12. Other Relevant Data

Consulting Engineering Center
(Sajdi & Partners)
C.E.C.

مركز الإستشارات الهندسية
(سجدي وشركاه)

Date: 17/5/2000
Ref.: 2000/103

M-S/Kume Sekkei Co., Ltd.
Tokyo – Japan

Attn. Mr. Tetsuro Nishimura
Project – Manager

Subject : ***Site Investigation Report.***
Project : ***Topographic & Geotechnical Surveys for T.C. Control Center / Aden – Yemen.***

Dear Sir,
We are pleased to submit this report of geotechnical investigation of the subject project site.

The work was executed in accordance with the agreement signed with you.

Thanking you for your confidence looking forward for further cooperation.

Best Regards,

Eng. Jamal F. Birjas
Yemen Branch Manager
C. E. C

تلفون ٥١٥٦٢٥١ - فاكس ٥١٥٢٨٢٧-٦-٩٦٢ - ص.ب ٩٦١١٠٥ عمان ١١١٩٦ الأردن • فرع اليمن : ص.ب ١٩٠٦٦ - فاكس ٢٠٨٠٧٣ - صنعاء - الجمهورية اليمنية
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CONTENTS

1.0 INTRODUCTION.

1.1 Why this Investigation?

Investigation of the underground conditions at a site is prerequisite to the economical design of the substructure elements. It is also necessary to obtain sufficient information for feasibility and economic studies for a proposed project. Public building officials may require soil data together with the recommendations of the geotechnical consultant prior to the issuance of building permit.

Elimination of the site exploration, which usually ranges from about 0.5 to 1.0 percent of total construction cost only, to find after construction has started that the foundation must be redesigned is certainly false economy.

This is generally recognized, and it is doubtful if any major structures are currently designed without site investigation being undertaken.

According to Bowles J.E., with the scarcity of building sites in urban areas and with considerable urban renewal and the accompanying backfill, often with no quality control, the underground conditions can have significant variation within a few meters in any direction.

For these reasons, an adequate ground subsurface investigation is an essential preliminary to the execution of this important project.

1.2 Objectives of Study.

The objective of the study is to describe, classify and test the soil strata at different locations to determine the surface and subsurface conditions with the mechanical, physical & chemical properties of soil strata in order to investigate the foundations problems to come up with most optimum solution that will sustain the loads with minimum cost.

Another main objective is to make topographic map of the site.

1.3 Scope of Work.

The scope of work consists of the following items to accomplish the objectives of the study.

1. Making visit to site to collect information about present land, surface topography and surface drainage.

2. Drilling two bore holes, at prescribed locations to20m depth each.

3. Performing the (SPT) test in both holes every 1.0 m.

4. Collecting disturbed & undisturbed samples from all holes.

5. Carrying out laboratory tests on the collected samples to measure the mechanical, physical & chemical properties of soil at the deep holes and the physical properties at the shallow holes

6. Developing conclusions and recommendations for foundation design & construction.

7. Prepare topographic maps for the site along with longitudinal and transverse sections.

2.0 SITE AND PROJECT DESCRIPTION.

2.1 Site Description.

The site under concern it located at the crossing of the main road penetrating Al-Mansourah town in Aden city, and a secondary road in Al-Mansourah. It is empty part of a large plot used as a compound of primary health center that has been occupied in two places with two single story buildings. The empty area allocated for this project is close to the main road of Al-Mansourah.

The area is almost flat, with many wild trees in it and on its periphery.

Two small wooden poles & steel poles exists at the boundary of the plot which are used for electrical cables.

The site can be reached through the secondary road crossing Al-Mansourah main road.

2.2 Project Description.

The project is a two story building ,each story is 1000m² which will be used as expansion of national tuberculoses control center. The project is a grant from Japan government to the government of Yemen.

Most probably the building will be concrete structure.

2.3 Existing Facilities.

The site is furnished with all municipal facilities, telephone cables, electrical supply, water manias and waste water network. These facilities exists at the two existing building in the plot and surrounding the specified project area but do not penetrate it. Location plan is attached.

3.0 ON-SITE EXPLORATION AND TESTING

3.1 Boring.

During the period between 24^{th} and 26^{th} April 2000,we drilled two bore holes at the third points on the diagonal line connecting the west – South corner with the East – north corner.

The location of the holes was predetermined in – situ by the client and our representative.

The bore holes were drilled to a depth of 20m each.

We drilled the holes using the Hollow – Stem Auger of 7 "out side diameter and 3.25" in side diameter. This technique of drilling was advanced up to the sandy gravel layer where it was ineffective to proceed with this, tricon pit percussion with water and GS stabilizing agent were used to the end of boring.

GS was used to prevent the sides of bore hole from collapse under pressure of the under ground water.

Drilling was executed using our ring type (Mobile drill, Model B-34) mounted on Mercedes truck.

3.2 Sampling.

Samples of soil representing all strata were collected in three forms;

- Undisturbed samples: which were taken utilizing the double – split Shelby tube, with sampling length of 45cm, and thin wall cutting edge, that results in min. disturbance of samples. These samples were taken in the cohesive layers,

- Semi-undisturbed samples: these samples were taken as out crop of the SPT sampler.
  These samples couldn't be considered true undisturbed because the ratio of cutting edge thickness to the open area of sampler is high, which will result in considerable disturbance to the samples, but these samples are good representative for some physical properties of soil such as gradation, Atterberg limits, specific gravity ....etc.

- Disturbed samples : taken as an out crop of the Hollow Stem and percussion drillings .With percussion drilling, large gravel is reduced to ¾" size and the sample is collected by screening and settling the return water carrying soil particles, location of bore holes are shown on the location plan.

3.3 Standard Penetration Test (SPT).

During the drilling of bore holes , the drilling tools were removed at regular intervals, then split spoon was inserted. The sampler was first seated 15cm to penetrate any cutting and then driven an additional 30cm with blows of 63.5 kg monkey free falling 760mm. The number of blows required to derive the additional 30cm was recorded as the standard penetration Number (N). The results are tabulated in table (1).

Table No. (1) :
Standard Penetration Test (S.P.T).

Depth	BH.1	BH2	Depth	BH.1	BH.2
1.0	11	10	11.0	21	17
2.0	14	9	12.0	18	18
3.0	13	14	13.0	16	17
4.0	18	18	14.0	21	37
5.0	17	14	15.0	34	48
6.0	17	17	16.0	47	60
7.0	16	18	17.0	57	60
8.0	17	19	18.0	60	60
9.0	18	16	19.0	60	60
10.0	14	22	-	-	-

3.4 Surveying.

Topographic survey was executed as chain and level survey.

It aims at setting out the main features of the plot with the neighboring buildings and streets.

Relative level of certain points were taken by ordinary level, the levels were related to an arbitrary bench mark with level equal 5.0m a.s.l (arbitrary). It was taken at the tile finish of building B (see attached drawing).

The plot was divided into grids of 10 m X 10m with starting base line 5m away from the edge of Building A.

4.0 LABORATORY TESTING.

Selected soil samples were tested to measure their geotechnical engineering properties, laboratory testing include:

- Natural moisture content	(BS 1377);
- Grain size distribution	(BS 1377);
- Specific gravity	(BS 1377);
- Atterberg limits (Liquid & Plastic)	(BS 1377);
- Shear tests	(ASTEM D-3080);
- Hydrometer analysis	(BS 1377);
- Chemical test	(BS 1377);
- Density Test	(BS 1377);
- Consolidation Test	(BS 1377);
- Permeability Test	(BS 1377);

Summary of results of Laboratory tests are presented in table 2,3,4,5.

Table No. (2)

Physical Properties of disturbed & semi disturbed samples.

BH. No.	Sample No.	Depth M	M.C %	% Passing Sieve No.				Hydrometer			Atterberg Limits		SP. Gr.	Shear Parameters		Permeability
				4	10	40	200	Sand %	Silt %	Clay %	L.L	PI		φ°	C KN/m²	mm/sec.
1	1	0.0 – 0.5	11.3	97.7	90.2	71.3	27.6									
	2	0.5 – 1.0											2.772			
	3	1.0 – 1.5														
	4	1.5 - 2.8	21.3	90.3	87.2	81.6	71.3	28.7	61.4	9.9	36.4	8.3	2.738			
	5	2.8 – 5.0														8.3×10^{-7}
	6	5.0 – 5.5	32.4	97.2	91.2	84.5	75.7									
	7	5.5 – 7.5														
	8	7.5 – 9.5														
	9	9.5 – 12.0									33.8	6.1				
	10	12.0 – 12.5	32.1	94.4	90.1	79.9	70.3	29.7	59.3	11.0			2.744			
	11	12.5 – 15.0									35.3	7.7				
	12	15.0 – 16.3														
	13	16.3 – 17.8	24.7	85.7	73.2	44.9	21.3							37	2.0	9.7×10^{-3}
	14	17.8 – 19.0												34	0.0	
	15	19.0 – 20.0	23.3											34	0.0	

<u>*Table No. (3)*</u>

<u>*Physical Properties of disturbed & semi disturbed samples.*</u>

BH. No.	Sample No.	Depth M	M.C %	% Passing Sieve No.				Hydrometer			Atterberg Limits		SP. Gr.	Shear Parameters		Permeability
				4	10	40	200	Sand %	Silt %	Clay %	L.L	PI		$\phi°$	C KN/m²	mm/sec.
2	1	0.0 – 0.3														
	2	0.0 – 1.5									31.2	5.8				
	3	1.5 – 2.8	20.3	94.4	88.3	80.2	74.7	25.3	65.4	9.3			2.738			
	4	2.8 – 3.5									34.3	7.2				
	5	3.5 – 5.5														7.2×10^{-7}
	6	5.5 – 8.5	33.4	90.0	97.2	85.3	73.6									
	7	8.5 – 11.0									35.1	7.8				
	8	11.0 – 13.0														
	9	13.0 – 15.0	32.8	96.2	91.3	84.2	77.1									
	10	15.0 – 16.0														
	11	16.0 – 17.5												34	0.0	
	12	17.5 – 19.0	24.4	84.4	68.2	33.1	19.6									
	13	19.0 – 20.0												32	1.0	

Table No. (3):
Physical Properties of undisturbed samples.

BH No.	Sample No.	Depth %	M.C %	% Passing Sieve No.				Hydrometer			Atterberg Limits	
				4	10	40	200	Sand %	Silt %	Clay %	L.L	PI
1	1	2.5 – 2.95	33.7	94.8	91.2	84.3	74.6				34.8	6.8
	2	8.0 – 8.45	33.9	99.2	97.6	90.3	77.8	22.2	64.8	13.0		
	3	15.5 – 15.95	31.8	91.4	88.2	80.1	70.6				32.1	5.9
2	1	3.5 – 3.95	34.3	99.7	94.9	85.3	76.2	23.8	61.1	15.1		
	2	9.0 – 9.45	33.8	97.3	91.8	81.2	71.6				33.3	7.1
	3	14.0 – 14.45	32.1	94.3	88.8	80.3	74.2	25.8	66.7	7.5		

Table No. (4):
Mechanical Properties of undisturbed samples.

BH No.	Sample No.	Depth %	M.C %	% Passing Sieve No.				Bulk dens. KN/cm³	Uncom. Compression qu KN/m²	Triaxial Shear		Consolidation	
				4	10	40	200			ϕ	C	EKN/m³	Cc
1	1	2.5 – 2.95	33.7	94.8	91.2	84.3	74.6	18.8	79	15	26	19200	0.134
	2	8.0 – 8.45	33.9	99.2	97.6	90.3	77.8	19.1	90				
	3	15.5 – 15.95	31.8	91.4	88.2	80.1	70.6	19.6	54				
2	1	3.5 – 3.95	34.3	99.7	94.9	85.3	76.2	18.7	94	12	31	22100	0.116
	2	9.0 – 9.45	33.8	97.3	91.8	81.2	71.6	18.9	82				
	3	14.0 – 14.45	32.1	94.3	88.8	80.3	74.2	19.1	66				

Table No. (5):
Chemical Analysis

Soil				Water			
BH No.	Depth	$SO3^{=}$ (%)	Cl^{-} (%)	BH No.	Depth	$SO3^{=}$ (PPM)	Cl^{-} (PPM)
1	4.0	0.008	0.03	2	7.0	105	2140
2	9.0	0.030	0.090				

5.0 GEOLOGY &SUBSURFACE CONDITIONS

Since Cambrian times thick sequences of sedimentary rocks have been deposited forming the upper part of the Arabian shield together with its Precambrian basement. In present geodynamics the Arabian shield is moving northwards separating itself from the large African shield and simultaneously being affected by the large Indian – Australian shield which is drifting eastwards and by this making the Arabian Peninsula dipping slightly towards the eastern Arabian Gulf leading to a present eastern inclination of the Arabian shield is of about 1 to 2 degrees. The southern basement flank of the Arabian shield is geologically formed by older Precambrian rock formations strongly stressed, broken, faulted and fissured with intruded dike swarms up to the subcrustal magma chamber of the lower crust. The intruded volcanic material is forming volcanic piles. Those volcanic piles average more than 1200m in thickness forming the high Yemen lava plateau with alternating flows of basalt interbedded with acid effusive ingnimbrites that range in composition from rhyolite to comendite. These basalt flows of the Trap Series rest on shallow marine Mekj-zir sandstone and conglomerates considered in the inner part of the Paleocene and spread in the Pliocene/Pleistocene far into the coastal plain of the Aden region interwedged there with thick quaternary sediments of evaporate and marine. These in confirmation with the preliminary soil investigation might form the upper subsoil layers of the considered site in the Aden Airport area.

