



**EARTHSCRAPERS:**  
Developing 3D printing for the rapid manufacture  
of earth-based building components

Project Date: 2010

Project Team: Ronald Rael, Virginia San Fratello, John Faichney,  
Maricela Chan, Chris DeHenzel, Emily Licht

**SUMMARY**

The creation of building components that can be seen as sustainable, inexpensive, stronger, recyclable, customizable and perhaps even repairable to the environment is an urgent, and critical focus of architectural research. In the U.S. alone, the construction industry produced 143.5 million tons of building-related construction and demolition debris in 2008, and buildings, in their consumption of energy produce more greenhouse gasses than automobiles or industry.

Because the inherent nature of 3D printing opens new possibilities for shaping materials, the process will reshape the way we think about architectural building components. Digital materiality, a term coined by Italian and Swiss architects Fabio Gramazio and Matthias Kohler, describes materiality increasingly enriched with digital characteristics where data, material, programming and construction are interwoven. The research aspires towards this classification through the use of parametric modeling tools, analytic software and quantitative and qualitative analysis.

Rapid Prototyping, which is the automatic construction of physical objects using additive manufacturing technology, typically employs materials intended for the immediate analysis of form, scale, and tactility. Rarely do the materials used in this process have any long-term value nor does the process, except in rare cases with expensive metal prototyping, have the ability to create actual and sustainable working products.



## EARTHSCRAPERS

This research intends to alter this state of affairs by developing methods for 3D printing using concrete for the production of long-lasting performance-based components.

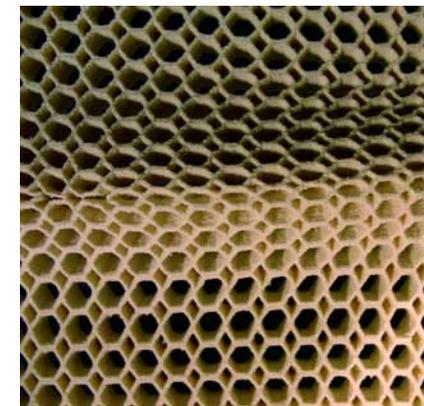
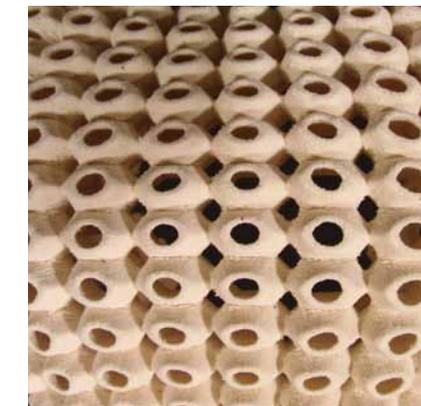
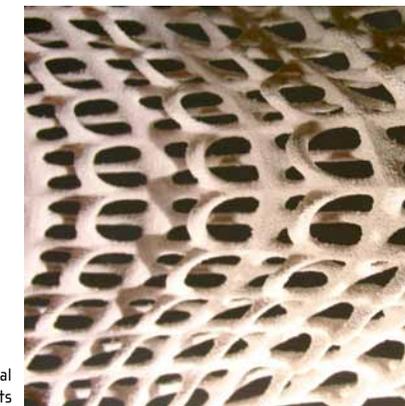
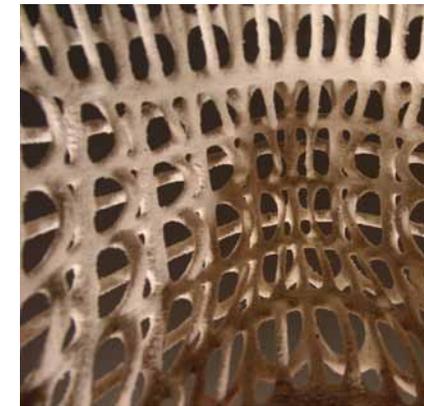
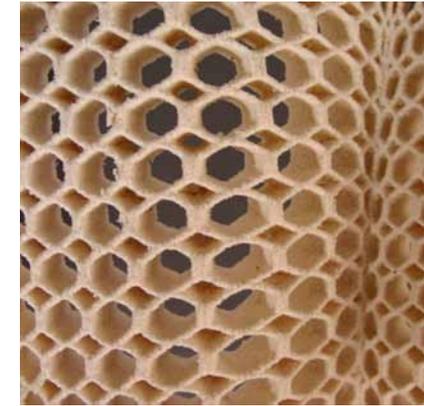
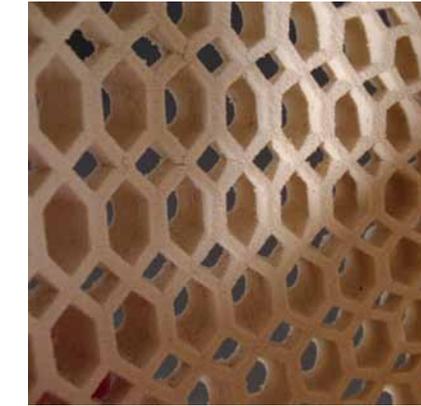
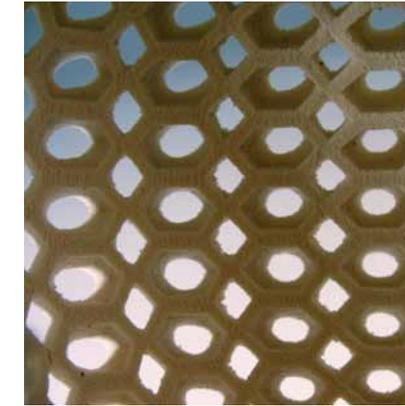
### MATERIAL INFORMATION

The word concrete comes from the Latin word “concretus” (meaning compact or condensed), the perfect passive participle of “concreso”, from “com-” (together) and “cresco” (to grow). The development of concrete has evolved for over two thousand years. The Romans used quicklime, pozzolana and aggregate or rubble to build concrete structures such as the Pantheon and the Baths at Caracalla. In 1756 John Smeaton rediscovered concrete by mixing hydraulic lime and powdered brick as aggregate. These mixtures produced concrete with a comprehensive strength comparable to the mixes that we use today. The mixes that we most frequently use today include:

**Portland cement:** which consists of a mixture of oxides of calcium, silicon and aluminium. Portland cement and similar materials are made by heating limestone (a source of calcium) with clay, and grinding this product (called clinker) with a source of sulfate (most commonly gypsum).

**Water:** Combining water with a cementitious material forms a cement paste by the process of hydration.

**Aggregates:** Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel and crushed stone are mainly used for this purpose. Recycled aggregates (from construction, demolition and excavation waste) are increasingly used as partial replacements of natural aggregates, while a number of manufactured aggregates, including air-cooled blast furnace slag and bottom ash are also permitted.



Left: Tools, materials and artifacts from the material development process. Right: Kiln-fired ceramic 3D prints

## EARTHSCRAPERS

When initially mixed together, Portland cement and water rapidly form a gel, formed of tangled chains of interlocking crystals. These continue to react over time, with the initially fluid gel often aiding in placement by improving workability. As the concrete sets, the chains of crystals join up, and form a rigid structure, gluing the aggregate particles in place. During curing, more of the cement reacts with the residual water (hydration).

Concrete is inherently weak in tension as the cement holding the aggregate can crack. The addition of steel reinforcement to concrete in the 19th century solved this problem. In addition to adding steel reinforcing bars, we now add steel fibers, glass fiber, or plastic fiber to carry tensile loads. Thereafter the concrete is reinforced to withstand the tensile loads upon it.

The mix for use in the 3d printer is similar to yet varies in composition from the traditional mixes used. The traditional processes used vary dramatically, from hand tools to heavy industry, but result in the concrete being placed in a formwork where it cures into a final form. In the case of 3d printing concrete there is no form work or mould. There is however, the constraint that all binding particles used in the concrete mix must fit through a 35 picoliter print head and all cement, aggregate and reinforcement must be smaller than 0.010". The mix that is used in the 3D printer is made of Portland cement, Plaster of Paris, Finely graded sand, Powdered sugar, Maltodextrin, Rice wine, Nylon fibers



## EARTHSCRAPERS

The Portland cement serves the same purpose as it does in a traditional mix. The finely graded sand, sugar and maltodextrin act as the aggregates. The rice wine is composed of 80% water and acts as the binder, although a slurry is not formed, and the nylon fibers serve as reinforcement.

### HOW IT WORKS

The 3D printer lays down a thin layer of the dry, powdered concrete mix, then using an ink jet sprays the image of one 'slice' of the 3D object, in this case a digital CMU (concrete masonry unit), onto the dry mix. The wet parts of each layer hydrate into rock-hard concrete, and the rest remains in a powder form which can be brushed off later. Because concrete cures via a chemical reaction – hydration—no air is required for curing, so the next layer can be deposited immediately. The cycle of laying down concrete and binder with the rice wine is repeated over and over, stacking layer upon layer, building up a solid object inside the pile of dry, powdered concrete mix. The dry concrete mix acts as a support structure during the printing process, so objects may have undercuts which is unseen in traditional concrete casting.

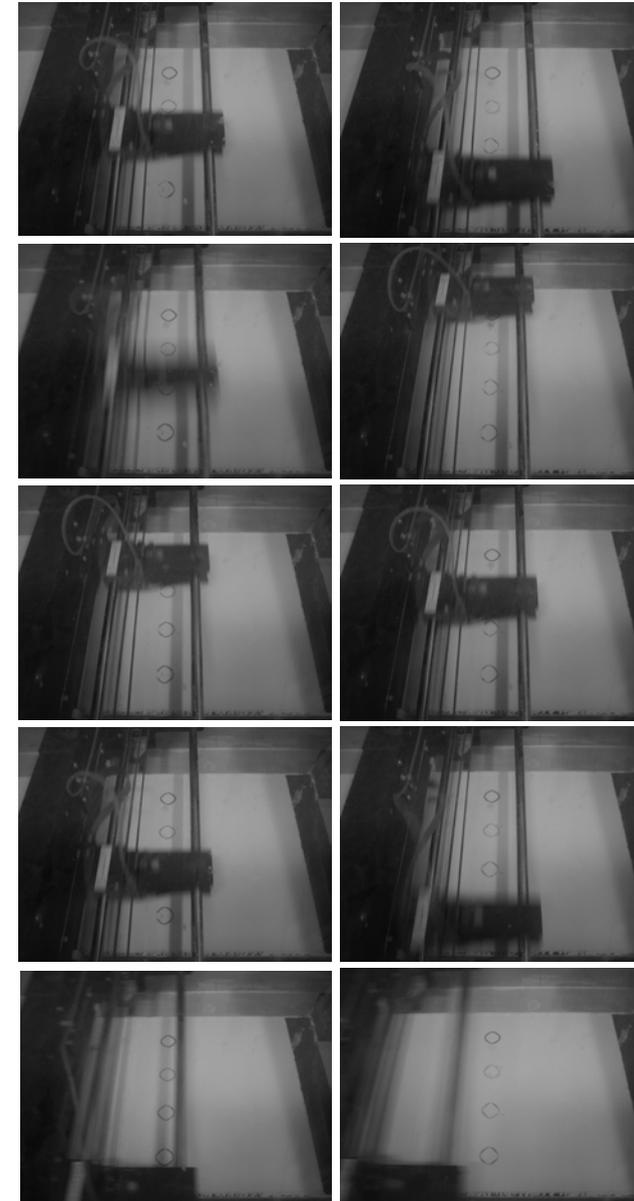
Once the concrete cures enough to handle, which typically takes about 12 hours, the finished object can be lifted out of the powder bed. The dry mix used to support the concrete object during printing can be recycled. Printing an intricate and unique concrete part would only consume a few dollars worth of material, would incur no cost for formwork and very little labor costs. Additionally compared to printing with z corps proprietary blend, the costs are considerably lower. The Z corp polymer / plaster powder, at it's cheapest, is \$3 a cubic inch and the 3D printed concrete costs mere cents per cubic inch.

### CONCRETE MEDIA

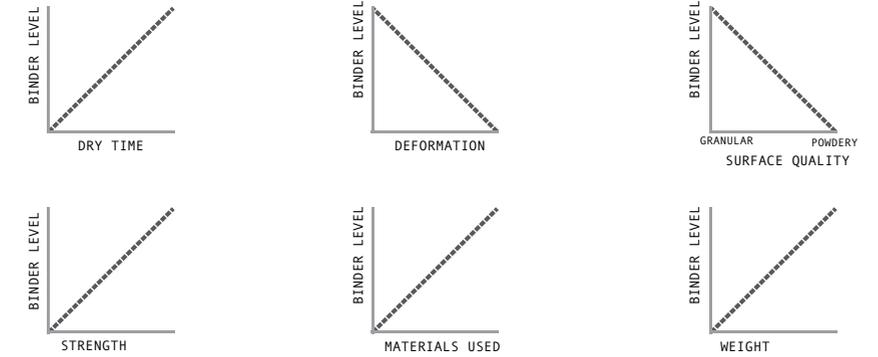
The initial impetus to work with concrete as a 3D printed material was driven by an installation we designed called *Earthscapers*. *Earthscapers* imagines the potential of employing Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) processes in the construction of a proto-architectural landscape—one where the building material source and the building itself are seamless. The project also imagines a future scenario for the material and the process as a scalable technology—one that also dissolves the role of the architect and builder. We imagined printing full scale buildings with in situ aggregates in a world where designer and geomorphologist merge.

The capability to 3D print at the scale of the building is gaining momentum and is certain to occur. Currently the largest 3D printer in the world is a 10' x 10' x 10' 3-D stereolithic printer that creates models entirely out of artificial sandstone using CAD-CAE modeling technologies and CAD-CAM software to control the plotter. The printing proceeds in 5-10mm layer segments and, in the end, produces a structure that has strength characteristics reminiscent of standard Portland Cement.

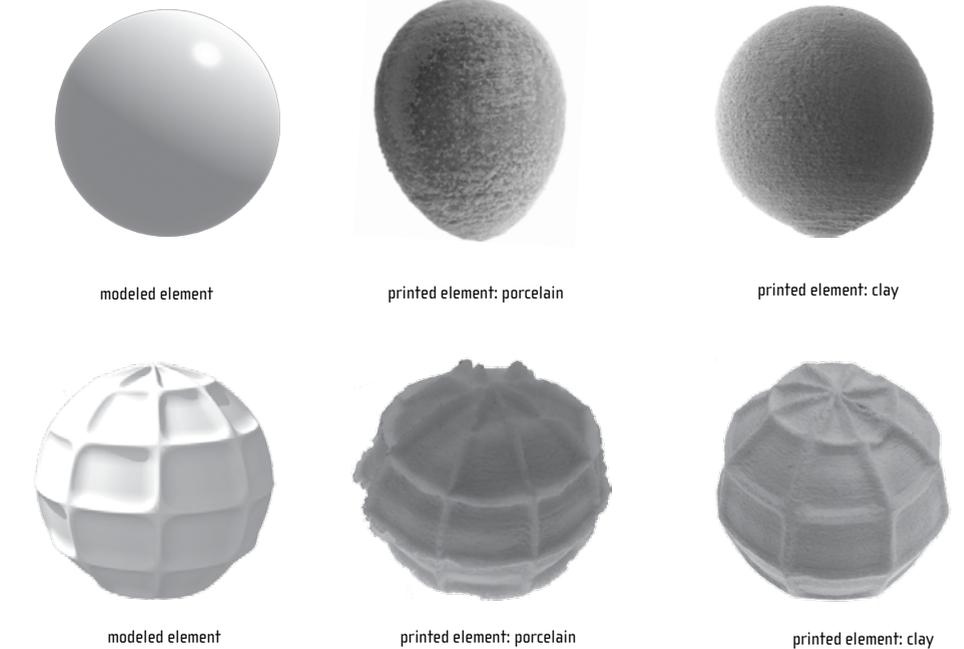
Dr. Behrokh Khoshnevis, of the University of Southern California has developed a different printing technique called Contour Crafting (CC). Contour crafting is a layered fabrication technology that has potential for automating the construction of whole structures as well as sub-components. Using this process, a single house or a colony of houses, each with possibly a different design, may be automatically constructed in a single run, embedded in each house all the conduits for electrical, plumbing and air-conditioning.



### EFFECTS OF BINDER LEVELS:



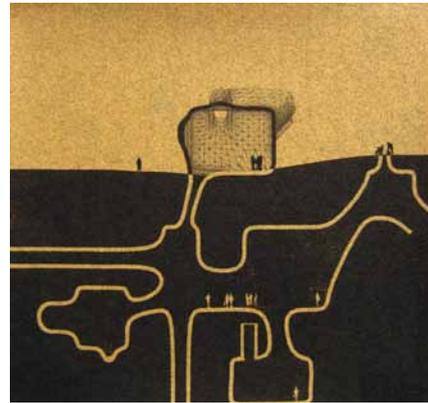
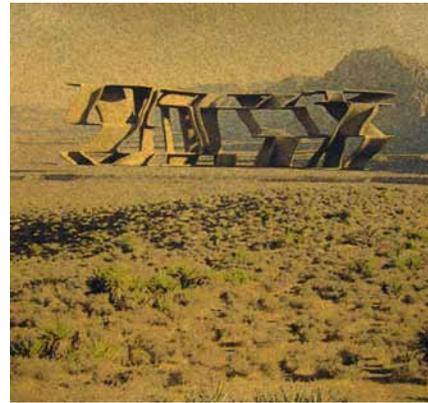
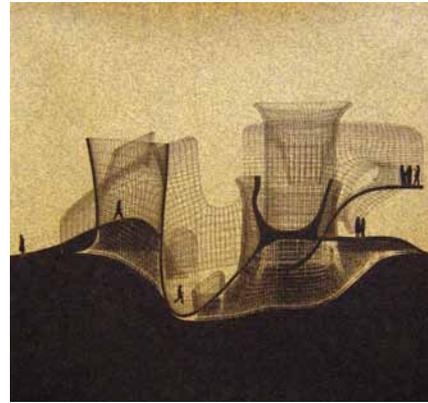
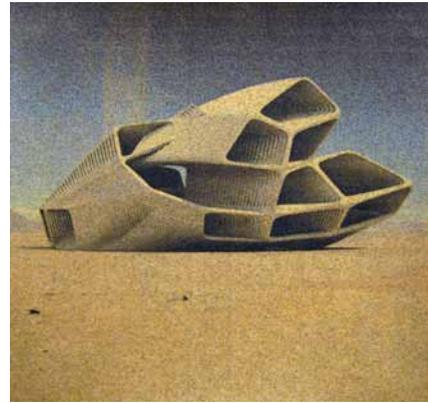
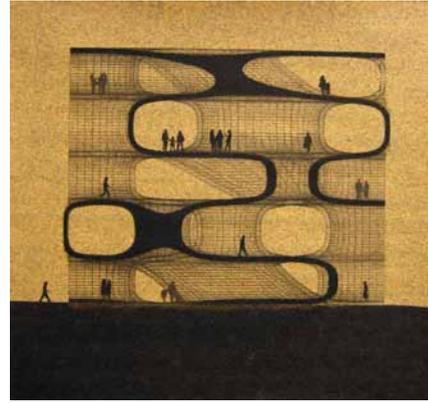
### MATERIAL DEFORMATION



## EARTHSCRAPERS

For the Earthscrapers exhibit we were uniquely interested in connecting the 3D printed material to the landscape therefore we started by printing various materials including clays (left both raw and fired to create ceramic objects), sands and fly ash. Ultimately we decided to print a small amount of portland cement mixed with a large portion of sand. The resulting concrete prints proved to be very stable, strong and have the effect of looking like earth due to the amount of natural aggregate within the mix.

