



# **Use of EcoSmart™ Concrete** for the Metro Skate Park - Burnaby, BC

## **Construction Report**

November 2004

space **2** place

**EcoSmart™ Concrete Project**  
A Concrete Contribution to the Environment™

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**Prepared by:**

**space2place** design inc.

309-318 Homer Street  
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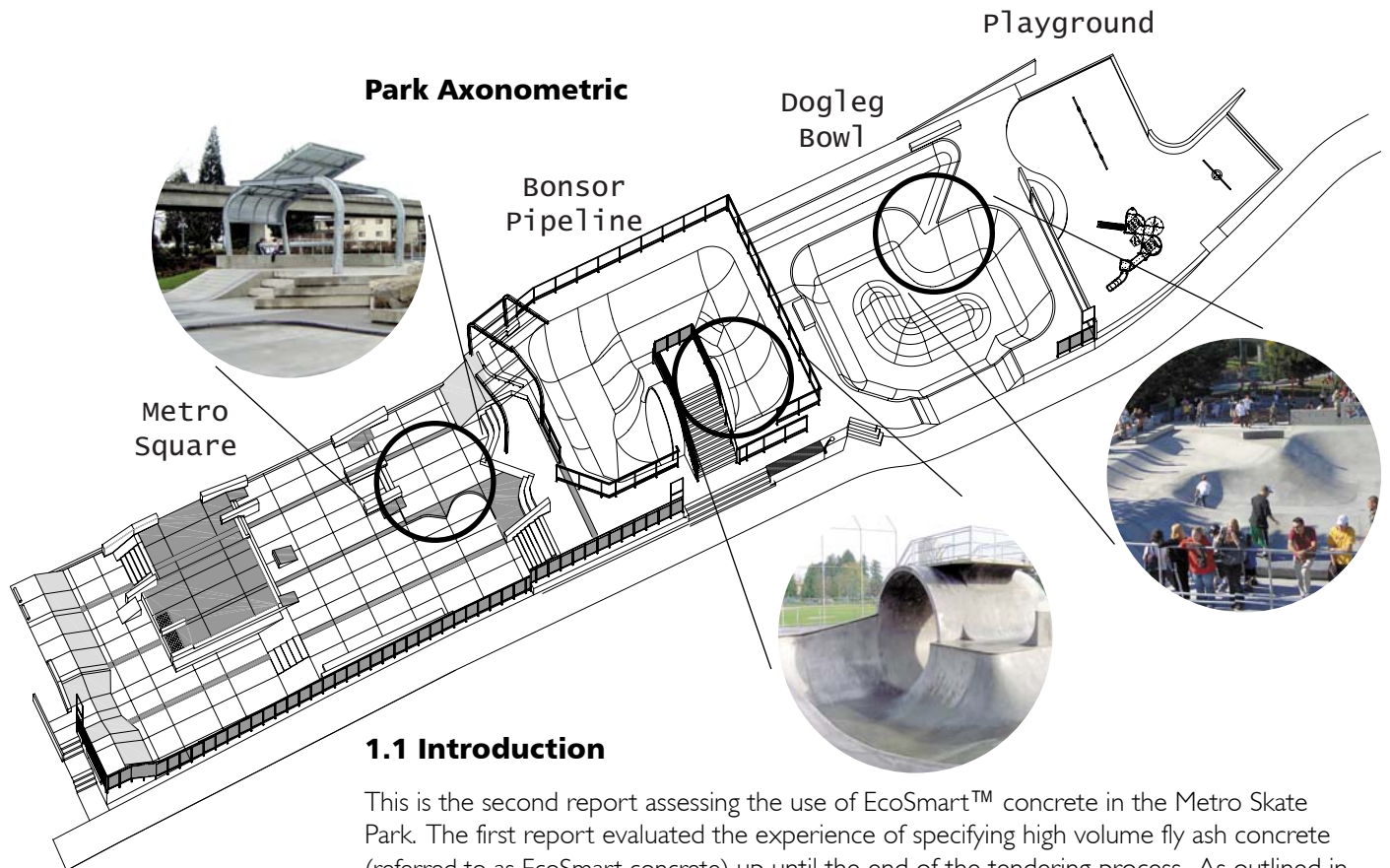
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# 1.0 The Project



