No.

バングラデシュ国
ベラマラ ガスタービン火力発電所
建設計画調査

ファイナルレポート
（付属書）

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Japan International Cooperation Agency (JICA)

FEASIBILITY STUDY ON BHERAMARA 450MW COMBINED CYCLE POWER STATION IN BANGLADESH

REPORT

ON

SOIL INVESTIGATION IN THE AREA OF PROPOSED 450 MW BHERAMARA COMBINED CYCLE POWER STATION

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1.0. INTRODUCTION

The Soil Investigation Report has been prepared under the Contract "Topographic Survey and Soil Investigation under the JICA Study on 450MW Bheramara Combined Cycle Power Station" signed on 6th June, 2008. According to contract EAL carried out a detail work such as, boring, sampling, SPT test, laboratory test etc. for 8 (Eight) bore holes in the proposed area of Site-A. Site-B and 1 (One) bore hole near the bank of Padma River during the period from 10th June, 2008 to 20th July, 2008. The subsurface investigation work includes execution of nine borings each extending upto the depth of 30.0m, performance of the varieties of field and the laboratory tests, evaluation of the Bearing Capacity and finally recommendation for safe and appropriate type of foundation suited to the subsoil conditions. The information obtained from carrying out the above subsurface investigation programme, are provided in detail, in the following sections.

2.0. LOCATION

The proposed 450 M.W. Bheramara Combined Cycle Power Station project will be located at Bheramara in the District of Kustia, Bangladesh. The exact location is Latitude between 23°-59′-59″ and 24°-0′-1″ North and Longitude between 88°-59′-59″ and 89°-0′-0″ East. 9 (Nine) positions of boreholes have been shown in the drawing enclosed under **Annex-1.**

3.0. OBJECTIVES

The purposes of subsoil investigation programme are to obtain the following information.

I. To stratify the formation of soil.

II. To record the level of ground water.

III. To evaluate the safe bearing capacities of the foundation at different layers, encountered at different Borehole positions.

IV. To determine the homogeneity of soil in the plant area.

V. Finally, to suggest for the safe and appropriate type of foundation for the prevailing subsoil condition.

4.0. METHODOLOGY

Locations of 9 (Nine) bores to be carried out were selected by TEPSCO. The bores extending upto the depth of 30.0m have been executed as per TOR. The method of Wash Boring was followed in drilling the Boreholes. The soil samples in the disturbed state usually have been extracted from depth at every 1.0m interval upto the depth of the investigation for each Borehole. No specimen of soil samples, in the undisturbed state could be collected due to the non-cohesive nature of the investigated soil. The above soil samples have been collected simultaneously with performance of Standard Penetration Test (SPT). The test includes dropping of a hammer weighing 63.5 kg (140 lbs.) and falling freely over a constant height of 76 cm (30") along the drill pipe in order to drive the sampler attached at the end of the same. The number of Blows necessary to produce the penetration was recorded, in three different stages, each at 15cm of interval. The number of Blows required in the 2nd and 3rd 15cm. of the penetration of the sampler is called the SPT value and is represented by N. The above `N' values are shown in the Bore-log chart against the respective interval of the depth. The Reduced Level (RL) of the investigated Boreholes as well as the Ground Water Level (GWL) of the investigated Boreholes, as recorded is given in the following Table.

Table no-1: The Reduced Level (RL) and the Ground Water Level (GWL) of the investigated Boreholes.

BH	R.L	GWL	BH	R.L	GWL
BH-1	13.90m	3.60m down	BH-6	14.40m	5.00m down
BH-2	13.82m	2.85m down	BH-7	14.50m	4.90m down
BH-3	13.70m	3.10m down	BH-8	14.40m	4.40m down
BH-4	14.30m	2.90m down	BH-9	13.70m	5.25m down
BH-5	14.60m	5.10m down			

5.0. STANDARD PENETRATION TEST (SPT)

The Standard Penetration Test (SPT) is a commonly used in situ test in order to determine the consistency/Relative density of the investigated site within the shortest possible period of time. The test includes dropping of a hammer weighing 63.5 kg (140 lbs) and falling freely over a constant height of 76cm (30") along the drill pipe in order to drive the sampler attached at the end of the same. The number of the Blows, necessary to produce the penetration was recorded in three different stages each at 15 cm (6") of interval. The number of Blows required in the 2nd and 3rd six inches of the penetration of the sampler is called the SPT value and is represented by "N". The above 'N' values are shown in the Bore-log chart against the respective interval of the depth, in the case of each Boring.

The term consistency of the cohesive soil is generally used on the basis of the SPT values (N) in the following way.

N	...	...	0-2	...	...	Very Soft
N	...	...	2-4	...	...	Soft
N	...	...	4-8	...	...	Medium
N	...	...	8-15	...	...	Stiff
N	...	...	15-30	...	...	Very Stiff
N	...	...	30-50	...	...	Hard
N	...	...	>50	...	...	Very Hard

The term relative density for the non-cohesive soil is based on the SPT values (N) in the following way.

N	...	...	0-4	...	...	Very loose
N	...	...	4-10	...	...	Loose
N	...	...	10-30	...	...	Medium dense
N	...	...	30-50	...	...	Dense
N	...	...	>50	...	...	Very dense

6.0. EMPIRICAL RELATIONSHIPS OF VARIOUS SOIL PARAMETERS ON THE BASIS OF SPT (N)

a. Empirical Relationships between ϕ, Dr & γ of Non-cohesive Soil on the basis of SPT (N) Value

The empirical correlations between N (SPT value after necessary corrections) and various soil parameters such as angle of internal friction (ϕ), unit weight (γ) & relative density (D_r) for cohesion less soils may be obtained from the book Foundation analysis & Design by J.E. Bowles, 3rd edition (Ref: Table No: 3-2, Page No-100)

Table No-2. Empirical values for ϕ D_r and unit weight of granular soils based on the standard penetration number with corrections for depth and for fine saturated sands.

Description	Very loose	Loose	Medium	Dense	Very dense
Relative density D_r*	0 – 0.15	0.15 – 0.35	0.35 – 0.65	0.65 – 0.85	0.85 – 1.00
Standard penetration no-N	5-10	8-15	10-40	20-70	>50
Approx. angle of internal friction ϕ †	25 – 30°	27-32°	30-35°	35-40°	38-43°
Approx. range of moist unit weight γ, pcf	70-100†	90–115	110–130	110–140	130-150
(kN/m^3)	(11-16)	(14-18)	(17-22)	(17-22)	(20-23)

b. Empirical Relationships between qu & Consistency of Cohesive soil on the basis of standard penetration number

The empirical correlations in between N (SPT) value & various soil parameter for cohesive soil such as consistency & q_u may be obtained from the book Foundation analysis & Design by J.E. Bowles, 3rd edition (Ref: Table No: 3-3, Page No-101).

Table 3. Empirical values for q_u and consistency of cohesive soils based on the standard penetration number.

Consistency Hard	Very soft	Soft	Medium	stiff	Very stiff	
q_u, ksf	0 – 0.5	0.5 – 1.0	1.0 – 2.0	2.0 – 4.0	4.0 – 8.0	
(k Pa)	(25)	(50)	(100)	(200)	(400)	
N, standard penetration resistance	0 – 2	2 – 4	4 – 8	8 – 16	16 – 32	
γsat, pcf	100–120		110-130		120 – 140	
(kN/m^3)	(16–19)		(17-20)		(19-22)	

7.0 LABORATORY TESTS OF SOIL

7.1 Laboratory Test Done :

The following soil tests have been performed in the laboratory for proper evaluation of the soil parameters:

i	Natural Moisture Content	9 Nos.
ii.	Grain size analysis	26 Nos.
iii.	Specific Gravity	26 Nos.
iv.	Permeability Test	9 Nos.
v.	pH & Electrical Conductivity	9 Nos.
vi.	Direct Shear	18 Nos.

The Grain size analysis and the Specific Gravity tests have been carried out in order to classify/stratify the subsoil formation of the investigated site. The Direct shear tests serve data on the shear parameters such as the cohesion and the angle of the Internal friction for both of the cohesive and the non-cohesive groups of soil.

