Estimating Geotechnical Design Pararmeters of Improved Soil by the Preloading Method Using Instrumentation Results and Numerical Approach- a Case Study

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1-Introduction

Before construction of engineering structures on compressible soft soils, it is inevitable to improve and modify these soils to prevent large unpredictable settlements resulting in damage to the structure. "Preloading" is a method widely used in soil improvement that dates back to the 1930s and earlier. It is a simple and economic method of increasing the strength parameters of saturated fine-grained soft soils. Easy implementation, monitoring and measuring the settlement of the ground using instrumentation and checking the behavior of this method during the procedure are among the advantages of this method. The preloading approach can be applied using radial drainage to enhance consolidation settlement rate, and without radial drainage by either embankment or vacuum. In general, soft clayey soils require a long time for settlement consolidation due to their low permeability. To increase the consolidation rate in these soils, radial drains are installed beneath the soil.

These drains cause artificial drainage paths under clay soils that increase the rate of the consolidation process by curtailing the drainage path, which in turn will rapidly increase the strength of the soil, increasing the capacity of bearing new load on the soil.

In this regard, in order to improve subsurface soft saturated clayey layers under the oil storage tanks in the Mahshahr project, the preloading method is assessed in this paper. In this case,we used embankment along with prefabricated vertical drains (PVDs) with a triangular pattern Considering the different layers of soil and subsurface conditions at the project site of Mahshahr oil depot and compressible layers located in relatively large depths, the improvement extent has been high to modify soil characteristics in order to avoid soil settlement and failure due to the application of high loads from the tanks. The inaccuracy of embankment settlement estimates and the prolonged preloading operations are among the challenges of soil improvement using preloading. Therefore, proper selection of soil parameters including effective parameters in consolidation settlement values (C_s, C_c and P_c) and soil consolidation time (K_h and K_v) can address preloading as a viable and practical option for soil improvement.

In this paper, back-analysis results of instrument data have been compared using Plaxis 3D software for EM-2B embankment (Figure.1), and the initial effective geotechnical parameters obtained from laboratory and field experiments have been modified using this method. Using the modified results of this study can help usto successfully evaluate and control the design of the mentioned project.

Fig 1. EM-2B embankment

2-Methodology

In order to perform numerical modeling, the Plaxis 3D software based on Finite Element Method has been used. This software was used to examine consolidation settlement according to Biot's theory formulations. For three-dimensional modeling of the embankment, the dimensions of both sides of the embankment must be set so that the actual ground conditions are considered with the least impact on the general behavior of the model. The embankment height of EM-2B is 14.6m. In order to determine the boundary conditions, three times the base of the embankment is considered from both sides of the model, and for the height of the geotechnical region influenced by the creation of the embankment which has been modeled in the program, a height equivalent to 60m has been considered based on bore holes data. Figure 2 shows the numerical modeling of the EM-2B embankment in the Plaxis 3D sofware. Besides, for the soil behavior the Soft Soil Creep is taken into account.

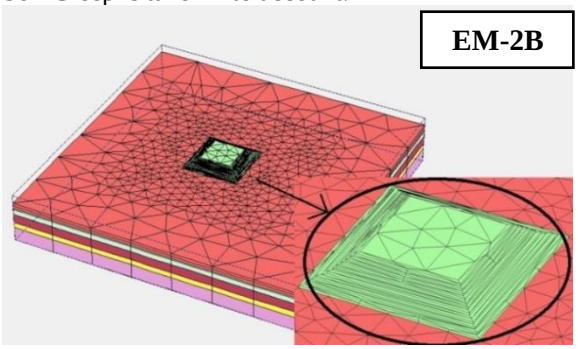

Fig 2. Three-dimensional modeling using Plaxis 3D Software

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In order to simulate drains, the Chai et al. method has been used. In this method, the equivalent permeability for drain zones is considered. Hence, based on back-analysis results, the value of C_f (the permeability ratio of site to laboratory) reaches 8. In addition, (C_c) and (P_c) are modified with with 0.12 and 190 kPa values in the software, respectively. Finally, the modified soil parameters are presented in Table 1.

Table 1. Back-analysis results of consolidation parameters of EM-2B

	K_h (CL-2) (m/day)	K_v (CL-2) (m/day)	C_f (CL-2)	C_c (CL-1)	Pc (CL-1-1) (kPa)
Plaxis 3D (After Preloading)	0.021	0.0104	8	0.12	190
Initial Design Parameters (Before Preloading)	0.0026	0.0013	…..	0.17	180

According to the initial designs, for example, recorded value of the settlement in the center of the EM-2B settlement is approximately 122.2cm, while the settlement calculated in the center of the EM-2B embankment has been 132cm. Therefore, initial values of calculated settlement based on assumed parameters were higher than the measured values of settlement.
Lower values of measured settlements relative to calculated settlements can be attributed to the conservative determination of geotechnical parameters for settlement calculations. Besides, soil settlement induced by oil tanks has been compared before and after preloading based on modified soil parameters. The obtained simulation results indicated that after removing the embankment and construction of the oil tank during 30 days, the final settlement value reached about 9 cm.

3- Concluding Remarks

In this research, the numerical modeling of soil consolidation has been discussed using the pre-loading method with radial drainages in the Mahshahr oil depot as a case study. In this regard, back-analysis using instrumentation results was conducted by using the Plaxis 3D software based on the finite element method, and the results were compared with each other. The basic geotechnical parameters obtained by laboratory and field experiments have been modified using the above mentioned method. The results obtained from the analysis indicate that settlement values from the instrument data were less than the results obtained from back-analysis. Indeed, the effective laboratory parameters intended for primary calculations of consolidation settlement values of the soil (C_c and P_c) were more and less than the actual measured values, respectively, and the effective laboratory parameters intended for time of soil consolidation calculations (K_h and K_v) were lower than the actual measured values. Finally, soil settlement indued by oil tanks was compared before and after preloading, and it was found that using this method for soil improvement can be very efficient in large-scale projects.