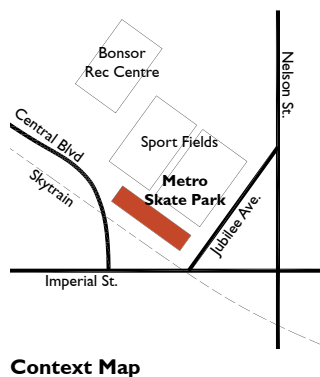
## 1.1 Introduction

This is the second report assessing the use of EcoSmart™ concrete in the Metro Skate Park. The first report evaluated the experience of specifying high volume fly ash concrete (referred to as EcoSmart concrete) up until the end of the tendering process. As outlined in the first report, there were a number of concerns on behalf of the client and contractor that a high volume fly ash concrete mix would lead to additional costs for this project. This report records the experience of the design and construction team utilizing high volume fly ash concrete and an integral concrete hardener, Hard-Cem™, in the construction of a skate park.

The Metro Skate Park lies to the southeast of Metrotown in Bonsor Park, Burnaby, B.C. 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 skate park built in Bonsor Park, serving the southwest quadrant will be the second skate park in Burnaby.

The park is divided into 3 sections representing the 3 different types of skateboarding (ie: street skating featuring ledges and stairs, bowl skating featuring transitions and flow skating featuring ramps). Additionally the park incorporates shade structures, seating nodes and lookout areas providing spots for youth and the public to watch the action. The park is 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
Completion Date	October 2004
Construction	March to October 2004
Project Size	2,600 sq m
Construction Cost	\$760,000

### 1.3 Project Team

Client Cultural Services	City of Burnaby, Dept of Parks, Recreation and
Landscape Architect	space2place design inc.
Structural Engineer	Fulton Engineering Ltd.
Materials Engineer	AMEC
Skate Park Specialist	Spectrum Skatepark Creations Ltd.
General Contractor	CAP Ventures Ltd.
Ready-Mixed Concrete Supplier	Ocean Construction Supplies Ltd.
Hard-Cem™ Supplier	Cementec Industries Inc.   Teck Cominco Metals Ltd.

## 2.0 EcoSmart Concrete Usage

### Typical Skatepark Features:



Transitions



Ramps



Ledges

Concrete is the primary material of the Metro Skate Park. There were three different concrete mixes: one for the foundations, and walls, a mix for flat slabs, stairs and ramps, and another mix for transition areas. The flat slabs, ramps, footings, walls and stairs were poured in place. The transitions (bowl shaped) and full pipe were shotcreted and hand towelled.

Concrete with recycled fly ash content was used for all types of construction, with varying fly ash quantities. The majority of the concrete construction is exposed concrete with a smooth trowel finish on all horizontal surfaces. The vertical surfaces are paper faced form finish. It is estimated that approximately 530 cubic metres of concrete will be used in the construction of the park.

Special Considerations for Concrete in Skate Parks:

**Finish** - Concrete is the preferred surface for the users of skate park facilities. The quality of the surface finish on the skateable surfaces is critical to the success of a skateboard facility. Imperfections such as wash boarding (ripples in the concrete surface) and kinks in transitions can seriously affect the skateability of the park. The contractors were held to very tight tolerances for the consistency of the surface. Initially it was thought that the colour of the concrete using the Hard-Cem would be darker in colour. However, after the concrete cured (approx. 20-25 days) the concrete lightened considerably. There is very little difference in colour between the concrete with Hard-Cem and the concrete without it.

**Workability** - The fluid forms of skate park transitions are difficult to form and finish. It is important to have a concrete mix that adheres well to the steel reinforcing and doesn't set up too quickly to enable a smooth finish.

**Durability** - The concrete at skateboard parks is subject to heavy wear and impacts from skateboards, and even bikes, which are generally not allowed in skateboard parks but do find their way in. The concrete is particularly subject to impact damage and wear at the edges of the concrete elements. The higher compressive strengths achieved with EcoSmart concrete are beneficial to this project. Additionally the concrete mixes for flat slabs and shotcrete utilize Hard-Cem, which is an integral concrete hardener that significantly improves the abrasion resistance of concrete, and mirco fibres, which reduces surface chipping. Hard-Cem is also unique because it is a hardener which is compatible with air-entrained concrete applications such as those required for concretes where freeze-thaw conditions exist. In all cases the concrete tests illustrated that the compressive strength of the concrete exceeded specifications.

