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**GEOTECHNICAL INVESTIGATIONS FOR CONSTRUCTION OF HIGH LEVEL
BRIDGE ON EXISTING CANAL ON U.B.D.C. CROSSING G.T ROAD(TAARAN
WALA PUL) IN AMRITSAR, PUNJAB.**

**EXECUTIVE ENGINEER
C.W. DIVISION NO. 1
PWD B & R,AMRITSAR.**

CLIENT :-

Report Prepared by:-

Checked by:-

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GEOTECHNICAL INVESTIGATIONS FOR CONSTRUCTION OF HIGH LEVEL BRIDGE ON U.B.D.C CROSSING G.T ROAD (TARRAN WALA PUL), AMRITSAR, PUNJAB.

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1. INTRODUCTION:

1.1 General:

The work was carried out at the behest of the EXECUTIVE ENGINEER C.W DIVISION, PUNJAB PWD B & R AMRITSAR.

1.2 Object

The object was to obtain sequence and extent of sub-soil and to ascertain the characteristics of sub-soil up to max. depth of 14m & 17 m so as to arrive at design parameters for the foundations of proposed structures.

1.3 Boreholes

Total 2 no. boreholes were used to carry out the desired investigation.

1.4 Sub-soil Water Conditions:

From the bore hole data (BH-1 & BH-2) it is found that there is variation in Water Table Lvl. Wter table is found at in BH-1 at depth 20 m and in BH-2 at 6m. The pile capacity will be governed by BH-2 where capacity will be on lower side.

2. LABORATORY INVESTIGATIONS:

These were done as per Appendix-1, under the following heads.

- 3.1 Index properties
- 3.2 Engineering Properties

3. FIELD INVESTIGATION:

These were done as per Appendix -3, under the following heads:

- 2.1 Boring Operation and Sampling
- 2.2 Disturbed/undisturbed samples
- 2.3 Standard Penetration Tests and related corrections

4. BOREHOLE LOG DETAILS:

Through field and laboratory investigations, all the relevant parameters pertaining to various strata met in boreholes were determined. Based upon these, borehole log charts and data sheets have been prepared and are reported in table BH1 & BH2.

The data of these sheets form the basis of evaluation of allowable bearing capacity of the proposed foundation.

5. INDEX AND ENGINEERING PROPERTIES [SP-36 (PART-1)-1987]:

Using the IS codes as given in compendium of Indian standards on Soil Engineering, Part 1. Laboratory Testing of Soils for Civil Engineering Purposes, SP-36 (Part-1)- 1987, relevant index and engineering properties of the strata met at different depth in the boreholes were determined.

6 FOUNDATION PARAMETERS:

6.1 Bored Cast-in-Situ Piles are recommended for heavy structures as below

Dia of Pile = 1.0m
Cut off length w.r.t. GL = 1.0 m

7. ALLOWABLE BEARING CAPACITY CRITERIA:

This is used to arrive at desired values of bearing capacity.

8. COMPUTATION VALUATION OF SAFE LOAD OF BORED CAST-IN-SITU PILE

The ultimate load capacity Q_u is estimated from the following expression:

$$Q_u = Q_p + Q_s$$

Where Q_b = Ultimate Base Resistance

Q_s = Ultimate Skin Resistance

Pile capacity is found

$$Q_s = Q_u / \text{FOS}$$

The code recommends that for working our safe load, a minimum value of factor of safety should be adopted as 2.5

Depending upon the nature of strata, the above ultimate resistances are computed as under:-

8.1 Ultimate Skin Resistance

a) Granular Soils

$$Q_s = K_s P_d' \tan \delta A_s$$

P_d' = Effective overburden pressure

K_s = 1 to 2 for Bored piles in loose to medium sands.
Value adopted = 1.0)

δ = Angle of wall friction between Pile and soil, in degrees
($3/4\phi$ for concrete pile)

A_s = Surface area of Pile stem.

b) Cohesive Soils

Q_s = $\alpha C_u A_s$

α = Reduction factor

C_u = Average undrained shear strength along the length of pile.