The plastic nature of both concrete and 3D printing offer up a powerful material solution to recent generative design processes in architecture, which often feature organic, doubly curved surfaces and complex ornamentation. The Earthscrapers exhibit explored a range of complexly curved forms. It also explored thinness and attempts to push the limits in terms of extracting thin surfaces and thin structural elements from the printer bed. Several of the complexly curved, fiber reinforced concrete prints were easily 1/16" of an inch thick which would be very difficult, if not impossible, to cast using traditional methods of mould making. Making the 3D printed models and objects that were on display in the Earthscrapers exhibit was an active process where software, geometry, material, fabrication and production were simultaneously linked. The complexity of form was limited by thinness and slump. If the form was not allowed to cure in the bed for at least 12 hours the concrete object would fail. The success of the mix depended on the amount of binder being laid down at each successive interval. For example, if the binder was sprayed at full capacity the concrete print would slump therefore the binder level should be set at 75%.



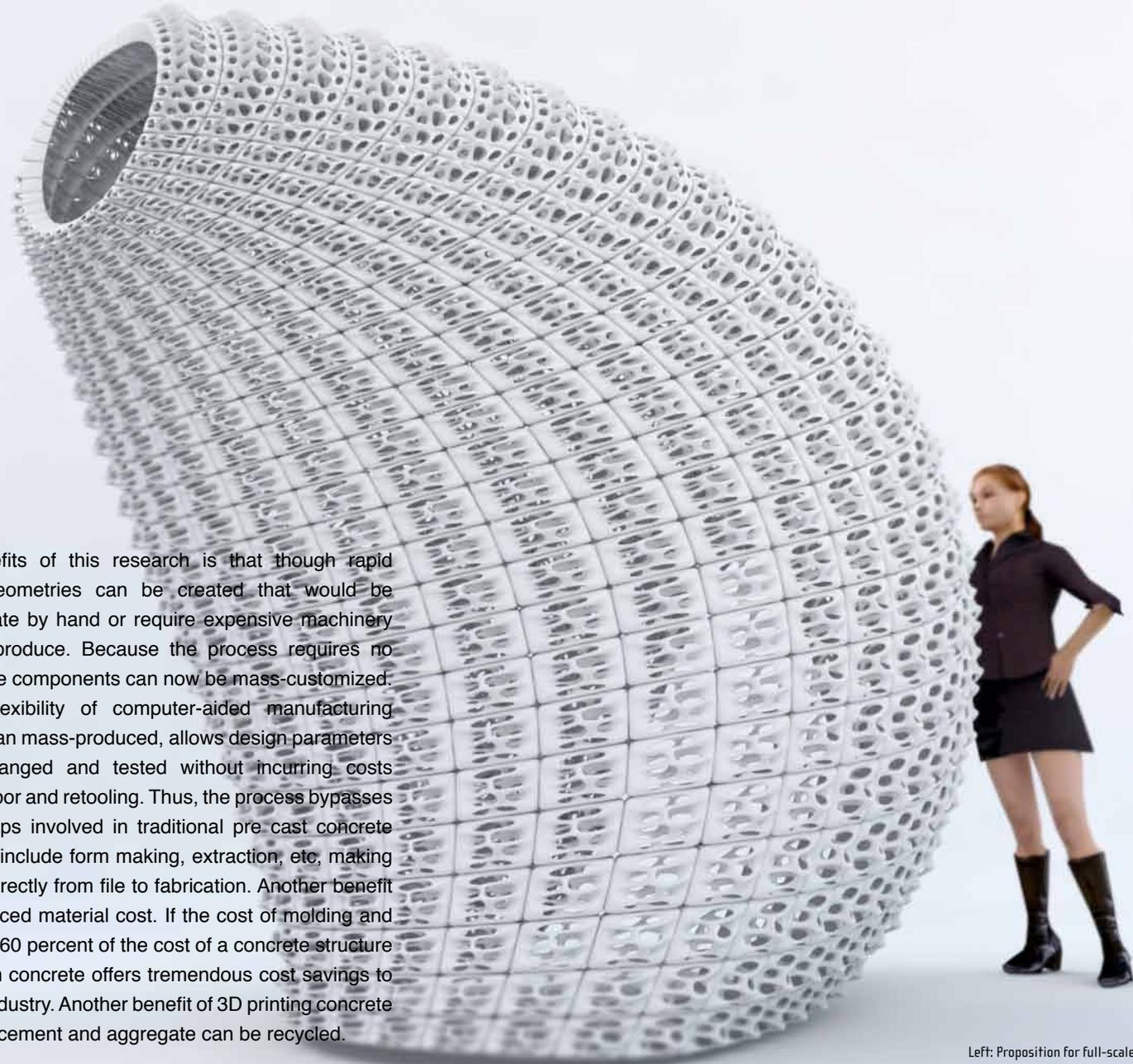
Sandpaper 2D prints



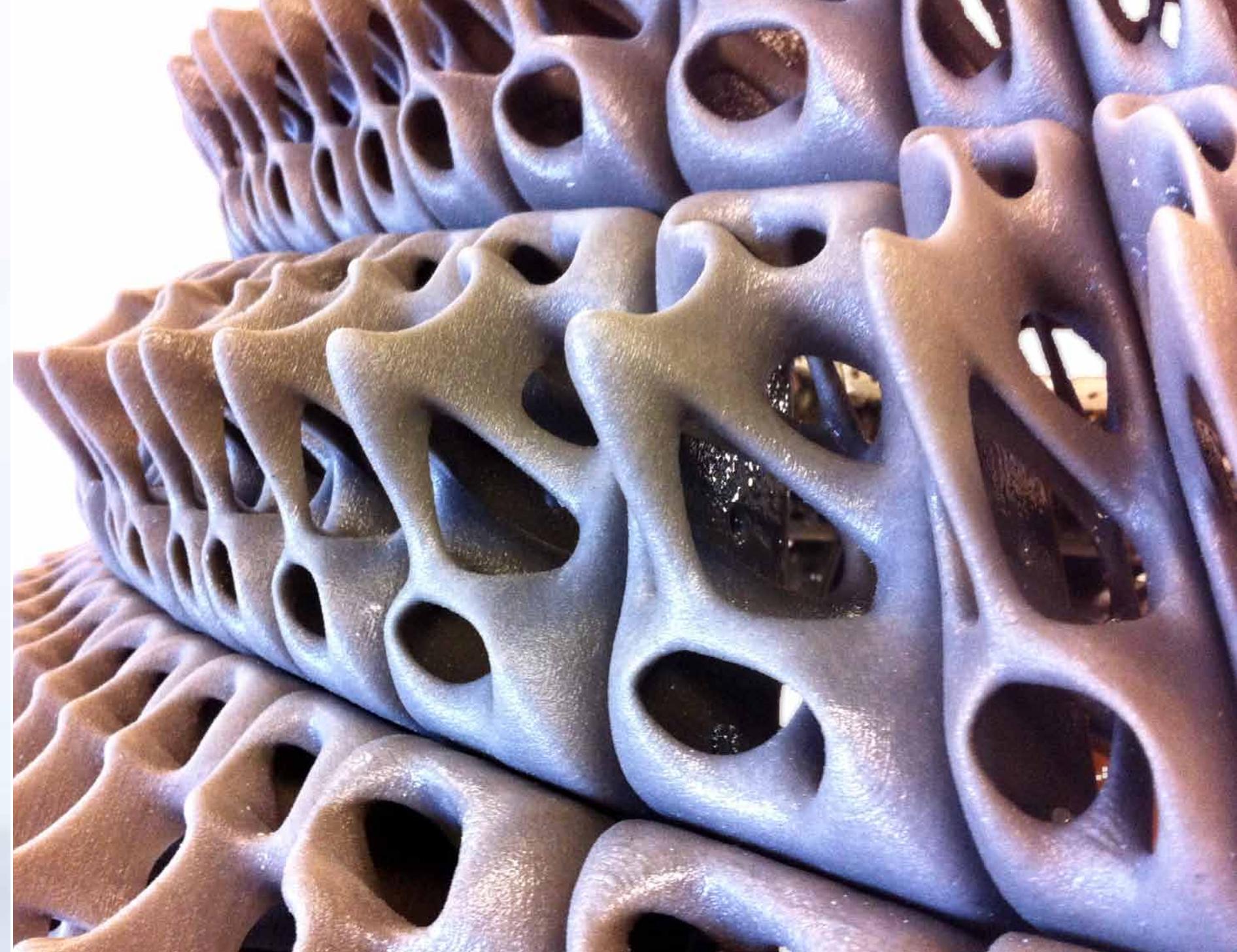
Sand 3D prints

#### IMPACTS

One of the benefits of this research is that through rapid manufacturing, geometries can be created that would be impossible to create by hand or require expensive machinery to produce or reproduce. Because the process requires no formwork, concrete components can now be mass-customized. Employing the flexibility of computer-aided manufacturing systems, rather than mass-produced, allows design parameters to be quickly changed and tested without incurring costs associated with labor and retooling. Thus, the process bypasses several of the steps involved in traditional pre-cast concrete production, which include form making, extraction, etc, making it possible to go directly from file to fabrication. Another benefit is the greatly reduced material cost. If the cost of molding and form work is 35 to 60 percent of the cost of a concrete structure then 3D printing in concrete offers tremendous cost savings to the construction industry. Another benefit of 3D printing concrete is that the excess cement and aggregate can be recycled.



Left: Proposition for full-scale 3D printed room.  
Right: 3D printed room under construction



## THE PLANTER BRICKS

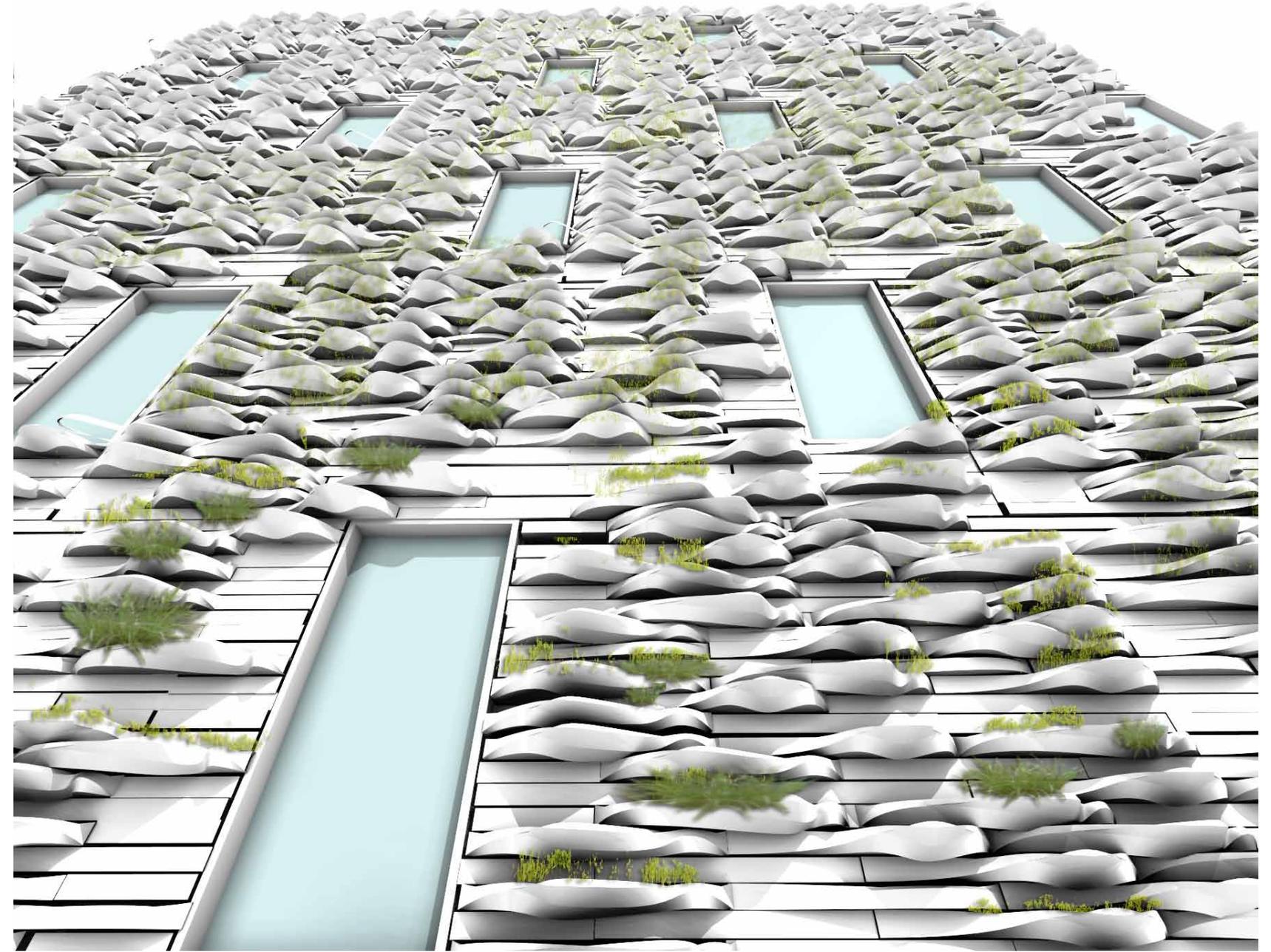
Project Date: 2009

Project Team: Ronald Rael, Virginia San Fratello, Molly Reichert

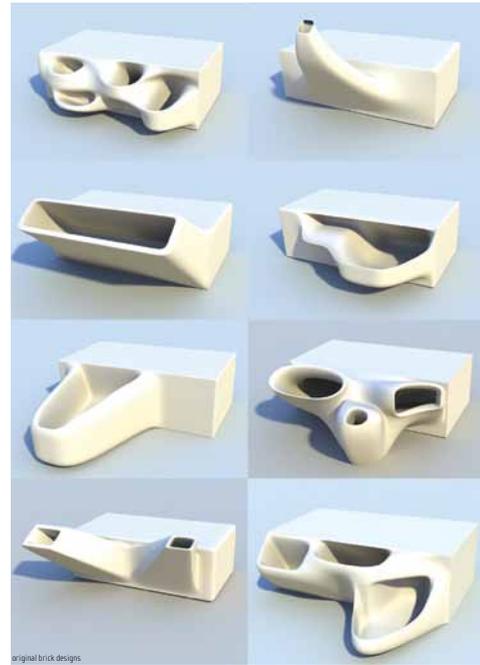
The planter brick wall is designed to be a combination of traditional masonry units combined with units that can hold plants and vegetation. Most plants do not need much, if any, soil but they do need water and nutrients. The plants held in the planter bricks will be fed water and nutrients through drip irrigation lines that are built into the cavity of the masonry wall.

The planter bricks have the potential to counter the heat island effect in big cities through evapotranspiration and pollution conversion and by the light, reflective color of the bricks. Additionally, edible plants such as rosemary and other fragrant herbs with shallow root systems may be planted in the bricks and accessed through openings in the wall. The plants in the bricks will help mediate the temperature of the microclimate surrounding the building, buffer sound and filter the air.

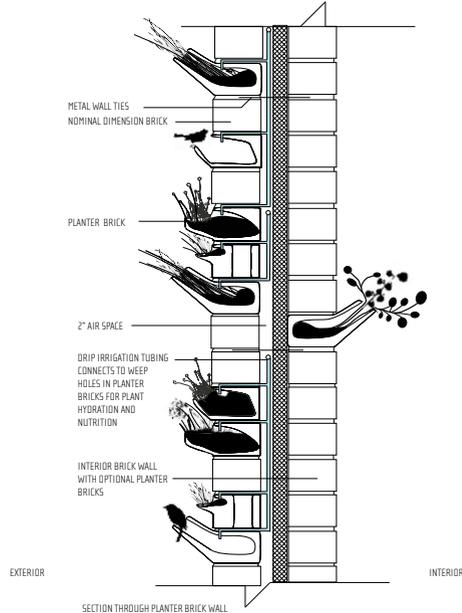
The planter bricks are made by direct digital manufacturing and rapid prototyping technology. Ceramic particles are printed and held together using an organic binder and then fired in a kiln just like traditional bricks. The bricks may be assembled in a load bearing cavity wall condition or installed as a traditional masonry curtain wall would be on a steel or concrete frame building and can be installed new or retrofitted.



## PLANTER BRICK



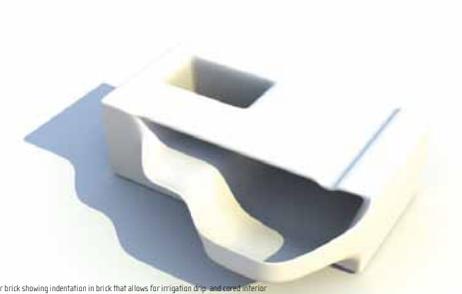
original brick designs



SECTION THROUGH PLANTER BRICK WALL  
SCALE: 2 1/2\"/>



planter brick showing indentation in brick that allows for irrigation drip



planter brick showing indentation in brick that allows for irrigation drip and eared exterior



planter brick with plants and drip line



planter brick with plants and drip line

The indentations in the bricks that allow for irrigation act much like weep holes allowing water and nutrients to move through a network of continuous drip irrigation tubes that run within the cavity of the masonry wall. The water for the irrigation may be pumped up from below or gravity fed from a cistern or water collection device on the roof.