7.2 Laboratory Test Not Done :

Laboratory test of some of the items have not been Performed because of non-plastic behavior and non cohesive nature of the investigated soil throughout the depth of 30.0 m. These reasons in details against each items is given in the following table.

Sl. No.	Items of Test Not Done	Reasons for not performing the Laboratory Tests
i.	Liquid Limit, Plastic Limit	Due to non cohesive nature of soil.
iii.	Unconfined Compression test	Due to non cohesive nature of soil.
iv.	Consolidation test	Due to non cohesive nature of soil.

8.0. PHYSICAL PROPERTIES

The physical properties i.e. the colour, odour and texture and the general index properties, such as plasticity have been determined by visual inspection and from the subsequent performance of certain laboratory tests. These may be summarized as follows:

a. Subsoil Stratification

The entire sub soil formation of the project site, throughout the depth of investigation, is of non-plastic nature. These non-plastic soil comprises Blackish ash to ash coloured silty soil, sand-silt mix and finally silty fine sand up to the depth of the investigation.

b. Consistency/Relative density

The top layer of the non-plastic silty soil, extending roughly to the depth of 3.0m/4.0m (BH-1, BH-2, BH-3 & BH-4), 5.0m (BH-4) to 8.0m (BH-5, BH-6, BH-7 & BH-8) generally have been observed to be in a very loose to loose state. Further below, the layers of the non-cohesive silty soil & sand-silt mix extending to a variable depth of 8.00m to 10.0m (BH-3, BH-5 & BH-9), 12.0m/13.0m (BH-1, BH-4, BH-6 & BH-7) to 19.0m (BH-2 & BH-8) generally have been found in a medium dense and occasionally in a loose state. The subsequent deep layers of the non-cohesive sand-silt mix and silty fine sand generally have been observed in a dense and very dense state.

c. Specific Gravity

The Specific gravity of the investigated soil usually varies from 2.60 to 2.64.

d. Natural moisture content:

The water content of soil sample is the ratio of the weight of the water in the sample to its dry weight. It is usually expressed as a percentage. The soil sample is weighed both in natural state and in over dry state and the moisture content is calculated by driving the loss of weight of the sample by its dry weight.

9.0. ENGINEERING PROPERTIES

The engineering properties of the subsoil formation of the project area have been determined by the performance of the laboratory tests. The evaluated properties may be summarized as follows.

a. Angle of the Internal Friction

The values of the angle of the Internal friction, as obtained from the performance of the Direct shear tests, vary from 11.0^{o} to 36.0^{o}.

b. Permeability

The permeability (K) of the investigated soil generally varies from 2.32×10^{-4} cm/sec to 9.11×10^{-3} cm/sec (Ref : Table no-6)

10.0. GEOLOGY OF THE AREA

The project area is situated in the western part of the Bengal Fore deep, which is surrounded on its north by the Shilling Plateau in Assam in India and on its west side by the Rajmahal Hills in India. The eastern limits of the Bengal Fore deep are the Tripura Hills to the east and the Chittagong Hills to the south- east. The Bengal Fore deep is floored with Quaternary sediments deposited by the rivers of the Brahammaputra, the Meghna and their numerous associated streams and distributaries. The Bengal Basin is subsiding owing mainly to compaction of the recent sediments and is possibly due to structural down warping.

Concerning tectonics and seism city, Bangladesh is situated in one of the most active tectonic region of the world where three plates - The Indian plate, the Tibet and the Burmese Subplates are colliding and thrusting against each other. Consequently, tremendous seismic activities have been resulted in the north and east of Bangladesh and caused some major earthquakes within and outside the country. As the earthquake epicenter in Assam in India is not far from Bangladesh, it is suggested to provide sufficient margin of safety, in designing any structure.

11.0 CORRECTION OF THE FIELD SPT VALUES

In saluted silty soil, silty for sand and very fine sand, the field SPT values (N) should be corrected to N′ according to Terzaghi in the following way,

$N' = 15+(N-15)/2$ … … … … … … … … … (i)

Accordingly, the overall field SPT values have been corrected and are adopted to determine the bearing capacities of the shallow foundations or for the determination of the skin friction as well as the end bearing capacities for deep foundations.

12.0. SHALLOW FOUNDATION

As the entire subsoil formula of the project site, is non-plastic by nature, the criteria for the determinations of the bearing capacities of the shallow foundations are based on the corrected values of the field SPT. This has been done considering the general equations of the bearing capacity of the foundations as suggested by Mayerhof, which is as follows.

$q_a = \frac{N}{F_1}\ k_d \text{ x } C_w$ … … … (ii)

q_a $q_a = \frac{N}{F_2}\left(\frac{B + F_3}{B}\right)^2$ $K_d \text{ x } C_w$ … … … (iii)

Where,

q_a = Allowable Bearing Pressure in Psf or kpa (for a maximum settlement = 25.4mm).

N = Statistical average of the field SPT values (N_f) within a pressure influence zone of about 0.5 D_f above the footing base to at least 2B below the same.

k_d = $1.0 + 0.33 \text{ x } D_f / B \leq 1.33$.

C_w = Water table correction factor

D_f = Depth of the foundation.

B = Width of the foundation, B = 1.25m & 2.5m have been considered respectively for the Continuous and the Isolated footing foundation.

According to the FPS system, the F factors are as follows:

F_1 … … 0.05(in meter)

F_2 … … 0.08 “

F_3 … … 0.30 “

F_4 … … 1.20 “

Based on the above formulae, the Bearing capacities of shallow foundations including both of continuous and isolated types of footing foundations have been evaluated on the basis of the corrected values of the field SPT.

The Bearing capacities of the shallow foundations have been evaluated according to the above equations and the evaluated values are provided in the following table.

Table No-4. The allowable Bearing capacities for the shallow foundation in kn/m^2 (allowable settlement =25.4mm).

BH	D_f (m.)	N_f	N′	C^w	Continues		square	
					N_{avg}	q_a	N_{avg}	q_a
BH-1	1.0	6	6	0.50	8	101.0	9	80.40
	2.0	9	9	0.50	10	133.30	11	110.00
	3.0	12	12	0.50	14	186.60	15	157.50
	4.0	14	14	0.50	12	159.95	12	126.00
	5.0	18	17	0.50	10	133.30	9	94.50
BH-2	1.0	3	3	0.50	4	50.50	5	44.65
	2.0	4	4	0.50	5	66.65	6	60.00
	3.0	7	7	0.50	8	106.65	9	94.50
	4.0	10	10	0.50	12	159.95	13	136.50
	5.0	15	15	0.50	15	200.00	13	136.50
BH-3	1.0	5	5	0.50	6	76.00	7	62.55
	2.0	7	7	0.50	9	119.95	10	100.00
	3.0	11	11	0.50	7	93.30	7	73.50
	4.0	13	13	0.50	5	66.65	6	63.00
	5.0	4	4	0.50	5	66.65	5	52.50
BH-4	1.0	5	5	0.50	7	88.50	8	71.50
	2.0	8	8	0.50	10	133.30	11	110.00
	3.0	12	12	0.50	10	133.30	9	94.50
	4.0	14	14	0.50	10	133.30	8	84.00
	5.0	9	9	0.50	7	93.30	6	63.00
BH-5	1.0	3	3	0.50	4	50.50	5	44.65
	2.0	4	4	0.50	5	66.65	5	50.00
	3.0	7	7	0.50	7	93.30	6	63.00
	4.0	6	6	0.50	6	80.00	6	63.00
	5.0	5	5	0.50	6	80.00	5	52.50
BH-6	1.0	3	3	0.50	4	50.50	4	35.75
	2.0	4	4	0.50	5	66.65	5	50.00
	3.0	5	5	0.50	5	66.65	5	52.50
	4.0	5	5	0.50	5	66.65	5	52.50
	5.0	4	4	0.50	5	66.65	4	42.00
BH-7	1.0	3	3	0.50	4	50.50	4	35.75
	2.0	5	5	0.50	5	66.65	6	60.00
	3.0	7	7	0.50	7	93.30	6	63.00
	4.0	4	4	0.50	6	80.00	5	52.50
	5.0	5	5	0.50	5	66.65	5	52.50

