Opal Sands Resort on South Clearwater Beach, Florida.

NEW CLEARWATER

A Challenging Wind and Flood Design

Opal Sands Resort is a new 17-story plus, 380,000-square-foot premier hotel located directly on the Gulf of Mexico in Clearwater Beach, Florida. The recipient of the 2016 ENR Southeast Regional Best Project Award, the Opal Sands Resort was born from the vision of the owner/developer, Ocean Properties, LTD (OPL). The owner desired a new flagship hotel to add to their portfolio of international resort hotels. Soon enough, that vision became a reality because of the innovative work by project architect, Nichols Brosch Wurst Wolfe & Associates, Inc. of Coral Gables, Florida, and their team of consulting engineers, including the structural engineers, McCarthy and Associates, a Division of Pennoni, and the general contractor, Moss & Associates LLC.

The Challenges

From the beginning, the apparent structural design challenges were numerous:

1) Design a 17-story curvilinear building, with a coastal exposure, to resist Florida's high hurricane wind loads.
2) Design a building located in multiple flood zones including two different FEMA V-zones, the Pinellas Gulf Beaches Coastal Construction Zone, and the Florida Department of Environmental Protection (DEP) Coastal Construction Control Line (CCCL).
3) Design a heavy concrete building on a site overlaid with loose beach sands.
4) Eliminate a critical transfer beam over the lobby during construction and after many of the upper floors had been constructed.

The Building

The Opal Sands Resort consists of 12 floors of hotel rooms, each of which has a magnificent view of the Gulf of Mexico. The hotel rooms sit above a spacious lobby, restaurant, numerous meeting room floors, and two levels of parking. At the lobby level, on the west waterfront side of the main tower, is a plaza deck with swimming pools, volleyball courts, and tiki hut bars. A large portion of that deck is cantilevered out over the water. A sand ramp was constructed, in cooperation with the City of Clearwater, to allow for visitors to easily access the beach from the deck above. On the east side of the main tower is another expansive space that contains a large ballroom, meeting rooms, and escalators from the main entrance up to the lobby level. Valet parking for guests is required because the hotel takes up the entire site and access to the parking levels is only available from a ramp on the street side and two large vehicle elevators. Considering the sheer size of the building, along with its ideal location and innovative design, it comes as no surprise that the hotel was an instant success upon opening in February 2016.

BEACH HOTEL

By E. Michael McCarthy, P.E., M.ASCE

The General Design Approach

The entire building superstructure and foundations were modeled in 3D using RAM Structural Systems. The output from that model was then sent directly to the 3D Revit model and refined to make the structural drawings more readable and consistent with industry standards. Due to the unusual shape of the floor plans and column bay spacing provided by the architects, unbonded mono strand post-tensioned concrete slabs supported by concrete columns and shear walls was an obvious choice for the superstructure. Post-tension design also helped to minimize floor heights and has been a popular system for multi-story residential buildings in the state of Florida for a long time. The delegated engineer for the post-tension system was Structural Technologies/VSL. Although the architects were very accommodating in locating columns to best support the structure, there were instances where it was necessary to introduce transfer beams to support discontinued columns from above. For example, a large transfer beam (3 feet x 4 feet), reinforced with a combined mild steel and bundled post-tension cables, was required over the lobby where the engineers were directed to provide a column-free space.

A very large cooling tower is located on the roof of the main tower and surrounded by hot dipped galvanized steel framed walls that are elliptical in plan. The walls are 19 feet 6 inches high and self-braced against wind tunnel test-wind pressures, reaching 125 pounds per square foot (psf), with a grid system of steel beams at the top of the walls. The steel framing is designed and detailed to be removable for future replacement of the equipment. The exterior walls of the building are a combination of glazing, in-fill masonry, and concrete shear walls. The size and configuration of the building dictated the need for expansion joints. The most logical location was between the main tower and lower building components on both the east and west sides.

