Paper presented at the International Conference on Urban Flood Management sponsored by UNESCO-IHP and COST Action C22, "Road Map Towards a Flood Resilient Urban Environment", November 25-27, 2009, Paris, France.

AMPHIBIOUS FOUNDATIONS AND THE BUOYANT FOUNDATION PROJECT: INNOVATIVE STRATEGIES FOR FLOOD-RESILIENT HOUSING

English[1] *E.*

[1] Associate Professor, University of Waterloo School of Architecture, Canada
english@ecenglish.ca

Abstract

Amphibious foundations are a cost-effective, resident-friendly alternative to permanent static elevation for housing in areas where rising flood waters are not accompanied by high flow speeds. There is growing awareness that homeowners in established neighborhoods are resistant to permanent static elevation, a strategy that disrupts a neighborhood's appearance and causes daily inconvenience, with no assurance of providing sufficient protection in an extreme flood event. Amphibious foundation systems retain a home's close proximity to the earth and relationship to the street by supporting the house at a slightly raised elevation under normal circumstances. When flooding occurs, the house floats to as high a level as is necessary to remain safely above water, then settles back into place as the water recedes. Successful amphibious foundation systems are functioning in Maasbommel, Netherlands, and at Raccourci Old River, Louisiana, where they provide flood protection that is both more reliable and more convenient than can be obtained from permanent static elevation. Two new amphibious houses have recently been completed in New Orleans, and a prototype amphibious house for slum dwellers has begun construction in Dhaka, Bangladesh.

In urban areas, amphibious foundations help encourage the preservation of established neighborhoods and existing architectural character. Homeowners in South Louisiana in general and New Orleans in particular are facing difficult decisions about how to comply with new flood protection regulations that privilege permanent static elevation at the expense of accessibility and neighborhood character. The absence of substantial improvements to the levees means that in most neighborhoods the risk of flooding above typical permanent static elevation levels remains significant. The Buoyant Foundation Project is developing an amphibious foundation system for retrofitting traditional New Orleans elevated wooden "shotgun" houses, so that displaced residents will feel safe in returning home to rebuild their communities. Amphibious foundations are a proven, low-cost, low-impact flood protection strategy that gives a community or a region enhanced flood resilience and improves its ability to recover from disaster.

Introduction

In the aftermath of Hurricanes Katrina and Rita, many homeowners in southern Louisiana are required to comply with new government regulations in order to retain their eligibility for flood insurance. For most, this means elevating their houses to comply with the new Base Flood Elevation (BFE) requirements issued by FEMA (the US Federal Emergency Management Agency). Furthermore, in the absence of significantly improved levees, many New Orleanians who do not face official requirements to elevate their houses remain concerned about their safety and wish to improve their protection from flooding.

Permanently elevating houses, in some areas by as much as 12-15 feet, may be FEMA's solution to the problem of flooding but it creates new problems, such as difficult access to living areas, loss of neighborhood character and increased vulnerability of the structure to wind damage. With permanent static elevation, even if a house is raised to the BFE or higher, it can still flood in an extreme event. In the meantime, residents must live with daily inconvenience and a reduced quality of life in the hope of avoiding flooding in a future event that is statistically very rare indeed. A look at floating docks and houseboats suggests that there may be an alternative approach, one that would allow a house to remain close to the ground under normal conditions but rise as much as necessary, even if far above the BFE, when flooding occurs.

Figure 1: Permanent static elevation of homes in south Louisiana. This is the flood mitigation strategy currently promoted by US government agencies.

Background

In February 2006, six months after Hurricane Katrina, I found myself questioning how I, in my position of Associate Professor - Research at the Louisiana State University (LSU) Hurricane Center, could help New Orleanians scattered across the country feel that it was safe to return home, to reverse the diaspora that had siphoned away the people who were New Orleans' heart and soul, the city's authentic cultural source and creative force. For me this meant, could I direct my work in a way that might serve to mitigate the dissolution of New Orleans' core culture? It became for

me a mission to devise a way to make the shotgun houses in the old New Orleans neighborhoods truly protected from flooding, so that the people who used to live in them would feel that it was safe to return and that restoring them was not an exercise in futility; so that the old neighborhoods could be reestablished, so that New Orleans' unique culture, currently displaced, fragmented and endangered, would not become extinct. Endangered plants and animals are protected by the federal government, but who protects endangered human cultures? What could an academic researcher in a technical field do to counteract a set of social and political forces that had compounded into what appeared to be nothing short of a cultural genocide?

