EcoSmart™ Concrete Project

A Concrete Contribution to the Environment™

Cedar Corner, Tofino, BC

A Case Study: The Use of EcoSmart™ Concrete In a Small Commercial Construction

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Table of Contents

List of Tables

1.0 EXECUTIVE SUMMARY

Cedar Corner is an 846 square metre restaurant and brewpub that was built in Tofino, on the west coast of Vancouver Island, during 2003.

At the project outset, the decision was made by the owner, Tofino Community Investments, that Cedar Corner should incorporate many green building aspects, and become a showcase for green design.

This decision led to the building being constructed almost entirely from reclaimed timber; the use of water and energy efficient fixtures and designs; the use of non-toxic building materials; and various other features.

The decision to use fly ash as a substitute for some of the cement in the building's concrete foundations, basement walls, and slab floors was supported by everyone on the team, as a way to reduce the building's ecological footprint, and the emissions of CO_2 associated with the use of cement. Discussions were held with EcoSmart™, and a goal of a 50% fly ash substitution was chosen for the project.

When the time came for the first of seven concrete pours, the local concrete supplier in Ucluelet had concerns about the use of 50% fly ash, and decided to increase the amount of cementing material in the concrete mixture, and reducing the fly ash replacement to 40%.

The building contractor and his crew had concerns about the use of fly ash, and as a result of discussions with EcoSmart, a seminar was held in Tofino during which the construction crew and the local concrete supplier received a very helpful briefing about the use of EcoSmart concrete, and were given reassurance about its characteristics. From this time onwards, the remaining pours proceeded with no concerns, and with much satisfaction as to the quality of the results.

The chief lessons obtained from the project's use of EcoSmart concrete relate to the need for clear communication between all the players involved – the owner, the project consultants, the building contractor and his team, the construction manager, the concrete supplier, and EcoSmart. A series of recommendations have been developed to assist EcoSmart in its future projects.

2.0 PROJECT DESCRIPTION

2.1 Project Overview

Cedar Corner is a new, 846 m^2 commercial building in Tofino, in Clayoquot Sound, on the west coast of Vancouver Island. Ucluelet, its sister community to the south-east and location of the concrete supplier for this project, is 40 kilometres down the coast.

Construction began in February 2003, and on completion in December 2003, the building will be occupied by The Wild Fish Restaurant, Tofino Brew Pub, and Salals Organic Grocery. The building consists of a full basement and two floors, with a second floor overhang that provides two small apartments for staff working at the restaurant and grocery store.

At the very beginning, the owner, Tofino Community Investments, stated that it wanted to create a building that would exemplify green building techniques, and create a green legacy for the community of Tofino. With this in mind, Cedar Corner was registered with the green building certification program known as LEED™ (Leadership in Energy and Environmental Design), which is operated by the US Green Building Council. LEED™ offers a total of 69 credits that a building can score for a wide variety of green features, ranging from site protection to energy efficiency and the use of recycled material. At the time of writing, the process of certification has not been completed.

There is not a specific LEED credit for the use of fly ash, but an 'innovation credit' can be achieved if it can be shown that the use of cement on a project has been reduced by 40% due to substitution with fly ash, compared to a standard baseline mix.

From the outside, the building looks like a typical well-designed timber-frame structure. When examined closer, however, its green features become apparent:

- Almost 100% of the timber has been obtained from older, deconstructed buildings, including the old cannery at Alert Bay (1881), the old Naval Officers Mess in Esquimalt, and the old Colwood Secondary School. The remainder comes from Issaak Forest Resources, a First Nations led forest services company operating in Clayoquot Sound, whose timber has been certified by the Forest Stewardship Council.
- Some of Tofino's rainfall (3.6 metres a year) is stored in rainwater harvesting tanks, for use in ultra-efficient dual-flush Caroma toilets. The urinals are waterless, and the washroom taps have sensors to make them more efficient. There are hot water heat recovery units on the apartment showers, and on the restaurant dishwasher. The building has been pre-plumbed for solar hot water, in case the heat recovery units do not provide enough hot water.
- The building strives to be as energy efficient as possible. It has higher levels of insulation, double-glazed argon-filled windows with super-spacers, heat pumps, heat recovery ventilators, efficient lighting, lighting occupancy sensors, and a MELINK sensor on the kitchen range-hood, which reduces the energy demand of the range-hood fan by 50%.
- All of the paints, caulkings and adhesives are low in volatile organic compounds (VOC), to reduce adverse health risks. The use of polyvinylchloride (PVC) has been reduced by 90%, and the building has been wired to minimize the risk from electromagnetic fields.
- Two cedar trees that stand right next to the building have been preserved, and the landscape will be planted with native species that need no irrigation.
- All the concrete in the building is EcoSmart concrete.

