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No. C-1

REGIONAL SOIL STUDIES FOR ENGINEERING PURPOSES
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1. Introduction. All regional studies carried by the Laboratory aim at correlating the results of settlements of observed buildings with Laboratory tests and field classification. It is becoming more evident that the Science of Foundation cannot rely entirely on Laboratory tests, and hence study of the layer formation becomes important. Although no systematic studies had been undertaken, nevertheless the uniformity of formation of the layers met with makes it possible to make certain conclusions with the limited data in hand.

Egypt is the Nile Valley and its Delta. The Valley was formed after a geological fault in the Eocene age, which formed a depression 4-20 kilometers wide, protected by two hills from the desert, and continues for about 3000 kilometers south of Cairo. In the north, the valley ends a few kilometers away from Cairo, and the Delta (20,000 sq.k.) begins. Through this depression ran for thousands of years the river Nile, carrying in suspension during the flood season, deposits brought over from the Abyssinian mountains. The geological age at which the river began to run in the depression is not agreed upon. From history we know that the present river trough existed for at least 5000 years, although the valley itself is estimated to rise at the rate of 1 m. every 1000 years. No data is available regarding the rise of the river bed. Until 100 years ago, the whole of the agricultural land was allowed to be covered by the flood water for 40 days, after which the clear water receded back to the already low level water in the river trough. The flood water is 1.5 - 3.5m. higher than ground level. Nowadays however perennial irrigation does not permit the depositing of the same quantity over the valley. This very general picture explains the comparative uniformity of soil formation.

The upper clay deposits must have been subject to continual drying during summer. In Fig. 11 of paper No. D-1 by Mr. Tschebotareff, one gets an idea of the extent of precompression due to drying. Generally clay and silty deposits vary from 10 - 20 m. in the valley, but are generally deeper in the Delta. To simplify Laboratory testing procedure, it was decided to term clay any material with the liquid limit over 40%. For numerical comparison of terms "hard" and "soft", the cone test with weights 1-5kg. as used by Dr. Terzaghi provides satisfactory results. By silt is meant material with W_L below 40% but having a certain plasticity judged by rolling. Fine sand is the material which could not be rolled.

Some typical boring results are given in Fig. 2, 3, 4. In general, silt is followed by a clay with a dark brown appearance, and this is followed by a dark greyish clay. These are underlain by silt, then fine sand, and later coarse sand, which continues for great depths. Therefore, all borings ended in this layer.

The depth of each layer varies from one place to another. Sometimes either the dark or brown clay is non-existent. Water is met with at depths of 3 - 5 m. below ground level, and this level rises by about 1.5m. during the flood. At places next to river bank, the rise is almost the same as the river level (about 5m.). Borings in the middle of the valley or in the Delta have so far been unable to reach the rock which outcrops at the edges of the valley. The deepest borings reach 20 - 24 ft. The properties of the clays will now be given.

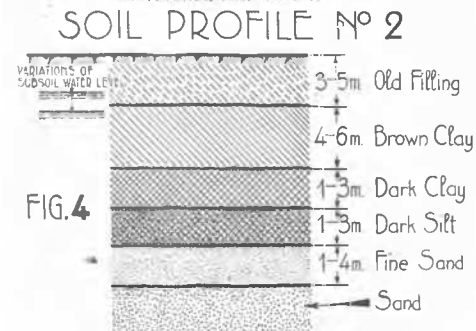
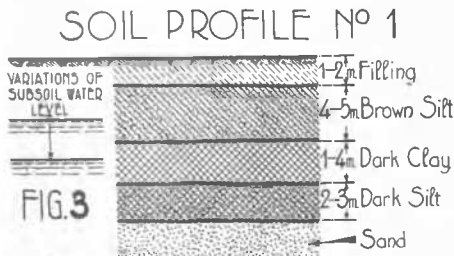
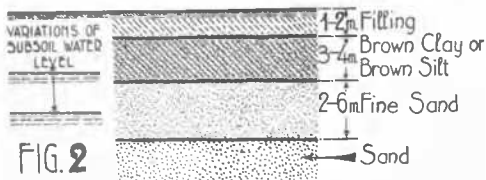
- 2. Properties of clays.** (Light clay)
- Water content at liquid limit W_L from 41 - 70% (of weight of solid)
 - Nat. water content W_n from 24 - 38%
 - Water content at pl. limit W_p from 20 - 28%
 - Water content at shrinkage limit W_s from 14 - 16%
 - Coeff. of permeability $K_{0.10}$ at $1.5 \text{ Kg/cm}^2 = 5 \times 10^{-6} - 3 \times 10^{-7} \text{ cm/min.}$
 - Swelling factor "A" = 30 - 60
 - Compressive strength (undisturbed) " q_d " = 1 - 3.5 Kg/cm^2
 - (This is unaffected by remoulding)
 - Angle of internal friction $\phi = 20^\circ$ and more
- (Dark clay)
- Water content at liquid limit W_L from 41 - 70%
 - Natural water content W_n from 32 - 54%
 - Water content at plastic limit W_p from 23 - 32%
 - Water content at shrinkage limit W_s from 16 - 19%
 - Coeff. of permeability $K_{0.10}$ at $1.5 \text{ Kg/cm}^2 = 1 \times 10^{-5} - 1 \times 10^{-6} \text{ cm/min.}$

Swelling factor "A" = 30 - 80

Compressive strength " q_d " (undisturbed) = 1.4 Kg/cm² \approx 0.4 K/cm²

This clay is affected by remoulding.

Angle of internal friction = 22° and more



SOIL PROFILE NO 3

phide smell in the samples of dark clay. Sodium unites with the CO_2 from the respiration of the bacteria and forms Na_2CO_3 which causes soil alkalinity. When water-logging is stopped, and the soil aerated, the brown colour is regained. Investigations are being carried to study the changes in the properties of the soil during these various stages of colour changes, and possible explanation of the relation to the origin of dark clays met with. The methods of extraction (See Paper No. B-4) enabled further classification of each clay into the following one:

- | | |
|-------------------|---|
| <u>Brown clay</u> | (1). Plastic hard |
| | (2). Plastic soft |
| | (3). Brittle crumbling |
| | (4). Brittle breaking into irregular prisms |
| | (5). Brittle slated horizontally |
| <u>Brown silt</u> | (6). Plastic |
| | (7). Brittle slated horizontally |
| | (8). Brittle crumbling |
| <u>Dark clay</u> | (11). Plastic hard |
| | (12). Plastic soft |
| | (13). Brittle slated horizontally |
| <u>Dark silt</u> | (15). Plastic |
| | (16). Brittle slated horizontally |
| | (22). Fine sand confined in thin streaks. |

(gaps in numbering to allow further classification)

For further classification (r) stands for decayed root openings (m) for mica when present in brown clays or silts, because it is generally present in the dark clays and silts. (l) denotes presence of stones of lime "secretions", and (f) denotes filling.

For a proper interpretation of settlement data derived from observations on structures, the additional classification combined with Laboratory tests becomes necessary (See Paper No. F-1).

The final value of the settlement, its rate, its distribution and the effect of remoulding are given in Papers No. D-1 and E-1.

One special sample of very rich clay of dark colour was met with in the Delta near the sea coast in semi-liquid state, near the surface. The following are the properties of this clay:
 $W_n = 165\%$; $W_l = 130\%$; $W_p = 25\%$; $W_s = 14\%$ $A = 6$ $K_o = 4 \times 10^{-8}$ cm/min. This type of clay is present

in many parts where possibly the soil was deposited under sea water.