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REVIEW

Laboratory simulation of field preloading on Jizan sabkha soil

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Abstract Jizan sabkha soil is characterized by being highly compressible with low bearing capacity. It cannot support a structure load without soil improvement. Preloading by embankment fill is one of the practical and economical methods to enhance the sabkha soil properties. Embankment fill of 3 m high with a pressure intensity of about 50 kPa is found to be adequate to achieve the required improvement. Simulation of preloading by laboratory consolidation test following a special loading sequence reasonably approximates the field settlement. The predicted settlement based on consolidation results is found to be close to the directly measured field settlement using the preloading technique. The pressure intensity and time of loading by embankment fill can be predicted by laboratory testing. In this research, the embankment preloading using a 3 m fill applied in two or three stages and sustained for about 6 months is found to be effective to improve the soft sabkha properties.

Contents

1. Introduction

Salt flat or sabkhas are salt bearing arid climate sediments covering vast areas of the coast of Middle Eastern and Northern African regions. The development of this material is due to low wave energy allowing the settlement of silt and

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clay particles to take place and then be loosely cemented by soluble material (Fookes, 1978; Akili, 1981; James and Little, 1994). Generally, sabkha sediments are characterized by high void ratio and low bearing capacity. Accordingly, upon loading on such soil significant consolidation settlement in the saturated sabkha takes place.

In Saudi Arabia, sabkha predominates in large areas along the coast of the Red Sea and Arabian Gulf. The urban development has led to the establishment of major projects such as multistory buildings, bridges, and highways in these regions. Jizan area in the Southern Western cost along the Red Sea is among the regions which were developed in the recent years.

The typical sabkha soil profile in Jizan consists of three layers, these are; the sabkha crust, the soft sabkha, and the sabkha base. The sabkha crust is very high salt bearing silty sand soil periodically subjected to welting and drying by sea water. During dry seasons the sabkha crust is relatively hard, however, upon welting the soil becomes very soft. Accordingly, this layer is unstable, and hence unsuitable as a foundation material. Therefore, it must be removed prior to any foundation construction. Soft sabkha underlying the crust is generally saturated sandy silt to silty clay deposit, with thickness averaging around 8 meters. Below the soft sabkha there is what is known as the sabkha base consisting of medium dense to very dense fine sand. Fig. 1 illustrates a typical soil profile in sabkha formation. A representation of cross-section of Jizan region is given in Fig. 2, (Dhowian et al., 1987). The cross-section indicates that Jizan town is situated on an elevated terrain underlain by a salt dome measuring an area of about 4 km^2, and reaching about 50 m above the sea level. Old Jizan town has been established on the elevated terrain whereby light structures, and one story buildings were used to be constructed on the terrain. However, upon development heavier structures built on the terrain suffered major damages due to large foundation settlement and failure as a result of dissolving the salt by percolating water rending them unlivable and thereby be demolished.

Recent development concentrated on soft sabkha area. However, this soil in its natural condition cannot be used as a foundation material due to its low bearing capacity and high compressibility. This behavior can be depicted from Fig. 1 where the recorded N-value, standard penetration test, is ranging between 1 and 6. Thus, the low load bearing sabkha cannot tolerate even light structures. The undesirable soil behavior necessitates that the soil must be treated to enhance its engineering properties prior to structural loading. Several soil treatment techniques are known in practice, including dynamic compaction, grouting, accelerated drainage, and use of reinforced fibers and geotextiles. Among the most practical methods of improving the soft sabkha mechanical properties is the preloading method in which a prescribed height of soil fill is placed at a specified density. The purpose of the preloading fill is to minimize the post construction settlement of weak and compressible soils (Aldrich, 1965; Johnson, 1970a,b; Stamatopoulos and Kotzias, 1993; Shamrani and Dhowian, 1997). Preloading technique to improve sabkha behavior in Jizan area has been done by Dhowian and Erol (1993), whereby an experimental station measuring 25 m × 25 m was established on the soft sabkha, and loaded by a fill of 3 m. The settlement of the soil was monitored for about 54 weeks.

Field investigation of the effectiveness of preloading method using embankment fill to improve the soil properties, however, poses some difficulties that may limit its use. Accordingly, field experimental station is difficult to construct for every area in the region. Among the problems associated with the field station establishment are the unavailability of the testing site as most of the representative areas are own properties, relatively costly instrumentation, measuring equipment, and monitoring of the field parameters by technical team. Therefore, a laboratory testing program may be adopted to simulate

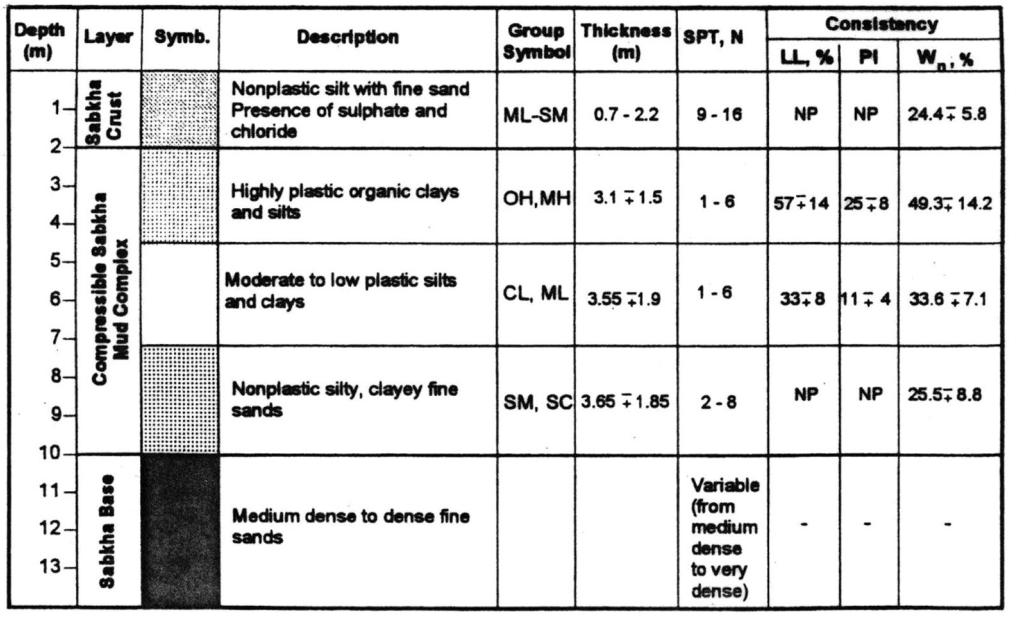

Figure 1 Typical soil profile in sabkha formation.