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Use of Surcharges as Treatment of Residual Soil Foundation—A Case History

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SYNOPSIS Predetermined locations for storage of leaching materials needed total warranty against cracking as result of differential settlements,

Two stockpiles had to be located on a platform, one placed in area of low height cuts of unsaturated residual soils, the other over fills placed without compaction criteria over saturated clayey soils of low consistency.

It was decided to preload the platform in order to minimize future absolute and differential settlements, reducing them to allowable limits.

The systematic interpretation of the instrumentation allowed the optimization of the treatment.

The behaviour during unloading of the soils indicated heaves much smaller than the limits preestablished.

INTRODUCTION

The scope of the present paper is to show the advantages of pre-loading a highly heterogeneous soil profile in order to guarantee the behaviour of a foundation within strict admissible settlement limits.

Data is also presented to demonstrate the almost negligible heave during unloading of these unsaturated natural and uncompacted fills.

DESCRIPTION OF THE PROBLEM

The problem to be dealt with was to provide safe foundations for 13 meters high stock piles of soluble and toxic material. The stockpiles had to be located partly in fill and partly in cut and had to be found in an unfissured foundation in order to prevent long term contamination of the water table (see Fig,1).

The engineers were asked to design a foundation with very strict differential settlement criteria, despite the ciclic and heterogeneous loading imposed by the handling of the ore.

Considering the characteristics of the job it was decided to preload the platform using material coming from the stripping of the mine rather than any concept of a structural slab with deep foundations,

GEOLOGICAL-GEOTECHNICAL DESCRIPTION OF THE SITE

The soil exposed by and worked with in the earthmoving was a saprolite originated for the intemperization of pre-cambrian gneisses.

The deepest cuts, located towards the north of the platform were 30 meters deep and just reached the water-table. Fills up to 12 meter deep had been constructed without any strict specification and inspection; the contractor had just been asked to remove the upper layer (= 50 centimeters) of vegetal soil, lay down the fill in layers and compact it with homogeneously distributed traffic of the transport equipment.

Before the earthmoving, after the earthmoving and after the removal of the preload percussion boreholes with blow counts following the Standart Penetration Test procedures were done in the area and the results are summarized in figure 2.

The N value data before loading showed an expected heterogeneity in the cut and a homogeneity in the fill area. It also indicated that the removal of the superficial layer of vegetal soil had been properly done before the earthmoving.

The advantages of the treatment can be easily seen in the mentioned figure, as well as the tendencies of influence of rod lengths, etc... as positioned by de Mello, V. (1971).

ESTIMATIVES OF SETTLEMENTS FOR OPERATIONAL LOADING OF THE STOCKPILES

In order to estimate settlements during handling of the ore in the stockpiles it was needed to access the necessary soil parameters (pc, Cc, Ce and E').

Previous experience of the engineers indicated that in saprolites values of the coefficient of compression Cc can be safely estimated as a function of the liquid limit LL. The preconsolidation pressure pc can be estimated from the subsoil profile, previous to the earthmoving, correlated to the N values (de Mello, V-1972; VFBM, 1977).

The oedometer type, e vs. log p, curves shown in figure 3 were constructed for the saprolites.

In order to estimate settlements of the area in which fill was placed, results from oedometer tests done in samples of similar profile (as correlated by soil type and N value) were also utilized.

Another procedure utilized to check the estimatives was based in available correlations of the N value with the coefficient of subgrade reaction for in situ load tests on 80cm diameter stiff plates (de Mello, V. 1971; de Mello, L.G. and Cepollina, M. 1978; Velloso, P.P.C. et al 1978).

At the same time a bibliographic research was done to determine the value of differential settlement that should be considered as a maximum permissible in order to prevent cracking of the compacted upper layer of the platform. It was decided to limit the value of differential settlements in 1:300.

Based on the characteristics of the subsoil, on the geomechanic parameters obtained and on the methodologies of the Theory of Elasticity estimatives of the settlements under the first overall loading of the area led to values of 1:120 to 1:180, therefore unaccepted.

