STRENGTHENING OF LAKETOWN WHARF NORTH PARKING GARAGE

BY MARC TESSIER

The Laketown Wharf Condominium complex, located in the Florida panhandle, is a newly constructed condominium complex on the shores of the Gulf of Mexico. Built to include 765 luxury condominiums, 18 restaurants and shops, as well as a theater, it also has two parking garage structures. Both are four levels with a sport plaza level on the roof. The North Parking Garage also supports a kiddie pool on the plaza level of the roof.

The North Parking Garage structure consists of prefabricated columns, shear walls, and double-tee slabs. The top slab received a waterproofing membrane. The plaza level that includes the pool was to be constructed of a layer of gravel; the pool was to be filled with 1 in. (25 mm) of water and would have a few concrete toys to play on, with a layer of sand around the pool, concrete pavers on top of that sand, and planters on the rim.

As it became progressively apparent that the load on the double-tee system was too large, efforts were conducted to reduce that load—from reducing the weight of the toys to replacing the heavy gravel with lighter insulation. These efforts, however, were not enough to comply with the maximum dead load allowable on the double-tee structure.

A strengthening method was suggested by the prefabricator to the general contractor that involved additional post-tensioning and carbon fiber-reinforced polymer (CFRP) shear strengthening, with an initial estimated cost of $500,000. For the general contractor and the owner, this was an extra unforeseen expense of unacceptable proportions.

When the subcontractor came on board, the initial task was to precisely identify the loads that would eventually be applied to the structure and tailor the strengthening solution to the structure and the constraints under which it is operating. For instance, the exterior walls could not be used for anchoring the additional post-tensioning system and the top of the slab could not be used either because existing insulation and waterproofing membrane were already installed. Also, the thickness of the concrete constituting the walls and floor of the pool were surveyed and documented precisely.

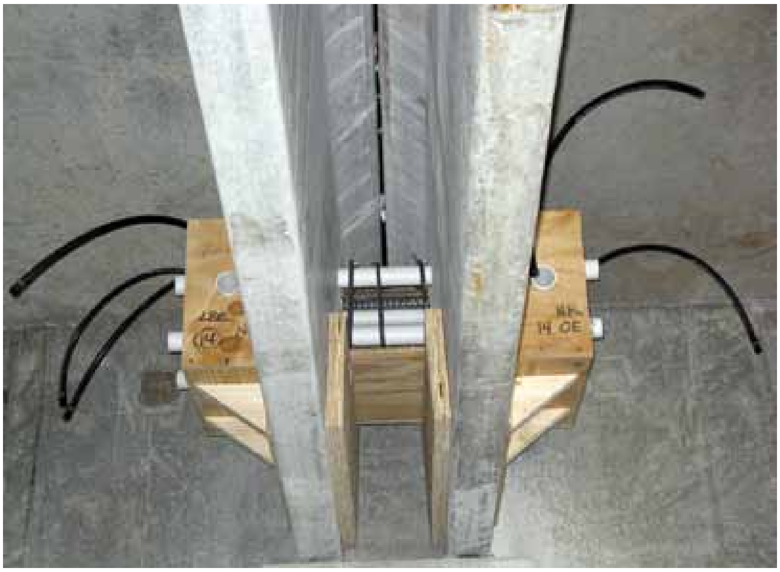
The subcontractor teamed up with a structural engineering firm to analyze the existing structure and develop the design of the strengthening system. The structural members were evaluated based on the worst load case for the double-tees. After this analysis portion of the job, it was shown that none of the columns, walls, or corbels supporting the beams needed additional strengthening. Also, it appeared that CFRP might not be needed. The structural engineer provided shop drawings, post-tensioning calculations, and stressing instructions for the project.

PROBLEM SOLVED

The chosen solution was threadbars, with concrete anchors at the end of the double-tees and steel deviators at the center of the stems, where the bars would be stressed. This stressing point allowed the exterior walls and slabs to not be pierced, saving money and time in cosmetic repairs. Also, the fact that the pool was already constructed above the parking structure and the waterproofing membrane placed on the roof slab made it impossible to use the top of the garage slab as a resting point for the anchorage. The placement of the anchors was chosen with these two constraints in mind.

