

REPORT ON
SOIL INVESTIGATION WORK FOR THE PROPOSED
MULTISTORIED BUILDING AT J.L. NO.- 29, R.S. & L.R. PLOT NO.-
135, R.S. & L.R. KHATIAN NO.- 352,355,356,362,402, MOUZA- RAIDI,
BLOCK- KULTI.

SOIL INVESTIGATION DONE BY:-

ASSOCIATED FOUNDATION ENGINEERS
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A. GENERAL

It has been proposed to construct a multi storied building at the above location.

For ascertaining the safe bearing capacity of soil, it was decided to carry out a detailed sub-soil investigation and M/s. Associated Foundation Engineers was awarded this work for suggesting the most suitable type of foundation for the above project.

The scope of the work comprised of sinking 4 nos. of bore holes (4 x 10 m.)

The bore holes were of 150mm. in diameter. Standard penetrometer tests were conducted at close intervals of depth. Undisturbed soil samples were recovered at suitable intervals and tested in the laboratory. Disturbed soil samples were also recovered at close intervals of depth for logging & identification purposes.

~~Depending on the above,~~ this report presents bore logs, soil profiles & laboratory tests results. It is seen that the sub-soils are of medium quality.



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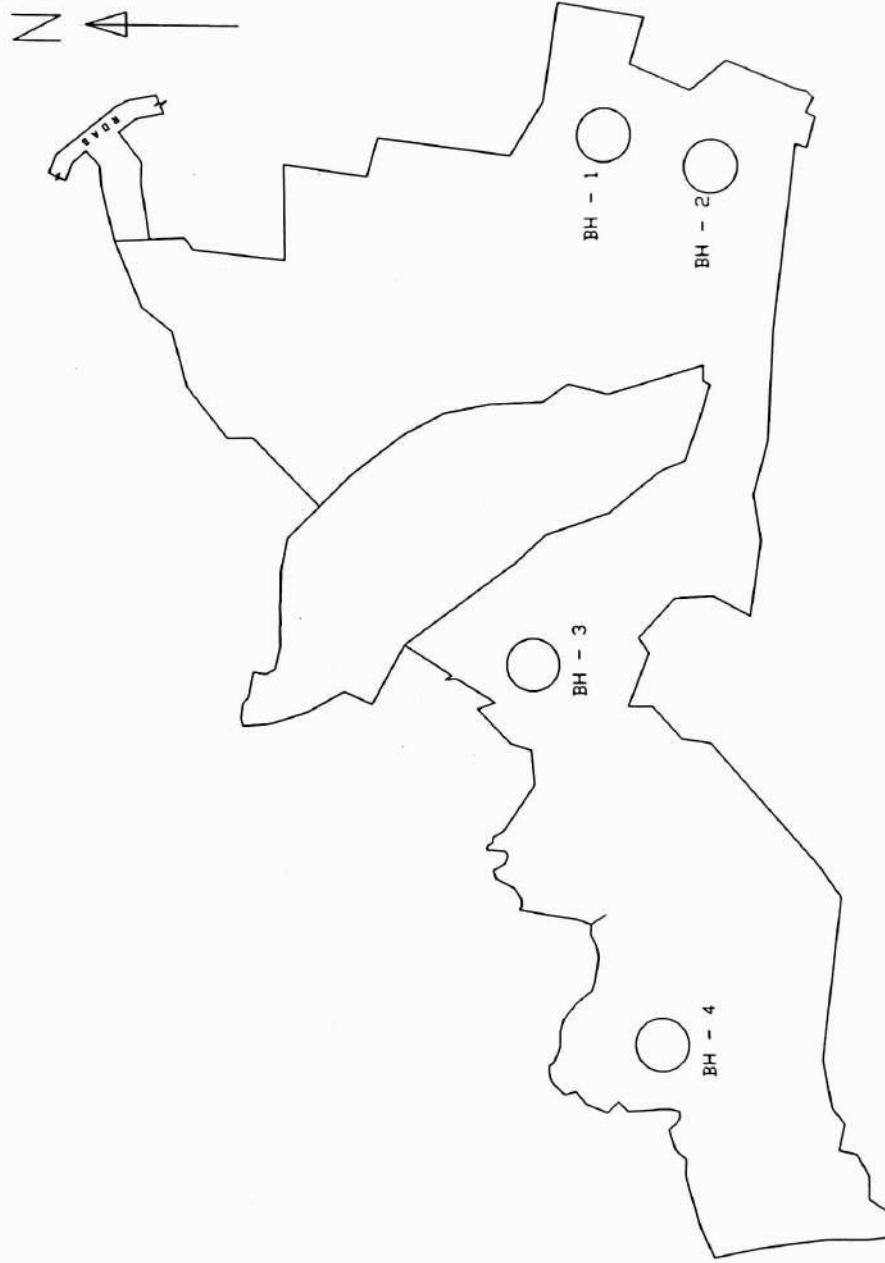


FIG. - 1. SCHEMATIC PLAN OF BORE HOLES.



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B. FIELD INVESTIGATION

The various operations adopted during the course of this investigation are discussed in brief below.

BORING

For sinking the bore holes, the shell and auger method of boring was adopted. The holes were of 150mm. in diameter. These were advanced up to the required depth. Casing pipes of 150mm. diameter were used initially and bentonite slurry later on for side stabilisation of bore holes.