Table no-4 : (Continued)

BH	D_f (m.)	N_f	N′	C^w	Continues		square	
					N_{avg}	q_a	N_{avg}	q_a
BH-8	1.0	4	4	0.50	5	63.00	6	53.60
	2.0	5	5	0.50	6	80.0	6	60.00
	3.0	8	8	0.50	7	93.30	6	63.00
	4.0	6	5	0.50	6	80.00	5	52.50
	5.0	4	4	0.50	5	66.65	4	42.00
BH-9	1.0	4	4	0.50	4	50.50	4	44.65
	2.0	6	6	0.50	7	93.30	7	70.00
	3.0	9	9	0.50	9	119.95	8	84.00
	4.0	8	8	0.50	8	106.65	9	94.50
	5.0	7	7	0.50	8	106.65	9	94.50

Note:

a. ***The above values are the Net Allowable Bearing capacities of the shallow foundation in kn/m^2 (allowable settlement =25.4mm).***

b. ***q_a = Allowable Bearing capacity for the shallow foundation in kn/m^2 (allowable settlement =25.4mm)***

c. ***BH = Borehole, D_f = Depth of the foundation,***

d. ***N_f = field SPT values, N′ =corrected value of ther field SPT, N_{avg} = Statistical average of the corrected field SPT values up to 0.5 D_f above & 2B below the foundation base***

e. ***The width B =1.25m & 2.50m have been considered respectively for the continuous and the Isolated type footing foundations.***

f. ***The position of the Ground Water Level (GWL) has been considered to be at the surface level.***

13.0. DEEP FOUNDATION

Due to the poor relative density as well as the poor bearing capacities of the topsoil roughly up to the depth of 4.00m /5.0m (BH-1, BH-2, BH-3 & BH-4) to 7.0/8.0m (BH-5, BH-6, BH-7 & BH-8) measured from the EGL, for the existing subsoil shallow foundations are not feasible to be provided. Therefore, we shall have to consider Deep foundations, preferably with Piles. As the layers of soil, up to the depth of the investigations are non-plastic by nature, the criteria for the determination of the skin friction as well as the end bearing capacities of the piles are based on the corrected values of the field SPT. This has been done considering the general equation of Mayerhof which is as following:

The values of the skin friction as well as the end Bearing capacities of the Pile for the Non-cohesive soil may be evaluated on the basis of the corrected values of the field SPT as suggested by Meyer of according to the following formulae:

$$f_{su} = q_c/200 = 4N/200 \text{ TON/ft}^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(iii)}$$

$$q_{pu} = q_c = 4N \text{ TON/ft}^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(iv)}$$

Where,

q_{pu} = Ultimate Pile End Bearing capacity

f_{su} = Ultimate Pile Skin friction

q_c = Static Cone Penetration Result

N = SPT value at the depth under consideration.

But in our case, the investigated soils are not sandy, rather these exhibit some silt materials, we may modify the above relations of Mayerhof according to Schmertmaun's (1970) observations in the following way.

$q_{pu} = q_c = 2.5$ N TON/ft^2 … … … … … (v)

$f_{su} = q_c/200 = 2.5$ N/200 TON/ft^2 … … … … … (vi)

Based on the above formulae, the skin friction as well as the end bearing capacities of the Pile have been determined and the evaluated values are provided in the Table No-5.

Table No-5: Skin friction & end bearing capacities for the driven pile in kn/m^2 (F.S. = 2.50).

Depth (m)	BH-1					BH-2				
	N_f	N′	C	f_{sa}	q_{pa}	N_f	N′	C	f_{sa}	q_{pa}
1.00	6	6	-	2.85	-	3	3	-	1.45	-
2.00	9	9	-	4.30	-	4	4	-	1.90	-
3.00	12	12	-	5.75	-	7	7	-	3.35	-
4.00	14	14	-	6.70	1340.70	10	10	-	4.80	95.65
5.00	18	17	-	8.15	1628.00	15	15	-	7.20	1436.45
6.00	10	10	-	4.80	957.65	17	16	-	7.65	1532.20
7.00	9	9	-	4.30	861.90	13	13	-	6.20	1244.95
8.00	16	16	-	7.65	1532.20	21	18	-	8.60	1723.75
9.00	21	18	-	8.60	1723.75	18	17	-	8.15	1628.00
10.0	24	20	-	9.60	1915.30	22	19	-	9.10	1819.50
11.0	27	21	-	10.05	2011.00	23	19	-	9.10	1819.50
12.0	36	26	-	12.45	2489.85	24	20	-	9.60	1915.30
13.0	40	28	-	13.40	2681.40	26	21	-	10.05	2011.00
14.0	45	30	-	14.35	2872.90	24	20	-	9.60	1915.30
15.0	20	18	-	8.60	1723.75	21	18	-	8.60	1723.75
16.0	22	19	-	9.10	1819.50	22	19	-	9.10	1819.50
17.0	27	21	-	10.05	2011.00	24	20	-	9.60	1615.30
18.0	31	23	-	11.00	2202.55	27	21	-	10.05	2011.00
19.0	34	25	-	11.95	2394.10	30	23	-	11.00	2202.55
20.0	39	27	-	12.95	2585.65	35	25	-	11.95	2394.10
21.0	42	29	-	13.90	2777.15	42	29	-	13.00	2777.15
22.0	45	30	-	14.35	2872.90	47	31	-	14.85	2968.70
23.0	48	32	-	15.30	3064.45	54	35	-	16.75	3351.75
24.0	54	35	-	16.75	3351.75	43	29	-	1300	2777.15
25.0	56	36	-	17.25	3447.50	36	26	-	12.45	2489.85
26.0	60	38	-	18.20	3639.05	41	28	-	13.40	2681.40
27.0	61	38	-	18.20	3639.05	46	31	-	14.85	2968.70
28.0	64	40	-	19.15	3830.55	51	33	-	15.80	3160.20
29.0	70	43	-	20.60	4117.85	54	35	-	16.75	3351.75
30.0	76	46	-	22.05	4405.15	60	38	-	18.20	3639.05

Table No- 5: (Continued)

Depth (m)	BH-3					BH-4				
	N_f	N′	C	f_{sa}	q_{pa}	N_f	N′	C	f_{sa}	q_{pa}
1.00	5	5	-	2.40	-	5	5	-	2.40	-
2.00	7	7	-	3.35	-	8	8	-	3.85	-
3.00	11	11	-	5.25	-	12	12	-	5.75	-
4.00	13	13	-	6.20	1244.95	14	14	-	6.70	1340.70
5.00	4	4	-	1.90	383.05	9	9	-	4.30	861.90
6.00	17	16	-	7.65	1532.20	5	5	-	2.40	478.80
7.00	24	20	-	69.60	915.30	11	11	-	5.25	1053.40
8.00	50	33	-	15.80	3160.20	16	16	-	7.65	1532.20
9.00	53	34	-	16.30	3256.00	18	17	-	8.15	1628.00
10.0	54	35	-	16.75	3351.75	20	18	-	8.60	1723.75
11.0	59	37	-	17.70	3543.25	21	18	-	8.60	1723.75
12.0	50	33	-	15.80	3160.20	23	19	-	9.10	1819.50
13.0	48	32	-	14.35	2872.90	28	22	-	10.55	2106.80
14.0	43	29	-	13.00	2777.15	33	23	-	11.00	2202.55
15.0	34	25	-	11.95	2394.10	38	27	-	12.95	2585.65
16.0	30	23	-	11.00	2202.55	41	29	-	13.00	2777.15
17.0	34	25	-	11.95	2394.10	42	29	-	13.00	2777.15
18.0	38	27	-	12.95	2585.65	37	26	-	12.45	2489.85
19.0	42	29	-	13.00	2777.15	32	23	-	11.00	2202.55
20.0	44	30	-	14.35	2872.90	39	27	-	12.95	2585.65
21.0	47	31	-	14.85	2968.70	46	31	-	14.85	2968.70
22.0	32	24	-	16.30	2298.35	52	34	-	16.30	3256.00
23.0	55	35	-	16.75	3357.75	58	37	-	17.70	3543.25
24.0	42	29	-	13.00	2777.15	49	32	-	15.30	3064.45
25.0	47	31	-	14.85	2968.70	43	29	-	13.00	2777.15
26.0	50	33	-	15.80	3160.20	37	26	-	12.45	2489.85
27.0	58	37	-	17.70	3543.25	45	30	-	14.35	2872.90
28.0	50	33	-	15.80	3160.20	52	34	-	16.30	3256.00
29.0	61	38	-	18.20	3639.05	59	37	-	17.70	3543.25
30.0	64	40	-	19.15	3830.55	64	40	-	19.15	3830.55

