EcoSmart™ Concrete Project

A Concrete Contribution to the Environment™

Whistler Conference Centre Renovation Case Study

USING ECOSMART™ CONCRETE
IN A RENOVATION PROJECT

Prepared by: Susan Hildebrand, GSC, LEED AP
CONSTRUCTION INFORMATION TECHNOLOGY INC.
(formerly of TASK CONSTRUCTION MANAGEMENT INC.)

July 11, 2003

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 EXECUTIVE SUMMARY

This report details the first time use of EcoSmart™ concrete by the project team members in renovating the Whistler Conference Centre, a concrete building located in Whistler, British Columbia. The re-construction included the use of EcoSmart concrete in slab on grade at the 35% cement replacement level, increasing to 40 % replacement level in suspended slab once the project team gained more confidence in working with EcoSmart concrete. The Conference Centre project is registered with LEED™ (in Energy and Environmental Design), and the team's goal was to achieve a "Gold" certified status for the project. High on the priority list was to re-construct the building with as many types of materials that were either salvaged from other areas or building products that contained a high recycled content of materials recovered from consumer or industrial waste streams. Initial concerns with using EcoSmart concrete included cool construction temperatures, permeability of the concrete in vertical elements, and pumpability and workability of the concrete in slabs. Overall, the team's experience with EcoSmart concrete was very positive, and project members were pleased with the concrete's strength development, workability, finishability, appearance, and cost.

2.0 PROJECT DESCRIPTION

2.1 Project Overview

Whistler Conference Center, located at 4010 Whistler Way, Whistler, British Columbia, is an existing building originally constructed as an ice arena in 1983. The building underwent many transformations over the years until 1985 when it became known as the Whistler Conference Center. Tourism Whistler operates out of this building hosting many festivals, conferences, and events from all over the world. It is probable that it will be used as a venue for the 2010 Olympics.

The existing building structure consisted of concrete foundations, filled concrete block walls and heavy timber construction. The building area, prior to the renovation, was approximately 7,897m^2.

The renovation increased the finished floor area by approximately 2,601m^2. However, the footprint of the structure was only extended by 186m^2. In order to achieve this, approximately 1,858m^2 of the interior of the building was deconstructed without altering the roofline or compromising the heavy timber structure. This process included removal of the concrete block walls, concrete beams, columns, ramps, stairs, slab on grade, footings and excavated materials. All the deconstructed materials taken out of the building were salvaged or recycled, right down to 1,540 tonnes of removed concrete and reinforcing steel.

The concrete reconstruction of this area included footings, 1,300m^2 slab on grade, structural steel columns, and a 1,300m^2 suspended slab. All of the concrete had to be poured through an opening in the roof of the building. The concrete was pumped 6.1m down to the slab on grade level from the suspended level where the concrete trucks were located. Therefore, pumpability and segregation of concrete posed a concern.

In following the project's goals to recycle and salvage everything that came out of the building, it only seemed natural to ensure that everything that went back in the building was of the same nature. These goals were achieved by combining the use of 90% recycled structural steel, 100% recycled reinforcing steel, and EcoSmart concrete for the new structural components.

2.2 Project Team

Client:	Tourism Whistler, doing business as Whistler Resort Association Doug Stackhouse - Director of Operations

Architectural & Engineering Team

Architect:	Lutz Associate Architects Inc. Allen Jury- Project Architect
Structural:	Bush Bohlman Partners Frank Nadalini – Structural Engineer
Materials:	Metro Testing Laboratories Ltd. Neil McAskill – Materials Specialist

Construction Team & Suppliers

Construction Manager:	TASK Construction Management Inc. Susan Hildebrand- Construction Manager
Concrete Supplier:	Cardinal Concrete
SCM Supplier:	Pozzolanic (originating from a coal fired thermoelectric plant in Centralia, WA, USA)

2.3 Project Details

Construction type:	Renovation
Construction period:	October 2002 – March 2003
Building area:	10,500 m^2 (7,900 m^2 original + 2,600 m^2 added)
Volume of concrete:	550 m^3 (154 m^3 ordinary Portland cement concrete + 396 m^3 EcoSmart concrete)
Number of storeys:	2

3.0 USE OF ECOSMART™ CONCRETE

3.1 Goals

The building is LEED™ (Leadership in Energy and Environmental Design) registered and the project team's goal is to achieve "Gold" status on the renovated and new areas of the building. The project is still underway and the results are unknown at the time of writing this report. The renovation of the building included many green building design strategies. High on the priority list was to re-construct the building with materials that were either salvaged from other areas or building products that contained a high recycled content of materials recovered from consumer or industrial waste streams. The recycled content materials had to perform equally or better than the virgin materials in terms of strength, durability, and service life.

The guideline as set out by the LEED™ Rating System 2.0 was to incorporate 25-50% of total building materials containing an aggregate minimum weighted average of 20% post consumer recycled material or a minimum weighted average of 40% post industrial recycled content material.