In summary quite irregular subsoil conditions of geologically comparatively young origin and this under the influences of ongoing plate tectonic movements may have to be expected.

Close inspection of soil samples retrieved from the two bore holes indicates almost a homogeneous layer of fine damp to dry, gray color fine silty sand up to a depth of 0.4m, this layer comprise the top soft soil.

Underneath this layer a clayey silt layer extends to a depth of 16.0m, this layer is characterized by its stratification of sub layers 1.0 – 3.0m thickness each.

The clay content in each sub layer differs slightly from others, but with general common characteristics such as dark brown Reddish color, stiff formation, low plasticity and medium compressibility and has some pea size gravel.

This layer overly another stratified silty gravel – sand layer which is gray to light brown in color, with very dense formation, very low compressibility.

6.0 Carrying capacity of soil

The analysis will consider shallow footing through theoretical and empirical approaches

Theoretical approach :

First: We will consider isolated footing dimensions of $2.0 \times 2.0m^2$ at a depth of 1.5m.

The following Terzaghi equation corrected by schultz will be adopted to calculate the safe bearing capacity :

$$Qull = (1 + 0.3\ B/L)\ CNc + \gamma_1 D_1 Nq + (1 - 0.2\ B/L)\ B\gamma_2\ N\gamma/2$$

Where:

Qult	=	Ultimate bearing capacity
B,L	=	Width & Length of footing
γ_1, γ_2	=	Density of soil above & beneath footing respectielly
C	=	Cohesion
D	=	Depth of footing
N1,Nq,Nγ	=	Factors dependent on angle of internal friction

The controlling stratum is at BH2, with

ϕ = 12, C = 31 KN/m²

Nc = 10.9, Nq = 3.42, Nγ = 1.22

Qult = 544 KN/m² For a factor of safety = 3

Qall = 181 KN/m²

Second: For strip footings with B = 1.0m at the same above conditions :

Qult = 439.7KN/m²

Qall = 147KN/m² For a factor of safety = 3

Empirical Approach

From the standard penetration test;

The average uncorrected (SPT vales to a depth = 5B below footing depth; i.e. to a depth = 10mm = 16

Taking into consideration the overburden effect and built up water pressure

SPT corrected = 13

Applying the following equation:

$$Qall = (N/F2)(B+0.3/B)^2$$

Where :

F2	=	A factor dependent on B
B	=	Width of footing
N	=	Corrected SPT value
Qall	=	162 KN/m²

7.0 SETTLEMENT ANALYSIS

The following equation is applied to calculate the settlement under isolated and strip footings.

$$\Delta H = (Cc + H/1+e_0)\log(P_0 + \Delta P/\Delta P)$$

Where:

Cc	=	Compressibility Index
H	=	Thickness of affected layer by the applied load
ΔP	=	Average applied load at center of affected layer
e	=	Initial voids ratio
P_0	=	Over burden stress at center of affected layers.

It we apply a load equal the safe bearing capacity calculated preciously

Then for a 2.5m × 2.5m isolated footing

ΔH = 6.7cm

For strip footing with B = 1.0m

ΔH = 3.4cm

8.0 DYNAMIC & SIESMIC FACTORS.

The clay silt soil has the following Dynamic characteristics.

Poison's ratio μ	=	0.38
Shear modulus (G)	=	7200 KN/m^2
Compression wave vc	=	143m/sec.
Shear wave	=	61m/sec.

9.0 CONCLUSIONS AND RECOMMENDATIONS

1. To enhance the soil strength and minimize the settlement, we recommend to design the building on strip footing.

2. If strip footing are inadequate mainly in the middle area of the building, isolated square or rectangular footing are recommended with width not exceeding 2.5m.

3. To minimize the settlement and increase the soil carrying capacity, we recommend to make soil replacement under the footing. To increase the safe soil capacity to 2.0 Kg/cm^2, the soil replacement should be 1.5m below footing level, to increase the soil capacity to 1.8Kg/cm^2, the replacement should be to 1.2 m below bottom level of footings.

4. Although the above figures are within the range of the calculated bearing capacity, but applying these figures without replacement will give high values of settlement, so the replacement is recommended to keep the safe bearing capacity in the range of 1.8 – 2.0Kg/cm^2 with settlement less than 1.5cm.

   Also soil replacement will enhance the soil underneath footing against dynamic loading.

5. For soil replacement it is recommended to consider the following factors:

- The soil used for replacement should be well graded granular material with max. size less than 4" and less then 10% should be passing sieve No. 200.
- The width of replacement should be at least 30.0 cm out side the edges of footings from all sides.
- The soil should be placed in layers less than 20.0 cm thickness and compacted to a minimum of 95% of max. dry density obtained in the laboratory.

6. The soil is stiff but can be excavated with simple mechanical equipment such as backhoe.

7. It is not recommended to use the excavated material in back fill operations around footings or directly below tiles.

8. Due to the high concentration of chlorides ,we recommend using ordinary Portland cement in amount not less than 425 kg/m3.

10. 0 REFERENCES

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4. Tomlinson M. J. Foundation Design and Construction. 4th ed. London.

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11.0 APPENDIX

CONSULTING ENGINEERING CENTER

JOB : 103/2000

SAMPLE No. : Sample 4

SITE : B. H. 1

C.E.C

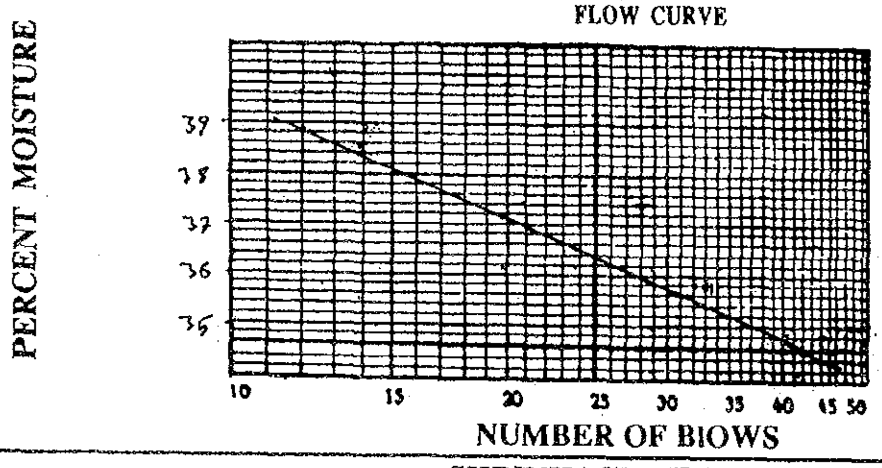
SOIL CONSISTENCY TEST

Sample Description

LIQUID LIMIT - PLASTIÇ - PLASTICITY INDEX

		Plastic Limit		Liquid Limit			
	Trial No.	1	2	1	2	1	2
	Dish No.	40	I	26	7	D	14
	No. of Blows	-	-	12	21	32	40
1	Wt. Dish + Wet Soil gr.	28.90	31.02	47.95	38.13	41.56	46.18
2	Wt. Dish + Dry Soil gr.	28.34	30.33	44.50	33.65	37.76	40.77
3	Wt. of Dish gr.	26.34	27.88	35.61	21.54	27.09	25.23
4	Wt. of Water (1-2) gr.	0.56	0.69	3.45	4.48	3.80	5.41
5	Wt. of Dry Soil (2-3) gr.	2.00	2.45	8.89	12.11	10.67	15.54
6	% Moisture (4/5 X 100)	28.00	28.2	38.8	37.00	35.60	34.80
7	A verage Plastic Limit %	28.1					

FLOW CURVE



SHRINKAGE TEST

1	Shrinkge Dish No. gr.		8	Vol. Shrinkage Dish (V) ml	
2	Wt. of Dish + Wet Soil gr.		9	Vol. Dry Soil (Vo) ml	
3	Wt. of Dish + Dry Soil gr.		10	V - Vo = (8 - 9)	
4	Wt. of Dish gr.		11	$\frac{V - V_o}{W_o}$ x 100 = $\left(\frac{10}{6} \times 100\right)$	
5	Wt. of Water (2-3) gr.				
6	Wt. of Soil (Wo) = (3-4) gr		12	Strinkage Limit (7 - 11) %	
7	% Moisture (5/6 x 100)		13	Shrinkage Ratio (6/6)	

Liquid Limit =	36.4	Pastic Limit =	28.1	Plasticty Index =	8.3	Shrinkage Limit =	

Soil Mechanics Laboratory Testing : **CONSISTENCY TESTS** Sample No. :

Tested & Computed by : .... Material Engineer : ....Q. N......... Date : ....

CONSULTING ENGINEERING CENTER

JOB : 103/2000

SAMPLE No. : 9

SITE : B. H. 1

C.E.C

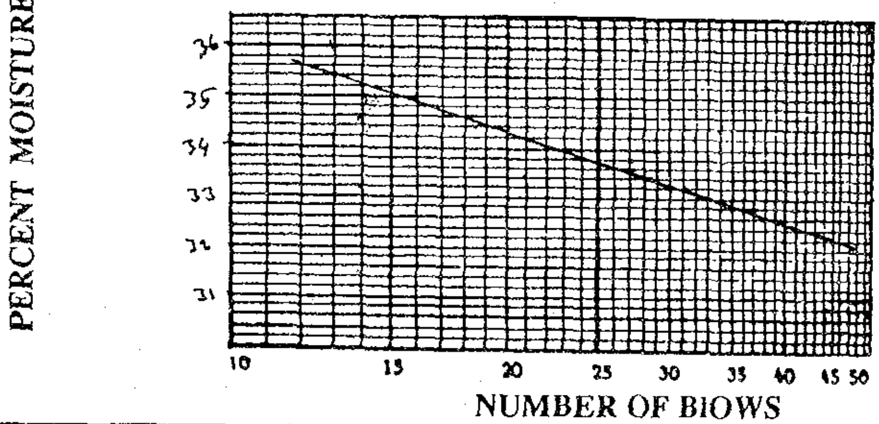
SOIL CONSISTENCY TEST

Sample Description

LIQUID LIMIT - PLASTIC - PLASTICITY INDEX

		Plastic Limit		Liquid Limit			
	Trial No.	1	2	1	2	1	2
	Dish No.	15	22	J	Q	12	34
	No. of Blows	-	-	13	23	31	39
1	Wt. Dish + Wet Soil gr.	27.47	33.28	68.23	53.58	43.50	47.48
2	Wt. Dish + Dry Soil gr.	27.09	32.58	60.68	48.89	38.18	40.87
3	Wt. of Dish gr.	25.71	30.07	39.35	35.10	22.16	20.59
4	Wt. of Water (1-2) gr.	0.38	0.70	7.55	4.69	5.32	6.61
5	Wt. of Dry Soil (2-3) gr.	1.38	2.51	21.33	13.79	16.02	20.28
6	% Moisture (4/5 X 100)	27.50	27.90	35.40	34.00	33.20	32.60
7	A verage Plastic Limit %	27.7					

FLOW CURVE



SHRINKAGE TEST

1	Shrinkge Dish No. gr.		8	Vol. Shrinkage Dish (V) ml		
2	Wt. of Dish + Wet Soil gr.		9	Vol. Dry Soil (Vo) ml		
3	Wt. of Dish + Dry Soil gr.		10	V - Vo = (8 - 9)		
4	Wt. of Dish gr.		11	$\frac{V - Vo}{Wo}$ x 100 =	$\left(\frac{10}{6} \times 100\right)$	
5	Wt. of Water (2-3) gr.					
6	Wt. of Soil (Wo) = (3-4) gr		12	Strinkage Limit (7 - 11) %		
7	% Moisture (5/6 x 100)		13	Shrinkage Ratio (6/6)		

Liquid Limit =	33.8	Pastic Limit =	27.7	Plasticty Index =	6.1	Shrinkage Limit =	

Soil Mechanics Laboratory Testing :	**CONSISTENCY TESTS**	Sample No. :

Tested & Computed by : .... Material Engineer : Q. N. .... Date : ....

CONSULTING ENGINEERING CENTER

JOB : 103/2000

SAMPLE No. : 11

SITE : B. H. 1

C.E.C

SOIL CONSISTENCY TEST

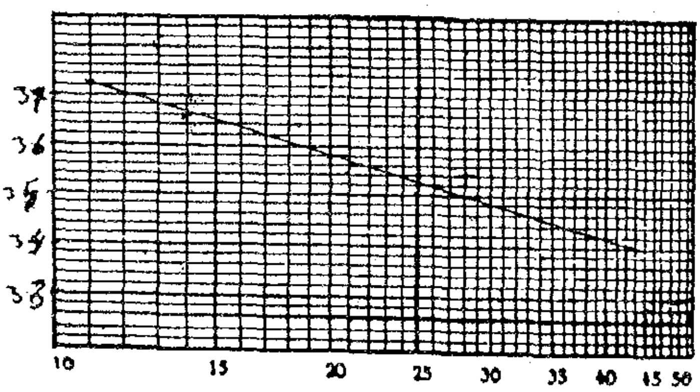
Sample Description

LIQUID LIMIT - PLASTIC - PLASTICITY INDEX

		Plastic Limit		Liquid Limit			
	Trial No.	1	2	1	2	1	2
	Dish No.	20	Y	A	B	I	2
	No. of Blows	-	-	11	20	29	38
1	Wt. Dish + Wet Soil gr.	23.21	26.81	25.63	38.53	52.64	41.72
2	Wt. Dish + Dry Soil gr.	22.85	26.37	23.07	35.07	46.22	36.51
3	Wt. of Dish gr.	21.54	24.78	16.19	25.41	27.88	21.28
4	Wt. of Water (1-2) gr.	0.36	0.44	2.56	3.46	6.42	5.21
5	Wt. of Dry Soil (2-3) gr.	1.31	1.59	6.88	9.66	18.34	15.23
6	% Moisture (4/5 X 100)	27.50	27.70	37.20	35.80	35.00	34.200
7	A verage Plastic Limit %	27.6					

FLOW CURVE

PERCENT MOISTURE



NUMBER OF BIOWS

SHRINKAGE TEST

1	Shrinkge Dish No. gr.		8	Vol. Shrinkage Dish (V) ml	
2	Wt. of Dish + Wet Soil gr.		9	Vol. Dry Soil (Vo) ml	
3	Wt. of Dish + Dry Soil gr.		10	V - Vo = (8 - 9)	
4	Wt. of Dish gr.		11	$\frac{V - Vo}{Wo}$ x 100 = $\left(\frac{10}{6} \times 100\right)$	
5	Wt. of Water (2-3) gr.				
6	Wt. of Soil (Wo) = (3-4) gr		12	Strinkage Limit (7 - 11) %	
7	% Moisture (5/6 x 100)		13	Shrinkage Ratio (6/6)	

Liquid Limit =	35.3	Pastic Limit =	27.6	Plasticty Index =	7.7	Shrinkage Limit =	

Soil Mechanics Laboratory Testing : **CONSISTENCY TESTS** Sample No. :

Tested & Computed by : .... Material Engineer : Q. N .... Date : ....

