

# Outstanding Shotcrete Project Award Winner

## 2006 Outstanding International Project

# Reform and Expansion of Bridgetown Port

Bridgetown, Barbados, BWI

**T**he Port of Bridgetown on the island of Barbados was originally constructed in the early 1960s and expanded in the mid-1970s to allow for increased growth in traffic from cruise ships and cargo ships. Further growth that was forecasted required that the Port again upgrade the existing berths and also upgrade and expand the cruise terminal facilities.

Delcan International of Toronto, ON, Canada, undertook the planning, project management, and design of the project. The successful bidder, Lagan Holdings Limited of Belfast, Northern Ireland, was awarded the contract to conduct the work and moved onsite in February 2005.

Continuous exposure to salt water had caused corrosion of the reinforcing steel and resulted in severe deterioration of the concrete throughout the facility (Fig. 1). Concrete removal exceeded 6 in. (150 mm) in depth in many areas. Delcan elected to specify shotcrete to replace the deteriorated concrete that was removed from berths, wharfs, and concrete dolphins. Delcan engineers were familiar with shotcrete from previous projects that

involved similar challenges and were aware of the benefits offered by shotcrete.

Due to availability and quality concerns with local shotcrete suppliers, Lagan submitted a proposal for shotcrete material to be supplied by King Packaged Materials Company. King proposed that shotcrete, produced at their Brantford, ON, Canada, ISO 9001-2000 registered production facility, be supplied in special 2205 lb (1000 kg) bulk tote bags. These bags were lined with polyethylene to prevent moisture from coming in contact with the cementitious material. All material was loaded into 20 ft (6.1 m) sea containers and shipped by sea freight to Port of Bridgetown, Barbados.

The shotcrete mixture design conformed to ACI gradation No. 2 and contained silica fume to reduce rebound, increase resistance to water washout, and decrease the permeability of the mixture. Concrete or shotcrete with low permeability values would prevent chlorides from migrating into the concrete and increase the rate of corrosion of the reinforcing steel. Low rebound levels had obvious monetary benefits; with a reduced potential for material entering the water, it also had a positive environmental impact. Lagan personnel also took several precautions to minimize the amount of chipped concrete and debris that could enter the water below.

Proper curing procedures were critical to reduce the amount of drying shrinkage because of the extremely hot conditions encountered on the island. To reduce the potential for shrinkage cracking, Delcan specified that synthetic fibers be preblended with the other shotcrete mixture components.

A shotcrete nozzelman, with years of experience on concrete rehabilitation projects, was brought in from the UK. He shot test panels, using the approved shotcrete mixture, under the supervision of both King and Delcan personnel. Test panels were evaluated by Delcan QC personnel and resulted in the nozzelman being approved to work on the project (Fig. 2).



Fig. 1: Severely deteriorated concrete beams (after concrete removal)

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Concrete removal was conducted using a combination of air hammers and hydrodemolition. On the wharf rehabilitation section of the project, the nozzelman was able to access concrete beams and columns located under the concrete slab and the underside (soffit) (Fig. 3). The shotcrete hoses ran from the shotcrete machine, which was stored with the prepackaged materials on the top of the slab, to the nozzelman who was positioned below the slab, just above the surface of the water (Fig. 4).

The anti-washout characteristics provided by the silica fume also allowed the nozzelman to shoot material until the tidal actions prevented him from continuing. Shotcrete eliminated the need for costly forming applications and allowed the general contractor, Lagan Holdings Ltd., to accelerate the repair process and meet the schedule demands. Finishing had to be completed quickly because of the effect that hot temperatures had on the plastic properties of the shotcrete mixture (Fig. 5). Curing procedures began as soon as possible after shooting to prevent surface cracking caused by drying shrinkage.

Large concrete dolphins, used to moor large cargo ships, also required substantial rehabilitation. Spalling, caused by corroding reinforcing steel, was extensive, and substantial amounts of concrete were removed. The flexibility offered by shotcrete again allowed Lagan personnel to store all materials on the surface concrete slab and run hoses to the nozzelman who stood on a floating raft to access the vertical sides of the dolphins (Fig. 6).

During the project, King Packaged Materials technical staff provided on-site technical assistance that provided an opportunity to exchange views with the European nozzelman, comparing the differences between the North American and European approach to dry-mix shotcreting. By the time the shotcrete portion of the project was completed, representatives of Delcan International and Barbados Port, Inc., were in agreement that the quality of the shotcrete repairs met all expectations.

There are many reasons that shotcrete contributed to the success of the Bridgetown Port project. Lagan was able to easily schedule the work because of the availability of prepackaged materials that were stored onsite. Access to the repaired areas was difficult because of the proximity of the beams and columns. The shotcrete nozzelman was able to easily place material in these confined areas without costly formwork that would have been required throughout the structure. This is



*Fig. 2: Nozzelman preparing to shoot on-site test panels*



*Fig. 3: The shotcrete hoses ran from the shotcrete machine, which was stored with the prepackaged materials, on the top of the slab to the nozzelman who was positioned below the slab, just above the surface of the water*

evident through some of the photos taken of the underside of the concrete slab. The dry-mix method allowed the contractor to move from section to section without having to wait for concrete trucks and, when required to stop, they were able to simply empty the machine and shut down on demand.

The mixture design chosen provided improved durability over the original concrete and with the proper surface preparation (hydrodemolition and

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*Fig. 4: Shotcrete machine and bulk bags containing the preblended materials were positioned on the top of the slab while shotcrete was applied underneath*

sandblasting), they were able to achieve excellent bond strengths between the shotcrete and the existing concrete. The nozzelman's skill combined with the use of quality materials (both mixture and mixture design), ensured that the quality of repairs exceeded the minimum specified requirements as outlined by the engineers.

The hot temperatures encountered during the project presented a challenge to the shotcrete crew but would have also have been a factor had the engineers and contractors elected to use a form-and-pump method of repair. In fact, the use of dry-mix shotcrete eliminated concerns about slump retention and pumpability. These concerns would have been prevalent, especially in cases where the repair areas were small and spread out on different areas of the structure.

The flexibility offered by dry-mix shotcrete and the benefits offered through prepackaged products (manufactured in a controlled, factory environment), allowed Lagan construction management personnel to focus on other aspects of the project. With the results of test panels available to them, it was only a short time after the shooting process began that Lagan management had full confidence in the excellent quality of the shotcrete work.



*Fig. 5: Finishing had to be completed quickly because of the affect that hot temperatures had on the plastic properties of the shotcrete mixture*



*Fig.6: Concrete dolphins after shotcrete was placed and finished*

## Outstanding International Project

### *Project Name*

Reform and Expansion of Bridgetown Port

### *Project Location*

Bridgetown, Barbados, BWI

### *Shotcrete Contractor*

Lagan Holdings Ltd.

### *Project Owner*

Barbados Port, Inc.

### *Architect/Engineer*

Delcan International

### *Material Supplier*

King Packaged Materials Company

### *General Contractor*

Lagan Holdings Ltd.