Nepal Electricity Authority

(Government of Nepal Undertaking)

Project Management Directorate
Kaligandaki Transmission Corridor Project
NEW BUTWAL SUBSTATION

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Ref No. :- 074/75 KGTCP/NBSS/84

Date: 17 June 2018

TATA Projects Ltd.
Okaya Centre, B-5, Tower-1, Floor-1 Sector-62,
Noida-201301, Uttar Pradesh, India

Contract No. : ICB-PMD-KGTCP-073/74-03
"Design, Supply, Installation & Commissioning of 220/132 kV New Butwal Substation" dated 08 November, 2017.

Kind Attn. : Mr. Indranil Banerjee, Project Representative

Reference : 1) Your letter ref no TPL/KGTCP/NBSS/059, dated 7 May 2018
2) Your letter ref no TPL/KGTCP/NBSS/081, dated 13 June 2018
2) Your Email dated 17 June 2018 11:46 AM

Subject : **Approval of Bearing Capacity of Soil**

Dear Sir,

In reference to above and taking in consideration the delay in starting design of various civil structures, only the allowable bearing capacity of soil for isolated footing and raft foundation of different sizes at different foundation level has been approved.

Sincerely,

(Chandan Kumar Ghosh)
Project Manager

CC:

1) PSC, Matatirtha, Kathmandu
2) Civil Section, KGTCP

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Project Management Directorate
Kaligandaki Transmission Corridor Project
NEW BUTWAL SUBSTATION

Ref No. :- 075/76 KGTCP/NBSS/ 269

Date: 28 May 2019

TATA Projects Ltd.
Okaya Centre, B-5, Tower-1, Floor-1 Sector-62,
Noida-201301, Uttar Pradesh, India

Contract No. : ICB-PMD-KGTCP-073/74-03
"Design, Supply, Installation & Commissioning of 220/132 kV New Butwal Substation" dated 08 November, 2017.

Kind Attn. : Mr. Indranil Banerjee, Project Representative
Ref : Your letter TPLK/GTCP/NBSS/242 dated 17Jan 2019

Subject : **Approval of Consolidation Test Report**

Dear Sir,

In reference to above, as per your letter, consolidation test has been approved.

Sincerely,

(Chandan Kumar Ghosh)
Project Manager

CC:

1) New Butwal Division (KGTCP)

Table of Contents

GEO-TECHNICAL INVESTIGATION

1. Introduction

This geotechnical investigation report is prepared based on the agreement between Tata Project Limited India as a client and Geotech Consult and Research Center Pvt.Ltd. as consignee.

The investigation characterizes the subsurface conditions and develops the necessary requirement for the proposed safe bearing capacity of the foundation.

The soil investigation work was carried out on 5 locations, bore hole was drilled by percussion machine up to 25.0 m depth from original ground level

The scope of work of present contract includes the following:

- Exploration of the subsurface conditions at various locations of proposed foundation sites and conduct requisite in-situ tests.
- Limited laboratory testing of representative samples obtained during the field investigation to evaluate relevant engineering parameters of the subsurface soils.
- Engineering analyses.
    - Preparation of this report includes:
        - Drill logs
        - Results of in situ and laboratory test
        - Assessment of bearing capacity
        - Liquefaction potential assessment
        - Recommendations of foundation type and depth

2. General Geology

The gangetic plain is also called the Terai which is a rich, fertile and ancient land in the southern parts of Nepal. It represents Holocene/Recent sedimentation belt where fluvial sedimentation is still in progress. This plain is less than 200 m above sea level and has thick (about 1500 m) alluvial deposit. The alluvial deposits mainly consists of boulders, gravel, sand, silt and clay. It is a foreland basin which consists of the sediments brought down from the northern part of Nepal. It is the Nepalese extension of the Indo-Gangetic Plains, which covers most of northern and eastern India, the most populous parts of Pakistan, and virtually all of Bangladesh. The Plains get their names from the rivers Ganges and Indus.

- The vast alluvial plains of the Indo-Gangetic Basin evolved as a foreland basin in the southern part of the rising Himalaya, before breaking up along a series of steep faults known as the Himalayan

Frontal Fault (Nakata 1989) or the Main Frontal Thrust (Gansser 1981). It comprises several sub-basins and all of them are quite shallow towards the south, but rather deep in the northern sections.

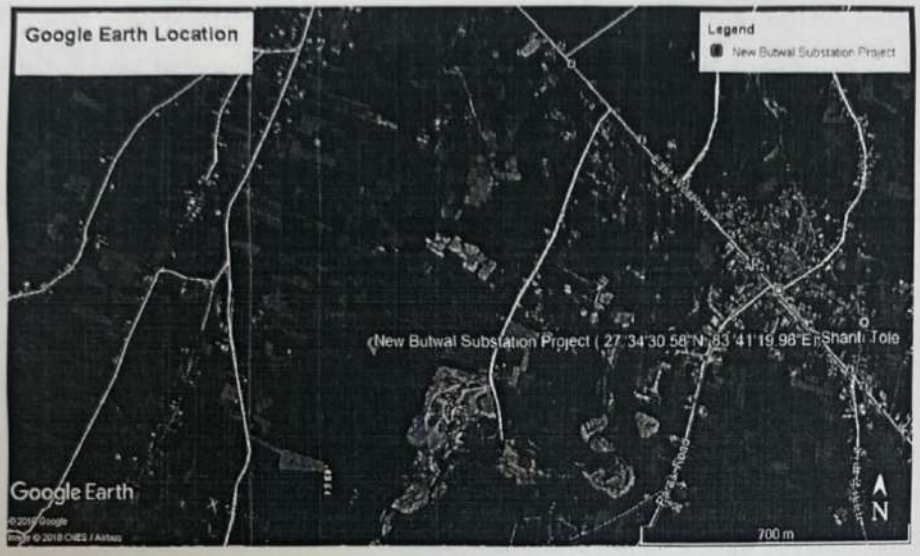

Figure 1: Google Earth Location of Site Area

3. Geo-technical Exploration

Geological condition/stratum at the test site is important aspect to determine the depth, size and types of foundation. Standard Penetration Tests carried out in different depths can give appropriateness of the densification of the soil strata, ground water table, cavities and changes in strata are major aspect of drilling.

As in general, drilling area lies on soft strata, Drilling team have been mobilized with percussion drilling rig. Safety mechanisms were developed for technical team and workers.

3.1 Boring

The drilling works were carried out using by Percussion Drilling Rig. The boreholes were logged continuously in the field. The borehole logs included visual classification of soil, records of SPT for penetration of 450 mm was reached and records position of water table. The field boreholes records were updated after completion of laboratory investigation works. The updated borehole logs for site are presented in Appendix including general ground water table.

Groundwater was monitored on drilled hole 24 hours after completion of drilling works.

Sampling

Before any disturbed samples were taken, the boreholes were washed clean to flush any loose disturbed soil particles deposited during the boring operation. The samples obtained in the split spoon barrel of SPT tube during SPT tests were preserved as representative disturbed samples. The disturbed samples

recovered were placed in air-tight double 0.5 mm thick transparent plastic bags, labeled properly for identification and finally sealed to avoid any loss of moisture. Only then, the samples were transportation to the laboratory for further investigation.

Disturbed sample (DS): before any sample was taken, the boreholes/pits were cleaned up loose disturbed soil deposited during boring / excavation operation. The sample obtained by drilling or by pit excavation and SPT tube is collected as respective disturbed sample for finding out physical and engineering properties. The sample thus obtain were placed in airtight double plastic bag labeled properly for identification and transported to the laboratory for analysis.

Undisturbed sample (US): Due to the presence of coarse grained soil and cohesive soils having appreciable amount of coarse grained soil just beneath the foundation level undisturbed samples could not be retrieved by thin wall samplers.

3.2 Field Test

The field test conducted at the site consisted of Standard Penetration Test (SPT). Sounding test such as SPT are methods for measuring soil characteristics of relative density and strength simply and quickly by penetrating, rotating resistance into the ground and pulling out it onto the ground.

Penetration tests were executed through all strata. Sounding test data were used to estimate soil strength parameter, subsoil distribution and possible existence of soft layer.

Standard Penetration Test (SPT) IS 2131:- It consists of driving a split spoon sampler with an out dia. of 50 mm into soil at the base of borehole. Driving is accomplished by a drop of hammer weighing 63.5 kg falling feed through a height of 750 mm onto the drive head .first of all the spoon is driven 150 mm into the soil at bottom of the borehole. It is driven further 300mm and the number of blows (N values) required to drive the distance is recorded.

Dynamic cone penetration test(DCPT) IS 4968 part I and II:-It was performed using a 50 mm cone the cone was driven with 63.5 kg hammer falling through the height of 750 mm the recorded number of blows required to penetrate the 300 mm is taken as DCPT value. These values are presented in log sheet. The dynamic cone resistance value can be changed to SPT value as given below:

N_{cr} =1.5N for depths up to 3.0 m

N_{cr} =1.75N for depths up to 3.0 m to 6.0 m

N_{cr} =2.0 N for depths greater than 6.0 m

Where,

N_{cr} =recorded DCPT value

N=SPT value

The converted (N) values are used for analysis of bearing capacity (B.C.) value.

If the blows per foot of penetration are more than 60, the driving is discontinued and the SPT value is simply recorded as more then 60. These values to the coarse gained soil and soft to hard rock mass.

Cohesion (c) and Angle of internal friction:-

Cohesion (c) and Angle of internal friction of the cohesive and semi cohesive layers are found by lab test result.

3.3 Lab test

Following laboratory tests were conducted for the retrieved soil samples to get the physical and strength properties of the sub soil, as per IS & ASTM standards code of practice.

a) Grain Size Distribution Analysis

b) Atterberg's Limit

c) Natural Moisture Contents. Bulk & Dry Density

d) Specific Gravity Tests

e) Direct Shear Tests

f) Consolidation Tests

Briefly Description

Grain size Analysis

Grain size distribution was determined by wet and dry mechanical process. Sieve analysis was carried out by sieving a soil sample through a set of sieves kept one over the other. The largest size being kept at the top and the smallest size at the bottom. The soil retained on each sieve was weighed and expressed as a percentage of the weight of sample. Finally, the gradation curve was found using % finer and corresponding particle size (D), dia.

Atterberg's Limit

The Liquid Limits (LL) and plastic limits (PL) were conducted on fine grained soils by standard methods. Casagrande's Plasticity Chart was used to classify the fine grained soil according to the Unified Soil Classification System (USCS).

Natural Moisture Content and Bulk Density

The natural water content and bulk density was determined from samples recovered through the split spoon sampler and the corrected SPT values.

Specific Gravity Test

The specific gravity test was conducted of the soil samples which passes the No. 200 mm sieve. The density bottle method is widely used in the laboratory test for finding out Specific Gravity (G) value.

Direct Shear Test

Direct shear tests were conducted on representative disturbed samples collected from the boreholes. The samples were carefully molded using standard moulds of 6.0 x 6.0 cm^2 cross-sectional areas and trimmed to 2.5 cm high solid metal plates were placed on both surfaces of the samples to prevent the dissipation of pore water during shearing. The direct shear test equipment was mechanically-operated and shearing was applied at more or less constant strain rate. The samples were sheared at three different normal stresses. The direct shear test results were presented in terms of the failure envelops to obtain the angle of internal frictions (Φ) and the cohesion intercepts (c)

Consolidation test

The consolidation index was calculated on the basis of Terzaghi & Peck Modified Empirical Eq. Cc = 0.009 (wl-10) where wl is liquit Limit in percent. The Consolidation index wasn't calculated by lab test due to dryness of sample. Therefore calculated by Empirical formula.

Analysis of Allowable Bearing Pressure

The allowable bearing pressure (q_a) is the maximum pressure that can be imposed on the foundation soil taking into consideration the ultimate bearing capacity of the soil and the tolerable settlement of the structure. Analysis to determine the ultimate bearing capacity and the pressure corresponding to a specified maximum settlement were performed and the minimum pressure obtained from the two analyses were adopted as the allowable bearing pressure.

5.1. SPT correction

The SPT values have been corrected in accordance with the proposal of Skempton, (1986) and Liao and Whitman (1987) as outlined below with consideration of field procedure, hammer efficiency, borehole diameter, sample and rod length.

Correction of SPT N-value using the relation after Skempton, 1986

$N_{60} = E_m C_B C_S C_R N/0.60$

Where: N_{60} = SPT N value corrected for field procedure

E_m = Hammer Efficiency

C_B = borehole diameter correction

C_S = Sample Correction

C_R = rod length correction

N = SPT N value recorded in the field

The correction factors taken are :

E_m =0.55 for hand drop hammer, due to lack of true verticalness and proper speed of SPT blow

C_B =1.0 for 65 mm to 115 mm dia. Borehole,

C_s =1.0 for standard sampler,

C_R =0.7 for rod length 0.00 - 2.99, =0.75 for rod length 3.00 - 3.99 m,

=0.85 for rod length 4.00 - 5.99 m, =0.95 for rod length 6.00 - 9.99 m,

=1 for rod length beyond 10.00 m,

Dilatancy Correction

Terzaghi and Peck (1967)

If $N_r \leq 15$, use $N = N_r$

If $N_r > 15$ then,

$N_c = 15 + 1/2(N-15)$

Where,

N_c = Corrected value of N_r

Correction for overburden

The correction for values of N should be made for the field SPT values for depths. Modified correction in 1974, peck, Hanson and Thornburn with suggested by the following equation:

$N_{cn} = N_r\, 0.77 \log(2000/p_0)$

Where p_0 is effective overburden pressure in kN/m^2.

Nr=SPT value from field after dilatancy Correction

Unit Weight of the Soil Layers (γ) KN/m^3

The unit weight of the soil layers are directly found from the retrieved soil samples through the SPT Tubes in the field or as per the observed N value from the field test. The ultimate design of the foundation is found for the worst condition i.e. submerged condition. So the saturated unit weight of the soil layers were found considering the above mostly adopted assumptions

γ_{sat} = Saturated Unit weight of the soil (KN/m^3)

16.0. 17.0. 18.0. 19.0 and 20.0 KN/m^3 (assumed as per observed (N) values)

If N≤10 (γ_{sat}=16 KN/ m3)

10<N≤15 (γ_{sat}=17 KN/ m3)

15<N≤20 (γ_{sat}=18 KN/ m3)

20<N≤30 (γ_{sat}=19 KN/ m3)

N>30 (γ_{sat}=20 KN/ m3)

5.2. Calculation of Bearing Capacity

A) Spread Footing

Assuming a typical having (1.5x1.5, 2.0 x2.0, 2.5x2.5, 3.0x3.0) m^2 Square open isolated Shallow foundation for light to medium load bearing structures.

Terzaghi's Relation (1943)

From Terzaghi's equation

q_{ult} = $1.3CN_c + \gamma_{sat} D_f (N_q-1) + 0.4 \gamma_{sat} B N_\gamma R_{w_2}$ .....(I)

q_{safe} = $(q_{ult} + \gamma_{sat} D_f)/F.S.$

Where,

γ_{sat} = Saturated unit weight of soil (KN/ m^3)

N_c,N_q,N_γ are bearing capacity factors

B = Width of foundation (m)

D_f = Depth of foundation (m)

C = Cohesion (KN/ m^3)

F.S. = Factor of Safety (3)

Rw_2 = water correction factor

If soils have loose to medium denseness and soft to medium stiff consistency then the foundation tails according as the local shear failure (LSF) otherwise fails in general shear failure (GSF) criterion.

i) **(Using Meyerhos956, 1974) Correlation Where.**

For 25mm settlement

$Q_{safe}=8.1\ N_{60}\ DKD1\ ((B+0.3)/B)\ 2\ Rw_2\ KN/m^2$ for

B>1.2m.....(II)

Where,

KD_1 = $1+0.33\ (D/B) \leq 1.33$

B and D = Breath and Depth of foundation (m)

Rw_2 = Water correction factors (0.5)

B) Mat Foundation

considering a typical (6.0 x 6.0) m or (8.0 x 8.0) m greater Mat Foundation for the heavy loaded structures

From Terzaghi's equation:

q ult = $1.3CNc+ \gamma_{sat}\ Df\ (Nq-1)+0.4\ \gamma_{sat}BN\gamma Rw_2$.....(I)

q safe = $(q_{ult}+\gamma_{sat}\ Df)/F.S.$

Where,

γ_{sat} = Saturated unit weight of soil (KN/ m3)

Nc,Nq,Nγ are bearing capacity factors

B = Width of foundation (m)

D_f = Depth of foundation (m)

C = Cohesion (KN/m^3)

F.S. = Factor of Safety ie. **3.0**

Rw_2 = water correction factor

If soils have loose to medium denseness and soft to medium stiff consistency then the foundation fails according as the local shear failure (LSF) otherwise fails in general shear

failure (GSF) criterion.

Using Meyerhofs (1965) & Bowles (1977) Correlation

$Q_{safe}=11.98\ N_{60}\ ((3.28B+1)/(3.28B))2f_d\ (S/25)\ Rw_2$ KN/ m^2.....(II)

Where,

N_{60} = SPT N value corrected for field procedure

B=Width of footing (m)

S=Settlement in mm

$F_d=1+0.33\ (D/B) \leq 1.33$

Rw_2=water table correction

From the above both testing methods the bearing capacity and other relevant data's are found and then correlated to each other that helps to verify the final product.

The both type of foundation and design parameters are given in the Annexes D

Settlement

The sub- surface layers are non plastic silts, slightly plastic clayey silts, silty sands etc, just below the assumed depth of foundation level Generally, the settlement analysis is found out as per soil layers.

(i) For Cohesive Soil Layers:

If the clay layer is encountered, the settlement was calculated by:

$$SO_c=H_t/(1+e_0)*C_c \log_{10}((p_0+\Delta p)/p_0)$$

Where: SO_c = Long term Consolidation or settlement in cm

H_t = Thickness of soil layer in cm

e_0 = Initial void ratio

P_0 = Effective stress at mid height of layer in t/m^2

Δp = Pressure increment t/m^2

Now, with average pore pressure coefficients for the clayey soil

B = average pore pressure coefficients

$Sc = \beta\ SOc$ mm

This is the total amount of settlement that will take place continuously for hundreds of years. The maximum permissible values for spread and mat/pile foundation will be 65 and 100mm respectively.

4. Liquefaction analysis

Liquefaction is a phenomena during which soil (mainly fine sand and silty sand) losses its shear strength significantly and behaves as a fluid. During earthquakes, due to generation of excess pore pressure, effective stress will be reduced and the soil may undergo complete liquefaction or decrease in shear strength causing settlement and lateral spreading of soil mass.

In general, for clean sand, if the SPT value is less than 30, the soil is prone to liquefaction. The increase in fines content, however, increases the liquefaction resistance of soil. In this report, the soil liquefaction analysis has been done based on SPT N value.

The factor of safety (FS) against liquefaction in terms of CSR (Cyclic stress ration) and CRR (cyclic resistance ratio) is defined by

$$FS = \frac{CRR_{7.5}}{CSR_{7.5,\sigma}}$$

where $CRR_{7.5}$ is the cyclic stress ratio (CRR) for earthquakes of magnitude 7.5, is the capacity of soil to resist liquefaction; $CSR_{7.5,\sigma}$ is the normalized cyclic stress ratio (CSR) for earthquakes of magnitude 7.5 and an effective overburden pressure of 100 kPa.

$CSR_{7.5,\sigma}$ is given by (Idriss and Boulanger, 2006)

$$CSR_{7.5,\sigma} = 0.65 \frac{\sigma_v}{\sigma'_v} \frac{a_{max}}{g} \frac{\gamma_d}{MSF} \frac{1}{K_\sigma}$$

where σ_v is the total vertical stress; σ'_v is the effective vertical stress; a_{max} is the peak horizontal ground surface acceleration; g is the acceleration of gravity; γ_d is the nonlinear shear stress mass participation factor (or stress reduction factor), MSF is the magnitude scaling factor; K_σ is the correction factor for effective overburden. The consideration of factors K_σ and Kα (for sloping ground) is beyond routine practice and can be precisely estimated using the method of Youd et al. (2001) if necessary.

