2. FIELD INVESTIGATION

2.01. GENERAL:

In an attempt for finalisation in the design of foundation for these proposed structures to be constructed at this site, Geotechnical Investigation was envisaged. The entire Investigation programme had been divided mainly into two parts, I) Field works & II) Laboratory tests.

I) Field works unfold the sub-surface deposit types and their characteristics and

II) Laboratory tests part would help determining the relevant physical and geotechnical properties of the sub-surface deposits leading to finalisation of foundation depths of the structures and the bearing capacity with particular reference to the sub-surface types and their strength parameters and settlement potentials at the site.

A list of the bore holes with the location, ground level, standing water level etc. are presented in a tabular form below:-

Name of Structure	Bore Hole No.	Co-ordinate, (M)					Terminating Depth (M)	Standing Water Level (M)	Top of rock below EGL (M)
		Easting	Northing	Easting	Northing	E.G.L.			
--	BH-01	950	1900	9.50 A	19.00 B	158.330	20.00	7.10	7.10
--	BH-02	978	1900	9.78 A	19.00 B	155.843	20.70	7.40	7.00
--	BH-03	945	1870	9.45 A	18.70 B	158.410	20.00	7.00	5.00
--	BH-04	978	1870	9.78 A	18.70 B	156.078	20.00	5.30	5.00
--	BH-05	1092	824	10.92 A	8.24 B	151.993	15.15	1.75	2.50
--	BH-06	953	1823	9.53 A	18.23 B	158.449	13.00	6.70	7.00
--	BH-07	908	1823	9.08 A	18.23 B	158.621	15.80	7.10	4.50
--	BH-08	933	1803	9.33 A	18.03 B	158.761	15.50	7.10	5.00
--	BH-10	972	1761	9.72 A	17.61 B	154.628	15.25	3.60	2.50
--	BH-11	1012	1614	10.12 A	16.14 B	158.123	15.00	7.70	4.50
New Wet Stack-Stage 1	BH-12	1241	1568	12.41 A	15.68 B	155.104	16.00	4.00	5.70
	BH-13	1229	1551	12.29 A	15.51 B	155.215	16.50	4.65	6.00
Absorber-Stage 1	BH-14	1235	1520	12.35 A	15.20 B	155.722	17.00	4.65	5.30
RC Pumps & Oxidation Blower House-Stage 1	BH-15	1217	1523	12.17 A	15.23 B	155.940	17.50	4.80	5.50
Booster Fan-Stage 1	BH-16	1221	1489	12.21 A	14.89 B	155.966	20.00	4.70	5.80
	BH-17	1221	1468	12.21 A	14.68 B	157.195	20.00	6.35	8.00
Duct-Stage 1	BH-18	1196	1400	11.96 A	14.00 B	154.110	15.00	3.20	4.30
--	BH-19	1286	1209	12.86 A	12.09 B	151.983	15.25	2.30	7.00
Duct-Stage 2 (Unit #4)	BH-20	1038	1252	10.38 A	12.52 B	151.370	15.20	1.65	4.50
	BH-21	1056	1391	10.56 A	13.91 B	154.359	20.25	2.05	3.00
Booster Fan-Stage 2 (Unit #4)	BH-22	1056	1410	10.56 A	14.10 B	155.308	19.50	2.80	3.00
	BH-23	1065	1433	10.65 A	14.33 B	155.799	20.25	3.15	4.50
	BH-24	1044	1434	10.44 A	14.34 B	155.749	20.00	3.05	7.00
ACW & DMCW Pump Shed	BH-25	1058	1462	10.58 A	14.62 B	156.754	25.00	3.50	3.50
Compressor House	BH-26	1072	1476	10.72 A	14.76 B	156.774	18.00	3.55	4.00
Stage II	BH-27	1002	1432	10.02 A	14.32 B	155.359	20.25	3.05	3.00
New Wet Stack-Stage 2 (Unit #5)	BH-28	966	1447	9.66 A	14.47 B	155.497	20.00	3.50	2.50
Pipe & Cable Rack	BH-29	917	1476	9.17 A	14.76 B	155.242	25.00	3.10	3.00

