HARD-CEM SHOTCRETE **IN THE FIELD**

BURNABY, BC, CANADA
METRO SKATE PARK

Hard-Cem shotcrete helped construct the bowl-shaped and full pipe areas of Metro Skate Park, giving it the resistance needed to endure years of skateboards gliding over its surfaces.

RICHMOND, BC, CANADA IONA ISLAND WASTE WATER TREATMENT PLANT

All the large solids going through the plant's screening process were significantly eroding the tanks. However, adding Hard-Cem shotcrete to the bottom and walls of each tank restored them and gave them the necessary protection against erosion.

SMART CONCRETE®

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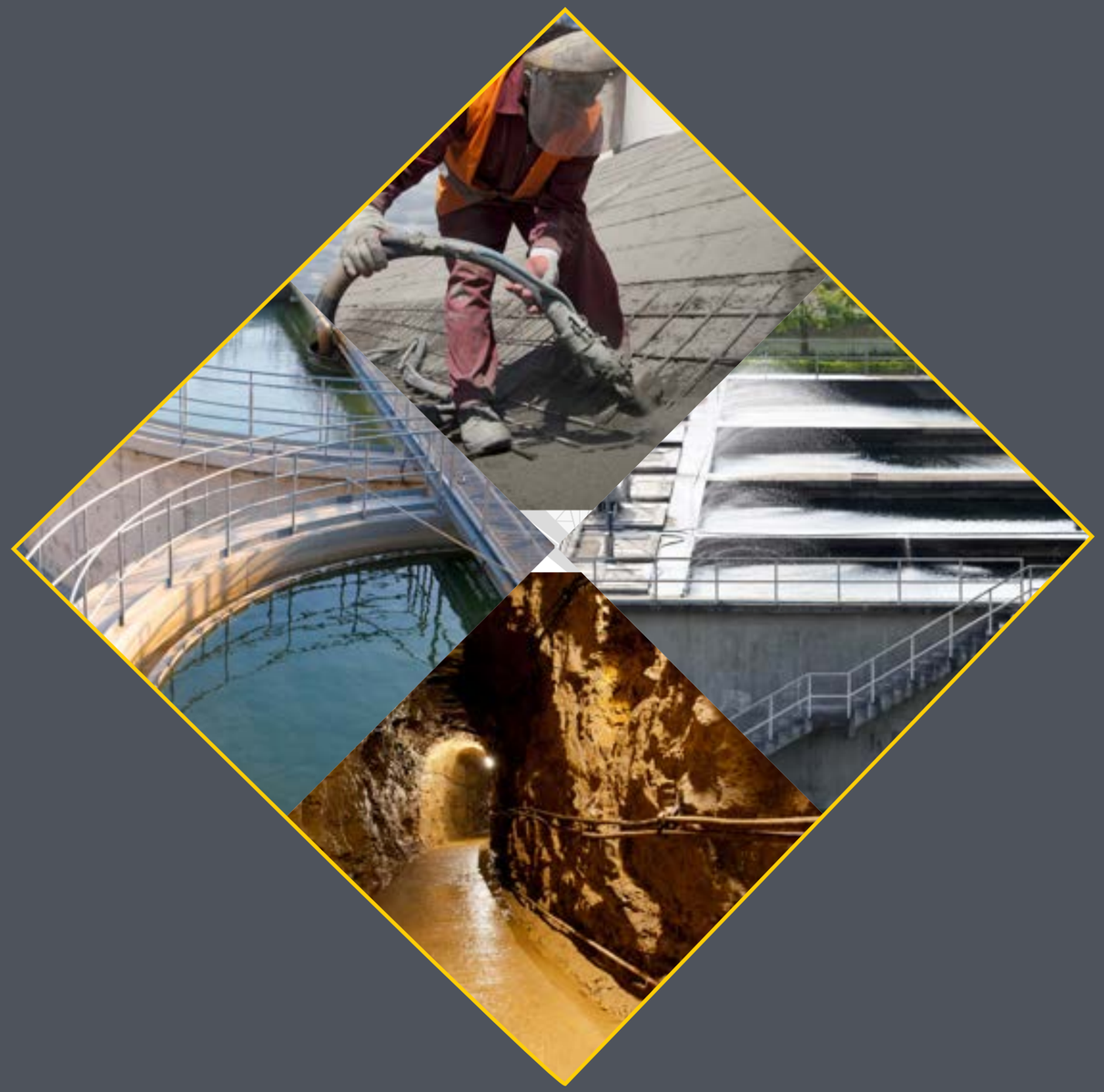
HARD-CEM®