The term γ_d provides an approximate correction for flexibility in the soil profile given by:

$$\gamma_d = \frac{(1-0.4113z^{0.5}+0.04052z+0.001753z^{1.5})}{(1-0.4177z^{0.5}+0.05729z-0.006205z^{1.5}+0.00121z^{2})}$$

where z = depth below ground surface in meters.

Cyclic resistance ratio (CRR), the capacity of soil to resist liquefaction, can be obtained from the corrected blow count $(N_1)_{60}$ using empirical correlations proposed by Seed et al. (1985). The CRR curves for a fines content of < 5% (clean sands) can be approximated by Youd et al. (2001)

$$CRR_{7.5} = \frac{1}{34-(N_1)_{60}} + \frac{(N_1)_{60}}{135} + \frac{50}{[10.(N_1)_{60}+45]^2} - \frac{1}{200}$$

for $(N_1)_{60} < 30$. For $(N_1)_{60} \geq 30$, clean granular soils are classified as non-liquefiable. The CRR increases with increasing fines content and thus $(N_1)_{60}$ should be corrected to an equivalent clean sand value, $(N_1)_{60CS}$ (Youd et al. 2001)

$$(N_1)_{60CS} = (N_1)_{60}; \text{FC} \leq 5\%$$

$$(N_1)_{60CS} = \exp[1.76-(190/FC^2)]+[0.99+(\text{FC}^{1.5}/1000](N_1)_{60}; \quad 5\% \leq \text{FC} \leq 35\%$$

$$(N_1)_{60CS} = 5+1.2(N_1)_{60}; \text{FC} \geq 35\%$$

where $(N_1)_{60}$ is the SPT blow count normalized to an overburden pressure of approximately 100 kPa and a hammer energy ratio of 60% expressed as (Youd et al. 2001)

$$(N_1)_{60} = NC_N C_E C_B C_R C_S$$

where N = measured standard penetration resistance; C_N =factor to normalize N to a common reference effective overburden stress (1 atm.); C_E = correction for hammer energy ratio; C_B = correction factor for borehole diameter; C_R =correction factor for rod length; C_S =correction for samplers with or without liners. The factor C_N is given by

$$C_N = \frac{2.2}{1.2+\sigma'_v/P_a}$$

Following the recommendation of NCEER 1996 (Youd et al. 2001), the lower and upper bounds for MSF values can be defined by $MSF = 10^{2.24}/M_w^{2.56}$ and $MSF = (M_w/7.5)^{-3.3}$, respectively (M_w is the moment magnitude). Similarly, K_σ is given by (Youd et al., 2001)

$$K_\sigma = (\sigma'_v/p_a)^{(f-1)}$$

where p_a is the atmospheric pressure (100 kPa) and f is assumed to be 0.75 (a value of 0.6-0.8 is recommended in Youd et al., 2001).

Analysis of Foundations

5.5.1 General Assumption

- Each stratum was considered as a combination of different heterogeneous layer, so maximum thickness considered for unique soil properties was limited to 1.5 m otherwise as tested.
- In between two tested samples, properties of soil in middle sections were interpolated as relevancy of data. And design data were interpolated between semi empirical data form field test and lab test results.
- Some of input and output data were refined as per relevancy with correlated data.

5.5.2 Input Data and Sample calculation

DESIGN INPUT DATA

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

CLIENT: Nepal Electricity Autority (NEA),Nepal — Hole No: 1

LOCATION: Suryabasti,Nawalparasi,Nepal — Foudation Type: Isolated

Foundation Width (mxm)	Depth Df (m)	Saturated Density up to the depth (γsat) KN/m³	Average SPT value N	Corrected N value N Corr	Saturated SPT value N_{sat}	Angle of Friction (Φ°) degree Lab	Angle of friction empirical	Angle of Friction (Φ) Radian Lab	Cohesion C Lab (KN/m²)	If clay, Apparent Field Based C, t/m²	Water correction factors (RW1 & RW2)	Depth factor (Fd)	Kd_2	Nc	Nq	Nγ	Bearing capacity from Laboratory test ,KN/m2	Initial Void Ratio e_0	Coefficient of Consolidation,C_c	Depth of Compression layers	Effective stress at mid layers (σ')	Increased stress at mid layers (Δσ')	Maximum settlement due to bearing capacity (mm)	Bearing Capacity Value 65/40mm max settelement (mm) KN/m² from lab test	Bearing Capacity for 25mm permissible Settelement (Mayerhof's) KN/m² from N Value_Isolated foundation	Bearing Capacity for 40 mm permissible Settelement (Mayerhof's) KN/m² from N Value_Isolated foundation	Recommended Allowable Bearing Capacity (KN/m²)	Remarks
1.5	1.5	16	10	14.79	11.1	10	28.3	0.17	20	9.2	0.5	1.33	1.33	9.6	2.7	1.2	92.3	0.5819	0.12	1.5	24.00	41.02	49.25	74.96	48.39	77.42	77.42	
1.5	2.3	17	11	14.47	10.9	10	28.2	0.17	20	9.0	0.5	1.33	1.33	9.6	2.7	1.2	98.95	0.5819	0.12	1.5	25.50	43.98	49.53	79.91	47.34	75.74	75.74	
1.5	3	16	10	12.47	9.35	10	27.2	0.17	20	7.8	0.5	1.33	1.33	9.6	2.7	1.2	100.66	0.5819	0.12	1.5	24.00	44.74	52	77.43	40.79	65.26	65.26	
1.5	4.5	17	14	15.28	11.5	10	28.5	0.17	20	9.6	0.5	1.33	1.33	9.6	2.7	1.2	113.18	0.5819	0.12	1.5	25.50	50.3	53.84	136.64	50	80	80.00	
2	1.5	16	10	14.79	11.1	10	28.3	0.17	20	9.2	0.5	1.33	1.248	9.6	2.7	1.2	92.55	0.5819	0.12	1.5	24.00	41.13	49.33	75.05	74.1	118.56	92.55	
2	2.3	17	11	14.47	10.9	10	28.2	0.17	20	9.0	0.5	1.33	1.33	9.6	2.7	1.2	99.23	0.5819	0.12	1.5	25.50	44.1	49.62	79.99	77.29	123.66	99.23	
2	3	16	10	12.47	9.35	10	27.2	0.17	20	7.8	0.5	1.33	1.33	9.6	2.7	1.2	100.9	0.5819	0.12	1.5	24.00	44.84	52.07	77.51	66.61	106.58	100.90	
2	4.5	17	14	15.28	11.5	10	28.5	0.17	20	9.6	0.5	1.33	1.33	9.6	2.7	1.2	113.47	0.5819	0.12	1.5	25.50	50.43	53.92	136.79	81.64	130.62	113.47	
2.5	1.5	16	10	14.79	11.1	10	28.3	0.17	20	9.2	0.5	1.33	1.198	9.6	2.7	1.2	92.79	0.5819	0.12	1.5	24.00	41.24	49.42	75.1	105.46	168.74	92.79	
2.5	2.3	17	11	14.47	10.9	10	28.2	0.17	20	9.0	0.5	1.33	1.304	9.6	2.7	1.2	99.52	0.5819	0.12	1.5	25.50	44.23	49.71	80.08	112.28	179.65	99.52	
2.5	3	16	10	12.47	9.35	10	27.2	0.17	20	7.8	0.5	1.33	1.33	9.6	2.7	1.2	101.15	0.5819	0.12	1.5	24.00	44.96	52.16	77.57	98.71	157.94	101.15	
2.5	4.5	17	14	15.28	11.5	10	28.5	0.17	20	9.6	0.5	1.33	1.33	9.6	2.7	1.2	113.76	0.5819	0.12	1.5	25.50	50.56	54.01	136.91	120.99	193.58	113.76	
3	1.5	16	10	14.79	11.1	10	28.3	0.17	20	9.2	0.5	1.33	1.165	9.6	2.7	1.2	93.04	0.5819	0.12	1.5	24.00	41.35	49.5	75.18	142.46	227.94	93.04	
3	2.3	17	11	14.47	10.9	10	28.2	0.17	20	9.0	0.5	1.33	1.253	9.6	2.7	1.2	99.81	0.5819	0.12	1.5	25.50	44.36	49.8	80.17	149.9	239.84	99.81	
3	3	16	10	12.47	9.35	10	27.2	0.17	20	7.8	0.5	1.33	1.33	9.6	2.7	1.2	101.4	0.5819	0.12	1.5	24.00	45.07	52.24	77.64	137.12	219.39	101.40	
3	4.5	17	14	15.28	9.3	10	28.5	0.17	20	9.6	0.5	1.33	1.33	9.6	2.7	1.2	114.05	0.5819	0.12	1.5	25.50	50.69	54.09	137.05	136.38	218.21	114.05	

DESIGN INPUT DATA

PROJECT :Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

CLIENT : Nepal Electricity Autority (NEA),Nepal

Hole No: 1

LOCATION :Suryabasti,Nawalparasi,Nepal

Foudation Type Raft

Foundation Width (mm)	Depth Df (m)	Saturated Density up to the depth (γ sat) KN/m³	Average SPT value N	Corrected N value N Corr	Satandard SPT value N_{60}	Angle of Friction (Φ°) degree Lab	Angle of friction emperical	Angle of Friction (Φ) Radian Lab	Cohesion C Lab (KN/m2)	If clay, Apparent Field Based C_u t/m²	Water correction factors (RW1 & RW2)	Depth factor (Fd)	Kd_2	Nc	Nq	Nγ	Bearing capacity from Laboratory test ,KN/m²	Initial Void Ratio e_0	Coefficient of Consolidation C_c	Depth of Compression layers	Effiective stress at mid layers (σ')	Increased stress at mid layers (Δσ')	Mavimum settlement due to bearing capacity (mm)	Bearing Capacity Value 65/40mm max settelement (mm) KN/m² from lab test	Allowablw Bearing Capacity for 25mm permissible Settelement (Mayerhof's) KN/m² from N Value_Isolated foundation	Allowablw Bearing Capacity for 25mm permissible Settelement (Mayerhof's) KN/m2 from N Value_RAFT foundation	Allowablw Bearing Capacity for 60 mm permissible Settelement (Mayerhof's) KN/m2 from N Value_raft foundation	Recommended Allowable Bearing Capacity (KN/m²)	Remarks
5	1.5	16	11	16.27	12.2	10	29.0	0.17	20	10.2	0.5	1.3	1.1	9.6	2.7	1.2	94.03	0.58	0.12	1.5	24.00	41.79	49.83	75.48	381.33	109.41	262.58	94.03	
5	2.3	17	10	13.16	9.87	10	27.6	0.17	20	8.2	0.5	1.3	1.33	9.6	2.7	1.2	100.96	0.58	0.12	1.5	25.50	44.87	50.16	80.51	373.35	88.51	212.42	100.96	
5	3	16	10	12.47	9.35	10	27.2	0.17	20	7.8	0.5	1.3	1.33	9.6	2.7	1.2	102.39	0.58	0.12	1.5	24.00	45.51	52.55	77.94	353.68	83.85	201.24	102.39	
5	4.5	17	14	15.28	11.5	10	28.5	0.17	20	9.6	0.5	1.3	1.33	9.6	2.7	1.2	115.2	0.58	0.12	1.5	25.50	51.2	54.42	137.6	433.49	102.77	246.65	115.20	
6	1.5	16	11	16.27	12.2	10	29.0	0.17	20	10.2	0.5	1.3	1.08	9.6	2.7	1.2	94.53	0.58	0.12	1.5	24.00	42.01	50	75.62	330.72	107.32	257.57	94.53	
6	2.3	17	10	13.16	9.87	10	27.6	0.17	20	8.2	0.5	1.3	1.33	9.6	2.7	1.2	101.53	0.58	0.12	1.5	25.50	45.12	50.34	80.68	527.53	86.83	208.39	101.53	
6	3	16	10	12.47	9.35	10	27.2	0.17	20	7.8	0.5	1.3	1.33	9.6	2.7	1.2	102.88	0.58	0.12	1.5	24.00	45.72	52.7	78.09	499.73	82.25	197.4	102.88	
6	4.5	17	14	15.28	11.5	10	28.5	0.17	20	9.6	0.5	1.3	1.33	9.6	2.7	1.2	115.77	0.58	0.12	1.5	25.50	51.45	54.58	137.87	612.51	100.81	241.94	115.77	
7	1.5	16	11	16.27	12.2	10	29.0	0.17	20	10.2	0.5	1.3	1.07	9.6	2.7	1.2	95.02	0.58	0.12	1.5	24.00	42.23	50.16	75.77	704.81	105.84	254.02	95.02	
7	2.3	17	10	13.16	9.87	10	27.6	0.17	20	8.2	0.5	1.3	1.11	9.6	2.7	1.2	102.11	0.58	0.12	1.5	25.50	45.38	50.52	80.85	590.29	85.63	205.51	102.11	
7	3	16	10	12.47	9.35	10	27.2	0.17	20	7.8	0.5	1.3	1.33	9.6	2.7	1.2	103.38	0.58	0.12	1.5	24.00	45.95	52.86	78.23	670.97	81.12	194.69	103.38	
7	4.5	17	14	15.28	11.5	10	28.5	0.17	20	9.6	0.5	1.3	1.33	9.6	2.7	1.2	116.35	0.58	0.12	1.5	25.50	51.71	54.75	138.13	822.39	99.42	238.61	116.35	
8	1.5	16	11	16.27	12.2	10	29.0	0.17	20	10.2	0.5	1.3	1.06	9.6	2.7	1.2	95.52	0.58	0.12	1.5	24.00	42.45	50.33	75.91	903.62	104.74	251.38	95.52	
8	2.3	17	10	13.16	9.87	10	27.6	0.17	20	8.2	0.5	1.3	1.09	9.6	2.7	1.2	102.68	0.58	0.12	1.5	25.50	45.64	50.7	81.01	753.76	84.74	203.38	102.68	
8	3	16	10	12.47	9.35	10	27.2	0.17	20	7.8	0.5	1.3	1.12	9.6	2.7	1.2	103.87	0.58	0.12	1.5	24.00	46.16	53.01	78.38	732.88	80.27	192.65	103.87	
8	4.5	17	14	15.28	9.3	10	28.5	0.17	20	9.6	0.5	1.3	1.33	9.6	2.7	1.2	116.92	0.58	0.12	1.5	25.50	51.96	54.91	138.4	862.75	79.85	191.64	116.92	

PROBABLE LIQUEFACTION ANALYSIS

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal

Bore Hole No:	1
Water Table (m) :	0.5
amax/g:	0.2
Mw:	7.5
MSF:	1
pa:	100

SN	Depth(m)	SPT (N)	Soil type	Fine content %	Unit wt (KN/m^3)	Total stress (KN/m^2)	Effective stress σv (KN/m^2)	C_N	$(N_1)_{60}$	$(N_1)_{60\,CS}$	rd	Kσ	CRR	CRR7.5σ	FoS	Result	Remarks
1	1.5	11	clayey silt	>35	17	25.5	25.5	1.51	16.61	24.932	0.99042	1.407	0.291	0.092	3.16	No Liq	
2	3	10	clayey silt	>35	17	51.0	41.2	1.36	13.60	21.32	0.97948	1.248	0.233	0.126	1.85	No Liq	
3	4.5	14	clayey silt	>35	17	76.5	52	1.28	17.92	26.504	0.96907	1.178	0.325	0.157	2.07	No Liq	
4	6	20	clayey silt	>35	17	102.0	62.8	1.2	24.00	33.8	0.9577	1.123	5.246	0.18	29.14	No Liq	
5	7.5	34	clayey silt	>35	17	127.5	73.6	1.14	38.76	51.512	0.94321	1.08	0.32	0.197	1.62	No Liq	
6	9	45	clayey silt	>35	17	153.0	84.4	1.08	48.60	63.32	0.92293	1.043	0.43	0.209	2.06	No Liq	
7	10.5	43	clayey silt	>35	17	178.5	95.2	1.02	43.86	57.632	0.8944	1.012	0.38	0.215	1.77	No Liq	
8	12	45	clayey silt	>35	17	204.0	106	0.97	43.65	57.38	0.85652	0.986	0.377	0.217	1.74	No Liq	
9	13.5	50	clayey silt	>35	17	229.5	116.8	0.93	46.50	60.8	0.81068	0.962	0.408	0.215	1.9	No Liq	
10	15	50	clayey silt	>35	17	255.0	127.6	0.89	44.50	58.4	0.76075	0.941	0.387	0.21	1.84	No Liq	
11	16.5	50	clayey silt	>35	17	280.5	138.4	0.85	42.50	56	0.71158	0.922	0.364	0.203	1.79	No Liq	
12	18	50	clayey silt	>35	17	306.0	149.2	0.82	41.00	54.2	0.66705	0.905	0.347	0.197	1.76	No Liq	
13	19.5	50	clayey silt	>35	17	331.5	160	0.79	39.50	52.4	0.62912	0.889	0.329	0.191	1.72	No Liq	
14	21	50	clayey silt	>35	17	357.0	170.8	0.76	38.00	50.6	0.598	0.875	0.31	0.186	1.67	No Liq	
15	22.5	50	clayey silt	>35	17	382.5	181.6	0.73	36.50	48.8	0.57292	0.861	0.289	0.182	1.59	No Liq	
16	24	50	clayey silt	>35	17	408.0	192.4	0.7	35.00	47	0.55272	0.849	0.266	0.179	1.49	No Liq	
17	25.5	50	clayey silt	>35	17	433.5	203.2	0.68	34.00	45.8	0.53631	0.838	0.25	0.177	1.41	No Liq	

5.5.3 FINDINGS

5.5.4.1 Shallow Foundation

Summary Sheet for Isolated Square Footing

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal

SN	Bore hole No	Depth of Foundation (m)	Foundation Width (mxm)	Recommended Allowable Bearing Capacity (KN/m^2)	Foundation Width (mxm)	Recommended Allowable Bearing Capacity (KN/m^2)	Foundation Width (mxm)	Recommended Allowable Bearing Capacity (KN/m^2)	Foundation Width (mxm)	Recommended Allowable Bearing Capacity (KN/m^2)	Remarks
1	1	1.5	1.5	85.17	2.0	92.55	2.5	92.79	3.0	93.04	
		2.3	1.5	68.90	2.0	99.23	2.5	99.52	3.0	99.81	
		3.0	1.5	65.26	2.0	100.90	2.5	101.15	3.0	101.40	
2	2	1.5	1.5	77.42	2.0	92.55	2.5	92.79	3.0	93.04	
		2.3	1.5	82.66	2.0	99.23	2.5	99.52	3.0	99.81	
		3.0	1.5	89.98	2.0	103.76	2.5	104.05	3.0	104.34	
3	3	1.5	1.5	93.77	2.0	96.36	2.5	94.34	3.0	94.63	
		2.3	1.5	82.66	2.0	101.53	2.5	99.52	3.0	99.81	
		3.0	1.5	58.78	2.0	102.88	2.5	101.15	3.0	101.40	
4	4	1.5	1.5	38.75	2.0	59.33	2.50	84.45	3.0	93.04	
		2.3	1.5	55.98	2.0	91.41	2.50	97.25	3.0	97.50	
		3.0	1.5	70.72	2.0	103.76	2.50	104.05	3.0	104.34	
5	5	1.5	1.5	46.42	2.0	71.09	2.5	92.79	3.0	93.04	
		2.3	1.5	75.74	2.0	99.23	2.5	99.52	3.0	99.81	
		3.0	1.5	103.48	2.0	103.76	2.5	104.05	3.0	104.34	

Summary Sheet for Raft Footing

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal

SN	Bore hole No	Depth of Foundation (m)	Foundation Width (mxm)	Recommended Allowable Bearing Capacity (KN/m^2)	Foundation Width (mxm)	Recommended Allowable Bearing Capacity (KN/m^2)	Foundation Width (mxm)	Recommended Allowable Bearing Capacity (KN/m^2)	Foundation Width (mxm)	Recommended Allowable Bearing Capacity (KN/m^2)	Remarks
1	1	1.5	5	94.03	6.0	94.53	7	95.02	8.0	95.52	
		2.3	5	100.96	6.0	101.53	7	102.11	8.0	102.68	
		3.0	5	102.39	6.0	102.88	7	103.38	8.0	103.87	
2	2	1.5	5	94.03	6.0	94.53	7	95.02	8.0	95.52	
		2.3	5	100.96	6.0	101.53	7	102.11	8.0	102.68	
		3.0	5	105.49	6.0	106.06	7	106.64	8.0	107.21	
3	3	1.5	5	95.78	6.0	96.36	7	96.93	8.0	97.51	
		2.3	5	100.96	6.0	101.53	7	102.11	8.0	102.68	
		3.0	5	102.39	6.0	102.88	7	103.38	8.0	103.87	
4	4	1.5	5	95.78	6.0	96.36	7	96.93	8.0	97.51	
		2.3	5	100.96	6.0	101.53	7	102.11	8.0	102.68	
		3.0	5	102.39	6.0	102.88	7	103.38	8.0	103.87	
5	5	1.5	5	94.03	6.0	94.53	7	95.02	8.0	95.52	
		2.3	5	100.96	6.0	101.53	7	102.11	8.0	102.68	
		3.0	5	105.49	6.0	106.06	7	106.64	8.0	107.21	

5. Conclusion and Recommendation

- The foundation design Engineer can choose the depth and dimension of foundation selected in the bearing capacity analysis of this report, generally isolated footing or Raft footing depending upon the load of structure. But minimum depth of foundation is recommended 1.5m depth below form natural ground level. However, Allowable bearing capacity depends on many variables such as adopted allowable settlement, type of foundation, size and depth of foundation, importance of structure etc. Hence based on parameters obtained from this investigation provided in this report.
- There is no liquefaction potential at site area due to higher range of SPT value and greater finer particles.
- The ground water levels indicated on the logs of borings represents the measured levels at the time of investigations and immediately 24 hourafter completion of drilling works, which may be seepage water from nearby small pouch of fractured/weathered strata or pouring water in to the drilling holes during drilling works but water table is assumed in surface of the ground.
- When the ground surface slopes downward adjacent to a footing, the sloping surface shall not intersect a frustum of bearing material under the footing having sides which make an angle of 30° with the horizontal for soil and horizontal distance from the lower edge of the footing to the sloping surface shall be at least 90 cm for soil.

