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CONSULTANCY PROJECT

SUBSOIL INVESTIGATIONS AT THE SITE OF PROPOSED EXTENSION OF PARKING NEAR NATIONAL HOTEL, TALLITAL, NAINITAL

AGENCY

CITY MAGISTRATE/JOINT SECRETARY
DISTRICT LEVEL DEVELOPMENT AUTHORITY,
REGIONAL OFFICE HALDWANI, DISTT. NAINITAL (UTTARAKHAND)

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1.1 INTRODUCTION

Extension of existing parking near National Hotel is proposed at Tallital, Nainital (Uttarakhand). The investigations presented in this report have been carried out in the month of October, 2021 on the authorization of City Magistrate/Joint Secretary, District Level Development Authority, Regional office Haldwani, district Nainital (Uttarakhand) vide letter No. 151/Re.Ka.Ha./2021-22, dated 02.08.2021.

1.2 OBJECTIVE AND SCOPE

The objectives of this investigation have been framed to provide necessary data required for evaluation of bearing capacity of soil/rock of above mentioned site. The scope of investigation has been as under:

(a) Excavation of trial pits/drilling of bore holes supplemented with penetration test (SPT/DCPT) up to a depth of 7.0m or refusal whichever occurs earlier, and simultaneously collection of soil samples for laboratory analysis.

(b) To conduct laboratory tests on disturbed and undisturbed soil samples for determination of natural moisture content, bulk density, dry density, void ratio, grain size distribution, liquid limit, plastic limit and specific gravity.

(c) To conduct triaxial compression test (undrained) on cohesive soils for determination of shear strength parameters, if clay is encountered.

(d) To conduct unconfined compression test, if clay is encountered.

(e) To conduct direct shear tests on samples of non cohesive soils, remoulded at field dry density and field moisture content, for determination of shear strength parameters (c & ϕ).

(f) To conduct consolidation test on cohesive soils, if met with.

(g) To evaluate the maximum probable settlement of the foundation.

(h) To locate the depth of ground water table and to estimate the seasonal variation.

(i) To evaluate the value of allowable bearing capacity of the soil on the basis of data obtained from (a) to (h).

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1.3 FIELD INVESTIGATION

Soil investigations at the proposed site were performed as per IS: 1892–1979.

Four trial pits were excavated at the site to observe the soil in its natural state and to locate the depth of filled up soil/bed rock, if any.

In all the trial pits, dynamic cone penetration test (DCPT) was conducted up to 7.0m depth or refusal of penetration whichever occurred earlier. Dynamic cone penetration tests were conducted as per IS: 4968 (Part–I)–1976.

Ground water table was not encountered during soil investigation.

Location of test points and penetration test data are shown in Figs. 1 and 3, respectively.

1.4 LABORATORY ANALYSIS

Soil samples collected from different trial pits/bore holes were subjected to the following tests in the laboratory:

(a) *In–situ* density

(b) *In–situ* moisture content

(c) Consistency limits

(d) Specific gravity

(e) Particle size distribution

(f) Direct shear box test

(g) Triaxial compression test

(h) Consolidation test

Direct shear tests were conducted on remoulded cohesionless soil and bed rock (at field dry density and field moisture content) for determining shear strength parameters.

Triaxial compression and consolidation tests were conducted on cohesive soil.

Results of the laboratory tests are given in appendices A–1 to A–4.

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1.5 SOIL PROFILE / ROCK FORMATION

In all the trial pits, the soil stratum consists of a thick deposit of mixture of silt, sand, gravels and rock fragments extending up to the depth of refusal/exploration.

The ground water table was not observed during the course of testing.

Strata chart, also showing the depth of refusal, is shown in Fig. 2.

1.6 ANALYSIS OF BEARING CAPACITY

Bearing capacity is evaluated on the basis of shear strength parameters (c and ϕ) of soil and the permissible settlement of structure, and it is taken least of the following as per IS: 6403–1981:

(a) Net ultimate bearing capacity divided by a suitable factor of safety, that is net safe bearing capacity.

(b) Net soil pressure that can be imposed on the base of the foundation without settlement exceeding the permissible values as given in IS: 1904–1986 to be determined for each structure and type of soil, that is safe bearing capacity.

