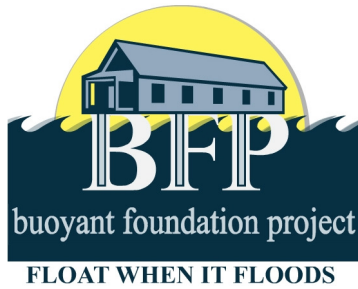


Amphibious Building:

A new strategy to reduce vulnerability
to extreme flooding



Deltas in Times of Climate Change
Rotterdam
30 September 2010

Elizabeth C. English, PhD
Associate Professor
University of Waterloo
Ontario, Canada



New Orleans after Hurricane Katrina



Problems with Elevated Homes

- Difficult access – especially for the elderly & disabled
- Expensive
- Insufficient protection in extreme flooding
- Greater risk of wind damage in a hurricane
- Creates gap-toothed effect in a neighborhood
- Homes lose close relationship to the street
- Loss of neighborhood character in an urban setting



Elevated homes at Raccourci Old River, Pointe Coupee Parish, LA

photos by D. D. Ewing



New Orleans: There must be a better way!

New amphibious homes in the Netherlands



The first development of amphibious housing in the Netherlands was in Maasbommel, along the Maas River, designed and built by Factor Architecten and Dura Vermeer.

Maasbommel, Netherlands

photo by Hans van Beek

BUOYANT FOUNDATIONS Create homes that float in a flood



Mission

The mission of the BFP, founded in 2006, is to support the recovery of New Orleans' unique and endangered traditional cultures by providing a strategy for the safe and sustainable restoration of traditional housing.

BUOYANT FOUNDATIONS

Create homes that float in a flood



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Flood-proofing the city's traditional elevated wooden shotgun houses by retrofitting them with buoyant (amphibious) foundations avoids the destruction of neighborhood character that results from permanent static elevation high off the ground.

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Buoyant Foundations provide increased safety and resilience in cases of extreme flooding and support the restoration of both the physical and the social structures of pre-Katrina New Orleans neighborhoods.

In rural Louisiana --



Amphibious homes at Racourci Old River, Pointe Coupee Parish, LA

photos by D. D. Ewing

When the Mississippi River rises in the spring, it floods Old River -- this happens almost every year, sometimes more than once.



Dry in September



Floating in February

For over 30 years, amphibious houses at Raccourci Old River have been rising and falling reliably with the level of flooding of the Mississippi River.



Dry in September . . . the same house . . . Floating in February

Average cost of buoyancy system is around \$5,000.



Dry in September . . . the same house . . . Floating in February



Amphibious foundations are not new!



Dry in September . . . the same house . . . Floating in February



**So why fight floodwater
when you can float on it?**

BUOYANT FOUNDATIONS

Create homes that float in a flood



Advantages

- House normally remains close to the ground
- Elevates house to exactly what is required to stay above water, even if high above BFE
- Less susceptible to hurricane wind damage
- Alleviates problems of soil subsidence and elevated sea level due to global warming
- Looks essentially the same as before Katrina
- Original traditional architecture is preserved
- Neighborhood retains original character

How a Buoyant Foundation works

It basically works like a floating dock. A structural frame that holds the flotation blocks is attached to the underside of the house. There are four “vertical guidance” posts not far from the corners of the house. The tops of the posts are attached to the structural frame. The posts telescope out of the ground, allowing the house to move up and down. Utility lines have either self-sealing “breakaway” connections or long, coiled “umbilical” lines. When flooding occurs, the flotation blocks lift the house, with the structural frame transferring the forces between the house and the blocks. The vertical guidance posts keep the house from going anywhere except straight up and down on top of the water.

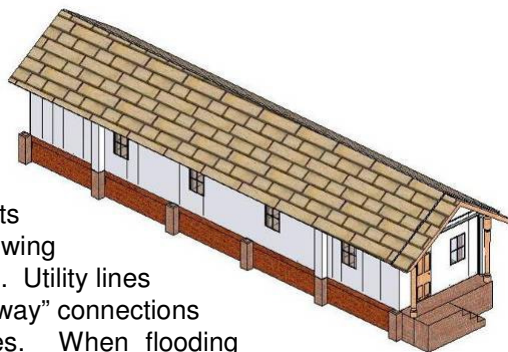


Figure Created by Ben Morvant

How it works

Section drawing of a shotgun house with a buoyant foundation installed, showing buoyancy blocks under the house and vertical guidance posts that telescope out of the ground

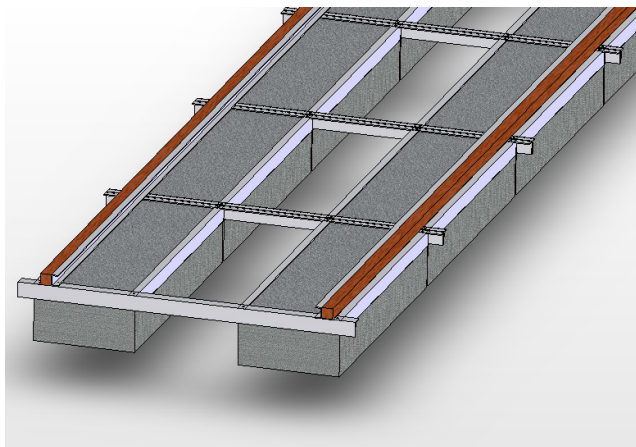


Figure Created by Stuart Broussard



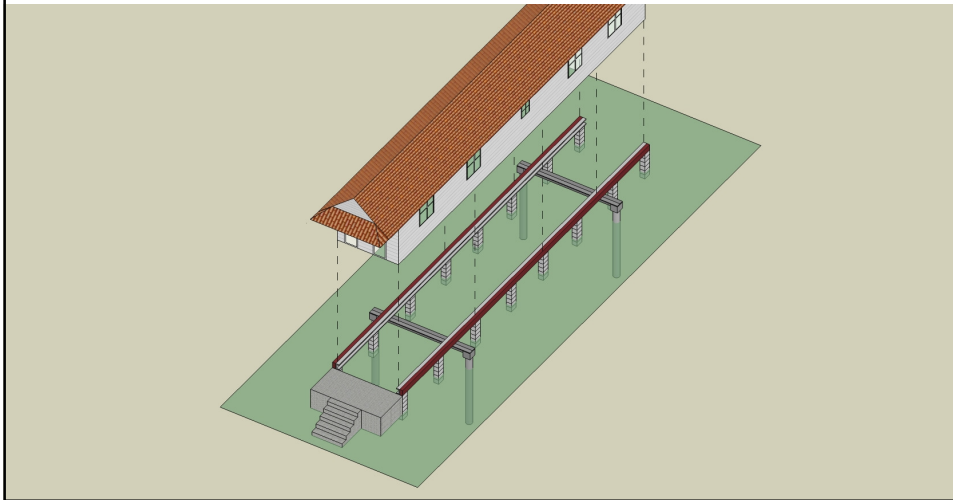
How it works

A steel frame attaches to the underside of the house and holds the buoyancy blocks off the ground. The house remains sitting on its original masonry piers after the buoyant foundation has been installed.