Name of Structure	Bore Hole No.	Co-ordinate, (M)					Terminating Depth (M)	Standing Water Level (M)	Top of rock below EGL (M)
		Easting	Northing	Easting	Northing	E.G.L.			
FGD Control Room	BH-30	903	1462	9.03 A	14.62 B	155.231	19.50	3.00	3.00
Booster Fan-Stage 2 (Unit #5)	BH-31	889	1434	8.89 A	14.34 B	154.628	20.30	2.85	2.50
	BH-32	910	1434	9.10 A	14.34 B	155.388	20.00	3.10	3.50
	BH-33	901	1410	9.01 A	14.10 B	154.125	18.56	2.60	3.00
	BH-34	901	1391	9.01 A	13.91 B	153.576	20.15	2.35	3.00
Duct-Stage 2 (Unit #5)	BH-35	884	1299	8.84 A	12.99 B	152.396	15.26	2.10	2.00
Duct Near Chimney Stage 2 (Unit #6)	BH-36	799	1207	7.99 A	12.07 B	151.888	15.22	2.30	2.50
Duct-Stage 2 (Unit #6)	BH-37	851	1320	8.51 A	13.20 B	151.837	15.25	2.35	1.50
Booster Fan-Stage 2 (Unit #6)	BH-38	837	1391	8.37 A	13.91 B	154.492	20.00	2.40	4.00
	BH-39	837	1410	8.37 A	14.10 B	154.863	20.00	2.55	3.00
	BH-40	824	1433	8.24 A	14.33 B	155.221	20.00	2.70	2.50
	BH-41	840	1438	8.40 A	14.38 B	154.866	20.50	2.60	2.50
Near FGD Control Room	BH-42	831	1462	8.31 A	14.62 B	155.502	20.50	2.45	2.50
Pipe & Cable Rack	BH-43	817	1476	8.17 A	14.76 B	155.742	18.50	3.65	2.00
RC Pumps & Absorber-Stage 2 (Unit #5)	BH-44	966	1400	9.66 A	14.00 B	154.413	24.25	2.50	2.00
Duct Near Chimney Stage 2 (Unit #5)	BH-45	917	1209	9.17 A	12.09 B	151.830	20.09	1.90	2.00
Duct Near Chimney Stage 2 (Unit #4)	BH-46	1011	1209	10.11 A	12.09 B	151.926	12.79	2.00	3.00
Duct Near Chimney Stage 1	BH-47	1320	1140	13.20 A	11.40 B	152.086	20.00	2.40	6.50
Limestone Slurry Storage Tank	BH-48	345	1387	3.45 A	13.87 B	158.737	20.25	3.65	1.50
Ball Mill Building	BH-49	353	1357	3.53 A	13.57 B	158.226	20.00	3.40	1.80
Gypsum Dewatering Building	BH-50	517	1572	5.17 A	15.72 B	157.111	15.00	3.70	1.50
	BH-51	473	1572	4.73 A	15.72 B	159.272	15.00	5.35	1.30
Hydrocyclone Feed Tank, Waste Water & Filtrate Water tank	BH-52	477	1544	4.77 A	15.44 B	159.391	15.00	4.20	1.50
	BH-53	508	1544	5.08 A	15.44 B	157.538	15.00	2.50	1.50
New Wet Stack-Stage II (Unit #6)	BH-54	793	1449	7.93 A	14.49 B	157.782	17.75	2.25	5.00
Absorber-Stage 2 (Unit #6)	BH-55	781	1413	7.81 A	14.13 B	155.242	16.25	2.20	3.50
New Wet Stack-Stage II (Unit #4)	BH-56	1109	1459	11.09 A	14.59 B	155.208	19.50	2.50	5.50
Absorber-Stage II (Unit #4)	BH-57	1109	1423	11.09 A	14.23 B	154.427	19.50	2.15	2.80
Duct-Stage 1	BH-58	1233	1125	12.33 A	11.25 B	152.163	15.00	2.45	4.30
--	BH-59	500	1364	5.00 A	13.64 B	156.882	15.00	2.60	2.00
Pipe & Cable Rack	BH-60	700	1500	7.00 A	15.00 B	155.700	14.75	2.10	1.30
	BH-61	575	1500	5.75 A	15.00 B	157.178	15.00	2.95	2.00
--	IBH-5	671	1898	6.71 A	18.98 B	159.147	6.15	Not Found	--
--	IBH-6	712	1898	7.12 A	18.98 B	159.071	5.05	Not Found	--
--	IBH-8	837	1887	8.37 A	18.87 B	158.836	25.00	5.50	4.50
--	IBH-9	861	1905	8.61 A	19.05 B	158.813	25.25	5.45	5.00
--	IBH-10	886	1898	8.86 A	18.98 B	158.739	25.10	5.40	5.00

