Geotechnical Properties of Lignite

Propriétés Géotechniques de Lignite

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SYNOPSIS The test methods and results of a geotechnical investigation on a lignite deposit are presented and discussed. The main property where lignite and the interlayered clay differ, is plasticity, pure lignite being non plastic; intermediate mixtures belong to the OH group of the unified soil classification system. Strength and compressibility tests gave the same type of results for lignite as for clay.

INTRODUCTION

Project site is located alongside river Alfios, near the town of Megalopolis in southern Greece. The investigation was commissioned by the Public Power Corporation (PPC), in order to provide information for the design of a levee which must be built between the riverbed and a planned open pit lignite mine.

The levee has a maximum height of 15 meters, a length of 4 kms and a total volume of about 1,500,000 m^3. The open pit will have a depth of 60 m. A generalized tentative section through the levee and the mine is shown in Figure 1. The main purpose of the investigation was to check the stability of the slope formed by the levee and the open cut of the mine and to estimate the settlement of the levee.

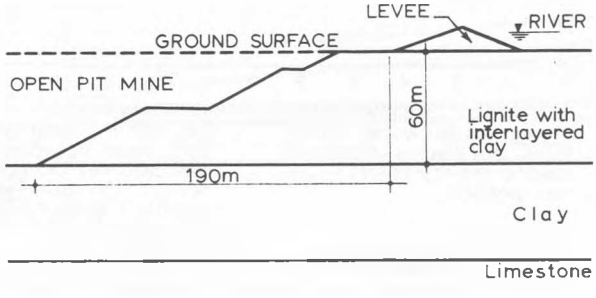


Fig.1 Section of Levee and Mine

SAMPLES

The lignite is found interlayered with clay. Both materials were sampled with the split tube sampler used for standard penetration tests (ASTM D 1586), with singls tube core barrel and also by driving into the soil a sampler with PVC liner, by blows of the same energy as in the standard penetration test. The liner was 1.5mm thick and had an inside diameter of 72 mm. Samples taken in this type of liner were used for oedometer and triaxial compression tests.

DIFFERENTIATION BETWEEN LIGNITE AND ORGANIC CLAY

In addition to pure lignite and pure clay, the subsurface included also mixtures of these two materials in varying proportions. The question, therefore, arose of how to distinguish between "lignite" and "clay". The differentiation which was being used prior to the geotechnical investigation depended on the value of the deposit as fuel for the nearby thermal plant of the PPC. In this investigation the distinction between "lignite" and "clay" was based partly on macroscopic examination and partly on the results of classification tests. Lumpy material that tended to become more fine grained as it was being sieved, and with such liquid and plastic limits that it plotted well below the A-line in the plasticity chart (Fig.2), was called "lignite"; otherwise it was called "clay".

Classification tests were performed according to the standard ASTM methods, despite the realization that in many cases a considerable fraction of the organic phase of the specimens being tested was lost by burning. For exemple, in the determination of the specific gravity and the natural water content, part of the mass was lost during exposure to the specified temperature of 110°C.

RESULTS OF CLASSIFICATION TESTS

Lignite was not amenable to sieve analysis because the resulting grainsize distribution depended more on the method of specimen preparation and the duration of sieving, than on the

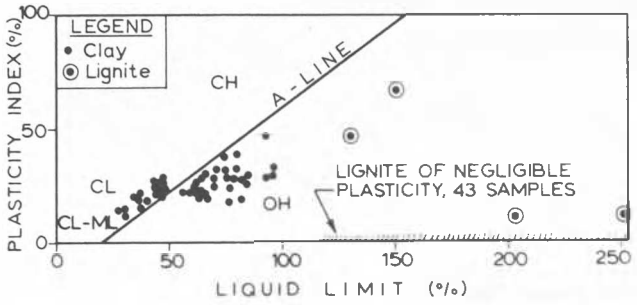


Fig.2 Plasticity Chart Showing Differentiation between Lignite and Interlayered Clay

nature of the material itself. Also, pure lignite could not be tested for liquid and plastic limits, being non plastic and lumpy. Mixtures of lignite and clay became more and more plastic with increasing clay content and had Atterberg limits corresponding to the OH region of the plasticity chart (Fig.2).

Water content varied over a wide range of values, being about 30% for a typical clay and about 180% for a typical lignite, the borderline cases ranging between about 100% and 130% (Fig.3). The specific gravity of the typicel lignite was 1.7 and of the typical clay 2.7 and it is noteworthy that the specific gravity correlates strongly with the natural water content (Fig.4).