(I) ALLOWABLE BEARING CAPACITY BASED ON SETTLEMENT CURVES:

Values of net allowable bearing capacity of soil/rock can be computed from settlement curves as given in IS: 8009 (Part–I)–1976, for determining settlement of soil/foundation.

For Isolated Column (square) / Strip Footing:

Taking D_f = 1.50m, R_w = 1.0,

For B = 1.2m, 1.5m, 2.0m & 2.5m; and $N_{corr.}$ = 14,

For B = 1.2m, For 17.69mm settlement, q_{na} = 10 t/m^2

For 25mm settlement, q_{na} = (10 / 17.69) x 25 = 14.13 t/m^2

For B = 1.5m, For 18.84mm settlement, q_{na} = 10 t/m^2

For 25mm settlement, q_{na} = (10 / 18.84) x 25 = 13.27 t/m^2

For B = 2.0m, For 26.25mm settlement, q_{na} = 10 t/m^2

For 25mm settlement, q_{na} = (10 / 20.00) x 25 = 12.50 t/m^2

For B = 2.5m, For 22.50mm settlement, q_{na} = 10 t/m^2

For 25mm settlement, q_{na} = (10 / 22.50) x 25 = 11.11 t/m^2

Taking D_f = 4.50m, R_w = 1.0 and $N_{corr.}$ = 35,

For B ≥ 6.0m, For 10.10mm settlement, q_{na} = 10 t/m^2

For 25mm settlement, q_{na} = (10 / 10.10) x 25 = 24.75 t/m^2

(II) BASED ON SHEAR FAILURE CONSIDERATION:

Net safe bearing capacity can also be computed from the equation recommended by IS: 6403–1981, as under:

$$q_{ns} = \frac{1}{F}\{CN_c s_c d_c i_c + \gamma D_f (N_q - 1) s_q d_q i_q R_{w1} + 0.5\gamma B N_\gamma s_\gamma d_\gamma i_\gamma R_{w2}\}$$

where,

q_{ns} = Net safe bearing capacity, (t/m^2)

F = Factor of safety

B = width of foundation (m)

C = Effective cohesion, (t/m^2)

D_f = Depth of foundation (m)

γ = *In–situ* density, (t/m^3)

N_c, N_q, N_γ = Bearing capacity factors

s_c, s_q, s_γ = Shape factors

d_c, d_q, d_γ = Depth factors

i_c, i_q, i_γ = Inclination factors

R_{w1}, R_{w2} = G.W.T. correction factors

Taking F = 3, γ = 1.75 t/m^3, N_q = 24.54, N_γ = 33.54 and $R_{w1} = R_{w2}$ = 1.0

(Bearing capacity factors for ϕ = 34°)

For Strip Footing:

$s_q = s_\gamma = 1.0$, $d_q = d_\gamma = 1.0$, $i_q = i_\gamma = 1.0$ & $R_{w1} = R_{w2} = 1.0$

$$q_{ns} = \frac{1}{3}\{1.75xD_f x(24.54-1)x1.0x1.0 + 0.5x1.75xBx33.54x1.0x1.0\}$$

q_{ns} = 13.73 D_f + 9.78 B

For D_f = 1.50m, q_{ns} = 20.59 + 9.78 B

For B = 1.2m, q_{ns} = 32.33 t/m^2

For B = 1.5m, q_{ns} = 35.26 t/m^2

For B = 2.0m, q_{ns} = 40.15 t/m^2

For B = 2.5m, q_{ns} = 45.04 t/m^2

For Isolated Column (Square) Footing:

s_q = 1.2, s_γ = 0.8, $d_q = d_\gamma$ = 1.0, $i_q = i_\gamma$ = 1.0 & $R_{w1} = R_{w2}$ = 1.00,

$$q_{ns} = \frac{1}{3}\{1.75xD_f x(24.54-1)x1.2x1.0 + 0.5x1.75xBx33.54x0.8x1.0\}$$

q_{ns} = 16.48 D_f + 7.82 B

For D_f = 1.50m, q_{ns} = 24.72 + 7.82 B

For B = 1.2m, q_{ns} = 34.10 t/m^2

For B = 1.5m, q_{ns} = 36.45 t/m^2

For B = 2.0m, q_{ns} = 40.36 t/m^2

For B = 2.5m, q_{ns} = 44.27 t/m^2

For Raft (Circular) Foundation:

Taking F = 7, γ = 1.84 t/m^3, N_q = 39.48, N_γ = 60.30 and $R_{w1} = R_{w2}$ = 1.0

(Bearing capacity factors for $\phi = 36°$)

$$q_{ns} = \frac{1}{7}\{1.84xD_f x(39.48-1)x1.2x1.0 + 0.5x1.84xBx60.30x0.6x1.0\}$$

q_{ns} = 12.13 D_f + 4.75 B

For D_f = 4.50m, q_{ns} = 54.58 + 4.75 B

For B = 6.0m, q_{ns} = 83.08 t/m^2

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1.7 SETTLEMENT ANALYSIS

Based on Penetration Test Data:

Settlement based on penetration test data for footing of width 'B' under unit intensity of pressure on cohesionless deposit with known value of penetration resistance, may be obtained from the curves showing relationship between settlement and penetration resistance as per IS: 8009 (Part-I)–1981, settlement under any other pressure may be computed by assuming that settlement is proportional to the intensity of pressure.

For Strip/Isolated Column (Square) Footing:

Taking D_f = 1.50m, For B = 1.20m, 1.50m, 2.00m & 2.50m; q = 15.0 t/m^2 and R_w = 1.0

For B = 1.20m, Corr. settlement = 0.0177 x 1.50 x 1000 x 0.624 = 16.57mm

For B = 1.50m, Corr. settlement = 0.0188 x 1.50 x 1000 x 0.707 = 19.94mm

For B = 2.00m, Corr. settlement = 0.0200 x 1.50 x 1000 x 0.801 = 24.03mm

For B = 2.50m, Corr. settlement = 0.0225 x 1.50 x 1000 x 0.857 = 28.92mm

For Raft (Circular) Foundation:

Taking D_f = 4.50m, For B = 6.00m and more, q = 25.0 t/m^2 and R_w = 1.0

Corrected settlement = 0.0101 x 2.50 x 1000 x 0.800 = 20.20mm

IS: 1904–1986 permits the following values of maximum settlement for different types of structures:

Sl. No.	Type of Structure	Isolated Foundation		Raft Foundation	
		Sand and hard Clay (mm)	Plastic Clay (mm)	Sand and hard Clay (mm)	Plastic Clay (mm)
1.	Steel Structure	50	50	75	100
2.	RCC Column Footing	50	75	75	100
3.	Load Bearing Walls (Continuous Footing)	60	80	- - -	- - -
4.	Water Tower & Silos	50	75	100	125

Since the computed values of maximum settlement are less than the permissible values as given in the above table, hence safe.

1.8 DISCUSSION AND RECOMMENDATIONS:

(a) The strata chart is shown in Fig. 2. Ground water table was not encountered during the course of soil investigation.

(b) The **net allowable bearing capacity** of soil/rock is recommended as given below:

Type of Footing	Minimum depth of foundation (m)	Net Allowable Bearing Capacity (t/m^2)
Strip/Isolated footing	1.50	15.0
Raft Foundation	4.50	25.0

(c) The filled up soil, if any should not be considered while deciding the minimum depth of foundation. The foundation should be laid minimum 50cm in the virgin soil/rock.

(d) Loose material and/or cavities, if any in the foundation soil should be plugged with coarse sand-gravel (2 to 20mm size) or lean concrete (1:5:10). The minimum thickness of the compacted plug of sand-gravel/lean concrete should not be less than 30cm.

(e) The proposed site is located in an active seismic zone. It is, therefore, suggested to provide bends at plinth, lintel and gabble levels and adopt such other measures as recommended by Bureau of Indian Standards for an earthquake resistant structure.