As the new components of the building were limited, every possible resource had to be investigated to find recycled content materials. In terms of volume, the new concrete was one of the largest single material types in the re-construction of the building, so it was extremely important that it be of the highest recycled content available.

An application was made to EcoSmart for their guidance and assistance in achieving this goal.

3.2 Project Chronology

The deconstruction of the existing interiors of the building took place in October 2002. The concrete footings were placed in December 2002. Due to the schedule and the unavailability of the results of the test mixtures, concrete for the footings and elevator shaft were a standard mix with no fly ash content.

Additionally, the contractor was concerned about the effects of introducing fly ash into the elevator shaft pour. The contractor was very adamant about the use of Kryton's KIM (Krystol Internal Membrane) admixture, in the shaft as a waterproofing agent. The concern was that the use of the KIM product, which typically acts as a retardant, combined with fly ash concrete, which was understood to also act as a retardant, would heavily compromise the setup time of the concrete. Unfortunately there was not enough time to perform tests that would have provided the contractor with the information needed to make a decision on a mix design for this area.

The first slab on grade concrete pour was placed in January 2003. Concrete work continued until mid March. It was fortunate that the concrete pours were inside the existing structure and were protected from adverse weather conditions, including cold winter temperatures. The building remained at an average temperature of about 15^{o}C, allowing the materials testing consultants to incorporate some constants into their concrete mixture designs.

3.3 Concrete Use in Structure

The total concrete requirement for this project was approximately 550 m^3. The footings and the elevator shaft had already been placed for this project while the fly ash test results were being assembled.

Metro Testing tested 9 mix designs ranging from 30 – 60 % fly ash content. Based on the results and data provided by Metro Testing in the trial mix program, a mixture with 35% fly ash replacement, total cementitious materials content of 310 kg/m^3, Pozzutech 20 (accelerator) and Polyheed 997 (water reducing admixture) was used in the first field placement for the slab on grade pour. In comparison, a standard 30MPa at 28 days, 20% fly ash content mix used by the concrete supplier on this project would typically contain 330 kg/m^3 total cementing materials content. The concrete supplier had proposed a mix design for a 30% fly ash content based on their standard 30MPa mix (see Mix P301 in the Appendix). The concrete supplier also submitted their standard 35MPa at 28 days, 20% fly ash content mix design for reference, where the total cementing materials content is 390 kg/m^3 (see Mix CP335 in the Appendix). However, neither of these two mixes designs was actually used in either of the two slabs. Rather, the slab concrete mixes were redesigned by the materials testing agency.

The mix used was easily pumped and placed, and although it took slightly longer to finish, the mix was considered successful. A total of 220m^3 of concrete was poured for the slab on grade. The slab on grade concrete had a specified 28-day strength of 30MPa, and a fly ash content of 35% (with a resulting 6% reduction in the total cementing materials content, compared to the concrete supplier's standard mix design). The actual cement reduction in the slab on grade concrete was 25%, compared to concrete supplier's standard 20% fly ash mix. As noted in the accompanying Metro Testing report for this project, the concrete reached its specified strength, but at a slower rate than regular concrete. No additional heat was used in the building for any slab pours. The field criteria and strength gain characteristics of this mix were encouraging and the decision was made to increase the fly ash replacement level in the suspended slab to 40%, for the remaining concrete placement of about 176m^3.

The suspended slab is a ComFlor steel deck system requiring an average of approximately 280mm concrete topping with a specified 28-day strength of 30MPa. This type of floor system was chosen due to the tight schedule established for the project. Using a steel deck and concrete topping system allowed the construction crew back on the slab sooner than a concrete suspended slab. Both the plastic and hardened performance properties of the 40% replacement mix were acceptable with good reports from the placers and finishers. The specifications called for a trowel finish to both slabs.

As noted in the accompanying Metro Testing report, the 28-day strength met the specified 30 MPa strength requirement with continuing strength gain noted at 56 and 112 days.

3.4 Concrete Mix Design

The mix designs used for the slab pours were obtained from the Metro Testing Analysis Report.

Table 1: High Fly Ash Mixture Designs for Whistler Convention Centre

Ingredient	35% Fly Ash Concrete Mixture	40% Fly Ash Concrete Mixture
Cement	200	185
Fly Ash	110	125
20 mm Aggregate	650	660
10 mm Aggregate	395	395
Concrete Sand	835	835
Water	130	130
Polyheed 997 (Mid-Range water reducing mixture)	1.0 L	1.1 L
Pozzutech 20 (Accelerator)	4.0 L	4.0 L
Entrained Air	3.0%	3.0%

Figure 1: Concrete Finishing Crew on the Suspended ComFlor Deck System (40% fly ash content)

Figure 2: Pumping Concrete into Building for New Slab on Grade Placement (January 2003)

Figure 3: Finished Slab on Grade Section (35% fly ash content)

3.5 Findings

Initially, there were concerns from the project team about the placing and workability of EcoSmart concrete due to the perceptions of a “waxy” feel to it and difficulties with placing and workability on slabs. Subsequently, the comments from the field personnel with respect to the workability and finishing of the concrete were very positive. The finishing crews liked working with the concrete and did not find it any more challenging than working with regular concrete mixes. Despite the concrete being pumped through an opening in the roof and in cool temperature conditions, the concrete pumped very smoothly and set up within the normal requirements.