HIGH PERFORMANCE **SHOTCRETE**



Hard-Cem: Kryton's Integral Concrete Hardener

Hard-Cem is an integral hardening admixture engineered to provide concrete and shotcrete with superior surface hardness and resistance to abrasion and erosion. Added during batching, it provides full-depth, integral protection. Unlike surface-applied hardeners, Hard-Cem is unique in its ability to harden horizontal, vertical, or inclined surfaces and is fully compatible with all common concrete admixtures.

Hard-Cem Shotcrete Test Program

To measure Hard-Cem's abrasion resistance in shotcrete, a Hard-Cem-treated shotcrete underwent a test program that compared its resistance to that of a control shotcrete with no Hard-Cem. The test program used wet-mix shotcrete supplied by an independent concrete producer. During the test, an independent, ACI-certified shotcrete crew pumped, shot, and finished each shotcrete. Both shotcrete mixes used the same mix design, except the Hard-Cem shotcrete contained 40 kg/m³ (66 lb/yd³) of Hard-Cem (with an equivalent volume of sand displaced).

All shotcrete materials, batching, sampling, and testing were conducted in accordance with ACI 506.R–Guide to Shotcrete. However, abrasion resistance was tested following ASTM C627 (i.e., the Robinson test), which was modified to work with higher loading and a longer test duration, making it more suitable to test concrete.

Hard-Cem Shotcrete Test Results

- Plastic Properties: The Hard-Cem shotcrete exhibited similar plastic properties relative to the control shotcrete without Hard-Cem (see Table 1).
- Application Properties: The Hard-Cem shotcrete exhibited similar pumpability, sprayability, rebound, hang, and finishability compared to the control shotcrete.
- Compressive Strength: The Hard-Cem shotcrete exhibited slightly higher compressive strength development compared to the control shotcrete (see Table 1).
- Abrasion Resistance: The Hard-Cem shotcrete exhibited substantially higher abrasion resistance than the control shotcrete (see Graph 1 and Figures 3 and 4).

Analysis of Abrasion Resistance Results

ASTM C627 subjects 3x3 foot test panels to mechanical abrasion from three hard cast-iron wheels that revolve over the surface of the panels under heavy load. Then, the number of machine revolutions (test time) and the depth of wear are measured and recorded. In the case of this test, the overlying paste thickness was approximately 2 mm for both the Hard-Cem and control test specimens.

As seen in Graph 1, the Hard-Cem shotcrete withstood 2.5 times more abrasion than the control shotcrete with no Hard-Cem before the paste was worn through and the coarse aggregate was exposed. That is, the wear life of the surface paste was 2.5 times longer for the Hard-Cem shotcrete compared to the control shotcrete under identical abrasive conditions.

Significance of Abrasion Resistance

By increasing the abrasion resistance of the shotcrete paste, Hard-Cem provides the following benefits:

- Extended service life of the shotcrete exposed to abrasive or erosive wear .
- Reduced and delayed development of surface roughness
- Reduced and delayed wear of surface cement paste

These benefits are particularly significant to shotcrete used in the following applications:

- Mining
  - In areas where shotcrete is subject to mechanical abrasion (e.g., ore-handling areas, material-handling equipment areas, etc.), Hard-Cem improves the shotcrete service life, functionality, wear durability, and safety.
- Hydropower and Hydraulic Infrastructure
  - In applications where shotcrete surfaces are subject to erosion from running water, Hard-Cem improves the shotcrete service life, functionality, wear durability, and safety. Otherwise, shotcrete surfaces may lose surface paste more quickly, increasing surface roughness, which directly affects the capacity of hydraulic structures and increases the risk of cavitation

Fig. 1: Vertical test panel shoot

Fig. 2: Horizontal shotcrete test panels before abrasion test (control - left. Hard Cem - right.)

