

Characterizing the Behavior of Sulfate Contaminated CL Soil

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Abstract: In this study, the effect of calcium sulfate on the liquid limit, plasticity index and the compaction properties of a CL soil were investigated. The sulfate concentration was varied up to 4% (40,000 ppm). Analyses of the test results showed the natural clay soil properties were changed with sulfate content in the soil.

1. Introduction

Sulfate, in various forms, are found primarily in soils in semi arid and arid regions, with calcium sulfate begin the most abundant (Mitchell, 1990). Various phases of calcium sulfate (gypsum, anhydrite, and bassanite) have been reported to exist in many local calcareous types of clay. Sulfate soils are problematic soils and are treated with lime, fly ash and cement to modify the geotechnical properties of the soil.

2. Objectives

The overall objective was to quantify the changes in the properties of a CL soil by varying the calcium sulfate content.

3. Methods and Materials

Commercially available clay soil was used in preparing the sulfate soil. Various amount of calcium sulfate was added to the soil and was cured for 7 days before testing. Based on the ASTM standards compaction and Atterberg limits tests were performed to determine the geotechnical properties of the selected natural soil mixes with various sulfate content.

Table 1. Index and Compacted Properties of Selected CL Soil

Soil Type (USCS)	% Passing Sieve #200	Specific gravity	LL %	PI %	OMC %	Max. Dry Density (gm/cm ³)
CL	60	2.66	40	19	16.5	1.52

4. Results and Analysis

Increase in sulfate content increased the index properties of CL soil. Addition of 4% of calcium sulfate increased the LL% and PI% by 44% and 80% respectively and the relationship was nonlinear. Addition of 4% of calcium sulfate increased the OMC% by 25% .The maximum dry density of CL soil decreased by 7% when the percentage of calcium sulfate was 4% Based on the inspection of the test data for the properties investigated following relationship is proposed.

$$Y - Y_o = \left(\frac{x}{A+B*x} \right) \dots\dots\dots (1)$$

Where: Yo: is the soil property without contamination.

A and B: are model parameters. X: is the sulfate concentration in (%).

	Index Properties (Y)	Yo	A	B	R ²
CL soil contaminated with calcium sulfate	LL%	40	0.04	0.05	0.94
	PI%	19	0.04	0.06	0.92
	OMC%	17	0.72	0.0	0.92
	γ _{dmax} . (gm/cm ³)	1.52	- 6.45	- 9.18	0.92

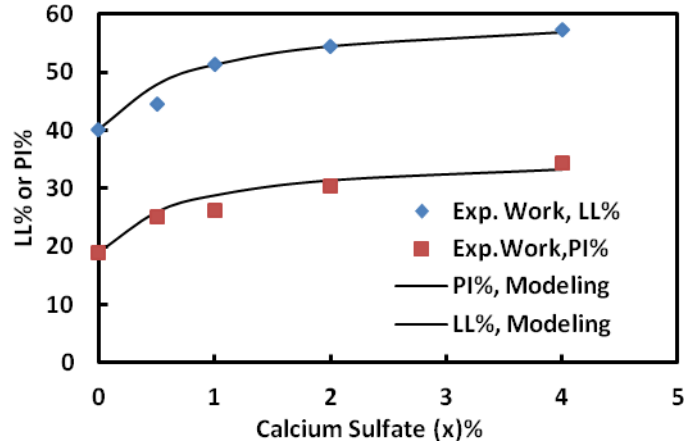


Figure 1 Variations of Index Properties with Sulfate

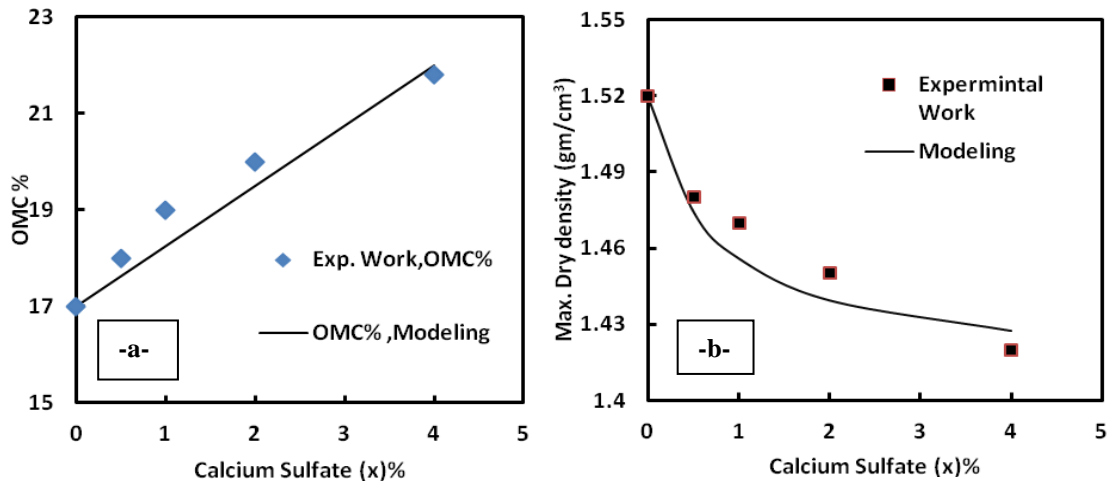


Figure 2 Compaction Characteristics of Soil with Varying Sulfate Content: (a) Optimum Moisture Content (%) (b) Max. Dry Density

5. Conclusions

Based on this study, CL soil contaminated with calcium sulfate increased the index properties and optimum moisture content with increasing sulfate content. The dry unit weight of the soil decreased with increasing sulfate content. The trends were represented by one relationship.

6. Acknowledgements

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7. References

1. James K. (1990). Clay soil heave caused by lime-sulfate reactions, ASTM Spec.Tech.Publ.1135, 41-64.
2. Abduljawwad S., S.Azam, Al-shayea A. (1999). Effect of phase transformation of calcium sulfate on the volume change behavior of calcareous expansive soil, Engineering for calcareous sediments, ISBN 90 5809 037 X.
3. Harris P., Tom S. and Stephen S. (2004). Hydrated Lime Stabilization of Sulfate-Bearing Soils In Texas, Report, FHWA/Tx-04/0-4240-2.