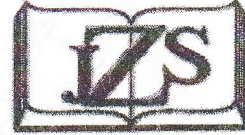


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## A Technical Report

### **Geotechnical and Geophysical Properties Study of Soil about Tabeen\_Dokan in Sulaimani Region.**



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#### **Abstract**

This research including field and laboratory detailed investigation for study of physical and chemical engineering of Tabeen\_Dokan in Sulymania Region. Experimental work included two main aspects , the was taken disturbed and undisturbed soil samples carry out to several tests in laboratory of soil mechanic .The second part was related to the field tests for calculating geophysical properties of soil in addition defining of water table level . The results of analysis collection data indicate that the soil in this region have a good bearing capacity but have a some problem in swelling index and the water table was not observed during the investigation period.

**Keywords:-** Augers, laboratory soil test, soil investigation, and swelling.

#### **A-Soil Investigation**

##### **1- Introduction**

##### **1-1 Authorization and Scope**

The soil investigation for project of construction 3000 houses in Tabeen region has been conducted by laboratory of soil mechanic in /National Center for Research & Construction Laboratories (NCCL)/Baghdad ,the soil investigation described in this research consists of digging the test pits, securing representative samples, testing these samples and analyzing the soil conditions with test results.

##### **1-2 Site Location and Description:**

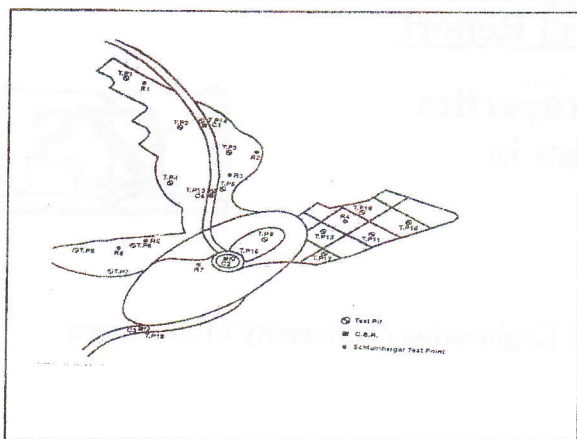
The site is located at Al-Sulaimani governorate; specifically in Tabeen area at Dokan region .

The site area is wide which represents the south hilly side of Tabeen Mountain with high difference in elevations plate (1).

##### **2- Filed Exploration**

##### **2-1 Drilling and sampling**

According to the nature of this site, considered as weathering deposit at the mountain edges these deposits. Consisted mainly of mixed soil of different sizes of rock fragments and silt clay. The usual drilling equipments were difficult to be used for field exploration. Accordingly digging was done by using Poclain machine. The disturbed samples (D) were collected at different depths. The undisturbed samples marked (core) were obtained using core tubes the undisturbed samples (U) were obtained from the test pits and boreholes by installing 100mm dia. in to the stratum.



Plat (1) site plane

Table 1: Depth of pits

| T.P.No. | Depth (m) | T.P. No. | Depth (m) | T.P. No. | Depth (m) |
|---------|-----------|----------|-----------|----------|-----------|
| 1       | 4         | 10       | 4         | 7        | 4         |
| 2       | 4         | 11       | 2         | 8        | 2         |
| 3       | 4         | 12       | 4         | 9        | 4         |
| 4       | 4         | 13       | 4         | 16       | 4         |
| 5       | 1.5       | 14       | 4         | 17       | 2         |
| 6       | 4         | 15       | 4         | 18       | 4         |

### 2-2 Number of test pits

Eighteen test pits were conducted for the project on the area under investigation at the locations assigned by the concerned authorities. The depths of these test pits are shown in table below.

### 2-3 Elevation of Pits location:

The elevation of each test pit was taken from a specified point elevation given by the concerned authorities. The elevation for each test pit is shown in table (2).

Table 2: Elevations of test pits Location

| T.P. No. | Elevation (m) | T.P. No. | Elevation (m) |
|----------|---------------|----------|---------------|
| 1        | 1039.638      | 10       | 1028.598      |
| 2        | 1040.638      | 11       | 1017.74       |
| 3        | 1046.648      | 12       | 1026.488      |
| 4        | 1019.638      | 13       | 1033.238      |
| 5        | 1031.228      | 14       | 1050.218      |
| 6        | 982.52        | 15       | 1014.098      |
| 7        | 980.54        | 16       | 1031.728      |
| 8        | 958.981       | 17       | 1013.55       |
| 9        | 1021.708      | 18       | 993.93        |

### 3-Laboratory testing:

The actual test proposed for a particular sample depends on the type of sample (U&D) and the nature of its material.

A full list of tests conducted for this project is:

#### A- Classification tests.

- Atterberg limits (L.L&P.L)
- Grain size analysis.
- Linear shrinkage limits (L.S).
- Unit weight (natural and dry).
- Natural moisture content.
- Free swelling test.

#### B- Consolidation test.

#### C- Collapse test.

#### D- Direct shear test.

#### E- Chemical tests for soil samples:-

- Sulphate Content (SO<sub>3</sub>%).
- Chloride Content (CI %).
- Organic matter content (ORG.%).
- Calcium carbonate content (CaCO<sub>3</sub>%).
- PH value.

The results of these tests are shown in the record of result sheet appended.

#### 4- Subsoil Stratification Condition

##### 4-1 Soil Profile:

According to the Unified Classification System the subsoil profile can be summarized as follows:-The main soil layer is a cohesive soil, which consists of light brown to brown grayish lean to fat clay sometime with sand mixed with carbonate and rock fragments to green elastic silt (CL, CH, and MH). This layer extends from the existing ground level down to the end of boring at (2-4) m depth .Through this layer, thin layers of brown rock fragments with a trace of lean clay or with clayey sand is observed at different depths. At pits (3, 5&14) the main layer consists of brown rock fragments with a trace of lean clay or sand or sometimes with clayey sand. This layer extends from the existing ground level to the end of boring at (1.5-4.0) m depth. Details of soil stratification for each test pit are shown in the bore log appended.

##### 4-2 Under G.W.L

The Underground water level was not encountered after completion of excavation within the deep borehole of 4m depth.

#### 5-Evaluation and Discussion of Results

##### 5-1 Direct Shear test results:

Direct Shear test were carried out on undisturbed cohesive soil samples. Table (3) shows the variations of shear test cohesion values (C) and angles of friction ( $\phi$ ).It is noticed that the values of (C) are range of (0-65) kN/m<sup>2</sup> and those of ( $\phi$ ) are in the range of (16-37) degrees.

##### 5-2 Consolidation Properties

The variation with depth of overburden and pre-consolidation pressure which are shown in Table (4) indicate that the cohesive soils and over consolidation.