## PLANTER BRICK



The planter bricks on this page have all been 3D printed using direct digital manufacturing . The bricks are modeled in a 3D software application and the digital file is sent directly to the 3D printer for manufacture. This means a very diverse and infinitely unique selection of bricks can be manufactured based on the clients or designers desires for a particular application.

The bricks are manufactured with clay instead of more ephemeral powders that are typically used for rapid prototyping. The 3d clay prints are then bisque fired at cone 5 and glazed to make them waterproof.

The oldest bricks date back to around 7500 BC, these were sun dried mud bricks, around the third millennium, fired bricks were invented. With the invention of the steam engine early brick-making machines used stiff mud which was forced out in long ribbons on a conveyor belt, transferred to moulds and cut by a revolving cutter. Today, as we march into the 21st century armed with new computer aided design (CAD) and computer automated manufacturing (CAM) technologies we can liberate ourselves from the traditional form of the brick without sacrificing any of the functionality of the brick such as it's ability to act as a thermal mass, it's longevity, it's compressive strength , the low cost of bricks and the ability to use a local and contextual material. This project represents the next step in the evolution of brick manufacturing and design using some of the most advanced methods for mass brick customization.



## TOPO TABLE

Project Date: 2007

Project Team: Virginia San Fratello, Danny Herrera



The TOPO table is made of corian. It has embedded in its surface, CNC milled corian dishes. The dishes are stored in the table and can be removed when needed. The dishes are flat on one side and topographic on the other. When all of the dishes are right side up, the table becomes a literal dining landscape.

The TOPO dishes can be embedded in the table or potentially even a wall to create a modern day china cabinet. The dishes are dishwasher safe, hygienic and cut marks or stains can be sanded out.



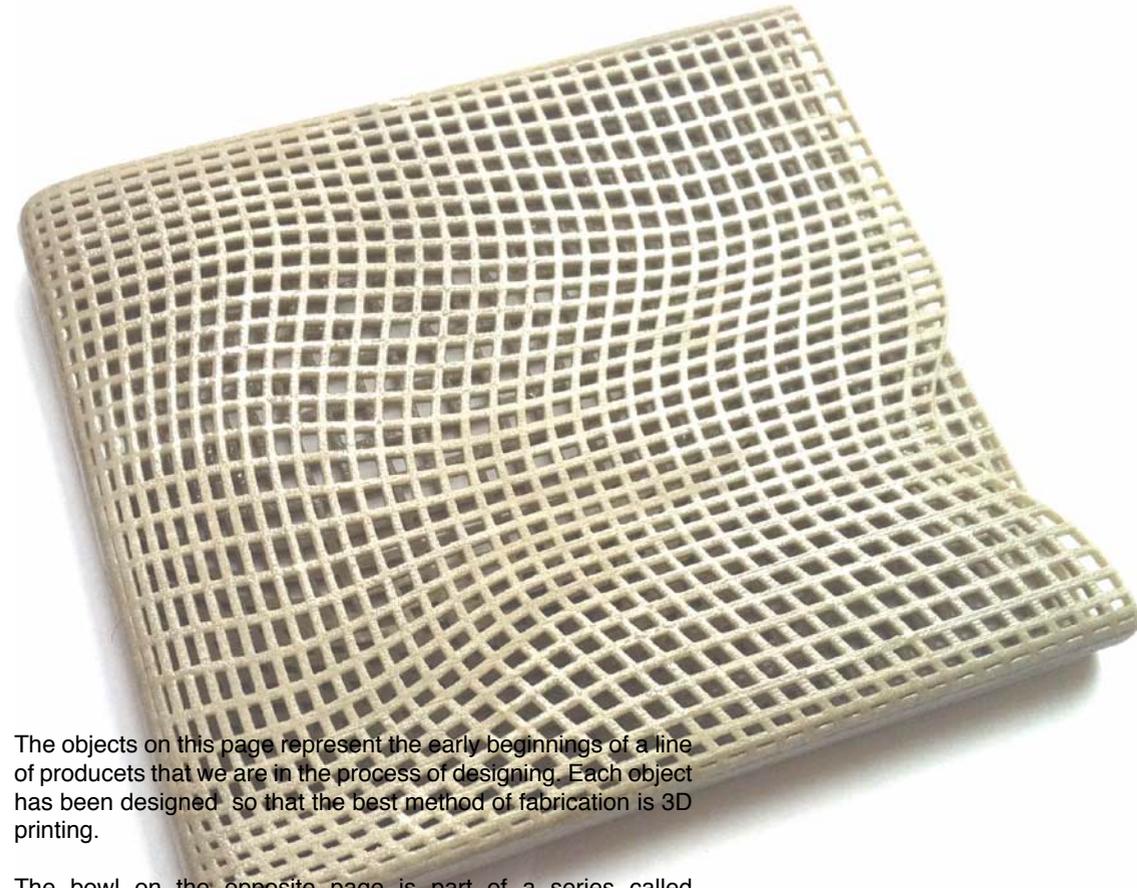
TOPO TABLE



## 3D PRINTED PRODUCTS

Project Date: 2011

Project Team: Virginia San Fratello, Emily Licht



The objects on this page represent the early beginnings of a line of products that we are in the process of designing. Each object has been designed so that the best method of fabrication is 3D printing.

The bowl on the opposite page is part of a series called bevelware - which is a series of dishes, plates and other tabletop accessories made by using the digital technique of beveling.

The two bowls shown in the upper right hand corner of this page are based on the illustrations of Ernest Haeckel. These fruit bowls are delicate fillagree structures printed out of concrete but could also be printed out of nylon, metal or glass.



## PRADA MARFA

Project Date: 2008

Project Team: Ronald Rael, Virginia San Fratello

On July 13, 2005, 22 miles north of the U.S./Mexico border, patrol agents from the Marfa Sector of the United States Border Patrol surrounded five people traveling through the Chihuahuah Desert in West Texas. Suspecting illegal activity, the agents had been informed that illegal immigrants were detected by the tethered aerostat radar system hovering overhead that provides counter-narcotics and border crossing surveillance and can distinguish targets down to a meter across at ground level.

It is not uncommon that coyotes, smugglers involved in the profession of human trafficking, drive the desolate roads searching for “wets”, the derogatory term for illegal immigrants, in the vast desert expanse surrounding Marfa. When the five suspects were questioned on the nature of their business the answer was not so clearly comprehended by the Border Patrol. The suspects were a gallery curator, a photographer, an artist, and two architects who were discussing the selection of the future building site of Prada Marfa, a minimalist sculpture that replicates the luxury boutique where the Fall 2005 line of Prada shoes and bags were to be displayed.

The juxtapositions between the United States and Mexico, or between wealth and poverty, that are clearly evident in the Big Bend region of Texas define a landscape charged with contrasting conditions in which Prada Marfa is built. The immense ranches that comprise the area, each several thousand acres or larger, often appear to be abandoned, but are owned by many of the wealthiest people in the United States. Most of the ranch owners have ties to oil, and more recently, dot com wealth, including a ranch owned by Amazon.com CEO and founder Jeff Bezos, where he has announced plans to construct a spaceport just down the road from Prada Marfa. Just as each of these polarities are somehow equally at home and “foreign” to this environment,

so to is Prada Marfa, with its delicate interiors and massive walls, schizophrenically positioned in the geo-political and cultural framework in which it is built. In fact, the process of building the project is as simultaneously contextually grounded and extrinsic as the work itself.

The primary building material used to construct Prada Marfa is dirt. While it may seem odd to construct a building with soil, particularly one with the associated title Prada, building with earth is actually quite common. It is estimated that currently 1/2 of the world’s population, more than 3 billion people on 6 continents, lives, works, or worships in buildings constructed of raw earth. This makes fragmental soil, not to be confused with other materials that come from the ground, such as stone, cement, or metals derived from ore, the most ubiquitous building material on the planet. Earth buildings can also be found in almost every climatic zone on the planet, from the deserts of Africa, Australia and the Americas to England, Denmark, China and the Himalayas.

Whereas earth is a material that westerners commonly perceive to be reserved for the small, humble structures of developing countries, there are earth buildings of almost every architectural type in use by every economic and social class. Examples of churches, hospitals, museums, embassies, and even an airport demonstrate the wealth of earth building types found throughout the world. Typically, earth is also considered to be a building material only used in rural environments, but earth architecture can be found just as easily in contemporary urban environments. The world’s first skyscrapers, 11 story buildings first constructed over 500 years ago, continue to be constructed entirely from mud in the dense cities of Yemen. Perceived as a material of low quality, earth buildings also represent the oldest extant buildings

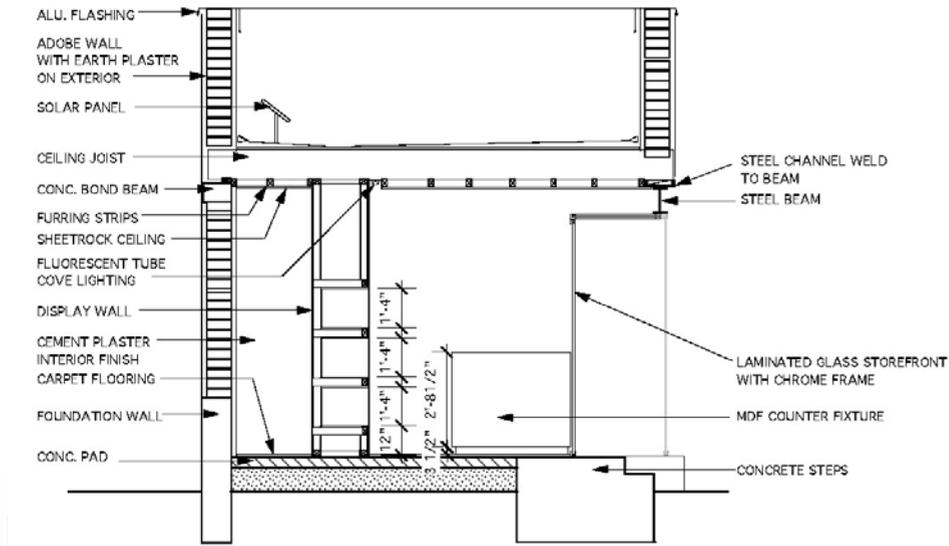


## PRADA MARFA

on the planet. Using approximately 7,000,000 mud bricks, the Ziggurat at Ur dates back to 4000 B.C. Taos Pueblo constructed between 1000 and 1450 A.D., in New Mexico is the oldest continuously occupied dwelling in North America and was also constructed from raw earth.

While earthen architecture is often considered the building material of the very poor, many wealthy residents inhabit the vast mud brick suburbs of Santa Fe, New Mexico. Ronald Reagan's former Ranch House (also known as "The Western White House") in California, Saddam Hussein's childhood home in Iraq, and Chairman Mao's childhood home in China were all constructed of mud brick, which speaks to the great breadth of ideological extremes represented by this omnipresent material. Now we can add Prada Marfa to this "A-List" of earthen architecture – the first Prada related building constructed of mud.

A large percentage of buildings in the region surrounding Prada Marfa, are also traditionally constructed of mud brick. Often made directly from soil excavated from the build site, mud brick, called adobe in Texas, is a brick made from soil mixed with water and straw and left to dry and harden in the sun. Historically, this was the traditional construction method used by the Mexican and Mexican American population. In the case of Prada Marfa, the 2,500 mud bricks used to construct the building were made by machine and express shipped to the site from a mud brick yard in Alcalde, New Mexico, over 500 miles away. Not unlike the luxury goods that fill the faux-boutique, the mud bricks arriving from this adobe yard are primarily manufactured to supply a growing population of southwestern affluence enamored with the romantic notion of living in a house constructed of earth. Increasingly, the demands made by wealthy interstate immigrants longing for mud brick residences have had a dramatic effect on the cultural and built landscape.



## PRADA MARFA

At one time, buildings made of earth were looked down upon, and ultimately made illegal to construct for several decades. Today, however, mud brick's increasing popularity has created a demand for the material that has transformed it into a status symbol in the southwestern United States. The humble earthen houses that comprise Marfa's residential district now fetch several hundred thousand dollars from New Yorkers, Houstonians and Los Angelenos. Thus, what was once a vernacular tradition has transformed into a capitalist driven process that often leaves the traditional descendants of earth dwellers unable to afford mud, forcing them to switch to an ironically more affordable consumption of prefabricated mobile homes and concrete-block houses. Much like the knockoffs of Prada bags that are a consequence of the high price tag of authentic Prada merchandise, adobe knockoffs, faux-adobes, are the preferred style of manufactured southwestern homes.

Unlike traditional mud brick buildings, whose bricks are laid in an earthen mortar, the mud bricks used to build Prada Marfa were set in a cement mortar. The juxtaposition between the industrial material of cement and the traditional mud brick could be read as a nod to Donald Judd, but the combination also represents the bipolar nature of the context in which it is built. In Marfa the use of industrially produced cement, introduced by the U.S. military

— each leaving built traces in the landscape that are evident today. By crossing a border between art as commodity and commodity as art, Prada Marfa offers a conceptual interpretation of the latest wave of occupation in the region - Judd and the gentry of gallery owners, artists and art lovers who are his followers. It also raises questions regarding the consequences of this history.

While Prada Marfa was not constructed with illegal labor, mud brick construction is labor intensive and labor provided by illegal aliens is cheap. The demand for inexpensive labor in America coupled with a search by immigrants for higher paying jobs work hand in hand to prompt people to cross the desert by foot. Although it is difficult to know exactly how many immigrants cross the border in the Marfa sector each year, in 2005 there were

10,536 illegal border-crossing apprehensions and approximately 12 migrant border-crossing deaths. Most of these deaths are attributed to heat stroke or hypothermia. From a distance, illegal aliens walking through the desert at night might perceive the illuminated building to be a possible source of water or shelter. However, upon closer inspection, Prada Marfa reveals an irony that connects the history of the region while also offering a prognostication. It is not uncommon for one's shoes to wear out during the arduous journey across the desert. In a desperate attempt to protect tired feet from the rough terrain, immigrants are known to try to fashion shoes from the only material available — the yucca plants that dot the landscape. The contrastingly opulent presentation of meticulously organized shoes and bags housed within the familiarity of mud brick walls also foretells the future — a growing socio-economic polarity at a local and, indeed, global level. — From the essay "House of Prada / House of Mud", Prada Marfa Catalog, Ronald Rael

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## HOMELESS HOUSE

“This project reinforced something for us as architects,” said Rael, a professor at U.C. Berkeley. “Our designs can send a social and political message, which is often hard to deliver. Clients don’t hire you to make social commentary, but we had the chance to express that through our work.” Inspired by a mosque made entirely of cardboard that Rael and San Fratello discovered in a Yemenite refugee camp a few years ago, the “Sukkah of the Signs” boasted roughly 280 signs, covering a 10-foot wooden structure of lumber pieces. The signs came from throughout the Bay Area, mostly in San Francisco. Rael and San Fratello drove down Van Ness, stopped at freeway exits and wandered through the Haight District. Sign bearers led them to others in Golden Gate Park. Rael even put an ad on Craigslist to get more.

“You see these guys on the streets all the time brandishing these signs,” Rael said. “We thought they were amazing and beautiful works of art.” Convincing the homeless of that took some time. Rael remembered how awkward it was initially approaching their subjects to ask for their signs — in many cases, it was all they had. He gradually learned that listening to their stories, coupled with an offer to buy the sign for a couple bucks, usually translated to success. Rael met people of all ages, races and religious backgrounds. They clutched signs that were humorous, serious, thought provoking and strange. One woman held a sign that said: “Need money for a new pair of shoes.” She didn’t have legs.

He approached people who couldn’t talk or write, grasping signs that made no sense as an act of desperation. In the bowels of



Examples of signs collected from San Francisco, Oakland, San Jose, San Diego, Los Angeles, Venice, Las Vegas and Denver



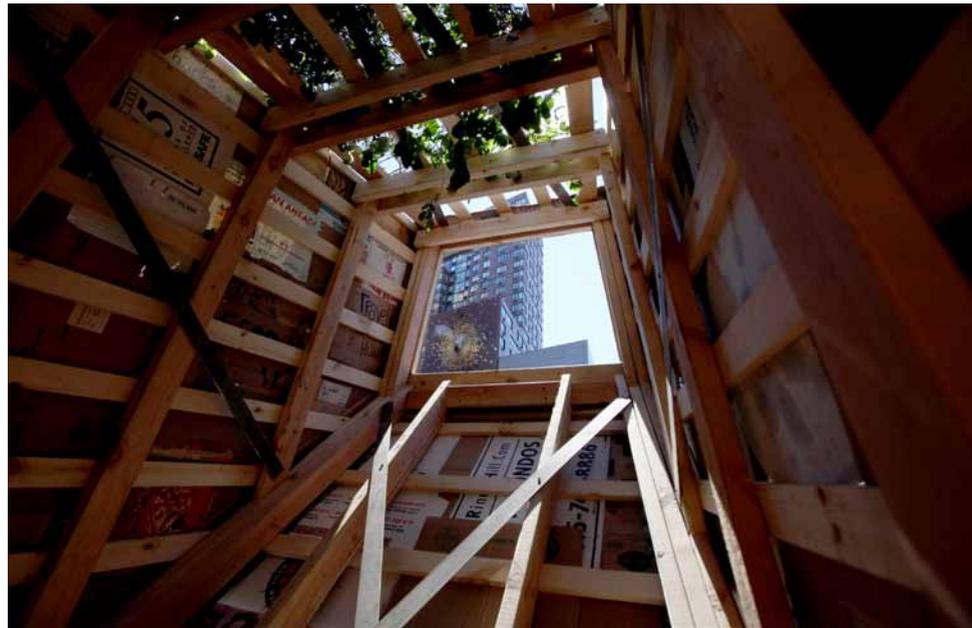
Above: People who contributed their sign to the project  
Below: Homeless man in Union Square Park in front of Sukkah of the Signs

## HOMELESS HOUSE

Golden Gate Park, he talked to individuals who lost their jobs and couldn't make rent, stuck in a vicious cycle they could not escape. "I was already empathetic toward people on the streets," Rael said. "To a greater extent, I understand the reasons of why they are there. Some accuse [the homeless] of being lazy or wanting to be on the streets, but so many have no choice."

