

Designing For *Hurricane Zones*

— Craig A. Shutt



Precast concrete's durability and strength make it a strong choice to withstand hurricanes, but designers must take such storms' unusual factors into account



Gulfport's U.S. Courthouse, designed to meet federal requirements for blast loading and other stringent zoning codes, withstood Hurricane Katrina's impact better than surrounding buildings.

'Precast concrete buildings have performed remarkably well under the most challenging environmental conditions and events.'

The devastating impact of last summer's hurricanes, notably Katrina and Rita, have every member of the construction team considering ways to ensure such damage cannot occur again. Precast concrete structures stood up well to the barrage of natural forces, withstanding much that destroyed other buildings. But even some of these structures had not accounted for all of the forces such hurricanes bring to bear.

As owners, designers, engineers and insurance companies examine the aftermath and consider solutions, they are seeing that precast concrete designs can offer some solutions, particularly for housing designs that already are being used in other areas impacted by tornados and other natural threats.

says Mitch Dees, project manager with Gate Precast in Monroeville, Ala., which worked on several projects in the affected areas. "In many places, only the steel was left standing."

Dees points to one project in particular, the Federal Courthouse in Gulfport, Miss., which was subjected to 132-mph winds during the height of Hurricane Katrina. The courthouse was designed to federal blast-resistance standards in 2001 and features architectural precast concrete panels with granite cladding around the base and entryway. The only apparent damage to the building was a few broken windows, a small area of broken granite and a few missing letters above the building's main entry.

Although some of the field-installed granite along the precast base of the building was damaged by wind-borne debris, Dees stated that the precast panels behind the granite cladding remained unaffected by these forces. Many neighboring buildings were severely damaged or destroyed because they were not constructed under the same precast-design criteria as was required for the courthouse.

Gate Precast also worked on a parking structure nearby the courthouse, consisting of a cast-in-place structure with architectural precast cladding, a significant portion of which consisted of brick-inlay panels. This structure also performed well during the hurricane, with no apparent damage to the precast panels.

"In areas that are prone to hurricanes, we are required to follow stringent zoning codes and design factors for reinforcing and connections," Dees notes. "Both the courthouse and parking structure were designed extremely well to meet the design-load criteria, which proved to be a tremendous asset in withstanding the forces they were subjected to by Hurricane Katrina."

Wind Damage Minimized

Throughout the Gulf Coast, structures clad with architectural precast concrete panels performed well against wind loads, thanks to their durability and the strength of the connections. Engineers, precasters and other observers in the area after the hurricanes passed through noted that many other buildings had been destroyed. "You could see right through some buildings, especially those that had steel frames and brick façades,"



'Water laden with heavy debris poses a tremendous impact on a structure.'

Due to the storm surge, the courthouse complex was closed temporarily while restoration efforts took place to dry the building's interior. Courthouse employees were able to return to work much sooner than if another product had been used on the exterior, Dees adds.

"It was extremely difficult to see the degree of devastation inflicted on the Gulf Coast area by Hurricane Katrina. On the other hand, it was impressive to see just how well architectural precast can perform under these extreme conditions."



Much of the damage done to precast concrete parking structures along the Gulf Coast by Hurricane Katrina was caused by the high storm surge, which flooded the structures and caused double tees to be pushed off their supports. Otherwise, the material performed well.

Surge And Scour Impact Structures

While winds caused some concerns, the wave surges faced in New Orleans and other oceanfront locations created some unexpected forces. "When you're dealing with areas below sea level and the levy breaks, there is a