**Table 3: Direct shear test results with Depth**

| T.P.No. | Depth (m) | C (kN/m <sup>2</sup> ) | $\phi$ Degree | $\gamma_{wet}$ (kN/m <sup>3</sup> ) | $\gamma_{dry}$ (kN/m <sup>3</sup> ) |
|---------|-----------|------------------------|---------------|-------------------------------------|-------------------------------------|
| 1       | 0-1       | 40                     | 33            | 17.9                                | 14.5                                |
| 3       | 1.5-3     | 24                     | 35            | 19.6                                | 14.9                                |
| 4       | 1-2.5     | 35                     | 32            | 19.0                                | 13.6                                |
| 6       | 1-3.5     | 65                     | 25            | 18.0                                | 13.4                                |
| 7       | 1.5-2.5   | 38                     | 23            | 20.2                                | 13.7                                |
| 8       | 0-0.5     | 30                     | 23            | 21.4                                | 14.6                                |
| 9       | 3.5-4.5   | 0                      | 37            | 20.2                                | 14.3                                |
| 10      | 2-4       | 24                     | 26            | 19.1                                | 14.2                                |
| 11      | 0.5-1.5   | 40                     | 23            | 18.9                                | 14.1                                |
| 12      | 2-3.5     | 56                     | 29            | 19.7                                | 13.5                                |
| 13      | 2-3.5     | 0                      | 34            | 18.8                                | 12.6                                |
| 14      | 0-1       | 0                      | 39            | 19.6                                | 13.9                                |
| 15      | 0-1.5     | 42                     | 16            | 19.9                                | 13.3                                |
| 16      | 3.5-4     | 25                     | 33            | 19.3                                | 14.9                                |
| 17      | 0.5-1.5   | 30                     | 27            | 17.9                                | 14.7                                |

##### 5-3 Swelling Behavior

The cohesive soil layers indicate swelling behavior at some locations. The swelling pressure measured from the Odometer test varies from (35) kN/m<sup>2</sup> to over (150) kN/m<sup>2</sup>. The results of free swell also indicate swelling behavior. These results are in the range of (0 to 75) percent while the results of linear shrinkage are in the range of (5 to 18) percent. The results of swelling pressure, free swell and linear shrinkage are shown in Table (5)

##### 5-4 Collapse Test

The test was done by using consolidation test apparatus, the sample was tested on the natural moisture until the pressure of (100kN/m<sup>2</sup>) is applied then the sample is wetted by adding water. The collapse

potential ( $I_c$ ) is defined as: 
$$I_c = \frac{\Delta e_c}{1 - e_o} * 100$$

Where:  $\Delta e_c$  = Change in void ratio upon wetting.

>  $e_o$  = Natural void ratio.

The results indicated the severity of collapse from (none) to (moderately severe). The collapse potential with depth is also shown in table (6).

**Table 4: Overburden, pre-consolidation with depth**

| T.P.No. | Depth (m) | $P_o$<br>kN/m <sup>2</sup> | $P_c$<br>kN/m <sup>2</sup> | Void ratio<br>$e_o$ | $\gamma_{wet}$<br>(kN/m <sup>3</sup> ) | $\gamma_{dry}$<br>(kN/m <sup>3</sup> ) | $C_c$ | $C_r$ |
|---------|-----------|----------------------------|----------------------------|---------------------|--|--|-------|-------|
| 1       | 3.5-4     | 67                         | 80                         | 0.664               | 17.9                                   | 16.1                                   | 0.15  | 0.022 |
| 2       | 3.5-4     | 74                         | 260                        | 0.597               | 19.6                                   | 16.9                                   | 0.18  | 0.028 |
| 3       | 3-3.5     | 62                         | 200                        | 0.542               | 19.0                                   | 17.5                                   | 0.1   | 0.007 |
| 4       | 3.5-4     | 68                         | 95                         | 0.686               | 18.0                                   | 15.9                                   | 0.18  | 0.033 |
| 7       | 1-1.5     | 25                         | 115                        | 0.626               | 20.2                                   | 16.6                                   | 0.12  | 0.032 |
| 8       | 1.5-2     | 37                         | 130                        | 0.402               | 21.4                                   | 19.4                                   | 0.14  | 0.017 |
| 9       | 3-3.5     | 61                         | 130                        | 0.591               | 20.2                                   | 17.1                                   | 0.17  | 0.034 |
| 10      | 1.5-2     | 33                         | 90                         | 0.60                | 19.1                                   | 17.0                                   | 0.15  | 0.032 |
| 11      | 1.5-2     | 33                         | 190                        | 0.609               | 18.9                                   | 16.9                                   | 0.24  | 0.040 |
| 12      | 0.5-1     | 15                         | 100                        | 0.572               | 19.7                                   | 17.3                                   | 0.18  | 0.031 |
| 13      | 3.5-4     | 71                         | 150                        | 0.888               | 18.8                                   | 14.3                                   | 0.10  | 0.008 |
| 15      | 2-2.5     | 44                         | 270                        | 0.600               | 19.6                                   | 17.0                                   | 0.14  | 0.046 |
| 16      | 1.5-2     | 35                         | 180                        | 0.638               | 19.9                                   | 16.6                                   | 0.10  | 0.027 |
| 17      | 1.5-2     | 34                         | 87                         | 0.609               | 19.3                                   | 16.9                                   | 0.14  | 0.029 |
| 18      | 1-1.5     | 26                         | 150                        | 0.486               | 20.8                                   | 18.3                                   | 0.17  | 0.034 |

**Table 5: Collapse potential with depth**

| T.P.No. | Depth (m) | Collapse Potential (Ic)% | Degree of collapse |
|---------|-----------|--------------------------|--------------------|
| 4       | 3.5-4.0   | 0.56                     | Slight             |
| 7       | 1.0-1.5   | 0.06                     | None               |
| 9       | 3.0-3.5   | 0.69                     | Slight             |
| 10      | 1.5-2.0   | 9.60                     | Moderately severe  |
| 11      | 1.5-2.0   | 6.1                      | Moderately severe  |
| 13      | 3.5-4.0   | 0.15                     | Slight             |
| 15      | 2.0-2.5   | 0.98                     | Slight             |
| 16      | 1.5-2.0   | 0.06                     | None               |
| 17      | 1.5-2.0   | 0.12                     | Slight             |
| 18      | 1.0-1.5   | 4.00                     | Moderate           |

\*According to ASTM D5333

Table 6: Free swelling, linear shrinkage& Swelling Pressure with depth.

