Cedar Corners
High Volume Fly Ash Concrete Implementation
Summary Report

Prepared for:

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1.0 INTRODUCTION

Cedar Corners development in Tofino, B.C. is a unique project in which construction was based on sustainable principles. The project consists of a three level structure to be utilized for mixed commercial space, including a pub and restaurant. The entire structure is being built from recycled building materials and high volume fly ash (HVFA) concrete was utilized for all of the concrete which included footings, basement walls, grade and suspended slabs.

The concrete supplier, Pacific Ready Mix, and the concrete placer, Versteeg Construction, were inexperienced in the use of HVFA concrete. However, the Owner, Cedar Corners Development, and their sustainability consultant, Guy Dauncey, were committed to the use of this concrete. It was therefore the objective of this program to assist in implementing the technology at Cedar Corners.

Work was carried out in accordance with the Levelton proposal of March 4, 2003. It was based on direction and discussions with EcoSmart who sponsored the portion of the program described here.

This report summarizes the implementation program. It focuses on the project's critical concrete placement of the basement grade slab.

Photograph 1 is a general view of the project.

2.0 CONCRETE REQUIREMENTS

Concrete was specified to be 25 MPa for structural purposes. It was also to be air-entrained.

Cedar Corners indicated that the grade slabs were to be eventually used for a brewery and, as such, would have service conditions of:

- organic acids;
- copious amounts of wash water.

It was decided to require 30 MPa concrete, capable of receiving a steel-troweled surface, for this purpose.

3.0 OUTLINE OF PROGRAM AND BACKGROUND INFORMATION

At the time of EcoSmart's involvement, the majority of the wall and footing concrete had been placed – see Photograph 2. The concrete supplier had been instructed to use higher volumes of fly ash in the concrete and, on the advice of a supplier, had adjusted his mix to:

- original design commonly used for 25 MPa concrete – 480 pcy* cement (280 kg/m³);
- adjusted to 360 pcy cements + 240 pcy fly ash (210 + 140 kg/m³).

* *Pacific operates in Imperial units.*

The total cementing materials factor was therefore increased from 480 to 600 pcy (355 kg/m³).

Compressive strength test cylinders had been cast for the previous placements. Results were variable, possibly due to non-standard casting and curing, but generally low strengths were obtained, certainly much less than would be expected for the 600 pcy (355 kg/m³) cementing materials factor.

Levelton's scope was:

1) Obtain and test aggregates from your concrete supplier – see report of March 7, 2003.

2) Review cylinder strengths from previous pours.

3) Provide orientation for all parties by a trip to Tofino and meeting with the stakeholders - developer, contractor, engineer, supplier. Levelton made a presentation on behalf of EcoSmart and addressed project specifics. This was conducted March 10, 2003.

4) Assemble background information for the concrete previously placed so that an overall $C0_2$ reduction could be calculated.

5) Determine supplier restraints in production of HVFA concrete.

6) Review the concrete mix design. Recommend adjustments as appropriate.

7) Attend the pour of the basement grade slab on May 6, 2003. Assist the supplier in adjusting the mix. Cast test cylinders. Document mix parameters. Take photographs.

8) Prepare a job-end report summarizing the results.

4.0 MIXTURE PROPORTIONS

Levelton initially adjusted the Pacific aggregate blend – see results in the Appendix.

The mixture proportions were then prepared as shown in the report in the Appendix. Pacific's cementing materials content was retained because the test data indicated that a reduction was not warranted.

During the site orientation meeting, Versteeg expressed concerns about delayed finishing of the mixture, given that placement was to be in cool weather and Pacific did not have heated mixing water.

Enquiries by Levelton of the admixture supplier indicated that Pozzolith 122 HE would provide set acceleration of HVFA concrete. Adjustments to the mixture proportion was made to include 122 HE – see Appendix. At Levelton's suggestion the adjusted concrete was used for project footing placement and adequate setting time was reported.

5.0 CONCRETE PROPERTIES

5.1 Test Program

Levelton was on site May 6, 2003 for the basement slab pour to test the concrete and to evaluate the performance of the HVFAS mixture.

Testing carried out was as follows:

- plastic concrete properties – CSA A23.2;
- setting time – ASTM C403;
- compressive Strength – CSA A23.2 on 100 mm x 200 mm cylinders.