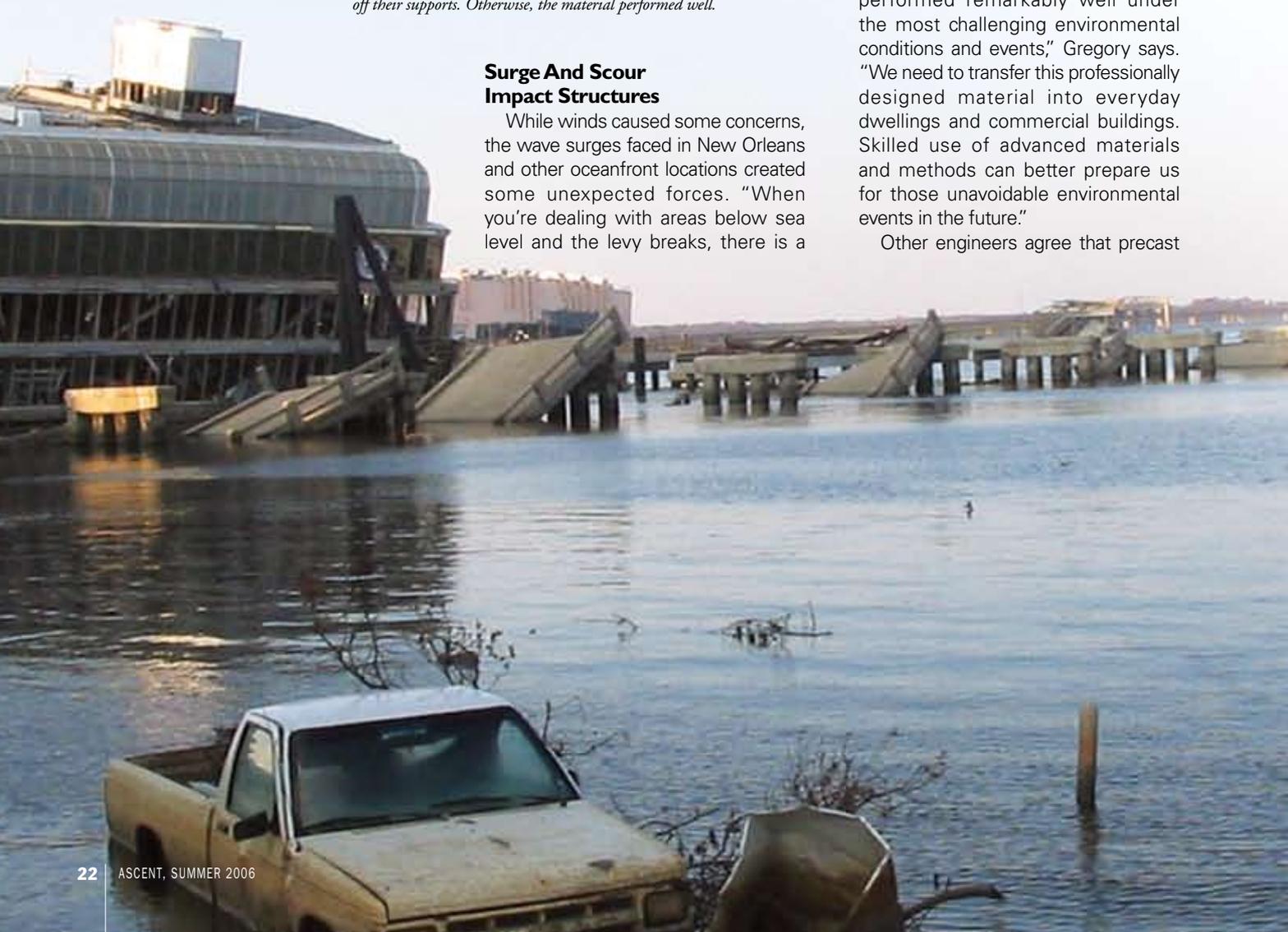
tremendous influx of water at a rapid rate," explains Ed Gregory, principal in Gregory Development Service Inc. (GDS) in Glenn, Mich. That surge gathers debris torn loose by winds and other forces, which poses added danger to structures in addition to the added load from the water itself. "Water laden with heavy debris poses a tremendous impact on a structure."

There is also the problem of scour, which results from water surging beneath a slab on grade. This action loosens the soil beneath the concrete, causing it to deteriorate or break up, resulting in a building that uses the slab for its base to tilt or become unstable.

Another unanticipated problem arose from the extraordinarily high level of water that surged into some of these communities. Between 12 and 18 feet of water covered some buildings as the water surged in off the ocean. These incredibly high water levels created the only true problem for precast concrete buildings, particularly parking structures built along the oceanfront.

"Professionally designed precast, prestressed concrete buildings have performed remarkably well under the most challenging environmental conditions and events," Gregory says. "We need to transfer this professionally designed material into everyday dwellings and commercial buildings. Skilled use of advanced materials and methods can better prepare us for those unavoidable environmental events in the future."