A_s = Surface area of Pile Shaft

8.2 Ultimate Point Resistance

Granular Soils

Q_b = $A_p P_d (N_{\gamma} - 1)$

A_b = Cross-sectional area of pile toe

A_b = $.785D$ where

γ = Effective unit weight of soil at pile toe

P_d = Effective overburden pressure at pile toe

N_q = Bearing capacity factors depending upon the angle of Internal friction ' ϕ ' at pile toe.

Note 1 N_{γ} = B.C. factor, dependent on ϕ value and D/B

8.3 Computations:

The skin resistance contributed by the cohesion less soil strata is governed by the average value of ' ϕ '.

Fully submerged conditions are being incorporated in the computations.

Pile Dia = .0m

Type of pile = bored and cast-in situ.

Bridge Flyover = km width

Carrying capacity of pile

Type of soil = cohesionless soil

Let us consider length of pile = 15m

Upto 8m depth the stratum is that of cohesive soil

Depth in sand stratum = 7.0m

ϕ = 30°

Base Resistance

$$Q_b = A_b P_d (N_\gamma - 1)$$

$$N_q = 26 \text{ (for } D/B = 15)$$

$$Q_b = .785 \times 1 \times \{ (1.791 \times 7) + (1.084 - 1) \times 7 \} \times 26$$

$$Q_b = A_b P_d (N_\gamma - 1)$$

$$Q_b = 353.7 \text{ T}$$

Skin friction of pile in cohesionless stratum

$$Q_s = K_s P_d' \tan \alpha A_s$$

$$\Delta = 3/4 \phi = 22.5^\circ$$

$$K_s = 1.0$$

$$Q_s = 135.7 \text{ T}$$

Skin friction of pile shaft in cohesive soil

$$Q_s = \alpha C_d A_s$$

$$\alpha = 0.45$$

$$C_u = 0.9 \text{ kg/cm}^2$$

$$Q_s = 89 \text{ T}$$

Total ultimate pile resistance = $353.7 + 135.7 + 89 = 578.4 \text{ T}$

With a F.O.S = 2.5

Safe pile load = 231 T

Also from eq. $Q_b/3 + Q_s/1.5$

Safe pile load = 230 T

For pile of dia 1m and 15m depth

Safe pile load = 275 T

For pile of 1m dia and depth 18 m

Bored cast in situ piles:-

Safe loads have been worked out by using static formula (borehole data). The safe loads work out to be as under :-

Cut off length of a pile w.r.to GL. = 1.0m

Dia of pile(m)	length of pile w.r.t cut off lvl.(m)	Qs(Safe load)
1m	14	230T
1m	17	275T

9. RECOMMENDATIONS:

It is recommended that :-

- 1) Pile shall always be terminated in dense sand to get good end bearing values.
In case at any location layer of low plasticity sandy silt is encountered, pile shall be extended further up to dense sand.
- 2)The values tabulated above should be taken as guide. Reliance should be based on pile load tests.

APPENDIX-1: LABORATORY INVESTIGATIONS

1.1 Index Properties { As per SP 36 (Part- 1)-1987}

The prerequisite of any soil investigation report is the classification of sub soil strata based upon laboratory classification tests. All the relevant classification tests on the samples obtained from the boreholes were carried out in the laboratory. The index properties obtained from such classification tests at different depths in the boreholes are reported in the in the borehole log chart and data sheets.

1.2 Engineering Properties {As per SP-36 (Part-1)-1987}

It comprised of conducting all the necessary tests on the disturbed and undisturbed soil samples to evaluate different engineering properties of the sub soil.

The unconfined compression strength and consolidated undrained triaxial shear tests were performed on undisturbed samples obtained from the cohesive strata so as to obtain undrained shear strength of the soil.

Direct shear tests were performed on cohesion less samples obtained from different depths in each borehole so as to determine the shear strength characteristics of cohesion less strata met in various boreholes

APPENDIX – 2 :
ALLOWABLE BEARING CAPACITY CRITERIA

A foundation can fail by two modes i.e.