SAMPLING

During the course of boring, undisturbed and disturbed samples were collected at fairly regular intervals. Undisturbed samples of 10cm. diameter were recovered (whenever feasible) by means of open drive sampling using samplers of standard length 45cm. A two tier assembly was used with a cutting shoe attached to the lower end of the tube. This was driven by a jarring link as far as practicable. After withdrawal, both ends of the tubes were sealed with paraffin wax capped, labeled and transported to the laboratory. A number of disturbed samples were also collected at suitable intervals for identification and logging purposes.

STANDARD PENETRATION TESTS

A number of standard penetration tests were conducted at regular intervals in the bore holes. The tests were conducted by driving a standard split spoon sampler by means of a monkey of 65kg. weight falling freely from a height of 75cm. The number of blows required for every 7.5cm. Penetration was recorded up to a total penetration of 60cm. The S.P.T. or 'N' value was estimated as the number of blows required for the middle 30cm. penetration.

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The split spoon sampler conformed to I.S. specification with an outer diameter of 50.8mm. and an inner diameter of 35mm. After completion of the test the sampler was withdrawn. It was opened and the soil specimen was preserved for logging and identification purposes.

C. LABORATORY TESTING

The following laboratory tests were performed on undisturbed and disturbed samples to determine the engineering properties of the sub-soil at different depths. All the tests were carried out according to Indian standard specifications.

1. Natural Moisture Content.
2. Atterberg Limits (LL. & PL.)
3. Hydrometer and Sieve Analysis.
4. Bulk Density (wet & dry)
5. Specific Gravity.
6. Strength Tests.
7. Consolidation.

The results of these tests have been presented systematically in result sheets later on.



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D. SUB-SOIL STRATIFICATION AND PROPERTIES

I. SUB-SOIL STRATIFICATION

The exploratory borings at the site revealed a medium quality of sub-soil. The generalised soil profile encountered at the site is shown in fig.2 and in the enclosed bore hole log data sheets in the appendix. The variation of 'N' values with depth is shown in figure 3 & in the bore hole log data sheets. The average sub-soil profile with properties are shown in fig. 4. The results of the laboratory tests conducted to determine the engineering properties of the sub-soil are presented in the appendix. The other back-up sheets are also presented therein. Based on visual classification and results of field & laboratory tests two major strata are identified.

Brief descriptions of the various soil strata are given below: -

1. STRATUM - I

Hard light grey to deep grey to brownish grey clayey silt with kankars, moorums etc extends down to a depth of 4.12 m. below E.G.L.

The maximum & minimum values of 'N' observed in this layer are >100 & 52 respectively.

The average engineering properties are as follows:-

Bulk density	1.93	gm /c.c.
Dry density	1.58	gm /c.c
Water content	21	%
Specific gravity	2.68	
Void ratio	0.70	
Cohesion	0.63	kg /sq.cm
Friction angle	0°	degree
Liquid limit	37	%
Plastic limit	17	%
Sand size particle	11	%
Silt size particle	66	%
Clay size particle	23	%

According to IS classification system, it may be symbolised as CL combination.



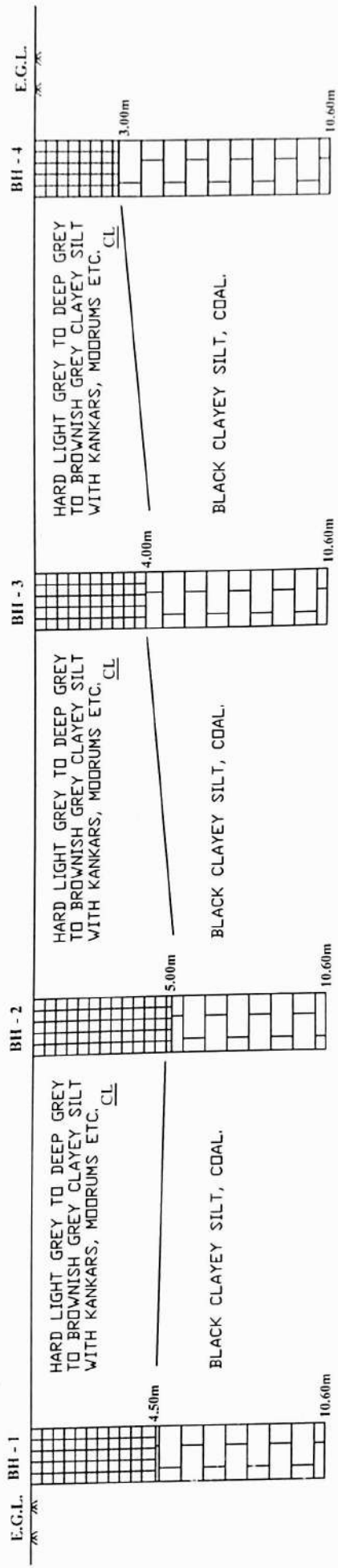


FIG. - 2. GENERALISED SUB-SOIL PROFILE.



