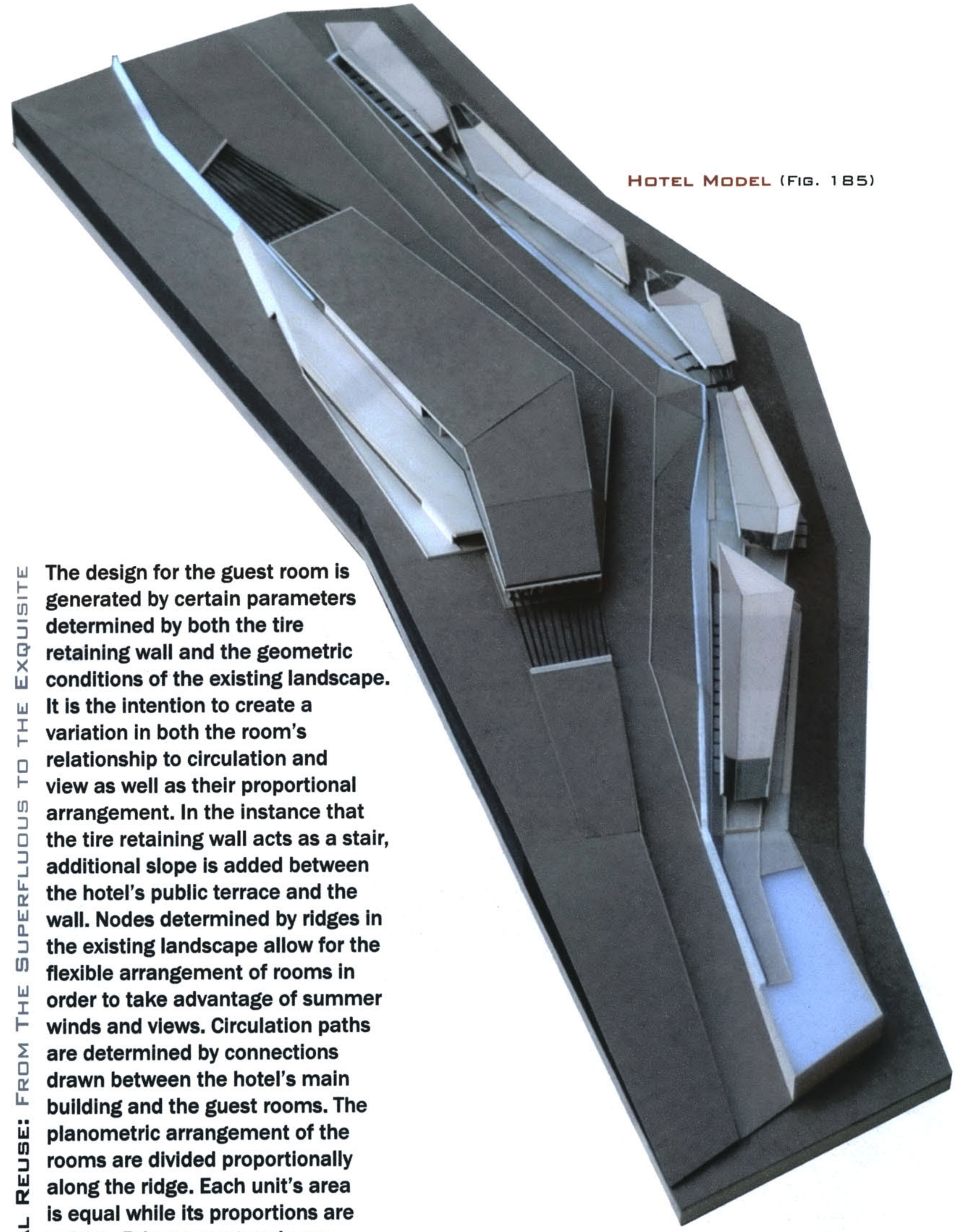
SITE WALL PERSPECTIVE (FIG. 184)

Retaining Wall



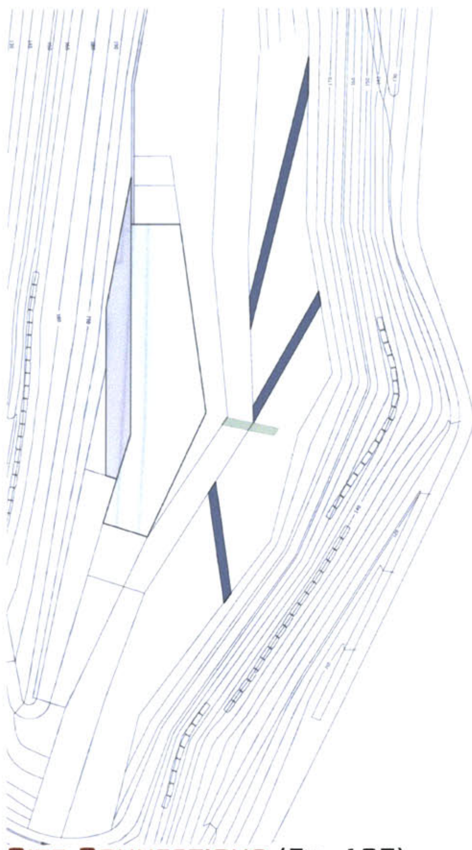
(Fig. 180)

Radical Reuse: From the Superfluous to the Exquisite

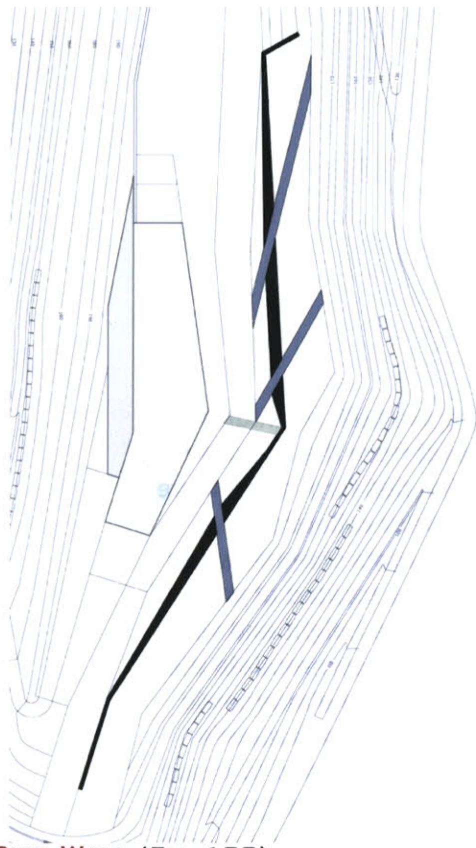


Hotel Model (Fig. 185)

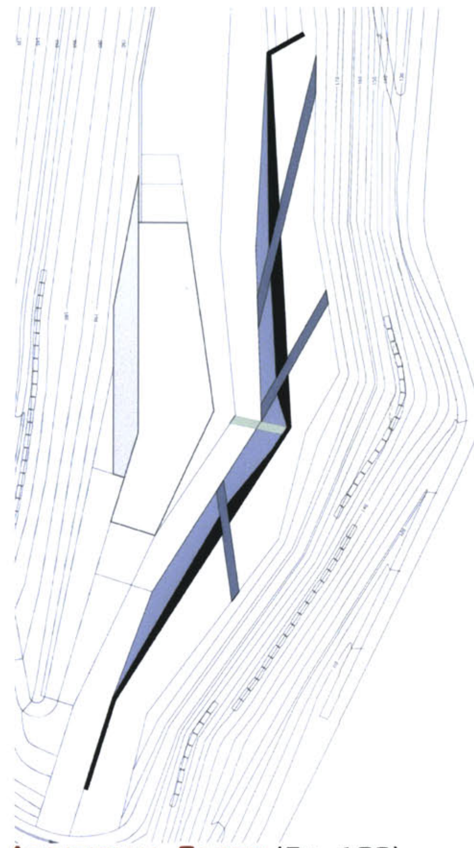
The design for the guest room is generated by certain parameters determined by both the tire retaining wall and the geometric conditions of the existing landscape. It is the intention to create a variation in both the room's relationship to circulation and view as well as their proportional arrangement. In the instance that the tire retaining wall acts as a stair, additional slope is added between the hotel's public terrace and the wall. Nodes determined by ridges in the existing landscape allow for the flexible arrangement of rooms in order to take advantage of summer winds and views. Circulation paths are determined by connections drawn between the hotel's main building and the guest rooms. The planometric arrangement of the rooms are divided proportionally along the ridge. Each unit's area is equal while its proportions are unique. Private courtyards are located on the opposite side of the circulation path.



