Use of EcoSmart™ Concrete

In The Bayview High-Rise Apartment

Vancouver, B.C.

November 2002

BUSBY + ASSOCIATES ARCHITECTS

TABLE OF CONTENTS

1.0 INTRODUCTION

This report was commissioned by the EcoSmart™ Steering Committee as part of the EcoSmart™ Concrete Project. The scope of this report is to investigate and record the impact of using High Volume Fly Ash (HVFA) concrete in the construction of a high rise residential/commercial building - specifically the newly completed - The Bayview High-Rise Apartment in Vancouver, in order to determine whether EcoSmart™ concrete which is known to take longer to gain strength and harden, can be introduced to the existing schedule driven high- rise construction market.

1.1 HIGHLIGHTS

- **Aesthetic Appeal –** Incorporating fly ash in the concrete mix produced a "beautiful", light coloured concrete with a much smoother finish.
- **Environmental Impact –** The concrete manufactured for the Bayview High-Rise Apartment incorporated 13% more fly ash in the mixes over the high-rise industry standard 20% fly ash concrete mix.
- **Workability** - The high volume fly ash mixes used in the podium were found to be easier to place, pump and vibrate than conventional mixes.
- **Future Use** - The contractor felt that he would be confident in setting a 50% fly ash replacement for cement for the podium areas but would keep the fly ash content at 15% for the tower slabs.

2.0 THE PROJECT

2.1 PROJECT STATISTICS

Location	1529 West Pender, Vancouver
Design	1998-1999
Construction	1999-2001
Site Size	2,492 m2 (26,830 sq. ft)
Density	7.2 floor space ratio
Height	83.2 m (273 ft)
Number of Storeys	30
Cost	$22 M
Concrete Used	11,630 cu.m. (410,707 cu.ft)

2.2 PROJECT TEAM

Client	Fine Line International Development
Architect	Busby + Associates Architects
Structural Engineer	Read Jones Christoffersen
Mechanical Engineer	Keen Engineering.
Electrical Engineer	Flagel Lewandowski

FIGURE 2.1.0
MODEL PHOTO

▪ Environmental Consultants	RWDI
▪ Contractor	Ledcor
▪ Material Engineer	Metro Testing
▪ Concrete Placer	Lava Concrete Placing
▪ Cement Supplier	Ocean Construction / Lehigh Northwest Cement
▪ Fly ash Supplier	Centralia, Washington

2.3 OVERVIEW

Located at 1529 West Pender in downtown Vancouver, Bayview at Coal Harbour is a mixed use project which includes a 30 storey rental residential tower, 11 live/work townhouses, and 2,950 m^2 of strata commercial space.

The site is the sole connection between the water oriented "Coal Harbour" development and the Pender and Georgia Street corridor. The commercial component of the development and the entrance to the residential tower constitute the Pender Street edge of the site. The townhouses are oriented to Hastings Street, which is restricted to traffic on this block. The three main elements of the programme (commercial, strata, townhouse, rental tower) have their own identity while sharing materials to create a unified project.

The rental residential tower has been oriented to maximize the number of units facing views. All upper units have at least a partial view of water and mountains. Units are predominantly small one bedroom suites with common laundry facilities on each floor

Commercial uses include at grade retail space to the Pender Street front with office use above facing both Pender and Hastings Streets.

The Hastings Street townhouses are live/work units incorporating a small office component (15.3 m^2 per suite) at entry level off Hastings Street, and two floors of living space above (2 bedroom units). The townhouses have direct access from the underground parking below.

The tower facade is broken up with vertical structural elements and a slight "stepping" of the facade emphasizing the height and slimness of the tower.