| T.P.No | Depth (m) | Free swelling% | Linear shrinkage % | Swelling pressure kN/m <sup>2</sup> |
|--------|-----------|----------------|--------------------|-------------------------------------|
| 1      | 0.0-1.0   | 17             | 14                 | -----                               |
|        | 2.5-3.5   | 25             | -----              | -----                               |
|        | 3.5-4.0   | -----          | -----              | >100*                               |
| 2      | 0.0-1.00  | 75             | 16                 | -----                               |
|        | 2.5-3.5   | 12             | -----              | -----                               |
|        | 3.5-4.0   | -----          | -----              | >100*                               |
| 3      | 0.5-1.0   | 33             | -----              | -----                               |
|        | 1.5-3.0   | 20             | -----              | -----                               |
| 4      | 0.0-1.0   | 20             | 4                  | -----                               |
|        | 2.5-3.5   | 10             | -----              | -----                               |
| 5      | 0.0-1.5   | 11             | -----              | -----                               |
| 6      | 0.0-1.0   | 50             | 18                 | -----                               |
|        | 3.5       | 50             | -----              | -----                               |
| 7      | 0.0-0.5   | 33             | -----              | -----                               |
| 8      | 0.0-0.5   | -----          | 12                 | -----                               |
|        | 0.5-1.5   | 20             | 11                 | -----                               |
| 9      | 0.0-1.5   | 0              | 10                 | -----                               |
|        | 1.5-2.5   | 10             | -----              | -----                               |
|        | 2.5-3.5   | -----          | -----              | 37                                  |
| 10     | 0.0-0.5   | 33             | 16                 | -----                               |
|        | 0.5-1.5   | 50             | -----              | -----                               |
| 11     | 0.0-0.5   | ---            | 16                 | -----                               |
|        | 0.5-1.5   | 50             | -----              | -----                               |
|        | 1.5-2.5   | -----          | -----              | 125                                 |
| 12     | 0.5-1.0   | -----          | -----              | 35                                  |
|        | 0.0-2.0   | 25             | 17                 | -----                               |
| 13     | 0.0-1.0   | 50             | 11                 | -----                               |
|        | 2.0-3.5   | 60             | -----              | -----                               |
| 14     | 0.0-1.0   | 0              | 5                  | ---                                 |
|        | 1.0-2.0   | 38             | -----              | -----                               |
|        | 2.0-3.5   | 35             | -----              | -----                               |
| 15     | 0.0-1.5   | 0              | 12                 | -----                               |
|        | 0.0-1.5   | 0              | 12                 | -----                               |
|        | 2.0-2.5   | -----          | -----              | 150                                 |
| 16     | 0.0-1.5   | -----          | 8                  | -----                               |
|        | 1.5-2.0   | -----          | -----              | 50                                  |
|        | 2.0-3.5   | 8              | -----              | -----                               |
| 17     | 0.0-0.5   | 25             | 15                 | -----                               |
|        | 0.5-1.5   | 40             | -----              | -----                               |
|        | 1.5-2.0   | -----          | -----              | 40                                  |
| 18     | 0.0-1.0   | -----          | 14                 | -----                               |
|        | 1.0-1.5   | -----          | -----              | 65                                  |
|        | 1.5-3.0   | 30             | -----              | -----                               |

\* This sample swelled after wetting in collapse test at the pressure of 100kN/m<sup>2</sup>

### 5-5 Chemical Properties:

The results of the chemical tests for the soil samples are shown in the “Test Results Sheets”. These results indicate low Sulphate content. The Sulphate contenting this soil layer ranges from (0.03) to (0.12) percent. The chloride content varies from (0.02)to (0.05) percent, whereas the pH value varies from (8.93)to (10.06) and the organic matter contents are in the range of(0.03-1.75) percent .The calcium carbonate contents are in the range of (3.0-96.0) percent.

### 5-6 Atterberge limits Test Results

The values of liquid limit (L.L), plasticity index (P.I) and moisture content (M.C) at different depths are shown in the “Record of test result sheets” and borehole logs appended. The results generally indicate that the value of moisture content is closer to the plastic limit than to the liquid limit. This trend suggests that the cohesive layer is over-consolidated. The liquid limits are in the range of (21to 60) percent, the plasticity index are in the range of (8to 35) percent, Linear shrinkage are in the range of (2 to 18) percent.

### 5-7 Compaction and CBR Test Results:

According to the required to the concerned authorities, four soil samples were collected from the top soil surface. Modified proctor method was used to find the maximum density and the optimum moisture content. Also California Bearing Ratio (CBR) at (95%) compacted samples were tested for the same soil samples taken from trial pits. Table (7) shows the maximum dry density and optimum moisture content values as well as the (CBR) values.

Table 7: Compaction parameters and California bearing ratio.

| Lump sample No. | Depth (m) | Max. dry density (kN/m <sup>3</sup> ) | Optimum moisture content % | CBR% |
|-----------------|-----------|---------------------------------------|----------------------------|------|
| 3088            | 0.0-0.5   | 17.83                                 | 15.4                       | 4    |
| 3089            | 0.0-0.5   | 19.20                                 | 16.8                       | 4    |
| 3090            | 0.0-0.5   | 18.09                                 | 14.6                       | 4    |
| 3091            | 0.0-0.5   | 17.90                                 | 16.4                       | 4    |

### 6-Precautions against swelling:

1. Water from any source should be prevented from reaching the stress zone of soil below foundations and ground slabs.
2. Either a foundation depth of (1.5-2.0) m. should be adopted or a layer of course gavel should be placed under shallow foundations and ground slabs.
3. Thin width foundations will reduce the affect of swelling soil on light structures.
4. There are many alternative methods regarding solution for expansive soils which are applied in other countries. These methods need extensive study of the type and magnitude of structural loads and type of foundation. This can be carried out by our consultants through an agreement with your company and consultants.
5. If low temperature below 0°C prevails for long period of times, there is a possibility for frost action which requires a separate study.

## B-Geophysical Investigation

### 7- Introduction

#### 7-1 Authorization and Scope:

This research includes (7) resistivity test profiles for evaluating the soil resistivity.

#### 7-2 Investigation layouts

This investigation consists of the following sections:-

- Resistivity method theory.
- Resistivity investigation. (Field work and results presentation).

### 8- Resistivity method theory

The basis of resistivity measurement is that when an electric current is applied, conduction takeplace into the ground through current electrodes. Any subsurface variation in conductivity will alter the current flow within the earth and affect the distribution of electrical potential. The degree to which the potential at the surface is affected depends upon size, location and conductivity of material within the ground. The usual practical resistance measurement is by passing a current of known value through the ground by two electrodes (C1,C2) and measuring the subsequent potential difference between two intermediate points in the ground using another two electrodes (P1,P2). The instrument used for this purpose is ABEM SAS 300 Resistivity-meter, with digital reading.

#### 8-1 Resistivity Sounding Measurement:

In this method, the current is applied via two outer electrodes C1, C2 of a distance equal to AB. Where another two inner electrodes P1, P2 are used measuring the

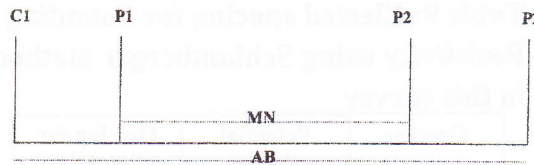


Fig.1: Electrical sounding method

potential difference. The distance between the latter electrodes equals to MN (Fig. 1)

The calculated apparent resistivity is given by the equation:

$$\rho = KR$$

$$K = \frac{AN * AN}{MN} \Pi \quad \text{Where:}$$

$\rho$  = Apparent resistivity measured in Ohm-meter ( $\Omega m$ ).

K = Constant factor.

AB = Distance between current electrodes in meter (m).

MN = Distance between potential electrodes in meter (m).

AM = Distance between current electrode and one potential electrode.

AN = Distance between current electrode and other potential electrode.

### 9- Resistivity investigation

#### 9-1 Field work

Seven profiles were implemented for soil resistivity sounding at the whole area some of these profiles were done on cut area, natural area and fill area as listed in table (8).the points were located on site plan fig (1).