### 2.1 Project Chronology

This project started construction in March of 2003 and concrete work started at the beginning of April. Construction continued throughout the summer until opening day Oct 2, 2004. The Dogleg Bowl was built from April until the beginning of June, the Bonsor Pipeline and Metro Square (refer to illustration at the beginning of the document) were constructed from end of June through September. Concrete pours generally took place in the morning.

## 2.0 EcoSmart Concrete Usage Continued

### Percentage of Fly Ash Specified Warm Weather Mix vs. Cold Weather Mix

Component	Warm	Cold
Foundations, Footings, Walls	40%	35%
Stairs, Decks, Slabs	30%	25%
Shotcrete	25%	20%

The specifications included 2 mix designs for each application a cold weather and warm weather mix. The cold weather mix was used until early May. Work completed with the cold weather mix includes the walls in the playground, and about 1/3 of the Dogleg Bowl. The cold weather mix contained a lower percentage of fly ash in consideration of the longer setting times. When the weather was consistently above 10 deg Celsius, the concrete mix design switched to the warm weather mix.

### 2.2 Concrete Mix Design

Please refer to case study report published March 2004 (available on the EcoSmart website) for details on the concrete mix design for the Metro Skate Park. There were some changes made to the original mix design for cost savings. These changes are outlined in section 2.6 of this report.

#### 2.2.1 Hard-Cem™

The Metro Skate Park is the first skate park to specify Hard-Cem for the abrasion resistance properties it imparts to concrete. Hard-Cem is an extremely hard, very fine aggregate that is directly introduced in to the concrete mix during the batching process, that results in a concrete paste that is 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 setting time, strength development or de-icing chemical resistance of the concrete. Because Hard-Cem is introduced during batching of the concrete mix no time consuming or special surface application procedures are required to impart an abrasion resistant surface to the concrete.

Hard-Cem was added to the mix for the flatwork and shotcrete. It was the experience of the concrete finishers that the addition of Hard-Cem made the concrete “creamier” in its plastic state enabling a smoother finish.

### 2.3 Concrete Test Data

Refer to appendix A for concrete test data results.

### 2.4 Application

#### 2.4.1 Flatwork

The majority of the skate park construction is based on flat slab concrete construction. This includes all horizontal surfaces in the Metro Square, the Dogleg Bowl and the decks around the Bonsor Pipeline. As discussed previously, the quality of the finish on these slabs is held to very high standards to eliminate imperfections in the skating surface. Hard-Cem was added to the concrete mix to increase abrasion resistance and surface wear resistance of the concrete.

As illustrated in the attached test results, the concrete mix for the ramped sections of the Dogleg Bowl had a lower than specified slump. However, this was considered acceptable for the placement of concrete on the steep slope. The concrete finishers expressed satisfaction with the concrete mix and they felt it was easy to work with. The finishers liked the creamy paste on the surface, which aided in achieving a smooth surface. This was attributed to the addition of Hard-Cem in the mix.

## 2.0 EcoSmart Concrete Usage Continued



Image 1

Stockpile of forms for the edge of the ramp portions of the skatepark.



Image 2

Placing Concrete on a ramp section. Concrete panels are built in leapfrog fashion. Shrinkage occurs in panels before adjacent panels are built. This is important because expansion joints are not acceptable in skateparks.



Image 3

Flat slabs are power trowelled and saw cut the next day. Hot summer weather accelerates concrete set up time. High volume fly ash concrete is beneficial under these conditions to allow more time for the finishers.

## 2.0 EcoSmart Concrete Usage Continued



Image 4

The completed flatwork was of exceptionally high quality. There is minor cracking in some of the slabs but this does not compromise the structural integrity of the slab.

### 2.4.2 Transitions

The transition or bowled sections of skateparks are the most specialized part of skate park construction. These are designed to very specific radii and must be free of any kinks or wash boarding in the surface. The top of the transition is capped with precast concrete, referred to as “pool coping”. This coping was precast on site using the shotcrete mix because of its higher strength specification.

The shotcrete mix contained a lower amount of fly ash than the flat slabs and wall portions of the park. However, the mix specified the inclusion of other industrial by-products such as silica fume and Hard-Cem. The finishers again expressed satisfaction with the concrete and were able to produce an excellent surface finish. After the concrete fully cured the addition of silica fume and Hard-cem did not result in a significant colour variation from concrete without these products.



Image 5

The transitions are screeded following the application of the shotcrete.