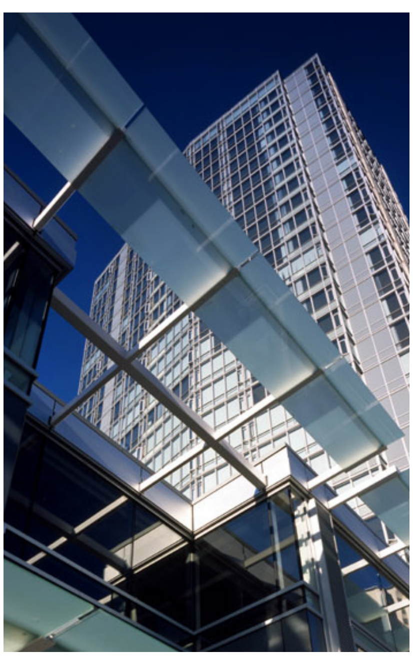


FIGURE 2.3.1
WEST TOWER ELEVATION

3.0 ECOSMART™ CONCRETE USAGE

3.1 GOALS

The numerous benefits of using EcoSmart™ concrete are very well documented. The product is simple in technology, has low initial cost, increases concrete durability and is very environmentally friendly. The Lower Mainland has two cement production plants on the north arm of the Fraser River - Lafarge Canada Inc. and Lehigh Northwest Cement Ltd. Together they produce about two million tonnes of carbon dioxide (CO_2) annually - almost 12 per cent of the GVRD's total CO_2 production. The use of fly ash, shipped from Alberta and Washington, eliminates both CO_2 production and huge energy costs associated with burning limestone to make conventional cement.

In B.C.'s lower mainland, fly ash has been added to concrete mixes since the 1970s, starting with 10 percent of the cement content. Today, 20 percent is almost standard for concrete projects including high-rise towers such as the Bayview Tower.

The goal in this project was to introduce higher levels (40% or more) of fly ash to a high rise building, preferably in a way that introduced no cost premium to the existing construction process. High rise construction is schedule driven with construction sequences that are highly repetitive and optimized over the years to take advantage of fast-setting concrete. Absorbing the perceived slow setting EcoSmart™ concrete into the process was deemed to be a risky proposition.

With the encouragement of the EcoSmart™ Steering Committee, the project team met shortly before completion of the building design to discuss the possibility of aggressively incorporating higher levels of fly ash in this building. The architect team of Busby + Associates Architects has had previous success in using HVFA concrete in institutional buildings and was predisposed to using the material. The owner expressed interest in using higher levels of fly ash but was understandably reluctant to pay a premium for the use of the product. As current practices are only most favorable when considered in concurrence with conventional concrete within fast setting mixes, it was clear from this meeting that changes to current construction procedures would have to be pursued in order to achieve a "cost-neutral" EcoSmart™ concrete usage. The construction company Ledcor, already accustomed to the use of fly ash in its cement concrete mixes, typically 20% for slabs and 40% for footings decided not make changes in its current construction practices to accommodate higher levels of fly ash in their concrete mixes.

3.2 GLOBAL DISTRIBUTION OF CONCRETE BY ELEMENT

Element	Estimated Volume (cu.m)	% Total Volume
Parking Slabs & Slab Bands	1770	15%
Slab on Grade Interior Parking	210	2%
Slab on Grade Exterior	90	1%
Core Footing	570	5%
Other Footings	430	4%
Shear Walls & Columns		
Foundation to 8th Floor	830	7%
8th to 12th Floor	250	2%
12th to 16th Floor	250	2%
16th Floor to Roof & Other Walls	2460	21%
Tower Slabs	4630	40%
Toppings & Housekeeping Pads	140	1%
	11630	100%

TABLE 3.2.1

From the table above, slabs and footings account for more than two thirds of the building's concrete, while walls and columns account for the remaining one third of building's concrete. A further review of the concrete distribution suggests that one third of the building's concrete is contained in the "podium" consisting of the parkade and commercial floors and two thirds in the tower.

