SUMMARY

Schnabel Engineering (Schnabel) appreciates the opportunity to present our Innovative Reuse of Dredged Material project for consideration for the 2014 WEDA Environmental Excellence Award under the Environmental Dredging category.

Under the "Innovative Reuse of Dredged Material" program of the Maryland Port Administration (MPA), Schnabel completed a laboratory and field demonstration project for the use of dredged material (DM) from Baltimore Harbor, blended with steel slag fines (SSF) for potential use as fill in highway and other construction. The laboratory study demonstrated, for the first time, that blending DM and SSF provides immobilization of the metal contaminants in the DM, and also improves the workability and strength of the DM in order to be used as geotechnically competent fill.

Presently the only permitted use for Baltimore Harbor DM is disposal in the Cox Creek Dredged Material Containment Facility (DMCF) and the Masonville DMCF. The innovative use of DM for highway embankment construction will assist MPA in meeting its current goal of using 500,000 cubic yards of Cox Creek DM per year, and help extend the life of the Cox Creek DMCF.

PROJECT TEAM MEMBERS

The following are the key participants in the MPA project.

Schnabel Engineering, Inc. – Nominating Entity
Michael Roscoe, PE (WEDA member), Senior Vice President – (610) 696-6066
1380 Wilmington Pike, Suite 100, West Chester, PA 19382
mroscoe@schnabel-eng.com

Maryland Environmental Service (operates the site on behalf of the MPA) - Cox Creek Dredge Material Facility Operators and Suppliers of Dredge Material for the project
David Peters, Project Manager – (410) 729-8200
259 Najoles Road, Millersville, MD 21108
dpete@menv.com

Phoenix Services, LLC - Sparrows Point Slag Reclamation Operators and Suppliers of Slag
Terry Wagaman, Executive Vice President – (610) 347-0444
148 West State Street, Kennett Square, PA 19348
terry@phxslag.com

In addition to the above, the following consultants and contractors also played a role in this project:

Stevens Institute of Technology - geo-environmental laboratory
Fredericktowne Laboratories, Inc. - environmental laboratory services (WBE)
Wince Construction - mixing and placing of DM-SSF blends
McCall Trucking - slag fines hauler (WBE)
NAES LLC - field support services (MBE)
ConeTec, Inc. - penetrometer testing
CTL Group - materials testing

PROJECT DESCRIPTION

The MPA "Innovative Reuse of Dredged Material" program focuses on developing one or several large opportunities to recycle upwards of 500,000 cubic yards of DM per year by 2023. Under Maryland State law, DM from the Baltimore Harbor shipping lanes can only be placed in a confined disposal facility. At this time, the Cox Creek DMCF and the Masonville DMCF are the only options for Baltimore Harbor DM disposal. Recycling of DM from DMCFs on a large scale would extend the useable life of existing DMCFs, reduce costs, and preserve valuable waterfront land in the Baltimore Harbor. The MPA goal for recycling of DM requires a sustainable, high volume outlet for the DM. Possible end uses for DM include earth fill for coal mine or quarry closure, landfill daily cover and/or general, earth embankment applications in and around the greater Baltimore metropolitan area.

The soft, fine-grained compressible nature of DM makes it generally undesirable for earth fill applications other than compacted liner, barrier and caps/covers. However, when mixed with coarser materials like sands/gravels, the blended materials can be used for almost all earth fill needs. This is only possible if local inexpensive sources of coarse-grained materials are available close to the DM sources. Fortuitously, the Sparrows Point Steel Plant Complex is situated almost directly across the Patapsco River from the MPA's Cox Creek DMCF. The steel mill, now closed, has large stock piles of two types of slag, blast furnace slag fines (BFF) and SSF, which have limited to no value and only limited recycling opportunities. The Schnabel staff recognized the potential of blending large volumes of DM from Cox Creek with the slag fines across the river to produce earth fills for urban and port construction use, combining these two materials into one marketable product.