- 1) **Shear failure**
- 2) **Excessive settlement**

Shear failure being catastrophic, an adequate factor of safety is applied to ultimate bearing capacity that can initiate this type of failure. BIS recommends a value of FOS = 2.5 To obtain the net safe bearing capacity 'q_{ns}' by using the physical characteristics of the foundation and relevant shear strength parameters of soil. Through settlement analysis a net loading intensity 'q_{ns}' is obtained by using the physical characteristics of the foundation and the relevant compressibility characteristics of the underlying soil. Here the settlement of pile group shall be determined as per IS 8009 (part II). The load capacities of piles are based on empirical correlation's, should be confirmed with conducting pile load test as per IS: 2911 (Part IV) on test piles before execution of working piles.

APPENDIX-3: FIELD INVESTIGATIONS

3.1 Boring Operation and Sampling

100mm dia borehole was advanced at the location using shell and auger method 100mm nominal dia flush steel casing was advanced with the boring and the full length of the borehole was encased at each location.

3.2 Disturbed/undisturbed Samples

Apart from the disturbed samples retrieved from the split spoon sampler, disturbed/undisturbed samples were obtained depending upon the nature of soil from different depths in the borehole. These samples were subsequently tested in the laboratory so as to determine the various index and engineering properties of the various sub soil strata met in the borehole.

3.3 Standard Penetration Test

This test was performed in the borehole. The standard split spoon sampler, attached to a string of drill rods was lowered to the bottom of the hole and allowed to rest under self weight. The drill rods were connected to driving assembly which consisted of a hoisting equipment, a drive weight (Hammer) of 63.5 kg, and a guide to ensure a 75cm free fall of hammer on an anvil. The number of blows that were required to penetrate the sampler through three runs of 150mm each were recorded. Initial driving of 150mm was disregarded and the number of blows required to drive the sampler through the remaining 300mm is called BLOW COUNT or PENETRATION NUMBER, N. At the end of the test, the sampler was withdrawn and the soil extracted for subsequent testing in the laboratory. If the penetration was less than 30cm for 100 blows, it is considered as refusal and the actual penetration was recorded

- 1) Correction to account for the effect of overburden pressure

$$N = C_N \times N$$

Where 'C_N' is overburden pressure correction and is scaled of from the figure as provided in the code. 'N' are the normalized blows.

- 2) Submergence Correction

$$\frac{N_n - 15}{2}$$

$$N_c = 15 + \frac{N_n - 15}{2} \quad \text{Provided } N_n \text{ is } > 15$$

Where 'N_c' is the final corrected value.

Where ever both the overburden and submergence correction are necessary, the overburden correction is applied first.

The overburden correction is meant for granular strata. Submergence correction is applied only in case of sands and non-plastic silts.

S.No.:	SAMPLE NO	DEPTH OF SAMPLE (FROM REF POINT)(M)	Blows/30cms Observed SPT (N)	DESCRIPTION OF SOIL WITH ITS CLASSIFICATION	Grain Size Analysis				L L	P L	P I	Bulk density gms/c	% MOISTURE	Field Dry density g	Silt Factor
					% GRAVEL	% SAND	% SILT	% CLAY							
1				clay0.00-2.0M											
2	SPT1	1.5	41		0.0	21.0	79.0				1.75	8.0	1.62		
3	SPT2	3.0	42	kankar +clay	16.7	11.3	72.0				1.82	9.8	1.66		
4				2.0-5.0m											
5	SPT3	4.5	44		16.6	14.4	70.0				1.80	11.0	1.62		
6	SPT4	6.0	31	silty sand	0.0	75.7	24.3				1.67	12.6	1.48		
7				5.0-9.5m											
8	SPT5	7.5	35		0.0	72.3	27.7				1.77	12.9	1.57		
9	SPT6	9.0	39		0.0	75.5	24.5				1.77	19.5	1.56		
10				fine sand											
11	SPT7	10.5	35	9.5-13.0m	0.0	79.5	20.5				1.74	14.5	1.52		
12	SPT8	12.0	28		0.0	80.4	19.6				1.76	15.0	1.53		
13															
14	SPT9	13.5	29	silty sand	0.0	17.5	82.5				1.83	15.4	1.59		
15	SPT10	15.0	32	+clay	0.0	13.1	86.9				1.84	15.7	1.59		
16				13.0-20.0m											
17	SPT11	16.5	54		0.0	12.4	87.6				1.86	14.9	1.62		
18	SPT12	18.0	70		0.0	10.8	89.2				1.89	15.7	1.63		
19															
20	SPT13	19.5	42		0.0	11.6	88.4				1.85	16.2	1.592		
21	SPT14	21.0	49	fine sand	0.0	88.1	11.9								
22				20.0-30.0m											
23	SP15	22.5	51		0.0	86.5	13.5								
24	SPT16	24.0	54		0.0	98.6	1.4								
25															
26	SPT17	25.5	46		0.0	98.0	2.0								
27	SPT18	27.0	R		0.0	98.9	1.1								
28															
29	SPT19	28.5	R		0.0	97.8	2.3								
30	SPT20	30.0	R		0.0	98.1	1.9								