2.1 Project Team

Owner	Tofino Community Investments Ltd.
Project Manager	James Rogers, Tofino Community Investments Ltd.
Architect	Martin Golder, Martin Golder Architect
Environmental Consultant	Guy Dauncey, Sustainable Communities Consultancy
Structural Engineer	Andrew Rushforth, Stantec Ltd.
Materials Engineer	Levelton Engineering Ltd.
Concrete Supplier	Bill & Dave Ennis, Pacific Ready-Mix Co. Ltd
Construction Manager	John Bradford, John Bradford Construction
Contractor	John Versteeg, John Versteeg Construction

2.2 Project Details

Location	Tofino, BC
Concrete Construction	January to August 2003
Completion Date	December 2003
Building Area	846 m^2
Size of Structure	2 storeys, with full basement and second floor overhang

3.0 USE OF ECOSMART CONCRETE

3.1 Goals

When the building's environmental consultant learned about EcoSmart concrete – that is, the use of fly ash to replace some of the Portland cement in concrete for the purpose of reducing the CO_2 signature of concrete – he made contact with the EcoSmart Project team in Vancouver, and set the wheels in motion to replace 50% of the cement in the building with fly ash.

The main reason for wanting to use EcoSmart concrete in this building was to reduce the greenhouse gas associated with the use of concrete in the project. By substituting fly ash for 50% of the cement, these problems are reduced by half. In this case study, the generally accepted figure that 1 tonne of cement produces 1 tonne of CO_2 is used, which comes from a combination of the energy needed to make the cement, and the calcination of the limestone.

The project manager and the architect supported the idea, as did the structural engineer and the concrete supplier, in spite of the fact that he had not used high volumes of fly ash in concrete before. Technical support and quality control testing was provided by Ocean Concrete (a concrete supplier more experienced with EcoSmart concrete), and by the materials engineer.

The concrete was poured on seven occasions – see Table 1 (information provided by Pacific Ready-Mix Co. Ltd.).

Table 1: Cedar Corner Concrete Pours

Date	Description	% Fly Ash Replace-ment	Cubic yards	Cubic metres	Temperature @ 3pm	Specified Strength (MPa)
Jan 29	Footings	40%	32	24.5	7.0°C	25
Feb 10	Walls	40%	48	36.7	6.5°C	25
Feb 25	Walls	40%	40	30.6	6.5°C	25
May 6	Basement slab	40%	34.5	26.4	13.5°C	30
May 30	Suspended slab level 1	40%	6.5	5	15.0°C	30
June 6	Suspended slab level 2	40%	6.5	5	30.7°C	30
Aug 22	Kitchen floor slab	40%	6.5	5	18.0°C	30
	Total		174	133		

3.2 Mix Design

Tofino is in a high-risk earthquake zone, and with public assembly planned for the brewpub on the second floor, the strength of the concrete foundations was important. The intention for the project was a 50% fly ash concrete mixture with a specified strength of 25 MPa at 28 days and 285 kg of cementing materials per cubic metre of concrete (142 kg/m^3 Portland cement and 142 kg/m^3 fly ash).

On the advice of another concrete supplier more experienced with EcoSmart concrete mixtures, the mix was adjusted by increasing the amounts of cementing materials to 214 kg/m^3 cement and 142 kg/m^3 fly ash to ensure that it was strong enough, creating a 40% fly ash blend, and ultimately, creating a higher strength concrete mixture than was required by the original project specifications. This combination of cement and fly ash was used in all the concrete in the building.

