Design and Structural Concerns for Hurricane Resistant Residences

David C. Lewis and Chris Eamon

SCH Report 2

2006

RESEARCH

Arguably, the most hurricane resistant house would be a square reinforced concrete bunker with thick walls and roof, few windows, and no overhangs. But who would want to live there? In light of the two recent devastating hurricanes, and equally significant, the long history of tornadoes, the design and structuring of houses must transform so to adequately respond to the destructive forces without sacrificing the aesthetics or livability of our houses.

There are three areas of concern that homeowners, architects, and engineers should consider. They are: 1) policy, which includes building codes and planning regulations; 2) design and structural concerns, which address foundation, walls, overhangs, and roofing; and, 3) proper construction, which focuses assurance that codes are enforced and correct construction techniques and procedures are used. All three of these areas should be thoughtfully resolved or respected, because if any are not, the safety of the house could be compromised, leading to damage or complete destruction. Realize, however, that all structures have some possibility of failure, regardless of robustness of construction.

Policy

Building codes were developed to insure that a minimum standard is defined for health and life safety of inhabitants and the community. Although not comprehensively adopted, the International Residential Code (IRC, 2003) is the newly accepted standard for residential construction. Since Hurricane Andrew, the state of Florida adopted a stringent hurricane code, which is similar to the IRC's regarding the structural resistance and design loads. The IRC is quite prescriptive about design and construction practices. Information on wind speeds is included. For example, the expected wind speeds for a 50 year mean recurrence interval range from 80 MPH in the northern half of Mississippi to over 150 MPH for the Gulf Coast region. The entire state of Mississippi has a high probability of termite infestation as well as decay. These concerns are relevant because hurricane resistance must consider not only lateral and uplift wind loads but the durability of materials, particularly resistance to insect infestation and moisture-related problems. Regarding hurricanes, there are sections devoted to correct construction practices and techniques for wood frame, steel stud, and masonry construction. It specifically addresses how foundations and walls, along with walls to roofs, are connected, including the type, size, number, and spacing of nails, and the type, thickness, and location of metal strapping.

Design and Structure

General planning and design are geographically dependent. There are two areas of consideration for hurricane loads: near the coast where storm surge is critical, and everywhere else, where wind loads are typically the primary concerns. There is little a homeowner can accomplish within reasonable costs for a light-frame wood house to avoid destruction under extreme storm surge loads. Other than raising the house from the ground to avoid storm surge loads, viable solutions may be to consider alternative construction materials such as reinforced concrete or move the house out of storm surge hazard zones.

No matter the quality of construction, if the original design is flawed, then the house will be susceptible to damage. Some salient design concerns are the shape of the building, the building's relationship with the ground, and the size, extent, and slope of the roof. Keeping house volume small and construction standards high are the most effective means to insure hurricane resistance. A building square in plan is potentially more hurricane resistant than other typical shapes because it keeps to a minimum the area impacted by high lateral winds and uplift loads (Figure 1); however, purpose and quality of construction are also influential. If a square shape does not accommodate the functions of the buildings, then a rectangular building shape should be used. And, if the rectangular shape does not suffice,

then consider more complicated configurations, such as an "L." It should be noted that a poorly constructed square-shaped house is not necessarily more resilient than a well constructed, larger volume rectangular house. Compared to a slab-on-grade foundation, the conventional floor system is potentially more hurricane resistant. A house set on piers benefits the southern house both climatically and structurally. It allows wind to ventilate the crawl space and allows wind and water to flow underneath the house. While the slab-on-grade foundation is less expensive, placing the house on the ground can cause the walls to act like weak dams against storm surges. Although raising the house above ground several feet or so will provide little benefit if the structure is exposed to extreme surge loads. Waves were over 30 feet high in some coastal areas during Hurricane Katrina. A raised floor may help avoid damage from minor surges and may also reduce flooding. Like the shape of buildings, the design of the roof is not a simple matter. Buildings in hot-humid climates, like those along the Gulf Coast, require extensive roof over hangs both to shade the walls and divert water away from the walls and foundation, which protects the house from potential water damage. Under high wind speeds, these expansive roofs generate what physicists and engineers call the Bernoulli Effect, where like an airplane wing, pressure drops on the top surface of the roof due to fast moving air across its surface, lifting up the roof. In other words, the roofs are not blown off, but are pulled up from, the walls. The extent of the overhangs is an issue, although not as significant as the size of the roof. Even for roofs with no overhangs, large uplift forces may be generated on the roof, especially if the area of roof is expansive. Some research recommends that houses should be constructed with no overhangs or that overhangs be open to reduce roof suction forces. The reason for prescribing these conditions is that the highest uplift forces occur at the corners and edges of the roof, whether overhangs are there or not. Particular structural and constructional attention must be made for corners and edges, which has been addressed by building codes in the form of nailing patterns. Recommended nailing patterns can be found in several common building codes – the Uniform Building Code, IRC, and American Plywood Association guidelines, for example, for high- wind regions (greater than 90 MPH). A typical pattern using 8d nails, which are 2 ½ inch long, is shown in Figure 2. This particular recommendation specifies that the interior panels be nailed every 6", for the flat panels along the ridge and eaves also every 6", and for the sloped panels along the gable sides every 4". Some research has indicated, however, that even though the edged panels are nailed more closely spaced than interior panels, they are still more likely to pull up than interior panels. Reducing the spacing of edged panels even further than code recommendations in these high wind regions would improve reliability.

