TECHNICAL NOTE

SUBJECT: PERFORMANCE COMPARISONS BETWEEN CEMENT AND TS-SS ADMIXTURES IN HIGH SULFATE SOILS

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Background

The stabilization of sulfate rich base and subgrade soils has been a challenge using traditional calcium-based stabilizers (i.e. cement and lime). Kota et al. (1996) proposed procedures for the remediation of soils including the double application of lime or use of geotextiles, depending on the sulfate levels in the soil. Sarkar and Little (1998) presented a stabilization case study on high sulfate soils where approximately 19% stabilizers including Type V cement and Class C fly ash were used. Puppala et al. (2003) also used very high stabilizer levels (ranging from 8 to 20%) on high sulfate soils in Arlington, Texas.

The effectiveness of non-calcium based stabilizers for base and subgrade soils has been studied by various researchers. These non-traditional stabilizers include barium hydroxide and barium chloride (Ferris et al. 1991), sulfonated naphthalene to enzymes and bioenzymes (Scholen 1995 and Marquart 1995), a potassium stabilizer (Addison and Petry 1998), a hydrogen ion exchange chemical (Sarkar et al. 2000), a low pH solution of sulfonated limonene (Katz et al. 2001), enzymes, lignosulfonates, petroleum emulsions, resins (Santoni et al. 2002), and chemical stabilizers (Petry and Das 2001)

Introduction

Twenty compaction and unconfined compressive strength tests on cement and TS-SS treated crushed limestone were performed. The TS-SS liquid polymer is in the form of aqueous dispersion. The TS-SS polymer was provided by Terra Pave International.

The particle size distribution of the crushed limestone is presented in Figure 1 below. The percent passing 40-mesh (i.e. soil binder) was approximately 22%. The cement was tested at a rate of 3% by weight while TS-SS was tested at 0.28%, 0.50%, and 1.00% by weight. Laboratory samples were prepared with and without sulfate in the aggregate. Based on the experience of contractors and TxDOT personnel, soils with sulfate concentration in excess of 7000 ppm are considered as high-sulfate soils (TTI 2005). A sulfate concentration of 20,000 ppm was used in this research. Calcium Sulfate Dihydrate (i.e. Gypsum) was used as it is the most common natural form of sulfate in Texas.

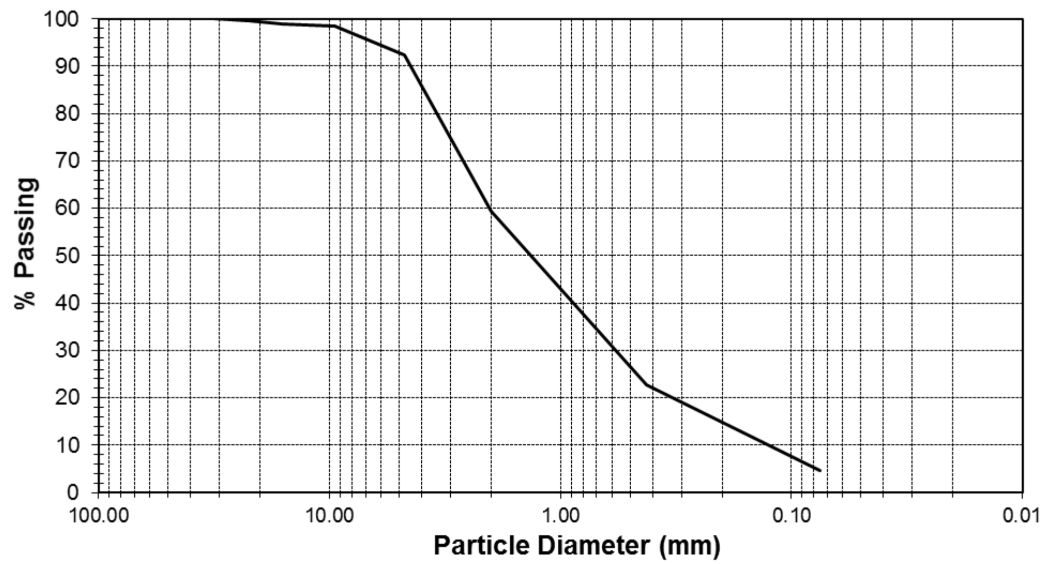

Figure 1: Crushed limestone particle size distribution

Test procedures

The sulfate wad added to the soil in solid form and left to cure overnight before addition of the stabilizers. Aggregates were compacted in a standard mold having a capacity of 1/30 ft^3 and having an internal diameter of 4 inches and a height of 4.584 inches. Samples in the mold were compacted in three layers with 25 blows per layer from a 5.5 pound hammer dropped from a height of 12 inches. All compacted specimens were cured in an oven at a constant temperature of 110 degree Celsius. Unconfined compression tests were carried out on compacted samples using a loading rate of 2.0% strain per minute 7 days after the compaction tests.