## 2.0 EcoSmart Concrete Usage Continued



Image 6

Following screeding the transitions are hand trowelled smooth.



Image 7

Application of shotcrete to the top section of the fullpipe.

## 2.0 EcoSmart Concrete Usage Continued



Image 8

Application of shotcrete to the top section of the fullpipe.



Image 9

Stripping the inside form from the full pipe.



Image 10

The completed bowl. The concrete finish of this section was of exceptionally high quality. The concrete panels are a dense hard concrete and exceptionally smooth. The response from skaters has been extremely positive. It is generally felt that the concrete finish on this skate park is the best in Canada.

## 2.0 EcoSmart Concrete Usage Continued

### 2.4.3 Wall Pours

The Metro Square section of the skate park is designed to emulate typical existing street plazas. The improved aesthetic qualities of high volume fly ash concrete were seen as beneficial to enhance the look of the square. The wall portions of the skate park were specified to be formed with paper faced plywood leaving a smooth consistent surface finish. The ledge walls form a minor portion of the work in the skate park construction.

Generally the quality of the wall construction is good. There isn't a noticeable improvement over traditional concrete mixes besides the slightly lighter colour of the concrete due to the use of fly ash. The skateable corners of the walls have embedded steel coping to improve the durability of the concrete element edges. It is hoped that the additional strength provided by high volume fly ash concrete will reduce wear of the concrete surfaces over time.



Image 11

Formwork for typical ledge wall.



Image 12

Completed Metro Square. This portion of the park consists mostly of ledge walls, stairs, and flatwork.

## **2.0 EcoSmart Concrete Usage Continued**

### **2.5 Schedule**

The construction of this project extended approximately 6 weeks beyond the proposed construction schedule. This is mostly attributed to the constraints of the site requiring the construction to be completed from West to East with access from the east side of the park only. There were some occasions where it was difficult to get concrete delivered to the site. This was attributed to a busy construction season and the concrete mix containing Hard-Cem was only available from one batch plant. This however was not considered a significant contributor to the prolonged schedule.

### **2.6 Cost Implications**

The supply cost for the concrete mix tendered was considerably higher than traditional concrete mix used for skate park construction. This was attributed to a) a general increase in the supply cost of concrete, b) preparation of the speciality mix, c) a premium for the supply of Hard-Cem, d) exposure class specified and e) amount of micro fibres added.

During a cost-saving exercise following the receipt of quotes from the tender, the concrete specification was modified to realize a credit of approximately \$10,000 to the project. This was accomplished by reducing the exposure class of the flat slab mix from C-1 to F-1. It was felt this could be done because the skate park will not be exposed to de-icing salts. Additional savings were realized by reducing the micro fibre content from 1.0 kg/cu.m to 0.6 kg/cu.m in slabs, decks and stairs and dropping the compressive strength requirements at 56 days from 35 MPa to 30 MPa for the flat slab mix. (Note: the test results show that a compressive strength of 49.1 MPa was obtained at 28 days, significantly higher than specified).

### 3.0 Conclusions

Leading into the construction of this project there were a number of concerns expressed by the client and contractor about the use of the high volume fly ash concrete mix. An examination of previous case studies, by the consultants, demonstrated a concern about the use of high volume fly ash mixes for horizontal slabs. However, most of the previous difficulties were associated with suspended slab construction. This project was primarily slab on grade construction and the use of a high volume fly ash concrete mix was a considerable success.

It is hoped that the specification of high volume fly ash concrete with Hard-Cem will become a standard for skate parks in the future. It was felt by the consultants and construction crew that addition of Hard-Cem has contributed to a higher quality and hopefully more durable concrete. Typically, skateparks are built with tight budgets so there may be some cost factors that will restrict the implementation of a similar concrete mix. Skate parks are built throughout the Province and across Canada with the majority located in smaller towns. This may hinder a quick adoption of high volume fly ash concrete for all skateparks due to more limited resources in some of the smaller centres.



Dogleg Bowl Opening Day



Metro Square - Opening Day



Bonsor Pipeline - Opening Day

## Appendix

### Concrete Test Results

06 August 2004

AMEC File: VA06376

Teck Cominco Metals Ltd.  
600 – 200 Burrard Street  
Vancouver, British Columbia  
V6C 3L9

Attention: Mr. Jacob Alexander

Dear Mr. Alexander,

**Reference: Bonsor Recreation Centre Skate Park  
Concrete and Shotcrete Testing**

Attached as requested are the results of quality control (QC) tests conducted on concrete and shotcrete supplied to the Bonsor Recreation Centre Skate Park in Burnaby, British Columbia, by AMEC Earth & Environmental (AMEC).

