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Determination of Hurricane Related Structural Damage and Review of the Code Requirements

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On August 29, 2005, Hurricane Katrina made landfall as a Category 4 storm that eventually resulted in a breach of the levee system of New Orleans. Interesting enough almost 13 years ago, the Fall 1992 Invention & Technology magazine published an article regarding the City of New Orleans; *“The linchpin of the entire system – pumps, spillways, the works – is the levee.”* *“Taken with the control structures upstream, the levee system around New Orleans could protect the city from virtually any river flood possible. The levees are also built to take a direct hit from a Category 3 hurricane, the other major natural disaster that the city might have to face. A Category 3 generates twelve-foot tides and 130 mile-per-hour winds. In 1969 Hurricane Camille, with twenty-six-foot tides and 190-mph winds, missed New Orleans by sixty miles.”* *“At this point a Camille-type hurricane is about the only thing that could overwhelm New Orleans. Although the pumping system wouldn’t be able to save the city from flooding, it would speed drainage and help bring things back to normal. People would die, but the city would not.”*

Although the City of New Orleans has a unique situation being situated at a level below the mean sea level elevation, it was susceptible to flooding during the Katrina storm event. The damage to structures from hurricanes is generally a result of storm surge, coastal flooding, or wind. Due to the fact that these types of damages are expected, building codes have included requirements for construction to provide life safety, an expected level of building performance and damage control.

Storm surge damage occurred due to the water ahead of Hurricane Katrina. According to the National Weather Service, a Category 4 hurricane has a storm surge generally 13 feet to 18 feet above normal. The storm surge typically resulted in major damage to lower levels of structures near the shore, with a significant number of complete losses due to

the surge. Occasionally some structural components will remain, but are generally destroyed by secondary effects such as floating debris impacting other structures. Section C2.3.3 of the American Society of Civil Engineering (ASCE) Standard, *Minimum Design Loads for Buildings and Other Structures* addresses flood load criteria to be used in the design of structures near the coast. According to ASCE, *“The flood load criteria were derived from an analysis of hurricane-generated storm tides produced along the U.S. East and Gulf Coasts, where storm tide is defined as the water level above the mean sea level resulting from wind-generated storm surge added to randomly phased astronomical tides.”*

From Hurricane Katrina, it is difficult to find structures only damaged by wind and not water. In most instances, those roofs damaged by wind were typically due to the fact that current prescriptive code provisions requirements were not adhered to in the construction. Such violations of the minimum code requirements resulting in damage include; improper roof sheathing attachment to structural members, improper member connections to bearing walls, and improper use of insulation board sheathing in lieu of structural sheathing. In general, roof damage was due to improper uplift connections and attachments as required by the building codes. As well, damage that was latent such as deterioration of subbase material due to the improper installation of products became apparent, such as EIFS being stripped off of rotted underlayment and long-term corrosion of structural members.

According to the American Wood Council of the American Forest & Paper Association (AF&PA), the *Wood Frame Construction Manual (WFCM) for One-and Two-Family Dwellings* was introduced in response to Hurricane Andrew’s destruction in 1992. The manual provides building design for high wind

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areas, especially those structures near coastal areas. AF&PA reported that many of the newer homes, in the impacted area of Hurricane Katrina, performed well due to the fact that they were built to specifications consistent with the requirements of the WFCM manual. In general, the WFCM requires that a continuous load path be provided to transfer all wind and gravity loads from the roof, wall, and floor systems to the foundation. The WFCM also specified the use of raised wood floors to help prevent flood damage. Buildings can be built above ground level, such as on support piles, to allow for rising water levels without significant damage to the residence.

In January 1999, The National Association of Home Builders Research Center published the *Reliability of Conventional Residential Construction: An Assessment of Roof Component Performance in Hurricane Andrew and Typical Wind Regions of The United States*. The Hurricane Andrew performance evaluation concluded the following:

“Actual performance (i.e. 69% of the homes losing at least one roof sheathing panel) was significantly worse than an acceptable level of performance (i.e., 15% of the homes experiencing roof sheathing damage) given the magnitude of Hurricane Andrew and the level of safety

implied or expected for conventionally-built homes in low wind regions of the United States.”

“Although slightly conservative, revised roof sheathing attachment requirements following Hurricane Andrew are practical and will significantly reduce the likelihood and extent of roof sheathing damage for future homes experiencing major hurricane events in South Florida.”

“Current design wind load provisions can be used to reasonably predict damage to roof sheathing on homes provided wind exposure, wind directionality effects, and internal pressurization is properly considered.”

A large portion of the damage to the residences impacted by Hurricane Katrina is the result of coastal flooding and general flooding due to rain. In addition to coastal flooding, the breach of the levees in New Orleans resulted in flooding. Typical flooding damage resulted in water damage to interior finish and contents. In many cases, these homeowners do not carry flood insurance. ASCE 7 provides the minimum requirements for determining flood loads and load combinations for buildings and structures located in flood hazard areas. ASCE 7 recognizes that the most important flood loads for structural design occur where the depth of flooding is greatest. The ASCE 7 load factor used in structural design (hydrostatic, steady flow, and wave

forces) is based on calculations of still-water depths ranging from 4 to 9 feet and applies to a wide variety of flood conditions. In addition, ASCE 24 was developed to provide minimum requirements for flood resistant design and construction of buildings and structures located in flood hazard areas.

Hurricanes can cause significant damage to structures due to wind, storm surge, and flooding. The building codes and various manuals provide structural designers the methods to minimize the associated hurricane-caused damage to the structures, prevent failures, and provide for life safety. Based on our review of structure damage due to hurricanes, much of the damage could have been prevented with proper design and construction that is in accordance with the adopted building codes and material guidelines and standards.

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