Name of Structure	Bore Hole No.	Co-ordinate, (M)					Terminating Depth (M)	Standing Water Level (M)	Top of rock below EGL (M)
		Easting	Northing	Easting	Northing	E.G.L.			
--	IBH-11	922	1898	9.22 A	18.98 B	158.599	25.05	5.25	5.00
Gypsum Belt Conveyor	IBH-12	520	1616	5.20 A	16.16 B	158.199	17.25	5.40	3.80
	IBH-13	520	1699	5.20 A	16.99 B	161.054	20.00	6.15	3.50
Pipe & Cable Rack	IBH-14	590	1434	5.90 A	14.34 B	156.185	17.25	1.80	1.50
LTP-1	IBH-15	437	1358	4.37 A	13.58 B	157.218	20.75	1.90	2.00
	IBH-16	417	1367	4.17 A	13.67 B	158.106	25.25	2.40	3.60
LBC-1A/B	IBH-17	388	1348	3.88 A	13.48 B	158.121	18.00	3.40	1.50
	IBH-18	312	1311	3.12 A	13.11 B	158.663	20.00	2.50	1.30
Limestone Crusher House	IBH-19	276	1280	2.76 A	12.80 B	158.069	14.50	2.30	0.80
	IBH-20	252	1296	2.52 A	12.96 B	159.277	17.50	2.25	1.00
Limestone Storage Silo	IBH-21	260	1317	2.60 A	13.17 B	159.298	15.75	2.30	0.80
	IBH-22	294	1333	2.94 A	13.33 B	158.956	20.75	2.50	1.20
--	PLT-04/BH	851	1253	8.51 A	12.53 B	151.979	15.00	2.30	3.50

2.02. BORING IN SOIL:

Boring was carried out by Shell and Auger method to sink nominal 150mm diameter bore holes to depths envisaged by using a mechanical winch. Undisturbed soil samples were collected at suitable intervals or at change of strata whichever is earlier by open drive sampling method since it was intended to ascertain the sub-soil characteristics.

2.03. SAMPLING:

Nominal 100 mm diameter undisturbed samples were recovered. The sampling equipment used consists of a two-tier assembly of sample tubes 450 mm in length fitted at its lower end. The sampling assembly was driven by means of a jarring link to its full length or as far downs as was found practicable. As the soil is very stiff to hard and contains sand mixtures / calcareous nodules, cutting shoe was used with a area ratio < 20%. After withdrawal the ends of the tubes were sealed with wax and capped before onward transmission to the laboratory. At close intervals in depth disturbed samples were collected for identification and logging purpose. These were tagged and packed in polythene packets and transported to the laboratory.

2.04. STANDARD PENETRATION TESTS:

Standard Penetration Tests were conducted in the bore holes at intervals of 2.0M depth (at the upper reaches due to collection of UDS) or 1m depth (at the lower reaches when no UDS could be collected) or at change of strata whichever is earlier using a split spoon sampler. The split spoon sampler used is of a Standard design having an outer diameter of 50.8 mm and inner diameter of 35 mm, driven with a monkey weighing 63.5 kgs, falling freely through

75cms. A record of the number of blows required to penetrate every 15cms to a maximum depth of 45cms was made. The first 15cm of drive are considered to be seating drive and are neglected. The total blows required for second & third 15cm of penetration is counted and termed as penetration resistance "N". On completion of a test, the split spoon sampler was opened and soil specimens were preserved in polythene bags for logging purpose.
All the boreholes were sunk with winch. However, raising of hammer for SP Tests were done manually. Hence there will not be any inertia loss and the efficiency of hammer blows should be considered as 100%.