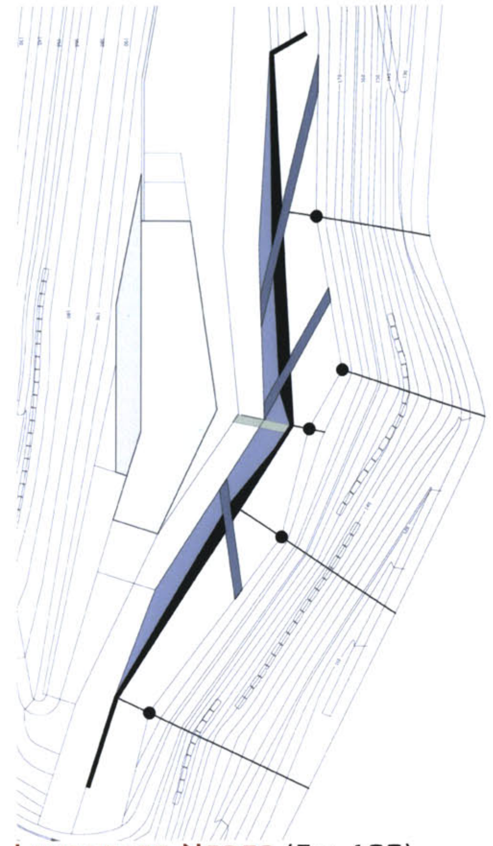
Site Connections (Fig. 187)



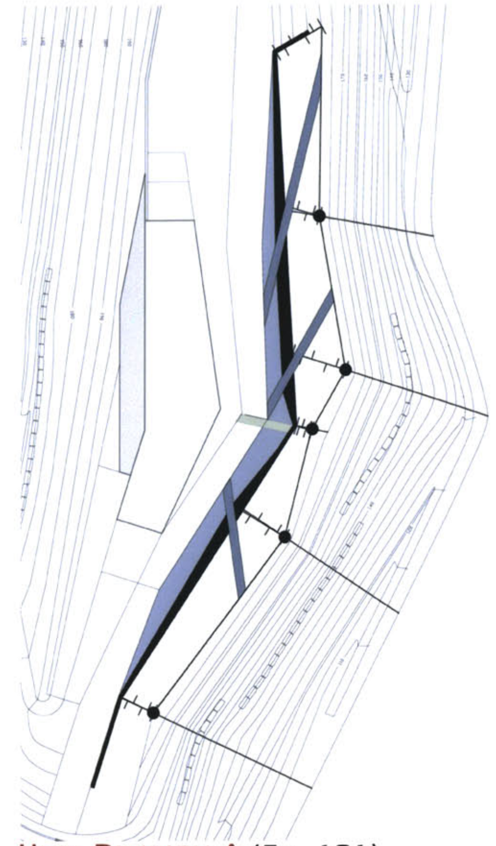
Site Wall (Fig. 188)



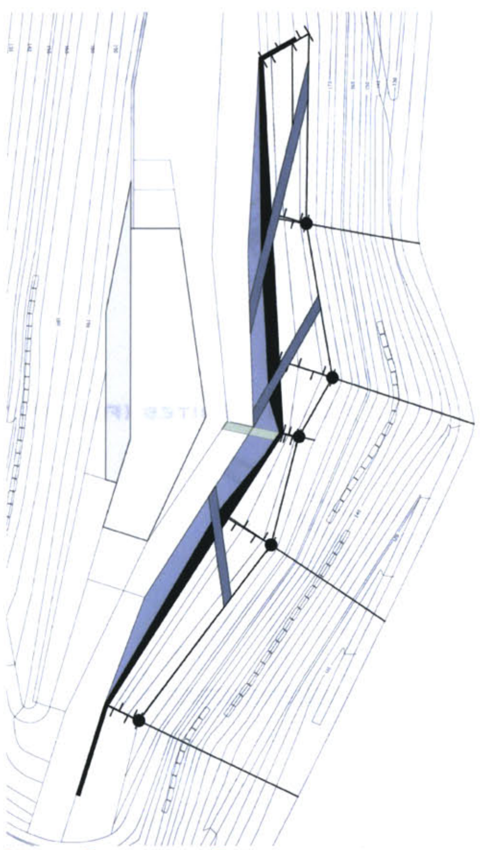
Additional Slope (Fig. 189)



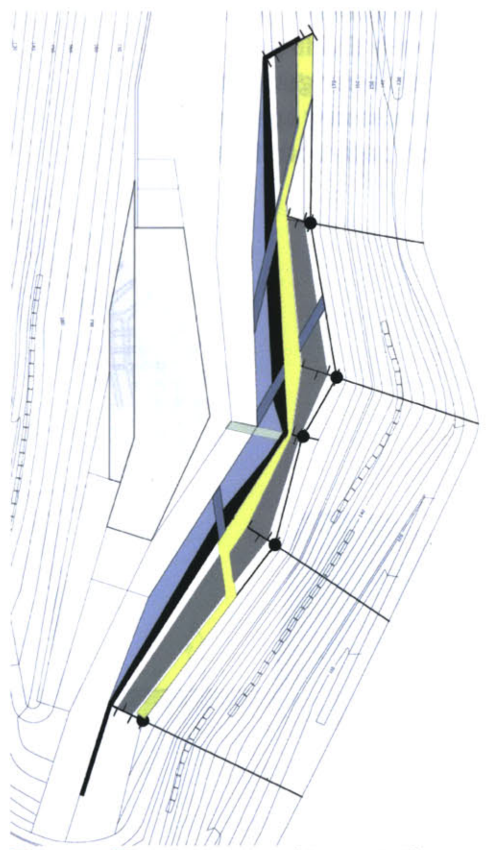
Landscape Nodes (Fig. 190)



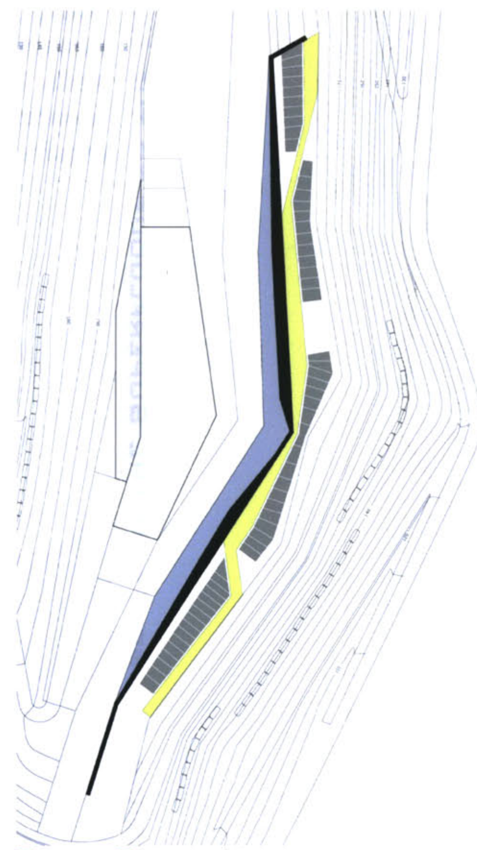
Unit Division A (Fig. 191)



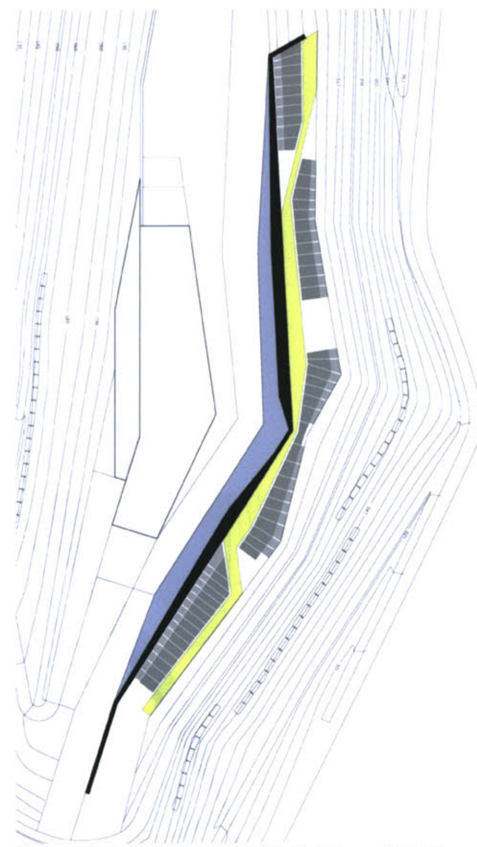
Unit Division B (Fig. 192)



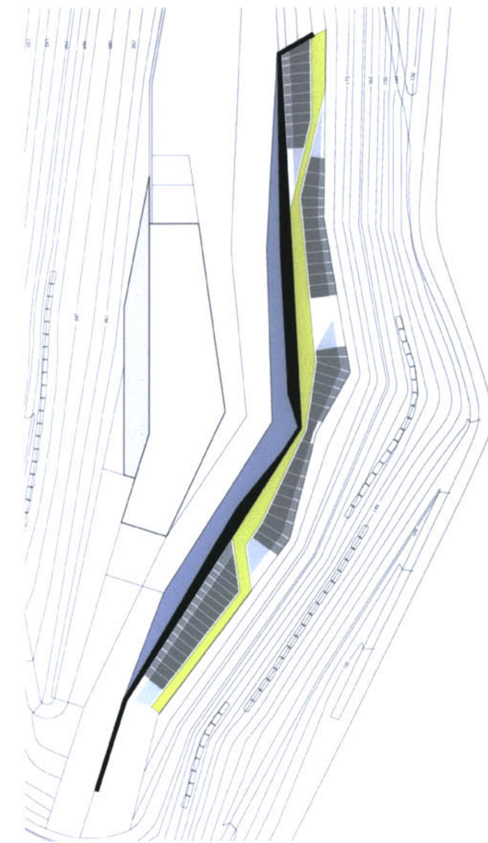
Guest Circulation (Fig. 193)



