Development of a standardized (American Society for Testing and Materials, ASTM), repeatable, and consistent geotechnical laboratory testing procedure for the Low Stress Consolidation Test for the Marsh Fill

Introduction

In order to recover and restore the coastal wetland loss in Louisiana, a wide spectrum of solutions or approaches aiming at alleviating, neutralizing, reversing the losses are being implemented or proposed by CPRA and other agencies with diverse purposes and missions. Several ongoing and completed coastal protection and restoration strategies involve marsh creation in the open coastal area by hydraulically dredging riverine sediments and pumping via pipeline for transportation, and reduction of tidal exchange in marshes, etc. Figure 1 shows the Sabine Refuge Marsh Creation Project from the construction of containment dike, pumping riverine sediment via pipeline and the new man-made marshland in large and open water areas north and northwest of Brown's Lake in Cameron Parish, Louisiana.

(a) (b) (c)

Figure 1: The Sabine Refuge Marsh Creation Project, (a) construction of the dike, (b) dredged riverine sediments pumped to the open water area, (c) newly created marshland

Rates of very high subsidence of fine-grained dredged soils are routinely monitored and predicted. The accuracy of any calculation of the consolidation settlement depends on the soil parameters used. Behaviors of the fine-grained dredged soils, such as natural moisture content, grain size distribution, specific gravity, and Atterberg limits, etc., should be tested in laboratory. Consolidation test is another important one. Three methods are available for conducting low-pressure consolidation tests on fine-grained dredged material: self-weight settling test, the controlled rate of strain test, and oedometer test, which is the most common type. The apparatus required by oedometer test could be found in all well-equipped soils laboratories, and the test has been used successfully on numerous dredged materials.

Objectives of the research

Significant oedometer testing of stiffer dredged fill materials has been accomplished essentially as specified in EM 1110-2-1906. In the proposed research, detailed procedures would be developed following standard ASTM D-2435. The purpose of the proposed research is to find out where the conventional procedure must be modified or supplemented to handle extremely soft dredged fill material. The major difference between regular soft clay, and very soft and unconsolidated dredged mud is in the initial sample preparation and the size of the load increments. Majority of dredged fill samples will be in the form of a heavy liquid rather than a mass capable of being handled and trimmed. Suggested research is briefly described as follows:

- Collect and analyze data and reports of low-pressure consolidation tests on dredged fill from CPRA offices and USACE websites.
- Review consolidation specifications EM 1110-2-1906 and ASTM D-2435 standards.
- Conduct multiple low-pressure consolidation tests by following, combining, and revising procedures from EM 1110-2-1906 and ASTM D-2435.
- Recommend procedures of oedometer tests specifically for dredged material, and test data interpretation. Special attentions will be paid for the following:

(1) Seating load: the first seating load must be determined in an effective way, which is from the top porous stone, the items between soil sample and dial gauge indicator spring, etc.
(2) Sample preparation: dredged soft slushes cannot be trimmed following the ways recommended by ASTM D-2435. An efficient method should be developed to make up consolidation samples by avoiding trapping air in the sample, and minimizing the disturbances exerted on it.
(3) Settlement measurement subject to the seating load: The seating load including the dial gauge weight will be applied quickly, and the settlement should be accurately measured. Research must be done to get an appropriate measuring device to check the height of the top of the porous stone above the sample ring during this first load increment.
(4) Intervals to take settlement readings after the seating load: Usually consolidation settlement is taken at the times 0.1, 0.2, 0.5, 1.0, 2.0, 4.0, 8.0, 15.0, and 30.0 minutes; 1, 2, 4, 8, and 24 hours, and then a load increment will be added. Studies will be conducted to see how many more readings must be taken daily after the 24-hour readings until primary consolidation is complete as determined by the time-consolidation curve.
(5) Loading schedule to recommend: The loading schedule recommended by ASTM D-2435 is most unlikely to follow for the very soft dredged soils. Studies will be done on the EM 1110-2-1906 recommended loading schedule: 0.005, 0.01, 0.025, 0.05, 0.10, 0.25, 0.50, and 1.00 tsf. The first load increment should depend on the weight of the top porous stone, loading column, and dial gage force. After the last load is applied, it needs to figure out the percentage of total consolidation. Conventionally, 50% of consolidation must be completed after the last load is applied.
(6) Research will be done on whether or not a specific gravity test should be accomplished for the actual material consolidated, since calculations are very sensitive to this value and typical estimated values may lead to significant error.

- Pre-consolidation pressure P_c', compression index C_c and swelling index C_s will be obtained following ASTM D-2435 and EM_1110-1-1904. The parameters will be utilized to make predictions for the marshland subsidence, respectively. The predictions will be compared with the field monitored subsidence in some CPRA-run marsh creation projects, and see which prediction is closer to field subsidence measurements.
- Research will be conducted on the correlations between compression index C_c and soil properties, such as liquid limit (LL), specific gravity (Gs), and initial void ratio (e_0). Empirical relationships will be studied as well between compression index C_c and swelling index C_s.
- Coefficient of consolidation (C_v) vs. consolidation pressure (P) from t_{50} and t_{90} will be plotted, respectively. The curves that are specifically for very soft dredged soils will be investigated by comparing them with stiffer fill materials.
- If field test data, such as CPT or/and SPT data are available at the soil sampling sites, the CPT or/and SPT data will be employed to find pre-consolidation pressure P_c', over-consolidation ratio (OCR). The results will be compared with the laboratory test results, and see if verifications could be made.

How this research is of interest to the Coastal Protection and Restoration Authority (CPRA) and how it fits within the 2017 CPRA Master Plan?

The research outcome will come up with a low-pressure consolidation test standard. It will be directly implemented to test dredged soft fills for the marsh creation projects run by CPRA.

Deliverable

Detailed procedures to perform low-pressure consolidation test following the ASTM standard.

Expertise

Dr. Wang is a professor at Louisiana Tech. He is a Louisiana registered civil engineer with 30-year extensive experiences in soils, slope stability and foundation engineering. Since year 2010, Dr. Wang has been working on the collaborative research with CPRA on the marsh creation projects.