Case Study

Wabush Wharf Rehabilitation

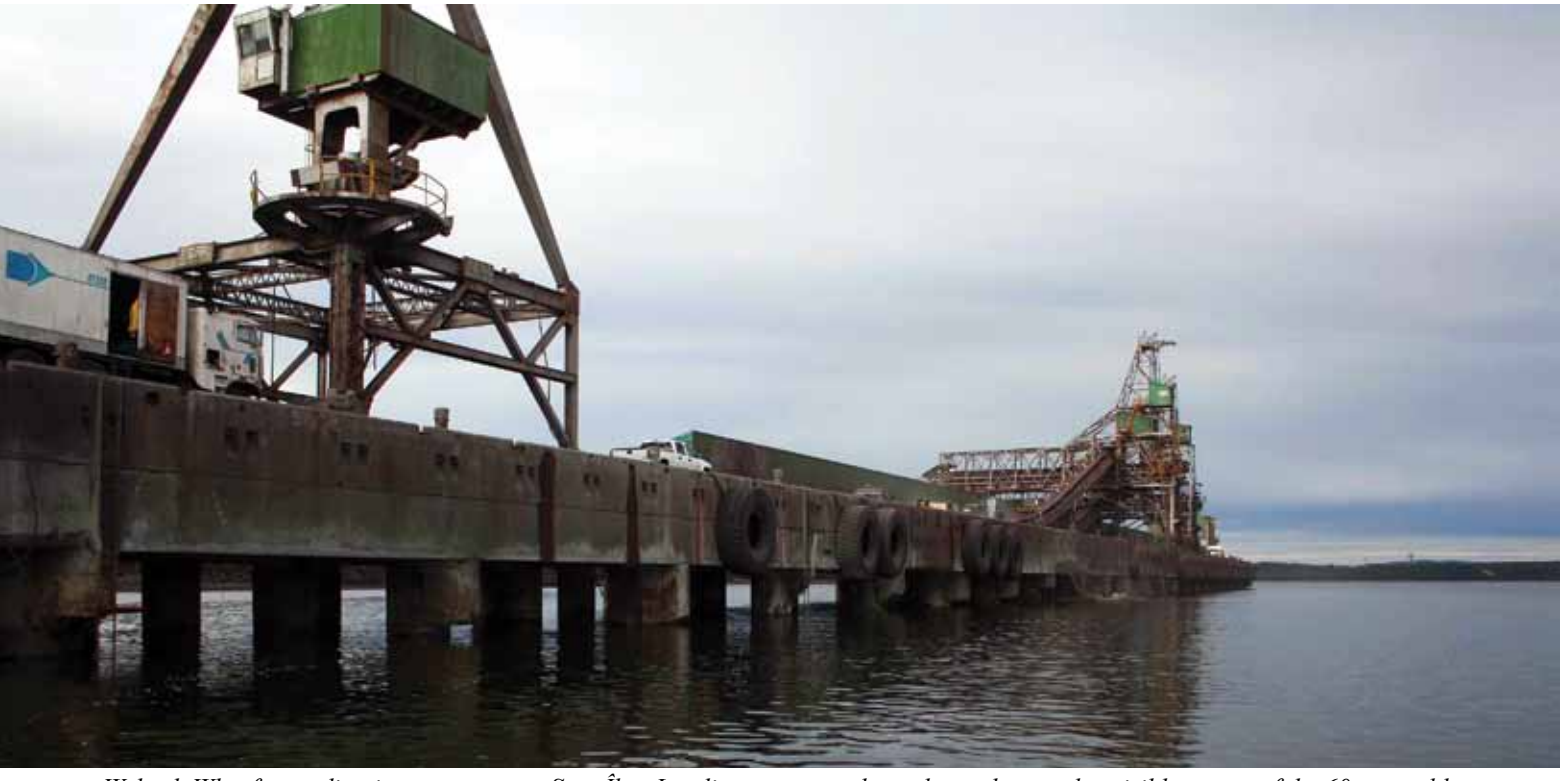
By Marc Ferland and Philip Sawoszczuk

The Port of Sept-Îles, Wabush's Wharf, on the shore of the Gulf of St. Lawrence was originally constructed in the early 1950s to allow cargo ships containing iron ore pellets to get from Labrador City to the Great Lakes region, the heart of the American manufacturing industry. The iron ore mining sector is continuously developing and the Sept-Îles Port must remain operational for a long time to come. Since its construction, the columns and beams of Wabush Wharf have been subjected to years of exposure to salt water, freezing-and-thawing cycling, the impact of waves and ice, and high/low tide cycles. Until recently, the original concrete has withstood the extreme exposure. The continuous exposure to the salt water, however, eventually allowed chloride ions to penetrate the concrete and reach the steel, causing substantial reinforcing bar corrosion and significant damage to the concrete structure.