3.3 CONCRETE REQUIREMENTS

Element	Min. 28 Day Strength (mPa)	Slump	Max. Aggregate	Exposure Class	Design Stripping Strength (.6 f'c) mPa
Parking Slabs & Slab Bands	35	70	20	C-1	21
Slab on Grade Interior Parking	25	70	20	C-4	N/A
Slab on Grade Exterior	32	70	20	C-2	N/A
Core Footing	30	80	40	N/A	N/A
Other Footings	25	80	40	N/A	N/A
Shear Walls & Columns					
Foundation to 8th Floor	40	80	20	N/A	24
8th to 12th Floor	35	80	20	N/A	21
12th to 16th Floor	30	80	20	N/A	18
16th Floor to Roof & Other Walls	25	80	20	N/A	15
Tower Slabs	25	70	20	N/A	15
Toppings & Housekeeping Pads	20	70	20	N/A	N/A

TABLE 3.3.1

FIGURE 3.3.2
NICOLA STREET

Element	Min. 28 Day Strength (mPa)	% flyash replacement (Ledcor Standard)	% flyash replacement (Actual)	W/CM
Parking Slabs & Slab Bands	35	15	33	0.40
Slab on Grade Interior Parking	25	20	20	0.50
Slab on Grade Exterior	32	20	20	0.45
Core Footing	30	40	45	0.50
Other Footings	25	40	45	0.50
Shear Walls & Columns				
Foundation to 8th Floor	40	15	33	0.45
8th to 12th Floor	35	15	33	0.45
12th to 16th Floor	30	20	33	0.45
16th Floor to Roof & Other Walls	25	20	33	0.45
Tower Slabs	25	15	15 to 25	
Toppings & Housekeeping Pads	20	15	45	

TABLE 3.4.1

3.4 TYPICAL FLY ASH CONTENTS IN MIX DESIGNS

The podium consisting of the parkade and commercial areas were constructed over a longer period of time due to more complex formwork required by a typically more complicated and less repetitive plan than the tower. In addition to the podium's less demanding schedule requirements, the concrete components also have the most demanding durability requirements lending it most conducive for EcoSmart™ concrete application. Fly ash in concrete mixes for most elements except slabs were increased from the normal Ledcor Standard. The contractor commented that had it not been winter time during most of the podium concrete work where outside temperatures were below 5 degrees C, the fly ash replacement in concrete would have been more aggressive.

For the tower slabs- comprising 40% of the project's total concrete distribution, incorporating EcoSmart™ concrete had proven to be more challenging. This project opted for a 3 day tower cycle schedule instead of the typical 5 day tower cycle schedule. The contractor felt that the "fast-tracking" of the tower construction sequences achieved from optimized scheduling could have potentially been jeopardized by stripping and/or finishing delays generally associated with EcoSmart™ concrete usage. In the end, the fly ash in concrete mixes for the tower slabs conservatively ranged between 15 to 25%.

Note: Although the concrete supplier provided the fly ash percentages used for the mixes. **they have** chosen to not to disclose the complete concrete mix designs for proprietary reasons.

3.5 CHRONOLOGY

Excavation was completed by mid-December 2000. Slab on grade was poured during the last week of December to early January. The concrete work on the parking levels was completed between January and mid February. The lower and ground floors were completed between February and March. During pours on the podium, the outdoor temperatures ranged between -1o C and 9o C. Concrete work on the towers were was primarily done during the summer months where outdoor temperatures were almost always over 9o C.

TABLE 3.6.1

3.6 FINDINGS

- QUALITY OF FLY ASH - A low Type C fly ash - designated C1, was supplied by Centralia in Washington. Typically, the higher calcium contents of Type C fly ash - normally between 8.0 to 20%, allow pozzolanic activity to begin earlier. At later ages, Type C behaves very much like Type F - yielding higher strengths than conventional concrete at 56 and 90 days. However, the Type C1 fly ash used in the concrete mixes had calcium content measured at 8.4. (see Appendix A) This is comparatively low when measured against the Type C fly ash used in York University with a calcium content of 16.6. This "low" type C fly ash would provide a more secondary cementing action much similar to a Type F fly ash and would be expected to gain strength more slowly at early ages than that of conventional concrete mixes or mixes with type C fly ash.