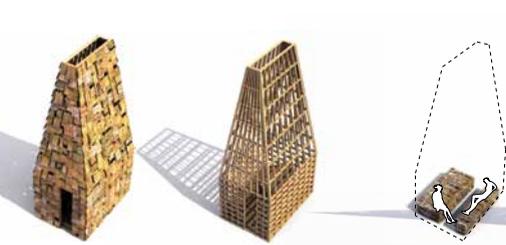
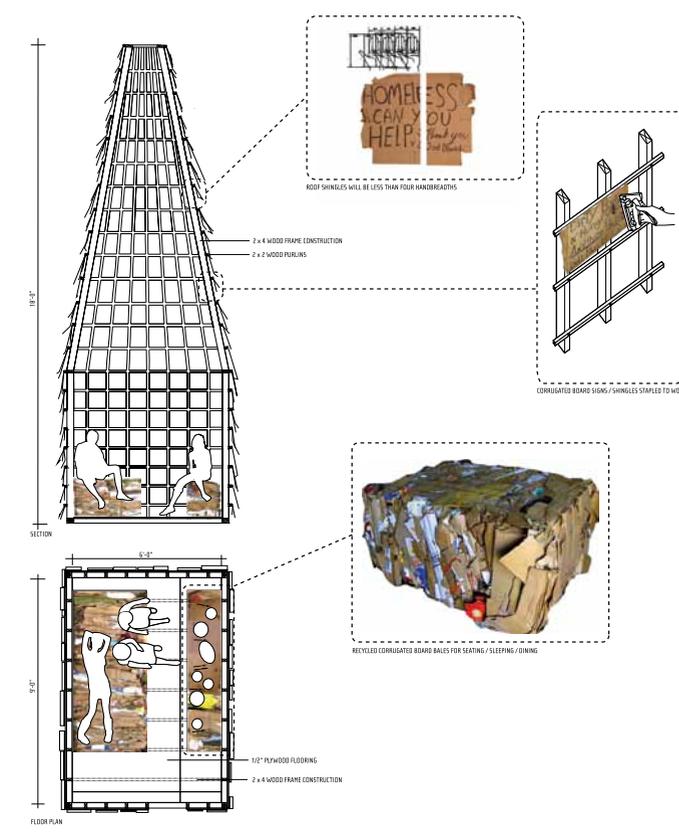
Creating the "Sukkah of the Signs" inspired Rael and San Fratello to start the Homeless House Project, whose aim is to bring attention to homelessness in America. Rael hopes to publish a book with images of the signs used in the sukkah. "When we learned about the concept of the sukkah, it was a nice way to think about the contemporary issues of homelessness in the U.S. and the interesting stigmas that arise," Rael said. "In a sense we were waiting for a project like Sukkah City. We had the signs and it was a good opportunity to marry the two projects."

Erected for one week each fall during the festival of Sukkot, the sukkah is traditionally a space for sharing meals, entertaining, sleeping and rejoicing. Its construction must adhere to precise parameters: the structure must be temporary, have at least two and a half walls, be big enough to fit a table, and have a roof made of shade-providing organic material through which one can gaze at the stars. "We've inherited this tradition of sukkah building, but very few of us know the real rules or even build them anymore," said Reboot Executive Director Lou Cove. "For those who do it's very nice, but it's not a widely shared creative enterprise. The idea of making the sukkah an architectural piece was a way of reinvigorating that tradition." While the sukkah's religious function is to commemorate the temporary structures



### CONCEPT:

Just as the sukkah commemorates shelter provided during the forty desert-wandering years of Exodus, the design for our sukkah brings attention to the contemporary state of homelessness and wandering within the United States and is clad with signs made by the homeless and destitute. By purchasing homeless signs, from the individuals who made them, we are also contributing to the need for someone who might not otherwise be able to eat today in honor of the primary and traditional role of sukkah, which is a feast of bounty, of hospitality, and of welcoming strangers. Additionally, the corrugated board shingles are made of the fibers of hand-cut trees, therefore one could equate them to the historical use of branches on the sukkah roofs. The frame of our sukkah tapers as it moves up toward the sky to draw the eye up and also to provide a smaller framework for the shingles that are less than 4 handbreadths—relating directly to the presence and scale of the hand-made signs. This sukkah, if built for Sukkah City, will be auctioned and the funds donated to a homeless shelter in New York City.



### STATISTICS:

—It is estimated that between 40% and 50% of homeless single adults residing in the municipal shelter system have a chronic mental illness.  
 —Approximately 90% of homeless New Yorkers are black or Latino, although only 53% percent of New York City's total population is black or Latino.  
 —Almost 17% of residents of the single adult shelter system are employed.  
 Coalition for the Homeless, Updated May 2002  
 Hunger Action Network of NYC, 1999  
 NY Coalition Against Hunger, 1998  
<http://www.nyc.gov/stats/nyshelter.htm>

—Each year 100,000 New Yorkers experience homelessness.  
 —Each night, over 38,000 homeless individuals sleep in the New York City shelter system. This includes more than 16,000 children and 8,000 single adults.  
 —Nearly 1-in-20 New York City residents have experienced homelessness.  
 —There are over 1,000 soup kitchens & food pantries in NYC and 2,700 in NY State serving 2 million New Yorkers annually. They will serve 60 million meals this year to hungry men, women & children.  
 —Families make up 70% of New York City's homeless shelter population.  
 —More than one-in-four children in NYC live in poverty. A typical homeless child is under 5 years old.  
 —Over half of homeless mothers in New York City have a history of domestic violence.  
 —Nearly one-in-five homeless parents were in foster care as a child.

### WHO IS HOMELESS RIGHT NOW?

Daily Census for July 29, 2010  
 —8,087 Families With Children  
 —1,310 Adult Families  
 —7,376 Single Adults  
 —35,148 Total Individuals are homeless in NYC today  
<http://www.nyc.gov/html/ohs/html/home/home.shtml>



## HOMELESS HOUSE

in which the Israelites dwelled during their exodus from Egypt, it is also a symbol of the transience of life as expressed in architecture.

Contestants did not have to be Jewish. The teams behind the 12 finalists received guidance from Judaic experts on how to craft a kosher sukkah. Neither Rael nor San Fratello are Jewish, but that didn't matter. "At this point, I think I'm much more familiar with the rules of constructing a sukkah than a lot of Jews," Rael said with a laugh. "Learning about lesser-known traditions of Judaism was really interesting." From dawn until dusk Sept. 19 to 20, nearly 200,000 passers-by wandered through Sukkah City in Union Square Park to marvel the sukkahs. "It turns out that architects viewed Jewish law in a way we could not anticipate," Foer said. "Working with the design constraints handed down for thousands of years was inspiring. They immediately understood how many levels of residence there are in the sukkah — what it means to be impermanent or homeless, to the role it plays in reconnecting Jews with their agricultural past. "All that is bound up with esoteric rules, some of which are playful," he continued, noting that a sukkah may be built out of an elephant's skeleton but no other animal's. "If that's not an invitation to do something weird, then I don't know what is."

*Excerpted from the article, "A booth with a view: Oakland architects build sukkah using signs from the homeless" by Amanda Pazornik. J! Weekly, Thursday, September 23, 2010.*

Photo: Nate Levy  
Sukkah City, NY



## HYDRO HOUSE

Project Date: 2009

Project Team: Virginia San Fratello

The Hydro House is a design proposal for a house that will collect water to use as a thermal mass and for evaporative cooling. The Hydro House has a roof pond, which contributes to thermal comfort in desert environments. Additionally, as water runs off the roof it is collected in the Hydro Walls that enclose the house. The walls store the water and take advantage of the flywheel effect to help keep the interior climate controlled. There is also an evaporative pond in the courtyard of the house that will help keep the house cool in the summer. Small perforation in the outer skin allow breezes to enter the courtyard and operable glass doors allow the cool evaporating drops of moisture to enter the house. An operable skylight at the opposite end of the house will act as a chimney pulling the cool air through the interior.

Hydro House  
in desert landscape



## HYDRO HOUSE



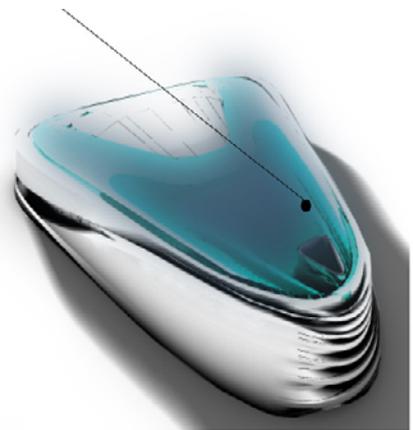
Hydro walls collect water in their interior; however, they also have multiple ridges on their exterior surface that can be planters. The planters also increase the cooled surface area of the building by shading the wall itself and protecting it from solar radiation. Water may sit in the ripples on the surface of the wall to contribute to evaporative cooling of the micro climate surrounding the house.



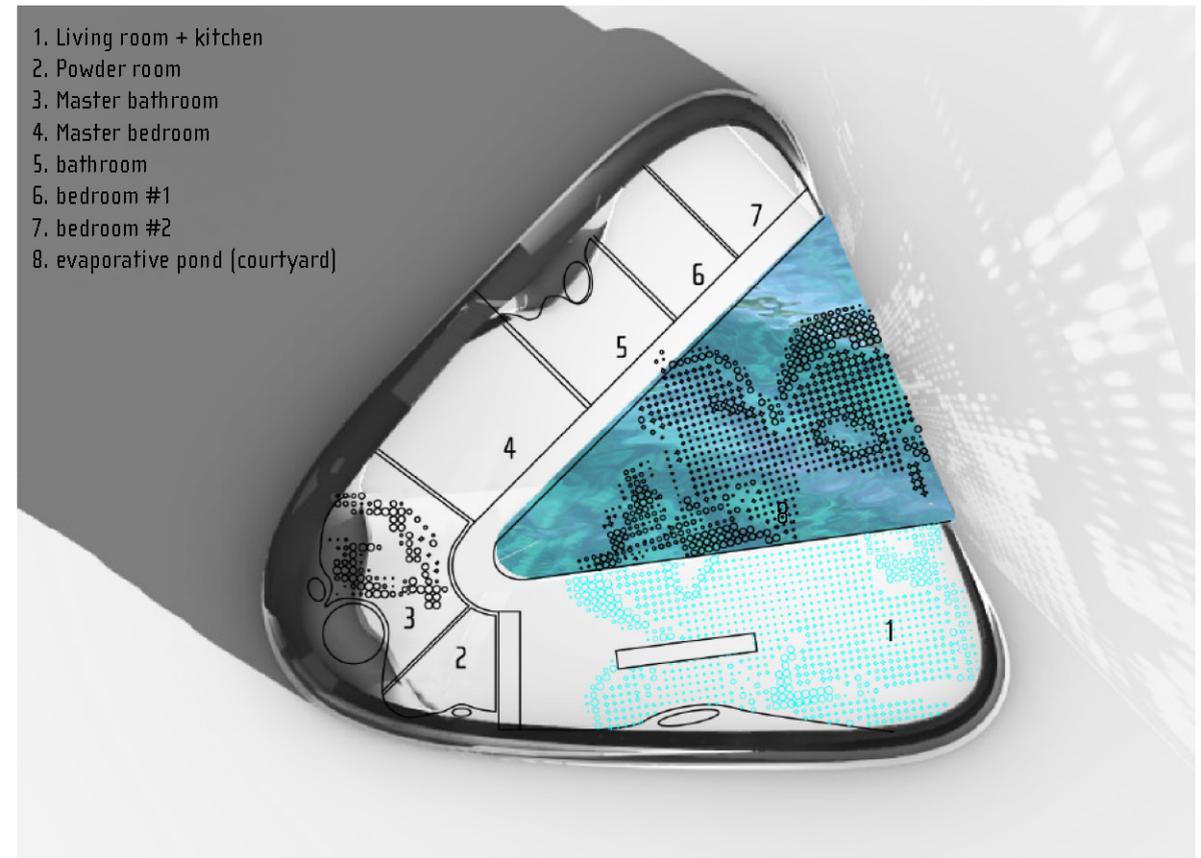
A ramp on the side of the house permits access to the cooling pond on the roof of the house. The ramp is embedded in the thick walls that hold the stored water.



The roof is higher over the courtyard allowing for more air movement within the courtyard to occur; the roof dips down over the house enclosure to allow more water to pond on the roof.

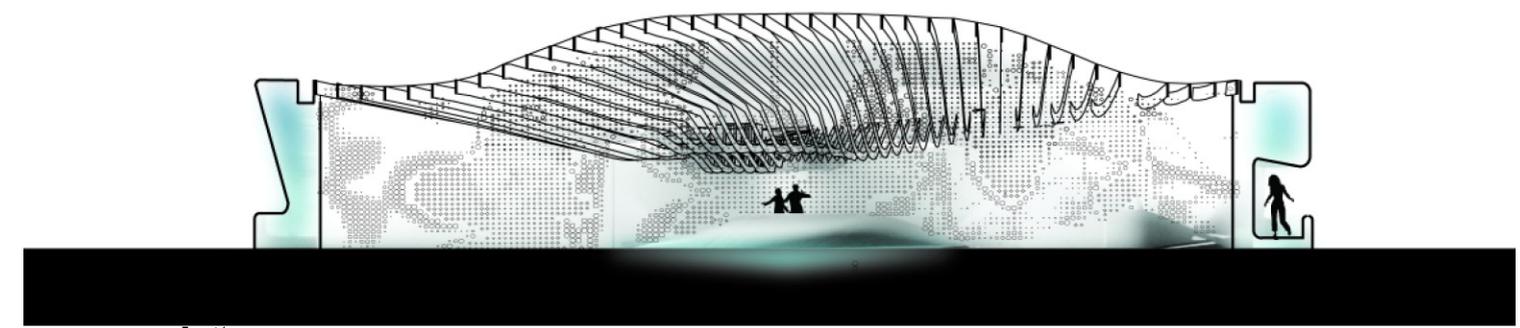


A ramp on the side of the house permits access to the cooling pond on the roof of the house. The ramp is embedded in the thick walls that hold the stored water.



- 1. Living room + kitchen
- 2. Powder room
- 3. Master bathroom
- 4. Master bedroom
- 5. bathroom
- 6. bedroom #1
- 7. bedroom #2
- 8. evaporative pond (courtyard)

Floor Plan

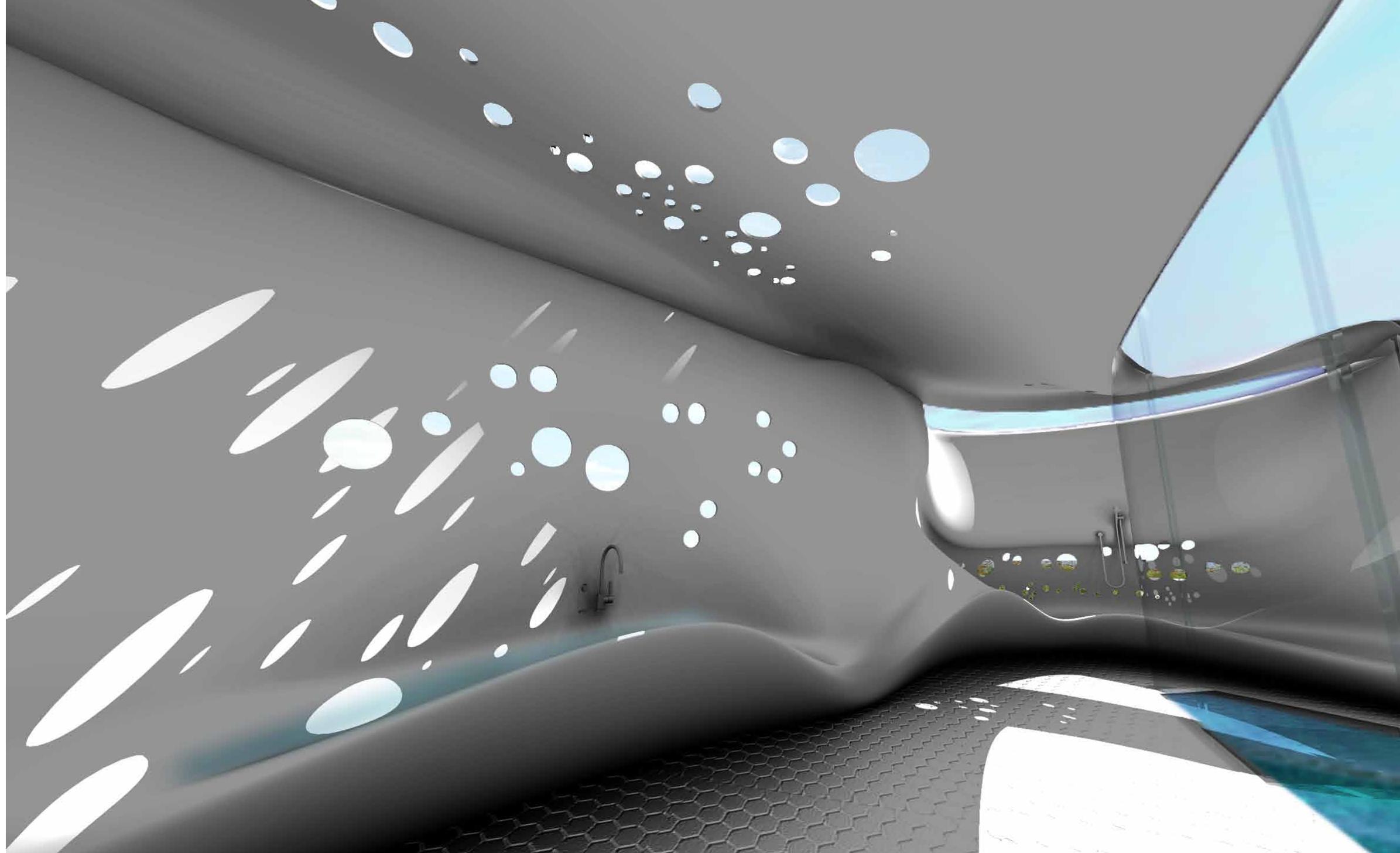


Section

HYDRO HOUSE

The tub and lavatory are part of the Hydro Wall. Apertures in the wall and ceiling allow natural light into the interior from the sky and south. In the lower right hand corner is the evaporative cooling