Results of the QC tests are attached to this letter:

- Set No. 1 was for concrete cast on 15 April 2004, using Ocean Construction Supplies Limited (Ocean) Cold Weather Concrete Mix No. 332PF6.

The specified and actual mix characteristics are summarized in the table below:

Parameter	Specified	Actual
Minimum compressive strength	30 MPa at 56 days	54.3 MPa at 28 days
Maximum aggregate size	20 mm	20 mm
Fly ash	20%	20%
HARD – CEM	40 kg/m <sup>3</sup>	40 kg/m <sup>3</sup>
Synthetic microfibre	0.6 kg/m <sup>3</sup>	0.6 kg/m <sup>3</sup>
Water reducing and high range water reducing admixture	√	√
Slump	80 ±20 mm	90 mm
Air content	4-7%	4.0%

This “cold weather mix” was supplied to a test slab in the playground area and readily satisfied all the specified performance requirements for the project.

- Set No. 2 was for "warm weather" concrete supplied to ramped wall sections at the southeast corner of the pit, plus infills at the upper level, southside on 14 May 2004 using Ocean Mix No. 2CAP2W. This "warm weather" concrete mix had the following specified and actual characteristics.

Parameter	Specified	Actual
Minimum compressive strength	30 MPa at 56 days	49.1 MPa at 28 days
Maximum aggregate size	20 mm	20 mm
Fly ash	30%	30%
HARD – CEM	40 kg/m <sup>3</sup>	40 kg/m <sup>3</sup>
Synthetic microfibre	0.6 kg/m <sup>3</sup>	0.6 kg/m <sup>3</sup>
Water reducing and high range water reducing admixture	√	√
Slump	80 ±20 mm	50 mm
Air content	4-7%	5.4%

This "warm weather" mix readily met all the specified performance requirements, except that the slump was slightly low (50 mm). This was, however, considered acceptable for placement of concrete on the steep ramped wall sections.

Finally, on 29 June 2004, Dr. D.R. Morgan of AMEC witnessed shooting of Ocean's "Warm Weather" Shotcrete Mix No. Y150 on walls at the southwest end of the skate park bowl. A test panel was shot and test specimens were extracted for testing. The specified and actual characteristics of the shotcrete were as follows:

Parameter	Specified	Actual
Minimum compressive strength	40 MPa at 56 days	38.2 MPa at 9 days 45.2 MPa at 28 days
Maximum aggregate size	14 mm	14 mm
Fly ash	25%	25%
Silica Fume	8%	8%
HARD – CEM	40 kg/m <sup>3</sup>	40 kg/m <sup>3</sup>
Synthetic microfibre	1 kg/m <sup>3</sup>	1 kg/m <sup>3</sup>
Air content	8 ±1% as delivered	--
Slump	70 ±20 mm	70 mm

In addition, the shotcrete was tested to ASTM C642 to determine the values of boiled absorption and volume of permeable voids. Test results are provided in the attached Technical Report. The boiled absorption value of 6.1% readily met the commonly specified maximum value of 8.0% and the volume of permeable voids value of 13.5% readily met the commonly specified value of 17.0%.

In summary, both the Ocean "Cold Weather" Concrete Mix No. 332PF6 and the "Warm Weather" Concrete Mix No. 2CAP2W, both with 40 kg/m<sup>3</sup> HARD-CEM satisfied all the specified concrete performance requirements. The Contractor expressed satisfaction with the way in which the concrete behaved during placing, consolidation and finishing. Dr. Morgan examined the finished concrete structures and they appeared visually to be of very good quality, pleasingly free of plastic or restrained drying shrinkage cracking.

Similarly, the Ocean "Warm Weather" shotcrete Mix No. Y150 with 40 kg/m<sup>3</sup> HARD-CEM behaved very well in both the plastic and hardened states. It met all the specified performance requirements and the Contractor was very satisfied with the way in which the shotcrete behaved during shooting and finishing. The shotcrete adhered well during application and finishing and produced an excellent smooth finish, suitable for skate boarding.