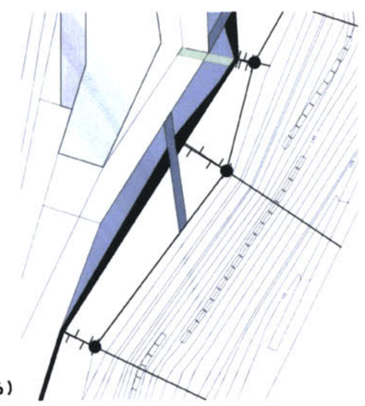
Guest Rooms (Fig. 194



Private Courtyards (Fig. 195)

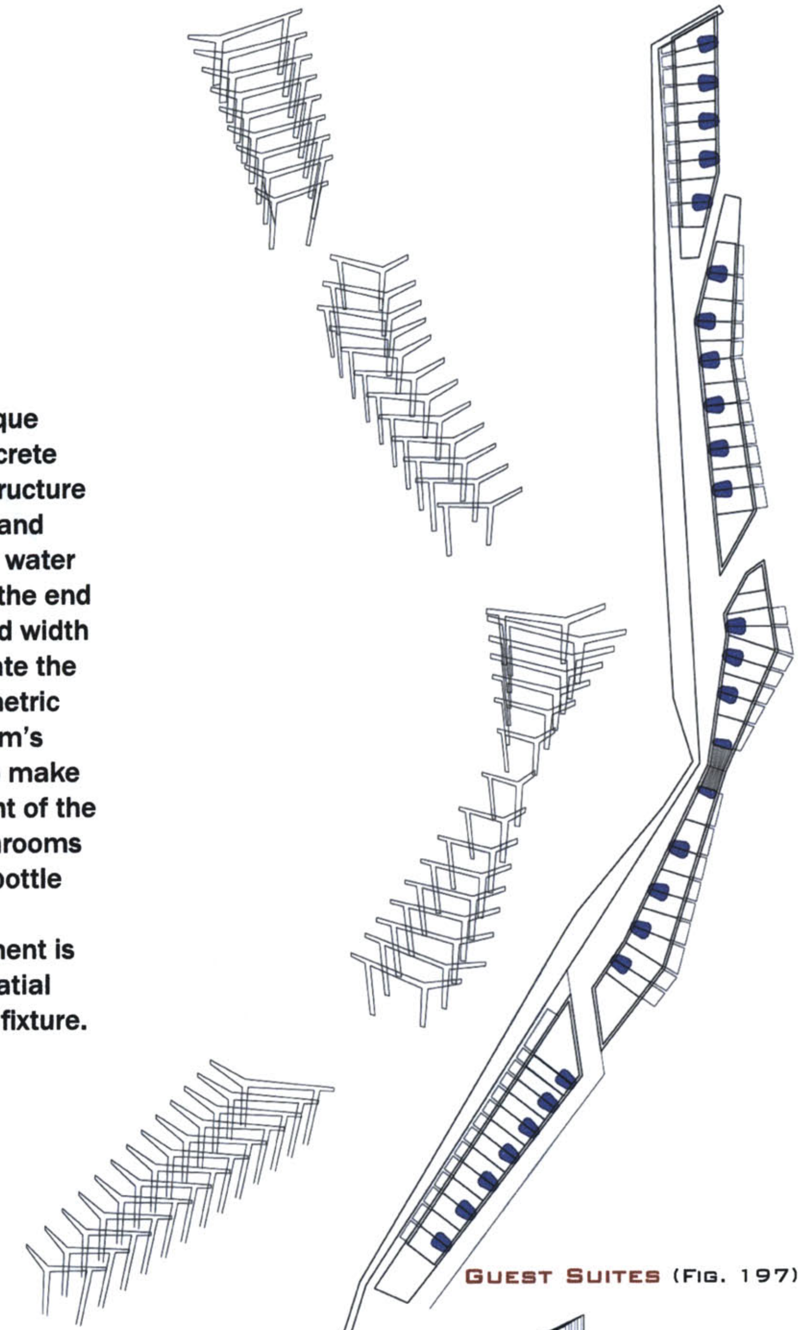


Cisterns (Fig. 196)

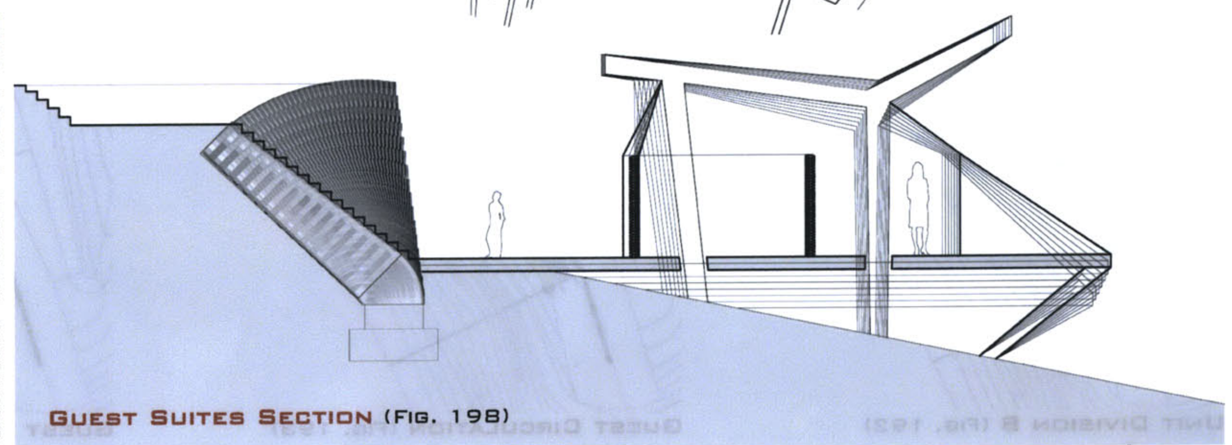


(Fig. 186)

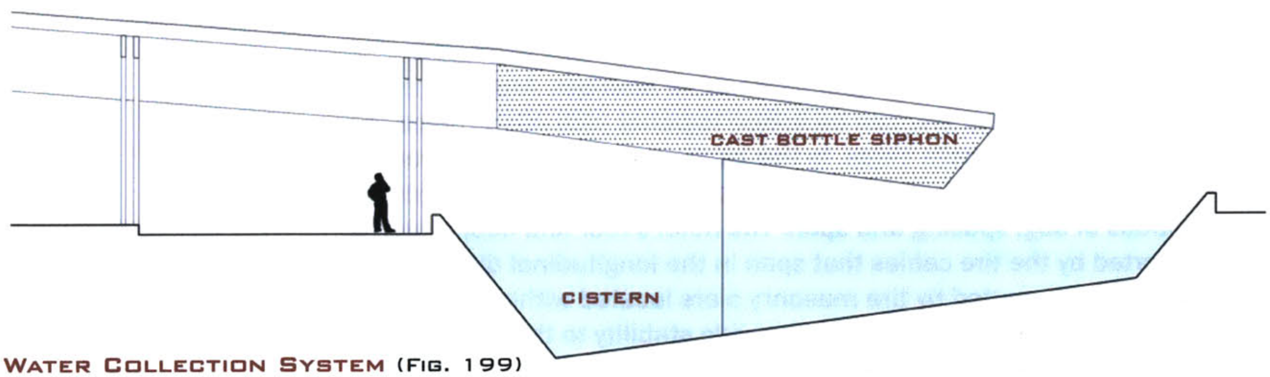
The guest rooms are built of unique structural ribs cast from the concrete bottle system. The ribs form a structure that supports a water collection and reuse system. The roofs channel water into multiple cisterns located at the end of the guest units. The height and width of each rib varies to accommodate the necessary roof pitch and planometric variation. The height of each room's floor planes are slightly varied to make up for the variation in base height of the masonry tire retaining wall. Bathrooms constructed of the compressed bottle system form the room's dividing walls. The planometric arrangement is tapered due to the necessary spatial requirements of each bathroom fixture.



