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Engineering Characteristics of Mansourah Peat layer.

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ABSTRACT

Many borings in Mansourah City should that there is a layer of peat with thickneaa ranges from 1.0 to 4.0 m at depths range from 6.0 to 12.0 m in all parts of the city and its surroundings.

Peat has a great capacity for taking up and holding water, high shrinkage, great range of density and specific grauity, high void ratio, high degree of permeability, low strength and high degree of settlement in the few hours of loading.

A complete testing programme was performed on samples taken out of the Mansourah City. Results showed that Mansourah peat is a quite complicated and strange material which mean that a great precautiona must be done to reach a safe highway or building project.

Many figures and relstionships are obtained in the paper to help engineers in the design and excution stages but tests must be performed in each individual case.

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INTRODUCTION

Mansourah is one of the biggest cities in Egypt. It lies at the East of the Egyptian Delta where the Dammitta branch of the River Nile. The city is 40 Kilometers south of the Midterranian Sea and 80 Kilometers west of the Suez Canal. The Boroless lake is about 30 Kilometers far from the city.

Mansourah city is one of the biggest and important economic and commercial centres in Egypt. It can be considered as the centre of activities in the Delta. Building of big tall houses, factories, big structural projects and highways ia growing continously specially after the erection of the big Dammitta port.

Many borings showed that there is a layer of peat with thickness ranges from 1.0 to 4.0 ms at depths range from 6.0 to 12.0 ms. in all parts of Mansourah city and it's surroundings. Peat which is a complex material conaists of decompoaed organic material has up to 95% organic content based on dry weight, if it is free of extraneous mineral matter. The organic material is generally combustible carbonaceous matter, while mineral content may be due to plant growth or extraneous matter. Usually mineral content, if exists, ranges between 4.5% to 66%. The smaller value due to cotton grass while the largeer corresponds to amorphous peat.

Peat has a great capacity for taking up and holding water. It acts like a sponge. The range of moisture contents of peat appears to be between 75 % to 1500%. It may be as low as 95% and in some cases it may reaches 3535% calculated as a percentage of the weight of the dry peat. When peat dries up in air, moisture content may ranges between 4.2% to 12% of the dry weight of the peat.

Generally, as peat dries out it will shrink, becoming harder and more firm. Causes greater water reduction more shrinkage. Shrinkage varies from 50% to 10% of the original weight.

The above figures and properties make the peat layer a complex material which needs a great care in dealing and in constructing buildings, bridges and highways above it specially after the variations in ground water table due to the High-Dam.

The aim of this paper is to discover, analyse and report the engineering characteristics of the peat layer which exists in Mansourah City of Egypt in order to help the desaigners, supervisors and contractors of buildinga and highways to reach a safe complete project. The paper is actually an analysis of many borings and tests have been performed on Mansourah soil. The results given here are only a guide and can not be considered and extra tests must be performed in each individual case.

The paper starts with a comprehensive collection of all values obtained by others in different parts of the world for the peat properties and it is followed by a full description and analysis of results obtained follow. A comparison between the local peat and other types of peat will be held and a set of conclusions may be reached with some recommendations.

(1) Peat Properties Obtained Previousely:

Macfarlane (3), and Colley (1) have collected the values of peat properties cited in more than 25 refrences and their reaults can be summarized as:

a) Classification: There are many types of peat as:
   - Peat which contains 65% to 100% organic matter.
   - Muck which contains 25% to 65% organic matter.
   - British muskage classified as "fen peat", "raised bog" and "blanket bog" according to a special topographical classification.

b) Acidity Reaction: Measured in PH values which is the negative logaritihm of the hydeogen ion concentration in an aqueous suspension of the soil. The values range from 3.1 to 7.5. It increases with depth which means the acidity is decreasing with depth.

c) Density and Specific Gravity: The specific gravity of the soil depends upon moisture content, organic and inorganic content. specific gravity ranges from 0.2 (12.5p. c.f.) for dry to 0.95 (59.4P. c.f.) for wet peat. Bulk density of woody and herbaceous peat ranges from 0.6(37.4P. c.f.) to 0.7 (43.7P. c.f.).

d) Water Holding Capacity: The highest value reached was 3525% for a sphangnum peat while the lowest value obtained for wet peat was 95%. For air-dry peat the moisture content ranges from 4.2% to 12%.

e) Void Ratio: Void ratio is calculated as the product of the moisture content and the specific gravity. Void ratio ranges from 2.84% to 13.08%.

f) Shrinksge On Drying: Drying out several peat samples showed that the shrinkage of a sample varies from 90% to 10% of the original volume. Shrinksge forces in peats can be extremely high.

g) Permeability: Using both the variable and constant-head permeameter. The average value in vertical direction is 9 cm/day while in horizontal direction ranges from 6 to 40 cm per day. The difference in the behavior of peat results mainly from the difference in the permeability and it is affected by the magnitude and duration of loading. When peat is loaded with 8 P.s.i. for Seven months permeability reduces 50,000 times than its intial value.

h) Strength and Deformation: Shear strength of peat ranges from 82 psf at 4 ft depth to 610 psf at 12 ft depth. It depends upon the percentage of mineral content. The laboratory results showed that shear strength from unconfind compression test is found to be ranging between Zero for undrained peat to 4 p.s.i. (576 psf) for drained peat of about 7 P.c.f. dry density. The strength is related to a deformation of up to 20% of the intial length of the sample.

The variation in strength is due to the different plant fibre structures and humification. The bearing capacity equal 7π times the shearing resistance. Bearing capacity of about 10 P.s.i. (1440 psf). Due to the high peak of stresses set up under a wheel or track, a smaller value of bearing capacity should be considered.

i) Consolidation and Settlement: For peat samples of 2 cm thickness, the logtime settlement curve becomes a straight line after a minute loading and remains straight throughout the test. Long term consolidation tests showed an averege of 9.4 inches while settlement based on 24-hr loading period averages 7.3 inches. These values did not consider the effect of traffic. Experiment of a peat layer 2-3 m thickness beneath road project proved that settlement being less for lower vehicle loads and greater for heavy loads. Generally settlement of peat would be equal to 50% of the layer thickness and half of the settlement would occure during the early few days or weeks.