Table 8: List of resistivity profiles depending on kind of area

| Profile No, | Kind of area |
|-------------|--------------|
| 1,4,7       | Natural      |
| 2,5         | Cut          |
| 3,6         | Fill         |

Table 9: Elected spacing for Sounding Resistivity using Schlumberger method in this survey

| Current electrode separation<br>C1 C2<br>AB/2 | Potential elected separation<br>P1 P2<br>(MN/2) <sub>1</sub> | Overlap for Potential elected<br>P1 P2<br>(MN/2) <sub>2</sub> |
|---|--|---|
| 1.5   | 0.5  | -----   |
| 2   | 0.5  | -----   |
| 3   | 0.5  | 1   |
| 4   | 0.5  | 1   |
| 5   | 0.5  | -----   |
| 6   | 1  | 2   |
| 8   | 1  | 2   |
| 10  | 1  | 2   |
| 15  | 2  | 5   |

These profiles were carried out with different intervals using Schumberger technique. The spacing between electrodes was listed in table (9) depending on the type of the Schumberger arrangement technique

### 9-2 Results Presentation

The apparent resistivity values were plotted against the distance (AB/2) on four cycle's log-log graph Figs. (2-8) were appended within report. The true resistivity value and thickness of each sequence depth were determined by using matching technique plotting the auxiliary standard curves method. The resistivity values in Ohm.meter, depth in meter for each station by Schumberger arrangement are listed in Table (10).

### Conclusions

1. Due to hilly nature of the site no underground water table was noticed at the test pits during the time of investigation.
2. Chemical tests indicate that the whitish brown color of soil is due to the high percentage of calcium carbonate content.

Table 10: Interpretation of sounding resistivity survey results by using Schlumberger method.

| Profile No. | Resistivity value<br>Ohm.m. | Depth (m) |
|-------------|-----------------------------|-----------|
| R1          | 64                          | 0.0-1.6   |
|             | 14                          | >1.6      |
| R2          | 280                         | 0.0-1.15  |
|             | 42                          | >1.15     |
| R3          | 600                         | 0.0-1.1   |
|             | 240                         | 1.1-6.71  |
|             | 25                          | >6.71     |
| R4          | 26                          | 0.0-1.05  |
|             | 8                           | 1.05-1.68 |
|             | 35                          | >1.68     |
| R5          | 390                         | 0.0-1.25  |
|             | 60                          | >1.25     |
| R6          | 150                         | 0.0-1.05  |
|             | 750                         | 1.05-1.78 |
|             | 230                         | >1.78     |
| R7          | 220                         | 0.0-1.05  |
|             | 86                          | >1.05     |

3. Swelling tests from odometers, free swell and linear shrinkage, indicated high amounts of swelling behavior of the soil of different depths, accordingly, special precautions against swelling should be adopted.
4. Collapse test results at different locations mostly indicated low collapse potential which has no problem on soil behavior. Only two locations showed high collapse potential which indicate Moderate Severity. This can be avoided by applying certain precautions similar to those against swelling.
5. The direct shear test results and density test results indicate that the soil accordingly an allowable bearing capacity used for the top soil layers should not exceed 7.0 tons/m<sup>2</sup>.

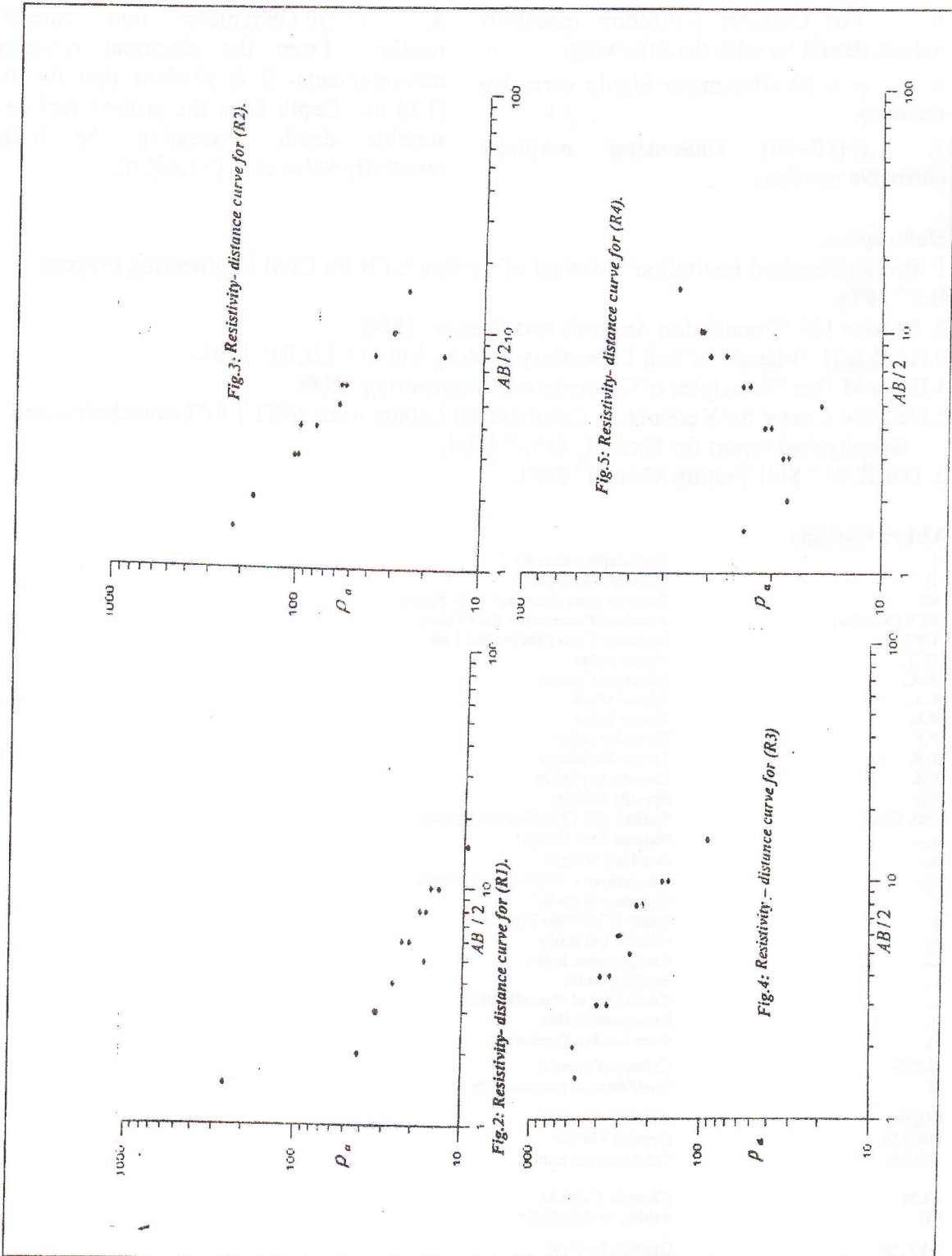
- 6- For Cahodic protection resistivity values should be with the following:
6.  $\rho < 10$  Ohm.meter highly corrosive medium.
7.  $\rho (10-50)$  Ohm.meter normally corrosive medium.
8.  $\rho > 50$  Ohm.meter non corrosive medium. From the electrical resistivity measurements- it is obvious that the first (1.0) m. Depth from the ground surface is suitable depth possessing the higher resistivity value is at (>1.68) m.