Other engineers agree that precast



concrete designs performed well, but adaptations will help them perform even better. "The conclusions we've drawn from examining precast concrete buildings in this area are fairly simple, because the damage related to one primary force; the storm surge," says Thomas L. Rewerts, principal in Thomas Rewerts & Co. LLC in Overland Park, Kan.

A structural engineer, Rewerts consulted with several insurance companies to assess damage to casinos and other companies in Gulfport and Biloxi, Miss. The parking structures featured typical precast concrete structural designs, consisting of double tees resting on inverted tee beams that provided the supported levels, which numbered between one and seven levels.

"The structures performed very well on lateral loads due to high winds," he says, noting that 90-mph winds were easily sustained during Hurricane Katrina, with gusts reaching 100 mph. "There was good lateral-load resistance, and the interior shear walls and connections performed extremely well." No damage was reported to any walls or connections. "That's a good sign, because if you consider the loads that were placed on these pieces, they were humongous."

The key problem arose from the 25-foot storm surge that the structures had to face in this area. The surge came up slowly, so it was not velocity that caused the impact, but the load and its buoyant capabilities,

he explains. In each case where damage occurred, it resulted from the supporting double tees being floated off the inverted-tee beam ledges on which they rested and collapsing when the support was gone.

'The [precast concrete] structures performed very well on lateral loads due to high winds.'

"You can be overwhelmed in looking at these structures by the visible damage, but it all relates to that one problem," he says. "The first supported level collapsed because the double tees had not been designed to withstand being lifted up and floated away from their connections. The weak point was the connections at the flanges on either end."

The slabs on which the structures were sitting did well, he noted, because they were placed on pile caps. "Those on pile caps performed extremely well," he says. "Using thicker slabs as was done in these cases and using pile caps provided a good solution."

Finding a solution to such high storm surges will take some consideration, he adds. "We may have to move the connections to the stems or create a different design to withstand this type of surge." Another option would be to create a hybrid design

in these oceanfront locations, with a post-tensioned, cast-in-place concrete design to support the first level and using precast concrete from there up.

"There's no other weakness in the design," he says. "In some places other damage was found, but it could be traced back to the collapse of the first supported level due to the double tees losing their support." The inverted tees themselves, he adds, also performed well. "The key is to secure the double tees or create a different design with different components on the first supported level."

The orientation of structures also must be reconsidered, he notes. Many of the parking structures were built parallel to the ocean, creating a large face toward the ocean that blocked the surge, putting more pressure on the structures. Interior ramps also were designed to face the ocean in many cases, creating an obstacle that produced more force. "The more that designers put in front of potential waves at the storm surge, the more damage will be caused," Rewerts explains. "The more you let water flow through the building, the less damage will be done. Designers didn't consider that action when they created these projects."

The long exposure to salt water also could pose long-term aftereffects, he notes, and that impact is still being considered. "We don't anticipate that it will have much effect, even after the 20 hours of immersion that we saw here," he says. "But designers may want to consider that impact as they look at how to design for these high-stress areas in the future. Certainly, owners will want to know that these factors have been addressed." In many cases, the design mixes already account for a marine environment, although not one that immerses the structure's first level.

Floating debris also caused some problems, especially large volumes. At one location, a semi truck was lifted up and slammed into the side of the structure, and in many places parked cars floated up and hit the parking structure's double tees from below. Smaller debris won't harm the structures, Rewerts says, although designers may want to consider putting soffits on beams around the structure's perimeter to prevent floating debris from entering the structure and impacting the exposed double-tee stems.





Arcadia Place in Chicago, designed by Landon/Bone/Baker Architects and developed by Dubin Residential, features stacked-bond patterned precast concrete wall panels, smooth panels with reveals, garage headers and precast concrete parapets provided by Prestress Engineering Corp. in Prairie Grove, Ill.

Building new homes
with precast concrete
hollow-core roofs
would add more
benefits.

Elevated Homes Offer Solution

Lifting functional spaces above the potential storm-surge level is the key to creating effective designs for both parking structures and housing, says Gregory. Slabs and other foundations can be secured by driving precast, prestressed pilings into the ground. "Scour won't undermine this type of construction, keeping the structure stable."

He recommends building an elevated platform using hollow-core or double-tee components, which rest on precast concrete pilings or columns. The house would be built at the 12- or 15-foot level, with the area beneath serving as a garage. "If water surges in, you drive the car away, and the living areas remain safe." Building a precast concrete perimeter wall to serve as the garage walls also would protect this space from floating debris.