Accordingly, Schnabel performed a combined laboratory and field demonstration project to evaluate the feasibility of using DM-SSF blends to be used as earth fill materials to support construction in the Baltimore area. Schnabel's study included an extensive geo-environmental investigation to address the Cox Creek DM arsenic contamination. This was very important to support the necessary environmental permits and approvals required by the Maryland Department of the Environment (MDE) for the use of this new type of earth fill material.

The Schnabel team felt it important to have a large user of earth fill to participate as a stakeholder during the project. The Maryland State Highway Administration (SHA), as a large user of earth fill for highway projects, was solicited by MPA and Schnabel to be a stakeholder, and they became an active participant during critical phases of the project.

In order to have very high technical review of Schnabel's study, generate consensus (public and technical), and maintain transparency, Schnabel's deliverables for the project were an integrated series of technical papers that were submitted to leading peer-reviewed technical journals and conferences for the geotechnical, environmental and beneficial use industries (list is provided after section D). The ultimate intent of public peer review was to validate the results of the study and establish the credibility of the final conclusions. It also can provide a sound technical basis for MDE to establish the appropriate regulatory controls and permitting needed for use of DM-SSF blends. Full scale use of DM-SSF blends in construction can assist the MPA in meeting their goals for beneficial reuse by 2023.

In the first project phase, Schnabel found that the DM from Cox Creek contained between 20 and 50 mg/kg total arsenic (As), which is well above the MDE's Voluntary Cleanup Program (VCP) standards for residential and non-residential sites (0.43 and 1.9 mg/kg, respectively).This became a key issue for Schnabel in their consideration for enabling Cox Creek DM for innovative reuse. Schnabel initially thought that up to 2% of cement would need to be added to the DM to immobilize the arsenic to get the levels below the clean up criteria; however, added cement increases the cost of producing DM as earth fill and may make it uneconomical.

Schnabel tested both the SSF and BFF from Sparrows Point in the laboratory to determine total metal concentrations as well as metals leachability using the toxicity characteristic leaching procedure (TCLP) and synthetic precipitation leaching procedure (SPLP). When the results were compared to the MDE VCP standards, both slags were found to have total metals concentrations below the standards, with the exception of iron. The SSF from Sparrows Point, because of its high environmental quality, residual lime content, reactive mineralogy (Ca, Fe contents) and granular nature was selected for the next phase of the project for mixing with the DM.

Phase II consisted of a detailed geotechnical and environmental evaluation of the DM-SSF blends in the laboratory, including a 360-day aging study. A comprehensive strength testing program of the blends was performed. The testing indicated that blending the DM with steel slag fines resulted in improved strength. Based on the results of the strength testing program, the DM steel slag blends are extremely competent for fill construction. Long term testing indicated that the blend strength's doubled within 60 days of aging and remained constant thereafter.

The most notable, positive and unexpected finding of the Phase II laboratory study was that, despite the fact that the raw DM used in this series of testing contained approximately 45 mg/kg total arsenic, the arsenic was found to be chemically bound in the blends. Arsenic leaching from the material was not detected, even after one year. TCLP and SPLP leaching results were all below detection limits for all blends for all testing intervals (1, 28, 60, 180 and 360 days).

Schnabel also found the arsenic leaching results of the DM-SFF blends were not improved upon when up to 2% cement was added, indicating that low doses of cement were not needed to immobilize arsenic. This made the DM-SSF blends more economical and improved the likelihood that they could be approved for use as earth fill in Maryland.

In Phase III, 5 trial highway embankments were constructed: 100% DM, 100% SSF, and 80/20, 50/50 and 20/80 DM-SFF blends. Using conventional soil mixing equipment (e.g. trailer-mounted pugmill mixer) and ordinary earth moving equipment, Schnabel demonstrated that the DM-SSF blends could be routinely produced at reasonable rates and within 5% of the blending target. We also verified that quality control for the embankment construction could be determined by conventional test methods.