Fig. 3: Horizontal shotcrete test panels after abrasion test (control - left. Hard Cem - right.) Control cracks highlighted in red. No Hard-Cem cracks developed during the test.

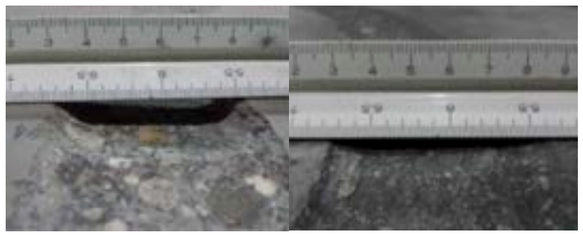


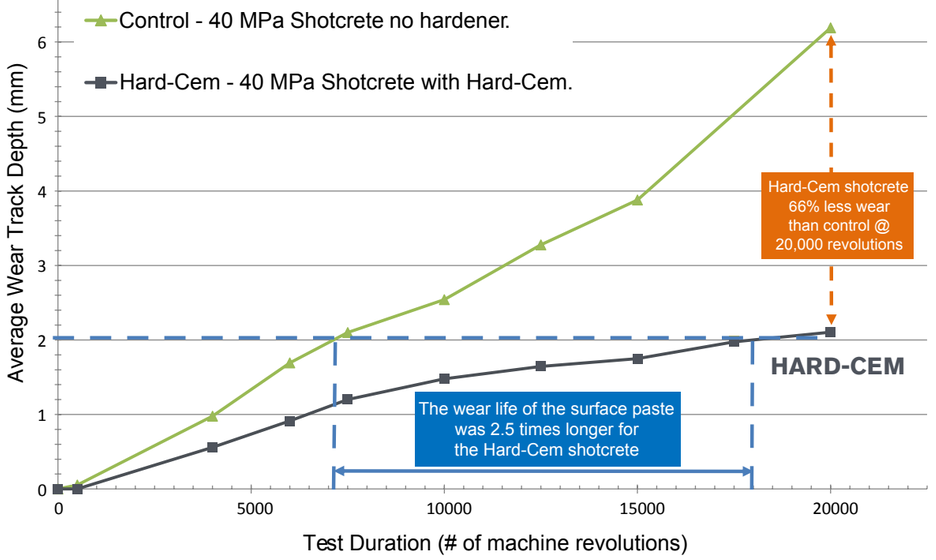
Fig. 4: Horizontal shotcrete test panels after abrasion test (control - left. Hard Cem - right.) Profile view of wear depth.

Table 1:
Plastic and Hardened Shotcrete Properties

	Control Mix (no Hard-Cem)	Hard-Cem Mix
Plastic Shotcrete Properties		
Slump (mm)	25-45 mm range	25-45 mm range
Air Content (% by volume)	6.2 to 7% range	6.2 to 7% range
Harderned Shotcrete Properties		
7 Day Compressive Strength (MPa)*	48	55
35 Day Compressive Strength (MPa)*	65	70

* Plastic and hardened concrete testing in accordance with CSA A23.1-14/ A23.2-14

Graph 1: Shotcrete Mix - ASTM C 627 Robinson Abrasion Test Results
Average Wear Track Depth Versus Machine Revolutions (Test Time)



Kryton International Inc.

Hard-Cem is part of a line of innovative Smart Concrete® products from Kryton International Inc. As a world leader in Smart Concrete technology, Kryton offers award-winning durability, waterproofing, and monitoring solutions to over 50 countries.

Disclaimer: *Product performance is affected by many factors including storage, method and conditions of application and use. User testing is essential to determine suit-ability of product for intended method of application and use. Seller's SOLE WARRANTY is that the product has been manufactured to specifications. No oral or written information or advice shall increase this warranty or create new warranties. Seller's SOLE LIABILITY is to replace product proved defective. In no event shall Seller be liable for any consequential, indirect or other damages whether arising from negligence or otherwise.*