- QUALITY OF CEMENT - CSA Type 10 Normal Portland Cement was supplied by Lehigh Northwest Cement of Delta, B.C

- STRENGTH -
  Compressive Strength Test of Estimates of 25 MPa Mix at different % of fly ash replacement (% of total cementitious)

Time	*Strength (mPa) 15% Fly ash*	*Strength (mPa) 50% Fly ash*
7days	20	16
28 days	29	27
56 days	32	34

  Although not conclusively suggested by the table above, a fly ash concrete mix will generally gain strength more slowly at early ages. After about seven days, the rate of strength gain of fly ash concrete exceeds that of conventional concrete, enabling equivalent strength at 28 days. This higher rate of strength gain continues over time enabling fly ash concrete to produce higher ultimate strength than can be achieved with conventional concrete.

  Instead of the standard 5 day tower cycle schedule this project followed a 3 day tower cycle schedule. With the "fast-tracked" schedule, the floors had to be steel-troweled, and the amount of fly ash that was substituted for slab elements was relatively small to a maximum of 25% depending on the outside temperature. Applying heat to the area or under the slab helped speed up setting in cold weather.

- WORKABILITY - The concrete placers found the mixes with higher levels of fly ash replacement more workable, with more even set and finish. Hotspots were practically non existent.

- FINISHING - With the fly ash levels on the tower slabs kept at the standard 15%, and the nominal increase from 20% to 33% fly ash in the parking slabs, finishers as expected, proceeded without changes to standard procedure. As normally done to help hasten concrete setting time, the slabs were preheated a day before finishing, and continued to be heated during and immediately after.

- APPEARANCE - Fly ash mixed into concrete created beautiful, "architectural" concrete according to the contractor. The final result is light in color and its extreme workability ensured smoother finishes

- ECONOMICS - Because of the low initial cost of fly ash, the contractors already incorporate fly ash in their mixes. Although thorough financial analysis was not available, the contractors suspect that the potential savings resulting from partial substitution of cement by fly ash is very small compared to the enormous expense that could result from an extended construction schedule and/or alternate methods such as incorporating a second set of fly forms, in order to accommodate EcoSmart™ concrete's perceived slower curing time.

FIGURE 3.6.2
PODIUM, HASTINGS ST. APRIL 2001

- PERCEPTION - In general, the workers were very pleased with the higher fly ash replacement mixes and the contractor suggested that without changes to current construction procedure and schedule, he would be confident in boosting the fly ash levels in the podium up to 50% , up to 37% in all tower vertical walls and columns but would still be very reluctant in changing the standard 15% fly ash concrete mix for the tower slabs.

4.0 THE TORONTO EXPERIENCE

Lloyd Keller of Ellis Don Construction of Toronto, still confident from its current success in incorporating 50% fly ash replacement for York University Computer Science building, commented that a typical tower floor utilizing a 3 day cycle schedule can easily incorporate a 50% fly ash replacement in its concrete mixes assuming a correct mix is used - i.e. Type C fly ash combined with cement with high C3A content - such as the cement available in Ontario. This combination used in York achieved 20 to 25 Mpa in 3 days, usually exceeding 30 Mpa's in 7 days. This is very encouraging as the tower floors generally take up over 40% of the concrete used in a tower project.

5.0 CONCLUSION

Under current high-rise design practices in Vancouver, EcoSmart™ concrete is not advocated for the tower portion of high-rise concrete construction due to constraints presented by HVFA concrete's slower early-strength development and hence the inability to turn forms around quickly adversely impacting the construction schedule. A study prepared by the Vancouver structural engineering firm Fast + Epp suggests the best places for using HVFA concrete in high rise projects would be in the podiums and parkades. These components have the most demanding durability requirements and the least demanding schedule requirements

For this project, although the contractor did not commit to the use of higher levels of fly ash prior to commencement of construction, fly ash percentages for concrete components were increased by approximately 13% over the contractors standard low fly ash mixes. Although this falls below the project teams' expectations, this boost in use of fly ash in most components suggests an increasing confidence in the use of the product for a high rise project.