The main conclusion reached by many authors is that it is evident that many gaps still exist in the knowledge of the engineering properties of peat. Avsilable information has very wide ranges and sometimes contradictory and confusing.

(2) Sampling:

The following samples are considered out of about 500 borings have been taken out from different places in Mansourah City. Sample spots are shown on the following attached map.

1. Sample No	Depth (m)	Location	Thickness of layer (m)
1	12.5	Al Gomhoria Street	2.0
2	11.5	Railway Square	1.0
3	11.5	Al Modier Street	1.0
4	13.20	Al Sanawia Street	2.2
5	12.0	Port Said Street	1.5
6	13.0	Al Shiek Hasaneen Square	0.8
7	10.5	Al Galaa Street	3.0
8	12.0	Mansoura University Axea	1.2

All soil tests have been performed on each sample according the following testing program.

(3) Testing Program:

A complete laboratory program is performed on each sample. The tests are:

1. Microfabric atudy for the structure of the peat leyer using modern electronic microscope.
2. Grain size distribution. Three distributions have been presented.

3. Atterberg limits which means the determination of the water content, liquid limit, plastic limit and plasticity index. Graphs have been presented relating the water content to the number of blows (cassagrand).

4. Peat chemical analysis, which strats with a full physical description of samples, colour and then determines the chemical composotion nf the peat.

5. Standard proctor test for different samples which ranges from 9.0 to 13.cm depth and 1.0m to 3.0m thickness of layer.

6. Direct shear test of the peat layer. Relations between:
   1) Shear displacement versus shear stress.
   2) Shear displacement versus vertical displacement.
   3) Normal stress versus shear stress.
   are intended to see whether this layer can be used as foundations or not and also to determine the maximum load which can be applied on highways placed above this layer (not direct loading).

7. Consolidation of direct shear test specimens, to determine the value of settlement per unit of time under 1, 2, 3 Kg/cm^2 normal load.

(4) Results of Tests:

1. Microfabric of Mansoura Peat:

A scanning electron microscope study has been undertaken for the microfabric of Mansoura peat using the electron microscope of the National Research Centre, Cairo, Egypt, (N.R.C.). Fig.(2).

It is observed that the structure of Mansoura peat seemed to be regular aggregation assemblings consisting of elementary silty particle arrangement interacting with clay particles.

2. Grain Size Distribution:

Since soil classification provides the engi neer with a good tool for predicting the behaviour of the subgrade soil performance and since it depends upon some few and simple procedure, so it is the first test to be applied. Results of sieve analysis of three samples from differentplaces are shown in Fig. (3). All samples show that the grain size distribution of the peat contains clay, silt and sand. The maximum size of particles is found to be 1.0mm whils the smaller particle size be less than 0.001m Which means a wide range of particle sizes. Particle size be coarser as the sample being less depth, i.e. samples taken at 3.0m depth are found to be coarser than that at 5.0m. The later sample is coarser than the sample taken st 12.0m depth. Most of the peat samples are lying in the silt area.

3. Peat Consistency (Atterberge Limits):

Values of water content, liquid limit and plastic limit are determined for three samples taken at depths 3.0m, 5.0 and 11.0m. Results are ahown in table (1).

TABLE(1)

	Sample. No. 1 3.0m depth	Sample. NO.2 5.0m depth	Sample NO.3 12.0m depth
Water content	210%	171.4%	250%
Liquid limit	185%	219%	230%
Plastic limit	NO P.L.	86.64%	50%
Plasticity Index	NO P.I.	132.36%	180%

A flow chart relating the number of blows against water content is shown in Fig. (4) for the three considered samples.

It is clear from the obtained results that the peat layer in Mansourah area has a high water content. The water content based on the same number of blows ranging between 171.4% to 250% by weight. The liquid limit is also high it reaches 230% in a sample while the lowest value obtained is 185%. The plastic limit is considerably low which gives a quite high plasticity index. The plasticity index can be as high as 180%.

4. Peat Chemical Analysis:

Mansourah peat has a dark blackish grey colour and visual inspection ststes that the peat is a cohesive silicicue organic clayey silt. The chemical analysis of the Mansourah peat layer is given below. The most notable fact is that it contains more than 75% silicon dioxide and inaoluble silicates. It contains ferric and aluminium soxides, calicium carbonate, suplpher trioxide, Magensium carbonste, sodium choloride and Hydeated gypsum. The PH (Log^{-1}) value determined by the electrochemical method is found to be 7.22% which means that the peat layer is aciditic material. The obtained value can be considered as high as the heighestvalue ever obtained in any place in the world.

(5) Direct Shear Test:

There are three methods of assessing the shearing strangth of peat:

a) Measuring the strength in situ by means of some apparatus.

b) Uaing the stability analysis in an area where a sliding failure has occured.

c) Securing undisturbed samples in the field and performing laboratory shear test.

The latter procedure is followed on one sample. The sample is completely saturated. The dead load is fixed at 7.4 Kg while the normal stress is changed and takes values of 1.0, 2.0 and 3.0 Kg/cm^2. The results are shown on Fig. (5) where the following relations were stated in each case of normal stress:

1) Shear displacement against shear stress.
2) Shear diaplacement against vertical displacement.

The relations state that the shear stress increases with the increase of normal stress and shear displacement. In contrast, vertical displacement decreases by increasing the normal stress and shear displacement.

The relation shown in Fig. (6) between normal stress and the shear stress seemed to be linear and increased positively, i.e. shear stress increases with the increase of normal stress.

(6) Consolidation of Direct Shear Test Specimens:

Long duration consolidation tests is not possible and hence a short duration laboratory consolidation tests are carried for 25-hours. Time-settlement curves are obtained under different values of normal stress values were 1.0, 2.0 and 3.0 Kg/cm^2.

Curves in Fig.(7 a, b, c) show that the relation between time and settlement is a positive relation, i.e. settlement increases with time increasing. Rate increases rapidly in the first two hours and the increase is very slow the rest of the observation time. The settlement value increases with the increase of the normal stress applied on the sample.

(7) Conclusions and Recommendations:

This work is aimed to more understanding of the basic fundemental properties of the local peat soil exists in Mansourah region. Before listing the set of conclusions obtained and recommendations, it should be recognized that the shown figures and interrelationships are merely approximate but they are good enough for estimating peat properties and in predicting its behaviour in working. Also the results of this study may be valuable for comparison and for highway and building constructions. The study shows that:

1) The structure of the local peat in Mansourah is a regular aggregation assemblings consisting of silty particules interacting with clay.

