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EFFECT OF SAMPLING DISTURBANCE ON SOIL DENSITY

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SYNOPSIS

An important phase of any major site investigation is the acquisition of high quality undisturbed samples of the sub-surface materials. Laboratory works have been carried out to simulate the to-date sampling process of the sub-surface soils in the fields. An investigation on the effect of sampling disturbance in terms of the soil density has been made with two sampling tubes of different wall thickness. The soil density from the driven sampling tubes was compared with the original soil density using remoulded residual soil prepared by different compaction operations. Two types of residual soils found in certain parts of Hong Kong, namely, decomposed granite and decomposed volcanics, were tested in the remoulded state under a range of various moisture contents. From an engineering point of view, the laboratory results obtained indicate that this sampling process yields very good samples of medium dense soils, but tends to densify loose soils and loosen dense soils. A correlation of dry densities was obtained between the remoulded and the sampled soils in various sampling conditions, i.e., moisture content, wall thickness of the sampling tube, density, etc.

INTRODUCTION

The need for high quality undisturbed samples of cohesionless soils has been highlighted in recent years. Consequently, it is necessary to preserve as closely as possible both the in-situ density and the in-situ soil structure, being two separate and distinct properties of the soil, including grain-to-grain contacts, with a minimum of disturbance. There is hardly any truly undisturbed sample, primarily for two reasons : (1) a sampling tube displaces a certain amount of soils, which inevitably produces strain and some disturbance of the sample; and (2) the state of stress in the soil sample undergoes a complex, and to some degree indeterminate, history of change during the sampling, handling, shipping, storage, extrusion, specimen preparation, and laboratory set-up processes. The in-situ state of stress, stress history, and state of stress in the sample are seldom known accurately. (Hvorslev, 1980).

In this study the disturbance effect in terms of the dry density is evaluated. Laboratory testing is carried out to simulate the sampling process of the sub-surface soils in the field. The soil density from the driven sampling tubes is compared with

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the original soil density using remoulded residual soils. A range of original soil densities can be obtained by using different compaction procedures, i.e. different compaction machine and different numbers of blows. Two sampling tubes having the same diameter but different wall thickness are used to examine the sampling disturbance effect. In addition, the effect of varying the moisture content is investigated.

TESTED SOILS

The main soil types encountered in Hong Kong are the residual soils, decomposed granite and decomposed volcanics; the marine deposits, soft normally consolidated clays and loose to dense sands; and the older alluvium, firm to stiff preconsolidated clays and clayey sands are also occasionally found. Detailed information regarding Hong Kong residual soils can be found in Lumb (1962 & 1965). These soil types were used in the laboratory testing procedures.

CAUSES OF SAMPLE DISTURBANCE

It is impossible to obtain a completely undisturbed sample, since the act of sampling inevitably disturbs the soil to some extent. The sample disturbance occurs principally due to the boring process, driving the sample tool, withdrawing the sampling tool, and the relief of stress in the soil. (Marcuson & Franklin, 1980) Fig. 1 illustrates the typical forces acting during the sampling operation.

The disturbance caused in driving the sampling tool depends on the thickness of the tube and the manner in which it is driven. A thin-walled sampler causes much less disturbance, but is easily damaged. The least disturbance is caused when the sampler is driven in by steady pressure but for stiff soils, this requires the provision of a secure anchorage. For routine investigations, the tool is usually driven down by blows from a monkey.

DISTURBANCE OF SOIL SAMPLES

The factors which lead to disturbance of the soil samples are : change in stress conditions, change in water content and void ratio, chemical changes, and mixing and segregation of soil constituents. The influence of these disturbances on the results of laboratory tests depends not only on the type and degree of disturbance but also on the characters of the soil. The effects of this disturbance are often variable.

EXPERIMENTAL WORKS INVOLVED

The laboratory testing procedure comprises two parts: compaction and sampling.

