CASE STUDY

Repair, Replace or Encapsulate?

A Practical Approach to Rehabilitating Concrete Marina Fingers

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A combination of conventional concrete repair, corrosion-resistant GFRP reinforcement, and underwater-applied glass FRP fabrics rehabilitated six deteriorated concrete fingers while minimizing disruption to marina operations.

A Landmark Caribbean Marina

Marina Casa de Campo, located in La Romana on the southeastern coast of the Dominican Republic, is one of the Caribbean's largest and most prominent full-service marinas. The Mediterranean-inspired waterfront complex covers more than 90,000 m^2 and provides approximately 350 slips. Its 16-ft draft and berthing facilities can accommodate vessels up to 250 ft long. Integrated into the internationally known Casa de Campo Resort, the marina serves recreational boats, sportfishing vessels, and large luxury yachts.

Reinforced-concrete waterfront structures in tropical marine environments face persistent exposure to saltwater, airborne chlorides, moisture, and oxygen. Once chlorides reach the reinforcing steel, corrosion products create expansive internal pressure that can crack and delaminate the concrete cover and eventually cause significant spalling. The rehabilitation described here addresses that familiar challenge through a six-finger pilot program.

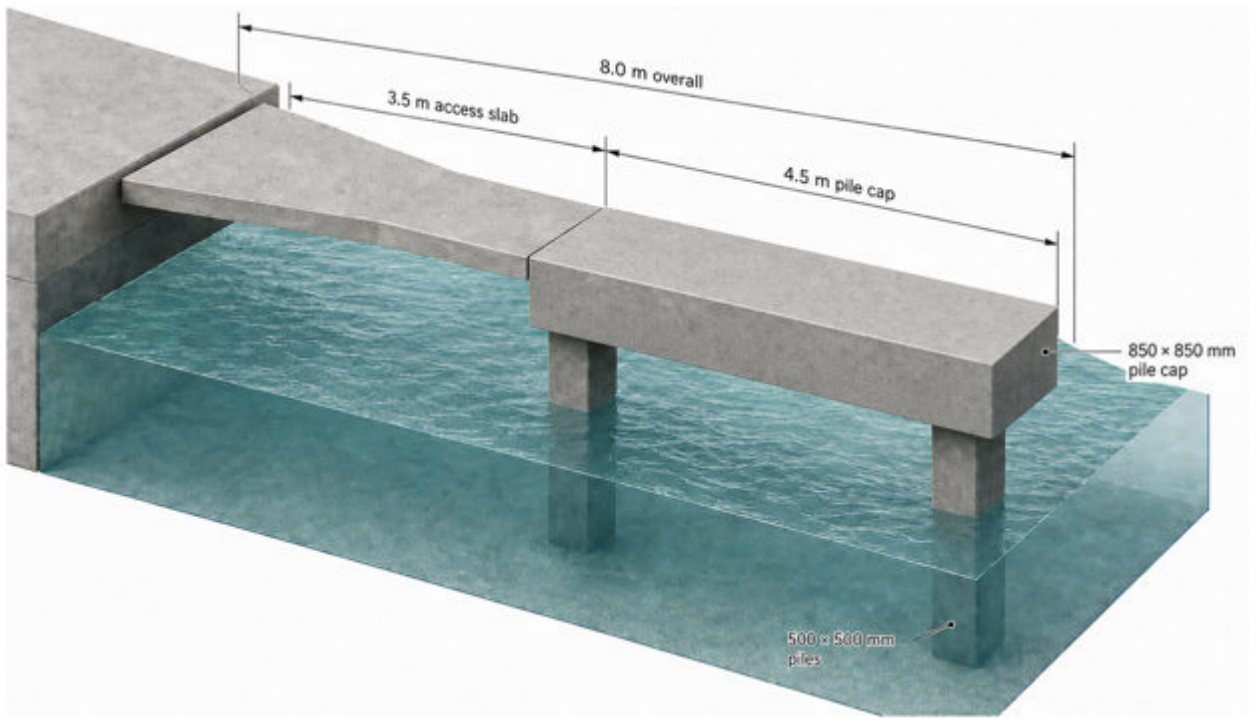


Figure 1. Each 8.0 m-long finger consists of two concrete piles, a recessed pile cap, and an access slab connecting the finger to the main pier.