The local concrete supplier's main concern was that he had not used high volume fly ash before, and he did not know how it would react with the different additives that he normally used; he needed more design mix information. The contractor was nervous, and the concrete supplier could not find anyone on the team who was willing to sign off on the perceived risk, which may have totaled in the order of $10,000 for the cost of a take-down if the product did not work properly. These problems could have been avoided if EcoSmart had been formally engaged at an earlier stage of the project, since the testing of trial mix designs would have identified any potential compatibility issues with the additives, and provided quality control data for the required strengths.

3.3 The First Pour

The concrete pour for the footings and the walls took place using high volume fly ash concrete but without EcoSmart's involvement, and without any orientation for the building crew. The contractor had worked with concrete for 50 years, and when his crew found an unusual amount of small air pockets in the concrete, and that it took longer than normal to set, they expressed some concerns.

3.4 Educating the Team

The construction manager immediately called the project's environmental consultant in Victoria, who emailed over two or three case studies from the EcoSmart website, which the construction manager was able to show to the contractor.

The environmental consultant also called EcoSmart in Vancouver, asking for help. EcoSmart agreed to accept Cedar Corner as a case study, and to arrange for a lunchtime seminar for the entire building crew to be held in Tofino.

At this time, it became apparent that a much more thorough job should have been done by the environmental consultant to involve all of the players in the decision to use EcoSmart concrete, and to inform them about the differences in the mix design, the construction methods, and performance of concrete that the use of high volumes of fly ash entails. The project's environmental consultant was also not clear what was involved in initiating an EcoSmart case study.

On March 10th 2003, the materials engineer, experienced with EcoSmart concrete, presented a lunch seminar on the use of fly ash in concrete to the whole building crew at the Long Beach Resort. This gave the crew members a chance to voice their concerns, namely, that the fly ash concrete would take longer to set, given that the placement was to be in cool weather, and that the local concrete supplier did not have heated mixing water. The seminar was a valuable process, and was instrumental in the subsequent success of the project.

3.5 Findings

When the rain finally stopped on May 6th, the construction manager arranged for the materials engineer to assist on site with the pour of the basement slab. It was decided to increase the concrete strength requirement to 30 MPa, resulting in a concrete capable of receiving a steel-troweled finish, since the slab on grade would eventually be used for a brewery, which would require frequent washing. In response to concerns about the slow setting time, the materials engineer considered the addition of Pozzolith 122HE (i.e., a water reducing admixture and accelerator) to the concrete mix. This was not implemented by the concrete supplier, and with the rising ambient air temperatures during subsequent pours, there was increasingly less need for it.

Everything went very smoothly, and the placing crew, who had no previous experience with the use of high volume fly ash in concrete, had no major complaints or problems in placing or finishing the mixture. The mix performed well, and showed no signs of segregation during placement. The only issue that the crew raised was the delay in the initial set time of the concrete, which took 8.5 hours – approximately 3 hours longer than was expected for an equivalent strength 100% Portland cement concrete (Levelton Engineering, 2003, and Personal Communication, Phil Seabrook, Levelton Engineering).

The main problem encountered with the concrete mixture was related to the uniformity of the concrete slump, which ranged from 120 to 160 mm, compared to the specified slump of 100mm +/- 20mm. This probably arose from an excessive use of water when the concrete supplier was

adding fly ash from bags directly into the back of the concrete truck. This method of mixing in the fly ash likely resulted in an initial drying out of the mixture as the dry fly ash powder came in contact with the wet concrete.

There was also a related problem with excessive bleed water, due to the same higher volume of mixing water, which was in the order of 164 litres per cubic meter (L/m^3), compared to 155 L/m^3 for normal concrete and the typical 135 L/m^3 for high volume fly ash concrete (Levelton Engineering, 2003).