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VALUES OF 'N' — Sheet No:- 08

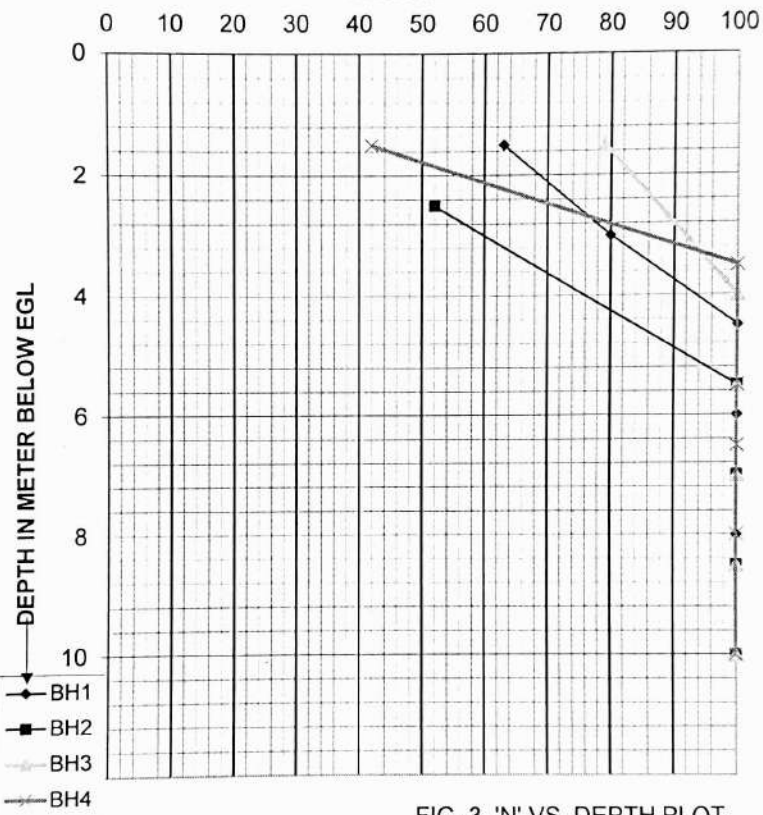


FIG. 3. 'N' VS. DEPTH PLOT.



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2. STRATUM - II

Black clayey silt, coal extends from 4.12 m. down to the termination depth of 10.60 m. below E.G.L.

The value of 'N' observed in this layer is >100.

From the above, it can be said that the sub-soils are of medium quality.

II. SUB - SOIL PROPERTIES

The details of laboratory tests results have been presented sequentially in the appendix. The other back-up sheets are given therein as below:-

1. Laboratory tests results tables.
2. Bore Hole log data sheets/ field records.
3. Consolidation characteristics.
4. Grain size distribution curves from sieve & hydrometer analysis.

Based on the bore logs and the laboratory tests results, the average sub-soil profile with the average properties are presented in fig. 4.



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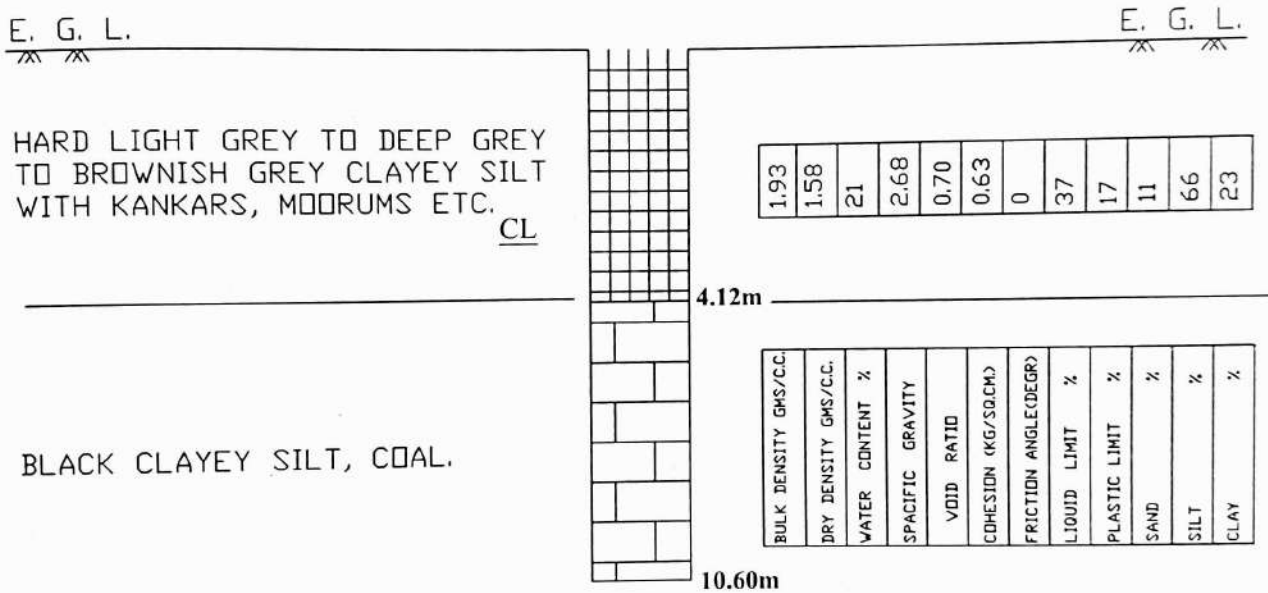


FIG. - 4. AVERAGE SUB-SOIL PROFILE WITH PROPERTIES.



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E. FOUNDATION CONSIDERATIONS AND BEARING CAPACITY

The proposed construction would be a multi storied building. Accordingly the loading would be moderate which would depend also on column spacing for the proposed RCC framed structure. However, the foundation design would not only depend on the height and loading but also on the sub-soil condition. For the sub-soil condition the two necessary conditions are to be satisfied i.e. the soil would not fail in shear and the settlement should be within permissible limit.

