

SMALL SCALE FIELD TESTS OF WATER INFILTRATION FOR COMPACTED SILTY LOESS SOIL

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ABSTRACT

Silty loess soils are widely spread on Córdoba city, Argentina. The ability to use this soil improved by compaction on embankments it is of interest to different types of local constructions, with purpose of reducing settlements and infiltration. This work research the water infiltration through compacted silty soils from Córdoba by small scale field test. Four small test embankments were constructed on natural soil with different compaction conditions using local silty soils. The site was characterized by typical geotechnical laboratory and field tests. The infiltration tests were performed using double ring infiltrometers for a time period around of 2 months. Results were used to field permeability estimated (k_f) and these were compared with laboratory results (k_l). Conclusions regarding the behavior observed in the field are presented.

Keywords: Embankment Test, Double Ring Infiltrimeters, Site Investigation, Córdoba Soil

INTRODUCTION

Compacted soils are frequently used for different engineering project. Soils excavated from nearest works may be utilized for embankment construction. This is an economic and sustainable alternative, but data are needed to characterize the mechanical and hydraulic performance of the material. Lagoons and other waterworks, require barrier systems generally include layers of compacted soil. In these cases it is of interest to determine the infiltration of water. Permeability tests are generally performed on samples in laboratory compaction molds, or undisturbed samples. However, these tests do not take into account possible effects of scale which can be noticed through large-scale laboratory [1] or field test [2], [3], [4]. The study presented in [5] explores, by laboratory and field test, the possibility uses of silty soil as landfill liner material. A test pad was constructed in field using different soil composition and different compaction effort. Sealed double ring infiltrometers were employed to hydraulic conductivity determination. Differences between the results of hydraulic conductivity obtained from laboratory and field were found. Laboratory values were lower [5].

This work research the field water infiltration through compacted silty soils from Córdoba [6], [7], [8]. Four small test embankments were constructed on natural soil with different compaction conditions using local silty soils. The site was characterized by typical geotechnical laboratory and field tests. The infiltration tests were performed using double ring infiltrometers. The results show the effect of scale compared with previous laboratory data on these soils, and the effect on field compaction conditions.

MATERIAL AND METHOD

Soil used in laboratory and field experiments was a silty loess from Cordoba. The Table 1 reports principal properties.

Table 1 Properties of liner soil

Properties	Unit	Value
Liquid limit	%	26.7
Plasticity index	%	4.3
Fines (<0.074mm)	%	97
Fraction <0.002mm	%	5
Specific gravity		2.67
Class (ASTM D2487)		ML
Max dry unit weight	kN/m ³	16.8
Optimal water content	%	19

Note: max dry unit weight and optimal water content are for Standard Proctor (ASTM D698).

For field infiltration test a small probe fills was constructed in the Universidad Tecnológica Nacional campus located on City Southern Cordoba City. The selected site was gated. The position of each cell was set and then excavations were undertaken (Fig. 1). For the excavation, a dimension plan of 1 m by 1 m was adopted and 0.55 m in thickness.

Soils excavations were scrapped because these contained many roots. Silty local materials were used, in depths of 3-5 m, in order to avoid impurities (Table 1), and prepared carefully to remove clods and mix well with added water. The construction of the cells was performed under controlled compacted soil layers. Each layer was compacted by dynamic

impacts. The compaction condition was controlled by the number of blows applied. Control tests as DCP (dynamic cone penetrometer) and in place unit weight were performed (Fig. 2).



Fig. 1 Construction stage.