Comments from the architect and site manager were also very positive with regards to the excellent appearance of the finished product both in texture and colour. None of the project team commented on any imperfections with the finished concrete.

The structural engineer had very positive comments regarding the finished product on both slabs. There were some cracks noted from shrinkage, but nothing unusual or uncommon for these types of pours.

4.0 CONCLUSIONS

All around feedback from all parties was very positive. It was an excellent learning experience for all those involved. The hesitation that was experienced when the construction manager, TASK, first suggested fly ash concrete was quickly dispelled after the first slab placement The construction manager, after experiencing the first 35% fly ash pour, was very willing to move up to a 40% fly ash mixture for the next pours.

There were no cost savings involved in going to a fly ash mix since the application of admixtures had to be increased, as shown in the accompanying Metro Testing report, due to winter conditions. However, the concrete supplier indicated that typically, using fly ash as a SCM would reduce cost.

5.0 RECOMMENDATIONS

The project team all enjoyed the education, and agree that they are quite comfortable with specifying/using fly ash concrete again in their upcoming projects. Many of the team members had not used EcoSmart concrete in previous projects so were unsure of what to expect. However, everyone on the team agreed that, for future projects, whether it is a "green" building or not, using fly ash concrete is as simple as using standard mixes. The use of EcoSmart concrete just needs to be addressed earlier in the project so that all the tests are completed before the first pour. As noted in the report, there were misconceptions about some of the properties of fly ash concrete, which could have been quickly dispelled if the testing had been addressed earlier.

It would also have been beneficial to bring the entire consulting and construction teams together, including the concrete finishing crew, to review the properties of fly ash concrete and educate the team regarding what to expect at the field level in terms of pumping, placing and setup of the concrete.

For this project the team requested the highest fly ash content possible. In future, a lower fly ash content would be considered for winter pours as the economics of using fly ash may not always be an advantage due to the associated costs of additional admixtures. The concrete supplier indicated that 25% fly ash is the most efficient and economical mix proportion.

Appendix

Concrete Supplier's Proposed Mix Design for 30 MPa at 28 days, 30% Fly Ash Content Concrete

Cardinal CONCRETE LTD.

CARDINAL CONCRETE LTD.
2543 MAMQUAM ROAD
SQUAMISH, BC V0N 3G0

DATE: Sept 03/03

PROJECT:

SUBJECT: MIX P301 30MPA EXPOSURE CLASS: F2

SUPPLIER: CARDINAL CONCRETE LTD. MIX ID: P301

		MASS kg/m³	DENSITY kg/m³	VOLUME m³
CEMENT: (TYPE 10)		260	3150	82.54
POZZOLAN: FLYASH		70	2200	31.82
OTHER			0	
COARSE AGGREGATE	20	650	2650	245.28
	10	400	2600	153.85
FINE AGGREGATE	1	775	2590	299.22
ESTIMATED WATER		140	1000	140 C
ADMIXTURES:			0	
AIR ENTRAINING		AS REQUIRED FOR		
AIR CONTENT 4-7				50
TOTAL MASS =			YIELD =	1.602

SPECIFIED COMPRESIVE STRENGTH = 30MPA 28DAYS
APPROX. WATER/CEMENTITIOUS RATIO = .45
SPECIFIED SLUMP = 80±30 mm
SAND CONTENT = 42.5%

COMMENTS:

REVIEWED BY: B. Snell
BRENT SNELL
PRODUCT QUALITY

C:\My Documents\Brent's & Pricing\Mix Design Submission form.doc

Concrete Supplier's Standard Mix Design for 35 MPa at 28 days, 20% Fly Ash Content Concrete

Cardinal Concrete Ltd.
Squamish, B.C.

elephone:
ish: 898-5015
1-800-972-9636
ax: 898-4852
ler: 932-3814

Mailing Address:
2543 Mamquam Road
Squamish, B.C.
V0N 3G0

MIX DESIGN SUBMITTAL

DATE:

MIX NUMBER : CP355
DESCRIPTION : 35MPA (-2)
SLUMP: 80 ± 30
CEMENT - 310
FLYASH - 80
WATER - 156
AIR - 5-8%
LL974 - STD. DOSE

W/C .40
FLYASH 20.5%
SAND 41.8%
PLASTIC DENSITY 2249 Kg
YIELD 1.013

SOURCE	SAND	10MM	20MM
COAST	720	410	590