The Existing Fingers

The initial repair program includes six fingers arranged in three opposing pairs along the main concrete pier. Many additional fingers at the marina may require similar rehabilitation; however, the owners and residents elected to begin with these six so they could evaluate the completed appearance and performance before deciding whether to continue the program. Each finger is approximately 8.0 m long and comprises three distinct structural zones:

- **Zone A - Piles.** Two 500 x 500 mm reinforced-concrete piles support each finger.
- **Zone B - Pile cap.** An approximately 850 x 850 mm reinforced-concrete pile cap extends 4.5 m and includes a recessed longitudinal section along its underside.
- **Zone C - Access slab.** A 200 mm-thick, 3.5 m-long slab connects the pile cap to the main pier. The first 1.6 m is approximately 0.85 m wide; the remaining 1.9 m is trapezoidal and widens to approximately 1.5 m at the main pier.

The 200 mm access slabs had experienced advanced reinforcement corrosion and significant concrete spalling. Their condition warranted complete replacement. By contrast, the piles and pile caps exhibited localized, less severe concrete damage and spalling and were suitable candidates for repair, strengthening, and encapsulation.

A Three-Zone Rehabilitation

The repair strategy was tailored to the condition and function of each zone. The access slabs were replaced, while the piles and pile caps were restored and externally reinforced with a wet-layup glass fiber-reinforced polymer (GFRP) system.

Repair or Replace? Let Condition Guide the Decision

Components of the same marina finger can deteriorate at different rates, so one repair method should not automatically be applied to the entire structure. After marine growth and loose concrete are removed, visual mapping, sounding, reinforcement observations, and appropriate testing can help distinguish localized damage from widespread section loss. At Casa de Campo, this assessment supported replacement of the heavily spalled access slabs but retention of the piles and pile caps, which had only localized damage and remained suitable for repair and wrapping.



Figure 2. Rolling the saturated fabric onto a PVC pipe simplified underwater transport, positioning, and controlled unrolling by the dive team.

Zone A: Repairing and Wrapping the Piles

Divers first removed marine growth, surface contamination, and unsound or spalled concrete to expose a sound substrate. Local voids and damaged areas were then restored with cementitious repair grout, reestablishing the pile geometry before wrapping.

The 4-ft-wide biaxial glass fabric was thoroughly saturated with a specially formulated two-part epoxy resin and rolled around a PVC pipe. This created a

compact package that divers could position and unroll without folding or tangling the wet laminate. The dive team wrapped the fabric around each square pile for one full turn plus a 12-in. closure overlap. Several layers of shrink wrap were then applied to consolidate the GFRP against the repaired concrete and hold it

Zone B: Encapsulating the Recessed Pile Caps

The pile caps received similar surface preparation. Marine growth, loose material, and unsound concrete were removed, and localized damage was restored with cementitious repair grout. Four-foot-wide strips of saturated biaxial glass fabric were then placed over the top of each cap, continued down both sides, and returned across the recessed underside. This arrangement provided continuous transverse reinforcement around the irregular profile.

Adjacent bands overlapped by 8 in. along the 4.5 m cap length. The end faces were also encapsulated, with the end laminates overlapping the transverse bands to complete the protective shell. Finally, a thin epoxy layer was applied to the upper surface, and sand was broadcast into the wet resin to create a slip-resistant walking surface.



Figure 3. Overlapping transverse GFRP bands followed the recessed pile-cap geometry and encapsulated the member on all faces.