Note:

a. N_f *= Field SPT values, C = Cohesion, the values have been estimated on the basis of field SPT values.*

b. f_{sa} *= Allowable value of the skin friction over the pile shaft, for the Driven pile (F.S. = 2.50).*

c. q_{pa} *= Allowable value of the pile end bearing capacity for the Driven pile (F.S. = 2.50).*

d. The values of f_{sa} *and* q_{pa} *may be reduced to 50% in making the Preliminary estimate about the Carrying capacity of the Bored type R.C.C. Pile.*

Table No- 5: (Continued)

Depth (m)	BH-5					BH-6				
	N_f	N′	C	f_{sa}	q_{pa}	N_f	N′	C	f_{sa}	q_{pa}
1.00	3	3	-	1.45	-	3	3	-	1.45	-
2.00	4	4	-	1.90	-	4	4	-	1.90	-
3.00	7	7	-	3.35	-	5	5	-	2.40	-
4.00	6	6	-	2.85	574.60	5	5	-	2.40	478.80
5.00	5	5	-	2.40	478.80	4	4	-	1.90	383.05
6.00	7	7	-	3.35	670.35	5	5	-	2.40	478.80
7.00	89	9	-	4.30	861.90	6	6	-	2.85	574.60
8.00	17	16	-	7.65	1532.20	5	5	-	2.40	478.80
9.00	29	22	-	10.55	2106.80	11	11	-	5.25	1053.40
10.0	32	24	-	16.23	2298.35	13	13	-	6.20	1244.95
11.0	37	26	-	12.45	2489.55	24	20	-	9.60	1915.30
12.0	31	23	-	11.00	2202.55	38	27	-	2.65	2585.65
13.0	34	25	-	11.95	2394.10	36	29	-	12.45	2489.55
14.0	37	26	-	12.45	2489.55	38	27	-	12.95	2585.65
15.0	25	20	-	9.60	1915.30	43	29	-	13.00	2777.15
16.0	27	21	-	10.05	2011.00	48	32	-	15.30	3064.45
17.0	29	22	-	10.55	2106.80	51	33	-	15.80	3160.20
18.0	33	24	-	16.30	2298.35	39	27	-	12.95	2585.65
19.0	31	23	-	11.00	2202.55	32	24	-	16.30	2298.35
20.0	28	22	-	10.55	2106.80	30	23	-	11.00	2202.55
21.0	29	22	-	10.55	2106.80	24	19	-	9.10	1819.50
22.0	31	23	-	11.00	2202.55	24	20	-	9.60	1815.30
23.0	28	22	-	10.55	2106.80	25	20	-	9.60	1915.30
24.0	31	23	-	11.00	2202.55	28	22	-	10.55	2106.80
25.0	34	25	-	11.95	2394.10	30	23	-	11.0	2202.55
26.0	36	26	-	12.45	2489.85	35	25	-	11.95	2394.10
27.0	39	27	-	12.95	2585.65	40	28	-	13.40	2681.40
28.0	44	30	-	14.35	2872.90	44	30	-	14.35	2872.90
29.0	46	31	-	14.85	2968.70	47	31	-	14.85	2968.70
30.0	53	34	-	16.30	3256.00	53	34	-	16.30	3256.00

Note:

a. N_f *= Field SPT values, C = Cohesion, the values have been estimated on the basis of field SPT values.*

b. f_{sa} *= Allowable value of the skin friction over the pile shaft for the Driven pile (F.S. = 2.50).*

c. q_{pa} *= Allowable value of the pile end bearing capacity for the Driven pile (F.S. = 2.50).*

d. The values of fsa and qpa may be reduced to 50% in making the Preliminary estimate about the Carrying capacity of the Bored type R.C.C. Pile.

Table No-5: (Continued)

Depth (m)	BH-7					BH-8				
	N_f	N′	C	f_{sa}	q_{pa}	N_f	N′	C	f_{sa}	q_{pa}
1.00	3	3	-	1.45	-	4	4	-	1.90	-
2.00	5	5	-	2.40	-	5	5	-	2.40	-
3.00	7	7	-	3.35	-	8	8	-	3.85	-
4.00	4	4	-	1.90	383.05	6	6	-	2.85	574.60
5.00	5	5	-	2.40	478.80	4	4	-	1.90	383.05
6.00	6	6	-	2.85	574.60	5	5	-	2.40	478.80
7.00	5	5	-	2.40	478.80	7	7	-	3.35	670.35
8.00	8	8	-	3.85	766.10	15	15	-	7.20	1436.45
9.00	13	13	-	6.20	1244.95	22	19	-	9.10	1819.50
10.0	20	18	-	8.60	1723.75	27	21	-	10.05	2011.00
11.0	28	22	-	10.55	2106.80	21	18	-	8.60	1723.75
12.0	40	28	-	13.40	2681.40	18	17	-	8.15	1628.00
13.0	45	30	-	14.35	2872.90	21	18	-	8.60	1723.75
14.0	47	31	-	14.85	2968.70	23	19	-	9.10	1819.50
15.0	52	34	-	16.30	3256.00	26	21	-	10.05	2011.00
16.0	38	27	-	12.95	2585.65	23	19	-	9.10	1819.50
17.0	33	24	-	16.30	2298.35	24	20	-	9.60	1915.30
18.0	38	27	-	12.95	2585.65	26	21	-	10.05	2011.00
19.0	42	29	-	13.00	2777.15	31	23	-	11.00	2202.55
20.0	35	25	-	11.95	2394.10	38	27	-	12.95	2585.65
21.0	30	23	-	11.00	2202.55	39	27	-	12.95	2585.65
22.0	32	24	-	16.30	2298.35	41	28	-	13.40	2681.40
23.0	37	26	-	12.45	2489.55	44	29	-	13.00	2777.15
24.0	40	28	-	13.40	2681.40	46	31	-	14.85	2968.70
25.0	44	29	-	13.00	2777.15	49	32	-	15.30	3064.45
26.0	46	31	-	14.85	2968.70	52	34	-	16.30	3256.00
27.0	50	33	-	15.80	3160.20	55	35	-	16.75	3351.75
28.0	52	34	-	16.30	3256.00	59	37	-	17.70	3543.25
29.0	57	36	-	17.25	3447.50	61	38	-	18.20	3639.05
30.0	60	38	-	18.20	3639.05	66	41	-	19.65	3926.50

Note:

a. N_f *= Field SPT values, C = Cohesion, the values have been estimated on the basis of field SPT values.*

b. f_{sa} *= Allowable value of the skin friction over the pile shaft for the Driven pile (F.S. = 2.50).*

c. q_{pa} *= Allowable value of the pile end bearing capacity for the Driven pile (F.S. = 2.50).*

d. The values of f_{sa} *and* q_{pa} *may be reduced to 50% in making the Preliminary estimate about the Carrying capacity of the Bored type R.C.C. Pile.*

Table No- 5: (Continued)