In the future as the initiative catches on, more contractors can expect to be working with the 'new' concrete - a concrete mix that has slightly different properties from the mixes they're accustomed to using. For some contractors like Ellis Don Construction who have successfully built a project with EcoSmart™concrete, the key to success is to experiment with the concrete and provide thorough orientation for the crew.

5.0 ACKNOWLEDGEMENTS

The author would like to thank John Rutherford of Lehigh Northwest Cement, Vince Kehoe of Ledcor, Lloyd Keller of Ellis Don Construction, Harry Watson of Metro Testing, Diana Klien of RJC Engineering & Roger Schmidt of Fast & Epp Engineering for their cooperation in the completion of this report and for advancing the concept of EcoSmart™ concrete at the Bayview High-Rise Apartment.

COMMERCIAL TESTING LABORATORIES

A DIVISION OF CTL/THOMPSON, INC.

Chemical and Physical Analysis of Fly Ash

Developed For: *I.S.G. Resources*
980 Andover Park East
Tukwila, WA 98188

Ticket: *1439*	**Plant of Origin:** *Centralia US*	**Sample Date Range:** *11/04/2001*
Job: *7876*	**Sample ID:** *081-01*	**to:**
Report Date: *12/17/2001*	**Docket:** *69970-70069 -*	**Date Received:** *11/09/2001*

Chemical Composition (%			CSA-A23.5-98 Specifications Class F	Class C1
Total Silica, Aluminum, Iron:	80.9			
Silicon Dioxide:		50.4		
Aluminum Oxide:		23.9		
Iron Oxide:		6.6		
Sulfur Trioxide:	0.4		5.0 Max	5.0 Max
Calcium Oxide:	8.4		8.0 Max	8.0 - 20.0
Moisture Content:	0.0		3.0 Max	3.0 Max
Loss on Ignition:	0.2		8.0 Max	6.0 Max

Physical Test Result		CSA-A23.5-98 Specifications Class F	Class C1
Fineness, Retained on #325 Sieve (%):	24.9	34 Max	34 Max
Strength Activity Index (%) ASTM C-311 (28 Days @ 23 C):	93.8	75 Min	75 Min
Water Requirement, % of Control:	91.3		
Soundness, Autoclave Expansion (%):	-0.04	0.8 Max	0.8 Max
Density:	2.33		

Comments:

This report is transmitted by e-mail. The final signed document has been sent.

Commercial Testing Laboratories

Orville R. Werner II, P.E.

METRO TESTING LABORATORIES LTD.
6991 Curragh Avenue, Burnaby B.C., V5J 4V6
Tel: (604) 436-9111 Fax: (604) 436-9050

CONCRETE TEST REPORT

PROJECT NO. 5102
CLIENT G.W.L REALTY ADVISORS INC.
C.C. READ JONES CHRISTOFFERSEN LTD
BUSBY & ASSOCIATES

TO
BUSBY & ASSOCIATES
1220 HOMER ST
VANCOUVER, BC
V6B 2Y5

ATTN: MR. PETER BUSBY

PROJECT THE BAYVIEW — 1529 WEST PENDER STREET VANCOUVER

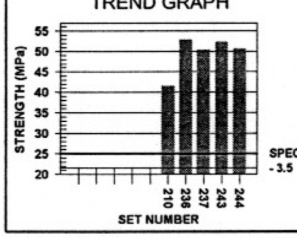
SET NO. 210 NO. OF SPECIMENS 5 DATE RECEIVED 2001.Apr.27 DATE CAST 2001.Apr.26

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.03	7	101.6	203.2	231	28.5		
B	Cylinder	Lab	May.24	28	101.6	203.2	335	41.3		
C	Cylinder	Lab	May.24	28	101.6	203.2	340	41.9	41.6	
D	Cylinder	Field	May.03	7	101.6	203.2	277	34.2		
E	Cylinder	Field	May.10	14	101.6	203.2	296	36.5		