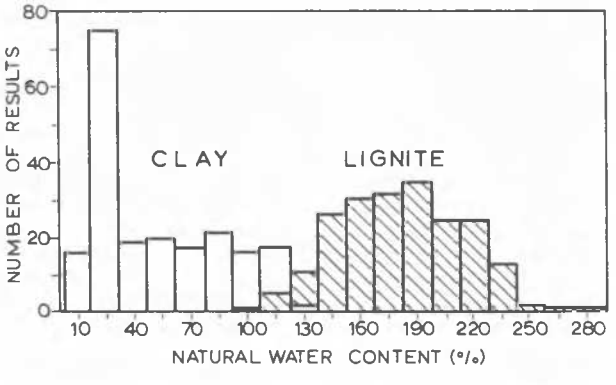


Fig.3 Histogram of Natural Water Content

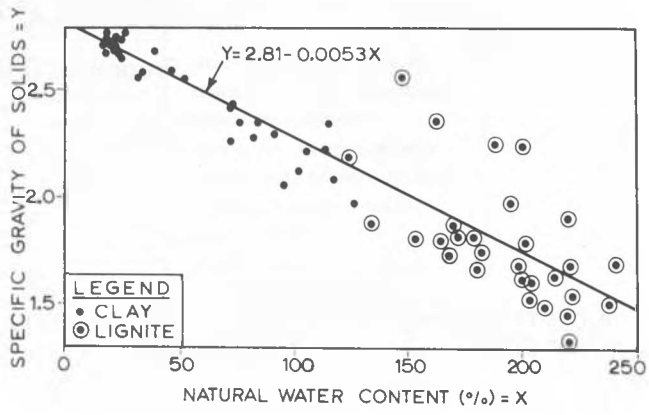
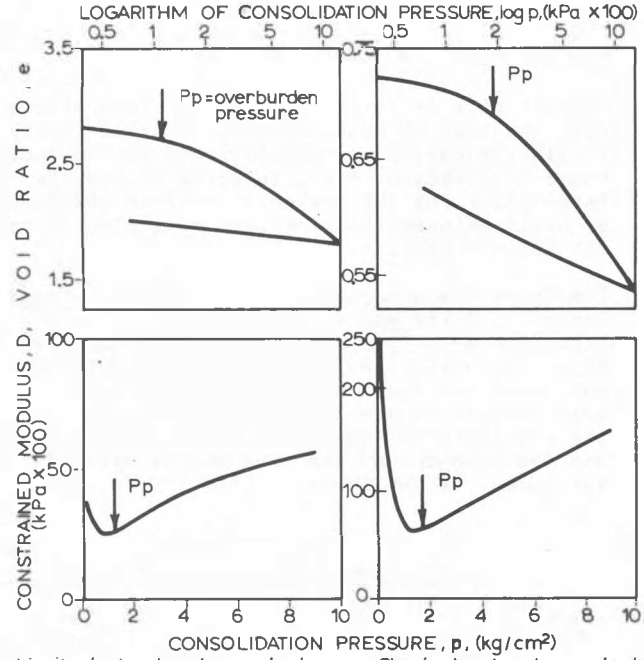


Fig.4 The Specific Gravity Correlates Strongly with the Natural Water Content. The Coefficient of Correlation Equals 0.92



Lignite (natural water content = 155%, dry density = 470 kg/m³, specific gravity of solids = 1.82, non plastic)

Clay (natural water content = 26%, liquid limit = 54%, plasticity index = 33%, dry density = 1540 kg/m³ specific gravity of solids = 2.73, % grains smaller than 0.002 mm = 52)

Fig.5 Compression and Compressibility. Curves for Typical Samples of Lignite and Clay

COMPRESSIBILITY AND STRENGTH

The compressibility of samples of lignite and clay was measured by carrying out oedometer tests. The plots of the void ratio e against the logarithm of the consolidation pressure p and of the constrained modulus D ($D = \Delta p/\Delta s$ where s = unit strain) against p have about the same shape for typical lignite as for typical clay (Fig.5). From each plot of D against p the value of D corresponding to p = natural overburden pressure +50 kPa was singled out and taken as the compressibility of the sample (a more complete explanation of this procedure appears in references (1) and (2)). The compressibility, thus determined, correlates with water content over a range of values between 20% and 230% and shows continuity between lignite and clay (Fig.6). The

value of the coefficient of correlation of 0.70 is indicative of a relatively strong correlation. This correlation is in agreement with the first part of the correlation published previously (Ref.1), but beyond a value of water content of about 35%, it gives higher values of compressibility.