Might not restoration of the physical habitat encourage restoration of the culture? Demolition and rebuilding would not reestablish the pre-Katrina neighborhoods, community culture, and culture of community that had flourished there; we would do better if we could "save the shotgun". In fact, the shotgun houses themselves are critical players in this project, because the uniqueness of New Orleans culture is, I believe, in no small part due to shotgun house typology. The strong sense of community at the heart of New Orleans cultural life is a direct response to an absence of privacy in a shotgun house that serves to foster social interaction, both within the house and among the houses in a neighborhood of shotguns.

Shotgun houses need a flood-proofing strategy that does not compromise the relationship of the house to the street or to the other houses in the neighborhood. What they do not need is permanent static elevation, which is occupant-unfriendly, neighborhood-disruptive and unable to provide sufficient protection in an extreme flood, but which is the only elevation strategy approved by the US National Flood Insurance Program (NFIP) and thus the only one FEMA has allowed. A buoyant foundation is a relatively inexpensive, unobtrusive retrofit to a shotgun house that provides it with buoyancy blocks and a vertical guidance system interconnected by a light structural frame, so that the house rises to float on the water when flooding occurs and settles back into its original place when the water recedes. Unlike such risk-concentrating, traditional flood mitigation strategies as levees and floodgates, buoyant foundations diffuse risk and increase a community's resilience. In action, buoyant foundations work with flood water rather than trying to fight it.

Amphibious Housing in Louisiana

There is a growing number of cost-effective amphibious houses around the world. Best known are the amphibious houses designed and built earlier this decade by Factor Architecten and DuraVermeer at Maasbommel in the Netherlands. In rural areas of south Louisiana, there have been clusters of amphibious housing functioning reliably for over thirty years. Raccourci Old River in Point Coupee Parish is one such location. The lake that is called Old River was once a part of the Mississippi River, and remains connected to the Mississippi at one end; thus the water level in Old River rises and falls with the Mississippi's spring floods. Unhampered by building codes in these rural areas, local residents and vacationing fishermen devised an amphibious foundation system that has been keeping their homes and fishing camps dry for over three decades. Large blocks of EPS (expanded polystyrene, or styrofoam) are secured underneath the home which has been raised to an elevation 3 - 4 ft above the ground.

Long poles or pipes are sunk into the ground near the corners of the house. When flooding occurs, the EPS blocks raise the house. Sleeves that have been placed around the poles and attached to the structural frame of the home are able to slide up and down, allowing the home to rise and fall with the level of flooding.

Figure 2: Amphibious houses in rural Louisiana, dry in September, floating in February.

Figure 3: An amphibious house in rural Louisiana, the same house in September and in February.

Make It Right FLOAT House in 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. Morphosis Architects designed the amphibious FLOAT House for MIR. It was completed just a few weeks ago in October 2009. The base of the house is a "chassis" formed of EPS encased in fiberglass-reinforced concrete. It acts as a raft, allowing the house to rise vertically by sliding on two guide posts that pass through sleeves in the chassis, one at each end, inside the house. The house can float up to twelve feet as water levels rise.

Figure 4: The FLOAT House, New Orleans. Elevation, interior guide post and sleeve detail.

Lakeview Amphibious 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 more than a year ago, but to date it has not been occupied. Due to difficulties with the permitting process, the contractor has been unable to obtain a Certificate of Occupancy. The house appears to be supported on a hollow steel box that provides its buoyancy. The box rests on a concrete slab-on-grade. Four wood vertical guidance posts are set near the corners of the house. Each post is attached to the house by two steel sleeves welded to the steel box. The sleeves are capable of sliding up and down on the posts.

Figure 5: Lakeview House, New Orleans. Elevation and detail of connection to post.