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### Abbreviations

|                   |                                    |
|-------------------|------------------------------------|
| U                 | Undisturbed Sample                 |
| D                 | Disturbed Sample                   |
| SS                | Samples from Standard Split Spoon  |
| SPT (N-value)     | Standard Penetration Test Value    |
| CPT               | Dynamic Cone Penetration Test      |
| W.T.              | Water Table                        |
| M.C.              | Moisture Content                   |
| L.L.              | Liquid Limit                       |
| P.L.              | Plastic Limit                      |
| P.I               | Plasticity Index                   |
| L.S.              | Linear Shrinkage                   |
| C.I.              | Consistency Index                  |
| G.s               | Specific Gravity                   |
| Uni. Class        | Unified Soil Classification System |
| $\gamma_{wet}$    | Natural Unit Weight                |
| $\gamma_{dry}$    | Dry Unit Weight                    |
| Qu                | Unconfined Compressive Strength    |
| C                 | Cohesion in $kN/m^2$               |
| $\phi$            | Angle of Internal Friction         |
| $e_0$             | Initial Void Ratio                 |
| $C_c$             | Compression Index                  |
| $C_r$             | Swelling Index                     |
| $C_v$             | Coefficient of Consolidation       |
| $p_c$             | Pre-consolidation                  |
| $P_0$             | Over burden Pressure               |
| C.P.%             | Collapse Potential                 |
| K                 | Coefficient of permeability        |
| SO <sub>3</sub> % | Sulphate Content                   |
| ORG.%             | Organic Matter                     |
| T.S.S%            | Total Soluble salts                |
| CL%               | Chloride Content                   |
| PH                | Acidity or Alkalinity              |
| GYP. %            | Gypsum Content                     |



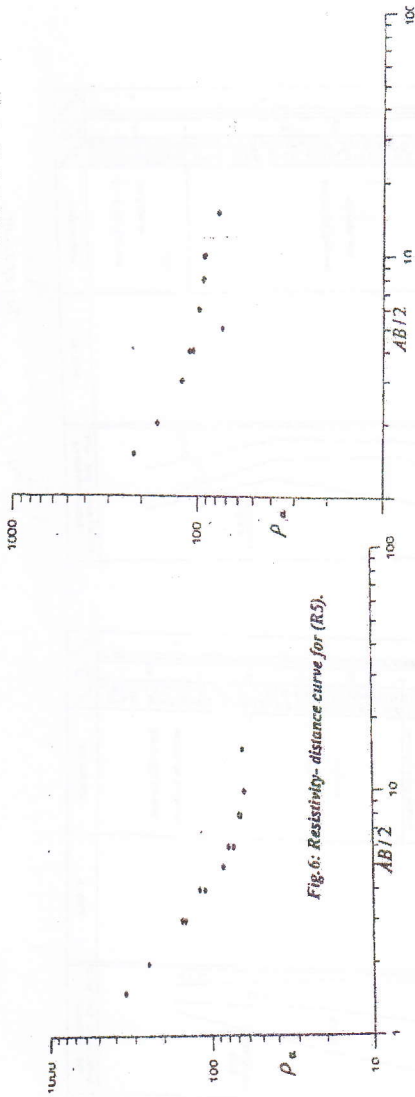


Fig. 7: Resistivity-distance curve for (R6).

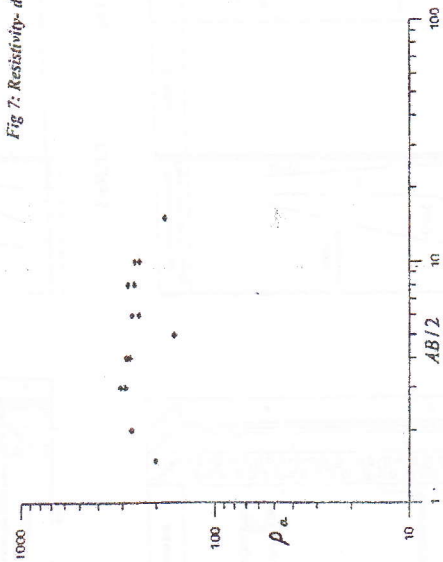
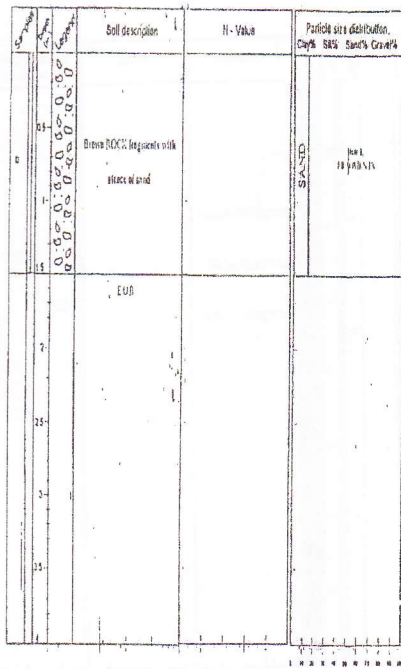


Fig. 8: Resistivity-distance curve for (R7).

