Computerized tomography technique applied to geotechnical engineering

Application du tomographe pour l'ingénierie géotechnique

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ABSTRACT: This paper deals with the application of Computerized Tomography (CT) tohelp in the understanding of soil collapse. The use of CT allowed to verify the distribution of matter, water concentration, homogeneity changes in void distribution after soil collapse.

RESUME: Cette comunication present la aplication du tomographie (CT) pour aidé la compreenssiom de l'enffondrement du sol. Le usage du CT permete la verification de la repartition du masse, de la concentration de l'eau, l'homogéneité, et la variation des indices des vides aprés le effondrement du sol.

1 - INTRODUCTION

In the Western part of Brazil, there are a lot of highlands where soil collapse is causing damages to houses, buildings, roads. The most serious economical problem has been the loss of grains - soybean and corn, due to excessive settlement on those infrastructure. In a special case, silo settled around one meter and caused the loss of 400 MN of soybean. To face this problem a test programme was carried out including field tests like SPT, CPT and plate load tests. It was also introduced the computerized tomography (CT) to help understanding of soil collapse phenomena. This paper aims to show the preliminary results of CT applied to geotechnical engineering.

2 - TOMOGRAPHY

Soil tomography is based on the attenuation of a γ-ray beam. When the sample is scanned, the attenuation coefficient and spatial position are recorded. Afterwards, the image is re-built by a computer software. The attenuation coefficient is related to dry unit weight and soil moisture through correlations. The correlations depend on the material being studied and the energy to scan the sample.

Although the use of tomography is widely spread and well developed in medicine technology, the same does not apply in engineering science. The earliest application of soil CT was made by Crestana et al. (1985). They were researching bulk density and water content in soil samples. The CT state-of-the-art presented by Aylmore (1993) shows the evolution of devices used to soil physics and demonstrates in part, how the technique has been improved.

Conciani et al. (1995) reported a geotechnical use of the CT in swelling soils. At this stage a dual energy scanner was required to investigate both volume and moisture variation at the same time.

The portable CT apparatus allows the scanning of soils with maximum 30 cm in size, with 2 mm image resolution. The system consists of a ^{137}Cs radioactive source, a CdTe semiconductor detector, a mechanic and an electronic system and a battery. The equipment utilizes the scanning pattern of a first generation tomograph, where a radioactive source performs translation and rotation around a static sample.

The displayed image is a distribution of 16 gray scale, according to soil density. Black represents the lowest attenuation coefficient (air) and white the highest one (solid). The image exhibition software allows to the user obtain the unit weight in every pixel of the image, as long as the system is previously calibrated. Figure 1 shows an image of an undisturbed soil sample damaged by handling and transport. A crack that goes across the sample is indicated by the darker gray.

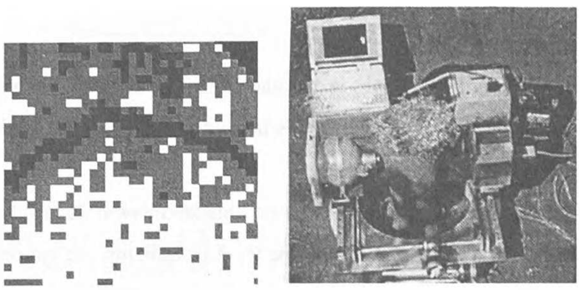

Figure 1: a) Tomographic image of soil sample with a crack. b) CT apparatus.

1.21	1.03	1.18	0.89	1.01	0.99	1.01	1.13	1.18	1.18	1.21	1.25
1.09	1.15	1.17	1.03	1.17	1.30	1.24	1.24	1.25	1.37	1.18	1.18
1.48	1.40	1.24	1.26	1.08	1.08	1.11	0.96	1.00	1.30	1.06	1.14
1.55	1.32	1.28	1.36	1.19	1.20	1.11	1.03	1.05	1.18	1.14	1.13
1.30	1.20	1.23	1.28	1.02	1.18	1.23	0.95	0.88	1.28	1.21	1.17
1.23	1.28	1.42	1.19	1.19	1.35	1.24	1.08	1.11	1.31	1.28	1.30
1.24	1.18	1.32	1.07	1.32	1.26	1.12	1.12	1.00	1.00	1.12	1.03

cluster

Figure 2: Part of a tomographic image table of values) of soil sample.

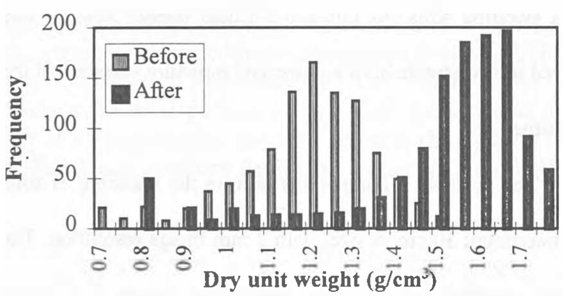

Figure 3: Histogram of dry unit weight values before and after loading

Figure 2 is part of a table of dry unit weight values obtained by tomography, showing the spatial variability of mass distribution in the scanned section. Each square cell represents a pixel of 2.5 x 2.5 mm and contains the value of unit weight. There are many informations to be pointed out from this table: the unit weight is point function, there are clusters in the soil sample with unit weight almost constant that demonstrates the soil non-homogeneities and consequntely soil anisotropy.

Figure 3 presents the histogram of dry unit weight values before and after soil collapse. The bell shape indicates a random distribution of values in the natural soil. After collapse the curve has a short dropp off around the value of 1.6 g/cm^3. This figure indicates collapse has created a top value of dry unit weight probably generated by fitting the pores of soil structure. The particles that move into void spaces has come from upper and side positions by translation and rotation.

The non-homogeneity of soil mass induces a non-uniform distribution of water. This kind of poor water distribution was detected in CT scannings performed by Aylmore (1993) and is also reported in Conciani et al. (1995). This point is important when one is measuring suction in laboratory soil specimens.

3 - FINAL REMARKS

As CT is a powerful tool for geotechnical engineering purposes, other technologies from another sciences can also be useful for the civil engineering development. In this paper, it was verified the importance of the fabric and microstructure in the soil collapse and behaviour.

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