Use of EcoSmart™ Concrete

for the Metro Skate Park - Burnaby, BC

Case Study

March 2004

space2place

EcoSmart™ Concrete Project

A Concrete Contribution to the Environment™

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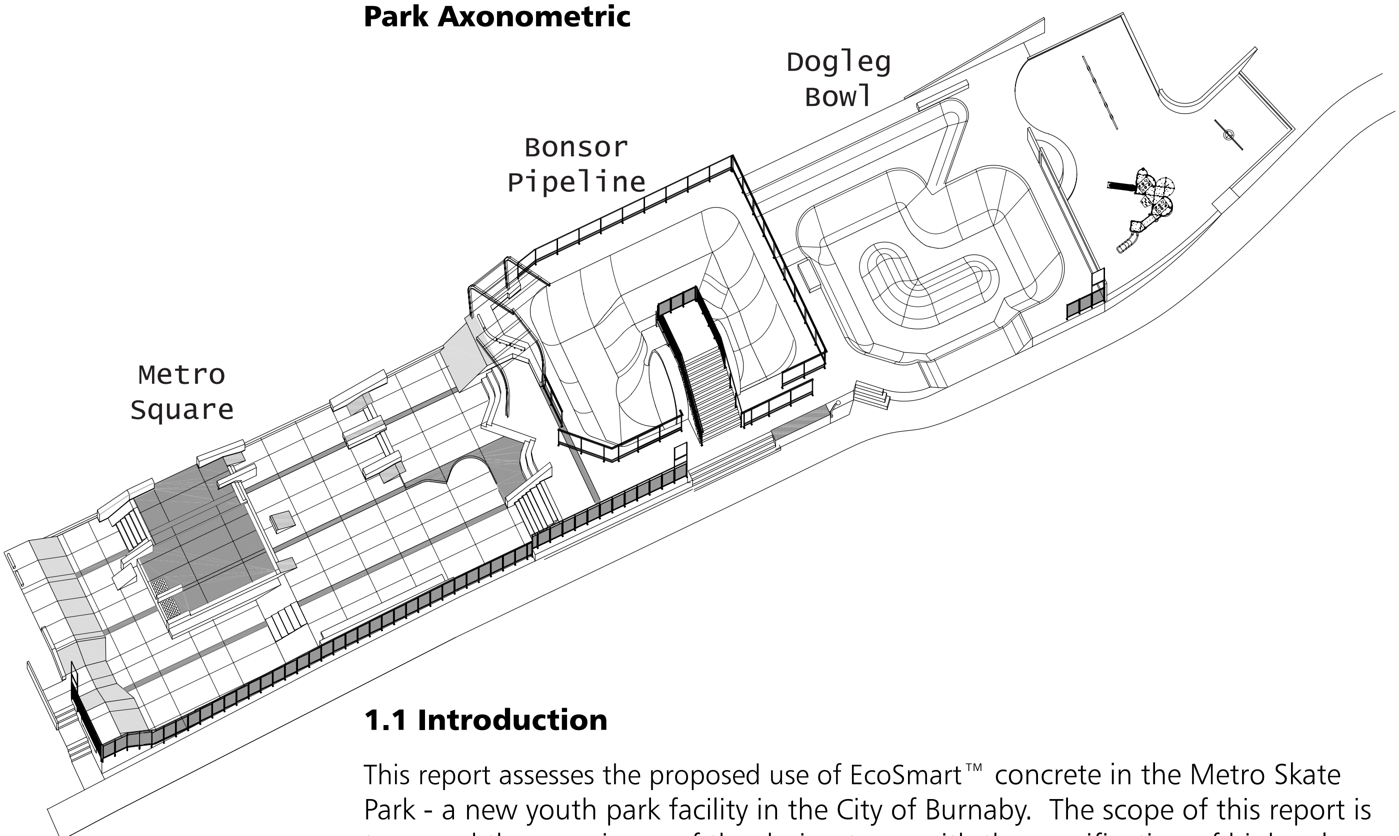
1.0 The Project

Park Axonometric



1.1 Introduction

This report assesses the proposed use of EcoSmart™ concrete in the Metro Skate Park - a new youth park facility in the City of Burnaby. The scope of this report is to record the experience of the design team with the specification of high volume fly ash concrete. This will be the first landscape oriented project to use EcoSmart concrete and it is hoped this study will lead to a further awareness of its aesthetic and environmental benefits.

