資料－９　地質調査に関する
再委託業者からの報告書

１．ブロバ変電所の試験結果概要

表１－１　標準貫入試験から算出した地耐力（BH01：132 kV 送電ルート上）

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH01	0.00	CLAYEY SAND						
	1.00		5	0.59	3	63	325	108
	2.00		8	0.59	5	89	456	152
	3.00		13	0.59	8	126	647	216
	4.00		17	0.67	11	167	859	286
	5.00	SILT	18	0.67	12	174	895	298
	6.00	CLAY	18	0.75	13	189	969	323
	7.00	SILTY SANDY	29	0.75	22	266	1366	455
	8.00		30	0.75	22	272	1400	467
	9.00	CLAY	33	0.75	25	292	1500	500
	10.00	SILT	46	0.75	34	371	1905	635
	11.00	CLAY	29	0.79	23	276	1418	473
	12.00	SILT	53	0.79	42	426	2188	729
	13.00	CLAY	79	0.79	62	568	2917	972
	14.00		44	0.79	35	372	1914	638
	15.00		70	0.79	55	520	2674	891
	16.00		47	0.79	37	390	2007	669
	17.00		40	0.79	32	348	1787	596
	18.00	SILT	22	0.79	17	226	1162	387
	19.00	CLAY	81	0.79	64	578	2970	990
	20.00		64	0.79	50	488	2507	836

［出所］再委託業者からの地質調査報告書（添付資料－８）

Cu=Pa・0.29・N60^0.72 ; Pa=100 kPa

Qult=5.14・Cu

Qall=Qult/3

表１－２　標準貫入試験から算出した地耐力（BH02：変電所内北側）

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH02	0.00	CLAY			0	0	0	0
	1.00	CLAYEY GRAVEL	14	0.59	8	133	682	227
	2.00	SILT	42	0.59	25	293	1505	502
	3.00		36	0.59	21	262	1347	449
	4.00		24	0.67	16	214	1101	367
	5.00		22	0.67	15	201	1034	345
	6.00		15	0.75	11	165	850	283
	7.00	SILTY GRAVEL	19	0.75	14	196	1008	336
	8.00	SILT	22	0.75	16	218	1120	373
	9.00		24	0.75	18	232	1192	397
	10.00		31	0.75	23	279	1434	478
	11.00		25	0.79	20	248	1274	425
	12.00	CLAY	20	0.79	16	211	1085	362
	13.00	SILT	36	0.79	28	322	1657	552
	14.00		29	0.79	23	276	1418	473
	15.00		22	0.79	17	226	1162	387
	16.00		21	0.79	17	219	1124	375
	17.00		26	0.79	20	255	1311	437
	18.00		35	0.79	28	316	1623	541
	19.00		43	0.79	34	366	1883	628
	20.00		44	0.79	35	372	1914	638
	21.00		36	0.79	28	322	1657	552
	22.00		44	0.79	35	372	1914	638
	23.00		46	0.79	36	384	1976	659
	24.00		22	0.79	17	226	1162	387
	25.00		32	0.79	25	296	1522	507
	26.00		75	0.79	59	547	2810	937
	27.00		73	0.79	57	536	2756	919
	28.00		73	0.79	57	536	2756	919

［出所］再委託業者からの地質調査報告書（添付資料－８）

Cu=Pa・0.29・N60^0.72 ; Pa=100 kPa

Qult=5.14・Cu

Qall=Qult/3

表１－３　標準貫入試験から算出した地耐力（BH03：220 kV 送電ルート上）

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH03	0.00	CLAYEY SAND						
	1.00	CLAY	4	0.59	2	54	277	92
	2.00		15	0.59	9	139	717	239
	3.00		13	0.59	8	126	647	216
	4.00		14	0.67	9	145	747	249
	5.00		12	0.67	8	130	668	223
	6.00	SILT	18	0.75	13	189	969	323
	7.00		15	0.75	11	165	850	283
	8.00		28	0.75	21	259	1332	444
	9.00	CLAY SAND	34	0.75	25	298	1532	511
	10.00	CLAY	43	0.75	32	353	1814	605
	11.00		20	0.79	16	211	1085	362
	12.00	SILT	26	0.79	20	255	1311	437
	13.00		35	0.79	28	316	1623	541
	14.00		30	0.79	24	283	1453	484
	15.00		37	0.79	29	329	1690	563
	16.00		34	0.79	27	309	1590	530
	17.00		39	0.79	31	341	1755	585
	18.00		37	0.79	29	329	1690	563
	19.00		27	0.79	21	262	1347	449
	20.00		38	0.79	30	335	1722	574
	21.00		44	0.79	35	372	1914	638
	22.00		43	0.79	34	366	1883	628
	23.00		37	0.79	29	329	1690	563
	24.00		47	0.79	37	390	2007	669
	25.00		Refusal	0.79	_	>450	>2300	>750
	26.00		45	0.79	35	378	1945	648
	27.00		77	0.79	61	557	2864	955
	28.00		74	0.79	58	541	2783	928
	29.00		54	0.79	43	432	2218	739

［出所］再委託業者からの地質調査報告書（添付資料－８）

Cu=Pa・0.29・N60^0.72 ; Pa=100 kPa

Qult=5.14・Cu

Qall=Qult/3

表１－４　標準貫入試験から算出した地耐力（BH04：変電所内南側）

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH04	0.00							
	1.00	CLAY	10	0.59	6	104	535	178
	2.00		8	0.59	5	89	456	152
	3.00		8	0.59	5	89	456	152
	4.00	SILT	10	0.67	7	114	586	195
	5.00	CLAY	17	0.67	11	167	859	286
	6.00		20	0.75	15	203	1046	349
	7.00		20	0.75	15	203	1046	349
	8.00		18	0.75	13	189	969	323
	9.00		13	0.75	10	149	767	256
	10.00	SILT	28	0.75	21	259	1332	444
	11.00		18	0.79	14	196	1006	335
	12.00		35	0.79	28	316	1623	541
	13.00	SILTY SAND	22	0.79	17	226	1162	387
	14.00	SILT	31	0.79	24	289	1487	496
	15.00		29	0.79	23	276	1418	473
	16.00		26	0.79	20	255	1311	437
	17.00		29	0.79	23	276	1418	473
	18.00		40	0.79	32	348	1787	596
	19.00		34	0.79	27	309	1590	530
	20.00		37	0.79	29	329	1690	563
	21.00		23	0.79	18	233	1200	400
	22.00		27	0.79	21	262	1347	449
	23.00		30	0.79	24	283	1453	484
	24.00		31	0.79	24	289	1487	496
	25.00		42	0.79	33	360	1851	617
	26.00		53	0.79	42	426	2188	729
	27.00		49	0.79	39	402	2068	689
	28.00		56	0.79	44	443	2277	759
	29.00		75	0.79	59	547	2810	937
	30.00		77	0.79	61	557	2864	955

［出所］再委託業者からの地質調査報告書（添付資料－８）

Cu=Pa・0.29・N60^0.72 ; Pa=100 kPa

Qult=5.14・Cu

Qall=Qult/3

表１－５　含水量（Natural Moisture Content）

試験方法		ASTM D4959			
		含水量 (%)			
ボーリング孔		BH1	BH2	BH3	BH4
深さ (m)	5.5 – 6.0	23.0	34.5	25.8	19.2
	10.5 – 11.0	24.5	37.3	31.0	22.1
	15.5 – 16.0	26.5	35.9	30.9	24.4
	20.5 – 21.0	28.9	29.5	29.2	29.7
	25.5 – 26.0	-	28.3	26.5	27.1
	28.5 – 29.0	-	22.6	-	-
	29.5 – 30.0	-	-	25.9	-
	30.5 – 31.0	-	-	-	22.7

［出所］再委託業者からの地質調査報告書（添付資料－８）

表１－６　液性限界・塑性限界（Liquid Limit and Plastic Limit）

試験方法		ASTM D4318			
		液性限界			
ボーリング孔		BH1	BH2	BH3	BH4
深さ (m)	5.5 – 6.0	47.4	65.6	64.9	53.9
	10.5 – 11.0	44.7	68	41.2	61.9
	15.5 – 16.0	44.8	61.3	59.9	66
	20.5 – 21.0	49.9	65.1	56.5	59.9
	25.5 – 26.0	-	62.6	57.7	54.8
	28.5 – 29.0	-	59.7	-	-
	29.5 – 30.0	-	-	61.3	-
	30.5 – 31.0	-	-	-	54.3
試験方法		ASTM D4318			
		塑性限界			
ボーリング孔		BH1	BH2	BH3	BH4
深さ (m)	5.5 – 6.0	24.4	44.6	39.8	20.1
	10.5 – 11.0	28.8	38.6	22.6	34.1
	15.5 – 16.0	28	42.6	33.7	32
	20.5 – 21.0	28.8	44	40.1	40.4
	25.5 – 26.0	-	41.7	36.6	33.9
	28.5 – 29.0	-	36.5	-	-
	29.5 – 30.0	-	-	36.3	-
	30.5 – 31.0	-	-	-	34.6

［出所］再委託業者からの地質調査報告書（添付資料－８）

表１－７　比重（Specific Gravity）

試験方法		ASTM D854			
		平均比重			
ボーリング孔		BH1	BH2	BH3	BH4
深さ (m)	5.5 – 6.0	2.595	2.732	2.650	2.795
	10.5 – 11.0	2.636	2.744	2.649	2.639
	15.5 – 16.0	2.599	2.713	2.637	2.694
	20.5 – 21.0	2.749	2.662	2.684	2.716
	25.5 – 26.0	-	2.691	2.693	2.682
	28.5 – 29.0	-	2.721	-	-
	29.5 – 30.0	-	-	2.592	-
	30.5 – 31.0	-	-	-	2.638

［出所］再委託業者からの地質調査報告書（添付資料－８）

表１－８　湿潤密度（Bulk Density）

試験方法		ASTM D2937			
		湿潤密度(Mg/㎥)			
ボーリング孔		BH1	BH2	BH3	BH4
深さ (m)	5.5 – 6.0	1.89	1.80	1.92	1.97
	10.5 – 11.0	2.00	1.70	1.83	2.01
	15.5 – 16.0	1.86	1.74	1.86	1.81
	20.5 – 21.0	1.94	1.82	1.88	1.79
	25.5 – 26.0	-	1.86	1.93	1.86
	28.5 – 29.0	-	1.71	-	-
	29.5 – 30.0	-	-	1.93	-
	30.5 – 31.0	-	-	-	1.93

［出所］再委託業者からの地質調査報告書（添付資料－８）

表１－９　一軸圧縮試験（Unconfined Compressive Strength）

試験方法		ASTM D2166			
		粘着力 Cu (kPa)			
ボーリング孔		BH1	BH2	BH3	BH4
深さ (m)	1.5 – 2.0	-	-	44	70
	3.0 – 4.0	-	33	-	-
	5.5 – 6.0	23.4	23	-	-
	7.5 – 8.0	-	-	35	-
	10.5 – 11.0	14	20	-	38
	11.5 – 12.0	-	-	-	20
	15.5 – 16.0	26	30	-	-
	18.5 – 19.0	-	-	31	-
	19.5 – 20.0	-	-	-	25
	23.5 – 24.0	-	-	-	37
	24.5 – 25.0	-	41	-	-
	25.5 – 26.0	-	-	44	-
	28.5 – 29.0	-	46	-	-
	29.5 – 30.0	-	-	24	-
	30.5 – 31.0	-	-	-	19

［出所］再委託業者からの地質調査報告書（添付資料－８）

表１－１０　三軸圧縮試験（Unconsolidated Undrained Triaxial Test）

試験方法		ASTM D2850 and D4767			
		粘着力 Cu (kPa)			
ボーリング孔		BH1	BH2	BH3	BH4
深さ (m)	5.5 – 6.0	68	60	118	133
	10.5 – 11.0	28	40	73	34
	15.5 – 16.0	31	36	55	84
	20.5 – 21.0	74	29	51	31
	25.5 – 26.0	-	100	-	86
	28.5 – 29.0	-	66	-	-
	29.5 – 30.0	-	-	-	-
	30.5 – 31.0	-	-	-	60

［出所］再委託業者からの地質調査報告書（添付資料－８）

表１－１１　圧密試験（Consolidation Test）

Borehole No.:	Depth (m)	Pre-Consolidation pressure (kN/m^2)	Overburden Pressure (kN/m^2)	Compression Index, C_c	Coefficient of Volume Compressibility Mv (m^2/MN)			Coefficient of Consolidation C_v (cm^2/sec)			Permeability, k (m/s) $x10^{-9}$		
					Min	*Max*	*Ave*	*Min*	*Max*	*Ave*	*Min*	*Max*	*Ave*
BH 01	5.5-6.0	200.0	101.9231	0.106	0.054	0.218	0.122	0.005	0.01	0.009	0.260	2.111	1.184
	10.5-11.0	210.0	206.4796	0.123	0.048	0.428	0.211	0.004	0.01	0.006	0.309	1.888	1.190
	15.5-16.0	282.11	282.1073	0.077	0.018	0.334	0.150	0.002	0.020	0.013	0.035	6.712	2.547
	20.5-21.0	390.6	390.6	0.153	0.056	0.123	0.079	0.001	0.003	0.002	0.108	0.225	0.169
BH 02	5.5-6.0	320.0	96.9883	0.469	0.085	0.395	0.165	0.003	0.010	0.006	0.257	1.493	0.857
	10.5-11.0	250.0	175.2315	0.108	0.036	0.200	0.123	0.012	0.018	0.015	0.410	3.172	1.895
	15.5-16.0	265.1	265.1	0.032	0.012	0.066	0.039	0.001	0.006	0.003	0.016	0.225	0.099
	20.5-21.0	366.4	366.3702	0.114	0.026	0.249	0.120	0.008	0.014	0.011	0.248	1.855	1.249
	25.5-26.0	465.5	465.5	0.108	0.039	0.239	0.133	0.009	0.016	0.012	0.329	3.855	1.783
	28.5-29.0	477.1	477.1	0.158	0.040	0.184	0.098	0.003	0.015	0.008	0.118	2.636	1.023
BH 03	5.5-6.0	200.0	103.484	0.075	0.036	0.095	0.060	0.0012	0.0015	0.0014	0.050	0.137	0.083
	10.5-11.0	205.0	188.0236	0.077	0.028	0.186	0.098	0.009	0.022	0.017	0.238	4.018	1.915
	15.5-16.0	283.3	283.3	0.103	0.042	0.306	0.145	0.016	0.021	0.017	0.852	4.730	2.301
	20.5-21.0	377.7	377.7	0.159	0.056	0.356	0.173	0.012	0.020	0.016	0.638	5.764	2.740
	25.5-26.0	483.1	483.1	0.212	0.079	0.251	0.135	0.004	0.007	0.006	0.490	0.913	0.671
	29.5-30.0	558.5	558.5	0.114	0.055	0.092	0.075	0.006	0.016	0.010	0.422	1.064	0.732
BH 04	5.5-6.0	260.0	106.4684	0.059	0.025	0.064	0.040	0.002	0.006	0.003	0.048	0.162	0.106
	10.5-11.0	260.0	206.5851	0.077	0.041	0.128	0.079	0.001	0.004	0.002	0.040	0.486	0.178
	15.5-16.0	274.8	274.8	0.138	0.062	0.217	0.147	0.003	0.007	0.005	0.382	0.816	0.602
	20.5-21.0	359.2	359.2	0.237	0.085	0.334	0.211	0.003	0.010	0.005	0.546	0.864	0.724
	25.5-26.0	464.2	464.2	0.182	0.095	0.537	0.287	0.002	0.003	0.002	0.268	1.143	0.627
	30.5-31.0	578.7	578.7	0.105	0.055	0.194	0.126	0.005	0.007	0.006	0.360	1.111	0.722

［出所］再委託業者からの地質調査報告書（添付資料－８）

２．カワラ変電所

表２－１　標準貫入試験から算出した地耐力（BH01：変電所内北側）

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH01	0.00	Moderate Reddish Brown imported fill Sandy Fat Gravel	0	0.00	0	0	0	0
	1.50		5	0.59	3	63	325	108
	2.50	Reddish Brown Sandy Fat Clay	3	0.59	2	44	225	75
	3.50		6	0.59	4	72	371	124
	4.50		5	0.67	3	69	356	119
	5.50		7	0.67	5	88	453	151
	6.50		7	0.75	5	96	491	164
	7.50		6	0.75	4	85	439	146
	8.50		12	0.75	9	141	724	241
	9.50		13	0.75	10	149	767	256
	10.50		17	0.75	13	181	930	310
	11.50	Yellowish Orange coarse grained Clayey Sandy	12	0.79	9	146	751	250
	12.50		26	0.79	20	255	1311	437
	13.50		14	0.79	11	163	839	280
	14.50		33	0.79	26	303	1556	519
	15.50	Yellowish Orange Sandy Silt	25	0.79	20	248	1274	425
	16.50		28	0.79	22	269	1382	461
	17.50		35	0.79	28	316	1623	541
	18.50		36	0.79	28	322	1657	552
	19.50		29	0.79	23	276	1418	473
	20.50		37	0.79	29	329	1690	563
	21.50		18	0.79	14	196	1006	335
	22.50		42	0.79	33	360	1851	617
	23.50		Refusal	0.79	_	>450	>2300	>750
	24.50		42	0.79	33	360	1851	617
	25.50		43	0.79	34	366	1883	628
	26.50		45	0.79	35	378	1945	648
	27.50		53	0.79	42	426	2188	729
	28.50	Sandy Clay highly weathered Pink Greenish Grey weak rock	56	0.79	44	443	2277	759
	29.50		46	0.79	36	384	1976	659
	30.50		Refusal	0.79	_	>450	>2300	>750

［出所］再委託業者からの地質調査報告書（添付資料－８）

Cu=Pa・0.29・N60^0.72 ; Pa=100 kPa

Qult=5.14・Cu

Qall=Qult/3

表２－２　含水量（Natural Moisture Content）

試験方法		ASTM D4959
		含水量 (%)
ボーリング孔		BH1
深さ (m)	3.0	26.2
	5.0	22
	6.0	22.7
	10.0	19
	11.0	21.5
	12.0	10.9
	15.0	19.3
	16.0	25.8
	18.0	24.2
	20.0	25.8
	24.0	22.6
	25.0	20.7
	27.0	22
	30.0	17.6

［出所］再委託業者からの地質調査報告書（添付資料－８）

表２－３　液性限界・塑性限界（Liquid Limit and Plastic Limit）

試験方法		ASTM D4318	
		液性限界(%)	塑性限界 (%)
ボーリング孔		BH1	BH1
深さ (m)	5.0	53.9	26.4
	10.0	57.7	31.6
	11.0	57.5	29.6
	15.0	53.2	31.3
	20.0	57.1	35.9
	30.0	42.1	24.1

［出所］再委託業者からの地質調査報告書（添付資料－８）

表２－４　比重（Specific Gravity）

試験方法		ASTM D854
		平均比重
ボーリング孔		BH1
深さ (m)	5.0	2.45
	10.0	2.48
	11.0	2.65
	15.0	2.61
	20.0	2.62
	30.0	2.55

［出所］再委託業者からの地質調査報告書（添付資料－８）

表２－５　湿潤密度（Bulk Density）

試験方法		ASTM D2937
		湿潤密度 (kg/m^3)
ボーリング孔		BH1
深さ (m)	5.0	1903.0
	10.0	1903.0
	11.0	1969.6
	15.0	1972.7
	20.0	1856.9

［出所］再委託業者からの地質調査報告書（添付資料－８）

表２－６　一軸圧縮試験（Unconfined Compressive Strength）

試験方法		ASTM D2166
		粘着力 Cu (kPa)
ボーリング孔		BH1
深さ (m)	5.0	24
	10.0	10
	11.0	54
	15.0	42.7
	20.0	33

［出所］再委託業者からの地質調査報告書（添付資料－８）

表２－７　三軸圧縮試験（Unconsolidated Undrained Triaxial Test）

試験方法		ASTM D2850 and D4767
		粘着力 Cu (kPa)
ボーリング孔		BH1
深さ (m)	5.0	53
	10.0	76
	15.0	14
	20.0	8
	25.0	22
	30.0	25

［出所］再委託業者からの地質調査報告書（添付資料－８）

表２－８　圧密試験（Consolidation Test）

Sample Source	Depth (m)	Pre-Consolidation pressure (kN/m^2)	Overburden Pressure (kN/m^2)	Compression Index, C_c	Coefficient of Volume Compressibility mv (m^2/MN)			Coefficient of Consolidation C_v (cm^2/sec)			Permeability, k (m/s) $x10^{-8}$		
					Min	*Max*	*Ave*	*Min*	*Max*	*Ave*	*Min*	*Max*	*Ave*
BH 1	5	150	92.2	0.195	0.072	4.057	0.8934	0.0010	0.0036	0.0018	7E-11	1.5E-09	2.83E-09
	10	180	172.1	0.201	0.070	1.846	0.502	0.0011	0.0042	0.0028	7.6E-11	6.5E-09	1.67E-09
	15		276.6	0.036	0.020	0.16	0.074	0.0032	0.0154	0.0083	1.12E-09	2.25E-09	9.25E-10
	20		368.8	0.029	0.016	0.16	0.07	0.0026	0.0081	0.0049	4.2E-09	1.12E-09	4.88E-10
	30		553.2	0.037	0.030	0.098	0.053	0.0020	0.0055	0.0035	8.76E-11	1.97E-10	1.5E-10

［出所］再委託業者からの地質調査報告書（添付資料－８）

３．新ムコノ変電所の地質調査の結果

表３－１　標準貫入試験から算出した地耐力（BH01：変電所内）

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH01	0.00	Inorganic Sandy Lean CLAY						
	1.50		6	0.59	4	72	371	124
	3.00	Inorganic Sandy SILT	7	0.59	4	81	414	138
	4.50	Inorganic Sandy Elastic SILT	5	0.59	3	63	325	108
	6.00	Inorganic Sandy SILT	10	0.67	7	114	586	195
	7.50		41	0.67	27	315	1618	539
	9.00	Poorly Graded SAND with Clay and Gravel	17	0.75	13	181	930	310
	10.50	Silty SAND with Gravel	70	0.75	52	501	2577	859
	12.00	Poorly Graded SAND with Silt and Gravel	30	0.75	22	272	1400	467
	13.50	Poorly Graded SAND with Clay and Gravel	40	0.75	30	335	1722	574
	15.00	Silty SAND with Gravel	9	0.75	7	114	588	196
	16.50		17	0.79	13	188	965	322
	18.00	Silty SAND	19	0.79	15	203	1046	349
	19.50		Refusal	0.79		>500	>2500	>850
	21.00		Refusal	0.79		>500	>2500	>850
	22.50		Refusal	0.79		>500	>2500	>850
	24.00		Refusal	0.79		>500	>2500	>850
	25.50		Refusal	0.79		>500	>2500	>850
	27.00		Refusal	0.79		>500	>2500	>850
	28.50		Refusal	0.79		>500	>2500	>850

［出所］再委託業者からの地質調査報告書（添付資料－８）

Cu=Pa・0.29・N60^0.72 ; Pa=100 kPa

Qult=5.14・Cu

Qall=Qult/3

表３－２　含水量（Natural Moisture Content）

試験方法		ASTM D4959
		含水量 (%)
ボーリング孔		BH1
深さ (m)	1.5	27.7
	3.0	26.8
	4.5	30.7
	6.0	30.9
	7.5	13.2
	9.0	15.5
	10.5	22.4
	12.0	5.5
	13.5	11.3
	15.0	9.3
	16.5	16.1
	18.0	9.4
	19.5	17.9
	27.0	19.5
	28.5	22.2

［出所］再委託業者からの地質調査報告書（添付資料－８）

表３－３　液性限界・塑性限界（Liquid Limit and Plastic Limit）

試験方法		ASTM D4318	
		液性限界(%)	塑性限界 (%)
ボーリング孔		BH1	BH1
深さ (m)	4.5	51.8	30.3
	6.0	45.8	28.3
	10.5	41.2	30.5
	28.5	35.3	25.7

［出所］再委託業者からの地質調査報告書（添付資料－８）

表３－４　比重（Specific Gravity）

試験方法		ASTM D854
		平均比重
ボーリング孔		BH1
深さ (m)	4.5	2.573
	6.0	2.571
	10.5	2.704
	28.5	2.722

［出所］再委託業者からの地質調査報告書（添付資料－８）

表３－５　湿潤密度（Bulk Density）

試験方法		ASTM D2937
		湿潤密度 (kg/m^3)
ボーリング孔		BH1
深さ (m)	4.5	1900
	6.0	1867
	10.5	1698
	28.5	1929

［出所］再委託業者からの地質調査報告書（添付資料－８）

表３－６　一軸圧縮試験（Unconfined Compressive Strength）

試験方法		ASTM D2166
		粘着力 Cu (kPa)
ボーリング孔		BH1
深さ (m)	4.5	19
	6.0	7
	10.5	40

［出所］再委託業者からの地質調査報告書（添付資料－８）

表３－７　三軸圧縮試験（Unconsolidated Undrained Triaxial Test）

試験方法		ASTM D2850 and D4767
		粘着力 Cu (kPa)
ボーリング孔		BH1
深さ (m)	4.5	43
	6.0	54
	10.5	71

［出所］再委託業者からの地質調査報告書（添付資料－８）

表３－８　圧密試験（Consolidation Test）

Borehole No.:	Depth (m)	Pre-Consolidation pressure (kN/m^2)	Overburden Pressure (kN/m^2)	Compression Index, C_c	Coefficient of Volume Compressibility Mv (m^2/MN)			Coefficient of Consolidation C_v (cm^2/sec)			Permeability, k (m/s) $x10^{-9}$		
					Min	*Max*	*Ave*	*Min*	*Max*	*Ave*	*Min*	*Max*	*Ave*
BH 01	4.5	140.0	83.86	0.197	0.070	0.3219	0.1617	0.0001	0.0003	0.0001	0.007	0.041	0.020
	6.0	200.0	109.90	0.104	0.053	0.179	0.099	0.001	0.002	0.001	0.091	0.185	0.120
	10.5	220.00	174.94	0.137	0.062	0.297	0.162	0.001	0.002	0.002	0.105	0.396	0.241
	28.5	539.4	539.4	0.061	0.031	0.135	0.085	0.003	0.006	0.004	0.096	0.403	0.281

［出所］再委託業者からの地質調査報告書（添付資料－８）

Intended for
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GREATER KAMPALA TRANSMISSION NETWORK PROJECT IN THE REPUBLIC OF UGANDA

BULOBA SUBSTATION DETAIL GEOTECHNICAL REPORT

YACHIYO ENGINEERING CO.,LTD.
Consulting Engineers & Architects

Revision **00**
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EXECUTIVE SUMMARY

This report mainly deals with the geological and geotechnical investigation findings of Buloba Substation. In this report the governing soil properties are considered based on the geological and geotechnical site investigation which was executed between December 2015 and January 2016. In addition, relevant non-geotechnical parameters are outlined. The evaluation of the field and laboratory investigations is included in this report.

Buloba substation is located in Mawokota, Mpigi district with coordinates 36 N 432115 UTM 28405 and approximately 29km west from Kampala city centre. The site is accessible via the Masaka to Kampala highway. The project area incorporated within the site boundary is approximately 113,000m^2.

The project area lies in zone 3 which is the least seismically active zone in Uganda. Therefore the risk of damage by earthquakes is low. Additionally, the geological conditions indicate that apart from the regional seismicity, no major geological hazards and constraints such as unstable slopes, thick deposits of weak soils, land ground subsidence and collapse were identified in the area.

Published geology indicates that the site is underlain by rocks from the Buganda group which are rocks predominantly composed of shale, slate and phyllite of complex formation comprising sedimentary, metamorphic and volcanic rocks.

The soil investigation was conducted in accordance with American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. The conducted geotechnical investigation consists of field investigation and laboratory tests on samples recovered from the borehole.

The geology of the site was variable and generally consisted of lateritic gravel underlain by interbedded layers of sand and clay overlying silt. Northwest of the site (BH03), sand was encountered from ground level up to 1mBGL underlain by 1m-10mBGL sandy clay, underlain by 10m-11mBGL clayey sand and 11m-29mBGL sandy silt. North of the site (BH02), black organic soil was encountered from ground level up to 1mBGL overlying 1m-5.5mBGL clayey gravel and 5.5m-28m silt. Southeast of the site (BH01), clayey sand was encountered from ground level up to 2.5mBGL overlying 2.5m-4mBGL gravelly clay, 4m-5mBGL clayey sand, 5m-12mBGL sandy silt, 12m-13mBGL clayey sand, 13m-18mBGL sandy silt and 18m-20mBGL silty clay. South of the site (BH04), clayey gravel was encountered from ground level up to 4mBGL underlain by 4m-5.5mBGL clay, 5.5m-6.5mBGL clayey sand, 6.5m-9mBGL clay, 9m-25mBGL sandy silt and 25m-30mBGL gravelly silt.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BGL	Below Ground Level
BH	Borehole
DGSM	Department of Geological Survey and Mines
JICA	Japan International Cooperation Agency
km	Kilometer
m	Meter
masl	Above Mean Sea Level
SPT	Standard Penetration Test
UTM	Universal Transverse Mercator
YEC	Yachiyo Engineering Company Ltd
^{0}C	Degrees Celsius

1 INTRODUCTION

1.1 About report

This report mainly deals with the geotechnical investigation finding for Buloba substation. It discusses the index and engineering properties of soil based on the geotechnical field investigation which was conducted during the period December 2015 to January 2016 and laboratory test conducted in January 2016. Relevant non-geotechnical parameters are outlined including the analysis and calculation results are given as part of this report (i.e. bearing capacity and settlements). Finally, recommendations were made for design and construction of the proposed development foundation.

1.2 Background

Yachiyo Engineering Company Ltd (YEC) were commissioned by the Japan International Cooperation Agency (JICA) to carry out a preparatory survey for the improvement of the greater Kampala metropolitan area transmission system in the republic of Uganda. Yachiyo Engineering Company Ltd (Universal Transverse Mercator) plans to construct a new substation and associated infrastructure at the proposed site. Geotechnical investigations were required to determine the suitability of the site for the proposed developments and to guide the design of the proposed infrastructure.

Following decision of conducting Geotechnical investigation at Bulooba substation and transmission line, Newplan limited have been contracted by Yachiyo Engineering Company Ltd to carry out a Topographic surveying and Geotechnical investigation.

1.3 The Consultant

Following a competitive bidding procedure Newplan Limited was appointed by Yachiyo Engineering Company Ltd to carry out topographic surveying and geotechnical investigation for the proposed site. The Contract was signed on 10th December 2015 and the assignment commenced on 11th December, 2015.

The study was carried out in two phases i.e.: initial geotechnical investigation and detailed investigation study. The initial geotechnical investigation was concluded on 14th December, 2015. Following that, detailed investigations commenced on 15th December, 2015. The field and laboratory tests were conducted by Comat lab limited. This report together with the Topographic report are deliverables that signify the conclusion of the Buloba substation Topographic surveying and Geotechnical investigations contract.

1.4 Scope of services

In order to facilitate the substation foundation design, a detailed geotechnical investigation was performed. Newplan limited conducted the geotechnical investigations as per the general guidance proposed in the American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. The scope of the services was as summarized below:

1. Drilling exploratory holes and recovering soil samples;
2. Determination of subsurface soil profile or logging borehole for strata profiles;
3. Carrying out standard penetration tests;
4. Conducting relevant laboratory tests on the recovered samples (i.e. Moisture Content, Particle Size Distribution, Atterberg limits (Consistency), consolidation tests and Triaxial tests for undisturbed samples);
5. Monitoring ground water occurrence (depth of water table);
6. Propose recommendations for foundation design; and
7. Preparation of a geotechnical interpretative report.

2 SITE DESCRIPTION

2.1 Location

The proposed site is located in Mawokota, Mpigi district with coordinates 36 N 432115 UTM 28405 and approximately 29km west from Kampala city center. The site is accessible via the Masaka to Kampala highway (see Figure 2.1).

The project area incorporated within the site boundary is approximately 113,000m^2. It is mainly marshy land which is sparsely populated with a few habited settlements.

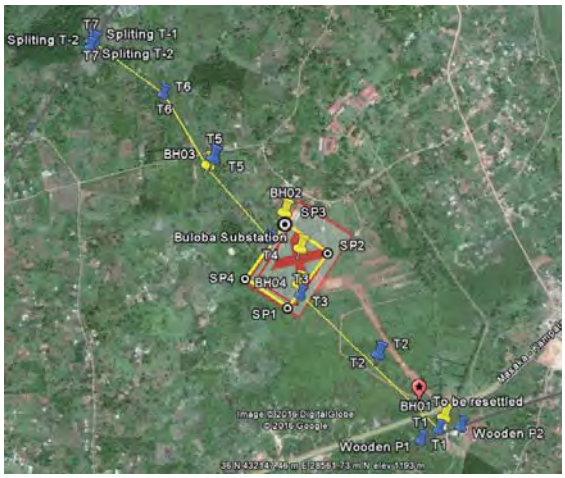


Figure 2. 1: Site location

2.2 Topography

A detailed topographic survey was carried out by Newplan in December 2015. This indicated the topography of the site is undulating with the elevation of the project area varying between 1163 to 1196masl.

2.3 Climate

The project area is classified under tropical climate with temperatures ranging from 15 to 29 ^{0}C. The project area receives rain in in two different season, March to May and in August to December. The mean annual rainfall is between 1125 and 1350mm.

2.4 Regional Geology

According to DGSM 1:100 000 sheet 70 for Entebbe, the regional geology is composed of sedimentary, volcanic and metamorphic complexes. The main rocks in the region include shale, slate and phyllite (see Figure 2.2). These are metamorphic rocks with shale being the parent rock and produces a sequence of metamorphic rocks that goes through slate, then through phyllite, schist and gneiss. These rocks are underlain by other rocks such as quartzite and granatoids or granitic rocks. These rocks belong the Buganda group which is in the lower Proterozoic series.

Figure 2. 2: Extract of geological map of the project site

2.5 Site Geology

Based on the drilled holes and visual observations, the site geology is dominated by rocks that have undergone some weathering to produce an overburden that typically grades from completely decomposed rocks (residual soil) to highly weathered rock with depth. Generally the overburden is deep at most of the site area and no rock was encountered in all the drilled boreholes. The formation that was encountered in top 20m BGL was variable and generally consisted of lateritic gravel underlain by interbedded layers of sand and clay overlying silt. Predominant structural trends could not easily be ascertained due to a general lack of rock exposures in the area

2.6 Geohazards

The project area of Buloba substation has not experienced any earthquakes historically and lies in zone 3 which is the least seismically active zone in Uganda. The seismicity map of Uganda (Figure 2.3) indicates that there are no epicenters close to the project site. Therefore the risk of damage by earthquakes is low. An overview of the geological

conditions indicate that apart from the regional seismicity, no major geological hazards and constraints such as unstable slopes, thick deposits of weak soils, land ground subsidence and collapse were identified in the area.

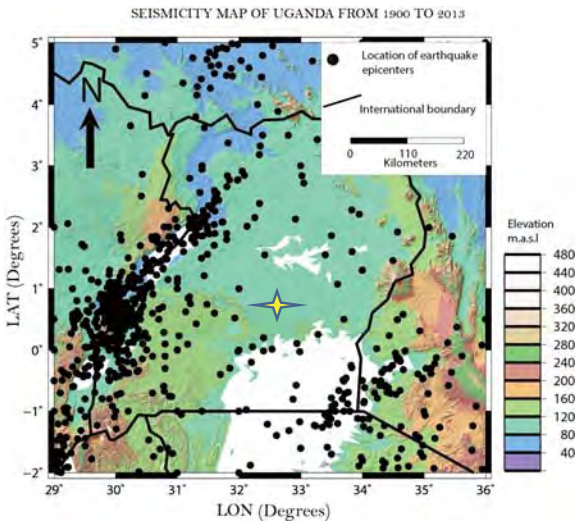


Figure 2. 3: Seismicity of Uganda for the period 1900-2013 showing project site

3 GEOTECHNICAL INVESTIGATION

3.1 Methodology

Geotechnical investigation were conducted in two main phases of investigation.

1. Initial geotechnical investigation
   - Desk study (Reviewing useful sources of geological, historical and topographic information)
   - Site reconnaissance (Sampling, description and visual field identification)
2. Detailed geotechnical investigation
   - Preliminary design stage investigation
   - Final design stage or phase investigation

Initial geotechnical investigation was concluded in December, 2015. This investigation was limited to detail geotechnical investigation mainly for preliminary design stage investigation.

This preliminary design detailed geotechnical investigation typically includes four borings and relevant soil testing for defining the general stratigraphy, soil and rock characteristics, groundwater conditions, and other existing features important to foundation design. Further final design stage investigation stages can be considered if there are significant design changes or if local subsurface anomalies warrant further study.

The investigation was conducted in accordance with American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. It consists of the following components:

- Field Investigations; these were intrusive and included drilling exploratory holes, SPTs and groundwater observation.
- Laboratory tests on samples recovered from borehole.

3.2 Field Investigations

The site work was executed on the basis of ASTM D 420 recommendation (i.e. ASTM D 1586, ASTM D 1587, ASTM D 2488, and ASTM D 5783). The field work comprised of the following;

- Rotary drilling of 4 boreholes to a maximum depth of 30m;

- Collecting disturbed and undisturbed samples;
- In-situ Standard Penetration Testing (SPT) within the boreholes. These were undertaken at 1.0m intervals. SPTs were based on a 65kg driving hammer falling 'free' from a height of 760mm;
- Driving the standard split-barrel sampler of internal and external diameters 35mm and 50mm respectively to reach a distance of 450 mm into the soil at the bottom of the boring after the chosen interval.
- Counting the number of blows to drive the sampler each 75 mm increment of a total of 450 mm penetration. The blow count for the first 150 mm increment was discarded and the sum of the blow counts for the second and the third 150 mm increment was recorded as the SPT 'N' value.