5.2 Mixture Proportions

Material	Mix Proportions / yd^3	
	Specified Weights	**Batch Target Weights**
Cement	360 lb	360 lb
Flyash	240 lb	240 lb
Coarse Aggregate, 20mm	1,600 lb	1,600 lb
Coarse sand	1,430 lb	1,560 lb (wet weight)
Fine sand	155 lb	160 lb (wet weight)
Water		Estimated *
Water/Cementitious Materials		0.50 estimated
Air entraining agent	as required	18 ounces
High Range water reducer	0.92 litres	1.25 litres

* Actual water contents could not be determined at this plant.

Note: Due to an oversight, the 122 HE accelerator was not added.

5.3 Specified Properties

Slump	100 mm +/- 20 mm.
Air content	3 to 4%.
28 day compressive strength	30 MPa.

5.4 Concrete Volumes at Cedar Corners

The concrete volumes for the project are as follows:

- Poured to date: 181 yd^3.

Poured to date quantity includes:

- Walls and footings: 136 yd^3.
- Basement slab: 27 yd^3.
- Other: 18 yd^3.

Remaining to be poured (as of May 6, 2003):

- Suspended slabs Level 1 and Level 2: 14yd^3.

6.0 CONCRETE PLACEMENT

Attached Photographs show concrete placement details.

The concrete for the floor slab was placed via a wheelbarrow. A chute was constructed to allow the concrete to travel from the mixer truck to the basement level – see Photograph 4. The mix performed rather well and showed no signs of segregation during placement. However, excess bleed water was visible on the surface of the slab after it was initially floated see - Photograph 5.

The placing crew, who had no experience with HVFA concrete, had no major complaints or problems placing and finishing the mixture. The only issue they raised was the delay in set time of the concrete. Traditional finishing techniques were utilized - see Photographs 6 and 7.

7.0 TEST RESULTS

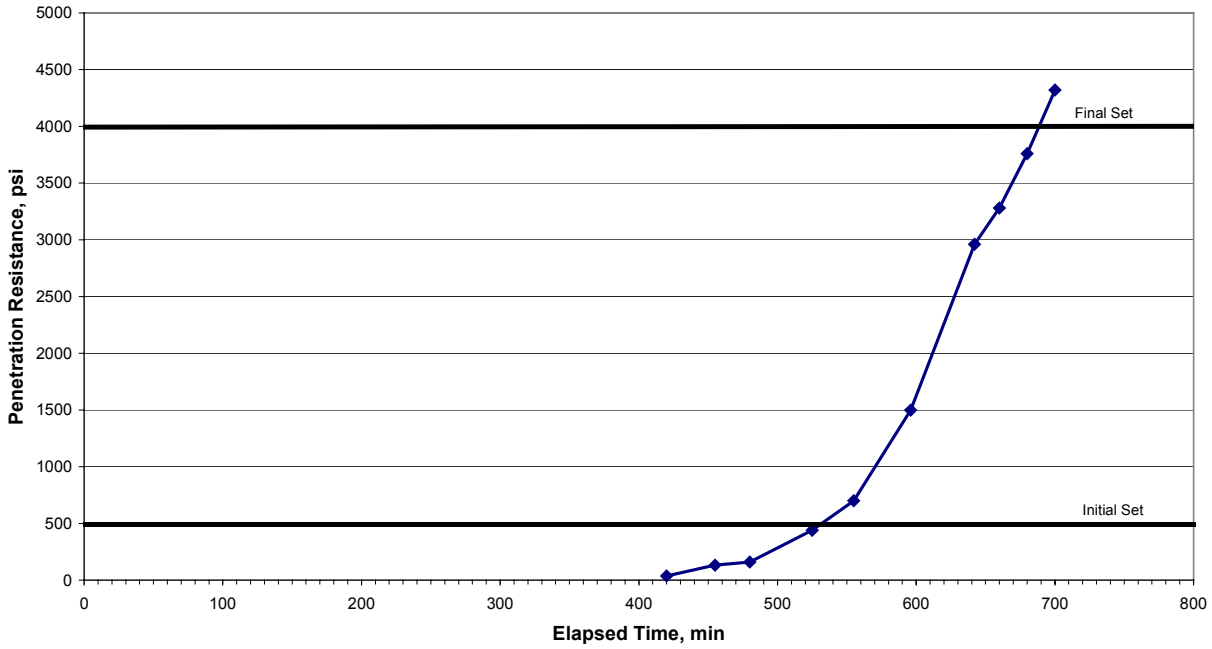
7.1 Plastic Properties

Slump:	160 mm
Air content:	2.8 %
Concrete Temperature:	16 ^{0}C
Ambient Temperature:	12 ^{0}C

7.2 Time of Set

Refer to Figure 1. The set of the concrete was delayed, with respect to a conventional concrete containing 0% fly ash. Initial set occurred at 8-½ hours and final set at 11-½ hours.

