Utilization of Recycled Glass in Non-Structural Concrete

Study of Recycled Glass Utilization in Concrete
AMEC, Earth and Environmental Ltd.
St. John's, Newfoundland

Senior Civil Design Project
ENGR 8700

Instructor:
Dr. Steve Bruneau

Client: AMEC
Kevin Penney
Tara Allison

Student Group: Alpha Engineering
Jason Finlay
James Dawe
Leah Hodder
Carmichael Polonio

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Mount Pearl, NL
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Kevin Penney and Tara Allison
AMEC Earth and Environmental Ltd.
36 Pippy Place
P. O. Box 13216
St. John's NL
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February 2, 2011

CC: Dr. Steve Bruneau

Dear Mr. Penney and Ms. Allison:

Alpha Engineering is currently conducting a study on the utilization of recycled glass as a replacement additive in concrete mixtures, as requested by the Earth and Environmental Division of AMEC. Please find enclosed the Project Plan for this study.

The Project Plan describes the activities that will be undertaken to complete the study. In addition, a schedule of these activities is also included. This plan provides a comprehensive list of the required tasks, with their deadlines, to be completed to ensure the successful completion of the study.

If you have any questions regarding the content of the enclosed plan, please feel free to contact Alpha Engineering.

Thank you,

Leah Hodder
On behalf of Alpha Engineering

Contents

1.0 Project Description

A study was requested by the Earth and Environmental Division of AMEC to determine the feasibility of utilizing recycled glass as an additive to concrete. The primary purpose of this study is to investigate the effect of powered glass as a partial replacement to Portland cement in concrete mixtures. The secondary purpose is to study the effect of oversized glass particles as a partial replacement of fine aggregate.

To conduct this study, concrete mixes containing 0.01 mm glass particles, and mixes containing 0.01 mm to 9.5 mm glass particles will be tested and compared against a standard concrete mix with no glass. Tests will allow Alpha Engineering to analyze the results of supplementing varying amounts of powdered glass for Portland cement and fine grained glass for fine aggregate into concrete mixtures. Concrete characteristics of interest include compressive strength, alkali aggregate reactivity (AAR), ductility, and setting time. In addition to determining the effects of supplementing glass into concrete mixtures, recommendations for alternative uses for recycled glass will be outlined in the final report.

Image 1 - Testing Compressive Strength

As previous research has been conducted in this field, this study aims to build on that research and expand upon it so that issues specific to the Newfoundland environment can be investigated.

2.0 Statement of Project Requirements

This study is composed of several major components that include research, testing, analysis, and providing recommendations. These components can be further broken down as follows.

Research:

- Previously conducted research of glass as an additive in concrete, conducted by person(s) of credit.
- Existing concrete mixtures designed for use in Newfoundland and Labrador
- Cost and environmental benefit of reducing fine aggregate and/or Portland cement in concrete mixtures
- Current disposal/usage of post consumer glass

Testing:

- 3, 7, 14, 28 day concrete compression testing by means of cast cylinders, as per CSA A23.1
- 14 day Alkali Aggregate/Silica Reactivity, as per CSA A 23.2-14A
- Flexural strength testing, as per CSA A23.2-09
- Setting time, as per ASTM C403/C403M

Analysis:

- Effects of glass additives on compression strength of concrete
- Effects of glass additives on Alkali Aggregate/Silica Reactivity
- Effects of glass additives on Flexural strength
- Effects of glass additives on Concrete Setting Time
- Energy usage for the production of glass aggregate
- Cost effectiveness of using glass additives

Recommendations:

- Resolution of glass additive issues
- Usage of post consumer glass
- Further research requirements

3.0 Methodology

3.1 Project Overview

This project requires both extensive research, as well as laboratory testing. First a detailed literature review will be conducted, so a hypothesis can be formed. The research will focus on previous studies in the field of glass replacement in concrete. This will include glass being used both as a cement powder replacement and as a fine aggregate replacement. Research will also include glass recycling and concrete testing standards.