bathroom interior



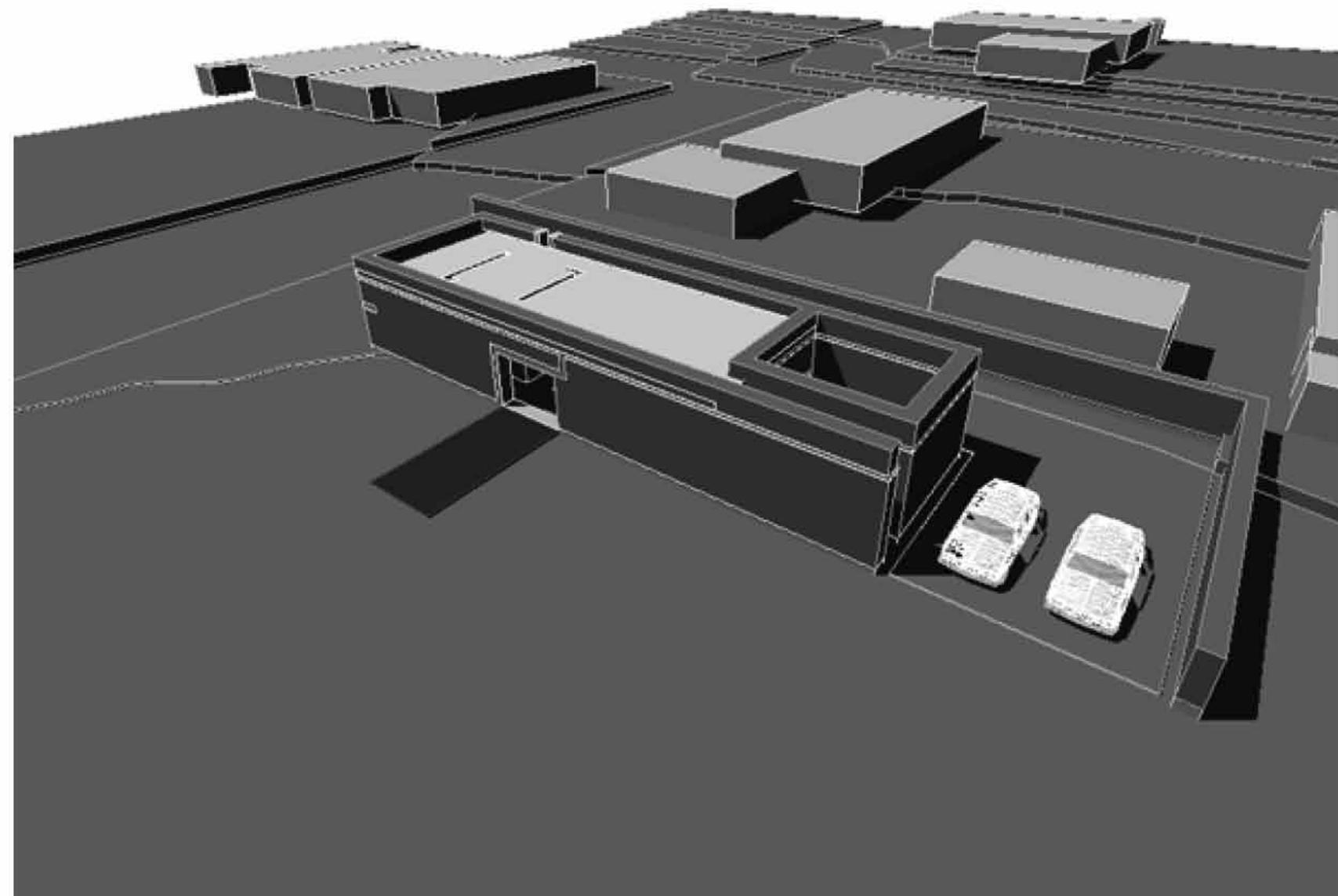
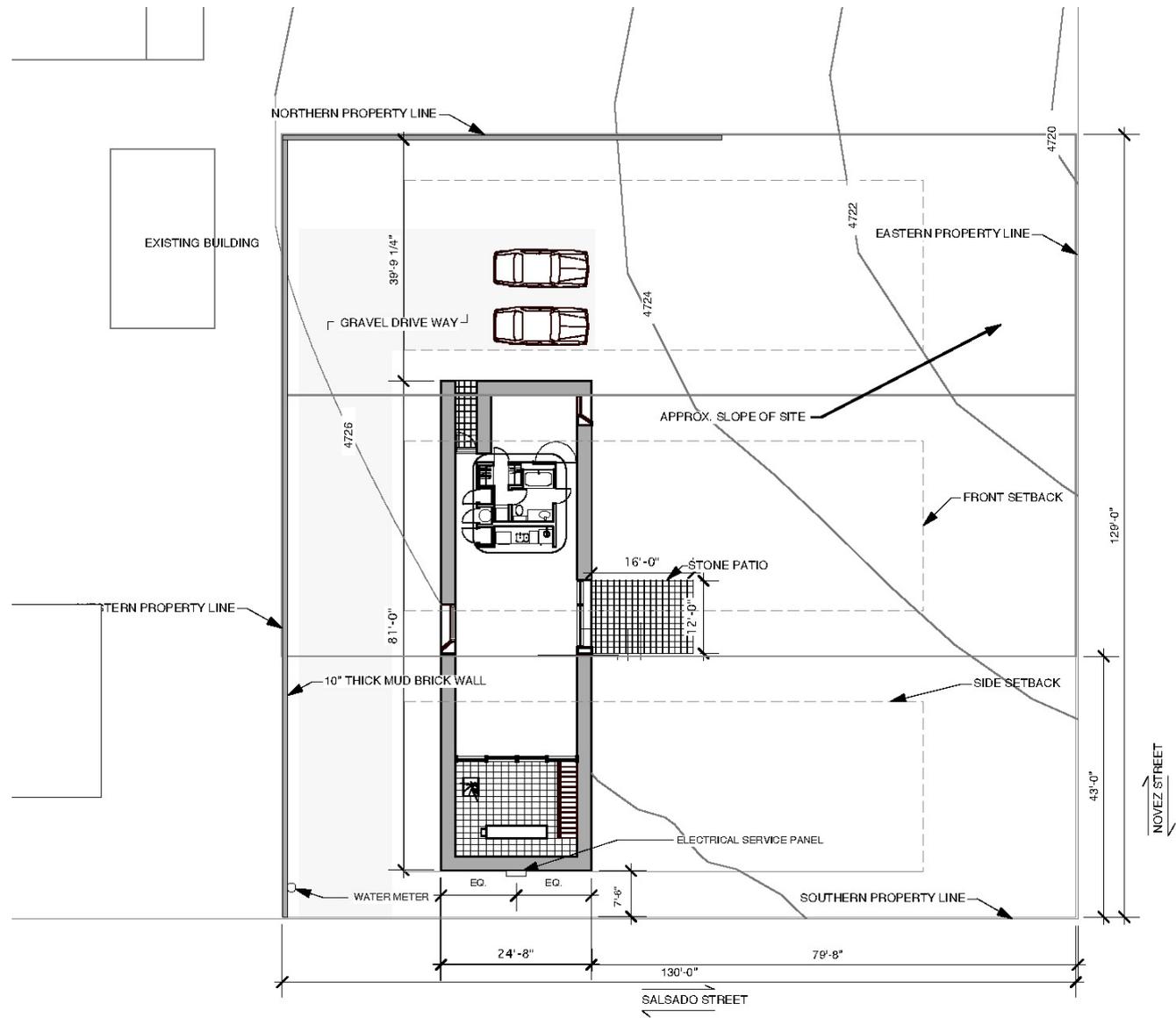
## BOX BOX HOUSE

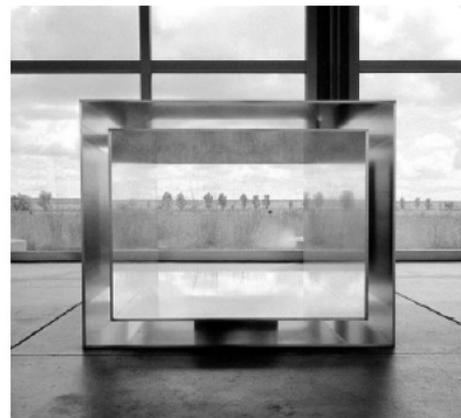
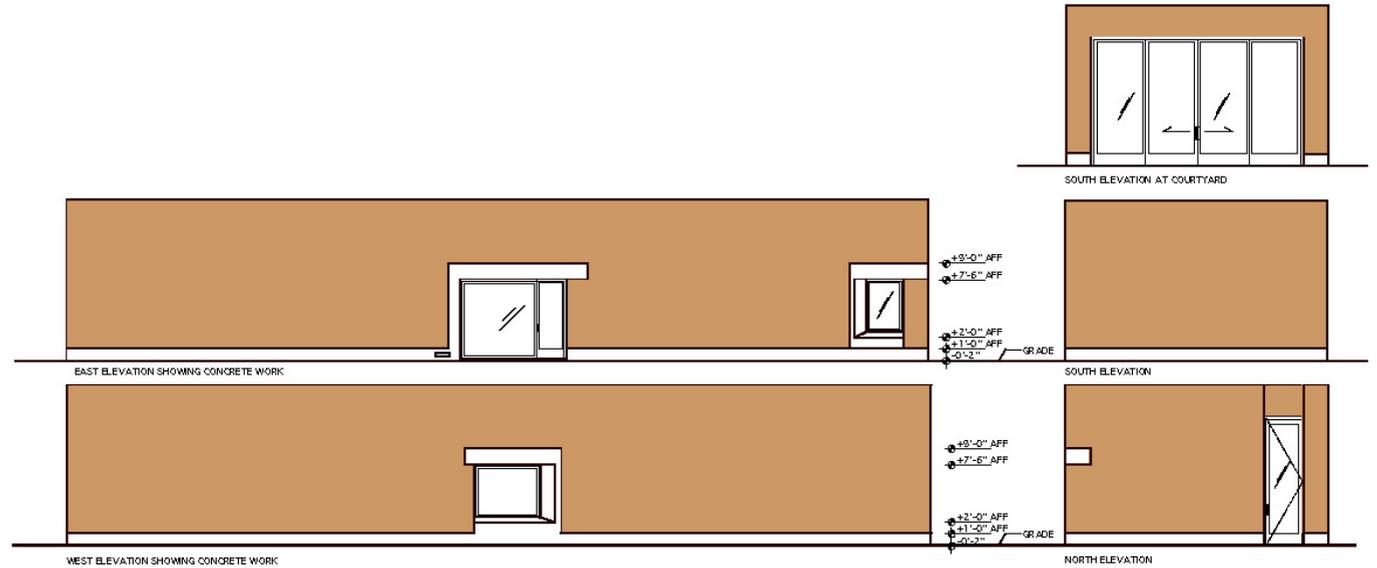
Project Date: 2008

Project Team: Ronald Rael, Virginia San Fratello,  
Jeremy Chinnis, Natalie Gambill

The Box Box House is currently under construction in Marfa, TX, a town invested in a culture of art and architecture as influenced by the late artist Donald Judd, and situated in the West Texas desert landscape. Ocotillo, mesquite, yucca and sotol serve as the backdrop and the view of the landscape from the house extends out to the Davis Mountains in the distance. The name of the house comes from the fact that it is a large, earthen box that inside contains a smaller box that houses the major utilities of the house (kitchen, bathrooms, storage, boiler, etc). The contrast between the thick, earthen walls and the concrete lintels that interpenetrate the facades to create openings, as well as the use of stainless steel in contrast with the earth, create a tension between old and new, rough and smooth, industrial and non-industrial. Inside, a large courtyard opens to the interior and to the sky.



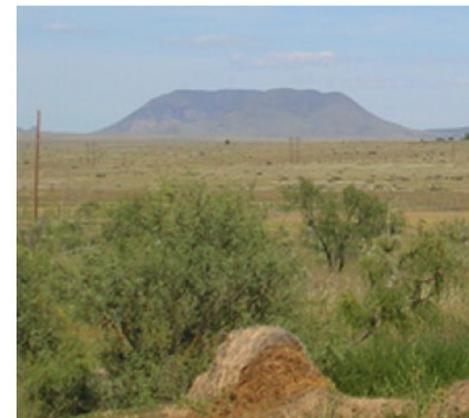




Donald Judd aluminum box



Interior perspective of aluminum inner box and ceiling that reflect the desert landscape and changing day light.



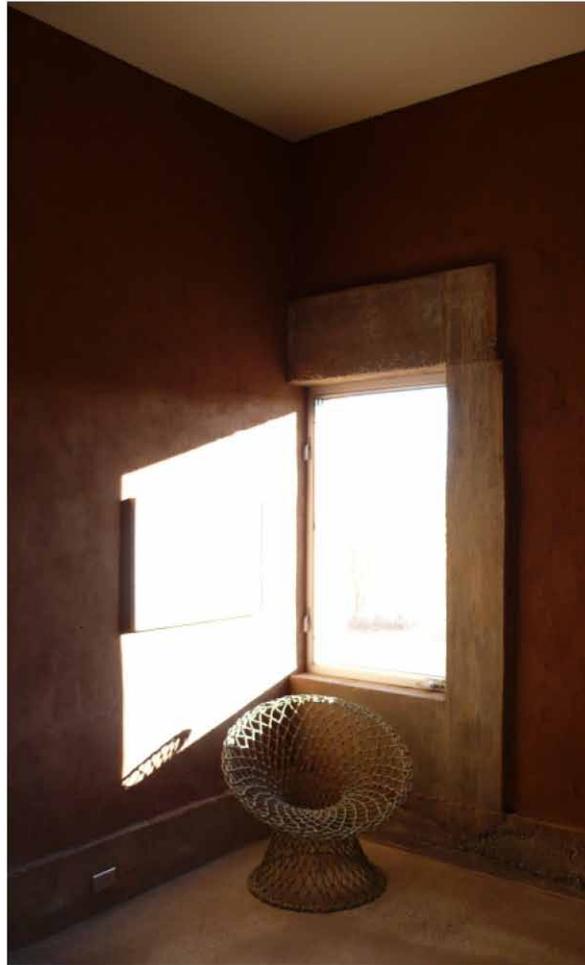
View of haystack mountain from big window

BOX BOX HOUSE



concrete lintel around window  
and stainless steel and glass kitchen

BOX BOX HOUSE



Marcel Wanders chair in bedroom



concrete lintel above bedroom window



roof drain



## CLOUD HOUSE

Project Date: 2010

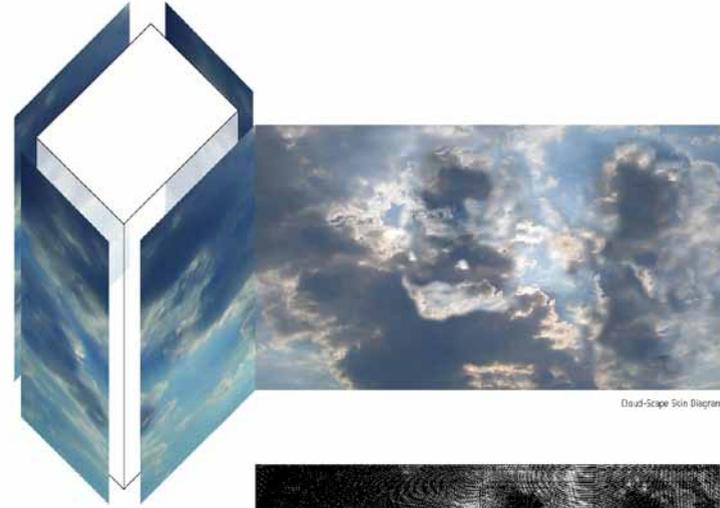
Project Team: Ronald Rael, Virginia San Fratello

The Cloud House is currently in schematic design for a site in Marfa, TX, a town invested in a culture of art and architecture as influenced by the late artist Donald Judd, and situated in the West Texas desert landscape. The West Texas sky is big. The Cloud house is a guest house that responds to the ever changing quality of light shaped by the high desert clouds. The house is a simple box, in the spirit of Judd, the walls of which are perforated to mimic the pattern of the clouds in the big Texas sky. In contrast to the low, long and horizontal box house, which is made of mud, the house is a vertical three story tower house that reaches towards the sky and the views beyond. The walls are a cloud -scape that has been digitally manipulated to correspond to a specific set of views and lighting conditions throughout the day. The patterns for the facade panels are cut from a 100% recycled material that are more porous at the top floor to facilitate air movement. The perforation in the skin buffers the light, creating dynamic patterns of shadow across the interior surfaces during the day and across the landscape at night.

exterior perspective of cloud house



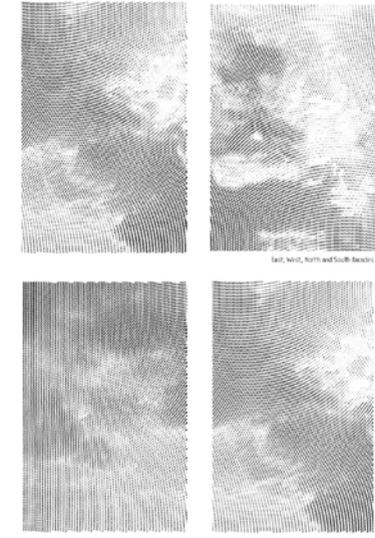
CLOUD HOUSE



Day-Scpce Skin Diagram



Perforated Skin Diagram showing openings in facade

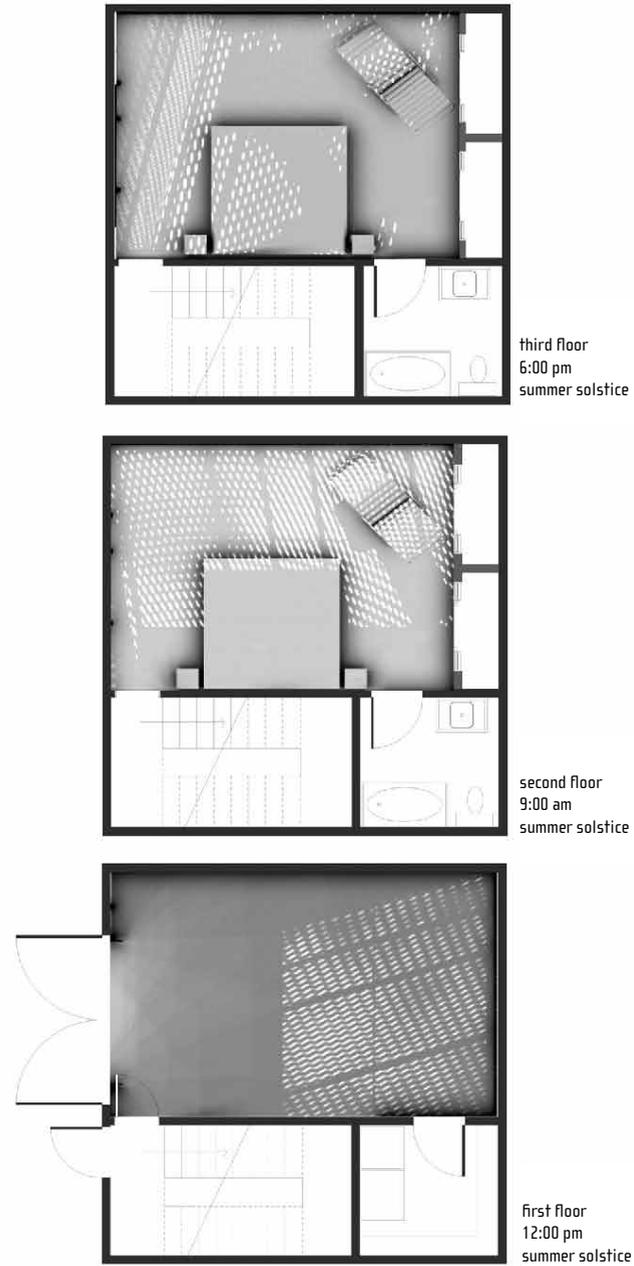


East, West, North and South Facades



Section through hidden garden that draws cool air up through the house

CLOUD HOUSE



## BORDERWALL AS ARCHITECTURE: A Proactive Manifesto of the U.S./Mexico Barrier

Project Date: 2009

Project Team: Ronald Rael, Virginia San Fratello, Brian Grieb, Nicholas Karklins, Emily Licht, Plamena Milusheva, Colleen Paz, Molly Reichert

