SCDNR Marine Resources Research Institute Corrosion Mitigation

Columbia, South Carolina

Submitted by Sika Corporation

South Carolina Department of Natural Resources Marine Resources Research Institute

Underside of wet labs show spalling and steel corrosion

The South Carolina Department of Natural Resources (SCDNR) Marine Resources Research Institute building contains administrative offices, classrooms, a library, an auditorium, "wet labs" for saltwater marine life research, and other research labs. The original building was constructed in 1974, with an addition completed in 1977. The total building is 50,000 ft^2 (4645 m^2); the area of Wet Lab A is approximately 5600 ft^2 (520 m^2) and the area of Wet Lab B is approximately 2700 ft^2 (250 m^2). The floor of the building consists of a raised, cast-in-place concrete structure to elevate it above the flood elevation. Reinforced concrete elements include columns, joists, girders, and floor slab. The roof framing above the concrete floor level consists of steel columns and beams supporting bar joists and a metal deck. The exterior walls are architectural precast concrete. Most of the interior walls are non-load-bearing concrete masonry units.

In 1989, the structure survived Hurricane Hugo but flooded as a result of this event. In the 1990s, the original wet lab showed signs of deterioration at the base of the steel columns and top surface of the concrete. The columns were remediated and the slabs were sealed. Beyond this, relatively little had been done (or appeared to be required) prior to the repairs undertaken in this submittal.

PROBLEMS THAT PROMPTED REPAIR

During an understory evaluation in 2006, some conditions of concern in the concrete structure under the wet labs were noted. Numerous locations of corrosion-related spalling within the floor areas of the wet lab locations and noticeable steel column corrosion caused concern that led to a more detailed evaluation.

INSPECTION AND EVALUATION TECHNIQUES

In the summer of 2006, an extensive visual and nondestructive testing investigation (NDT) was conducted on the concrete floor slabs, beams, and columns at two locations that house the wet labs. The investigation included visual inspections, rapid chloride testing (RCT), half-cell potential (HCP), and the use of ground-penetrating radar (GPR) and a cover meter.

Further investigations were conducted in the summer of 2008 as part of the overall design/build contract. This investigation included visual and destructive investigation. Saw cutting and removal of concrete by chipping hammers at several beam and underside slab locations provided an opportunity to inspect actual conditions within the concrete and the reinforcing steel.

The visual investigations in 2006 and 2008 found several degraded structural conditions, including deteriorated reinforcement, spalled concrete, cracked concrete, and rust-stained concrete. The 2008 destructive investigation uncovered many areas in which 25 to 50% section loss of the reinforcing steel had occurred. Some areas had complete section loss of the reinforcing steel. Approximately 20% of the 50,000 ft^2 (4645 m^2) building required concrete repair.

The top surface of the floor slab in the wet labs had been coated with an epoxy floor coating that had failed, allowing saturation from the saltwater tanks. These wet labs remain constantly wet as routine washing down of the floors and tanks occur.

It was determined that the root cause of the steel corrosion and resulting spalling was due to high chlorides and, in some cases, insufficient cover. This situation was exacerbated by the marine environment in which the building is situated, as well as the saltwater tanks within the building and the routine washing of various areas throughout the lab.

REPAIR SYSTEM SELECTED

The goals of the owner and design/build team were to address the root cause of corrosion; repair the damaged concrete, coatings, and cracks; and extend the service life of the building. To accomplish these goals, the owner provided the design/build team with a list of priorities:

1. Concrete repair and protection to restore structural integrity, including the following:
   a. Full slab removal in some areas (Wet Lab A) as well as partial depth removal in Wet Labs A and B;
   b. Floor coating removal and replacement;
   c. Gravity-fed cracks with epoxy resin;
   d. Concrete repair of spalled concrete;
   e. Local and general corrosion mitigation and protection;
   f. Resloping and new floor coatings; and
   g. Carbon-fiber structural strengthening.
2. Repair floor systems within the wet labs, including waterproofing to protect the slabs.
3. Removal and replacement of all support clips for the exterior precast wall panels.
4. Removal and replacement of exterior concrete stairs and supports.
5. Installation of new windows (insulated, low-e) and doors throughout.
6. Installation of new heating, ventilating, and air-conditioning (HVAC) and energy control systems, including air and water temperature controls of the wet lab spaces and tanks.