LIFT House in Dhaka, Bangladesh

This prototype of a low-cost, sustainable amphibious house for urban slum-dwellers broke ground in November of this year in Dhaka, Bangladesh. Initiated and designed by Prithula Prosun, currently a Master of Architecture student at the University of Waterloo School of Architecture, each independent structure consists of two to eight floatable bamboo dwellings clustered around a shared courtyard. A stationary brick base supporting the dwellings contains plumbing, utilities and rainwater storage

cisterns. Each two-room amphibious bamboo dwelling unit provides living and sleeping quarters for a single family.

Figure 6: The LIFT House in Dhaka, Bangladesh. Eight-unit and two-unit clusters.

Figure 7: The LIFT House in Dhaka, Bangladesh. Concrete and brick base structure under construction; buoyancy block made of recapped, recycled plastic bottles.

The Buoyant Foundation Project

The Buoyant Foundation Project (BFP) is a non-profit research initiative founded in 2006 at the LSU Hurricane Center with the goal of designing and implementing retrofittable buoyant foundations for New Orleans "shotgun" houses.

What is a Buoyant Foundation?

A buoyant foundation is a type of amphibious foundation that is specially designed to be retrofitted to an existing south Louisiana shotgun house. It allows the house to sit just above the ground like a normal elevated house under normal conditions, but to rise up and float safely on the water when there is a flood. It has a structural subframe that attaches to the underside of the house and supports the flotation elements, or buoyancy blocks. Extensions of the structural subframe attach to the tops of vertical guidance poles near the corners of the house that telescope out of the ground to provide resistance to lateral forces from wind and flowing water. When flooding occurs, the flotation blocks lift the house, with the structural subframe transferring the forces between the house, blocks and poles. The vertical guidance poles keep the house from going anywhere except straight up and down on top of the water.

The elements of the structural subframe are inserted underneath the house in pieces. Most of the pieces are small and light enough to be installed by two persons without machinery. After the buoyant foundation is in place, the house remains supported on its original piers except when flooding occurs. Utility lines have either long, coiled "umbilical" lines or self-sealing "breakaway" connections that disconnect gas and sewer lines when the house begins to rise.

Figure 8: Schematic diagrams of the buoyant foundation system.

In 2007 our team of LSU Hurricane Center faculty and students successfully constructed and tested a full-scale prototype buoyant foundation system installed on a platform structure representing the full width (13 ft) and 40% (24 ft) of the full length (approx. 60 ft) of a typical shotgun house.

Figure 9: Full-scale testing of prototype buoyant foundation system. Constuction of prototype; stability test showing floating platform tilted due to unevenly distributed sandbags representing imbalanced live load.

Preservation and Sustainability Considerations

Buoyant foundations preserve traditional shotgun houses. They are considerably less expensive ($20-25k US) than permanent static elevation ($40-60k US). They alleviate any long-term deterioration of protection resulting from soil subsidence and elevated sea level from global warming, something that permanent static elevation

cannot avoid. The house is not permanently elevated and it is therefore less vulnerable to hurricane wind damage.

A house when retrofitted with a buoyant foundation looks essentially the same as it did before, unlike a house with permanent static elevation. The original traditional architecture and the relationship of the house to the street are preserved. New Orleans neighborhoods retain their original, unique character.

The use of buoyant foundations is an approach to flood mitigation that disperses risk rather than concentrating it. They are a low impact solution that improves community resilience. They promote restoration rather than demolition, which is a much more sustainable response to local housing needs. They preserve a form of traditional vernacular housing that is particularly appropiate for the local climate and made of a particularly appropriate local material (native cypress is termite-, mold- and rot-resistant) that is no longer available and thus irreplaceable.

Future directions

We are currently exploring the use of Thermoplastic Timber, a new structural material made of recycled plastic bottles, reinforced with fiberglass from recycled automobile bumpers, to replace the steel in the structural subframe and telescoping vertical guidance poles. We are also exploring the use of containers filled with recapped recycled plastic waterbottles to replace the styrofoam in the buoyancy blocks. Our goal, with proper funding, is to install buoyant foundations on 300 shotgun houses in New Orleans' Lower 9th Ward in the next eight to ten years.

Conclusions

Amphibious foundations are a proven, low-cost, low-impact flood protection strategy that can increase a flood-prone community's resilience in the face of disaster.

Why fight floodwater when you can float on it?

Figure 10: Rendering of a shotgun house retrofitted with buoyant foundation system.