3.2.1 Borehole

Four boreholes were drilled as per ASTM D 5783 and terminated at depths between 20m and 30.5mBGL. The location of each borehole GPS coordinates is summarized in below Table 3.1 (Arc 1960 Geographic coordinate system). The drilled borehole logs were prepared for each borehole as per ASTM D 2488. The exploratory borehole records and logs are included in Appendix 1 and should be read in conjunction with the accompanying general notes therein. The records also give details of the samples taken together with the observations made during boring.

Table 3- 1: Borehole location coordinates

Borehole	X	Y
Borehole 1 (BH1)	432635	28061
Borehole 2 (BH2)	432010	28859
Borehole 3 (BH3)	431710	29043
Borehole 4 (BH4)	432066	28579

3.2.2 Soil profile

Northwest of the site (BH03), clayey sand was encountered from ground level up to 1mBGL, 1m-5mBGL sandy clay, 5m-8mBGL silty sand, 8m-9mBGL sandy clay, 9m-

11mBGL clayey sand and 11m->29mBGL sandy silt. North of the site (BH02), sandy clay was encountered from ground level up to 1mBGL, 1m-2mBGL clayey gravel, 2m-6mBGL sandy silt, 6m-7mBGL silty gravel, 7m-11mBGL sandy silt, 11m-12mBGL sandy clay, 12m-24mBGL sandy silt, 24m-27mBGL sandy clay and sandy silt below 27m. Southeast of the site (BH01), clayey sand was encountered from ground level up to 4mBGL, 4m-5mBGL sandy silt, 5m-6mBGL sandy clay, 6m-8mBGL silty sand, 8m-9mBGL sandy clay, 9m-10mBGL sandy silt, 10m-11mBGL sandy clay, 11m-12mBGL sandy silt, 12m-17mBGL sandy clay, 17m-18mBGL sandy silt and sandy clay below 18m. South of the site (BH04), sandy clay was encountered from ground level up to 1mBGL, 1m-3mBGL clayey sand, 3m-4mBGL sandy silt, 4m-6mBGL sandy clay, 6m-9mBGL sandy clay, 9m-12mBGL sandy silt, 12m-13mBGL silty sand, 13m->30mBGL sandy silt (see Appendix 1 up to 4).

Generally, the soil layers were dipping towards the south of the site (see ground profile in Appendix 30 and the geological sequence at the site comprises of a clayey sand and clayey gravel from ground level to a depth of 2m, overlying clay up to a depth of 10m, underlain by silt up to a depth of 31m.

3.2.3 Ground water

To determine the elevation of the ground water table, observations were carried out during the drilling. These groundwater observations in the boreholes were conducted as per ASTM D 4750.

Groundwater was encountered in 3 out of 4 boreholes (BHs 01, 03 & 04) at depths ranging between 0.4m and 3.8mBGL with the gradient towards the south of the site. This implies that the groundwater table is relatively high and considerations have to be made for design and construction. It is obvious that ground water levels fluctuate with a number of influences including season, rainfall, dewatering and pumping activities. Therefore, groundwater levels significantly higher than those encountered could be present. The Ground water observation result is presented in the borehole logs Appendix 1.

The presence of this ground water close to the foundation level can reduce the ability of soils to carry high foundation pressures, when the ground water level is above the lowest floor, water proofing and resistance against hydrostatic uplift become serious consideration. In addition, the construction below ground water level often presents difficulties. The upward flow of water into a foundation excavation can create a quick condition, construction is impossible without pre drainage. Due to the above mentioned point the effect of the ground water on foundation and way of construction should be taken into consideration during foundation design.

3.2.4 The Standard Penetration Test (SPT)

Standard penetration tests were performed during the advancement of a soil boring to obtain an approximate measure of the dynamic soil resistance, as well as a disturbed drive sample (split barrel type) to determine the arrangement of different layers of the soil with relation to the proposed foundation elevation. The test was conducted as per ASTM D 1586. Four boreholes were drilled with depths varying from 20m and 30mBGL and SPTs carried out at 1m intervals as per the client's requirements.

Information obtained from SPT combined with other geotechnical laboratory test results, on site topography and area climatic records, provides basic planning material essential to the logical and effective development of substation and other infrastructure.

The observed field standard penetration values (N) were corrected to the average energy ratio of 60% (N_{60}) on basis of field observation as function of the input driving energy and its dissipation around the sampler into the surrounding soil. SPT correction were applied as per Seed *et al.* (1985) and Skempton (1980). Furthermore, the undrained shear strength (c_u) of the soil was determined using the corrected standard penetration values (N_{60}) as per Hara *et al.* (1971) and Peck *et al.* (1974) empirical relationship respectively. Finally, the approximate ultimate bearing capacity (Q_{ult}) and approximate allowable bearing capacity (Q_{all}) were computed using the derived undrained shear strength (c_u) of the soil. Overconsolidation (OCR) was determined using Mayne and Kemper (1988).

A factor of Safety (FoS) of 3.0 was used irrespective of the site conditions for computation

of allowable bearing capacity (Q_{all}). Penetration refusal was achieved between depths varying from 20m to 30mBGL which implied presence of hard stratum. The hard stratum was confirmed at 20mBGL at BH01, 27mBGL at BH02, 29mBGL at BH03 and 30mBGL at BH04. Detailed bearing capacity results are attached as Appendix 5 and the summary of undrained shear strength (c_u) given in Table 3.2, 3.3,.3.4, & 3.5.

Basing on the undrained shear strength derived from the SPT values, generally, the strength was directly proportional to the depth from ground level. BH01 was characterised by stiff soils from ground level up to 2mBGL underlain by very stiff cohesive soils from 2m to 7mBGL overlying hard cohesive soils. BH02 was characterised by very stiff soils from the surface up to 1mBGL overlying medium dense granular soils from 1m to 2mBGL underlain by very stiff cohesive soils from 2m up to 6mBGL overlying hard cohesive soils. BH03 was comprised of loose granular soils from the surface up to 1mBGL overlying very stiff soil from 1.5m to 7.5mBGL underlain by hard cohesive soils. BH04 was cohesive soils from ground level up to 4m overlying very stiff cohesive soils from 4m to 6.5mBGL, hard soils from 6.5m to 8mBGL interbedded with very stiff soil from 8m to 9.5mBGL and hard soils below 9.5mBGL.

Furthermore, the insitu soil is over consolidated as demonstrated by the insitu SPTs executed at all exploratory holes from BH01 to BH04 (see Table 3.2, 3.3, 3.4,& 3.5).

Table 3- 2: Standard penetration test result for BH1

			BH1			
Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	N	N_{60}	Undrained Shear Strength, C_u (kPa)	Overcon solidation ratio (OCR)
0						
1	0.02	0.59	5	3	63	6
2	0.04	0.59	8	5	89	5
3	0.06	0.59	13	8	126	6
4	0.08	0.67	17	11	167	6
5	0.10	0.67	18	12	174	5
6	0.12	0.75	18	13	189	5
7	0.14	0.75	29	22	266	6
8	0.16	0.75	30	22	272	6
9	0.18	0.75	33	25	292	6
10	0.20	0.75	46	34	371	7
11	0.22	0.79	29	23	276	5
12	0.24	0.79	53	42	426	7
13	0.26	0.79	79	62	568	9
14	0.27	0.79	44	35	372	5
15	0.29	0.79	70	55	520	7
16	0.31	0.79	47	37	390	5
17	0.33	0.79	40	32	348	4
18	0.35	0.79	22	17	226	3
19	0.37	0.79	81	64	578	7
20	0.39	0.79	64	50	488	5

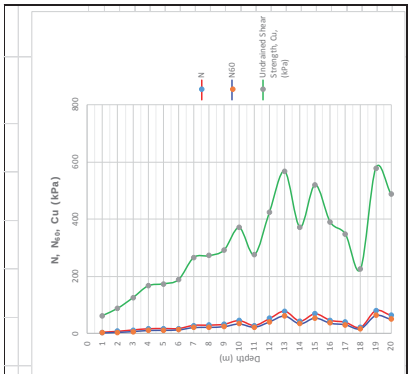


Table 3- 3: Standard penetration test result for BH2

			BH2			
Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	N	N_{60}	Undrained Shear Strength, C_u (kPa)	Overcon solidation ratio (OCR)
0						
1	0.02	0.59	14	8	133	12
2	0.04	0.59	42	25	293	16
3	0.06	0.59	36	21	262	11
4	0.08	0.67	24	16	214	8
5	0.10	0.67	22	15	201	6
6	0.12	0.75	15	11	165	4
7	0.14	0.75	19	14	196	5
8	0.16	0.75	22	16	218	5
9	0.18	0.75	24	18	232	5
10	0.20	0.75	31	23	279	5
11	0.22	0.79	25	20	248	4
12	0.24	0.79	20	16	211	3
13	0.26	0.79	36	28	322	5
14	0.27	0.79	29	23	276	4
15	0.29	0.79	22	17	226	3
16	0.31	0.79	21	17	219	3
17	0.33	0.79	26	20	255	3
18	0.35	0.79	35	28	316	4
19	0.37	0.79	43	34	366	4
20	0.39	0.79	44	35	372	4
21	0.41	0.79	36	28	322	4
22	0.43	0.79	44	35	372	4
23	0.45	0.79	46	36	384	4
24	0.47	0.79	22	17	226	2
25	0.49	0.79	32	25	296	3
26	0.51	0.79	75	59	547	5
27	0.53	0.79	73	57	536	5
28	0.55	0.79	73	57	536	5

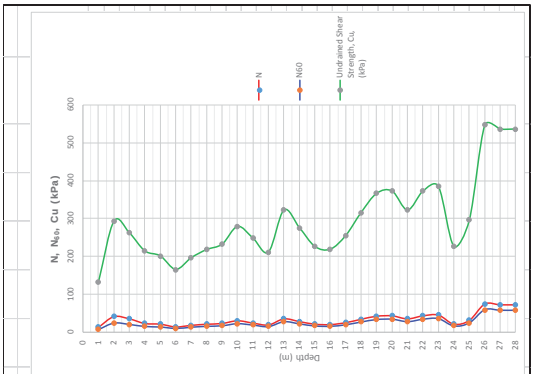
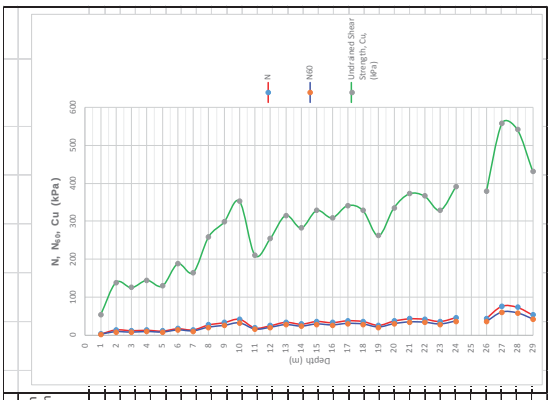
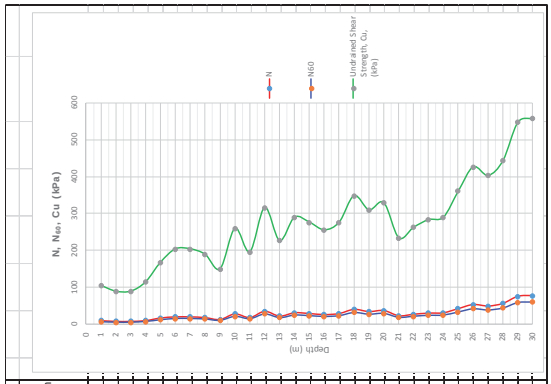


Table 3- 4: Standard penetration test result for BH3



Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	BH3 N	BH3 N_{60}	BH3 Undrained Shear Strength, C_u (kPa)	BH3 Overcon solidation ratio (OCR)
0						
1	0.02	0.59	4	2	54	5
2	0.04	0.59	15	9	139	8
3	0.06	0.59	13	8	126	6
4	0.08	0.67	14	9	145	5
5	0.10	0.67	12	8	130	4
6	0.12	0.75	18	13	189	5
7	0.14	0.75	15	11	165	4
8	0.16	0.75	28	21	259	6
9	0.18	0.75	34	25	298	6
10	0.20	0.75	43	32	353	6
11	0.22	0.79	20	16	211	4
12	0.24	0.79	26	20	255	4
13	0.26	0.79	35	28	316	5
14	0.27	0.79	30	24	283	4
15	0.29	0.79	37	29	329	5
16	0.31	0.79	34	27	309	4
17	0.33	0.79	39	31	341	4
18	0.35	0.79	37	29	329	4
19	0.37	0.79	27	21	262	3
20	0.39	0.79	38	30	335	4
21	0.41	0.79	44	35	372	4
22	0.43	0.79	43	34	366	4
23	0.45	0.79	37	29	329	3
24	0.47	0.79	47	37	390	4
25	0.49	0.79				
26	0.51	0.79	45	35	378	4
27	0.53	0.79	77	61	557	5
28	0.55	0.79	74	58	541	5
29	0.57	0.79	54	43	432	4

Table 3- 5: Standard penetration test result for BH4



Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	BH4 N	BH4 N_{60}	BH4 Undrained Shear Strength, C_u (kPa)	BH4 Overcon solidation ratio (OCR)
0						
1	0.02	0.59	10	6	104	10
2	0.04	0.59	8	5	89	5
3	0.06	0.59	8	5	89	4
4	0.08	0.67	10	7	114	4
5	0.10	0.67	17	11	167	5
6	0.12	0.75	20	15	203	5
7	0.14	0.75	20	15	203	5
8	0.16	0.75	18	13	189	4
9	0.18	0.75	13	10	149	3
10	0.20	0.75	28	21	259	5
11	0.22	0.79	18	14	196	3
12	0.24	0.79	35	28	316	5
13	0.26	0.79	22	17	226	4
14	0.27	0.79	31	24	289	4
15	0.29	0.79	29	23	276	4
16	0.31	0.79	26	20	255	3
17	0.33	0.79	29	23	276	4
18	0.35	0.79	40	32	348	4
19	0.37	0.79	34	27	309	4
20	0.39	0.79	37	29	329	4
21	0.41	0.79	23	18	233	3
22	0.43	0.79	27	21	262	3
23	0.45	0.79	30	24	283	3
24	0.47	0.79	31	24	289	3
25	0.49	0.79	42	33	360	4
26	0.51	0.79	53	42	426	4
27	0.53	0.79	49	39	402	4
28	0.55	0.79	56	44	443	4
29	0.57	0.79	75	59	547	5
30	0.59	0.79	77	61	557	5

3.3 Laboratory Investigations

Samples from the exploration works were labelled, protected and taken to the laboratory with the aim of carrying out tests as per American Society for Testing and Materials (ASTM) D 4220. All undisturbed samples were collected as per Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes (ASTM) D 1587. The testing was scheduled by Comatlab limited. The following lab tests have been carried out on samples taken from the different boreholes:

- Moisture content
- Liquid limit
- Plastic limit & plasticity index
- Linear shrinkage
- Particle density determination/Specific Gravity Test
- Particle size distribution
- Unconfined compression
- Consolidation test-Oedometer/Undisturbed
- Triaxial test/Undisturbed (i.e. Unconsolidated Undrained (UU) Test)
- pH value
- Chemical test (sulphates and chlorides)

3.3.1 Moisture content

Moisture content test was conducted to determine the amount of water present in a quantity of soil in terms of its dry weight and to provide general correlations with strength, settlement, workability and other properties. The moisture content test was conducted on more than 22 samples collected from borehole (i.e. both disturbed and undisturbed) as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 2216. The test result is presented in Figure 3.1 and Appendix 6 with respect to depth. Natural moisture content of the insitu soil varied between 19 and 37%.

The test result shows the moisture content in all borehole is increasing from ground surface up to 20m and finally decreases from 20m up to 30m. Such type of decrease in

water content results in a decrease in cation layer thickness and an increase in the net attractive forces between particles. This means the soil strength below 20m is increasing with depth while compared with soil layer between ground surface and 20m.

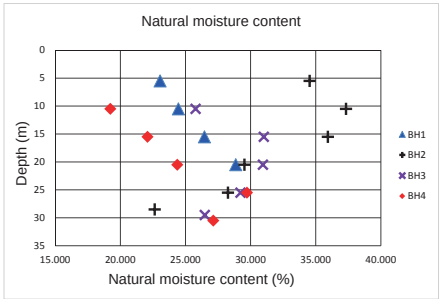


Figure 3- 1: Trend of Natural Moisture Content

3.3.2 Atterberg Limits

To describe the consistency and plasticity of fine-grained soils with varying degrees of moisture, liquid limit and plastic limit tests were conducted on samples collected from borehole as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 4318. A total of 214 atterberg limit tests were conducted. The test result is presented in Appendix 4. All the result obtained from atterberg laboratory tests were used for soil classification and the project area soil is predominantly silt of high plasticity, elastic silt up to 30m in all boreholes.

Shrinkage limit tests were also conducted on samples recovered from the boreholes as per Standard Test Methods for American Society for Testing and Materials (ASTM D) 427 and D 4943. The test result for shrinkage limit tests is presented in appendix 11. All Shrinkage limit test results were less than 15 percent, this indicates that Kaolinite clay

mineral is dominant or high in insitu soil and the project area is not prone to swelling or expansive soil.

3.3.3 Particle size distribution

To determine the percentage of various grain sizes, sieve analysis tests were conducted. Results from grain size distribution were used to determine the textural classification of soils (i.e. gravel, sand, silt, and clay) which in turn is useful in evaluating the engineering characteristics such as permeability, strength, and swelling potential. A total of 107 sieve analysis tests were conducted as per Standard Test Methods for American Society for Testing and Materials per (ASTM) D 422. The test results are presented in Figure 3-11 up to 3-14 and Appendix 4.

From texture classification given in Appendix 7 and Figure 3-2 up to 3-5, the engineering characteristics such as permeability, strength, and swelling potential are evaluated as below;
The insitu soils at all boreholes are semipervious to impervious when compacted, fair to poor shearing strength when compacted and saturated, low to high compressibility when compacted and saturated. This implies poor workability as a construction material, and poor relative desirability for foundation.

Generally, the *insitu* material was composed of predominantly fine soils mixed with coarse soils. The fine soils were silt and clay while the coarse fraction was composed of gravel and sand. At BH01, the soil is predominantly composed of silt and clay (52%), sand (45%) and gravel (3%). The fine fraction increased at BH02 to silt and clay (78%) while sand was 19% and gravel 3%. Similarly, at BH03, silt and clay constituted 66%, sand 33% and gravel 1%. At BH04, silt and clay were at 65%, sand 35% and gravel 1%. This implies that the *insitu* soil has low permeability and high compressibility.

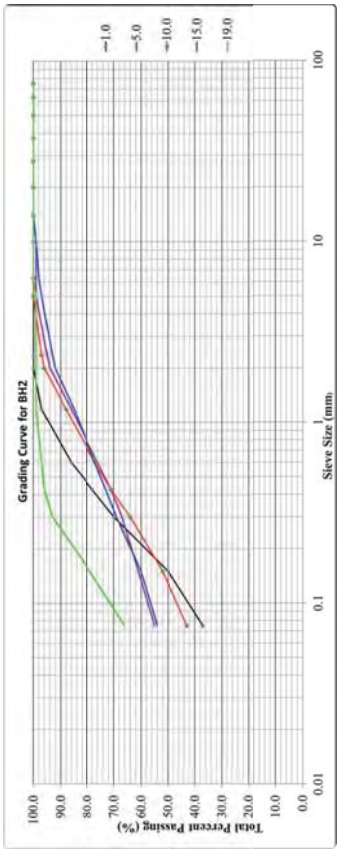


Figure 3- 2: Particle distribution curve for BH1

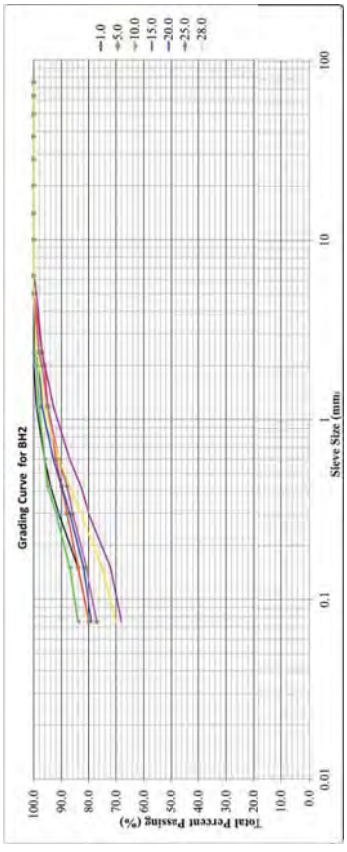


Figure 3- 3: Particle distribution curve for BH2

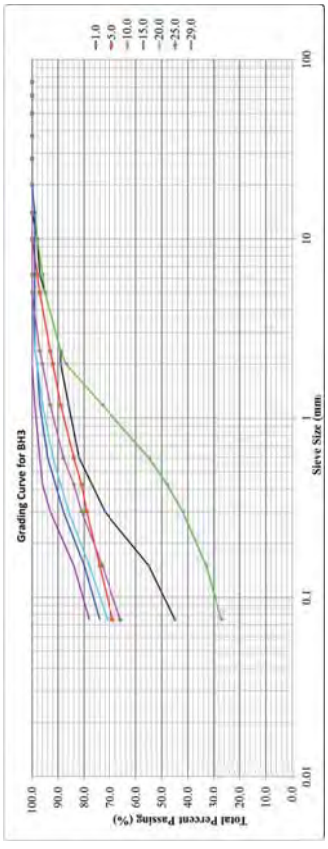


Figure 3- 4: Particle distribution curve for BH3

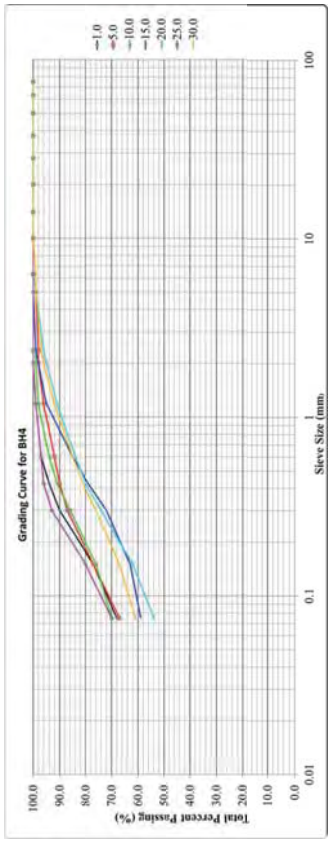


Figure 3- 5: Particle distribution curve for BH4

3.3.4 Specific Gravity

To determine the specific gravity of the soil grains specific gravity test was conducted as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 854. The specific gravity of the project area soil varies between 2.59 and 2.79 and the average specific gravity is 2.68. The test results are presented in appendix 8 and Table 3.7.

Table 3- 6: Specific gravity summary

BOREHOLE NO.	DEPTH (m)	SPECIFIC GRAVITY (GS)
1	5.5-6.0	2.595
	10.5-11.0	2.636
	15.5-16.0	2.599
	20.5-21.0	2.749
2	5.5-6.0	2.732
	10.5-11.0	2.744
	15.5-16.0	2.713
	20.5-21.0	2.662
	25.5-26.0	2.691
	28.5-29	2.721
3	5.5-6.0	2.650
	10.5-11.0	2.649
	15.5-16.0	2.637
	20.5-21.0	2.684
	25.5-26.0	2.693
	29.5-30.0	2.592
4	5.5-6.0	2.795
	10.5-11.0	2.639
	15.5-16.0	2.694
	20.5-21.0	2.716
	25.5-26.0	2.682

	30.0-30.50	2.638

3.3.5 Bulk density

Bulk density test was conducted to obtain overburden stresses within a soil mass required for evaluations of the unit weight or mass density of the various strata. Bulk density for the undisturbed samples were determined using drive tubes as per American Society for Testing and Materials (ASTM) D 2937. More than 22 bulk density tests were conducted. The unit bulk density of the insitu soil at all boreholes are almost the same except borehole 2. This shows as parental material, degree of consolidation and compaction, and degree of weathering are uniform between boreholes. The test result shows the bulk density for the project area varies between 1.71 and 2.0 1 Mg/m^3. For any further use and design we recommend to consider bulk density at each soil layer and borehole presented in appendix 12.

3.3.6 Corrosivity of soils

To determine the aggressiveness and corrosivity of soils, pH, sulphate and chloride content of soils tests were conducted. A total of 15 aggressiveness and corrosivity tests were conducted as per Standard Test Methods for American Society for Testing and Materials (ASTM) G 51 and D 4327. The test result is presented in table 3.7 and Appendix 9.

Sulphate and chloride ions lead to accelerated corrosion of steel reinforcement. Furthermore, high concentrations of sulphates are nocuous to concrete. Increased corrosion rates can also result from lowering of the soil pH to acidic generated by sulphate reducing bacteria whose indicators are sulphides in the soil (California Transport, 2012). The aggressiveness and corrosivity of soils test result is summarized as below:

- The PH was slightly acidic to neutral with a value between 5.8 and 7.1, this associated with insignificant corrosion rates.
- The chlorides content test result value varies between 520 and 8330 ppm, this associated with significant corrosion rates.
- The sulphate content test result value varies between 11390 and 42870 ppm, this associated with significant corrosion rates.

Generally, Bulooba substation foundation soil is prone to corrosion. This tends to reduction in life time of the foundation structure if appropriate measures are not taken. In order to avoid this problem, it is recommended to use stainless steel for foundation reinforcement or provide appropriate concrete foundation cover to avoid the ingress of chlorides and sulphates. Stainless steel reinforcement does not rely on concrete for its corrosion protection and is a straightforward solution when concrete is subjected to the ingress of chlorides. Stainless rebar is also used for long design life structures and when equipment is sensitive to magnetic fields and needs non-magnetic reinforcement.

Table 3- 7: Summary of chemical test results

Borehole No.	Depth (m)	PH	Chlorides (%)	Sulphates (%)
BH 1	7.0 - 8.0	7.04	0.88	4.29
	17.0 - 18.0	6.66	0.80	2.74
BH 2	7.0 - 8.0	6.79	0.30	1.37
	18.0 - 19.0	6.73	0.35	2.45
BH 3	3.0 - 4.0	5.84	0.05	1.32
	17.0 - 18.0	6.88	0.27	2.54
BH 4	3.0 - 4.0	6.79	0.35	2.45
	20.0 - 21.0	7.09		1.18

3.3.7 Unconsolidated undrained triaxial tests

To determine the strength characteristics of soils including detailed information on the effects of lateral confinement, pore water pressure and drainage, unconsolidated undrained triaxial tests were conducted on undisturbed samples. The conducted triaxial tests further used to determine a friction angle of clays & silts and the stiffness (modulus).

A total of 22 triaxial tests were conducted as per as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 2850, and D 4767. The undrained shear strength parameter angle of internal friction (degrees) for this specific project varies between 0 to 19°, the minimum cohesion is 28kPa with 2 degrees internal friction angle at 10mBGL depth of borehole 1, and the maximum cohesion is 133kPa with 0 degrees

internal friction angle at 5mBGL of borehole 4.

The computations of the Undrained triaxial test parameters (un-drained cohesion and angle of internal friction) are presented in Appendix 13. Table 3.8 below shows the summary of the undrained unconsolidated triaxial test results.

Table 3- 8: Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)

Borehole No	Depth (m)	Bulk density (kg/m³)	Dry density (kg/m³)	Angle of Internal Friction (degrees)	Cohesion (kPa)
1	5.5-6.0	1830	1487.80	0	68
	10.5-11.0	1840	1520.66	2	28
	15.5-16.0	1850	1516.39	0	31
	20.5-21.0	1890	1512.00	0	74
2	5.5-6.0	1720	1264.71	0	60
	10.5-11.0	1710	1230.22	6	40
	15.5-16.0	1680	1183.10	3	36
	20.5-21.0	1830	1418.60	3	29
	25.5-26-0	1670	1336.00	1	100
	28.5-29.0	1720	1354.33	3	66
3	5.5-6.0	1830	1464.00	4	118
	10.5-11.0	1800	1395.35	0	73
	15.5-16.0	1800	1395.35	13	55
	20.5-21.0	1830	1418.60	0	51
4	5.5-6.0	1920	1454.55	0	133
	10.5-11.0	1740	1487.18	3	34
	15.5-16.0	1800	1451.61	19	84
	20.5-21.0	1780	1401.57	3	31
	25.5-26-0	1800	1451.61	0	86
	30.5-31.0	1870	1496.00	2	60

3.3.8 Unconfined Compressive Strength

To determine the undrained shear strength of the insitu soil a total of 20 Unconfined Compressive Strength of Soils tests were conducted as pre Standard Test Methods for American Society for Testing and Materials (ASTM) D 2166 on remolded soil sample at natural moisture content.

The UCS ranged from 14 to 26kpa for Borehole 1, 20 to 46kpa for borehole 2, 24 to 44kpa for borehole 3, and 20 to 70kpa for borehole 4. The computations of the unconfined compressive strength test parameters are presented in Appendix 14. Table 3.9 shows the summary of the unconfined compressive strength test results

Table 3- 9: Summary of Unconfined Compressive Strength Test Results

Borehole No.	Test Depth (mm)	Unconfined compresive strength,qu (kpa)	Undrained cohesion,Cu (kpa)	Unit strain (%)
1	5.5 - 6.0	47	23.4	14.3
	10.5-11.0	32	14	7.9
	15.5-16.0	51	26	13.4
2	3.0 - 4.0	66	33	4.7
	5.5 - 6.0	46	23	12.6
	10.5 - 11.0	40	20	11.5
	15.5- 16.0	61	30	10.6
	24.5 -25.0	83	41	12.9
	28.5 - 29.0	92	46	9.6
3	1.5 - 2.0	87	44	13.2
	7.5 - 8.0	70	35	11.5
	18.5 - 19.0	63	31	6.7
	25.5 - 26.0	87	44	8.3
	29.5 - 30.0	49	24	10.3
4	1.5 - 2.0	140	70	8.8
	10.5 - 11.0	77	38	7.3
	11.5 - 12.0	40	20	11.8
	19.5 - 20.0	50	25	9.2
	23.5 - 24.0	74	37	7.8
	30.5 - 31.0	39	19	10.8

3.3.9 Consolidation

Compression properties of the project area soil were determined using laboratory test result. The result from this test was used to determine preconsolidation stress, compression characteristics, creep, stiffness, and flow rate properties of soils under loading.

To determine those properties of the soil One-Dimensional Consolidation (Oedometer test) using incremental loading was conducted as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 2435. A total of 22 representative One-Dimensional Consolidation (Oedometer test) were conducted.

The summary of Oedometer test result is given in Table 3.7 and Appendix 10. The test result shows the average compression index (Cc), coefficient of volume compressibility (M_v), Coefficient of consolidation, and coefficient of permeability for the project area insitu soil is 0.15, 0.13MN/m^2, 0.008cm^2/sec and 1.1E-9 m/sec respectively. For accurate settlement analysis we recommend to consider values mentioned in below Table 3.10 for each borehole and depth.

Table 3- 10: The summary of Oedometer test result

Borehole No.:	Depth (m)	Pre-Consolidation pressure (kN/m²)	Overburden Pressure (kN/m²)	Compression Index, C_c	Coefficient of Volume Compressibility Mv (MN/m²)		Coefficient of Consolidation C_v (cm²/sec)			Permeability, k (m/s) x10⁻⁹		
					Min	Max	Min	Max	Ave	Min	Max	Ave
BH01	5.5-6.0	200.0	101.9231	0.106	0.054	0.218	0.005	0.01	0.009	0.260	2.111	1.184
	10.5-11.0	210.0	206.4796	0.123	0.048	0.428	0.004	0.01	0.006	0.309	1.888	1.190
	15.5-16.0	282.11	282.1073	0.077	0.018	0.334	0.002	0.020	0.013	0.035	6.712	2.547
	20.5-21.0	390.6	390.6	0.153	0.056	0.123	0.001	0.003	0.002	0.108	0.225	0.169
BH02	5.5-6.0	320.0	96.9883	0.469	0.085	0.395	0.003	0.010	0.006	0.257	1.493	0.857
	10.5-11.0	250.0	175.2315	0.108	0.036	0.200	0.012	0.018	0.015	0.410	3.172	1.895
	15.5-16.0	265.1	265.1	0.032	0.012	0.066	0.001	0.006	0.003	0.016	0.225	0.099
	20.5-21.0	366.4	366.3702	0.114	0.026	0.249	0.008	0.014	0.011	0.248	1.855	1.249
	25.5-26.0	465.5	465.5	0.108	0.039	0.239	0.009	0.016	0.012	0.329	3.855	1.783
	28.5-29.0	477.1	477.1	0.158	0.040	0.184	0.003	0.015	0.008	0.118	2.636	1.023
BH03	5.5-6.0	200.0	103.484	0.075	0.036	0.095	0.0012	0.0015	0.0014	0.050	0.137	0.083
	10.5-11.0	205.0	188.0236	0.077	0.028	0.186	0.098	0.099	0.022	0.017	0.238	1.915
	15.5-16.0	283.3	283.3	0.103	0.042	0.306	0.145	0.016	0.021	0.017	0.852	4.730
	20.5-21.0	377.7	377.7	0.159	0.056	0.356	0.173	0.012	0.020	0.016	0.638	5.764
	25.5-26.0	483.1	483.1	0.212	0.079	0.251	0.135	0.004	0.007	0.006	0.490	0.913
	29.5-30.0	558.5	558.5	0.114	0.055	0.092	0.075	0.006	0.016	0.010	0.422	1.064
BH04	5.5-6.0	260.0	106.4984	0.059	0.025	0.064	0.040	0.002	0.006	0.003	0.048	0.162
	10.5-11.0	260.0	206.5851	0.077	0.041	0.128	0.079	0.001	0.004	0.002	0.040	0.486
	15.5-16.0	274.8	274.8	0.138	0.062	0.217	0.147	0.003	0.007	0.005	0.382	0.816
	20.5-21.0	359.2	359.2	0.237	0.085	0.334	0.211	0.003	0.010	0.005	0.546	0.864
	25.5-26.0	464.2	464.2	0.182	0.095	0.537	0.287	0.002	0.003	0.002	0.268	1.143
	30.5-31.0	578.7	578.7	0.105	0.055	0.194	0.126	0.005	0.007	0.006	0.360	1.111

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Geological and geotechnical assessment at the Buloba substation site was essential for obtaining fundamental information in terms of foundation conditions. This information was obtained from borehole drilling as well as onsite surveys and laboratory testing. All soil investigation test were conducted in accordance with American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. The following conclusions were reached;

1. The project area of Buloba substation has not experienced any earthquakes over years. This project area lies in zone 3 which is the least seismically active zone in Uganda. Therefore the risk of damage by earthquakes is low. An overview of the geological conditions indicate that apart from the regional seismicity, no major geological hazards and constraints such as unstable slopes, thick deposits of weak soils, land ground subsidence and collapse are identified in the area.
2. The site is underlain by rocks of from the Buganda group which are rocks predominantly composed of shale, slate and phyllite of complex formation comprising sedimentary, metamorphic and volcanic rocks.
3. Groundwater was encountered in 3 out of 4 boreholes (BHs 01, 03 & 04) at depths ranging between 0.4m and 3.8mBGL with the gradient towards the south of the site. This implies that the groundwater table is relatively high and considerations have to be made for design and construction.
4. Basing on the undrained shear strength derived for SPTs, BH01 was characterized by stiff soils from ground level up to 2mBGL underlain by very stiff cohesive soils from 2m to 7mBGL overlying hard cohesive soils. BH02 was characterized by very stiff soils from the surface up to 1mBGL overlying medium dense granular soils from 1m to 2mBGL underlain by very stiff cohesive soils from 2m up to 6mBGL overlying hard cohesive soils. BH03 was comprised of stiff soil from the surface up to 1mBGL overlying very stiff soil from 1.5m to 7.5mBGL underlain by hard cohesive soils. BH04 was loose granular soils from ground level up to 4m overlying very stiff cohesive soils from 4m to 6.5mBGL,

hard soils from 6.5m to 8mBGL interbedded with very stiff soil from 8m to 9.5mBGL and hard soils below 9.5mBGL.

5. The laboratory investigation confirmed that the geological sequence at the site was comprised of the following; BH01 was characterised by grey clayey sand from ground level up to 4mBGL succeeded by grey sandy silt from 4m to 5mBGL, followed by grey sandy clay from 5m to 6mBGL, 6m-8mBGL silty sand, 8m-9mBGL sandy clay, 9m-10mBGL sandy silt, 10m-11mBGL sandy clay, 11m-12mBGL sandy silt, 12m-17mBGL sandy clay, 17m-18mBGL sandy silt and sandy clay below 18m. At BH02, sandy clay was encountered from ground level up to 1mBGL, 1m-2mBGL clayey gravel, 2m-6mBGL sandy silt, 6m-7mBGL silty gravel, 7m-11mBGL sandy silt, 11m-12mBGL sandy clay, 12m-24mBGL sandy silt, 24m-27mBGL sandy clay and sandy silt below 27m. BH03 was characterised by clayey sand from ground level up to 1mBGL, 1m-5mBGL sandy clay, 5m-8mBGL silty sand, 8m-9mBGL sandy clay, 9m-11mBGL clayey sand and 11m->29mBGL sandy silt. At BH04, sandy clay was encountered from ground level up to 1mBGL, 1m-3mBGL clayey sand, 3m-4mBGL sandy silt, 4m-6mBGL sandy clay, 6m-9mBGL sandy clay, 9m-12mBGL sandy silt, 12m-13mBGL silty sand, 13m->30mBGL sandy silt.
6. Natural moisture content of the insitu soil varied between 19 and 37%.
7. All shrinkage limit test results are less than 15 percent, this indicates as the Kaolinite clay mineral is dominant or high in insitu soil and the project area is not prone to swelling or expansive soil.
8. The specific gravity of the insitu soil varied from 2.59 to 2.79 which implied that it is comprised of a blend of clay, sand and silt.
9. The insitu soil is prone to corrosion due to high chloride and sulphates concentrations.
10. The undrained shear strength parameter angle of internal friction (degrees) for this specific project varies between 0 to 19°, the minimum cohesion is 28kPa with 2 degrees internal friction angle at 10mBGL depth of borehole 1, and the maximum cohesion is 133kPa with 0 degrees internal friction angle at 5mBGL of borehole 4.
11. Unconfined Compressive Strength of the insitu soil ranges from 14 to 26kpa for Borehole 1, 20 to 46kpa for borehole 2, 24 to 44kpa for borehole 3, and 20 to 70kpa for borehole 4.