*“But when one draws a boundary it may be for various kinds of reasons. If I surround an area with a fence or a line or otherwise, the purpose may be to prevent someone from getting in or out; but may also be part of a game and the players be supposed, say, to jump over the boundary; or it may show where the property of one man ends and that of another begins; and so on. So if I draw a boundary line that is not yet to say what I am drawing it for.”—Wittgenstein*

By some measures, the U.S. Secure Fence Act of 2006 funded the single largest and most expensive building project in the United States of the 21st Century. It finances approximately 800 miles of fortification dividing the U.S. from Mexico that can cost up to \$16 million dollars per mile. Known as the Mexico - United States Barrier, the Great Wall of Mexico, Border Fence and Border Wall, the construction of this wall has transformed the large cities, small towns, and the multitude of cultural and ecological biomes along its path. It is a utopian scenario, engineered for a conceptual tabula rasa defined by Department of Homeland Security Secretary Michael Chertoff who was given unprecedented powers by President George Bush to waive any and all laws in order to expedite the wall’s construction. Ignoring the rich and diverse contexts found along the border not only raises critical questions of ecology, politics, economics, archaeology, urbanism and eminent domain (to name a few), it also radically redefines and transforms the territories of the frontera.

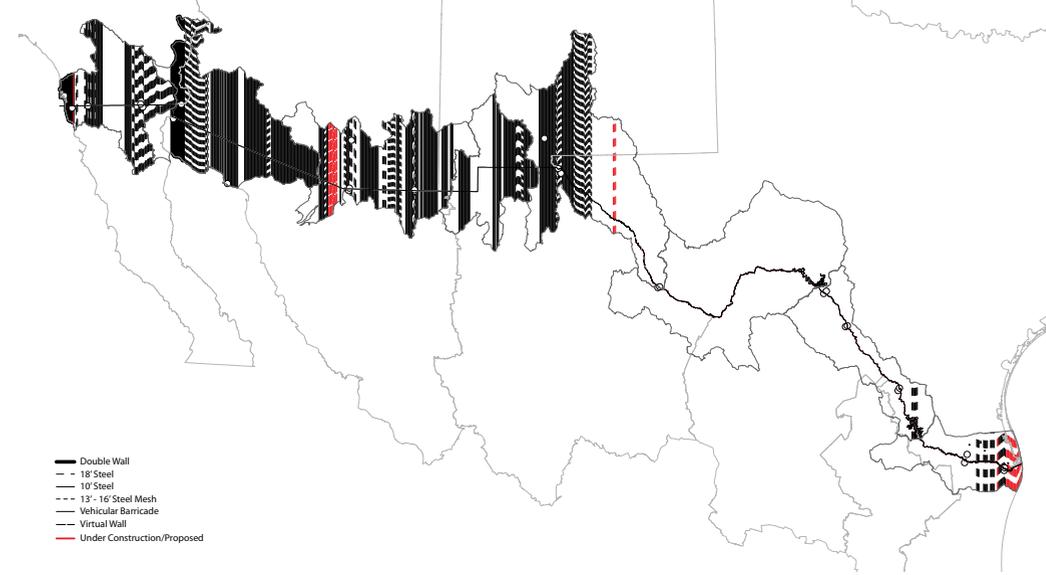
In many locations the wall is fabricated of steel, wire mesh, concrete, even re-purposed Vietnam-era Air Force landing strips. Elsewhere, it makes use of high-tech surveillance systems—

aerostat blimps, subterranean probes and heat sensors. In all cases, the concept of “national security” governs and militates construction and design of the wall, and the success of the wall has been measured in the numbers of intercepted illegal crossings. Border Wall as Architecture suggests that the wall, at such prices, should and could be thought of not only as security, but also as productive infrastructure—as the very backbone of a borderland economy. Indeed, coupling the wall with viable infrastructure—and this proposal focuses on water, renewable energy, and urban social infrastructure—is a pathway to security and safety in border communities and the nations beyond them. Border Wall as Architecture is a proposition for a wide array of retrofits and new schemes for the U.S./ Mexico border wall that builds on existing conditions and seeks to ameliorate current problems created by the physical divider.

Over 700 miles of barriers have been constructed since 2006, at the cost of \$3.4 billion. Additionally, the new wall has been breached over 3000 times, incurring \$4.4 million in repairs. The construction and maintenance costs are estimated to exceed \$49 billion over the next twenty-five years—and there are several hundred more miles of wall construction recently proposed.



## BORDERWALL AS ARCHITECTURE



Recent statistics do show a 50 percent drop over the past two years in the number of people caught illegally entering the United States from Mexico. However, human rights groups put the number of deaths during attempted crossings at its highest, since 2006 and almost 6,000 deaths have occurred since 1994. It might also be noted that 30 laws were waived or suspended for the construction of the wall, including important environmental, wildlife and Native American heritage protections.

*was not considered free...[and that]...the Wall was not really a single object but a system that consisted partly of things that were destroyed on the site of the Wall, sections of buildings that were still standing and absorbed or incorporated into the Wall, and additional walls some really massive and modern, others more ephemeral all together contributing to an enormous zone. That was one of the most exciting things: it was one wall that always assumed a different condition."*

For the most part, architects and designers have stayed away from the border security issue. Ricardo Scofidio of Diller Scofidio + Renfro in New York said about architect's involvement in a border fence project: "It's a silly thing to design, a conundrum. You might as well leave it to security and engineers." Architect Rem Koolhaas had great interest in the related topic of the Berlin Wall and said of his studies of the wall:

*"I had hardly imagined how West Berlin was actually imprisoned by the Wall. I had never really thought about that condition, and the paradox that even though it was surrounded by a wall, West Berlin was called "free", and that the much larger area beyond the Wall*

There is a similar exciting potential occurring on both sides of the U.S./Mexico wall, but at a much larger scale. In many places, the border wall is constructed as much as two miles away from the actual territorial border. Currently, the land surrounding the border security infrastructure has lost its productive value. Removed from the market economy, it is essentially fallow. There are approximately 40,000 acres of U.S. land that already do—or are planned to—lie on the Mexican side of the border wall—an area equal to twice the size of Manhattan. It contains rivers, farms, homes, public lands, cultural sites, wildlife reserves and even a university. This land has been isolated from U.S. public access and economically neutralized. To counter this, the



Floating Fence: Calexico, CA



Crosses placed by family members of those who died while attempting to cross



Near Arizona's San Pedro Riparian National Conservation Area

## BORDERWALL AS ARCHITECTURE

security infrastructure must be put to work through contextual engagement and investment. Border Wall as Architecture seeks to create a productive border through site specific but also modular solutions, retrofits and new schemes focused on the following areas: Water infrastructure, Renewable Energy, Social Infrastructure. This proposal will also highlight some of the potential benefits these productive improvements can engender.

The border wall has already proven to be an effective, if accidental water collection system. Water from desert rains typically drain across the border – yet in areas such as the port of entry at Sonoyta, Mexico and Organ Pipe Cactus National Monument and in the Ambos Nogales (Arizona and Sonoma) the fence acts as a dam. It not only attempts to block northern flows of immigrants, but diverts water flows on both sides of the border into nearby cities. If water collection were considered pro-actively along the border, it could be realized on a much larger scale with massive consequences for communities. For example, the city of El Paso levies storm water fees on all residents and businesses based on the amount of impervious surface that is located on a given property. This is then used to pay for a proposed system of storm water catchments to ameliorate the consequences of flooding in the rapidly growing desert city.

El Paso plans to raise \$650 million for the entire project,

which will distribute storm water catchments throughout the city. Dividing El Paso from Juarez is the large concrete basin defining the location where the Rio Grande/Rio Bravo River once flowed. By locating the catchments along the river, a linear park and riparian ecology could once again flow through the two cities. Locating additional rainwater collection shed roofs along the existing wall can increase the amount of water collected, and also create cool, well shaded places where performances, markets and events could take place. If this resource is then water-banked, it could lead to the eventual re-opening of the river to the city.

Creating a linear water park has important security implications as well. The purpose of wall construction is not to stop the flow of immigrants from the south, but to slow it down. According to the Department of Homeland Security, the wall gives border patrol agents only a few minutes more time to apprehend an illegal crossing. The department also sees rivers as natural obstacles that also offer 5 minutes of added time to border patrol's advantage. A linear water park along the wall that meanders on both sides can create a doubly-secure linear tactical, social, ecological and hydrological infrastructure. Allowing the River to once again flow, triples that security measure.

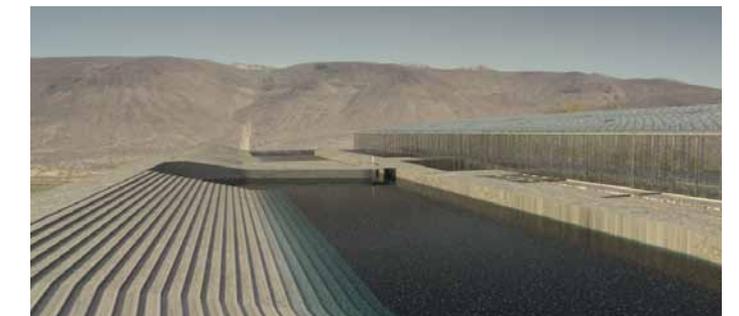
The New River is considered the most polluted river in the United States. It flows north from Mexicali, Mexico, and crosses the border at Calexico, California. New River toxicity



Water Catchment Wall: El Paso, TX

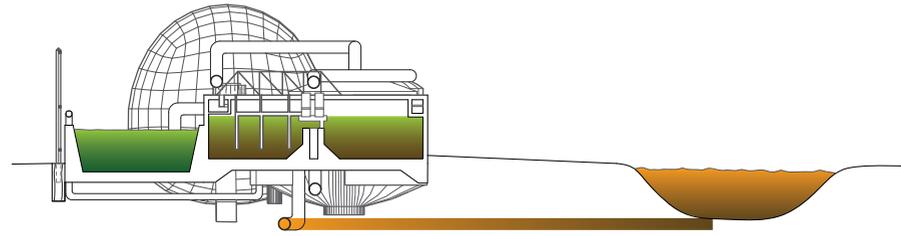


Flooding: Nogales, AZ



Water Catchment Wall: El Paso, TX

## BORDERWALL AS ARCHITECTURE



is comprised of chemical runoff from farm industry, sewage, contaminants—such as volatile organic compounds, heavy metals, pesticides—pathogens like tuberculosis, hepatitis, and cholera—as well as fecal coliform bacteria, which at the border checkpoint far exceed U.S.-Mexico treaty limits. The New River then flows through the Imperial Valley, which is a major source of winter fruits and vegetables, cotton, and grain for both U.S. and international markets. While the Secure Fence Act of 2006 was enacted, according to President Bush, to “help protect the American people” from illegal immigration, drug smuggling and terrorism, the new river represents a far more dangerous flow north from Mexico in need of containment.

A wastewater treatment wall located in the 2-mile long wasteland that buffers the dense border city of Mexicali from the agricultural Eden of the Imperial Valley would offer a solution to the “illegal entry” of toxins to the U.S. The pollution problem is expected to worsen as Mexicali’s population—already at 1.3 million—continues to expand without adequate infrastructure. For \$33 million, the same cost as the wall that divides Calexico and Mexicali, a treatment facility with the capacity to handle 20 million gallons/day of effluent from The New River could be constructed. This proposed facility would be comprised of a linear pond filtration and purification system creating a secure and invaluable border.

The positive by-product of the wastewater treatment facility

includes methane and water. Methane could be used to generate electricity and light streets. The water could be used to irrigate parks. In fact, the combination of methane and water could fuel the needs for a linear urban park connecting the entire city through a series of lighted, green corridors, creating a healthy social infrastructure between these growing border cities.

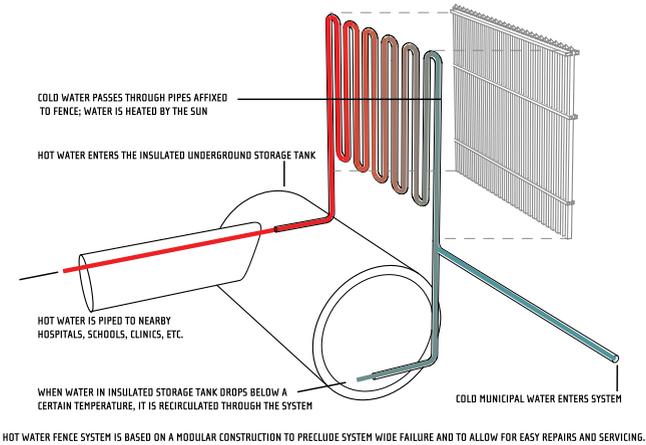
The most untapped potential for solar development in the United States lies along the U.S./Mexico border. Solar farms, in turn, are highly secure installations. What if funds to construct and maintain the border wall were to be re-allocated for the construction of energy infrastructure along the border? This would actually create scenarios in many instances that are more secure than the existing wall, and that simultaneously provide solar energy to the energy hungry cities of the southwest.

Consider the 100-mile stretch of border between Nogales, Arizona and Douglas Arizona where 87 miles of border wall have been constructed at a cost of \$333.5 million. Compare that figure to the cost of the largest solar farm in the world, the Olmedilla Photovoltaic Park in Olmedilla, Spain, which cost \$530 million. For \$333.5 million, 54 miles of profit generating solar farm could have been constructed, 40 feet wide providing 60 Mega Watts of electricity. That is enough for 40,000 households. Electricity is an important bi-national commodity and many border towns share electrical grids where electricity could be sold across the border. Because transmission lines would also be put in place



Calexico, CA Waste Water Treatment Plant

## BORDERWALL AS ARCHITECTURE



along the border, reliable electrical infrastructure would be available for both nations to tap. This has important implications when it is understood that, according to the U.S. Department of Energy, “one square foot of solar energy production along the border can power a dishwasher for 1 year”. Solar energy has important economic implications as it relates to jobs as well. In Germany, a country that is a leader in the new energy economy, the 5.3 Gigawatts of solar farms they have built have generated 10,000 jobs.

There are still further border improvements possible that combine solar heat gain with water issues. In urban environments, the border wall can be coupled with hot water production, creating low-cost additional resources that supplement the infrastructure of rapidly growing border cities. The massive steel walls are enormous heat absorbing agents, and they could easily be retrofitted with panels that produce hot water, which is a much-needed amenity in border cities. The hot water could then be used in markets, clinics, hospitals and schools.

When solar energy is coupled with water collection, it also offers a key component for the establishment of life safety

beacons along the border. The principal cause of death among migrants attempting to cross the border illegally is exposure<sup>14</sup> to the elements, which causes heat stroke and dehydration. Solar generated electricity could power beacons that inform border patrol of both immigrants or American citizens who find themselves in danger in the harsh extremes of the southern deserts.

The photovoltaic panels would also be designed to collect water runoff; to power atmospheric water extractors; or to pump water from wells or rivers that could be stored, purified and dispensed as needed to distressed crossers in the desert. Engaging the water dispenser, or even approaching the life safety beacon would alert border patrol. Such devices could also ameliorate the effects that access to water has on wildlife, who find themselves unable to travel their natural routes in search of water.

While most of this work has been focused on public utility-style resources, the importance of social improvements along the border should be stressed. Sports, for example, are inherently social activities where networks between people with common interests are formed. The social capital produced by these



Water and Life Safety Wall



Nogales, AZ solar fence



Solar Facility

## BORDERWALL AS ARCHITECTURE

networks is a core element in the fabric of communities: it produces safety and security, friendship and community, civic identity and economic value. Over time, social capital builds what may be termed “social infrastructure,” a key element in the success and health of communities. One of the most devastating consequences of border wall security in its present state is the division of communities, cities, neighborhoods and families, and the erosion of social infrastructure. Even so, sports have served as a way to cope with the realities of the wall. Volleyball has been known to be played using the fence as a net in several sites along the border and bi-national yoga classes have been held through the border wall as well. As such, the border wall can and should be envisioned as a linear urban park through certain urban geographies. When supplemented with green spaces, connected to schools and other parks, there is no reason not to think of the wall as the organizing condition for an urban park, offering pedestrian and bicycle routes through the city. The linear park, in turn, has the potential to increase adjacent property values and the quality of life on both sides of the border while providing an important green corridor through the city.