Based upon research findings, a hypothesis will be generated, an optimum mix will be designed, and laboratory testing will be conducted, according to CSA Standards. Test batches will be created to test the hypothesis. Although aware of the highly variable nature of

concrete, because of time constraints, we will only be able to conduct a maximum of 2 trial batches with the longest curing time being 28 days.

A group website has been created for internal file-keeping and communication between group members.

Trial mixes for testing are detailed in Table 1:

Batch Concrete Name	Cement/ Glass Powder Replacement	Sand/ Glass Fine Aggregate Replacement
1	0%	0%
2	10%	0%
3	30%	0%
4	20%	0%
5	20%	25%
6	20%	50%

Table 1: Concrete Batch Mixes

3.2 Client Role

Bi-weekly meetings will occur between Alpha Engineering and the clients, AMEC. Testing will occur in the client's facilities, during and after working hours, as converging schedules allow. In addition, AMEC will also hold a supervisory role, providing guidance and clarification, as required.

AMEC's concrete lab on Pippy Place will be the location for the mixing and curing of the concrete specimens. The compression testing and flexural testing will be conducted at the Memorial University Concrete Laboratory. Setting testing and AAR testing will be conducted at the AMEC laboratory.

3.3 Feasibility Study

Another part of the project will include a conceptual cost benefit analysis of recycling glass as a concrete additive versus placing glass in the landfill. This will include finding quantities of glass available on the island and methods of manufacturing glass into glass powder and glass pellets. Consideration will also be given to energy needed to crush glass versus the energy needed to produce sand with current methods.

4.0 Tasks

Table 2 outlines the task and resource allocation for the completion of the study.

Task Name	Personnel	Duration	Resource
Research concrete mix	James Dawe	1 week	ACI, ASTM, CSA
Research cost estimate	Jason Finlay	2 weeks	MMSB, City of St. John's, powdered glass manufacturers
Research processing glass	Leah Hodder	1 week	ACI, powdered glass manufacturers
Design concrete mix	Carmichael Polonio	0.5 week	Alpha Engineering, AMEC
Test batching	James Dawe, Jason Finlay, Carmichael Polonio, Leah Hodder	1 week	Alpha Engineering, AMEC, CSA
Supplementary testing	James Dawe, Jason Finlay, Carmichael Polonio, Leah Hodder	1 month	Alpha Engineering, AMEC, CSA
Result analysis	James Dawe, Jason Finlay	1 week	Alpha Engineering
Report Writing	Carmichael Polonio, Leah Hodder	3 week	Alpha Engineering

5.0 Schedule

As the completion date for the study was set, it was important to determine the time available for each task. The tasks outlined in Section 4 were sub divided into smaller tasks to determine the duration of the overall task. Each task's duration was defined by CSA/ ASTM requirements or resource constraints. In addition to the duration, the expected start date was defined by availability of resources, materials and personnel.

The schedule was based on an end date constraint. To ensure that the project will be completed on time the scheduling of those tasks requiring the highest amount of resources was completed first. 28 days was allocated to the concrete mixing, curing, and specimen testing. Following the 28 day breaks enough time must be given to finalizing the analysis of the results and prior to project review and submittal. As the concrete testing must be completed within a specified period, this task is inflexible. Other tasks demanding a high level of resources include report writing and research; however, these tasks are able to be completed over the duration of the study. The full schedule can be seen in Figure 2.

As part of the project tracking, the project schedule will be reviewed during weekly project reviews. To ensure the project remains on schedule, the fixed tasks will be completed efficiently. Where delays are encountered, flexible tasks will have resources adjusted to ensure the completion of the fixed tasks. Alpha Engineering's task managers will be kept up to date on all delays to ensure that resources are increased to reduce the effects of delays.

