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Design Shortcomings Seen in New Orleans Flood Walls

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NEW ORLEANS, Sept. 20 - Along the Mississippi River and Lake Pontchartrain, great earthen levees were ample to hold off much of the surging water propelled by Hurricane Katrina.

But concrete flood walls installed over the last several decades along the drainage and barge canals cutting into New Orleans were built in a way that by Army Corps of Engineers standards left them potentially unstable in a flood, according to government documents and interviews. The walls collapsed in several places during the storm.

A corps engineering manual cautions that such flood walls "rarely exceed" seven feet because they can lose stability as waters rise. But some of the New Orleans canal walls rose as high as 11 feet above dirt berms in which they were anchored.

As a result of federal budget constraints, the walls were never tested for their ability to withstand the cascades of lake water that rushed up to, or over, their tops as storm waves pulsed through the canals on Aug. 29, corps and local officials say.

Hurricane Katrina was the first serious test of the flood walls, said Stevan Spencer, chief engineer for the Orleans Levee District, and it "just overwhelmed the system."

Since the storm, corps officials have said that there is a simple explanation for the devastation: Hurricane Katrina was a Category 4 storm and Congress authorized a flood control system to handle only a Category 3 storm. "Anything above that, all bets are off," said Al Naomi, a senior project manager in the corps's New Orleans district.

But federal meteorologists say that New Orleans did not get the full brunt of the storm, because its strongest winds passed dozens of miles east of the city. While a formal analysis of the storm's strength and surges will take months, the National Hurricane Center said the sustained winds over Lake Pontchartrain reached only 95 miles per hour, while Category 3 storms are defined by sustained winds of 111 to 130 m.p.h.

This raises a series of questions about how the walls that failed were designed and constructed, as well as whether the soil in some spots was too weak to hold them. Investigations by federal engineers and outside experts are just now beginning.

One factor could be height, said Robert G. Bea, a former corps engineer and professor at the University of California, Berkeley, who is part of a National Science Foundation

inquiry into the flood controls failures. The higher the wall, Professor Bea said, the greater the risk it could tip under the ever greater pressure of rising waters.

The 2000 edition of the Army Corps of Engineers manual "Design and Construction of Levees" says that the height of flood walls built on levees is an important factor in their ability to withstand a flood. For that reason, the manual says walls like those used in New Orleans "rarely exceed" seven feet. But on two of the three canals where breaks occurred - the 17th Street and London Avenue canals - the concrete sections rise 11 feet above the dirt berms.

Each wall resembles a row of teeth set in a jaw. Individual slabs are anchored to a continuous steel sheet buried in the dirt, giving the wall its strength. Above a short foundation, the slabs are linked only by rubbery gaskets that allow the concrete to expand and contract without cracking.

Hassan S. Mashriqui, an engineering professor at Louisiana State University and an expert on storm surges, said the segmented nature of the walls could be an additional problem, since any weak point could cause a catastrophic failure.

"Since they're not tied together you get a little bit of a gap and that's what water needs to make it fail," Dr. Mashriqui said.

Other questions surround the walls' design, known as an "I-wall" for its slim cross section that fits easily into densely developed areas.

The corps manual for flood control construction suggests a different design for walls higher than seven feet - walls shaped like an inverted T, with the horizontal section buried in the dirt for extra stability.

But that option was never considered, corps engineers said, because "T walls" were more expensive, required a broad base of dense soil for support and were not necessarily stronger.

The corps and local levee authorities also never tested whether the chosen I-wall design could survive if water flowed over the top and cascaded onto dirt embankments below.

Corps officials said they were proscribed from considering stronger wall designs for the canals both by the tight quarters and by federal law, which requires that they seek and study only the level of flood control authorized by Congress.

"Our hands are tied as to looking at higher-level events," Mr. Naomi said.

Mr. Naomi said that the recommendations in the flood control engineering manual were "general guidance," and that conditions at a particular site could justify deviations.

He defended the walls, saying: "The flood walls have functioned over the years very successfully and without incident. The design works. It has worked in other locales. And will likely continue to be used as long as you do not subject it to pressures that it was not designed to handle."