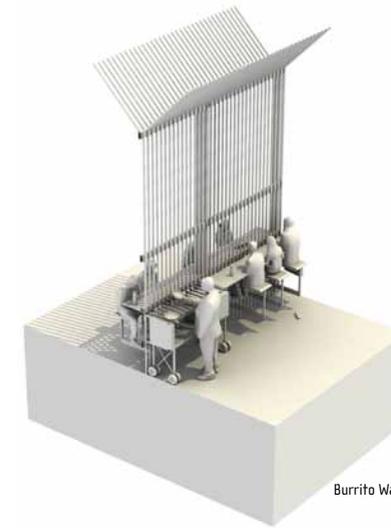
It should be clear that the infrastructural improvements under consideration here play the legislative hand the U.S. has been dealt, and they work firmly within the complex and often labyrinthine fiscal, cultural and political realities of the border and that the transformation of the borderwall has important consequences on at least three fronts—improving the quality of life along the border, increasing security and creating



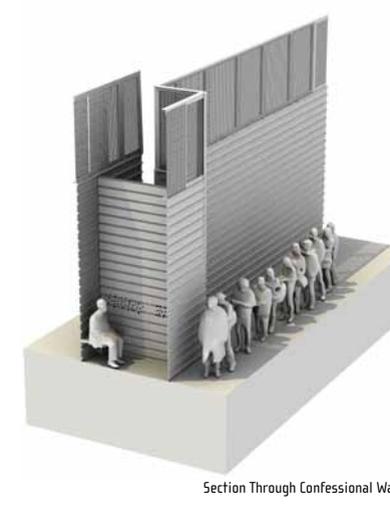
Library Wall

jobs. Increasing the quality of life in Mexico is a step towards immigration reform. Border towns lack the infrastructure that allows them to be sustainable, healthy cities and infrastructural wall elements have the potential to provide city amenities amid urban growth. Infrastructural elements are highly secure facilities and profits from infrastructure development projects and infrastructural improvements to border cities would go a long way towards contributing to increased national security and immigration reform. The construction of large-scale infrastructure projects create jobs, as do the manufacturing of the vital components that make up infrastructural technologies. These could also take place along the border.

Franklin Delano Roosevelt set out a course for U.S. / Mexico relations at the onset of World War II with a vision of hemispheric security that was not beholden to a limited view of border fortification. He said, "What I seek to convey is the historic truth that the United States as a nation has at all times maintained opposition --clear, definite opposition-- to any attempt to lock us in behind an ancient Chinese wall." (Jan 6., 1941)<sup>15</sup> Yet, the border fence in its current form recalls the inflexibility and ancient strategy of a wall as a singular means of security. Michael Chertoff, the architect of the existing wall said, "A fence by itself not going to work, but in conjunction with other tools, it can help." There are many reasons to think that border security can be achieved—and will only be achieved—by employing a more multi-valent and flexible tool in the form of a vision of border infrastructure than has yet been imagined.



Burrito Wall



Section Through Confessional Wall



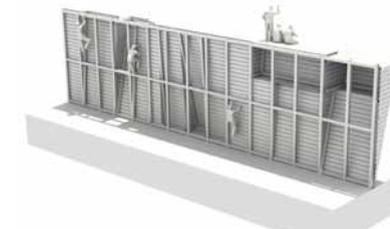
South Elevation Climbing Wall



Family Visits, San Diego, CA - Tijuana, MX



Cross Border Communion, San Diego, CA - Tijuana, MX



North Elevation Climbing Wall



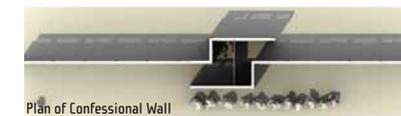
Ceaseless cat and mouse between crossers and border patrol agents

BURRITO WALL

Casual exchange is common across the border wall ranging from small talk, long visits with friends and family, and commercial exchanges of items ranging from food and bracelets to illegal merchandise. The Burrito Wall accommodates for a food cart to be inserted into the wall. The proximity to the wall and the security overhang create shade. Seating is built into the wall and food, conversation or a bi-national game of footsies can occur across the border.

CONFESSONAL WALL

The division created by the wall often heightens border exchanges. In Friendship Park, a beach park that spans both San Diego, CA and Tijuana, Mexico, intimate exchanges are common. Each Sunday afternoon Holy Communion is offered through the fence – increasingly as an act of civil disobedience. Here the fence serves as an opportunity for confession, with both confessor and priest must ask that his trespasses be forgiven as they must transcend the border to perform the rite.

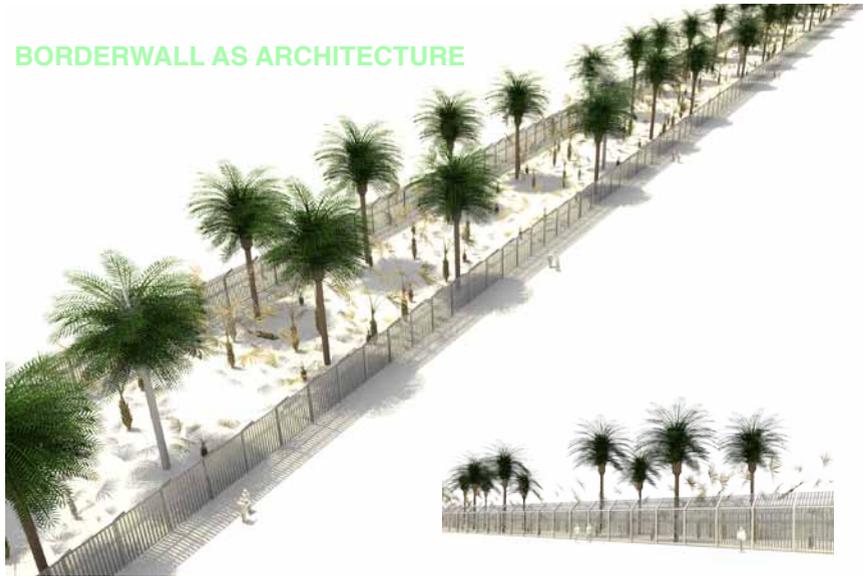


Plan of Confessional Wall

CLIMBING WALL

"Show me a 20 foot fence and I'll show you a 21 foot ladder" has become a mantra for describing the fence's inadequacies. Various techniques have been used to surmount the wall. Artist Judi Werthein has created special shoes called Brincos (jumpers) – "crossing trainers" – designed to help illegal immigrants negotiate the sometimes deadly terrain they encounter when crossing the border from Mexico to the U.S. Various makeshift platforms/ramps have also been erected to allow cars to drive over the border fence. Here, the act of climbing the fence becomes not more difficult, but more challenging, as it takes on the language of a rock climbing wall with various routes and grading.

**BORDERWALL AS ARCHITECTURE**



**FOREST WALL**

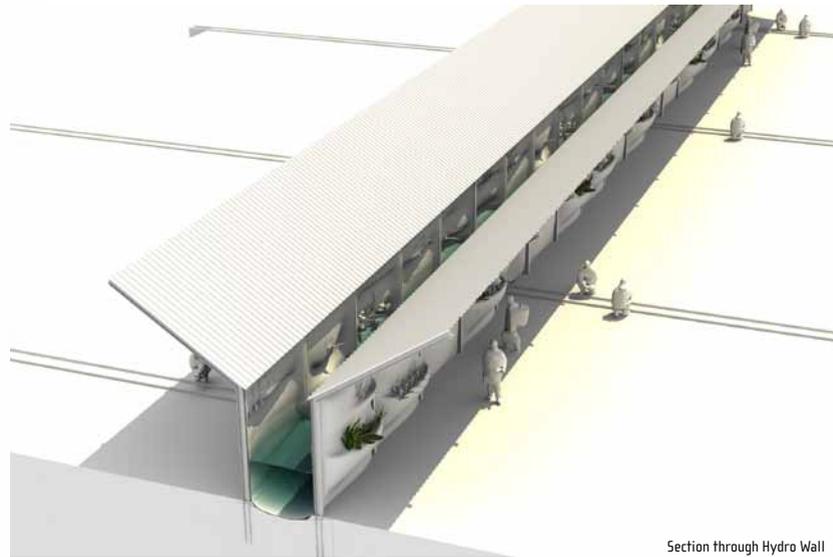
Once found across much of the lower Gulf Coast, sabal palm forests have all but vanished under the plow. While some scattered trees can be found on private lands in the region, the significant remaining stands of these palms are located in three conservation areas located in the path of the border fence. In order to save the sabal palms from being leveled by fence construction, the Conservancy is partnering with the U.S. Fish and Wildlife Service and Audubon Texas, in coordination with the U.S. Army Corps of Engineers, to carefully transplant the palms, one tree at a time.

Simultaneously, along the border with Eagle Pass, Texas, Mexicans, with support

from their government, have begun to plant the first of 400,000 trees to form a "green wall" in protest of the fence. The tree-line will eventually stretch for 318 miles along the border between the Mexican state of Coahuila and Texas.

Forest Wall adapts the tree-line protest by proposing a double fence condition around the sabal palm preserve, thus addressing security concerns and protecting our environmental heritage.

A forest surrounded by a double or triple fence is a perverse take on a reserve – a preservation of an ecology that in a post-border condition could serve to stitch the two sides back together again.



Section through Hydro Wall



**HYDRO WALL**

Water and air quality in the border regions suffer a disproportionate amount of environmental degradation compared to each nation's overall environmental standing. The 14 metropolitan areas along the border have abysmal air and water quality.

Water is the most limited resource in this primarily arid region. Many migrant deaths are caused by dehydration as they cross the harsh desert. The border wall has also caused severe flooding where rain has fallen, blocking natural drainage systems and damming in entire neighborhoods. A Hydro Wall would collect water and store potable safe water over the span of several

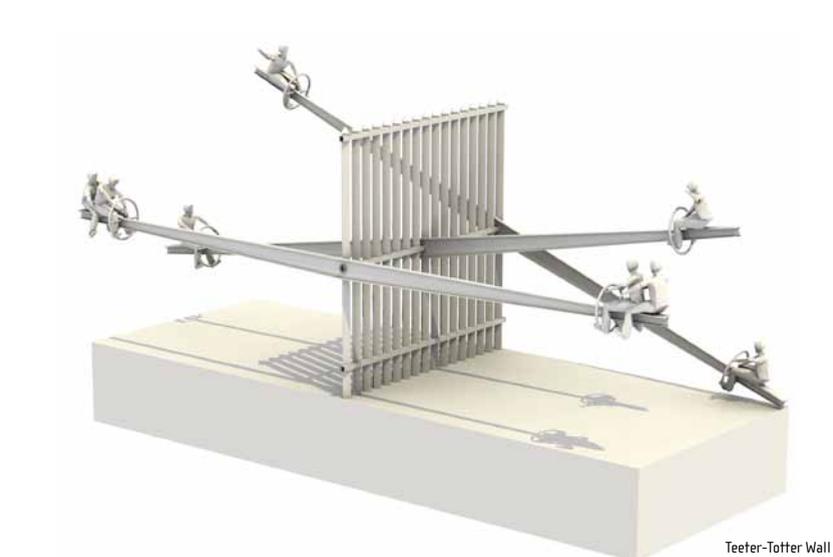


Flooding: Nogales, AZ

miles for distribution on both sides of the wall.



Section through Hydro Wall



Teeter-Totter Wall



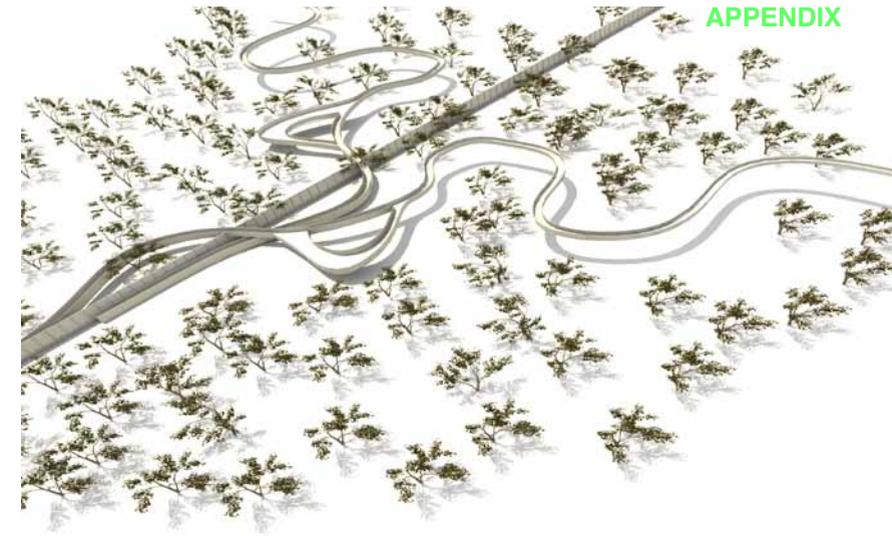
Makeshift ramps and ladders used to cross border wall

**TEETER-TOTTER WALL / SWING WALL**

The trade and labor relationships between the U.S. and Mexico are in delicate balance. Mexicans throng to the U.S. to find work, but often long to live comfortably in their own country. U.S. industry and agriculture is dependant upon immigrant labor pools, yet the Department of Homeland Security, Border Patrol, and Immigration and Naturalization Services have made it increasingly difficult to attract foreign labor. These proposals demonstrate the delicate balances between the two nations.



Swing Wall



**APPENDIX**



Jabalinas thwarted by the border wall

**WILDLIFE WALL**

The Border Wall, existing and proposed, cuts through countless wildlife and nature reserves. The borderland between the U.S. and Mexico includes grasslands, mountains and desert habitats that support a diverse range of wildlife. The Lower Rio Grande Valley alone hosts 17 endangered or threatened species. Ensuring the free movement of critically endangered species between Mexico and the U.S. will have important impacts on breeding and genetic diversity for those animals. The biggest concern is that the barrier will break small populations of animals into even smaller groups resulting in fewer animals interacting. The wall could ultimately threaten entire species. The key is to have



gaps in the fence that are sufficient to allow passage of animals while at the same time meeting security needs. A Wildlife Wall would contain special openings that allow for the passage of wildlife, and would create opportunities for shelter and safe nesting spots. It would also allow for people from each country to experience nature on both sides of the wall.



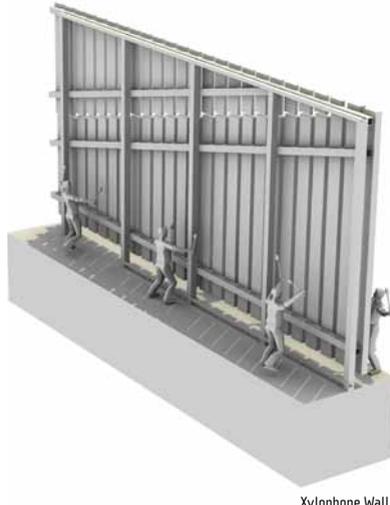
Defenders of Wildlife, Department of Homeland Security | MAP: By Nathaniel Vaughn Kelso and Gene Thorp, The Washington Post - April 19, 2008

## BORDERWALL AS ARCHITECTURE



XYLOPHONE WALL

Musician, Glenn Weyant, performs music on the wall that divides Mexico from the United States. Weyant places contact microphones on a section of the wall near Nogales, Arizona, and then he uses a cello bow against the metal of the wall to create exotic and avant-garde sounds. The Xylophone Wall allows for multi-person/bi-national informal and formal performances on the border.



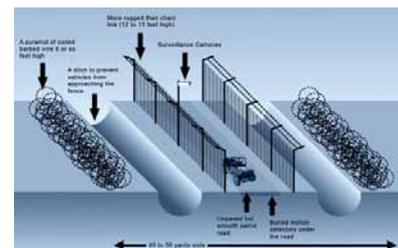
Xylophone Wall



Section Xylophone Wall



Vert Wall



VERT WALL

The introduction of the double fence in many areas offers an opportunity to activate this interstitial zone. Vert Wall understands this area as a space of play, while also challenging the strategy of crossing. The double barrel section is reminiscent of initial security schemes that involved double ditches. This section also allows for the containment and distribution of water along the border channeling overflow away from flooded regions and diverting water to areas experiencing drought.



Theater Wall



THEATER WALL

Many events take place through the border wall, bringing people from both nations together. These include yoga, volleyball, communion, prayer and deaf signing. A Theater Wall would allow for bi-national collaborations in performance, music, theater and film.

## FOOTNOTES

<sup>1</sup> Genova, Judith. Wittgenstein: a way of seeing. Psychology Press, 1995. 122.

<sup>2</sup> While there are a number of architectural definitions to define the barrier, Chertoff describes the intervention as a “tool” see: Chertoff, Michael. Homeland Security: Assessing the First Five Years. Philadelphia: University of Pennsylvania, 2009. 42.

<sup>3</sup> While it is difficult to accurately measure the exact scope and cost of the fence project, it has spanned more than 700 miles through 4 states and will cost as much as \$49 billion over the expected 25-year life span of the fence according to a nonpartisan Congressional Research Service. See: Tyche Hendricks. “Study: Price for border fence up to \$49 billion: Study says fence cost could reach \$49 billion/ Lawmakers’ estimate falls far short of total, research service says,” San Francisco Chronicle, January 8, 2007. Page B-1.

<sup>4</sup> Deaths along the border are also difficult to account for. Many bodies have not been discovered and the cause of deaths vary and can be attributed to many factors. See: Spencer S. Hsu, “Border Deaths Are Increasing: Rise Is Despite Fewer Crossers, U.S. and Mexican Groups Say,” Washington Post, September 30, 2009.

<sup>5</sup> William Hamilton, “A Fence with More Beauty, Fewer Barbs,” The New York Times, June 18, 2006. sec. Week in Review.

<sup>6</sup> Hans Ulrich Obrist, “Part 1: On Berlin’s new architecture,” in Interviews, Volume I, ed. Thomas Boutoux, Fondazione Pitti Immagine Discovery, Charta, Milan 2003. 507-528.

<sup>7</sup> This estimation was emerged by calculating the total estimated area of U.S. land that is south of the U.S-Mexico barrier using available maps of barrier locations and proposed construction sites.

<sup>8</sup> In 2008 the border fence was responsible for causing 7-foot deep water levels in the cities of Nogales. See: “Report: Faulty design turned border fence into dam.” Arizona Daily Star 15, August 2008

<sup>9</sup> David McLemore, “Texas to see border fence construction next year Despite opposition: Rio Grande set for 150 miles of barriers,” The Dallas Morning News, December 5, 2007.

<sup>10</sup> Frisvold, G. B. and Caswell, M. F. (2000). Transboundary water management Game-theoretic lessons for projects on the US–Mexico border. Agricultural Economics, 24: 101–111. doi: 10.1111/j.1574-0862.2000.tb00096.x

<sup>11</sup> George W. Bush, “Introductory Speech at the Signing of the Secure Fence Act,” The Roosevelt Room, The White House, Washington, D.C., October 26, 2006.

<sup>12</sup> Calculations were based on the cost per square foot of recently constructed waste water treatment plants in the U.S.