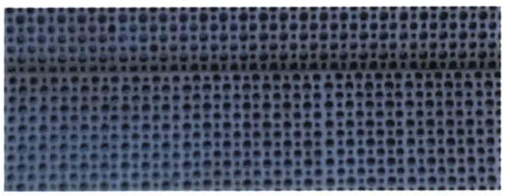
Guest Suites (Fig. 197)



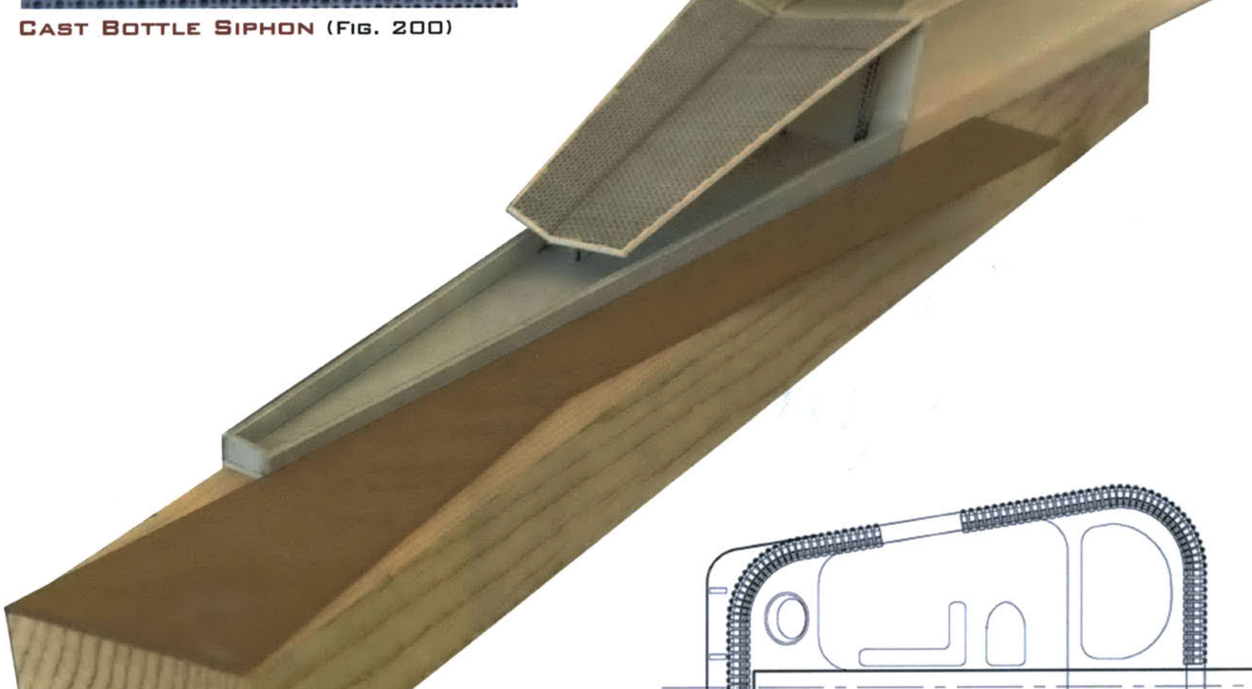
Guest Suites Section (Fig. 198)



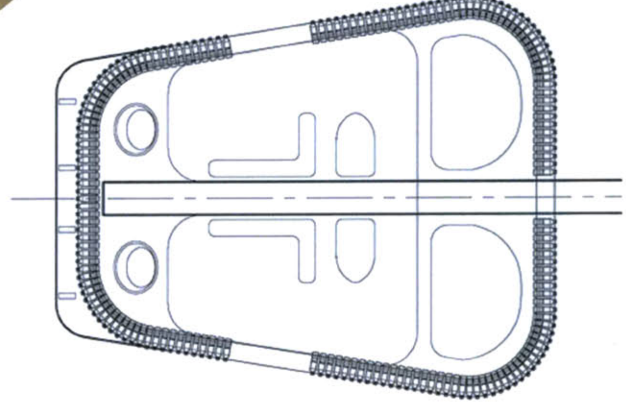
WATER COLLECTION SYSTEM (FIG. 199)



CAST BOTTLE SIPHON (FIG. 200)

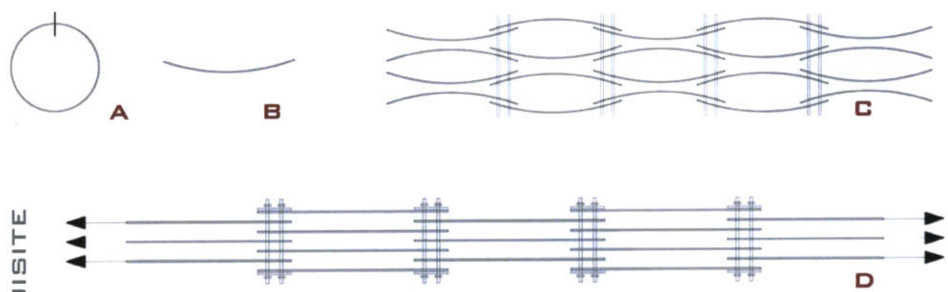


CISTERN MODEL (FIG. 201)



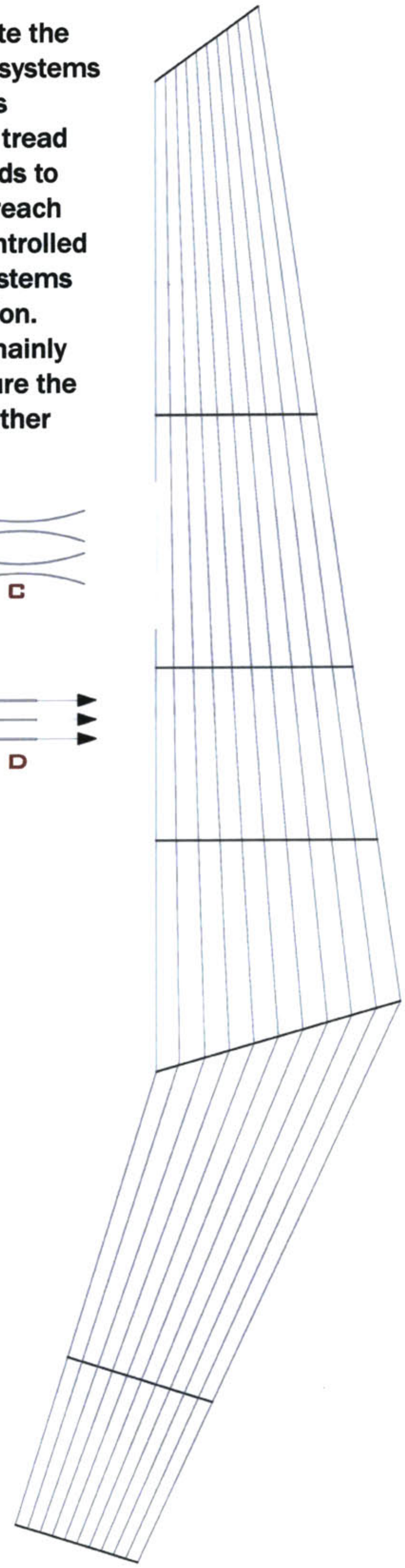
GUEST BATHROOMS (FIG. 202)

The main hotel structure requires substantial spans to accommodate the complex program and site constraints. The tire masonry and bottle systems are not sufficient to accommodate this requirement. The tire tread's embedded steel mesh gives it significant tensile strength. After the tread is cut in half, the flexible unit can be bolted together with other treads to form a high strength tensile cable. In this configuration, spans can reach upwards of one hundred feet. The parameters of the system are controlled by quantities of sag, spacing and span. The hotel's roof and floor systems are supported by the tire cables that span in the longitudinal direction. The cables are supported by tire masonry piers located within the mainly open plan of the structure. In order to provide stability to the structure the tire cables must physically connect to the ground. This condition further accentuates the building's connection to the ground plane.