The Metro Skate Park lies to the southeast of Metrotown in Bonsor Park. Bonsor Park is the site of a large recreation centre and South Central Youth Centre offering support facilities. The skate park is located equidistant between two skytrain stations (Metrotown and Royal Oak) ensuring easy accessibility for the youth of Burnaby.

An objective of the Burnaby Parks, Recreation and Culture Commission is to provide a skateboard facility in each of Burnaby's four quadrants in support of youth related activities. Currently, one skateboard facility built in 1996 exists at Confederation Park serving the northwest quadrant of Burnaby. The youth facility proposed for Bonsor Park, serving the southwest quadrant will be the second youth facility in Burnaby.

The design of the youth centre creates a place layered to serve multiple users following the needs of the youth as illustrated in the design workshops. The park is divided into 3 sections enabling a wide variety in skateboard styles. Shade, seating and lookout areas are provided to allow spots for youth and the public to watch the action. The vision is for a space for the neighbourhood youth that is integrated with the site and eliminates barriers between the youth and the general public.

1.0 The Project Continued

1.2 Project Statistics

Location	Burnaby British Columbia
Design	2003
Construction	March to August 2004
Project Size	2,600 sq m
Construction Cost	$760,000

1.3 Project Team

Client	City of Burnaby, Dept of Parks, Recreation and Cultural Services
Landscape Architect	space2place design inc.
Structural Engineer	Fulton Engineering Ltd.
Materials Engineer	AMEC
Skate park Specialist	Spectrum Skatepark Creations
General Contractor	CAP Ventures

2.0 EcoSmart Concrete Usage

Concrete is the primary material used in the construction of the Metro Skate Park. The foundations, flat slabs, walls, bowl and full pipe are proposed to be formed on site. It is proposed that poured in place concrete will be used for flat slabs, footings, walls and stairs. For the bowl and full pipe it is proposed that shotcrete construction will be used. It is proposed that concrete with recycled fly ash content will be used for all types of construction, with varying amounts of fly ash quantities. The majority of the concrete construction will be exposed with either a smooth trowel finish or sandblast depending on the application. Concrete is the preferred surface for the users of skate park facilities. It is estimated that approximately 500 cubic metres of concrete will be used in the construction of the park.

2.1 Goals

The projects landscape architect learned of EcoSmart concrete while attending an information session in the spring of 2003. This project is unique for a landscape architect because it does not include any planting. To meet the sustainable goals of the consultant it was proposed that EcoSmart concrete technology be used to reduce the CO2 emissions resulting from the construction of this project.

The client , the City of Burnaby, was enthusiastic about the environmental benefits of using EcoSmart concrete providing it did not increase the costs of this project. Technical support was provided by Fulton Engineering and AMEC.

The finish of skate parks is typically set at a higher standard than typical concrete paving. The finer finish that can be achieved through EcoSmart concrete is one potential advantage of using this material. The additional strength provided by EcoSmart concrete will allow the park to age better with fewer concrete repairs.

2.2 Concrete Mix Design Requirements

Component	Min 56 Day Strength MPa	Max Slump mm	Fly Ash Content %	Silica Fume Content %	Hard-Cem Content kg/m^3	Max Agg. Size mm	Min CM * Content kg/m^3	W/CM ratio	Exp. Class
Foundations, Footings, Walls -Warm	25	80+/-20	40	0	0	20	n/a	.55	F2
Foundations, Footings, Walls -Cold	25	80+/-20	35	0	0	20	n/a	.55	F2
Stairs, Decks and Slabs -Warm	30	80+/-20	30	0	40	20	380	.50	F1
Stairs, Decks and Slabs -Cold	30	80+/-20	25	0	40	20	380	.50	F1
Shotcrete -Warm	40	70+/-20	25	8	40	20	450	.40	C1
Shotcrete -Cold	40	70+/-20	20	8	40	20	450	.40	C1

Note: Cold is the period when ambient temperature at time of pour or shotcreting and expected within 7 days to fall below 10 deg. Celsius.
* CM = Cementing Materials (Cement, Fly Ash, Silica Fume)

2.0 EcoSmart Concrete Usage Continued

This concrete specification was adjusted slightly from the originally tendered concrete specification to help reduce project costs. The exposure class of the flat slabs was reduced from C-1 to F-1. This was due in part because salt is not placed on skate parks to defrost them. Typically these parks are too slippery if they are wet. Additional revisions included a decrease in the compressive strength requirements from 35 MPa to 30 MPa, and changing the W/CM ratio from .40 to .50. These changes resulted in a substantial savings to the project while keeping the high fly ash content intact and maintaining the strength reuirement for the CSA F-1 exposure classification. The contractor did not include a premium to their bid price for the high volume fly ash concrete.