Depth (m)	BH-9					BH-				
	N_f	N′	C	f_{sa}	q_{pa}	N_f	N′	C	f_{sa}	q_{pa}
1.00	4	4	-	1.90	-					
2.00	6	6	-	2.85	-					
3.00	9	9	-	4.30	-					
4.00	8	8	-	3.85	766.10					
5.00	7	7	-	3.35	670.35					
6.00	12	12	-	5.75	1149.15					
7.00	14	14	-	6.70	1340.70					
8.00	19	17	-	8.15	1628.00					
9.00	22	19	-	9.10	1819.50					
10.0	27	21	-	10.05	2011.00					
11.0	32	24	-	16.30	2298.35					
12.0	36	26	-	12.45	2489.55					
13.0	38	27	-	12.95	2585.65					
14.0	42	29	-	13.00	2777.15					
15.0	37	26	-	12.45	2489.55					
16.0	34	25	-	11.95	2394.10					
17.0	31	23	-	11.00	2202.55					
18.0	34	25	-	11.95	2394.10					
19.0	39	27	-	12.45	2585.15					
20.0	44	29	-	13.00	2777.15					
21.0	39	27	-	12.95	2585.65					
22.0	36	26	-	12.45	2489.55					
23.0	34	25	-	11.95	2394.10					
24.0	37	26	-	12.45	2489.55					
25.0	41	28	-	13.40	2681.40					
26.0	45	30	-	14.35	2872.90					
27.0	47	31	-	14.85	2968.70					
28.0	50	33	-	15.80	3160.20					
29.0	55	35	-	16.75	3351.75					
30.0	58	37	-	17.70	3543.25					

Note:

a. N_f *= Field SPT values, C = Cohesion, the values have been estimated on the basis of field SPT values.*

b. f_{sa} *= Allowable value of the skin friction over the pile shaft for the Driven pile (F.S. = 2.50)*

c. q_{pa} *= Allowable value of the pile end bearing capacity for the Driven pile (F.S. = 2.50).*

d. The values of f_{sa} *and* q_{pa} *may be reduced to 50% in making the Preliminary estimate about the Carrying capacity of the Bored type R.C.C. Pile.*

14.0 ESTIMATED CARRYING CAPACITIES OF PILES.

Table no-6a : Estimated carrying capacities of Bored R.C.C. pile in kn/m^2 (F.S=2.5)

PILE LENGTH (M)	PILE DIAMETER:457 mm								
	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6	BH-7	BH-8	BH-9
11.0	212.6	193.9	357.4	183.3	256.7	181.1	201.6	176.2	238.4
12.0	259.9	208.5	337.9	197.5	241.5	244.2	272.9	174.3	264.5
13.0	284.9	223.4	325.2	228.1	265.5	245.4	290.8	188.2	281.5
14.0	310.6	222.6	327.2	243.7	282.1	262.4	301.2	202.4	306.5
15.0	224.6	213.4	304.7	283.7	242.8	287.4	336.0	225.0	292.0
16.0	238.8	227.6	280.8	308.8	257.7	321.2	291.5	216.1	292.9
17.0	261.4	242.2	321.2	318.1	273.0	340.3	278.4	230.7	285.5
18.0	284.6	257.14	345.8	303.7	298.5	303.4	312.5	245.7	309.4
19.0	308.6	280.3	370.8	288.5	300.3	290.3	337.5	268.9	334.4
20.0	333.2	304.3	388.5	328.5	300.2	292.3	315.0	308.9	359.5
21.0	358.6	344.7	406.8	359.29	307.7	268.1	307.5	318.3	353.1
22.0	376.0	370.4	363.0	404.7	323.3	282.6	325.2	335.6	354.3
23.0	402.9	413.2	461.3	440.5	323.2	289.5	351.2	352.9	355.2
24.0	438.0	376.7	424.9	413.1	338.8	312.4	376.2	358.6	371.8
25.0	458.1	362.2	473.6	399.6	362.8	328.1	393.5	365.9	396.8

Table no-6b: Estimated carrying capacities of Bored R.C.C. pile in kn/m^2 (F.S=2.5)

PILE LENGTH (M)	PILE DIAMETER:508 mm								
	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6	BH-7	BH-8	BH-9
11.0	256.6	231.5	432.9	221.0	310.3	220.5	245.3	218.2	288.4
12.0	314.1	251.1	407.5	237.8	290.6	297.4	312.9	210.1	319.3
13.0	343.8	268.6	390.4	216.8	319.1	297.8	343.3	226.5	338.8
14.0	374.2	266.8	391.6	293.0	338.5	317.6	364.7	243.2	369.8
15.0	267.0	254.6	352.8	341.4	289.1	347.4	406.2	270.3	349.6
16.0	283.7	271.3	323.1	371.1	306.7	376.5	349.9	258.5	349.7
17.0	291.4	288.5	381.9	381.5	324.6	409.9	332.5	275.7	339.4
18.0	338.6	296.3	410.4	362.5	354.7	363.2	373.3	293.2	367.9
19.0	367.1	314.4	440.2	342.8	355.9	345.8	403.0	321.0	397.7
20.0	396.5	362.4	460.8	391.1	354.8	347.0	374.2	369.4	427.5
21.0	426.6	411.1	482.1	441.0	363.2	316.2	363.9	379.7	418.4
22.0	447.5	441.6	426.6	482.5	381.5	333.4	384.5	399.9	418.9
23.0	478.8	493.0	546.5	525.2	380.4	341.0	415.3	420.2	419.0
24.0	520.65	446.7	500.2	509.3	398.7	368.4	445.1	450.7	438.2
25.0	543.9	427.7	530.7	472.0	427.3	386.7	465.3	472.4	467.9

Table no- 7: Permeability & Electrical conductivity of soil.

BH NO.	Sample no.	Depth (m)	P^H	Electric Conductivity (μS/cm)	permeability K (cm/sec)
BH-1	P-1	0.60	-	-	6.1431×10^{-3}
	D-6	6	6.70 at 29^o c	13.40 at 28.6^o c	-
BH-2	P-2	0.60	-	-	4.432×10^{-4}
	D-4	4	6.20 at 29^o c	6.61 at 29^o c	-
BH-3	P-3	0.45	-	-	7.32×10^{-3}
	D-5	5	5.80 at 29^o c	10.42 at 28.6^o c	-
BH-4	P-4	0.45	-	-	9.11×10^{-3}
	D-2	2	5.70 at 29^o c	8.42 at $28.60^{o\ c}$	-
BH-5	P-5	0.50	-	-	5.172×10^{-3}
	D-8	8	6.50 at 29^o c	11.62 at 28.6^o c	-
BH-6	P-6	0.60	-	-	2.114×10^{-3}
	D-2	2	6.40 at 29^o c	8.84 at 29^o c	-
BH-7	P-7	0.70	-	-	2.32×10^{-4}
	D-4	4	6.10 at 29^o c	7.21 at 29^o c	-
BH-8	P-8	0.45	-	-	4.45×10^{-4}
	D-3	3	5.80 at 29^o c	6.91 at 28.6^o c	-
BH-9	P-9	0.50	-	-	8.17×10^{-2}
	D-7	7	6.60 at 29^o c	12.60 at 28.6^o c	-

15.0. CONCLUSIONS

The following conclusions may be drawn regarding the subsoil formation of the project area.

a. The layers of soil have been found regular in between the Boreholes.

b. The entire sub soil formation of the project site, thorough out up to the depth of the investigation, is of non-plastic nature.

c. These non-plastic soil comprises silty soil, sand-silt mix and finally silty fine sand up to the depth of the investigation.

d. The top layer of the non-plastic silty soil, extending roughly to the depth of 3.0m/4.0m (BH-1, BH-2, BH-3 & BH-4), 5.0m (BH-4) to 8.0m (BH-5, BH-6, BH-7 & BH-8) generally have been observed to be in a very loose to loose state.

e. Further below, the layers of the non-cohesive silty soil & sand-silt mix extending to a variable depth of 8.00m to 10.0m (BH-3, BH-5 & BH-9), 12.0m/13.0m (BH-1, BH-4, BH-6 & BH-7) to 19.0m (BH-2 & BH-8) generally have been found in a medium dense and occasionally in a loose state.

f. The subsequent deep layers of the non-cohesive sand-silt mix and silty fine sand generally have been observed in a dense and very dense state.

g. Due to the poor relative density as well as the poor bearing capacities of the investigated soils roughly up to the depth of 4.00m /5.0m (BH-1, BH-2, BH-3 & BH-4) to 7.0/8.0m (BH-5, BH-6, BH-7 & BH-8) measured from the EGL, the shallow foundations are not feasible to be provided, for the existing subsoil condition.

h. Therefore, we shall have to consider the Deep foundation, preferably with Piles.

i. The required values of the skin friction as well as the end bearing capacities of the pile (Driven type) are provided in the table No-5.

j. Moreover, the carrying capacities of the Bored R.C.C. piles have also been estimated and the evaluated values are Table no-6a & 6b.

