

# Bordeaux Prison: Rehabilitation and Repair of the Perimeter Walls

By Kevin Robertson and Pierre Brassard

In 1891, the city of Montreal, QC, Canada, purchased land in Bordeaux (now the borough of Ahuntsic-Cartierville) for construction of a new prison to replace the outdated 1820s Pied-du-Courant prison, located in the Ville-Marie borough.

The prison, one of the few Pennsylvanian-styled prisons in Canada, was designed by Jean-Omer Marchand and R.A. Brassard, and built between 1908 and 1912 at a cost of \$2.5 million, an astronomical amount in 1912.

On November 18, 1912, Bordeaux Prison opened its doors for the first time to 100 prisoners. It was then, as it is now, the largest provincial prison in Quebec; it was built to hold 500 prisoners but now has a capacity of 1189 inmates. The star-shaped building consists of a central 12-sided domed hub from which spring six cellblock wings that feature large outside cells ranged along the exterior walls. The new jail included state-of-the-art workshops placed at the heart of the prison, in front of the cellblock, and on both sides of the administration building. The whole complex stands within a five-sided compound surrounded by a double wall.

Today, Bordeaux Prison is the largest and most important prison in the province of Quebec. It is owned and operated by Société québécoise des infrastructures (SQI). The prison is protected by two peripheral concrete walls separated by an interior path. The heights of the inside and outside walls are 25 and 14 ft (7.4 and 4.4 m) and approximately 30 ft (9.1 m) wide, respectively. Exposure to over 100 years of the freezing-and-thawing cycles experienced during Montreal winters resulted in significant deterioration throughout the concrete walls. Core samples revealed that concrete deterioration ranged from 2.5 to 4 in. (65 to 100 mm) in depth. This contract was the fourth phase of the entire restoration project.

The first two phases called for a removal of the deteriorated concrete. Lightweight precast panels were installed using a steel stud hanger system to protect the walls from any further deterioration. Phase three called for removal of the deteriorated concrete and replacement using the form-and-pour method. Upon evaluation, however, it was

evident this method was more costly and created longer delays. The section of walls that were to be repaired using the form-and-pour method required construction of a temporary wall in front of the existing wall to prevent inmates from climbing the wall formwork and escaping. The formwork had to be fireproof and thicker to provide room for the concrete to be placed within the form. The entire work area required an around-the-clock security patrol to prevent escape attempts.

Phase four of the project was released for tender in late 2014 and was awarded in 2015 to General Contractor Construction Jessiko Inc. Shotcrete-related work was a large portion of the project and included surface preparation, shotcrete placement, and curing. Jessiko chose Groupe Lefebvre M.R.P., an experienced and well-known concrete repair, waterproofing, and shotcrete contractor from the greater Montreal region for that portion of the contract.

## SIGNIFICANCE OF SHOTCRETE

For phase four, the structural engineering firm Geniex investigated the use of shotcrete to place the significant amount of concrete that would be required to replace the removed deteriorated concrete. Although they had never before specified shotcrete as a concrete placement method, the engineers conducted considerable research into the benefits of the shotcrete process and eventually determined that the dry-mix shotcrete process would provide the best option. The main benefit offered by the shotcrete process was the speed of repairs (extremely important because the courtyard could not be shut down for long periods of time unless a new, temporary wall was constructed in front (as was the case using the form-and-pour method). A long-term durable concrete repair was also critical to ensure overall performance.

The engineer specified the use of King MS-D1 SY, a silica-fume-enhanced, prepackaged shotcrete material for dry-process applications. Among the important factors in selecting this product was the fact it was air-entrained. Although some believed that achieving consistent air content in dry-mix shotcrete was impossible, test data from

repeated projects, provided by King, verified that not only could dry-mix shotcrete be air-entrained but also results of freezing-and-thawing salt-scale testing were dramatically improved when compared with non-air-entrained dry-mix shotcrete.

Among the many challenges faced by the contractor on this project was dealing with high-level security throughout the facility. Construction workers, equipment, and material delivery trucks had to pass through mandatory security checkpoints to make sure no illegal contraband was being smuggled into the prison. All workers were required to sign in and out and wait for a security guard to be escorted to the work area. Each work area was monitored by a trained, high-level security team.

## SCOPE OF WORK

The shotcrete portion of the work required removal and replacement of deteriorated concrete on both inside and outside of the perimeter walls. The original scope called for the removal of 32,000 ft<sup>2</sup> (3000 m<sup>2</sup>) of concrete at an average depth of 4 in. (100 mm). Hydrodemolition was used to remove the deteriorated concrete and prepare the concrete surface. This removal method was chosen because it would provide an ideal surface for the shotcrete material to bond to and minimized microcracking that often accompanied the use of conventional mechanical chipping equipment. The original concrete mixture was produced using very large aggregates 1 to 1.5 in. (25 to 38 mm) in diameter. Special attention to the removal was critical to make sure that any large stone that was exposed would stay intact and not loosen because that could potentially create a bonding issue.

During the demolition phase, it was revealed that the depth of deterioration was far greater than expected. In some cases, the outside of the perimeter wall had sections that required up to 18 in. (450 mm) of concrete removal. Apparently, the hydrodemolition equipment penetrated much deeper into the poor-quality concrete than originally expected. Thus, a special depth gauge was eventually used to maintain the proper depth of concrete removal. The specification also called for the installation of a 4 x 4 x W2.9 x W2.9 (102 x 102 x MW18.7 x MW18.7) galvanized wire mesh mounted every 20 in. (500 mm) center-to-center.

