2014 Outstanding Infrastructure Project

McCormick Dam & Power Station: Submerged Concrete Repairs

By Roger Côté, Harold Ferland, and Kevin Robertson

The McCormick Dam and power station was built in 1952 on the Manicouagan River by the Quebec and Ontario Paper Company and the Canadian British Aluminium Company. It was named after Colonel Robert R. McCormick, who owned and published the *Chicago Tribune*. It is currently owned and operated by the Société en Commandite Hydroélectrique Manicouagan. The dam is situated approximately 1.9 miles (3 km) west of Baie-Comeau, QC, Canada, in the Côte-Nord area of the province of Quebec.

Groupe-conseil TDA, a well-established and leading consulting firm from la Côte-Nord area, was hired to inspect the dam, the retaining walls of the reservoir, and the water discharge (tailrace) to determine the condition of the concrete after 60 years of exposure to heavy water flow and freezing-and-thawing cycling and to formulate a plan to rehabilitate the structure.

The project was released for tender in early 2013 and was awarded to BBMarine. BBMarine is a specialized marine contractor from la Côte-Nord with over 35 years of experience in the construction, inspection, repair, and maintenance of marine structures.

Fig. 1: Area to be repaired

Scope of Work

The results of Groupe-conseil TDA's inspection confirmed abundant surface scaling at and below the waterline along the entire length of the reservoir (basin) retaining walls and the tailrace (spillway). The average depth of the repairs was approximately 2 in. (50 mm). Damage to the reservoir (basin) retaining walls equated to a surface area of approximately 10,763 ft^2 (1000 m^2), while the tailrace (spillway) required approximately 6458 ft^2 (600 m^2) of repair (Fig. 1).

The location of the repairs created many logistical and procedural challenges. To overcome those challenges, Le Groupe-conseil TDA specified that the damaged concrete be removed and replaced using pressure grouting techniques, through which nonshrink grout would be pumped from surface into the forms. Divers would be required to direct the pressure grouting process and to ensure the watertight forms retained all of the grout.

The thought of forming a total area of 17,221 ft^2 (1600 m^2), much of it underwater (using divers), concerned the construction team because of cost implications and the effect it would have on the entire construction schedule.

Logistics

The logistical challenges continued after BBMarine mobilized on site. The majority of the areas to be repaired provided limited access or room for equipment, materials, and formwork. Access to the repair locations was therefore limited to barges.

BBMarine initiated discussions with Groupe-conseil TDA, Béton projeté MAH Inc., and King Shotcrete Solutions to investigate alternative solutions for completing the concrete repairs. The group reached consensus that if concrete replacement was executed using the shotcrete process, it would allow easier access to the repair areas and it would contribute to an accelerated construction schedule. More importantly, all agreed that replacing nonshrink grout with concrete (as a repair material) would result in much more durable and

longer-lasting repairs, especially considering the extreme freezing-and-thawing environment.

For a number of reasons, Béton projeté MAH Inc. elected to use the dry-mix process over wet-mix shotcrete. The dry-mix process allowed them the ability to start and stop without having to clean out hoses. The challenges associated with the placement of shotcrete on the water (primarily lighter-weight hoses and longer conveying distances) were also better addressed using the dry-mix process. Easier access to the shotcrete material, through the use of 2200 lb (1000 kg) bulk tote bags, was another key benefit of the dry process. And in addition to the logistical benefits such as easier material handling, prepackaged materials provided much improved consistency, which resulted in higher levels of quality control.

Materials engineers from King Shotcrete Solutions (the material supplier) designed a mixture that would provide reduced shrinkage and long-term durability. Silica fume provided a denser matrix and improved adhesion and cohesion during placement. The use of powdered air-entraining admixtures provided optimal spacing factor and air void system to improve durability. The use of micro-synthetic fibers helped reduce the potential for shrinkage cracking, which also added to the long-term durability of the repairs.

Béton projeté MAH Inc. was awarded the subcontract to complete the shotcrete placement and finishing. They have over 120 years of combined shotcrete experience in all aspects of shotcrete placement (repair, new construction, and artistic work). BBMarine retained the responsibility for all other logistics, concrete removal, surface preparation, and so on.

Repair Process

For the shotcrete process to work, BBMarine worked closely with the shotcrete subcontractor to develop a planned procedure for surface preparation, shotcrete placement, and shotcrete finishing. The key challenge was access to the repair areas located below the waterline. BBMarine relied on their extensive experience working in marine environments to design a special mobile cofferdam system that would allow them to move the unit along the 0.6 mile (1 km) reservoir (basin wall). All surface areas to receive the shotcrete were prepared using the hydrodemolition method (Fig. 2 and 3). A special hydro rig was set up on a floatable barge, which allowed the crew to complete the concrete removals using a 20,000 psi (140 MPa) water blast. The barge that hosted the hydrodemolition rig was set up ahead of the shotcrete barge and moved along the reservoir basin wall so that the repair area was prepared before the arrival of the shotcrete barge.