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APPENDIX–1

CHARACTERITICS OF FOUNDATION SOIL (TRIAL PIT No: 1)

Sl. No.	Properties	Depth of Strata Below Ground Level (m)	
		1.50m	3.90m
1.	Soil Classification	Mixture of silt, sand, gravel/ rock fragments	Mixture of silt, sand, gravel/ rock fragments
2.	Particle size Distribution, % Clay (Less than 0.002mm) Silt (0.002–0.075mm) Sand (0.075–4.75mm) Gravel/Kankar (4.75–80mm)	 --- --- --- ---	 --- --- --- ---
3.	Unit Weight (t/m^3)	1.75	1.84
4.	Moisture Content (%)	---	---
5.	Specific Gravity	---	---
6.	Consistency Limits Liquid Limit (%) Plastic Limit (%)	NP	NP
7.	Cohesion (t/m^2)	---	---
8.	Angle of Shearing Resistance in Degrees	33	35
9.	Compression Index (C_c)	---	---

APPENDIX–2

CHARACTERITICS OF FOUNDATION SOIL (TRIAL PIT No: 2)

Sl. No.	Properties	Depth of Strata Below Ground Level (m)	
		1.50m	3.30m
1.	Soil Classification	Mixture of silt, sand, gravel/ rock fragments	Mixture of silt, sand, gravel/ rock fragments
2.	Particle size Distribution, % Clay (Less than 0.002 mm) Silt (0.002–0.075 mm) Sand (0.075–4.75 mm) Gravel/Kankar (4.75-80 mm)	 --- --- --- ---	 --- --- --- ---
3.	Unit Weight (t/m^3)	1.76	1.83
4.	Moisture Content (%)	---	---
5.	Specific Gravity	---	---
6.	Consistency Limits Liquid Limit (%) Plastic Limit (%)	NP	NP
7.	Cohesion (t/m^2)	---	---
8.	Angle of Shearing Resistance in Degrees	34	36
9.	Compression Index (C_c)	---	---

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APPENDIX–3

CHARACTERITICS OF FOUNDATION SOIL (TRIAL PIT No: 3)

Sl. No.	Properties	Depth of Strata Below Ground Level (m)	
		1.80m	4.20m
1.	Soil Classification	Mixture of silt, sand, gravel/ rock fragments	Mixture of silt, sand, gravel/ rock fragments
2.	Particle size Distribution, % Clay (Less than 0.002mm) Silt (0.002–0.075mm) Sand (0.075–4.75mm) Gravel/Kankar (4.75–80mm)	 --- --- --- ---	 --- --- --- ---
3.	Unit Weight (t/m^3)	1.76	1.85
4.	Moisture Content (%)	---	---
5.	Specific Gravity	---	---
6.	Consistency Limits Liquid Limit (%) Plastic Limit (%)	NP	NP
7.	Cohesion (t/m^2)	---	---
8.	Angle of Shearing Resistance in Degrees	35	36
9.	Compression Index (C_c)	---	---