2) The grain size distribution of the peat extends over a large range sand to the fine clay. (size ranges from 1.00mm to 0.001mm).

3) The peat size becomes finer as depth increases.

4) Liquid limit of local peat is quite high, it ranges from 185% to 230% with an average value of 211%. The plastic limit is a relatively low. P.L. ranges from NP to 86.64 which means a high value of plasticity index. The soil having a great degree of swelling and shrinkage which has, a bad effect on highway and building supper structures.

5) The water holding capacity ranges between 171.4% to 250% calculated on weight bases. It means that the peat layer may have a very high shrinkage factor when dried up.

6) Peat layer contains mostly all chemical components expected to exist such as silicondioxide, insoluble silicates, calicium carbonate, magnesium laborate, sulphate, sodium chloride and gypsum. This means a great amount of precautions against these effects should be applied.

7) Acidity of local peat is quite high, it reaches the heighest value ever obtained in the world. Antiacid materials should be added under bases of buildings and highways.

8) Shear stress of peat increases with the increase of applied normal stress. The maximum shear stress reached is 2.0 Kg/cm^2 under 3Kg/cm^2 normal load at 3.5 mm shear displacement. At the above conditions the maximum vertical displacement is about 1.0mm.

9) Consolidation of local peat layer reaches more than 4.0mm in the first few minutes of applying the normal stress. Most of the consolidation amount occures in the first two hours. It reaches about 6.00mm after 2-hours under 2Kg/cm^2 normal load. In the rest 22-hours small settlement occurss. It reaches 6.75mm. It means that about:
60% of the settlement occurs in the first few minutes.
30% " " " " " " " 2-hours.
10% " " " " after that.

10) Tests on peat layer, if exist, must be performed before designing any expressway or big building due to the peat strange properties.

11) Precautions against sulphate, acid, sodium and magnisum should be considered.

Many authors like to stress that the figures and results obtained in this study are of great importance and value to the higway and structural people in both the design and construction but tests should be applied only for the individual cases.

(8) References:

1. Colly, B.C., (1950),"Construction of Highways over peat and Muck Areas". American Highways, Vol. 29, No. 1, PP. 3-6.

2. Lewis, W.A., (1956),"The settlement of the Approach Embankments to a New Road Bridge at lackford, west suffolk" Geotechnique, Vol. 6, No. 3, PP. 106-114.

3. Macfarlane, I.C. (1959),"A Review of the Engineering Characteristics of peat", ASCE, SMI, PP. 21-35.

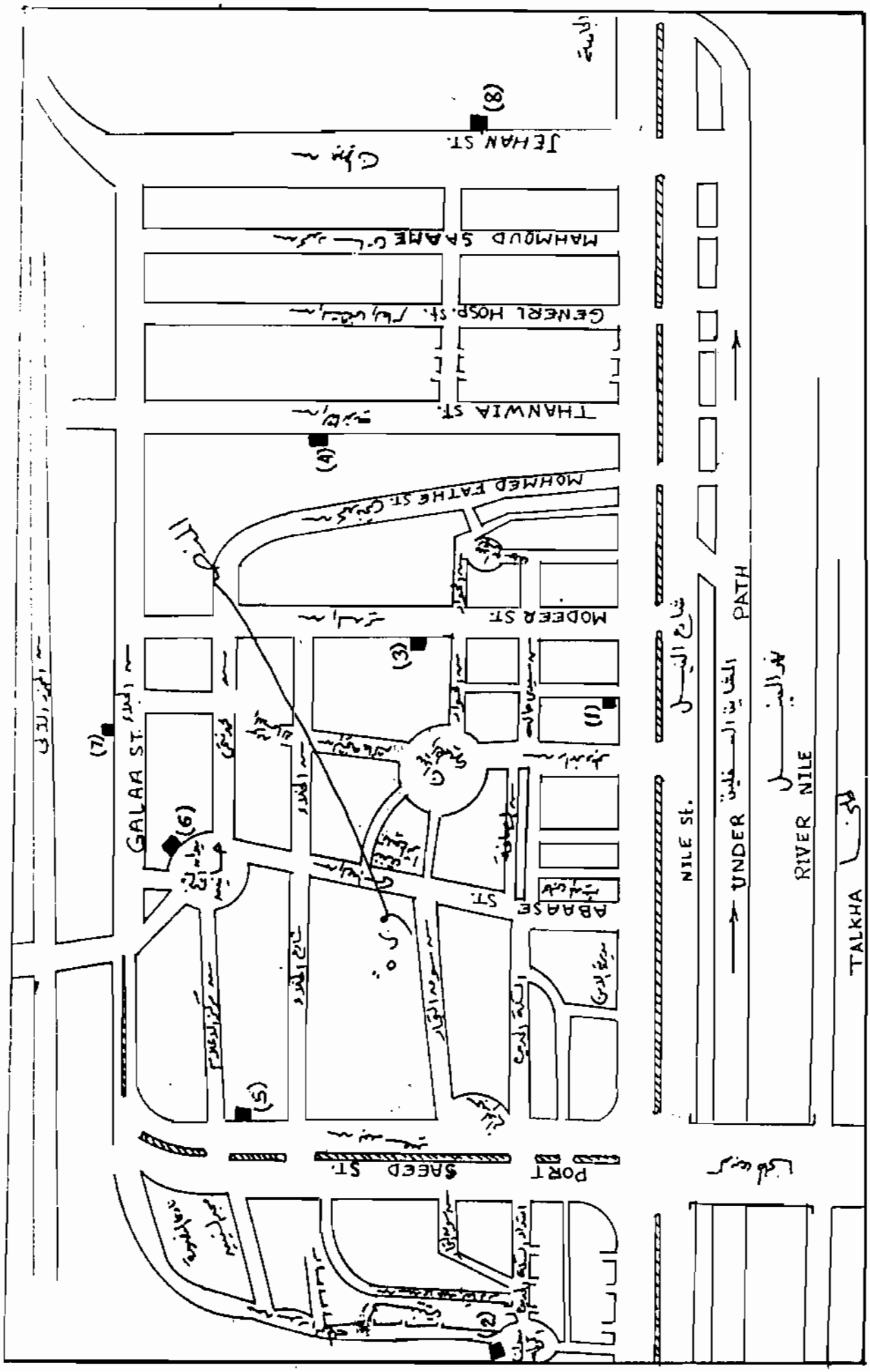


FIG.(1) LOCATIONS OF BORINGS

FIG. (2) MICROSCOPIC FOTO FOR PEAT IN MANSOURA . scale 5.5 mm = 10 m.