2.2.1 Calculation of: Measure of Success in Reducing Portland Cement

1. 32 MPa regular, poured slabs

$$\frac{70\ \text{FA}}{[\text{CM}]\ \underset{\text{PC}}{330} \times \underset{\text{FA}}{70}} = 17.5\% \qquad \text{Base Line}$$

$$\frac{114\ \text{FA}}{[\text{CM}]\ \underset{\text{PC}}{266} + \underset{\text{FA}}{114}} = 30\% \qquad \text{Metro}$$

2. Shotcrete 40 MPa Whistler Base Mix

$$\frac{40\ \text{kg. FA}}{[\text{CM}]\ \underset{\text{PC}}{380} + \underset{\text{SiF}}{30} + \underset{\text{FA}}{40}} = 8.9\% \qquad \text{Base Line}$$

$$\frac{112.5\ \text{FA}}{[\text{CM}]\ \underset{\text{PC}}{301.5} + \underset{\text{SiF}}{36} + \underset{\text{FA}}{112.5}} = 25\% \qquad \text{Metro}$$

Note: The baseline mix is based on the concrete mix used for the construction of the Whistler Skateboard park.

2.2.2 Measure of Success in Reducing Portland Cement (PC)

% improvement (using above breakdown)	Poured Slabs	Shotcrete Shapes
$\frac{\text{PC base line - PC Metro}}{\text{PC base line}}$	$\frac{330-266}{330} = 19.4\%$	$\frac{380-301.5}{380} = 20.1\%$

2.0 EcoSmart Concrete Usage Continued

2.2.3 Hard-Cem Additive

The consultants were contacted by Teck Cominco about using Hard-Cem for this project. Hard-Cem uses by-products of the smelting process to create an integral concrete Hardener. Hard-Cem is used to replace a portion of the sand in the concrete mixture.

Hard-Cem is supposed to increase the abrasion resistance of concrete by functioning as an extremely hard, very fine aggregate in the concrete mix, making the concrete paste much harder and more resistant to abrasion and erosion. Hard-Cem acts as a speciality functional filler in the concrete matrix, providing increased abrasion resistance, while having no effect on the set time, strength development or de-icing chemical resistance of the concrete. (additional Hard-Cem information is included in the Appendix)

2.3 Design Considerations

The long term strength boost from using high volume fly ash was not calculated into the design to reduce thickness of slabs. Slabs on grade require a minimum thickness for rebar cover. (The minimum was thickness was specified). Therefore, slab thickness cannot be reduced taking advantage of superior long term strength of high volume fly ash content mixes.

The only way to improve this situation is to reduce the total quantity of concrete by voiding forms, where possible, for mass pours, such as: benches, footings, piers, buttresses, etc. (This was designed-in where possible). For slabs (5” thick) this is much more of a challenge due to space restriction.

Fulton Engineering Co. Ltd. is developing a new voiding design which will reduce slab concrete volume and also improve rebar placing, with other benefits such as drainage during and after construction – this could benefit all types of slab construction for skate parks.

2.4 Technical Considerations

The main concern of the engineers, AMEC and Fulton Engineering was the problem (and resulting higher construction costs) using high FA was in the slower setting time and the different finishing techniques, i.e., when to start working the wet concrete surfaces. The setting time is slower at lower temperatures, requiring adjustment to the mix design. This is reflected in the chart (page 4 of 18) of Technical Specification Section 03300, in which the mixes were designed for ‘warm’ and ‘cold’ temperature ranges.

2.0 EcoSmart Concrete Usage Continued

Providing warm and cold mix designs complicates the chart and resulted in higher engineering fees (about 3 times for that function only - for both the material and structural engineers) and results in marginal cost increases in the field inspections. (i.e., keeping track of the temperature range and coordinating with suppliers) However, the construction period for this project has been delayed and will occur in the spring and summer. As a result temperature considerations should not be a major problem.

The possibility of increased costs from contractors due to perceived higher finishing cost (due to requirement for higher skill level of workers, higher possibility of rejects and longer waiting time for the optimum set-up point, sometimes into the late evening or early morning the next day) is largely eliminated by the tendering process with sufficient competition and providing a pre-qualified list of contractors.