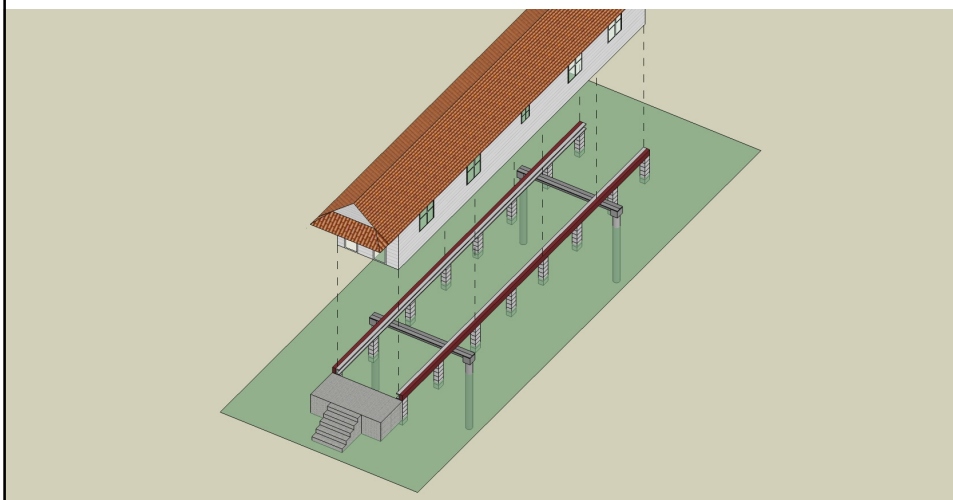
Construction Process:

- 1. Jack up house to BFE (3 feet) and build up existing masonry piers as required**



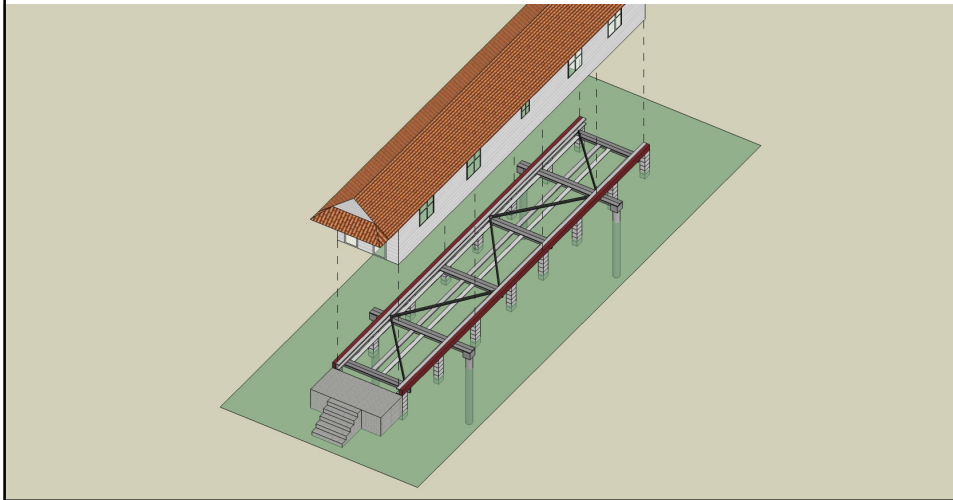
Construction Process:

- 2. Put in vertical guidance posts and attach channels to inside surfaces of sill beams**



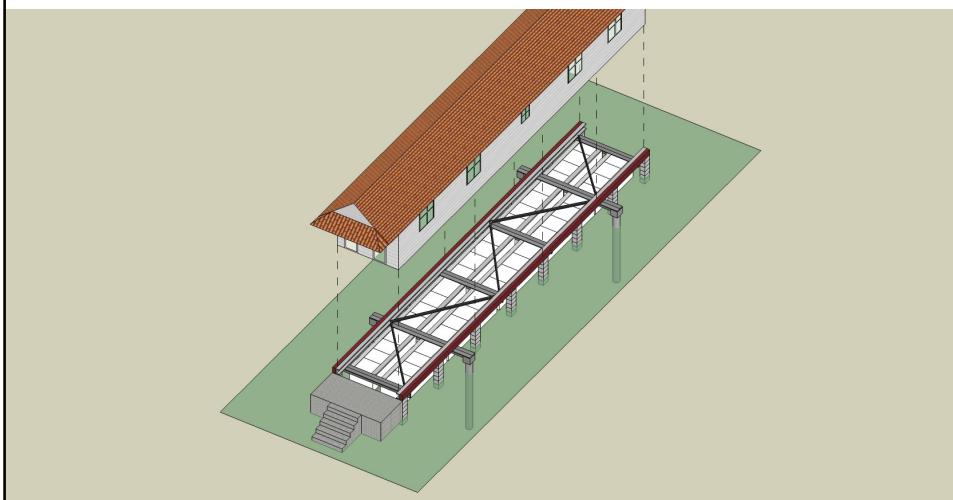
Construction Process:

3. Add T-beams and secondary angles to support buoyancy blocks



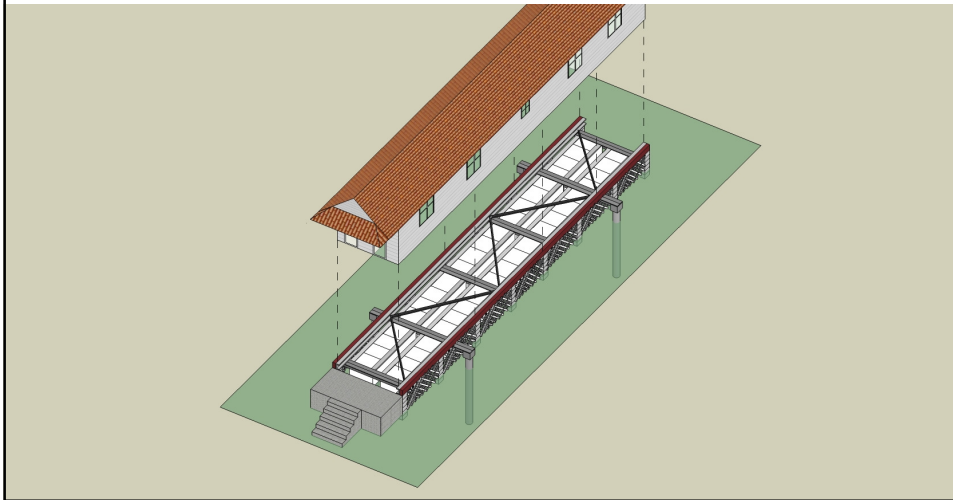
Construction Process:

4. Add foam buoyancy blocks



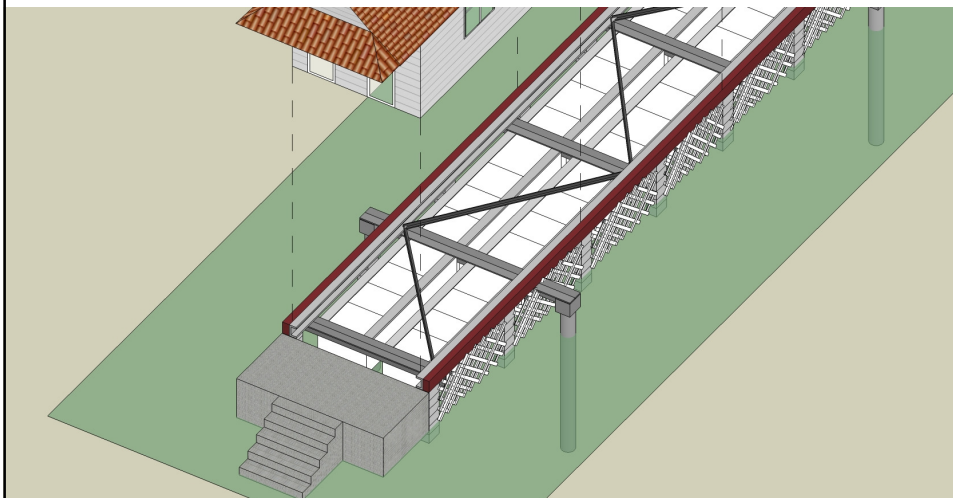
Construction Process:

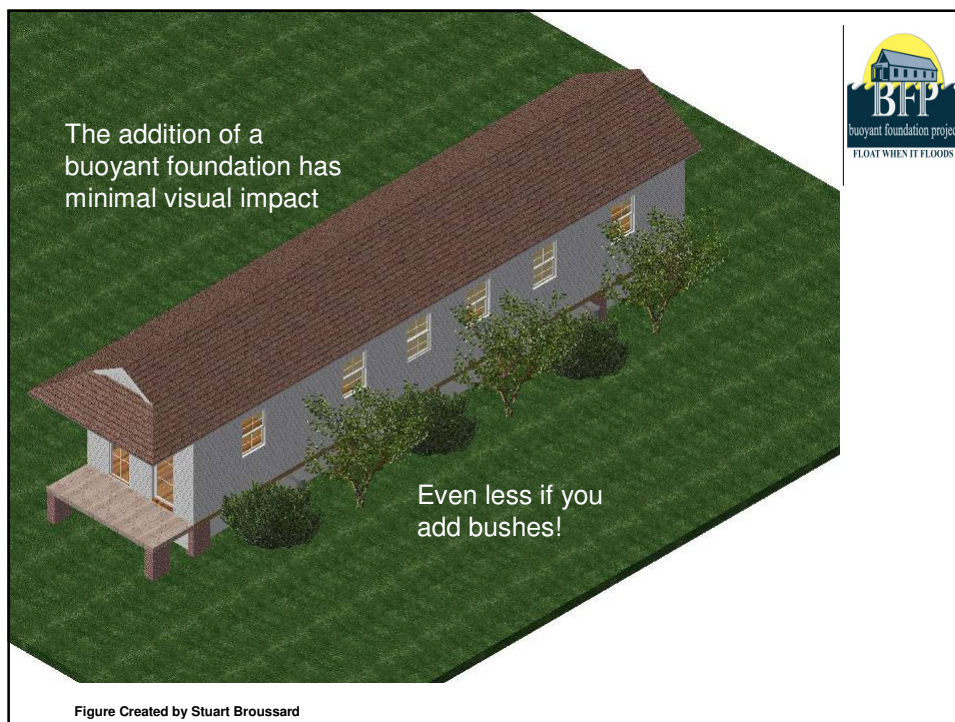
5. Add protective screen to keep waterborne debris from settling underneath the house



Construction Process:

Detailed view





Comparison of 3 Conditions



House on
traditional
masonry piers

House
elevated
to 8 feet

House with
a Buoyant
Foundation

Figure Created by Stuart Broussard

NOW ADD WATER . . .



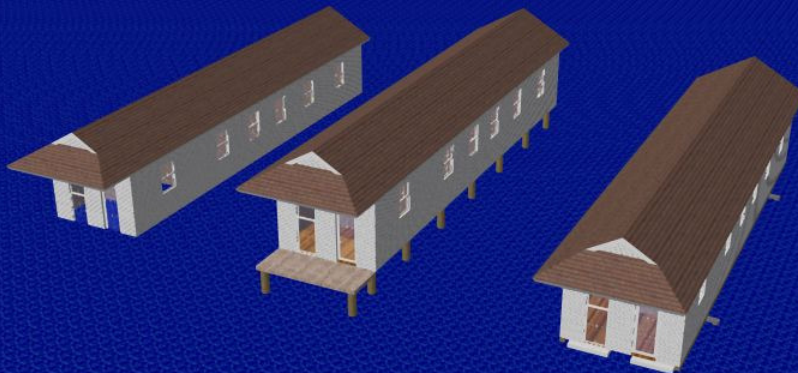
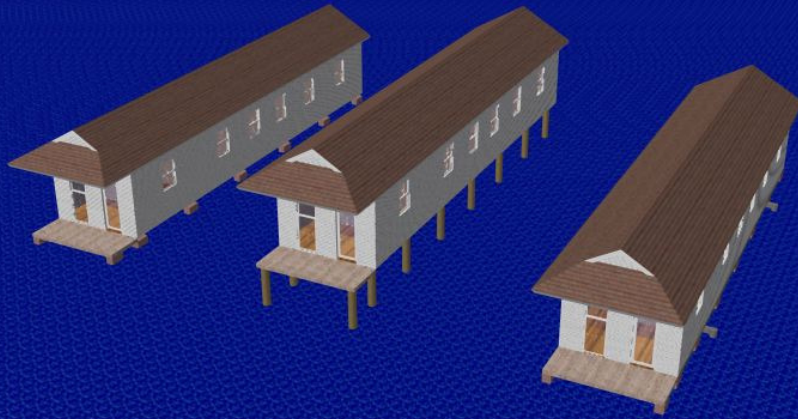
Existing
Shotgun
House