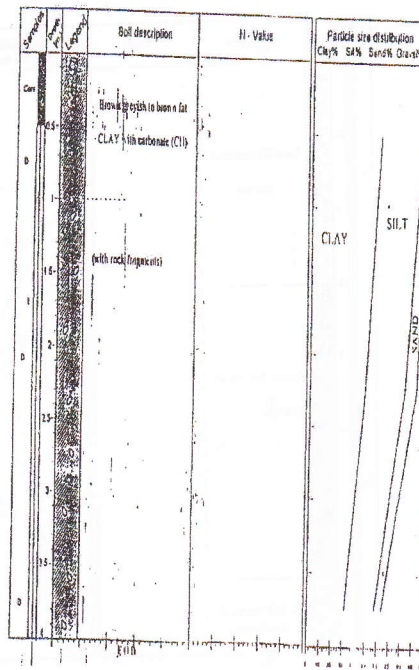




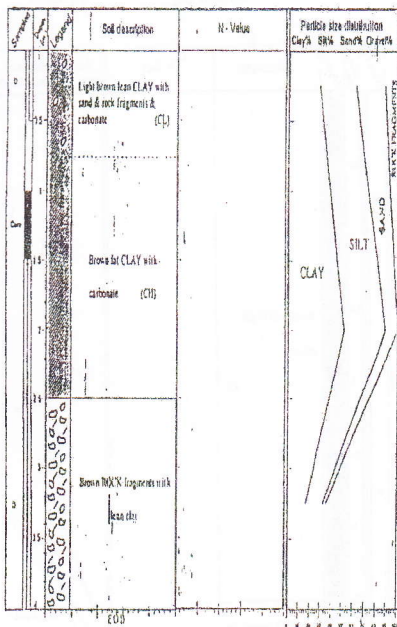
Borehole Log T.P.No:5



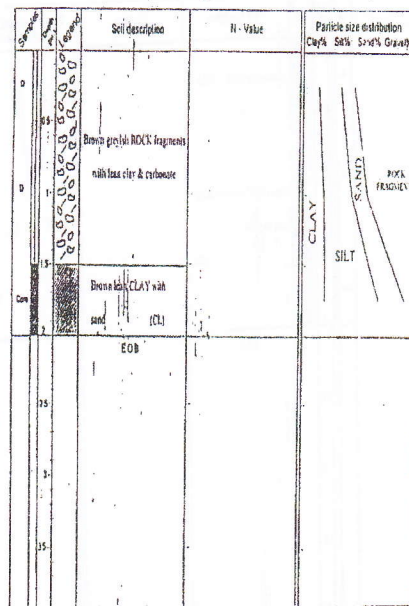
Borehole Log T.P.No:6

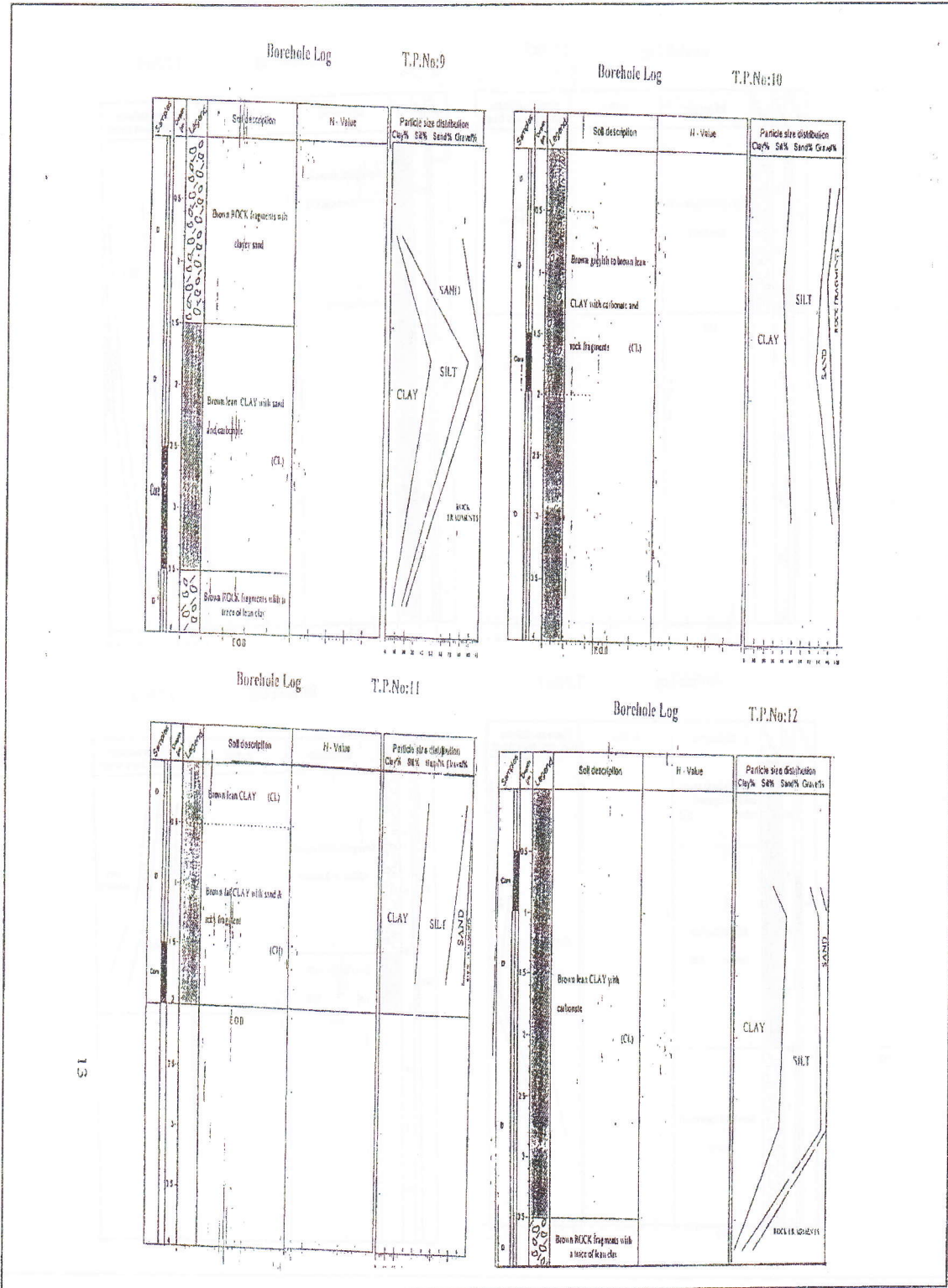


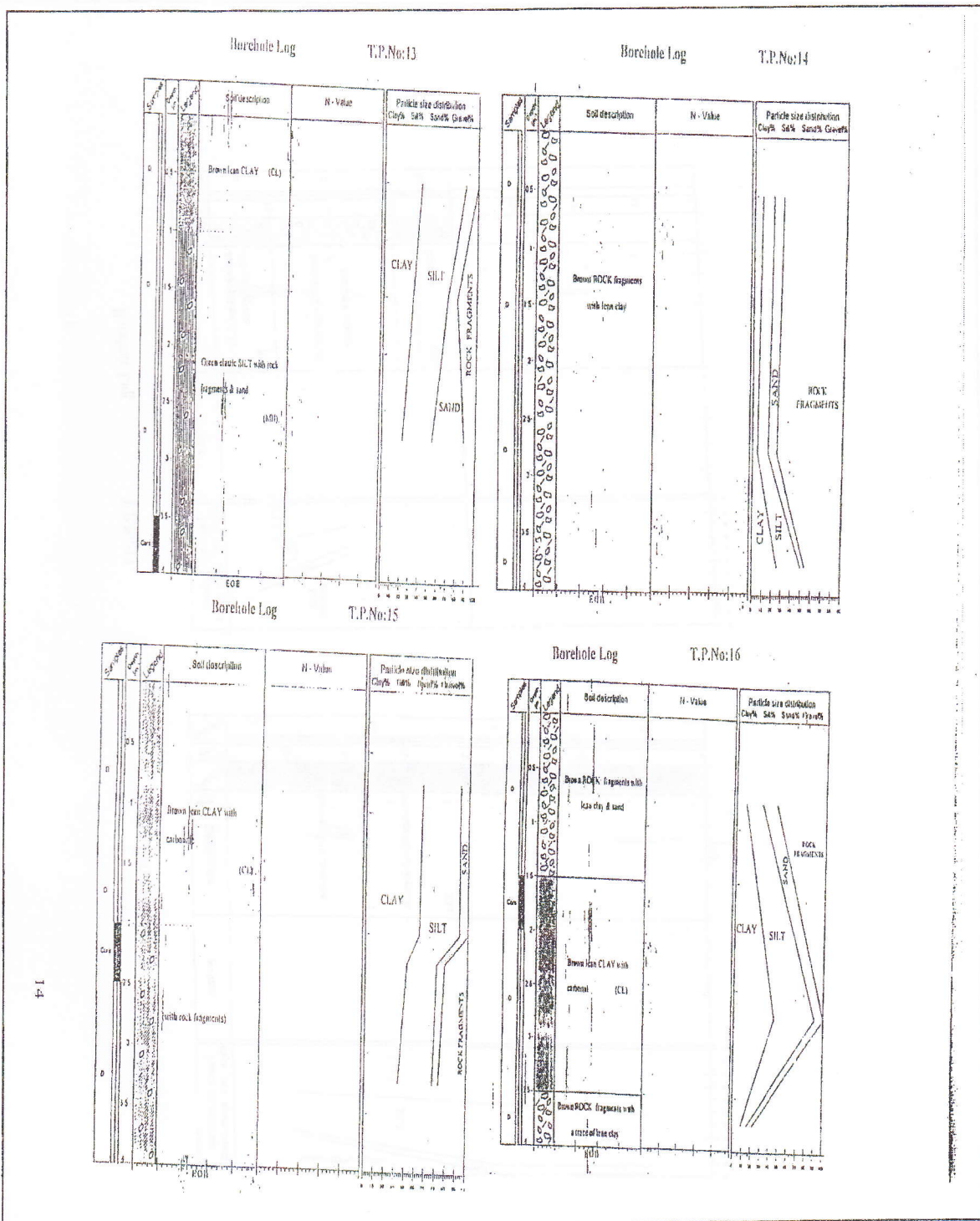
Borehole Log T.P.No:7



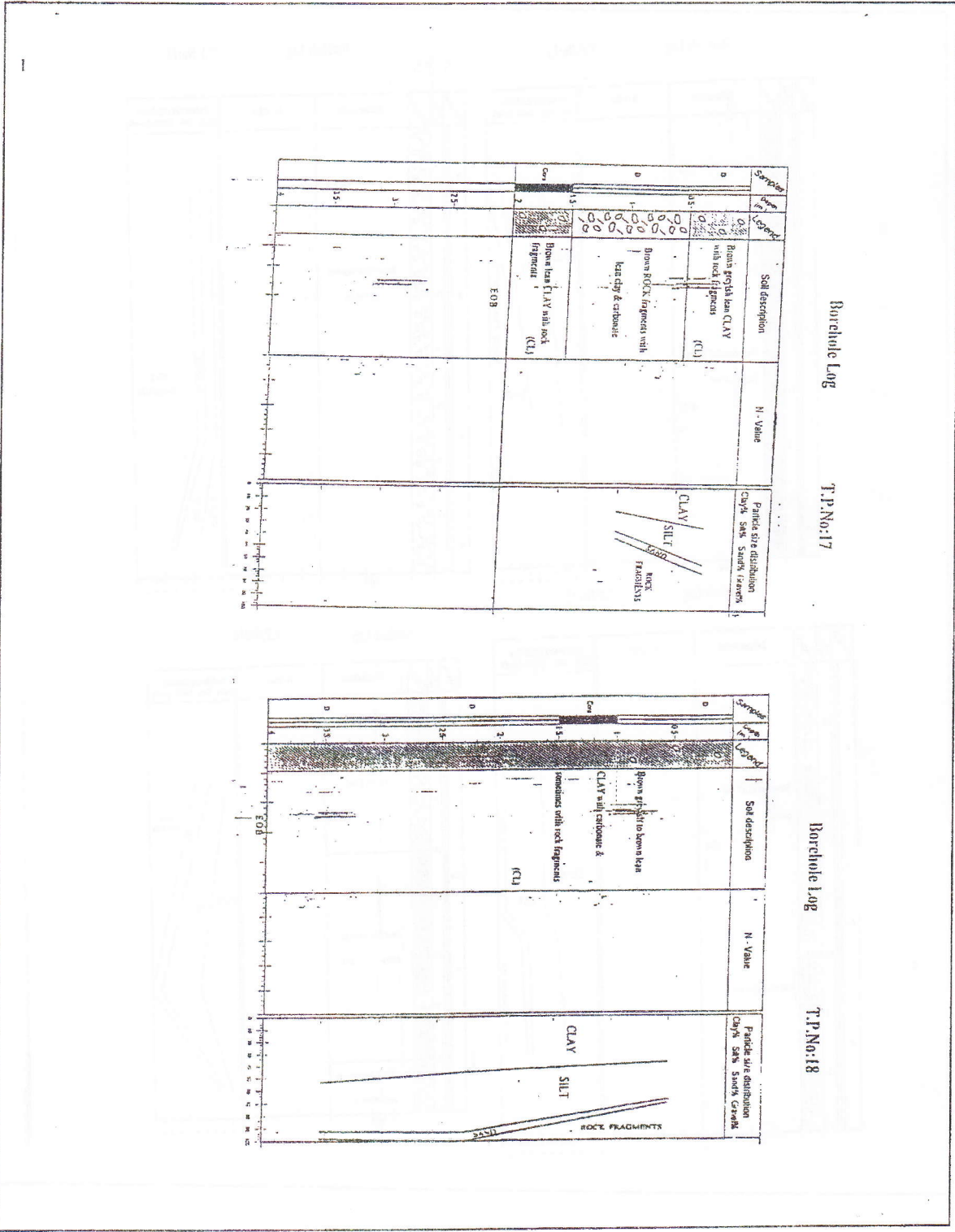
Borehole Log T.P.No:8







14















Record of test Results

T.P.No.13&14

| Samples                      | Field No. | Lab No. | Type | Depth of sample |       | M.C % | Index Property |       |         | Particle size distribution & Hydrometer analysis |        |        |        |  | SPT<br>con<br>Val. | Sym<br>bol | Description of soil | Chemical Tests    |         |        |       |                     |    |
|------------------------------|-----------|---------|------|-----------------|-------|-------|----------------|-------|---------|--|--------|--------|--------|--|--------------------|------------|---------------------|-------------------|---------|--------|-------|---------------------|----|
|                              |           |         |      | From m.         | To m. |       | L.L %          | P.I % | L. sh % | Test Pit No. 13                                  | Clay % | Silt % | Sand % | Gra vel %                                      |                    |            |                     | So <sub>s</sub> % | T.S.S % | ORG. % | Gyp % | CaCO <sub>3</sub> % | PH |
| 1                            | 3135      |         | D    | 0.0             | 1.0   | 42    | 20             | 11    | (40)    | 47   | 0)     | ---    | CL     | Brown lean clay.                               | 0.11               |            | 0.47                |                   | 57      | 9.3    | 0.02  |                     |    |
| 2                            | 3136      |         | D    | 1.0             | 2     | 60    | 22             |       | (32)    | 37   | 21)    | ---    | MH     | Green elastic with rock fragments.             | 0.01               | 2          |                     | 75                |         |        |       |                     |    |