The broken walls, which were long seen as a second choice to earthen levees, are testament to 40 years of fiscal and political compromises made by elected officials, from local levee boards to Congress and several presidential administrations, as they balanced costs and environmental concerns with the need to protect a city that lies largely below sea level and is still subsiding.

Ever since Hurricane Betsy flooded parts of New Orleans in 1965, the federal government has financed a hurricane defense system designed to guard against an equivalent storm.

But as the threat of a more intense hurricane became better understood in recent years, government financing for flood prevention in New Orleans did not keep pace with a growing alarm among many local residents, scientists and even the corps's own engineers.

Standing next to the shattered remains of one of the concrete walls last week, Cynthia Hedge-Morrell, a New Orleans councilwoman, said, "In my opinion, they were playing Russian roulette with people's lives."

"Do you realize that if those walls had held, we'd have just had a little cleaning job?" said Ms. Hedge-Morrell, whose district between downtown and the lakefront was covered with 10 feet of water from the breaks of flood walls. "We would not have this massive loss of life and destruction."

On Tuesday, streams of dump trucks hurriedly dumped loads of gravel into the breaches in New Orleans's flood defenses, in case Hurricane Rita shifts toward here later this week.

In the wake of Hurricane Katrina, a surge from Lake Pontchartrain poured into the main parts of the city through breaks on the walls lining the 17th Street and London Avenue canals, which normally carry runoff pumped out of the city into the lake. A separate surge from the Gulf of Mexico overwhelmed the walls along the Industrial Canal, inundating the Lower Ninth Ward. Officials say that break may have been caused by a barge that broke loose from its moorings.

When the hurricane hit, the only earthen levees that failed in a way that produced substantial flooding were on the Mississippi River Gulf Outlet, a man-made ship canal east of the city. These levees, which were not as high as those on the river or Lake Pontchartrain, let in the floodwaters that ravaged eastern New Orleans and St. Bernard Parish.

A surge from Lake Pontchartrain was the catastrophic situation that the corps had been guarding against since Hurricane Betsy 40 years ago. Initially, the corps wanted to build a giant barrier to keep water from the Gulf of Mexico from reaching Lake Pontchartrain and flooding the canals.

That project was delayed by lawsuits from environmental groups that contended the corps had failed to study ecological effects. By the late 1970's, the corps abandoned that approach and began raising levees along the lake and the [Mississippi](#) and adding flood walls on the canals.

In the mid-1990's, engineering professors at [Louisiana](#) State began publicizing computer models that showed how a Category 5 storm could kill tens of thousands of people and flood the French Quarter. Corps officials in Louisiana pushed local officials to help seek more money from Congress, both to finish existing upgrades and to start bolstering the city against bigger threats.

Joseph Suhayda, who was one of the Louisiana State professors, said corps officials privately urged him to "raise the consciousness" about the dire threats.

But upgrading the flood control system never became a major priority for corps officials in Washington, local and federal officials say.

Corps veterans said it was not surprising that federal engineers did not issue more vocal warnings.

"I don't think it was culturally in the system for the corps to say 'this is crazy,' " said William F. Marcuson III, the former director of the Waterways Experiment Station for the corps in Vicksburg, Miss., and president-elect of the American Society of Civil Engineers.

"The corps works for Congress," Mr. Marcuson said, "and when the boss says design for a Category 3 storm, culturally the corps is not going to go back and say this is wrong."

Investigations into how the walls failed are just now beginning. Col. Richard Wagenaar, commander of the corps district in New Orleans, said the soil behind the flood walls could have been weakened after they were topped by the storm surge, or the walls could have simply given way as the water - and the pressure - mounted against them.

Indeed, as several engineers said, while a dirt levee of similar height might eventually be topped as well, and possibly eroded, only the walls were vulnerable to a sudden collapse.

The determination of how the walls fell will bear on how officials decide to remake the flood control system.

Max Hearn, executive director of the Orleans Levee District, said that if the federal government was now ready to pay for Category 5 protection, it seemed unlikely that the flood wall system could be upgraded to that level.

But Mr. Hearn said the only answer might be the construction of flood gates designed to limit a hurricane surge in Lake Pontchartrain - the same idea that was considered and dropped in the 1970's.

Christopher Drew reported from New Orleans for this article and Andrew C. Revkin from New York.