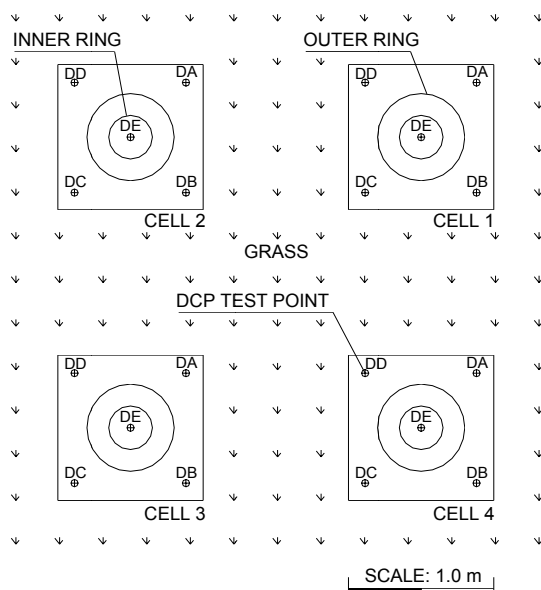


Fig. 2 Location sketch of cell.

Results of in place unit weight test were 13.3 kN/m^3 (Cell 1), 15.8 kN/m^3 (Cell 2), 14.5 kN/m^3 (Cell 3), 15.2 kN/m^3 (Cell 4). Relating to Standard Proctor the relative compaction were 79% (Cell 1), 94% (Cell 2), 86% (Cell 3), 90% (Cell 4). These values can be easily achieved in construction practice. Figure 3 shows DCP test results. Generally, a first surface layer of 5 cm with relatively low compaction is observed, then the embankment with a thickness of approximately 50 cm, followed by a layer of compacted natural soil to 65 or 70 cm deep. Finally, natural soil not affected by compaction, with a DCP index of 30 mm/blow is detected.

The infiltration tests were performed using

double ring infiltrometer. Inner ring of 30 cm diameter and outer ring of 60 cm were used. The water level was preserved approximately constant with a height of 5 cm. During the test progress, a waterproof cover was installed on each cell to prevent from rain event (Fig. 4). Additionally, a container for controlling evaporation occurred during the test was used. This determination not intended to provide weather information, it was made only for the purpose of correcting the volume of water infiltrated into the ring.

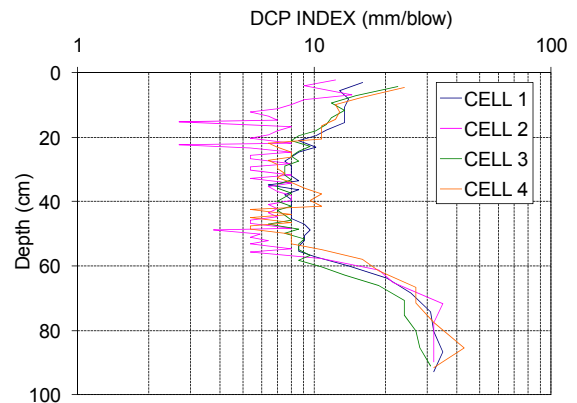


Fig. 3 DCP test results.

Infiltration tests were conducted at the site on the natural soil without compacting, in order to assess the influence of compaction. For this, the rings were installed on a prepared surface where it was removed coverage of grass and roots.



Fig. 4 Test in progress.

RESULTS AND ANALYSIS

Measurements of water infiltration into the natural silty soil are shown in Fig. 5. To analyze the results the infiltration rate (I_f) is adopted. Eq. (1) presents the formulation for field infiltration rate calculation.

$$I_r = \frac{\Delta V(t)}{\Delta t \cdot A} \quad (1)$$

Where ΔV : volume infiltrate during time Δt , A : inner ring area.

For natural silty soil the I_r results 2×10^{-6} m/s. This value characterizes the material located beneath the cells with compacted soil.

In the case of the compacted soil a correction was made for the infiltrate water, due the long test duration, and consequently the evaporation effect. Fig. 6 shows results of evaporation control test. In simplified form, a constant correction factor of 5.2 mm/day was adopted.