Compaction test results

Figure 2 displays the compaction curves with admixtures (i.e. TS-SS and cement). For each compaction test, the moisture content of the compacted aggregate was determined in the laboratory and the dry unit weight was calculated. The compaction curves were generated by plotting the dry unit weights and corresponding moisture contents. The objective here was to obtain the maximum dry unit weight and the optimum moisture content for each mix.

Table 1 shows the optimum moisture content (w_{opt}), maximum dry unit weight ($\gamma_{dry,max}$), and unit weight compacted at the optimum moisture content (γ) values for each mix. In this research, it was assumed that the optimum moisture content for the Soil + Water-TS-SS Mix is equal to the Soil + Water Mix.

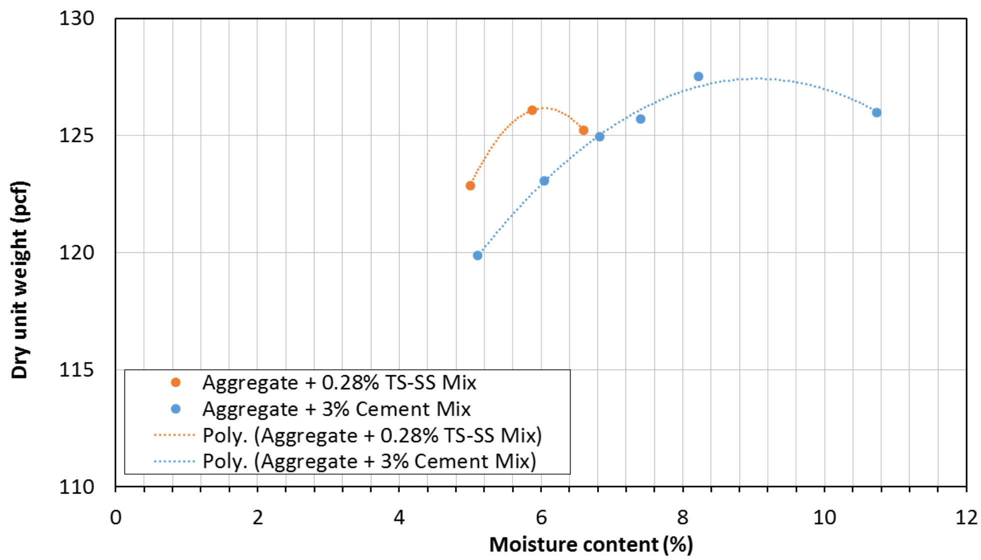

Figure 2: Compaction test results

Table 1: Optimum moisture content (w_{opt}), maximum dry unit weight ($\gamma_{dry,max}$), and unit weight compacted at the optimum moisture content (γ) values for each mix

Mix Name	w_{opt} (%)	$\gamma_{dry,max}$ (pcf)	γ (pcf)
Soil + 0.28% TS-SS mix	5.9	126	134
Soil + 3.00% Cement mix	9.0	128	140

Unconfined compression test results

Figure 3 displays the unconfined compression test results of cement and TS-SS treated crushed limestone with and without sulfate after 7 days of curing times. A control test with no additives was also performed for reference. The following observations are made:

- The unconfined compression strength increases with both cement and TS-SS treatment
  - The unconfined compression strength with 1% TS-SS is on average 10.0 times the unconfined compression strength of untreated aggregate
  - The unconfined compression strength with 0.5% TS-SS is on average 7.0 times the unconfined compression strength of untreated aggregate
  - The unconfined compression strength with 0.28% TS-SS mix is on average 3.7 times the unconfined compression strength of untreated aggregate
  - The unconfined compression strength with 3% cement is on average 3.5 times the unconfined compression strength of untreated aggregate
- Soluble sulfates present in soils will contribute in significant loss of strength in cement treated aggregate
- Soluble sulfates present in soils will not affect the strength of TS-SS treated aggregates.