Shallow foundations in the form of individual footings may be investigated at first in this case for supporting lightly to moderately loaded structures. Individual footings of size 2.0m to 3.0m. founded at a depth of **1.2 m.** below G. L. may be used according to the column spacing and planning of the building. Net allowable bearing capacities for such footings have been calculated keeping the settlement within permissible limit of 7.5 cm. and these have been shown below :-

Footing Size	Net Allowable Bearing Capacity, (t / sq.m.)	Settlement(mm.)	Recommended Capacity, (t / sq.m.)
2.0m x 2.0m	16.9	30.6	16.9
2.5m x 2.5m	16.6	35.7	16.6
3.0m x 3.0m	16.3	41.0	16.3
15.0m x 15.0m	15.4	67.5	15.4
25.0m x 25.0m	15.2	71.4	15.2

Shallow foundations in the form of 1.5m., 2.0m. & 2.5m. wide strip footings have also been investigated. Net allowable bearing capacities with permissible settlements of 7.5 cm. for such footings have been worked out and shown below :-

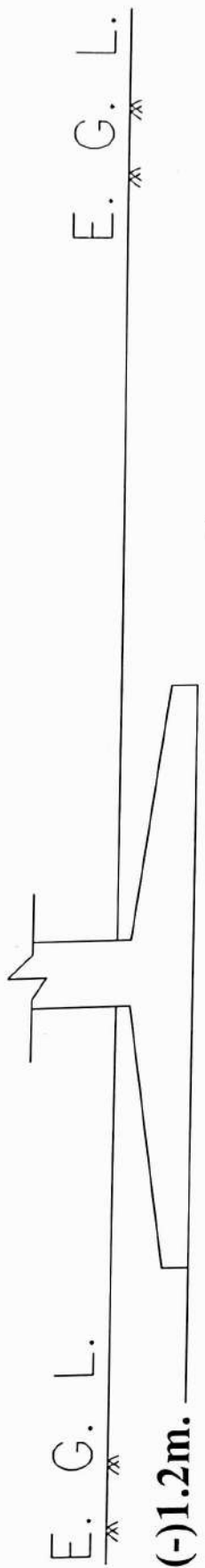
Footing Size	Net Allowable Bearing Capacity, (t / sq.m.)	Settlement(mm.)	Recommended Capacity, (t / sq.m.)
1.5m wide	14.6	39.5	14.6
2.0m wide	14.1	43.4	14.1
2.5m wide	13.8	46.3	13.8



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C	=	0.63 KG/SQ.CM.
Ø	=	0 degree
Mv	=	0.022 SQ.CM/KG
α	=	0.85
E	=	189 kg/sq.cm.

HARD LIGHT GREY TO DEEP GREY
 TO BROWNISH GREY CLAYEY SILT
 WITH KANKARS, MOORUMS ETC.



FOUNDATION DESIGN MODEL FOR SHALLOW FOOTINGS.

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F. RECOMMENDATIONS

Based on the field and the laboratory tests results and the above discussions, the followings are summarized :-

1. The sub-soils are of medium quality.
2. Hard light grey to deep grey to brownish grey clayey silt with kankars, moorums etc extends down to a depth of 4.12 m. below E.G.L. The strength of this layer is medium ($C = 0.63$ kg/sq.cm.) and compressibility is medium ($M_v = 0.022$ sq.cm./kg for 0.50 to 1.0 kg/sq.cm. pressure range).
3. Black clayey silt, coal extends from 4.12 m. down to the termination depth of 10.60 m. below E.G.L.
4. Depth of foundation for the proposed construction is estimated at (-) 1.2m. below the E.G.L. However, the foundations should go at least 200 to 300mm. in side the parent soil depending on the location.
5. The standing water level was observed at (-) 3.25 m. below the E.G.L. during boring.
6. Isolated footings, if used, are suggested to be tied at the foundation level to reduce the differential settlement. Construction in stages is recommended.



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7. The following net safe bearing capacity values may be taken for routine design:-

Type of Footing	Size	Net safe bearing capacity, t/sq.m.
Individual	2m x 2m	16.9
	2.5m x 2.5m	16.6
	3.0m x 3.0m	16.3
	15.0m x 15.0m	15.4
	25.0m x 25.0m	15.2
Strip	1.5m Wide	14.6
	2.0m Wide	14.1
	2.5m Wide	13.8

The values for the intermediate sizes of footings should be obtained by interpolation.

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TABLE : 1. LABORATORY TESTS RESULT

BORE HOLE	SAMPLE NO	DEPTH (M.)	BULK DENSITY (gms/c.c.)	DRY DENSITY (gms/cc)	W %	G	eo	C (kg/sqc m)	0° (Degree)	LL %	PL %	SAND %	SILT %	CLAY %
BH-1	UDS-1	1.00-1.45	1.90	1.58	20	2.69	0.711	0.56	0°	39	19	7	64	27
BH-1	UDS-2	2.50-2.95	1.92	1.57	22	2.68	0.693	0.60	0°	37	17	9	67	24
BH-2	UDS-1	1.00-1.45	1.91	1.59	20	2.69	0.704	0.59	0°	38	17	6	69	25
BH-2	UDS-2	3.50-3.95	1.93	1.57	23	2.67	0.682	0.66	0°	36	16	10	68	22
BH-3	UDS-1	1.00-1.45	1.93	1.58	22	2.66	0.719	0.67	0°	37	17	13	67	20
BH-4	UDS-1	1.00-1.45	1.94	1.60	21	2.67	0.704	0.68	0°	36	16	14	65	21
BH-4	UDS-2	2.50-2.95	1.95	1.60	22	2.68	0.682	0.67	0°	35	15	15	65	20
			1.93	1.58	21.43	2.68	0.70	0.63	#VALUE!	36.86	16.71	10.57	66.43	22.71