SPECIFIED STRENGTH 25 MPa @ 28 DAYS
CEMENT CONTENT kg/m³ TYPE 10
POZZOLAN CONTENT kg/m³ TYPE F.A.
MAXIMUM SIZE AGGREGATE 20 mm
BATCH TIME 07:59
ADMIXTURES

CONCRETE TEMP. 15 °C AIR TEMP. 12 °C
SLUMP 80 mm SPEC. 80 ±
AIR 2.0 % SPEC. 2.0 ± 1.0
PLASTIC DENSITY kg/m³
HARDENED DENSITY kg/m³
CAST TIME 09:20
CAST BY MTS AS
CURING CONDITIONS CURING BOX
INITIAL CURING TEMP: MAXIMUM 20 °C MINIMUM 15 °C

TREND GRAPH



MOULD TYPE PLASTIC

LOCATION
SUSPENDED SLAB - LINE T/7 TO 9+

COMMENTS

SUPPLIER OCEAN CONSTRUCTION
MIX NO. 3PT48
TRUCK NO. 115 TICKET NO. 1601640
LOAD VOL. 10.6 m³ CUM. VOL. 10.6 m³
WATER ADDED l AUTH. BY

Page 1 of 1 2002.May.17

METRO TESTING LABORATORIES LTD. PER. [signature]

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

NOTE: Only mixes over 35 mPa were tested for 56 Day Strength

METRO TESTING LABORATORIES LTD.
6991 Curragh Avenue, Burnaby B.C., V5J 4V6
Tel: (604) 436-9111 Fax: (604) 436-9050

TEST SAMPLE REPORT

SUPPLIER	S6	SUPPLIER NAME	OCEAN C0NSTRUCTION
MIX IDENTIFIER	335PM6	PROJECT NUMBER	5102
CEMENT CONTENT		PROJECT NAME	THE BAYVIEW
POZZLN CONTENT		PROJECT SCOPE	
SPEC. STRENGTH	35 MPa @56	CLIENT	G.W.L REALTY ADVISORS INC.
SPECIFIED AIR	6.5 ± 1.5 %		C/O REDDEN & ASSOCIATES
SPECIFIED SLUMP	80 mm		
CEMENT TYPE	10		

REPORT GENERATED
2002.May.14 13:53

POZZOLAN TYPE	F.A.	FIRST SINGLE SPECIMEN AGE	7	TEST SET RANGE	ALL SETS
AGGREGATE	20 mm	SECOND SINGLE SPECIMEN AGE	28	CAST DATE RANGE	ALL DATES
CUMULATIVE SETS	14	MULTIPLE SPECIMEN AGE	56		

FOR CYLINDER SPECIMENS OF MATCHING SCHEDULED AGE CAST BY US

PROJECT NUMBER	TEST SET	CAST DATE	SLUMP (mm)	AIR %	7 DAY RESULT	MOVING AVG OF 3	28 DAY RESULT	MOVING AVG OF 3	56 DAY RESULTS		AVG OF 56 DAYS	MOVING AVG OF 3	MAX RANGE
5102	78	2001.01.23	80	5.5	34.9		40.5		53.9	52.5	53.2		1.4
5102	79	2001.01.24	80	5.0	38.1		42.8		53.3	54.6	54.0		1.3
5102	80	2001.01.24	80	5.2	40.8	37.9	44.4	42.6	64.3	62.9	63.6	56.9	1.4
5102	85	2001.01.27	80	5.8	37.0	38.6	43.9	43.7	50.9	51.9	51.4	56.3	1.0
5102	91	2001.01.31	80	5.4	41.6	39.8	N/A	43.7	60.8	59.6	60.2	58.4	1.2
5102	92	2001.01.31	80	5.0	41.7	40.1	51.7	46.7	62.2	63.4	62.8	58.1	1.2
5102	93	2001.01.31	80	5.0	33.9	39.1	50.1	48.6	58.2	57.2	57.7	60.2	1.0
5102	104	2001.02.07	70L	4.0L	34.9	36.8	49.3	50.4	62.8	61.7	62.3	60.9	1.1
5102	105	2001.02.07	80	4.2L	36.3	35.0	53.9	51.1	64.8	65.6	65.2	61.7	0.8
5102	114	2001.02.14	80	5.9	25.5	32.2	N/A	51.1	38.9	39.6	39.3	55.6	0.7
5102	117	2001.02.17	80	5.4	32.6	31.5	43.2	48.8	51.1	50.4	50.8	51.7	0.7
5102	131	2001.02.24	80	6.2	28.6	28.9	37.0	44.7	48.5		48.5	46.2	0.0
5102	143	2001.03.05	80	6.1	28.9	30.0	35.2	38.5	39.2	40.0	39.6	46.3	0.7
5102	284	2001.07.24	90H	6.8	21.0	26.2	N/A	38.5	41.2	40.7	41.0	43.0	0.5

