EcoSmart™ Concrete Project

A Concrete Contribution to the Environment™

NORTHWEST COMMUNITY COLLEGE
PRINCE RUPERT, BC

USING ECOSMART™ CONCRETE
IN A REMOTE LOCATION IN BC

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The EcoSmart™ Concrete Project

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1. Executive Summary

Implementing EcoSmart concrete technology is particularly challenging in remote areas of Canada, such as the Northwest Community College in Prince Rupert, British Columbia. Availability of fly ash, limited or complete lack of experience of various project team members with the use of fly ash in concrete, limited competition for concrete supply, and cold and rainy weather conditions, all contributed to the challenges of introducing EcoSmart concrete on this project. To overcome these challenges, a strong commitment to "green" construction and the ability to collaborate with various stakeholders, such as those exhibited by the architect and the College on this project, are a definite necessity. The beginning stages of EcoSmart concrete implementation on this project were very successful, in terms of increasing the knowledge about this technology among new users. In the end, however, the wavering commitment to reducing the environmental impact of this project by one of the stakeholders eliminated this opportunity to implement this greenhouse gas emissions reduction initiative. This report summarizes the steps taken during the design and tender stages of the projects, as well as outlines the steps that a similar project would need to take to continue with the implementation of EcoSmart concrete during the construction stage.

2. Introduction

Northwest Community College, located in Prince Rupert, British Columbia, was to be one of four BC Government Green Building Pilot Projects. These projects were designed to demonstrate the feasibility of designing and constructing green buildings within current funding levels, and were primarily to focus on reductions in energy consumption. Thus, the main reason for incorporating EcoSmart concrete was that the Ministry of Advanced Education had stipulated that the College be built as a green building. However, due to a change in commitment of the BC Government, the project did not go ahead as green. Figure 1 provides a view of the project site prior to construction.

The structural design for the College contained a significant volume of concrete in the foundations, columns, shear walls and topping on metal deck (approximately 1000 m^3). Subsurface conditions of the site were challenging, requiring foundations consisting of a combination of pile supported structural slabs and grade beams, deep foundation walls and some slab on structural fill areas. This project represented an opportunity to demonstrate implementation of EcoSmart principles in a geographic location remote from the technology hub of the Lower Mainland. Local concrete supply and placement companies had no direct experience with EcoSmart concrete, but were both supportive of the initiative and had potential facilities to supply concrete containing fly ash. The lack of direct experience, however, was anticipated to impact project costs.

Figure 1: View of project site, Prince Rupert, BC

2.1. Project Team

Owner:	BC Ministry of Advanced Education and the Northwest Community College
Architect:	Larry McFarland Architects
Materials Engineer:	Levelton Engineering Ltd.
Structural Engineer:	CWMM Consulting Engineers Ltd.
General Contractor:	TBA
Concrete Supplier:	TBA

2.2. Project Description

Location:	Prince Rupert, BC
Concrete Construction:	Anticipated concrete work start Spring 2003
	Anticipated concrete work completion August 2003
Building Area:	4400 m^2
Size of Structure:	2 storeys
Concrete Volume:	1067 m^3

In June 2002, EcoSmart discussed with the architect the possibility of collaborating on the NWCC project. The project went to tender January 6, 2003 and the tender closed on February 14, 2003. Unfortunately, when the tender closed, the lowest bid was 18% over the approved construction budget, and the project was put on-hold as of March 2003. Rather than negotiate with the low bidder, the Ministry of Advanced Education decided to re-tender with design changes that would effectively remove all the sustainability items. Given these changes to the design approach, McFarland Architects negotiated a termination of their contract and turned their drawings over to new architects.

2.3. Use of EcoSmart Concrete

EcoSmart anticipated that the remote location of Prince Rupert would be a factor in implementing high volume fly ash concrete. In addition, because there are only two local suppliers of concrete in Prince Rupert, there is limited competition. The limited competition would have an economic impact on EcoSmart concrete, and would require co-operation of the contractor / supplier to get prices.

According to the materials engineer, the use of EcoSmart concrete presented several technical issues:

- Monitoring of early age strength gain to support scheduling.
- Batching sequence and use of superplasticizers.
- The time required to finish flatwork under Prince Rupert's weather conditions could impact schedule and cost if prolonged periods of rain occurred.
- Limited available facilities meant that the local supply of concrete would be from a relatively unsophisticated ready-mixed concrete plant.

The architect and structural engineer originally proposed the levels of replacement of Portland cement with fly ash indicated in Table 1 for the various structural elements.

Table 1: Proposed Levels of Replacement of Portland Cement with Fly Ash

			EcoSmart Mix Design (1)		**Standard Mix Design (2)**	
Building Element	**Design Strength (MPa @ 56 days)**	**Volume of Concrete (m^3)**	**% Fly Ash**	**Total Cementing Materials (kg/m^3)**	**% Fly Ash**	**Total Cementing Materials (kg/m^3)**
Footings, pile fill, pile caps & grade beams	30	484	50	N/A	15	320
Columns & shear walls	35	139	40	N/A	18	390
Topping on metal deck	25	88	35	N/A	20	235
Suspended slab on permanent formwork and foundation walls	30	356	30	N/A	18	275

(1) The total cementing materials content would be determined by the concrete supplier based on performance specifications, and thus, was not available (N/A) from the architect.
(2) Standard Mix Design = typical fly ash use in B.C. in the absence of an EcoSmart focus for the project.

