

# OHIO DEPARTMENT OF TRANSPORTATION

## OFFICE OF MATERIALS MANAGEMENT

### RESEARCH IMPLEMENTATION PLAN

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**Title:** Evaluation of Portland Cement Concretes Contained Ground Granulated Blast Furnace Slag

**State Job Number:** 14559

**PID Number:**

**Research Agency:** University of Akron

**Researcher(s):** Allen Shen

**Technical Liaison(s):** Lloyd Welker

**Research Manager:** Karen Pannell

**Sponsor(s):** William Lindenbaum

**Study Start Date:** 8/16/1993

**Study Completion Date:** 2/16/1999

**Study Duration:** 66 Months

**Study Cost:** \$364,450.00

**Study Funding Type:** 80 Federal / 20 State from ODOT SPR (2)

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#### **STATEMENT OF NEED:**

A two part laboratory experimental program was conducted to evaluate strength and durability of various concrete mix designs. In Part I of the study, the influence of using Grade 120 ground granulated blast furnace slag (GGBFS) on the strength and durability properties of concrete was evaluated. GGBFS was used to replace Portland cement at replacement rates ranging from 0 to 75 percent. In Part II of the study, the influence of coarse aggregate size on the strength and durability of the ODOT Class C mix designs was evaluated. Coarse aggregate sizes included #57, #46, and #357. The ODOT high performance concrete mix designs were also included in this study.

#### **RESEARCH OBJECTIVES:**

The primary objectives of Part I are to investigate the strength, durability, and workability of several concretes containing different percentages of ground granulated blast furnace slag (GGBFS) as a partial replacement for Portland cement. The research focuses on the use of Grade 120 GGBFS.

The primary objectives of Part II of the research project are to investigate the strength and durability of several concrete mixes based on the standard ODOT Class C concrete mix and incorporating various coarse aggregate sizes and various mix options allowed by ODOT specifications, to evaluate the strength and durability characteristics of several concrete mixes similar to the four high performance concrete (HPC) mixes of Proposal Note 350 but with lower cement factors, and to evaluate the strength and durability characteristics of the ODOT Silica Fume Concrete Overlay mix and variations of that mix with a reduced silica fume or with a reduced Portland cement and silica fume content.

#### **RESEARCH TASKS:**

Part I Research tasks:

1. To evaluate the strength, durability and workability of concretes with 15% of the Portland-GGBFS combination replaced with Class C fly ash and with Class F fly ash.
2. To evaluate the strength, durability and workability of standard ODOT Class S and Micro-Silica concrete.
3. To compare the properties of concretes containing GGBFS to those of ODOT Class S and Micro-Silica concretes.

4. To evaluate the length change due to drying for ODOT High Performance Concretes used in ODOT construction projects.
5. To evaluate the chloride permeability of ODOT High Performance Concretes used in ODOT construction projects.
6. To monitor the concrete temperatures during the first five days after placement where ODOT High Performance Concrete is being used.
7. To establish guidelines for the specification and use of concretes containing GGBFS as a partial replacement for Portland cement.
8. To identify and/or establish test procedures for the evaluation and acceptance of GGBFS and concretes containing GGBFS.
9. To evaluate the economics of using concretes containing GGBFS.

Part II Research tasks:

1. Evaluate the strength and durability of twelve laboratory-prepared concrete mixes.
2. Develop new mix designs that are similar to the four mixes of the ODOT High Performance Concrete (HPC) proposal Note, but with a reduced cementitious content.
3. Evaluate the strength and durability of the four laboratory prepared concrete mixes which are the ODOT Micro-Silica Concrete Overlay Mixes and variations of that mix with a reduced silica fume content or with a reduced Portland cement and silica fume content.

**RESEARCH DELIVERABLES:**

- The final report will describe all research activities, findings, and conclusions.

**RESEARCH RECOMMENDATIONS:**

Based on the test results, the addition of GGBFS at rates as high as 55 percent of the total cementitious material resulted in strengths that, after 14 days, equals or exceeded those of baseline concrete mix. The incorporation of GGBFS in concrete mix significantly improved the resistance to chloride ion penetration.

**PROJECT PANEL COMMENTS:**

No project panel was formed. Comments are being made based on 2005 status and a review of the final research as of Dec of 2005.

1. What the research provided supporting data for was current knowledge of GGBFS that has been developed in other avenues for 30 + years.
2. The research was limited to GGBFS Grade 120. The Grade rating is based on testing that 1 pound of a 50% GGBFS/50% type 1 cement will produce 120% of the strength that 1 pound of type 1 cement would. The researchers did not use Grade 100.
3. While the 55% recommendation has merit for strength only the freeze thaw and abrasion issues do not totally support the recommendation for 55%

ODOT currently has four different concrete mixes that allow the use of GGBFS (either grade 100 or 120). The allowable percentage of replacement is limited to approximately 30%. The ODOT mixes are HPC 2, HPC 4, and Class C and S option 3. No further increase will be recommended nor is it recommended on a national level.

**IMPLEMENTATION STEPS & TIME FRAME:**

It has already been implemented; see Table 499.04-4 Class HP Concrete and Table 499.04-3 Option 3 in the 2005 Construction and Materials Specifications. These mixes were part of supplemental specifications of 499 since 2000.

**EXPECTED BENEFITS:**

- Concrete that has high durability and resists chloride ion penetration; thus increasing concrete life span.
- Lower cost as a replacement for Type 1 cements

**EXPECTED RISKS, OBSTACLES, & STRATEGIES TO OVERCOME THEM:**

None

**OTHER ODOT OFFICES AFFECTED BY THE CHANGE:**

Construction, structures, pavement, production, and districts.

**PROGRESS REPORTING & TIME FRAME:**

None

**TECHNOLOGY TRANSFER METHODS TO BE USED:**

- The final report of this research will be available online at the ODOT website.
- The final report was also distributed to all other state departments of transportation in addition to national libraries and repositories.

**IMPLEMENTATION COST & SOURCE OF FUNDING:**

No funding needs are anticipated

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**Approved By:** (attached additional sheets if necessary)

**Office Administrator(s):**

Signature: Lloyd Welker Office: OMM Date: 12/5/2005

**Division Deputy Director(s):**

Signature: William Lindenbaum Division: DCM Date: 12/12/2005