The building foundations were designed in accordance with a geotechnical report prepared by the project geotechnical engineers, Driggers Engineering Services, Inc. (DESI). DESI conducted a series of deep borings and discovered that the site is underlaid with mostly sandy soils of varying densities down to lime rock deep underground. Based on those findings and the column and wall loads provided by McCarthy, DESI recommended reinforced concrete drilled shafts or caissons for building support. The drilled shafts varied in diameter from 2 feet to 5 feet and were drilled into the rock about 70 feet below the ground surface. Before construction, a load test was conducted on a sample shaft to confirm the foundation design recommendations. A pilot hole was then drilled at each shaft location to confirm there was no variance in the subgrade.

Opal Sands with Sand Key Bridge in the background.

Wind Design

The governing code for the design of the Opal Sands Resort was the 2010 *Florida Building Code* (FBC) which, by reference, incorporated much of the ASCE 7-10 *Minimum Design Loads for Buildings and Other Structures* for wind design. According to a Pinellas County local technical amendment, the minimum design wind velocity for this site is 145 mph with an ultimate 3-second gust, Risk Category II, and Exposure Category D as defined by the FBC. In addition to wind forces, the exterior glazing must also meet wind-borne debris or missile impact criteria and be certified by the manufacturer with a Florida Product Approval Number or Miami/Dade Notice of Acceptance.

Due to the curved shape of the main tower and in anticipation of cost savings, OPL agreed to McCarthy's recommendations to complete a wind tunnel test. CPP, Inc. of Fort Collins, CO, was retained to build a model of South Clearwater Beach and the proposed Opal Sands building, and then subject that model to hurricane force winds in a wind tunnel. The resulting pressures were less than what would have been required by code and were used by McCarthy in the design of the building for both the main wind force resisting system and components and cladding. Additionally, the wind tunnel testing provided the architects with accurate feedback on locations around the base of the main tower where wind accelerations are likely to affect pedestrians adversely. Screen walls, landscaping, and other types of buffers were then incorporated into the building design to mitigate this concern.

The initial building design included multiple shear walls to resist powerful coastal winds but, as the design progressed, many of those walls were reduced or eliminated to accommodate interior space planning. It soon became apparent that the remaining shear walls were no longer adequate. The 3D RAM analysis/design model was changed to supplement the shear walls with the natural stiffness of the columns and slab framing to develop shear wall/frame interaction. While this solution solved the lateral bracing problem, the reinforcing steel and shear head reinforcing in the slabs and columns had to be increased to account for the additional bending moment transfer at each column-to-slab intersection. The model did not indicate excessive diaphragm shear force transfer at the upper level(s) of the building at the interaction point of the flexural deflection of the shear walls as they tried to exceed the lateral shear distortion of the frame. All wind pressures were input into the RAM 3D model as load cases in the overall design of the building.

Flood Design

The 2010 FBC incorporates by reference ASCE 24-05 *Flood Resistant Design and Construction* which was used in conjunction with the national, state, and local flood regulations in the design of the Opal Sands Resort. These included two different FEMA V-zones, Pinellas Gulf Beaches Coastal Construction Code, and the Florida DEP CCCL. The lowest horizontal beam supporting the first elevated and occupied floor of the building was required to be either at or above the design flood elevation (DFE), derived from the FEMA maps

Post-tension slab construction.

and the appropriate freeboard, to comply with these complex flood regulations. Also, all construction below the DFE must allow storm water to flow through the building unimpeded. Specifically, any wall that is not a shear wall, stair, or elevator wall was designed to withstand wind forces but must fail or breakaway under storm-driven wave action. In this case, the lower floors of the building are primarily open parking, making it easy to comply with the Flow-through requirements. Additionally, the mechanical and electrical equipment that is normally placed on lower levels of buildings had to be located on platforms above the DFE.

The most stringent flood code at the Opal Sands site is governed by the DEP and affects all construction located seaward of the CCCL. Fortunately, the CCCL wrapped around the west and north property lines of the site so that most of the building was not affected. However, the portion of the pool deck and tiki hut deck that was designed to cantilever out over the water was subject to CCCL requirements. Those decks had to be elevated above the cresting wave elevation established by the DEP to minimize the potential for damage from wave forces.

