ABSTRACT

El Howayek, Alain. Ph.D., Purdue University, August 2016. Structure, geology, and engineering properties of two carbonate fine-grained soils. Major Professors: Maria C. Santagata and Antonio Bobet.

Soft, carbonate-rich, fine-grained soils, also referred to as marls, are commonly found in glaciated regions of the northern United States and throughout Canada. In addition to the high compressibility potential and low shear strength; these sediments are typically characterized by alternating layers of silts and clays as well as high calcium carbonate content. The unique properties of these deposits make them challenging soils for geotechnical engineers. Despite the prevalence of marls in Indiana and the concerns associated with their behavior, very limited work has been done to study the engineering properties of these soils. This was the motivation for this research presented in this thesis which is founded on an in-depth characterization of a glaciolacustrine carbonatic fine-grained soil deposit formed about 22,000 calendar years ago in the southwestern part of the State of Indiana, USA, with the aim of developing an improved knowledge of the behavior of carbonate fine-grained soils.

The project involved field tests (seismic cone penetration tests, standard penetration tests, field vane shear tests), and laboratory experiments (index tests, incremental and constant rate of strain consolidation tests, and $K_0$-consolidated undrained triaxial tests) conducted on high quality Shelby tubes samples. Additionally, the mineralogy and microstructure of the soil has been studied in detail.

The laboratory tests reveal that the deposit was not homogeneous as was initially anticipated, but was, instead, formed by two types of soils that repeat in horizontal thin layers. These two soils, referred to as ‘soil M’ and ‘soil C’, are both characterized by very high calcium carbonate contents but show distinct index and engineering properties, that may be ascribed to differences in mineralogy and composition. This stratification is not detected by the field tests.

The microstructural investigation shows that the soil consists of clay platelets that are covered by a thin layer of a carbonatic coating, and interconnected by carbonatic bridges to form aggregates. The laboratory results show that these interparticle bonds alter the macroscopic behavior of the soil (i.e. index and engineering properties).

The consolidation tests show that the deposit has an OCR less than 2 and compressibility parameters markedly dependent on stress level, as typical of sensitive soils. $K_0$-consolidated undrained compression triaxial tests show that both soils exhibit normalized behavior, and that the relationship between strength and stress history is well described by the SHANSEP equation (although the SHANSEP parameters differ for the two soils).

Comparison of the field data and laboratory results provides the means to validate published correlations for interpretation of the geotechnical properties of marls from field results. For the site examined, correlations to estimate shear wave velocity, stress history, and undrained strength from CPT results are identified.

**Keywords:** Carbonate soil, marl, lacustrine deposit, cementation, mineralogy, consolidation properties, undrained shear strength, SHANSEP