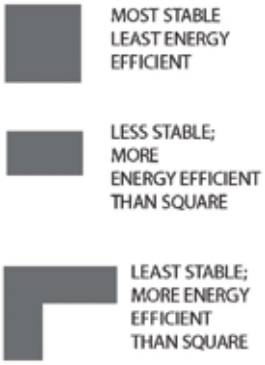

Figure 1. Building Plans

Proper Construction

Proper construction for hurricane resistant building depends on connections between foundation, wall, and roof, connections between walls, particularly at corners, and connections amongst all the components that make up a wall and roof. The nailing pattern regulation is a prime example; nails must be spaced according to codes or by engineer's guidelines. The purpose of architectural construction drawings and engineering shop drawings are to inform the contractor respectively how to erect

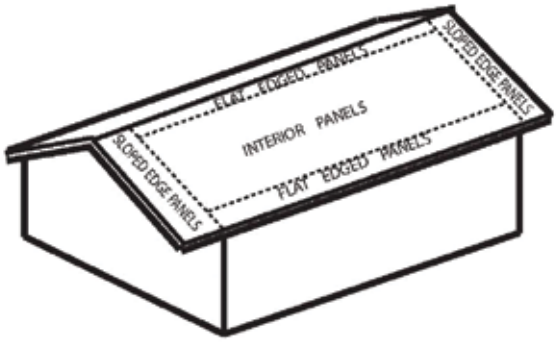

Figure 2. Roof Sheathing Layout and Nailing Pattern.

the building or fabricate the component. It is the contractor's responsibility to follow the drawings and to inform the architect or engineer if there is a problem.

Proper construction can insure against some types of structural damage, while poor construction can dramatically exacerbate problems. The characteristics of fasteners, whether they are nails, screws, straps, strong ties, or adhesives; their size, width, length or diameter, their spacing, their material composition, whether cement coated, galvanized, or hot dipped, affect the structural integrity. The crucial issue is that the building should act unified and interconnected. How the foundation sets in the ground can affect the stability of the roof as well as how well the roof connects with walls affects the stability of the walls.

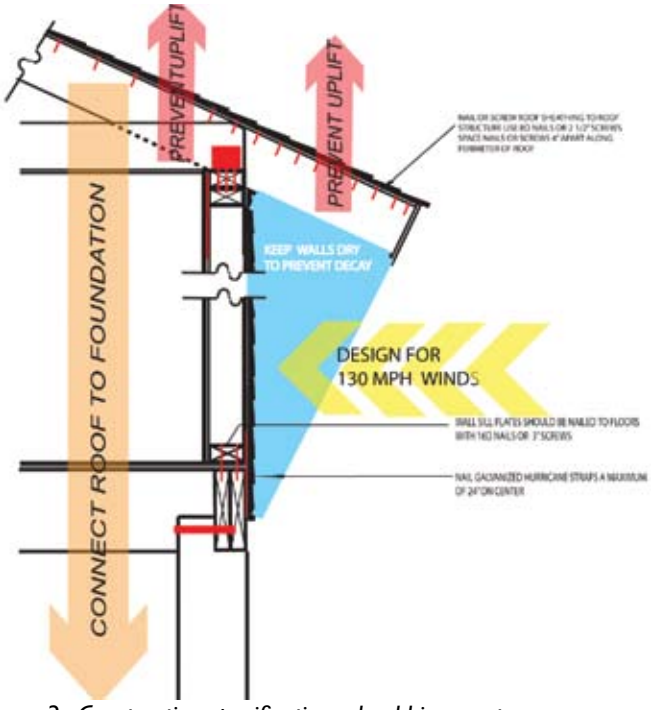

Figure 3. Construction specifications should insure strong connections between foundation and walls, and between walls and roof.

Conclusion

Hurricane resistant wooden houses are not an impossible idea. They require proper respect for the physics of nature, although not without foregoing aesthetic appeal. Homeowners should recognize that the shape of the building, including the roof, may affect the stability. And, that a hurricane resistant shape is not necessarily the most energy efficient shape for a house in a hot-humid climate.

Advanced Housing Research Center
Forest Products Laboratory Madison, Wisconsin
Mississippi State University

The MSU Southern Climatic Housing Research Team is a collaborative effort involving Architecture, Civil Engineering, Electrical Engineering, Forest Products, Landscape Architecture, and Mechanical Engineering. The MSU Southern Climatic Housing Research Team is affiliated with the Coalition for Advanced Wood Structures (CAWS) as a partnership with the USDA Forest Service, Forest Products Laboratory in Madison, Wisconsin. CAWS is a partnership between universities, industry and government to advance research for wood structures related to residential, non-residential and transportation uses.

southern • climatic Housing
mississippi state university

Mississippi State University complies with all applicable law regarding affirmative action and equal opportunity in all its activities and programs and does not discriminate against anyone protected by law because of age, color, disability, national origin, race, religion, sex, handicap, or status as a veteran or disabled veteran.