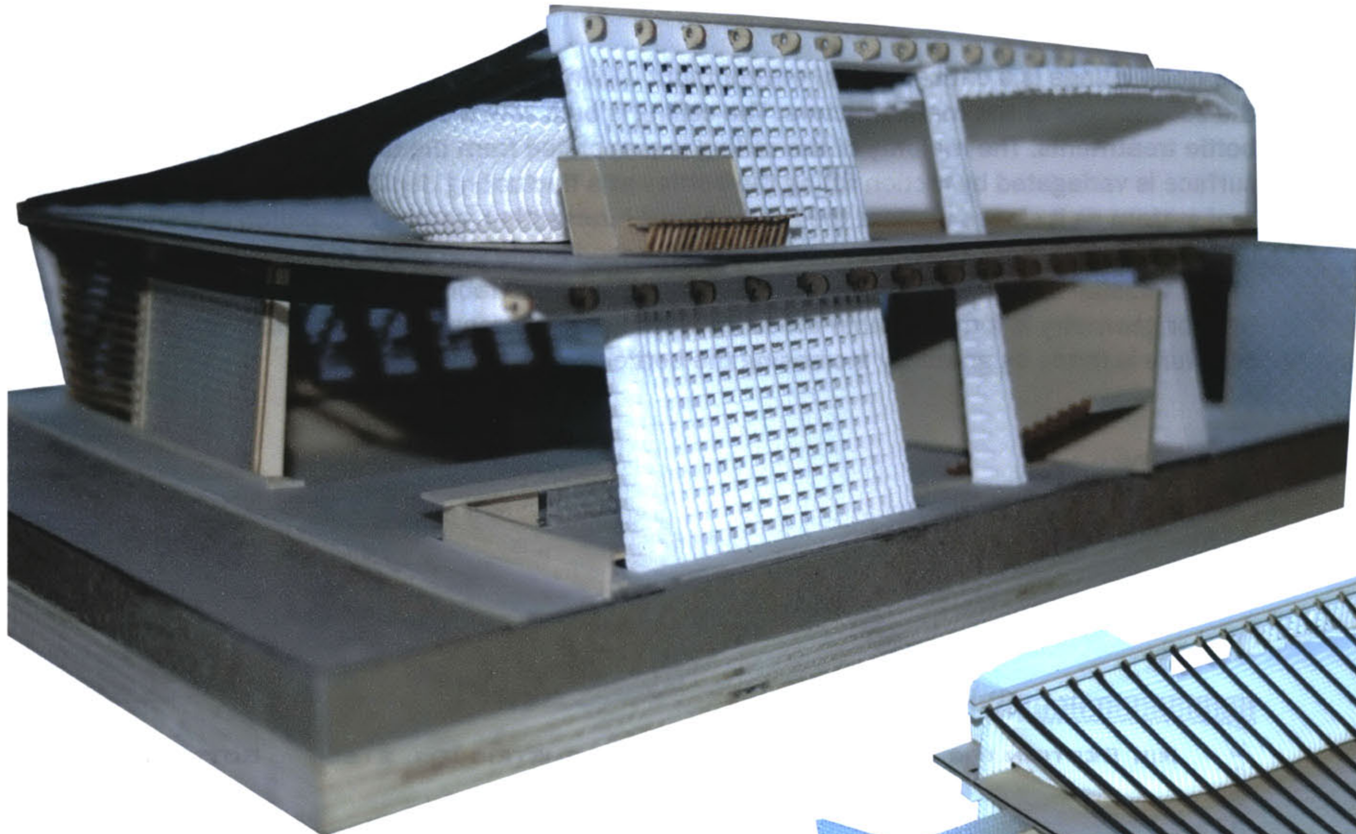


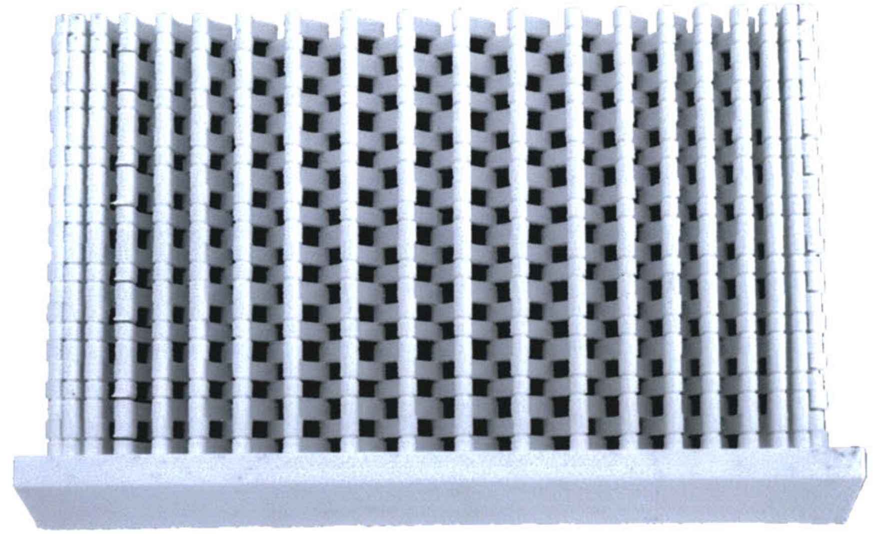
TIRE TENSION SYSTEM (FIG. 203)

STRUCTURAL MODEL DETAIL (FIG. 204)



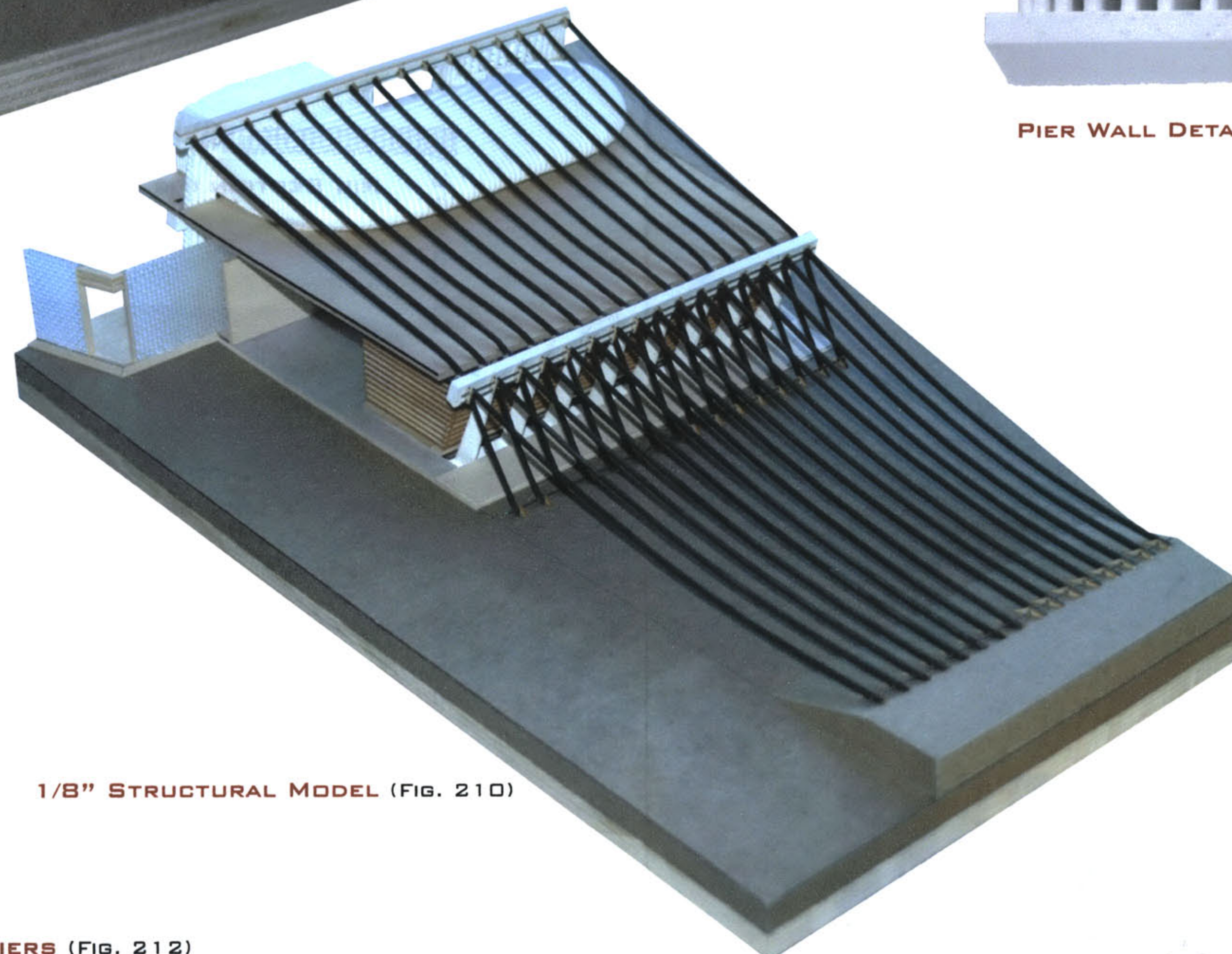
TENSILE TIRE ROOF (FIG. 205)



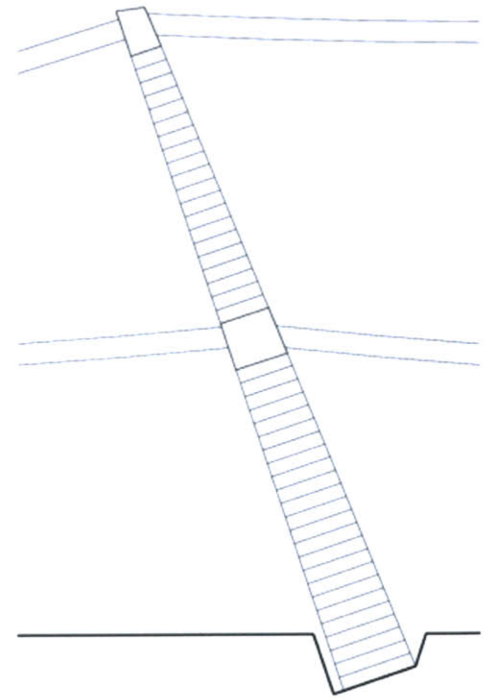


Pier Wall Detail (Fig. 208)