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BORE LOG DATA SHEET

BORE HOLE NO : 1

NETROMETER (SPT)	NOS.		NOS.	COMMENCED ON :	28-09-2021
NETROMETER (SPT)	6	UNDISTURBED (UDS)	2	COMPLETED ON :	28-09-2021
LINE (PC)		PENETROMETER (SPT)	6	BORE HOLE DIA :	150mm.
ANE (V)		DISTURBED (DS)	1	R.L. OF GROUND :	
				WATER STRUCK AT :	3.50m
				STANDING WATER LEVEL :	3.50m

DESCRIPTION	SYMBOL	N - VALUE				SAMPLES	
		25	50	75	100	REF NO.	DEPTH (M)
HARD LIGHT GREY TO DEEP GREY TO BROWNISH GREY CLAYEY SILT WITH KANKARS, MOORUMS ETC.						DS - 1	0.50
						UDS - 1	1.00- 1.45
					N = 63	SPT - 1	1.50 - 2.10
						UDS - 2	2.50- 2.95
					N = 80	SPT - 2	3.00 - 3.60
					N = 100	SPT - 3	4.50 - 5.10
	4.50M				N = 100	SPT - 4	6.00 = 6.60
					N = 100	SPT - 5	
BLACK CLAYEY SILT, COAL.					N = 100	SPT - 6	10.00 - 10.60
	10.60M						



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BORE LOG DATA SHEET

BORE HOLE NO : 2

NETROMETER (SPT)	NOS.		NOS.	COMMENCED ON :	28-09-2021
NETROMETER (SPT)	5	UNDISTURBED (UDS)	2	COMPLETED ON :	29-09-2021
NE (PC)		PENETROMETER (SPT)	5	BORE HOLE DIA :	150mm.
ANE (V)		DISTURBED (DS)	1	R.L. OF GROUND :	
				WATER STRUCK AT :	3.00m
				STANDING WATER LEVEL :	3.00m

DESCRIPTION	SYMBOL	N - VALUE				S A M P L E S	
		25	50	75	100	REF NO.	DEPTH (M)
HARD LIGHT GREY TO DEEP GREY TO BROWNISH GREY CLAYEY SILT WITH KANKARS, MOORUMS ETC.						DS - 1	0.50
						UDS - 1	1.00- 1.45
					N = 52	SPT - 1	2.50 - 3.10
						UDS - 2	3.50- 3.95
	5.00M				N = 100	SPT - 2	5.50 - 6.10
BLACK CLAYEY SILT, COAL.					N = 100	SPT - 3	7.00 - 7.60
					N = 100	SPT - 4	
	10.60M				N = 100	SPT - 5	10.00 - 10.60



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BORE LOG DATA SHEET				BORE HOLE NO : 3	
PENETROMETER (SPT)	NOS.		NOS.	COMMENCED ON :	29-09-2021
PENETROMETER (SPT)	6	UNDISTURBED (UDS)	1	COMPLETED ON :	01-10-2021
LINE (PC)		PENETROMETER (SPT)	6	BORE HOLE DIA :	150mm.
LINE (V)		DISTURBED (DS)	1	R.L. OF GROUND :	
				WATER STRUCK AT :	3.00m
				STANDING WATER LEVEL :	3.00m

DESCRIPTION	SYMBOL	N - VALUE				SAMPLES	
		25	50	75	100	REF NO.	DEPTH (M)
HARD LIGHT GREY TO DEEP GREY TO BROWNISH GREY CLAYEY SILT WITH KANKARS, MOORUMS ETC.						DS - 1	0.50
						UDS - 1	1.00- 1.45
					N = 79	SPT - 1	1.50 - 2.10
		4.00M			N = 100	SPT - 2	4.00 - 4.60
					N = 100	SPT - 3	5.50 - 6.10
					N = 100	SPT - 4	7.00 - 7.60
BLACK CLAYEY SILT, COAL.				N = 100	SPT - 5	8.50 - 9.10	
				N = 100	SPT - 6	10.00 - 10.60	