CONSULTING ENGINEERING CENTER

JOB : ....2000/103.........................

SAMPLE No. : ..4............................

SITE : .....BH2..Depth..2.8..-..3.5..

C.E.C

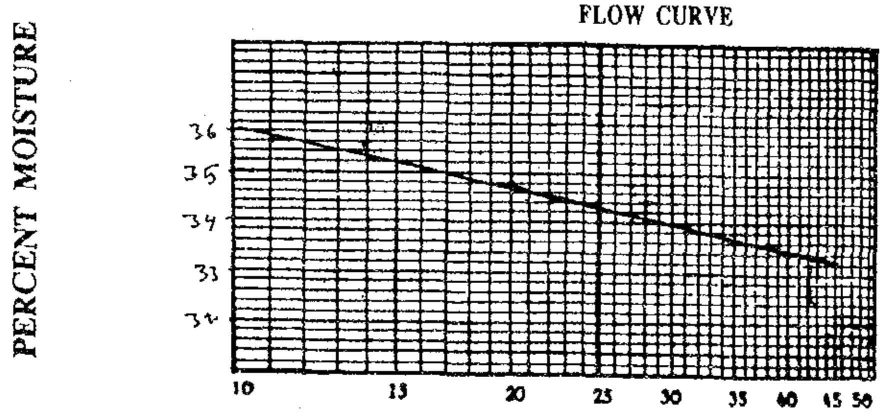
SOIL CONSISTENCY TEST

Sample Description

LIQUID LIMIT - PLASTIC - PLASTICITY INDEX

		Plastic Limit		Liquid Limit			
	Trial No.	1	2	1	2	1	2
	Dish No.	5	6	23	24	28	29
	No. of Blows	-	-	11.00	20.00	31.00	42.00
1	Wt. Dish + Wet Soil gr.	26.20	21.73	60.91	56.08	53.98	42.02
2	Wt. Dish + Dry Soil gr.	25.20	20.68	53.09	49.67	49.39	36.33
3	Wt. of Dish gr.	21.48	16.83	31.12	31.25	35.89	19.29
4	Wt. of Water (1-2) gr.	1.00	1.05	7.82	6.41	4.59	5.69
5	Wt. of Dry Soil (2-3) gr.	3.72	3.85	21.97	18.42	13.50	17.04
6	% Moisture (4/5 X 100)	26.90	27.30	35.60	34.800	34.00	33.40
7	A verage Plastic Limit %	27.1					

FLOW CURVE



NUMBER OF BIOWS

SHRINKAGE TEST

1	Shrinkge Dish No. gr.		8	Vol. Shrinkage Dish (V) ml	
2	Wt. of Dish + Wet Soil gr.		9	Vol. Dry Soil (Vo) ml	
3	Wt. of Dish + Dry Soil gr.		10	V - Vo = (8 - 9)	
4	Wt. of Dish gr.		11	$\frac{V - Vo}{Wo}$ x 100 = $\left(\frac{10}{6} \times 100\right)$	
5	Wt. of Water (2-3) gr.				
6	Wt. of Soil (Wo) = (3-4) gr		12	Strinkage Limit (7 - 11) %	
7	% Moisture (5/6 x 100)		13	Shrinkage Ratio (6/6)	

Liquid Limit =	34.3	Pastic Limit =	27.1	Plasticty Index =	7.2	Shrinkage Limit =	

Soil Mechanics Laboratory Testing :	**CONSISTENCY TESTS**	Sample No. :

Tested & Computed by : .... Material Engineer : .....D.N............................ Date : ....

CONSULTING ENGINEERING CENTER

JOB : ....2000/103.........................

SAMPLE No. : ...2..............................

SITE : .Bh2,..Depth..9.0.....9.45....

C.E.C

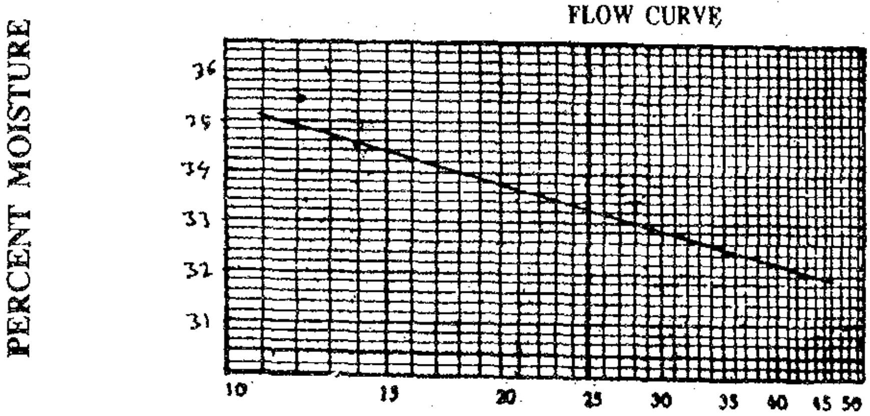
SOIL CONSISTENCY TEST

Sample Description

LIQUID LIMIT - PLASTIC - PLASTICITY INDEX

			Plastic Limit		Liquid Limit			
	Trial No.		1	2	1	2	1	2
	Dish No.		3	4	23	24	D	H
	No. of Blows		-	-	12.00	20.00	28.00	35.00
1	Wt. Dish + Wet Soil	gr.	24.19	27.53	51.88	50.29	52.96	48.64
2	Wt. Dish + Dry Soil	gr.	23.75	26.82	46.51	45.48	46.54	42.66
3	Wt. of Dish	gr.	22.08	24.10	31.12	31.25	27.09	24.32
4	Wt. of Water (1-2)	gr.	0.44	0.71	5.37	4.81	6.42	5.98
5	Wt. of Dry Soil (2-3)	gr.	1.67	2.72	15.39	14.23	19.45	18.34
6	% Moisture	(4/5 X 100)	26.30	26.10	34.90	33.80	33.00	32.60
7	A verage Plastic Limit	%	26.2					

FLOW CURVE



NUMBER OF BLOWS

SHRINKAGE TEST

1	Shrinkge Dish No.	gr.		8	Vol. Shrinkage Dish (V) ml	
2	Wt. of Dish + Wet Soil	gr.		9	Vol. Dry Soil (Vo) ml	
3	Wt. of Dish + Dry Soil	gr.		10	V - Vo = (8 - 9)	
4	Wt. of Dish	gr.		11	$\frac{V - Vo}{Wo}$ x 100 = $\left(\frac{10}{6} \times 100\right)$	
5	Wt. of Water (2-3)	gr.				
6	Wt. of Soil (Wo) = (3-4)	gr		12	Strinkage Limit (7 - 11) %	
7	% Moisture (5/6 x 100)			13	Shrinkage Ratio (6/6)	

Liquid Limit =	33.3	Pastic Limit =	26.2	Plasticty Index =	7.1	Shrinkage Limit =	

Soil Mechanics Laboratory Testing : **CONSISTENCY TESTS** Sample No. :

Tested & Computed by : .... Material Engineer : .....Q.N............................ Date : ....

C.E.C.

HYDROMETER TEST

KIND OF MATERIAL	:	**ITEM No.**	:
SAMPLED AT	: BH 1 Sample 4	**DATE**	:
		TESTED BY	:

- **Hydrometer Type:**

% Passing sieve No. 10 = 87.2
Wt. Of sample = 100

- **Readings**

Time minuets	Hydrometer Reading Corrected	% Finner	Diameter mm.
10	56	63.9	0.0337
30	50	49.0	0.0205
60	43	42.1	0.0155
1440	31	30.4	0.0035
2880	20	19.6	0.0026
4320	12	11.7	0.0020

% Clay in test = 11.7
% Clay in Sample = 9.9

Material Eng. O.N
CEC

C.E.C.

HYDROMETER TEST

KIND OF MATERIAL	:	**ITEM No.**	:
SAMPLED AT	: BH 1 Sample 10	**DATE**	:
		TESTED BY	:

- **Hydrometer Type:**

% Passing sieve No. 10 = 90.1
Wt. Of sample = 100 gm

- **Readings**

Time minuets	Hydrometer Reading Corrected	% Finner	Diameter mm.
10	60	58.8	0.0318
30	52	51.0	0.0261
60	45	44.1	0.0152
1440	32	31.4	0.0035
2880	20	19.6	0.0026
4320	13	12.7	0.0021

% Clay in test = 12.7
% Clay in Sample = 11.0

Material Eng. O.N
CEC

C.E.C.

Sp.Gr. & ABSORPTION OF COARSE & FINE AGGREGATE

JOB : 2000/103
DATE :
LOCATION : BH 1

SAMPLE No. :2
OPERATOR :

Sp.Gr. & ABSORPTION OF COARSE AGGREGATE				Result
1	Wt. Of Dry sample (gr.)	(A)	199.9	
2	Wt. Of Saturated surface of dry sample(gr.)	(B)	-	
3	Wt. Of (Flask + Water + Sample) (gr.)	(C)	937.3	
4	Wt. Of (Flask + Water till Mark) (gr.)	(D)	809.5	
5	Sp. Gravity (dry sample) = A/(B + D)- C	=		-
6	Sp. Gravity (Sat. surf. dry) = B/(B + D)– C	=		-
7	Sp. Gravity (Apparent) = A/(A + D) – C	=		2.772
8	% age of water absorption = (B – A)/A × 100			-

Material Eng. Q.N

C.E.C.

Sp.Gr. & ABSORPTION OF COARSE & FINE AGGREGATE

JOB : 2000/103 **SAMPLE No.** :10
DATE : **OPERATOR** :
LOCATION: BH 1

Sp.Gr. & ABSORPTION OF COARSE AGGREGATE				Result
1	Wt. Of Dry sample (gr.)	(A)	200.0	
2	Wt. Of Saturated surface of dry sample(gr.)	(B)	-	
3	Wt. Of (Flask + Water + Sample) (gr.)	(C)	936.6	
4	Wt. Of (Flask + Water till Mark) (gr.)	(D)	809.5	
5	Sp. Gravity (dry sample) = A/(B + D)- C	=		-
6	Sp. Gravity (Sat. surf. dry) = B/(B + D)- C	=		-
7	Sp. Gravity (Apparent) = A/(A + D) – C	=		2.744
8	% age of water absorption = (B – A)/A × 100			-

Material Eng. Q.N

Sp.Gr. & ABSORPTION OF COARSE & FINE AGGREGATE

JOB : 2000/103
DATE :
LOCATION : BH 1

SAMPLE No. :4
OPERATOR :

Sp.Gr. & ABSORPTION OF COARSE AGGREGATE				Result
1	Wt. Of Dry sample (gr.)	(A)	199.6	
2	Wt. Of Saturated surface of dry sample(gr.)	(B)	-	
3	Wt. Of (Flask + Water + Sample) (gr.)	(C)	936.2	
4	Wt. Of (Flask + Water till Mark) (gr.)	(D)	809.5	
5	Sp. Gravity (dry sample) = A/(B + D)- C	=		-
6	Sp. Gravity (Sat. surf. dry) = B/(B + D)- C	=		-
7	Sp. Gravity (Apparent) = A/(A + D) – C	=		2.738
8	% age of water absorption = (B – A)/A × 100			-

Material Eng. Q.N

C.E.C.