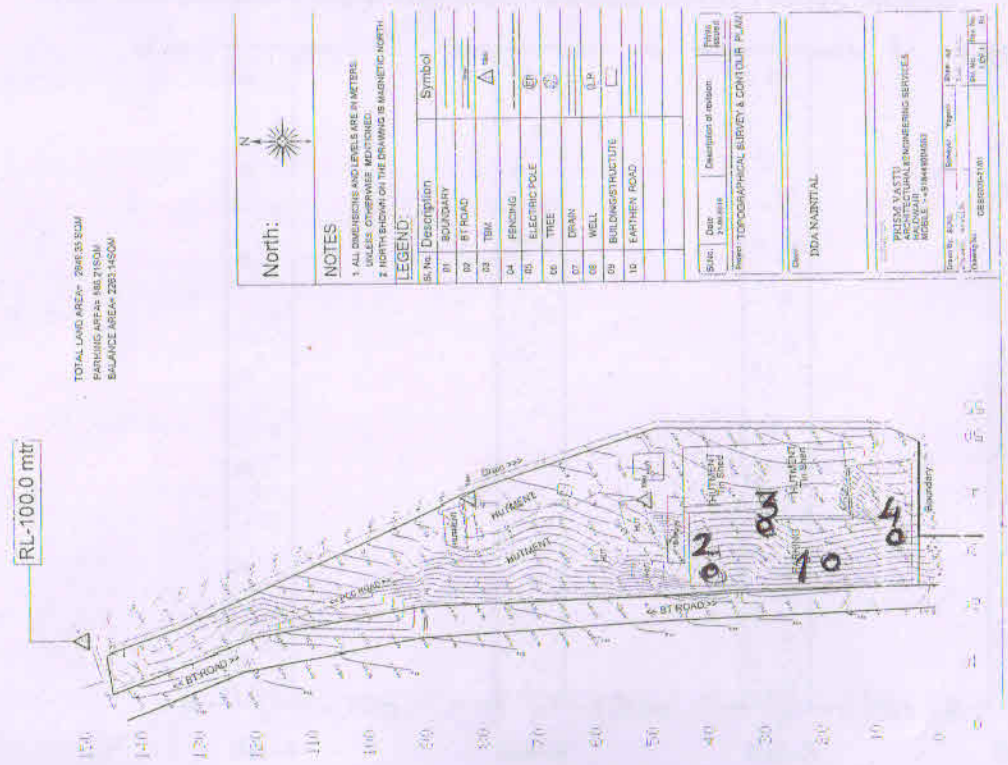
APPENDIX–4

CHARACTERITICS OF FOUNDATION SOIL (TRIAL PIT No: 4)

Sl. No.	Properties	Depth of Strata Below Ground Level (m)	
		1.50m	3.60m
1.	Soil Classification	Mixture of silt, sand, gravel/ rock fragments	Mixture of silt, sand, gravel/ rock fragments
2.	Particle size Distribution, % Clay (Less than 0.002 mm) Silt (0.002–0.075 mm) Sand (0.075–4.75 mm) Gravel/Kankar (4.75-80 mm)	 --- --- --- ---	 --- --- --- ---
3.	Unit Weight (t/m^3)	1.75	1.86
4.	Moisture Content (%)	---	---
5.	Specific Gravity	---	---
6.	Consistency Limits Liquid Limit (%) Plastic Limit (%)	NP	NP
7.	Cohesion (t/m^2)	---	---
8.	Angle of Shearing Resistance in Degrees	34	36
9.	Compression Index (C_c)	---	---

LAYOUT PLAN SHOWING TEST LOCATIONS

Test Site: Extension of Parking near National Hotel at Tallital, Nainital



LEGEND

⊙ BORING, SAMPLING & PENETRATION TEST LOCATIONS

FIGURE–1

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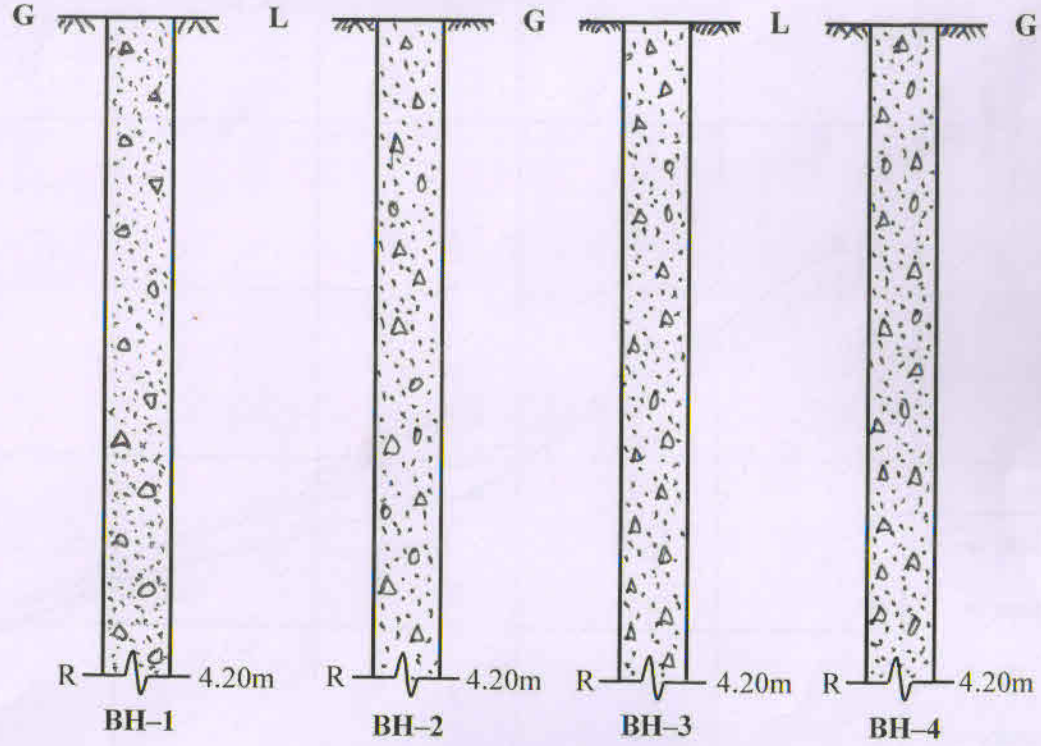
STRATA–CHART