Schnabel found in the demonstration project that they only had to add 20% SSF to the DM to produce a usable commercial fill material. Long term 360 day strength testing indicated that the blends generally doubled in strength over a year.

Schnabel completed the study under contract to MPA within the budgeted cost of $948,000. We were responsible for the entire budgeted cost and actual cost.

Due to the favorable study results and SHA's interest in the processed DM as earthen fill material, the MPA contracted with Schnabel to work with SHA to prepare special provisions for the use of DM-SSF blends. The goal is to establish the technical specifications and regulatory process by which DM/SSF blends can be used on a routine, large scale basis. Such use could reduce highway construction material costs, based on results of other studies.

What Makes This Project Deserving of the WEDA Environmental Excellence Award

The purpose of Schnabel's demonstration project was to determine whether dredged material (DM) from the MPA's Cox Creek Dredged Material Containment Facility (DMCF) could be successfully improved into an earth fill material by mixing with steel slag fines (SSF) from Sparrows Point steel mill. The project demonstrated that the blending significantly improved the strength of the DM and reduced the mobility of metals in the DM. The project also showed that there were no major impediments to using the blends to build earth fills using ordinary construction equipment.

This study has important implications for the greater Baltimore region in terms of the sustainability of the Port of Baltimore. The study has the potential to allow the Port to attain some of the highest recycling rates in the country for DM, thus avoiding the long-term costs and expanded land use associated with confined disposal facilities. In closing, the peer-reviewed research papers and data resulting from this study will enable the MPA and MDE to develop rationally based criteria to enable local, large-scale beneficial use of DM and other industrial byproducts and recycled materials in Maryland. Completion of the development of special provisions with SHA and regulatory approval from MDE will be an important step toward moving this program to the next level.

Outreach and Education

Schnabel reached out to the industry, profession, and community by conducting an open house at the Cox Creek DMCF for interested parties, and presented our findings at engineering and Department of Transportation conferences. Additionally, the following publications and professional papers have been produced.

MAGAZINE ARTICLES

Grubb, D.G., 2011. "Recycling on the Waterfront," *Geo-Strata,* American Society of Engineers, Reston, VA, March/April, 15(2), p 24-29.

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Malasavage, N.E., Jagupilla, S.C., Grubb, D.G., Wazne, M., and Coon, W.P., 2012. Geotechnical performance of dredged material-steel slag fines blends: Laboratory and Field Evaluation, *J. Geotech. Geonenviron. Eng.,* pp 28 (accepted).

Grubb D.G., Wazne, M., Jagupilla, S.C., and Roscoe, M.S., 2011a. "Aging effects in dredged material-steel slag fines (DM-SSF) blends," in: E.A. Foote and A.K. Bullard (Conference Chairs), *Remediation of Contaminated Sediments—2011,* Sixth International Conference on Remediation of Contaminated Sediments (New Orleans, LA; February 7–10, 2011), ISBN 978-0-9819730-3-6, Battelle Memorial Institute, Columbus, OH, Paper C-91 (pp. 8).

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Grubb D.G., Wazne, M., Jagupilla, S.C., and Malasavage, N.E., 2010b. "Arsenic immobilization using slag fines," *Protection & Restoration of the Environment X*, Corfu, Greece, July 5-9, pp.8 (CD-ROM).

Grubb, D.G., 2009. "A Program to Determine the Construction Fill Properties of Dredged Material Blended with Slag fines, *4th International Symposium on Contaminated Sediments*," Trinity College, Dublin, Ireland, 29 June-3 July, pp. 4.

Grubb, D.G., 2009. "A Program to Determine the Construction Fill Properties of Dredged Material Blended with Slag fines, *4th International Symposium on Contaminated Sediments*," Trinity College, Dublin, Ireland, 29 June-3 July, pp. 4.