March 31, 2004 EBA File: 0701-1780097

EcoSmart™ Concrete Project
504 - 999 Canada Place
Vancouver, BC V6C 3E1

Via Fax: (604) 666-8123
No. of Pages: 28

Attention: Ms. Maggie Wojtarowicz, E.I.T.

Subject: EcoSmart™ Concrete Program
Fly Ash Concrete Trials,
Government of Canada Building, Yellowknife NT

1.0 INTRODUCTION

As requested, EBA Engineering Consultants (EBA) has produced three fly ash concrete mixes for the above captioned project. The trial mixes were produced at the specified fly ash contents of 25%, 35%, and 45% by mass of cementing materials. The objective of this work was to confirm the suitability of fly ash concrete produced with local materials for construction of the new Government of Canada building in Yellowknife. Building construction is scheduled to start in the spring of 2004.

Authorization to proceed with this work was received from Ms. Maggie Wojtarowicz, E.I.T. of the EcoSmart™ Concrete Project (EcoSmart). The work was completed under a service agreement contract dated October 29, 2003.

2.0 SCOPE OF WORK

EBA's scope of work was outlined in a proposal (0701-P1780007) dated October 28, 2003. The proposed work in the letter was divided into four tasks, as summarized below:

- Task 1. Revision of contract specifications to incorporate the use of Fly Ash.
- Task 2. Laboratory Trial Mixes.
- Task 3. Pre-Tender Meeting to discuss the use of Fly Ash Concrete.
- Task 4. Summary report of Pre-Construction Activities.

Task 1 was completed in November 2003. The reporting of Task 2 is contained herein.

P.O. Box 2244, #201, 4916 - 49 Street, Yellowknife, Northwest Territories X1A 2P7
Tel: (867) 920-2287 - Fax: (867) 873-3324 Internet: yellowknife@eba.ca - Web Site: www.eba.ca

3.0 BACKGROUND

3.1 Project

Public Works and Government Services Canada (PWGSC) will be constructing a new low-rise office building in Yellowknife, NT. The construction is scheduled to start in the spring of 2004. The project architect is Manasc Isaac Architects Ltd. (Manasc Isaac). As a LEED™ certified architect, there was a desire to reduce the environmental footprint of this project. Manasc Isaac invited EcoSmart™ to assist in confirming the feasibility of using fly ash to replace a portion of the cement in the concrete used for this project. EBA was retained to review the concrete specifications for the project and to complete the laboratory trials.

A discussion of the revisions to the contract specifications is provided in Appendix 1.

3.2 Concrete Supply in Yellowknife

Capital Transit Mix (Capital) is the only major supplier of ready-mixed concrete in Yellowknife. Cement is supplied by Lafarge Canada Inc. (Lafarge). Currently, the Capital batch plant has two cement silos. The large silo reportedly contains Type 10 (Normal) cement, and the smaller one contains Type 50 (Sulphate Resistant) cement. There is also a third silo being stored in the yard, which could potentially be attached to the plant and used for fly ash.

As of early March 2004, (prior to the award of the contract), Capital has not identified their proposed method of producing fly ash concrete. If the contractor elects to use a constant ratio of fly ash to cement, one silo could be used for pre-blended cement /fly ash. It is also possible that Capital will erect the third silo for fly ash. This would permit concrete to be produced using differing fly ash contents depending on the needs of the day.

It is understood that the major concrete application on this project will be the interior slabs. The structural engineer (A.D. Williams Engineering Inc.) has identified a 25 MPa, non air-entrained concrete produced with Type 10 cement for use in the interior flatwork. It is assumed that the majority of the interior slabs will receive a floated or trowel finish.

4.0 CEMENTING MATERIALS

Bulk samples of Type 10 cement were obtained from Capital by EBA. Lafarge manufactures the Type 10 cement supplied to Yellowknife the Exshaw, AB plant. The attached Mill Certificate for November 2003 production indicates compliance with the requirements of CSA A5.

Lafarge markets a Class CI (intermediate lime) fly ash produced at the Sundance Power Plant. This fly ash is widely used in concrete production in Western Canadian concrete and is available as a bagged product. The fly ash used for the trial mix production was obtained from Lafarge's Edmonton, AB cement terminal.

5.0 CONCRETE AGGREGATE

Coarse and fine aggregate were sampled from the stockpiles at the Capital Transit Mix yard in Yellowknife by an EBA technician. The samples were returned to EBA's Yellowknife lab for testing including determination of grain size distribution, bulk specific gravity, and absorption. The coarse aggregate was tested to determine dry-rodded density, and the fine aggregate was tested for organic impurities (colour plate).

The physical properties of the coarse and fine aggregate, which were used for the determination of the theoretical mix designs, as tested by EBA, are summarized as follows:

Physical Property	20-5 mm crushed aggregates	Sand
Bulk Specific Gravity (SSD)	2.99	2.67
Absorption (%)	0.3 %	0.4 %
Dry Rod Density, kg/m3	1740	--

5.1 Coarse Aggregate

The coarse aggregate crushed basalt from the Giant quarry. The grading of the nominal 20 mm coarse concrete aggregate is presented in the following table. The grading has been compared to the CSA A23.1-00 20-5 mm coarse aggregate grading requirements.

Table 1
20-5 mm Coarse Aggregate Grading
(Percent Passing by Mass)

Aggregate	Sieve Size (mm)						
	28	20	14	10	5	2.5	0.080
20-5 mm Coarse Agg.	100	100	87	44	2	1	0.7
CSA 20-5 mm Min.	100	85	60	25	0	0	0
CSA 20-5 mm Max.	100	100	90	60	10	5	1
Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass

The coarse aggregate grading is on the fine side of the specified grading limits. This tends to increase the fine aggregate ratio required to produce a workable concrete mix. The crushed basalt particles also tend to be tabular rather than cubical in shape, which also acts to increase the fine aggregate ratio.

5.2 Fine Aggregate

The grading of the concrete sand from the Prosperous Lake Pit is shown in the following table. The grading has been compared to the CSA A23.1-00 FA1 fine aggregate grading requirements.

Table 2
Sand Aggregate Grading
(Percent Passing by Mass)

Aggregate	Sieve Size (mm)								
	10	**5**	**2.5**	**1.25**	**0.630**	**0.315**	**0.160**	**0.080**	**FM**
Sand	100	91	73	55	37	19	9	4.2	3.15
Specified Min.	100	95	80	50	25	10	2	0	2.3
Specified Max.	100	100	100	90	65	35	10	3	3.1
Pass/Fail	Pass	Fail	Fail	Pass	Pass	Pass	Pass	Fail	Fail

The fine aggregate fails to comply with the CSA F1 fine aggregate grading requirements, being coarse on the 5 mm and 2.5 mm sieves. The fineness modulus (FM) of 3.15 is outside of the specified range of 2.3 to 3.1. Fortunately, the coarse grading of the fine aggregate is offset by the coarse aggregate grading, which is deficient in material retained on the same sieve sizes.