TREATMENT OF THE FOUNDATIONS

The decision of preloading the area was taken to minimize future differential settlements.

The solution was highly appropriate due to the easily available stripping material from the adjacent mine and to the schedule of operation of the whole interprize.

Experience available from other sites indicated that settlements of the saprolites would stabilize almost instantly (de Mello, V. 1972; Garga, V.K. et al 1977; Barksdale, R.D. et al 1975) and their behaviour on the recompression curve would situate the future settlements within the required limits.

In areas filled with poorly compacted material, over a saturated clayey layer, settlements, due to the surcharge, would obviously take longer time to stabilize. Considering a surcharge 25% higher than the maximum operational load, it was anticipated that 90% of the previously previewed settlements would occur in 3 to 4 months.

Having taken the decision to preload the area, estimatives of settlements on the recompression curves of the materials were done, leading to values of the order to 1:500.

It was also decided to leave the surcharge the maximum time possible in order to minimize future settlements due to further reduction of the coefficient of recompression caused by the colapse of the soil structure with the applied load.

Considering that the site was located on a hillside, overall slope stability, including the surcharges, was checked. Two extreme conditions were calculated - end of construction of the surcharge and end of construction of the surcharge with cleft water pressure on a tension crack - for typical soil strength parameters. Figure 4 summarizes the results which demonstrated the overall stability of the site.

Estimatives of the settlement due to the surcharge were done following the same procedures previously described. Figure 5 present the results for two longitudinal profiles of the platform, one in cut and the other in fill. It can be seen that higher settlements were expected in fill area, not only due to its compressibility but also due to its foundation material.

INSTRUMENTATION AND INTERPRETATION

Instrumentation was needed in order to interpret the settlement behaviour of the platform.

Taking in consideration the characteristics of the job site, very simple instruments were installed:

a) settlement of the base of the surcharges was measured, in a number of places, with steel rods conveniently isolated from the fill and welded normally to a steel plate;

b) excess pore pressures on the foundation material under the fill was monitored with Casagrande piezometers installed 1 meter under the premanent water table.

Precision topographic survey was available at the site. A statistical analysis of 50 readings of the same instrument (MR-A1) from different topographical stations showed an accuracy of ± 1mm on the readings. The frequency of observations of settlement was determined taking this value in consideration.

Piezometers were routinely tested and showed a basic time lag smaller than 20 minutes, which was considered compatible with the expected rate of loading.

All instruments were installed before loading started.

Taking in consideration the slope stability analysis previously mentioned, the rate of loading of the platform was not specified. As soon as preloading started mining rate had to be altered and the availability of stripping material for the construction of the surcharges diminished. As a consequence the rate of loading was not as fast as it could have been.

Figures 6 to 9 present all data available for the 8 instrumented sections of the platform.

SUMMARY OF DATA AND CONCLUSIONS

Interpretation of loading and unloading data of each of the instrumented sections showed that the foundation of the platform had been improved and the operational settlements would be within allowable limits.

The data obtained demonstrated the almost instantaneous stabilization of settlements of unsaturated and saturated saprolites.

The unloading curve of the materials showed heaves much smaller than those that would be obtained when utilizing available relationship Ce = 1/8 to 1/10 Cc. In this case it was obtained a relation of Ce < 1/20, reaching values of 1/42.

It is believed that the reduction of Ce value could be associated with the silty-fine sand characteristics of the residual soil and to the time of loading, since the surcharge was kept for a period of time after dissipation of eventual excess pore water pressures. Colapse of the structure of the silty-fine sand soils, in a phenomenon similar to secondary compression, would explain the obtained values of Ce.

Another interesting information obtained is that the pattern of settlements of fill area changed abruptly at a value of load, which could be associated to it's preconsolidation pressure. The average value obtained, pc ≈ 1.2kg/cm², could be associated with compaction obtained from a homogeneous traffic distribution of earthmoving equipment.

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