UNIVERSITY of HOUSTON
Project Summary Report 7-4935-S
Project 7-4935: Use of Foundry Sands in Transportation Applications
Authors: Cumaraswamy Vipulanandan, Sungro Cho, and S. Wang

PROJECT SUMMARY REPORT

Applications For Foundry Sands: Flowable Fill And Cemented Sand

Foundry sand (FS) is a by-product of the metal casting industry. Only about 20 percent of the FS generated annually currently are recovered and used in beneficial applications; the rest are disposed in landfills. The sand in the foundry is re-used a number of times, until they are so altered that they must be discarded. There are three types of molding process: greensand, chemically bonded, and shell molded. The most commonly used process is the greensand. In the greensand process clay is typically added as binding agent. Several mid-western states such as Iowa, Indiana, Illinois, Michigan, Ohio and Wisconsin have investigated the use of FS in their transportation facilities. Research has shown that FS has the potential for use in highway construction and several other civil engineering applications. EPA's Final Rule in 40 CFR Part 247 (2000) is a comprehensive guideline for procurement of products containing recovered materials. The Final Rule includes the use of ferrous foundry sands in flowable fill. It must be noted that the EPA has removed any characterization of non-ferrous foundry sands as hazardous in the final Comprehensive Procurement Guideline (CPG).

Figure 1. Flowable Fill Field Study (Brownwood District)

In this study, an extensive literature review was undertaken to collect information on the potential FS applications, case studies on FS use, engineering and environmental properties of FS, relevant regulations and specifications. The information was synthesized to determine the two potential applications for FS in Texas. A survey was undertaken to determine the availability of FS in Texas. The study also included testing of number of FS available in the State of Texas to determine their engineering and environmental Properties and compare it to published data from other locations outside Texas. A detailed evaluation of flowable fill and cemented sand using the FS in Texas was performed by combining laboratory tests and field applications. Field tests on the flowable fill and cemented sand were done in the Brownwood District and Houston District respectively.

What We Did...

The primary objective of this project is to verify the availability and suitability of Texas-generated FS for TxDOT and to develop specifications for use of

these sands in TxDOT construction and maintenance applications. Based on the TxDOT needs, use of foundry sand in flowable fill and cemented sand was investigated in the laboratory and field. In order to achieve the objective, the following were done:

(1) conducted an extensive literature review to investigate and document potential uses for FS in various construction, maintenance and rehabilitation. The literature review was focused on collecting information such as (a) potential applications for FS in transportation facilities and methods of constructions; (b) experiences of other SDOTs, (c) availability of FS on a statewide basis, and (d) regulations and specifications on FS. Based on the information collected and the needs of TxDOT, identify applications for FS in Texas.

(2) performed limited laboratory tests to evaluate the properties of foundry sand avialble in Texas.

(3) demonstrated the performance of Texas generated foundry sand in flowable fill and cemented sand in the laboratory and field.

(4) developed specifications for FS applications with QA/QC plan for testing FS.

Based on the literature review, some of the most popular applications for foundry sand were in roadway sub-base, embankment, asphalt concrete and flowable fill. Also, a number of other applications have been identified where foundry sand has been used. Foundry sand was not used in cemented sand. Few state DOTs have specifications for using foundry sand in flowable fill mixes. EPA's Final Rule on comprehensive guidelines for procurement of products containing recovered materials recommends the use of ferrous foundry sand in flowable fills.

Foundry Sand In Texas

A survey was undertaken with the participation of the Texas Cast Metal Association (TCMA) and the survey sheet was mailed to all the members of the TCMA and other known foundries around the State of Texas. A total of 23 foundries responded to the survey. Analyzing the survey results showed that the foundries using only steel or iron (ferrous) in their production was 65% with 13% of the foundries using steel and other metals. Non-ferrous foundries accounted for 22% of the respondents. Green sand was produced by 30% of the ferrous foundries while the other 57% of the foundries produced both green and chemically bonded sands.

Over 93,000 tons of foundry sand is produced in Texas annually in 13 TxDOT Districts. Of this amount, over 60,000 tons (green sand and chemically stabilized sand) are available for use by TxDOT. Survey also indicated that ferrous foundries were producing over 42,000 tons of green sand annually. Currently over 3.3 million tons of foundry sand is available in stock piles mainly in the Dallas and Houston TxDOT Districts .