1/8" Structural Model (Fig. 207)

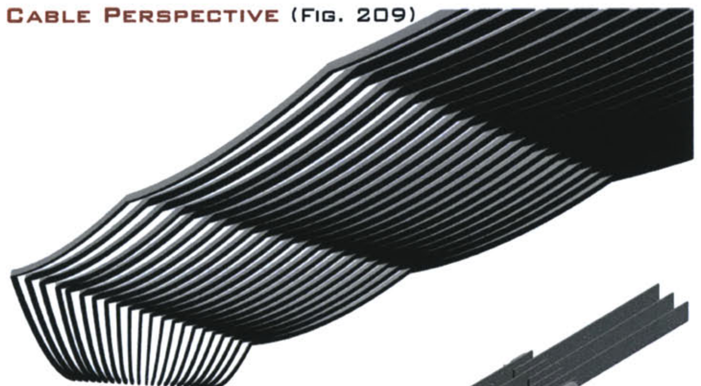


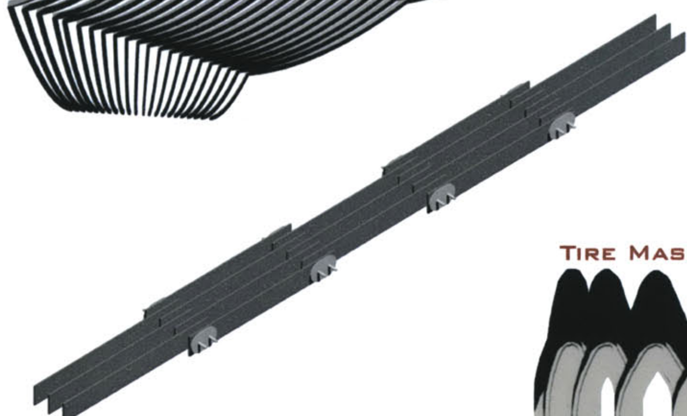
1/8" Structural Model (Fig. 210)



Pier / Cable Section (Fig. 213)

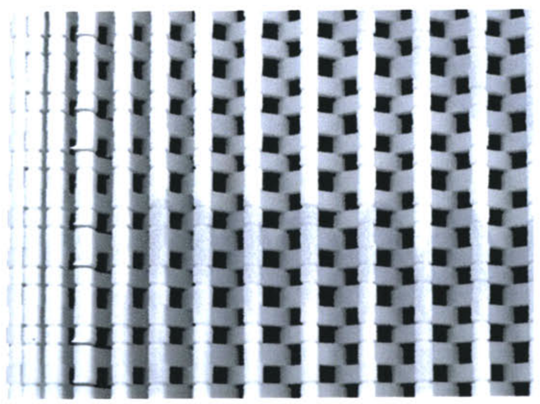
Cable Perspective (Fig. 209)





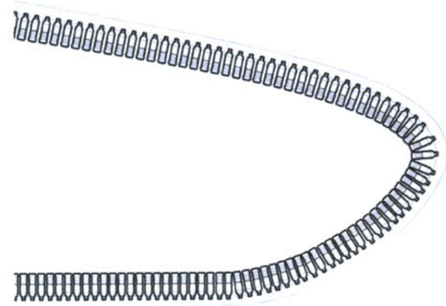
Cable Detail (Fig. 211)

Tire Masonry Piers (Fig. 212)

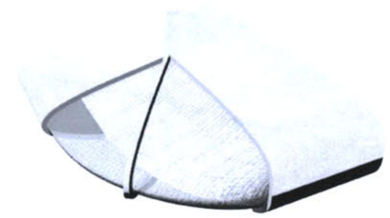


(Fig. 206)

The hotel lounge is a critical spatial environment within the hotel. It is located on the south end of the second floor of the main structure. The ceiling is built with a combination of the two interior bottle treatments. The majority of the ceiling is suspended from the tire cable structure. The surface is variegated by friction fitting the bottles at a fluctuating depth. The lounge intersects the roof system as it slopes to meet the earth. At this intersection, spatial occupation is limited. The illuminated ceiling system works with the fabric based bottle surface to define the physical limits of this unusual space. By introducing stationary ribs and the fabric based bottle surface a complex interior geometry is formed within the leftover volume. The transition from ceiling structure to fabric structure is made by gradually increasing the bottle density of the ceiling.

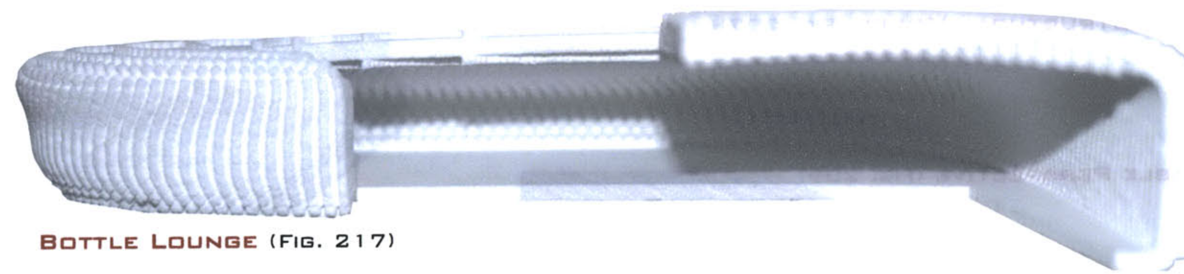


Rib Section (Fig. 214)

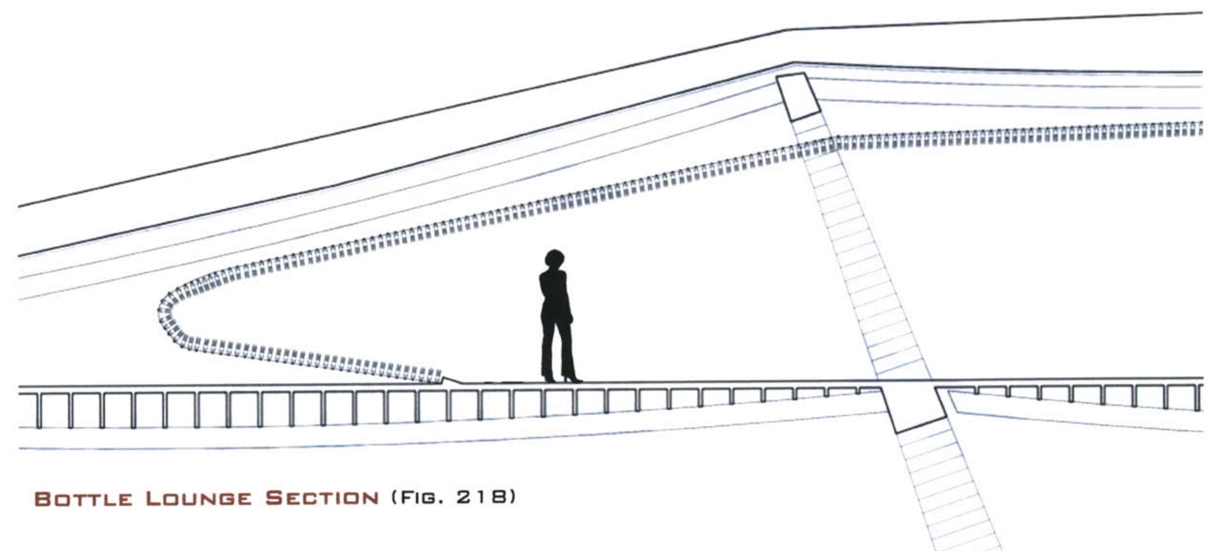


Surface / Rib Isometric (Fig. 215)