6. References and Standards

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2. Dr. Arora, K.R., 'Soil Mechanics & Foundation Engineering'.

3. Compendium of Indian Standards on Soil Engineering – Part 1, Laboratory Testing of Soils from Civil Engineering Purposes, SP: 36 (Part – 1) 1987, Bureau of Indian Standards, new Delhi.

4. Teng, W.C. (1988), 'Foundation Design', Prentice Hall, New Delhi.

5. Peck, R. B., Hanson, W.E. and Thornburn, T.H. (1974), 'Foundation Engineering', John Wiley and Sons.

6. Terzaghi, K. and Peck, R.B. (1967), 'Soil Mechanics in Engineering Practice', John Wiley and Sons.

7. Simons, N.E. and Menzies, B.K. (1979), 'A short Course in Foundation Engineering', ELBS and Newnes Butterworth, London.

8. Indian Standard Code of Practice for Determination of 'Bearing Capacity of Shallow Foundation IS 6403:1981'.

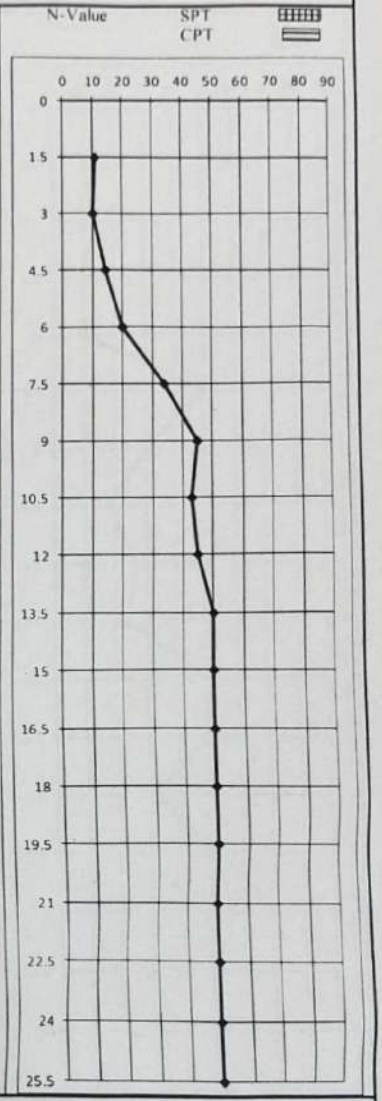
9. Indian Standard Code of Practice for 'Calculation of Settlement of foundation IS 8009 (Part I)– 1976'.

DRILLING LOG

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
Co-ordinate: 3050920.094 N,469532.193 E
Method of Drilling:Percussion
Driller: Mr.Shyamji

Hole No.: 1
Date: April 2018
Station:
Elevation:
Ground water: 0.5 m
Hole Dia.: 150 mm

Soil Description	Depth, m	Symbol	SPT/DCPT	USCS	No. of blows 15 cm	15 cm	15 cm	N-Value	G.W.T., m
Yellowish grey colour clayey silt with sand	1		SPT		2	5	6	11	
	2								
	3		SPT		2	4	6	10	
	4		SPT		3	6	8	14	
	5								
	6		SPT		7	9	11	20	
Dark grey colour clayey silt with sand	7		SPT		15	17	17	34	
	8								
	9		SPT		21	24	21	45	
	10		SPT		17	26	17	43	
	11								
	12		SPT		12	20	25	45	
	13		SPT	ML	24	33	41	50	
	14								
	15		SPT		22	24	33	50	
	16		SPT		24	26	30	50	
	17								
	18		SPT		20	27	33	50	
Yellowish grey colour clayey silt with sand	19		SPT		24	23	27	50	
	20								
	21		SPT		26	28	34	50	
	22		SPT		26	29	36	50	
	23								
	24		SPT		27	28	32	50	
	25		SPT		30	32	34	50	



End Depth: * Completed at 25.0 m — Ground: Dry

Types of Soil		N Value					
Granular Soil	Compactness	0 to 4 Very Loose	4 to 10 Loose	10 to 30 Med Dense	30 to 50 Dense	> 50 Very Dense	
Cohesive Soil	Consistency	0 to 2 Very Soft	2 to 4 Soft	4 to 8 Med Soft	8 to 16 Stiff	16 to 32 Very Stiff	> 32 Hard

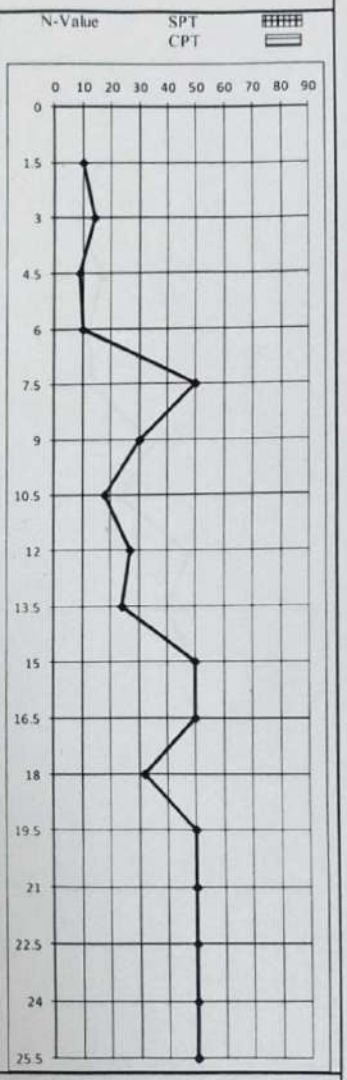
TATA PROJECTS LIMITED

DRILLING LOG

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
Co-ordinate: 3050804.668 N,469554.7418 E
Method of Drilling:Percussion
Driller: Mr.Shyamji

Hole No.: 2
Date: April 2018
Station:
Elevation:
Ground water: 0.5 m
Hole Dia.: 150 mm

Soil Description	Symbol	Depth, m			USCS	No. of blows 15 cm	15 cm	15 cm	N-Value	G W T, m
Yellowish grey colour clayey silt with fine sand		1		SPT		5	5	5	10	
		2								
		3		SPT		6	8	6	14	
		4		SPT		4	4	5	9	
		5								
		6		SPT		3	5	5	10	
		7		SPT		19	26	24	50	
		8								
		9		SPT		11	14	16	30	
		10		SPT		8	9	9	18	
Dark grey colour clayey silt with fine sand		11								
		12		SPT		15	13	14	27	
		13		SPT		15	12	12	24	
		14								
		15		SPT	ML	21	28	33	50	
Grey clour sandy silt with clay		16		SPT	SM	23	25	26	50	
		17								
		18		SPT		16	12	20	32	
		19		SPT		18	27	27	50	
		20								
		21		SPT		17	20	31	50	
Light grey colour clayey silt with fine sand		22		SPT	ML	18	22	31	50	
		23								
		24		SPT		22	32	31	50	
		25		SPT		25	28	30	50	



End Depth: * Completed at 25.0 m — Ground: Dry

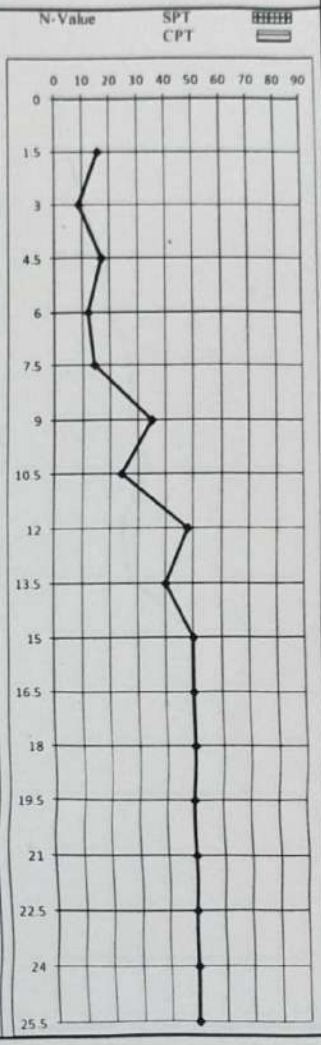
Types of Soil		N Value					
Granular Soil	Compactness	0 to 4 Very Loose	4 to 10 Loose	10 to 30 Med. Dense	30 to 50 Dense	> 50 Very Dense	
Cohesive Soil	Consistency	0 to 2 Very Soft	2 to 4 Soft	4 to 8 Med. Soft	8 to 16 Stiff	16 to 32 Very Stiff	> 32 Hard

DRILLING LOG

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
Co-ordinate: 3050521.781 N, 469497.7668 E
Method of Drilling:Percussion
Driller: Mr.Shyamji

Hole No.: 3
Date: April 2018
Station:
Elevation:
Ground water: 0.5 m
Hole Dia.: 150 mm

Soil Description	Symbol	Depth, m			USCS	No. of blows 15 cm	15 cm	15 cm	N-Value	G.W.T., m
Yellowsh grey colour clayey silt		1	SPT			8	8	8	16	
		2								
		3	SPT			3	4	5	9	
		4								
		5	SPT			6	8	9	17	
		6	SPT			6	5	7	12	
		7								
		8	SPT			8	7	7	14	
Light grey occasionally dark grey colour clayey silt with sand		9	SPT		ML	13	15	20	35	
		10								
		11	SPT			7	11	13	24	
		12	SPT			20	22	26	48	
		13	SPT			19	18	22	40	
		14								
		15	SPT			20	39	39	50	
		16								
		17	SPT			35	42	42	50	
		18	SPT			30	42	42	50	
		19								
		20	SPT			25	44	44	50	
		21	SPT			17	39	39	50	
		22								
		23	SPT			18	39	39	50	
		24	SPT			22	44	44	50	
		25	SPT			25	38	38	50	



End Depth: * Completed at 25.0 m — Ground: Dry

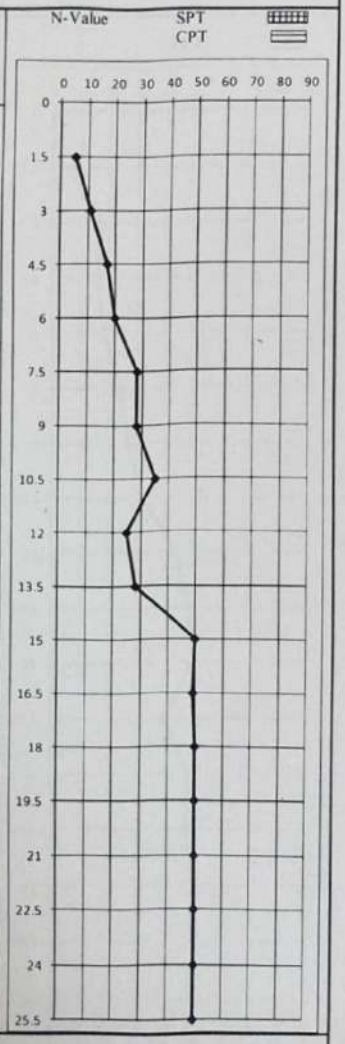
Types of Soil		N Value					
Granular Soil	Compactness	0 to 4 Very Loose	4 to 10 Loose	10 to 30 Med. Dense	30 to 50 Dense	> 50 Very Dense	
Cohesive Soil	Consistency	0 to 2 Very Soft	2 to 4 Soft	4 to 8 Med. Soft	8 to 16 Stiff	16 to 32 Very Stiff	> 32 Hard

DRILLING LOG

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
Co-ordinate: 3050926.4087 N,469512.1182 E
Method of Drilling:Percussion
Driller: Mr.Shyamji

Hole No.: 4
Date: April 2018
Station:
Elevation:
Ground water: 0.5 m
Hole Dia.: 150 mm

Soil Description	Symbol	Depth, m		USCS	No. of blows 15 cm	15 cm	15 cm	N-Value	G.W.T., m
Yellowish colour clayey silt with fine sand		1	SPT		3	2	3	5	
		2							
		3	SPT		4	5	6	11	
		4							
		5	SPT		5	7	10	17	
		6	SPT		7	9	11	20	
		7							
		8	SPT		9	12	16	28	
		9	UD		-	-	-		
Light yellow occasinally dark colour clayey silt with fine sand		10	SPT		11	16	19	35	
		11							
		12	SPT		8	14	11	25	
		13		ML					
		14	SPT		12	13	15	28	
		15	SPT		20	25	31	50	
		16							
		17	SPT		24	22	27	49	
		18	SPT		20	30	48	50	
		19							
		20	SPT		33	27	45	50	
		21	SPT		36	29	31	50	
		22							
		23	SPT		37	39	38	50	
		24	SPT		33	31	35	50	
		25							
			SPT		30	34	37	50	



End Depth	* Completed at 25.0 m				Ground: Dry	
Types of Soil	N Value					
Granular Soil — Compactness	0 to 4 Very Loose	4 to 10 Loose	10 to 30 Med. Dense	30 to 50 Dense	> 50 Very Dense	
Cohesive Soil — Consistency	0 to 2 Very Soft	2 to 4 Soft	4 to 8 Med. Soft	8 to 16 Stiff	16 to 32 Very Stiff	> 32 Hard

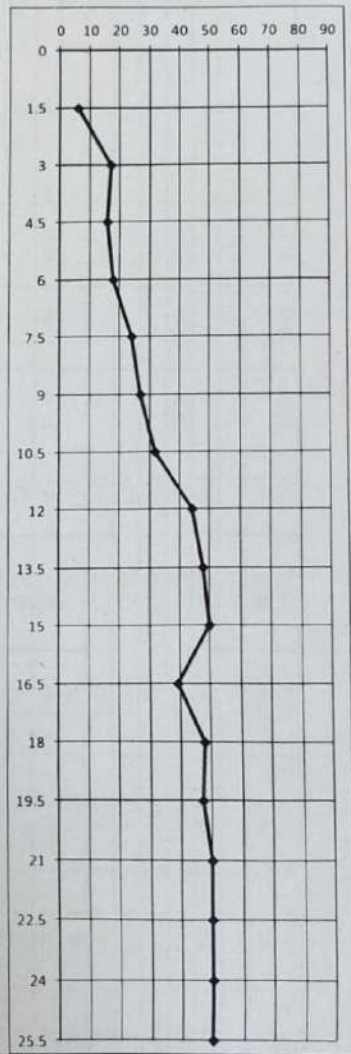
DRILLING LOG

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
Co-ordinate: 3050752.4767 N,469737.9403 E
Method of Drilling:Percussion
Driller: Mr.Shyamji

Hole No.: 5
Date: April 2018
Station:
Elevation:
Ground water: 0.5 m
Hole Dia.: 150 mm

Soil Description	Symbol	Depth, m		USCS	No. of blows 15 cm	15 cm	15 cm	N-Value	G.W.T., m
Light redish to yellwish grey colour clayey silt with sand		1	SPT		2	3	3	6	
		2							
		3	SPT		5	7	10	17	
		4	SPT		5	6	10	16	
		5							
		6	SPT		6	8	9	17	
		7	SPT		9	11	13	24	
		8							
		9	SPT		11	11	16	27	
Dark grey colour clayey silt with sand		10	SPT		13	15	17	32	
		11							
		12	SPT		19	21	23	44	
		13	SPT	ML	23	22	26	48	
		14							
		15	SPT		33	27	45	50	
Yellowish to dark colour clayey silt with sand		16	SPT		22	19	20	39	
		17							
		18	SPT		24	22	26	48	
		19	SPT		23	24	23	47	
		20							
		21	SPT		31	26	27	50	
		22	SPT		26	28	30	50	
		23							
		24	SPT		28	31	36	50	
		25	SPT		31	36	36	50	

N-Value SPT CPT



End Depth	* Completed at 25.0 m			Ground: Dry		
Types of Soil	N Value					
Granular Soil — Compactness	0 to 4 Very Loose	4 to 10 Loose	10 to 30 Med. Dense	30 to 50 Dense	> 50 Very Dense	
Cohesive Soil — Consistency	0 to 2 Very Soft	2 to 4 Soft	4 to 8 Med. Soft	8 to 16 Stiff	16 to 32 Very Stiff	> 32 Hard

Lab Test Summary Sheet

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal

Bore Hole -No:	Depth (m)	Percentage of					NMC	Specific Gravity	Atterberg Limit			Direct Shear Test		Unconfined Compression Test Qu (KN/m2)	Consolidation Test (Cc)	Remarks
		Slit & Clay	Clay	Silt	Sand	Gravel			LL	PL	PI	C (KN/m2)	ϕ Degree (°)			
1	3.00	96.31	26.71	69.60	3.69	0.00	22.47	2.58	27.70	21.61	6.09	20	17			
	7.50	85.67	24.93	60.74	14.33	0.00	19.15	2.62								
	15.00	84.92	28.29	56.63	15.08	0.00	14.01	2.67	23.10	17.14	5.96	21.00	10		0.12	
	16.50	84.69	28.21	56.48	15.31	0.00	17.10	2.71								
	19.50	88.72	29.66	59.07	9.03	2.24	20.29	2.69								
	25.50	85.45	28.38	57.07	14.55	0.00	24.56	2.72								
2	1.50	87.16	29.04	58.12	12.84	0.00	15.82	2.71								
	3.00	99.00	33.33	65.67	1.00	0.00	13.97	2.66								
	4.50	88.45	29.62	58.83	11.55	0.00	14.77	2.68								
	9.00	83.12	23.67	59.45	16.88	0.00	14.67	2.72								
	12.00	98.54	32.95	65.60	1.46	0.00	28.79	2.69	24.20	18.58	5.62				0.13	
	15.00						14.47					2	28.84			
	18.00	88.00	29.29	58.71	12.00	0.00	9.99	2.71								
	25.50	85.45	28.38	57.07	14.55	0.00	11.17	2.61								
3	1.50	88.29	29.31	58.98	11.71	0.00	17.34	2.72								
	3.00	85.91	28.91	57.00	14.09	0.00	21.14	2.66	35.00	25.69	9.31	21	18			
	4.50	96.80	32.31	64.49	3.20	0.00	22.44	2.70								
	7.50	93.68	31.49	62.18	6.32	0.00	17.34	2.66								
	9.00	98.06	28.24	69.82	1.94	0.00	19.84	2.67								
	25.50	93.89	31.35	62.53	6.11	0.00	21.50	2.69	35.00	23.07	11.93					
4	1.50	93.51	31.15	62.36	6.49	0.00	27.31	2.71								
	3.00	96.32	32.43	63.88	3.68	0.00	23.71	2.66								
	4.50	98.46	33.29	65.17	1.54	0.00	25.45	2.64								
	9.00	88.36	25.23	63.12	11.64	0.00	14.04	2.71						0.53		
	15.00	92.55	31.57	60.97	7.45	0.00	16.57	2.60								
	22.50	88.30	30.05	58.25	11.70	0.00	20.37	2.61	37.30	22.49	14.81				0.25	
	25.50	67.11	22.80	44.31	32.89	0.00	17.33	2.62								
5	1.50	79.09	26.72	52.37	20.91	0.00	17.28	2.642								
	3.00	93.89	31.83	62.06	6.11	0.00	13.40	2.628								
	4.50	98.74	33.09	65.65	1.26	0.00	13.85	2.678				23	19			
	9.00	96.42	27.35	69.07	2.54	1.04	14.23	2.737	27.80	20.31	7.49				0.16	
	13.50	78.42	26.13	52.29	21.58	0.00	17.05	2.705								
	16.50						15.31									
	19.50	90.84	30.32	60.51	9.16	0.00	20.04	2.696								
	25.50	94.72	32.12	62.60	5.28	0.00	19.36	2.626	33.00	22.49	10.51				0.21	