12. The insitu soil is compressible and poor to facilitate drainage. The test result shows the average compression index (Cc), coefficient of volume compressibility (M_v), Coefficient of consolidation, and coefficient of permeability is 0.15, 0.13MN/m^2, 0.008cm^2/sec and 1.1E-9 m/sec respectively.
13. Basing on the index properties and its classification, the insitu soils have poor workability as a construction material, and poor relative desirability for foundation.

4.2 Recommendations

1. The design of the proposed foundations shall take into account the poor ground conditions to ensure that the risk of failure is minimised.
2. To minimise corrosion, special corrosion protection considerations for steel are required. These include; stainless steel be used to provide reinforcement for foundation structure. Provision of appropriate concrete cover to the foundation to avoid the ingress of chlorides and sulphates. Application of corrosion resistant concrete mix designs and epoxy coated reinforcing steel.
3. In order to avoid ground water related problem, effect of the ground water on foundation and way of construction should be taken into consideration during foundation design.
4. For accurate settlement analysis during foundation design we recommend to consider values for each borehole location and depth.
5. For preliminary foundation design we recommend to use undrained shear strength result from SPT and undrained unconsolidated triaxial test results instead of Unconfined Compressive Strength test result.

5 REFERENCES

1. AMERICAN SOCIETY FOR TESTING AND MATERIALS: Annual Book of ASTM international Standards. 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, United States.

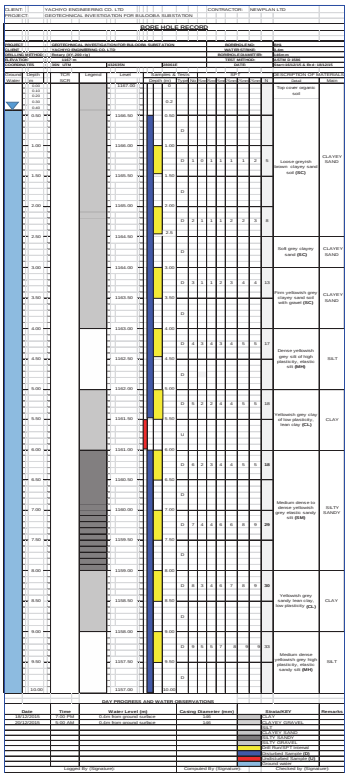
- D 420 Standard Guide to Site Characterization for Engineering Design and Construction Purposes
- D 421 Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
- D 427 Standard Test Method for Shrinkage Factors of Soils by the Mercury Method
- D 422 Test Method for Particle-Size Analysis of Soils
- D 512 Standard Test Methods for Chloride Ion In Water
- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 1586 Test Method for Penetration Test and Split-Barre Sampling of Soils
- D 2113 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
- D 2434 Standard Test Method for Permeability of Granular Soils (Constant Head)
- D 2435 Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading
- D 2487 Classification of Soils for Engineering Purposes
- D 2216 Test Method for Laboratory Determination of Water Moisture) Content of Soil and Rock (Unified Soil Classification System).
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
- D 2850 Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
- D 3740 Practice for Minimum Requirements of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction Plasticity Index of Soils
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

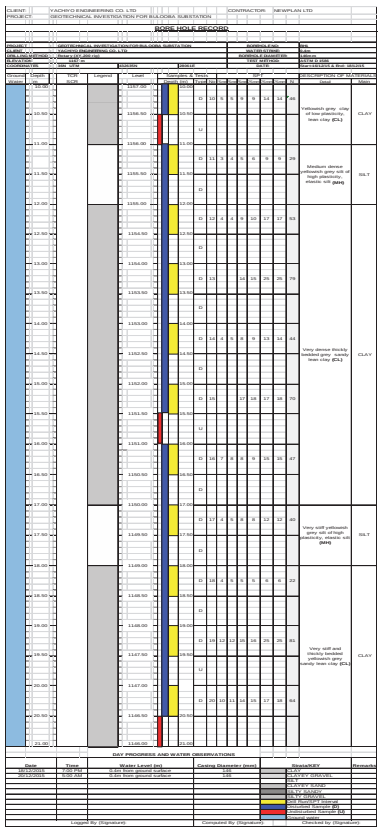
- D 4750 Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
- D 4767 Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils
- D 4943 Standard Test Method for Shrinkage Factors of Soils by the Wax Method
- G 51 Test Method for pH of Soil for Use in Corrosion Testing

2. Bowles Joseph E; Foundation Analysis and Design, Second Edition. McGraw Hill Companies, Tokyo, 1997.
3. California Department of Transportation, 2012. Corrosion Guidelines version 2.0.
4. Department of Geological Surveys and Mines, 2012. Geological Map of Uganda sheet No 70.
5. VICKERS, BRIAN (1978); Laboratory work in Civil Engineering Soil Mechanics. Granada Publishers, London.
6. G.E Barney; Principles and Practice of Soil Mechanics, First Edition. Macmillan Press Ltd, London, 1995
7. Department of US Army Corps of Engineers, CECW-EG Engineer Manual 1110-1-1904 Engineering and Design of SETTLEMENT ANALYSIS, Washington, DC 20314-1000, 1990.
8. MJ Tomlinson; Foundation Design & Construction, Sixth Edition. Addison Wesley Longman Limited, Edinburgh Gate, Harlow Essex CM20 2JE, 1998.
9. R.F.Craig. E & FN Spon, 2004. CRAIG'S SOIL MECHANICS. Seventh Edition, London.

6 APPENDIX

Appendix 1: Borehole logs


BORE HOLE RECORD


BORE HOLE RECORD

CLIENT: YACHIYO ENGINEERING CO. LTD CONTRACTOR: NEWPLAN LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION

BORE HOLE RECORD

PROJECT	: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	BOREHOLE NO:	BH2
CLIENT	: YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	NIL
DRILLING METHOD	: Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION	: 1187 m	TEST METHOD:	ASTM D 1586
COORDINATES	: 36N UTM 432010N 28859E	DATE:	Start:21/12/15 & End: 22/12/15

Ground Water: No Water Table Encountered

Depth m	Level	Samples & Tests Depth (m)	Type	No	75mm	75mm	75mm	75mm	75mm	75mm	N	Description Detail	Main
0.00	1187.00	0										black organic top cover soil	
0.10													
0.20		0.2											
0.30													
0.40													
0.50	1186.50	0.50	D									Clay of high plasticity, flat clay **(CH)**	CLAY
1.00	1186.00	1.00	D	1	1	2	2	3	4	5	14		
1.50	1185.50	1.50	D									brown clayey gravel with sand **(GC)**	CLAYEY GRAVEL
2.00	1185.00	2.00	D	2	6	6	9	10	11	12	42		
2.50	1184.50	2.5	D										
3.00	1184.00	3.00	D	3	6	7	8	8	10	10	36		
3.50	1183.50	3.50	D										
4.00	1183.00	4.00	D	4	3	4	5	6	6	7	24	Medium dense silt of high plasticity, elastic silt **(MH)**	SILT
4.50	1182.50	4.50	D										
5.00	1182.00	5.00	D	5	2	3	4	5	6	7	22		
5.50	1181.50	5.50	U										
6.00	1181.00	6.00	D	6	1	2	3	3	4	5	**15**	Silty gravel with sand **(GM)**	SILTY GRAVEL
6.50	1180.50	6.50	D										
7.00	1180.00	7.00	D	7	2	2	4	4	5	6	**19**		
7.50	1179.50	7.50	D										
8.00	1179.00	8.00	D	8	4	4	4	5	6	7	**22**	Yellowish brown silt of high plasticity, elastic sandy silt **(MH)**	SILT
8.50	1178.50	8.50	D										
9.00	1178.00	9.00	D	9	3	3	5	6	6	7	24		
9.50	1177.50	9.50	D										
10.00	1177.00	10.00											

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
				CLAY	
				CLAYEY GRAVEL	
				SILT	
				CLAYEY SAND	
				SILTY SANDY	
				SILTY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	
				Ground water	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

CLIENT: YACHIYO ENGINEERING CO. LTD CONTRACTOR: NEWPLAN LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION

BORE HOLE RECORD

PROJECT	: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	BOREHOLE NO:	BH2
CLIENT	: YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	NIL
DRILLING METHOD	: Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION	: 1187 m	TEST METHOD:	ASTM D 1586
COORDINATES	: 36N UTM 432010N 28859E	DATE:	Start:21/12/15 & End: 22/12/15

Ground Water: No Water Table Encountered

Depth m	Level	Samples & Tests Depth (m)	Type	No	75mm	75mm	75mm	75mm	75mm	75mm	N	Description Detail	Main
10.00	1177.00	10.00	D	10	5	5	7	7	8	9	31	Yellowish brown silt of high plasticity, elastic silt **(MH)**	SILT
10.50	1176.50	10.50	U										
11.00	1176.00	11.00	D	11	3	3	5	5	7	8	25	Yellowish brown clay of low plasticity, lean clay **(CL)**	CLAY
11.50	1175.50	11.50	D										
12.00	1175.00	12.00	D	12	3	3	4	5	5	6	20		
12.50	1174.50	12.50	D										
13.00	1174.00	13.00	D	13	3	4	7	8	10	11	36		
13.50	1173.50	13.50	D										
14.00	1173.00	14.00	D	14	4	5	6	6	8	9	29		
14.50	1172.50	14.50	D										
15.00	1172.00	15.00	D	15	2	3	4	5	6	7	22		
15.50	1171.50	15.50	U										
16.00	1171.00	16.00	D	16	2	3	4	5	6	6	21	Yellowish grey silt of high plasticity, elastic silt **(MH)**	SILT
16.50	1170.50	16.50	D										
17.00	1170.00	17.00	D	17	3	3	5	6	7	8	26		
17.50	1169.50	17.50	D										
18.00	1169.00	18.00	D	18	2	3	7	8	10	10	35		
18.50	1168.50	18.50	D										
19.00	1168.00	19.00	D	19	5	6	10	10	11	12	43		
19.50	1167.50	19.50	U										
20.00	1167.00												

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
				CLAY	
				CLAYEY GRAVEL	
				SILT	
				CLAYEY SAND	
				SILTY SANDY	
				SILTY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	
				Ground water	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

CLIENT: YACHIYO ENGINEERING CO. LTD CONTRACTOR: NEWPLAN LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION

BORE HOLE RECORD

PROJECT	: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	BOREHOLE NO:	BH2
CLIENT	: YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	NIL
DRILLING METHOD	: Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION	: 1187 m	TEST METHOD:	ASTM D 1586
COORDINATES	: 36N UTM 432010N 28859E	DATE:	Start:21/12/15 & End: 22/12/15

Ground Water: No Water Table Encountered

Depth m	Level	Samples & Tests Depth (m)	Type	No	75mm	75mm	75mm	75mm	75mm	75mm	N	Description Detail	Main
20.00	1167.00	20.00	D	20	6	6	10	9	12	13	44		
20.50	1166.50	20.50	U										
21.00	1166.00	21.00	D	21	5	6	8	8	10	10	36	Dense brownish grey silt of high plasticity, elastic silt **(MH)**	SILT
21.50	1165.50	21.50	D										
22.00	1165.00	22.00	D	22	4	5	9	9	13	13	44		
22.50	1164.50	22.50	D										
23.00	1164.00	23.00	D	23	5	6	10	11	12	13	46		
23.50	1163.50	23.50	D									Dense reddish brown silt of high plasticity, elastic silt **(MH)**	SILT
24.00	1163.00	24.00	D	24	3	4	5	5	6	6	22		
24.50	1162.50	24.50	D										
25.00	1162.00	25.00	D	25	4	4	7	8	8	9	32		
25.50	1161.50	25.50	U										
26.00	1161.00	26.00	D	26			18	19	19	19	75		
26.50	1160.50	26.50	D										
27.00	1160.00	27.00	D	27			17	18	19	19	73	Hard yellow silt of high plasticity, elastic silt **(MH)**	SILT
27.50	1159.50	27.50	D										
28.00	1159.00	28.00	D	28			17	18	19	19	73		
28.50	1158.50	28.50	U										
29.00	1158.00	29.00											

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
				CLAY	
				CLAYEY GRAVEL	
				SILT	
				CLAYEY SAND	
				SILTY SANDY	
				SILTY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	
				Ground water	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

CLIENT: YACHIYO ENGINEERING CO. LTD CONTRACTOR: NEWPLAN LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION

BORE HOLE RECORD

PROJECT	: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	BOREHOLE NO:	BH3
CLIENT	: YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	0.9m
DRILLING METHOD	: Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION	: 1177 m	TEST METHOD:	ASTM D 1586
COORDINATES	: 36N UTM 431710N 29043E	DATE:	Start:24/12/15 & End: 31/12/15

Depth m	Level	Samples & Tests Depth (m)	Type	No	75mm	75mm	75mm	75mm	75mm	75mm	N	Description Detail	Main
0.00	1177.00	0										Organic top cover soil	
0.10													
0.20		0.2											
0.30													
0.40													
0.50	1176.50	0.50	D									Stiff yellowish grey clayey sand **(SC)**	CLAYEY SAND
1.00	1176.00	1.00	D	1	1	0	0	1	1	2	4		
1.50	1175.50	1.50	D										
2.00	1175.00	2.00	D	2	1	2	4	4	3	4	15		
2.50	1174.50	2.5	D									Stiff yellowish grey clay of low plasticity, lean clay **(CL)**	CLAY
3.00	1174.00	3.00	D	3	1	2	3	3	3	4	13		
3.50	1173.50	3.50	D										
4.00	1173.00	4.00	D	4	2	2	3	3	4	4	14	Dense yellowish grey clay of high plasticity, flat clay **(CH)**	CLAY
4.50	1172.50	4.50	D										
5.00	1172.00	5.00	D	5	2	2	3	3	3	3	12		
5.50	1171.50	5.50	U										
6.00	1171.00	6.00	D	6	2	2	4	4	5	5	**18**		
6.50	1170.50	6.50	D									Dense yellowish grey silt of high plasticiy, elastic sandy silt **(MH)**	SILT
7.00	1170.00	7.00	D	7	1	2	3	3	4	5	**15**		
7.50	1169.50	7.50	D										
8.00	1169.00	8.00	D	8	1	2	4	5	9	10	**28**	Dense yellowish grey clay of low plasticity, lean clay **(CL)**	CLAY
8.50	1168.50	8.50	D										
9.00	1168.00	9.00	D	9	3	4	7	7	10	10	34	Dense yellowish grey clayey sand **(SC)**	CLAYEY SAND
9.50	1167.50	9.50	D										
10.00	1167.00	10.00											

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
31/12/2015	5:00 PM	0.9m from ground surface	146	CLAY	
5/1/2016	9:00 AM	0.9m from ground surface	146	CLAYEY GRAVEL	
				SILT	
				CLAYEY SAND	
				SILTY SANDY	
				SILTY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	
				Ground water	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

CLIENT: YACHIYO ENGINEERING CO. LTD CONTRACTOR: NEWPLAN LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION

BORE HOLE RECORD

PROJECT	: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	BOREHOLE NO:	BH3
CLIENT	: YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	0.9m
DRILLING METHOD	: Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION	: 1177 m	TEST METHOD:	ASTM D 1586
COORDINATES	: 36N UTM 431710N 29043E	DATE:	Start:24/12/15 & End: 31/12/15

Depth m	Level	Depth (m)	Type	No	75mm	75mm	75mm	75mm	75mm	75mm	N	Detail	Main
10.00	1167.00	10.00	D	10	4	4	10	11	11	11	43	Dense yellowish grey clayey sand **(SC)**	CLAYEY SAND
10.50	1166.50	10.50	U										
11.00	1166.00	11.00	D	11	2	2	4	4	6	6	20		
11.50	1165.50	11.50	D										
12.00	1165.00	12.00	D	12	3	3	6	7	6	7	26		
12.50	1164.50	12.50	D										
13.00	1164.00	13.00	D	13	4	4	8	9	9	9	35		
13.50	1163.50	13.50	D										
14.00	1163.00	14.00	D	14	2	3	6	6	9	9	30		
14.50	1162.50	14.50	D										
15.00	1162.00	15.00	D	15	3	4	7	8	11	11	37	Dense very thickly bedded grey silt of high plasticity, elastic silt **(MH)**	SILT
15.50	1161.50	15.50	U										
16.00	1161.00	16.00	D	16	4	4	7	7	10	10	34		
16.50	1160.50	16.50	D										
17.00	1160.00	17.00	D	17	4	5	8	8	11	12	39		
17.50	1159.50	17.50	D										
18.00	1159.00	18.00	D	18	4	4	7	8	11	11	37		
18.50	1158.50	18.50	D										
19.00	1158.00	19.00	D	19	3	3	6	6	7	8	27		
19.50	1157.50	19.50	U										
20.00	1157.00												

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
31/12/2015	5:00 PM	0.9m from ground surface	146	CLAY	
5/1/2016	9:00 AM	0.9m from ground surface	146	CLAYEY GRAVEL	
				SILT	
				CLAYEY SAND	
				SILTY SANDY	
				SILTY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	
				Ground water	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

CLIENT: YACHIYO ENGINEERING CO. LTD CONTRACTOR: NEWPLAN LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION

BORE HOLE RECORD

PROJECT	: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	BOREHOLE NO:	BH3
CLIENT	: YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	0.9m
DRILLING METHOD	: Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION	: 1177 m	TEST METHOD:	ASTM D 1586
COORDINATES	: 36N UTM 431710N 29043E	DATE:	Start:24/12/15 & End: 31/12/15

Depth m	Level	Depth (m)	Type	No	75mm	75mm	75mm	75mm	75mm	75mm	N	Detail	Main
20.00	1157.00	20.00	D	20	2	3	7	8	11	12	38		
20.50	1156.50	20.50	U										
21.00	1156.00	21.00	D	21	6	7	10	11	11	12	44		
21.50	1155.50	21.50	D										
22.00	1155.00	22.00	D	22	5	6	9	10	12	12	43	Dense grey silt of high plasticity, elastic silt **(MH)**	SILT
22.50	1154.50	22.50	D										
23.00	1154.00	23.00	D	23	4	4	8	9	10	10	37		
23.50	1153.50	23.50	D										
24.00	1153.00	24.00	D	24	5	5	10	10	13	14	47		
24.50	1152.50	24.50	D										
25.00	1152.00	25.00	D	25							0		
25.50	1151.50	25.50	U										
26.00	1151.00	26.00	D	26	5	6	10	10	12	13	45		
26.50	1150.50	26.50	D										
27.00	1150.00	27.00	D	27			19	19	19	20	77	Very dense reddish yellowish grey silt of high plasticity, elastic silt **(MH)**	SILT
27.50	1149.50	27.50	D										
28.00	1149.00	28.00	D	28			18	18	19	19	74		
28.50	1148.50	28.50	D										
29.00	1148.00	29.00	D	29			13	12	15	14	54		
29.50	1147.50	29.50	U										
30.00	1147.00	30.00											

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
31/12/2015	5:00 PM	0.9m from ground surface	146	CLAY	
5/1/2016	9:00 AM	0.9m from ground surface	146	CLAYEY GRAVEL	
				SILT	
				CLAYEY SAND	
				SILTY SANDY	
				SILTY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	
				Ground water	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

CLIENT: YACHIYO ENGINEERING CO. LTD CONTRACTOR: NEWPLAN LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION

BORE HOLE RECORD

PROJECT	: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	BOREHOLE NO:	BH4
CLIENT	: YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	3.8m
DRILLING METHOD	: Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION	: 1173 m	TEST METHOD:	ASTM D 1586
COORDINATES	: 36N UTM 432066N 28579E	DATE:	Start:05/01/16 & End: 08/01/16

Depth m	Level	Depth (m)	Type	No	75mm	75mm	75mm	75mm	75mm	75mm	N	Detail	Main
0.00	1173.00	0										black organic top cover soil	
0.10													
0.20		0.2											
0.30													
0.40													
0.50	1172.50	0.50	D									Loose brown clay of low plasticity, lean clay **(CL)**	CLAY
1.00	1172.00	1.00	D	1	2	2	2	3	2	3	10		
1.50	1171.50	1.50	D										
2.00	1171.00	2.00	D	2	1	2	2	2	2	2	8	Loose brown clay of high plasticity, flat clay **(CH)**	CLAY
2.50	1170.50	2.5	D										
3.00	1170.00	3.00	D	3	2	2	2	2	2	2	8		
3.50	1169.50	3.50	D									Loose brown silt with sand **(ML)**	SILT
4.00	1169.00	4.00	D	4	2	2	2	3	2	3	10		
4.50	1168.50	4.50	D										
5.00	1168.00	5.00	D	5	2	3	3	4	5	5	17	Yellowish brown clay of high plasticity, flat clay **(CH)**	CLAY
5.50	1167.50	5.50	U										
6.00	1167.00	6.00	D	6	3	3	4	4	6	6	**20**	Medium dense yellowish grey clay of low plasticity, lean clay **(CL)**	CLAY
6.50	1166.50	6.50	D										
7.00	1166.00	7.00	D	7	2	3	4	4	6	6	**20**	Firm grey clay of high plasticity, flat clay **(CH)**	CLAY
7.50	1165.50	7.50	D										
8.00	1165.00	8.00	D	8	2	3	3	4	5	6	**18**	Firm grey clay of low plasticity, lean clay **(CL)**	CLAY
8.50	1164.50	8.50	D										
9.00	1164.00	9.00	D	9	1	2	2	3	4	4	13	Soft yellowish grey silt of high plasticity, elastic silt **(MH)**	SILT
9.50	1163.50	9.50	D										
10.00	1163.00	10.00											

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
8/1/2016	5:00 PM	3.8m from ground surface	146	CLAY	
11/1/2016	10:00 AM	3.8m from ground surface	146	CLAYEY GRAVEL	
				SILT	
				CLAYEY SAND	
				SILTY SANDY	
				SILTY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	
				Ground water	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

CLIENT: YACHIYO ENGINEERING CO. LTD CONTRACTOR: NEWPLAN LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION

BORE HOLE RECORD

PROJECT	: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	BOREHOLE NO:	BH4
CLIENT	: YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	3.8m
DRILLING METHOD	: Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION	: 1173 m	TEST METHOD:	ASTM D 1586
COORDINATES	: 36N UTM 432066N 28579E	DATE:	Start:05/01/16 & End: 08/01/16

Depth m	Level	Depth (m)	Type	No	75mm	75mm	75mm	75mm	75mm	75mm	N	Detail	Main
10.00	1163.00	10.00	D	10	3	3	6	6	8	8	28	Soft yellowish grey silt of high plasticity, elastic silt **(MH)**	SILT
10.50	1162.50	10.50	U										
11.00	1162.00	11.00	D	11	2	2	4	4	5	5	18		
11.50	1161.50	11.50	D										
12.00	1161.00	12.00	D	12	4	4	7	7	10	11	35	Soft yellowish grey siltilty sand **(SM)**	SILTY SAND
12.50	1160.50	12.50	D										
13.00	1160.00	13.00	D	13	2	2	4	5	6	7	22		
13.50	1159.50	13.50	D										
14.00	1159.00	14.00	D	14	3	4	6	7	9	9	31		
14.50	1158.50	14.50	D										
15.00	1158.00	15.00	D	15	3	4	6	7	8	8	29		
15.50	1157.50	15.50	U										
16.00	1157.00	16.00	D	16	2	2	5	5	8	8	26	Soft to stiff very thickly bedded yellowish grey silt of high plasticity, elastic silt **(MH)**	SILT
16.50	1156.50	16.50	D										
17.00	1156.00	17.00	D	17	2	3	6	7	8	8	29		
17.50	1155.50	17.50	D										
18.00	1155.00	18.00	D	18	4	5	8	9	11	12	40		
18.50	1154.50	18.50	D										
19.00	1154.00	19.00	D	19	4	3	6	7	10	11	34		
19.50	1153.50	19.50	U										
20.00	1153.00												

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
8/1/2016	5:00 PM	3.8m from ground surface	146	CLAY	
11/1/2016	10:00 AM	3.8m from ground surface	146	CLAYEY GRAVEL	
				SILT	
				CLAYEY SAND	
				SILTY SANDY	
				SILTY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	
				Ground water	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

CLIENT:	YACHIYO ENGINEERING CO. LTD	CONTRACTOR:	NEWPLAN LTD
PROJECT:	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION		

BORE HOLE RECORD

PROJECT	: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION			BOREHOLE NO:	BH4
CLIENT	: YACHIYO ENGINEERING CO. LTD			WATER STRIKE:	3.8m
DRILLING METHOD	: Rotary (XY-200 rig)			BOREHOLE DIAMETER:	146mm
ELEVATION	: 1173 m			TEST METHOD:	ASTM D 1586
COORDINATES	: 36N UTM	432066N	28579E	DATE:	Start:05/01/16 & End: 08/01/16

Ground Water	Depth m	TCR SCR	Legend	Level	Samples & Tests Depth (m)	Type	No	SPT 75mm	75mm	75mm	75mm	75mm	75mm	N	DESCRIPTION OF MATERIALS Detail	Main
	20.00			1153.00	20.00	D	20	4	4	7	8	11	11	37		
	20.50			1152.50	20.50	U										
	21.00			1152.00	21.00	D	21	2	2	5	5	6	7	23		
	21.50			1151.50	21.50	D										
	22.00			1151.00	22.00	D	22	2	3	5	6	8	8	27		
	22.50			1150.50	22.50	D										
	23.00			1150.00	23.00	D	23	3	4	7	8	7	8	30		
	23.50			1149.50	23.50	D										
	24.00			1149.00	24.00	D	24	3	3	7	7	8	9	31		
	24.50			1148.50	24.50	D										
	25.00			1148.00	25.00	D	25	7	7	9	10	11	12	42		
	25.50			1147.50	25.50	U									Soft to stiff very thickly bedded yellowish grey silt of high plasticity, elastic silt (MH)	SILT
	26.00			1147.00	26.00	D	26	8	9	12	13	14	14	53		
	26.50			1146.50	26.50	D										
	27.00			1146.00	27.00	D	27	6	7	10	10	14	15	49		
	27.50			1145.50	27.50	D										
	28.00			1145.00	28.00	D	28	6	6	12	12	16	16	56		
	28.50			1144.50	28.50	D										
	29.00			1144.00	29.00	D	29			18	18	19	20	75		
	29.50			1143.50	29.50	D										
	30.00			1143.00	30.00	D	30			19	19	19	20	77		
	30.50			1142.50	30.50	U										
	31.00			1142.00	31.00											

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
8/1/2016	5:00 PM	3.8m from ground surface	146	CLAY	
11/1/2016	10:00 AM	3.8m from ground surface	146	CLAYEY GRAVEL	
				SILT	
				CLAYEY SAND	
				SILTY SANDY	
				SILTY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	
				Ground water	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

Appendix 2: Drilling pictorial logs


XY 200 rotary drilling rig mobilized for the ground investigations

SPT at 2m for BH1, moist greyish brown loose granular clayey sand soil

SPT at 3m for BH1, moist brownish grey medium dense granular clayey sand


SPT at 4m for BH1, moist greyish yellow firm intact silt of high plasticity, elastic silt

SPT at 5m for BH1, moist greyish yellow firm intact clay of low plasticity, lean clay

SPT at 6m for BH1, moist greyish yellow medium dense granular elastic sandy silt

SPT at 7m for BH1, moist greyish yellow medium dense granular elastic sandy silt

SPT at 8m for BH1, moist greyish yellow stiff intact sandy lean clay, low plasticity


SPT at 9m for BH1, moist greyish yellow stiff intact high plasticity, elastic sandy silt

SPT@10m for BH1, moist greyish yellow stiff intact clay of low plasticity, lean clay


Recovered samples 0-10m @BH01

SPT@12m for BH1, moist mottled whitish grey very stiff intact sandy lean clay

SPT@13m for BH1, moist mottled whitish grey very stiff intact sandy lean clay


SPT@14m for BH1, moist mottled whitish grey very stiff intact sandy lean clay

SPT@15m for BH1, moist mottled whitish grey very stiff intact sandy lean clay

SPT@16m for BH1, moist mottled whitish grey very stiff intact sandy lean clay

SPT@17m for BH1, moist greyish brown firm intact silt of high plasticity, elastic silt


SPT@18m for BH1, moist brown very stiff intact sandy lean clay

SPT at 1m for BH2, moist reddish brown dense clayey gravel with sand

SPT@2m for BH2, moist reddish brown stiff intact silt of high plasticity, elastic silt

SPT at 3m for BH2, moist reddish brown stiff intact silt of high plasticity, elastic silt

SPT at 4m for BH2, moist reddish brown stiff intact silt of high plasticity, elastic silt

Stratigraphy 0-10m for BH2

Stratigraphy 11-15m for BH2

Stratigraphy 11-20m for BH2

SPT at 5m, moist reddish brown stiff intact silt of high plasticity, elastic silt

SPT at 6m for BH2, moist mottled reddish brown medium dense silty gravel with sand

SPT@7m for BH2, moist mottled yellowish brown firm intact silt of high plasticity, elastic sandy silt

SPT at 8m for BH2, moist reddish firm intact silt of high plasticity, elastic sandy silt

SPT at 9m for BH2, moist mottled reddish firm intact silt of high plasticity, elastic sandy silt

SPT at 10m for BH2, moist reddish brown firm intact silt of high plasticity, elastic silt

SPT at 11m for BH2, moist mottled reddish brown firm intact clay of low plasticity, lean clay

SPT at 12m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 13m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 14m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 15m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 16m for BH2, moist mottled reddish stiff intact silt of high plasticity, elastic silt

SPT at 17m for BH2, moist mottled reddish stiff intact silt of high plasticity, elastic silt

SPT at 18m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 19m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 20m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 21m for BH2, Moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 22m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 23m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 24m for BH2, moist mottled yellowish brown stiff intact sandy lean CLAY


SPT at 26m for BH2, moist mottled yellowish brown stiff intact sandy lean CLAY

SPT at 27m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt

SPT at 28m for BH2, moist mottled yellowish brown stiff intact silt of high plasticity, elastic silt


Stratigraphy 20-28m for BH2

SPT at 1m for BH3, moist greyish brown very loose granular clayey sand

SPT at 2m for BH3, moist greyish brown firm intact clay of low plasticity, lean clay


SPT at 3m for BH3, moist greyish brown firm intact clay of low plasticity, lean clay


SPT at 4m for BH3, moist mottled yellowish brown firm intact clay of high plasticity, flat clay

SPT at 5m for BH3, moist greyish yellow firm intact silt of high plasticity, elastic sandy silt

SPT at 6m for BH3, moist greyish yellow firm intact silt of high plasticity, elastic sandy silt

SPT at 7m for BH3, moist greyish yellow firm intact silt of high plasticity, elastic sandy silt

SPT at 8m for BH3, moist brownish yellow stiff intact clay of low plasticity, lean clay

SPT at 9m for BH3, moist yellowish brown dense granular clayey sand

SPT at 10m for BH3, moist yellowish brown medium dense clayey sand

SPT at 11m for BH3, moist mottled brownish yellow firm intact silt of high plasticity, elastic silt


Stratigraphy from 0 to 10m for BH3

SPT at 12m for BH3, moist mottled brownish yellow firm intact silt of high plasticity, elastic silt

SPT at 13m for BH3,moist mottled brownish yellow firm intact silt of high plasticity, elastic silt

SPT at14m for BH3, moist mottled brownish yellow firm intact silt of high plasticity, elastic silt

SPT at 15m for BH3, moist mottled brownish yellow firm intact silt of high plasticity, elastic silt

SPT at 16m for BH3, moist mottled brownish yellow firm intact silt of high plasticity, elastic silt

SPT at 17m for BH3, moist mottled brownish yellow firm intact silt of high plasticity, elastic silt

SPT at 18m for BH3, moist mottled brownish yellow firm intact silt of high plasticity, elastic silt

SPT at 19m for BH3, moist mottled brownish yellow firm intact silt of high plasticity, elastic silt

SPT at 20m for BH3, moist yellowish grey stiff intact silt of high plasticity, elastic silt

SPT at 21m for BH3, moist yellowish grey stiff intact silt of high plasticity, elastic silt

SPT at 22m for BH3, moist yellowish grey stiff intact silt of high plasticity, elastic silt

SPT at 23m for BH3, moist yellowish grey stiff intact silt of high plasticity, elastic silt

SPT at 24m for BH3, very dense reddish yellowish grey silt of high plasticity, elastic silt

SPT at 26m for BH3, very dense reddish yellowish grey silt of high plasticity, elastic silt

SPT at 27m for BH3, very dense reddish yellowish grey silt of high plasticity, elastic silt

SPT at 28m for BH3, very dense reddish yellowish grey silt of high plasticity, elastic silt

SPT at 29m for BH3, very dense reddish yellowish grey silt of high plasticity, elastic silt

Stratigraphy from 20 to 29m for BH3

SPT at 1m for BH4, Moist reddish brown soft intact clay of high plasticity, flat clay

SPT at 2m for BH4, moist reddish brown soft intact clay of high plasticity, flat clay

SPT at 3m for BH4, moist reddish brown soft intact silt with

SPT at 4m for BH4, moist reddish brown firm intact clay of high plasticity, flat clay

SPT at 5m for BH4, moist reddish brown firm intact clay of high plasticity, flat clay

SPT at 6m for BH4, moist mottled yellowish brown firm intact clay of low plasticity, lean clay

SPT at 7m for BH4, moist mottled yellowish brown firm intact clay of high plasticity, flat clay

SPT at 8m for BH4, moist greyish brown clay of low plasticity, lean clay

SPT at 9m for BH4, moist greyish yellow stiff intact silt of high plasticity, elastic silt

SPT at 10m for BH4, moist mottled yellowish brown firm intact silt of high plasticity, elastic silt

SPT at 11m for BH4, moist mottled yellowish brown firm intact silt of high plasticity, elastic silt

SPT at 12m for BH4, moist mottled greyish yellow medium dense siltilty sand

SPT at 13m for BH4, moist mottled greyish yellow stiff intact silt of high plasticity, elastic silt

SPT at 14m for BH4, moist mottled greyish yellow stiff intact silt of high plasticity, elastic silt

SPT at 15m for BH4, moist mottled greyish yellow stiff intact silt of high plasticity, elastic silt

SPT at 16m for BH4, Moist mottled greyish yellow stiff intact silt of high plasticity, elastic silt

SPT at 17m for BH4, moist mottled greyish yellow stiff intact silt of high plasticity, elastic silt

SPT at 18m for BH4, Moist mottled greyish yellow stiff intact silt of high plasticity, elastic silt

SPT at 19m for BH4, moist mottled greyish yellow stiff intact silt of high plasticity, elastic silt

SPT at 20m for 20m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 21m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 22m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 23m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 24m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 25m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 26m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 27m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 28m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 29m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

SPT at 30m for BH4, moist mottled greyish brown firm intact silt of high plasticity, elastic silt

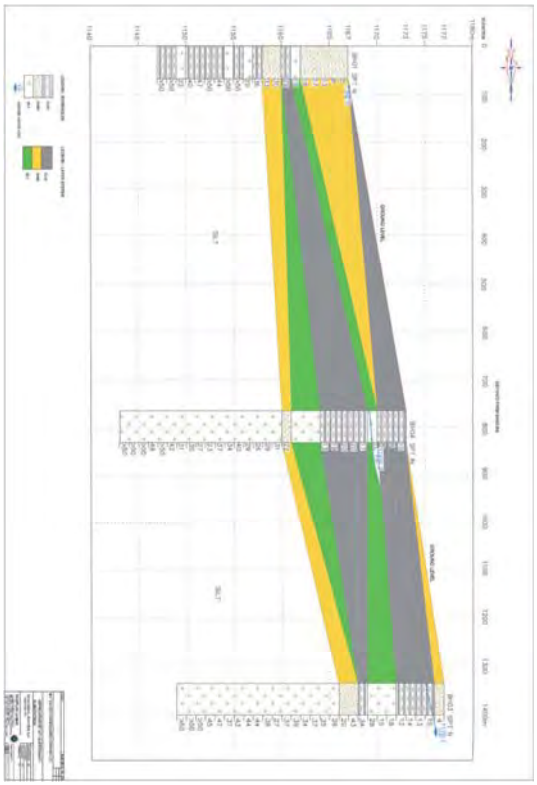

Stratigraphy 0-10m for BH4

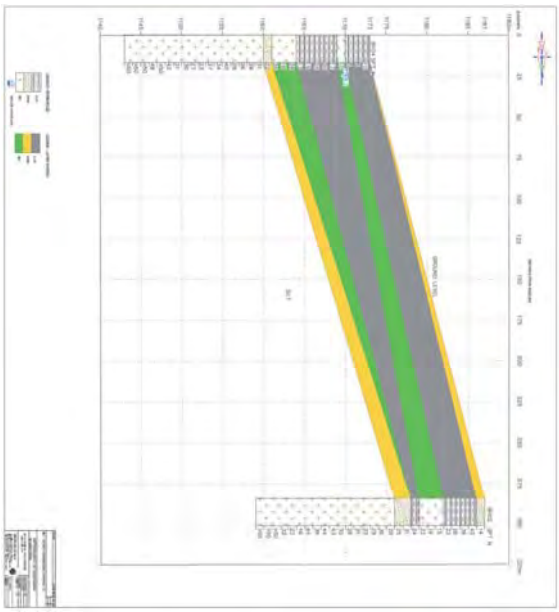

Stratigraphy 10-20m for BH4


Stratigraphy 20-30m for BH4

Appendix 3: Borehole layout

Appendix 4: Soil Profile



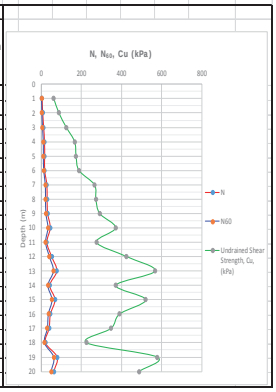


Appendix 5: Standard Penetration test result

CLIENT:	YACHIYO ENGINEERING COMPANY LTD
PROJECT:	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR:	NEWPLAN LIMITED

SUMMARY FOR STANDARD PENETRATION TEST (SPT) RESULTS

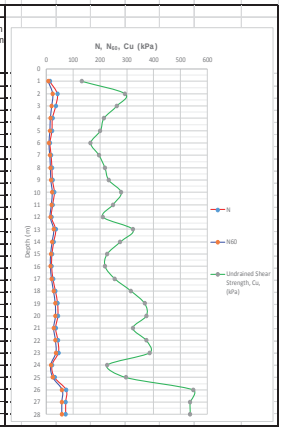
			BH1			
Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	N	N_{60}	Undrained Shear Strength, C_u (kPa)	Overconsolidation ratio (OCR)
0						
1	0.02	0.59	5	3	63	6
2	0.04	0.59	8	5	89	5
3	0.06	0.59	13	8	126	6
4	0.08	0.67	17	11	167	6
5	0.10	0.67	18	12	174	5
6	0.12	0.75	18	13	189	5
7	0.14	0.75	29	22	266	6
8	0.16	0.75	30	22	272	6
9	0.18	0.75	33	25	292	6
10	0.20	0.75	46	34	371	7
11	0.22	0.79	29	23	276	5
12	0.24	0.79	53	42	426	7
13	0.26	0.79	79	62	568	9
14	0.27	0.79	44	35	372	5
15	0.29	0.79	70	55	520	7
16	0.31	0.79	47	37	390	5
17	0.33	0.79	40	32	348	4
18	0.35	0.79	22	17	226	3
19	0.37	0.79	81	64	578	7
20	0.39	0.79	64	50	488	5



CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SUMMARY FOR STANDARD PENETRATION TEST (SPT) RESULTS

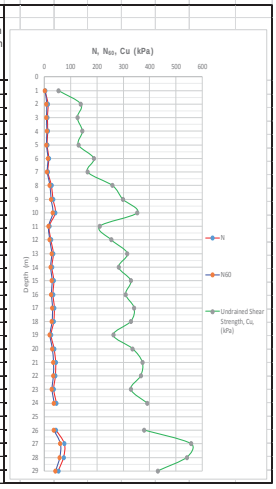
			BH2			
Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	N	N_{60}	Undrained Shear Strength, C_u (kPa)	Overconsolidation ratio (OCR)
0						
1	0.02	0.59	14	8	133	12
2	0.04	0.59	42	25	293	16
3	0.06	0.59	36	21	262	11
4	0.08	0.67	24	16	214	8
5	0.10	0.67	22	15	201	6
6	0.12	0.75	15	11	165	4
7	0.14	0.75	19	14	196	5
8	0.16	0.75	22	16	218	5
9	0.18	0.75	24	18	232	5
10	0.20	0.75	31	23	279	5
11	0.22	0.79	25	20	248	4
12	0.24	0.79	20	16	211	3
13	0.26	0.79	36	28	322	5
14	0.27	0.79	29	23	276	4
15	0.29	0.79	22	17	226	3
16	0.31	0.79	21	17	219	3
17	0.33	0.79	26	20	255	3
18	0.35	0.79	35	28	316	4
19	0.37	0.79	43	34	366	4
20	0.39	0.79	44	35	372	4
21	0.41	0.79	36	28	322	4
22	0.43	0.79	44	35	372	4
23	0.45	0.79	46	36	384	4
24	0.47	0.79	22	17	226	2
25	0.49	0.79	32	25	296	3
26	0.51	0.79	75	59	547	5
27	0.53	0.79	73	57	536	5
28	0.55	0.79	73	57	536	5



CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SUMMARY FOR STANDARD PENETRATION TEST (SPT) RESULTS

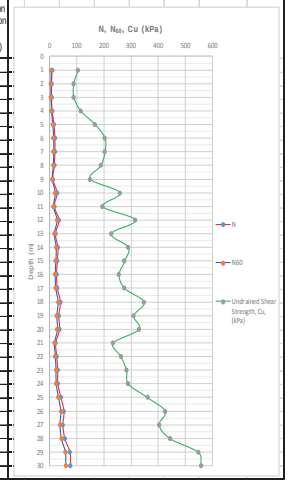
			BH3			
Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	N	N_{60}	Undrained Shear Strength, C_u (kPa)	Overconsolidation ratio (OCR)
0						
1	0.02	0.59	4	2	54	5
2	0.04	0.59	15	9	139	8
3	0.06	0.59	13	8	126	6
4	0.08	0.67	14	9	145	5
5	0.10	0.67	12	8	130	4
6	0.12	0.75	18	13	189	5
7	0.14	0.75	15	11	165	4
8	0.16	0.75	28	21	259	6
9	0.18	0.75	34	25	298	6
10	0.20	0.75	43	32	353	6
11	0.22	0.79	20	16	211	4
12	0.24	0.79	26	20	255	4
13	0.26	0.79	35	28	316	5
14	0.27	0.79	30	24	283	4
15	0.29	0.79	37	29	329	5
16	0.31	0.79	34	27	309	4
17	0.33	0.79	39	31	341	4
18	0.35	0.79	37	29	329	4
19	0.37	0.79	27	21	262	3
20	0.39	0.79	38	30	335	4
21	0.41	0.79	44	35	372	4
22	0.43	0.79	43	34	366	4
23	0.45	0.79	37	29	329	3
24	0.47	0.79	47	37	390	4
25	0.49	0.79				
26	0.51	0.79	45	35	378	4
27	0.53	0.79	77	61	557	5
28	0.55	0.79	74	58	541	5
29	0.57	0.79	54	43	432	4



CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SUMMARY FOR STANDARD PENETRATION TEST (SPT) RESULTS

			BH4			
Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	N	N_{60}	Undrained Shear Strength, C_u (kPa)	Overconsolidation ratio (OCR)
0						
1	0.02	0.59	10	6	104	10
2	0.04	0.59	8	5	89	5
3	0.06	0.59	8	5	89	4
4	0.08	0.67	10	7	114	4
5	0.10	0.67	17	11	167	5
6	0.12	0.75	20	15	203	5
7	0.14	0.75	20	15	203	5
8	0.16	0.75	18	13	189	4
9	0.18	0.75	13	10	149	3
10	0.20	0.75	28	21	259	5
11	0.22	0.79	18	14	196	3
12	0.24	0.79	35	28	316	5
13	0.26	0.79	22	17	226	4
14	0.27	0.79	31	24	289	4
15	0.29	0.79	29	23	276	4
16	0.31	0.79	26	20	255	3
17	0.33	0.79	29	23	276	4
18	0.35	0.79	40	32	348	4
19	0.37	0.79	34	27	309	4
20	0.39	0.79	37	29	329	4
21	0.41	0.79	23	18	233	3
22	0.43	0.79	27	21	262	3
23	0.45	0.79	30	24	283	3
24	0.47	0.79	31	24	289	3
25	0.49	0.79	42	33	360	4
26	0.51	0.79	53	42	426	4
27	0.53	0.79	49	39	402	4
28	0.55	0.79	56	44	443	4
29	0.57	0.79	75	59	547	5
30	0.59	0.79	77	61	557	5



CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SUMMARY FOR EVALUATION OF ALLOWABLE BEARING CAPACITY BASED ON FIELD SPT 'N' VALUES

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH01	0.00							
	1.00	CLAYEY SAND	5	0.59	3	63	325	108
	2.00		8	0.59	5	89	456	152
	3.00		13	0.59	8	126	647	216
	4.00		17	0.67	11	167	859	286
	5.00	SILT	18	0.67	12	174	895	298
	6.00	CLAY	18	0.75	13	189	969	323
	7.00	SILTY SANDY	29	0.75	22	266	1366	455
	8.00		30	0.75	22	272	1400	467
	9.00	CLAY	33	0.75	25	292	1500	500
	10.00	SILT	46	0.75	34	371	1905	635
	11.00	CLAY	29	0.79	23	276	1418	473
	12.00	SILT	53	0.79	42	426	2188	729
	13.00	CLAY	79	0.79	62	568	2917	972
	14.00		44	0.79	35	372	1914	638
	15.00		70	0.79	55	520	2674	891
	16.00		47	0.79	37	390	2007	669
	17.00		40	0.79	32	348	1787	596
	18.00	SILT	22	0.79	17	226	1162	387
	19.00	CLAY	81	0.79	64	578	2970	990
	20.00		64	0.79	50	488	2507	836

*The undrained shear strength (cu) of the soil is determined using the corrected standard penetration values (N_{60}) as per Hara et al. (1971) and Peck et al. (1974) empirical relationship respectively.Cu = Pa*0.29*N60^0.72, where Pa is Atmospheric presure and qult = 5.14 x Cu. Qall is evaluated usinga factor of safety of 3*

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SUMMARY FOR EVALUATION OF ALLOWABLE BEARING CAPACITY BASED ON FIELD SPT 'N' VALUES

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH02	0.00	CLAY			0	0	0	0
	1.00	CLAYEY GRAVEL	14	0.59	8	133	682	227
	2.00	SILT	42	0.59	25	293	1505	502
	3.00		36	0.59	21	262	1347	449
	4.00		24	0.67	16	214	1101	367
	5.00		22	0.67	15	201	1034	345
	6.00		15	0.75	11	165	850	283
	7.00	SILTY GRAVEL	19	0.75	14	196	1008	336
	8.00	SILT	22	0.75	16	218	1120	373
	9.00		24	0.75	18	232	1192	397
	10.00		31	0.75	23	279	1434	478
	11.00		25	0.79	20	248	1274	425
	12.00	CLAY	20	0.79	16	211	1085	362
	13.00	SILT	36	0.79	28	322	1657	552
	14.00		29	0.79	23	276	1418	473
	15.00		22	0.79	17	226	1162	387
	16.00		21	0.79	17	219	1124	375
	17.00		26	0.79	20	255	1311	437
	18.00		35	0.79	28	316	1623	541
	19.00		43	0.79	34	366	1883	628
	20.00		44	0.79	35	372	1914	638
	21.00		36	0.79	28	322	1657	552
	22.00		44	0.79	35	372	1914	638
	23.00		46	0.79	36	384	1976	659
	24.00		22	0.79	17	226	1162	387
	25.00		32	0.79	25	296	1522	507
	26.00		75	0.79	59	547	2810	937
	27.00		73	0.79	57	536	2756	919
	28.00		73	0.79	57	536	2756	919

*The undrained shear strength (cu) of the soil is determined using the corrected standard penetration values (N_{60}) as per Hara et al. (1971) and Peck et al. (1974) empirical relationship respectively.Cu = Pa*0.29*N60^0.72, where Pa is Atmospheric presure and qult = 5.14 x Cu. Qall is evaluated usinga factor of safety of 3*

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SUMMARY FOR EVALUATION OF ALLOWABLE BEARING CAPACITY BASED ON FIELD SPT 'N' VALUES

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH03	0.00	CLAYEY SAND						
	1.00	CLAY	4	0.59	2	54	277	92
	2.00		15	0.59	9	139	717	239
	3.00		13	0.59	8	126	647	216
	4.00		14	0.67	9	145	747	249
	5.00		12	0.67	8	130	668	223
	6.00	SILT	18	0.75	13	189	969	323
	7.00		15	0.75	11	165	850	283
	8.00		28	0.75	21	259	1332	444
	9.00	CLAY SAND	34	0.75	25	298	1532	511
	10.00	CLAY	43	0.75	32	353	1814	605
	11.00		20	0.79	16	211	1085	362
	12.00	SILT	26	0.79	20	255	1311	437
	13.00		35	0.79	28	316	1623	541
	14.00		30	0.79	24	283	1453	484
	15.00		37	0.79	29	329	1690	563
	16.00		34	0.79	27	309	1590	530
	17.00		39	0.79	31	341	1755	585
	18.00		37	0.79	29	329	1690	563
	19.00		27	0.79	21	262	1347	449
	20.00		38	0.79	30	335	1722	574
	21.00		44	0.79	35	372	1914	638
	22.00		43	0.79	34	366	1883	628
	23.00		37	0.79	29	329	1690	563
	24.00		47	0.79	37	390	2007	669
	25.00		Refusal	0.79		>450	>2300	>750
	26.00		45	0.79	35	378	1945	648
	27.00		77	0.79	61	557	2864	955
	28.00		74	0.79	58	541	2783	928
	29.00		54	0.79	43	432	2218	739

*The undrained shear strength (cu) of the soil is determined using the corrected standard penetration values (N_{60}) as per Hara et al. (1971) and Peck et al. (1974) empirical relationship respectively.Cu = Pa*0.29*N60^0.72, where Pa is Atmospheric presure and qult = 5.14 x Cu. Qall is evaluated usinga factor of safety of 3*

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SUMMARY FOR EVALUATION OF ALLOWABLE BEARING CAPACITY BASED ON FIELD SPT 'N' VALUES

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH04	0.00							
	1.00	CLAY	10	0.59	6	104	535	178
	2.00		8	0.59	5	89	456	152
	3.00		8	0.59	5	89	456	152
	4.00	SILT	10	0.67	7	114	586	195
	5.00	CLAY	17	0.67	11	167	859	286
	6.00		20	0.75	15	203	1046	349
	7.00		20	0.75	15	203	1046	349
	8.00		18	0.75	13	189	969	323
	9.00		13	0.75	10	149	767	256
	10.00	SILT	28	0.75	21	259	1332	444
	11.00		18	0.79	14	196	1006	335
	12.00		35	0.79	28	316	1623	541
	13.00	SILTY SAND	22	0.79	17	226	1162	387
	14.00	SILT	31	0.79	24	289	1487	496
	15.00		29	0.79	23	276	1418	473
	16.00		26	0.79	20	255	1311	437
	17.00		29	0.79	23	276	1418	473
	18.00		40	0.79	32	348	1787	596
	19.00		34	0.79	27	309	1590	530
	20.00		37	0.79	29	329	1690	563
	21.00		23	0.79	18	233	1200	400
	22.00		27	0.79	21	262	1347	449
	23.00		30	0.79	24	283	1453	484
	24.00		31	0.79	24	289	1487	496
	25.00		42	0.79	33	360	1851	617
	26.00		53	0.79	42	426	2188	729
	27.00		49	0.79	39	402	2068	689
	28.00		56	0.79	44	443	2277	759
	29.00		75	0.79	59	547	2810	937
	30.00		77	0.79	61	557	2864	955

*The undrained shear strength (cu) of the soil is determined using the corrected standard penetration values (N_{60}) as per Hara et al. (1971) and Peck et al. (1974) empirical relationship respectively.Cu = Pa*0.29*N60^0.72, where Pa is Atmospheric presure and qult = 5.14 x Cu. Qall is evaluated usinga factor of safety of 3*

Appendix 6: Natural Moisture Content

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	1
Depth (m)	5.5-6.0
Sample no.	
Container no.	KNG
Mass of wet soil + container (g)	195.4
Mass of dry soil + container (g)	163.6
Mass of container (g)	25.7
Mass of moisture (g)	31.8
Mass of dry soil (g)	137.9
Moisture content (%)	23.0
Average Moisture Content (%)	**23.0**

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATIO
CONTRACTOR: NEWPLAN LIMITED

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	1
Depth (m)	10.5-11.0
Sample no.	
Container no.	81
Mass of wet soil + container (g)	207.9
Mass of dry soil + container (g)	172.1
Mass of container (g)	25.8
Mass of moisture (g)	35.8
Mass of dry soil (g)	146.4
Moisture content (%)	24.5
Average Moisture Content (%)	**24.5**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	1
Depth (m)	15.5-16.0

Sample no.	
Container no.	Q6
Mass of wet soil + container (g)	205.2
Mass of dry soil + container (g)	167.2
Mass of container (g)	23.5
Mass of moisture (g)	38.0
Mass of dry soil (g)	143.6
Moisture content (%)	26.5
Average Moisture Content (%)	**26.5**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	1
Depth (m)	20.5-21.0

Sample no.	
Container no.	BA
Mass of wet soil + container (g)	184.8
Mass of dry soil + container (g)	150.0
Mass of container (g)	29.6
Mass of moisture (g)	34.7
Mass of dry soil (g)	120.4
Moisture content (%)	28.9
Average Moisture Content (%)	**28.9**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	2
Depth (m)	5.5-6.0

Sample no.	
Container no.	**XT**
Mass of wet soil + container (g)	248.5
Mass of dry soil + container (g)	202.7
Mass of container (g)	70.1
Mass of moisture (g)	45.8
Mass of dry soil (g)	132.6
Moisture content (%)	34.5
Average Moisture Content (%)	**34.5**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	2
Depth (m)	10.5-11.0

Sample no.	
Container no.	102
Mass of wet soil + container (g)	225.2
Mass of dry soil + container (g)	183.1
Mass of container (g)	70.1
Mass of moisture (g)	42.2
Mass of dry soil (g)	113.0
Moisture content (%)	37.3
Average Moisture Content (%)	**37.3**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	2
Depth (m)	15.5-16.0

Sample no.	
Container no.	**TY**
Mass of wet soil + container (g)	251.6
Mass of dry soil + container (g)	204.0
Mass of container (g)	71.5
Mass of moisture (g)	47.6
Mass of dry soil (g)	132.5
Moisture content (%)	35.9
Average Moisture Content (%)	**35.9**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	2
Depth (m)	20.5-21.0

Sample no.	
Container no.	RS
Mass of wet soil + container (g)	218.7
Mass of dry soil + container (g)	185.3
Mass of container (g)	71.9
Mass of moisture (g)	33.5
Mass of dry soil (g)	113.3
Moisture content (%)	29.5
Average Moisture Content (%)	**29.5**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	2
Depth (m)	25.5-26.0

Sample no.	
Container no.	x8
Mass of wet soil + container (g)	193.5
Mass of dry soil + container (g)	164.6
Mass of container (g)	62.2
Mass of moisture (g)	28.9
Mass of dry soil (g)	102.3
Moisture content (%)	28.3
Average Moisture Content (%)	**28.3**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	2
Depth (m)	28.5-29.0

Sample no.	
Container no.	**ZH**
Mass of wet soil + container (g)	**234.8**
Mass of dry soil + container (g)	**203.4**
Mass of container (g)	**64.6**
Mass of moisture (g)	**31.4**
Mass of dry soil (g)	**138.8**
Moisture content (%)	**22.6**
Average Moisture Content (%)	**22.6**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	3
Depth (m)	5.5-6.0

Sample no.	
Container no.	135
Mass of wet soil + container (g)	158.8
Mass of dry soil + container (g)	131.9
Mass of container (g)	27.5
Mass of moisture (g)	26.9
Mass of dry soil (g)	104.4
Moisture content (%)	25.8
Average Moisture Content (%)	**25.8**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	3
Depth (m)	10.5-11.0

Sample no.	
Container no.	SE
Mass of wet soil + container (g)	177.8
Mass of dry soil + container (g)	142.9
Mass of container (g)	30.4
Mass of moisture (g)	34.9
Mass of dry soil (g)	112.5
Moisture content (%)	31.0
Average Moisture Content (%)	**31.0**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	3
Depth (m)	15.5-16.0

Sample no.	
Container no.	JJ
Mass of wet soil + container (g)	171.4
Mass of dry soil + container (g)	137.3
Mass of container (g)	27.0
Mass of moisture (g)	34.1
Mass of dry soil (g)	110.3
Moisture content (%)	30.9
Average Moisture Content (%)	**30.9**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	3
Depth (m)	20.5-21.0

Sample no.	
Container no.	PRO
Mass of wet soil + container (g)	154.3
Mass of dry soil + container (g)	126.9
Mass of container (g)	33.2
Mass of moisture (g)	27.4
Mass of dry soil (g)	93.7
Moisture content (%)	29.2
Average Moisture Content (%)	**29.2**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	3
Depth (m)	25.5-26.0

Sample no.	
Container no.	**PAN**
Mass of wet soil + container (g)	264.0
Mass of dry soil + container (g)	222.6
Mass of container (g)	66.4
Mass of moisture (g)	41.4
Mass of dry soil (g)	156.2
Moisture content (%)	26.5
Average Moisture Content (%)	**26.5**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	3
Depth (m)	29.5-30.0

Sample no.	
Container no.	ZF
Mass of wet soil + container (g)	192.7
Mass of dry soil + container (g)	167.9
Mass of container (g)	72.1
Mass of moisture (g)	24.8
Mass of dry soil (g)	95.8
Moisture content (%)	25.9
Average Moisture Content (%)	**25.9**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	4
Depth (m)	5.5-6.0

Sample no.	
Container no.	B
Mass of wet soil + container (g)	222.5
Mass of dry soil + container (g)	198.7
Mass of container (g)	74.7
Mass of moisture (g)	23.8
Mass of dry soil (g)	123.9
Moisture content (%)	19.2
Average Moisture Content (%)	**19.2**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	4
Depth (m)	10.5-11.0

Sample no.	
Container no.	XF
Mass of wet soil + container (g)	208.7
Mass of dry soil + container (g)	184.0
Mass of container (g)	72.3
Mass of moisture (g)	24.7
Mass of dry soil (g)	111.7
Moisture content (%)	22.1
Average Moisture Content (%)	**22.1**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	4
Depth (m)	15.5-16.0

Sample no.	
Container no.	MI
Mass of wet soil + container (g)	228.6
Mass of dry soil + container (g)	197.8
Mass of container (g)	71.2
Mass of moisture (g)	30.9
Mass of dry soil (g)	126.6
Moisture content (%)	24.4
Average Moisture Content (%)	**24.4**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	4
Depth (m)	20.5-21.0

Sample no.	
Container no.	ZT
Mass of wet soil + container (g)	229.7
Mass of dry soil + container (g)	192.3
Mass of container (g)	66.7
Mass of moisture (g)	37.3
Mass of dry soil (g)	125.7
Moisture content (%)	29.7
Average Moisture Content (%)	**29.7**

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

MOISTURE CONTENT TEST SUMMARY

Test Method:	ASTM D 4959
Borehole No.	4
Depth (m)	25.5-26.0

Sample no.	
Container no.	XK
Mass of wet soil + container (g)	278.9
Mass of dry soil + container (g)	233.1
Mass of container (g)	64.3
Mass of moisture (g)	45.8
Mass of dry soil (g)	168.8
Moisture content (%)	27.1
Average Moisture Content (%)	**27.1**

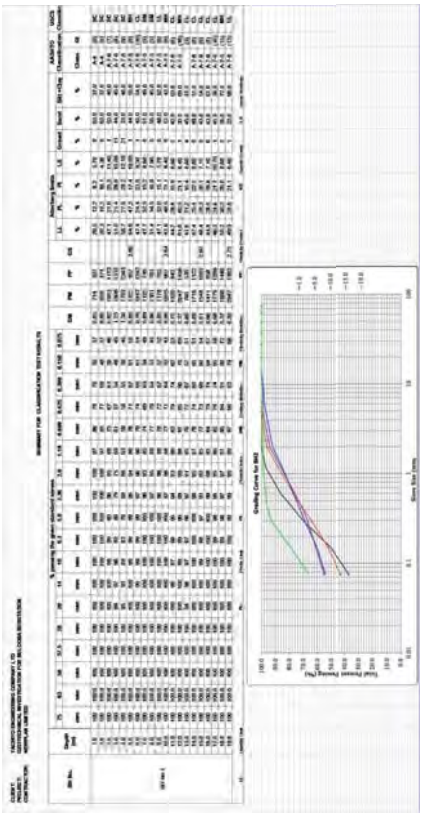
CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**
CONTRACTOR:	**NEWPLAN LIMITED**

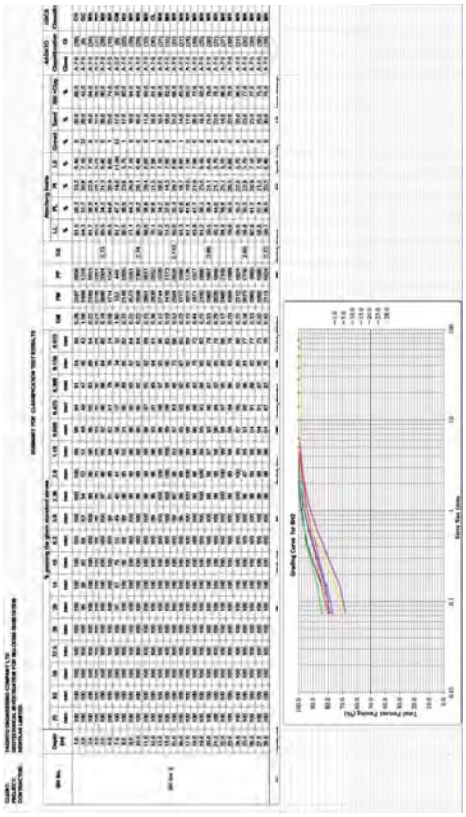
MOISTURE CONTENT TEST SUMMARY

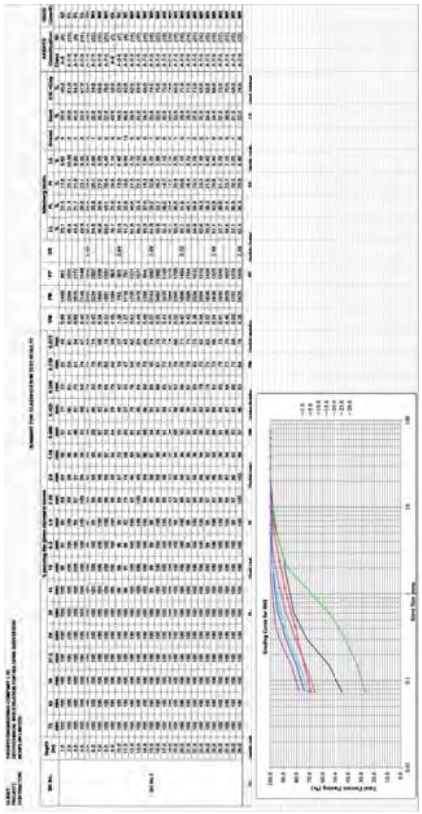
Test Method:	ASTM D 4959
Borehole No.	4
Depth (m)	30.5-31.0

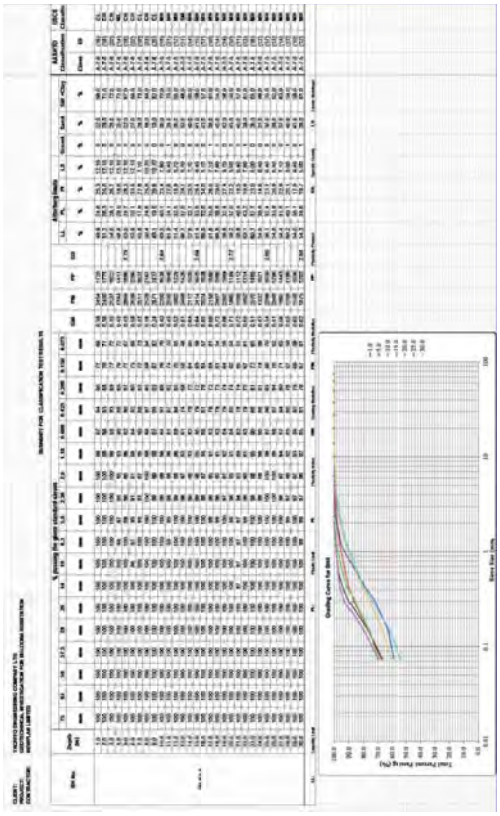
Sample no.	
Container no.	S2
Mass of wet soil + container (g)	265.3
Mass of dry soil + container (g)	229.2
Mass of container (g)	70.4
Mass of moisture (g)	36.1
Mass of dry soil (g)	158.8
Moisture content (%)	22.7
Average Moisture Content (%)	**22.7**

Appendix 7: Summary of Texture Classification









Appendix 8: Specific Gravity

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**					
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**					
CONTRACTOR:	**NEWPLAN LIMITED**					
SPECIFIC GRAVITY TEST REPORT						
Site Location: Bulooba Substation						
Test Method: ASTM D 854.						
Borehole No.: BH01	**Depth:** 5.5-6.0m					
Specimen reference				**D-Sample**	**D-Sample**	
Pyknometer label				**NH**	**KB**	
Mass of bottle +soil + water	m_3	g		85.5	85.1	
Mass of bottle +soil	m_2	g		37.3	37.0	
Mass of bottle full of water	m_4	g		79.3	78.9	
Mass of density bottle	m_1	g		27.2	27.0	
Mass of soil sample alone	m_2-m_1	g		10.0	10.0	
Mass of water in full bottle	m_4-m_1	g		52.1	52.0	
Mass of water used	m_3-m_2	g		48.2	48.1	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml		3.9	3.9	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3		2.584	2.606	**Average Specific gravity**
	ρs	Mg/m^3		2.584	2.606	2.595

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**					
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**					
CONTRACTOR:	**NEWPLAN LIMITED**					
SPECIFIC GRAVITY TEST REPORT						
Site Location: Bulooba Substation						
Test Method: ASTM D 854.						
Borehole No.: BH01	**Depth:** 10.5-11.0m					
Specimen reference				**D-Sample**	**D-Sample**	
Pyknometer label				**OJ**	**NG**	
Mass of bottle +soil + water	m_3	g		83.0	85.0	
Mass of bottle +soil	m_2	g		37.8	36.3	
Mass of bottle full of water	m_4	g		76.9	78.7	
Mass of density bottle	m_1	g		27.8	26.3	
Mass of soil sample alone	m_2-m_1	g		10.0	10.0	
Mass of water in full bottle	m_4-m_1	g		49.1	52.4	
Mass of water used	m_3-m_2	g		45.2	48.6	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml		3.9	3.7	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3		2.600	2.673	**Average Specific gravity**
	ρs	Mg/m^3		2.600	2.673	2.636

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**					
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**					
CONTRACTOR:	**NEWPLAN LIMITED**					
SPECIFIC GRAVITY TEST REPORT						
Site Location: Bulooba Substation						
Test Method: ASTM D 854.						
Borehole No.: BH01	**Depth:** 15.5-16.0m					
Specimen reference				**D-Sample**	**D-Sample**	
Pyknometer label				**MA**	**EE**	
Mass of bottle +soil + water	m_3	g		87.5	86.4	
Mass of bottle +soil	m_2	g		37.4	39.5	
Mass of bottle full of water	m_4	g		81.4	80.3	
Mass of density bottle	m_1	g		27.3	29.5	
Mass of soil sample alone	m_2-m_1	g		10.1	10.0	
Mass of water in full bottle	m_4-m_1	g		54.0	50.7	
Mass of water used	m_3-m_2	g		50.2	46.9	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml		3.9	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3		2.592	2.605	**Average Specific gravity**
	ρs	Mg/m^3		2.592	2.605	2.599

CLIENT:	**YACHIYO ENGINEERING COMPANY LTD**					
PROJECT:	**GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION**					
CONTRACTOR:	**NEWPLAN LIMITED**					
SPECIFIC GRAVITY TEST REPORT						
Site Location: Bulooba Substation						
Test Method: ASTM D 854.						
Borehole No.: BH01	**Depth:** 20.5-21.0m					
Specimen reference				**D-Sample**	**D-Sample**	
Pyknometer label				**C**	**LG**	
Mass of bottle +soil + water	m_3	g		88.0	85.1	
Mass of bottle +soil	m_2	g		40.5	36.5	
Mass of bottle full of water	m_4	g		81.6	78.7	
Mass of density bottle	m_1	g		30.4	26.5	
Mass of soil sample alone	m_2-m_1	g		10.0	10.1	
Mass of water in full bottle	m_4-m_1	g		51.2	52.2	
Mass of water used	m_3-m_2	g		47.5	48.5	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml		3.6	3.7	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3		2.768	2.731	**Average Specific gravity**
	ρs	Mg/m^3		2.768	2.731	2.749

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH02 **Depth:** 5.5-6.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			NG	OM	
Mass of bottle +soil + water	m_3	g	85.0	86.6	
Mass of bottle +soil	m_2	g	36.3	37.8	
Mass of bottle full of water	m_4	g	78.7	80.2	
Mass of density bottle	m_1	g	26.3	27.7	
Mass of soil sample alone	m_2-m_1	g	10.0	10.1	
Mass of water in full bottle	m_4-m_1	g	52.4	52.5	
Mass of water used	m_3-m_2	g	48.7	48.8	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.7	3.7	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.737	2.727	Average Specific gravity
	ρs	Mg/m^3	2.737	2.727	2.732

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH02 **Depth:** 10.5-11.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			ND	TS	
Mass of bottle +soil + water	m_3	g	88.5	87.5	
Mass of bottle +soil	m_2	g	36.7	38.1	
Mass of bottle full of water	m_4	g	82.1	81.1	
Mass of density bottle	m_1	g	26.6	28.0	
Mass of soil sample alone	m_2-m_1	g	10.1	10.1	
Mass of water in full bottle	m_4-m_1	g	55.6	53.0	
Mass of water used	m_3-m_2	g	51.9	49.4	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.7	3.7	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.738	2.750	Average Specific gravity
	ρs	Mg/m^3	2.738	2.750	2.744

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH02 **Depth:** 15.5-16.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			NG	C	
Mass of bottle +soil + water	m_3	g	85.0	87.9	
Mass of bottle +soil	m_2	g	36.4	40.5	
Mass of bottle full of water	m_4	g	78.7	81.6	
Mass of density bottle	m_1	g	26.3	30.5	
Mass of soil sample alone	m_2-m_1	g	10.0	10.0	
Mass of water in full bottle	m_4-m_1	g	52.3	51.2	
Mass of water used	m_3-m_2	g	48.6	47.4	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.7	3.7	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.725	2.702	Average Specific gravity
	ρs	Mg/m^3	2.725	2.702	2.713

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH02 **Depth:** 20.5-21.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			OJ	NH	
Mass of bottle +soil + water	m_3	g	82.5	85.4	
Mass of bottle +soil	m_2	g	37.0	37.2	
Mass of bottle full of water	m_4	g	76.3	79.1	
Mass of density bottle	m_1	g	26.9	27.2	
Mass of soil sample alone	m_2-m_1	g	10.0	10.0	
Mass of water in full bottle	m_4-m_1	g	49.4	51.9	
Mass of water used	m_3-m_2	g	45.6	48.2	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.8	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.650	2.674	Average Specific gravity
	ρs	Mg/m^3	2.650	2.674	2.662

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH02 **Depth:** 25.5-26.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			EE	KN	
Mass of bottle +soil + water	m_3	g	86.6	85.0	
Mass of bottle +soil	m_2	g	39.7	37.2	
Mass of bottle full of water	m_4	g	80.3	78.7	
Mass of density bottle	m_1	g	29.7	27.1	
Mass of soil sample alone	m_2-m_1	g	10.0	10.1	
Mass of water in full bottle	m_4-m_1	g	50.6	51.6	
Mass of water used	m_3-m_2	g	46.9	47.8	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.7	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.695	2.687	Average Specific gravity
	ρs	Mg/m^3	2.695	2.687	2.691

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH02 **Depth:** 28.5-29.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			NM	KB	
Mass of bottle +soil + water	m_3	g	85.6	85.2	
Mass of bottle +soil	m_2	g	38.0	37.0	
Mass of bottle full of water	m_4	g	79.2	78.8	
Mass of density bottle	m_1	g	28.0	27.0	
Mass of soil sample alone	m_2-m_1	g	10.0	10.0	
Mass of water in full bottle	m_4-m_1	g	51.2	51.9	
Mass of water used	m_3-m_2	g	47.6	48.2	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.7	3.7	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.734	2.708	Average Specific gravity
	ρs	Mg/m^3	2.734	2.708	2.721

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH03 **Depth:** 5.5-6.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			TS	KN	
Mass of bottle +soil + water	m_3	g	87.5	85.0	
Mass of bottle +soil	m_2	g	38.2	37.2	
Mass of bottle full of water	m_4	g	81.2	78.8	
Mass of density bottle	m_1	g	28.1	27.2	
Mass of soil sample alone	m_2-m_1	g	10.0	10.1	
Mass of water in full bottle	m_4-m_1	g	53.1	51.6	
Mass of water used	m_3-m_2	g	49.3	47.8	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.8	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.672	2.627	Average Specific gravity
	ρs	Mg/m^3	2.672	2.627	2.650

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH03 **Depth:** 10.5-11.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			LG	CF	
Mass of bottle +soil + water	m_3	g	85.0	86.6	
Mass of bottle +soil	m_2	g	36.5	39.3	
Mass of bottle full of water	m_4	g	78.7	80.4	
Mass of density bottle	m_1	g	26.5	29.2	
Mass of soil sample alone	m_2-m_1	g	10.1	10.1	
Mass of water in full bottle	m_4-m_1	g	52.3	51.2	
Mass of water used	m_3-m_2	g	48.5	47.3	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.8	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.670	2.627	Average Specific gravity
	ρs	Mg/m^3	2.670	2.627	2.649

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH03 **Depth:** 15.5-16.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			C	OM	
Mass of bottle +soil + water	m_3	g	87.9	86.6	
Mass of bottle +soil	m_2	g	40.5	37.7	
Mass of bottle full of water	m_4	g	81.7	80.4	
Mass of density bottle	m_1	g	30.5	27.7	
Mass of soil sample alone	m_2-m_1	g	10.0	10.0	
Mass of water in full bottle	m_4-m_1	g	51.2	52.7	
Mass of water used	m_3-m_2	g	47.4	48.8	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.8	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.647	2.628	Average Specific gravity
	ρs	Mg/m^3	2.647	2.628	2.637

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH03 **Depth:** 20.5-21.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			ND	NM	
Mass of bottle +soil + water	m_3	g	88.6	85.6	
Mass of bottle +soil	m_2	g	36.6	38.1	
Mass of bottle full of water	m_4	g	82.3	79.3	
Mass of density bottle	m_1	g	26.6	28.0	
Mass of soil sample alone	m_2-m_1	g	10.0	10.0	
Mass of water in full bottle	m_4-m_1	g	55.7	51.3	
Mass of water used	m_3-m_2	g	52.0	47.5	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.7	3.7	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.678	2.690	Average Specific gravity
	ρs	Mg/m^3	2.678	2.690	2.684

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH03 **Depth:** 25.5-26.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			EE	NM	
Mass of bottle +soil + water	m_3	g	86.5	85.6	
Mass of bottle +soil	m_2	g	39.6	38.1	
Mass of bottle full of water	m_4	g	80.2	79.3	
Mass of density bottle	m_1	g	29.5	28.0	
Mass of soil sample alone	m_2-m_1	g	10.0	10.1	
Mass of water in full bottle	m_4-m_1	g	50.7	51.2	
Mass of water used	m_3-m_2	g	47.0	47.5	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.7	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.705	2.680	Average Specific gravity
	ρs	Mg/m^3	2.705	2.680	2.693

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH03 **Depth:** 29.5-30.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			OJ	KN	
Mass of bottle +soil + water	m_3	g	82.8	84.9	
Mass of bottle +soil	m_2	g	37.9	37.2	
Mass of bottle full of water	m_4	g	76.7	78.7	
Mass of density bottle	m_1	g	27.8	27.1	
Mass of soil sample alone	m_2-m_1	g	10.1	10.1	
Mass of water in full bottle	m_4-m_1	g	48.9	51.5	
Mass of water used	m_3-m_2	g	45.0	47.7	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	4.0	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.542	2.642	Average Specific gravity
	ρs	Mg/m^3	2.542	2.642	2.592

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH04 **Depth:** 5.5-6.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			LG	TS	
Mass of bottle +soil + water	m_3	g	85.1	87.6	
Mass of bottle +soil	m_2	g	36.6	38.1	
Mass of bottle full of water	m_4	g	78.7	81.2	
Mass of density bottle	m_1	g	26.5	28.1	
Mass of soil sample alone	m_2-m_1	g	10.1	10.0	
Mass of water in full bottle	m_4-m_1	g	52.2	53.1	
Mass of water used	m_3-m_2	g	48.6	49.5	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.6	3.6	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.788	2.801	Average Specific gravity
	ρs	Mg/m^3	2.788	2.801	2.795

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH04 **Depth:** 10.5-11.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			CF	OM	
Mass of bottle +soil + water	m_3	g	86.5	86.5	
Mass of bottle +soil	m_2	g	39.2	37.7	
Mass of bottle full of water	m_4	g	80.3	80.3	
Mass of density bottle	m_1	g	29.2	27.7	
Mass of soil sample alone	m_2-m_1	g	10.0	10.0	
Mass of water in full bottle	m_4-m_1	g	51.2	52.5	
Mass of water used	m_3-m_2	g	47.4	48.7	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.8	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.637	2.641	Average Specific gravity
	ρs	Mg/m^3	2.637	2.641	2.639

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH04 **Depth:** 15.5-16.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			NH	TS	
Mass of bottle +soil + water	m_3	g	85.5	87.5	
Mass of bottle +soil	m_2	g	37.3	38.1	
Mass of bottle full of water	m_4	g	79.2	81.2	
Mass of density bottle	m_1	g	27.3	28.1	
Mass of soil sample alone	m_2-m_1	g	10.0	10.0	
Mass of water in full bottle	m_4-m_1	g	51.9	53.1	
Mass of water used	m_3-m_2	g	48.2	49.4	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.7	3.7	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.680	2.708	Average Specific gravity
	ρs	Mg/m^3	2.680	2.708	2.694

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH04 **Depth:** 20.5-21.0m

Specimen reference			D-Sample	D-Sample	
Pyknometer label			KN	LG	
Mass of bottle +soil + water	m_3	g	85.1	85.0	
Mass of bottle +soil	m_2	g	37.2	36.5	
Mass of bottle full of water	m_4	g	78.7	78.7	
Mass of density bottle	m_1	g	27.2	26.5	
Mass of soil sample alone	m_2-m_1	g	10.1	10.1	
Mass of water in full bottle	m_4-m_1	g	51.5	52.2	
Mass of water used	m_3-m_2	g	47.9	48.4	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.6	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.765	2.668	Average Specific gravity
	ρs	Mg/m^3	2.765	2.668	2.716

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH04 **Depth:** 25.5-26.0m

Specimen reference			D-Sample ND	D-Sample KB	
Pyknometer label					
Mass of bottle +soil + water	m_3	g	88.5	85.2	
Mass of bottle +soil	m_2	g	36.6	37.0	
Mass of bottle full of water	m_4	g	82.2	78.9	
Mass of density bottle	m_1	g	26.6	27.0	
Mass of soil sample alone	m_2-m_1	g	10.0	10.0	
Mass of water in full bottle	m_4-m_1	g	55.5	51.9	
Mass of water used	m_3-m_2	g	51.8	48.1	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.7	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.699	2.664	Average Specific gravity
	ρ s	Mg/m^3	2.699	2.664	2.682

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SPECIFIC GRAVITY TEST REPORT

Site Location: Bulooba Substation
Test Method: ASTM D 854.