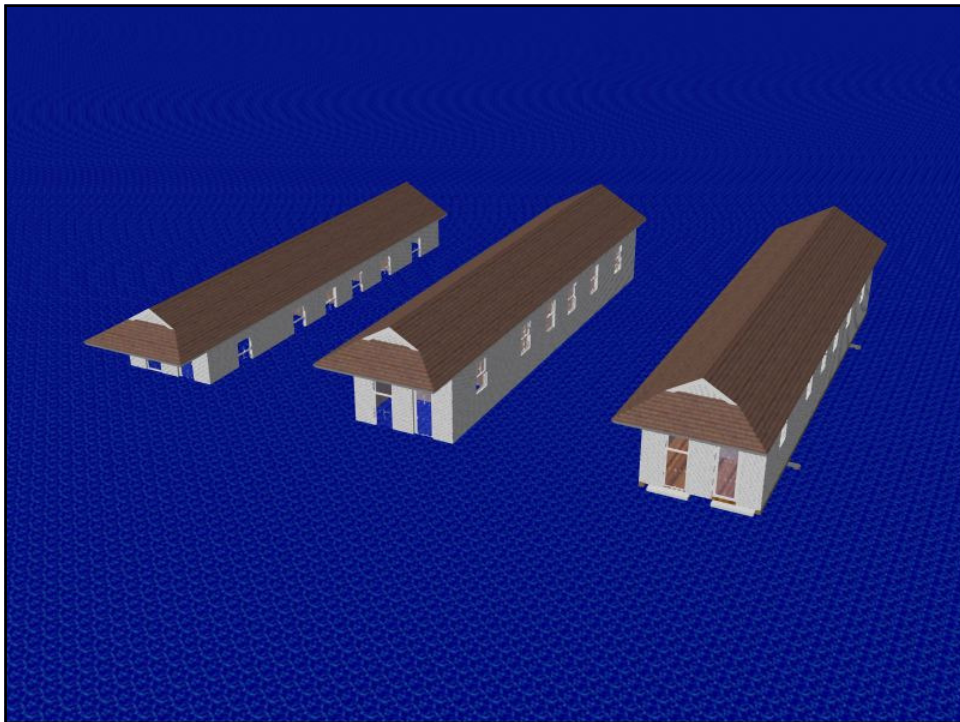
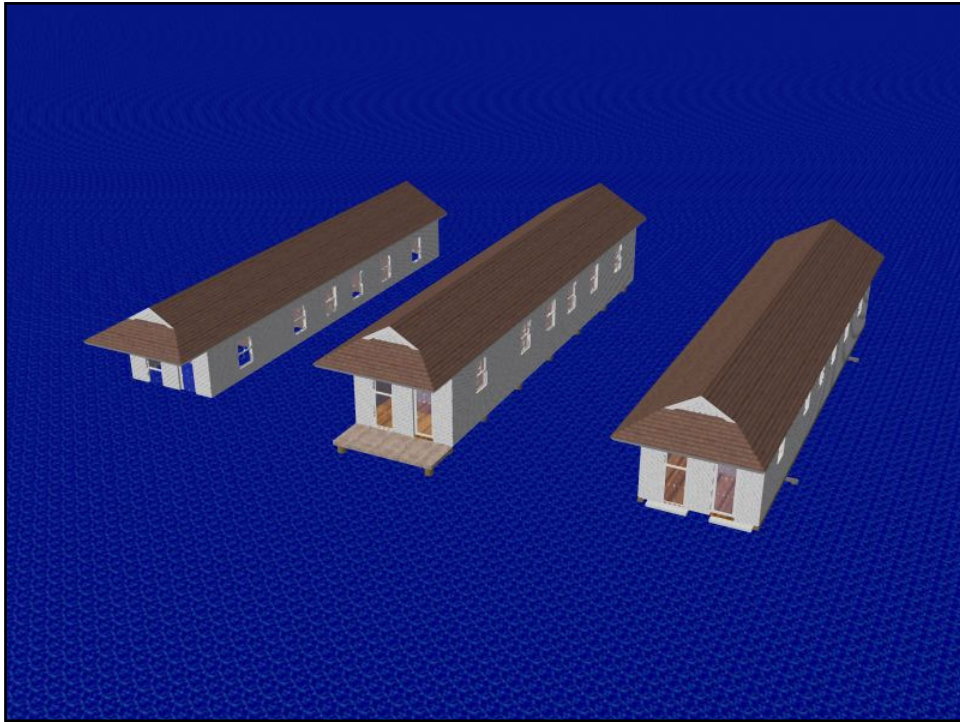
Shotgun House
Elevated to 6 ft

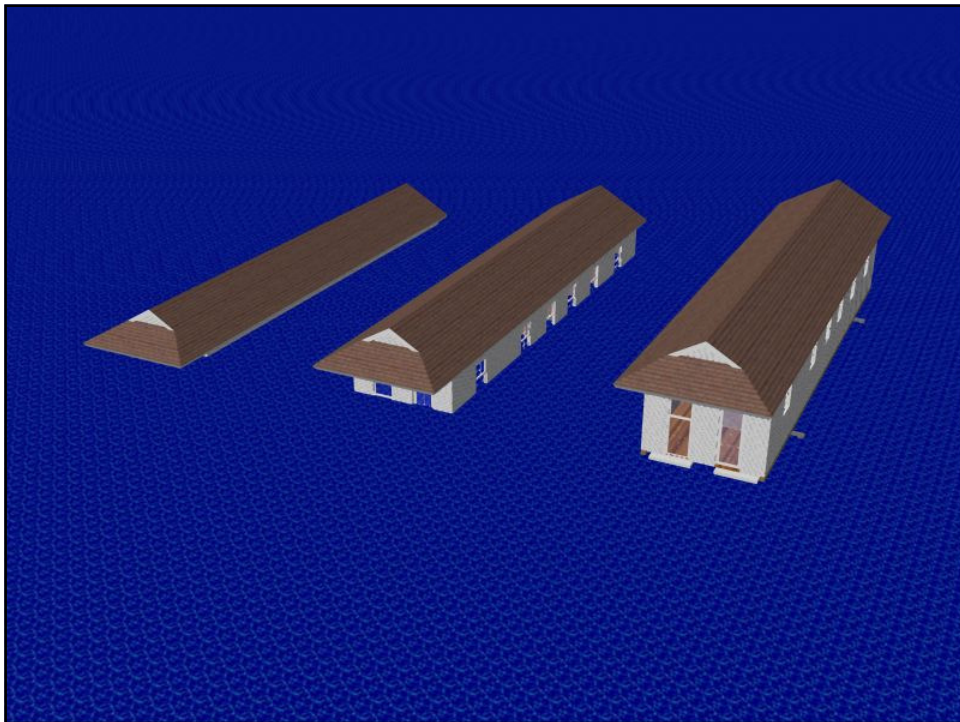
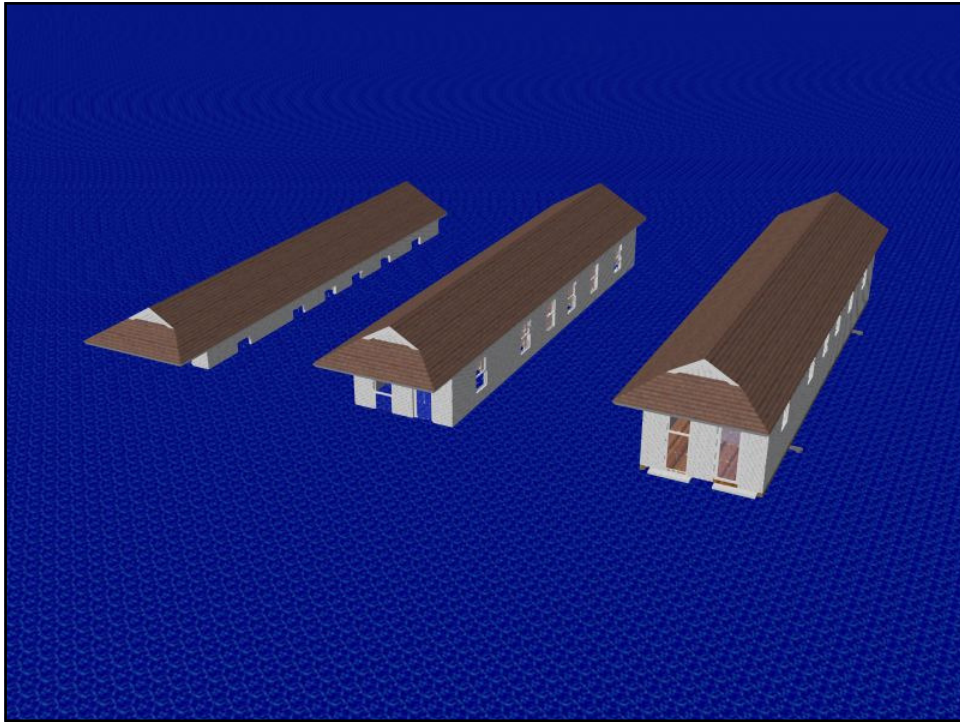
Shotgun House on a
Buoyant Foundation

