TECHSUMMARY July 2014

State Project No. 30000728 / LTRC Project No. 13-2GT

Implementation of Slag Stabilized Blended Calcium Sulfate (BCS) in a Pavement Structure

INTRODUCTION

This research was the field implementation follow-up to laboratory research conducted at LTRC. It also met a need of District 61 staff by allowing an alternative to the removal and replacement of the old, non-standard BCS found on site.

The researchers used the previous research to draft, finalize, approve, and implement specifications to allow for the stabilization of BCS with GGBFS on the shoulders of US 61 just south of LA 22 in Sorrento, LA. Two specifications were used to change-order this project. The first addressed the inplace stabilization of BCS with slag. The second specification addressed a market-driven implementation of the research, specifically, the applicability of Honeywell's "fines" material treated with slag in a pugmill for use as base material. The researchers worked with Honeywell, District 61 staff, and the contractor to design a plan for the test sections. The partnership with Honeywell and its contractor, Brown Industries, and their investment (financial and reputation) toward the project benefited the research.

OBJECTIVE

This project focused on the variation of strengths obtained through stabilization of BCS with GGBFS to meet highway needs. The project also seeks to further the implementation of this stabilized material within DOTD and to a broader, commercial market (nationally, locally, contractors, etc.). The project researched and documented slag-treated BCS test sections conducted by LTRC.

SCOPE

The highway project identified for the research was DOTD project H.000329, which entailed an overlay on Airline Highway, US 61, from LA 22 to LA 74 in Ascension Parish. The researchers focused specifically on the outside shoulders of Airline Hwy, south of its intersection with LA 22 in Sorrento, LA to about one-half mile south in both travel directions.

METHODOLOGY

The fieldwork constructed four test sections. SB-1 and SB-2 were located on the southbound shoulder and intended to show the mixing of slag into raw non-standard BCS. The FWD, Dynaflect, DCP, and field cores were used to verify strengths over time. The northbound shoulder sections of US 61 were intended to show the pugmill operations. At NB-Inplace, the existing BCS material was stabilized inplace. At NB-Pug, the existing BCS was removed, hauled away, and replaced with pug-milled slag/BCS from offsite.

Discussion of Results

SB-1 was inadvertently pulverized by the contractor to a depth of 12 in., which contaminated the BCS with soil. Slag was spread over this section and mixed to 12 in. This diluted the slag percentage from 8 in. to 12 in. While working on SB-1, the pulverization depth was corrected and the section changed to SB-2. Therefore, SB-2 is similar to SB-1, except the slag was only mixed to 8 in. (the intended depth). Though there were pulverization and mixing depth issues, and the initial results were marginal, the resulting sections gained strength over time.

The pulverization issue led to an adjustment of the planned northbound sections. The NB-Inplace section was mixed in-place to produce the intended section (from the southbound). The BCS while mixing was on the wet side of optimum, which is generally good for the slag/BCS bonds; however, this excess moisture led to compaction pumping, and grading problems in this non-standard (finer

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grained) BCS. The NB-Pug section showed differences in testing and performance results between placement days. The early part of the section proved weaker than the latter (second day of placement). This was confirmed by the contractor's laboratory (Terracon) results.

Though these sections were slow to develop strength at 7 and 28 days, subsequent testing with the DCP, FWD, Dynaflect, and unconfined compressive strengths (UCS) from field cores showed strength target were generally achieved.

CONCLUSIONS

The field constructed test sections showed the benefit of the slag stabilized BCS.

The two test sections (SB-1 and SB-2) with pulverization and mixing depth issues (too deep) initially had marginal results, but the resulting sections gained strength over time, which the FWD, Dynaflect, DCP, and field cores confirmed. This is likely due to the slower reaction of slag (as compared to cement's rate of reaction).

Higher concentrations of slag in the BCS/soil mixture produced higher strengths. The slag in SB-1 was diluted over a larger volume due to the mixing error, but still gained strength. SB-2 performed better, likely due to the higher (intended/desired) concentration of slag in the BCS/soil pulverized mixture.