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BORE LOG DATA SHEET

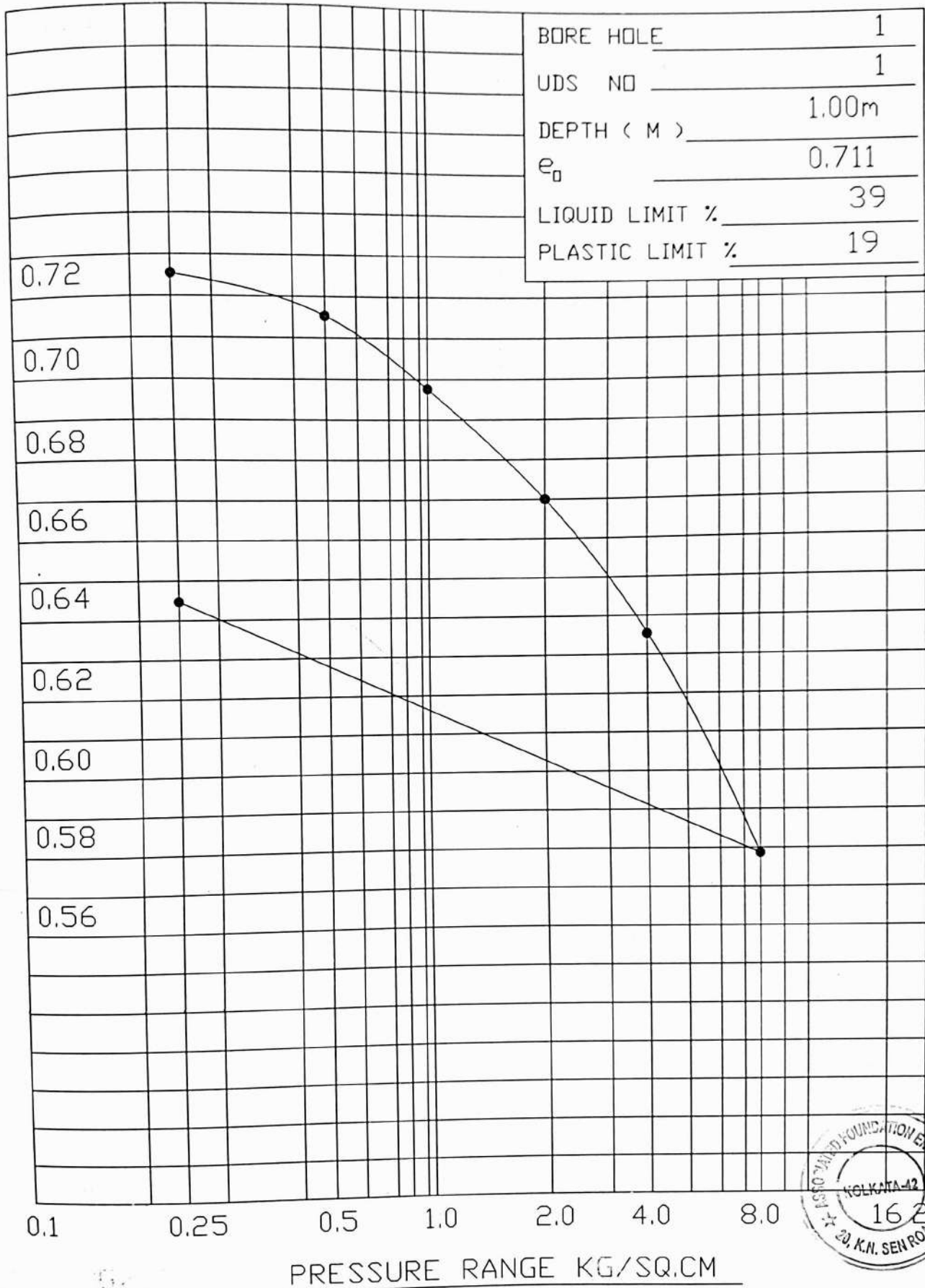
BORE HOLE NO : 4

NETROMETER (SPT)	NOS.		NOS.	COMMENCED ON :	02-10-2021
NETROMETER (SPT)	6	UNDISTURBED (UDS)	2	COMPLETED ON :	03-10-2021
ONE (PC)		PENETROMETER (SPT)	6	BORE HOLE DIA :	150mm.
ANE (V)		DISTURBED (DS)	1	R.L. OF GROUND :	
				WATER STRUCK AT :	3.50m
				STANDING WATER LEVEL :	3.50m