Compaction

The soil is compacted in five layers of approximately equal mass over a range of moisture content from about 12 percent to 21 percent, the range normally encountered in the field in Hong Kong. Different compaction efforts have been obtained by varying the number of blows of drop, between 0 and 25 blows per layer, from a constant height of 300 mm above the soil of the standard 2.5 kg hammer. (Anon, B.S. 1377:1975)

Sampling

Two different soil samplers (having different wall thickness) were used. The sample tool was usually well oiled inside and out to reduce friction, and was clear from any soil particles left from previous trials. The metal cap was placed on the blunt end of the sampling tube for protection during the driving process. They were lowered on the central part of the soil surface compacted inside the CBR mould and pushed slowly into the soil by hand. The tool was forced into the soil either by blows

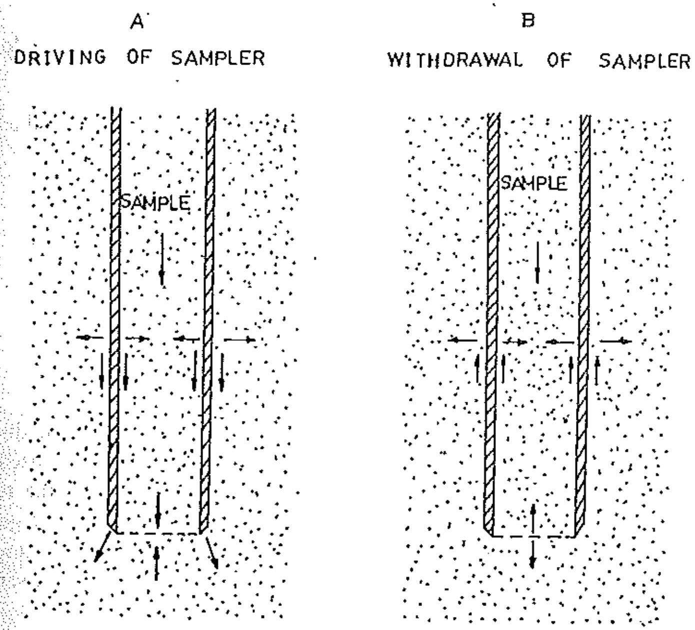

Fig. 1 Forces acting during the drive sampling operation.

from a hammer, or by jacking. Although jacking is preferable, good quality samples were still obtained by careful driving and serious remoulding of the sample was not caused. The distance to which the tool was driven was checked to avoid undue soil compression in the sampler by the cap.

After driving, with the cap removed, metal rods were put into the holes on the blunt end. They were rotated to break off the core and the sampler was carefully withdrawn. The soil sample was removed from the tube by means of an extrusion machine. The length and weight of the sample were then measured. The weight of both the soil left inside the CBR mould and the soil sample was determined. A representative sample of the specimen was taken and its moisture content was determined. The remainder of the soil specimen was broken up, rubbed through the 20 mm BS sieve, and then mixed with the remainder of the original sample, suitable increments of water being added successively and mixed into the sample. The above procedure including compaction was then repeated for each increment of water added.

DIMENSIONS OF SAMPLERS USED

Two samplers of different wall thickness were used with the following principal dimensions:-

	sampling tube 1	sampling tube 2
thickness (mm)	2.7	1.8
internal dia. (mm)	38	38
length (mm)	179	178
weight (g)	374.05	283.3
area ratio (%)	15	10

Fig. 2 shows the characteristic dimensions of the samplers.

LINEAR REGRESSION ANALYSIS

Fig.3 and Fig. 4 depict typical graphical representations of sampling disturbance effect for remoulded decomposed granite and remoulded decomposed volcanics respectively. Linear regression analysis are used to analyze the results obtained and the results are shown on Table 1. Fig. 5 to Fig. 8 depict the general sampling disturbance effect at different water contents, for the respective combinations of decomposed granite/decomposed volcanics with thicker/thinner sampler tubes.