Sp.Gr. & ABSORPTION OF COARSE & FINE AGGREGATE

JOB : 2000/103
DATE :
LOCATION: BH 1

SAMPLE No. :14
OPERATOR :

Sp.Gr. & ABSORPTION OF COARSE AGGREGATE				Result
1	Wt. Of Dry sample (gr.)	(A)	200.4	
2	Wt. Of Saturated surface of dry sample(gr.)	(B)	-	
3	Wt. Of (Flask + Water + Sample) (gr.)	(C)	940.9	
4	Wt. Of (Flask + Water till Mark) (gr.)	(D)	809.5	
5	Sp. Gravity (dry sample) = A/(B + D)- C	=		-
6	Sp. Gravity (Sat. surf. dry) = B/(B + D)- C	=		-
7	Sp. Gravity (Apparent) = A/(A + D) – C	=		2.897
8	% age of water absorption = (B – A)/A × 100			-

Material Eng. Q.N

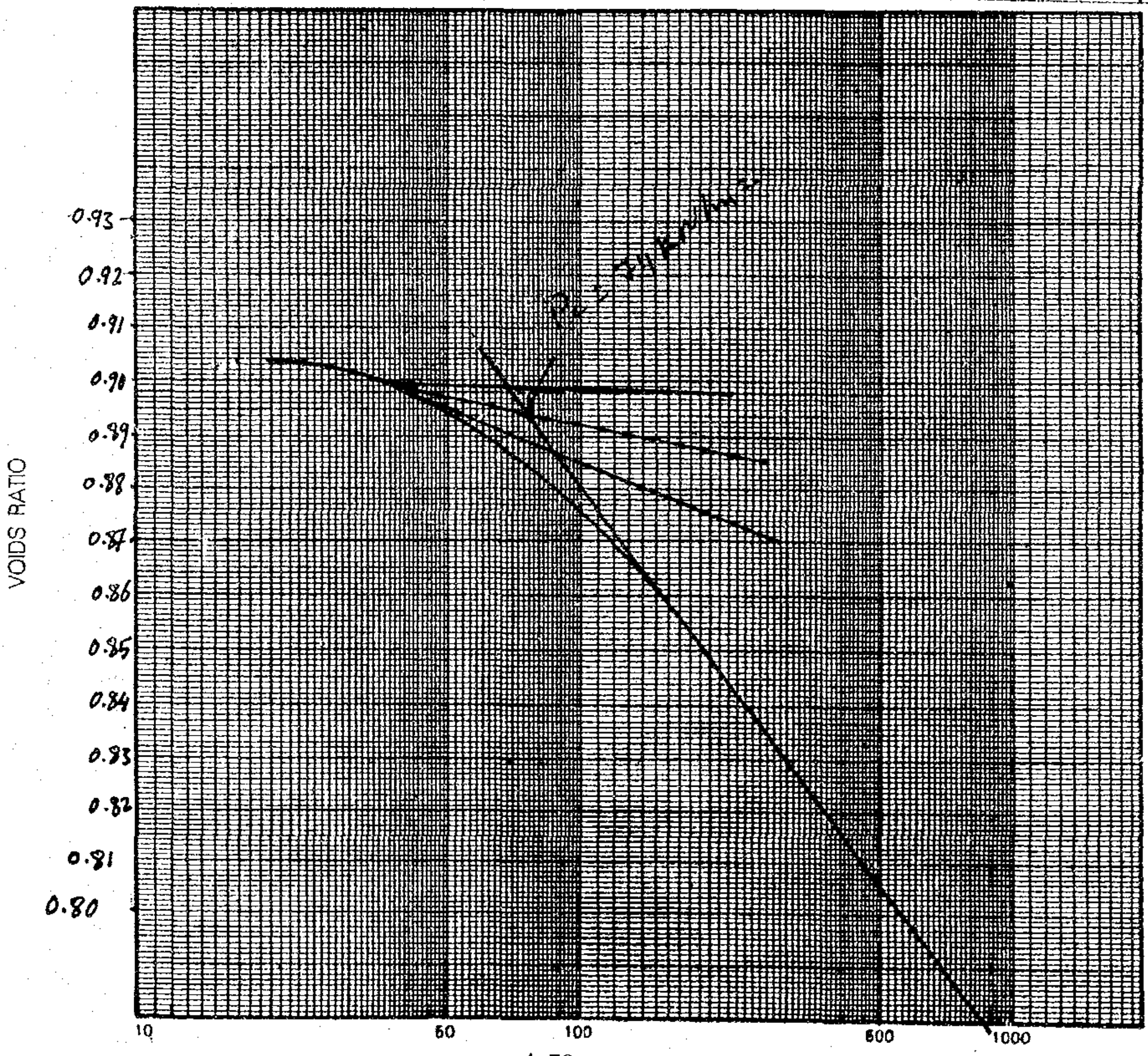
C.E.C.

CONSOLIDATION TEST RESULTS

CONTRACT : ....

DATE : ....

Borehole Sample No.	Depth m	Initial Moisture Content %	Initial Bulk Density Kg/m³	S. G.	Pressure Range kN/m²	Mv m²/kN	Cv Log t method mm²/s	DESCRIPTION
B.H 2								
	3.5-3.95	34.3	1.90	2.699				
Sample								



C.E.C.

DIRECT SHEAR TEST

Project	:	Tested by	:
Location	: BH 1 Sample 15	Date	:

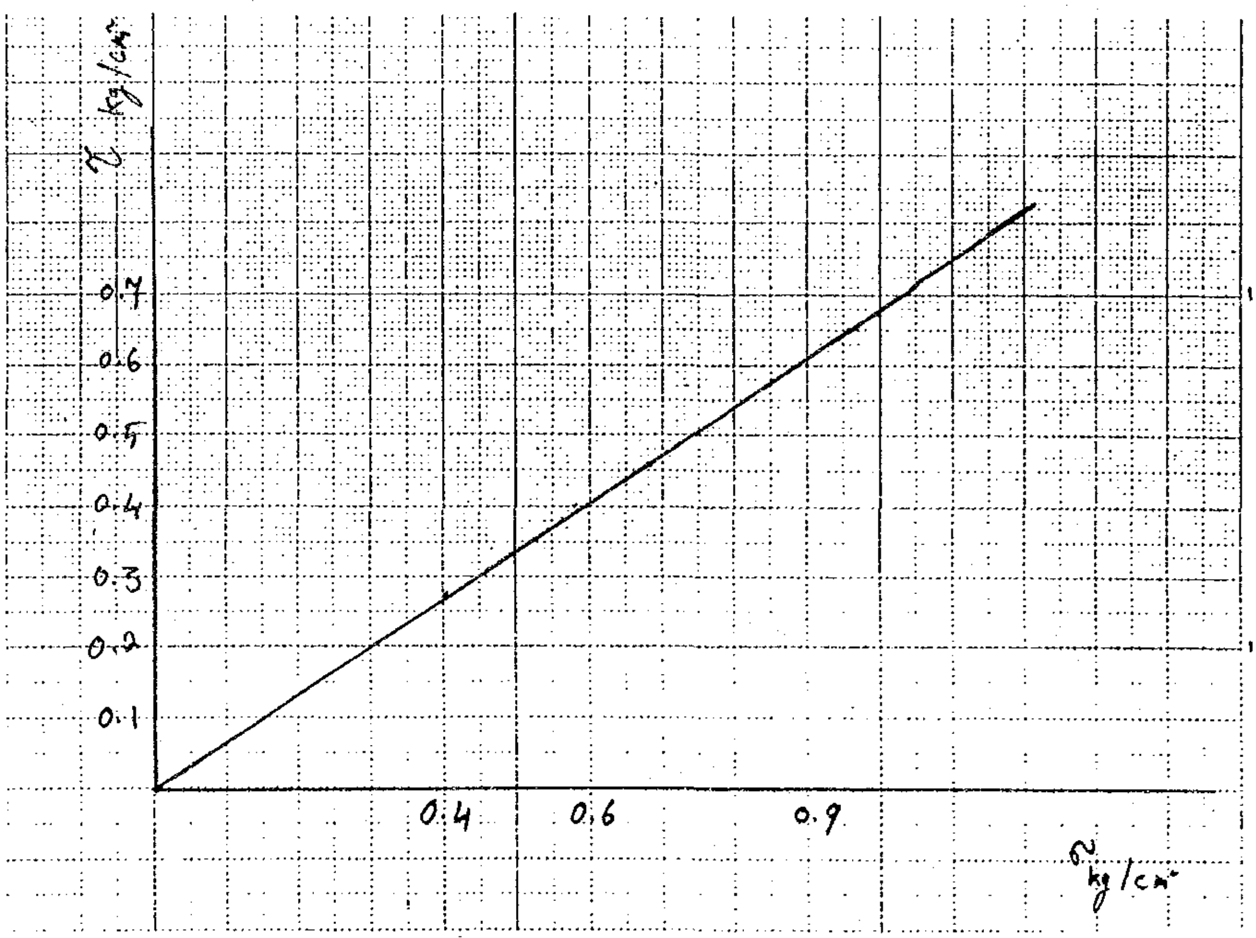
Area of Sample = 36 cm² Ring factor = 0.205 KN/div.

Test Readings:

Normal load	Dial Reading
14.5	48
24.5	81
34.5	113.5

Test Results:-

θ = 34° C = 0.0 KN/m²



C.E.C.

DIRECT SHEAR TEST

Project :
Location : BH1
Sample 13

Tested by :
Date :

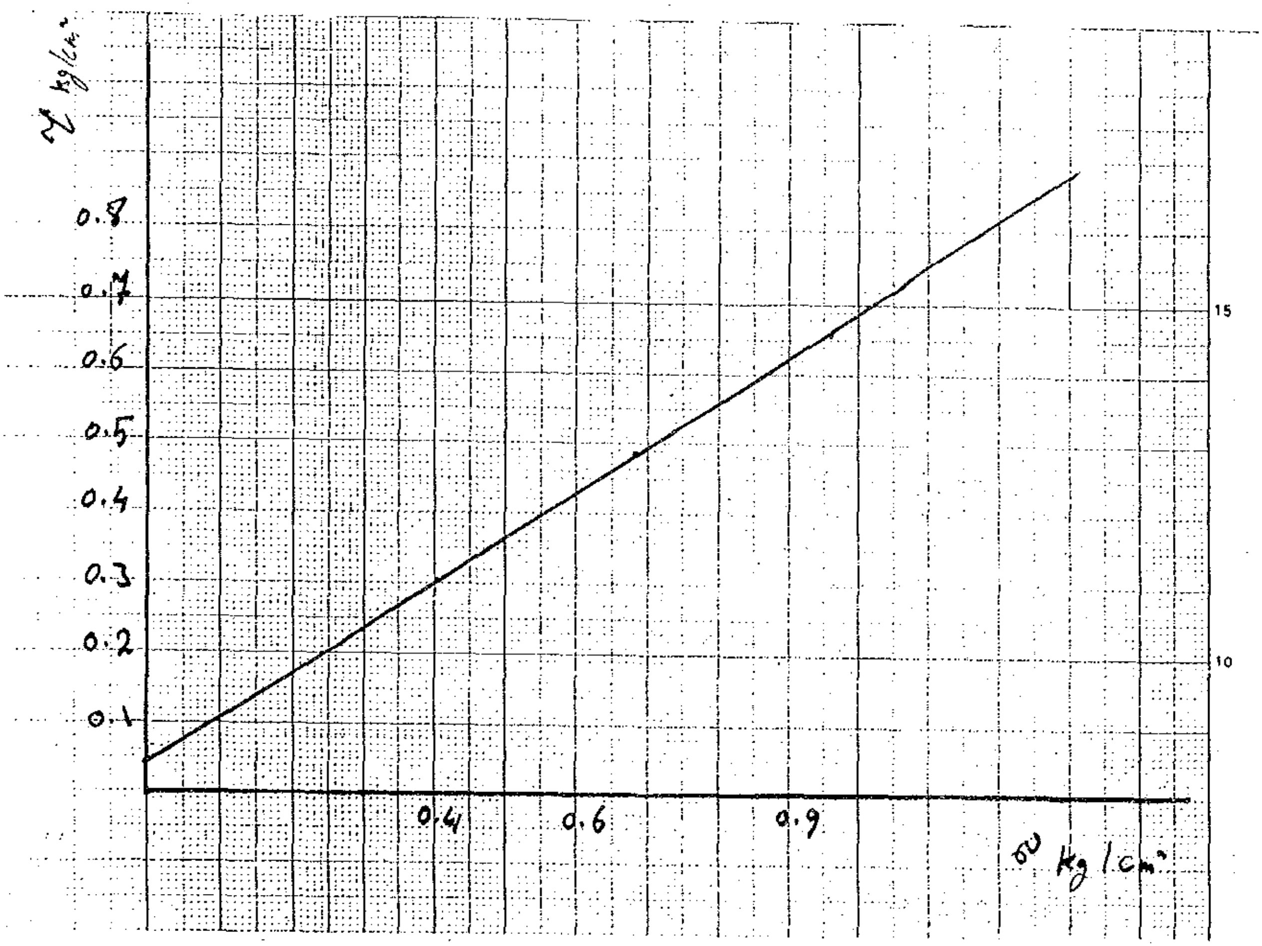
Area of Sample = 36 cm²   Ring factor = 0.205 KN/div.

Test Readings:

Normal load	Dial Reading
14.5	46
24.5	77.5
34.5	109

Test Results:-

θ = 33°   C = 4.0 KN/m²



C.E.C.