The fine aggregate is unwashed, as is evidenced by the excessive fines (material passing the 80-µm sieve) content of 4.2. The fines are predominately silt sized materials. Fine aggregate from this pit has been used to produce concrete in Yellowknife for a number of years.

The colour plate of 1 does not exceed the standard value of 3.

5.3 Blended Aggregate

The theoretical grading of the coarse (5 mm retained) aggregate fraction has been calculated after adjusting for the difference in relative density and is presented in the following table. The grading has been compared to the CSA A23.1-00 20-5 mm coarse aggregate grading requirements.

Table 3
>5 mm Coarse Aggregate Grading – Blended Product
(Percent Passing by Mass)

Aggregate	Sieve Size (mm)						
	28	**20**	**14**	**10**	**5**	**2.5**	**0.080**
20-5 mm Coarse Agg.	100	100	88	47	2	0	0
CSA 20-5 mm Min.	100	85	60	25	0	0	--
CSA 20-5 mm Max.	100	100	90	60	10	5	--
Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass

The theoretical grading of the fine (5 mm passing) aggregate fraction was also calculated and is presented in the following table. The grading has been compared to the CSA A23.1-00 FA1 fine aggregate grading requirements:

Table 4
<5 mm Aggregate Grading
(Percent Passing by Mass)

Aggregate	Sieve Size (mm)								
	10	**5**	**2.5**	**1.25**	**0.630**	**0.315**	**0.160**	**0.080**	**FM**
Sand	100	100	80	60	41	22	10	5	2.87
Specified Min.	100	95	80	50	25	10	2	0	2.3
Specified Max.	100	100	100	90	65	35	10	5	3.1
Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

6.0 ADMIXTURES

The mix designs assumed the use of a water-reducing admixture. Capital uses admixtures manufactured by Master Builders Technologies Ltd. (MBTL). Polyheed 997 (a multi-range water reducer) was used in accordance with the manufacturer's recommendations. MBTL recommends this product as suitable for use in fly ash concrete, and it is widely used by ready mixed concrete producers in Alberta and British Columbia. The dosage rate used for Polyheed 997 was based on total cementing materials content (i.e. cement plus fly ash).

7.0 MIX DESIGN

The mix designs presented herein were based on the non-air entrained 25 MPa mix design currently supplied by Capital. The as-batched mix proportions were adjusted for the current aggregate properties. The mix designs were then revised based on fly ash substitution rates of 25%, 35% and 45%. The improved workability of the fly ash concrete mixes resulted in a slight decrease in water demand. Batch quantities for one cubic metre of fresh concrete produced with saturated surface dry (SSD) aggregates are summarized in the following sections.

7.1 Theoretical 25 MPa, No Fly Ash Replacement

The trial mixes produced by EBA were based on Capital's design for 25 MPa, low-air entrained concrete, as summarized in the table below.

Table 5
25 MPa Concrete (20 mm aggregate)

Material	Mix Design
W/CM ratio	0.555
Water, kg/m^3	165
Cement, kg/m^3	297
Fly Ash, kg/m^3	--
20-5 mm Coarse Aggregate, kg/m^3	1010
Sand, kg/m^3	1025
Air Content, %	1.5

8.0 FLY ASH CONCRETE TRIALS

The trial batches with fly ash replacement were designed based on Capital's design for 25 MPa, low-air entrained concrete, summarized previously. Several mixes were started and adjusted to determine the workability and the finish of the concrete. The trial mixes were adjusted based on the as-batched mixes. Trials were produced with 25%, 35% and 45% fly ash replacement. The following sections present the theoretical mix design and the actual "as-batched" quantities (including extra fine aggregate, tempering water, etc.).

8.1 25 MPa, 25% Fly Ash Replacement

The 25 MPa, 25 % Fly Ash replacement trial mix was produced on December 24, 2003. The mix was produced using the theoretical mix design listed below. The as-batched quantities and adjusted mix design based on a nominal 1.000 m^3 yield are also summarized.

Table 6
25 MPa 25% Fly Ash Concrete

Material	Mix Design	As-Batched	Adjusted Mix Design
W/CM ratio	0.547	0.547	0.547
Water (kg/m^3)	164	164	164
Cement (kg/m^3)	225	225	225
Fly Ash (kg/m^3)	75	75	75
20-5 mm Coarse Aggregate (kg/m^3)	980	980	980
Sand (kg/m^3)	1013	1013	1013
Polyheed 997 (mL/100 kg CM)	650	650	650
Slump (mm)	70 – 90	80	80
Air Content (%)	2.0	2.0	2.0
Yield (m^3)	1.000	1.000	1.000
Yield (kg/m$^{3)}$	2457	2485*	2457

* Measured

The 25% fly ash replacement concrete produced was judged to have good consistency and workability.

8.2 25 MPa, 35% Fly Ash Replacement

The 25 MPa, 35 % Fly Ash replacement trial mix was produced on December 23, 2003. The mix was produced using the theoretical mix design listed below. The as-batched quantities and adjusted mix design based on a nominal 1.000 m^3 yield are also summarized.

Table 7
25 MPa 35% Fly Ash Concrete

Material	Mix Design	As-Batched	Adjusted Mix Design
W/CM ratio	0.527	**0.527**	0.527
Water (kg/m^3)	158	**158**	158
Cement (kg/m^3)	195	**195**	195
Fly Ash (kg/m^3)	105	**105**	105
20-5 mm Coarse Aggregate (kg/m^3)	985	**985**	985
Sand (kg/m^3)	1010	**1010**	1010
Polyheed 997 (mL/100 kg CM)	650	**650**	650
Slump (mm)	80	**80**	80
Air Content (%)	2.0	**2.0**	2.0
Yield (m^3)	1.000	**1.000**	1.000
Yield (kg/$m^{3)}$	2453	**2504***	2453

* Measured

The 35% fly ash replacement concrete produced was judged to have good consistency and workability.

8.3 25 MPa, 45% Fly Ash Replacement

The 25 MPa, 45 % Fly Ash replacement trial mix was produced on January 21, 2004. The mix was produced using the theoretical mix design listed below. The as-batched quantities and adjusted mix design based on a nominal 1.000 m^3 yield are also summarized.

