Coastal Hazards:

The Importance of "Going Green and Building Strong"

Insurance Institute for Business & Home Safety®

Summary

Coastal resilience means taking meteorological realities facing our coastlines into account so the impact of severe weather events can truly become a "bump in the road," rather than an economic and environmental disaster for coastal communities. This is increasingly important based on both demographic and weather trends:

- The latest census report indicates 39% of the United States population lives in coastal counties, and 22.9 million people live in properties at elevations less than 20 feet above high tide (2010 U.S. Census).
- According to AIR Worldwide, the value of insured property in coastal counties from Texas to Maine totals approximately $10.6 trillion.
- According to the Property Claims Services® (PCS®), seven of the ten most costly insured catastrophes in the U.S. were land-falling hurricanes. These storms resulted in an estimated $132 billion in total insured losses (in 2013 dollars) and caused damage in 28 states.
- In addition to economic losses, these and other significant weather events destroyed numerous communities and left mountains of debris that overwhelmed landfills.
- The Insurance Institute for Business & Home Safety (IBHS) believes that "building strong" is critical to helping coastal communities prepare for and respond to current and future storms. Building strong must include thoughtful land-use practices, low-impact design and construction, strengthening of homes and businesses, and making sure "green" structures also meet wind resistance and storm surge requirements.

Meteorology

Even in a landscape of changing large-scale weather patterns and rising sea levels, hurricanes and tsunamis that reach land have been and always will be some of the greatest threats to coastal communities from Texas to Maine, Guam, the Caribbean Islands and the Hawaiian Islands. This threat will continue to grow given the long-term migration of population from inland to coastal communities, and the resulting increase in property values in some of the most vulnerable counties in the U.S.

Damage from tropical cyclones comes from both high winds and storm surge:

- The most vulnerable area is at the immediate coastline, where structures are subjected to the most intense wind and storm surge.
- Storm surge is dependent not only on the internal kinetic energy of the hurricane, but also on its size and the coastal geometry and bathymetry.
- Wind effects can penetrate well inland, even hundreds of miles beyond the effects of storm surge.

In addition, non-hurricane coastal flooding events in recent years have highlighted a growing concern for coastal communities. The increase in extreme precipitation combined with coastal storms, rising sea levels, aging infrastructure, and poor land-use planning has led to greater impacts from events which are far more frequent than hurricanes that make landfall.

- Nine of the top ten annual precipitation totals have occurred since 1990.
- The frequency and intensity of heavy precipitation events is forecast to increase.
- There has been an increase in the average number of coastal flooding days as shown in a recent NOAA report (Sweet et al. 2014).

Case Study

An example of the increasing threat of coastal flooding is the Norfolk/Hampton Roads area of Virginia. The contribution of increasing precipitation extremes, subsidence of -0.5 inches per 10 years, and a sea level rise of 14.5 inches since 1933 has led to a change in the return period of flood events. Of the top ten coastal flooding events, six have occurred within the past decade and only two were related to hurricanes or tropical storms. Two of these events reached 100-year flood levels. This means what was thought to be a 100-year event a decade ago, is now more like a 25-year equivalent flood event. Infrastructure and buildings designed using recurrence intervals from decades ago may not now be able to handle this evolving hazard. It appears that in the face of changing precipitation patterns, what once were considered “nuisance” flooding events will become far more commonplace.