DIRECT SHEAR TEST

Project :
Location : BH 1
Sample 14

Tested by :
Date :

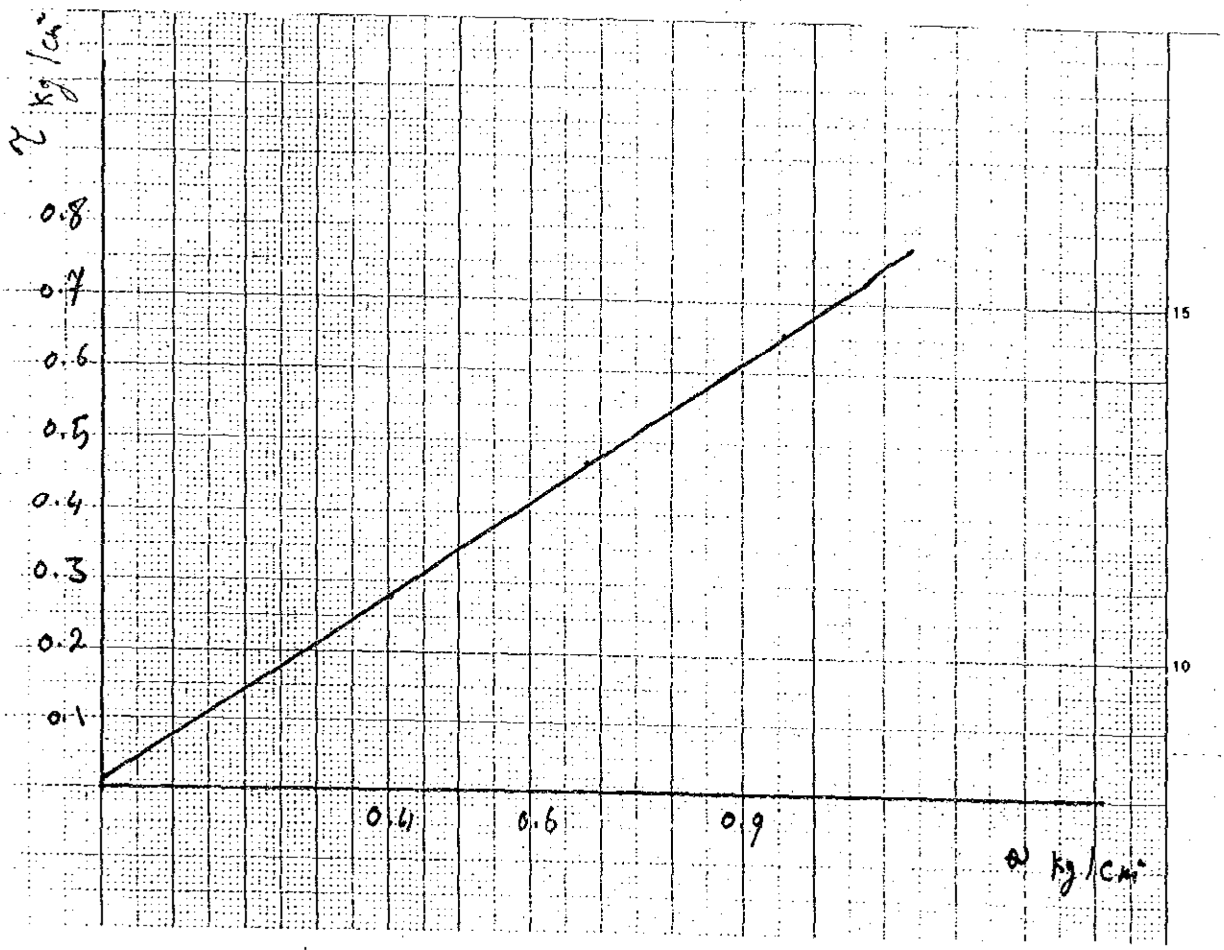
Area of Sample = 36 cm^2 *Ring factor* = 0.205 KN/div.

Test Readings:

Normal load	Dial Reading
14.5	47.5
24.5	80.5
34.5	113.5

Test Results:-

θ = 34° C = 1 KN/m^2



C.E.C.

DIRECT SHEAR TEST

Project	:	Tested by	:
Location	: BH2 Sample 13	Date	:

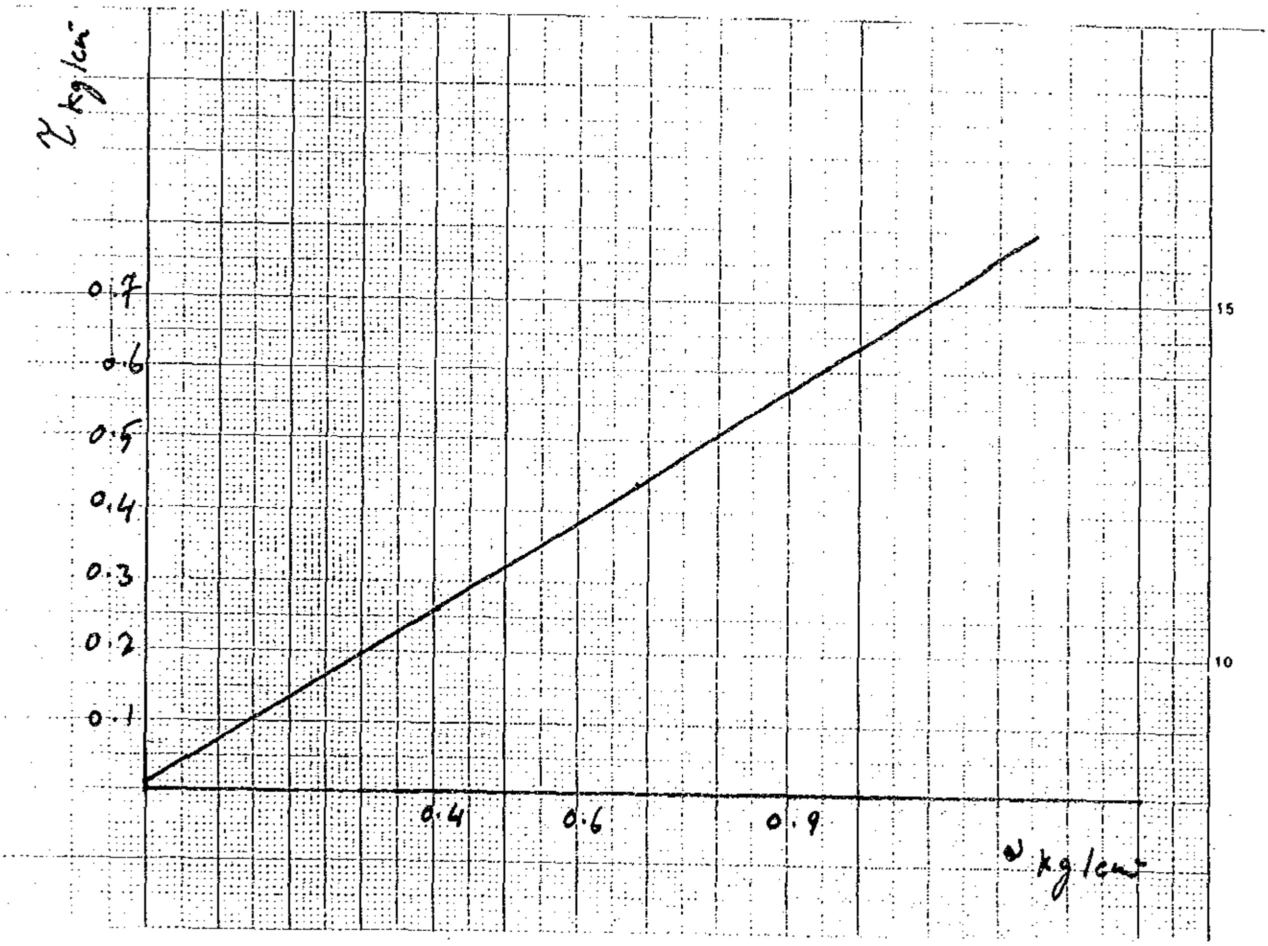
Area of Sample = 36 cm²   Ring factor = 0.205 KN/div.

Test Readings:

Normal load	Dial Reading
14.5	44
24.5	75
34.5	105

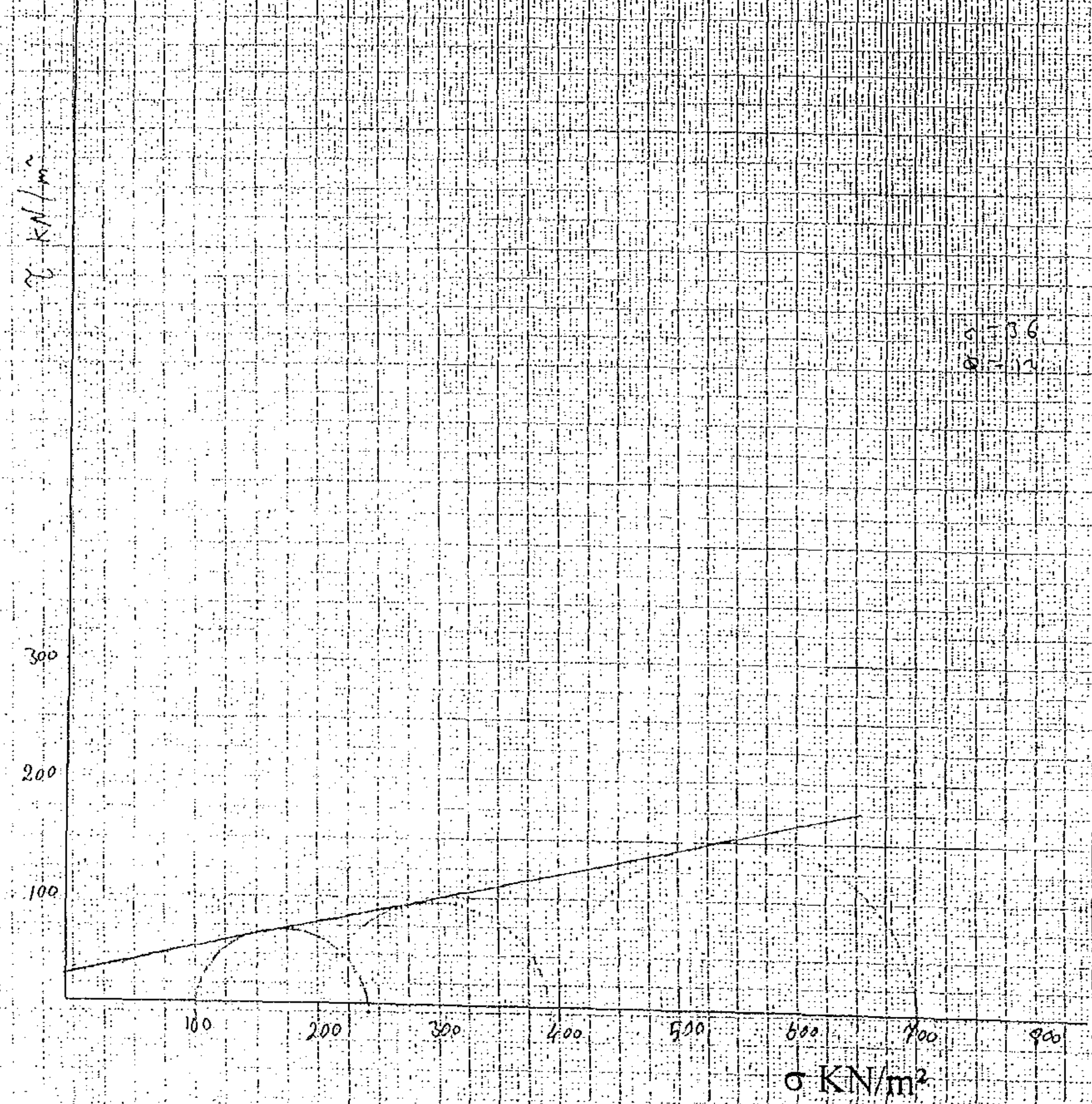
Test Results:-

θ = 32°   C = 1.0 KN/m²



BH. NO. 2 L = 7.0 cm
Depth 9.0 - 9.45 D = 3.4 cm
Stress ring factor = 0.0025 KN/div

σ_3 (KN/m²)	Final load Reading	Final defor. Reading	Δ L (mm)	Unit Strain	Corrected area (cm²)	Deviator stress (KN/m²)
100	56	59.5	5.95	0.085	9.35	141
200	78	63.0	6.30	0.090	9.90	194
400	120	57.4	5.74	0.082	9.82	299



BH. NO.

Depth: 2.5 – 2.95

Stress ring factor = 0.0025 KN/div

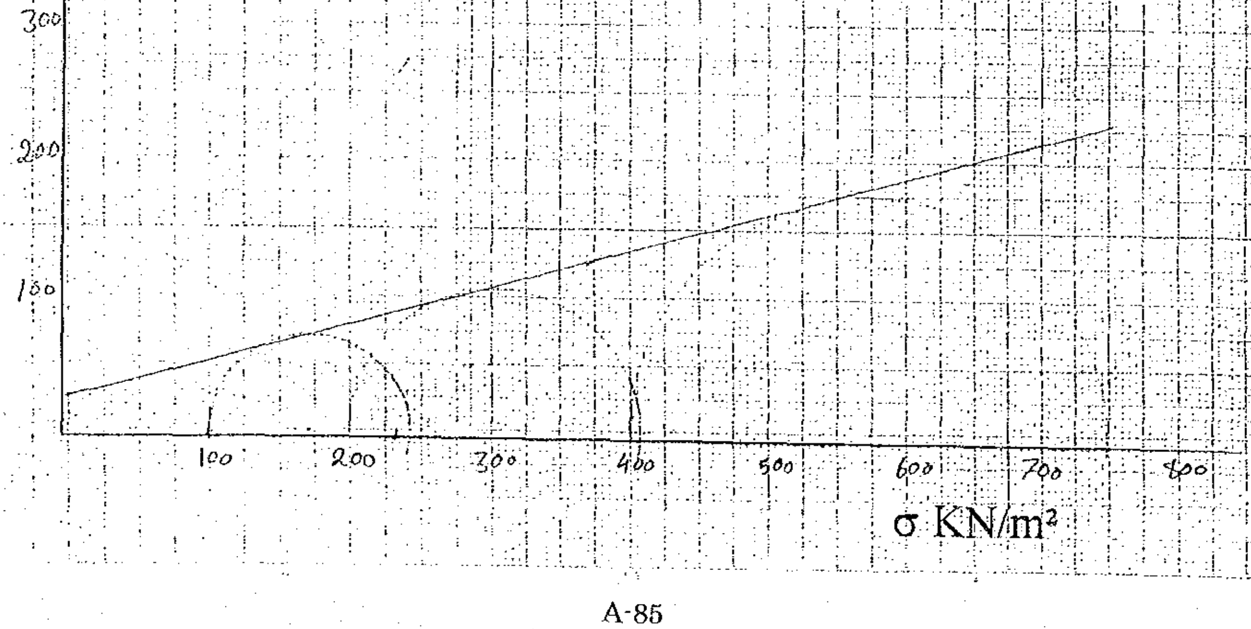
L = 6.96 cm

D = 3.4 cm

σ_3 (KN/m²)	Final load Reading	Final defor. Reading	Δ L (mm)	Unit Strain	Corrected area (cm²)	Deviator stress (KN/m²)
100	55	68.1	6.81	0.098	8.97	138
200	83	61.9	6.19	0.089	9.99	207
400	139	64.6	6.46	0.093	9.92	347

c = 6

φ = 15



PERMEABILITY TEST

TYPE OF SOIL : -
SAMPLE NO. : (5)
LOCATION : BH.1

JOB :2000/103
DATE :

- **Test method :** Falling head method.
- **Specimen size :**

  D = 9.6cm, A = 72.4cm²
  L = 13.2cm, γ = gr./cm³

- **Water flow :** Down ward

Total time	=	86400 Sec.
Total discharge (Q)	=	2583 mm³
Q	=	0.0299 mm³/sec.
Temp.	=	20c°
Rt.	=	1
Difference in head (h)	=	165 cm

i = h/i = 12.5

k = (q/i) × (Rt/A) = 3.3×10^{-7} mm/sec.