Photographs of the shotcrete work in progress and the finished, hardened shotcrete and concrete are in the project file and can be made available on request.

This completes AMEC's quality control testing on this project. We trust this report meets your requirements. If you have any questions, please contact us.

Yours truly,

**AMEC Earth & Environmental,  
a division of AMEC Americas Limited**

*D. R. Morgan*

D. R. Morgan, Ph.D., P.Eng  
Chief Materials Engineer



Reviewed by:

*M. Ezzet*

Mazin Ezzet, P.Eng.  
Senior Project Manager

DRM/ml  
Enclosures

cc: Mr. Bob Fulton, P.Eng.  
Fulton Engineering

# CONCRETE TEST REPORT

2227 Douglas Road, Burnaby, BC V5C 5A9

Tel: (604) 294-3811 Fax: (604) 294-4664



CERTIFIED CONCRETE TESTING LABORATORY  
IN ACCORDANCE WITH STD.A283.2-94

TO  
Fulton Engineering Inc.  
8605 Sunbury Place  
Delta, BC, BC  
V4C 3Y9

PROJECT NO. VA-06376

CLIENT Fulton Engineering Inc.  
C.C.

ATTN: Bob Fulton, P. Eng., M. Eng

PROJECT FULTON ENGINEERING  
BONSOR REC CENTER

BURNABY

SET NO. 1

NO. OF SPECIMENS 3

DATE RECEIVED 2004.Apr.16

DATE CAST 2004.Apr.15

SPCM NO.	SPECIMEN TYPE	CURE CONDN	DATE TESTED	AGE AT TEST (DAYS)	AVERAGE DIAMETER (mm) OR SIDE (mm x mm)	AVERAGE LENGTH OR SPAN (mm)	MAXIMUM LOAD (kN)	COMPRESSIVE OR FLEXURAL STRENGTH (MPa) Average	FAILURE TYPE
A	Cylinder	Lab	Apr.22	7	101.6	203.2	275	33.9	
B	Cylinder	Lab	May.13	28	101.6	203.2	446	55.0	
C	Cylinder	Lab	May.13	28	101.6	203.2	434	53.5 54.3	

SPECIFIED STRENGTH		30 MPa @ 28 DAYS		CONCRETE TEMP. 19 °C		AIR TEMP. 10 °C		TREND GRAPH	
CEMENT CONTENT		kg/m <sup>3</sup> TYPE 10		SLUMP 90 mm		SPEC. 80 ± 20			
POZZOLAN CONTENT		kg/m <sup>3</sup> TYPE		AIR 4.0 %		SPEC. 5.5 ± 1.5			
MAXIMUM SIZE AGGREGATE		mm		PLASTIC DENSITY		kg/m <sup>3</sup>			
BATCH TIME 10:50				HARDENED DENSITY		kg/m <sup>3</sup>			
ADMIXTURES				CAST TIME 12:00					
NOT INDICATED				CAST BY AEE		AA		MOULD TYPE PLASTIC	
				CURING CONDITIONS					
				INITIAL CURING TEMP: MAXIMUM		20 °C		MINIMUM 17 °C	
SUPPLIER Ocean Construction				LOCATION					
MIX NO. 332PF6				TEST SLAB IN PLAYGROUND					
TRUCK NO. 116		TICKET NO. 1714834		COMMENTS					
LOAD VOL. 7.4 m <sup>3</sup>		CUM. VOL. 7.4 m <sup>3</sup>							
WATER ADDED I		AUTH. BY							
Page 1 of 1		2004.Jun.28		AMEC		PER. <i>D.H. Morgan</i>			

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of test results is provided only on written request.

# CONCRETE TEST REPORT

2227 Douglas Road, Burnaby, BC V5C 5A9  
Tel: (604) 294-3811 Fax: (604) 294-4664



CERTIFIED CONCRETE TESTING LABORATORY  
IN ACCORDANCE WITH STD.A283.2-94

TO [ Fulton Engineering Inc.  
8605 Sunbury Place  
Delta, BC, BC  
V4C 3Y9

PROJECT NO. VA-06376

CLIENT Fulton Engineering Inc.  
C.C.