1. FIGURE 1: TIME OF SET



7.3 Compressive Strength

Refer to Figure 2.

Figure 2: Compressive Strength vs. Age

8.0 DISCUSSION

The placement of the HVFA concrete went well, given that the parties involved had no previous experience with such concrete. There were however a few problems during the pour. The major problem being the uniformity of the concrete slump which ranged from 120 to 160 mm. However, it should be noted that if the producer had more experience with this type of concrete, and the admixtures used, this may not have occurred. The other notable problem during the day was the excessive bleed water.

The excess bleed water was a surprise given that HVFA concrete, properly proportioned, does not bleed. It is noted that the net mixing water was in the order of 274 pcy (164 kg/m^3) which is higher than the common 155 ℓ/m^3 for normal concrete and excessive for HVFA concrete which typically has significantly less water, perhaps in the 135 ℓ/m^3 range. This may have accounted for the bleeding. The Pacific batch plant does not have an accurate water control system.

As indicated in 5.2, the accelerator was not used. This would account for the slower set in Fig. 1 and the bleeding.

The total amount of fly ash used at Cedar Corners is in the order of 30,000 kg. All of this was added by bag, no small feat. The net saving of cement, and therefore GHG, was in the order of 20,000 kg. Note that Pacific did not directly replace cement with fly ash as is commonly done, but chose to increase the total cementing materials content in the interests of assuring the strength. It is possible that the original proposed 480 pcy cement would not have been sufficient for the strength increase from 25 to 30 MPa that was implemented by Levelton in the interests of providing service life in the brewery floor surface.

The 28 day strength achieved was in the order of 37 MPa. This readily met the design criteria but would be low for a W/CM of 0.46 which suggests that the actual W/CM may have been higher. The Figure 2 strength plot shows the linearity expected with HVFA concrete when the semi-log scale is used. The 20 MPa 2 day strength would be more than adequate for form stripping or backfilling.

The program of pre-work orientation used here was a good investment and should be considered mandatory for future similar projects. The commitment of the Owner and his Consultants, and the co-operation of the supplier and contractor, contributed to the success of the program. The positive and constructive attitude of the parties was refreshing.

9.0 CONCLUSIONS

This program showed that sustainable HVFA concrete technology can be applied to projects of small size in smaller locations and that such techniques can be implemented with success in circumstances where the supplier and placement crew have little or even no experience providing that all parties cooperate in the process.

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Photograph 1: General view of site looking east to Inlet. Note namesake cedar tree.

Photograph 2: Wall finish is high quality.

Photograph 3: Delivery of concrete by Pacific Ready Mix.

Photograph 4: Concrete placement chute.

Photograph 5: Excess bleed water visible on the floated concrete surface.

Photograph 6: Typical hand finishing technique utilized.

Photograph 7: Typical power-trowel technique utilized.

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APPENDIX

March 14, 2003
File: 2803-0193

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Attention: Mr. James Rodgers, Project Manager

PROJECT: Cedar Corners, Tofino

SUBJECT: Proposed Mix Design for Grade Slab Concrete

James:

Further to our discussions with the Contractor and Supplier March 10, 2003, following is a proposed mix design that will address these aspects:

- low coarse aggregate content in previous Pacific Rim design;
- trowel/finishability;
- setting time.

I have also discussed admixture selection with Master Builders and have incorporated their suggestions. Incidentally, their Island representative, Bill Wild, would like to attend the pour and Pacific Rim should advise him of the schedule.

Properties

56 day compressive strength	-	*30 MPa
Air	-	3 to 4%
Slump	-	100 mm +/- 20

* For improved abrasion resistance (only 25 MPa required for structural strength).

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Proportions

Material	1 m³ - Metric	1 cy - Imperial
Cement	212 kg	360 lb
Fly ash	142 kg	240 lb
20 mm Coarse Aggregate	945 kg	1,600 lb
Coarse sand	845 kg	1,430 lb
Fine sand	90 kg	155 lb
Air entraining agent	As required	
Accelerator - 122 HR	1.5 ℓ	1.15 ℓ
High range water reducer	1.2 ℓ	0.92 ℓ

We have included an accelerator to try to address the Contractor's concerns. There is no history of use of 122 HE with the fly ash volumes here but we see no negative aspects.