- **REMARKS**

Material Eng. Q.N
C. E. C

C.E.C.

PERMEABILITY TEST

TYPE OF SOIL	: -	**JOB**	:2000/103
SAMPLE NO.	: (13)	**DATE :**	
LOCATION	: BH.1		

- **Test method :** Falling head method.
- **Specimen size :**

D	=	9.6cm, A		=	$72.4 cm^2$
L	=	13.2cm,	γ	=	$gr./cm^3$

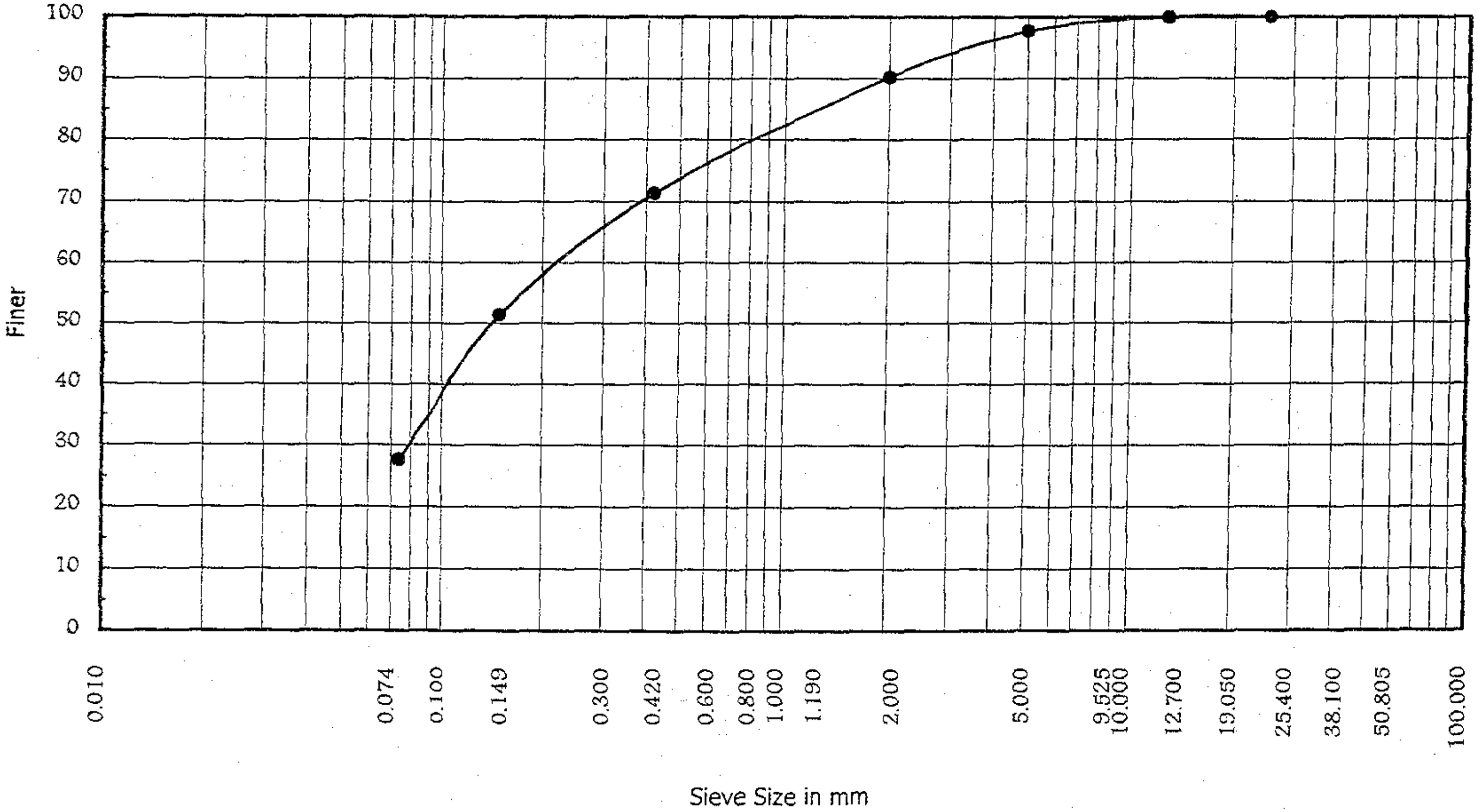
- **Water flow :** Down ward

Total time	=	600 Sec.
Total discharge (Q)	=	$526710\ mm^3$
Q	=	$877.85\ mm^3/sec.$
Temp.	=	22c°
Rt.	=	1
Difference in head (h)	=	165 cm
i	=	h/i = 12.5
k	=	$(q/i) \times (Rt/A) = 9.7\times10^{-3}$ mm/sec.

- **REMARKS**

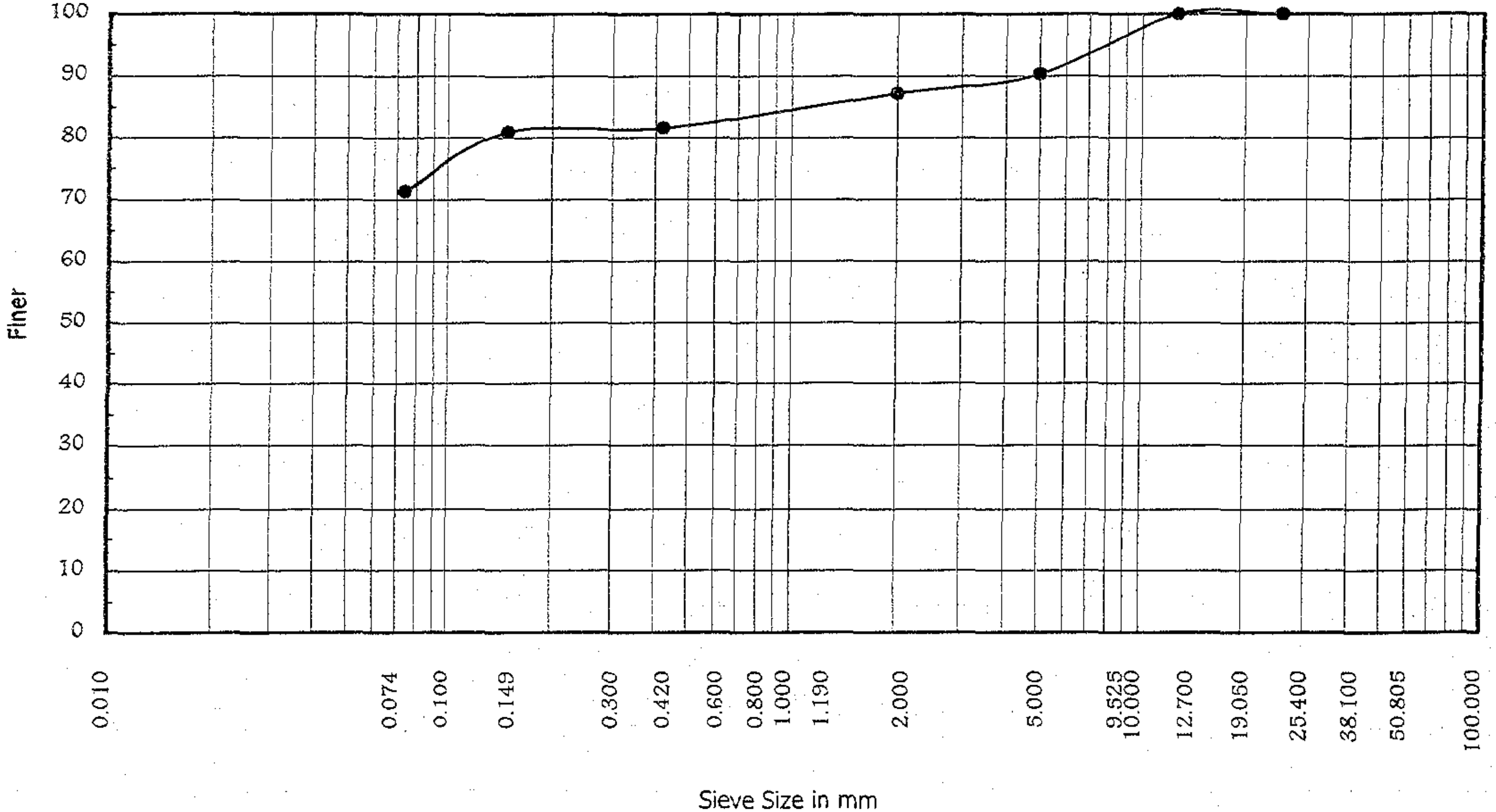
Material Eng. Q.N
C. E. C

Graphical Representation of Soil Gradation
Bore Hole no BH -1 (Depth 0.0 m to 0.5 m)
Location:Al-Mansora



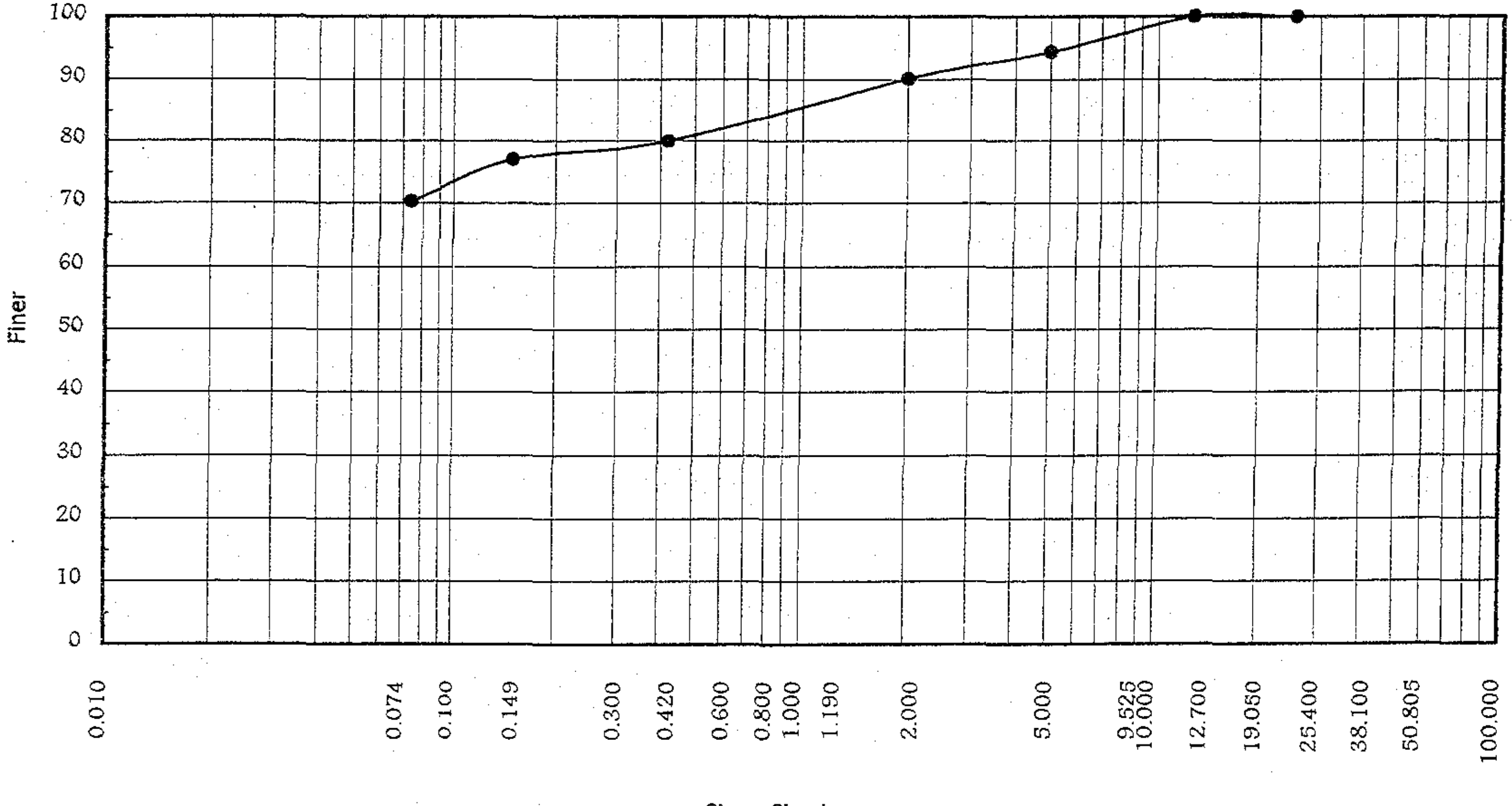
CLAY/SILT	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