ATTN: Bob Fulton, P. Eng., M. Eng

PROJECT FULTON ENGINEERING  
BONSOR REC CENTER

BURNABY

SET NO. 2 NO. OF SPECIMENS 3 DATE RECEIVED 2004.May.15 DATE CAST 2004.May.14

SPCM NO.	SPECIMEN TYPE	CURE CONDN	DATE TESTED	AGE AT TEST (DAYS)	AVERAGE DIAMETER (mm) OR SIDE (mm x mm)	AVERAGE LENGTH OR SPAN (mm)	MAXIMUM LOAD (kN)	COMPRESSIVE OR FLEXURAL STRENGTH (MPa) Average	FAILURE TYPE
A	Cylinder	Lab	May.21	7	101.6	203.2	270	33.3	
B	Cylinder	Lab	Jun.11	28	101.6	203.2	399	49.2	
C	Cylinder	Lab	Jun.11	28	101.6	203.2	397	49.0 49.1	

SPECIFIED STRENGTH 30 MPa @ 56 DAYS

CEMENT CONTENT kg/m<sup>3</sup> TYPE 10

POZZOLAN CONTENT kg/m<sup>3</sup> TYPE

MAXIMUM SIZE AGGREGATE 14 mm

BATCH TIME 08:21

ADMIXTURES

MICROFIBRE  
HRWR A9) @ PLANT

SUPPLIER Ocean Construction

MIX NO. 2CAP2W

TRUCK NO. 182 TICKET NO. 1715419

LOAD VOL. 5.4 m<sup>3</sup> CUM. VOL. 5.4 m<sup>3</sup>

WATER ADDED I AUTH. BY

Page 1 of 1 2004.Jun.28

CONCRETE TEMP. 20 °C AIR TEMP. 19 °C

SLUMP 50 mm SPEC. 80 ± 20

AIR 5.4 % SPEC. 5.5 ± 1.5

PLASTIC DENSITY kg/m<sup>3</sup>

HARDENED DENSITY kg/m<sup>3</sup>

CAST TIME 09:55

CAST BY AEE GW

CURING CONDITIONS

INITIAL CURING TEMP: MAXIMUM 20 °C MINIMUM 17 °C

LOCATION

SKATEBOARD FACILITY RAMPED WALL SECTIONS  
AT SOUTHEAST CORNER OF PIT PLUS INFILLS  
AT UPPER LEVEL SOUTH SIDE.  
COMMENTS

AMEC

PER.

*J. L. Morgan*

## TECHNICAL REPORT

Fulton Engineering Company Limited  
8605 Sunbury Place  
N.Delta, BC V4C 3Y9



FILE: VA0 6376  
DATE: 3 August 2004

**ATTENTION:** Mr. Bob Fulton, P.Eng., M.Eng.

**PROJECT:** Metro Youth Park

**SUBJECT:** Compressive Strength of Shotcrete Core Specimens

Core No.	Age (Days)	Length (mm)	Diameter (mm)	Max.Load (kN)	L/D Ratio	Correction Factor	Calculated Compressive Strength [MPa]	Corrected Compressive Strength [MPa]	Avg. Comp. Strength (MPa)
1A	9	93	77	194	1.21	0.92	41.7	38.3	
1B	9	77	77	204	1.00	0.87	43.8	38.1	38.2
1C	28	94	77	223	1.22	0.92	47.9	44.2	
1D	28	93	77	234	1.21	0.92	50.3	46.2	45.2

Panel Shot : June 29, 2004

**Per:**

*D. R. Morgan*

D.R.Morgan, Ph.D., P.Eng.  
Chief Materials Engineer  
Materials Division

Tested By: Greg Wilson



## TECHNICAL REPORT

Fulton Engineering Company Limited  
8605 Sunbury Place  
N.Delta, BC V4C 3Y9

AMEC File: VA06376  
Date: August 2, 2004

**Attention:** Mr. Bob Fulton, P.Eng., M.Eng.

**PROJECT:** Metro Youth Park

**SUBJECT:** Density, Absorption, and Voids in Hardened Shotcrete to ASTM C642

Specimen Identification	Absorption after immersion [%]	Absorption after immersion and boiling [%]	Volume of permeable voids [%]	Bulk density after immersion and boiling [kg/m <sup>3</sup> ]
1A	5.9	6.2	13.7	2345
1B	6.1	6.1	13.4	2336
AVERAGE	6.0	6.1	13.5	2340

Panel Shot: June 29, 2004

Tested By: Vipin Sharma, P.Eng.  
Materials Engineer

Reviewed By:

D.R. Morgan, Ph.D, P.Eng.  
Chief Materials Engineer