Test Site: Extension of Parking near National Hotel at Tallital, Nainital



LEGEND

Mixture of Silt, Sand, Gravel & Rock Fragments

R: Refusal

FIGURE–2

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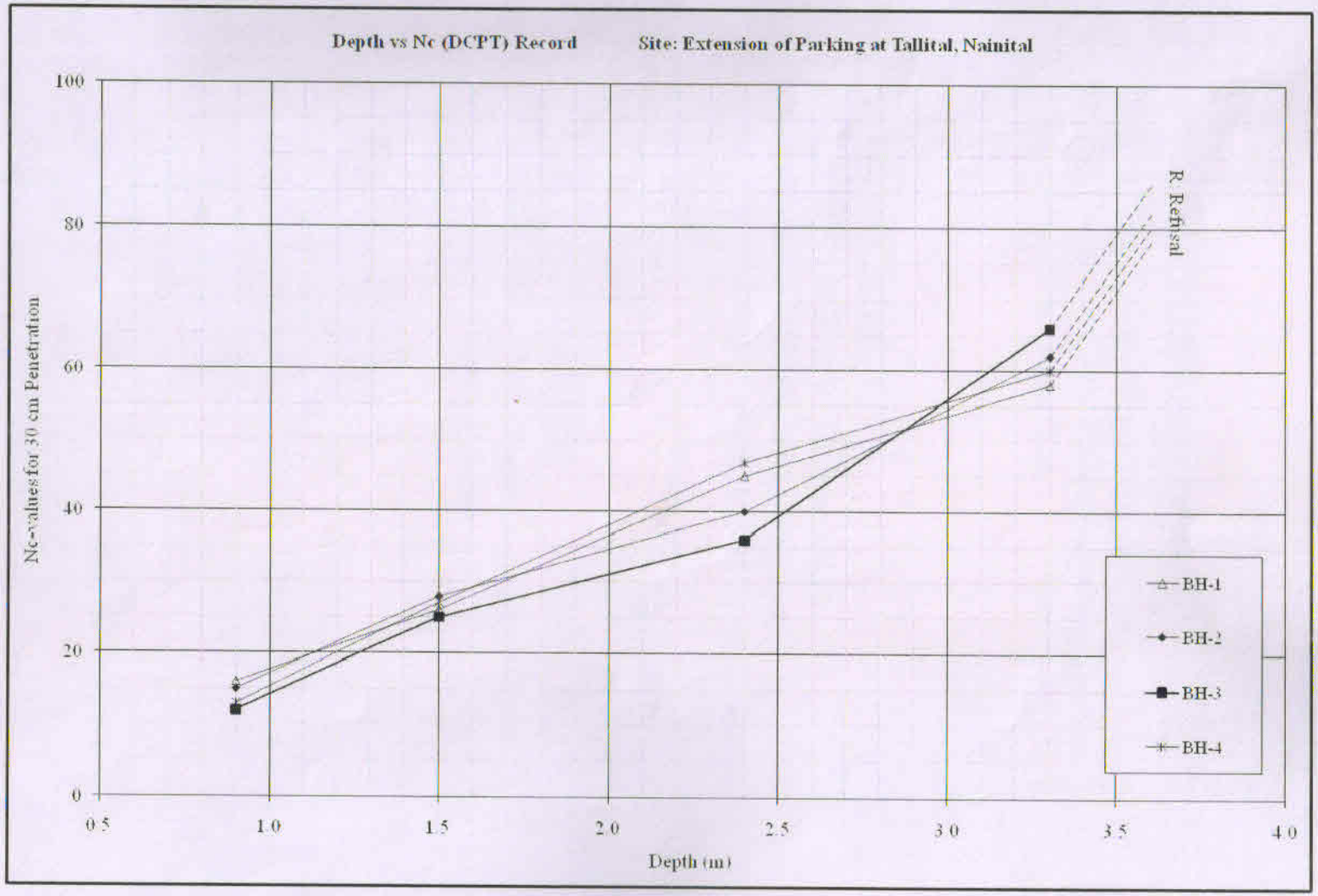

FIGURE–3

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