2.5 Tender Process

Dr. Rusty Morgan, P.Eng. from AMEC attended a bidder's meeting on behalf of EcoSmart to provide an overview of issues regarding the use of high volume fly ash concrete. There was some concern expressed by the contractors about the scheduling of the concrete curing process. Many of the questions and concerns were a result of unfamiliarity with the material. Space2place provided an explanation of the issues regarding the use of EcoSmart concrete which was included with the minutes of the meeting provided to all of the contractor's in attendance. (the detailed explanation developed has been included in the Appendix)

Following the meeting the City of Burnaby representatives were concerned about the potential effects using Ecosmart concrete could have on the bids. Discussions with the contractors following the submission of the bids revealed that the contractors included little if any premium for using Ecosmart concrete.

2.6 Start up Construction Meeting

The contractor was reminded about the required test panels and curing plan. It was also explained that there will be more testing for this project and that there will be strong quality control for this project.

3.0 Conclusions

This report was written prior to the construction of the park so construction experience is not included. This project was under intense cost pressures due in part to the increased competitiveness in the construction industry at the time of bidding. The consultants have had to educate their client and the contractors throughout the bidding process to keep EcoSmart concrete as a component of this project.

It is hoped that EcoSmart concrete will provide a superior surface finish, a stronger more durable material and provide environmental benefits. Despite the challenges with implementing EcoSmart concrete experienced thus far within the tender process, it is believed that this project will be a success.

Appendix

Description of EcoSmart concrete included in Bidder's Meeting Minutes.

Hard-Cem Information

Description of EcoSmart concrete included in Bidder's Meeting Minutes.

The concrete specified contains a higher percentage of fly ash than typical concrete. The fly ash is a replacement for Portland Cement. Concrete mixes typically contain 18% to 20% percentage of fly ash. The mixes associated with this project look to increase the percentage of fly ash used (refer to the concrete specification for percentages associated with different mix applications). The mixes have been designed to balance the environmental benefits and the workability of the concrete.

-Test Panels: trial panels will be cast and shot before project start-up to evaluate properties and set standards for surface finish used as comparison throughout the project. The following properties shall be evaluated in the trial: workability, air content, finish quality, setting time, temperature development, hardened air-void parameters, strength and durability.

-Finishing: the timing for finishing will be determined by the site trial pours, and laboratory trial mixes may give some insight with regard to the setting time for a given concrete mix. Finishers typically rely on the presence of bleed water as an indicator for commencement of finishing. However, with high volume fly ash concretes, bleed water is significantly reduced, and therefore, the finishers must gain hands-on experience during the site trial pours to determine when they should begin finishing. High volume fly ash will produce a better surface finish than normal concrete.

-Curing Plan: The Contractor shall submit curing plan/ quality control plan for each concrete element to Engineer for review prior to commencement of concrete work. The curing plan shall include:

- Type of curing material
- Duration of curing
- Procedures and methods for keeping concrete moist for the required time period
- Protection of surfaces being cured from construction traffic and activities
- Provisions to address adverse weather conditions such as high winds and hot weather

-There are 2 general mixes provided these are for cold weather concrete pours and warm weather pours.

-Ready Mix Supply: Supplies are indicating there will be no extra charges for fly ash or HardCem additions.

-Testing and Consulting: Both EcoSmart (fly ash) and Teck Cominco (Hard-Cem) have committed to pay for additional concrete testing, consultation on field trials and answering questions during construction. Fulton Engineering with AMEC has budgeted to do all the concrete testing over and above basic testing as per Tech Spec Section 3300 and to be available for consultation as part of our engineering assurance commitment to the project.

Description of EcoSmart concrete included in Bidder's Meeting Minutes. Continued

-The mix for the shotcrete includes silica fume, which is also an industrial by-product cement replacement and results in a darker concrete. This makes the concrete stickier when spraying on surfaces.

-Hard-Cem is being incorporated into the mix design for wearable surfaces. AMEC has performed extensive testing of this material and report its good qualities, the most important is improved thru-mass abrasion resistance, reduction of bleeding in the plastic concrete state and doesn't affect air entrainment as other hardeners do. Hard-Cem will considerably increase the abrasion and wear resistance of the surface (43% reduction in wear). The contact at Teck Cominco is Jacob Alexander ph # 604-241-5712 ext. 141.

