Storm Surge: a Dangerous and Neglected Hazard

Ricardo A. Alvarez[1]

WIND and ***WATER***! These are the main tools tropical cyclones use to cause direct damage when impacting vulnerable communities in their paths.

Wind can apply loads to buildings through ***wind-velocity pressure***, which can be either *positive* or *negative* depending on whether it pushes or creates suction on a building. Wind also has the capacity to pick-up loose objects or materials from damaged buildings generating *flying debris*, which applies impact loads to buildings during hurricanes.

Water as a *damage component* of hurricanes can take several forms. It can come as *storm surge* that rushes overland applying ***hydrodynamic pressure*** to buildings and infrastructure in its path, or it could be raising water that generates *flooding* and applies *hydrostatic pressure* to buildings as it surrounds them. Water is also capable of propelling various objects as *floating debris*, which can apply large impact loads when hitting a building. Damage can also be caused by *waves* riding above the surge and generating impact loads as they break or run-up against buildings.

Recognizing the potential for damage from the impact of wind engineers have developed standards and methodologies to quantify loads applied to buildings by wind, which are quite detailed and specific and which have been incorporated into the Florida Building Code and the International Building Code. One such standard is the well-known ***ASCE-7*** standard developed by the *American Society of Civil Engineers* [ASCE]. ASCE-7 is so specific that it establishes the ***basic wind speed***, measured as a 3-second gust in miles per hour at a specific location, that structural engineers must use to calculate wind loads and establish design criteria for buildings to resist them.

Relative to water, specifically storm surge, the same standards and codes are much less detailed and lack key data to provide engineers with a practical method to calculate loads generated by hydrodynamic pressure on buildings. One critical piece of data, the velocity of flow, is missing altogether leaving design professionals to make assumptions or to commission other studies or tests in order to quantify loads and arrive at design criteria. The Florida Building Code contains only a generic statement relative to the need for taking into consideration flooding and surge when designing buildings that may be vulnerable to such hazards.

In considering this disparity in the standard regarding how it addresses wind loads and hydrodynamic loads, it is important to highlight that water is on the average 800 times denser that air, and in the case of storm surge since we are talking of salt water, which will in addition be carrying silt as it comes overland and impacts a building, it is possible that storm surge waters are 1000 times the density of air at sea level. That is quite a difference. This huge difference in density accounts for the catastrophic results of storm surge impacts when compared to wind.

To make things even worse, storm surge is being exacerbated by sea level rise, which means that vulnerable coastal locations may be subjected to more catastrophic storm surge impacts in the future. As sea level continues to increase, this will lead to deeper storm surge waters, which increases the velocity of flow and promotes higher waves. Consequently loads from hydrodynamic pressure and wave impact will gradually become stronger in the future.

Clearly there is a deficiency in the way existing standards and codes address building design for storm surge impact. This deficiency must be corrected to provide tools for design professionals so

that design criteria to mitigate the impact of storm surge can be incorporated in every new or retrofitted building in vulnerable coastal locations.

The scientific and research community need to address this problem by focusing on methodology that will provide a velocity of flow and other characteristics of storm surge from a given hurricane, on the basis of location specific parameters. The engineering community will need to work to complement and enhance existing standards and codes, to implement a new paradigm for building design that will result in a reduced potential for damage from the impact of storm surge. The emergency management sector, especially those focusing on mitigation, should embrace and support these efforts for the benefit of vulnerable communities everywhere.

This workshop will articulate the existing problem, and sketch out a framework for the research, engineering and regulatory initiatives that will be necessary to solve it. Comments and questions from workshop participants will help this process.

KEY WORDS: Hurricane; Wind; Water; Storm Surge; Wind-velocity pressure; Hydrodynamic pressure; Hydrostatic pressure; Flying debris; Floating debris; Wave; Wave run-up; Impact loads; Basic wind speed; Velocity of flow.