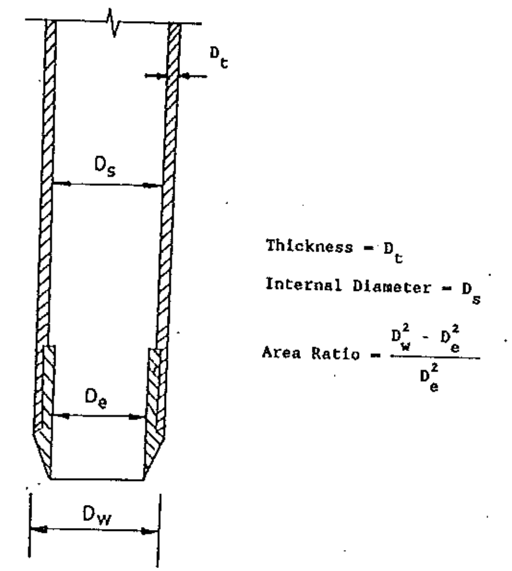

Fig. 2 Characteristic dimensions of a sampler.

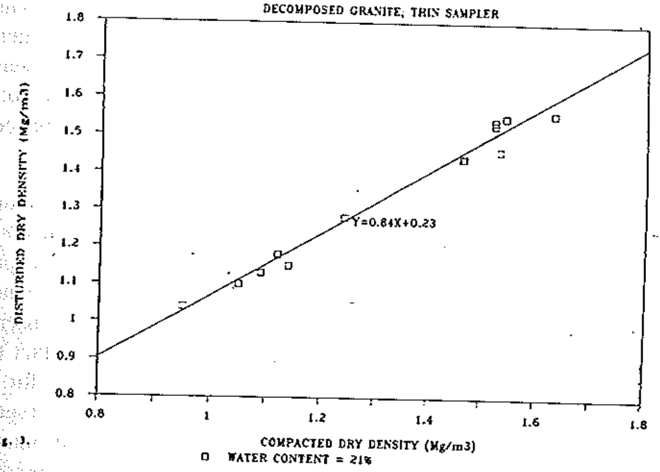

Fig. 3 Sampling disturbance effect for remoulded decomposed granite using 1.8 mm thick sampler at 21% water content.

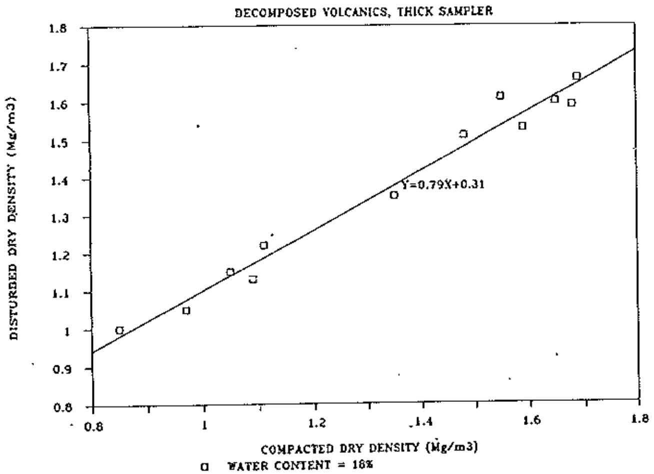

Fig. 4 Sampling disturbance effect for remoulded decomposed volcanics using 2.7 mm thick sampler at 18% water content.

ANALYSIS OF EXPERIMENTAL DATA

Comparing the graphs of disturbed dry density vs compacted dry density for various types of soil with different wall thicknesses of sampler, it can generally be concluded that the sampling process tends to densify loose soils and loosen dense soils. For both types of soil used, decomposed granite and decomposed volcanics, it is generally true that the thinner-walled samplers result in less disturbance effect than the thicker-walled samplers.

For decomposed granite, the results seem to follow a similar pattern for all the four moisture contents used in the experiment. However, the results for decomposed volcanics at a high water content, i.e. 21%, appear uncharacteristic. The point for no change in density after sampling, shifts up to a higher values of dry density, in the range of 1.4 Mg/m^3 to 1.8 Mg/m^3. A large disturbance effect is observed for moderately loose soil. The above results can be explained by the fact that the decrease of cohesive strength with water content is more significant for decomposed volcanics than for decomposed granite. The cohesive strength is at such a low level that loose soil is easily compacted even by the sampling action and hence a large disturbance effect is observed. For the typical range of moisture content of decomposed volcanics in Hong Kong the behaviour accords with the general pattern of the decomposed granite.