16.0 RECOMMENDATIONS

The following recommendations are suggested for construction of the proposed **450 M.W. Bheramara Combined Cycle Power station** at Bheramara, District of Kustia, Bangladesh.

a. Deep foundations, preferably with piles are required.

b. The Bored type R.C.C. Piles are the most appropriate type of Deep foundation for the existing subsoil condition and may be provided from the EGL.

c. Values of the skin friction as well as the end bearing capacities of the piles (Driven type) are provided in the Table no-5.

d. Moreover, Carrying capacities of the Bored R.C.C. piles for different diameters/embedment lengths have also been estimated and are provided in the Table No-6a & 6b.

e. Carrying capacities of the Bored R.C.C. Piles to be calculated from the table values (Ref: Table no-5) or estimated from the table values (Ref: Table No-6a & 6b) must be confirmed by carrying out load test, covering the entire building area.

Note:

a. 1 Ton = 2,000 Lbs., 1 Tsf = 95.764 kn/m^2, 1 kg/cm^2 = 98.0665 kn/m^2, 1 kg/cm^2= 0.97653 Tsf, EGL = Existing Ground Level.

b. The designer may select any other alternative type, depth as well as the Bearing capacity of the foundation or the method of improving the topsoil, according to his requirements, in the light of information provided in this report.

BORE LOG

Client : TEPSCO
Project : Feasibility Study on 450 M.W. combined cycle power Station at Bheramara.
Location :Bheramara Power Station Area, Kustia, Bheramara.

Borehole No. : BH-1 (One)
Boring Depth : 30.0m.
R.L. : 13.90m.
G.W.L. : 3.60m below
Date : 09-06-2008 & 10-06-2008

Sample Depth (Thick)	Depth (m.)	Sample Type & No.	Description of Materials	BORE LOG	Standard Penetration Test Values 15 cm	15 cm	15 cm	30 cm	S. P. T.
			Extg. G.L.						10 20 30 40 50 60 70
(3.0)	1.0	D-1	Blackish ash very loose SILT, some fine sand.		2	2	4	6	
	2.0	D-2			2	4	5	9	
3.0	3.0	D-3			4	5	7	12	
	4.0	D-4	Ash coloured medium dense & loose SILT, & fine SAND		4	5	9	14	
(5.0)	5.0	D-5			6	7	11	18	
	6.0	D-6			3	4	6	10	
	7.0	D-7			3	5	5	11	
8.0	8.0	D-8			5	7	9	16	
	9.0	D-9	Ash coloured medium dense & dense silt little, fine SAND.		6	9	12	21	
	10.0	D-10			6	10	14	24	
	11.0	D-11			9	10	15	27	
(7.0)	12.0	D-12			12	16	20	36	
	13.0	D-13			13	18	22	40	
	14.0	D-14			15	20	25	45	
15.0	15.0	D-15			6	9	11	20	
	16.0	D-16	Ash coloured medium dense to dense SILT, little fine sand		6	10	12	22	
	17.0	D17			7	12	15	27	
(4.0)	18.0	D18			9	13	18	31	
	19.0	D-19			9	14	20	34	
19.0	20.0	D-20	Ash coloured dense to very dense SILTY FINE SAND.		11	16	23	39	
	21.0	D-21			12	17	25	42	
	22.0	D-22			12	19	26	45	
	23.0	D-23			12	20	28	48	
	24.0	D-24			14	23	31	54	
(8.0)	25.0	D-25			14	24	32	56	
	26.0	D-26			16	26	34	60	
	27.0	D27			16	26	35	61	
	28.0	D-28			16	27	37	64	
	29.0	D-29			18	30	40	70	
30.0	30.0	D-30			19	32	44	76	

Client : TEPSCO
Project : Feasibility Study on 450 M.W. combined cycle power Station at Bheramara.
Location :Bheramara Power Station Area, Kustia, Bheramara.

Borehole No. : BH-2 (Two)
Boring Depth : 30.0m.
R.L. : 13.82m.
G.W.L. : 2.85m below
Date : 14-06-2008 & 15-06-2008

Sample Depth (Thick)	Depth (m.)	Sample Type & No.	Description of Materials	BORE LOG	Standard Penetration Test Values 15 cm	15 cm	15 cm	30 cm	S. P. T. 10 20 30 40 50 60 70
			Extg. G.L.						
	1.0	D-1			0	1	2	3	
(4.0)	2.0	D-2	Blackish ash very loose SILT, little fine sand.		1	2	2	4	
	3.0	D-3			2	3	4	7	
4.0	4.0	D-4			3	4	6	10	
	5.0	D-5	Ash coloured occasionally loose medium dense SILT, little/some fine SAND		5	6	9	15	
	6.0	D-6			5	7	10	17	
	7.0	D-7			5	5	7	13	
	8.0	D-8			6	9	12	21	
(11.0)	9.0	D-9			6	8	10	18	
	10.0	D-10	Ash coloured medium dense SILT& fine SAND		7	10	12	22	
	11.0	D-11			7	9	14	23	
	12.0	D-12			8	10	14	24	
	13.0	D-13			8	11	15	26	
	14.0	D-14			7	10	14	24	
	15.0	D-15			7	9	12	21	
15.0	16.0	D-16			8	9	13	22	
	17.0	D17			9	10	14	24	
(4.0)	18.0	D18	Ash coloured medium dense SILT, little/some fine sand		10	12	15	27	
	19.0	D-19			10	13	17	30	
19.0	20.0	D-20			12	15	20	35	
	21.0	D-21			14	18	24	42	
	22.0	D-22			14	20	27	47	
	23.0	D-23			16	23	31	54	
	24.0	D-24			12	19	24	43	
(11.0)	25.0	D-25			11	16	20	36	
	26.0	D-26	Ash coloured dense to very dense SILTY FINE SAND.		12	18	23	41	
	27.0	D27			14	21	25	46	
	28.0	D-28			14	23	28	51	
	29.0	D-29			15	24	30	54	
	30.0	D-30			15	26	34	60	
30.0									

Client : TEPSCO
Project : Feasibility Study on 450 M.W. combined cycle power Station at Bheramara.
Location :Bheramara Power Station Area, Kustia, Bheramara.