When tested for unconsolidated undrained triexial compressive strength, the results obtained with the lignite were found to be comparable to those obtained with the clay (Fig.7). The same is true for consolidated drained tests (Fig.8).

The results of standard penetration tests presented in Figure 9, show considerable similarity (statistically) between results obtained in clay layers and results obtained in lignite layers.

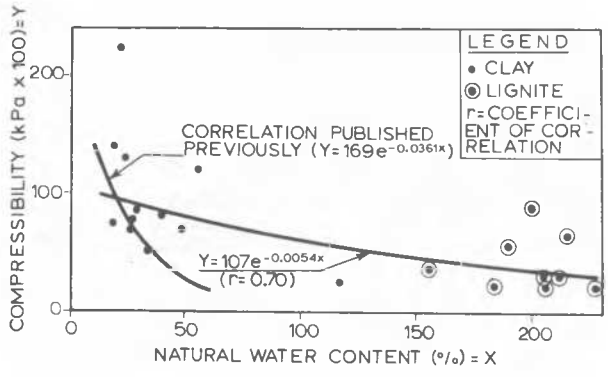


Fig.6 Compressibility versus Natural Water Content

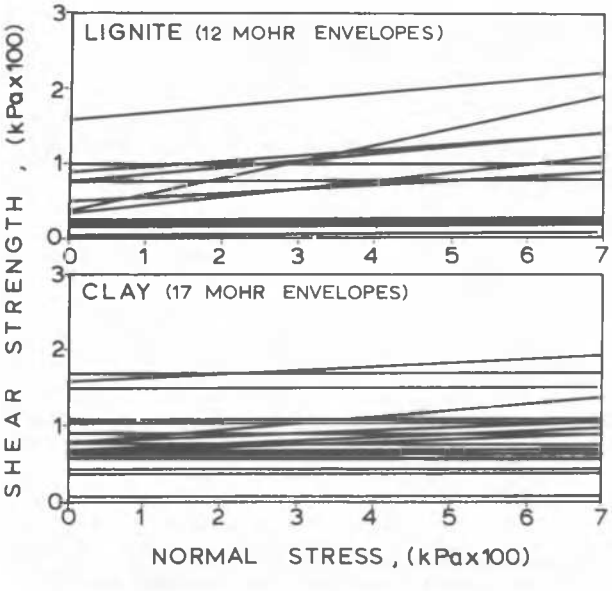


Fig.7 Results of Unconsolidated Undrained Triaxial Tests

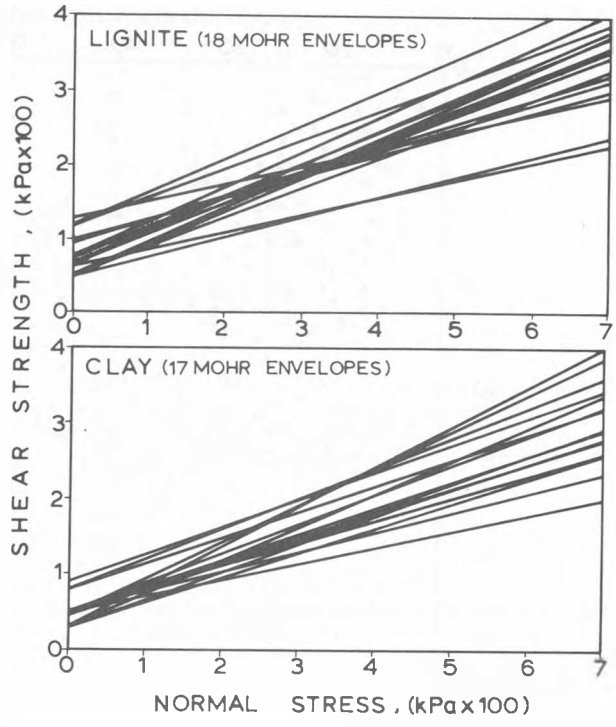


Fig.8 Results of Drained Triaxial Tests

SETTLEMENT RECORDS

A 9 m high embankment was built in 1969 within about 100 m from the area of investigations. Between the time of completion and March 1979, the PPC recorded settlements of 0.22 m to 0.40 m at various points of the crest of the embankment. By assuming that soil layers under the embankment are as indicated in the nearest boring, it was estimated that the average compressibility of the lignite is about 18,000 kPa.