Table 8
25 MPa 45% Fly Ash Concrete

Material	Mix Design	As-Batched	Adjusted Mix Design
W/CM ratio	0.527	0.527	0.527
Water (kg/m^3)	158	158	158
Cement (kg/m^3)	165	165	165
Fly Ash (kg/m^3)	135	135	135
20-5 mm Coarse Aggregate (kg/m^3)	985	988	987
Sand (kg/m^3)	990	1002	1000
Polyheed 997 (mL/100 kg CM)	550	550	550
Slump (mm)	80	70	80
Air Content (%)	2.0	1.8	1.8
Yield (m^3)	1.000	1.002	1.000
Yield (kg/$m^{3)}$	2438	2496*	2444

* Measured

The 45% fly ash replacement concrete produced was judged to have good consistency and workability.

9.0 RESULTS

9.1 Compressive Strength Results

Compressive strength test data from 150 mm diameter test cylinders cast from the laboratory trial mixes are summarized in Table 9 below, and are presented graphically as Figure 1. Note that, for all three trials, the 28-day compressive strengths of cylinders laboratory cured in accordance with CSA A23.2-3C greatly exceeded the specified 28-day compressive strength of 25 MPa.

Table 9
Compressive Strength Summary

Age	Compressive Strength (MPa)*		
	25% fly ash	35% fly ash	45% fly ash
3-day	22.5	18.9	14.3
3-day	21.9	18.7	11.8
Average 3-day	**22.2**	**18.8**	**13.1**
7-day	29.6	27.4	25.2
7-day	28.3	26.3	24.1
Average 7-day	**29.0**	**26.9**	**24.7**
14-day	37.9	32.6	32.9
14-day	34.8	32.9	31.3
Average 14-day	**36.4**	**32.8**	**32.1**
28-day	42.8	38.4	35.7
28-day	43.9	39.0	37.0
Average 28-day	**43.4**	**38.7**	**36.4**
56-day	45.3	44.4	43.3
56-day	46.1	45.3	45.0
Average 56-day	**45.7**	**44.9**	**44.2**

* Laboratory cured at 23 ± 2 °C in saturated lime solution

The results of the compressive strength testing indicate that there is a significant opportunity for the contractor and concrete producer to work together to optimize the floor slab mix for stripping strength and total cement and fly ash contents. As a rule, higher water and cementing materials contents increase the potential for shrinkage and curling. Large factors of safety in compressive strength do not necessarily result in an improved quality of construction.

9.2 Time of Setting

The initial time of setting for all 3 trial batches was determined using ASTM C403 “Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance.” Time of setting testing was completed both at room temperature (~22 °C) and at cool temperatures (5 °C – 8 °C). A refrigerated cooler was used to cure the cylinder at cool temperature. The temperature in the cooler was regulated with a thermostat. Results of the testing are presented in Table 10 below. The results are also presented graphically in Figure 2. The concrete curing temperatures are provided in Figures 3, 4 and 5.

Table 10 - Time of Setting

Fly Ash Replacement	Initial Time of Setting (min)	
	Room Temperature	Cool Temperature
25%	540	710
35%	560	960
45%	615	980

The was a significant increase in cool temperature setting time with the 35% and 45% fly ash trials. This suggests that fly ash contents over about 30% require additional study to optimize their use in floor slabs placed in cool weather.

9.3 Setting Temperatures

The temperature of setting was recorded for all three trial batches using "Hobo" meter temperature probes installed in a 150 mm cylinder sample. For the 25% and 35% fly ash replacement concrete, the temperature of a cylinders used in the time of setting tests were recorded for both the room temperature cylinder and the cool temperature cylinder. The ambient temperatures were recorded with a thermometer. For the 45% fly ash replacement concrete, in addition to the two probes recording the temperature of the concrete, the ambient temperatures were also recorded with the Hobo meter. The temperature plots have been included for reference as Figures 3, 4 and 5.

The temperature of the concrete samples did not vary significantly from the ambient temperature. Nevertheless, evidence of the heat of hydration and the affect of concrete temperature on the rate of hydration can be seen in Figures 3, 4 and 5.

10.0 DISCUSION AND RECOMMENDATIONS

Based on the results of the trial mix program, it is concluded that fly ash replacement of up to 45% is feasible without significantly reducing the compressive strength of the concrete.

As expected, the use of fly ash tended to improve the workability of the mix. Contrary to our typical experience, the improvement in workability was not reflected in a decrease in water demand. Typically, the use of fly ash will result in a 5 to 10% reduction in water demand. This was not seen in the trial mixes. The lack of decrease in water demand is attributed to the harsh, angular shape and relatively fine grading of the coarse aggregate. Attempts to decrease the volume of the mortar fraction (water, sand and cementing materials) resulted in an unworkable mix.

The low temperature setting times indicate that a fly ash content greater than 35% will retard the setting times significantly.

The use of fly ash concrete for grade-supported slabs is standard practice in Alberta. The vast majority of interior slabs for commercial and industrial are placed with concrete mixes containing 15 to 25 % fly ash. Very few of this mixes have had problems with achieving the specified 28-day compressive strength. Unfortunately, because of the very dry Alberta climate, there have been a number of projects with surface finish defects. These defects typically include minor crazing and dusting. At lower temperatures, some projects have experienced crusting (surface drying) during finishing, which has resulted blistering and loss of the toweled surface.

Based on these Alberta experiences, the use of higher dosages of admixtures to reduce the water content of the mix (reducing the W/CM ratio) must be approached with caution. The use of high range water reducer tends to increase setting times, especially at lower temperatures. Any increase in setting time increases the potential for surface defects. In dry weather, misting with water may be required to offset moisture loss due to evaporation

All three (3) trial batches produced were based on the current mix design used to produce 25 MPa concrete at Capital Transit Mix in Yellowknife. The trial batches had compressive strengths significantly higher than the specified 25 MPa. Prior to construction, it is recommended that the trial mixes should be revised to concrete properties more consistent with the 25 MPa design strength.

A partnering meeting for the project was held on March 16, 2004. A short summary of the discussion of fly ash concrete is provided in Appendix 2.

11.0 LIMITATIONS

The recommendations provided herein are based on the findings from samples obtained from Capital and Lafarge. The results of the gradations are considered to be reasonably representative of the general conditions, but if aggregate, cement or fly ash other than those reported are used in the manufacturing of concrete as described in this letter, EBA should be given the opportunity to review the present recommendations.

This report has been prepared for the exclusive use of the EcoSmart™ Project and its agents for specific application to the development described in Section 1.0 of this letter. It has been prepared in accordance with generally accepted materials engineering practices. No other warranty is made, either expressed or implied.

12.0 CLOSURE

We trust the information provided meets your present requirements. Should you have any questions, please contact the undersigned at your convenience.