S.No.:	SAMPLE NO	DEPTH OF SAMPLE (FROM REF POINT)(M)	Blows/30cms Observed SPT (N)	DESCRIPTION OF SOIL WITH ITS CLASSIFICATION	Grain Size Analysis				L L	P L	P I	Bulk density gms/c	% MOISTURE	Field Dry density g	Silt Factor
					% GRAVEL	% SAND	% SILT	% CLAY							
1				black											
2	SPT1	1.5	8	clay0.00-	0.0	2.0	98.0				1.63	8.5	1.50		
3	SPT2	3.0	10	kankar	10.5	9.4	80.1		27.9	18.3	9.6	1.75	9.5	1.59	
4				+clay											
5	SPT3	4.5	11	1.5-8.0m	12.5	11.2	76.3		27.0	18.3	8.7	1.81	10.6	1.62	
6	SPT4	6.0	14		9.8	11.5	78.7		27.6	10.5	9.1	1.83	11.4	1.62	
7															
8	SPT5	7.5	18	silty sand	9.5	10.5	81.0		26.7	18.0	8.5	1.83	13.0	1.62	
9	SPT6	9.0	35	8.0-11.0m	0.0	90.1	8.9						15.6	1.46	
10															
11	SPT7	10.5		fine sand	0.0	88.5	12.5					1.65	15.0	1.44	
12	SPT8	12.0	46	11.0-17.0m	0.0	97.6	2.4								
13															
14	SPT9	13.5	56		0.0	96.9	3.1								
15	SPT10	15.0	51		0.0	97.8	2.2								
16															
17	SPT11	16.5	58		0.0	97.0	3								
18	SPT12	18.0		clay	0.0	93.7	6.3								
19			50	fine sand											
20	SPT13	19.5	R	18.0-23.5m	0.0	90.7	9.3								
21	SPT14	21.0	R		0.0	87.6	12.4								
22															
23	SP15	22.5	R		0.0	91.2	8.8								
24	SPT16	24.0	R	very fine	0.0	96.5	3.5								
25				sand23.5m-											
26	SPT17	25.5	R	30.0m	0.0	98.0	2.0								
27	SPT18	27.0	R		0.0	97.2	2.8								
28															
29	SPT19	28.5	R		0.0	96.8	3.2								
30	SPT20	30.0	R		0.0	97.5	2.5								