| 3                            | 3137      |         | D    | 2.0             | 3.5   | 60    | 22             |       | (22)    | 32   | 12)    | ---    | MH     | Do (with sand)                                 | 0.1                |            |                     | 50                |         | 0.03   |       |                     |    |
|                              |           |         | Core | 3.5             | 4     | 32    |                |       |         |  |        |        | MH     | Do   |                    |            |                     |                   |         |        |       |                     |    |
| Water table was not observed |           |         |      |                 |       |       |                |       |         |  |        |        |        |  |                    |            |                     |                   |         |        |       |                     |    |
| 1                            | 3139      |         | D    | 0.0             | 1.0   | 27    | 11             | 5     | (8)     | 12   | 70)    | ---    |        | Brown rock fragments with a face of lean clay. | 0.09               |            | 0.3                 |                   | 87      | 9.38   | 0.03  |                     |    |
| 2                            | 3140      |         | D    | 1.0             | 2     | 36    | 16             |       | (5)     | 11   | 75)    | ---    |        | Do.  | 0.11               |            | 0.07                |                   | 52.6    |        |       |                     |    |
| 3                            | 3141      |         | D    | 2               | 3.5   | 41    | 23             |       | (26)    | 24   | 46)    | ---    |        | Do.  | 0.04               |            |                     |                   |         |        |       |                     |    |
| 4                            | 3142      |         | D    | 3.5             | 4.0   |       |                |       |         |  |        | ---    |        | Brown rock fragments with lean clay.           |                    |            |                     |                   |         |        |       |                     |    |





