440 West Condominium Parking Garage Repairs

Clearwater Beach, Florida

Submitted by The Euclid Chemical Company

440 West Condominium, "The Concrete Ship." Parking is below grade and below high-tide line

Airplane crash investigators say that catastrophes are rarely the result of a single incident. It's almost always a combination of events, such as multiple safety checks being overlooked combined with a lack of knowledge of the local conditions. Concrete repair projects can work the same way. It's not the single oversight that kills you, but the combination of challenges which, taken singly, appear harmless.

A recent condominium repair project at Clearwater Beach, FL, may have required a "disaster analysis" had the engineer, contractor, and materials manufacturer not worked together in unison. An extreme chloride environment, combined with limited access, excessive slab reinforcement, poor concrete condition, and continuous "on-stage" deployment, posed a significant challenge to overcome.

The structure consists of two 16-story towers and a central plaza deck overlooking the beach. It rests on an elevated parking deck and a 94,000 ft^2 (8700 m^2) sublevel parking garage. The parking deck is constructed of 11 in. (279 mm) thick, two-way, cast-in-place, conventionally reinforced concrete flat-plate slabs. Constructed in 1975, the structure had never undergone any concrete restoration prior to this project.

The structure is called "a concrete ship" because it was built closer to the Gulf of Mexico than practically any other building in the area. During high tide, the floor of the basement sits below the water line. Electronic sump pumps run almost continuously to drain water from the foundation.

PROBLEMS THAT PROMPTED REPAIR/ CAUSES OF DETERIORATION

Large scale corrosion damage was obvious throughout the garage; stalactites were growing from some ceiling cracks. Water constantly leaked through the ceiling. The corrosion appeared to have been caused, in part, through exposure to a salt-rich coastal environment, exacerbated by cracking and inadequate coverage over the reinforcing steel. Due to its proximity to salt water, the humidity (moisture availability) within the garage area routinely reached 100%. Small holes and poor consolidation of the concrete were visible everywhere. These conditions suggested elevated porosity and subsequent corrosion risk.

INSPECTION/EVALUATION METHODS

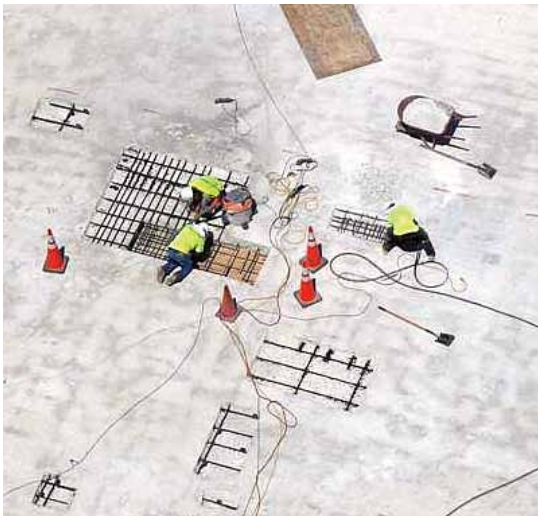
In addition to a visual survey, nondestructive half-cell potential measurements of the slab were performed to estimate the corrosion risk of the slab's reinforcing steel. The tested areas were later opened for the purpose of concrete repair.

TEST RESULTS

Concrete slab potential measurements varied between –224 mV and –510 mV, relative to the



Deterioration prior to repair


Repairs to top deck prior to waterproofing

reference cell. The data indicated that the entire survey area was susceptible to corrosion. The reinforcing steel's protective passivating layer had been compromised and nearly 30% of the area was classified as "highly vulnerable," according to ASTM International C876-91. This data was used to map out potential problem areas ahead of time and give the owner insight into possible future repair locations.

SITE PREPARATION/SURFACE PREP

Prior to the repairs, existing sand-set concrete pavers and a previously installed aliphatic waterproofing membrane were removed. Pavers were removed by hand and the sand was shoveled and swept away. The existing membrane was removed using a combination of shot-blasting and grinding. The top deck was then mechanically sounded with chains to find delaminated concrete. The many facets of surface preparation required were in accordance with ICRI Technical Guidelines.