NATURAL MOISTURE CONTENT

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal

Sample No.	Depth,m	Container No.	Wet Soil	Dry Soil (B)	Wt. of Water	Wt. of Dry Soil	Moisture Content (%)
Bore Hole No.				1			
SPT-1	3	C2	101.47	82.85	18.62	82.85	22.47
SPT-5	7.5	B4	104.02	87.3	16.72	87.30	19.15
SPT-10	15	B9	106.05	93.02	13.03	93.02	14.01
SPT-11	16.5	C7	97.59	83.34	14.25	83.34	17.10
SPT-13	19.5	B2	107.32	89.22	18.10	89.22	20.29
SPT-17	25.5	B3	103.36	82.98	20.38	82.98	24.56
Bore Hole No.				2			
SPT-1	1.5	B6	133.47	115.24	18.23	115.24	15.82
SPT-2	3	B1	133.5	117.14	16.36	117.14	13.97
SPT-3	4.5	B5	132.86	115.76	17.10	115.76	14.77
SPT-6	9	A2	133.28	116.23	17.05	116.23	14.67
SPT-8	12	AA9	130.09	101.01	29.08	101.01	28.79
SPT-10	15	C8	132.17	115.46	16.71	115.46	14.47
SPT-12	18	C10	131.21	119.29	11.92	119.29	9.99
SPT-17	25.5	B8	131.8	118.56	13.24	118.56	11.17
Bore Hole No.				3			
SPT-1	1.5	B10	131.16	111.78	19.38	111.78	17.34
SPT-2	3	A4	130.82	107.99	22.83	107.99	21.14
SPT-3	4.5	A3	132.42	108.15	24.27	108.15	22.44
SPT-5	7.5	B10	131.16	111.78	19.38	111.78	17.34
SPT-6	9	A9	130.09	108.55	21.54	108.55	19.84
SPT-17	25.5	A7	133.53	109.9	23.63	109.90	21.50
Bore Hole No.				4			
SPT-1	1.5	C2	132.86	104.36	28.50	104.36	27.31
SPT-2	3	B8	133.36	107.8	25.56	107.80	23.71
SPT-3	4.5	C10	134.8	107.45	27.35	107.45	25.45
SPT-6	9	C8	130.94	114.82	16.12	114.82	14.04
SPT-10	15	B1	132.13	113.35	18.78	113.35	16.57
SPT-15	22.5	B2	133.77	111.13	22.64	111.13	20.37
SPT-17	25.5	A12	130.44	111.17	19.27	111.17	17.33
Bore Hole No.				5			
SPT-1	1.5	C3	129.29	110.24	19.05	110.24	17.28
SPT-2	3	B7	130.41	115	15.41	115.00	13.40
SPT-3	4.5	C4	131.99	115.93	16.06	115.93	13.85
SPT-6	9	C5	131.6	115.21	16.39	115.21	14.23
SPT-9	13.5	C3	133.27	113.86	19.41	113.86	17.05
SPT-11	16.5	C1	132.37	114.79	17.58	114.79	15.31
SPT-13	19.5	S11	131.12	109.23	21.89	109.23	20.04
SPT-17	25.5	C9	129.29	108.32	20.97	108.32	19.36

GRAIN SIZE ANALYSIS

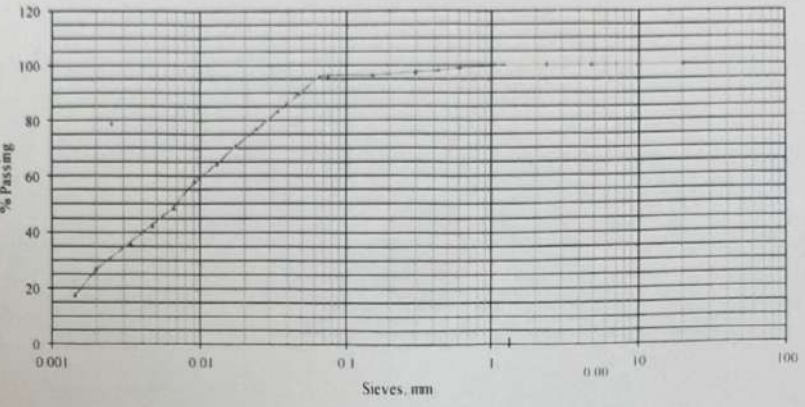
Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal — Borehole : -1 - SPT 2

CLIENT : Nepal Electricity Autority (NEA),Nepal — Depth: 3.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	100.00
1.180 mm	100.00
0.600 mm	99.03
0.425 mm	98.19
0.300 mm	97.59
0.150 mm	96.38
0.075 mm	96.31
0.065 mm	95.83
0.047 mm	89.55
0.034 mm	83.27
0.024 mm	76.98
0.017 mm	70.70
0.013 mm	64.41
0.009 mm	58.13
0.007 mm	48.70
0.005 mm	42.42
0.003 mm	36.13
0.002 mm	26.71
0.001 mm	17.28



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
26.7 %	69.60 %	3.7 %	0.0 %

GRAIN SIZE ANALYSIS

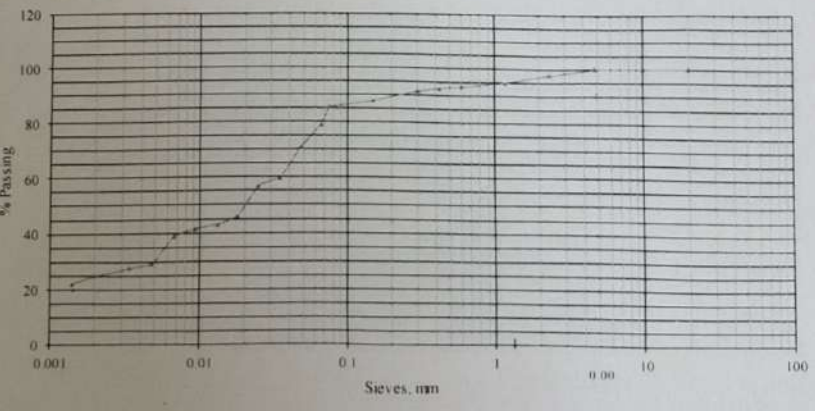
Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal — Borehole : -1 - SPT 5

CLIENT : Nepal Electricity Autority (NEA),Nepal — Depth: 7.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	97.82
1.180 mm	94.89
0.600 mm	93.29
0.425 mm	92.60
0.300 mm	91.57
0.150 mm	87.90
0.075 mm	85.67
0.066 mm	78.96
0.048 mm	70.65
0.035 mm	59.56
0.025 mm	56.79
0.018 mm	45.71
0.013 mm	42.94
0.009 mm	41.56
0.007 mm	38.79
0.005 mm	29.09
0.003 mm	27.70
0.002 mm	24.93
0.001 mm	22.16



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
24.9 %	60.74 %	14.3 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

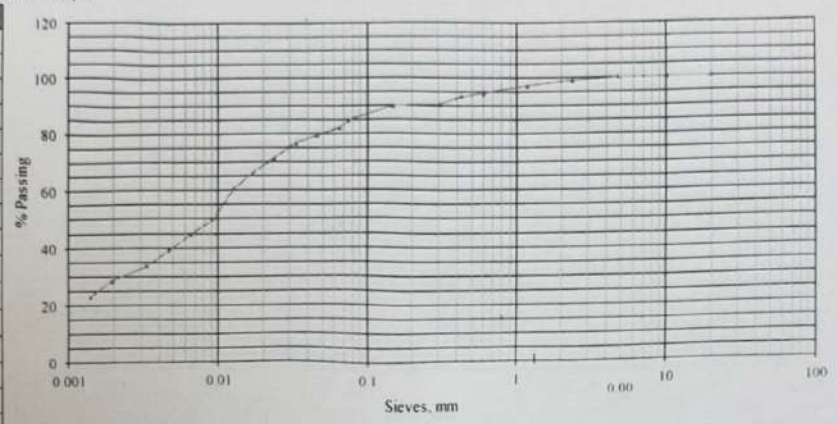
Borehole -1 - SPT 10

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 15.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	99.03
1.180 mm	97.20
0.600 mm	94.30
0.425 mm	93.33
0.300 mm	90.43
0.150 mm	89.86
0.075 mm	84.92
0.065 mm	82.16
0.047 mm	79.47
0.033 mm	76.77
0.024 mm	71.39
0.017 mm	66.00
0.013 mm	60.61
0.009 mm	49.84
0.007 mm	44.45
0.005 mm	39.06
0.003 mm	33.67
0.002 mm	28.29
0.001 mm	22.90



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
28.3 %	56.63 %	15.1 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

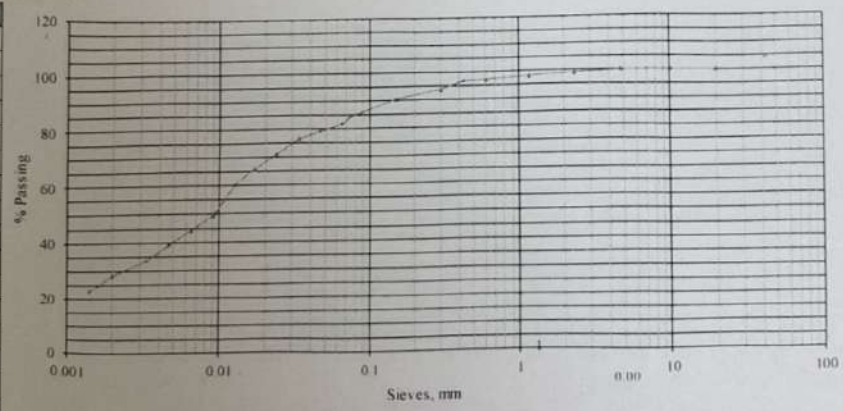
Borehole: -1 - SPT 11

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 16.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	98.92
1.180 mm	98.08
0.600 mm	97.12
0.425 mm	96.84
0.300 mm	93.60
0.150 mm	90.33
0.075 mm	84.69
0.065 mm	81.94
0.047 mm	79.26
0.033 mm	76.57
0.024 mm	71.20
0.017 mm	65.82
0.013 mm	60.45
0.009 mm	49.70
0.007 mm	44.33
0.005 mm	38.96
0.003 mm	33.58
0.002 mm	28.21
0.001 mm	22.84



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
28.2 %	56.48 %	15.3 %	0.0 %

TATA PROJECTS LIMITED

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

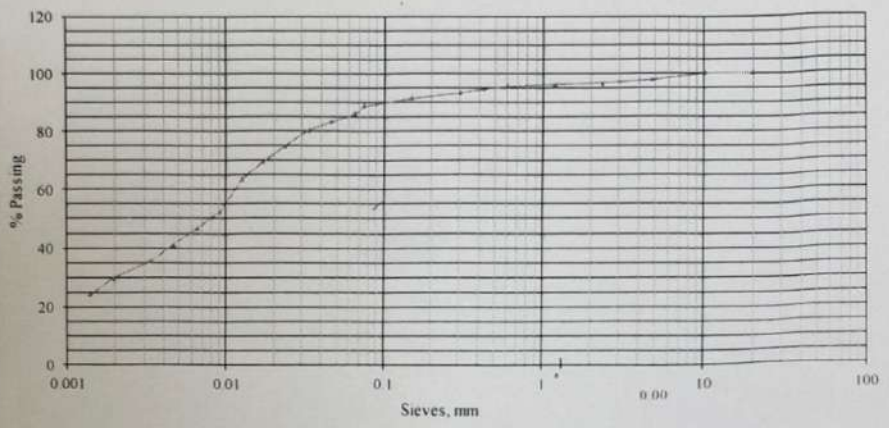
Borehole -1 - SPT 13

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 19.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	97.76
2.360 mm	96.75
1.180 mm	96.19
0.600 mm	95.63
0.425 mm	94.62
0.300 mm	93.28
0.150 mm	91.48
0.075 mm	88.72
0.065 mm	86.15
0.047 mm	83.32
0.033 mm	80.50
0.024 mm	74.85
0.017 mm	69.20
0.013 mm	63.55
0.009 mm	52.25
0.007 mm	46.60
0.005 mm	40.96
0.003 mm	35.31
0.002 mm	29.66
0.001 mm	24.01



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
29.7 %	59.07 %	9.0 %	2.2 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

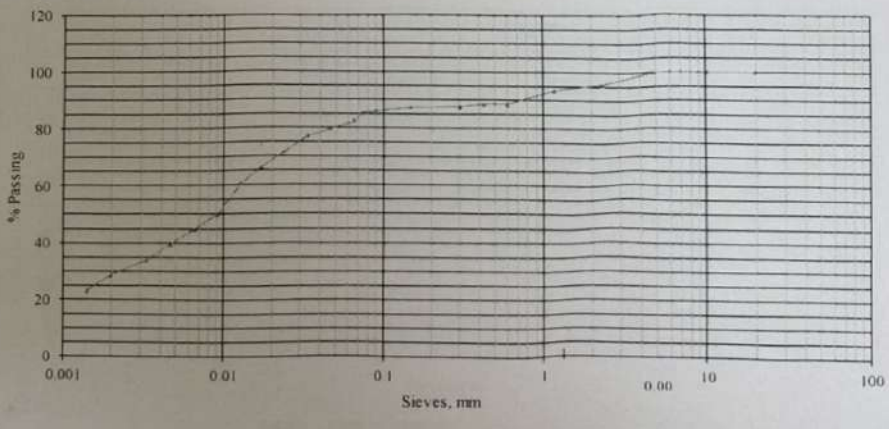
Borehole -1 - SPT 17

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 25.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	95.87
1.180 mm	93.46
0.600 mm	88.64
0.425 mm	88.64
0.300 mm	87.55
0.150 mm	87.31
0.075 mm	85.45
0.065 mm	82.45
0.047 mm	79.75
0.033 mm	77.04
0.024 mm	71.64
0.017 mm	66.23
0.013 mm	60.82
0.009 mm	50.01
0.007 mm	44.60
0.005 mm	39.20
0.003 mm	33.79
0.002 mm	28.38
0.001 mm	22.98



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
28.4 %	57.07 %	14.5 %	0.0 %

GRAIN SIZE ANALYSIS

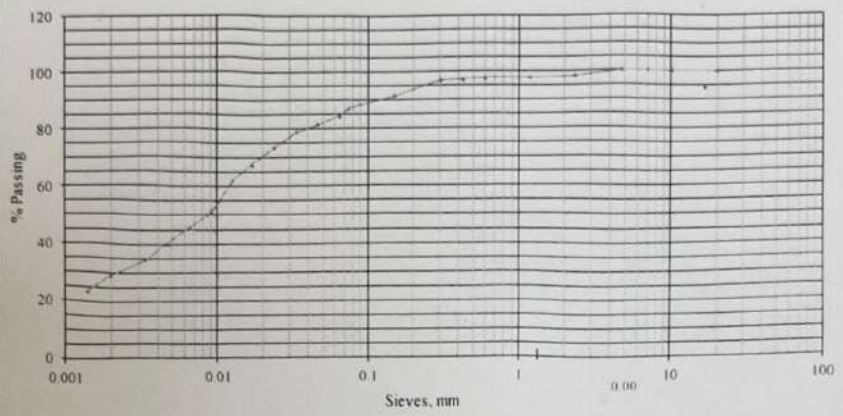
Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal — Borehole -2 - SPT 1

CLIENT : Nepal Electricity Autority (NEA),Nepal — Depth 1.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	98.26
1.180 mm	97.83
0.600 mm	97.66
0.425 mm	97.22
0.300 mm	96.96
0.150 mm	91.41
0.075 mm	87.16
0.065 mm	84.35
0.047 mm	81.59
0.033 mm	78.82
0.024 mm	73.29
0.017 mm	67.76
0.013 mm	62.23
0.009 mm	51.16
0.007 mm	45.63
0.005 mm	40.10
0.003 mm	34.57
0.002 mm	29.04
0.001 mm	23.51



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
29.0 %	58.12 %	12.8 %	0.0 %

GRAIN SIZE ANALYSIS

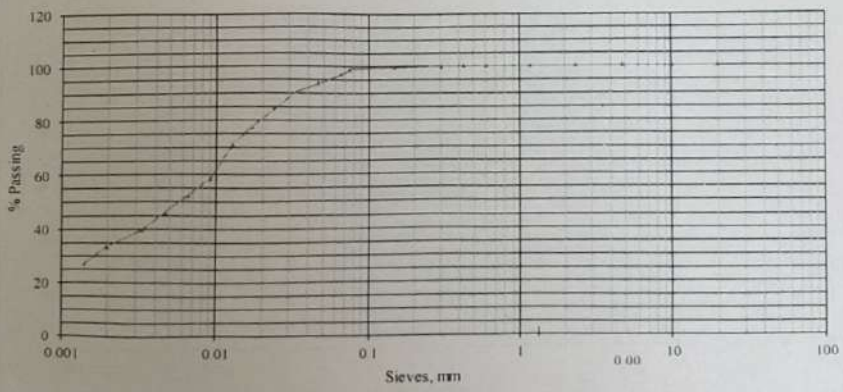
Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal — Borehole -2 - SPT 2

CLIENT : Nepal Electricity Autority (NEA),Nepal — Depth 3.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	100.00
1.180 mm	100.00
0.600 mm	100.00
0.425 mm	100.00
0.300 mm	99.81
0.150 mm	99.60
0.075 mm	99.00
0.065 mm	96.81
0.047 mm	93.64
0.033 mm	90.47
0.024 mm	84.12
0.017 mm	77.77
0.013 mm	71.42
0.009 mm	58.72
0.007 mm	52.38
0.005 mm	46.03
0.003 mm	39.68
0.002 mm	33.33
0.001 mm	26.98