LOCATION: El Mansoura - Peat Layer

BOREHOLE NUMBER:

DEPTH OF SAMPLE:

I. PHYSICAL PROPERTIES OF SAMPLE:

1) Description of sample: Cohesive silicious organic clayey silt (Peat)

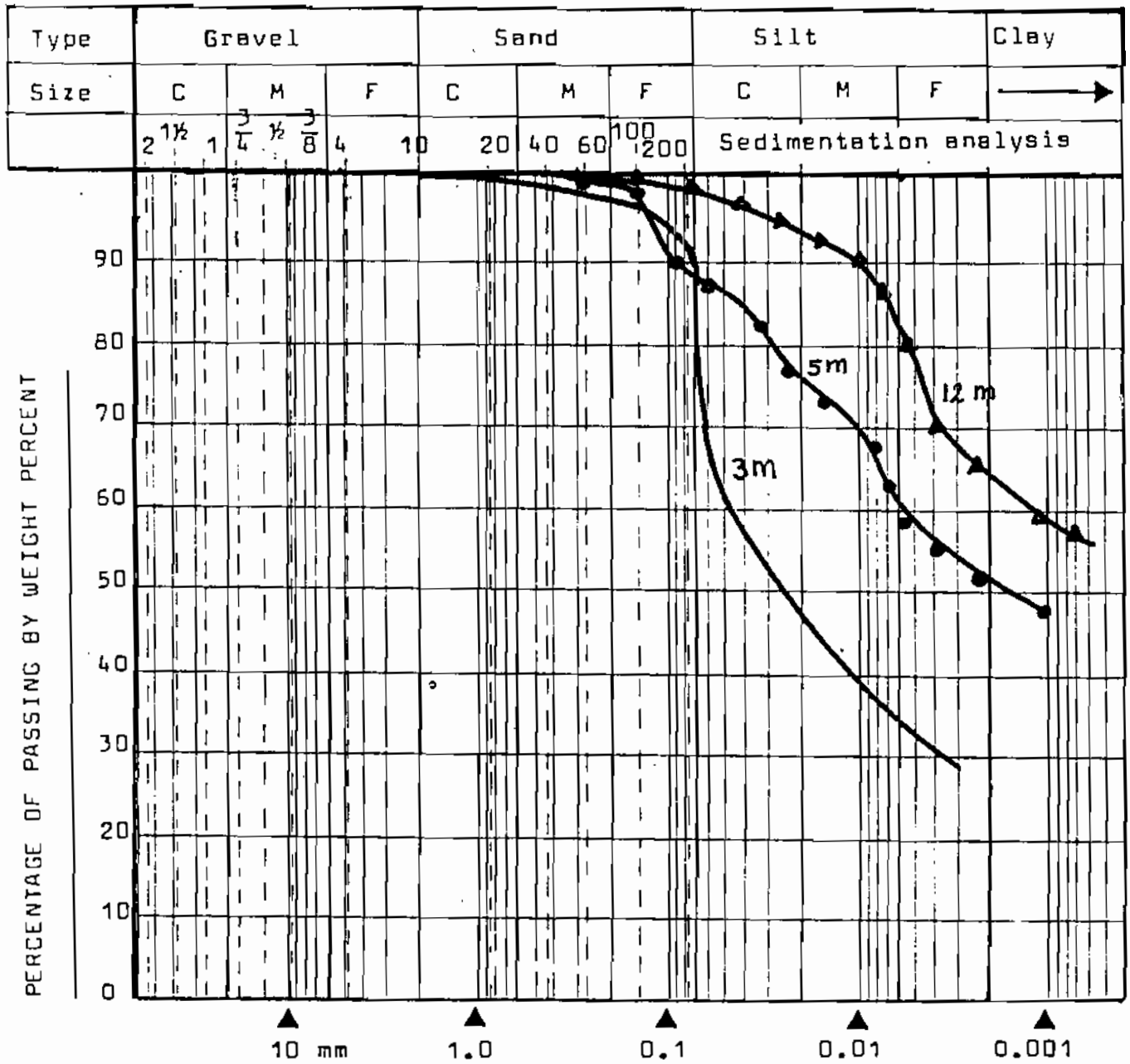
2) Colour of sample: Dark blackish grey

II. Chemical composition of sample:

Serial number	Chemical compound calculated as weight percent from dry sample	Molecular Formula	Result of analysis by (wt %)
1	Silicon dioxide &insoluble silicates	$Si\ O_2$	75.61
2	Soxides (Ferric and Aluminium)	$Fe_2\ O_3$ + $Al_2\ O_3$	13.97
3	Calicium carbonate	$Ca\ CO_3$	1.84
4	Magnesium carbonate	$Mg\ CO_3$	0.42
5	Loss due to ignition	Gases	2.61
6	Sulpher trioxide	$S\ O_3$	3.64
7	Sodium chloride	Na Cl	0.23
8	Hydrated gypsum	$Ca\ SO_4.2H_2O$	7.83
9	pH Value by the electrochemical method determibation	$Log \frac{1}{(H^+)}$	7.22

TABLE (2) Soil Chemical Analysis

Location = El Mansoura (Peat Layer)



VISUAL AND MANUAL IDENTIFICATION:

Dark greyish black organic clayey

silt contains traces of sand (Peat)