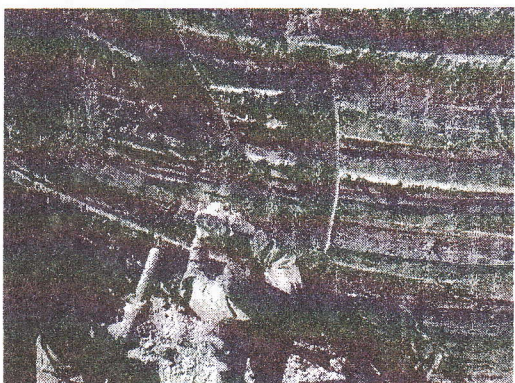


Plate (2) Digging of Boreholes

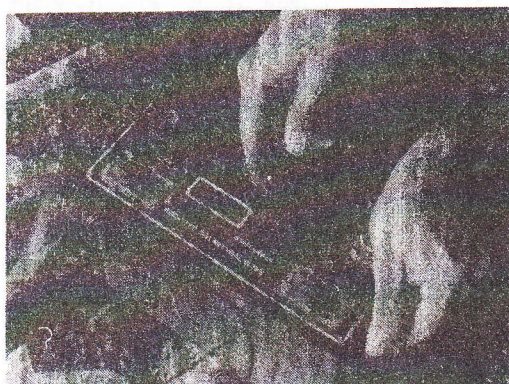
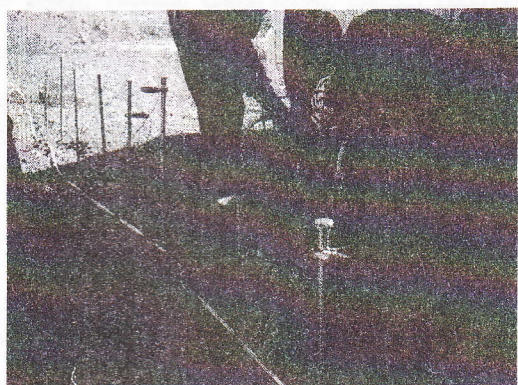


Plate (3) Taken Undisturbed and Disturbed Samples

## لیکۆلینەوهی هەسۆکەوتی ئەندازیاری خاک بۆ ناوچەی تابین\_دوکان سەر بە پارێزگای سلیمانی

احمد صالح محمد ، بەشی بیناکاری ، کۆلیجی ئەندازیاری ، زانکۆی سلیمانی ، هەرێمی کوردستان / عێراق

### پوختە

ئەم توێژینەوهیە هەڵدەستی بە لیکۆلینەوهیەکی درێژکراو و گشتی دەربارەی چەند تاقیکردنەوهیەکی تاقیگەیی وە کێلگەیی بۆ بەشەکانی خاک وە هەسۆکەوتی ئەندازیاری ئە ناوچەی (تابین\_دوکان) سەر بە پارێزگای سلیمانی ، ئەم لیکۆلینەوهیە دوو تەوهری سەرەکی ئەگرێتەخۆی . یەکەمیان وەرگرینی نمونەیی تیکدراو و تیکنەدراو ئە شوێنی ناویراودا وە گواستنهوهی بۆ تاقیگەیی خاک بۆ جی بە جی کردنی تاقیکردنەوهی پێویست وەک ( ریزۆی ناو وە نەرمی ریزۆی شیبی ئاسایی وە تاقیکردنەوهی کانی بەرگری وە بەیەک داچوون وە هەندێ تاقیکردنەوهی کیمیایی وە هەروەها چەند تاقیکردنەوهیەکی تر ئە کێلگەدا وەک تاقیکردنەوهی جیۆفیزیایی وە پێوانی ناستی ناوی ژێر زهوی) . دووهمیان لیکۆلینەوهی ئە نجامە دەستکەوتووکان وە شیکارکردنەوهی بە شیوهیەکی ناماریانە پیش ئەوهی بچیتە ناو خشتەیی تاییەت بۆ ئەوهی زیاتر پەسەند بکریت. وەهەو سەرنجی تاییینانەیی گەشتوینەتی بە هۆی ئەم لیکۆلینەوهیە سەماندی کە خاکی ئەم ناوچەیی ئە روانگەیی بەرگری پەسەندکراو بەلام هەندێ کۆسپی هەییە ئەلایەن هەناوسان کە ئەبیتە هۆی داروخانی ئەو بیناییە ئەسەر ئەم خاکە دروست دەکریت ، وەهەروەها ناستی ناوی ژێر زهوی ئەبندرا ئە کاتی ئە نجامدان تاقیکردنەوهیەکانی کێلگەیی .

## دراسة جيوتکنیکية وجیوفیزیائیة لخواص التربة في منطقة تابین\_دوکان التابعة الى محافظة السليمانية.

احمد صالح محمد ، قسم البناء والانشاءات ، كلية الهندسة ، جامعة السليمانية ، إقليم كوردستان / العراق

### الغلاصة

یتضمن هذا البحث دراسة شاملة وتفصیلة للفحوص المختبرية الموقعية لطبقات التربة وخواصها الهندسية في منطقة (تابین\_دوکان) التابعة الى محافظة السليمانية ، دراسة شملت محورين اساسين: اولهما اخذ النماذج المشوشة و غير المشوشة في الموقع وجلبها الى المختبر ميكانيك التربة لاجراء الفحوصات الازمة عليها ومنا الحد المائي واللدن ونسبة الرطوبة الطبيعية وفحوص القوى والانضمام وكذلك الفحوصات الكيمياء المختلفة لمعرفة مدى تواجد المواد الكيميائية المختلفة ،بالاضافة الى بعض فحوصات الموقعية ومنها الفحوصات الجیوفیزیائیة وقياس مستوى المياه الجوفية ، وثانيهما دراسة النتائج التي تم الحصول عليها ثم تحليل النتائج احصائيا قبل ان تدرج في الجداول الخاصة لمعرفة درجة الثقة بها . اكدت الاستنتاجات التي توصلت اليها الدراسة بان تربة المنطقة قوية من ناحية قوة تحملها ولكن هناك مشاكل من ناحية الانتفاخ في التربة والتي قد يؤدي الى فشل في الابنية المقامة عليها ، وكذلك لم يتم الوصول الى مستوى المياه الجوفية خلال فترة اجراء التحريات .