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FLOOD PROTECTION

Hurricane Protection System Reviewed, Deemed Successful during Hurricane Gustav

ACCORDING TO a recently published report, the upgrades and repairs to the New Orleans area levee system in the wake of Hurricane Katrina, which struck in 2005, successfully withstood the rising waters brought by Hurricane Gustav, which struck on September 1, 2008. The city was thus protected from flooding associated with the hurricane's storm surge. This was achieved even though the U.S. Army Corps of Engineers was still in the process of upgrading levees, floodwalls, flood gates, and pumping stations there.

These conclusions appear in the report *Reconnaissance of the New Orleans Hurricane and Storm Damage Risk Reduction System after Hurricane Gustav*, which was published in February of this year by the California-based Geo-engineering Extreme Events Reconnaissance Association. The study was completed with the aid of funds provided by the National Science Foundation and was authored by R. Lee Wooten, P.E., M.ASCE, Robert B. Gilbert, Ph.D., P.E., M.ASCE, William F. Marcuson III, Ph.D., P.E., Hon.M.ASCE, Leslie F. Arder, Jr., Ph.D., P.E., M.ASCE, and Peter G. Nicholson, Ph.D., P.E., F.ASCE. (ASCE was not involved in preparing the report.)

According to the Corps of Engineers (www.mvn.usace.army.mil/hps2/hps_background.asp), Katrina reached land at Buras, Louisiana, on August 29, 2005. A category 5 storm on the Saffir-Simpson scale less than 12 hours before making landfall, it had been downgraded to category 3 by the time it reached land. Even so, Katrina generated a 28 ft (8.5 m) storm surge with 55 ft (17 m) waves. The rising water overtopped New Orleans's hurricane protection system of levees and floodwalls in a number of areas and breached some floodwalls before the water reached their tops. These events, combined with the 14 in. (356 mm) of rain that fell within a 24-hour period, compromised 48 percent of the city's levee protection system.



According to the February report, Gustav made landfall just west of Grand Isle in Cocodrie, Louisiana, on September 1 as a category 2 hurricane with sustained winds of about 110 mph (177 km/h). Its storm surge reached a maximum level of approximately 14 ft (4.3 m). On the Inner Harbor Navigation Canal (IHNC), which links the Mississippi to Lake Pontchartrain, waves overtopped floodwalls during the maximum surge from Gustav, which occurred at a level that was roughly 3 ft (0.9 m) lower than the maximum Katrina surge.

According to the report, aspects of the hurricane protection system found wanting during Katrina included the design strength and structural response of I-wall sections and a lack of overtopping protection, as well as "vulnerabilities to erosion at transitions between different components of the system, use of erodible materials for construction of earthen levees, improper design heights for hurricane protection components, and [a] general lack of resilience and/or redundancy for critical life safety structures."

The report credits the efforts of the Corps in providing an improved level of protection to New Or-

The storm surge on September 1, 2008, from Hurricane Gustav was held back by the Inner Harbor Navigation Canal's new east T-type floodwall, center background, and upgraded I-type floodwall, left foreground, near the Lower 9th Ward. The east floodwall had been breached during Hurricane Katrina.

leans in the brief period since Katrina. Indeed, it says that "some amount of breaching and damage may have been averted due to these improvements."

The work that the Corps completed prior to the arrival of Gustav included increasing the height and erosion resistance of earthen levees, increasing the stability and height of floodwalls, hardening the