FIG. (3) GRAIN SIZE DISTRIBUTION

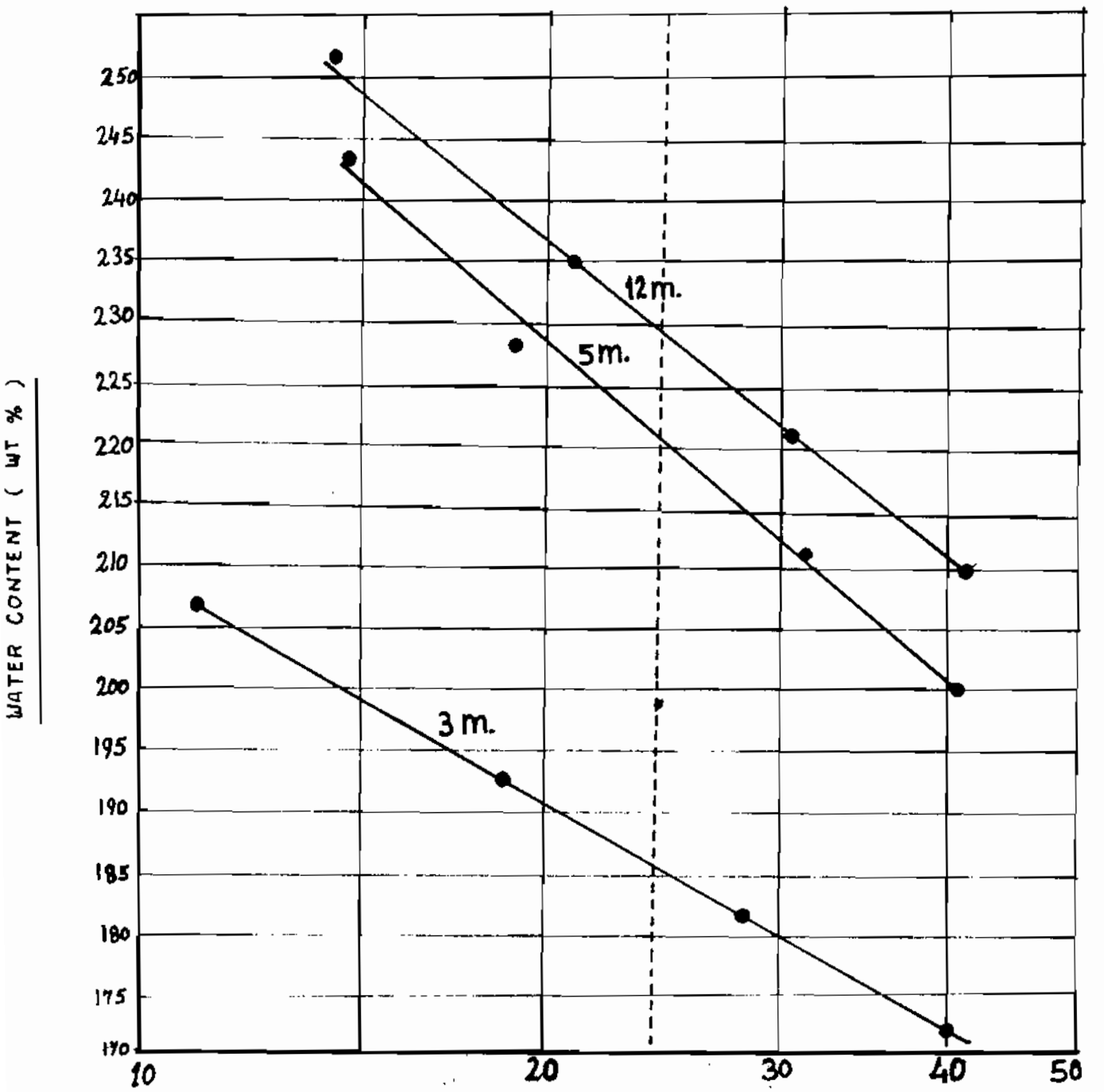
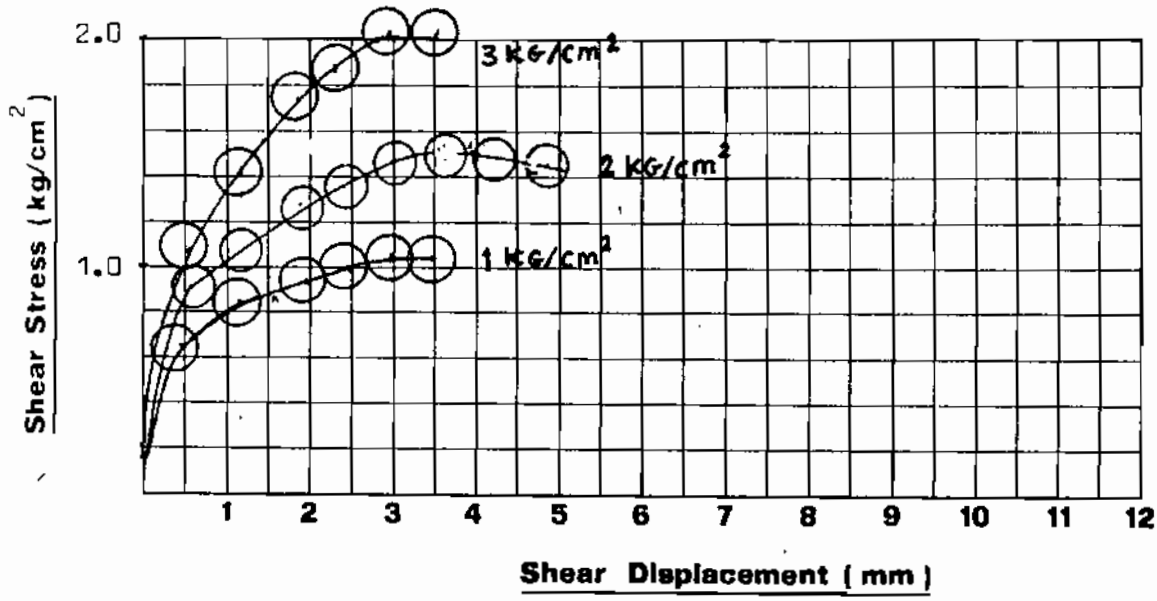
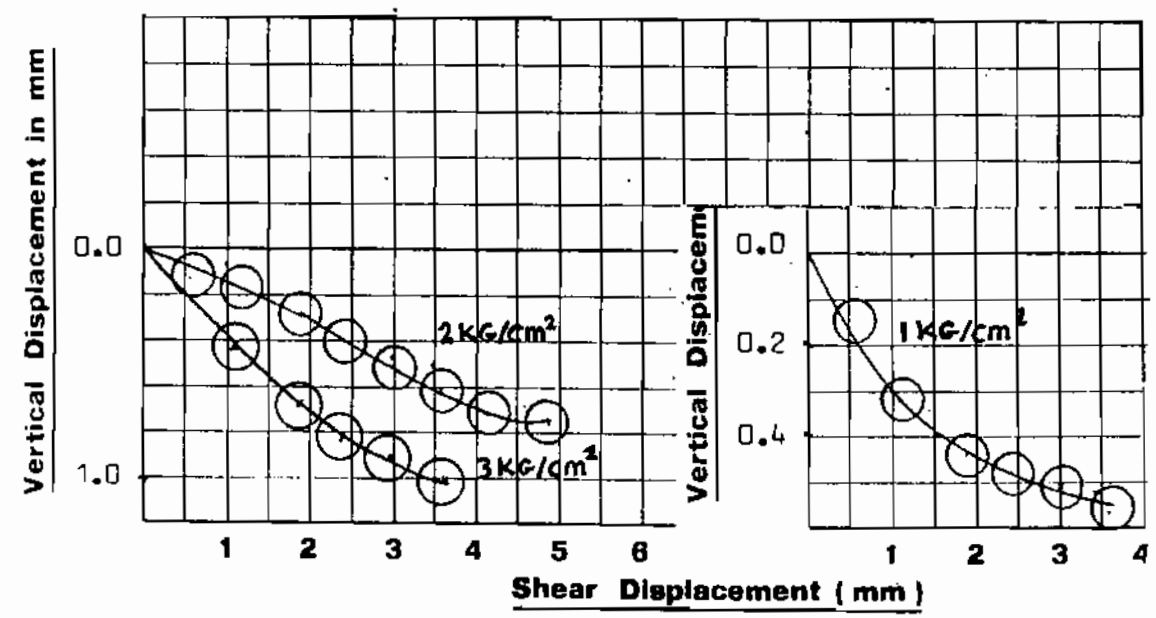