ID	Task Name	Duration	Start	Finish	Predecessors
1	Match Night / Contract Award	0 days	Mon 17/01/11	Mon 17/01/11	
2					
3	**Litrature Review**	**35 days**	**Mon 17/01/11**	**Sun 20/02/11**	1
4	Previous Project Review	7 days	Mon 17/01/11	Sun 23/01/11	
5	Concrete Mix Study	7 days	Mon 31/01/11	Sun 06/02/11	20
6	Feasibility Study	14 days	Mon 07/02/11	Sun 20/02/11	5
7					
8					
9	**Concrete Trial Mixes**	**44 days**	**Thu 03/02/11**	**Fri 18/03/11**	
10	Crushing Recycled Glass	4 days	Thu 03/02/11	Sun 06/02/11	5SS+3 days
11	Batching Concrete Mixes & Setting	5 days	Mon 07/02/11	Fri 11/02/11	10
12	3 Day Testing	5 days	Thu 10/02/11	Mon 14/02/11	11SS+3 days
13	7 Day Testing	5 days	Mon 14/02/11	Fri 18/02/11	11SS+7 days
14	14 Day Testing & AAR Testing	5 days	Mon 21/02/11	Fri 25/02/11	11SS+14 days
15	28 Day Testing & Flexural Testing	5 days	Mon 07/03/11	Fri 11/03/11	11SS+28 days
16	Analysis of Results	7 days	Sat 12/03/11	Fri 18/03/11	15
17					
18					
19	**Report Writing**	**71 days**	**Mon 24/01/11**	**Tue 05/04/11**	
20	Project Plan	7 days	Mon 24/01/11	Sun 30/01/11	4
21	Final Report	21 days	Thu 10/03/11	Wed 30/03/11	
22	Editing and Review	4 days	Thu 31/03/11	Sun 03/04/11	21
23	Final Deliverable to Client and 870(	0 days	Mon 04/04/11	Mon 04/04/11	22
24	Final Presentation	0 days	Tue 05/04/11	Tue 05/04/11	23

Project: 8700 Final
Date: Tue 01/02/11

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Figure 1: Project Schedule

6.0 Project Costs

Costs that are directly associated with this project includes:

- Laboratory testing equipment and labor costs
- Concrete standards: ASTM and CSA
- Concrete mix materials: Aggregate, Portland cement, glass etc.
- Miscellaneous costs: printing costs, stationary, and other required project material

AMEC will be covering all concrete mix materials costs, as well as providing access to their laboratory. For convenience, some laboratory testing may also be completed at Memorial University of Newfoundland. Access to concrete standards will be provided by both AMEC and Memorial University. Miscellaneous costs will be met by Alpha Engineering.

7.0 Deliverables

7.1 Literature Review

As a requirement of the research component, an in depth literature review is required for the following reasons: -

- to understand previous studies
- to reduce the scope of testing
- to determine areas requiring further investigation

Further literature review will be conducted to establish: -

- typical constituents of concrete mixes,
- standards by which concrete construction are governed
- typical concrete problems specific to Newfoundland and Labrador

7.2 Laboratory Study

A detailed report regarding the specified mix designs, compressive strength results, flexural testing results, AAR test results, and setting time test results will be submitted for client review. Mix designs will include percentages of replacement additives and their corresponding strength results. An optimum mix design will be recommended based on the experimental results.

7.3 Feasibility Study

A Cost-Benefit analysis on the utilization of recycled glass as a concrete additive will be submitted to the client for review. Methods of collection, transportation, and processing will be reviewed to develop an estimated cost for manufacturing and utilizing glass additives in concrete production.

As a result of this study, it will be determined if using recycled glass as an additive in concrete mixtures is acceptable for general construction. To be deemed acceptable, the glass additive must be easily produced, have a negligible effect on concrete characteristics, and be economical to produce and utilize.

8.0 Risks

Every project has associated risks. Potential risks of concrete testing include, but are not limited to:-

- Laboratory accidents
- Poor quality batching
- Inconclusive results

To mitigate all these risks, CSA and ASTM procedures will be closely followed. Also, AMEC and Memorial Engineering laboratory rules will be followed.