A consulting firm was retained by the Port of Sept-Îles to evaluate the damage to the wharf and design a strategy to rehabilitate the structure. They specified that all corroded steel be exposed, cleaned, and, if necessary, replaced. Concrete removal would be tedious and difficult because most of the damaged areas were located in the underside of the structure where access is very difficult.

The original specification called for the replacement concrete to be placed using a form-and-pump method and the repairs were tendered to the invited contractors this way. The hired contractor, who specialized in maritime civil construction, soon realized the overwhelming challenges and complications they needed to overcome if they proceeded with the specified repair method. Much of the difficulty was related to limited access due to the location of the structure. Representatives of the contractor met with engineers from the consulting firm to explore options that might alleviate the access problem.

The shotcrete process was suggested as an alternative, but the unfamiliarity of shotcrete by the owners made them reluctant to accept this option. Nevertheless, the consulting firm and the contractor, who previously partnered with a



Wabush Wharf extending into a cove near Sept-Îles. Loading cranes and supply trucks are also visible on top of the 60-year-old concrete structure

particular shotcrete subcontractor on other projects, succeeded in convincing the port authority to accept their recommendation. Factors that lead to the acceptance of shotcrete included the explanation that shotcrete was just a process for placing concrete and the properties that were originally specified for the form-and-pump mixture (including air entrainment for improved durability, silica fume for reduced permeability, and the use of coarse aggregate to reduce shrinkage) would also apply if shotcrete was chosen as a concrete placement method. The contractor also ensured that every nozzleman working on the shotcrete subcontractor's team would be ACI certified. In addition, an impressive track record of the shotcrete projects by the contractor was submitted, including the bobsled track for the 1980 Lake Placid Olympic Games and the Sudbury Neutrino Observatory.

Another benefit provided by the shotcrete process that contributed to its acceptance was scheduling and time constraints. During the 3-year timeline estimated for the project, the window in which construction could take place was only open from June to September, leaving only 3 to 4 months per year to prepare and complete the work. The contractor, with help from the shotcrete subcontractor team, estimated that they could complete the repairs in the amount of time it would take to set up formwork. All parties agreed that shotcrete was clearly the superior repair method.

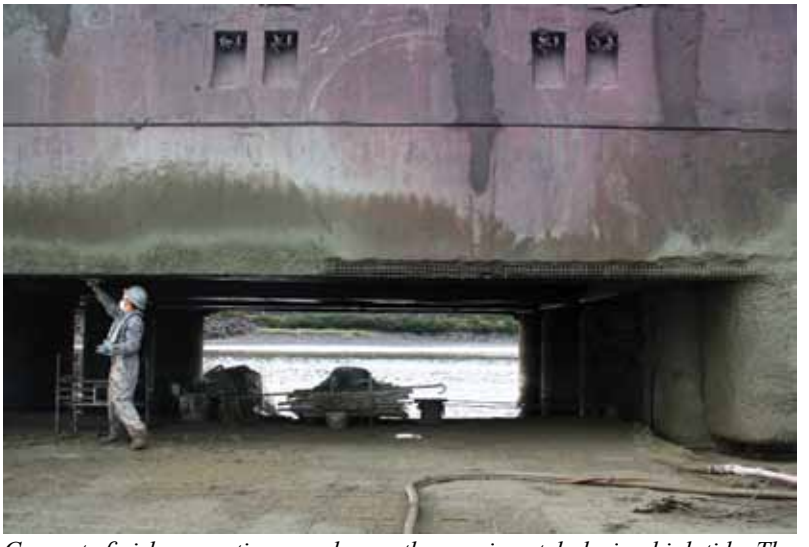
The consulting firm and the shotcrete subcontractor worked with material supplier engineers to determine an acceptable shotcrete mixture with all of the properties required for this project. It was agreed that the product used must contain air-entraining admixture to provide resistance to continued effects of freezing-and-thawing cycles, and silica fume to reduce permeability and increase resistance to washouts from wave action in the tidal zones during shotcrete operation. The use of silica fume also added the additional benefit of lowering the permeability of the hardened concrete, which limits chloride ion migration to the steel reinforcing bar, thus protecting it from future corrosion.

Even before the project began, the shotcrete crew realized that they faced some unique challenges, mainly due to the location of the project, but felt confident that there were no challenges that they hadn't overcome before. Safety concerns caused by high winds frequently forced the crews to suspended work. The team also had to operate with the rhythm of the tides, starting at one end of the wharf during high tide and moving down with the receding tide.