PROJECT INSTALLATION/ SITE PREPARATION

To prepare for the repair project, the owner had to relocate the marine life in Wet Lab A to other facilities and completely remove all laboratory equipment, tanks, piping, electrical services, and office locations in the 1974 portion of Wet Lab A (to allow for complete slab removal) and Wet Lab B (to allow for sacrificial anode installation). The Wet Lab A and B areas were phased sequentially to accommodate the spawning cycle of the marine life in Wet Lab B and to allow the administrative offices of the building to remain functional during the project.

APPLICATION METHOD SELECTION

The Wet Lab A area required complete removal of the concrete slab and removal of the upper 5 in. (127 mm) of the beams and girders. Due to the connection of the new floor slab reinforcing being tied to existing beam reinforcing, 100 sacrificial galvanic anodes were installed to reduce the effects of incipient anode corrosion.

The new ready mix concrete (approximately 50 yd^3 [38 m^3]) design included a corrosion-inhibiting admixture to provide additional protection for reducing the same incipient anode affect throughout the entire slab placement areas.

It was determined that the Wet Lab B area did not require complete floor slab removal, but long-term corrosion protection was required. Due to the high levels of chlorides found in the concrete, another system of sacrificial anodes (634 in total) was installed.

Demolition at Wet Lab A

Demolition and forming


Cored holes and slots for galvanic protection

To provide complete global protection of the entire underside of the exposed concrete, a surface-applied penetrating corrosion inhibitor was applied to the beams and underside of the slabs. Eleven hundred gallons (4163 L) of material were applied to 50,000 ft^2 (4645 m^2) by means of pump-up sprayers.

The underside spall repairs (approximately 5000 ft^2 [4645 m^2]) included large, deep repair areas that required forming and pumping the repair mortar. The shallow, smaller areas were repaired by means of hand-applying the repair mortar. There were over 800 of these repair-type locations.

The structural strengthening of different beam locations was accomplished using 18 oz/yd^3 (532 mL/m^3) of unidirectional carbon-fiber fabric that was saturated in epoxy, then wrapped around the sides and undersides of four beams comprising approximately 60 ft (18 m) of beam strengthening.

The Wet Lab B area received a cementitious overlay to provide better pitch to drains and improve the floor finish. Finally, all wet lab floor slabs (8000 ft^2 [743 m^2]) were coated with a high-build epoxy floor-coating system.

UNFORESEEN CONDITIONS FOUND

Once the tanks had been removed in the Wet Lab B area, it became apparent that the condition was worse than originally anticipated. The engineer determined that the chloride contents were very high and performed a life-cycle cost analysis. It was concluded that additional corrosion protection (drilling and installing anodes) provided a more cost-effective solution than removal and replacement of the concrete beams and slabs.

PROJECT SUMMARY

Overall, this project consisted of a complete concrete repair scope that included conventional repair techniques of remove and replace, hand-applied spall repairs, form-and-pour repairs, epoxy reinforcing bar protective coatings, epoxy crack injection, high-build epoxy floor coatings, and "state-of-the-art" systems. The project began in December 2008 and was substantially complete by October 2009. An average crew size of six worked 6 to 7 days per week throughout the project.


Completing lab finishes

The team is confident that the thorough inspection leading to a comprehensive repair and protection approach extended the service life of this important structure that resides in an aggressive coastal marine environment and houses saltwater tanks. This service-life extension will allow for the continued study of marine wildlife for many years to come.

Marine Resources Research Institute

OWNER
South Carolina
Department of Natural Resources
Columbia, South Carolina

PROJECT ENGINEER/DESIGNER
Davis & Floyd, Inc.
Charleston, South Carolina

REPAIR CONTRACTOR
Trident Construction Company, Inc.
North Charleston, South Carolina

MATERIAL SUPPLIERS/MANUFACTURERS
Sika Corporation
Lyndhurst, New Jersey

Guaranteed Supply Company
North Charleston, South Carolina