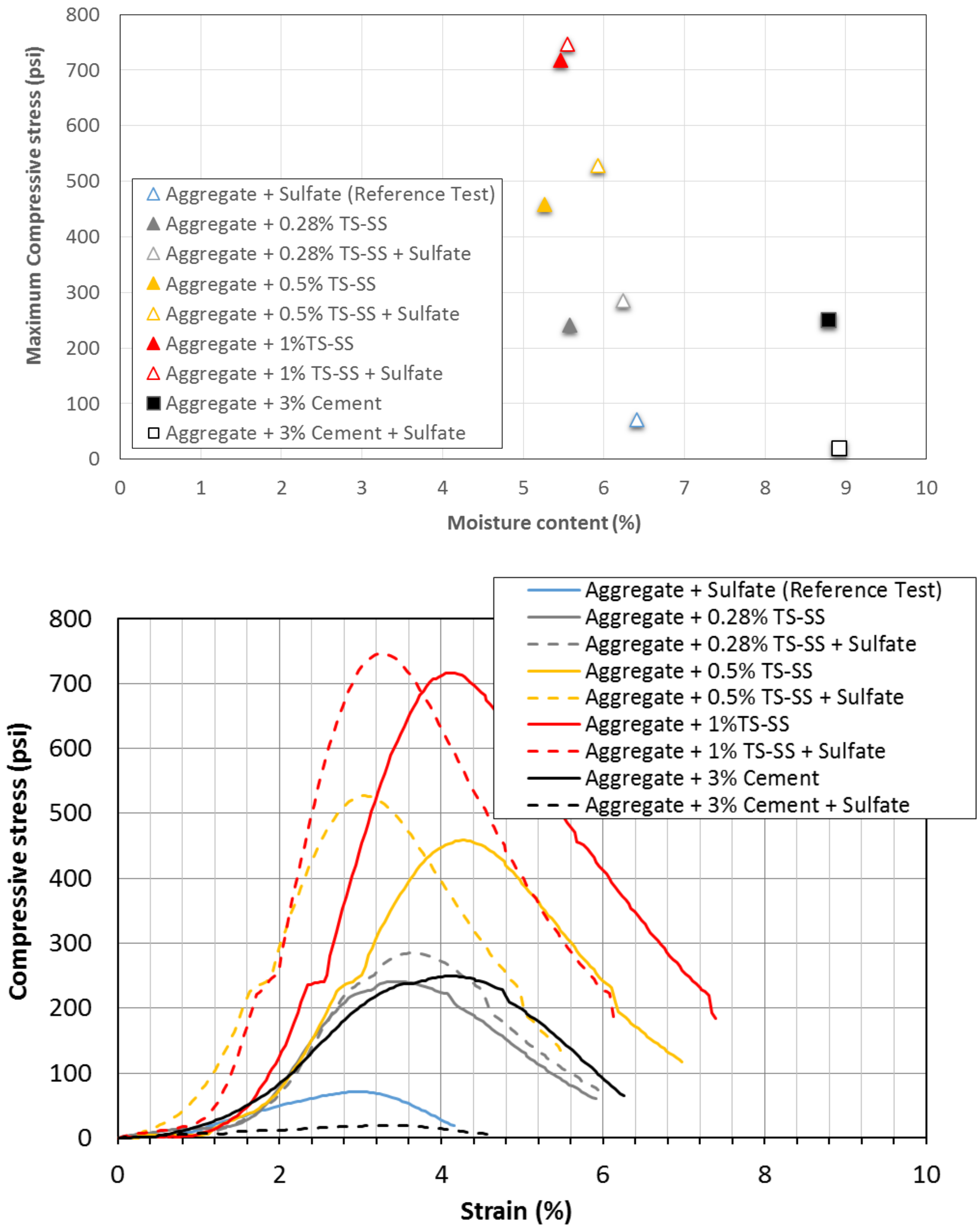

Figure 3 Unconfined compression test results

Figure 4 shows a comparison of unconfined compressive strength values between the control sample and 0.28% TS-SS and 3% Cement treated samples with and without sulfate. The results reveal that if there is no sulfate in the soil, the strength after 0.28% TS-SS treatment, is comparable to that of 3% cement treatment. However, with the inclusion of sulfate in the soil the strength of the TS-SS treated samples was increased by approximately 20% whereas the strength of cement treated samples was significantly reduced.

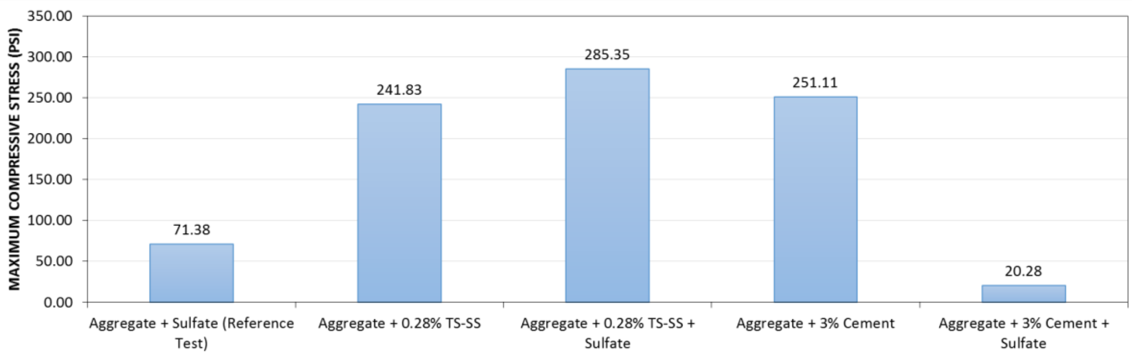

Figure 4 A comparison of unconfined compressive strength values between the control sample and 0.28% TS-SS and 3% Cement treated samples with and without sulfate

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