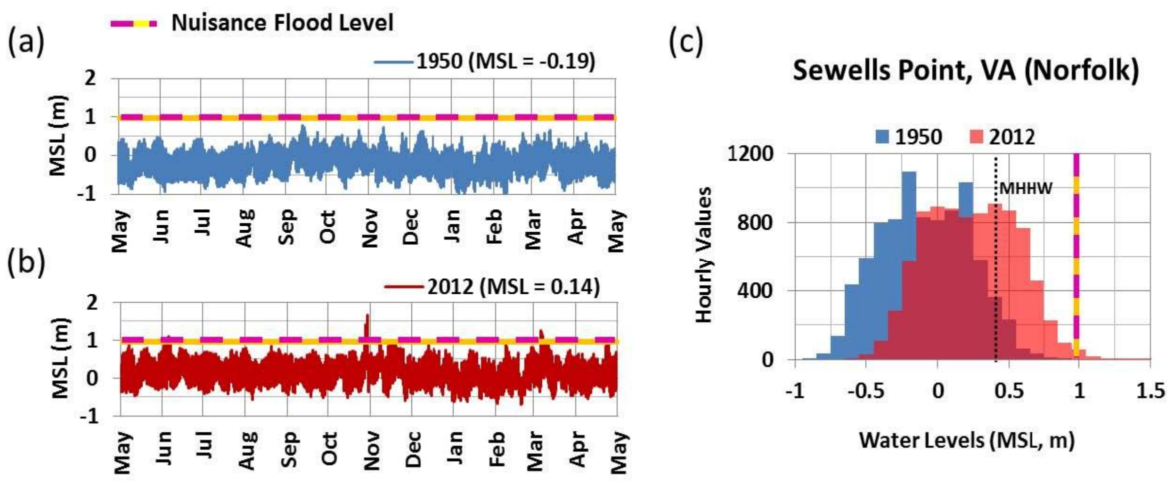

Figure 1: Hourly water level observations at the NOAA gauge at Sewells Point (Norfolk), Virginia for (a) 1950 and (b) 2012 and their (c) yearly water level distribution plotted with the nuisance flood level elevation threshold. All figures are plotted relative to 1980–2001 mean sea level datum and reveal in (a) and (b) a monthly spring-tide influence and a few discrete storm events. Readily apparent in (c) is the increase in mean sea level between 1950 and 2012. Adapted from Sweet et al. (2014).

Coastal Vulnerability Concerns

Our nation's coastlines are vulnerable not only because of the natural effects of extreme precipitation, high winds, and storm surge, but also because of location, design, and construction decisions that put people and property directly in harm's way. As renowned disaster sociologist Dennis Mileti has said, "Disasters do not happen simply as an act of God, but are the result of how we build and design human communities" (Mileti 1999). Here are some of the ways coastal resilience can be undermined by human development of coastal communities.

- Lack of wind-resistant construction
- Insufficient elevation of structures
- Reduction or destruction of natural barriers
- Altering natural drainage basins
- Creating too many impermeable surfaces

With this in mind, coastal resilience solutions should address high winds, storm surge, and heavy precipitation, as discussed below.

Solutions: Strengthening Wind Protections

Figure 2: High wind test in the IBHS large test chamber. The home on the left was built to withstand gust wind speeds of 90 mph while the home on the right was built to the IBHS Fortified level and withstood more extreme wind conditions.

The adoption and enforcement of modern building codes in coastal communities is vital for mitigating the effects of extreme winds from a hurricane that makes landfall. Hurricane Andrew (1992) proved the dual need for stronger building standards coupled with adequate enforcement to ensure these codes are being met. Since then, more than two decades of sound scientific research has helped to influence the development of modern building codes that do a much better job of taking wind hazards into account. However, not all coastal states adopt and enforce strong building codes, as is clear from the wide range of individual state scores in IBHS' "Rating the States" report, which evaluated building code regimes in the 18 most hurricane-prone states. Also, post-disaster field research by IBHS confirms stronger building code systems better protect people and property.

While they provide critical life-safety protections, it is important to understand that building codes represent minimum regulatory standards, and damage can be further reduced through additional voluntary structural and operational hardening, i.e., using hazard-specific design and construction standards. An example of such standards can be found in IBHS' FORTIFIED programs, which are a set of superior building standards that are technically proven and cost-effective at mitigating the effects of high winds beyond the minimum level required by state or local building codes. Homes built to these standards are expected to incur significantly less damage from hurricane winds, protecting both lives and livelihoods.

Solutions: Protection Against Storm Surge

Coastal flood risk traditionally has been stated in terms of its estimated recurrence interval. This, however, gives many people a false sense of security because they think a "100-year flood" can occur only once in 100 years. In fact, within the 100-year flood plain, there is a 26% probability that a damaging flood will occur over the course of a 30-year mortgage, a probability that increases to 40% for a 50-year time span. It is also true that "100-year events" can occur with much greater frequency. During an interview with ABC news in 2010, Federal Emergency Management Agency (FEMA) Administrator Craig Fugate said about the many devastating disasters of 2010, "It just seemed like it was back-to-back and it came in waves … the term '100-year event' really lost its meaning this year."

Unfortunately, significant storm surge events have become increasingly common, with some of the most notable coastal events including Hurricanes Isaac, Ike, Katrina, Rita, and Ivan, as well as post-tropical storm Sandy. A combination of the loss of coastal wetlands, subsidence, and rising sea levels could be contributing to a change in the true recurrence intervals.

When it comes to flooding, the best solution is to choose a property location that is well outside the 100- or (even better) 500-year flood plain. However, this is not practical in coastal areas where the entire community is located in the flood plain. Recognizing this reality, the most effective defense against storm surge has been to elevate structures beyond the water level of an appropriate recurrence interval. The National Flood Insurance Program (NFIP) bases its insurance and elevation requirements on the 100-year occurrence interval (1% annual probability flooding will reach or exceed this elevation) — considered the "base flood elevation" — whereas the IBHS FORTIFIED for Safer Living® standard calls for a higher level of protection at the 500-year occurrence interval (0.2% annual probability). The Bolivar Peninsula case study described below demonstrates the importance of significant elevation in protecting against storm surge.