TILBURY

Tilbury Cement Limited
7777 Ross Road
Delta, British Columbia
Tel: (604) 946-0411
Fax: (604) 946-2420

Mailing Address:
P.O. Box 950
Delta, British Columbia
V4K 3S6

AVERAGE CHEMICAL AND PHYSICAL CHARACTERISTICS OF CSA TYPE 10 NORMAL PORTLAND CEMENT PRODUCED AT TILBURY CEMENT, DELTA, B.C.

Certificate No.	D1-226	D1-227	D1-228	D1-229	D1-230
Dates Produced:	Jul 08 2001 Jul 14 2001	Jul 15 2001 Jul 21 2001	Jul 22 2001 Jul 28 2001	Jul 29 2001 Aug 04 2001	Aug 05 2001 Aug 11 2001
SiO_2 (%)	20.8	20.9	21.0	21.0	21.0
Al_2O_3 (%)	4.8	4.8	4.8	4.7	4.8
Fe_2O_3 (%)	3.8	3.7	3.8	3.7	3.7
CaO (%)	64.4	64.3	64.3	64.3	64.3
MgO (%)	0.8	0.8	0.8	0.8	0.8
SO_3 (%)	2.88	2.90	2.91	2.93	2.86
Na_2O (%)	0.24	0.24	0.24	0.24	0.25
K_2O (%)	0.29	0.31	0.29	0.30	0.32
TiO_2 (%)	0.28	0.28	0.28	0.27	0.28
C_3S (%)	59	57	57	56	57
C_2S (%)	15	17	17	18	17
C_3A (%)	6.3	6.3	6.2	6.3	6.4
C_4AF (%)	11.4	11.3	11.4	11.3	11.2
Total Alkalis (%)	0.43	0.44	0.43	0.44	0.46
Loss on Ignition (%)	1.27	1.46	1.28	1.21	1.32
Insoluble Residue (%)	0.19	0.15	0.12	0.15	0.19
Free Calcium Oxide (%)	0.37	0.37	0.27	0.43	0.46
Blaine (m2/kg)	384	411	401	408	403
+325 mesh (%)	1.4	1.3	0.9	0.9	0.9
Vicat Setting Time					
Initial (min)	102	89	95	94	108
Final (min)	207	191	199	197	214
Air Content (%)	7.7	7.5	7.4	7.8	7.8
Soundness (Expansion) (%)	-0.04	-0.04	-0.04	-0.03	-0.03

Compressive Strength	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi
3 Day	28.5	4140	29.2	4230	30.0	4350	29.9	4330	29.0	4200
7 Day	35.9	5200	36.4	5270	36.7	5330	37.8	5480	35.5	5140
28 Days	42.6	6170	43.7	6340	43.6	6330	43.5	6310	42.0	6100

This will certify that the above described cement meets CSA Specifications A5 for Type 10 Normal Portland Cement.

Plant Chemist: Jasper van de Wetering ________________ 5-Oct-2001

[illegible]