Table 1: Tabulated Results on Linear regression analysis.

Soil type	moisture content	type of tube	y = ax + b: a	b	regression coefficient r	no. of results
D.G.	12	thicker	0.66	0.37	0.89	12
D.G.	15	thicker	0.67	0.35	0.93	12
D.G.	18	thicker	0.77	0.25	0.99	12
D.G.	21	thicker	0.77	0.28	0.98	12
D.G.	12	thinner	0.64	0.45	0.84	12
D.G.	15	thinner	0.64	0.43	0.96	12
D.G.	18	thinner	0.79	0.28	0.99	12
D.G.	21	thinner	0.84	0.23	0.99	12
D.V.	12	thicker	0.63	0.41	0.98	12
D.V.	15	thicker	0.71	0.34	0.98	12
D.V.	18	thicker	0.79	0.31	0.99	12
D.V.	21	thicker	0.49	0.78	0.96	11
D.V.	12	thinner	0.62	0.48	0.96	12
D.V.	15	thinner	0.75	0.33	0.98	12
D.V.	18	thinner	0.73	0.44	0.99	12
D.V.	21	thinner	0.48	0.80	0.76	11

N.B. D.G. denotes decomposed granite &
D.V. denotes decomposed volcanics

DIFFERENCE BETWEEN LABORATORY & SITE CONDITION

There exists the following discrepancies between the laboratory simulation and the actual field conditions:

(1) The tested sample is a remoulded sample while on site the soil is undisturbed. Therefore the soil grains arrangement are quite different for the two cases.

(2) In the field condition, the soil properties adjacent to the soil sample will

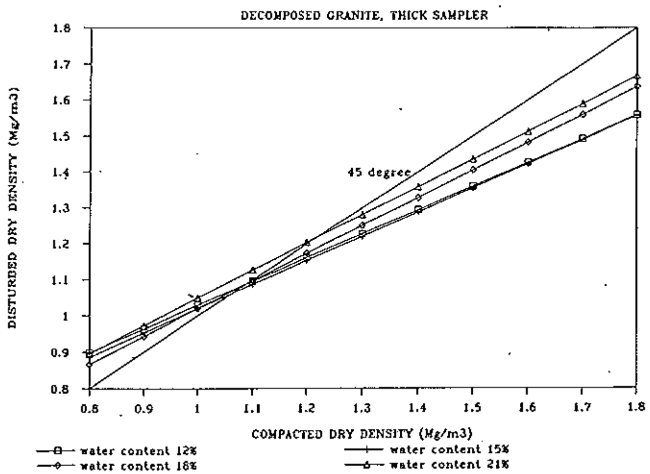

Fig. 5 Linear regression analysis of sampling disturbance effect for remoulded decomposed granite using 2.7 mm thick sampler at different water contents.

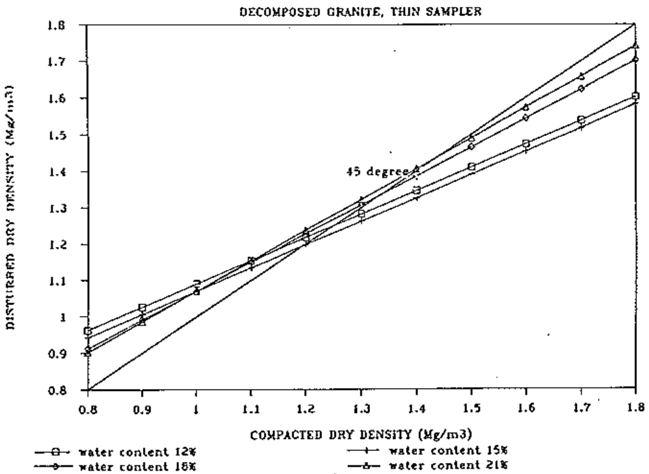

Fig. 6 Linear regression analysis of sampling disturbance effect for remoulded decomposed granite using 1.8 mm thick sampler at different water contents.