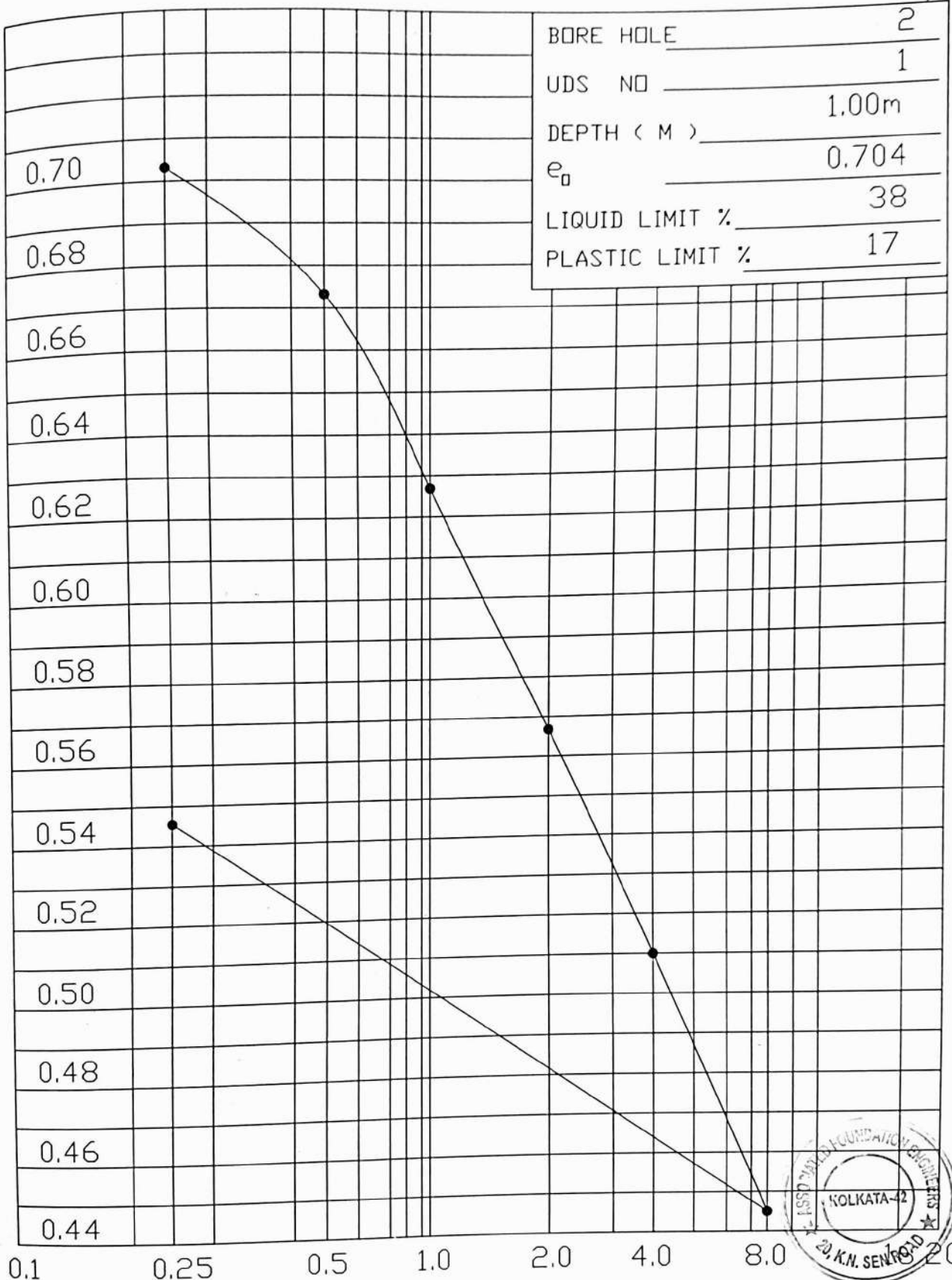
DESCRIPTION	SYMBOL	N - VALUE				SAMPLES	
		25	50	75	100	REF NO.	DEPTH (M)
HARD LIGHT GREY TO DEEP GREY TO BROWNISH GREY CLAYEY SILT WITH KANKARS, MODRUMS ETC.						DS - 1	0.50
						UDS - 1	1.00- 1.45
					N = 42	SPT - 1	1.50 - 2.10
						UDS - 2	2.50- 2.95
	3.00M				N = 100	SPT - 2	3.50 - 4.10
					N = 100	SPT - 3	5.50 - 6.10
BLACK CLAYEY SILT, COAL.					N = 100	SPT - 4	6.50 - 7.10
					N = 100	SPT - 5	
	10.60M				N = 100	SPT - 6	10.00 - 10.60