<sup>13</sup> SolarBuzz, “Fast Solar Energy Facts,” <http://www.solarbuzz.com/FastFactsGermany.htm> (accessed January 13, 2011).

<sup>14</sup> Eschbach, K., J. Hagan and N. Rodriguez (2001): Causes and Trends in Migrant Deaths Along the U.S.-Mexico Border 1985-1998. Center for Immigration Research, University of Houston.

<sup>15</sup> Franklin D. Roosevelt, “Four Freedoms,” January 6, 1941 in Great Speeches, ed. John Grafton (New York, NY: Dover Publications, 1999), 93.

## THE BAY LINE: Bay Bridge Adaptive Reuse

Project Date: 2009

Project Team: Ronald Rael, Virginia San Fratello, Emily Licht, Duncan Young

The Historic Bridges of the United States website lists 1,788 bridges that have been “closed” to traffic and 321 classified as “abandoned”. According to the website, “with all of the Federal stimulus money sloshing around, it’s no surprise that bridge replacement projects are quite common this summer.” Many of the bridges that have been neglected are largely former railroad bridges--a testament to the decline of rail as a means of freight and passenger transportation. Engineered as rail bridges, the structures have the capacity to support tremendous loads.

The Bay Line imagines abandoned and closed bridges as sites of potential parks, cultural centers, and housing. The eastern section of the historic James “Sunny Jim” Rolph Bridge, commonly known as the Bay Bridge, in San Francisco/Oakland, which is currently being replaced by a new concrete bridge structure, serves as a prototype for considering the potential of re-utilizing bridge infrastructure to create new social, housing and sustainable infrastructures.

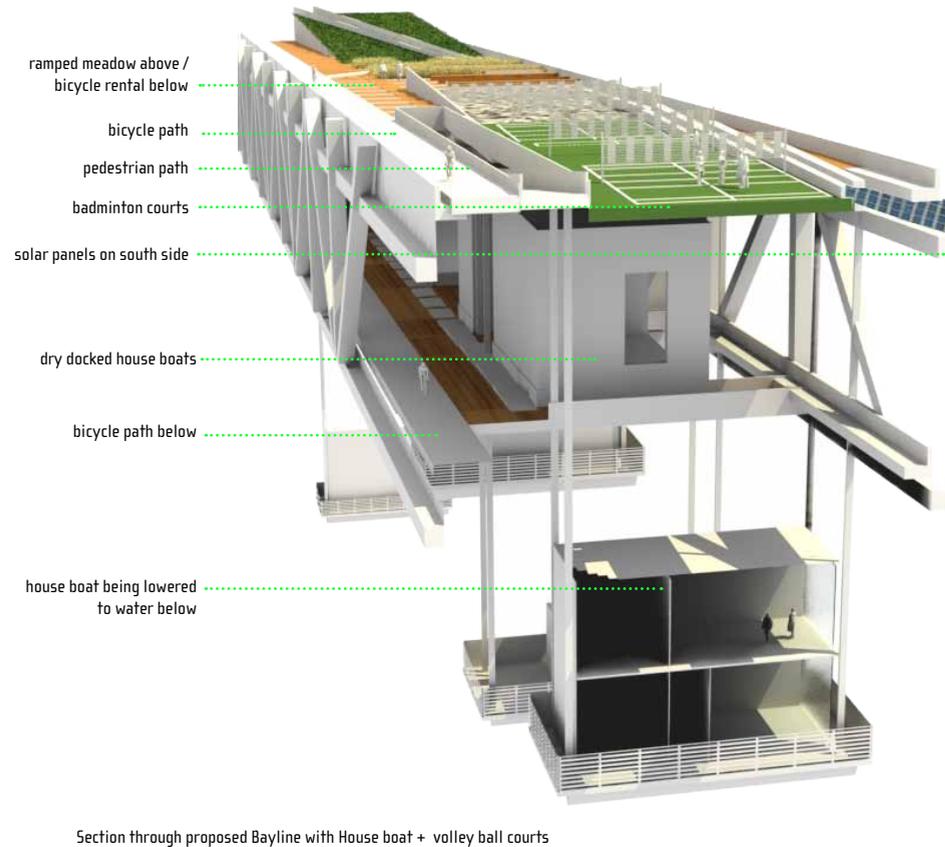
Both rural and urban areas have demonstrated an increased interest in converting abandoned railways into linear parks (best illustrated by the recent opening of the High Line in New York City). This proposal goes a step further in suggesting the possibility that housing be included in the re-thinking of abandoned bridges. The immense load bearing capacity of rail bridges suggests an “urbanization” of bridge infrastructure could be plausible. While the current economic climate suggests a surplus of housing, economic and ecological realities demand settlement patterns based on density. By using abandoned bridges in urban areas as the framework, we are creating opportunities for sustainable low-cost housing within the urban



Current construction on the new Bay Bridge



San Francisco-Oakland Bay Bridge Plan



Section through proposed Bayline with House boat + volley ball courts

realm and opening up the potential for creative speculation among housing developers by expounding upon the nascent potential of a layered housing-park-bridge typology.

“Bridge housing” is not a new conception. The Ponte Vecchio in Florence, Italy, the pre 1756 London Bridge, the Chateau Chenonceau in France and the Pulteney Bridge in Bath, England are all historical and successful examples of inhabited bridge spans in urban areas. This proposal understands defunct bridges to be viable, cost effective, enterprising, and ecologically responsible sites for potential housing development. Recent interest in the revivification of urban infrastructure demonstrates a political and cultural climate amenable to new and bold approaches to our built environment.

## THE BAY LINE

### CORE PREMISE AND OBJECTIVES

The specific objective of The Bay Line is to re-imagine the replaced eastern span of the Bay Bridge as a linear park with bicycle and pedestrian access, housing and cultural activities, such as theaters, commerce and museums, as well as 1.92 miles of bicycle lanes, sporting facilities, such as tennis courts, climbing walls, squash courts, and skate parks in addition to orchards, gardens and meadows, that are easily accessible and interconnected to the larger Bay Area. More broadly, we hope that this project is the genesis for creating a series of prefabricated prototypes and widely applicable concepts that can help others realize the potential in abandoned bridge infrastructure world-wide.



Hotel rooms + outdoor amphitheater



Dormitories + climbing wall



Bungalow house + tennis courts



Row houses + gardens



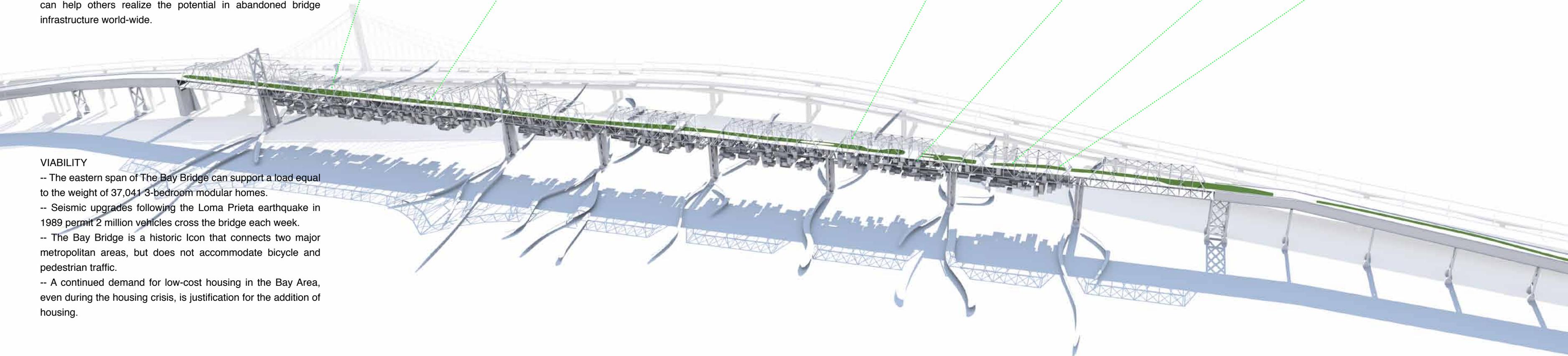
Live / work lofts + orchards



Condos + swimming pool

### VIABILITY

- The eastern span of The Bay Bridge can support a load equal to the weight of 37,041 3-bedroom modular homes.
- Seismic upgrades following the Loma Prieta earthquake in 1989 permit 2 million vehicles cross the bridge each week.
- The Bay Bridge is a historic Icon that connects two major metropolitan areas, but does not accommodate bicycle and pedestrian traffic.
- A continued demand for low-cost housing in the Bay Area, even during the housing crisis, is justification for the addition of housing.

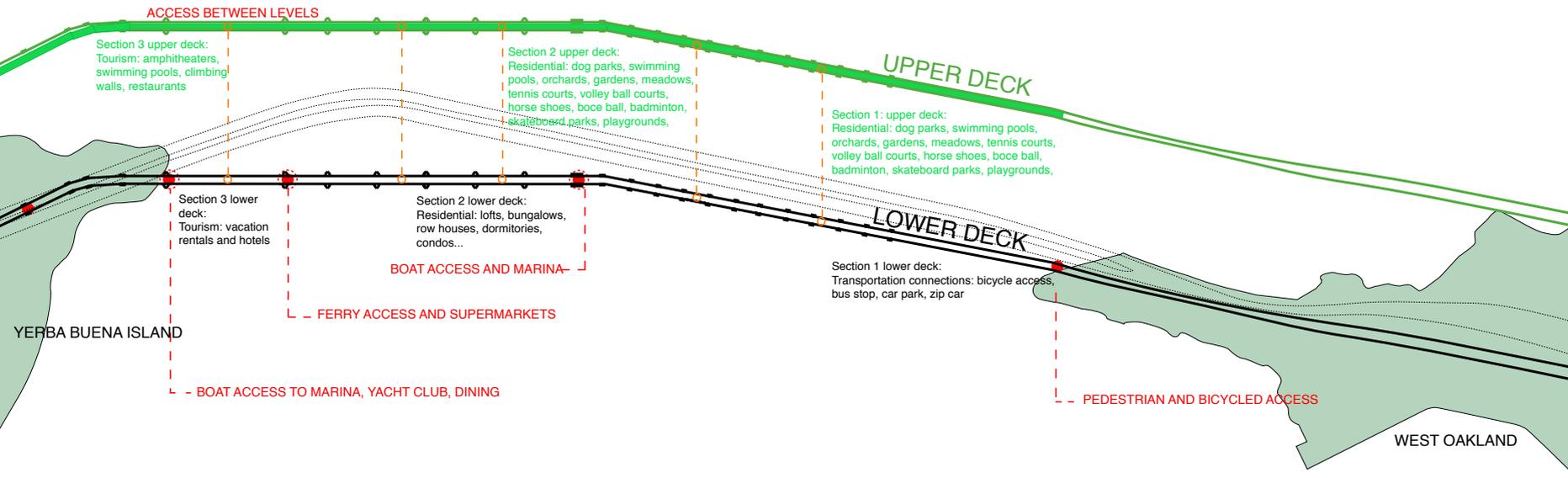


## THE BAY LINE

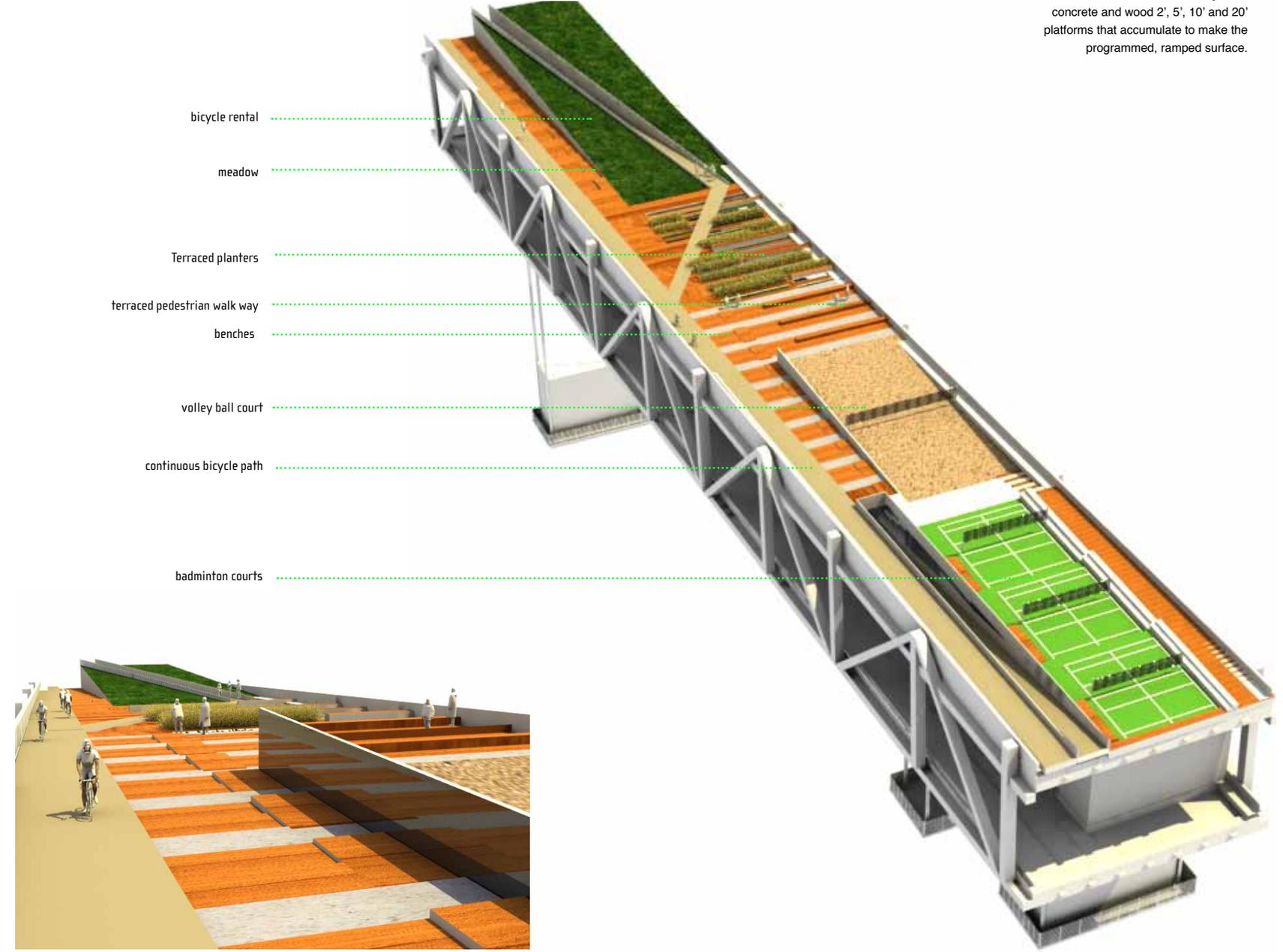
### LINEAR PARKS ALONG THE UPPER DECK

The upper deck of the Bay Line will be re-appropriated as an urban park. The park will include sports facilities that are often quite difficult to find in dense urban centers such as tennis courts, swimming pools and skate parks. It will include edible gardens and orchards as part of the urban agriculture network established in the Bay area by organizations such as the League of Urban Gardeners, there will also be gardens, meadows and woodlands for leisure activities and amphitheatres and museums to support local culture. A system of prefabricated terraces will be constructed to build the different programs and to smoothly allow one program to segue into the next.

The recreational, cultural, leisure and agricultural programs will promote diverse user groups along the bridge. The continuous bicycle path that runs the length of the bridge will become a part of the growing bay trail which connects cities along the perimeter of the bay.



Terraced construction system:  
concrete and wood 2', 5', 10' and 20'  
platforms that accumulate to make the  
programmed, ramped surface.



## THE BAY LINE

### COMMUNITY: RECREATION AND SPORTS

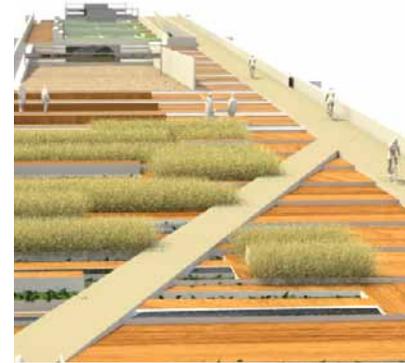
Sports are inherently very social activities where networks between people with common interests are formed. These networks form social capital which is the underpinning and core fabric of communities. Social capital has a stream of benefits, including safety and security, friendship and community, a sense of civic identity and economic value. Over time, social capital builds what may be termed as social infrastructure which is key for any successful and healthy community.

### SUSTAINABILITY: GARDENS AND AGRICULTURE

Recently there has been a large movement to bring agriculture back into the city. The Bay Line has up to 15 acres of "land" that can potentially be used for edible gardens and orchards. These gardens may be incorporated by institutions such as non profit community organizations such as SLUG (San Francisco League of Urban Gardeners) who currently run 40 small gardens in the city that generate it's \$1.6 million dollar annual budget. The gardens not only provide food but they are economically self sustainable.

### PUBLIC PRESENCE: LEISURE AND CULTURE

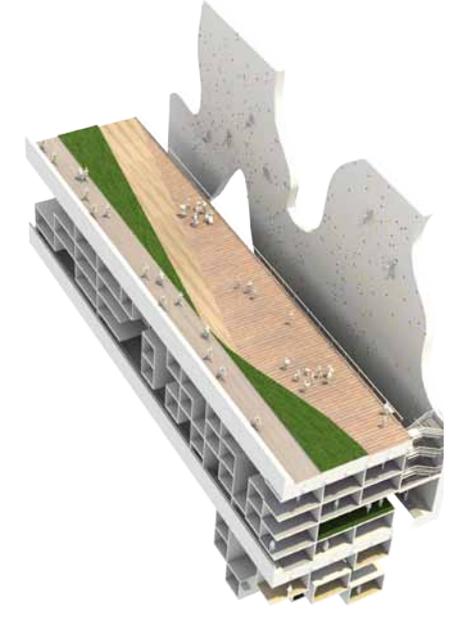
Like the Golden Gate Park, the Bay Line would be a destination for tourist and locals alike. The Bay Line would be suitable for hotels, restaurants and museums as well as picnickers, walkers and kids in search of playgrounds.



CULTURE: outdoor amphitheater



RECREATION: swimming pools



COMMUNITY: dog park



SUSTAINABILITY: urban agricultural plots



SUSTAINABILITY: urban orchards



RECREATION: tennis courts