FIG. (4) FLOW CURVE





Notes :

1. **The dead Load** = 7.4 **kg**
2. **The Type of Sample** = Saturated

FIG(5) The Relation Between Shear Displacement ;Shear; and Vertical Displacement

Item	Test	Result	Item	Test	Result
1	Water content wt%	230.42	4	Test density in gm/cm^3	1.183
2	Feed rate in mm/min.	0.06	5	C in kg/cm^2	0.58
3	Shearing area in cm^2	31.67	6	ϕ in degrees	25.00

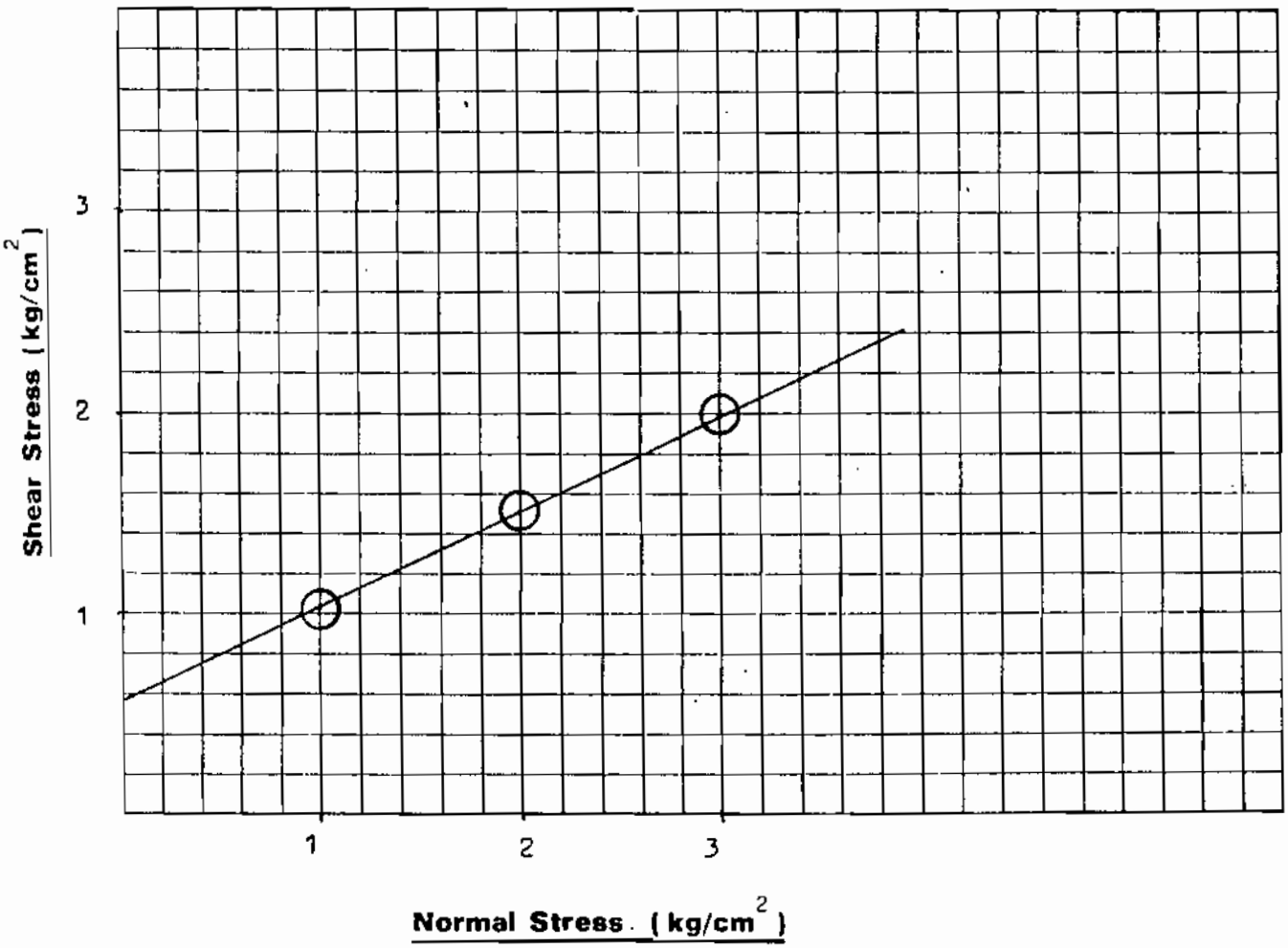
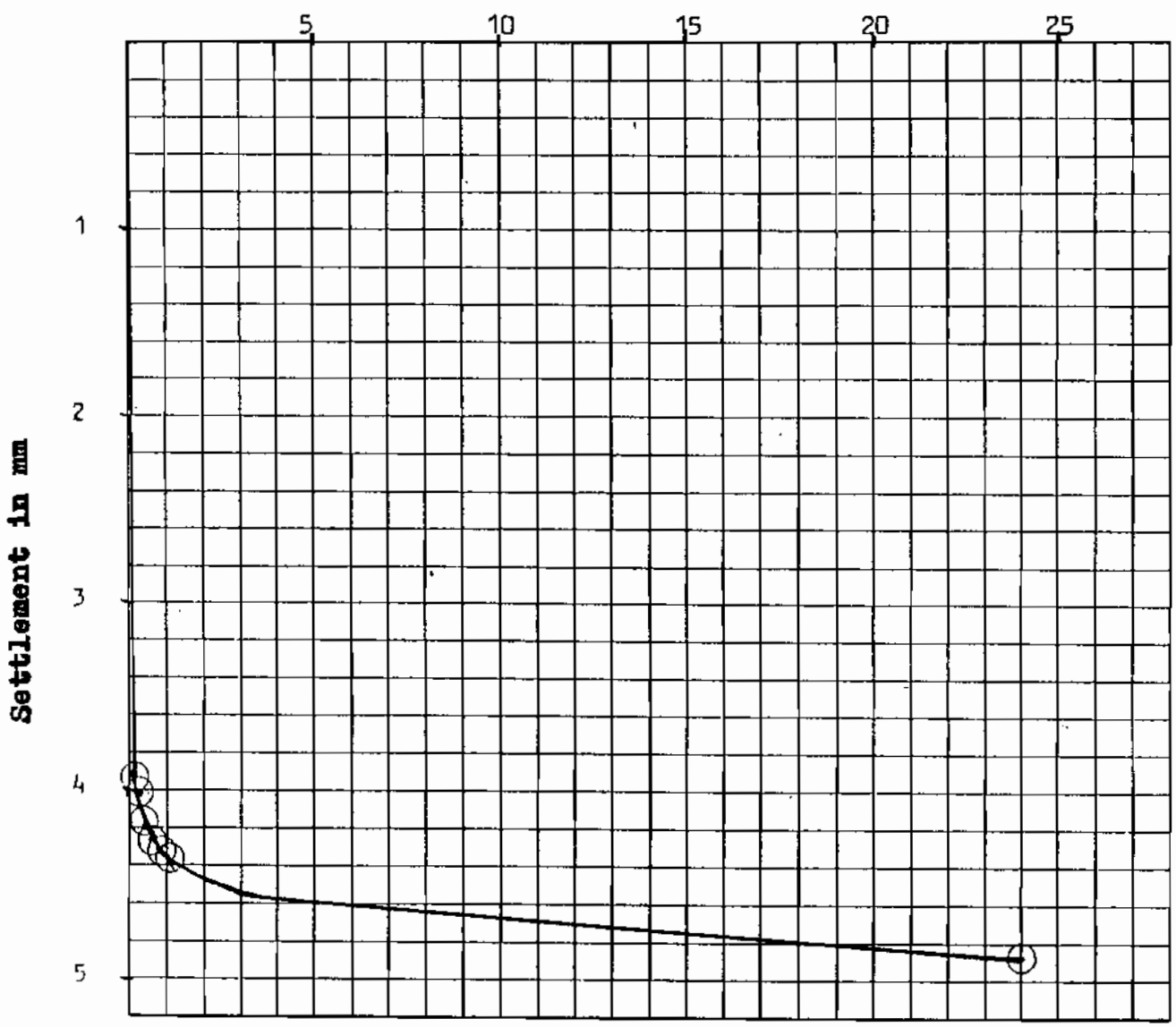


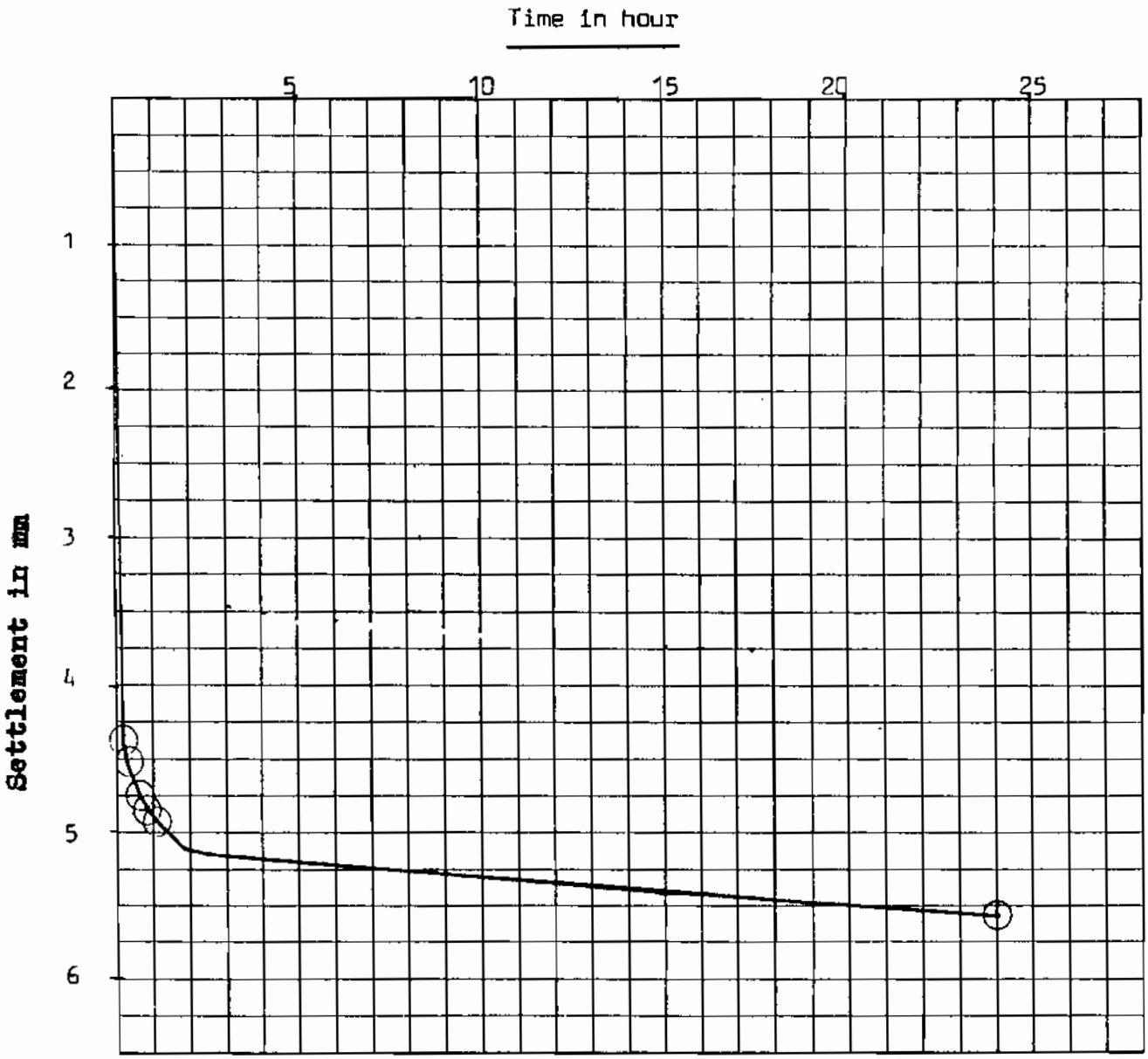
FIG. (6) The Relation Between She Stress And Normal Stress.