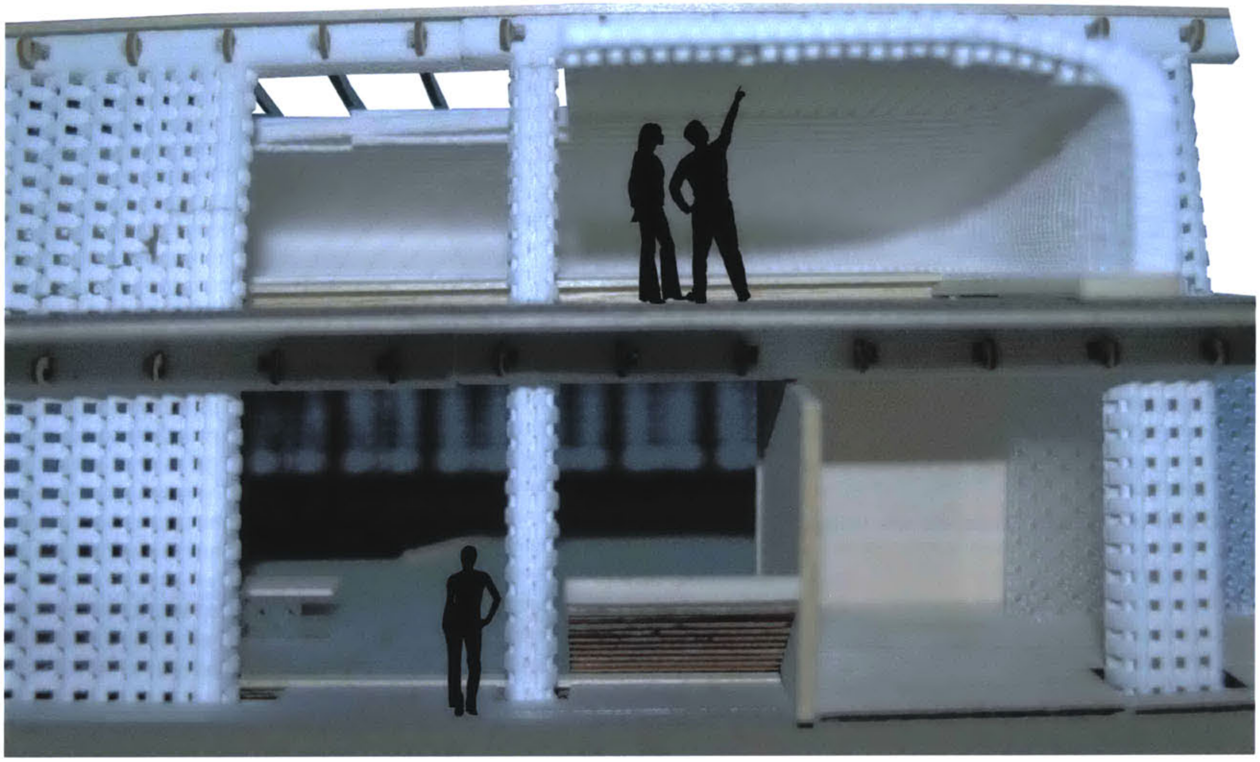
Bottles (Fig. 216)



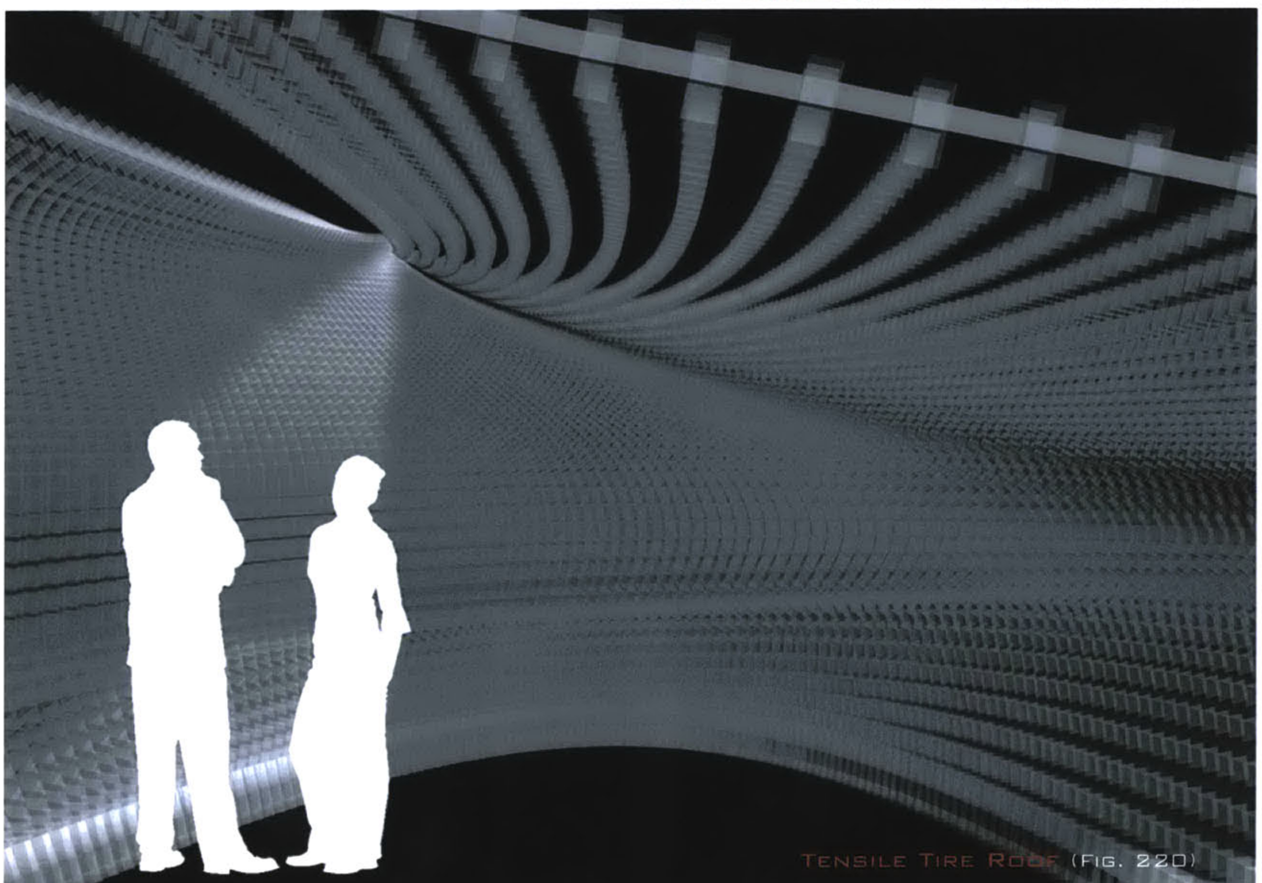
Bottle Lounge (Fig. 217)



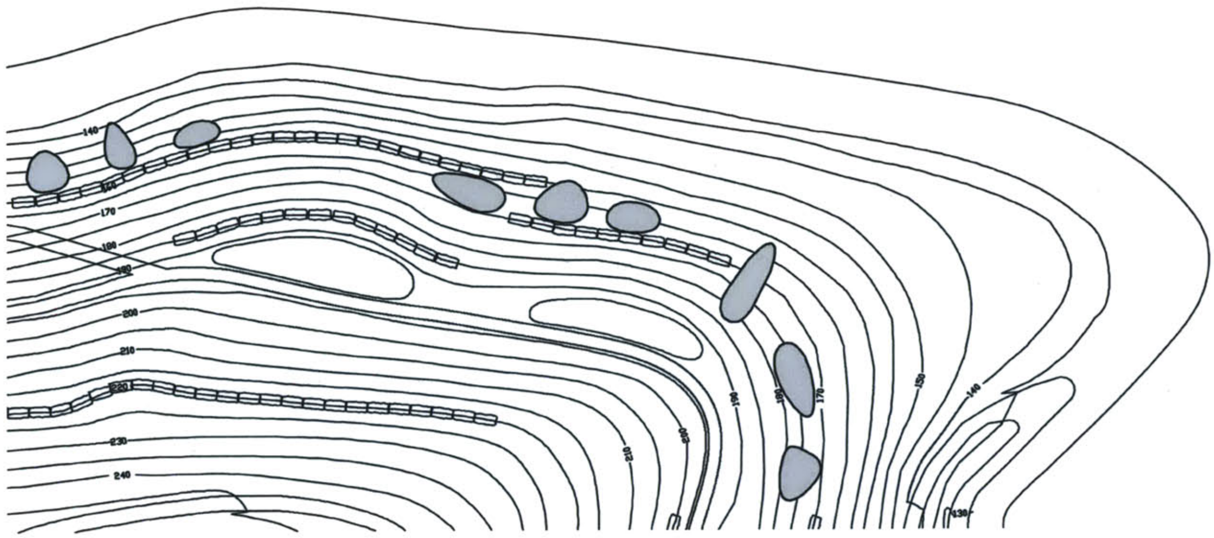
Bottle Lounge Section (Fig. 218)



1/8" Lounge / Lobby Model (Fig. 219)

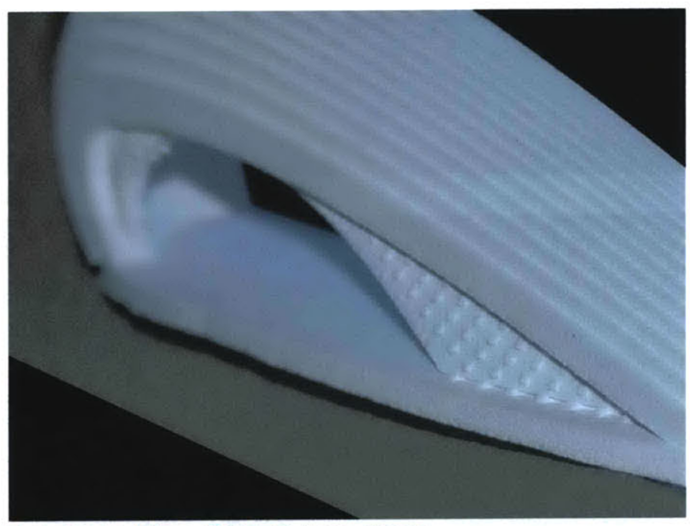


Tensile Tire Roof (Fig. 220)