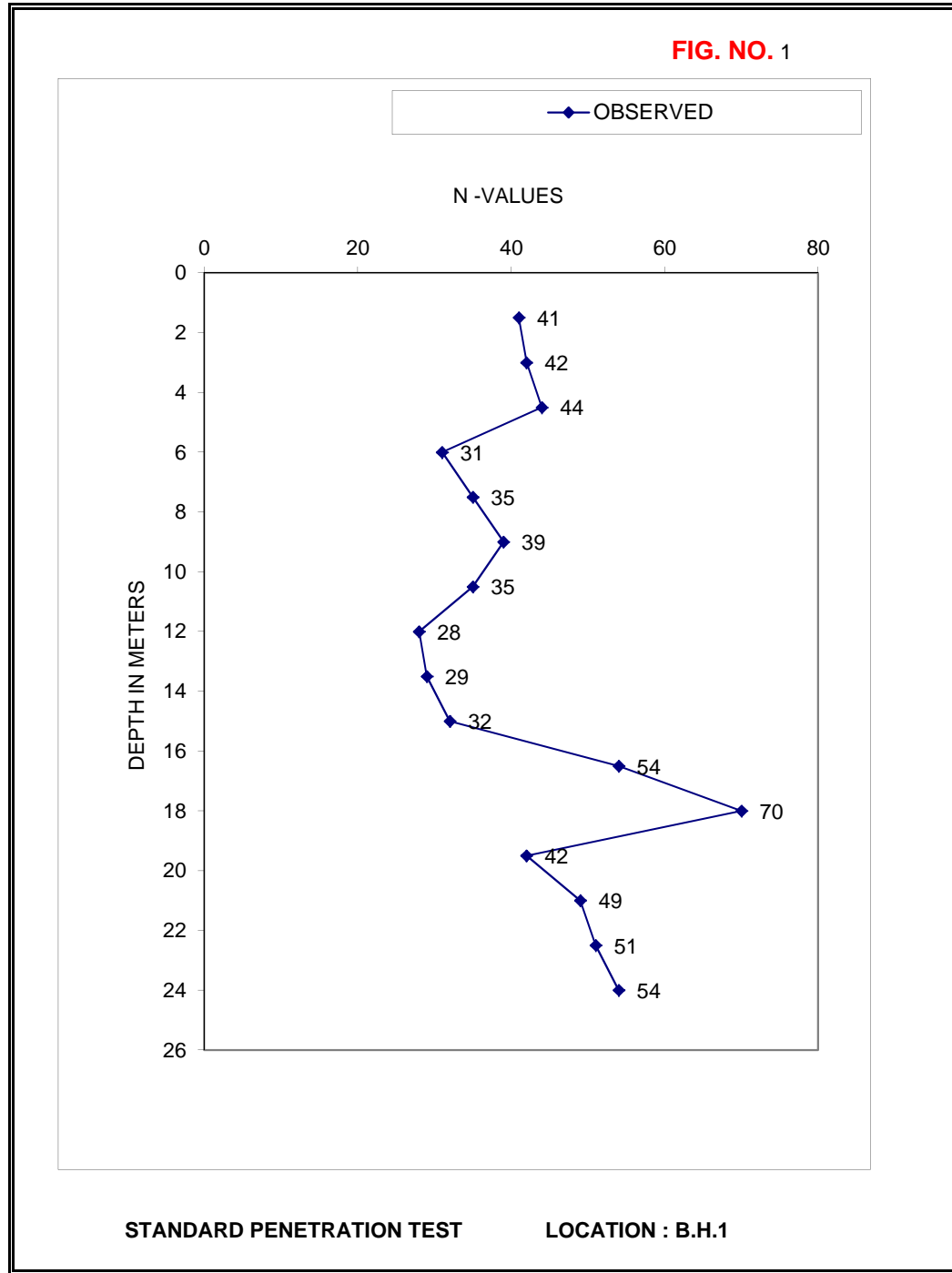
S.No.:	SAMPLE NO	DEPTH OF SAMPLE (FROM REF POINT)(M)	Blows/30cms Observed SPT (N)	DESCRIPTION OF SOIL WITH ITS CLASSIFICATION	Grain Size Analysis				L L	P L	P I	Bulk density gms/c	% MOISTURE	Field Dry density g	Silt Factor
					% GRAVEL	% SAND	% SILT	% CLAY							
1				clay0.00-2.0M											
2	SPT1	1.5	32		0.0	15.2	84.8					1.79	11.8	1.61	
3	SPT2	3.0	27	kankar +clay 2.0-8.0m	18.5	8.3	73.2					1.86	12.3	1.66	
4															
5	SPT3	4.5	30		15.1	7.4	77.5					1.83	13.4	1.62	
6	SPT4	6.0	43		12.1	10.1	77.8					1.85	14.2	1.62	
7															
8	SPT5	7.5	45	silty sand 8.0-11.0m	9.7	12.0	78.3					1.87	14.3	1.63	
9	SPT6	9.0	42		0.6	75.5	23.9					1.66	15.3	1.44	
10															
11	SPT7	10.5	48	fine sand 11.0-23.0m	0.0	73.1	26.9					1.70	15.5	1.47	
12	SPT8	12.0	52		0.0	91.0	9.0					1.73	16.0	1.49	
13															
14	SPT9	13.5	R		0.4	85.4	14.2					1.70	16.3	1.46	
15	SPT10	15.0	R		0.0	86.0	14					1.67	16.0	1.44	
16															
17	SPT11	16.5	R		0.0	85.2	14.8						16.6		
18	SPT12	18.0	R		0.0	84.6	15.4						17.8		
19															
20	SPT13	19.5	R		0.0	88.4	11.6						17		
21	SPT14	21.0	R	0.0	90.5	9.5						16.4			
22															
23	SP15	22.5	R	very fine sand 23.0-30.0m	0.0	88.6	11.4						17.2		
24	SPT16	24.0	R		0.0	88.0	12.0						17.5		
25															
26	SPT17	25.5	R		0.0	92.0	8.0						17.6		
27	SPT18	27.0	R		0.0	93.5	6.5						18		
28															
29	SPT19	28.5	R		0.0	91.6	8.4						18.4		
30	SPT20	30.0	R		0.0	92.0	8.0						18.6		