EBA ENGINEERING CONSULTANTS LTD.

Prepared by:

, P.ENG.

for C.G. (Christian) Babuin, P.Eng.
Geotechnical Engineer
phone: (867) 920-2287

Reviewed by:

J.D. (Dave) Robson, P.Eng. (Alberta)
Senior Materials Engineer
Direct Line: (780) 451-2130, Ext. 237

Attachments

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
PERMIT NUMBER
P 013
EBA ENGINEERING CONSULTANTS LTD.
MAR 31/04

ATTACHMENTS

LAFARGE CANADA INC.

CEMENT TEST REPORT

Analysis for Laboratory: Exshaw, December 7, 2003
Samples from: Exshaw - Mill Run Type 10
Average Analysis from Period: 01 November to 30 November, 2003

Chemical Analysis

Silica ($Si0_2$)	20.7 %
Alumina (Al_20_3)	4.2 %
Iron Oxide (Fe_20_3)	2.8 %
Calcium Oxide, Total (TCaO)	64.0 %
Magnesium Oxide (MgO)	3.7 %
Sulphur Trioxide (SO_3)	2.5 %
Loss on Ignition @ 1050°C	2.8 %
Loss on Ignition @ 550°C	1.0 %
Insoluble Residue	0.3 %
Calcium Oxide, Free (FCaO)	1.2 %
Equivalent Alkali (as Na_20)	0.52 %
C3S	63.6 %
C2S	11.4 %
C3A	6.5 %
C4AF	8.5 %

Physical Analysis

Fineness 45 µm % Retained	2.2 %
Blaine	405 m^2 / kg
Setting Time - Initial	100 min.
Early Stiffening (False Set)	87 %
Autoclave Expansion	0.05 %
Compressive strength at 1 day	16.3 MPa
Compressive strength at 3 days	29.7 MPa
Compressive strength at 7 days	36.9 MPa
*Compressive strength at 28 days	45.6 MPa

*** Note** : 28 day Strength is from previous month.

Specifications: Current CSA Standards A-5

The cement represented here is certified to comply with all standard requirements of the above noted specification

Joanne Leclerc

Certified: Joanne Leclerc
Quality Assurance Coordinator

Cement Group / Exshaw Plant
PO Box 160, Exshaw, Alberta TOL 2CO
Telephone: (403) 673-3815 Fax: (403) 673-3975

LAFARGE NORTH AMERICA

Cement

FLY ASH TEST REPORT

Analysis by:	Lafarge Edmonton Lab
Sample from :	Sundance Power Plant, **Classified**
Average Analysis:	01-Nov-03 to 30-Nov-03

Chemical Analysis

Silicon Dioxide (SiO_2)	54.7 %
Aluminum Oxide (Al_2O_3)	23.6 %
Iron Oxide (Fe_2O_3)	3.4 %
Sulphur Trioxide (SO_3)	0.16 %
Calcium Oxide (CaO)	10.6 %
Moisture Content	0.10 %
Loss on Ignition	0.43 %

Physical Analysis

Fineness Retained on 45 μm (No. 325 Sieve)	15.5 %
Strength Activity Index with Cement	
% of Control at 7 Days	83.6 %
% of Control at 28 Days (previous month's result)	98.1 %
Water Requirement, Percent of Control	94.8 %
Autoclave Expansion	0.09 %
Density	2.01 g/cc

We hereby certify the fly ash represented by the above chemical and physical analysis meets the requirements of CAN/CSA - A23.5-98 for Type CI Fly Ash.

Certified : GW Winch

Garry W. Winch, P. Eng.
Technical Services Engineer

CEMENT GROUP / ALBERTA SALES
P.O. Box 3060, Sherwood Park, Alberta T8A 2A6
Telephone: (780) 472-6933 Fax: (780) 472-6648 Toll Free: 1-800-661-1522

MASTER BUILDERS

MID-RANGE WATER-REDUCING ADMIXTURES

degussa.

Construction Chemicals

POLYHEED® 997

Superior pumping/finishing admixture

Applications

Recommended for use in:

- Conventionally placed concrete mixes containing a wide range of cements, granulated slags, Class C and F fly ashes, silica fume and aggregates
- Reinforced, precast, prestressed, lightweight or normal weight concrete and pumped concrete
- Residential/commercial flatwork and formed surfaces

Description

PolyHeed 997 is a patented multi-component, non-chloride, mid-range water-reducing admixture.

PolyHeed 997 admixture meets ASTM C 494 requirements for Type A, water-reducing, and Type F, high-range water-reducing admixtures.

Features

- True mid-range water reduction (5-15%) and excellent performance across a wide concrete slump range, especially the difficult slump range of 5-8 inches (125-200 mm)
- Superior workability, pumpability and finishability qualities even in concrete mixes containing low amounts of cementitious materials
- Compressive and flexural strength performance increased at all ages
- Strength performance comparable to chloride-bearing, water-reducing admixtures at all ages
- Improved concrete durability to damage from freezing and thawing
- Superior finishing characteristics for residential/commercial flatwork and formed surfaces

Benefits

- Significantly reduced placement and finishing time resulting in lower in-place concrete costs
- Increased service life of concrete structures

Performance Characteristics

MIXTURE DATA

500 lb of Type I cement per cubic yard (295 kg/m^3); slump, 6-7 inches (150-180 mm); 5-6% air; concrete temperature 70 °F (21 °C); ambient temperature, 70 °F (21 ° C).

SETTING TIME PERFORMANCE[1]

MIXTURE	INITIAL SET h:min	DIFFERENCE h:min
PLAIN	6:01	–
PolyHeed 997		
5 fl oz/cwt (325 mL/100 kg)	6:22	+0:21
10 fl oz/cwt (650 mL/100 kg)	6:57	+0:56
15 fl oz/cwt (980 mL/100 kg)	7:31	+1:30

COMPRESSIVE STRENGTH PERFORMANCE

MIXTURE	7 DAY psi	7 DAY MPa	7 DAY %	28 DAY psi	28 DAY MPa	28 DAY %
PLAIN	2360	16.3	100	3320	22.9	100
PolyHeed 997						
5 fl oz/cwt (325 mL/100 kg)	3060	21.1	129	3930	27.1	118
10 fl oz/cwt (650 mL/100 kg)	3740	25.8	158	4610	31.8	136
15 fl oz/cwt (980 mL/100 kg)	4620	31.9	196	5460	37.7	165

[1]Note: The data shown are based on controlled laboratory tests. Reasonable variations from the results shown here may be experienced as a result of differences in concrete making materials and jobsite conditions.