The amount of post-tensioning effort provided by the bars, as well as the increased eccentricity allowed by the position of the deviators and anchors, optimized the strengthening solution to compensate both for the flexural requirement at midspan and for the shear reinforcement at the end of the beams.

Double-tee beams before strengthening



Anchor blocks formwork

Finished anchor block

Parking garage tees after strengthening

The effort of the longitudinal bars would be transferred to the double-tee stems via a steel deviator and concrete blocks acting as anchorages. Given the small thickness of the stems, the force is transferred by friction, which required transverse post-tensioning bars to exert compressive force on the blocks.

One of the main concerns when strengthening a structure, whether it is with additional post-tensioning or any other method, is to ensure that the solution does not create new problems within the structure. Particularly in the case of additional post-tensioning, it is paramount to ensure that the existing structure has the intrinsic ability to both transfer the strengthening loads and to withstand any "side effect" that the external post-tensioning might add. The members transferring the strengthening force had to be optimized to ensure a distribution of the force on the stem that would not exceed its resistance. All the dimensions of the post-tensioning system, as well as the placement of the members, were optimized to establish the most efficient setup and not disturb the existing structure.

The camber of the double-tees during the temporary phase of partial load and full additional post-tensioning load was evaluated to ensure that the deviator elements would not interfere with the existing structure. Finally, the double-tees were stressed in several steps to ensure that minute cracking of the top slab under temporary conditions would not exceed the tolerance of the existing waterproofing membrane.

One particularly constraining geometrical factor was the small distance available between two adjacent double-tees. The amount of post-tensioning effort either conveyed by strand or by bars required a large deviator and anchor block. These two incompatible requirements were satisfied by the subcontractor/structural engineer design team by criss-crossing the post-tensioning bars of two adjacent stems and offsetting the deviators one with respect to the other. This became a more pronounced condition when the site measurements were found to be even more stringent than as-built drawings indicated. The "interior" anchor blocks of two adjacent stems were "fused" together to optimize construction cost and time in the field.

Aesthetically, the cosmetics of the parking garage were respected using galvanized apparent steel items.

The final estimate for the project arrived at $270,000, including the analysis of the structure and the design of the solution—almost half of the original estimate.

Because the strengthening solution was not part of the original plan, the contractor was under significant pressure to conduct the work as fast as possible. High-performance ready mixed concrete with an early strength of 6000 psi (41.4 MPa) was used in the anchor blocks, and special attention was paid to the curing of the grout and the precise grouting of the transverse post-tensioning bars. The subcontractor was able to complete the work on the 13 double-tee beams in just over a month.

__Marc Tessier__ is the Sales Manager for the Repair Division of DYWIDAG-Systems International USA, Inc. (DSI). He has over 10 years of experience in structural repair with techniques such as additional post-tensioning, carbon fiber-reinforced polymer (CFRP), and shotcrete and concrete repair in both buildings and bridges. Recently, with DSI, he has been involved in post-tensioning investigation and monitoring technology, post-tensioning repair, and structural lifting. He received his MSc in civil engineering from the Pennsylvania State University and his MEng. from the Ecole Centrale de Lyon in France and is currently serving on ICRI Committee 330, Strengthening. He can be contacted at marc.tessier@dsiamerica.com.

Laketown Wharf North Parking Garage

OWNER

Laketown Wharf, LLC
Destin, FL

GENERAL CONTRACTOR

Walton Construction
Pensacola, FL

STRUCTURAL ENGINEER/ SUBCONTRACTOR

DYWIDAG-Systems International USA, Inc.
Washington, DC

Planning, supply, and installation of DYWIDAG threadbar with associated hex nuts; and planning, design, supply, and installation of custom concrete anchorages and steel deviators.

Janssen & Spaans Engineering
Indianapolis, IN