S.No.:	SAMPLE NO	DEPTH OF SAMPLE (FROM REF POINT(M)	Blows/30cms Observed SPT (N)	DESCRIPTION OF SOIL WITH ITS CLASSIFICATION	Grain Size Analysis				L L	P L	P I	Bulk density gms/cc	% MOISTURE	Field Dry density g/	Silt Factor		
					% GRAVEL	% SAND	% SILT	% CLAY									
1				clay0.00-1.5M													
2	SPT1	1.5	36			0.0	17.8	82.2				1.75	8.1	1.61			
3	SPT2	3.0	33	kankar +clay1.5-4.0m	31.4	13.1	55.5				1.78	9.3	1.63				
4																	
5	SPT3	4.5	31	silty sand 4.0-6.0	1.8	68.5	29.7				1.68	9.7	1.53				
6	SPT4	6.0	36			2.3	73.8	23.9				1.71	10.1	1.55			
7				fine sand 6.0-17.0m													
8	SPT5	7.5	43			0.0	90.6	9.4				1.66	12.6	1.47			
9	SPT6	9.0	45			0.0	88.5	11.5				1.67	13.2	1.48			
10																	
11	SPT7	10.5	48			0.0	90.0	10.0				1.65	14.5	1.44			
12	SPT8	12.0	55			0.0	89.7	10.3				1.65	15.0	1.43			
13																	
14	SPT9	13.5	R			0.4	85.0	15.0									
15	SPT10	15.0	R			0.0	82.2	17.8									
16																	
17	SPT11	16.5	R	17.0-20.0m sand +clay	0.0	84.4	15.6										
18	SPT12	18.0	R			0.7	54.4	44.9				1.74	15.8	1.50			
19																	
20	SPT13	19.5	R			0.0	72.5	27.5									
21	SPT14	21.0	R		fine sand 20.0-30.0m	0.0	85.1	14.9									
22																	
23	SP15	22.5	R				0.0	87.5	12.5								
24	SPT16	24.0	R				0.0	92.0	8.0								
25																	
26	SPT17	25.5	R				0.0	91.2	8.8								
27	SPT18	27.0	R			0.0	90.1	9.9									
28																	
29	SPT19	28.5	R		0.0	95.0	5.0										
30	SPT20	30.0	R		0.0	94.5	5.5										