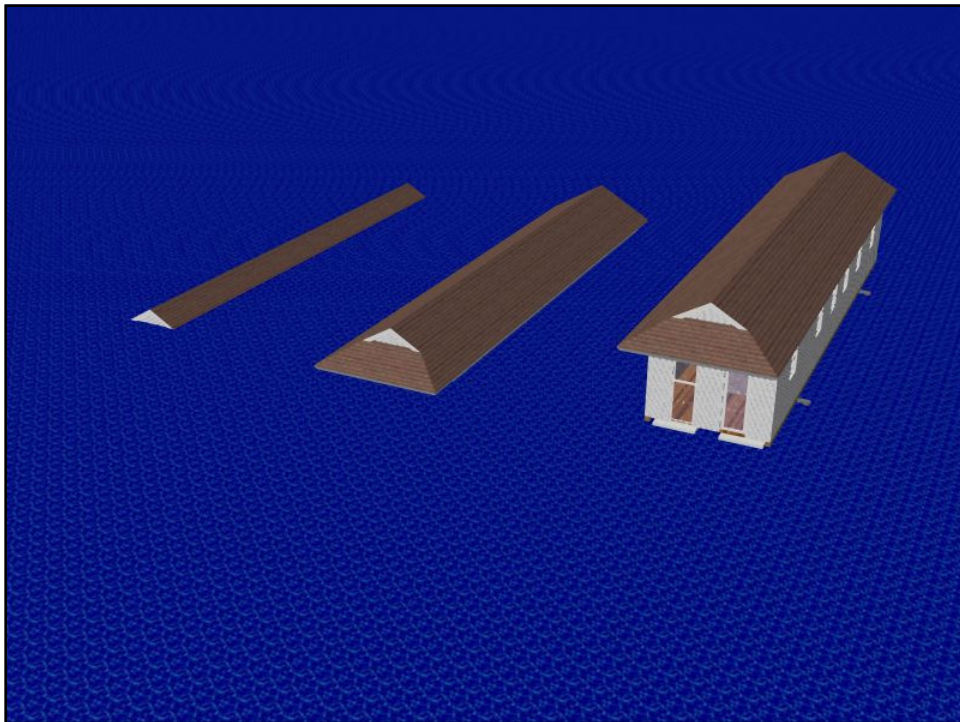
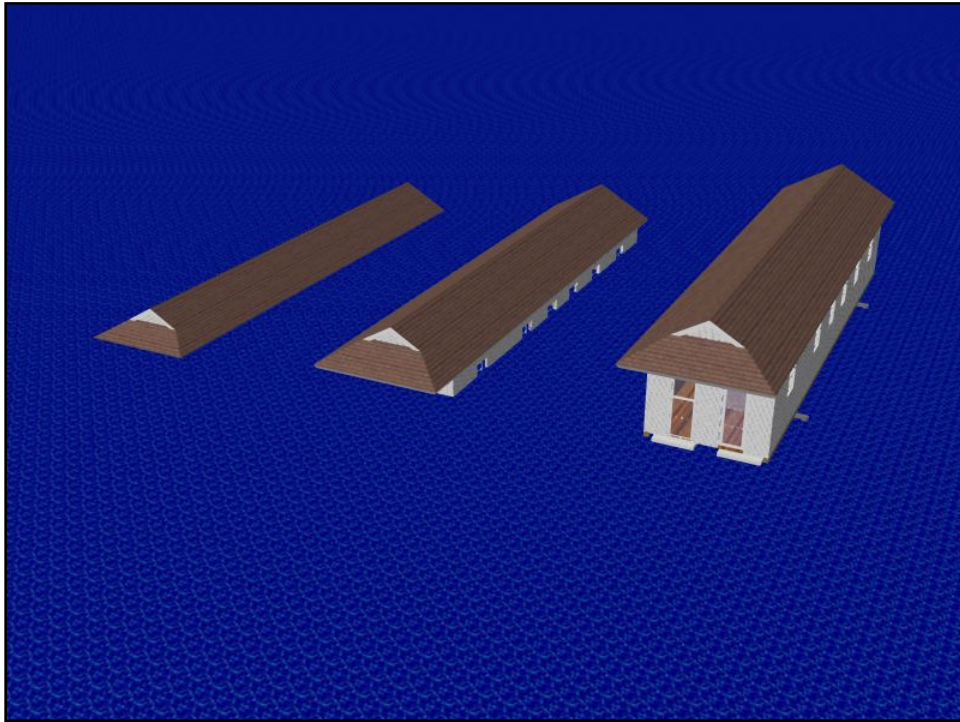
Figure Created by Stuart Broussard