CONCLUSIONS

The lignite investigated near Megalopolis was sampled and tested by the same methods as normally applied to soils. The main difference in geotechnical properties between lignite and the interlayered clay is that pure lignite is non plastic. There is, however, a gradual transition of plasticity between lignite and clay, the intermediate mixtures belonging to the OH group of the unified soil classification system. Measurements of compressibility by the oedometer test and of strength by the triexial test gave the same type of results for the lignite as for the interlayered clay. The correlation between compressibility and water content is continuous for lignite and clay. Also, the results of standard penetration tests were about the same for lignite and clay.

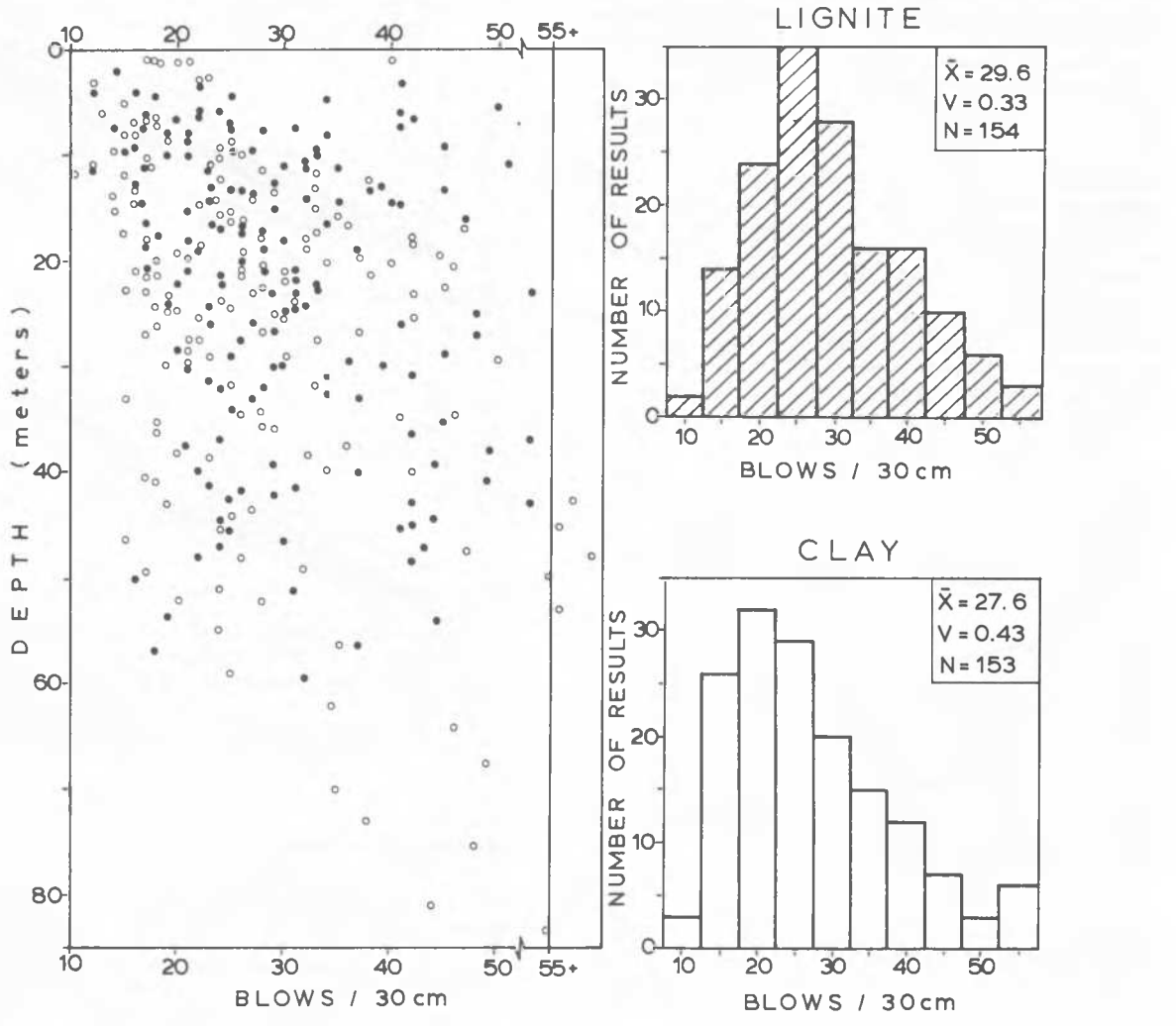


Fig.9 The Results of Standard Penetration Tests are Practically the Same for Lignite and Clay ($\bar{X}$ = mean value, v = coefficient of variation, N = total number of samples)

The modulus of compressibility of lignite derived from settlement records is about 4 times higher than the corresponding value derived from oedometer tests.

ACKNOWLEDGEMENT

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