Testing And Specifications

In order to determine the quality of the foundry sand (FS) in Texas, it was necessary to determine the engineering and environmental properties of foundry sands available in Texas. Hence ten samples were collected from around the State of Texas for limited laboratory testing. A QA/QC plan was developed for foundry sand testing. It was also necessary to verify if the foundry sand selected for field testing met the TxDOT Specification DMS 1100 for "Non-hazardous Recyclable Materials (NRMs)". Hence, a testing program was undertaken to characterize the geotechnical properties of the foundry sands and determine its leaching characteristics using the EPA and TNRCC (presently

Figure 2. Cemented Sand Field Study (Houston District)

known as Texas Commission on Environmental Quality) testing methods. Another reason for the testing the Texas foundry sand was to show the amount of tests involved in qualifying the FS for use in TxDOT applications.

Material specification for foundry sand and a MSDS sheet have been developed. Based on the TxDOT needs and the properties of the foundry sands, its potential use in flowable fill and cemented sand was investigated. Design approaches for flowable fill and cemented sand mixes have been developed by varying the foundry sand-to-cement ratio and water-to-cement ratio. More than two hundred laboratory and field specimens were tested for a period of over one year. Relating the pulse velocity and cement content to the compressive strength of the cured materials developed property relationships for flowable fill and cemented sand. Laboratory and field test results indicate that the foundry sand can be used for the selected applications. TxDOT specifications on flowable fill (ITEM 4438-Flowable Backfill) and cemented sand (ITEM 400.6-Cement stabilized backfill for structures; ITEM 423.2- Backfill material for retaining wall) were modified to include the foundry sand.

What We Found...

Based on the literature review, some of the most popular applications for foundry sand are in roadway sub-base, embankment, asphalt concrete and flowable fill. Also, a number of other applications have been identified where foundry sand has been used. Foundry sand has not been used in cemented sand. Few state DOTs have specifications for using foundry sand in flowable fill mixes.

From the Texas foundry survey it was determined that over 93,000 tons of foundry sand is produced in Texas of which over 60,000 tons are available for TxDOT projects in 13 Districts. There are over 3.3 million tons of foundry sand in stock piles in Texas. A total of ten foundry sands were randomly collected from around the State of Texas for the laboratory study. The specific gravity of the Texas foundry sands varied from 2.4 to 2.68. The moisture content of the foundry sands varied from 0 to 5.5%. Particle size of all the Texas foundry sand tested was finer than that of ASTM C-33 sand. The pH of the FS varied from 7 to 10.2. Few foundry sands were tested using the EPA (including the TCLP) and TNRCC (presently known as TCEQ) leaching tests. The engineering and environmental properties of the Texas foundry sands were within the range of values reported in the literature.

The Researchers Recommend...

- Laboratory and field test results indicate that the foundry sand can be used in flowable fill and cemented sand applications. The testing was limited to one year and hence long-term properties must be determined for the flowable fill and cemented sand. Foundry sand selected for use should satisfy the DMS-11000 guidelines for Nonhazardous Recyclable Material (NRM).

Reference:

Vipulanandan, C., Cho, S. and Wang, S. "Use of Foundry Sands in Transportation Applications," Research Report 7-4935-1, Project Report for the Texas Department of Transportation (TxDOT), December 2005.

Vipulanandan, C. Weng Y. and Zhang, C. "Designing Flowable Grout Mixes Using Foundry Sand, Clay and Fly Ash," Proceedings, Advances in Grouting Technologies ASCE, GSP 104, Denver, CO, pp. 215-233.

For More Details...

This research is documented in Report 7-4935-1: Use of Foundry Sand in Transportation Applications. (URL: http://cigmat.uh.edu/cigmat%20Folder/research.htm)

Research Supervisor: Dr. Cumaraswamy Vipulanandan (Vipu) P.E., Chairman and Professor of Civil Engineering, Director of CIGMAT, Department of Civil and Environmental Engineering, University of Houston, Houston, Texas. cvipulanandan@uh.edu (713) 743-4278.

TxDOT Project Director: Walter Bryan Neaves, Brownwood District Office, bneaves@mail.gw.state.tx.us (254) 629-3845

TxDOT Research Engineer: German Carlos, Ph.D., P.E., Research and Technology Implementation Ofice, gcarlos@dot.state.tx.us, (512) 465-7403

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