Guidelines for Use

DOSAGE

PolyHeed 997 admixture has a recommended dosage range of 3-15 fl oz /100 lb (195-975 mL/100 kg) of cementitious material for most concrete mixes.

As the dosage of PolyHeed 997 admixture increases to 15 fl oz/100 lb (975 mL/100 kg) of cementitious materials, normal concrete setting time characteristics are maintained and early and ultimate compressive strengths increase.

Master Builders does not recommend the use of dosages outside the recommended range without trial testing. Consult your local Master Builders sales representative for assistance in determining the dosage for optimum performance.

Recommendations

CORROSIVITY

NON-CHLORIDE, NON-CORROSIVE

PolyHeed® 997 admixture will neither initiate nor promote corrosion of reinforcing steel in concrete. PolyHeed 997 admixture does not contain intentionally added calcium chloride or chloride-based ingredients.

COMPATIBILITY

PolyHeed 997 admixture may be used in combination with any Master Builders admixtures and may be used in all colored and architectural concrete. When used in conjunction with other admixtures, each admixture must be dispensed separately into the mix.

TEMPERATURE

If PolyHeed 997 admixture freezes, thaw at 35 °F (2 °C) or above and completely reconstitute by mild mechanical agitation.

Do not use pressurized air for agitation.

SHELF LIFE

PolyHeed 997 admixture has a minimum shelf life of 18 months. Depending on storage conditions, the shelf life may be greater than stated. Please contact your Master Builders representative regarding suitability for use and dosage recommendations if the shelf life of PolyHeed 997 admixture has been exceeded.

Packaging

PolyHeed 997 admixture is supplied in 55 gal (208 L) drums, 275 gal (1040 L) totes and by bulk delivery.

Related Documents

Material Data Safety Sheet — PolyHeed 997

Additional Information

For additional information on PolyHeed 997 admixture or on its use in developing a concrete mixture with special performance characteristics, contact your Master Builders representative.

MASTER BUILDERS, INC.

United States
23700 Chagrin Boulevard
Cleveland, Ohio 44122-5554
Phone 800.MBT.9990
Fax 216.839.8821

Canada
1800 Clark Blvd
Brampton, Ontario L6T 4M7
Phone 800.387.5862
Fax 905.792.0651

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FIGURES

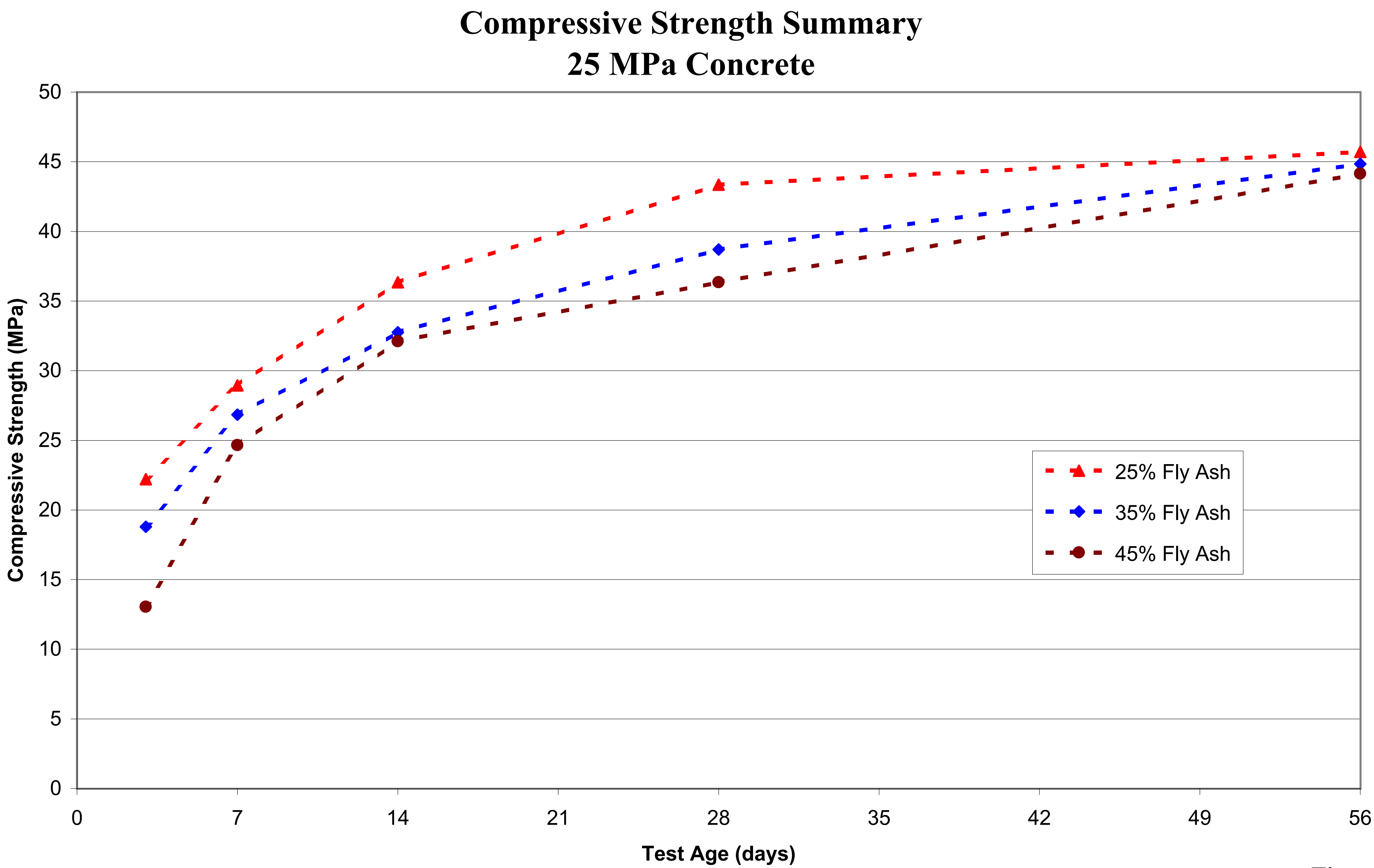

Figure 1
Compressive Strength Summary
Ecosmart Fly Ash Concrete Trial
Yellowknife GOCB
EBA Job #1780097