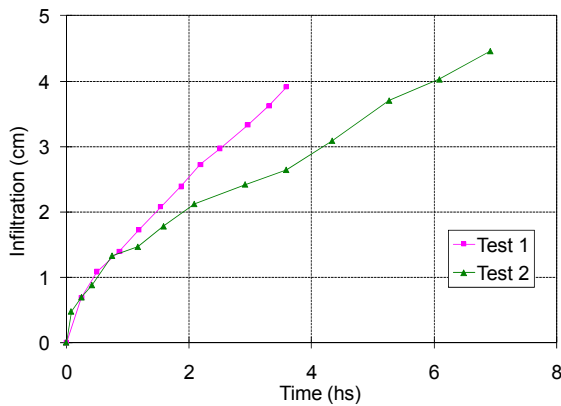


Fig. 5 Field infiltration test on natural silty soil.

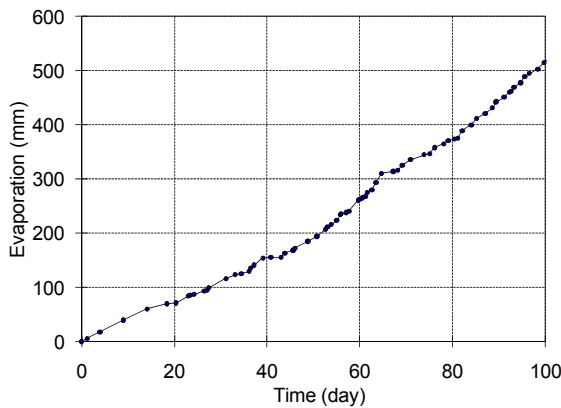


Fig. 6 Evaporation control test.

Fig. 7 shows corrected results of field infiltration test from cells. For compacted silty soil the I_r results 2.0×10^{-7} m/s (Cell 1), 9.8×10^{-8} m/s (Cell 2), 2.4×10^{-7} m/s (Cell 3), 1.7×10^{-7} m/s (Cell 4).

The comparison of results is performed by a factor relating infiltration rate of two cases (Eq. 2). Thus, η results 2.4 for cells 2 and 1. Comparing natural silty soil relative to the improvement by compaction, values for η between 8 to 20.

Concerning results of laboratory tests on samples compacted under similar conditions can be observed that in field values are similar without a clear scale effect.

$$\eta = \frac{I_{r1}}{I_{r2}} \quad (2)$$

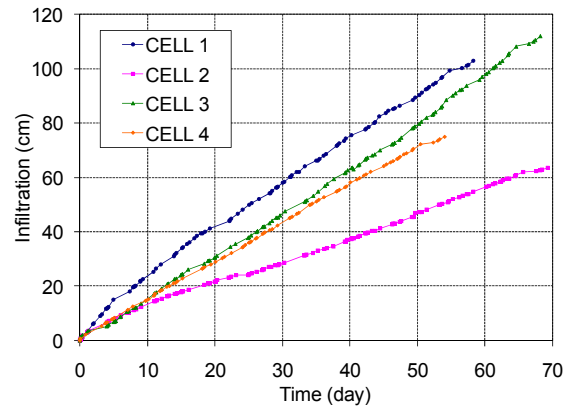


Fig. 7 Field infiltration test on compacted silty soil.

CONCLUSION

In this paper, an experimental study of field infiltration tests on small silty soil compacted embankments is presented. The embankments were prepared under controlled compaction conditions. Cells were protected from the rain and the effect of water evaporation was contemplated due to the long test duration.

Compaction provides improved hydraulic performance, considerably reducing the rate of infiltration respect the natural soil. The condition of compaction affected the results. The greater relative compaction (Cell 2) determined the lowest cumulative infiltration, while the cell with lower relative compaction (Cell 1) presented the highest cumulative infiltration. Field results were similar to available laboratory compaction by similar conditions.

Despite soil compaction, the infiltration rate may be high for many project.

It could increase the relative compaction or incorporate some added material in order to attempt to reduce the infiltration rate. However, this work is one of the few local experiences with field infiltration tests on compacted silty soil. So, more embankments tests are needed in order to reach conclusions of general behavior.

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