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
33.3 %	65.67 %	1.0 %	0.0 %

TATA PROJECTS LIMITED

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

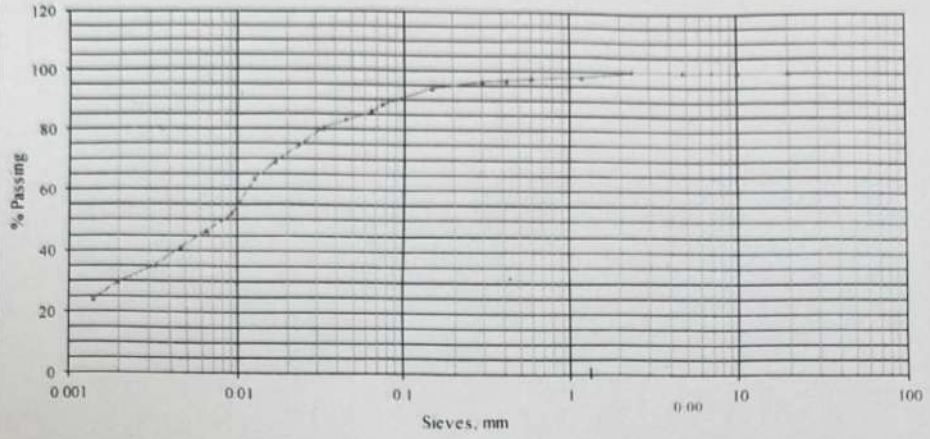
Borehole: -2 - SPT 3

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth: 4.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	100.00
1.180 mm	97.98
0.600 mm	97.37
0.425 mm	96.68
0.300 mm	96.12
0.150 mm	94.05
0.075 mm	88.45
0.065 mm	86.05
0.047 mm	83.23
0.033 mm	80.41
0.024 mm	74.77
0.017 mm	69.12
0.013 mm	63.48
0.009 mm	52.20
0.007 mm	46.55
0.005 mm	40.91
0.003 mm	35.27
0.002 mm	29.62
0.001 mm	23.98



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
29.6 %	58.83 %	11.5 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

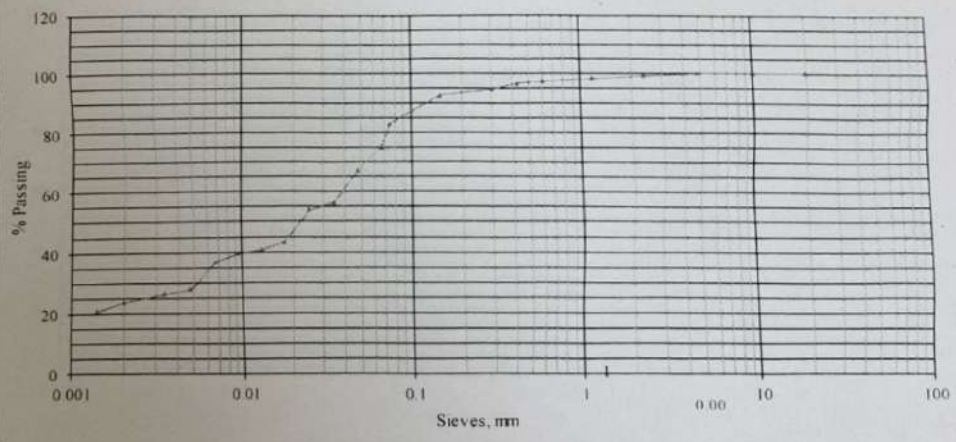
Borehole: -2 - SPT 6

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth: 9.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	99.23
1.180 mm	98.19
0.600 mm	97.35
0.425 mm	96.60
0.300 mm	94.62
0.150 mm	92.70
0.075 mm	83.12
0.066 mm	74.94
0.048 mm	67.05
0.035 mm	56.53
0.025 mm	53.90
0.018 mm	43.39
0.013 mm	40.76
0.009 mm	39.44
0.007 mm	36.81
0.005 mm	27.61
0.003 mm	26.29
0.002 mm	23.67
0.001 mm	21.04



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
23.7 %	59.45 %	16.9 %	0.0 %

TATA PROJECTS LIMITED

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

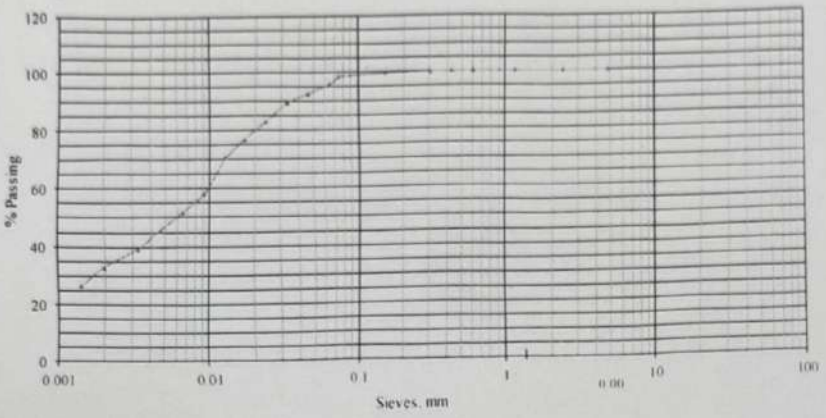
Borehole -2 - SPT 8

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 12.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	
10.000 mm	
4.750 mm	100.00
2.360 mm	100.00
1.180 mm	100.00
0.600 mm	100.00
0.425 mm	100.00
0.300 mm	99.83
0.150 mm	99.53
0.075 mm	98.54
0.065 mm	95.70
0.047 mm	92.56
0.033 mm	89.43
0.024 mm	83.15
0.017 mm	76.88
0.013 mm	70.60
0.009 mm	58.05
0.007 mm	51.77
0.005 mm	45.50
0.003 mm	39.22
0.002 mm	32.95
0.001 mm	26.67



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
32.9 %	65.60 %	1.5 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

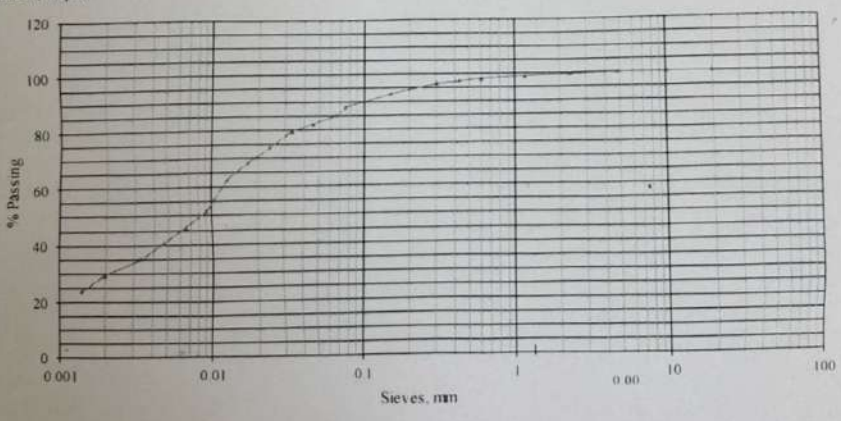
Borehole -2 - SPT 12

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 18.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	99.66
1.180 mm	98.84
0.600 mm	97.92
0.425 mm	97.28
0.300 mm	96.34
0.150 mm	92.78
0.075 mm	88.00
0.065 mm	85.07
0.047 mm	82.28
0.033 mm	79.49
0.024 mm	73.91
0.017 mm	68.33
0.013 mm	62.75
0.009 mm	51.60
0.007 mm	46.02
0.005 mm	40.44
0.003 mm	34.86
0.002 mm	29.29
0.001 mm	23.71



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
29.3 %	58.71 %	12.0 %	0.0 %

TATA PROJECTS LIMITED

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

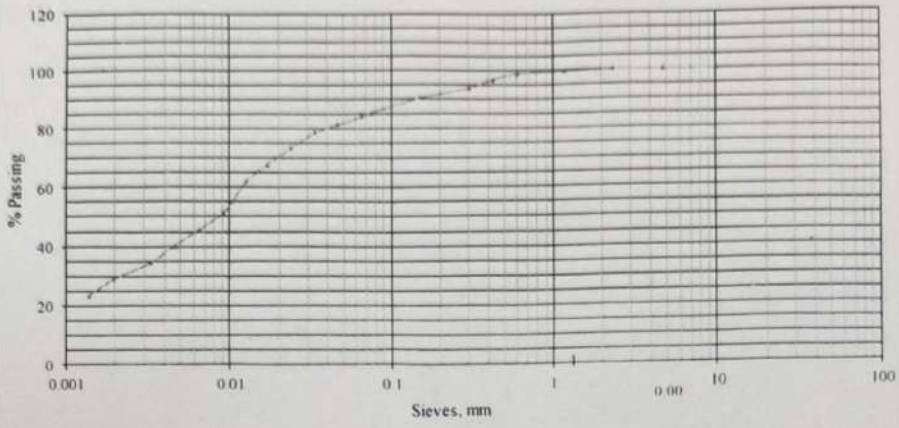
Borehole: -2 - SPT 17

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth: 25.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	100.00
1.180 mm	99.58
0.600 mm	98.82
0.425 mm	96.75
0.300 mm	93.83
0.150 mm	90.61
0.075 mm	85.27
0.065 mm	84.33
0.047 mm	81.56
0.033 mm	78.80
0.024 mm	73.27
0.017 mm	67.74
0.013 mm	62.21
0.009 mm	51.15
0.007 mm	45.62
0.005 mm	40.09
0.003 mm	34.56
0.002 mm	29.03
0.001 mm	23.50



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
29.0 %	56.24 %	14.7 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

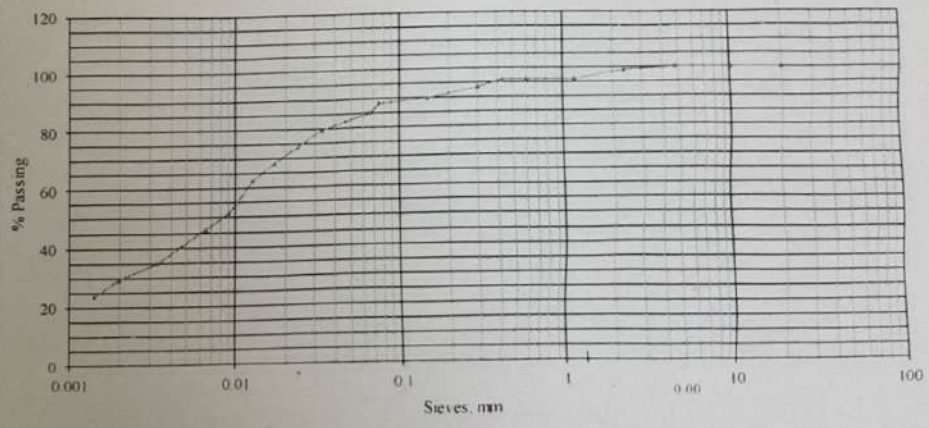
Borehole: -3 - SPT 1

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth: 1.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	99.02
1.180 mm	96.07
0.600 mm	96.07
0.425 mm	95.86
0.300 mm	93.35
0.150 mm	89.99
0.075 mm	88.29
0.065 mm	85.15
0.047 mm	82.36
0.033 mm	79.57
0.024 mm	73.99
0.017 mm	68.40
0.013 mm	62.82
0.009 mm	51.65
0.007 mm	46.07
0.005 mm	40.48
0.003 mm	34.90
0.002 mm	29.31
0.001 mm	23.73



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
29.3 %	58.98 %	11.7 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

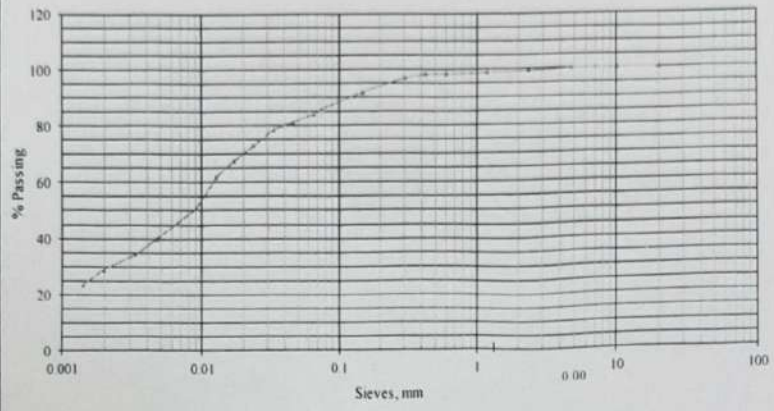
Borehole -3 - SPT 2

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 3.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	99.08
1.180 mm	98.62
0.600 mm	98.20
0.425 mm	98.20
0.300 mm	96.85
0.150 mm	91.67
0.075 mm	85.91
0.065 mm	83.97
0.047 mm	81.22
0.033 mm	78.46
0.024 mm	72.96
0.017 mm	67.45
0.013 mm	61.95
0.009 mm	50.93
0.007 mm	45.43
0.005 mm	39.92
0.003 mm	34.41
0.002 mm	28.91
0.001 mm	23.40



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
28.9 %	57.00 %	14.1 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

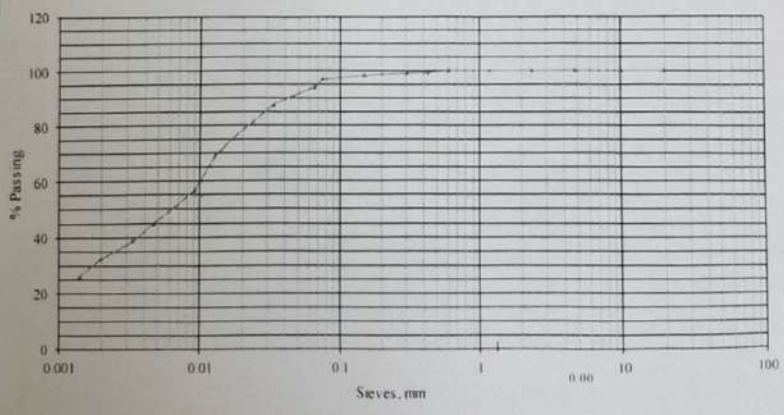
Borehole -3 - SPT 3

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 4.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	100.00
1.180 mm	100.00
0.600 mm	100.00
0.425 mm	99.48
0.300 mm	99.06
0.150 mm	98.23
0.075 mm	96.80
0.065 mm	93.84
0.047 mm	90.76
0.033 mm	87.69
0.024 mm	81.53
0.017 mm	75.38
0.013 mm	69.23
0.009 mm	56.92
0.007 mm	50.77
0.005 mm	44.61
0.003 mm	38.46
0.002 mm	32.31
0.001 mm	26.15



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
32.3 %	64.49 %	3.2 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

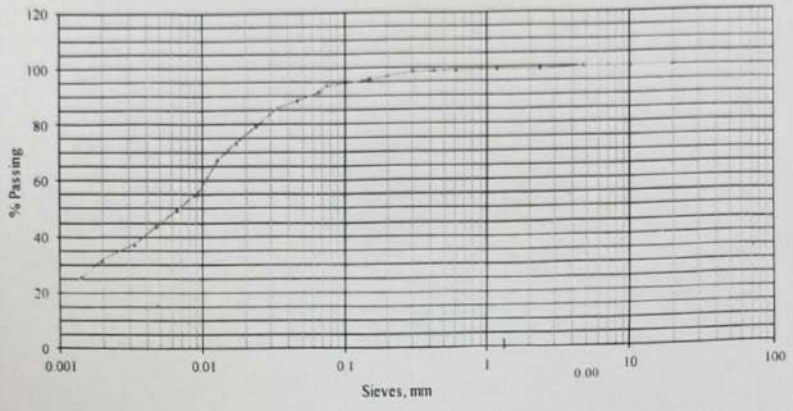
Borehole -3 - SPT 5

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 7.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	99.19
1.180 mm	99.08
0.600 mm	98.86
0.425 mm	98.69
0.300 mm	98.59
0.150 mm	95.97
0.075 mm	93.68
0.065 mm	91.48
0.047 mm	88.48
0.033 mm	85.48
0.024 mm	79.48
0.017 mm	73.49
0.013 mm	67.49
0.009 mm	55.49
0.007 mm	49.49
0.005 mm	43.49
0.003 mm	37.49
0.002 mm	31.49
0.001 mm	25.49



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
31.5 %	62.18 %	6.3 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

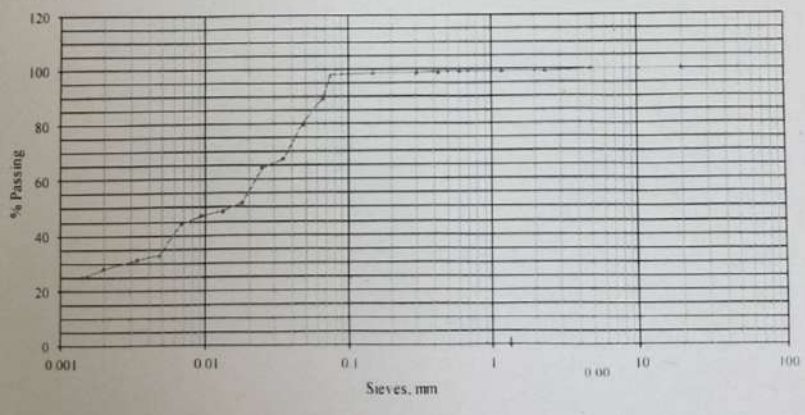
Borehole -3 - SPT 6

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth 9.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	99.17
1.180 mm	99.17
0.600 mm	99.06
0.425 mm	98.89
0.300 mm	98.77
0.150 mm	98.66
0.075 mm	98.06
0.066 mm	89.42
0.048 mm	80.01
0.035 mm	67.46
0.025 mm	64.32
0.018 mm	51.77
0.013 mm	48.63
0.009 mm	47.06
0.007 mm	43.93
0.005 mm	32.94
0.003 mm	31.38
0.002 mm	28.24
0.001 mm	25.10



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
28.2 %	69.82 %	1.9 %	0.0 %

GRAIN SIZE ANALYSIS

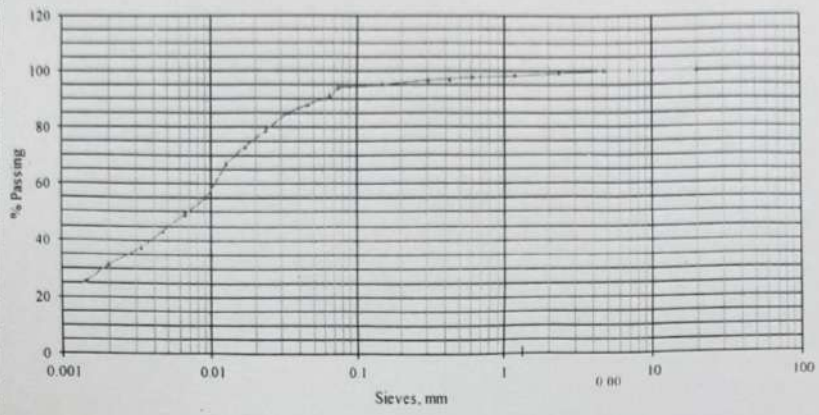
Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal — Borehole: -3 - SPT 17

CLIENT : Nepal Electricity Autority (NEA),Nepal — Depth: 25.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	99.18
1.180 mm	98.29
0.600 mm	97.68
0.425 mm	97.16
0.300 mm	96.75
0.150 mm	95.02
0.075 mm	93.89
0.065 mm	91.08
0.047 mm	88.09
0.033 mm	85.11
0.024 mm	79.13
0.017 mm	73.16
0.013 mm	67.19
0.009 mm	55.24
0.007 mm	49.27
0.005 mm	43.30
0.003 mm	37.33
0.002 mm	31.35
0.001 mm	25.38



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
31.4 %	62.53 %	6.1 %	0.0 %

GRAIN SIZE ANALYSIS

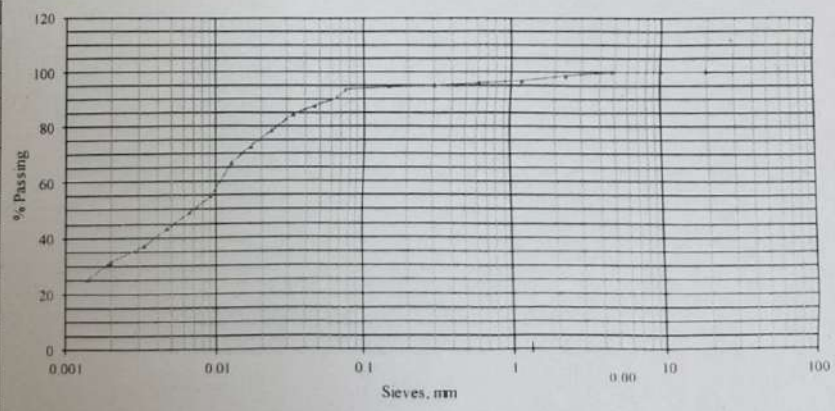
Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal — Borehole: -4 - SPT 1