Borehole No.: BH04 **Depth:** 30.5-31.0m

Specimen reference			D-Sample NH	D-Sample C	
Pyknometer label					
Mass of bottle +soil + water	m_3	g	85.4	87.9	
Mass of bottle +soil	m_2	g	37.3	40.5	
Mass of bottle full of water	m_4	g	79.2	81.6	
Mass of density bottle	m_1	g	27.2	30.5	
Mass of soil sample alone	m_2-m_1	g	10.1	10.0	
Mass of water in full bottle	m_4-m_1	g	52.0	51.1	
Mass of water used	m_3-m_2	g	48.1	47.4	
Volume of soil particle	$(m_4-m_1)-(m_3-m_2)$	ml	3.9	3.8	
Particle Density (Specific gravity)	$\rho s = 1000\times \frac{(m_2-m_1)}{(m_4-m_1)-(m_3-m_2)}$	Mg/m^3	2.617	2.659	Average Specific gravity
	ρ s	Mg/m^3	2.617	2.659	2.638

Appendix 9: Chemical Test

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN Limited

SUMMARY FOR SOIL PH CONTENT TEST RESULTS

Site Location: Bulooba Substation
Testing Date: 27 January 2016
Test Method: ASTM G 51

BOREHOLE NO.	DEPTH (m)	TRIAL 01	TRIAL 02	AVERAGE PH VALUE	REMARKS
1	7.0 - 8.0	7.03	7.04	7.04	Neutral
	17.0 - 18.0	6.64	6.68	6.66	Neutral
2	7.0 - 8.0	6.88	6.7	6.79	Neutral
	18.0 - 19.0	6.71	6.74	6.73	Neutral
3	3.0 - 4.0	5.84	5.84	5.84	Slightly Acidic
	17.0 - 18.0	6.87	6.89	6.88	Neutral
4	3.0 - 4.0	6.85	6.73	6.79	Neutral
	20.0 - 21.0	7.08	7.1	7.09	Neutral

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN Limited

SUMMARY FOR SOIL CHLORIDE CONTENT TEST RESULTS

Site Location: Bulooba Substation
Testing Date: 27 January 2016
Test Method: ASTM D 4327

BOREHOLE NO.:	DEPTH (m)	TEST 01 (%)	TEST 02 (%)	AVERAGE CHLORIDE CONTENT (%)
BH - 01	8	0.883		0.883
	18	0.803	0.795	0.799
BH - 02	8	0.295		0.295
	19	0.337	0.369	0.353
BH - 03	4	0.052		0.052
	18	0.258	0.28	0.269
BH - 04	21	0.345		0.345

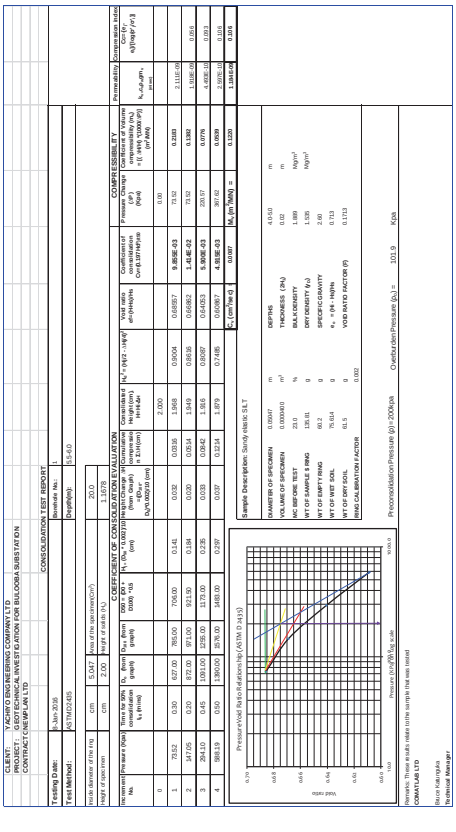
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN Limited

SUMMARY FOR SOIL SULPHATE CONTENT TEST RESULTS

Site Location: Bulooba Substation
Testing Date: 27 January 2016
Test Method: ASTM D 4327

BOREHOLE NO.:	DEPTH (m)	TEST 01 (%)	AVERAGE SULPHATE CONTENT (%)
BH - 01	7.0 - 8.0	4.287	4.287
	17.0 - 18.0	2.744	2.744
BH - 02	7.0 - 8.0	1.372	1.372
	18.0 - 19.0	2.45	2.45
BH - 03	3.0 - 4.0	1.319	1.319
	17.0 - 18.0	2.541	2.541
BH - 04	3.0 - 4.0	2.45	2.45
	20.0 - 21.0	1.183	1.183

Appendix 10: One-Dimensional Consolidation (Oedometer test)



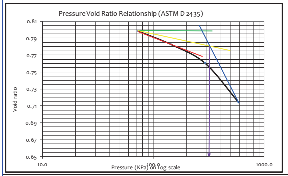
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:		**Borehole No.:**	1
Test Method:	ASTM D2435	**Depth(m):**	20.5-21.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.1067

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.90	318.00	366.00	342.00	0.068	0.010	0.0096	1.990	0.9567	0.79843	**3.490E-03**	73.52	**0.0656**	2.246E-10	
2	147.05	2.10	283.00	372.00	327.50	0.066	0.018	0.0274	1.973	0.9408	0.78234	**1.471E-03**	73.52	**0.1227**	1.771E-10	0.053
3	294.10	1.00	409.00	530.00	469.50	0.094	0.024	0.0516	1.948	0.9039	0.76048	**2.968E-03**	220.57	**0.0563**	1.639E-10	0.073
4	588.19	1.80	635.00	890.00	762.50	0.153	0.051	0.1026	1.897	0.8291	0.71440	**1.512E-03**	367.62	**0.0731**	1.085E-10	0.153
											C_v (cm^2/sec) =	**0.0024**	M_v (m^2/MN) =	**0.0794**	**1.685E-10**	**0.153**



Sample Description: Sandy Lean CLAY

DIAMETER OF SPECIMEN	0.05047	m	**DEPTHS**	19.0-20.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	**THICKNESS ($2H_1$)**	0.02	m
MC BEFORE TEST	28.9	%	**BULK DENSITY**	1.942	Mg/m^3
WT OF SAMPLE $ RING	137.42	g	**DRY DENSITY (γ_D)**	1.507	Mg/m^3
WT OF EMPTY RING	59.671	g	**SPECIFIC GRAVITY**	2.75	
WT OF WET SOIL	77.747	g	**e_o = (Hi - Hs)/Hs**	0.807	
WT OF DRY SOIL	60.3	g	**VOID RATIO FACTOR (F)**	0.1807	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 390.6kpa   Overburden Pressure (ρ_o) = 390.6 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

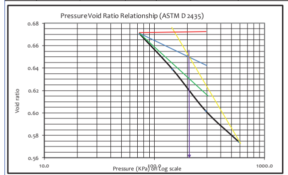
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	8-Jan-2016	**Borehole No.:**	1
Test Method:	ASTM D2435	**Depth(m):**	10.5-11.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.1608

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.65	365.00	670.00	517.50	0.104	0.061	0.0610	1.939	0.8904	0.67037	**4.498E-03**	73.52	**0.4279**	1.888E-09	
2	147.05	0.40	750.00	935.00	842.50	0.169	0.037	0.0980	1.902	0.8261	0.63849	**6.781E-03**	73.52	**0.2646**	1.760E-09	0.106
3	294.10	0.32	1020.00	1235.00	1127.50	0.226	0.043	0.1410	1.859	0.7623	0.60145	**7.822E-03**	220.57	**0.1049**	8.047E-10	0.123
4	588.19	0.35	1390.00	1550.00	1470.00	0.294	0.032	0.1730	1.827	0.7056	0.57388	**6.619E-03**	367.62	**0.0476**	3.094E-10	0.092
											C_v (cm^2/sec) =	**0.0064**	M_v (m^2/MN) =	**0.2112**	**1.190E-09**	**0.123**



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	**DEPTHS**	9.0-10.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	**THICKNESS ($2H_1$)**	0.02	m
MC BEFORE TEST	24.5	%	**BULK DENSITY**	2.005	Mg/m^3
WT OF SAMPLE $ RING	139.91	g	**DRY DENSITY (γ_D)**	1.611	Mg/m^3
WT OF EMPTY RING	59.671	g	**SPECIFIC GRAVITY**	2.64	
WT OF WET SOIL	80.238	g	**e_o = (Hi - Hs)/Hs**	0.723	
WT OF DRY SOIL	64.5	g	**VOID RATIO FACTOR (F)**	0.1723	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 210kpa   Overburden Pressure (ρ_o) = 206.5 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Laboratory Manager

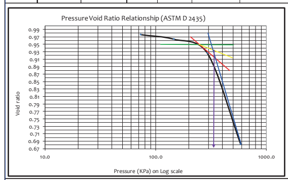
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	29-Jan-2016	**Borehole No.:**	2
Test Method:	ASTM D2435	**Depth(m):**	5.5-6.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.0053

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.30	1159.00	1225.00	1192.00	0.238	0.013	0.0132	1.987	0.8720	0.97632	**9.543E-03**	73.52	**0.0904**	8.460E-10	
2	147.05	0.90	1379.00	1441.00	1410.00	0.282	0.012	0.0256	1.974	0.8403	0.96399	**3.066E-03**	73.52	**0.0854**	2.569E-10	0.041
3	294.10	0.27	1604.00	1795.00	1699.50	0.340	0.038	0.0638	1.936	0.7799	0.92599	**9.484E-03**	220.57	**0.0894**	8.322E-10	0.126
4	588.19	0.50	973.00	2200.00	1586.50	0.317	0.245	0.3092	1.691	0.5869	0.68189	**3.854E-03**	367.62	**0.3948**	1.493E-09	0.811
											C_v (cm^2/sec) =	**0.0065**	M_v (m^2/MN) =	**0.3948**	**8.569E-10**	**0.469**



Sample Description: Sandy Elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	**DEPTHS**	4.0-5.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	**THICKNESS ($2H_1$)**	0.02	m
MC BEFORE TEST	34.5	%	**BULK DENSITY**	1.798	Mg/m^3
WT OF SAMPLE $ RING	132.15	g	**DRY DENSITY (γ_D)**	1.336	Mg/m^3
WT OF EMPTY RING	60.2	g	**SPECIFIC GRAVITY**	2.73	
WT OF WET SOIL	71.953	g	**e_o = (Hi - Hs)/Hs**	0.989	
WT OF DRY SOIL	53.5	g	**VOID RATIO FACTOR (F)**	0.1989	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 320kpa   Overburden Pressure (ρ_o) = 97.0 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

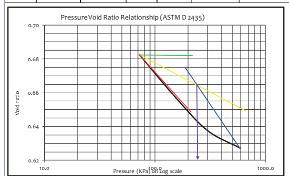
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:		**Borehole No.:**	1
Test Method:	ASTM D2435	**Depth(m):**	15.5-16.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.1605

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.14	720.00	960.00	840.00	0.168	0.048	0.0480	1.952	0.8724	0.68200	**2.046E-02**	73.52	**0.3345**	6.712E-09	
2	147.05	0.19	1077.00	1212.00	1144.50	0.229	0.027	0.0750	1.925	0.8195	0.65873	**1.416E-02**	73.52	**0.1908**	2.650E-09	0.077
3	294.10	0.18	1380.00	1500.00	1440.00	0.288	0.024	0.0990	1.901	0.7718	0.63805	**1.408E-02**	220.57	**0.0572**	7.904E-10	0.069
4	588.19	1.20	1704.00	1766.00	1735.00	0.347	0.012	0.1114	1.889	0.7354	0.62737	**2.012E-03**	367.62	**0.0179**	3.525E-11	0.035
											C_v (cm^2/sec) =	**0.0127**	M_v (m^2/MN) =	**0.1501**	**2.547E-09**	**0.077**



Sample Description: Sandy Lean CLAY

DIAMETER OF SPECIMEN	0.05047	m	**DEPTHS**	14.0-15.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	**THICKNESS ($2H_1$)**	0.02	m
MC BEFORE TEST	26.5	%	**BULK DENSITY**	1.855	Mg/m^3
WT OF SAMPLE $ RING	134.46	g	**DRY DENSITY (γ_D)**	1.467	Mg/m^3
WT OF EMPTY RING	60.2	g	**SPECIFIC GRAVITY**	2.60	
WT OF WET SOIL	74.2634	g	**e_o = (Hi - Hs)/Hs**	0.723	
WT OF DRY SOIL	58.7	g	**VOID RATIO FACTOR (F)**	0.1723	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 282.1kpa   Overburden Pressure (ρ_o) = 282.1 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

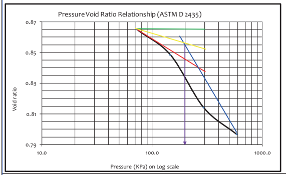
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	29-Jan-2016	**Borehole No.:**	2
Test Method:	ASTM D2435	**Depth(m):**	20.5-21.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.0533

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) $=((D_{100}-D_0)*0.002)/10$ (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation $Cv=(0.197Hd^2)/t50$	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.38	810.00	990.00	900.00	0.180	0.036	0.0360	1.964	0.8780	0.86460	**7.586E-03**	73.52	**0.2493**	1.855E-09	
2	147.05	0.19	1143.00	1229.00	1186.00	0.237	0.017	0.0532	1.947	0.8356	0.84827	**1.444E-02**	73.52	**0.1202**	1.702E-09	0.054
3	294.10	0.18	1350.00	1530.00	1440.00	0.288	0.036	0.0892	1.911	0.7804	0.81409	**1.423E-02**	220.57	**0.0854**	1.193E-09	0.114
4	588.19	0.25	1828.00	1920.00	1874.00	0.375	0.018	0.1076	1.892	0.7268	0.79662	**9.545E-03**	367.62	**0.0264**	2.477E-10	0.058
											C_v (cm^2/sec) =	**0.0115**	**M_v (m^2/MN) =**	**0.1203**	**1.249E-09**	**0.114**



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	19.0-20..0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	29.5	%	BULK DENSITY	1.822	Mg/m^3
WT OF SAMPLE $ RING	133.12	g	DRY DENSITY (γ_D)	1.407	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.66	
WT OF WET SOIL	72.922	g	e_o = (Hi - Hs)/Hs	0.899	
WT OF DRY SOIL	56.3	g	VOID RATIO FACTOR (F)	0.1899	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 366.4kpa Overburden Pressure (ρ_o) = 366.4 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

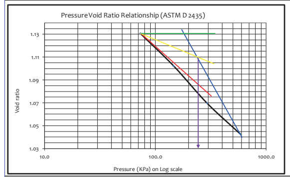
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	29-Jan-2016	**Borehole No.:**	2
Test Method:	ASTM D2435	**Depth(m):**	10.5-11.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	0.9251

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) $=((D_{100}-D_0)*0.002)/10$ (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation $Cv=(0.197Hd^2)/t50$	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.18	815.00	960.00	887.50	0.178	0.029	0.0290	1.971	0.8857	1.13050	**1.616E-02**	73.52	**0.2001**	3.172E-09	
2	147.05	0.18	1160.00	1292.00	1226.00	0.245	0.026	0.0554	1.945	0.8299	1.10196	**1.514E-02**	73.52	**0.1846**	2.742E-09	0.095
3	294.10	0.14	1535.00	1685.00	1610.00	0.322	0.030	0.0854	1.915	0.7688	1.06953	**1.803E-02**	220.57	**0.0710**	1.256E-09	0.108
4	588.19	0.20	2010.00	2135.00	2072.50	0.415	0.025	0.1104	1.890	0.7076	1.04251	**1.162E-02**	367.62	**0.0360**	4.101E-10	0.090
											C_v (cm^2/sec) =	**0.0152**	**M_v (m^2/MN) =**	**0.1229**	**1.895E-09**	**0.108**



Sample Description: Sandy Elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	9.0-10.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	37.3	%	BULK DENSITY	1.701	Mg/m^3
WT OF SAMPLE $ RING	128.30	g	DRY DENSITY (γ_D)	1.239	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.74	
WT OF WET SOIL	68.095	g	e_o = (Hi - Hs)/Hs	1.162	
WT OF DRY SOIL	49.6	g	VOID RATIO FACTOR (F)	0.2162	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 250kpa Overburden Pressure (ρ_o) = 175.2 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

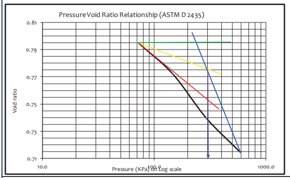
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	29-Jan-2016	**Borehole No.:**	2
Test Method:	ASTM D2435	**Depth(m):**	25.5-26.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.0954

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) $=((D_{100}-D_0)*0.002)/10$ (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation $Cv=(0.197Hd^2)/t50$	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.18	597.00	770.00	683.50	0.137	0.035	0.0346	1.965	0.8997	0.79418	**1.641E-02**	73.52	**0.2394**	3.855E-09	
2	147.05	0.25	909.00	1031.00	970.00	0.194	0.024	0.0590	1.941	0.8501	0.77191	**1.116E-02**	73.52	**0.1710**	1.873E-09	0.074
3	294.10	0.20	1185.00	1362.50	1273.75	0.255	0.036	0.0945	1.906	0.7904	0.73950	**1.298E-02**	220.57	**0.0845**	1.075E-09	0.108
4	588.19	0.28	1610.00	1745.00	1677.50	0.336	0.027	0.1215	1.879	0.7317	0.71485	**8.580E-03**	367.62	**0.0391**	3.291E-10	0.082
											C_v (cm^2/sec) =	**0.0123**	**M_v (m^2/MN) =**	**0.1335**	**1.783E-09**	**0.108**



Sample Description: Sandy lean CLAY

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	25.0-26.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	28.3	%	BULK DENSITY	1.861	Mg/m^3
WT OF SAMPLE $ RING	134.68	g	DRY DENSITY (γ_D)	1.451	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.69	
WT OF WET SOIL	74.483	g	e_o = (Hi - Hs)/Hs	0.826	
WT OF DRY SOIL	58.1	g	VOID RATIO FACTOR (F)	0.1826	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 465.5kpa Overburden Pressure (ρ_o) = 465.5 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

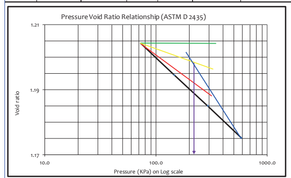
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	29-Jan-2016	**Borehole No.:**	2
Test Method:	ASTM D2435	**Depth(m):**	15.5-16.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	0.9030

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) $=((D_{100}-D_0)*0.002)/10$ (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation $Cv=(0.197Hd^2)/t50$	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.90	318.00	366.00	342.00	0.068	0.010	0.0096	1.990	0.9567	1.20418	**3.490E-03**	73.52	**0.0656**	2.246E-10	
2	147.05	2.10	518.00	562.00	540.00	0.108	0.009	0.0184	1.982	0.9289	1.19444	**1.452E-03**	73.52	**0.0604**	8.605E-11	0.032
3	294.10	3.60	744.00	787.00	765.50	0.153	0.009	0.0270	1.973	0.8991	1.18491	**8.200E-04**	220.57	**0.0198**	1.590E-11	0.032
4	588.19	0.50	973.00	1017.00	995.00	0.199	0.009	0.0358	1.964	0.8693	1.17517	**5.708E-03**	367.62	**0.0122**	6.824E-11	0.032
											C_v (cm^2/sec) =	**0.0029**	**M_v (m^2/MN) =**	**0.0395**	**9.870E-11**	**0.032**



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	14.0-15.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	35.9	%	BULK DENSITY	1.743	Mg/m^3
WT OF SAMPLE $ RING	129.98	g	DRY DENSITY (γ_D)	1.283	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.71	
WT OF WET SOIL	69.783	g	e_o = (Hi - Hs)/Hs	1.215	
WT OF DRY SOIL	51.3	g	VOID RATIO FACTOR (F)	0.2215	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 265.1kpa Overburden Pressure (ρ_o) = 265.1 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

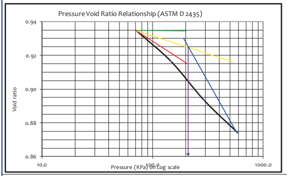
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	8-Jan-2016	**Borehole No.:**	3
Test Method:	ASTM D2435	**Depth(m):**	10.5-11.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.0203

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	H_j = (D_{50} * 0.002)/10 (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume compressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	$Cc=-[e_j-e_i]/[log(σ'_j/σ'_i)]$
0									2.000				0.00			
1	73.52	0.14	290.00	425.00	357.50	0.072	0.027	0.0270	1.973	0.9382	0.93382	2.200E-02	73.52	0.1861	4.018E-09	
2	147.05	0.15	541.00	630.00	585.50	0.117	0.018	0.0448	1.955	0.8993	0.91638	1.969E-02	73.52	0.1238	2.391E-09	0.058
3	294.10	0.15	795.00	913.00	854.00	0.171	0.024	0.0684	1.932	0.8521	0.89324	1.865E-02	220.57	0.0554	1.014E-09	0.077
4	588.19	0.30	1155.00	1252.00	1203.50	0.241	0.019	0.0878	1.912	0.8027	0.87423	8.785E-03	367.62	0.0276	2.378E-10	0.063
											C_v (cm^2/sec) =	0.0173	M_v (m^2/MN) =	0.0982	1.915E-09	0.077



Sample Description: Clayey SAND

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	9.0-10.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	31.0	%	BULK DENSITY	1.825	Mg/m^3
WT OF SAMPLE $ RING	132.74	g	DRY DENSITY (γ_D)	1.393	Mg/m^3
WT OF EMPTY RING	59.671	g	SPECIFIC GRAVITY	2.65	
WT OF WET SOIL	73.066	g	e_o = (Hi - Hs)/Hs	0.960	
WT OF DRY SOIL	55.8	g	VOID RATIO FACTOR (F)	0.1960	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 205kpa   Overburden Pressure (ρ_o) = 188.0 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

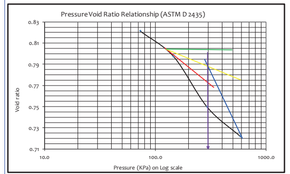
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	29-Jan-2016	**Borehole No.:**	2
Test Method:	ASTM D2435	**Depth(m):**	28.5-29.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.0949

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	H_j = (D_{50} * 0.002)/10 (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume compressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	$Cc=-[e_j-e_i]/[log(σ'_j/σ'_i)]$
0									2.000				0.00			
1	73.52	0.40	570.00	599.00	584.50	0.117	0.006	0.0058	1.994	0.9368	0.82133	7.689E-03	73.52	0.0396	2.984E-10	
2	147.05	0.20	740.00	873.00	806.50	0.161	0.027	0.0324	1.968	0.8901	0.79703	1.461E-02	73.52	0.1839	2.636E-09	0.081
3	294.10	0.31	985.00	1245.00	1115.00	0.223	0.052	0.0844	1.916	0.8137	0.74954	8.618E-03	220.57	0.1231	1.040E-09	0.158
4	588.19	0.90	1487.00	1640.00	1563.50	0.313	0.031	0.1150	1.885	0.7471	0.72159	2.725E-03	367.62	0.0442	1.181E-10	0.093
											C_v (cm^2/sec) =	0.0084	M_v (m^2/MN) =	0.0977	1.023E-09	0.158



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	30.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	22.6	%	BULK DENSITY	1.706	Mg/m^3
WT OF SAMPLE $ RING	128.51	g	DRY DENSITY (γ_D)	1.392	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.72	
WT OF WET SOIL	68.307	g	e_o = (Hi - Hs)/Hs	0.827	
WT OF DRY SOIL	55.7	g	VOID RATIO FACTOR (F)	0.1827	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 477.1kpa   Overburden Pressure (ρ_o) = 477.1 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

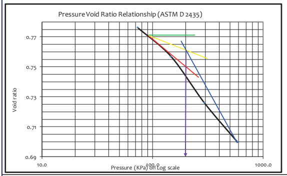
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	8-Jan-2016	**Borehole No.:**	3
Test Method:	ASTM D2435	**Depth(m):**	15.5-16.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.1013

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	H_j = (D_{50} * 0.002)/10 (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume compressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	$Cc=-[e_j-e_i]/[log(σ'_j/σ'_i)]$
0									2.000				0.00			
1	73.52	0.19	350.00	570.00	460.00	0.092	0.044	0.0440	1.956	0.9120	0.77602	1.576E-02	73.52	0.3060	4.730E-09	
2	147.05	0.18	712.00	818.00	765.00	0.153	0.021	0.0652	1.935	0.8633	0.75677	1.575E-02	73.52	0.1490	2.302E-09	0.064
3	294.10	0.16	945.00	1115.00	1030.00	0.206	0.034	0.0992	1.901	0.8080	0.72590	1.658E-02	220.57	0.0811	1.319E-09	0.103
4	588.19	0.12	1285.00	1430.00	1357.50	0.272	0.029	0.1282	1.872	0.7535	0.69957	2.062E-02	367.62	0.0421	8.523E-10	0.087
											C_v (cm^2/sec) =	0.0172	M_v (m^2/MN) =	0.1446	2.301E-09	0.103



Sample Description: Elastic SILT with sand

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	14.0-15.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	30.9	%	BULK DENSITY	1.863	Mg/m^3
WT OF SAMPLE $ RING	134.78	g	DRY DENSITY (γ_D)	1.423	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.64	
WT OF WET SOIL	74.584	g	e_o = (Hi - Hs)/Hs	0.816	
WT OF DRY SOIL	57.0	g	VOID RATIO FACTOR (F)	0.1816	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 283.3kpa   Overburden Pressure (ρ_o) = 283.3 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
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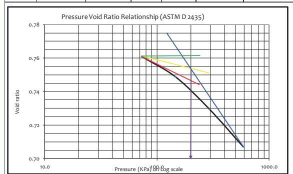
CONSOLIDATION TEST REPORT

Testing Date:	8-Jan-2016	**Borehole No.:**	3
Test Method:	ASTM D2435	**Depth(m):**	5.5-6.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.1308

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	H_j = (D_{50} * 0.002)/10 (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume compressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	$Cc=-[e_j-e_i]/[log(σ'_j/σ'_i)]$
0									2.000				0.00			
1	73.52	2.70	215.00	259.00	237.00	0.047	0.009	0.0088	1.991	0.9678	0.76089	1.177E-03	73.52	0.0601	6.940E-11	
2	147.05	2.10	306.00	375.00	340.50	0.068	0.014	0.0226	1.977	0.9442	0.74868	1.476E-03	73.52	0.0949	1.375E-10	0.041
3	294.10	2.00	433.00	542.00	487.50	0.098	0.022	0.0444	1.956	0.9090	0.72941	1.492E-03	220.57	0.0505	7.399E-11	0.064
4	588.19	2.00	620.00	747.00	683.50	0.137	0.025	0.0698	1.930	0.8666	0.70694	1.423E-03	367.62	0.0358	4.996E-11	0.075
											C_v (cm^2/sec) =	0.0014	M_v (m^2/MN) =	0.0603	8.270E-11	0.075



Sample Description: Sandy fat CLAY

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	4.0-5.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	25.8	%	BULK DENSITY	1.918	Mg/m^3
WT OF SAMPLE $ RING	136.98	g	DRY DENSITY (γ_D)	1.525	Mg/m^3
WT OF EMPTY RING	60.205	g	SPECIFIC GRAVITY	2.65	
WT OF WET SOIL	76.772	g	e_o = (Hi - Hs)/Hs	0.769	
WT OF DRY SOIL	61.0	g	VOID RATIO FACTOR (F)	0.1769	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 200kpa   Overburden Pressure (ρ_o) = 103.5 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
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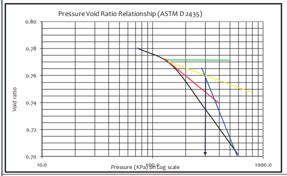
CONSOLIDATION TEST REPORT

Testing Date:	8-Jan-2016	**Borehole No.:**	3
Test Method:	ASTM D2435	**Depth(m):**	29.5-30.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.1180

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - \Delta Hj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume compressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.20	9.00	58.00	33.50	0.007	0.010	0.0098	1.990	0.9869	0.78016	**1.620E-02**	73.52	**0.0670**	1.064E-09	
2	147.05	0.50	170.00	237.00	203.50	0.041	0.013	0.0232	1.977	0.9569	0.76818	**6.284E-03**	73.52	**0.0922**	5.683E-10	0.040
3	294.10	0.28	330.00	510.00	420.00	0.084	0.036	0.0592	1.941	0.9014	0.73598	**1.057E-02**	220.57	**0.0841**	8.720E-10	0.107
4	588.19	0.35	660.00	852.00	756.00	0.151	0.038	0.0976	1.902	0.8343	0.70163	**7.827E-03**	367.62	**0.0549**	4.216E-10	0.114
											C_v (cm^2/sec) =	**0.0102**	**M_v (m^2/MN) =**	**0.0745**	**7.316E-10**	**0.114**



Sample Description: Elastic SILT with sand

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	29.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	25.9	%	BULK DENSITY	1.930	Mg/m^3
WT OF SAMPLE $ RING	137.45	g	DRY DENSITY (γ_D)	1.533	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.59	
WT OF WET SOIL	77.247	g	e_o = (Hi - Hs)/Hs	0.789	
WT OF DRY SOIL	61.4	g	VOID RATIO FACTOR (F)	0.1789	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 558.5kpa   Overburden Pressure (ρ_o) = 558.5 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
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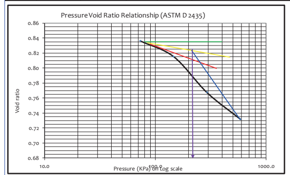
CONSOLIDATION TEST REPORT

Testing Date:	8-Jan-2016	**Borehole No.:**	3
Test Method:	ASTM D2435	**Depth(m):**	20.5-21.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.0615

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - \Delta Hj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume compressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.18	335.00	590.00	462.50	0.093	0.051	0.0510	1.949	0.9051	0.83610	**1.651E-02**	73.52	**0.3559**	5.764E-09	
2	147.05	0.20	738.00	850.00	794.00	0.159	0.022	0.0734	1.927	0.8530	0.81500	**1.400E-02**	73.52	**0.1581**	2.172E-09	0.070
3	294.10	0.13	920.00	1174.00	1047.00	0.209	0.051	0.1242	1.876	0.7842	0.76714	**1.981E-02**	220.57	**0.1228**	2.386E-09	0.159
4	588.19	0.20	1415.00	1603.00	1509.00	0.302	0.038	0.1618	1.838	0.7117	0.73172	**1.168E-02**	367.62	**0.0556**	6.378E-10	0.118
											C_v (cm^2/sec) =	**0.0155**	**M_v (m^2/MN) =**	**0.1731**	**2.740E-09**	**0.159**



Sample Description: Elastic SILT with sand

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	19.0-20.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	29.2	%	BULK DENSITY	1.878	Mg/m^3
WT OF SAMPLE $ RING	134.93	g	DRY DENSITY (γ_D)	1.453	Mg/m^3
WT OF EMPTY RING	59.763	g	SPECIFIC GRAVITY	2.68	
WT OF WET SOIL	75.171	g	e_o = (Hi - Hs)/Hs	0.884	
WT OF DRY SOIL	58.2	g	VOID RATIO FACTOR (F)	0.1884	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 377.7kpa   Overburden Pressure (ρ_o) = 377.7 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

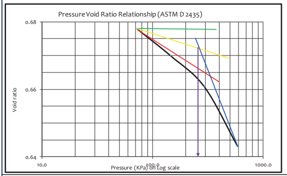
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	19-Jan-2016	**Borehole No.:**	4
Test Method:	ASTM D2435	**Depth(m):**	5.5-6.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.1886

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - \Delta Hj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume compressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	1.60	337.00	366.00	351.50	0.070	0.006	0.0058	1.994	0.9595	0.67776	**1.969E-03**	73.52	**0.0396**	7.641E-11	
2	147.05	1.40	455.00	502.00	478.50	0.096	0.009	0.0152	1.985	0.9379	0.66986	**2.200E-03**	73.52	**0.0644**	1.390E-10	0.026
3	294.10	1.50	682.00	736.00	709.00	0.142	0.011	0.0260	1.974	0.9054	0.66077	**1.982E-03**	220.57	**0.0248**	4.823E-11	0.030
4	588.19	0.50	940.00	1045.00	992.50	0.199	0.021	0.0470	1.953	0.8591	0.64310	**5.641E-03**	367.62	**0.0292**	1.619E-10	0.059
											C_v (cm^2/sec) =	**0.0029**	**M_v (m^2/MN) =**	**0.0395**	**1.064E-10**	**0.059**



