Effect of Surfactants on the Strength Characteristics of the Chemical Grout

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Abstract: In this study, the influence of surfactants on the pull-out strength and compressive strength of the grout and grouted sand were investigated. Pullout tests were performed to determine the pullout strength and failure mode and the sensitivity of this test to changes made in the grout mix using the addition of surfactants in the grout. The pullout strength of grout and grouted sand reduced with the addition of SDS and CTAB. Addition of CTAB and SDS increased the compressive strength of the grouted sand.

1 Introduction

From the materials perspective, the grouts can be divided into two broad categories, they are, chemical grouts (true solutions) and suspended solid grouts (like cement grouts) (Karol, 1982; Vipulanandan et al. 1992). Among the chemicals used for grouting, acrylamide grouts take one of the prime spot. Acrylamide grouts are aqueous solutions having more than two chemical components. Considering chemical grouts, their penetrability is primarily dependent on the viscosity of the solution that enables a reasonable flow of the grout at applied permissible pressures (Karol, 1982). Surfactants are predominantly used in different applications because they lower the surface tension of the liquid to which they are added. Critical micelle concentration (CMC) of a surfactant is that concentration where the micelles are formed and this determines the amount of surfactant to be added to the grout solution if the surfactant is to change the surface tension of the liquid.

2 Objective

The main objective of this study was to investigate the effects of adding of an anionic and cationic surfactant on the behavior of acrylamide grout and grouted sand. The specific objective was to investigate the sensitivity of the pullout test to identify the effects of changes in the grout and grouted sand properties.

3 Materials Required and Experimental Program

AV-100 grout, a blend of acrylamide monomer and methylenebisacrylamide was used. The surfactants used were cetyl trimethyl ammonium bromide (CTAB, $[CH_3\ (CH_2)_{15}\ N\ (CH_3)_3]\ Br$), a cationic surfactant and Sodium Dodecyl sulfate (SDS, $C_{12}H_{25}SO_4Na$), an anionic surfactant. A commercially available sand with a coefficient of uniformity (Cu) of 2.90, coefficient of gradation (Cc) of 0.79 and d_{50} of 0.7 mm was used in this study. Fig 1 shows the setup of the pull-out strength test of the grout and grouted sand specimens. The grout and grouted sand specimens were prepared using Plexiglas molds of diameter 1.5 in. (38 mm) and height 4.5 in. (114 mm). For preparing the grouted sand specimens, sand was poured into the mold and then the grout mix was poured into the sand filled mold. Care was taken to saturate the sand with maximum grout mix to remove the air voids. The load taken to pull the anchor out of the specimen divided by the area of the failure plane gave the pull-out strength of the sample. For unconfined compressive test, the grouted sand specimens were prepared by injecting the grout mix at a pressure of 1 to 2 psi (6.89 -13.78 kPa) into the cylindrical mold containing sand with a diameter 1.5 in. (38. mm) and height 4.5 in. (114 mm). Once the specimens were prepared, they were cured at room condition for 7 days and unconfined compression tests were performed using a strength testing machine which was operated at a strain rate of 1% / min.

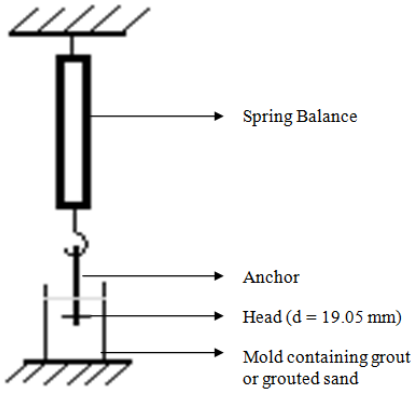

Fig 1: Pull-out Strength Test Apparatus

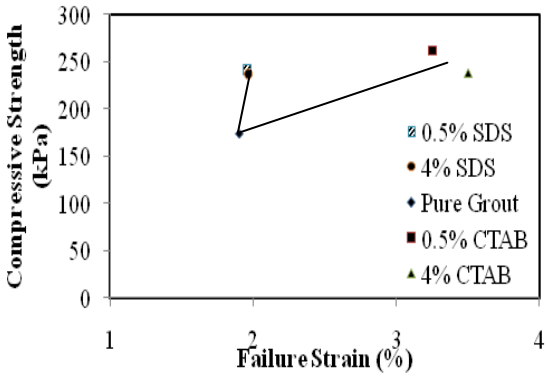

Fig 2: Compressive Strength of Grouted Sand

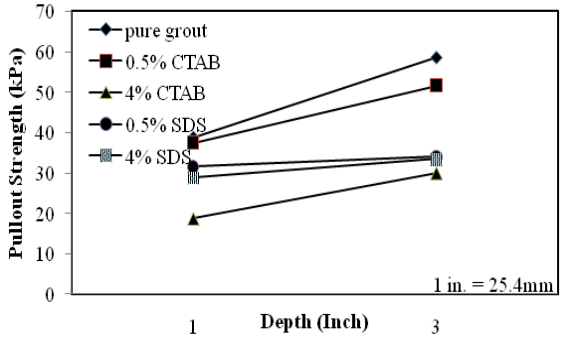

Fig 3: Pullout Strength of Grouts

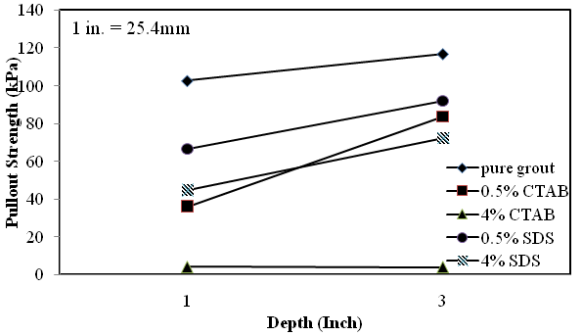

Fig 4: Pullout Strength of Grouted Sand

4 Results and Discussion

As shown in Fig 2, addition of surfactants affected the compressive strength and the failure strain of the grouted sand. The grouted sand strength and strain without any surfactant was 174 kPa and 1.9% respectively. Addition of SDS increased the strength of grouted sand. Addition of SDS didn't influence the failure strain of grouted soil. Addition of CTAB increased the strength of grouted sand. The failure strain increased from 1.9% to 3.25% and 3.5% when 0.5% and 4% of CTAB was added to the grout mix. The pull-out strength of grout and grouted sand is shown in Fig 3 and Fig 4. The pull-out failure was by shearing at the anchor-grout and anchor-grouted sand interfaces. The pullout strength in the grout varied between 40 and 60 kPa with an average pull-out strength of 50 kPa. The pull-out strength for the grouted sand varied between 100 to 120 kPa with an average pull-out strength of 110 kPa. Hence the pull-out test was sensitive to the testing material, grout and grouted sand. Both surfactants reduced the pull-out strength of grout and grouted sand.

6 Conclusion

Based on the test results, following conclusions are advanced.

1. The pullout strength of the grout and grouted sand decreased with the addition of surfactants. The pullout strengths in the grouted sand were higher than the grout. The failures in the grout and grouted sand were at the interface, shear failure.
2. Addition of surfactants increased the compressive strength of the grouted sand however the failure strain was increased when CTAB was added to the grout.

7 Conclusions

Karol, R.H., (1982) "Seepage Control with Chemical Grout." Conference Proceedings on Grouting in Geotechnical Engineering, ASCE, pp 564-575.

Vipulanandan, C. and Shenoy, S. (1992)" Properties of Cement Grouts and Grouted Sands with Additives," Proceedings, Grouting, Soil Improvement and Geosynthetics, ASCE, pp. 500-511.