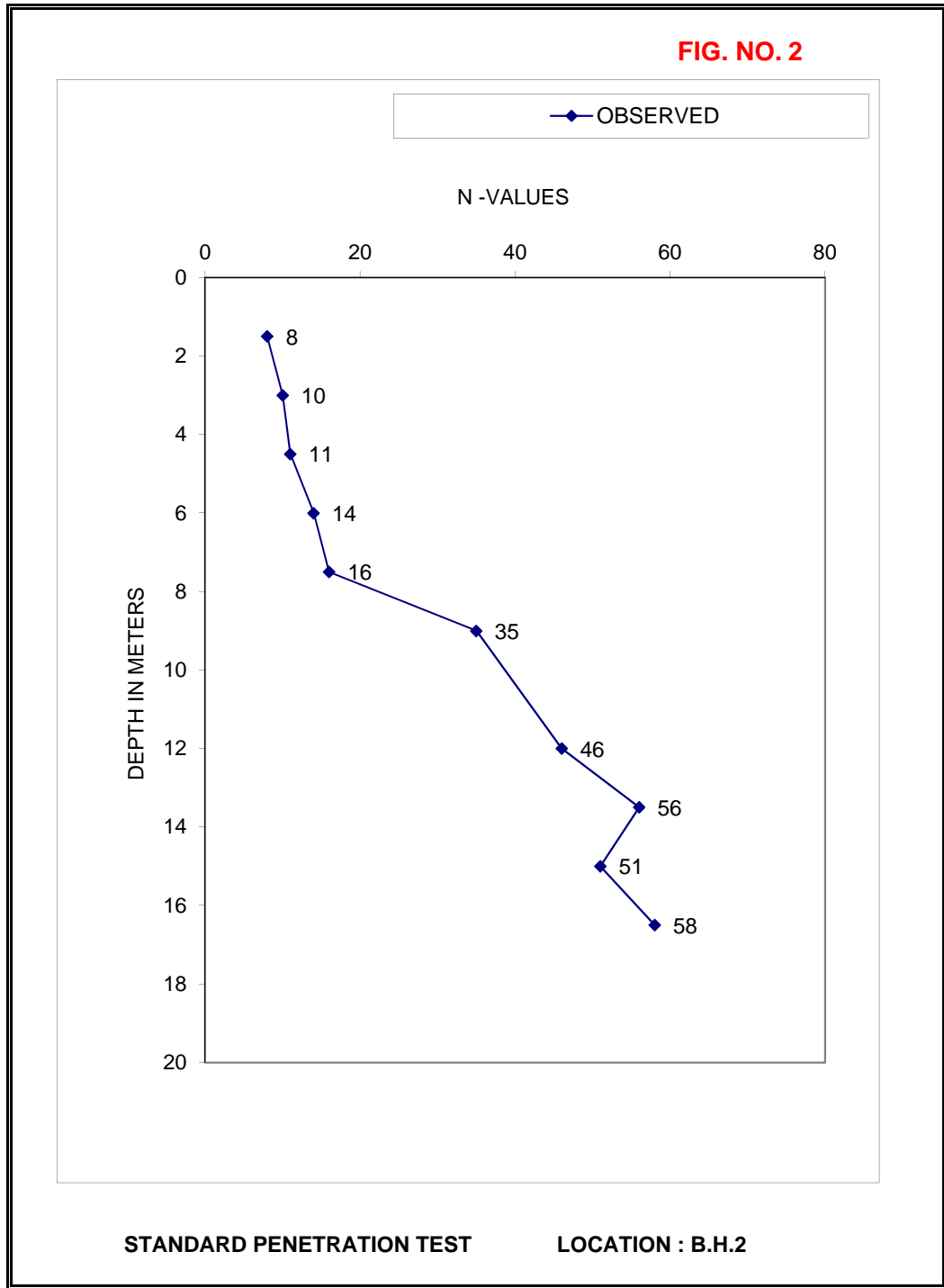
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N VALUES