In one particularly large section, approximately 10,000 ft<sup>2</sup> (930 m<sup>2</sup>) of the inside of the perimeter wall, the specification called for removal of the light scaling from the concrete surface and to repair with conventional hand-applied mortar. Geniex initiated conversations with King Shotcrete Solutions to investigate an alternative using the high-velocity dry-mix shotcrete to shoot and finish a thin layer of shotcrete and create the same look as the original construction. The engineer accepted the proposal after it was explained that the extremely strong bond between the shotcrete and the parent concrete would ensure a longer life and help minimize the progression of corrosion that had begun. However, this portion of the work was put off until the next phase of repairs.



Fig. 1: Hydrodemolition machine setup



Fig. 2: Close-up of hydrodemolition concrete ready for shotcrete



Fig. 3: Repairs ranging from 2.5 to 18 in. (64 to 450 mm)



Fig. 4: Mesh installed using gunite hooks



Fig. 5: Soaker hose creating a saturated surface-dry surface on area to be repaired

In each section of wall, a vertical expansion joint was placed to full depth at approximately 15 ft (4.5 m) spacing and a horizontal joint was placed 7.2 ft (2.2 m) up from the ground to help control any potential drying shrinkage that may occur from shooting these large concrete sections. A 7-day wet cure was specified to further reduce the potential for shrinkage cracking. Perforated water dripper hoses were installed at the top of the wall and turned on once the shotcrete reached final set. The specification originally called for burlap to hang down from the top of the wall, but this was



Fig. 6: Soaker hose used to cure the dry-mix shotcrete



Fig. 7: Shotcrete application and finishers

removed from the plan as it could also provide a climbing device for the prisoners to escape.

A specific sequence had to be followed to assure that the security personnel could still see and maintain order in the prison. The walking platforms that sat on the top of the walls had to be removed section by section, allowing work on only one section of the perimeter wall at a time. An entire section of the wall had to be completed and the walking platform had to be replaced before allowing work to begin on another section.

Periodic compressive strength testing using the ASTM C1604 method was conducted throughout the project. In addition, bond strength testing using ASTM C1583 was conducted to ensure that the shotcrete had a strong bond with the large exposed aggregates and especially on the large, relatively thin sections that had no wire mesh or a mechanical tie to the original structure concrete.

## SHOTCRETE MATERIALS

Specifying a prepackaged, preblended dry-mix shotcrete provided the engineer with confidence that the quality control would be maintained throughout the project and the skill and expertise of the experienced ACI-certified nozzlemen, along with an experienced shotcrete team, ensured that the placement would be completed to meet the project specifications. Groupe Lefebvre (the concrete repair contractor) has been in the concrete repair, waterproofing, and shotcrete industries since its inception over 25 years ago. Groupe Lefebvre also brought on the team from Béton projeté MAH to help with the shotcrete portion. The management team of Béton projeté MAH Inc. has over 120 years of combined shotcrete placement experience.

The dry-process mixture design chosen included silica fume to reduce the permeability of the concrete and to increase resistance to moisture and increase protection the reinforcement bars. Air entrainment was provided to help protect against damage from freezing-and-thawing cycling. Synthetic fibers were included to help minimize potential early-age plastic shrinkage cracking, especially because of the large surface area and some areas that had extremely deep repair thicknesses. Aggregate gradation No. 2 from ACI 506R with up to 3/8 in. (10 mm) stone was used to help with compaction and reduce the shrinkage



Fig. 8: Dry-mix shotcrete equipment setup on trailer

potential. The fact that the King MS-D1 SY was silica-fume-enhanced allowed the contractor to shoot thicker passes to accelerate the work to bring the repair back to the original surface dimensions. By doing so, they minimized the hours of security personnel required and shortened the closure of the courtyard. A total of seven-hundred-sixty-eight 2205 lb (1000 kg) bags were used on the project.



**Kevin Robertson** is the Business Development Manager, U.S. Markets, for King Shotcrete Solutions. He began his career with King in 2007 as a Technical Sales Representative. Over the past decade, Robertson has played a key role in the growth of King's concrete rehabilitation and tunneling business in Eastern Ontario,

Quebec, and Northeast United States markets. His area of expertise includes shotcrete materials, applications, and equipment, focused mainly on concrete rehabilitation applications. Robertson is a member of ASA, the American Concrete Institute (ACI), and the International Concrete Repair Institute (ICRI), and has also served on the Board of Directors for the Quebec Chapter of ICRI, most recently as its Vice President.



**Pierre Brassard, Eng.,** is a graduate of construction engineering from L'École de Technologie Supérieure (ETS) in 1994. He spent nearly 12 years as team leader of the project management office (PMO) for major projects in Quebec and abroad for Hydro-Quebec. Since 2005, Brassard has been the President and

Senior Engineer of the Quebec-based engineering firm he founded. Geniex Ingénierie specializes in structural and foundation design for residential, commercial, and industrial buildings. In mid-2015, he co-founded Geniex Construction Ingénierie, which provides a full design-build value-engineering service for the Montréal and regional areas.

## 2016 OUTSTANDING INFRASTRUCTURE PROJECT

*Project Name*

**Bordeaux Prison:  
Rehabilitation and Repair of the Perimeter Walls**

*Project Location*

**Montreal, QC, Canada**

*Shotcrete Contractor*

**Groupe Lefebvre M.R.P. Inc. & Béton projeté M.A.H., Inc.**

*General Contractor*

**Jessiko Inc.**

*Architect/Engineer*

**Héloïse Thibodeau architecte Inc., Geniex (Engineer)**

*Material Supplier/Manufacturer*

**King Shotcrete Solutions\***

*Project Owner*

**Société québécoise des infrastructures**

\*Corporate Member of the American Shotcrete Association