Graphical Representation of Soil Gradation
Bore Hole no BH -1 (Depth 1.5 m to 2.8 m)
Location:Al-Mansora

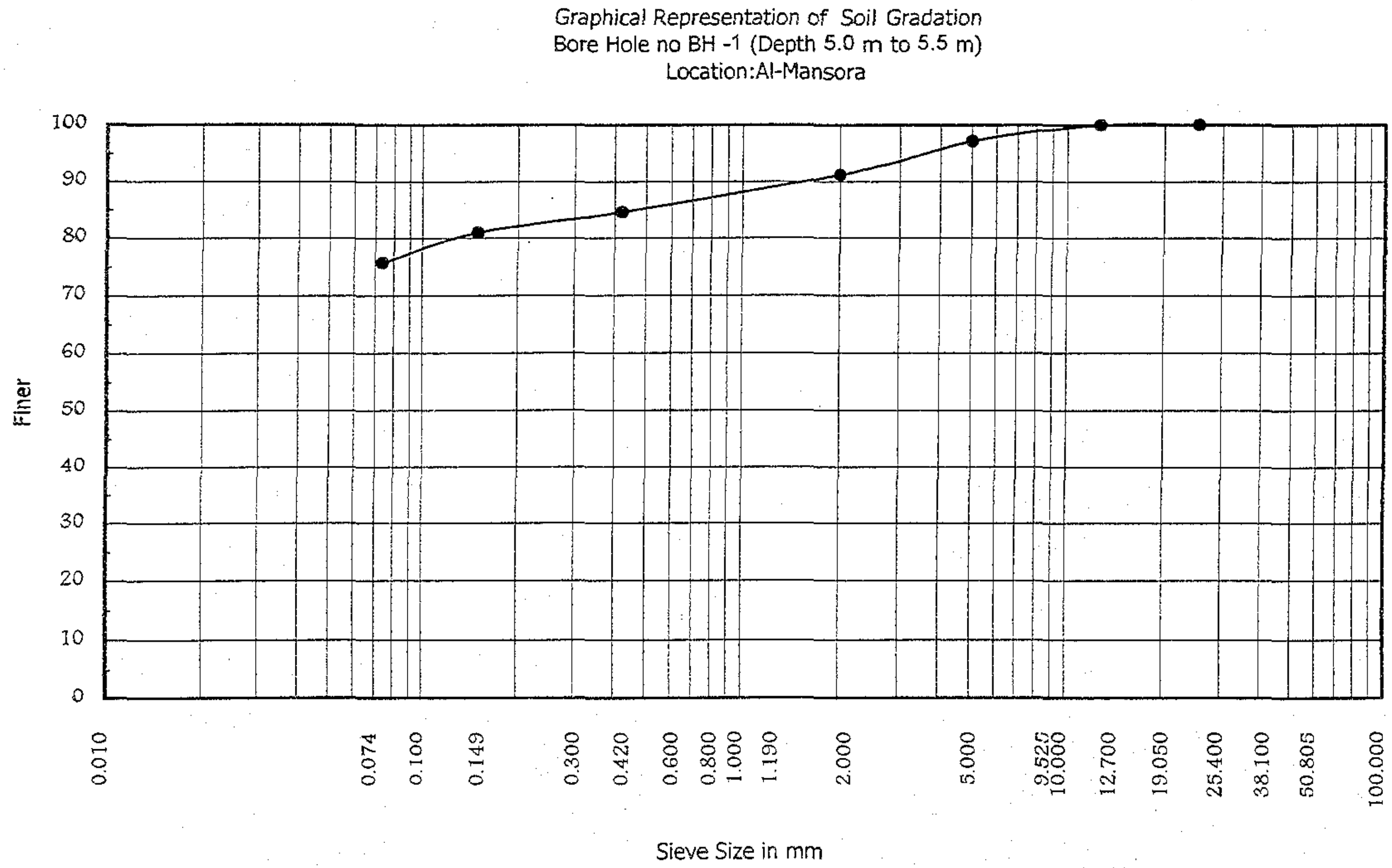


CLAY/SILT	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

Graphical Representation of Soil Gradation
Bore Hole no BH -1 (Depth 12.0 m to 12.5 m)
Location:Al-Mansora



CLAY/SILT	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE



CLAY/SILT	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

Test Boring Log No.1

	TEST BORING LOG	BORING NO. 1
PROJECT: T.C.Control Center		SHEET NO. 1/1
DRILLING METHOD: H. Stem Auger + Tricon Pit		DATE: April. 2000
LOCATION: Al Mansourah - Aden		TIME:

ELEV. (m)	THICK (m)	MOIST. COND.	COLOR	SYMBOL	IDENTIFICATION	REMARKS
	0.5	Dry	Grey		Silty Sand	loose
1						
2	-2.8 ∇					
3						
4						
5						
6						
7						hard
8						
9	15.8	Wet	Brown to Redish		Stratified clayey silt layers Each 1 - 3m	
10						
11						
12						
13						
14						
15						
16						
17						
18	3.7	Wet	Cray Light Brown		Stratified silty gravel Sand	Very dense
19						
20						

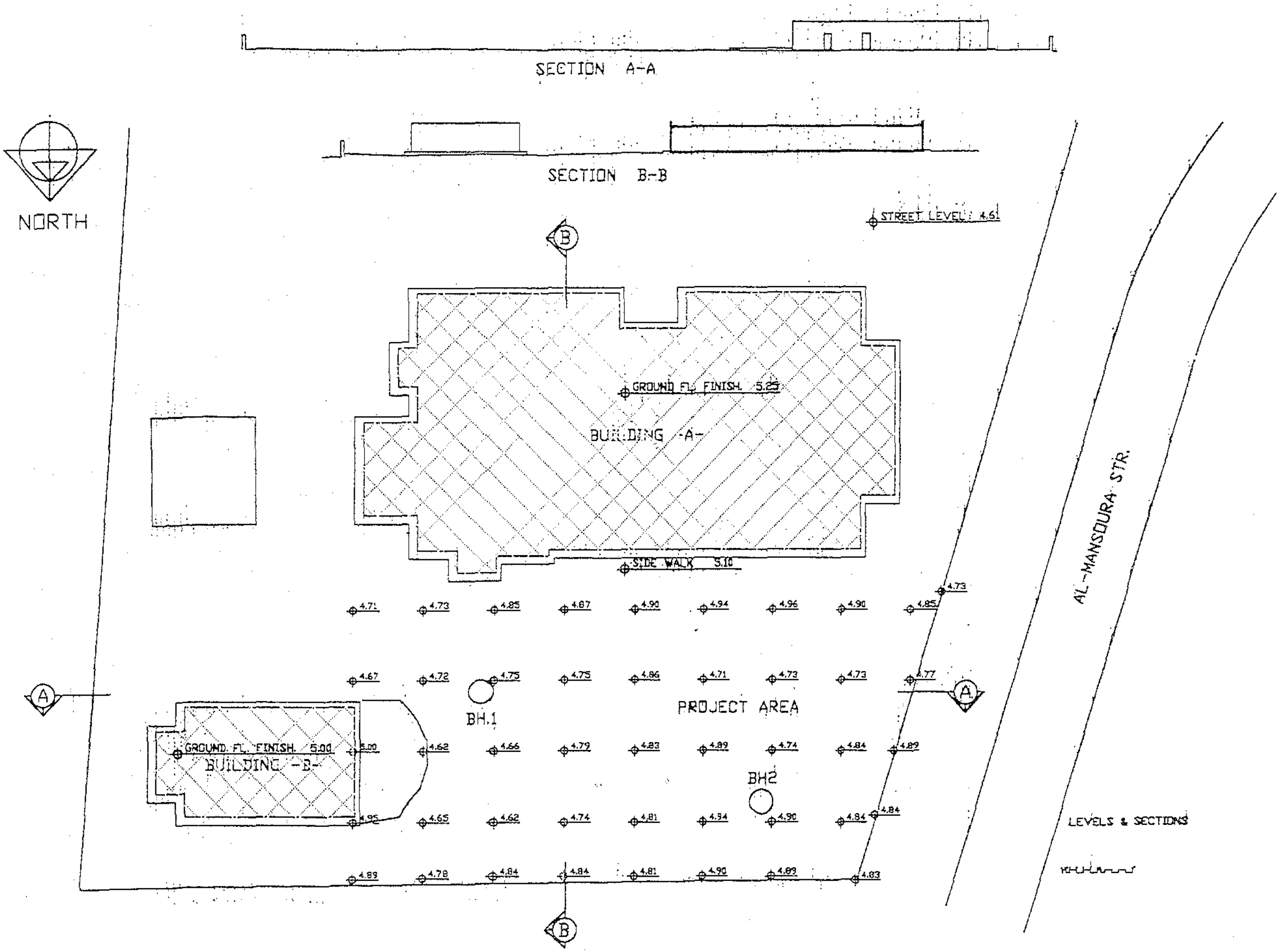
End of Excavation

Test Boring Log No.2

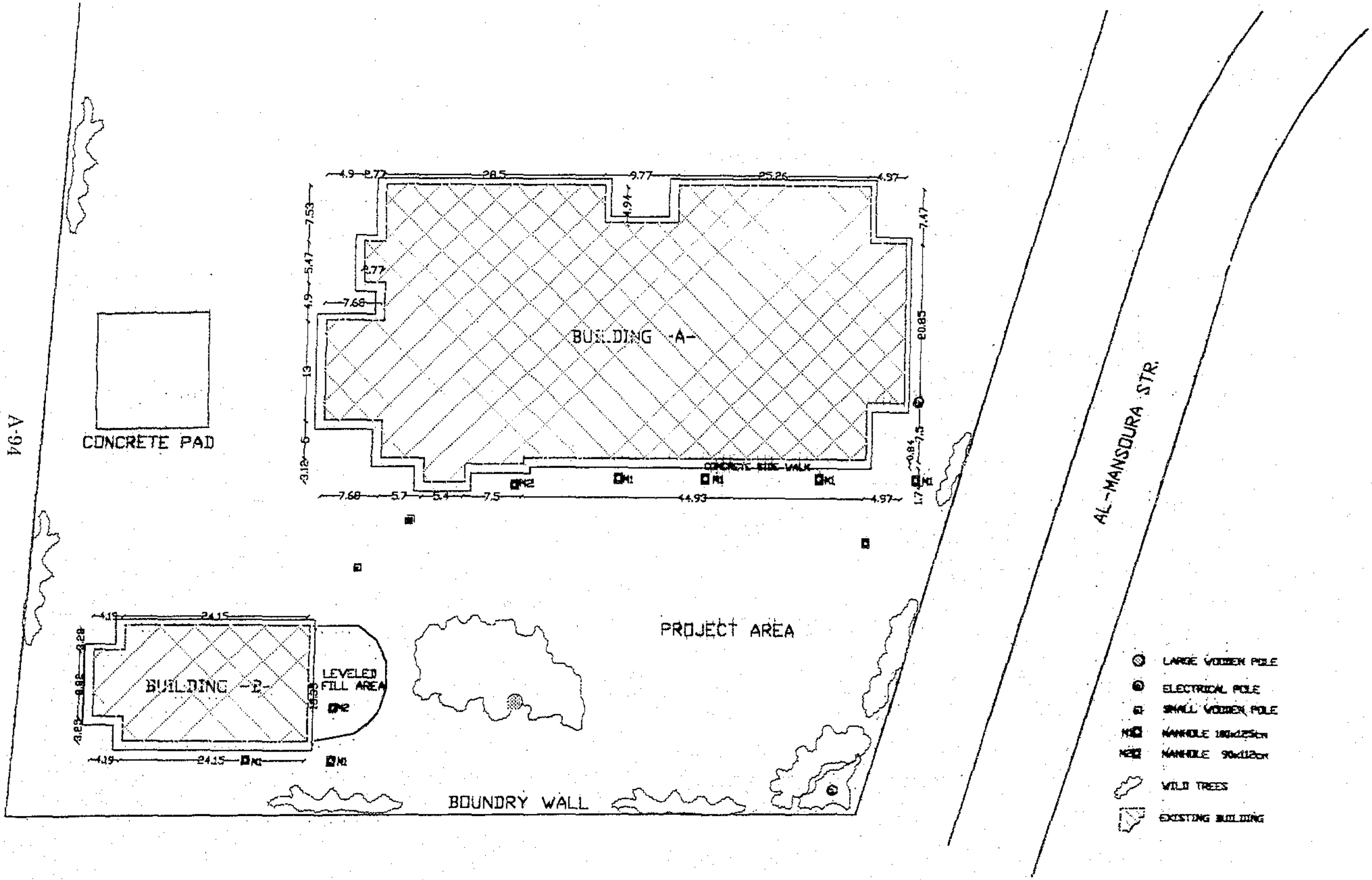
	TEST BORING LOG	BORING NO. 2
PROJECT: T.C.Control Center		SHEET NO. 1/1
DRILLING METHOD: H. Stem Auger + Tricon Pit		DATE: April. 2000
LOCATION: Al Mansourah - Aden		TIME:

ELEV. (m)	THICK (m)	MOIST. COND.	COLOR	SYMBOL	IDENTIFICATION	REMARKS
	0.3	Dry	Grey		Silty Sand	loose
1						
2	-2.9 ∇					
3						
4						
5						
6						
7						hard
8						
9	15.7	Wet	Brown to Redish		Stratified clayey silt layers Each 1 - 3m	
10						
11						
12						
13						
14						
15						
16						
17						
18	4.0	Wet	Cray Light Brown		Stratified silty gravel Sand	Very dense
19						
20						

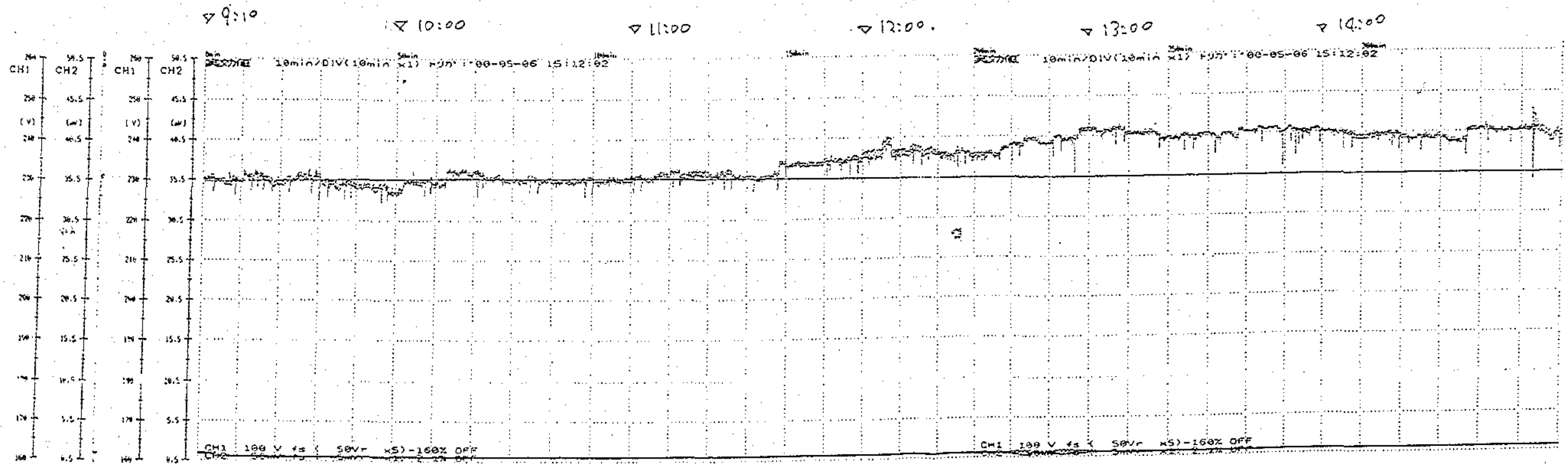
End of Excavation

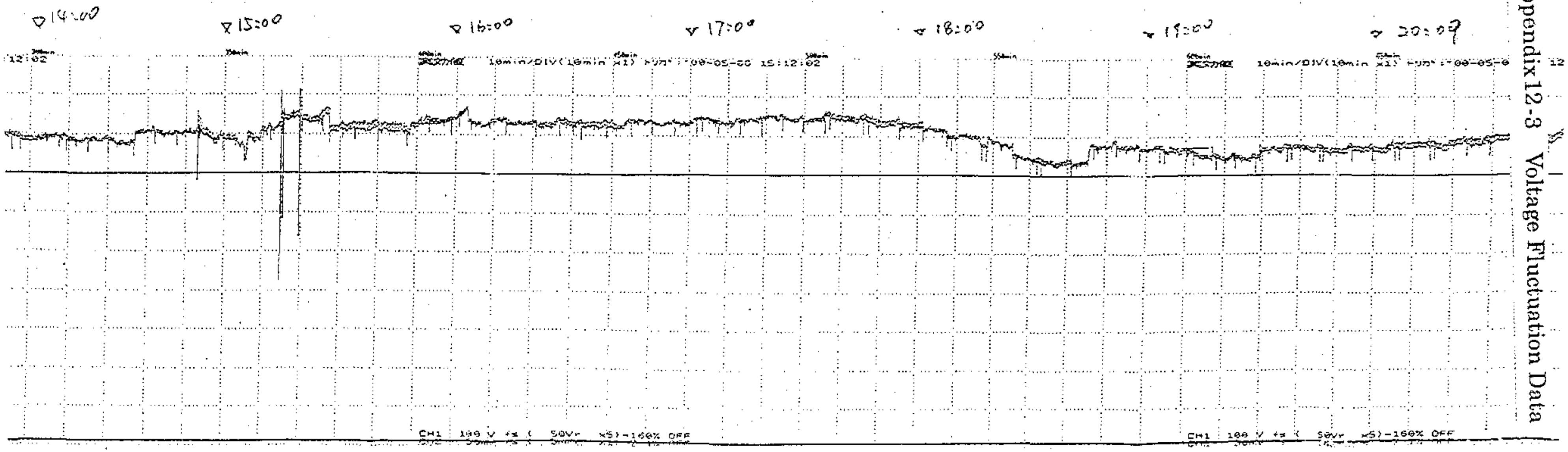


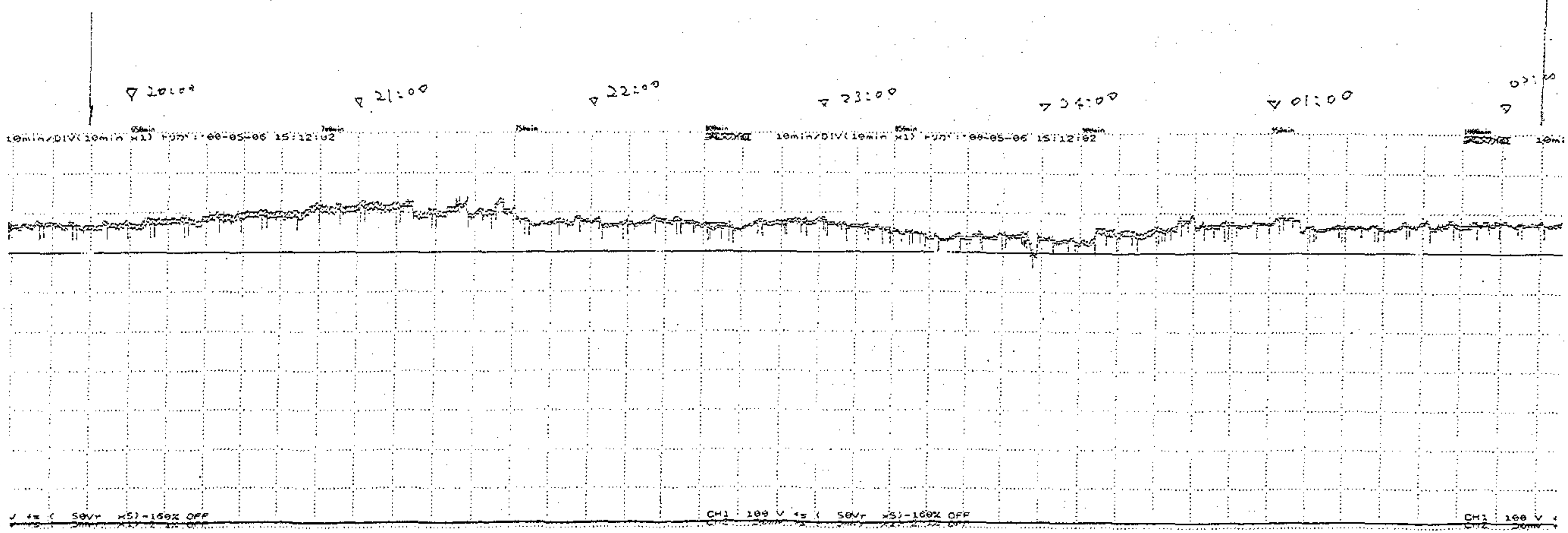
Appendix12-2 Topographical Survey


BUILDING -A-
CONCRETE SIDE WALK
CONCRETE PAD
A-94
AL-MANSOURA STR.
BUILDING -B-
LEVELED FILL AREA
PROJECT AREA
BOUNDRY WALL
LARGE WOODEN POLE
ELECTRICAL POLE
SMALL WOODEN POLE
MANHOLE 180x125cm
MANHOLE 90x112cm
WILD TREES
EXISTING BUILDING

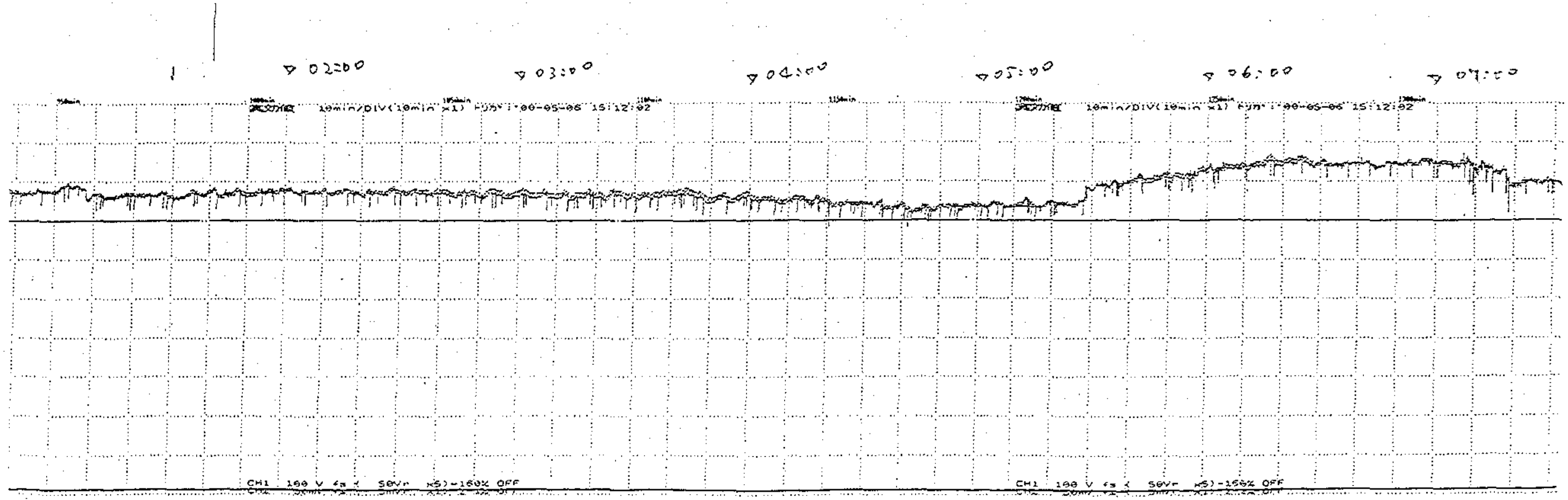
Appendix12-3 Voltage Fluctuation Data



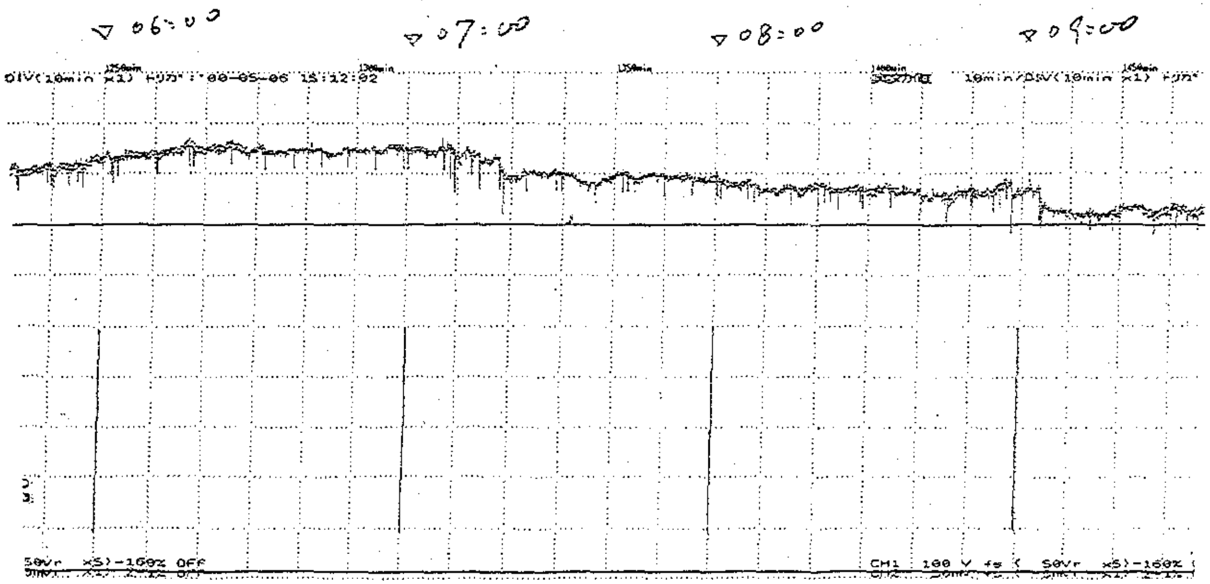




20:00
21:00
22:00
23:00
24:00
01:00



02:00
03:00
04:00
05:00
06:00
07:00



5/7
9:40 AM
DRC