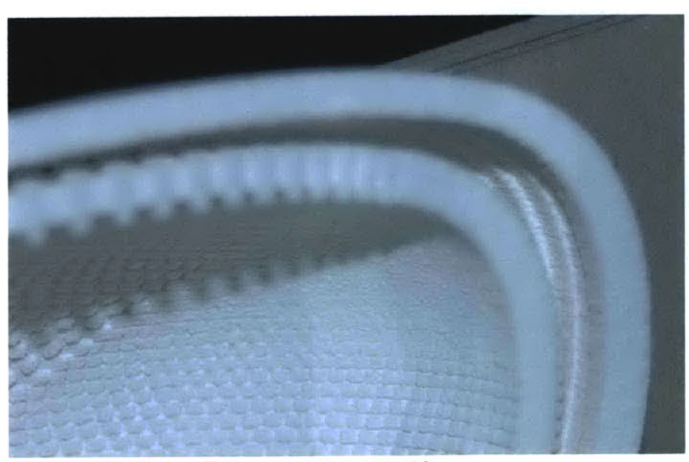


Camping Pod Site Plan (Fig. 221)

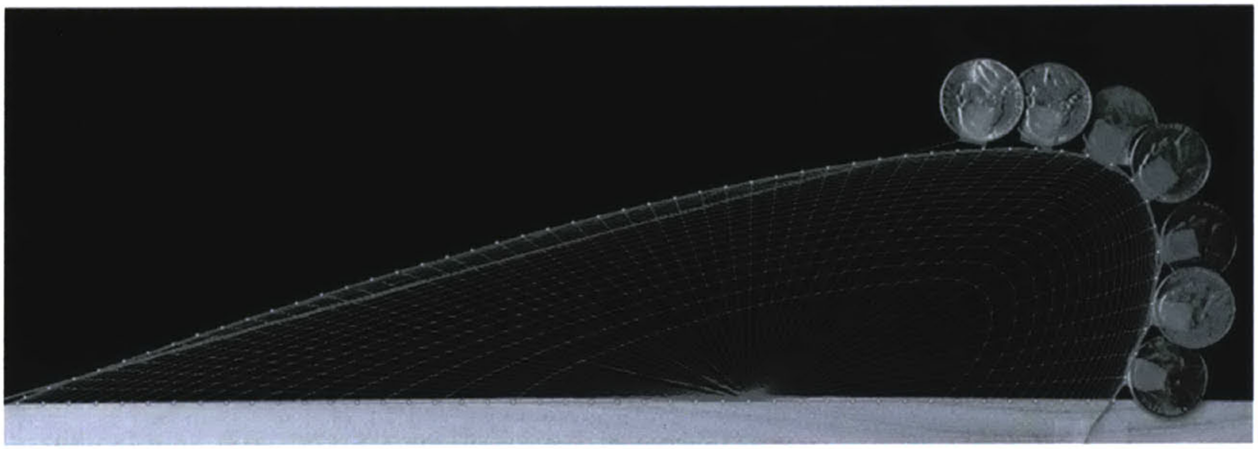
Pods constructed of formed tire masonry voussoirs are arranged along the lower northeast hillside of the north drumlin. The pods are comprised of a series of arches built in response to the forces of the hillside. The forces are simulated through the use of a hanging chain study and the form is modified to the corresponding shape. The pods provide island visitors with an insulated shelter for camping. The interior of the structure incorporates the fabric bottle surface as a light source. The suspended bottle surface corresponds to the pod's internal volume.



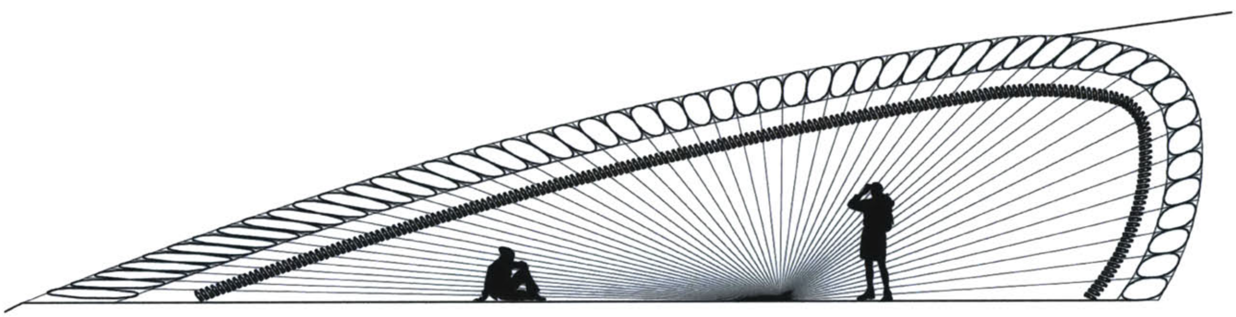
Camping Pod Entry (Fig. 222)



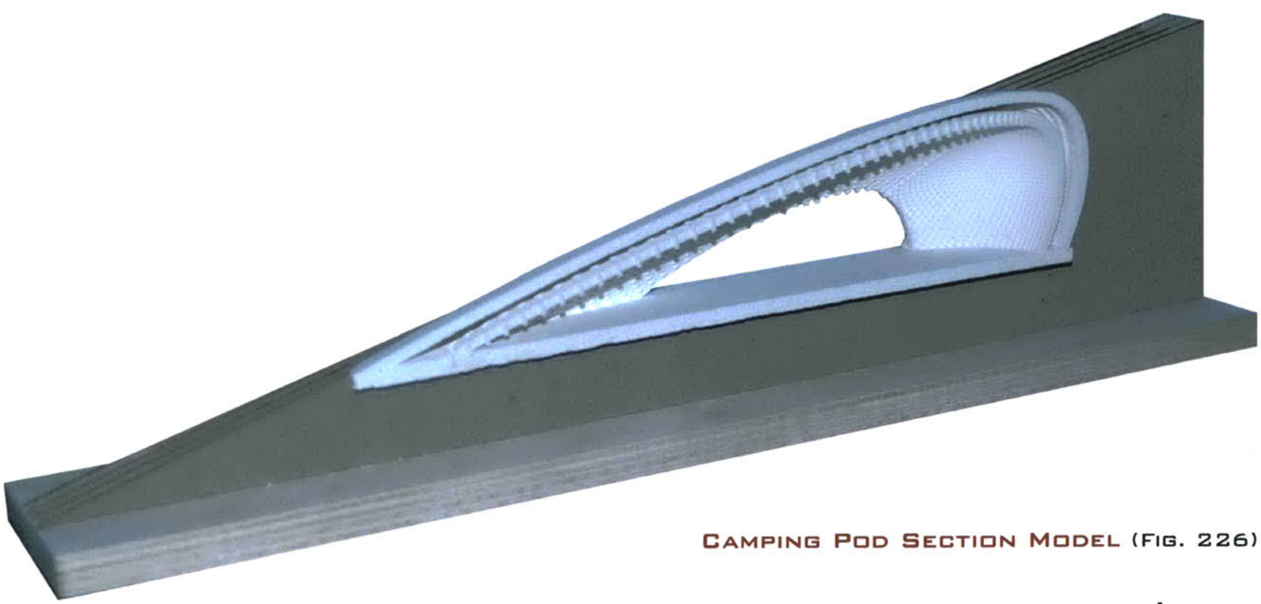
Camping Pod Detail (Fig. 223)



FORM FINDING STUDY (FIG. 224)



CAMPING POD SECTION (VOUSSOIRS) (FIG. 225)



CAMPING POD SECTION MODEL (FIG. 226)

Conclusion

The challenge of transforming the unwanted into something of elegance and substance is both provocative and restrictive. The limits of the materials are considerable because the tire and PET bottle are both designed without any thought of reuse. It is here that the project really became interesting. In general, architecture is a struggle with limits, whether they be financial, cultural, climatic, code based, or structural. This thesis begins to address the combined constraints inherent in both the waste materials and these basic architectural restrictions.

The primary focus is placed on the material systems themselves. It is through their development that the potential for reuse is displayed. The hotel is simply a vehicle for which to explore these systems more thoroughly. The choice to limit the structure of the buildings to that of the tire and the bottle systems demanded creative solutions and pushed the design into the realm of the fantastic. This resultant is inevitable due to the strict focus placed on the creation of elegant and complex structural systems and surfaces. In future work, the systems will be incorporated in architectural projects with more restraint placed on their scale and frequency of use.

The work accomplished in this thesis hopes to illustrate the exquisite potential waiting to be extracted from our everyday waste.

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1/8" Lounge / Lobby Model (Fig. 227)