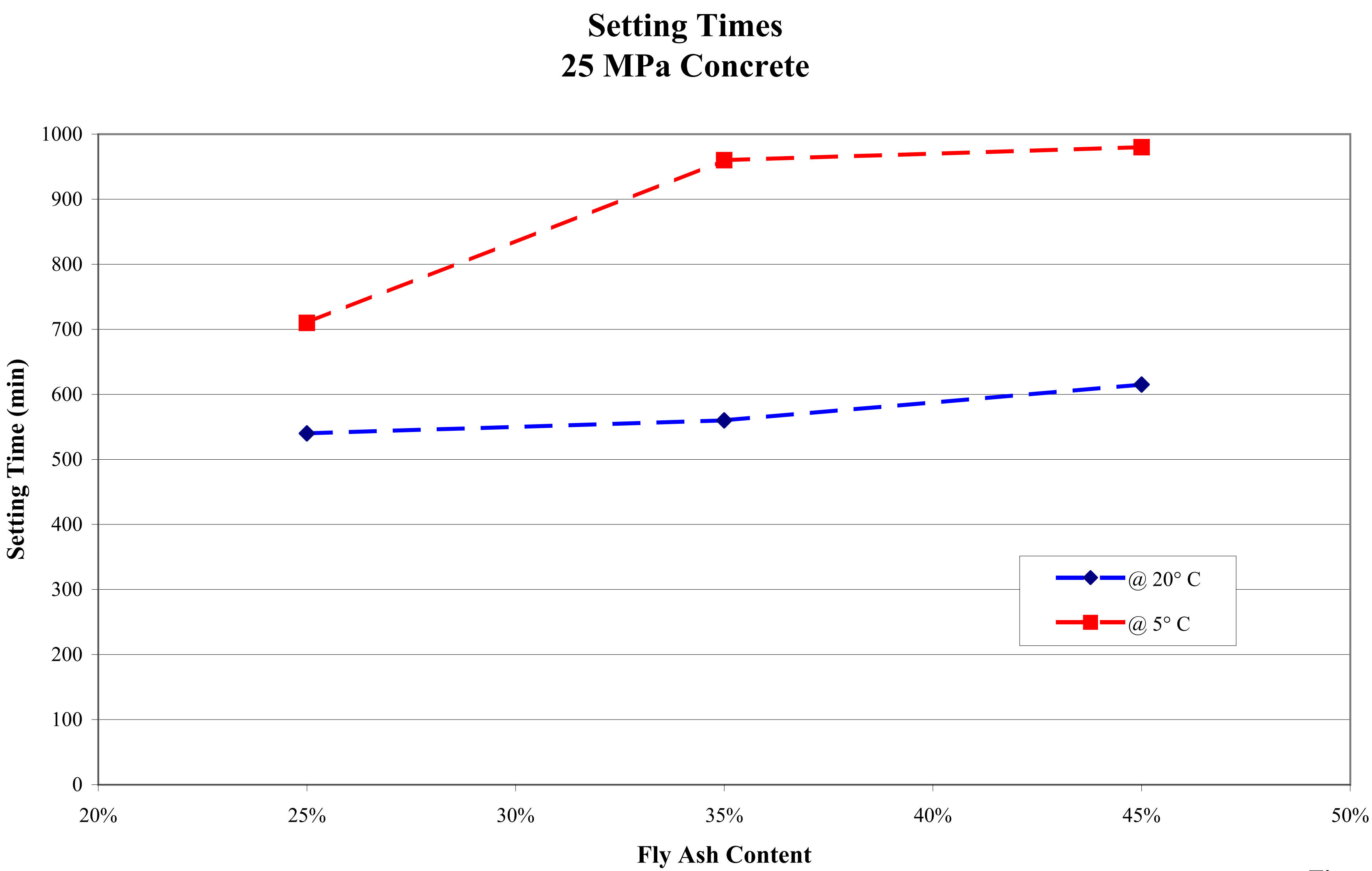

Figure 2
Setting Times
Ecosmart Concrete Trial
Yellownife GOCB
EBA Job #1780097

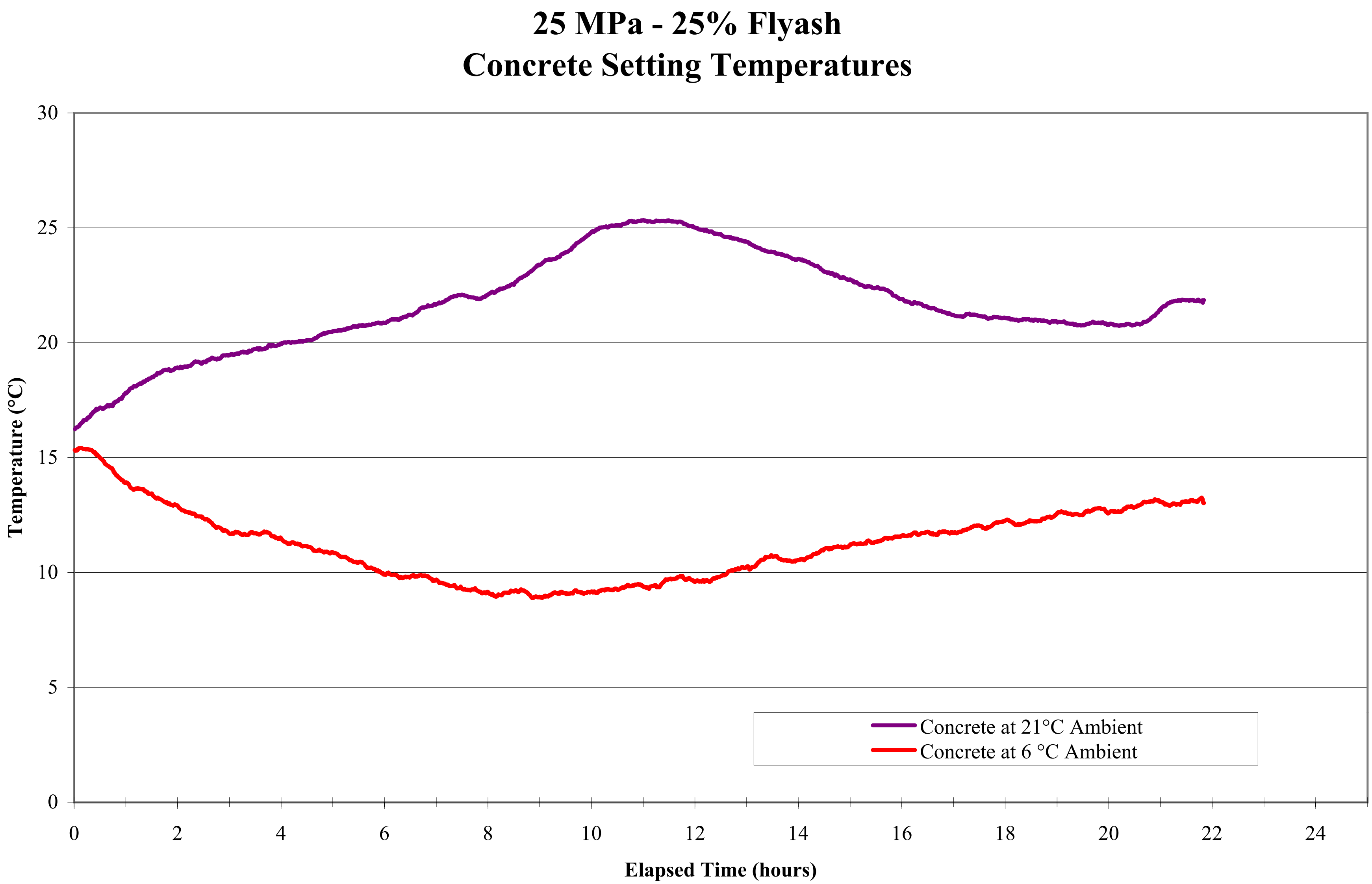

Figure 3
Ecosmart Fly Ash Concrete Trials
Yellowknife GOCB
EBA Job# 17800097

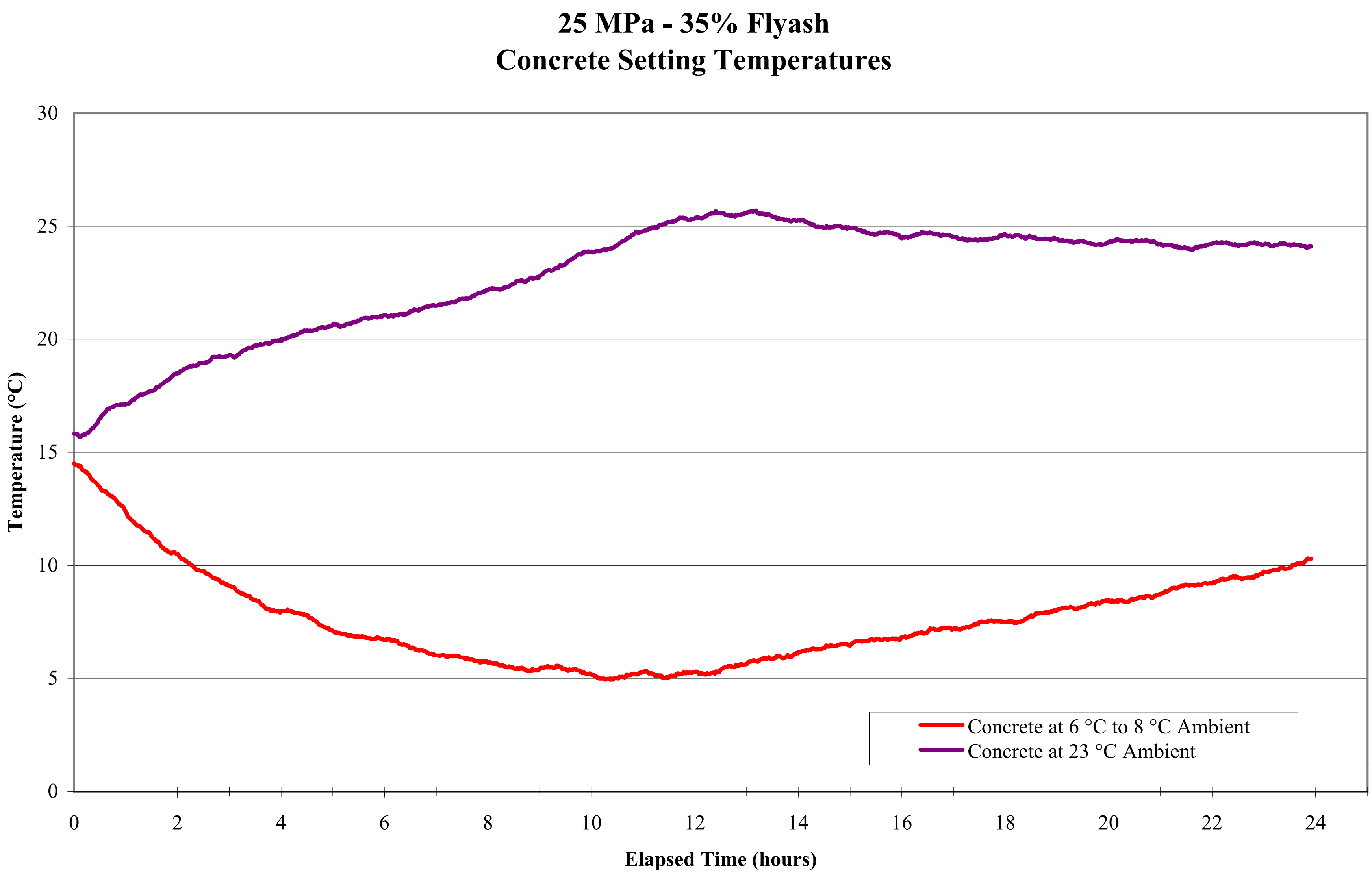

Figure 4
Ecosmart Fly Ash Concrete Trials
Yellowknife GOCB
EBA Job# 1780097

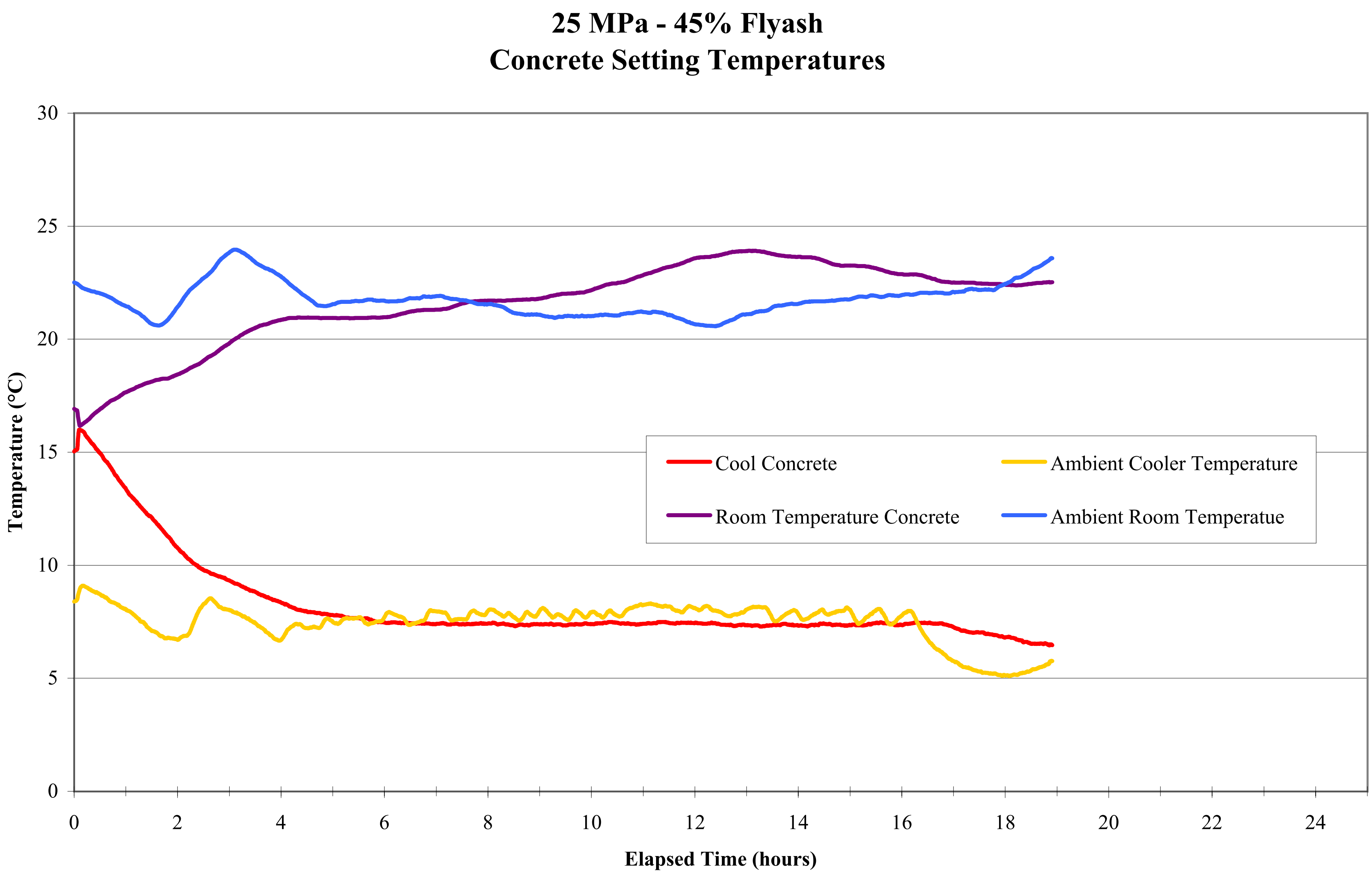

Figure 5
Ecosmart Fly Ash Concrete Trial
Yellowknife GOCB
EBA Job #1780097

APPENDIX 1

APPENDIX 1

SUMMARY OF CHANGES TO CONTRACT SPECIFICATIONS

As a part of developing fly ash concrete mixes for use on the Government of Canada Yellowknife project, EBA reviewed the proposed contract specifications for concrete. The Project Architect provided EBA with the draft for Section 03300, Cast-in-Place Concrete. This document was reviewed to provide for increased levels of fly ash utilization. These recommendations were provided to EcoSmart™. EcoSmart™ forwarded the marked up Section 03300 to the project architect for consideration by the structural engineer.

Revisions to Section 03300 were suggested in the following areas:

1) Depending on application and season, minimum fly ash contents of 25 to 50% by mass of cement materials.
2) Specified compressive strength at 56-days rather than 28-days.
3) Type of fly ash (Type F or CI)
4) Addition of a section on curing to Item 3.2 "Construction" to emphasize the need for proper moist curing of fly ash concrete.

Section 03300 of the tender documents specified:

1) Maximum fly ash replacement of 20%.
2) Compressive strength at 28-days.
3) No specification for type of fly ash.
4) No increased curing requirements.

Revisions to Section 03300 were contained in Addendum Nos. 4, 6 and 7:

1) Minimum fly ash 20% by mass of cementing material.

2) Compressive strength at 56-days was specified for the following applications:
   - Grade Beams
   - Interior Slabs-on-Grade
   - Footings, Pile Caps
   - Columns

   The specified compressive strength remained at 28-days for the following applications:

- Interior structural slab and beams (which includes the majority of the concrete for this project)
- Walls and retaining walls
- Exterior Slabs-on-Grade

3) Winter specifications apply to concrete pours when the air temperature is below 5°C.

The limited adoption of the suggested revisions to the concrete specifications was discussed with the structural engineer at the pre-award meeting in Yellowknife. The structural engineer was apparently unaware that EBA had been involved in preparing the document forwarded by EcoSmart™. The designer's comfort level would have been much higher if there had been direct communication between the local materials engineering firm and the structural designer.

APPENDIX 2

APPENDIX 2

Pre-Construction Partnering Meeting

The pre-construction partnering meeting for the Yellowknife Government of Canada Building took place in Yellowknife, NWT on March 16, 2004. The meeting was attended by a total of 43 people, including the design team (including the major sub-consultants), the owner and various representatives from local government and the prime contractor (PCL-Northern) and sub trades.

The discussion of fly ash concrete started an overview of the use of fly ash to reduce the environmental footprint of construction. Every tonne of cement replaced (or eliminated) results in a tonne decrease in CO_2 emissions. After lunch, the wide spread use of fly ash in the Alberta market was presented. Because this project will use the same cement, fly ash and admixtures proven on Alberta projects, this project will be not be a trial of the unknown. The use of a well-proven technology on this project was well received by all, not the least of which being the contractor's foreman.