We strongly recommend that this mix be tried in the footings. The Contractor could assess setting time and workability.

Please keep up posted on the slab schedule. We need some notice to mobilize our Technician.

Please also advise if you require anything further at this time.

LEVELTON ENGINEERING LTD.

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John Bradford -

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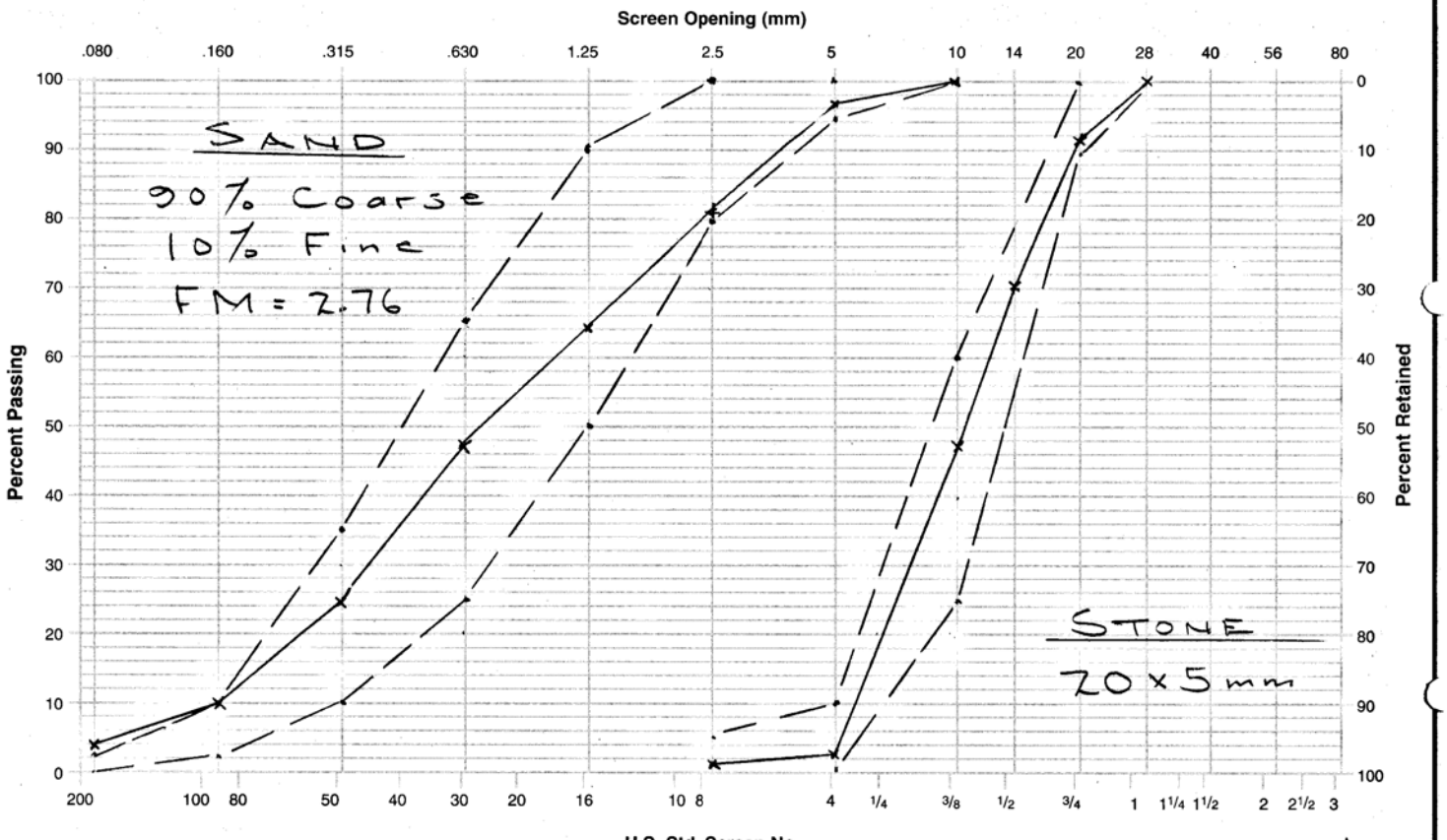
AGGREGATE GRADATION CHART