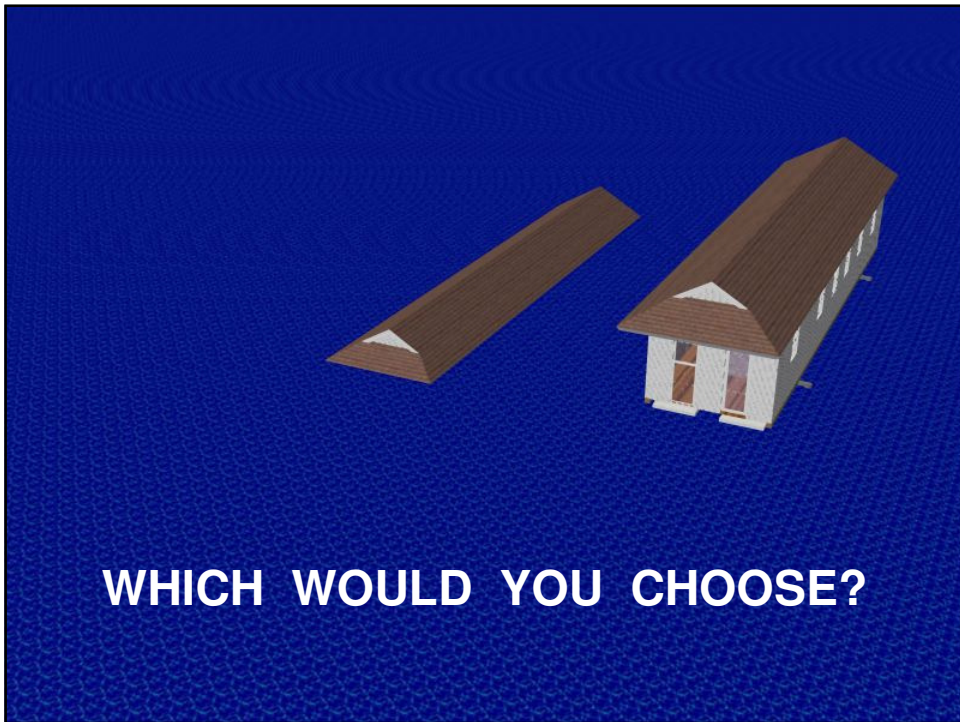
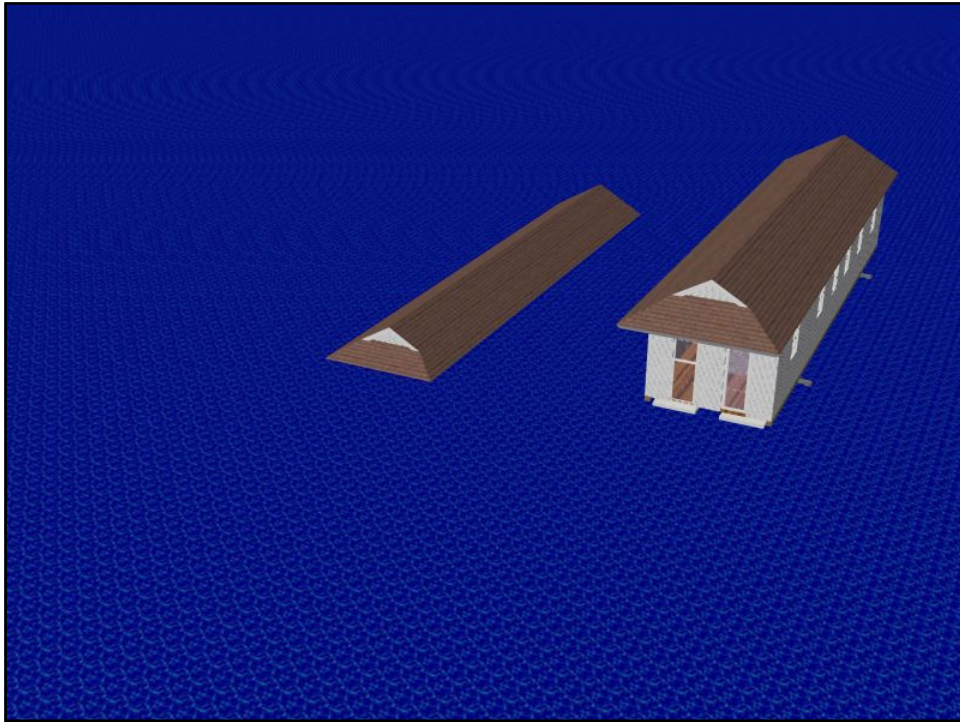
NOW ADD WATER ...

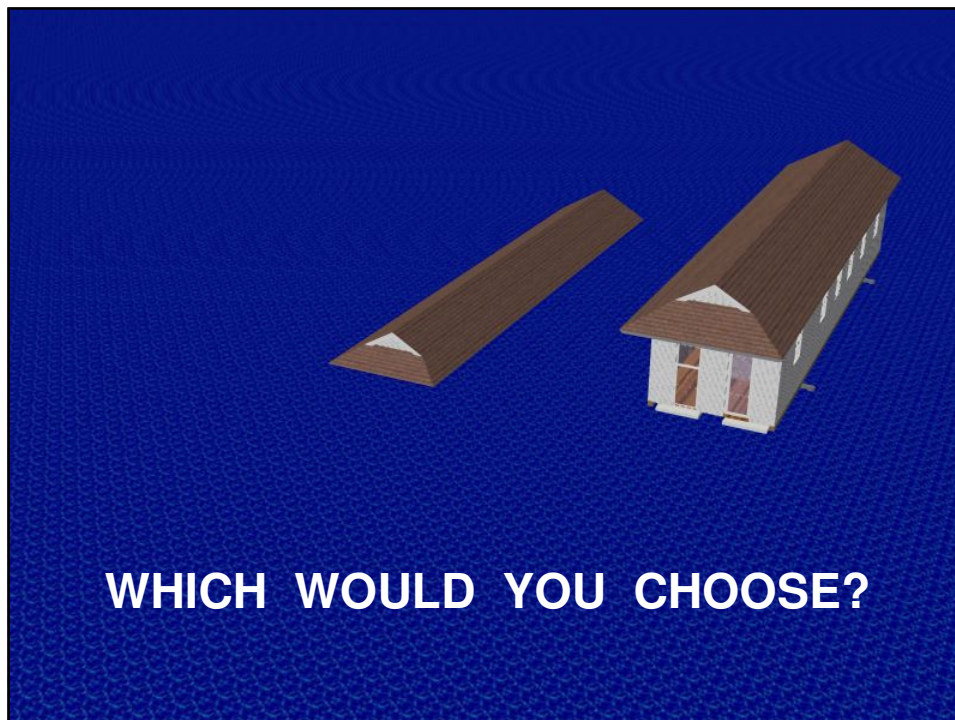












SPRING - SUMMER 2007



**Five LSU Mechanical Engineering students
built a platform with a buoyant foundation to
test the design for flotation and stability:**

**Scott Schroth
Dustin Husser
Dustin Ewing**

**Matt Guidry
Ben Morvant**

**Students from the LSU Hurricane Center added a
house frame and built the flood tank to run the tests:**

**Stuart Broussard
Ezra Boyd**

Construction of prototype: Setting the piers



Adding the platform



Setting the vertical guidance posts

(Note post design has since been changed to telescoping posts)



House frame almost complete



A layer of sand holds down the liner



Now add water . . .