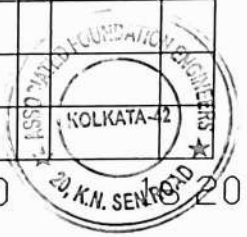
e VS LOG p CURVE



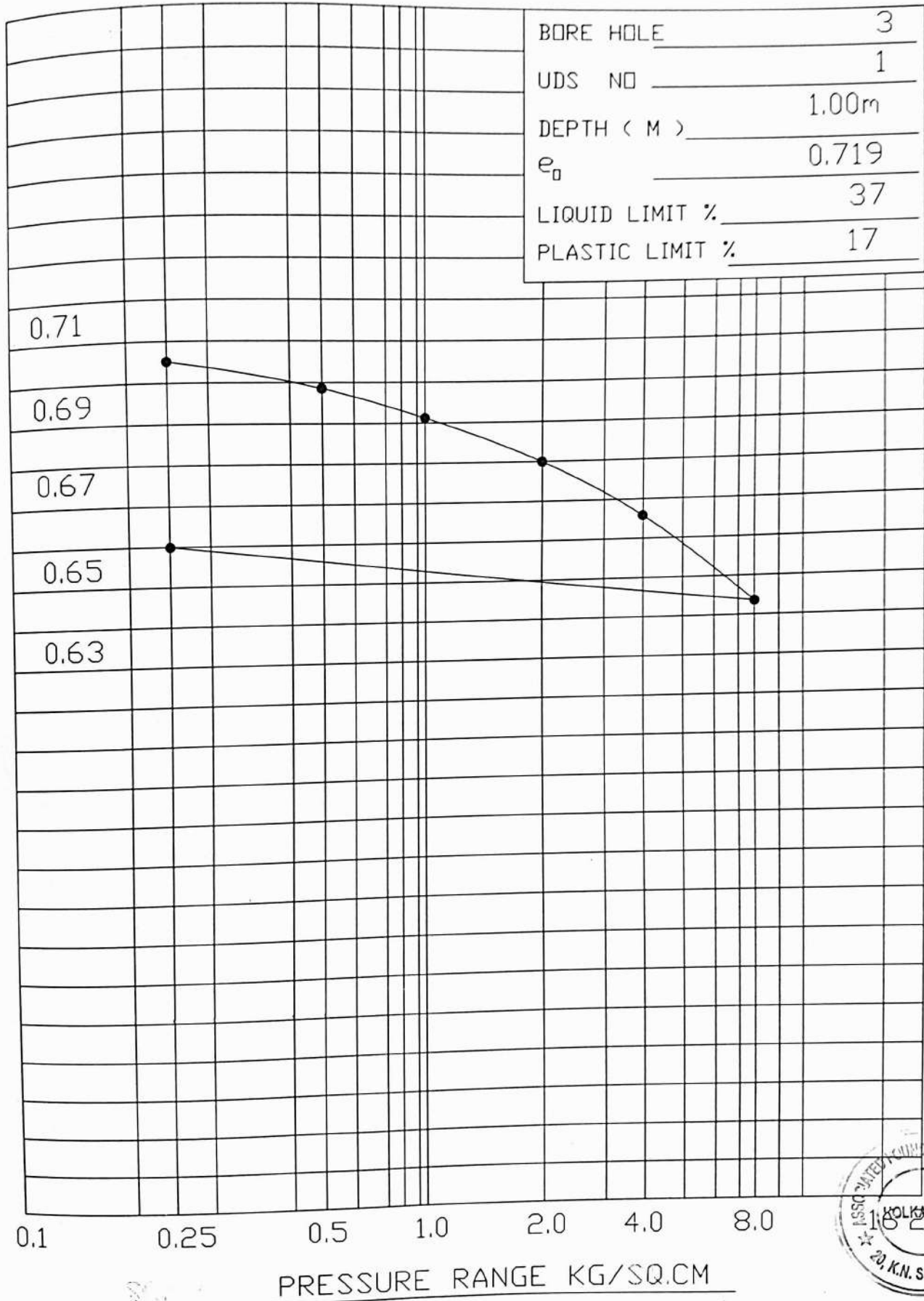
e VS LOG p CURVE



PRESSURE RANGE KG/SQ.CM

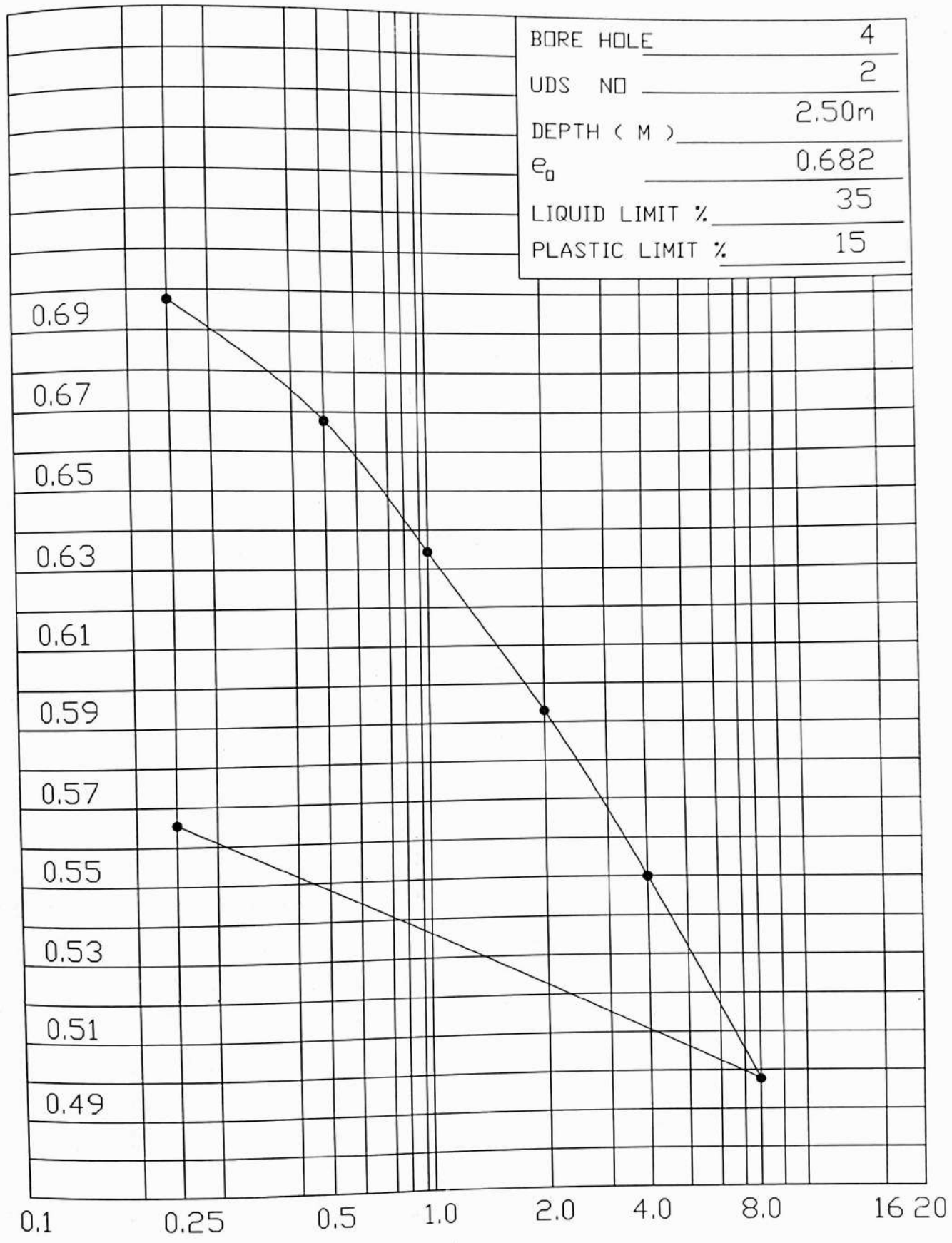


e VS LOG p CURVE



e VS LOG p CURVE

BORE HOLE	4
UDS NO	2
DEPTH (M)	2.50m
e_0	0.682
LIQUID LIMIT %	35
PLASTIC LIMIT %	15



PRESSURE RANGE KG/SQ.CM