CLIENT : Nepal Electricity Autority (NEA),Nepal — Depth: 1.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	98.40
1.180 mm	96.59
0.600 mm	95.95
0.425 mm	95.40
0.300 mm	94.97
0.150 mm	94.54
0.075 mm	93.51
0.065 mm	90.48
0.047 mm	87.51
0.033 mm	84.55
0.024 mm	78.61
0.017 mm	72.68
0.013 mm	66.75
0.009 mm	54.88
0.007 mm	48.95
0.005 mm	43.01
0.003 mm	37.08
0.002 mm	31.15
0.001 mm	25.22



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
31.1 %	62.36 %	6.5 %	0.0 %

GRAIN SIZE ANALYSIS

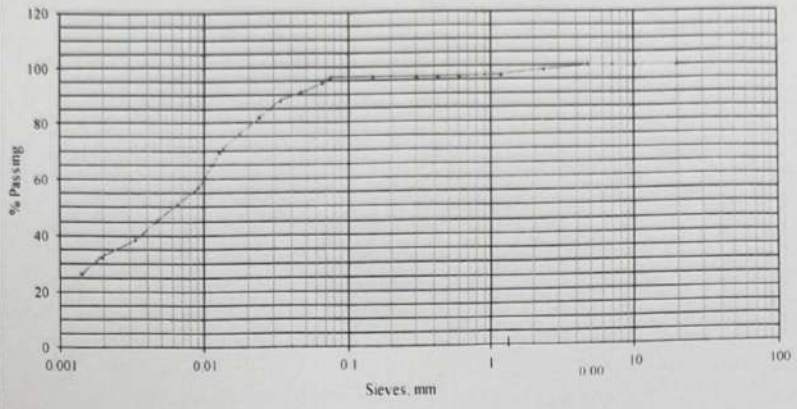
Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal — Borehole -4 - SPT 2

CLIENT : Nepal Electricity Autority (NEA),Nepal — Depth 3.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	98.45
1.180 mm	96.70
0.600 mm	96.32
0.425 mm	96.32
0.300 mm	96.32
0.150 mm	96.32
0.075 mm	96.32
0.065 mm	94.21
0.047 mm	91.12
0.033 mm	88.03
0.024 mm	81.86
0.017 mm	75.68
0.013 mm	69.50
0.009 mm	57.14
0.007 mm	50.97
0.005 mm	44.79
0.003 mm	38.61
0.002 mm	32.43
0.001 mm	26.26



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
32.4 %	63.88 %	3.7 %	0.0 %

GRAIN SIZE ANALYSIS

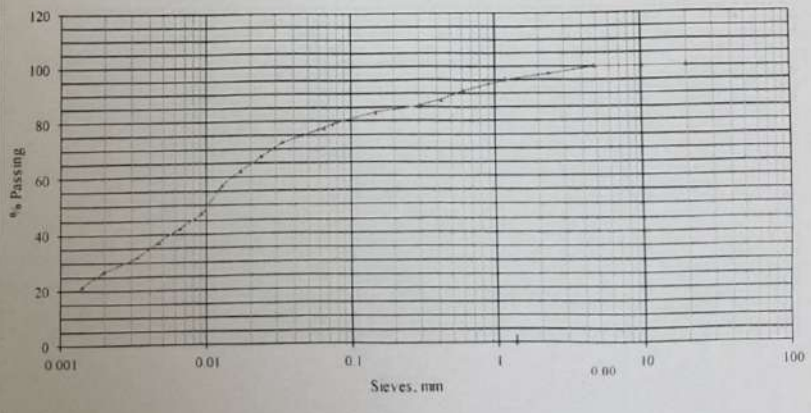
Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal — Borehole -5 - SPT 1

CLIENT : Nepal Electricity Autority (NEA),Nepal — Depth 1.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	97.31
1.180 mm	95.04
0.600 mm	90.90
0.425 mm	87.67
0.300 mm	85.35
0.150 mm	83.13
0.075 mm	79.09
0.065 mm	77.63
0.047 mm	75.08
0.033 mm	72.54
0.024 mm	67.45
0.017 mm	62.36
0.013 mm	57.27
0.009 mm	47.09
0.007 mm	42.00
0.005 mm	36.90
0.003 mm	31.81
0.002 mm	26.72
0.001 mm	21.63



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
26.7 %	52.37 %	20.9 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

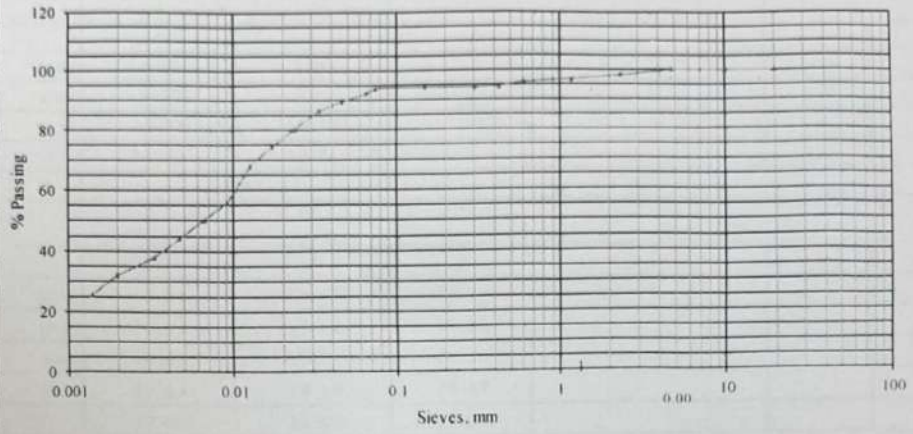
Borehole: -5 - SPT 2

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth: 3.00 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	98.15
1.180 mm	96.57
0.600 mm	95.90
0.425 mm	94.37
0.300 mm	94.25
0.150 mm	94.15
0.075 mm	93.89
0.065 mm	92.45
0.047 mm	89.42
0.033 mm	86.39
0.024 mm	80.33
0.017 mm	74.26
0.013 mm	68.20
0.009 mm	56.08
0.007 mm	50.01
0.005 mm	43.95
0.003 mm	37.89
0.002 mm	31.83
0.001 mm	25.76



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
31.8 %	62.06 %	6.1 %	0.0 %

GRAIN SIZE ANALYSIS

Test Method : IS: 2720 (Part 4) - 1985

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

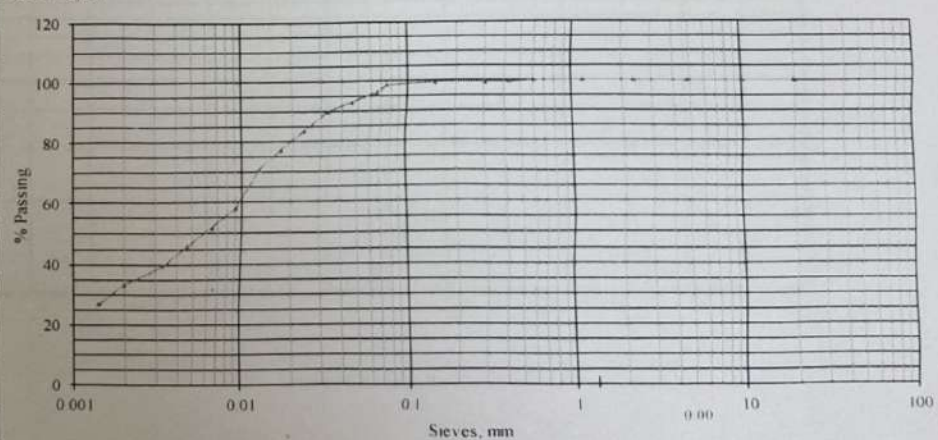
Borehole: -5 - SPT 3

CLIENT : Nepal Electricity Autority (NEA),Nepal

Depth: 4.50 m

LOCATION:Suryabasti,Nawalparasi,Nepal

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	100.00
1.180 mm	100.00
0.600 mm	100.00
0.425 mm	99.65
0.300 mm	99.39
0.150 mm	99.28
0.075 mm	98.74
0.065 mm	96.13
0.047 mm	92.98
0.033 mm	89.82
0.024 mm	83.52
0.017 mm	77.22
0.013 mm	70.91
0.009 mm	58.31
0.007 mm	52.00
0.005 mm	45.70
0.003 mm	39.40
0.002 mm	33.09
0.001 mm	26.79



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
33.1 %	65.65 %	1.3 %	0.0 %

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal

CLIENT : Nepal Electricity Autority (NEA),Nepal

LOCATION:Suryabasti,Nawalparasi,Nepal

Bore hole: 1

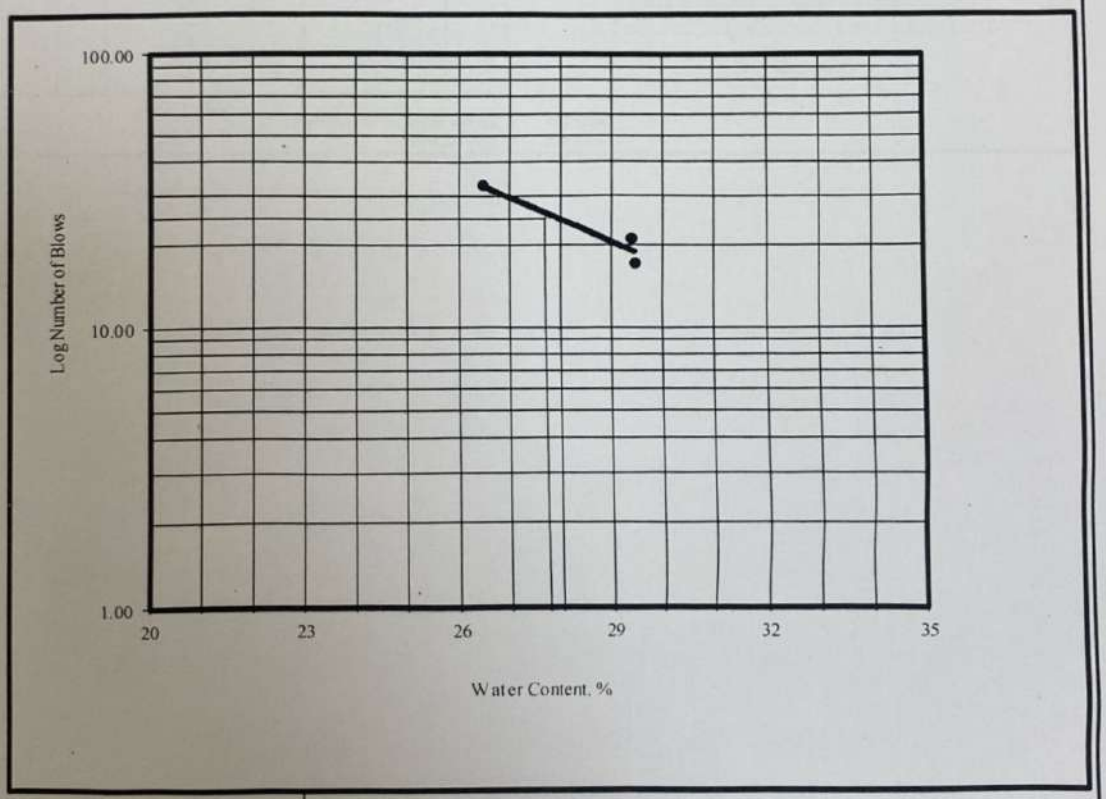
Depth (m) : 3.0 m

PLASTIC LIMIT

Determination No.		1		2		3	
Continer No		1	2				
Weight of wet soil	gms	4.59	3.70				
Weight of dry soil	gms	3.79	3.03				
Weight of Can	gms	18.56	17.56				
Water content	%	21.11	22.11				
Plastic limit	%	21.61					

LIQUID LIMIT

Determination No.		1	2	3	4	5	6
Weight of Wet soil	gms	17.23	18.75	14.24			
Weight of dry soil	gms	13.31	14.49	11.26			
Weight of Can	gms	16.69	18.13	17.36			
Water content	%	29.45	29.40	26.47			
Number of blows		17.00	21.00	33.00			



Liquid Limit, W_L 27.70

Plastic Limit, W_p 21.61

Plascicity Index, PI 6.09

Remarks:

TATA PROJECTS LIMITED

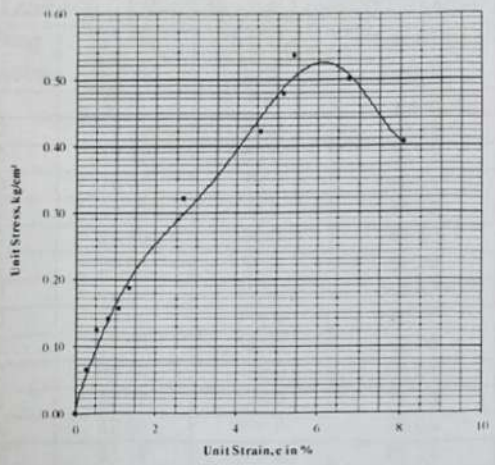
UNCONFINED COMPRESSION TEST

PROJECT :Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Nepal
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION Suryabasti,Nawalparasi,Nepal

Diameter of sample (Do)	:	3.7 cm
Height of sample (Lo)	:	7.4 cm
Original Area of sample (Ao)	:	10.75 cm²
Weight of Sample (gm)	:	176.00 gm
Volume of Sample, cm3	:	79.598 cu c
Proving Ring Constant (PRC)	:	0.338 kg/div
Deformation Dail Reading Least Count (DDRLC)	:	0.01 mm/div

Borehole No	4
Depth, m	9.00
Sample No	UDS
Water Content, %	14.04
Unit Weight, gm/cc	2.21

Deformation dail Reading (DDR)	Load Dial Units (LDU)	Sample Deflomation ΔL mm (DDR x DDRLC)	Unit Strain ΔL/Lo, e in %	1-e	Corrected Area cm² (Ac) A=Ao/1-e	Total Load on Sample, kg (TL) (LDU x PRC)	Stress kg/cm² TL/Ac
0.0	0.00	0.00	0.000	1.000	10.750	0.000	0.000
20.0	2.00	0.20	0.270	0.997	10.779	0.676	0.063
40.0	4.00	0.40	0.541	0.995	10.808	1.352	0.125
60.0	4.50	0.60	0.811	0.992	10.838	1.521	0.140
80.0	5.00	0.80	1.081	0.989	10.867	1.690	0.156
100.0	6.00	1.00	1.351	0.986	10.897	2.028	0.186
200.0	10.50	2.00	2.703	0.973	11.049	3.549	0.321
340.0	14.00	3.40	4.595	0.954	11.268	4.732	0.420
380.0	16.00	3.80	5.135	0.949	11.332	5.408	0.477
400.0	18.00	4.00	5.405	0.946	11.364	6.084	0.535
500.0	17.00	5.00	6.757	0.932	11.529	5.746	0.498
600.0	14.00	6.00	8.108	0.919	11.699	4.732	0.404



Unconfined Compressive Strength (q_u) **0.53 kg/cm²**
Cohesion = $q_u/2$ **0.27 kg/cm²**

TATA PROJECTS LIMITED

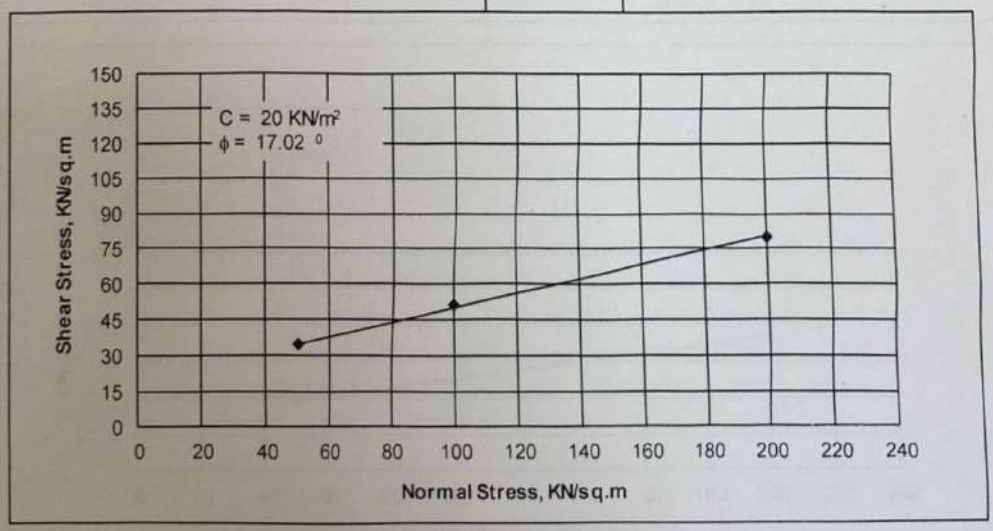
Direct Shear Test

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Ne
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
BH No: 1

Depth (m) **3.0**

PRG Factor, kN/Div.: 0.0019
Area m²: 0.0036
Date:

Test No. 1	1		2		3	
Horiz. Dial Reading (x 0.01mm)	Normal Load 50 kN/m²		Normal Load 100.0 kN/m²		Normal Load 200.0 kN/m²	
	Load Ring Dial	Shear Stress	Load Ring Dial Reading	Shear Stress	Load Ring Dial	Shear Stress KN/m²
0.00	0.0	0.00	0.0	0.00	0.0	0.00
25.00	9.0	4.75	25.0	13.19	50.0	26.39
50.00	11.0	5.81	33.0	17.42	58.0	30.61
75.00	15.0	7.92	38.0	20.06	76.0	40.11
100.00	18.0	9.50	44.0	23.22	84.0	44.33
150.00	22.0	11.61	50.0	26.39	90.0	47.50
200.00	27.0	14.25	55.0	29.03	98.0	51.72
250.00	33.0	17.42	62.0	32.72	107.0	56.47
300.00	38.0	20.06	68.0	35.89	114.0	60.17
350.00	44.0	23.22	72.0	38.00	121.0	63.86
400.00	50.0	26.39	75.0	39.58	130.0	68.61
450.00	58.0	30.61	80.0	42.22	138.0	72.83
500.00	65.0	34.31	90.00	47.50	144.0	76.00
600.00	63.0	33.25	97.00	51.19	152.0	80.22
700.00			95.00	50.14	145.0	76.53
					140.0	73.89



TATA PROJECTS LIMITED

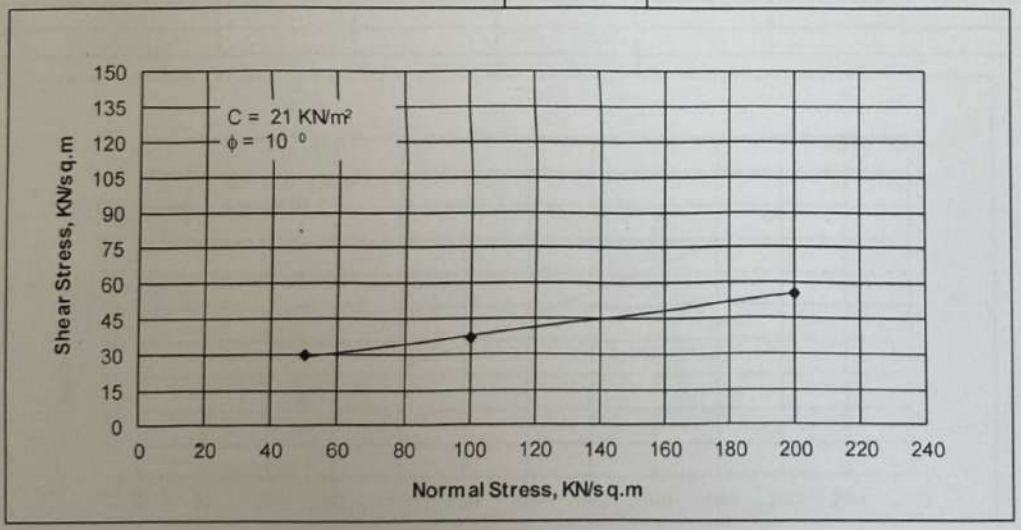
Direct Shear Test

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Ne
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
BH No: 1