3.5.1 Concrete Properties

The EcoSmart concrete for the basement slab pour reached its initial set at 8.5 hours, and its final set at 11.5 hours. Its compressive strength was 20 MPa after 2 days, 28 MPa after 7 days, and 37 MPa after 28 days (Levelton Engineering, 2003). The specified strength for the main basement slab pour was 30 MPa after 56 days, which was achieved and already surpassed at 28 days. 56 day testing for the other pours was not required.

Table 2 presents the concrete mix proportions used for the slabs. The concrete used for the footings and walls had slightly different mix proportions, except for the cementing materials amounts, which were the same.

Table 2: Batch Target Weights

Material	Kg per cubic meter (Metric)	Pounds per cubic yard (Imperial)
Cement	214 kg	360 lbs
Fly ash	142 kg	240 lbs
Coarse aggregate, 20mm	949 kg	1600 lbs
Coarse sand	925 kg	1560 lbs
Fine sand	95 kg	160 lbs
Water	Could not be determined	Could not be determined
Water-to-Cementing Materials ratio	0.50 estimated	0.50 estimated
Air-entraining agent	0.7 L	18 oz
High range water reducer	1.64 L	2.20 pints

(Levelton Engineering, 2003)

3.5.2 Costs

In normal circumstances, there is no additional cost for the use of fly ash as a partial cement substitute. However, on this project, the cost of the fly ash mix was higher than a comparable 100% Portland cement mix by approximately $\$20/m^3$. The reasons for the concrete supplier to charge this premium include:

- they had to deal with special delivery costs to Ucluelet;
- they had no silo and had to handle the fly ash by the bag;
- they had to use their own crane and bucket to put the fly ash into the mix; and
- they had to deal with the pallets left over after the fly ash delivery.

6.0 CONCLUSIONS AND RECOMMENDATIONS

On technical grounds, the high volume fly ash concrete mix has worked very well on the Cedar Corner project. It has given a superior product that is more durable and polishes to a much finer finish than regular concrete. It has also achieved the environmental objectives of the project, in helping to reduce the global ecological footprint of building, while utilizing an unwanted waste product. The project team is very grateful that EcoSmart was able to help introduce a new technology to the Tofino/Ucluelet area, and to familiarize the local concrete industry with the use of high volume fly ash concrete.

Since breaking ground on Cedar Corner, another project in Tofino has been completed with a 10% fly ash mix, and it is hoped that future projects will strive for the 50% fly ash mix that was the target for this project.

The financial surcharge for the use of the fly ash was not anticipated, and relates to the fact that Cedar Corner was the first project in Tofino to use the product. As more projects begin to use fly ash, the local concrete suppler will hopefully acquire their own equipment to handle the shipping, storage and delivery of the fly ash, so that there is no increased cost.

The problems that arose on the project were related to communication, not technical performance, and include the following:

- the process of establishing a partnership with EcoSmart and proposing a project as a case study for EcoSmart was not clearly understood;
- the need to provide detailed information to each of the key players on the team with information about high volume fly ash concrete's constructability characteristics was not clearly understood; and
- there was not a clearly laid out assembly of information about EcoSmart, which could have reassured the concrete supplier and the contractor about the characteristics of high volume fly ash concrete.

None of these problems need be generic; indeed, they may only rarely arise. The solutions are very simple, however, and it is believed that if implemented, the following recommendations will safeguard future EcoSmart projects against similar problems.

Recommendation #1: It might be helpful if EcoSmart produced a checklist, which could be downloaded and used by the relevant person on the project team, to ensure that everyone was on board.

Recommendation #2: It might be helpful if EcoSmart published a progress chart, describing the sequence of steps involved in initiating an EcoSmart case study.

Recommendation #3: It might be helpful if EcoSmart were to take the material on the characteristics of high volume fly ash cement that is on its website, and present it as a PDF document that could be printed and handed to the project team.

7.0 REFERENCES

Levelton Engineering Ltd. July 3, 2003. "Cedar Corners – High Volume Fly Ash Concrete Implementation – Summary Report".

Personal Communication, Phil Seabrook, P.Eng., Levelton Engineering Ltd., October 17, 2003.