Borehole No. : BH-3 (Three)
Boring Depth : 30.0m.
R.L. : 13.70m.
G.W.L. : 3.10m below
Date : 16-06-2008 & 17-06-2008

Sample Depth (Thick)	Depth (m.)	Sample Type & No.	Description of Materials	BORE LOG	Standard Penetration Test Values 15 cm	15 cm	15 cm	30 cm	S. P. T. 10 20 30 40 50 60 70
			Extg. G.L.						
(3.0)	1.0	D-1	Blackish very loose SILT, little fine sand.		1	2	3	5	
	2.0	D-2			2	3	5	7	
3.0	3.0	D-3			3	5	6	11	
	4.0	D-4			3	6	7	13	
(5.0)	5.0	D-5	Ash coloured occasionally loose medium dense SILT, little/some fine SAND		1	2	2	4	
	6.0	D-6			3	6	11	17	
	7.0	D-7			4	8	16	24	
8.0	8.0	D-8			14	23	27	50	
	9.0	D-9			14	24	29	53	
	10.0	D-10			15	24	30	54	
	11.0	D-11			16	26	33	59	
	12.0	D-12			14	20	30	50	
(12.0)	13.0	D-13	Ash coloured very dense and dense SILT& fine SAND		12	19	29	48	
	14.0	D-14			11	18	25	43	
	15.0	D-15			9	15	19	34	
	16.0	D-16			10	16	18	34	
	17.0	D17			10	17	21	38	
	18.0	D18			10	19	23	42	
20.0	19.0	D-19			10	20	24	44	
	20.0	D-20			12	22	25	47	
	21.0	D-21			13	24	28	52	
	22.0	D-22			13	25	30	55	
	23.0	D-23			12	19	23	42	
(10.0)	24.0	D-24	Ash coloured dense to very dense SILTY FINE SAND.		12	21	26	47	
	25.0	D-25			12	22	28	50	
	26.0	D-26			14	25	33	58	
	27.0	D27			14	26	34	60	
	28.0	D-28			14	26	35	61	
	29.0	D-29			14	28	36	64	
30.0	30.0	D-30							

Client : TEPSCO
Project : Feasibility Study on 450 M.W. combined cycle power Station at Bheramara.
Location :Bheramara Power Station Area, Kustia, Bheramara.

Borehole No. : BH-4 (Four)
Boring Depth : 30.0m.
R.L. : 14.30m.
G.W.L. : 2.90m below
Date : 17-06-2008 & 18-06-2008

Sample Depth (Thick)	Depth (m.)	Sample Type & No.	Description of Materials	BORE LOG	Standard Penetration Test Values 15 cm	15 cm	15 cm	30 cm	S. P. T.
			Extg. G.L.						10 20 30 40 50 60 70
(3.0)	1.0	D-1	Blackish ash very loose SILT, little fine sand.		2	2	3	5	
	2.0	D-2			2	3	5	8	
3.0	3.0	D-3			4	5	7	12	
	4.0	D-4			4	6	8	14	
	5.0	D-5			3	4	5	9	
(7.0)	6.0	D-6	Ash coloured medium dense and dense SILT, little/some fine SAND		2	2	3	5	
	7.0	D-7			4	5	6	11	
	8.0	D-8			5	7	9	16	
	9.0	D-9			6	8	10	18	
10.0	10.0	D-10			7	9	11	20	
	11.0	D-11			8	9	12	21	
	12.0	D-12			8	10	13	23	
	13.0	D-13			9	12	16	28	
	14.0	D-14			9	14	19	23	
(12.0)	15.0	D-15	Ash coloured medium dense to dense SILT& fine SAND		10	15	23	38	
	16.0	D-16			10	16	26	42	
	17.0	D17			8	12	15	27	
	18.0	D18			9	14	18	32	
	19.0	D-19			11	17	22	39	
	20.0	D-20			12	20	26	46	
22.0	21.0	D-21			12	22	30	52	
	22.0	D-22			14	25	33	58	
	23.0	D-23			12	20	29	49	
	24.0	D-24			10	18	25	43	
(8.0)	25.0	D-25	Ash coloured very dense SILTY FINE SAND.		9	16	21	37	
	26.0	D-26			12	20	25	45	
	27.0	D27			12	23	29	52	
	28.0	D-28			14	26	33	59	
	29.0	D-29			14	28	36	64	
30.0	30.0	D-30							

Client : TEPSCO
Project : Feasibility Study on 450 M.W. combined cycle power Station at Bheramara.
Location :Bheramara Power Station Area, Kustia, Bheramara.

Borehole No. : BH-5 (Five)
Boring Depth : 30.0m.
R.L. : 14.60m.
G.W.L. : 5.10m below
Date : 19-06-2008 & 20-06-2008

Sample Depth (Thick)	Depth (m.)	Sample Type & No.	Description of Materials	BORE LOG	Standard Penetration Test Values 15 cm	15 cm	15 cm	30 cm	S. P. T. 10 20 30 40 50 60 70
			Extg. G.L.						
	1.0	D-1			1	1	2	3	
	2.0	D-2			1	2	2	4	
	3.0	D-3			2	3	4	7	
(8.0)	4.0	D-4			2	3	3	6	
	5.0	D-5			2	2	3	5	
	6.0	D-6	Ash coloured very loose & loose SILT, little/some fine sand.		3	3	4	7	
	7.0	D-7			3	4	5	9	
	8.0	D-8			4	7	10	17	
8.0	9.0	D-9			7	13	16	29	
	10.0	D-10			8	14	18	32	
	11.0	D-11			10	16	21	37	
	12.0	D-12			10	12	16	28	
	13.0	D-13			9	15	19	34	
	14.0	D-14			11	16	21	37	
	15.0	D-15			8	10	15	25	
	16.0	D-16			8	11	16	27	
(16.0)	17.0	D17			9	12	17	29	
	18.0	D18	Ash coloured medium dense and dense SILT& fine SAND		10	15	18	33	
	19.0	D-19			9	14	17	31	
	20.0	D-20			8	12	16	28	
	21.0	D-21			8	12	17	29	
	22.0	D-22			10	13	18	31	
	23.0	D-23			9	12	16	28	
24	24.0	D-24			10	14	17	31	
	25.0	D-25			10	15	19	34	
	26.0	D-26			10	16	20	36	
	27.0	D27			12	17	22	39	
(6.0)	28.0	D-28	Ash coloured dense to very dense SILTY FINE SAND.		12	19	25	44	
	29.0	D-29			12	20	26	46	
30.0	30.0	D-30			14	23	30	53	

Client : TEPSCO
Project : Feasibility Study on 450 M.W. combined cycle power Station at Bheramara.
Location :Bheramara Power Station Area, Kustia, Bheramara.

Borehole No. : BH-6 (Six)
Boring Depth : 30.0m.
R.L. : 14.40m.
G.W.L. : 5.0m below
Date : 20-06-2008 & 21-06-2008

Sample Depth (Thick)	Depth (m.)	Sample Type & No.	Description of Materials	BORE LOG	Standard Penetration Test Values				S. P. T.
					15 cm	15 cm	15 cm	30 cm	10 20 30 40 50 60 70
			Extg. G.L.						
	1.0	D-1	Ash coloured very loose SILT, little fine sand.		1	1	2	3	
	2.0	D-2			1	2	2	4	
	3.0	D-3			1	2	3	5	
(8.0)	4.0	D-4			2	2	3	5	
	5.0	D-5			1	2	2	4	
	6.0	D-6			2	2	3	5	
	7.0	D-7			2	3	3	6	
8.0	8.0	D-8			2	2	3	5	
	9.0	D-9	Ash coloured medium dense SILT& fine SAND		3	5	6	11	
	10.0	D-10			3	6	7	13	
(4.0)	11.0	D-11			6	10	14	24	
12.0	12.0	D-12			8	18	20	38	
	13.0	D-13			7	17	19	36	
	14.0	D-14	Ash coloured medium dense to medium dense SILT& very fine SAND		9	18	20	38	
	15.0	D-15			10	20	23	43	
	16.0	D-16			10	22	26	48	
(12.0)	17.0	D17			12	23	28	51	
	18.0	D18			10	18	21	39	
	19.0	D-19			12	14	18	32	
	20.0	D-20			12	13	17	30	
	21.0	D-21			7	10	14	24	
	22.0	D-22			8	10	14	24	
	23.0	D-23			8	10	15	25	
24.0	24.0	D-24			10	12	16	28	
	25.0	D-25			10	13	17	30	
	26.0	D-26	Ash coloured dense to very dense SILTY FINE SAND.		11	15	20	35	
	27.0	D27			12	18	22	40	
(6.0)	28.0	D-28			14	20	24	44	
	29.0	D-29			14	21	26	47	
30.0	30.0	D-30			14	23	30	53	

Client : TEPSCO
Project : Feasibility Study on 450 M.W. combined cycle power Station at Bheramara.
Location :Bheramara Power Station Area, Kustia, Bheramara.