Project risks, not associated with concrete quality, include but are not limited to:-

- Not having access to the lab
- Not being able to obtain glass material
- Not being able to sufficiently crush glass to standard required size
- Not being able to sufficiently sort glass to standard size

9.0 References

http://www.astm.org/Standards/cement-and-concrete-standards.html

http://www.csa.ca/cm/ca/en/standards/products/construction

http://www.concrete.org/general/home.asp

10.0 Appendix Statement of Qualifications

STATEMENT OF QUALIFICATIONS

Carmichael Polonio
James Dawe
Leah Hodder
Jason Finlay

alphaengineering2011@gmail.com

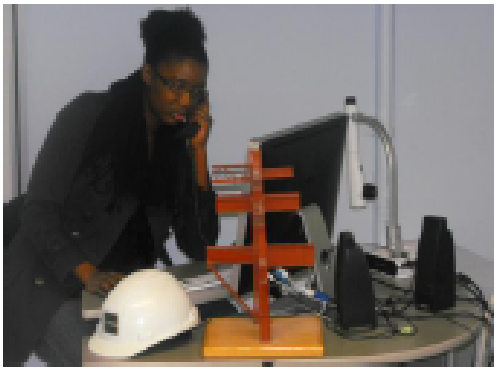
MISSION STATEMENT

Alpha Engineering, established in January 2011, is dedicated to providing clients with innovative solutions and reliable services. Alpha Engineering aims to achieve the highest quality work while ensuring projects remain within the scope and on schedule.

ALPHA ENGINEERING TEAM

At Alpha Engineering, our staff are dedicated to providing quality products and information to our clients while maintaining a safe working environment for all employees and clientele. We offer a broad range of experience in fields such as heavy civil construction, geotechnical engineering, health and safety, quality control, oil and gas, earthworks, project management, and procurement.

Carmichael Polonio
Project Manager



Carmichael Polonio is a senior civil engineering student at Memorial University. Her strengths include research, communication skills, and organizational skills. Carmichael has a strong interest in power utilities, construction, and project supervision. She believes that nothing is more important than completing a project safely.

Fields of experience include:

- Health and Safety program creation and maintenance
- Project supervision
- Power line design
- Earthworks and Construction

James Dawe
Project Engineer

James Dawe is currently a Senior Civil Engineering student at Memorial University. He has gained experience in heavy civil/ geotechnical construction, quality assurance, production analysis, project coordination and project management. James is confident working independently but is also a great addition to any team.
He has worked with a range of business managers, quality managers, senior engineers and construction superintendants.

Fields of experience include:

- Quality control of deep underground utilities
- Pipeline installation
- Heavy civil production analysis
- Quantity takeoffs and material procurement
- Cost-production analysis
- Structural construction

Leah Hodder
Research & Development

Leah Hodder is a senior engineering student at Memorial University. Leah has experience managing projects, developing technical reports, producing cost estimates and completing project drawings. Through her experience as a consultant she has become comfortable working with highly technical projects that involve a significant degree of client and contractor interaction.

Fields of experience include:

- Geotechnical analysis and design of diversion channels and embankments
- Subsurface borehole investigations and analysis
- Estimating, design, and management of municipal infrastructure projects
- Technical studies related to industrial and municipal wastewater systems

Jason Finlay
Scheduling and Estimating

Jason Finlay is a senior engineering student at Memorial University. Through his working experience, Jason has gained experience in client and contractor relations, quality control and quality assurance, focusing on both soil and concrete. Jason has also gained experience in cost control, project management and quality inspections.

Fields of experience include:

- Geotechnical monitoring of earth dam construction
- Soil and concrete materials testing on a variety of projects
- Quality control for industrial and marine projects
- Completion and review of turnover documentation
- Tracking of subcontractor and supplier costs