THE STORY OF A SURVIVOR

SAND PALACE OF MEXICO BEACH

By John A. Dal Pino, S.E.

Hurricane Michael, one of the strongest Atlantic hurricanes to ever make landfall in the contiguous United States, made a direct hit on Mexico Beach, Florida, on October 10, 2018. The Category 4 storm strengthened unexpectedly as it raced through the Gulf of Mexico with maximum wind speeds of 155 mph. At landfall in Mexico Beach, the measured storm surge was nearly 16 feet and, if wave height is added, the height of the wall of water was over 20 feet. The storm caused 45 deaths and resulted in damage of approximately $15 billion.

In Mexico Beach, almost all of the homes along the beach were destroyed by the wind and waves and swept away. However, one building along the shoreline (*Figure 1*) remained standing, alone in a field of devastation. Several news reports, including coverage in the *New York Times*, suggested that, from an engineering perspective, something unique had occurred and was worthy of further investigation. This attracted STRUCTURE's attention.

So, John Dal Pino, Chair of the STRUCTURE magazine Editorial Board, tracked down the building's owners, Russell King of Chattanooga, Tennessee, and Lebron Lackey of Cleveland, Tennessee, and their structural engineer Southeastern Consulting Engineers of Wewahitchka, Florida, to learn the full story. The Southeastern Consulting Engineers (SCE) team consisted of co-owners Jack Husband, President, Lance Watson, Vice President, and Matthew DeVito, Project Manager and lead engineer.

Figure 1. Sand Palace after the hurricane.

Unbeknownst to the owners, working closely with SCE, *performance-based design concepts* were employed to design and build a genuinely sturdy building that satisfied their own goals for performance and longevity while also conforming with the local building code. The evolving trend toward using performance-based concepts to increase the likelihood of achieving a specific set of goals is being used more frequently and something worth highlighting when it is performed successfully, all the more so when it is done by non-specialist owners (Mr. King is an attorney, and Mr. Lackey is a physician).

As you might imagine, the owners are very busy recovering as is SCE with their other clients, so we are grateful for their time. Lance Watson mentioned that his own home was flooded with three feet of water.

Figure 2. Concrete base – beams and piles.

Figure 3. ICF walls.

What first got you concerned about building performance?

Lackey/King: We have each owned several homes, but we had always purchased existing buildings. The house in Mexico Beach was going to be our first new, ground up building. We had decided that we wanted a vacation house and wanted to build something that would stay in the family for several generations, say 100 years or so. Russell had visited Costa Rica in the past and had noticed that a lot of the properties were constructed from concrete. Media coverage of climate change and the expectation that tropical storms were going to be more frequent and more intense also got our attention.

Were you concerned that the building code was not adequate for your situation?

Lackey/King: No. We did not believe that the building code was inadequate, but we did believe it only represented a minimum. We knew the code was a compromise document that was drafted by many different groups that did not necessarily share our goals.

What was your overall performance goal? Did you do your own research, or did you rely on the advice and expertise of your engineers?

Lackey/King: The survivability of the building in a major hurricane, you might call it the Big One, was our primary concern and the driver behind all of our decisions. We came up with that goal ourselves as we thought about the longevity we desired and factored in the news stories about storms.

Did you start with a completed design and then make changes, or did the process evolve differently?

Lackey/King: We worked with local designers to come up with an architectural floor plan that we liked. Then we worked with our structural engineers to come up with a design for the building focused on survivability as the goal and what made sense to us. Only then did we worry about the code. We had our engineers confirm that we had satisfied the code.

Figure 4. Wood floor trusses.

Would you describe the building's structural system?

SCE: The base of the building consists of 12-inch square precast, pre-stressed concrete piles that cantilever upward from the bearing stratum below the surface beach sands. Atop the piles, there are precast concrete beams that support the exterior and interior walls. (See *Figure 2* for the base of the pile base of the structure and the concrete beams at the first elevated floor.) The beams are attached to the piles with epoxied #10 reinforcing steel bars for uplift and shear transfer. The perimeter walls are constructed using Insulated Concrete Forms (ICF) with a seven-inch thick concrete wall inside with a single layer of #5 bars at 18 inches on center, each way (*Figure 3*). There are 2½ inches of insulation on each side for a total thickness of 12 inches. The interior walls are non-bearing wood stud. The floors and roof are constructed with pre-manufactured wood trusses (*Figure 4*).