Depth (m) **7.5**

PRG Factor, kN/Div.: 0.0019
Area m²: 0.0036
Date:

Test No. 1	1		2		3	
Horiz. Dial Reading (x 0.01mm)	Normal Load 50 kN/m²		Normal Load 100.0 kN/m²		Normal Load 200.0 kN/m²	
	Load Ring Dial	Shear Stress	Load Ring Dial Reading	Shear Stress	Load Ring Dial	Shear Stress KN/m²
0.00	0.0	0.00	0.0	0.00	0.0	0.00
25.00	5.0	2.64	15.0	7.92	25.0	13.19
50.00	10.0	5.28	20.0	10.56	30.0	15.83
75.00	15.0	7.92	25.0	13.19	35.0	18.47
100.00	20.0	10.56	30.0	15.83	40.0	21.11
150.00	25.0	13.19	35.0	18.47	45.0	23.75
200.00	30.0	15.83	40.0	21.11	50.0	26.39
250.00	35.0	18.47	45.0	23.75	55.0	29.03
300.00	40.0	21.11	50.0	26.39	60.0	31.67
350.00	45.0	23.75	55.0	29.03	65.0	34.31
400.00	52.0	27.44	60.0	31.67	70.0	36.94
450.00	57.0	30.08	65.0	34.31	75.0	39.58
500.00	50.0	26.39	70.00	36.94	80.0	42.22
600.00			65.00	34.31	95.0	50.14
700.00				0.00	105.0	55.42
					95.0	50.14



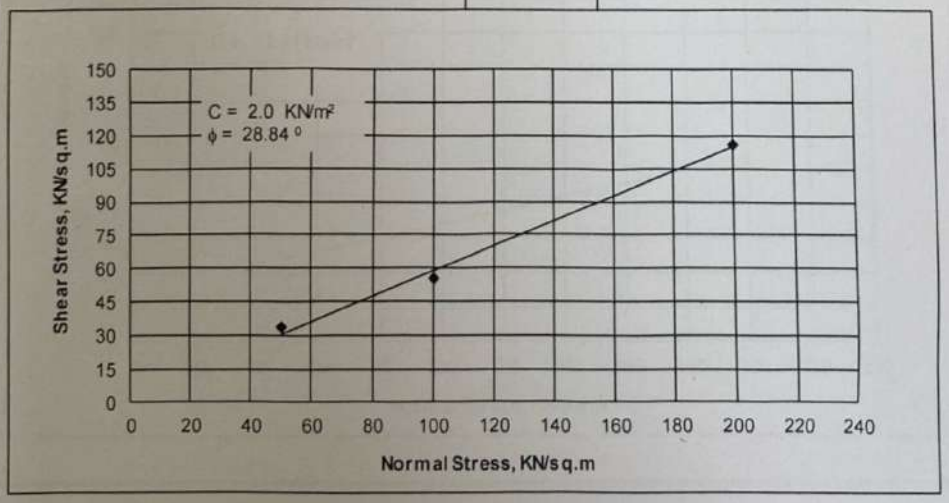
Direct Shear Test

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Ne
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
BH No: 2

Depth (m) **15.0**

PRG Factor, kN/Div.: 0.00354
Area m²: 0.0036
Date:

Test No. 1	1		2		3	
Wt. of Mould + sample (gm)	287.00					
Wt. of mould (gm)	147.00					
Density (gm/cm.³)	1.94					
Horiz. Dial Reading (x 0.01mm)	Normal Load 50 kN/m²		Normal Load 100.0 kN/m²		Normal Load 200.0 kN/m²	
	Load Ring Dial	Shear Stress	Load Ring Dial Reading	Shear Stress	Load Ring Dial	Shear Stress KN/m²
0.00	0.0	0.00	0.0	0.00	0.0	0.00
25.00	9.0	8.85	12.0	11.80	25.0	24.58
50.00	11.0	10.82	19.0	18.68	39.0	38.35
75.00	12.0	11.80	25.0	24.58	47.0	46.22
100.00	17.0	16.72	27.0	26.55	52.0	51.13
150.00	22.0	21.63	37.0	36.38	62.0	60.97
200.00	28.0	27.53	42.0	41.30	74.0	72.77
250.00	30.0	29.50	44.0	43.27	80.0	78.67
300.00	32.0	31.47	45.0	44.25	86.0	84.57
350.00	32.5	31.96	45.5	44.74	90.0	88.50
400.00	33.0	32.45	49.0	48.18	93.0	91.45
450.00	33.5	32.94	51.0	50.15	98.0	96.37
500.00	34.0	33.43	53.00	52.12	105.0	103.25
600.00	32.0	31.47	54.00	53.10	110.0	108.17
700.00	30.0	29.50	56.00	55.07	115.0	113.08
			55.00	54.08	118.0	116.03
					115.0	113.08



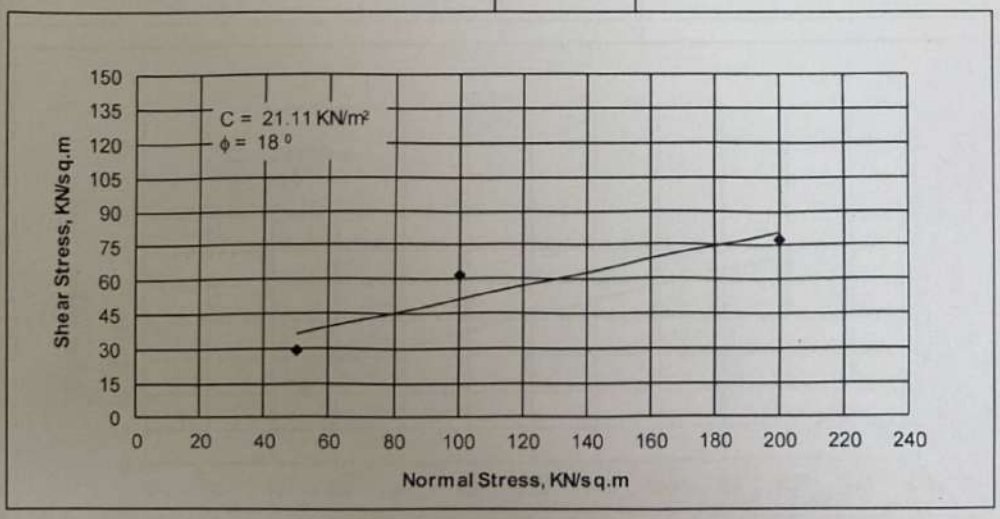
Direct Shear Test

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Ne
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
BH No: 3

Depth (m) **3.0**

PRG Factor, kN/Div.: 0.0019
Area m²: 0.0036
Date:

Test No. 1	1		2		3	
Horiz. Dial Reading (x 0.01mm)	Normal Load 50 kN/m²		Normal Load 100.0 kN/m²		Normal Load 200.0 kN/m²	
	Load Ring Dial	Shear Stress	Load Ring Dial Reading	Shear Stress	Load Ring Dial	Shear Stress KN/m²
0.00	0.0	0.00	0.0	0.00	0.0	0.00
25.00	8.0	4.22	20.0	10.56	40.0	21.11
50.00	15.0	7.92	28.0	14.78	45.0	23.75
75.00	20.0	10.56	35.0	18.47	52.0	27.44
100.00	25.0	13.19	42.0	22.17	58.0	30.61
150.00	30.0	15.83	50.0	26.39	64.0	33.78
200.00	35.0	18.47	61.0	32.19	70.0	36.94
250.00	40.0	21.11	71.0	37.47	76.0	40.11
300.00	45.0	23.75	80.0	42.22	83.0	43.81
350.00	50.0	26.39	90.0	47.50	84.0	44.33
400.00	55.0	29.03	102.0	53.83	100.0	52.78
450.00	50.0	26.39	110.0	58.06	111.0	58.58
500.00	45.0	23.75	117.00	61.75	119.0	62.81
600.00			114.00	60.17	128.0	67.56
700.00			110.00	58.06	138.0	72.83
					147.0	77.58
					140.0	73.89
					135.0	71.25



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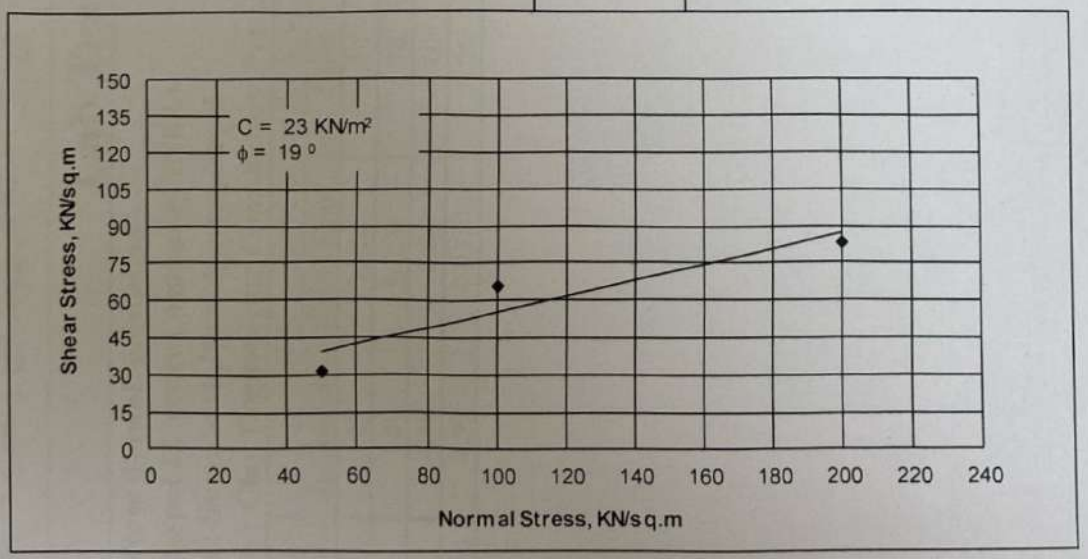
Direct Shear Test

PROJECT: Geotechnical Investigation for the New Butwal Substation Project at Nawalparasi,Ne
CLIENT : Nepal Electricity Autority (NEA),Nepal
LOCATION:Suryabasti,Nawalparasi,Nepal
BH No: 5

Depth (m) **4.5**

PRG Factor, kN/Div.: 0.0019
Area m²: 0.0036
Date:

Test No. 1	1		2		3	
Horiz. Dial Reading (x 0.01mm)	Normal Load 50 kN/m²		Normal Load 100.0 kN/m²		Normal Load 200.0 kN/m²	
	Load Ring Dial	Shear Stress	Load Ring Dial Reading	Shear Stress	Load Ring Dial	Shear Stress KN/m²
0.00	0.0	0.00	0.0	0.00	0.0	0.00
25.00	5.0	2.64	25.0	13.19	30.0	15.83
50.00	10.0	5.28	35.0	18.47	40.0	21.11
75.00	17.0	8.97	45.0	23.75	48.0	25.33
100.00	24.0	12.67	52.0	27.44	61.0	32.19
150.00	32.0	16.89	60.0	31.67	72.0	38.00
200.00	40.0	21.11	68.0	35.89	82.0	43.28
250.00	47.0	24.81	74.0	39.06	92.0	48.56
300.00	55.0	29.03	80.0	42.22	101.0	53.31
350.00	60.0	31.67	99.0	52.25	110.0	58.06
400.00	55.0	29.03	100.0	52.78	121.0	63.86
450.00	48.0	25.33	112.0	59.11	130.0	68.61
500.00			125.00	65.97	141.0	74.42
600.00			120.00	63.33	148.0	78.11
700.00					158.0	83.39
					155.0	81.81
					150.0	79.17



Consolidation test :-

Lab Test Summary Sheet

Project:New Butwal Substation
Client : Nepal Electrical Authority (NEA)
Location : Suryabasti,Nawalparasi,Nepal
Tested By: Clay Engineering Consultancy Pvt.Ltd.

Bore Hole - No:	Depth (m)	Percentage of			NMC	Specific Gravity	Consolidation Test (Cc)	Remarks
		Slit & Clay	Sand	Gravel				
1	3.00	93.52	4.19	2.28	23.76	2.71	0.073	
2	3.00	97.59	1.78	0.64	21.29	2.72	0.131	
3	4.50	98.64	1.10	0.26	27.64	2.67	0.103	
4	4.50	91.75	8.25	0.00	19.36	2.70	0.093	

TATA PROJECTS LIMITED

CONSOLIDATION TEST

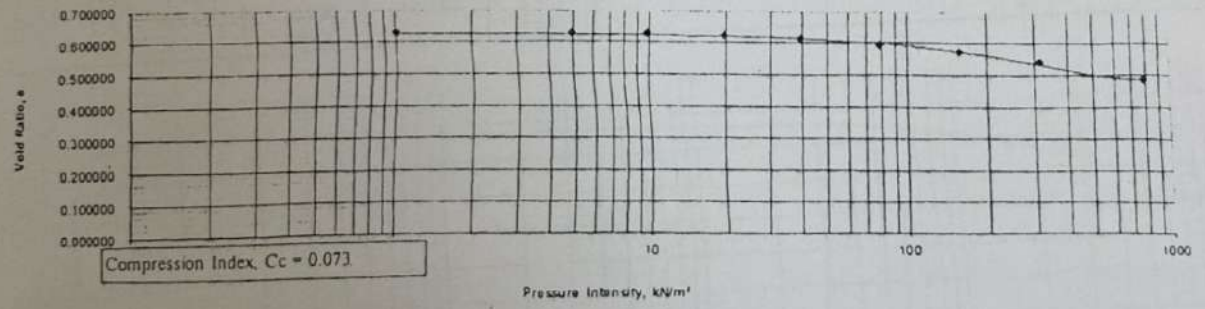
Project:New Butwal Substation
Client : Nepal Electrical Authority (NEA)
Location : Suryabasti,Nawalparasi,Nepal
Tested By: Clay Engineering Consultancy Pvt.Ltd.

SAMPLE NO. : UDS-1

BOREHOLE NO. : 1 DEPTH, m : 3.00

Wt. of Ring + Wet soil, gm	304.53								Initial moisture content (w) , %	21.23
Wt. of Ring + Dry soil, gm	277.42								Initial void ratio, eo = w G	0.628
Wt. of Ring, gm	186.51	C2							Specific Gravity of solids (G)	2.709
Ht. of solids,2Ho = [ho/(1+eo)], m	12.28								Initial height of sample (ho), mm	20.00
sure Intensity (kg/sq.cm)	0.05	0.10	0.20	0.40	0.80	1.60	3.20	8.00		
Pressure Intensity (kN/sq.m)	4.91	9.81	19.62	39.24	78.48	156.96	313.92	784.80		
Elapsed Time (minnutes)	Dial Gauge Reading									
0	1100.00	1099.60	1098.60	1089.80	1077.50	1056.00	1029.00	989.00		
0.5	1100.00	1099.50	1093.00	1079.80	1062.50	1036.00	999.00	941.00		
1	1100.00	1099.40	1092.50	1079.40	1062.00	1035.00	998.20	938.00		
2	1100.00	1099.30	1092.20	1079.20	1061.00	1034.00	997.00	936.30		
4	1100.00	1099.20	1092.00	1079.10	1060.6	1033.50	996.00	935.00		
8	1100.00	1099.20	1091.90	1078.90	1060.00	1033.20	995.20	933.60		
16	1100.00	1099.20	1091.90	1078.70	1059.70	1032.90	994.80	932.30		
30	1100.00	1099.20	1091.80	1078.20	1059.10	1032.20	993.50	930.50		
60	1099.90	1099.10	1091.60	1078.10	1058.50	1031.80	992.90	929.40		
120	1099.90	1099.10	1091.00	1078.10	1058.00	1031.20	991.90	928.70		
240	1099.80	1099.10	1090.80	1077.90	1058.00	1030.80	991.00	927.60		
480	1099.70	1099.10	1090.00	1080.00	1057.00	1030.00	978.40	926.00		
1440	1099.60	1098.60	1089.80	1077.50	1056.00	1029.00	989.00	924.00		

Pressure Intensity kN/sq.m.	Dial Reading	Change in height mm	Ht. of sample mm [2H]	Equiv ht. of voids [2H-2Ho]	Void ratio e=(2H-2Ho)/2Ho	m, m²/kN
1	11.00	-	20.00	7.72	0.628664	
5	11.00	0.00400	20.00	7.72	0.628339	5.12E-05
10	10.99	0.01400	19.99	7.71	0.627524	1.02E-04
20	10.90	0.10200	19.90	7.62	0.620358	4.49E-04
39	10.78	0.22500	19.78	7.50	0.610342	3.14E-04
78	10.56	0.44000	19.56	7.28	0.592834	2.74E-04
157	10.29	0.71000	19.29	7.01	0.570847	1.72E-04
314	9.89	1.11000	18.89	6.61	0.538274	1.27E-04
785	9.24	1.76000	18.24	5.96	0.485342	6.90E-05



Geo-Tech Consult & Research Centre (P) Ltd.