Wood-frame roofs could still be used, he notes, but they would need to be well connected and use quality construction. However, a precast concrete hollow-core roof would add more benefits. Creating such a flat roof would allow for additional living space with a parapet wall added at the perimeter. "It would give you

a deck for a garden area or lanai, particularly in an environment such as New Orleans," he points out. "The goal should be to make the homes from materials that will be more enduring and will perform well while providing more value to the homeowner."

Interiors can still be created from wood, he notes, to provide the familiarity homeowners may want. "The threat is to the exterior, which destabilizes and allows wind and water to destroy the home," he explains. If storm surge infiltrates the home, mold and mildew would have to be remediated from drywall and wood, which would require removing the interior walls. But the exterior shell could remain in place and offer protection to prevent having to demolish and start new.

Gregory envisions connecting homes via second-story walkways, passing over streets to keep them free for cars. "You could even have commercial stores on the upper levels and create a community over the ground."

Precast concrete designs offer great potential for meeting structural needs while also providing the look and atmosphere that is highly

regarded in New Orleans, he notes. "The capabilities of architectural precast concrete are great. It can emulate the designs of past communities, including the French Quarter."

Some of these ideas must be considered if the area is to rebound successfully, he notes. "Building in flood-prone areas will require new designs, because the government won't give flood insurance to structures otherwise, and insurance companies won't protect them. The homes must be elevated, and as long as that is occurring, elevating

them high enough to completely protect them makes sense. Precast concrete designs will not only protect the homes, they will add value."

The changes will be made, and designers should consider what approach works best for their clients in their locations, he stresses. "You'll either do it better in these areas, or you won't do it at all. New Orleans has a chance to create its own unique solutions that meet its functional and aesthetic needs." ■

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For more information on this or other projects visit www.pci.org/ascent.



Radiant tubing cast into the Fortified floor panels. Photo: Dukane Precast Inc.



Precast houses near O'Hare airport offer superior sound attenuation. Photo: Dukane Precast Inc.



Double-wall precast system provides energy-efficiency from the footings up. Photo: Dukane Precast Inc.



Eighty-four-unit assisted living facility built to withstand an F-4 tornado. Photo: Dukane Precast Inc.

Precast Creates Fortified Home

In regions of the country where tornados can wreak havoc on homes, precasters are working with local communities and designers to create solutions. Although tornados differ from hurricanes in the danger they present, the ideas being used in other regions offer concepts that can be adapted for other areas.

"Fortified...for Safer Living" is a program sponsored by the Institute for Business & Home Safety, a national nonprofit group supported by insurance-company members. The group's "fortified" standard includes such features as:

- Connections that securely tie the house together from roof to foundation, providing protection for winds up to 130 mph.
- Impact-resistant roof materials that better withstand high winds and fire.
- Windows and doors with higher wind and water design pressure ratings and a garage door capable of withstanding impact from large objects.
- Construction materials and siting work that eliminate the threat of flood or wildfire.



In Illinois, the group worked with Dukane Precast Inc. in Naperville, Ill., and AAA Chicago Motor Club and AAA Insurance to create fortified homes in Bolingbrook, Ill. The insurance company offered premium discounts to homes built to the standard, which added about three to eight percent to the home's cost, depending on materials used.

Dukane and Prestress Engineering Corp. in Prairie Grove, Ill., have worked with the Illinois Emergency Management Agency (IEMA) and the American Red Cross to create Safe Home Illinois, which acts as a clearinghouse for ideas for wind-damage mitigation, safe construction standards and other aids. The precasters provide seminars to designers that discuss designing structurally superior homes.

A variety of precast concrete housing designs have been constructed across the country. These designs not only protect homes from wind damage but also cut energy costs, are constructed quickly and provide a range of aesthetic designs that can blend with any neighborhood.

Precast homes provide significantly more protection from wind-borne debris than any other building materials, according to tests conducted by the Portland Cement Association. The group tested various walls with the impact of a 2x4 wood stud traveling at 100 mph, the equivalent of wind-borne debris during a tornado with 250-mph winds. About 90 percent of tornadoes have wind speeds of less 150 mph, the group says.

Of all the types tested, only the concrete design stopped the debris from penetrating the wall. All others suffered penetration.