2.05. MEASUREMENT OF WATER TABLE:

Standing water level after 24 hours of removal of casing was also noted and shown in the profile.

2.06. ROTARY CORE DRILLING IN ROCK:

This drilling technique is regarded as the most satisfactory method of assessing the character of rock formations, which lie at depth below the ground surface. Specimens of rock in the form of cylindrical cores are recovered from the drill holes by means of a core barrel. Double barrel technique is adopted according to field condition. The core barrel is provided at its lower end with a detachable shoe or core bit, which is of diamond. All rotary core bits were of NX (73mm) size.

2.07. TRIAL PITS:

1 no. Trial Pit was excavated for physical verification of subsoil with depth. The co-ordinate and ground level of the Trial Pit locations are presented below.

Trial Pit No.	Co-ordinate (M)				E.G.L. (M)	Depth (M)	Standing Water Level (M)
	Easting	Northing	Easting	Northing			
ITP-02	263	1274	2.63 A	12.74 B	159.196	1.50	Not Found

2.08. PLATE LOAD TESTS:

Total five (5) sets of Plate Load Tests were conducted **using a 450mm and 600mm square plate** (two nos. tests are of routine type & rest three nos. are of cyclic type). Tests are continued upto a maximum desired loading intensity or specified plate settlement which ever is earlier. The load is applied through a hydraulic jack. The reaction for applying the load on the plate is obtained by a loading platform with sandbags. After applying the load

increments, settlement records are made at intervals of 1, 2.25, 4, 6.25, 9, 16, 25 & 60 minutes and thereafter at an interval of an hour. Next increment of load was applied only when the rate of plate settlement reduced to 0.02 mm per minute.

In case of CPLT, when the rate of plate settlement reduced to 0.02 mm per minute, the final reading of the dial gauges is recorded. The applied load is then released and the plate allowed to rebound. When no further rebound occurs or the rate of rebound becomes negligible, the readings of the dial gauges are again noted. The load then is increased gradually till its magnitude acquires a value equal to the proposed next higher stage of loading which is to be maintained constantly and the final dial gauge readings are noted as earlier. The entire load is then reduced to zero and final dial gauge readings recorded when the rate of rebound becomes negligible.

The coordinate, ground level and depth of test locations are given below.

PLT No.	Type of Tests	Plate size (mm x mm)	Co-ordinates (M)				Ground Level (M)	Depth (M)
			Easting	Northing	Easting	Northing		
PLT-02	Routine Type	450 x 450	1196	1353	11.96 A	13.53 B	153.655	3.00
PLT-03	Routine Type		1037.84	1329.678	**Cancelled due to obstruction**			
PLT-04	Routine Type	600 x 600	858	1410	8.58 A	14.10 B	155.444	3.00
CPLT-01	Cyclic Type	600 x 600	851	1405	8.51 A	14.05 B	154.672	2.00
CPLT-02	Cyclic Type	600 x 600	1041	1400	10.41 A	14.00 B	154.267	3.00
CPLT-03	Cyclic Type	600 x 600	1234	1478	12.34 A	14.78 B	155.681	2.00

2.09. DYNAMIC CONE PENETRATION TESTS:

Total six (6 nos.) Dynamic Cone Penetration Tests were conducted at the following locations. The co-ordinates, ground level and depth of test at each DCPT locations are presented below. The DCPT values vs. depth plots are presented in Appendix.