Sample Description: Sandy fat CLAY

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	5.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	19.2	%	BULK DENSITY	1.973	Mg/m^3
WT OF SAMPLE $ RING	139.19	g	DRY DENSITY (γ_D)	1.655	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.79	
WT OF WET SOIL	78.986	g	e_o = (Hi - Hs)/Hs	0.683	
WT OF DRY SOIL	66.2	g	VOID RATIO FACTOR (F)	0.1683	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 260kpa   Overburden Pressure (ρ_o) = 106.5 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

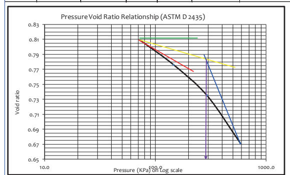
CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	8-Jan-2016	**Borehole No.:**	3
Test Method:	ASTM D2435	**Depth(m):**	25.5-26.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.0994

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - \Delta Hj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume compressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.50	277.00	335.00	306.00	0.061	0.012	0.0116	1.988	0.9582	0.80854	**6.292E-03**	73.52	**0.0793**	4.898E-10	
2	147.05	0.80	420.00	600.00	510.00	0.102	0.036	0.0476	1.952	0.9038	0.77580	**3.709E-03**	73.52	**0.2508**	9.126E-10	0.109
3	294.10	0.50	685.00	910.00	797.50	0.160	0.045	0.0926	1.907	0.8351	0.73487	**5.484E-03**	220.57	**0.1070**	5.754E-10	0.136
4	588.19	0.35	980.00	1330.00	1155.00	0.231	0.070	0.1626	1.837	0.7412	0.67120	**6.953E-03**	367.62	**0.1036**	7.069E-10	0.212
											C_v (cm^2/sec) =	**0.0056**	**M_v (m^2/MN) =**	**0.1352**	**6.712E-10**	**0.212**



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	25.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	26.5	%	BULK DENSITY	1.931	Mg/m^3
WT OF SAMPLE $ RING	137.51	g	DRY DENSITY (γ_D)	1.527	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.69	
WT OF WET SOIL	77.309	g	e_o = (Hi - Hs)/Hs	0.819	
WT OF DRY SOIL	61.1	g	VOID RATIO FACTOR (F)	0.1819	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 483.1kpa   Overburden Pressure (ρ_o) = 483.1 Kpa

Remarks: These results relate to the sample that was tested
COMATLAB LTD

Bruce Katunguka
Technical Manager

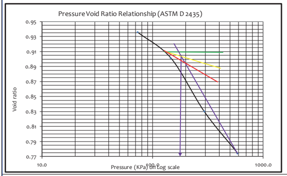
CLIENT:	YACHIYO ENGINEERING COMPANY LTD
PROJECT:	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO	NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	19-Jan-2016	**Borehole No.:**	4
Test Method:	ASTM D2435	**Depth(m):**	20.5-21.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.0084

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	H_j = (D_{50} * 0.002)/10 (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	H_d^2 = (Hj/2 + ΔHj/4)^2	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	k_v=$c_v$$\rho_wgm_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	1.30	315.00	555.00	435.00	0.087	0.048	0.0480	1.952	0.9955	0.93578	**2.514E-03**	73.52	**0.3345**	8.249E-10	
2	147.05	1.20	660.00	835.00	747.50	0.150	0.035	0.0830	1.917	0.9918	0.90107	**2.714E-03**	73.52	**0.2483**	6.610E-10	0.115
3	294.10	1.00	945.00	1305.00	1125.00	0.225	0.072	0.1550	1.845	0.9580	0.82967	**3.145E-03**	220.57	**0.1769**	5.459E-10	0.237
4	588.19	0.30	1384.00	1665.00	1524.50	0.305	0.056	0.2112	1.789	0.9421	0.77394	**1.031E-02**	367.62	**0.0855**	8.645E-10	0.185
											C_v (cm^2/sec) =	**0.0047**	**M_v (m^2/MN) =**	**0.2113**	**7.241E-10**	**0.237**



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	**DEPTHS**	20.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	**THICKNESS ($2H_1$)**	0.02	m
MC BEFORE TEST	29.7	%	**BULK DENSITY**	1.786	Mg/m^3
WT OF SAMPLE $ RING	131.69	g	**DRY DENSITY (γ_D)**	1.377	Mg/m^3
WT OF EMPTY RING	60.2	g	**SPECIFIC GRAVITY**	2.72	
WT OF WET SOIL	71.489	g	**e_o = (Hi - Hs)/Hs**	0.983	
WT OF DRY SOIL	55.1	g	**VOID RATIO FACTOR (F)**	0.1983	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 359.2kpa Overburden Pressure (ρ_o) = 359.2 Kpa

Remarks: These results relate to the sample that was tested

COMATLAB LTD

Bruce Katunguka

Technical Manager

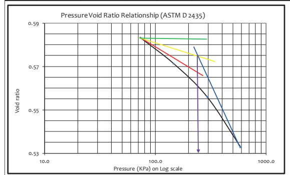
CLIENT:	YACHIYO ENGINEERING COMPANY LTD
PROJECT:	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO	NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	19-Jan-2016	**Borehole No.:**	4
Test Method:	ASTM D2435	**Depth(m):**	10.5-11.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.2516

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	H_j = (D_{50} * 0.002)/10 (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	H_d^2 = (Hj/2 - ΔHj/4)^2	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	k_v=$c_v$$\rho_wgm_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	0.80	327.00	420.00	373.50	0.075	0.019	0.0186	1.981	0.9448	0.58315	**3.878E-03**	73.52	**0.1277**	4.857E-10	
2	147.05	2.80	453.00	528.00	490.50	0.098	0.015	0.0336	1.966	0.9191	0.57116	**1.078E-03**	73.52	**0.1038**	1.097E-10	0.040
3	294.10	1.70	577.00	673.00	625.00	0.125	0.019	0.0528	1.947	0.8880	0.55582	**1.715E-03**	220.57	**0.0447**	7.521E-11	0.051
4	588.19	2.80	742.00	887.00	814.50	0.163	0.029	0.0818	1.918	0.8434	0.53265	**9.890E-04**	367.62	**0.0411**	3.990E-11	0.077
											C_v (cm^2/sec) =	**0.0019**	**M_v (m^2/MN) =**	**0.0793**	**1.776E-10**	**0.077**



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	**DEPTHS**	10.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	**THICKNESS ($2H_1$)**	0.02	m
MC BEFORE TEST	22.1	%	**BULK DENSITY**	2.006	Mg/m^3
WT OF SAMPLE $ RING	140.48	g	**DRY DENSITY (γ_D)**	1.643	Mg/m^3
WT OF EMPTY RING	60.2	g	**SPECIFIC GRAVITY**	2.64	
WT OF WET SOIL	80.279	g	**e_o = (Hi - Hs)/Hs**	0.598	
WT OF DRY SOIL	65.8	g	**VOID RATIO FACTOR (F)**	0.1598	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 260kpa Overburden Pressure (ρ_o) = 206.6 Kpa

Remarks: These results relate to the sample that was tested

COMATLAB LTD

Bruce Katunguka

Technical Manager

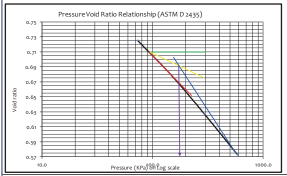
CLIENT:	YACHIYO ENGINEERING COMPANY LTD
PROJECT:	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO	NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	8-Jan-2016	**Borehole No.:**	4
Test Method:	ASTM D2435	**Depth(m):**	25.5-26.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.1154

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	H_j = (D_{50} * 0.002)/10 (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	H_d^2 = (Hj/2 - ΔHj/4)^2	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	k_v=$c_v$$\rho_wgm_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	1.30	520.00	900.00	710.00	0.142	0.076	0.0760	1.924	0.8584	0.72488	**2.168E-03**	73.52	**0.5373**	1.143E-09	
2	147.05	1.20	970.00	1225.00	1097.50	0.220	0.051	0.1270	1.873	0.7773	0.67916	**2.127E-03**	73.52	**0.3703**	7.726E-10	0.152
3	294.10	1.00	1310.00	1600.00	1455.00	0.291	0.058	0.1850	1.815	0.6968	0.62716	**2.288E-03**	220.57	**0.1449**	3.252E-10	0.173
4	588.19	0.70	1700.00	2005.00	1852.50	0.371	0.061	0.2460	1.754	0.6152	0.57247	**2.886E-03**	367.62	**0.0946**	2.678E-10	0.182
											C_v (cm^2/sec) =	**0.0024**	**M_v (m^2/MN) =**	**0.2868**	**6.271E-10**	**0.182**



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	**DEPTHS**	25.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	**THICKNESS ($2H_1$)**	0.02	m
MC BEFORE TEST	27.1	%	**BULK DENSITY**	1.856	Mg/m^3
WT OF SAMPLE $ RING	134.46	g	**DRY DENSITY (γ_D)**	1.459	Mg/m^3
WT OF EMPTY RING	60.19	g	**SPECIFIC GRAVITY**	2.68	
WT OF WET SOIL	74.273	g	**e_o = (Hi - Hs)/Hs**	0.793	
WT OF DRY SOIL	58.4	g	**VOID RATIO FACTOR (F)**	0.1793	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 464.2kpa Overburden Pressure (ρ_o) = 464.2 Kpa

Remarks: These results relate to the sample that was tested

COMATLAB LTD

Bruce Katunguka

Technical Manager

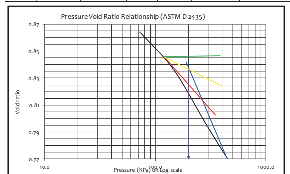
CLIENT:	YACHIYO ENGINEERING COMPANY LTD
PROJECT:	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTO	NEWPLAN LTD

CONSOLIDATION TEST REPORT

Testing Date:	19-Jan-2016	**Borehole No.:**	4
Test Method:	ASTM D2435	**Depth(m):**	15.5-16.0

Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0
Height of specimen	cm	2.00	Height of solids (H_s)	1.0562

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	H_j = (D_{50} * 0.002)/10 (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	H_d^2 = (Hj/2 - ΔHj/4)^2	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume ompressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	k_v=$c_v$$\rho_wgm_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'$_j$/σ'$_i$)]
0									2.000				0.00			
1	73.52	1.20	443.00	600.00	521.50	0.104	0.031	0.0314	1.969	0.9182	0.86378	**2.512E-03**	73.52	**0.2169**	5.347E-10	
2	147.05	0.70	710.00	856.00	783.00	0.157	0.029	0.0606	1.939	0.8659	0.83613	**4.062E-03**	73.52	**0.2048**	8.159E-10	0.092
3	294.10	0.40	965.00	1185.00	1075.00	0.215	0.044	0.1046	1.895	0.7991	0.79447	**6.560E-03**	220.57	**0.1052**	6.773E-10	0.138
4	588.19	0.38	1330.00	1540.00	1435.00	0.287	0.042	0.1466	1.853	0.7309	0.75471	**6.316E-03**	367.62	**0.0616**	3.819E-10	0.132
											C_v (cm^2/sec) =	**0.0049**	**M_v (m^2/MN) =**	**0.1472**	**6.024E-10**	**0.138**



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	**DEPTHS**	15.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	**THICKNESS ($2H_1$)**	0.02	m
MC BEFORE TEST	24.4	%	**BULK DENSITY**	1.807	Mg/m^3
WT OF SAMPLE $ RING	132.55	g	**DRY DENSITY (γ_D)**	1.453	Mg/m^3
WT OF EMPTY RING	60.2	g	**SPECIFIC GRAVITY**	2.69	
WT OF WET SOIL	72.35	g	**e_o = (Hi - Hs)/Hs**	0.894	
WT OF DRY SOIL	58.2	g	**VOID RATIO FACTOR (F)**	0.1894	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 274.8kpa Overburden Pressure (ρ_o) = 274.8 Kpa

Remarks: These results relate to the sample that was tested

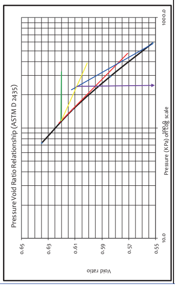
COMATLAB LTD

Bruce Katunguka

Technical Manager

CLIENT:	YACHIYO ENGINEERING COMPANY LTD														
PROJECT:	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION														
CONTRACTO	NEWPLAN LTD														
CONSOLIDATION TEST REPORT															
Testing Date:	19-Jan-2016					Borehole No.:	4								
Test Method:	ASTM D2435					Depth(m):	30.5-31.0								
Inside diameter of the ring	cm	5.047	Area of the specimen(Cm^2)	20.0											
Height of specimen	cm	2.00	Height of solids (H_s)	1.2079											

COEFFICIENT OF CONSOLIDATION EVALUATION													COMPRESSIBILITY		Permeability	Compression index
Increment No.	Pressure (Kpa)	Time for 50% consolidation t_{50} (mins)	D_o (from graph)	D_{100} (from graph)	D50 = (D0 + D100) *0.5	$H_j = (D_{50} * 0.002)/10$ (cm)	Height Change ΔH (from Graph) =((D_{100}-D_0)*0.002)/10 (cm)	Cumulative compression ΣΔH (cm)	Consolidated Height (cm), H=Hi-ΔH	$H_d^2 = (Hj/2 - ΔHj/4)^2$	Void ratio ef=(H-Hs)/Hs	Coefficient of consolidation Cv=(0.197Hd²)/t50	Pressure Change (ΔP) (Kpa)	Coefficient of Volume compressibility (m_v) = [(ΔH/H) *(1000/ΔP)] (m^2/MN)	$k_v = c_v \rho_w g m_v$ (m/sec)	Cc=-[e_j-e_i]/[log(σ'j/σ'i)]
0									2.000				0.00			
1	73.52	0.60	350.00	477.00	413.50	0.083	0.025	0.0254	1.975	0.9344	0.63475	5.113E-03	73.52	0.1750	8.776E-10	
2	147.05	0.50	551.00	690.00	620.50	0.124	0.028	0.0532	1.947	0.8881	0.61174	5.832E-03	73.52	0.1942	1.111E-09	0.076
3	294.10	0.40	800.00	970.00	885.00	0.177	0.034	0.0872	1.913	0.8320	0.58359	6.829E-03	220.57	0.0806	5.399E-10	0.094
4	588.19	0.38	1095.00	1285.00	1190.00	0.238	0.038	0.1252	1.875	0.7707	0.55213	6.659E-03	367.62	0.0551	3.602E-10	0.105
											C_v (cm^2/sec) =	0.0061	M_v (m^2/MN) =	0.1262	7.222E-10	0.105



Sample Description: Sandy elastic SILT

DIAMETER OF SPECIMEN	0.05047	m	DEPTHS	30.0	m
VOLUME OF SPECIMEN	0.0000400	m^3	THICKNESS ($2H_1$)	0.02	m
MC BEFORE TEST	22.7	%	BULK DENSITY	1.934	Mg/m^3
WT OF SAMPLE $ RING	137.61	g	DRY DENSITY (γ_D)	1.576	Mg/m^3
WT OF EMPTY RING	60.2	g	SPECIFIC GRAVITY	2.64	
WT OF WET SOIL	77.414	g	e_o = (Hi - Hs)/Hs	0.656	
WT OF DRY SOIL	63.1	g	VOID RATIO FACTOR (F)	0.1656	
RING CALIBRATION FACTOR		0.002			

Preconsolidation Pressure (ρ)= 578.7kpa   Overburden Pressure (ρ_o) = 578.7 Kpa

Remarks: These results relate to the sample that was tested

COMATLAB LTD

Bruce Katunguka

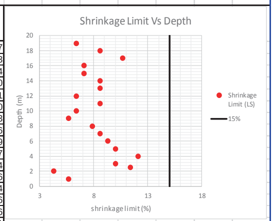
Technical Manager

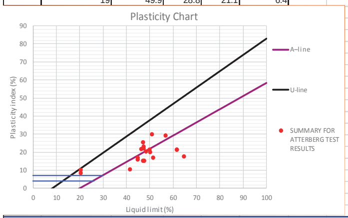
Appendix 11: Atterbeg Test Results

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LTD

SUMMARY FOR ATTERBERG TEST RESULTS

BH No.	Depth (m)	Liquid Limit (LL)	Plastic Limit (PL)	Plastic index (PI)	Shrinkage Limit (LS)
BH No. 1	1	20.5	12.2	8.3	5.7
	2	20.3	10.2	10.1	4.3
	2.5	47.1	21.6	25.5	11.4
	3	51	21.4	29.6	10
	4	56.7	27.5	29.2	12.1
	5	64.6	47.2	17.4	10
	6	47.4	24.4	23	9.3
	7	47.7	32.5	15.2	8.6
	8	51.4	34.5	16.9	7.9
	9	47.1	32	15.1	5.7
	10	61.6	40.5	21.1	6.4
	11	44.7	28.8	15.9	8.6
	12	61.6	40.5	21.1	6.4
	13	41.6	31.2	10.4	8.6
	14	47.4	25.4	22	8.6
	15	48.4	28.3	20.1	7.1
	16	44.8	28	16.8	7.1
	17	46.3	24.6	21.7	10.7
	18	50.2	30.2	20	8.6
	19	49.9	28.8	21.1	6.4

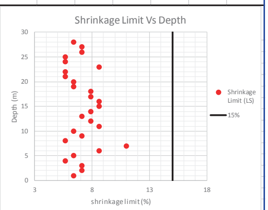


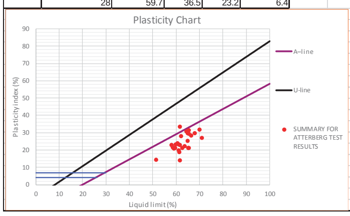


CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LTD

SUMMARY FOR ATTERBERG TEST RESULTS

BH No.	Depth (m)	Liquid Limit (LL)	Plastic Limit (PL)	Plastic index (PI)	Shrinkage Limit (LS)
BH No. 2	1	61.5	28.3	33.2	6.4
	2	64.3	33.7	30.6	7.1
	3	61.7	38.9	22.8	7.1
	4	65.5	36.4	29.1	5.7
	5	65.5	34.2	31.3	6.4
	6	65.5	44.6	20.9	8.6
	7	61.7	47.7	14	11
	8	60.5	36.9	23.6	5.7
	9	71.1	44.3	26.8	7.1
	10	66.3	38.2	28.1	6.4
	11	68	38.6	29.4	8.6
	12	70.1	38.6	31.5	7.9
	13	62.2	34.2	28	7.1
	14	51.3	37	14.3	7.9
	15	65	35.3	29.7	8.6
	16	61.3	42.6	18.7	8.6
	17	61.1	41.6	19.5	7.9
	18	63.6	41.7	21.9	7.9
	19	61.2	38.2	23	6.4
	20	59.5	38.4	21.1	6.4
	21	65.1	44	21.1	5.7
	22	64.9	39.8	25.1	5.7
	23	59	38.5	20.5	8.6
	24	58	35.2	22.8	5.7
	25	58	35.2	22.8	5.7
	26	62.6	41.7	20.9	7.1
	27	58.6	37.4	21.2	7.1
	28	59.7	36.5	23.2	6.4

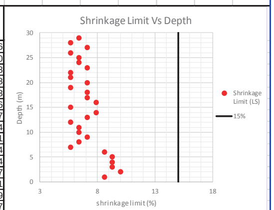


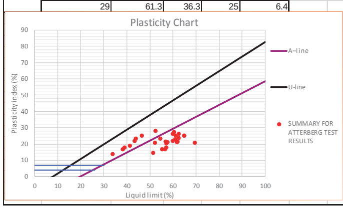


CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LTD

SUMMARY FOR ATTERBERG TEST RESULTS

BH No.	Depth (m)	Liquid Limit (LL)	Plastic Limit (PL)	Plastic index (PI)	Shrinkage Limit (LS)
BH No.3	1	39.1	21.3	17.8	8.6
	2	46.4	21.3	25.1	10
	3	43.5	21.7	21.8	9.3
	4	43.9	20.8	23.1	9.3
	5	52.4	24.4	28	9.3
	6	64.9	39.8	25.1	8.6
	7	56.8	35.6	21.2	5.7
	8	69.5	49.1	20.4	6.4
	9	38.1	21.5	16.6	7.1
	10	33.9	20.4	13.5	6.4
	11	41.2	22.6	18.6	6.4
	12	61.9	40.6	21.3	5.7
	13	60.5	33.3	27.2	7.1
	14	51.3	37	14.3	7.9
	15	61	38.2	22.8	5.7
	16	59.9	33.7	26.2	7.9
	17	55.3	38.6	16.7	7.1
	18	57.1	39.4	17.7	7.1
	19	62.4	36.5	25.9	5.7
	20	52.2	31.6	20.6	7.1
	21	56.5	40.1	16.4	5.7
	22	64.9	39.8	25.1	5.7
	23	62.6	39.3	23.3	7.1
	24	59.9	38.3	21.6	6.4
	25	61.7	40.9	20.8	6.4
	26	57.7	36.6	21.1	5.7
	27	54.6	31.5	23.1	7.1
	28	57.1	36.9	20.2	5.7
	29	61.3	36.3	25	6.4

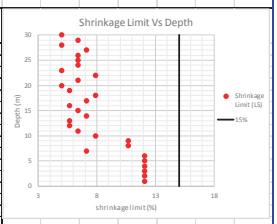


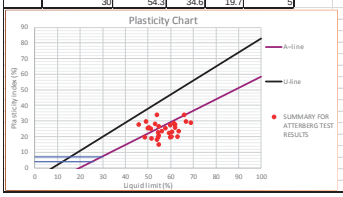


CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LTD

SUMMARY FOR ATTERBERG TEST RESULTS

BH No.	Depth (m)	Liquid Limit (LL)	Plastic Limit (PL)	Plastic index (PI)	Shrinkage Limit (LS)
BH No.4	1	49.9	24.6	25.3	12.1
	2	51.3	26.3	25	12.1
	3	54.8	28.1	26.7	12.1
	4	48.6	29	19.6	12.1
	5	53	24.7	28.3	12.1
	6	53.9	20.1	33.8	12.1
	7	45.8	17.9	27.9	7.1
	8	50.4	24.6	25.8	10.7
	9	49.1	19.5	29.6	10.7
	10	63.5	40.1	23.4	7.9
	11	61.9	34.1	27.8	6.4
	12	51.4	32.5	18.9	5.7
	13	66.7	37	29.7	5.7
	14	57.6	32.1	25.5	7.1
	15	61.4	33	28.4	6.4
	16	66	32	34	5.7
	17	61.8	35.8	26	7.1
	18	68.8	39.8	29	7.9
	19	59.8	32.4	27.4	5.7
	20	59.2	37	22.2	5
	21	59.9	40.4	19.5	6.4
	22	63.1	43.2	19.9	7.9
	23	60.7	37.7	23	5
	24	54.6	39.8	14.8	6.4
	25	56.1	32.4	23.7	6.4
	26	54.8	33.9	20.9	6.4
	27	54.4	31.5	22.9	7.1
	28	60.2	40.1	20.1	5
	29	54	36.1	17.9	6.4
	30	54.3	34.6	19.7	5





Appendix 12: Bulk Density

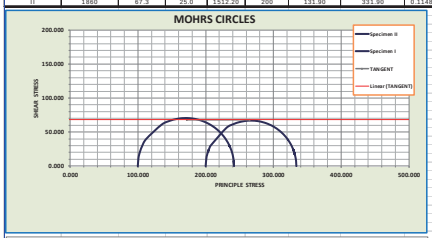
Borehole No.:	Depth (m)	Bulk Density (Mg/m³)
BH 01	5.5-6.0	1.89
	10.5-11.0	2.00
	15.5-16.0	1.86
	20.5-21.0	1.94
BH 02	5.5-6.0	1.80
	10.5-11.0	1.70
	15.5-16.0	1.74
	20.5-21.0	1.82
	25.5-26.0	1.86
	28.5-29.0	1.71
BH 03	5.5-6.0	1.92
	10.5-11.0	1.83
	15.5-16.0	1.86
	20.5-21.0	1.88
	25.5-26.0	1.93
	29.5-30.0	1.93
BH 04	5.5-6.0	1.97
	10.5-11.0	2.01
	15.5-16.0	1.81
	20.5-21.0	1.79
	25.5-26.0	1.86
	30.5-31.0	1.93

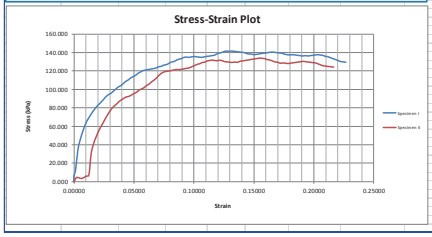
Appendix 13: Unconsolidated undrained triaxial tests result

Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 1
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	5.5-6.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm		Original Length=76mm				Rate of strain = 2 mm/min				
						AT FAILURE				
Specimen No	Bulk Density (kg/m³)	Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1830	66.0	23.0	1487.80	100	141.66	241.66	0.13158	0	68
II	1860	67.3	25.0	1512.20	200	131.90	331.90	0.11487		

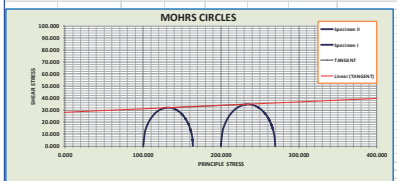


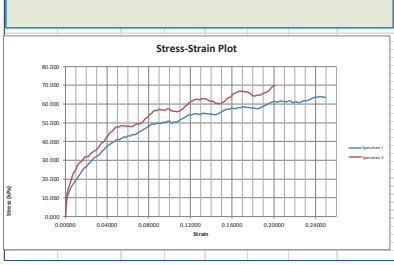


Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 1
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	10.5-11.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm		Original Length=76mm				Rate of strain = 2 mm/min				
						AT FAILURE				
Specimen No	Bulk Density (kg/m³)	Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1870	57.5	21.0	1545.45	100	64.02	164.02	0.24368	2	28
II	1840	61.0	23.0	1520.66	200	69.72	269.72	0.19697		



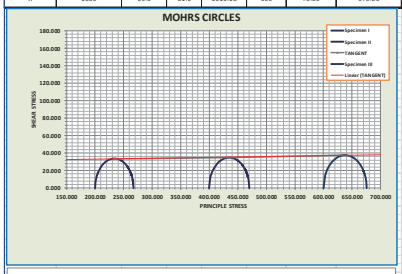


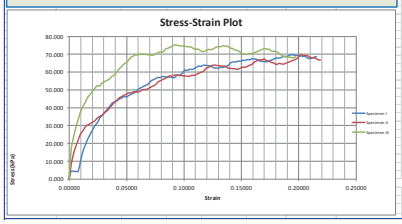
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 1
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	15.5-16.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm; Rate of strain = 2.0 mm/min

Specimen No	Bulk Density (kg/m³)	Original Length=76mm Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	AT FAILURE: Maximum Deviator Stress (kPa)	AT FAILURE: Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1850	61.3	22.0	1516.39	200	69.73	269.73	0.19303	0	31
II	1860	60.7	24.0	1524.59	400	69.71	469.71	0.20145		
II	1880	69.0	21.0	1516.13	600	75.26	675.26	0.09197		



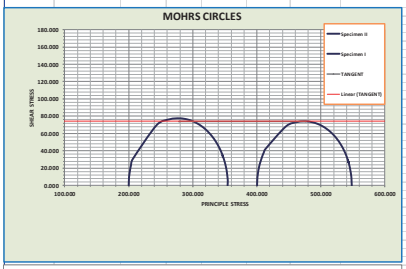


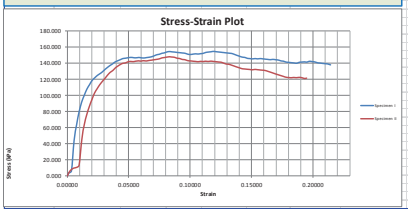
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 1
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	20.5-21.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm; Rate of strain = 2.0 mm/min

Specimen No	Bulk Density (kg/m³)	Original Length=76mm Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	AT FAILURE: Maximum Deviator Stress (kPa)	AT FAILURE: Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1890	67.0	25.0	1512.00	200	154.62	354.62	0.11882	0	74
II	1890	69.7	25.0	1512.00	400	147.98	547.98	0.08289		



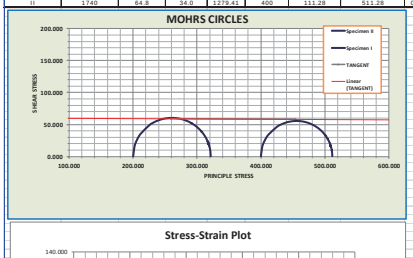


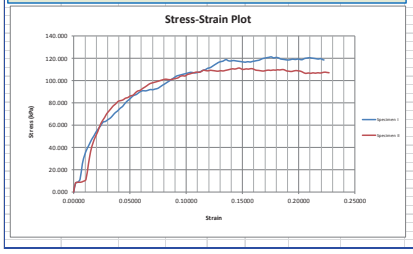
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	5.5-6.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm; Rate of strain = 2 mm/min

Specimen No	Bulk Density (kg/m³)	Original Length=76mm Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	AT FAILURE: Maximum Deviator Stress (kPa)	AT FAILURE: Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1720	62.6	36.0	1264.71	200	121.37	321.37	0.17579	0	60
II	1740	64.8	34.0	1279.41	400	111.28	511.28	0.14724		



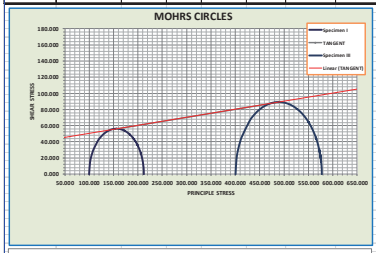


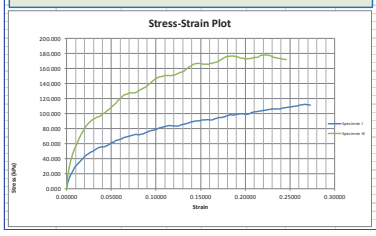
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	10.5-11.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm; Rate of strain = 2.0 mm/min

Specimen No	Bulk Density (kg/m³)	Original Length=76mm Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	AT FAILURE: Maximum Deviator Stress (kPa)	AT FAILURE: Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1720	55.8	36.0	1264.7	100	112.56	212.56	0.26632	6	40
III	1710	59.0	39.0	1230.2	400	177.97	577.97	0.22368		

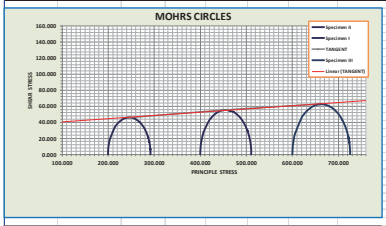


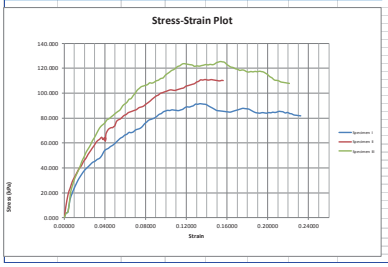


Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	15.5-16.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm		Original Length=76mm				Rate of strain = 2 mm/min AT FAILURE				
Specimen No	Bulk Density (kg/m³)	Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1680	65.9	42.0	1183.10	100	91.72	191.72	0.13216		
II	1720	65.8	37.0	1211.27	200	110.95	310.95	0.13408	3	36
II	1700	64.3	26.0	1240.88	600	125.39	725.39	0.15355		

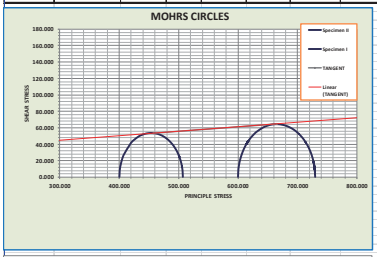


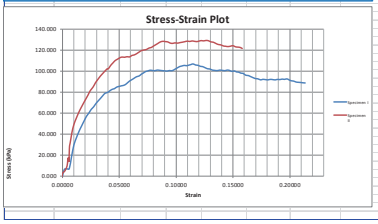


Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	20.5-21.0
CONTRACTOR	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm		Original Length=76mm				Rate of strain = 2.0 mm/min AT FAILURE				
Specimen No	Bulk Density (kg/m³)	Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1830	75.9	29.0	1418.60	400	106.91	506.91	0.11500	3	29
II	1850	66.4	27.0	1434.11	600	129.40	729.40	0.12645		

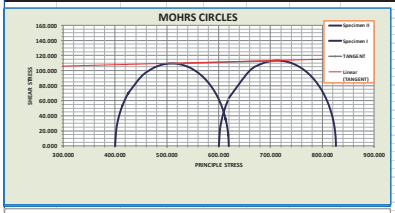


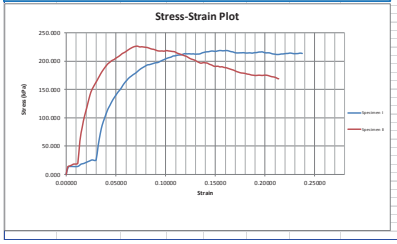


Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	25.5-26.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm		Original Length=76mm				Rate of strain = 2 mm/min AT FAILURE				
Specimen No	Bulk Density (kg/m³)	Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1790	64.2	25.0	1432.00	400	218.92	618.92	0.06342		
II	1670	70.5	26.0	1336.00	600	226.70	826.70	0.04816	1	100

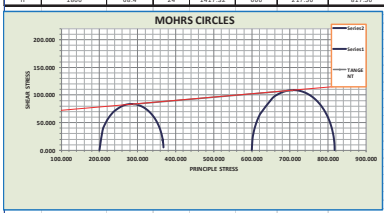


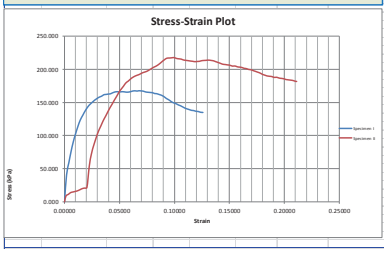


Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	28.5-29.0
CONTRAC	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm		Original Length=76mm				Rate of strain = 2 mm/min AT FAILURE				
Specimen No	Bulk Density (kg/m³)	Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1720	71.1	27.0	1354.33	200	167.66	367.66	0.06408	3	66
II	1800	68.4	24	1417.32	600	217.50	817.50	0.09974		



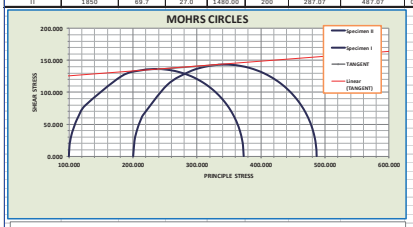


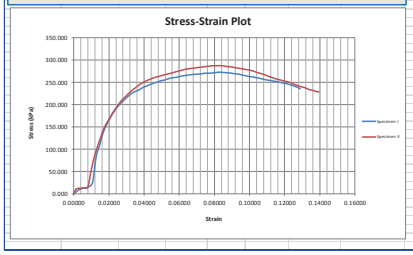
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 3
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	5.5-6.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm

Specimen No	Bulk Density (kg/m³)	Original Length=76mm / Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Rate of strain = 2 mm/min AT FAILURE: Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1830	69.7	25.0	1464.00	100	272.52	372.52	0.08289	4	118
II	1850	69.7	27.0	1480.00	200	287.07	487.07	0.08289		



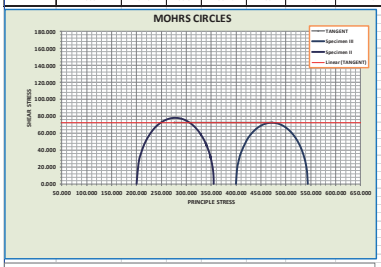


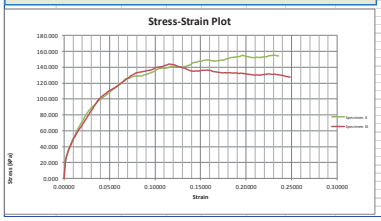
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 3
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	10.5-11.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm

Specimen No	Bulk Density (kg/m³)	Original Length=76mm / Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Rate of strain = 2.0 mm/min AT FAILURE: Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
II	1800	61.0	29.0	1395.3	200	164.55	155.35	0.19697	0	73
III	1800	67.3	30.0	1384.6	400	144.34	144.34	0.11513		



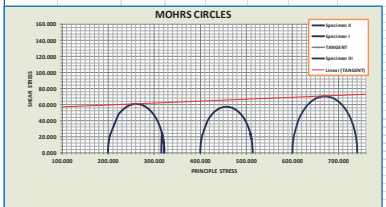


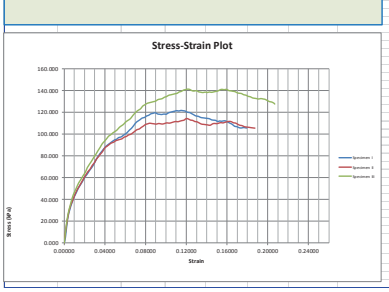
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 3
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	15.5-16.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm

Specimen No	Bulk Density (kg/m³)	Original Length=76mm / Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Rate of strain = 2 mm/min AT FAILURE: Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1800	67.3	29.0	1395.35	200	121.77	321.77	0.11474		
II	1830	66.9	30.0	1418.60	400	114.10	514.10	0.11974	13	55
III	1830	66.8	28.0	1407.69	600	141.01	741.01	0.12132		



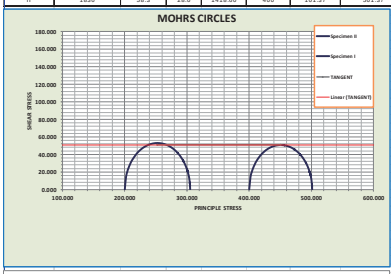


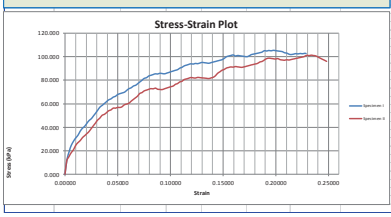
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 3
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	20.5-21.0
CONTRACTOR	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm

Specimen No	Bulk Density (kg/m³)	Original Length=76mm / Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Rate of strain = 2.0 mm/min AT FAILURE: Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1830	61.0	29.0	1418.60	200	105.43	305.43	0.19750	0	51
II	1830	58.3	28.0	1418.60	400	101.37	501.37	0.23355		



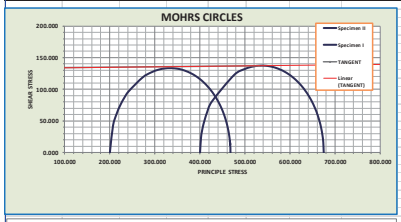


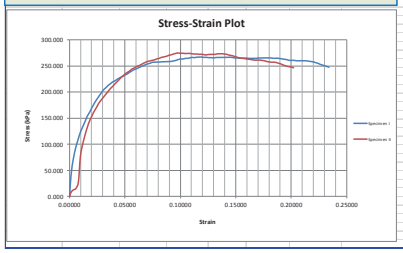
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 4
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	5.5-6.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm; Rate of strain = 2 mm/min

Specimen No	Bulk Density (kg/m³)	Original Length=76mm / Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	AT FAILURE: Maximum Deviator Stress (kPa)	AT FAILURE: Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1920	67.0	32.0	1454.55	200	267.24	467.24	0.11895	0	133
II	1930	68.6	33.0	1462.12	400	274.46	674.46	0.09776		



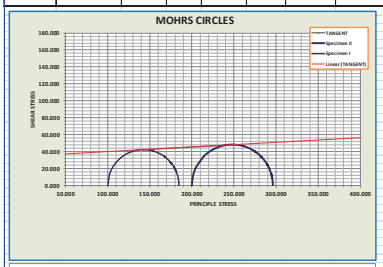


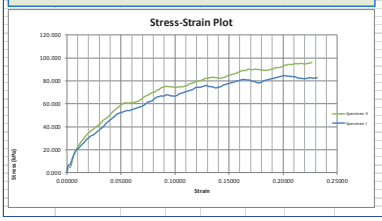
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 4
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	10.5-11.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm; Rate of strain = 2.0 mm/min

Specimen No	Bulk Density (kg/m³)	Original Length=76mm / Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	AT FAILURE: Maximum Deviator Stress (kPa)	AT FAILURE: Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1740	60.7	17.0	1487.2	100	84.56	84.56	0.20079	3	34
II	1770	58.8	23.0	1439.0	200	88.44	96.17	0.22645		



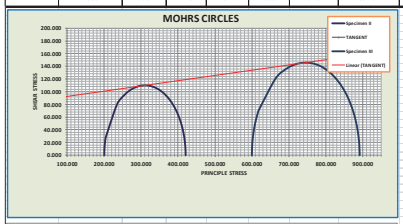


Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 4
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	15.5-16.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm; Rate of strain = 2 mm/min

Specimen No	Bulk Density (kg/m³)	Original Length=76mm / Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	AT FAILURE: Maximum Deviator Stress (kPa)	AT FAILURE: Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1800	68.0	24.0	1451.61	200	219.98	419.98	0.10579	19	84
III	1800	66.9	24.0	1451.61	600	292.01	892.01	0.11921		

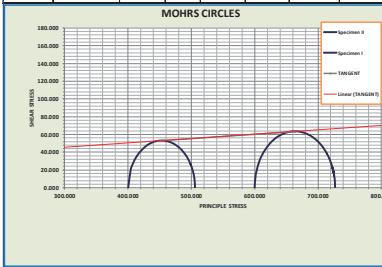


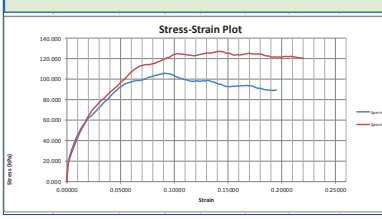
Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 4
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	20.5-21.0
CONTRACTOR	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm; Rate of strain = 2.0 mm/min

Specimen No	Bulk Density (kg/m³)	Original Length=76mm / Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	AT FAILURE: Maximum Deviator Stress (kPa)	AT FAILURE: Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1780	69.1	27.0	1401.57	400	105.88	505.88	0.09026	3	31
II	1810	65.2	28.0	1425.20	600	127.16	727.16	10.76000		

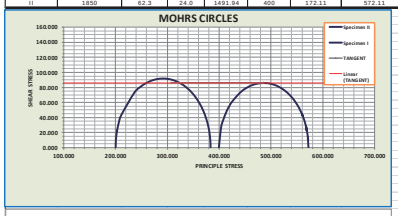


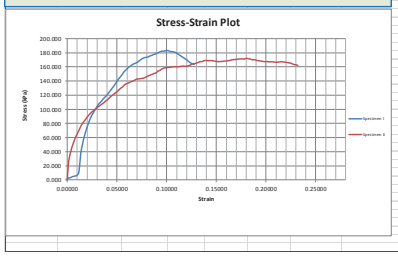


Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 4
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	25.5-26.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm										
		Original Length=76mm				Rate of strain = 2 mm/min				
						AT FAILURE				
Specimen No	Bulk Density (kg/m³)	Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1800	68.3	24.0	1451.61	200	183.07	383.07	0.10118	0	86
II	1850	62.3	24.0	1491.94	400	172.11	572.11	0.17987		

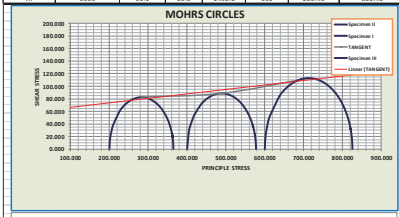


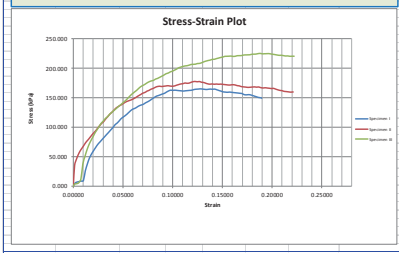


Summary of Unconsolidated Undrained Triaxial Test (UU Triaxial Test)-Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 4
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	30.5-31.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2850

Specimen diameter = 38mm										
		Original Length=76mm				Rate of strain = 2 mm/min				
						AT FAILURE				
Specimen No	Bulk Density (kg/m³)	Final Length (mm)	Moisture Content (%)	Dry Density (kg/m³)	Cell Pressure (σ3 in kPa)	Maximum Deviator Stress (kPa)	Major Principal Stress (σ1 in kPa)	Strain at Failure	Angle of Internal Friction (degrees)	Cohesion (kPa)
I	1870	66.3	25.0	1496.0	200	165.33	365.33	0.12789		
II	1870	66.4	26.0	1484.1	400	177.21	577.21	0.12684	2	60
III	1880	61.1	26.0	1492.1	600	225.45	825.45	0.19671		



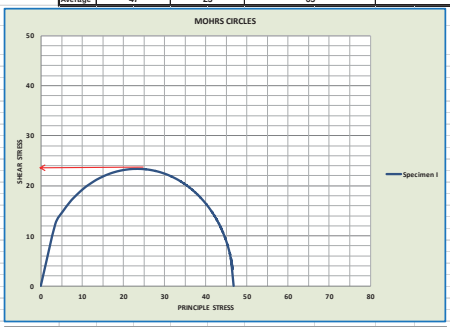


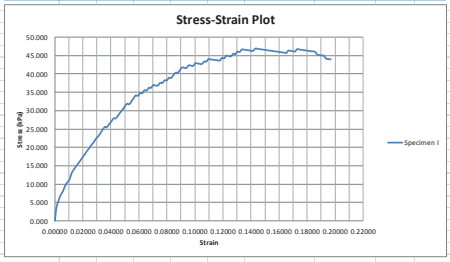
Appendix 14: Unconfined Compressive Strength

Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 1
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	5.5-6.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	47	23	65	23.0	14.3
Average	47	23	65		

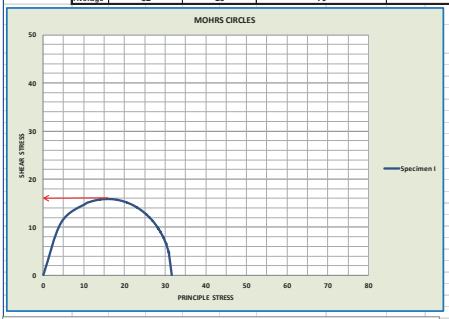


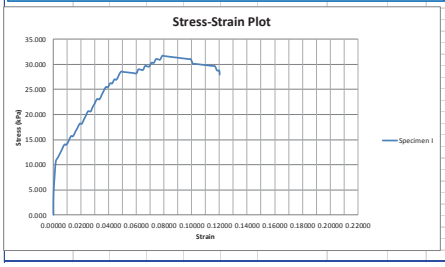


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 1
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	10.5-11.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	32	16	70	24.5	7.9
Average	32	16	70		

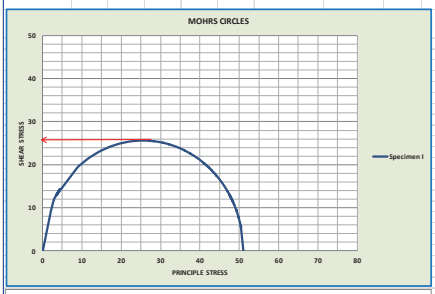


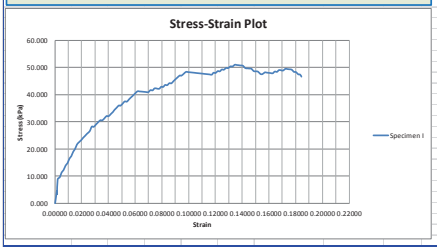


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 1
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	15.5-16.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	51	26	66	26.5	13.4
Average	51	26	66		

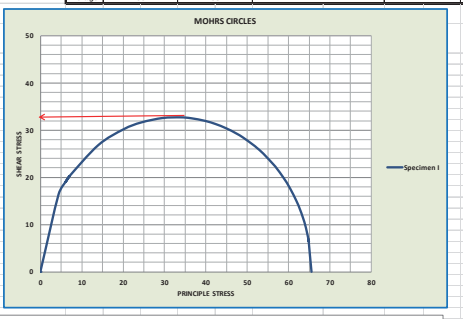


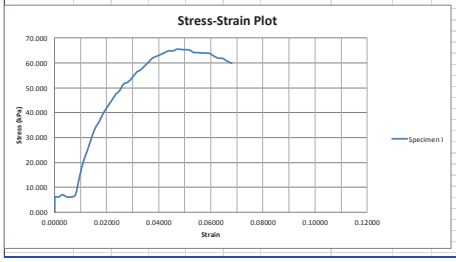


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	3.0-4.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	66	33	72	34.5	4.7
Average	66	33	72		

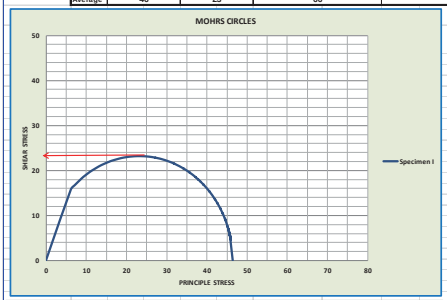


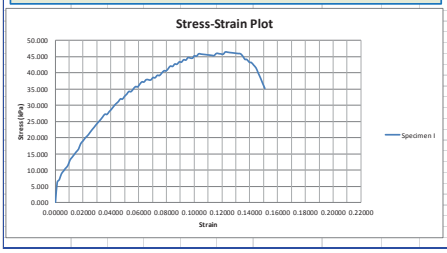


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	5.5-6.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	46	23	66	25.8	12.6
Average	46	23	66		

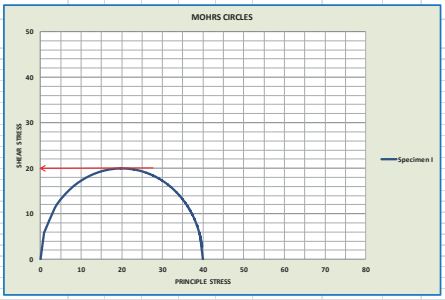


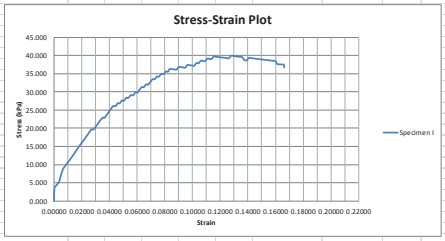


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	10.5-11.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	40	20	67	37.3	11.5
Average	40	20	67		

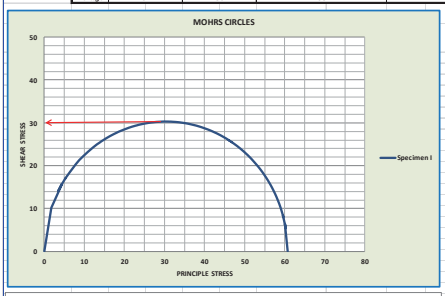


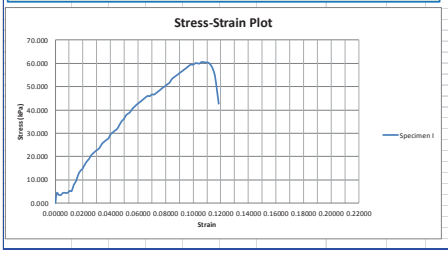


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	15.5-16.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	61	30	68	35.9	10.6
Average	61	30	68		

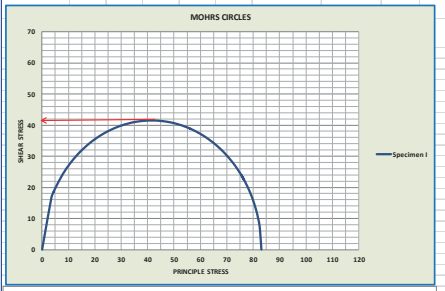


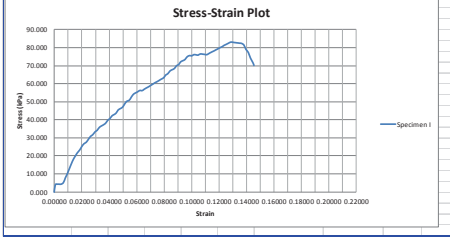


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	24.5-25.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	83	41	66	28.3	12.9
Average	83	41	66		

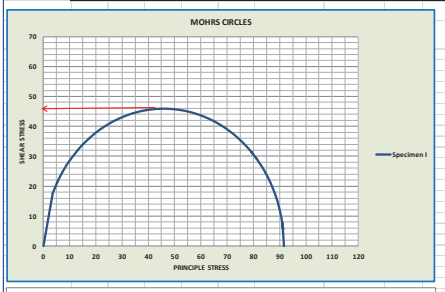


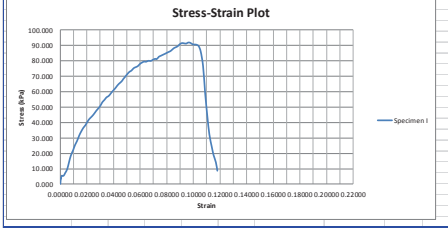


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 2
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	28.5-29.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	92	46	69	22.6	9.6
Average	92	46	69		

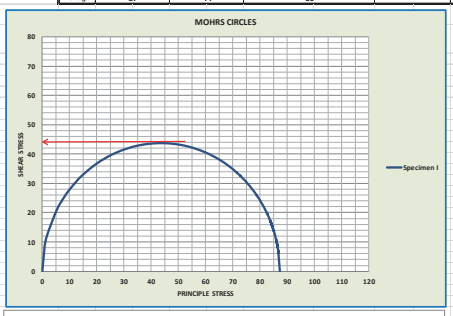


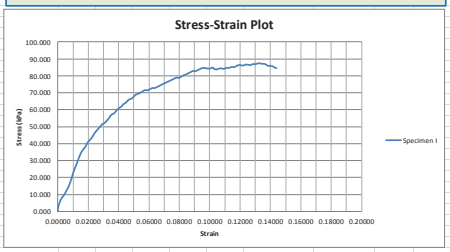


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 3
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	1.5-2.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	87	44	66	25.8	13.2
Average	**87**	**44**	**66**		

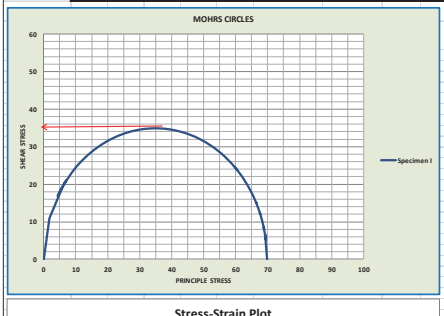


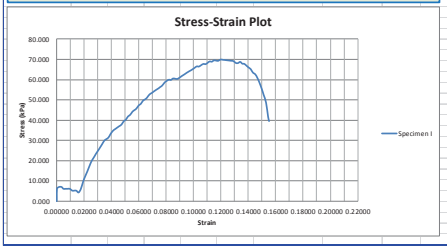


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 3
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	7.5-8.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	70	35	67	31.0	11.5
Average	**70**	**35**	**67**		

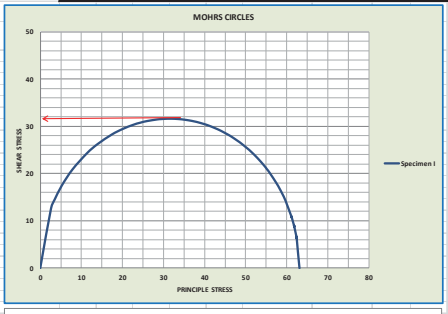


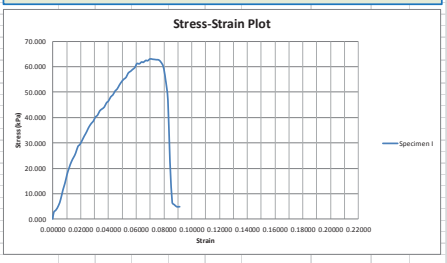


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 3
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	18.5-19.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	63	32	71	29.2	6.7
Average	**63**	**32**	**71**		

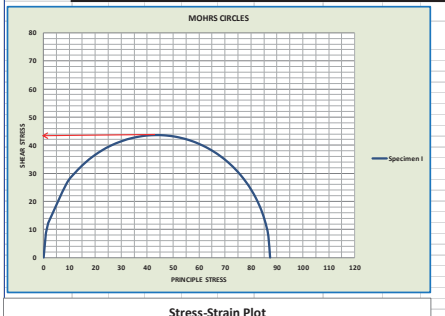


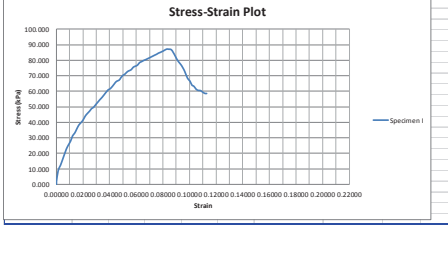


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 3
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	25.5-26.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	87	44	70	27.1	8.3
Average	**87**	**44**	**70**		

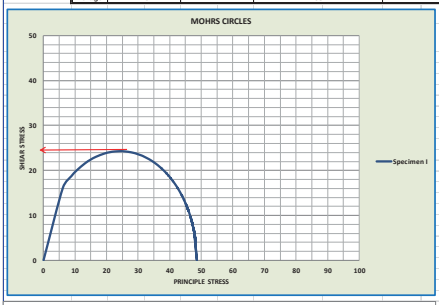


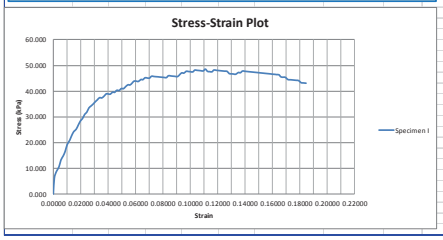


Summary Unconfined Compressive Strength Test Results

PROJECT	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION	Borehole No.:	BH 3
CLIENT:	YACHIYO ENGINEERING COMPANY LTD	Depth	29.5-30.0
CONTRACTOR:	NEWPLAN LTD	Test Method:	ASTM D 2166

Specimen diameter = 38mm			Original Length=76mm	Moisture Content	Unit strain
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	Final Length (mm)	%	%
Specimen	49	24	68	25.9	10.3
Average	49	24	68		





Intended for
Uganda Electricity Transmission Company Limited (UETCL)

Document type
Geotechnical report

Date
January, 2016

GREATER KAMPALA TRANSMISSION NETWORK PROJECT IN THE REPUBLIC OF UGANDA

KAWAALA SUBSTATION DETAIL GEOTECHNICAL REPORT

Revision **00**
Date **29.12.2015**
Made by **DA/DS**
Checked by **DS**
Approved by **DA**

YACHIYO ENGINEERING CO.,LTD.
Consulting Engineers & Architects

EXECUTIVE SUMMARY

This report mainly deals with the geological and geotechnical investigation findings of Kawaala Substation. In this report the governing soil properties are considered based on the geological and geotechnical site investigation which was executed between November and December 2015. In addition, relevant non-geotechnical parameters are outlined. The analysis and calculation results are given as part of this report (i.e. bearing capacity, stability and settlements).

Kawaala substation is located in Namungoona, a local town suburb located in Kawempe division. It is located approximately 6km North West of Kampala city centre accessible via Nakibinge road off Hoima road. The approximate centroid of the project area coordinates is 36 N 448650 UTM 37400. The project area incorporated within the site boundary is approximately 14,000m^2. The elevation of the project area varies between 1181 to 1195amsl. The entire project area is covered by levelled gravelly fill embankment of approximately 1.5m thick.

The project area of Kawaala substation has not experienced any earthquakes over years. It lies in zone 3 which is the least seismically active zone in Uganda. Therefore the risk of damage by earthquakes is low. An over view of the geological conditions indicate that apart from the regional seismicity, no major geological hazards and constraints such as unstable slopes, thick deposits of weak soils, land ground subsidence and collapse are identified in the area.

Kampala is found in the Buganda region underlain by Porphyroblastic Phyllite (P_1BNamp), Shale, Slate Phyllite (P_1BNsh), granitoids and orthogneiss (A_3KAgr). The site is underlain by rocks composed of Kampala granitoids which are rocks predominantly composed of feldspar and quartz and orthogneiss (A_3KAgr) of complex formation comprising sedimentary, metamorphic and volcanic rocks.

The soil investigation was conducted in accordance with American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. The conducted geotechnical investigation consists of field investigation and laboratory tests on samples recovered from the borehole.

The site investigation confirmed that the geological sequence at the site generally comprises of a moderate reddish brown imported fill sandy fat gravel from the ground surface to a depth of 2m, overlying homogenous reddish brown sandy fat clay up to a depth of 11m, underlain by homogenous yellowish orange coarse grained clayey sand up to a depth of 15m, overlying homogenous yellowish

orange sandy silt up to a depth of 27.5m which is underlain by highly weathered pink greenish grey weak rock up to a depth of 30.5m. The stratigraphy indicates that the soil is a product of completely weathered rock which is in form of residual clay.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BGL	Below Ground Level
masl	Above Mean Sea Level
SPT	Standard Penetration Test

1 INTRODUCTION

1.1 About report

This report mainly deals with the geotechnical investigation finding of Kawaala. This report discusses index and engineering properties of soil based on the geotechnical field investigation which was conducted in November 2015 and laboratory test conducted between November and December, 2015. Relevant non-geotechnical parameters are outlined including the analysis and calculation results are given as part of this report (i.e. bearing capacity and settlements). Finally, recommendations were made for design and construction of the proposed development foundation.

1.2 Background

Yachiyo Engineering Company Ltd (YEC) were commissioned by Japan International Cooperation Agency (JICA) to carry out a preparatory survey for the improvement of the greater Kampala metropolitan area transmission system in the republic of Uganda. Yachiyo Engineering Company Limitedplan to upgrade the substation which was constructed in the period 2008-2012 known as Kawaala substation in Namungoona. This will involve construction of a substation and associated infrastructure. In order to upgrade the existing substation, geotechnical investigations were required to determine the suitability of the site for the proposed developments and to guide the design of the proposed infrastructure.

Following decision of conducting Geotechnical investigation at Kawaala substation in Namungoona, Newplan limited have been contracted by Yachiyo Engineering Company Ltd to carry out a Topographic surveying and Geotechnical investigation in Namungoona, Kampala district.

1.3 The Consultant

Following a competitive bidding procedure Newplan Limited were appointed by Yachiyo Engineering Company Ltd to carry out topographic surveying and geotechnical investigation for the proposed site. The Contract was signed on 10th November 2015 and the assignment commenced on 16th November, 2015.

The study was carried out in two phases i.e.: initial geotechnical investigation and detailed investigation study. The initial geotechnical investigation was concluded on November 20th, 2015. Following that, detailed investigations commenced on November 23rd, 2015. Field and laboratory tests were conducted by Tec lab limited and Comat lab limited. This report together with the Topographic report are deliverables that signify the conclusion of the Kawaala substation Topographic surveying and Geotechnical investigation contract.

1.4 Site Description

1.4.1 Location

Kawaala substation is located in Namungoona, a local town suburb located in Kawempe division. It is located approximately 6km North West of Kampala city centre accessible via Nakibinge road off Hoima road. The approximate centroid of the project area coordinates is 36 N 448650 UTM 37400. It is neighbouring a residential area generally consisting of one storey high buildings in the North, West and South with an access road east of the site.

It is an existing substation with developments on the site. The project area incorporated within the site boundary is approximately 14,000m^2. The entire project area is covered by levelled gravelly fill embankment of approximately 1.5m thick.

1.4.2 Topography

The elevation of the project area varies between 1181 to 1195masl.

1.4.3 1.4.3 Climate

The project area is classified under tropical climate with temperatures ranging from 15 to 29 ^{0}C. The project area receives rain in in two different season, March to May and in August to December. The mean annual rainfall is between 1125 and 1350mm.

1.4.4 Geohazards

The project area of Kawaala substation has not experienced any earthquakes historically and lies in zone 3 which is the least seismically active zone in Uganda. Therefore the risk of damage by earthquakes is low. An over view of the geological conditions indicate that apart from the regional seismicity, no major geological hazards and constraints such as unstable slopes, thick deposits of weak soils, land ground subsidence and collapse were identified in the area.

1.4.5 Published Geology

Kampala is found in the Buganda region underlain by Porphyroblastic Phyllite (P_1BNamp), Shale, Slate Phyllite (P_1BNsh), and granitoids, orthogneiss (A_3KAgr). The site is underlain by rocks composed of Kampala granitoids which are rocks predominantly composed of feldspar and quartz and orthogneiss (A_3KAgr) of complex formation comprising sedimentary, metamorphic and volcanic rocks (see Figure 1-1)

Figure 1. 1: Extract of geological map showing project site

1.5 Scope of services

In order to facilitate the substation foundation design, a detailed geotechnical investigation was performed. Newplan limited conducted the geotechnical investigations as per the general guidance proposed in the American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. The scope of the services was as summarized below:

1. Drilling exploratory holes and recovering soil samples;
2. Determination of subsurface soil profile or logging borehole for strata profiles
3. Carrying out standard penetration tests;
4. Conducting relevant laboratory tests on the recovered samples (i.e. Moisture Content, Particle Size Distribution, Atterberg limits (Consistency), Consolidation Tests, and Triaxial tests for undisturbed samples);
5. Monitoring ground water occurrence (depth of water table);
6. Propose recommendations for foundation design; and
7. Preparation of a geotechnical interpretative report.

2 GEOTECHNICAL INVESTIGATION

2.1 Methodology

Geotechnical investigation were conducted in two main phases of investigation.

1. Initial geotechnical investigation
   - Desk study (Reviewing useful sources of geological, historical and topographic information)
   - Site reconnaissance (Sampling, description and visual field identification)
2. Detailed geotechnical investigation
   - Preliminary design stage investigation
   - Final design stage or phase investigation

Initial geotechnical investigation was concluded in November 20th, 2015. This investigation is limited to detail geotechnical investigation mainly for preliminary design stage investigation.
This preliminary preliminary design detailed geotechnical investigation typically includes one boring and relevant soil testing for defining the general stratigraphy, soil and rock characteristics, groundwater conditions, and other existing features important to foundation design. Further final design stage investigation stages can be considered if there are significant design changes or if local subsurface anomalies warrant further study.

The investigation was conducted in accordance with American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. It consists of the following components:

- Field Investigations; these were intrusive and included drilling exploratory holes, SPTs and groundwater observation
- Laboratory tests on samples recovered from borehole

2.2 Field Investigations

The site work was carried out in month of November 2015 on the basis of ASTM D 420 recommendation (i.e. ASTM D 1586, ASTM D 1587, ASTM D 2488, and ASTM D 5783). The field work comprised of the following;

- Rotary drilling of 1 borehole to a maximum depth of 30m;
- Collecting disturbed and undisturbed samples;

- In-situ Standard Penetration Testing (SPT) within the boreholes. These were undertaken at 1.0m intervals. SPTs were based on a 65kg driving hammer falling 'free' from a height of 760mm;
- Driving the standard split-barrel sampler of internal and external diameters 35mm and 50mm respectively to reach a distance of 450 mm into the soil at the bottom of the boring after the chosen interval.
- Counting the number of blows to drive the sampler each 75 mm increment of a total of 450 mm penetration. The blow count for the first 150 mm increment was discarded and the sum of the blow counts for the second and the third 150 mm increment was recorded as the SPT 'N' value.

2.2.1 Borehole

The boreholes were drilled as per ASTM D 5783. The drilled borehole logs were prepared for each borehole as per American Society for Testing and Materials (ASTM) D 2488.

The exploratory borehole records and logs are included in Appendix 2 and should be read in conjunction with the accompanying general notes therein. The records also give details of the samples taken together with the observations made during boring. The photographs of the boreholes are attached as Appendix 3.

2.2.2 Soil profile

The site investigation confirmed that the geological sequence at the site generally comprises of a moderate reddish brown imported fill sandy fat gravel from ground level to a depth of 2m, overlying homogenous reddish brown sandy fat clay up to a depth of 11m, underlain by homogenous yellowish orange coarse grained clayey sand up to a depth of 15m, overlying homogenous yellowish orange sandy silt up to a depth of 27.5m underlain by highly weathered pink greenish grey weak rock up to a depth of 30.5m. The stratigraphy indicates that the insitu soil is a product of completely weathered rock which is in form of residual clay. The log descriptions consistently indicate blotched colours as shown in Appendix 2.

2.2.3 Ground water

To determine the elevation of the ground water table a borehole observation was conducted during borehole drilling. This groundwater observations in borehole was conducted as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 4750.

The ground water table was not encountered within a depth of 30m depth. This indicates the ground water table is deep far from the lowest foundation footing and free from hydrostatic uplift. Ground water observation result is presented in a borehole log Appendix 2.

2.2.4 **The Standard Penetration Test (SPT)**

The standard penetration test (SPT) were performed during the advancement of a soil boring to obtain an approximate measure of the dynamic soil resistance, as well as a disturbed drive sample (split barrel type) to determine the arrangement of different layers of the soil with relation to the proposed foundation elevation. The test was conducted as per Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils, American Society for Testing and Materials (ASTM) D 1586. One borehole was drilled and 30 standard penetration tests over 30.5m depth of borehole were conducted. The location of this borehole coordinates is 36 N 448664 UTM 37368.

Information obtained from SPT combined with other geotechnical laboratory test results, on site topography and area climatic records, provides basic planning material essential to the logical and effective development of substation and other infrastructure.

The observed field standard penetration values (N) were corrected to the average energy ratio of 60% (N_{60}) on basis of field observation as function of the input driving energy and its dissipation around the sampler into the surrounding soil. SPT correction were applied as per Seed *et al*. (1985) and Skempton (1980). Furthermore, the undrained shear strength (c_u) of the soil was determined using the corrected standard penetration values (N_{60}) as per Hara *et al*. (1971) and Peck *et al*. (1974) empirical relationship respectively. Finally, the approximate ultimate bearing capacity (Q_{ult}) and approximate allowable bearing capacity (Q_{all}) were computed using the derived undrained shear strength (c_u) of the soil. Overconsolidation (OCR) was determined using Mayne and Kemper (1988).

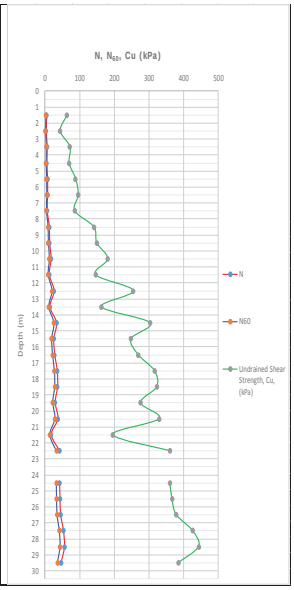
A factor of Safety (FoS) of 3.0 was used irrespective of the site conditions for computation of allowable bearing capacity (Q_{all}). Detailed bearing capacity results are attached as Appendix 1 and the summary of undrained shear strength (c_u) given in table 2.1.

Depending on the standard penetration value (N_{60}) and unconfined shear strength result, the insitu soil

comprises of soft to medium consistency clay soil from the ground surface to a depth of 6m, underlain by stiff consistency clay soil up to a depth of 10m, overlying very stiff consistency clay soil up to a depth of 22m, underlain by hard consistency clay soil up to a depth of 30m. Furthermore, the insitu soil is over consolidated.

Table 2. 1: Standard Penetration Test value (N), N60, and undrained shear strength cu (kN/m2) with respect to depth

			BH1			
Depth (m)	Vertical stress (MN/m2)	Overall Efficiency	N	N_{60}	Undrained Shear Strength, C_u (kPa)	Overconsolidation ratio (OCR)
0						
1.5	0.03	0.59	5	3	63	5
2.5	0.05	0.59	3	2	44	2
3.5	0.07	0.59	6	4	72	3
4.5	0.09	0.67	5	3	69	2
5.5	0.11	0.67	7	5	88	3
6.5	0.13	0.75	7	5	96	2
7.5	0.15	0.75	6	4	85	2
8.5	0.17	0.75	12	9	141	3
9.5	0.19	0.75	13	10	149	3
10.5	0.21	0.75	17	13	181	3
11.5	0.23	0.79	12	9	146	3
12.5	0.25	0.79	26	20	255	4
13.5	0.26	0.79	14	11	163	3
14.5	0.28	0.79	33	26	303	4
15.5	0.30	0.79	25	20	248	3
16.5	0.32	0.79	28	22	269	4
17.5	0.34	0.79	35	28	316	4
18.5	0.36	0.79	36	28	322	4
19.5	0.38	0.79	29	23	276	3
20.5	0.40	0.79	37	29	329	4
21.5	0.42	0.79	18	14	196	2
22.5	0.44	0.79	42	33	360	4
23.5	0.46	0.79				
24.5	0.48	0.79	42	33	360	4
25.5	0.50	0.79	43	34	366	4
26.5	0.52	0.79	45	35	378	4
27.5	0.54	0.79	53	42	426	4
28.5	0.56	0.79	56	44	443	4
29.5	0.58	0.79	46	36	384	3
30.5	0.60	0.79				



2.3 Bulk density

Bulk density test was conducted to obtain overburden stresses within a soil mass required for evaluations of the unit weight or mass density of the various strata. Bulk density for the undisturbed samples were determined using drive tubes as per American Society for Testing and Materials (ASTM) D 2937 at 6 point on boreholes between ground surface and 30m depth. The unit bulk density of this project area soil is varies between 1.81 and 2.01 Mg/m^3. This shows the insitu soil is highly compacted due to the previous construction.

2.4 Laboratory Investigations

Samples from the exploration works were labelled, protected and taken to the laboratory with the aim of carrying out tests as per American Society for Testing and Materials (ASTM) D 4220. All undisturbed samples were collected as per Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes (ASTM) D 1587. The testing was scheduled by Tec lab limited and Comat lab limited. The following lab tests have been carried out on samples taken from the different boreholes and test pits:

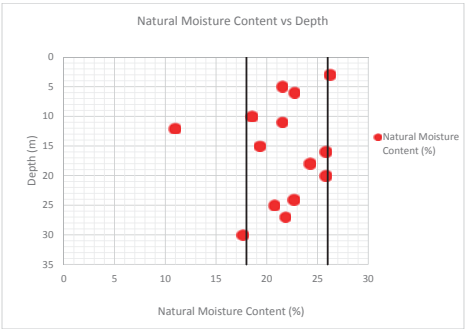
- Moisture content
- Liquid limit
- Plastic limit & plasticity index
- Linear shrinkage
- Particle density determination/Specific Gravity Test
- Particle size distribution
- Unconfined compression
- Consolidation test-Oedometer/Undisturbed
- Triaxial test/Undisturbed (i.e. Unconsolidated Undrained (UU) Test)
- pH value
- Chemical test (sulphates and chlorides)

2.5 Index Properties

2.5.1 Moisture content

Moisture content test was conducted to determine the amount of water present in a quantity of soil in terms of its dry weight and to provide general correlations with strength, settlement, workability and other properties. The moisture content test was conducted on 15 samples collected from borehole (i.e. both disturbed and undisturbed) as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 4959. The test result is presented in Figure 2.1 and Appendix 7 with respect to depth. The water content test result shows the natural water content of the insitu soil is almost uniform along the depth of borehole. Generally, the natural moisture content of the insitu soil varied between 18 and 26 % from 30mBGL to ground level respectively.

Figure 2. 1: Natural Moisture Content vs Depth



2.5.2 Atterberg Limits

To describe the consistency and plasticity of fine-grained soils with varying degrees of moisture, liquid limit and plastic limit tests were conducted on a borehole as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 4318. A total of 30 atterberg limit tests were conducted (i.e. 15 liquid limit and 15 plastic limit). The test result is presented in Figure 2.2 and Appendix 4. As indicated in Figure 2.2 most of the insitu soil from ground surface up to 11m delineated above A-line and there plastic index is greater than 15%. This implies that this layer comprises of soil stiff clay soil. Most plasticity chart value for depth between 11 and 30m is delineated below A-line and this implies that the insitu soil between depth of 11 and 30m is silt.