TATA PROJECTS LIMITED

CONSOLIDATION TEST

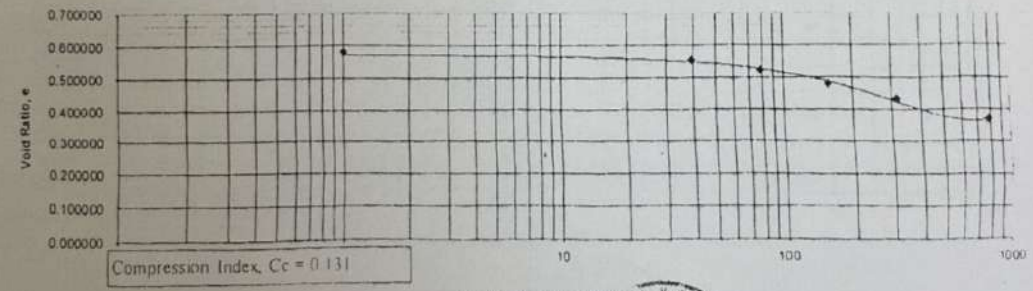
Project New Butwal Substation
Client : Nepal Electrical Authority (NEA)
Location : Suryabasti, Nawalparasi, Nepal
Tested By Clay Engineering Consultancy Pvt Ltd

SAMPLE NO. UDS-1

BOREHOLE NO. 2 DEPTH, m 3.00

Wt. of Ring + Wet soil, gm	296.78					Initial moisture content (w), %				21.29
Wt. of Ring + Dry soil, gm	277.93					Initial void ratio, eo = w G				0.578
Wt. of Ring, gm	186.52					Specific Gravity of solids (G)				2.715
Ht. of solids, 2Ho = [ho/(1+eo)], m	12.67					Initial height of sample (ho), mm				20.00
sure Intensity (kg/sq.cm)	0.40	0.80	1.60	3.20	8.00					
Pressure Intensity (kN/sq.m)	39.24	78.48	156.96	313.92	784.80					
Elapsed Time (minnutes)	Dial Gauge Reading									
0	1100.00	1066.20	1023.40	973.20	914.10					
0.5	1081.00	1034.00	985.00	929.00	851.00					
1	1079.00	1032.00	983.80	926.00	848.00					
2	1077.50	1031.00	982.00	924.70	844.00					
4	1076.50	1029.80	980.60	923.00	843.00					
8	1075.80	1028.70	979.80	921.80	842.40					
16	1075.10	1027.40	978.50	920.00	839.20					
30	1074.00	1027.00	977.90	919.40	838.30					
60	1070.00	1026.20	977.00	918.20	837.00					
120	1069.80	1025.00	976.00	917.30	835.70					
240	1069.60	1024.80	975.20	916.30	834.90					
480	1068.00	1024.20	974.00	915.00	833.00					
1440	1066.20	1023.40	973.20	914.10	831.20					

Pressure Intensity kN/sq.m.	Dial Reading	Change in height mm.	Ht. of sample mm [2H]	Equiv ht. of voids [2H-2Ho]	Void ratio e=(2H-2Ho)/2Ho	m, m²/kN
1	11.00	-	20.00	7.33	0.578532	
39	10.66	0.33800	19.66	6.99	0.551855	4.42E-04
78	10.23	0.76600	19.23	6.56	0.518074	5.46E-04
157	9.73	1.26800	18.73	6.06	0.478453	3.20E-04
314	9.14	1.85900	18.14	5.47	0.431807	1.88E-04
785	8.31	2.68800	17.31	4.64	0.366377	8.81E-05



CONSOLIDATION TEST

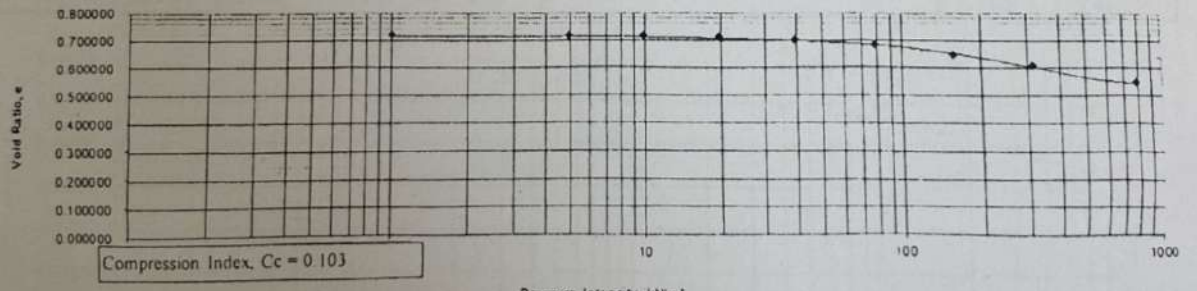
Project:New Butwal Substation
Client : Nepal Electrical Authority (NEA)
Location : Suryabasti,Nawalparasi,Nepal
Tested By: Clay Engineering Consultancy Pvt.Ltd

SAMPLE NO. : UDS-1

BOREHOLE NO. 3 DEPTH, m 4.50

Wt. of Ring + Wet soil, gm	300.93								Initial moisture content (w), %	26.87
Wt. of Ring + Dry soil, gm	273.11								Initial void ratio, eo = w.G	0.715
Wt. of Ring, gm	186.31	C2							Specific Gravity of solids (G)	2.660
Ht. of solids, 2Ho = [ho/(1+eo)], n	11.66								Initial height of sample (ho), mm	20.00
sure Intensity (kg/sq.cm)	0.05	0.10	0.20	0.40	0.80	1.60	3.20	8.00		
Pressure Intensity (kN/sq.m)	4.91	9.81	19.62	39.24	78.48	156.96	313.92	784.80		
Elapsed Time (minnutes)	Dial Gauge Reading									
0	1100.00	1099.50	1099.00	1091.40	1079.10	1057.50	1021.20	976.20		
0.5	1100.00	1099.40	1098.00	1085.00	1063.50	1029.00	994.00	924.00		
1	1100.00	1099.40	1097.00	1084.00	1062.90	1028.00	992.00	921.30		
2	1100.00	1099.40	1095.00	1083.50	1062.20	1027.50	991.00	919.00		
4	1100.00	1099.40	1094.00	1083.10	1061.90	1027.00	990.00	917.80		
8	1100.00	1099.30	1093.30	1082.90	1061.40	1026.20	988.80	916.10		
16	1100.00	1099.30	1093.40	1082.60	1061.10	1025.80	987.20	913.00		
30	1100.00	1099.20	1093.20	1082.00	1060.40	1025.00	986.00	911.40		
60	1099.90	1099.10	1093.10	1081.00	1060.00	1024.40	983.20	910.00		
120	1099.80	1099.00	1093.00	1081.00	1059.40	1023.90	980.90	909.00		
240	1099.60	1099.00	1093.00	1080.00	1058.00	1023.20	979.50	907.80		
480	1099.50	1099.00	1092.20	1080.00	1057.00	1022.00	978.40	908.00		
1440	1099.50	1099.00	1091.40	1079.10	1057.50	1021.20	976.20	903.00		

Pressure Intensity kN/sq.m	Dial Reading	Change in height mm	Ht. of sample mm [2H]	Equiv. ht. of voids [2H-2Ho]	Void ratio e=(2H-2Ho)/2Ho	m, m²/kN
1	11.00	-	20.00	8.34	0.715266	
5	11.00	0.00500	20.00	8.34	0.714837	6.40E-05
10	10.99	0.01000	19.99	8.33	0.714408	5.10E-05
20	10.91	0.08600	19.91	8.25	0.707890	3.87E-04
39	10.79	0.20900	19.79	8.13	0.697341	3.14E-04
78	10.58	0.42500	19.58	7.92	0.678816	2.75E-04
157	10.21	0.78800	19.21	7.55	0.647684	2.31E-04
314	9.76	1.23800	18.76	7.10	0.609091	1.43E-04
785	9.03	1.97000	18.03	6.37	0.546312	7.78E-05



Compression Index, Cc = 0.103

CONSOLIDATION TEST

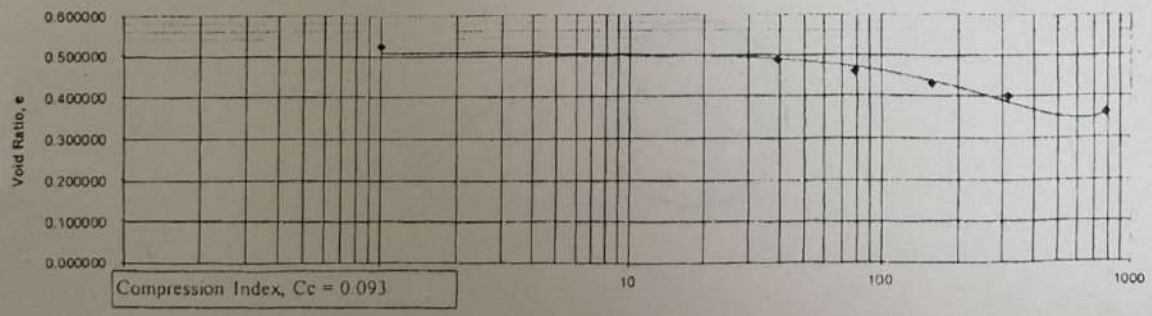
Project: New Butwal Substation
Client : Nepal Electrical Authority (NEA)
Location : Suryabasti, Nawalparasi, Nepal
Tested By: Clay Engineering Consultancy Pvt Ltd.

SAMPLE NO : UDS-1

BOREHOLE NO : 4 DEPTH, m 4.50

Wt. of Ring + Wet soil, gm	303.95					Initial moisture content (w), %			19.36
Wt. of Ring + Dry soil, gm	284.76					Initial void ratio, eo = w G			0.522
Wt. of Ring, gm	190.60					Specific Gravity of solids (G)			2.695
Ht. of solids, 2Ho = [ho/(1+eo)], n	13.14					Initial height of sample (ho), mm			20.00
sure Intensity (kg/sq.cm)	0.40	0.80	1.60	3.20	8.00				
Pressure Intensity (kN/sq.m)	39.24	78.48	156.96	313.92	784.80				
Elapsed Time (minnutes)	Dial Gauge Reading								
0	1100.00	1051.50	1015.70	978.90	935.00				
0.5	1076.00	1032.00	989.00	947.00	898.00				
1	1074.80	1028.00	988.00	945.70	894.50				
2	1072.40	1025.30	987.50	944.80	893.20				
4	1068.80	1023.20	985.00	942.90	892.40				
8	1063.00	1020.80	983.20	941.20	891.00				
16	1057.20	1019.40	982.00	939.90	890.00				
30	1054.30	1018.80	981.10	938.80	889.00				
60	1053.50	1017.60	980.20	937.90	888.50				
120	1052.40	1017.20	979.30	937.00	886.90				
240	1052.20	1016.80	979.00	936.20	886.00				
480	1051.80	1016.00	979.00	935.70	885.00				
1440	1051.50	1015.70	978.90	935.00	884.00				

Pressure Intensity kN/sq.m.	Dial Reading	Change in height mm.	Ht. of sample mm [2H]	Equiv ht. of voids [2H-2Ho]	Void ratio e=(2H-2Ho)/2Ho	m, m²/kN
1	11.00	-	20.00	6.86	0.522070	
39	10.52	0.48500	19.52	6.38	0.485160	6.34E-04
78	10.16	0.84300	19.16	6.02	0.457915	4.56E-04
157	9.79	1.21100	18.79	5.65	0.429909	2.35E-04
314	9.35	1.65000	18.35	5.21	0.396499	1.40E-04
785	8.84	2.16000	17.84	4.70	0.357686	5.42E-05



NATURAL MOISTURE CONTENT

Project:New Butwal Substation
Client : Nepal Electrical Authority (NEA)
Location : Suryabasti,Nawalparasi,Nepal
Tested By: Clay Engineering Consultancy Pvt.Ltd

Sample No.	Depth,m	Container No.	wt of container	Wet Soil (A)	Dry Soil (B)	Wt of Water WW=(A-B)	Wt of Dry Soil Wd=(B-C)	Moisture Content (%)
Bore Hole No.					1			
SPT-1	3	S4	7.23	42.5	34.34	8.16	34.34	23.76
Bore Hole No.					2			
SPT-2	3	S8	7.58	38.17	31.47	6.70	31.47	21.29
Bore Hole No.					3			
SPT-1	4.5	S3	7.45	42.26	33.11	9.15	33.11	27.64
Bore Hole No.					4			
SPT-1	4.5	Q	6.72	36.68	30.73	5.95	30.73	19.36
Bore Hole No					5			
SPT-1	4.5	S10	7.35	43.84	35.35	8.49	35.35	24.02

SPECIFIC GRAVITY TEST

Project:New Butwal Substation
Client : Nepal Electrical Authority (NEA)
Location : Suryabasti,Nawalparasi,Nepal
Tested By: Clay Engineering Consultancy Pvt.Ltd.

Borehole No.		1	
Depth, m		3.00	3.00
Wt. Pycnometer + Water + Soil	gm	190.20	187.85
Wt. Pycnometer + Water		174.34	169.03
Wt. Soil	gm	25	30
Specific Gravity of Water		0.9988	0.9998
Specific Gravity of Soil		2.732	2.683
Avg. Specific Gravity of soil		2.7075	
Borehole No.		2	
Depth, m		3.00	3.00
Wt. Pycnometer + Water + Soil	gm	187.97	187.16
Wt. Pycnometer + Water	gm	172.18	168.16
Wt. Soil	gm	25	30
Specific Gravity of Water		0.9986	0.9986
Specific Gravity of Soil		2.711	2.723
Avg. Specific Gravity of soil		2.717	
Borehole No.		3	
Depth, m		4.50	4.50
Wt. Pycnometer + Water + Soil	gm	186.99	187.91
Wt. Pycnometer + Water	gm	171.48	169
Wt. Soil	gm	25	30
Specific Gravity of Water		0.9988	0.9988
Specific Gravity of Soil		2.631	2.702
Avg. Specific Gravity of soil		2.6665	
Borehole No.		4.00	
Depth, m		4.50	4.50
Wt. Pycnometer + Water + Soil	gm	183.76	190.65
Wt. Pycnometer + Water	gm	167.93	171.84
Wt. Soil	gm	25.00	30.00
Specific Gravity of Water		0.9988	0.9988
Specific Gravity of Soil		2.723	2.678
Avg. Specific Gravity of soil		2.7005	
Borehole No.		5.00	
Depth, m		4.50	4.50
Wt. Pycnometer + Water + Soil	gm	183.76	189.88
Wt. Pycnometer + Water	gm	168.05	170.67
Wt. Soil	gm	25.00	30.00
Specific Gravity of Water		0.9986	0.9986
Specific Gravity of Soil		2.687	2.776

TATA PROJECTS LIMITED

Grain Size Analysis

Test Meth : IS: 2720 (Part 4) - 1985

Project:New Butwal Substation

Borehole -1 - SPT 2

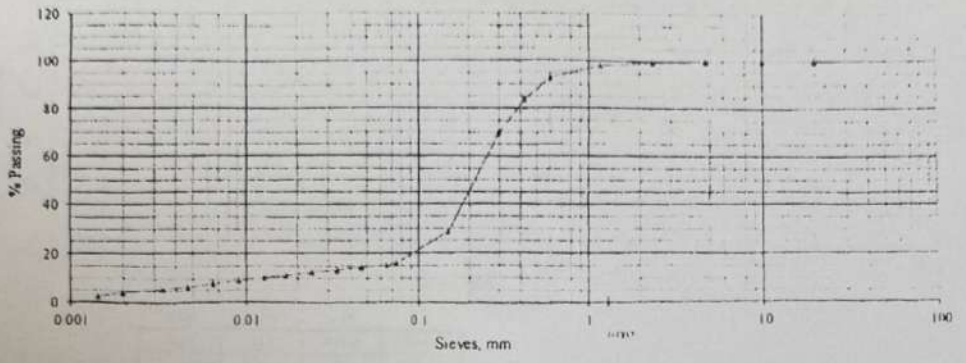
Client : Nepal Electrical Authority (NEA)

Depth 3.00 m

Location : Suryabasti,Nawalparasi,Nepal

Tested By: Clay Engineering Consultancy Pvt.Ltd.

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	97.72
2.360 mm	96.13
1.180 mm	95.45
0.600 mm	95.27
0.425 mm	95.15
0.300 mm	94.96
0.150 mm	94.45
0.075 mm	93.52
0.065 mm	90.46
0.047 mm	87.50
0.033 mm	81.56
0.024 mm	75.63
0.017 mm	66.73
0.013 mm	54.87
0.009 mm	48.94
0.007 mm	43.01
0.005 mm	37.07
0.003 mm	34.11
0.002 mm	31.14
0.001 mm	28.18



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
31.1 %	62.38 %	4.2 %	2.3 %

Grain Size Analysis

Test Meth : IS: 2720 (Part 4) - 1985

Project:New Butwal Substation

Borehole -2 - SPT 1

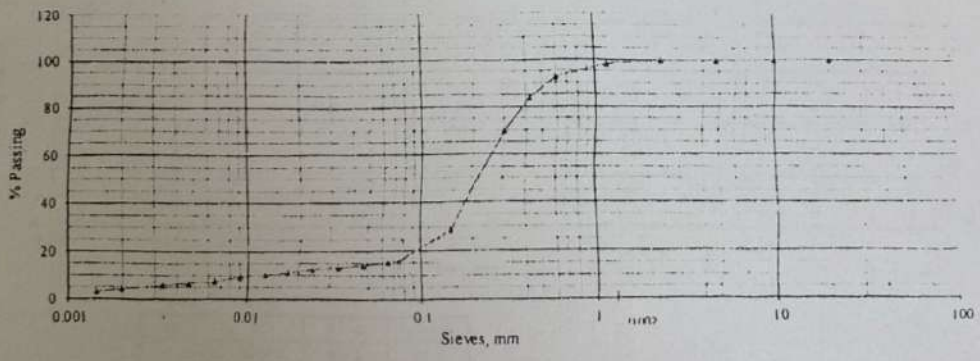
Client : Nepal Electrical Authority (NEA)

Depth 3.00 m

Location : Suryabasti,Nawalparasi,Nepal

Tested By: Clay Engineering Consultancy Pvt.Ltd.

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	99.36
2.360 mm	99.36
1.180 mm	98.89
0.600 mm	98.68
0.425 mm	98.59
0.300 mm	98.49
0.150 mm	98.22
0.075 mm	97.59
0.066 mm	91.11
0.047 mm	88.02
0.033 mm	84.93
0.024 mm	81.84
0.017 mm	78.76
0.013 mm.	63.31
0.009 mm	47.87
0.007 mm	41.69
0.005 mm	38.61
0.003 mm	37.06
0.002 mm	35.52
0.001 mm	32.43



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
35.5 %	62.07 %	1.8 %	0.6 %

Grain Size Analysis

Test Meth : IS: 2720 (Part 4) - 1985

Project:New Butwal Substation

Borehole -3 - SPT 3

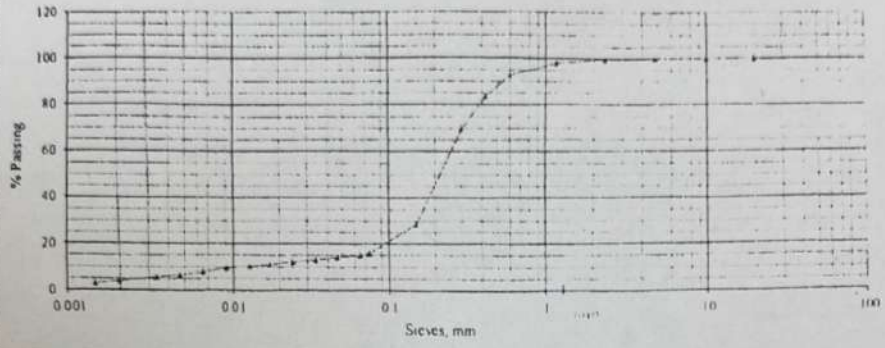
Client : Nepal Electrical Authority (NEA)

Depth 4.50 m

Location : Suryabasti,Nawalparasi,Nepal

Tested By: Clay Engineering Consultancy Pvt.Ltd.

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	99.74
2.360 mm	99.63
1.180 mm	99.57
0.600 mm	99.57
0.425 mm	99.57
0.300 mm	99.46
0.150 mm	99.37
0.075 mm	98.64
0.065 mm	96.28
0.047 mm	93.12
0.033 mm	89.96
0.024 mm	83.65
0.017 mm	77.34
0.013 mm	58.40
0.009 mm	50.51
0.006 mm	61.55
0.005 mm	42.61
0.003 mm	39.46
0.002 mm	36.30
0.001 mm	33.14



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
36.3 %	62.34 %	1.1 %	0.3 %

Grain Size Analysis

Test Meth : IS: 2720 (Part 4) - 1985

Client : Nepal Electrical Authority (NEA)

Borehole -4 - SPT 3

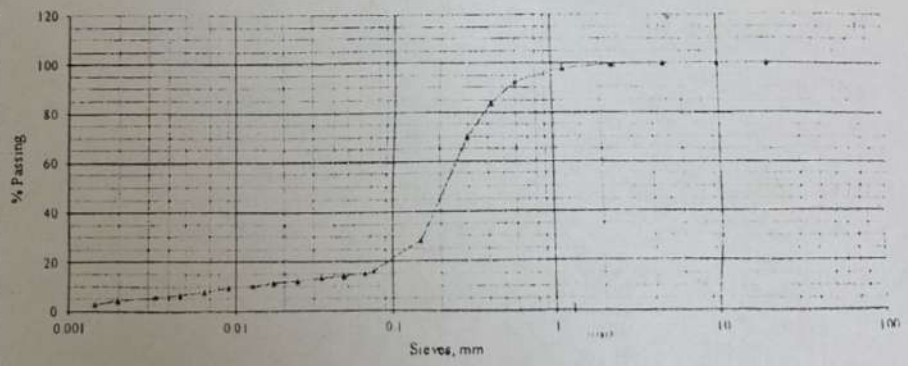
Client : Nepal Electrical Authority (NEA)

Depth 4.50 m

Location : Suryabasti,Nawalparasi,Nepal

Tested By: Clay Engineering Consultancy Pvt.Ltd.

Sieve	% Passing
20.000 mm	100.00
10.000 mm	100.00
4.750 mm	100.00
2.360 mm	100.00
1.180 mm	99.92
0.600 mm	99.83
0.425 mm	99.83
0.300 mm	99.73
0.150 mm	99.59
0.075 mm	91.75
0.065 mm	88.88
0.047 mm	85.97
0.033 mm	83.05
0.024 mm	77.22
0.017 mm	68.48
0.013 mm	53.91
0.009 mm	39.34
0.007 mm	36.43
0.005 mm	37.88
0.003 mm	36.43
0.002 mm	33.51
0.001 mm	33.51



0.002	0.075	4.75	
CLAY	SILT	SAND	GRAVEL
33.5 %	58.24 %	8.2 %	0.0 %

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