REPAIR SYSTEM SELECTION/ DEMOLITION METHOD/REPAIR PROCESS EXECUTION/APPLICATION METHOD

The majority of the repairs for the garage would be overhead repairs. A robotic tool support arm was purchased to aid in overhead chipping. A chipping hammer was attached to the arm, which was then electronically guided by a repair worker. It was operated in shifts, all day long, without having to rest or stop for a lunch break. This permitted tremendous progress for chipping out large areas of repairs. Given the amount of required concrete repairs (2500 ft^3 [71 m^3] by the end of the project), the machine provided a significant technological advantage. Another beneficial component was the concrete repair application process and material. The dry-mix method of shotcrete was employed, allowing the nozzleman to instantaneously adjust the water content as needed. A microsilica-modified, one-component shotcrete material was used. The microsilica modification was desired to increase densification of the finished product. This makes the repair more impervious to future chloride and moisture penetration.

An overall corrosion management scheme was detailed by the engineer during the bid phase. The plan combined three essential elements: fresh, highly alkaline mortar for the primary repair material; sacrificial zinc anodes at repair perimeters to combat the "anode ring" effect; and an aliphatic, rapid curing, elastomeric waterproofing membrane on top of the slab.

CHALLENGES TO OVERCOME

The conservative 1970s design methodology used on the slab resulted in heavily reinforced concrete. The concrete repair crews, therefore, had to take special care to ensure complete encapsulation of the reinforcing steel. At one point, a routine quality control test revealed voids (air pockets) in the repair material on top of the lower reinforcing steel mat. The owner became concerned that all of the repairs in the parking garage might have voids. To save time and expense, the engineer recommended nondestructive testing as a way of locating additional voids in the slab (if any) and determining the extent of the problem.

A high-frequency ground-penetrating radar (GPR) was tried first to locate the voids. The large amount of reinforcement, however, created radar shadows, which made it impossible to examine the area above the reinforcing steel. Pulse velocity testing, defined in ASTM International C597-02, was eventually used.

Approximately 1800 discrete points were tested using the Pulse Velocity Method. Of these, approximately 600 were marked as suspect using criteria from American Concrete Institute's (ACI) *Manual of Concrete Inspection*. Sixty-seven of those suspect areas were examined. One additional void of structurally insignificant size was found. All other tested areas appeared to consist of dense, well-bonded repair material. Using a 10% acceptable

margin of error with a 90% confidence level, statistical analysis of the data suggested a maximum of two voids, both structurally insignificant, in the entire population. Based on the physical evidence produced by drilling and chipping into the slab, the engineer recommended to the owner that no further action be taken to look for voids.

CHALLENGING ENVIRONMENT

As with many condominiums, parking spaces are at a premium. The contractor was only given access to about 20% of the garage at any given time. Resident access to the two towers had to be constantly maintained. Drive lanes, directional signage, and dust barriers were typically moved overnight as the concrete repair process snaked its way through the garage. Because the repairs were going on in the condominium residents' "backyard," appropriate dress, language, and behavior for the laborers was a must. The winning contractor was chosen, in part, because of his experience in working "on-stage" at high-dollar value properties.

VALUE ENGINEERING

The winning contractor met with the engineer during the bid process to propose a value-engineered alternative to the engineer's initial waterproofing specification. The substitution was permitted because the manufacturer pledged an extended warranty and the contractor demonstrated its bond strength through test mock-ups. This substitution saved the owner many thousands of dollars in material costs.

CUSTOMER SATISFACTION WITH FINAL RESULTS

By the end of the project, approximately 60,000 ft^2 (5575 m^2) of parking deck had been waterproofed and then covered with a drainage mat, sand, and pavers to encourage drainage of water from the deck. Approximately 2500 ft^3 (71 m^3) of concrete repairs had been performed. Through computer-aided design and drafting on the part of the engineer, top-side landscaping planters were reinstalled in such a way that the condominium gained several new, coveted parking spaces. Even if the owners couldn't appreciate the technical aspects of the corrosion protection plan, they easily understood the benefits of being able to park closer to their apartment. Following the work, the condominium association was so pleased that they presented their Concrete Restoration Committee Chair with a golden hard hat and safety glasses.

By using state-of-the-art technology, advanced materials, and old fashioned attention to detail, 440 West Condominium in Clearwater Beach received a cosmetic overhaul and repairs that will keep the structure looking great for years.

Sacrificial zinc anodes at repair perimeters

Congested steel reinforcement

High-dollar value environment

440 West Condominium

OWNER
440 West Condominium Associates
Clearwater Beach, Florida

PROJECT ENGINEER/DESIGNER
Karins Engineering Group, Inc.
Sarasota, Florida

REPAIR CONTRACTOR
Restocon Corporation
Tampa, Florida

MATERIAL SUPPLIER/MANUFACTURER
The Euclid Chemical Company
Cleveland, Ohio