- Truck spreading (of the slag) may have also affected concentrations available for stabilization, and thus the strengths. For example, SB-2 station 12+00 was one of the best performing sample locations, and likely received higher application rates at the end of the section (possibly due to cleanout of the spreader truck).

Previous research, LTRC# 03-8GT, utilized a BCS of a coarser nature (rock BCS) and based slag amounts on the percentage smaller than a number four sieve, since the larger particles have their own intergranular friction. The current project, LTRC# 13-2GT, with its old BCS was uniformly finer than the "rock" BCS, and in hindsight, the slag percentage should have been higher to account for the increase in surface area of the finer material. The additional slag would likely have also resulted in higher strengths in a shorter time period.

Two sections were completed on the northbound lane of US 61. At NB-Inplace, the existing BCS material was stabilized inplace. At NB-Pug, the existing BCS was removed, hauled away, and replaced with pug-milled slag/BCS from offsite.

- The NB-Inplace section showed that moisture control is important during construction. Immediately after stabilization with slag, the slag-BCS bonds have yet to form, and the material can be moisture sensitive. Though water is good for the slag/BCS reaction, too much water with BCS can cause pumping and hinder compaction and grading operations. Over time, the bonds grow and reduce the moisture susceptibility of the slag stabilized BCS. Once cured, research and field results show the strong, green-colored bond is not moisture sensitive.
- The NB-Pug section showed variations between placement days. The consistency throughout each day was stable, but varied from day to day. This was also confirmed by the Terracon results. Further QC/QA appears necessary at the plant level.

The inplace treatment of BCS with slag offers a solution to the choice of cement as a stabilizing agent, which can create the expansive mineral, ettringite, and lead to expansion and ride quality issues. Based on 03-8GT, the slow slag reaction inhibits the growth of the expansive ettringite.

The slag reaction with BCS is slower than a standard soil cement reaction, but eventually gained suitable strength/stiffness.

- The application of the research on the Airline Highway shoulders allowed suitable cure time, without the need to open immediately to traffic.
- The slower slag reaction provided timing-flexibility for pugmill operations allowing slag stabilized BCS to be prepared off-site, hauled to the site, and utilized as base course material for the shoulders.

The potential to utilize Honeywell byproduct, BCS "fines," stabilized with slag offers the Department an option to address the environmentally friendly "green" initiatives of reducing Louisiana landfills.

The strength data shows that each section, even with its various cross-sections, was capable of reaching 300 psi, offering a way to treat inplace BCS; and offering an alternative base course solution when remove and replace options, potential expansion exists, or the cost of stone replacement material may be too expensive.

Stabilizing old non-standard BCS inplace provided a cost benefit of $15.5/s.y., which yielded a saving of $55,000 for the test sections.

RECOMMENDATIONS

Researchers recommend the use of slag stabilization on BCS encountered during forensic or rehabilitation operations of BCS sections. Slag stabilization of BCS provides:

- a cost-effective way to deal with these areas of old, non-standard BCS, as compared to a remove and replace option.
- a strong bond that renders the BCS less-moisture-sensitive compared to untreated BCS.
- a relatively slow slag-BCS reaction to reduce the likelihood of expansive reactions, an alternative to cement stabilization that may cause ettringite formation and therefore expansion issues and/or ride quality issues.
- another base course option to meet Department needs.

The draft specifications included can be used to incorporate this research into the Department's "toolbox." The design slag percentages should be verified with laboratory testing and then increased slightly to account for spreading inconsistencies, and increased surface areas of old, non-standard BCS or the Honeywell "fines" material.

The continued use of BCS as a base course material can be supplemented with the addition of a slag stabilized BCS (inplace and pugmilled). This research offers the Department other base course alternatives, and addresses the "green" philosophy and market need to recycle BCS. Further refinements to the pugmill plant process are necessary to ensure consistent output by the hour and by the day. The pug-mill process is, however, an excellent way to control and balance the moisture of the mixture to create the slag/BCS reaction without excess moisture that may cause pumping.

The slag-BCS reaction can realize excellent strength gains with time. The researchers recommend that care, including specific testing with onsite materials, be used in selecting sites for the application and implementation of this research.