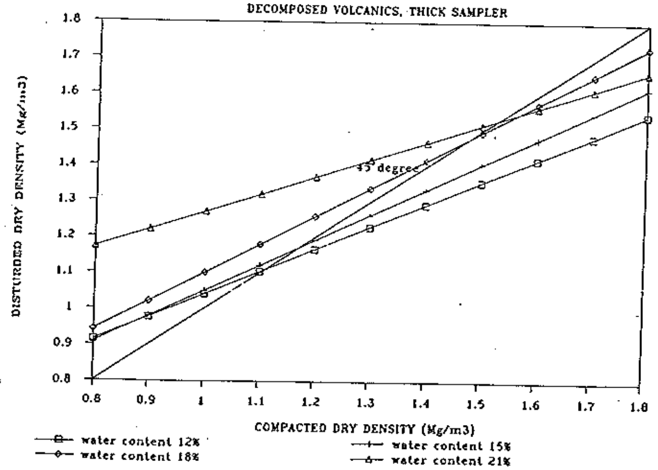

Fig. 7 Linear regression analysis of sampling disturbance effect for remoulded decomposed volcanics using 2.7 mm thick sampler at different water contents.

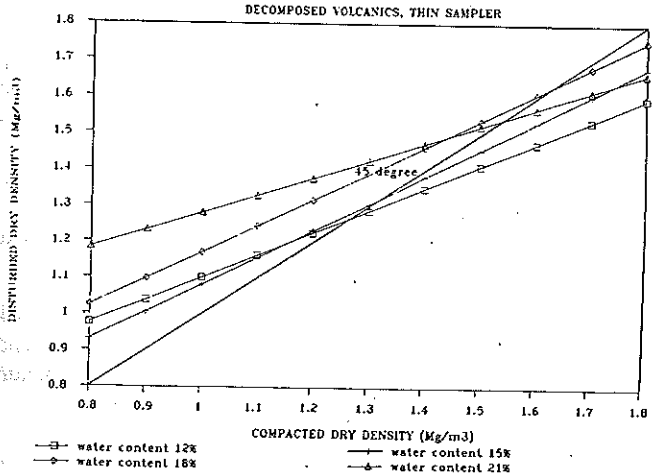

Fig. 8 Linear regression analysis of sampling disturbance effect for remoulded decomposed volcanics using 1.8 mm thick sampler at different water contents.

usually be similar to certain distance but for the existence of a hard rock layer. However, in the laboratory sampling process, the boundary effect from both sides and the bottom of the CBR mould cannot be ignored. The effects of bottom and sides of the sampler can be minimized to a certain extent by reducing the length of the soil sample.

(3) The dimensions of drive samplers used in the field are usually of larger size than the ones used in the laboratory. It is suggested that there will be less disturbance effect on the soil mass for a larger area ratio and thus the laboratory results are on the conservative side.

FIELD APPLICATION

A knowledge of density is essential in all engineering problems where the body weight of the strata is an important factor, e.g. (i) in the stability of slopes and of earth dam, (ii) in determining the earth pressure on retaining walls, tunnel linings, and the timbering of excavations. (Anon, B.S. 5930:1981) Although the sampling tube is used more often in ground investigations than for compliance testing and other methods are more usually adopted, the sample can be taken out from the filled embankment and its density can be measured to indicate the state of compaction achieved.

CONCLUSIONS

From the above laboratory works, it is concluded that the sampling process, excluding those samples which are cored such as mazier, tends to densify loose soils and loosen dense soils. For both types of the residual soils used, namely, decomposed granite and decomposed volcanics, it is generally true that the thinner-walled samplers give less disturbance effect than the thicker-walled samplers. The correlation between compacted dry density and disturbed dry density varies slightly with water content and follows a similar trend for all the soils tested except for decomposed volcanics at high moisture content.

However, only two types of residual soils in Hong Kong, decomposed granite and decomposed volcanics, have been studied so far. It is recommended that works be carried out with other types of soil so as to get a broader picture of the sampling disturbance effect for soils with different properties.

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