As important as elevation is for protecting structures, the use of natural defenses can play a critical role in reducing wave energy and resulting storm surge effects. In fact, one study (Sheng et al. 2012) found "a sufficiently wide and tall vegetation canopy reduces inundation on land by five to 40 percent." Simulations of Hurricane Rita's (2005) storm surge showed coastal wetlands were effective in reducing high water levels by one foot for every two to four miles of inland surge penetration (Resio and Westerink 2008). However, it is important to understand that natural defenses and coastal ecosystems have limits and are not static. Slow-moving storms have the potential to overwhelm the effects of natural barriers, while events in quick succession, such as during the late 1990s across the Outer Banks of North Carolina and the northern Gulf Coast in 2004–2005, can take their toll on natural defenses which need time to recover. Because of the limitations of both coastal ecosystems and structural protections, the best way to improve coastal resiliency is to balance man-made defenses with natural ones.

Case Study

Figure 3: Homes on the Bolivar Peninsula following Hurricane Ike (2008). These structures were elevated above the 100-year flood level and built to the IBHS Fortified standard.

The Bolivar Peninsula east of Galveston was devastated by the storm surge associated with Hurricane Ike in 2008. Most homes that were built to the 100-year flood elevation or slightly above were completely destroyed by a storm surge approaching 16 feet with wave action extending peak water levels to nearly 20 feet above the ground (1–3 feet above the 100-year occurrence level). At the time of Hurricane Ike's landfall, 13 homes on the Bolivar Peninsula had been constructed using the IBHS FORTIFIED for Safer Living® standard; therefore, they were built to a 500-year occurrence interval. After the storm, 10 of the 13 homes remained standing with minimal damage, while all other homes in the vicinity were totally destroyed. A driving force behind the survivability of the FORTIFIED homes was the combination of the IBHS program's elevation requirements and additional design and construction material choices made by the homes' builder. Three FORTIFIED houses that did not survive actually were destroyed by the impact of debris from traditionally built homes knocked off their foundations by storm surge. (Reference IBHS' report, Hurricane Ike: Nature's Force vs. Structural Strength.)

Solutions: Protecting Against “Nuisance” Flooding

During the past several years, coastal flood events not associated with tropical weather systems have become more damaging. This is mostly due to land use and development issues, which have drastically increased impervious surfaces, altered natural drainage basins, and reduced the natural ability of ecosystems to store floodwater. This is an issue affecting not only hurricane-prone coastlines, but also all other coastal areas in the U.S. and many inland watersheds as well. Impacts from these events include overwhelmed stormwater drainage systems, road closures, deterioration of infrastructure (e.g., water and sewer systems), and minor inundation of non-elevated structures.

An effective means of mitigating the high-frequency, relatively low-impact flood events is to reduce impervious surfaces through landscape selection that helps contain rapid runoff. Also, retaining topsoil and reducing the wholesale grading of land helps reduce runoff and maintain the natural drainage state. While permits are required to alter drainage within the 100-year flood plain, this process may need to be enhanced as the frequency of events changes.

Steps can be taken to help reduce rapid runoff and the overwhelming of drainage systems through the use of small-scale changes in land-use practices such as:

- **bioswales**: a vegetated, open channel management practice designed to reduce stormwater runoff and mitigate pollutants using vegetation and soils;
- **constructed wetlands**: man-made wetlands effective for the capture, temporary storage, and treatment of runoff. They are designed to replicate natural wetlands and incorporate certain features such as variable water depths and wetland vegetation, which promote multiple pollutant removal processes; and
- **rain gardens**: planting areas installed in shallow basins such that rooftop runoff can be captured and filtered by plants and soil material.

Solutions: “Going Green and Building Strong”

Consistent with coastal resilience, it is imperative to ensure green structures also meet wind resistance and storm surge requirements. An estimated 50% of solid waste results from construction/reconstruction debris, much of it from structures that are damaged or destroyed by severe weather or other disasters. Strengthening buildings will help minimize weather-related damage and associated debris and maintain a smaller carbon footprint by reducing community repairing and rebuilding. Additionally, recognition of the true natural hazard risk as part of the design and construction process tends to produce developments that are more sensitive to natural habitats and more consistent with natural floodplains.

Conclusion

Coastal resilience is defined as the ability of communities to proactively protect themselves against hazardous events and bounce back, rather than simply react, when they occur. It is also the ability to prevent a short-term hazardous event from becoming a community- or even region-wide disaster. It is clear that the combined effects of rising sea levels, increased precipitation, development in coastal areas, and tropical weather systems underscore the importance of resilience in coastal communities and the nation as a whole.

Sound scientific and engineering research has allowed for the development of building practices which can mitigate the impact of high winds and storm surge on structures. Additionally, natural barriers and protective systems should play a complementary role in addressing storm surge and nuisance flooding. The large-scale application of all of these solutions has the potential to create communities that are well-suited to handle current, and hopefully future, coastal weather risks.

References

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