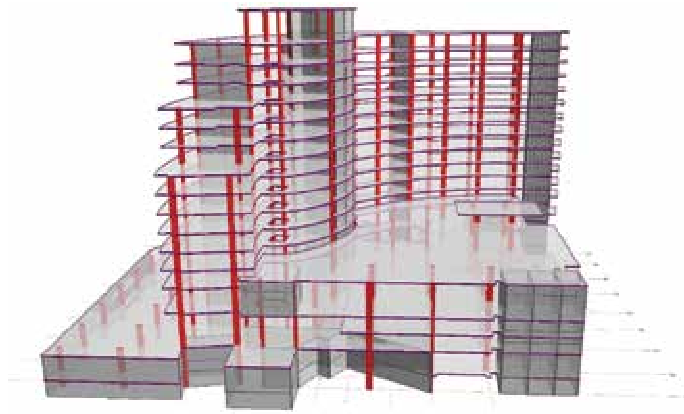
Because this building has direct coastal exposure, the open plaza deck and two levels of parking below on the west side are reinforced with a special two-layer zinc coated rebar, and the concrete included a corrosion inhibitor admixture. Additionally, all hydrostatic and hydrodynamic forces were input into the RAM 3D model as a load case, in addition to waterborne debris impact forces, in order to account for these flood zone forces in the overall design of the building.

This array of complex flood design codes required the use of unique and creative solutions in the design of Opal Sands.

Construction

At McCarthy's recommendation, OPL agreed to have a full-time representative from McCarthy on site during construction of the structural building components. That representative worked with the contractor on a daily basis in responding to RFI's, reviewing shop drawing submittals, and reviewing the ongoing construction for conformance to the drawings and specifications. In addition to facilitating a smooth construction flow, this level of service at the job site allowed McCarthy to meet the requirements of the Florida Threshold Law as the Special Inspector.

Also during construction, a particularly interesting development occurred. OPL noticed the large transfer beam above the lobby and its impact on the ceiling height. For the better of the building, they decided to remove the beam and insert the lobby column, which the transfer beam initially replaced, back into the floorplan. That column was originally designed to extend from the foundation to the ballroom roof above the 6th level but was discontinued at the 3rd-floor lobby as



RAM structural systems model.

an interior design decision. At the time it was decided to eliminate the transfer beam, all the upper slabs had already been poured, complicating the change. It was an "all hands on deck" moment with McCarthy's engineering staff to develop a solution that could be completed quickly and without affecting ongoing construction. The biggest challenge was to support the upper slab levels from the time the transfer beam was demolished until the new column was in place and ready to carry the load. Other difficulties included de-tensioning post-tension cables in the beam and strengthening the drilled shaft foundation to handle the additional loads. Fortunately, the column stack below the lobby floor was found to have enough excess capacity and did not need to be reinforced. The final solution involved the following steps, all of which were completed successfully:

1) Install temporary shoring from the foundation up to the 5th floor.
2) De-tension the post-tension cables in the transfer beam.
3) Install new steel micropiles under the direction of the geotechnical engineer and expand the pile cap.
4) Demolish the transfer beam using a Tru-line hydraulic chipping hammer operated by remote control on the lobby floor.
5) Form, reinforce, and pour back the new column.

After all this, the interior designers could work the column into the lobby space design after all.

Summary

Construction of the Opal Sands Resort was completed in February 2016 and the building was an immediate success, opening with over 15,000 reservations. It has become the centerpiece of South Clearwater Beach, Florida, and one of OPL's finest hotels. Looking back, the decision to have a wind tunnel test done was of the utmost importance as it resulted in overall reduced costs as well as a more accurate design. Additionally, having a full-time representative on-site during construction allowed McCarthy to assist the contractor and ensure the building was built in accordance with the structural drawings and specifications. Most importantly, the use of a 3D RAM analysis/design model synchronized with the Revit model allowed McCarthy's engineers to design an accurate and economical structural system on a challenging site that is subject to high hurricane force winds and complex flood zone regulations.▪

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