Wind naturally controls lateral force design. What were the pressures?

SCE: The building code wind pressures are based on a 140 mph wind speed. On an allowable stress basis, the windward and leeward wind pressures are 34 pounds per square foot (psf) and 19 psf respectively. The sidewall pressures were 24 psf. The roof uplift pressure was 30 psf.

Would you describe the interaction between the owners and the engineers? How did you decide what changes to make and what parts of the building were modified?

Lackey/King: We started at the foundations and went through all of the major elements and evaluated them in terms of their contribution to survivability.

We started with the piles. It turned out that 40-foot piles did not cost much more and allowed us to penetrate the more solid ground beneath the sand, so

Figure 5. Nearing completion.

that is what was built. 50-foot piles were much more expensive, because of handling and trucking, so we decided against them. The extra length in the piles, since they are cantilevers, added significantly to the lateral strength of the building and better protected against scour for a small cost. We wanted to have a solid slab-on-grade but learned that everything in the path of the storm surge needs to be designed to break away to protect the piles and the superstructure. Some of the only damage the building sustained was where the slab did not break away cleanly and contacted the piers, producing some cracking.

Then we focused on the walls. Our engineers told us that plywood sheathed wood stud walls would work but, thinking back to Costa Rica, we opted for insulated concrete form (ICF) walls. Our engineers told us that they would withstand 235 to 240 mile per hour winds, which sounded good to us. The doors and windows were custom made in Ocala, Florida, to the 140 mph, 4-pound-projectile Miami Dade County criteria. This is not 235 mph, but it was the best available. We focused on potential weak points and made sure that the wall piers had two-foot-wide minimum widths and that a door or window failure would not compromise the entire building.

Lastly, we focused on the roof. It was robustly designed using multiple factors of safety to account for any construction errors, unprecedented storm events, and more to provide an exceptional design in the event of an unforeseen act of nature. Particular focus was placed on the eave design because our engineers told us that the eave design had a significant influence on survivability. It turned out that a hipped roof is better than a gable roof. We made the eaves as small as possible, about 12 inches, and enclosed the soffits to minimize the forces on the roof. Then we had the roof trusses secured to the concrete walls with Simpson Strong-Tie hurricane tie-downs which were conservatively designed.

If we might ask, how much more did the design changes cost and what impact was there on schedule?

Lackey/King: The cost premium turned out to be 15% to 20% on a per square foot basis over the cost of an equivalent, existing building in the same area. We evaluated many options and, if the extra cost was reasonable and we thought it represented an upgrade, we went with it, while always keeping an eye on the overall cost. We actually found that some elements, such as the ICF walls, did not cost that much more at all because the extra material costs are offset by lower labor costs. The ICF also had the side benefit of better insulation and resulted in lower insurance costs. We calculated that the on-going cost savings would offset the original extra costs in six to eight years. There was no noticeable impact on the project schedule. The cost of the lot is also the same regardless of what is built. (The building at the time of near completion is shown in *Figure 5*.)

What advice would you have for other owners seeking to mitigate specific risks?

Lackey/King: We did not have any special skills going into this process (it was our first house remember). It just takes asking the right questions and the ability to analyze alternatives rationally and not emotionally. Spend time talking with your structural engineer so that you understand why things are the way they are and what you get with minimum code compliance. Understand the local risks (wind, earthquake or flood) and then build to match your own goals and comfort level so that you can sleep at night. Also, we recommend that owners stay personally involved throughout the construction process. If you live far away, hire a local representative. Just do not be an absentee owner. You need to have eyes and ears on the site continuously to make sure that the contractor follows the plans and builds in the quality that the structural engineer designed. We installed cameras on site so we could watch the contractor and monitor progress. These cameras also let us watch the building go through the storm.

Any last words?

Lackey/King: For us, function always won out over form. Before Hurricane Michael, we would not have said that we had the prettiest house in Mexico Beach but, after Michael, it would seem we have the *only* house still standing in Mexico Beach.▪

Sand Palace owners, Mr. Lackey (left), Mr. King (right).