DCPT No.	Co-ordinate (M)				E.G.L. (M)	Depth (M)	
	Easting	Northing	Easting	Northing		Starting Depth	Ending Depth
DCPT-01	972	1716	9.72 A	17.16 B	155.305	0.00	2.30
DCPT-02	1012	1561	10.12 A	15.61 B	156.418	0.00	2.90
DCPT-03	851	1366	8.51 A	13.66 B	154.055	0.00	2.40
DCPT-04	996	1215	9.96 A	12.15 B	151.907	0.00	3.00
DCPT-05	1196	1286	11.96 A	12.86 B	152.151	0.00	4.40
IDCPT-02	349	1330	3.49 A	13.30 B	158.324	0.00	1.80

2.10. FIELD PERMEABILITY TESTS:

Field Permeability Tests were conducted in three (3 nos.) borehole locations using falling head method as per IS: 5529 (Part 1). The test locations, type of test and depth of test are presented below.

Test Locations	Co-ordinates (M)				E.G.L. (M)	Type of Test	Depth of Test (M)
	Easting	Northing	Easting	Northing			
BH-01	950	1900	9.50 A	19.00 B	158.330	Falling Head	0.80 – 1.50
						Falling Head	2.70 – 3.50
						Falling Head	4.80 – 5.60
						Double Packer	7.50 – 9.00
						Double Packer	11.70 – 12.50
BH-16	1221	1489	12.21 A	14.89 B	155.966	Falling Head	0.80 – 1.30
						Falling Head	2.70 - 3.40
						Falling Head	4.80 – 5.50
						Double Packer	7.50 – 9.00
						Double Packer	11.50 – 13.00
BH-28	966	1447	9.66 A	14.47 B	155.497	Falling Head	0.80 – 1.50
						Falling Head	2.80 – 3.60
						Double Packer	4.50 – 6.00
						Double Packer	7.50 – 9.00
						Double Packer	11.00 – 12.50
BH-38	837	1391	8.37 A	13.91 B	154.492	Falling Head	0.50 – 1.20
						Falling Head	2.50 – 3.30
						Double Packer	4.50 – 6.00
						Double Packer	7.50 – 9.00
						Double Packer	11.50 – 13.00
IBH-06	712	1898	7.12 A	18.98 B	159.071	Falling Head	0.80 – 1.50
						Falling Head	2.70 – 3.40
						Falling Head	4.30 – 5.00

2.11. ELECTRICAL RESISTIVITY TESTS:

Ten (10) nos. Electrical Resistivity Tests were carried out at the following locations. The test procedure and results are presented in Section 8.

ERT	Co-ordinate (M)				E.G.L. (M)
	Easting	Northing	Easting	Northing	
ERT-01	962	1433	9.62 A	14.33 B	154.852
ERT-02	1003	1416	10.03 A	14.16 B	154.226
ERT-03	1003	1453	10.03 A	14.53 B	155.451
ERT-04	852	1437	8.52 A	14.37 B	155.276
ERT-05	1038	1437	10.38 A	14.37 B	155.386
ERT-06	1212	1515	12.12 A	15.15 B	155.925
ERT-09	924	1452	9.24 A	14.52 B	155.482

ERT	Co-ordinate (M)				E.G.L. (M)
	Easting	Northing	Easting	Northing	
ERT-10	333	1359	3.33 A	13.59 B	158.853
ERT-11	482	1561	4.82 A	15.61 B	158.760
IERT-02	265	1300	2.65 A	13.00 B	158.842

2.12. CROSS HOLE TEST:

Five (5) nos. Cross Hole Test was carried out to determine the dynamic properties of the layer for the construction of machine foundations at the following locations. The test procedure and results are presented and discussed in Section-9.

CHT No.	Co-ordinates (M)				E.G.L. (M)
	Easting	Northing	Easting	Northing	
CHT -2	817	1400	8.17 A	14.00 B	155.464
CHT -3	916	1400	9.16 A	14.00 B	153.937
CHT -4	1074	1400	10.74 A	14.00 B	154.523
CHT -5	1206	1479	12.06 A	14.79 B	155.621
CHT -6	1347	338	13.47 A	3.38 B	158.871