Notes:

1) Normal Load = 1.0 kg/cm^2

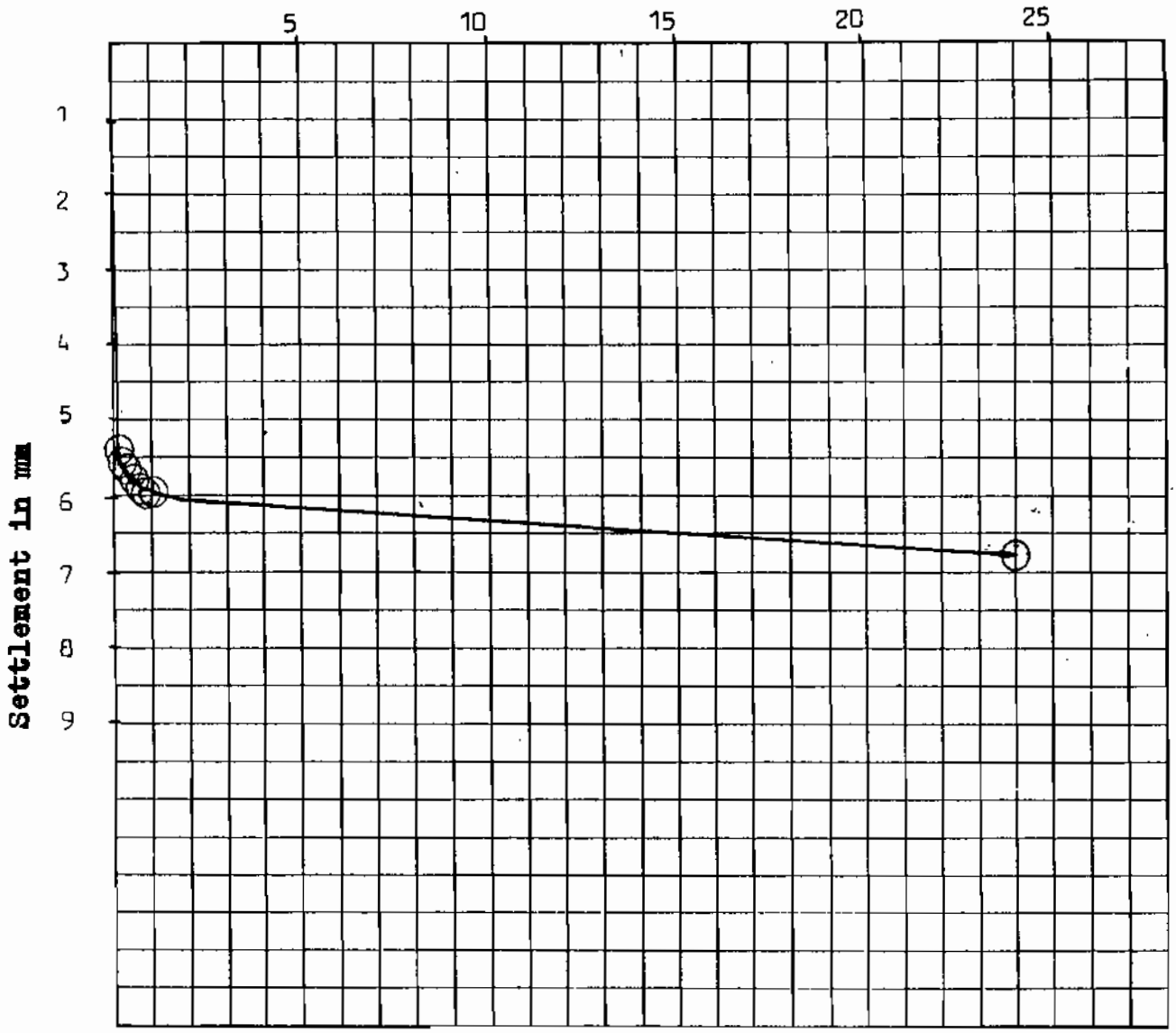
FIG. (7a). CONSOLIDATION OF DIRECT SHEAR TEST SPECIMENS



Notes:

1) Normal Load = 2.0 kg/cm^2

FIG. (7 b) CONSOLIDATION OF DIRECT SHEAR TEST SPECIMENS



Notes:

1) Normal Load = 3.0 kg/cm^2

FIG. (7 c) CONSOLIDATION OF DIRECT SHEAR TEST SPECIMENS