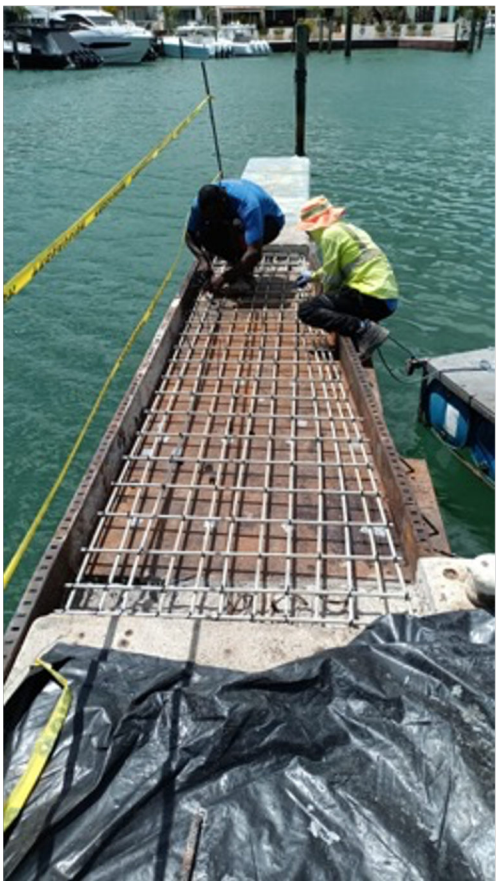


Figure 4. The deteriorated access slabs were replaced in their original geometry using noncorroding GFRP reinforcement.

Zone C: Replacing the Access Slabs

Because corrosion and spalling were extensive, the existing 200 mm-thick access slabs were demolished rather than patched. The replacement slabs were formed to match the original 3.5 m geometry, including the 0.85 m-wide rectangular segment and the trapezoidal segment widening to approximately 1.5 m at the main pier. They were reinforced with GFRP bars, which do not corrode and therefore directly address the deterioration mechanism that damaged the original slabs.



Figure 5. Completed repair showing the wrapped piles, pile cap and the new slab.

Strengthening and Protection in One System

The biaxial fabric used on the piles and pile caps has a tensile capacity equivalent to No. 4 steel reinforcing bars spaced at 6 in. on center. Fibers oriented in two directions provide external reinforcement for flexural and shear demands while also confining the repaired concrete. An 8 oz/sq yd chopped-strand mat bonded to one face of the fabric helps form a resin-rich, continuous outer layer.

Once saturated and cured, the composite jacket serves both structural and durability functions. It greatly reduces the entry of seawater, chlorides, moisture, and oxygen; protects the cementitious repairs; and helps contain the concrete if future cracking occurs. The lightweight, flexible fabric can conform to square piles, corners, and recessed surfaces and can be installed underwater without cofferdams or heavy lifting equipment. These combined benefits made it possible to strengthen and protect the retained concrete members while limiting disruption to normal marina activities.

Practical Lessons for Durable Encapsulation

Successful FRP repair depends on sound surface preparation, thorough fabric saturation, adequate overlaps, consolidation, and curing. The laminate must remain in close contact with a sound substrate, while closure and strip overlaps maintain structural and environmental continuity. On this project, the PVC-tube technique controlled the saturated fabric during underwater installation, and temporary shrink wrap consolidated it during cure.

The two forms of glass reinforcement served complementary roles: GFRP bars provided noncorroding internal reinforcement in the new slabs, while external GFRP fabric strengthened and protected the retained piles and pile caps. This allowed each zone to receive a repair suited to its actual condition.

Conclusion

The rehabilitation of the first six fingers demonstrates how different corrosion-resistant technologies can be combined within a single marina repair program. Severely deteriorated access slabs were replaced with GFRP-reinforced concrete, while the serviceable piles and pile caps were repaired, strengthened, and encapsulated with wet-layup glass FRP. Tailoring the work to each structural zone avoided unnecessary replacement of the supporting members and produced a continuous protective system suited to the aggressive Caribbean marine environment.

For marina owners, the project illustrates a practical alternative to extensive demolition: retain the concrete that remains serviceable, restore damaged areas, add external reinforcement where needed, and isolate the repaired surfaces from renewed exposure. The six-finger pilot also gives owners and residents an opportunity to assess the finished appearance and construction approach before deciding whether to extend the system to the marina's many remaining fingers.

Project Information

Project: Initial rehabilitation of six marina fingers, Marina Casa de Campo

Location: La Romana, Dominican Republic

FRP system: Wet-layup biaxial glass fabric with chopped-strand mat and two-part epoxy resin

Article author: Mo Ehsani, PhD, PE, SE, President, QuakeWrap, Inc.

Contractor: Holsteinson & Associates

Engineer: QuakeWrap, Inc.

Construction date and duration: June-July 2026

Marina background information source: Marina Casa de Campo official website