Both mobile cofferdam systems were set up to allow a work area of approximately 17 ft long x 4 ft high x 4 ft deep (5.2 x 1.2 x 1.2 m) and were temporarily anchored to the concrete wall of the reservoir basin (Fig. 4 to 6). The area of contact between the mobile cofferdam and the surface of the concrete was sealed to prevent water from reentering the cofferdam. Gas-powered dewatering pumps were then used to remove the water from inside the cofferdam system and allow access for the removal crew and the shotcrete crew. The shotcrete crew was provided with a wooden platform system, set up behind the cof-

Fig. 2: Mobile hydrodemolition rig

Fig. 3: Surface preparation, hydrodemolition rig

Fig. 4: Area ready for shotcrete

ferdam, which allowed the shotcrete nozzleman to maintain the proper distance 3 to 5 ft (0.9 to 1.5 m) from the end of the nozzle to the receiving surface. Once placement and finishing was complete, the portable cofferdam would be moved to the next section while skipping the section directly beside to be able to be anchored into existing concrete and not the fresh shotcrete.

The flexibility of the dry-mix shotcrete process allowed Béton projeté MAH Inc. to set up the machine on solid ground in areas that gave them access to a forklift and enough room to maneuver the 2205 lb (1000kg) bulk bags. On average, they required approximately 250 to 300 ft (76 to 91.5 m) of hose to access the work area. With the repair areas in most cases submerged, the receiving area was always saturated, which helped to ensure a strong and durable bond between the parent concrete and the repair material. Approximately 350 to 2205 lb (1000 kg) bulk bags were used on the project (Fig. 7).

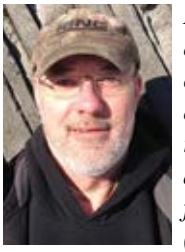
A line wire was used by the Béton projeté MAH Inc. crews to maintain the same thickness and surface profile as the existing concrete. Once an area was shot, the crew cut off any excess shotcrete, ensuring the area was plumb and level with the existing concrete. A mechanical spinning trowel was used for the rough finish and then a magnesium trowel for the final finish. Once the shotcrete reached its initial set, the dewatering pumps were shut off to re-submerge the repair and maintain ideal curing conditions (Fig. 8).

The cooperation between the general contractor (BBMarine), the shotcrete contractor (Béton projeté MAH Inc.), and the material and equipment supplier (King Shotcrete Solutions) resulted in an extremely successful project with the end result being a satisfied owner (Société en Commandite Hydroélectrique Manicouagan). The success of this project will no doubt result in more opportunities in which shotcrete will play a vital role in the marine infrastructure rehabilitation market in la Côte-Nord (Fig. 9 and 10).

Fig. 5: Mobile cofferdam set up

Fig. 6: Nozzleman shooting in mobile cofferdam system

***Roger Côté**, Eng., is the Director of Engineering for BBMarine. His area of expertise includes application and design equipment for concrete rehabilitation.*



***Harold Ferland** is the co-owner of Béton projeté MAH Inc., a company that has been doing only shotcrete work for 14 years throughout Canada. Ferland is an ACI Certified Nozzleman for dry- and wet-mix shotcrete (overhead and vertical). He has been in the shotcrete industry for 29 years.*

***Kevin Robertson** is a Technical Sales Representative for King Shotcrete Solutions, Boisbriand, QC, Canada. His areas of expertise include shotcrete materials, application, and equipment, focused mainly on concrete rehabilitation applications. Robertson is a member of ASA, the American Concrete Institute (ACI), and is on the Board of Directors of the Quebec Province Chapter of the International Concrete Repair Institute (ICRI).*

Fig. 7: Shotcrete equipment setup

Fig. 8: Shotcrete crew cutting and doing the rough finish using mechanical trowel

Fig. 9: Finished section of reservoir (basin) wall

The Outstanding Infrastructure Project

Project Name
McCormick Dam & Power Station:
Submerged Concrete Repairs

Project Location
Baie-Comeau, QC, Canada

Shotcrete Contractor
Béton projeté MAH Inc.

General Contractor
BBMarine

Architect/Engineer
Groupe-conseil TDA

Material Supplier/Manufacturer
King Shotcrete Solutions*

Project Owner
Société en Commandite Hydroélectrique
Manicouagan

*Corporate Member of the
American Shotcrete Association

Fig. 10: Finished section