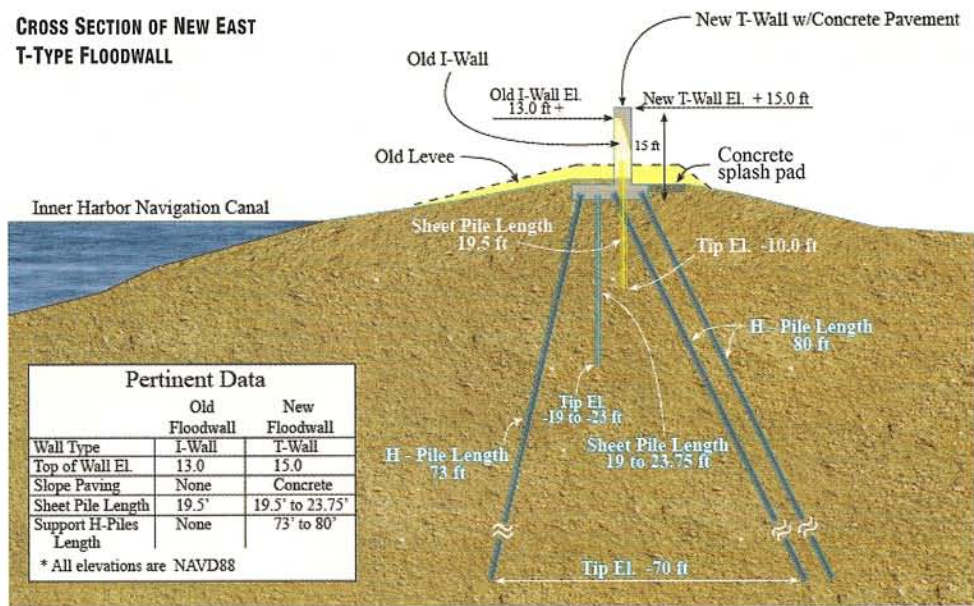
protected sides of floodwalls and the transition points between floodwalls and levees with grouted riprap or concrete splash aprons, and constructing interim floodgates and large pumping facilities along the city's three drainage canals. Moreover, 30 of the city's 73 pumping stations were in the process of being repaired, modified, or rebuilt to remain operational during storms when Gustav struck.

The report concludes that the current and future configurations of the federal levee system that protects the city against rising waters induced by hurricanes and storms "are significantly superior" to what existed before Katrina.

Data for the report were collected during the team's visit to nine sites within the federal levee system located along three major waterways: the Mississippi River-Gulf Outlet, located to the east of the city; the IHNC; and the portion of the Gulf Intracoastal Waterway that extends into the city from Lake Borgne, bisecting the IHNC. The team also visited a nonfederal levee in Plaquemines Parish, southeast of New Orleans, that was in an impaired state. Team members observed the points of the levee protection system that they understood to have been most affected by Gustav.

According to the report, the team did not detect any evidence of seepage distress at transitions between differing types of levees and floodwalls; nor did it find significant underseepage distress in

CROSS SECTION OF NEW EAST T-TYPE FLOODWALL



Not to scale

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the areas surrounding levees. Moreover, the floodwalls that were loaded with still water to their tops did not exhibit any signs of structural distress. Walls that were overtopped did not exhibit any signs of erosion on their outer sides.

The report notes that the speedy removal of all large, floatable objects from areas susceptible to flooding, for example, rail cars, tanks, shipping containers, boats, and barges, during an evacuation order will be crucial for the continued success of the hurricane protection system. Because of the collision risk that these items pose to the floodwall system, their removal will be of the utmost importance in protecting the structural stability of the hurricane protection system, particularly along the IHNC and the Gulf Intracoastal Waterway.

Despite the good news pertaining to the federal levee system, the team found that the nonfederal earthen levee located to the southeast of the city in

Plaquemines Parish had been in danger of failing during Gustav. According to the report, much of the levee had been overtopped, and a slide approximately 300 ft (91.5 m) long with a scarp of approximately 1 ft (0.3 m) occurred on the outer side of the levee. The team noted that this levee could be improved by implementing such measures as requiring better materials, controlling water content, and compacting the soil used to build the levee. The report found that a network of desiccation cracks formed in the levee's soil prior to Gustav, a development that may have affected the structural integrity of the levee by providing ready entry points for the floodwater. The team noted that "improved control of placement water content and compaction, revised material requirements relative to plasticity and organic content, or landscaping measures such as establishment of dense vegetation may be required to prevent desiccation."

Additional work that is expected to be completed on the federal levee system by 2011 includes raising levees,

floodwalls, and gate structures to provide protection from 100-year flood levels and completing the barrier across the Mississippi River–Gulf Outlet and the Gulf Intracoastal Waterway to protect these waterways from surge in Lake Borgne. The conceptualization of a floodgate to be designed and constructed for the IHNC at Lake Pontchartrain also is under way. (See "Corps's Largest Design/Build Civil Works Project to Shield New Orleans," *Civil Engineering*, July 2009, pages 22–23.)

The report concludes that although the upgraded levee system operated successfully during Gustav, "protection of life in the southern Louisiana area will require continued emphasis on evacuation." Storm surges larger than those brought by Gustav and Katrina are to be expected. According to the report, it will take years, if not decades, to upgrade the federal levee system to ensure that New Orleans is fully protected.

The complete report may be viewed by clicking on "Post-Event Reports" at www.geerassociation.org.

—CATHERINE A. CARDNO, PH.D.