-Accelerator ad mixtures are not desirable. The increase the shrinkage of the concrete leading to cracking. It is the intent to reduce the amount of cracking on this project.

-Saw cuts are to be made at the earliest possible time. Saw cuts made too late resulting in splaying of the concrete surface especially at joint edges. Micro fibre addition improves joint strength when sawing. Timing is important. There is a "soff-cut" system available that enables the contractor to make the cuts sooner.

INTRODUCING: A NEW CONCRETE ADDITIVE FOR ABRASION RESISTANCE OF CONCRETE – COMPATIBLE WITH AIR-ENTRAINED CONCRETE

Erosion of concrete surfaces through mechanical erosion (direct or water-borne) leads to deterioration of the concrete and exposure of steel reinforcement, necessitating frequent, costly repair works. Conventional "hardening admixtures" used to increase abrasion resistance of concrete, such as dry-spread surface hardeners, are unsuitable for air-entrained concrete in exterior applications. Attempts to use other admixtures or pozzolan additives to increase concrete hardness in external applications have, in some cases, proven costly and problematic without attaining the desired effect.

HARD-CEM is a new, engineered product that provides concrete with significantly increased hardness and abrasion resistance, while also providing ease of application and labor savings.

HARD-CEM is not a chemical admixture, but rather a functional filler additive and, therefore, can be used in any concrete mix / composition with no effect on other concrete qualities such as air entrainment. HARD-CEM is a powder material and is added to the concrete during batching or mixing (usage: 40kg/m^3 or 67.4lb/yd^3), providing consistent quality and through-hardening of the concrete with significant labor savings.

HARD-CEM is excellent for applications requiring mechanical or erosion protection such as:

- industrial floors and warehouses;
- parkades, bridges and interchanges;
- dams, dykes, spillways, stilling basins, flumes, pipes, penstocks, hydro-turbine chambers, revetments, and breakwaters; and
- precast concrete pipe and vaults.

CEMENTEC Industries Inc. (est. 1987) is an award-winning developer, manufacturer and distributor of engineered materials based in Calgary, Alberta, and a member of the PILDYSH Group of Companies. HARD-CEM is available now in 40kg bags or in bulk shipment throughout North America.

For more information, please visit our website at www.cementec.ca or contact us directly at 403-720-6699 or info@cementec.ca.

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Hard-Cem

Concrete Hardener Technology

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Cementec Industries Inc. is a Member of the Pildysh Group.

What is Hard-Cem?

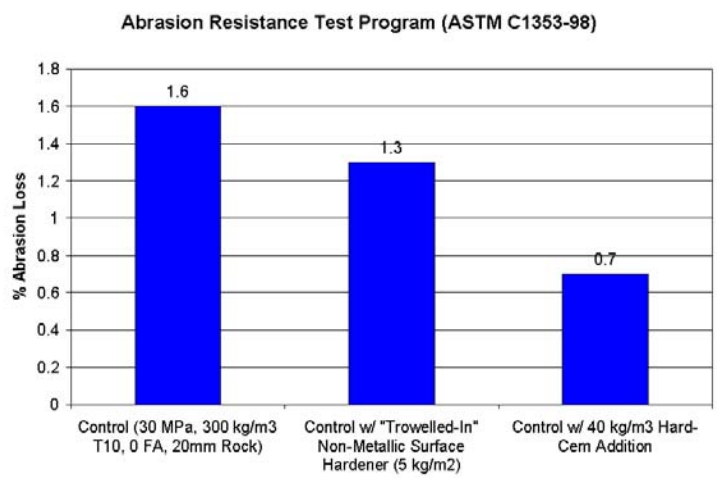
Hard-Cem is a specialty concrete hardener which was developed for ready-mix concrete applications.

What does Hard-Cem do for Concrete?

Tests show that Hard-Cem increases the abrasion resistance of concrete.

Unlike traditional surface-applied hardeners, which are quite labour-intensive to apply, Hard-Cem is simply added to the concrete mix during the batching operation.

Hard-Cem has the advantage of being able to be utilized in air-entrained concretes.



Hard-Cem Applications:

Hard-Cem is a benefit in any application requiring abrasion resistance including industrial/commercial floors, parkades, paving, precast, etc.

How is Hard-Cem Applied?

Hard-Cem is supplied in 40 kg bags or bulk and is simply added to the concrete mix during the batching process.

Recommended dosage is one 40 kg bag per cubic meter of concrete.

Please contact Cementec at (403) 720-6699 for more information.