DEPTH

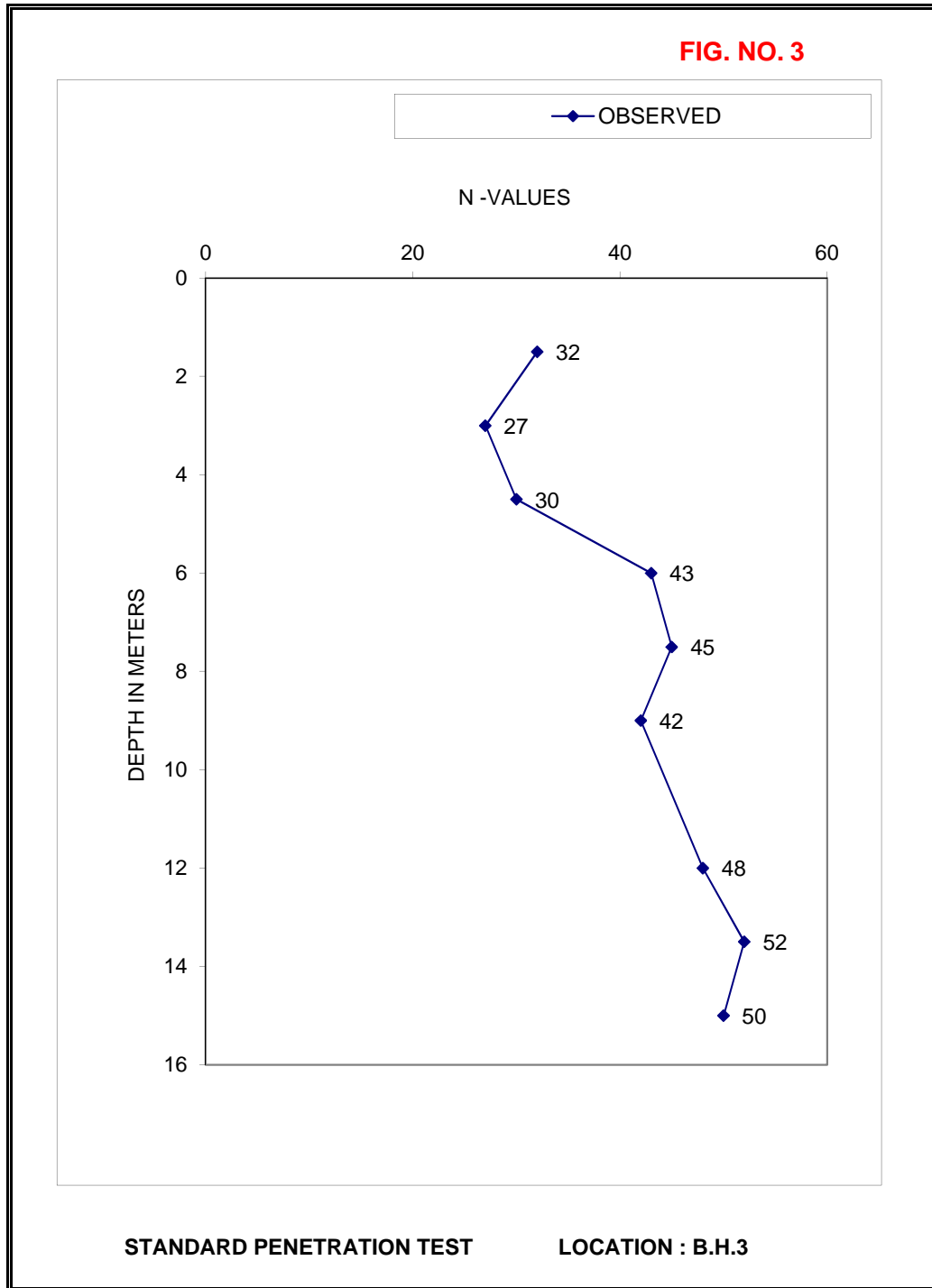
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42	3
44	4.5
31	6
35	7.5
39	9
35	10.5
28	12
29	13.5
32	15
54	16.5
70	18
42	19.5
49	21
51	22.5
54	24
46	25.5



OBSERVED N VALUES	DEPTH
8	1.5
10	3
11	4.5
14	6
16	7.5
35	9
46	12
56	13.5
51	15
58	16.5
	18



OBSERVED N VALUES	DEPTH
32	1.5
27	3
30	4.5
43	6
45	7.5
42	9
48	12
52	13.5
50	15



OBSERVED N VALUES	DEPTH
36	1.5
33	3
31	4.5
36	6
43	7.5
45	9
48	12
55	13.5