Project: Cedar Corners
Date Sampled: Feb./03
File No.: 2303-0193
Specification: CSA A23.1

Material: Concrete Aggregate
Sample No.: by Pacific R/M

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Fig. 1

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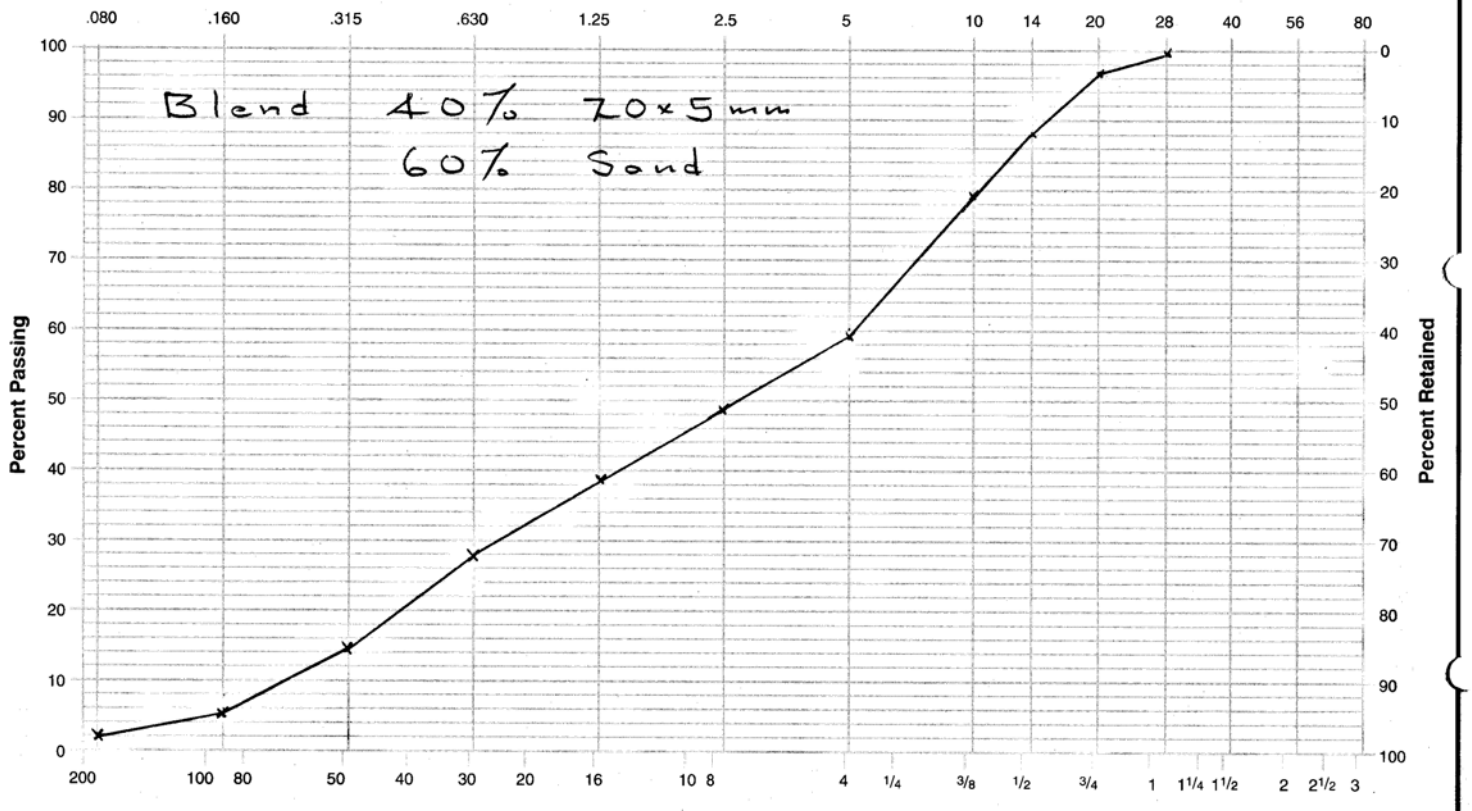
AGGREGATE GRADATION CHART



Project: Cedar Corners

Date Sampled: Feb./03

File No.: 7-803-0193

Specification:

Material: Concrete Aggregate

Sample No.: Combined

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Fig. 2

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