This meeting provided a much needed opportunity to discuss the use of fly ash concrete with both the structural engineer and the contractor. The results of EBA's trial mix program were reviewed with both parties. The ability to achieve high 3-day compressive strengths with fly ash came as a surprise.

It was stressed that good initial curing is the key to success with fly ash concrete. If the concrete isn't provided with sufficient heat during cool weather, it may be necessary to delay stripping forms for a day or two. This is relatively easy to monitor. Unfortunately, the affect of cool ambient conditions on setting time combined with the generally low relative humidity in Yellowknife suggests that poor curing significantly increase the risk of surface defects. The contractor was cautioned that misting may be required during concrete placement to prevent surface desiccation and/or crusting.

The limited adoption of the suggested revisions to the concrete specifications was discussed with the structural engineer. The structural engineer was apparently unaware that EBA had been involved in preparing the document forwarded by EcoSmart™. The designer's comfort level would have been much higher if there had been direct communication between the local materials engineering firm and the structural designer.

Unfortunately, the local ready mixed concrete producer did not attend the meeting. It was understood that the producer retained hope that the fly ash would not be used on the project. It appears that one of the major tasks remaining as this project moves into construction will be educating the concrete producer. Based on the results of the trial mix program, it appears that there are significant opportunities for the producer to improve the quality of the coarse aggregate and the efficiency of the concrete mixes.