Based on previous experience with EcoSmart concrete and considering the proposed levels of cement replacement, the materials engineer proposed to assist the structural engineer in adapting their specifications to incorporate EcoSmart concrete. During a meeting between the materials and structural engineers in October 2002, the standard concrete specifications were revised in accordance with the EcoSmart principle to minimize the GHG emissions of the concrete by partially replacing the Portland cement with a maximum amount of supplementary cementing materials while maintaining or improving cost, concrete performance, and constructability.

On January 21, 2003, the materials engineer attended the pre-tender meeting in Prince Rupert, and presented the facts on EcoSmart concrete to the general contractors interested in bidding on the tender, the City and College officials, and the ready-mixed concrete suppliers. At this meeting, the materials engineer also proposed to attend a pre-construction meeting and address any concerns of the site crew. Following the pre-tender meeting, after consultation with the materials engineer and the structural engineer, minor revisions were issued to the tender documents, which clarified acceptable percentages of fly ash for cold weather conditions. The revised specifications allowed for the reduction of the minimum level of cement replacement of 5-10% (e.g., from 30 to 25%), when the air temperature in which concrete would be poured fell below 10^{o}C. Table 2 presents the revised concrete specification table.

Table 2: Specification for Concrete Proportioning

3. CONCRETE

3.1 UNLESS NOTED OTHERWISE, CONCRETE SHALL BE PROPORTIONED AS FOLLOWS:

	MINIMUM 56 DAY STRENGTH (MPa)	SLUMP AT POINT OF DISCHARGE (mm)	AIR CONT. (%)	MAX. AGG. (mm)	EXPO-SURE CLASS	MIN. % CEMENT REPLACEMENT WITH FLY ASH	
						TEMPERATURE >10°C	TEMPERATURE <10°C
FOOTINGS, SPREAD & STRIP CONC. FILLED STEEL PIPE PILES	30	75 ± 25	3 – 6	40	F–2	50	50
FOUNDATION WALLS AND PILASTERS UP TO MAIN FLOOR	30	75 ± 25	4 – 7	25	F–2	30	20
GRADE BEAMS, PILE CAPS	30	75 ± 25	4 – 7	25	F–2	50	50
INTERIOR COLUMNS	30	75 ± 25	–	20	NONE	40	30
EXTERIOR COLUMNS AT GRID Ls AND 13s TO 16s	35	75 ± 25	5 – 8	20	C–1	40	30
SHEARWALLS ABOVE MAIN FLOOR	30	75 ± 25	–	20	NONE	40	30
EXT. SLAB AND STAIRS ON GRADE	32	60 ± 20	5 – 8	20	C–2	25	25
INT. FLOOR SLABS	30	75 ± 25	–	20	NONE	30	25
TOPPING ON METAL DECK	25	75 ± 25	–	10	NONE	35	25

SLUMP: REFER TO CLAUSE 14.2.3 OF CSA–A23.1–94

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TITLE: GENERAL NOTES REVISED
REFERENCE DRAWING: S101
PROJECT: NORTHWEST COMMUNITY COLLEGE
SCALE: NTS
DATE: JAN. 27, 2003
DRAWN: MC
PROJ. NO.: 9433
REV.:
DWG. NO.: AD S19

2.4. Steps to Implementing EcoSmart Concrete During Construction

Figure 2: Cross-sectional view of the architectural model of the NWCC building

Since the bids came in over budget and the project was put on hold, the implementation of EcoSmart concrete on this project did not proceed beyond the stages of revision of concrete specifications and presentation during the pre-tender meeting. Had the project proceeded with the use of EcoSmart concrete, the project team would have undertaken the following steps.

Prior to the pre-construction meeting, the supplier's materials would have been qualified and some preliminary trial mixes tested.

During the initial concreting on site, the materials engineer planned to provide opportunities to place test batches of each mix design. This would have given workers a chance to become familiar with the concrete and possibly to practice finishing it. Testing would have included:

- Strength qualification including age and strength curves.
- Development of the Strength: Maturity relationship so that the in situ strength of the concrete could be subsequently determined.
- Setting time.

To ensure quality control during concreting, the materials engineer planned to cast extra test cylinders to determine both early and late age strengths based on standard moist curing. In addition, maturity probes would have been installed in the concrete to monitor actual strength gain for all major pours, or for those with critical strength development requirements, such as the foundation walls. Typically, early strengths in foundation walls are not very critical, and with fly ash concrete, design strengths are easily achieved within the specified 56 days, thereby, not requiring actual strength monitoring. However, due to the challenging subsurface conditions on this project, the foundations walls would be required to support the early loads from the backfill material. Using maturity probes is a recognized non-destructive test method.

3. Conclusions

Although EcoSmart concrete was ultimately not used on this project, EcoSmart did have the opportunity to educate potential bidders and the community in a remote area of BC during the pre-tender and tender periods. EcoSmart also was able to transfer the knowledge about high volume fly ash concrete to a structural engineer unfamiliar with its implementation, and collaborate with a forward-thinking architect on bringing together all the stakeholders to ensure the most successful application of EcoSmart concrete on this project.