LIFT-OFF!



Buoyant foundation at rest on the water



Water barrels and sandbags are added to simulate weight of house and its contents



Moving the sandbags to tilt the house



Testing complete!



**Buoyant Foundations
Save Shotgun Houses**



Lakeview House in New Orleans



This house in the Lakeview neighborhood of New Orleans was built by a contractor as a commercial spec house. It was completed in the fall of 2007, but to date it has not been occupied. Due to difficulties with the permitting process, the contractor was denied a Certificate of Occupancy . . . but that may soon change.



"FLOAT House" Make It Right Foundation, New Orleans

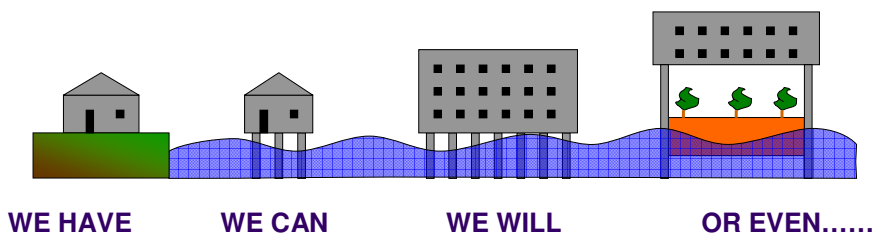


Actor Brad Pitt launched the Make It Right (MIR) Foundation in 2007, promising to give to former residents of the Lower Ninth Ward in New Orleans 150 affordable, sustainable and storm-resistant new homes.

Stuart Broussard & Scott Schroth
Project for
UNESCO Urban Flood Mitigation Workshop
Delft, Netherlands, July 2007



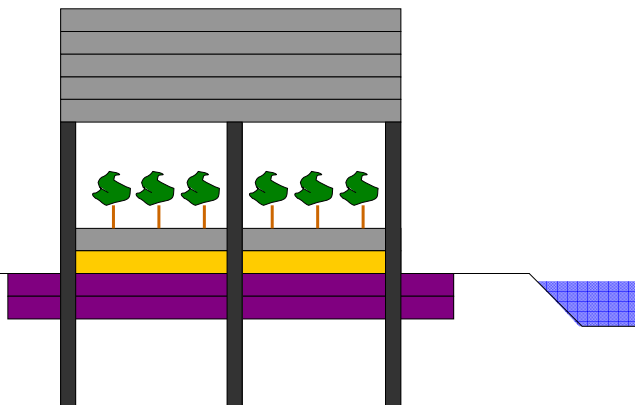
Hybrid Flood Resilient Building



Concept



- Housing
- Shops
- Parking
- Water



Only the 2 lowest levels will float,
not the whole structure

Concept

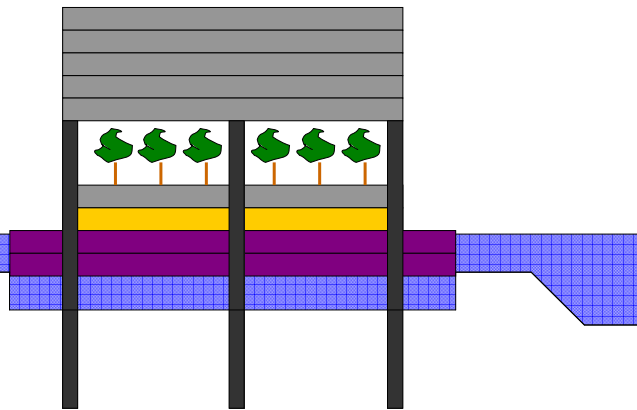


■ **Housing**

■ **Shops**

■ **Parking**

■ **Water**



**Parking garage provides buoyancy
when flooding occurs**

New Community Core Facility



- Can house critical facilities in coastal communities
- Hurricane shelter for local community
- Police and emergency services
- Hospital / health clinic
- Municipal offices
- Library and elementary school
- Community services
- Shops and offices on ground floor
- After a hurricane, if homes do not survive, core facility provides support for rebuilding community

Future Considerations: Using Sustainable Materials

The use of recapped, recycled empty water bottles in place of EPS (styrofoam) flotation blocks:

Bundles of air-filled, sealed plastic bottles can provide both buoyancy and redundancy.



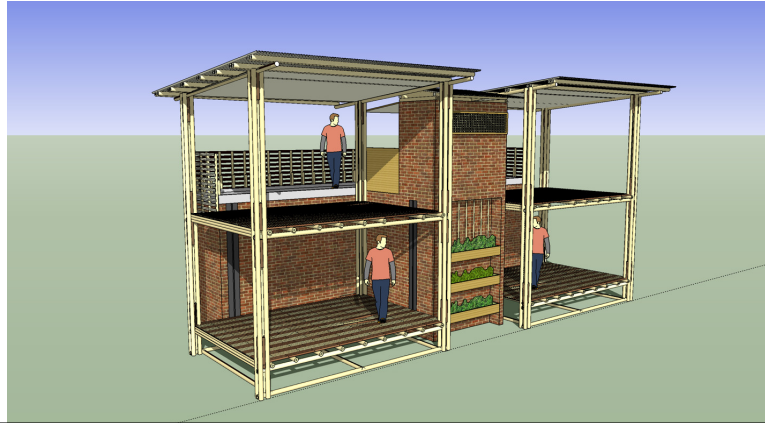
LIFT House, Dhaka, Bangladesh

This prototype of a low-cost, sustainable amphibious house for urban slum-dwellers broke ground in November 2009 in Dhaka, Bangladesh. Initiated and designed by Prithula Prosun,

currently a Master of Architecture student at the University of Waterloo School of Architecture, each unit consists of two to eight floatable bamboo dwellings clustered around a shared courtyard.



The stationary brick base structure contains plumbing, utilities and rainwater storage cisterns. Each two-room amphibious bamboo dwelling unit is living and sleeping quarters for a single family.