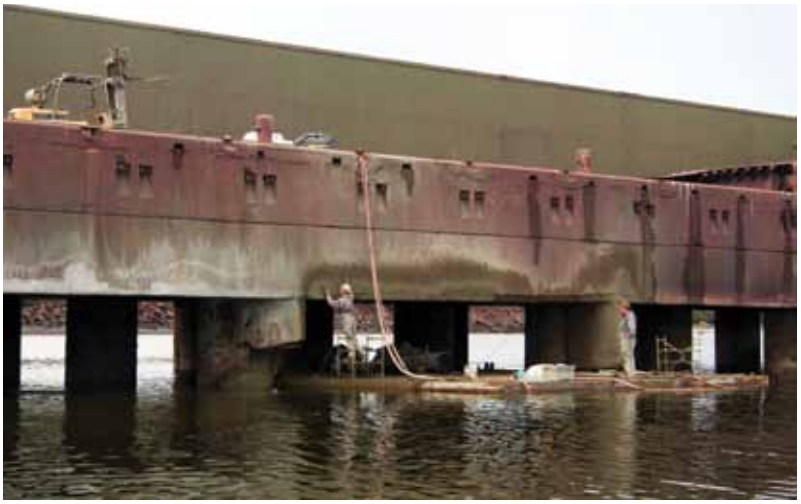
During the shotcreting operation, the shotcrete machine and compressors were set up on the deck of the wharf and the hose ran across the deck onto a floating barge platform below. The special barge

Barge platform supporting both a finisher and a nozzleman, working in tandem to complete the repair patch before moving to another area

Nozzleman applying the initial coat of shotcrete to a repair 3 to 6 in. (75 to 150 mm) deep using the dry-mix process during high tide



Concrete finisher creating an edge on the repair patch during high tide. The securily fastened metallic trellis can be seen in the uncompleted section



A finisher is completing the repair with a trowel while a fork-lift and some of the shotcrete equipment remain on top of the wharf, allowing efficient resupplying while creating more space

Finished repair zone beneath the wharf along some support beams

platform was leased from the contractor and spanned the width of the wharf. It was large enough to carry both the shotcrete crew and the finishing crew. The barge platform provided two purposes. It could float on the surface of the water when the tide was high, but it could also be suspended from the wharf when the tide was low. This unique capability allowed for quick progression from repair zone to repair zone. When each section was completed, the crews moved back onto the deck as the platform-barge moved to the next section.

The demolition and the surface preparation procedures were conducted using hydrodemolition, which provided optimal surface preparation without introducing microcracking in the concrete substrate. On some occasions, when the tides and the waves were high, the repair section had to be first cleaned with potable water to remove salt contamination from the wire mesh and algae growth from the existing substrate. In some areas that were below the waterline during high tide, more than 6 in. (150 mm) of deteriorated concrete had to be removed. Most of these sections were repaired in a single pass.

Representatives from The Port of Sept-Îles were extremely satisfied with the performance of the contractor and in particular made reference to their attention to detail. The contractor, consulting engineers, and owner were also pleased with the on-site technical support and the assistance with mixture design selection provided by the materials supplier. The shotcrete subcontractor was awarded contracts to repair the wharf during the summers of 2007, 2008, and 2009, during which time over 590 yd^3 (450 m^3) of shotcrete were applied. The shotcrete subcontractor is currently negotiating contracts for several other sections of the wharf, also to be repaired within the next few years using the dry-mix shotcrete process.

Marc Ferland *is President of Béton Projeté M.A.H., a shotcrete contractor in the province of Québec, Canada. The company has over 25 years of experience in the shotcrete business and specializes in artificial rock, pools, spas, water parks, water gardens, statues, zoo exhibits, parking lots, repair, and much more.*

Philip Sawoszczuk*, Jr.Eng., is a Technical Services Representative for King Packaged Materials Company. His areas of expertise include rehabilitation and preservation of infrastructure, structural engineering, and durability of concrete. He received his degree in civil engineering from McGill University, Montreal, QC, Canada.*

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Consulting Firm
Axor Experts-Conseils
Sept-Îles, QC, Canada

Contractor
Bouchard & Blanchette Marine Ltd.
Sept-Îles, QC, Canada

Shotcrete Subcontractor
Béton Projeté M.A.H.
St-Ferréol-les-Neiges, QC, Canada

Material Supplier
King Packaged Materials Company
Burlington, ON, Canada

Material: King MS-D1
Synthetic Fiber-Reinforced Shotcrete