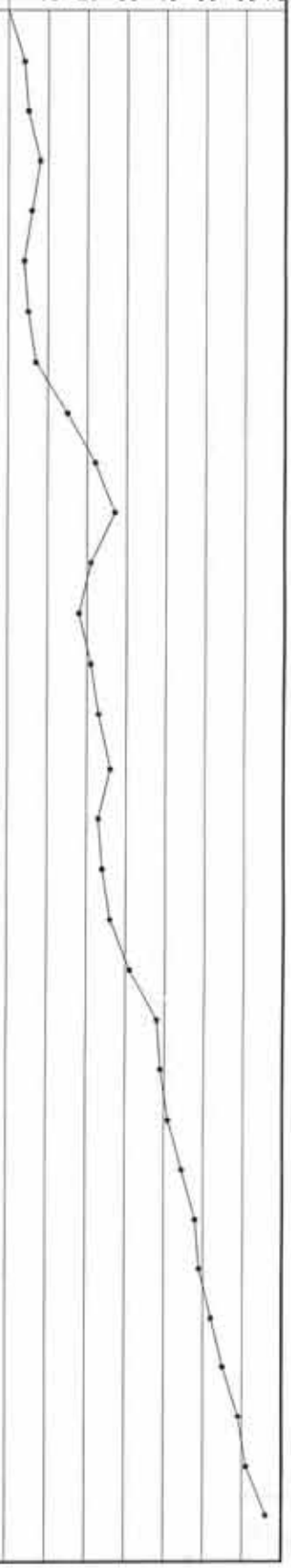
Borehole No. : BH-7 (Seven)
Boring Depth : 30.0m.
R.L. : 14.50m.
G.W.L. : 4.90m below
Date : 21-06-2008 & 22-06-2008

Sample Depth (Thick)	Depth (m.)	Sample Type & No.	Description of Materials	BORE LOG	Standard Penetration Test Values 15 cm	15 cm	15 cm	30 cm	S. P. T.
			Extg. G.L.						10 20 30 40 50 60 70
	1.0	D-1			1	1	2	3	
	2.0	D-2			1	2	3	5	
	3.0	D-3			2	3	4	7	
(8.0)	4.0	D-4	Ash coloured very loose SILT, little fine sand.		1	2	2	4	
	5.0	D-5			2	2	3	5	
	6.0	D-6			2	2	4	6	
	7.0	D-7			2	2	3	5	
8.0	8.0	D-8			2	3	5	8	
	9.0	D-9			3	4	9	13	
(4.0)	10.0	D-10			6	8	12	20	
	11.0	D-11	Ash coloured loose to medium dense dense SILT, little/some fine SAND		8	12	16	28	
12.0	12.0	D-12			10	18	22	40	
	13.0	D-13			12	20	25	45	
	14.0	D-14			12	21	26	47	
	15.0	D-15			10	23	29	52	
	16.0	D-16			10	18	20	38	
(12.0)	17.0	D17			9	14	19	33	
	18.0	D18			11	17	21	38	
	19.0	D-19	Ash coloured dense SILT & fine SAND		12	19	23	42	
	20.0	D-20			10	16	19	35	
	21.0	D-21			9	12	18	30	
	22.0	D-22			11	12	20	32	
	23.0	D-23			12	14	23	37	
24.0	24.0	D-24			12	15	25	40	
	25.0	D-25			14	17	27	44	
	26.0	D-26			14	18	28	46	
	27.0	D27			12	23	29	52	
(6.0)	28.0	D-28	Ash coloured dense to very dense SILTY FINE SAND.		14	21	31	52	
	29.0	D-29			16	23	34	57	
30.0	30.0	D-30			16	24	36	60	

Client : TEPSCO
Project : Feasibility Study on 450 M.W. combined cycle power Station at Bheramara.
Location :Bheramara Power Station Area, Kustia, Bheramara.

Borehole No. : BH-8 (Eight)
Boring Depth : 30.0m.
R.L. : 14.40m.
G.W.L. : 4.40m below
Date : 22-06-2008 & 23-06-2008

Sample Depth (Thick)	Depth (m.)	Sample Type & No.	Description of Materials	BORE LOG	Standard Penetration Test Values 15 cm	15 cm	15 cm	30 cm	S. P. T.
			Extg. G.L.						10 20 30 40 50 60 70
	1.0	D-1			1	2	3	4	
	2.0	D-2			2	2	3	5	
	3.0	D-3			3	4	4	8	
(8.0)	4.0	D-4	Ash coloured very loose SILT, little fine sand.		2	3	3	6	
	5.0	D-5			2	2	2	4	
	6.0	D-6			2	2	3	5	
	7.0	D-7			3	3	4	7	
8.0	8.0	D-8			4	6	9	15	
	9.0	D-9			6	9	13	22	
	10.0	D-10			6	11	16	27	
	11.0	D-11			5	9	12	21	
	12.0	D-12			5	8	10	18	
	13.0	D-13	Ash coloured medium dense to dense SILT& fine SAND		6	9	12	21	
	14.0	D-14			8	10	13	23	
(15.0)	15.0	D-15			10	12	14	26	
	16.0	D-16			9	11	12	23	
	17.0	D17			10	11	13	24	
	18.0	D18			8	12	14	26	
	19.0	D-19			9	14	17	31	
	20.0	D-20			11	17	21	38	
	21.0	D-21			11	17	22	39	
	22.0	D-22			12	18	23	41	
23.0	23.0	D-23			12	19	25	44	
	24.0	D-24			12	21	27	48	
	25.0	D-25	Ash coloured dense to very dense SILTY FINE SAND.		12	21	28	49	
	26.0	D-26			13	22	30	52	
(7.0)	27.0	D27			14	24	31	55	
	28.0	D-28			14	25	34	59	
	29.0	D-29			14	25	36	61	
30.0	30.0	D-30			16	27	39	66	



Client : TEPSCO
Project : Feasibility Study on 450 M.W. combined cycle power Station at Bheramara.
Location :Bheramara Power Station Area, Kustia, Bheramara.

Borehole No. : BH-9 (Nine)
Boring Depth : 30.0m.
R.L. : 13.70m.
G.W.L. : 5.25m below
Date : 23-06-2008 & 24-06-2008

Sample Depth (Thick)	Depth (m.)	Sample Type & No.	Description of Materials	BORE LOG	Standard Penetration Test Values 15 cm	15 cm	15 cm	30 cm	S. P. T.
			Extg. G.L.						10 20 30 40 50 60 70
	1.0	D-1			1	2	2	4	
	2.0	D-2	Ash coloured loose SILT & fine SAND		2	3	3	6	
(5.0)	3.0	D-3			3	4	5	9	
	4.0	D-4			3	4	4	8	
5.0	5.0	D-5			2	3	4	7	
	6.0	D-6			4	5	7	12	
(5.0)	7.0	D-7	Ash coloured medium dense SILT & fine Sand		4	6	8	14	
	8.0	D-8			6	8	11	19	
	9.0	D-9			7	9	13	22	
10.0	10.0	D-10			8	11	16	27	
	11.0	D-11			10	13	19	32	
	12.0	D-12			10	15	21	36	
	13.0	D-13			11	16	22	38	
	14.0	D-14			13	18	24	42	
	15.0	D-15			12	17	20	37	
	16.0	D-16			12	16	18	34	
	17.0	D17			10	14	19	31	
	18.0	D18	Ash coloured medium dense to dense & very dense SILTY fine SAND		10	15	19	34	
	19.0	D-19			11	15	22	39	
(20.0)	20.0	D-20			11	19	25	44	
	21.0	D-21			11	18	21	39	
22.0	22.0	D-22			9	17	19	36	
	23.0	D-23			9	16	18	34	
	24.0	D-24			10	17	20	37	
	25.0	D-25			11	19	22	41	
	26.0	D-26			11	21	24	45	
	27.0	D27			12	22	25	47	
	28.0	D-28			12	23	27	50	
	29.0	D-29			13	25	30	55	
30.0	30.0	D-30			14	26	32	58