DHAKA: November 2009 – Soils testing before the start of construction



Day 1 – Start of excavation, November 12, 2009





Concrete foundation for the service core



Starting the brick walls for the composting latrines and rainwater storage cisterns



Bamboo for the amphibious housing units



Day 10 – Brick foundation walls are started for water cisterns and composting latrine storage



Buoyancy blocks made of recapped empty plastic bottles



Day 11 – Sample buoyant foundation is tested with live load



Building up the water storage cistern walls



Prithula Prosun supervising construction



Day 15 – Bamboo poles are submerged in chemical for treatment



Day 32 – water cistern top slab and brick walls with concrete beams are finished



Day 33 – Ferrocement frame prepared for one of the buoyant foundations



Day 40 – Empty used water bottles are prepared for second buoyant foundation



Day 46 – Brick work is finished and bamboo frame for one dwelling is started



Day 50 – Pre-fabricated bamboo columns for second dwelling are erected



Day 55 – Bamboo frames are erected for both dwellings





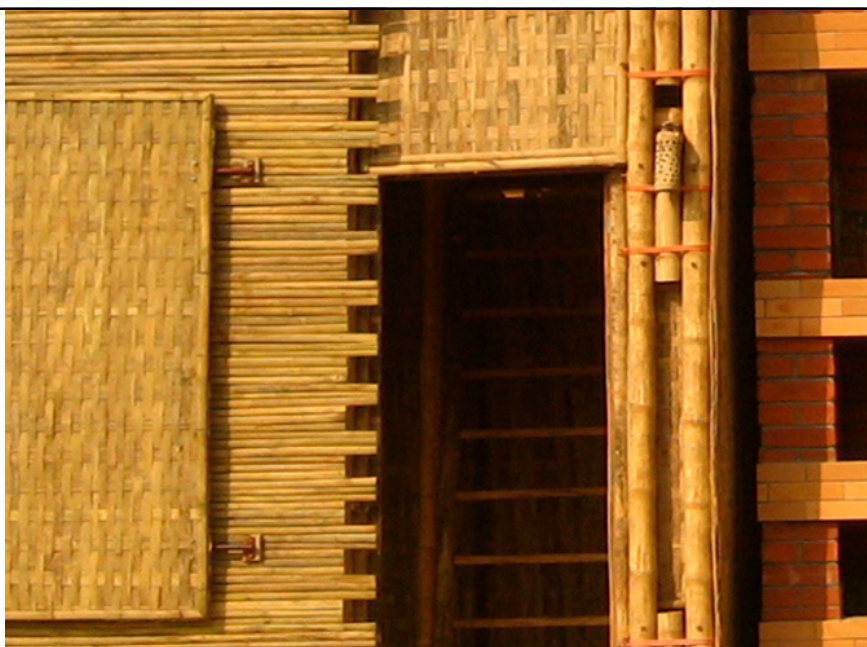
Day 66 – "You will notice in Photo25...the house on the right is higher than the left.. its floating!" (this has the recapped plastic bottle buoyancy blocks)



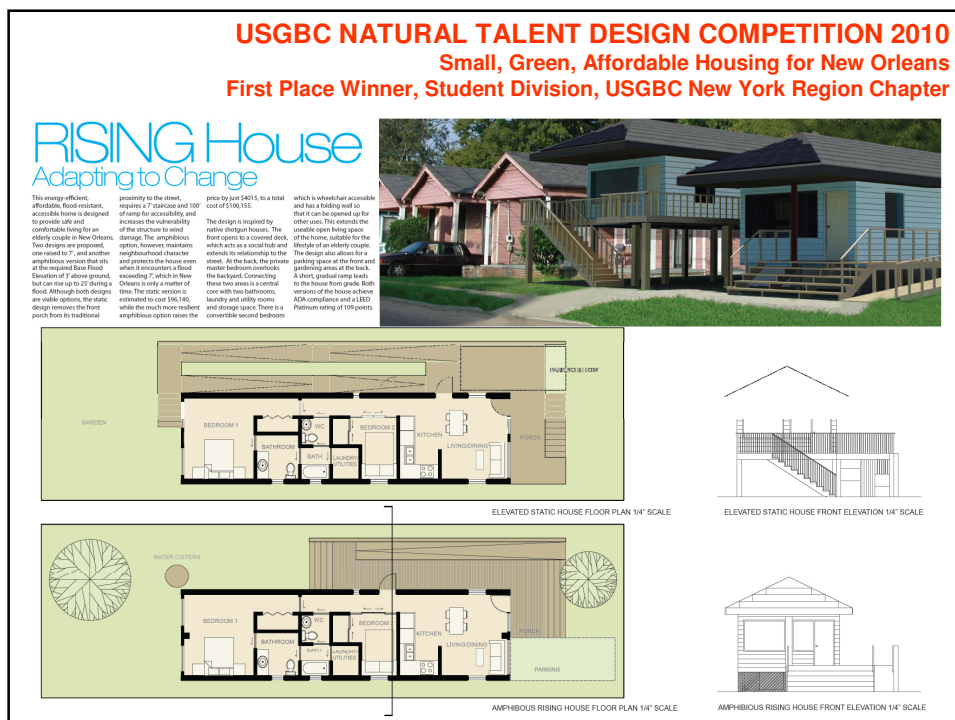
Day 68 – Photo of bamboo entrance door and brick vertical garden

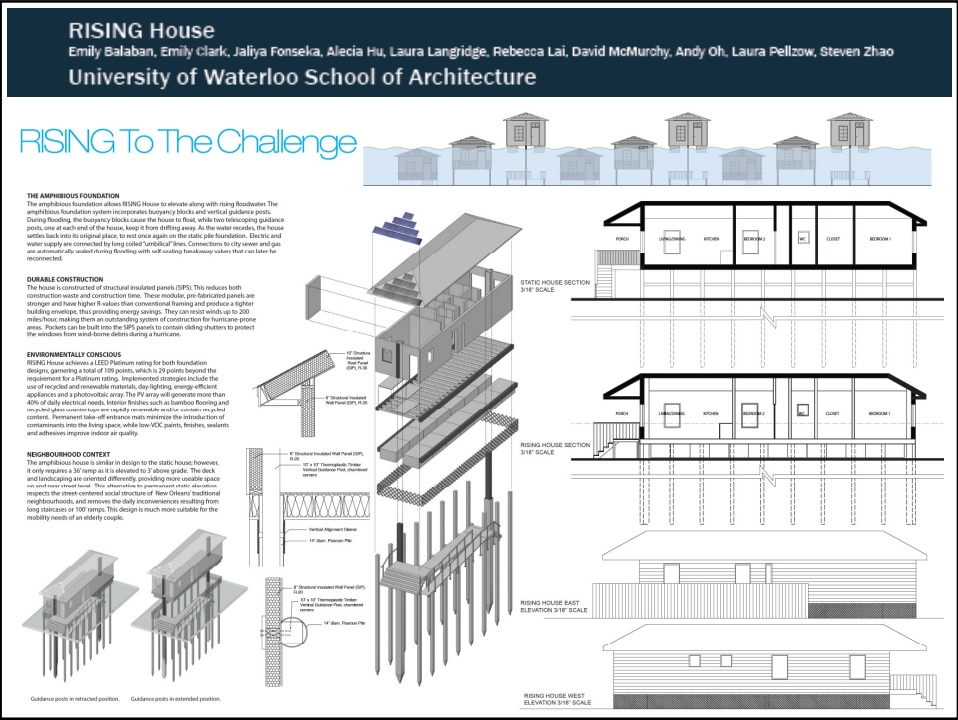


Day 69 – The lift house from across the pond











The *TILT* House

Experiential Learning Center for Sustainability