In addition to the above mentioned Atterberg limit tests a shrinkage limit tests were conducted on 3 samples collected from borehole between a depth of 0 and 10m. Those shrinkage limit tests were conducted as per Standard Test Methods for American Society for Testing and Materials (ASTM D) 427 and D 4943. The test result for shrinkage limit tests is presented in Figure 2.3 and appendix 4. All Shrinkage limit test results are less than 15 percent, this indicates as the Kaolinite clay mineral is dominant or high in insitu soil and the project area is not prone to swelling or expansive soil.

Figure 2. 2: Plasticity Chart

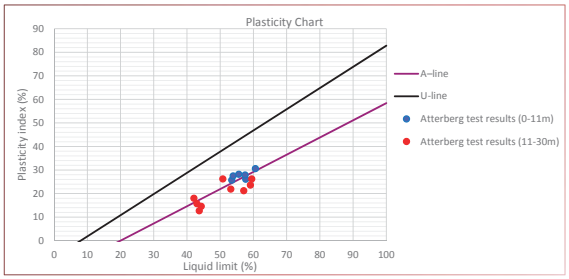
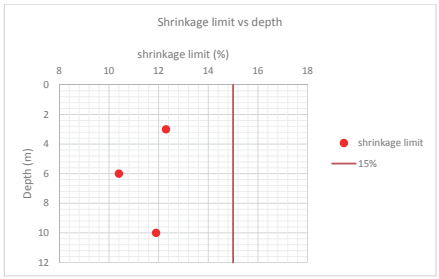


Figure 2. 3: Shrinkage limit vs Depth



2.5.3 Particle density /Specific Gravity

To determine the specific gravity of the soil grains a total of six specific gravity test was conducted as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 854. The test result from specific gravity test summarized as below:

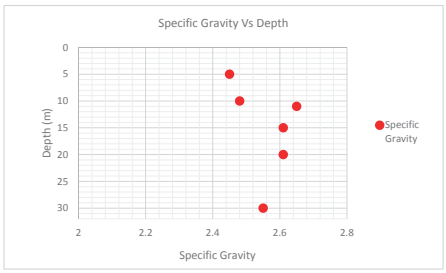
- The specific gravity of the top layer soil from ground surface up to a depth of 10m is almost constant and varies between 2.45 and 2.48. This implies that the insitu soil parent material and

degree of weathering is the same. In addition, it indicates that the parent material of the insitu soil is loose material.

- The specific gravity of the top layer soil from ground surface up to a depth of 10m is almost the same and varies between 2.55 and 2.65. This shows as the insitu soil parent material and degree of weathering is the same. In addition, it shows as the parent material of the insitu soil is loose material. The average specific gravity for the second layer between 10 and 30m is 2.60.
- The difference in specific gravity of the above mentioned two layer happens due to degree of weathering in parent material.

The test result are presented in Figure 2.4 and Appendix 6.

Figure 2. 4: Specific gravity vs depth



2.5.4 Particle size distribution

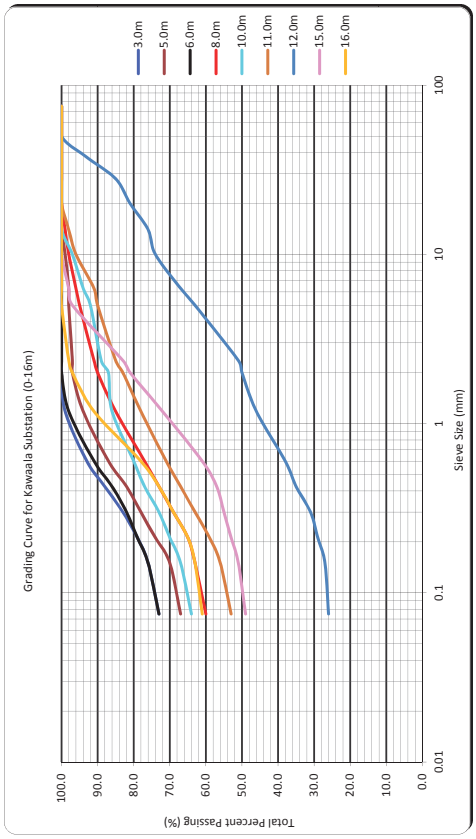
To determine the percentage of various grain sizes, sieve analysis tests were conducted. Results from grain size distribution were used to determine the textural classification of soils (i.e. gravel, sand, silt, and clay) which in turn is useful in evaluating the engineering characteristics such as permeability, strength, and swelling potential. A total of 15 sieve analysis tests were conducted as per Standard Test Methods for American Society for Testing and Materials per (ASTM) D 422. The test result presented on appendix 4 and Figure 2.5 & 2.6.

From texture classification given in Appendix 4 and Figure 2.5 & 2.6, the engineering characteristics such

as permeability, strength, and swelling potential are evaluated as below;

- The first layer from ground surface up to a depth of 11m is impervious when compacted, poor shearing strength when compacted and saturated, high compressibility when compacted and saturated. This implies poor workability as a construction material, and poor relative desirability for foundation.
- The second layer from 11 up to a depth of 15m is impervious when compacted, fair shearing strength when compacted and saturated, low compressibility when compacted and saturated. It implies good workability as a construction material, and good relative desirability for foundation.
- The third layer from 15 up to a depth of 20m is semipervious when compacted, fair shearing strength when compacted and saturated, high compressibility when compacted and saturated. This implies poor workability as a construction material and poor relative desirability for foundation.
- The fourth layer from 20 up to a depth of 25m is semipervious when compacted, fair shearing strength when compacted and saturated, medium compressibility when compacted and saturated. This implies fair workability as a construction material, and fair relative desirability for foundation.
- The fifth layer from 27 up to a depth of 30m is impervious when compacted, fair shearing strength when compacted and saturated, low compressibility when compacted and saturated. This implies good workability as a construction material, and good relative desirability for foundation.

Figure 2. 5: Particle Size Distribution curve 16-30m



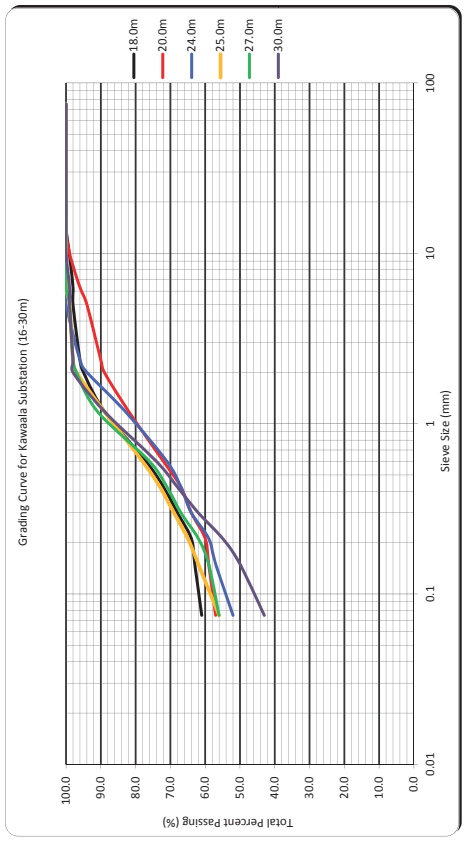


Figure 2. 6: Particle Size Distribution curve 16-30m

2.5.5 Corrosivity of soils

To determine the aggressiveness and corrosivity of soils, pH, sulphate and chloride content of soils tests were conducted. A total of 15 aggressiveness and corrosivity tests were conducted as per Standard Test Methods for American Society for Testing and Materials (ASTM) G 51 and D 4327. The test result is presented in table 2.2 and Appendix 5. The aggressiveness and corrosivity of soils test result is summarized as below:

- The PH is slightly acidic with a value between 6.6 and 6.9, this associated with insignificant corrosion rates and using metallic reinforcements is possible.
- The chlorides content test result value varies between 440 and 730 ppm, this associated with significant corrosion rates.
- The sulphate content test result value varies between 6100 and 21400 ppm, this associated with significant corrosion rates.

Generally, Kawaala substation foundation soil is prone to corrosion. This tends to reduction in life time of the foundation structure. In order to avoid this problem, it is recommended that stainless steel be used to provide reinforcement for foundation structure or provide appropriate foundation cover to avoid the ingress of chlorides and sulphates. Stainless steel reinforcement does not rely on concrete for its corrosion protection and is a straightforward solution when concrete is subject to the ingress of chlorides. Stainless rebar is also used for long design life structures and when equipment is sensitive to magnetic fields and needs non-magnetic reinforcement.

Table 2. 2: Aggressiveness and corrosivity test result

Borehole No.	Depth (m)	PH	Chlorides (%)	Sulphates (%)
BH 1	5	6.6	0.073	0.61
	10	6.8	0.061	1.32
	15	6.9	0.061	1.77
	20	6.9	0.044	2.14

2.6 Strength Tests

2.6.1 Triaxial Strength

To determine the strength characteristics of soils including detailed information on the effects of lateral confinement, pore water pressure and drainage, unconsolidated undrained triaxial tests were conducted on undisturbed samples. The conducted triaxial tests further used to determine a friction angle of clays &

silts and the stiffness (modulus).

A total of 6 triaxial tests were conducted as per as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 2850, and D 4767. The undrained shear strength parameter angle of internal friction (degrees) for this specific project varies between 9 to 19°, the minimum cohesion is 8kPa at 20m depth, and the maximum cohesion is 76kPa at 10mBGL.

The computations of the Undrained triaxial test parameters (un-drained cohesion and angle of internal friction) are presented in Appendix 9. Table 2.3 below shows the summary of the undrained unconsolidated triaxial test results.

Table 2. 3: Summary of the undrained triaxial test results

Bore Hole No.	Bulk Density (Kg/m^3)	Cohesion (C) (kPa)	Angle of Internal Friction (Φ) (deg)
BH01 (5.0m)	1903	53	19
BH01 (10.0m)	1980	76	11
BH01 (15.0m)	1810	14	8.9
BH01 (20.0m)	1841	8	14.2
BH01 (25.0m)	1851	22	13.1
BH01 (30.0m)	1893	25	12.6

Furthermore, the undrained shear strength (su) and the undrained elastic moduli (Eu) are obtained from a UU test. The calculated value shows the average undrained elastic moduli (Eu) is $40MPa^{-1}$ from ground surface up to 5m depth and $70MPa^{-1}$ for depth below 5m.

2.6.2 Unconfined Compressive Strength

To determine the undrained shear strength of the insitu soil a total of 5 Unconfined Compressive Strength of Soils tests were conducted as pre Standard Test Methods for American Society for Testing and Materials (ASTM) D 2166.

The UCS ranged from 21 to 108kPa. The computations of the unconfined compressive strength test parameters are presented in Appendix 10. Table 2.4 shows the summary of the unconfined compressive strength test results.

Table 2. 4: Summary of the unconfined compressive triaxial test results

Bore Hole No.	Bulk Density (Kg/m^3)	Unconfined compressive strength (kpa)	Undrained cohesion (kpa)
BH01 (5.0m)	1903.0	47	24
BH01 (10.0m)	1903.0	21	10
BH01 (11.0m)	1969.6	108	54
BH01 (15.0m)	1972.7	85.3	42.7
BH01 (20.0m)	1856.9	65	33

2.6.3 **Consolidation**

Compression properties of the project area soil were determined using laboratory test result. The result from this test was used to determine preconsolidation stress, compression characteristics, creep, stiffness, and flow rate properties of soils under loading.

To determine those properties of the soil One-Dimensional Consolidation (Oedometer test) using incremental loading was conducted as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 2435. A total of 6 representative One-Dimensional Consolidation (Oedometer test) were conducted.

The summary of Oedometer test result is given in Table 2.5 and Appendix 8. The test result shows the average compression index (Cc), coefficient of volume compressibility (M_v), and Coefficient of consolidation is 0.20, $0.89MN/m^2$, and $6.36m^3$/year respectively from ground surface up to 5m and 0.2, $0.5 MN/m^2$, and $9.1m^3$/year respectively for depth below 5 up to 11m. From 11m up to 30m the insitu soil was not subjected to consolidation settlement.

Table 2. 5: Consolidation test result summary

Sample Source	Depth(m)	Pre-Consolidation pressure (kN/m²)	Overburden Pressure (kN/m²)	Compression Index, Cc	Coefficient of Compressibility mv (MN/m²)		Volume	Coefficient of Consolidation Cv (m²/yr)			Permeability, k (m/s) x10⁻⁹		
					Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
BH 1	5	150	92.2	0.195	0.072	4.057	0.8934	3.148	11.496	6.36	7E-11	1.5E-09	2.83E-09
	10	180	172.1	0.201	0.070	1.846	0.502	3.336	13.5	9.04	7.78E-11	6.5E-09	1.67E-09
	15		276.6	0.036	0.020	0.16	0.074	10.18	48.71	26.37	1.12E-09	2.29E-09	9.25E-10
	20		368.8	0.029	0.016	0.16	0.07	8.440	25.58	15.59	4.2E-09	1.12E-09	4.88E-10
	30		553.2	0.037	0.030	0.098	0.053	6.420	17.49	11.07	8.76E-11	1.97E-10	1.5E-10

2.6.4 Settlement analysis

Soils have a tendency to settle under loads, causing subsidence of structures founded on or within them. If the settlement is not kept to a tolerable limit, the desired use of the structure may be impaired and the design life of the structure may be reduced. Taking into account the above principle, uniform and nonuniform (differential) settlement are among the important parameters to be determined during settlement analysis.

For this specific project, results of the One-Dimensional Consolidation (Oedometer test) tests were considered as uniform over the project area. This means effect of nonuniform (differential) consolidation or settlement is insignificant for this specific project.

Settlement analysis is governed by composition of immediate or elastic compression, primary consolidation, and secondary compression. Settlement analysis included in this report includes all the above mentioned types of settlement (i.e. Immediate or elastic compression settlement, primary consolidation settlement, and secondary consolidation settlement).

The calculated immediate or elastic compression and primary consolidation settlement in this report considers a constant interval vertical stress due to superstructure (i.e. 20 kPa interval vertical stress increase from 20 to 200kPa). The exact settlement due to vertical stress increase from the building and other structures over the embankment fill or insitu soil is calculated or determined simultaneously with the foundation design. This is because, the settlement due to those additional vertical stress over fill embankment or insitu soil is affected by type, shape, size, and depth of embedment of the foundation, and soil stiffness. This settlement analysis result is for general guide.

All the settlement analysis parameters determined or calculated from One-Dimensional Consolidation (Oedometer test) test result are summarized in Table 2.5. The immediate or elastic compression settlement result was calculated using elastic displacement theory. Primary consolidation and secondary compression results are calculated using one dimensional consolidation settlement analysis. The total settlement for long term is the summation of immediate or elastic, primary consolidation, and secondary compression. Finally the total result is compared with Serviceability Limit States. The calculated settlement analysis for immediate or elastic compression settlement, primary consolidation settlement, secondary consolidation settlement, and total vertical settlement is given in Figure 2.7.

During settlement analyses, a constant average undrained elastic moduli (Eu), average coefficient of volume compressibility (m_v), and average secondary compression index are used for the entire depth of the soil profile. A total of 11m thick clay layer is considered for the analysis. From one dimensional consolidation analysis, the primary consolidation settlement takes place in the first one year and nine months (21 months). Secondary consolidation settlement take places after primary consolidation settlement. During secondary settlement analysis two scenarios are considered:

1. The first scenario is the project design period is 25 years
2. The second scenario is the project design period is 50 years.

Parameters used for analyses from One-Dimensional Consolidation (Oedometer test) test result are summarized as below:

- Average undrained elastic moduli is 40000kPa;
- Average coefficient of volume compressibility (m_v) is 0.25 MN/m^2;
- Average secondary compression index is 0.006;
- Average compression index (Cc) is 0.20;
- Average Coefficient of Consolidation 7.6m^2/year;and
- Total thickness of clay layer is 11m.

Results from the analysis are summarized as below:

- Primary consolidation settlement take place in the first one years and nine months after embankment fill is constructed;
- Primary consolidation settlement at 200kpa is approximately 247.5mm;
- Immediate or elastic compression at 200kpa is approximately 34mm;
- Secondary consolidation settlement at 200kPa, if the project design period is 25 years is approximately 38.5mm;
- Secondary consolidation settlement at 200kPa, if the project design period is 50 years is approximately 48.5mm;
- Total vertical settlement at 200kPa, if the project design period is 25 years is approximately 320mm;and
- Total vertical settlement at 200kPa, if the project design period is 50 years is approximately 330mm.

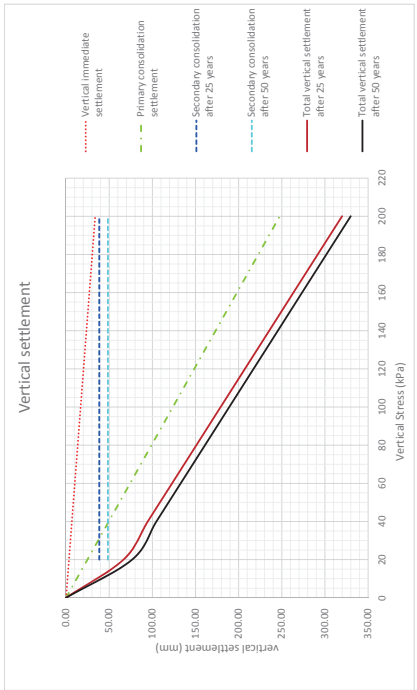


Figure 2. 7: Vertical settlement due to vertical stress increase

3 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

Geological and geotechnical assessment at the Kawaala substation site was essential for obtaining fundamental information in terms of foundation conditions. This information was obtained from a borehole drilling as well as onsite surveys and laboratory testing. All soil investigation test were conducted in accordance with American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. The following conclusions were reached;

1. The project area of Kawaala substation has not experienced any earthquakes over years. This project area lies in zone 3 which is the least seismically active zone in Uganda. Therefore the risk of damage by earthquakes is low. An overview of the geological conditions indicate that apart from the regional seismicity, no major geological hazards and constraints such as unstable slopes, thick deposits of weak soils, land ground subsidence and collapse are identified in the area.
2. The site is underlain by rocks composed of Kampala granitoids which are rocks predominantly composed of feldspar and quartz and orthogneiss (A_3KAgr) of complex formation comprising sedimentary, metamorphic and volcanic rocks.
3. Basing on the standard penetration value (N_{60}) and unconfined shear strength result, the insitu soil comprises of soft to medium consistency clay soil from groundlevel to a depth of 6m, underlain by stiff consistency clay soil up to a depth of 10m, overlying very stiff consistency clay soil up to a depth of 22m, underlain by hard consistency clay soil up to a depth of 30m.
4. Groundwater was not encountered during the field investigations.
5. The laboratory investigation confirmed that the geological sequence at the site generally comprises of a moderate reddish brown imported fill sandy fat gravel from the ground surface to a depth of 2m, followed by homogenous reddish brown sandy fat clay up to a depth of 11m, followed by homogenous yellowish orange coarse grained clayey sand up to a depth of 15m, followed by homogenous yellowish orange sandy silt up to a depth of 27.5m, and followed by highly weathered pink greenish grey weak rock up to a depth of 30.5m. The stratigraphy indicates that the soil is a product of completely weathered rock which is in form of residual clay.
6. Generally, the natural moisture content of the insitu soil varied between 18 and 26 % from 30mBGL to ground level respectively.
7. All shrinkage limit test results are less than 15 percent, this indicates as the Kaolinite clay mineral is dominant or high in insitu soil and the project area is not prone to swelling or expansive soil.

8. The unit bulk density of the insitu soil varies between 1.81 and 2.01 Mg/m^3. This shows the insitu soil is highly compacted due to the previous construction.
9. Generally, Kawaala substation foundation soil is prone to corrosion.
10. The undrained shear strength parameter angle of internal friction (degrees) for this specific project varies between 9 to 19° on the otherhand, the cohesion ranged between 8 to 76kPa.
11. Undrained elastic moduli (Eu) are obtained from a UU test. The calculated value shows the average undrained elastic moduli (Eu) is 40MPa^{-1} from ground surface up to 5m depth and 70MPa^{-1} for depth below 5m.
12. The unconfined compressive strength ranged from 21 to 108kPa.
13. The insitu soil is highly compressible and poor to facilitate drainage. The test result shows the average compression index (Cc), coefficient of volume compressibility (M_v), and Coefficient of consolidation is 0.20, 0.89MN/m^2, and 6.36m^3/year respectively from ground surface up to 5m and 0.2, 0.5 MN/m^2, and 9.1m^3/year respectively for depth below 5 up to 11m. From 11m up to 30m the insitu soil is not subjected to consolidation settlement.
14. Basing on the index properties and its classification, the insitu soil is rated from poor to good desirability for foundation, the quality improvement is directly proportional to the depth from ground level. This observation is consistent with the engineering properties of the soil.

3.2 Recommendations

1. The design of the proposed foundations shall take into account the poor ground conditions to ensure that the risk of failure is minimised.
2. Stainless steel be used to provide reinforcement for foundation structure or provide appropriate concrete cover to the foundation to avoid the ingress of chlorides and sulphates.

4 REFERENCES

1. AMERICAN SOCIETY FOR TESTING AND MATERIALS: Annual Book of ASTM international Standards. 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, United States.

- D 420 Standard Guide to Site Characterization for Engineering Design and Construction Purposes
- D 421 Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
- D 427 Standard Test Method for Shrinkage Factors of Soils by the Mercury Method
- D 422 Test Method for Particle-Size Analysis of Soils
- D 512 Standard Test Methods for Chloride Ion In Water
- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 1586 Test Method for Penetration Test and Split-Barre Sampling of Soils
- D 2113 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
- D 2434 Standard Test Method for Permeability of Granular Soils (Constant Head)
- D 2435 Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading
- D 2487 Classification of Soils for Engineering Purposes
- D 2216 Test Method for Laboratory Determination of Water Moisture) Content of Soil and Rock (Unified Soil Classification System).
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
- D 2850 Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
- D 3740 Practice for Minimum Requirements of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction Plasticity Index of Soils
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- D 4750 Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
- D 4767 Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils
- D 4943 Standard Test Method for Shrinkage Factors of Soils by the Wax Method
- G 51 Test Method for pH of Soil for Use in Corrosion Testing

2. VICKERS, BRIAN (1978); Laboratory work in Civil Engineering Soil Mechanics. Granada Publishers, London.

3. Bowles Joseph E; Foundation Analysis and Design, Second Edition. McGraw Hill Companies, Tokyo, 1997.
4. G.E Barney; Principles and Practice of Soil Mechanics, First Edition. Macmillan Press Ltd, London, 1995
5. Department of US Army Corps of Engineers, CECW-EG Engineer Manual 1110-1-1904 Engineering and Design of SETTLEMENT ANALYSIS, Washington, DC 20314-1000, 1990.
6. MJ Tomlinson; Foundation Design & Construction, Sixth Edition. Addison Wesley Longman Limited, Edinburgh Gate, Harlow Essex CM20 2JE, 1998.
7. Simplified geological map of Uganda (Extracts from the Africa Mining Journal Ltd 2000)
8. R.F.Craig. E & FN Spon, 2004. CRAIG'S SOIL MECHANICS. Seventh Edition, London.

5 APPENDIX

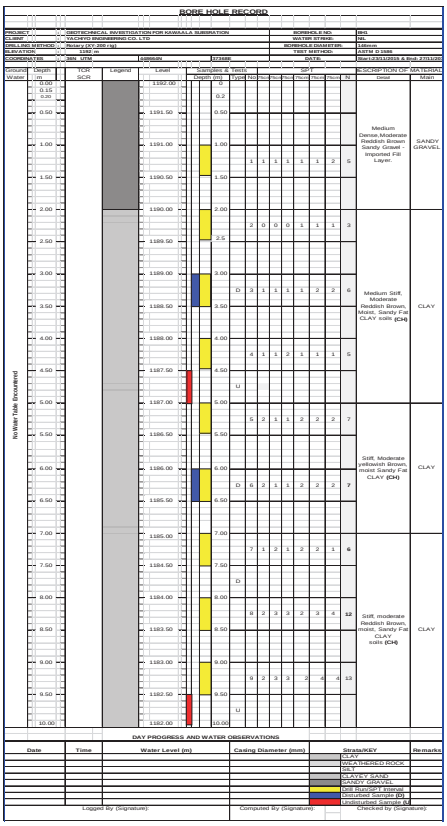
Appendix 1: SPT result

EVALUATION OF ALLOWABLE BEARING CAPACITY BASED ON FIELD SPT 'N' VALUES

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH01	0.00	Moderate Reddish Brown imported fill Sandy Fat Gravel	0	0.00	0	0	0	0
	1.50		5	0.59	3	63	325	108
	2.50	Reddish Brown Sandy Fat Clay	3	0.59	2	44	225	75
	3.50		6	0.59	4	72	371	124
	4.50		5	0.67	3	69	356	119
	5.50		7	0.67	5	88	453	151
	6.50		7	0.75	5	96	491	164
	7.50		6	0.75	4	85	439	146
	8.50		12	0.75	9	141	724	241
	9.50		13	0.75	10	149	767	256
	10.50		17	0.75	13	181	930	310
	11.50	Yellowish Orange coarse grained Clayey Sandy	12	0.79	9	146	751	250
	12.50		26	0.79	20	255	1311	437
	13.50		14	0.79	11	163	839	280
	14.50		33	0.79	26	303	1556	519
	15.50	Yellowish Orange Sandy Silt	25	0.79	20	248	1274	425
	16.50		28	0.79	22	269	1382	461
	17.50		35	0.79	28	316	1623	541
	18.50		36	0.79	28	322	1657	552
	19.50		29	0.79	23	276	1418	473
	20.50		37	0.79	29	329	1690	563
	21.50		18	0.79	14	196	1006	335
	22.50		42	0.79	33	360	1851	617
	23.50		Refusal	0.79	_	>450	>2300	>750
	24.50		42	0.79	33	360	1851	617
	25.50		43	0.79	34	366	1883	628
	26.50		45	0.79	35	378	1945	648
	27.50		53	0.79	42	426	2188	729
	28.50	Sandy Clay highly weathered Pink Greenish Grey weak rock	56	0.79	44	443	2277	759
	29.50		46	0.79	36	384	1976	659
	30.50		Refusal	0.79	_	>450	>2300	>750

*The undrained shear strength (cu) of the soil is determined using the corrected standard penetration values (N_{60}) as per Hara et al. (1971) and Peck et al. (1974) empirical relationship respectively.Cu = Pa*0.29*N60^0.72, where Pa is Atmospheric presure and qult = 5.14 x Cu. Qall is evaluated usingg factor of safety of 3*

Appendix 2: Borehole record



BORE HOLE RECORD

PROJECT :	GEOTECHNICAL INVESTIGATION FOR KAWAALA SUBSRATION	BOREHOLE NO:	BH1
CLIENT :	YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	NIL
DRILLING METHOD :	Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION :	1192 m	TEST METHOD:	ASTM D 1586
COORDINATES :	36N UTM 448664N 37368E	DATE:	Start:23/11/2015 & End: 27/11/20

Ground Water: No Water Table Encountered

Depth m	Level	Samples & Tests Depth (m)	Type	No	75cm	75cm	75cm	75cm	75cm	75cm	N
10.00	1182.00	10.00	D	10	3	3	3	4	5	5	17
10.50	1181.50	10.50									
11.00	1181.00	11.00		11	2	2	3	3	3	3	12
11.50	1180.50	11.50									
12.00	1180.00	12.00	D	12	5	5	6	7	6	7	26
12.50	1179.50	12.50									
13.00	1179.00	13.00		13	4	4	2	3	4	5	14
13.50	1178.50	13.50									
14.00	1178.00	14.00		14	7	7	7	7	9	10	33
14.50	1177.50	14.50	U								
15.00	1177.00	15.00	D	15	3	4	5	6	7	7	25
15.50	1176.50	15.50									
16.00	1176.00	16.00	D	16	3	4	5	6	8	9	28
16.50	1175.50	16.50									
17.00	1175.00	17.00		17	3	4	6	6	11	12	35
17.50	1174.50	17.50									
18.00	1174.00	18.00	D	18	4	5	7	8	10	11	36
18.50	1173.50	18.50									
19.00	1173.00	19.00		19	4	4	6	7	8	8	29
19.50	1172.50	19.50	U								
20.00	1172.00	20.00									

Depth (m)	Description of Material – Detail	Main
10.00–11.00	Stiff, moderate Reddish Brown, moist, Sandy Fat CLAY soils (CH)	CLAY
11.00–12.50	Medium Dense,Moderate Reddish Brown, coarse grained clayey SAND soils. **(SC)**	CLAYEY SAND
12.50–13.50	Medium Dense,Dark Yellowish Orange, coarse grained clayey SAND with Gravel soils.	CLAYEY SAND
13.50–15.00	Medium Dense, Moderate Yellow, Coarse grained Clayey SAND with cobbles soils **(SC)**	CLAYEY SAND
15.00–18.50	Very Stiff, Moderate Orange Pink, Moist Sandy Elastic SILT soil. **(MH)**	SILT
18.50–19.50	Very Stiff, Mottled Moderate Yellow, sandy Elastic SILT soil. **(MH)**	SILT
19.50–20.00	Hard, Mottled Moderate yellow, Sandy Elastic SILT soil. **(MH)**	SILT

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
				CLAY	
				WEATHERED ROCK	
				SILT	
				CLAYEY SAND	
				SANDY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U)**	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

BORE HOLE RECORD

PROJECT :	GEOTECHNICAL INVESTIGATION FOR KAWAALA SUBSRATION	BOREHOLE NO:	BH1
CLIENT :	YACHIYO ENGINEERING CO. LTD	WATER STRIKE:	NIL
DRILLING METHOD :	Rotary (XY-200 rig)	BOREHOLE DIAMETER:	146mm
ELEVATION :	1192 m	TEST METHOD:	ASTM D 1586
COORDINATES :	36N UTM 448664N 37368E	DATE:	Start:23/11/2015 & End: 27/11/2

Ground Water: No Water Table Encountered

Depth m	Level	Samples & Tests Depth (m)	Type	No	75cm	75cm	75cm	75cm	75cm	75cm	N
20.00	1172.00	20.00		20	3	4	6	7	12	12	37
20.50	1171.50 1171.50	20.50 20.50									
21.00	1171.00	21.00		21	3	4	3	4	5	6	18
21.50	1170.50	21.50									
22.00	1170.00	22.00		22	4	5	9	9	12	12	42
22.50	1169.50	22.50									
23.00	1169.00	23.00		23	#	#	#	#	#	#	R
23.50	1168.50	23.50									
24.00	1168.00	24.00	D	24	4	5	9	9	12	12	42
24.50	1167.50	24.50	U								
25.00	1167.00	25.00		25	4	4	8	9	13	13	43
25.50	1166.50	25.50									
26.00	1166.00	26.00		26	4	5	9	10	13	13	45
26.50	1165.50	26.50									
27.00	1165.00	27.00	D	27	5	6	10	11	16	16	53
27.50	1164.50	27.50									
28.00	1164.00	28.00		28	6	6	10	11	17	18	56
28.50	1163.50	28.50									
29.00	1163.00	29.00		29	5	6	9	9	14	14	46
29.50	1162.50	29.50	U&D								
30.00	1162.00	30.00		30	#	#	#	#	#	#	R
30.50	1161.50	30.50									

Depth (m)	Description of Material – Detail	Main
20.00–21.00	Hard, Mottled Moderate yellow, Sandy Elastic SILT soil. **(MH)**	SILT
21.00–22.50	Hard, Mottled Yellowish Grey, moist Sandy SILT soil. **(ML)**	SILT
22.50–24.50	Hard, Mottled Dark Yellowish Grey, Moist Sandy SILT soil. **(MH)**	SILT
24.50–26.00	HHard,Pale Yellowish Orange, Moist Sandy SILT soil. **(MH)**	SILT
26.00–27.50	Hard, Yellowish Grey, moist Sandy SILT soil and Residual Rock Material.	SILT
27.50–30.50	Highly Weathered, Pink, Greenish Grey, weak Rock material and Clayey SAND Soil infill **(SC)**	WEATHERED ROCK

DAY PROGRESS AND WATER OBSERVATIONS

Date	Time	Water Level (m)	Casing Diameter (mm)	Strata/KEY	Remarks
				CLAY	
				WEATHERED ROCK	
				SILT	
				CLAYEY SAND	
				SANDY GRAVEL	
				Drill Run/SPT Interval	
				Disturbed Sample **(D)**	
				Undisturbed Sample **(U**	

Logged By (Signature): Computed By (Signature): Checked by (Signature):

Appendix 3: Drilling pictorial Logs

Medium Dense, Moderate Reddish Brown Sandy Gravel, Imported Fill Layer from surface up to 1.5m

Moist dark reddish brown soft homogeneous silty sandy CLAY drilled from BH1 at a depth of 2.0-2.5 m

Moist reddish yellowish brown soft homogeneous silty sandy CLAY drilled from BH1 at a depth of 3.0-3.5 m

Moist reddish yellowish brown soft homogeneous silty sandy CLAY drilled from BH1 at a depth of 4.0-4.5 m

Moist reddish yellowish brown soft homogeneous silty sandy CLAY drilled from BH1 at a depth of 5.0-5.5 m

Moist reddish yellowish brown soft homogeneous silty sandy CLAY drilled from BH1 at a depth of 6.0-6.5 m

Moist reddish yellowish brown soft homogeneous silty sandy CLAY drilled from BH1 at a depth of 7.0-7.5 m

Moist reddish yellowish brown soft homogeneous silty sandy CLAY drilled from BH1 at a depth of 8.0-8.5 m

Moist reddish brown stiff homogeneous silty sandy CLAY drilled from BH1 at a depth of 9.0-9.5 m

Moist reddish brown stiff homogeneous silty sandy CLAY drilled from BH1 at a depth of 10.0-10.5 m

Stiff, Moderate Reddish Brown, moist, Sandy Fat CLAY drilled from BH1 at a depth of 11-11.5 m

Medium Dense,Moderate Reddish Brown, coarse grained clayey SAND soils drilled from BH1 at a depth of 12-12.5 m

Medium Dense, Moderate Yellow, Coarse grained Clayey SAND with cobbles soils drilled from BH1 at a depth of 14-14.5 m

Very Stiff, Moderate Orange Pink, moist, Sandy Elastic SILT soil drilled from BH1 at a depth of 15.0-15.5 m

Very Stiff, Mottled Moderate Yellow, sandy Elastic SILT soils drilled from BH1 at a depth of 19-19.5 m

Hard, Moderate Yellow, moist, Sandy Elastic SILT soils drilled from BH1 at a depth of 20-20.5 m

Hard, Mottled Yellowish Grey, moist Sandy SILT soils drilled from BH1 at a depth of 22-22.5 m

Hard, Mottled Dark Yellowish Grey, Moist Sandy SILT soil drilled from BH1 at a depth of 24.0-24.5 m

Hard, Yellowish Grey, moist Sandy SILT soil and Residual Rock Materialdrilled from BH1 at a depth of 26-26.5 m

Hard, Yellowish Grey, moist Sandy SILT and Residual Rock material drilled from BH1 at a depth of 27-27.5 m

Highly weathered, Pink, Greenish Grey, Coarse grained Weak Rock drilled from BH1 at a depth of 28-28.5 m

Highly weathered, layered, Pink, Greenish Grey, Weak ROCK and Clayey SAND infill soil drilled from BH1 at a depth of 29.0-29.5 m

Packed and sealed Un disturbed soil samples retrieved at 15.0m depth for the
Triaxial and consolidation tests from BH1 at a depth of 15-15.5 m

Retrieved Soil samples between 1.0m depth and 6.0m depth. Imported soil layers between 1.0m and 2.5m depth was of Moderate Reddish Brown Clayey SAND soils with Gravel.

Photographs	Description of each photograph
	A team of technicians using the GY – 200 drilling Rig for Boring of Borehole BH -1 on the southern side of the site near the existing Switch yard.
	Retrieved Soil samples between 1.0m depth and 6.0m depth. Imported soil layers between 1.0m and 2.5m depth was of Moderate Reddish Brown Clayey SAND soils with Gravel.
	The natural Ground encountered between 2.0m and 11.0m depth has soil layers of medium stiff to Stiff, Moderate Reddish Brown, moist, Sandy Fat CLAY soils

Photographs	Description of each photograph
	A team of technicians Conducting the Standard Penetration Test (SPTs) at 11.0m depth.
	Samples retrieved from the Borehole between 11.0m and 15.0m. Medium Dense, Coarse grained Clayey SAND soils with deposits of Gravel in the upper layers.
	Samples retrieved from the Borehole between 11.0m and 20.0.0m. Soil samples retrieved between 15.0m and 20.0m were Very Stiff, Sandy Elastic SILT.
Photographs	Description of each photograph

	Samples retrieved from the Borehole between 21.0m and 26.0.0m. Soil samples were Hard, moist Sandy SILT.
	Samples retrieved from the Borehole between 24.0m and 30.0m. Soil samples retrieved between 27 and 30.0m depth were Highly weathered, Pink, Greenish Grey, weak ROCK and Clayey SAND infill soil
	Drilling of the Borehole ongoing up to 30.0m depth.

Appendix 4: Summary of texture classification

SUMMARY FOR CLASSIFICATION TEST RESULTS (TRIAL PITS)

BH No.	Depth (m)	% passing the given standard sieves: 75 mm	50 mm	37.5 mm	28 mm	20 mm	14 mm	10 mm	6.3 mm	5.0 mm	2.36 mm	2.0 mm	1.18 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.150 mm	0.075 mm	GM	PM	PP	GS	Atterberg limits: LL %	PL %	PI %	LS %	Gravel %	Sand %	Silt +Clay %	AASHTO Classification: Class	GI	USCS Classific
BH No.1	3.0m	100	100	100	100	100	100	100	100	100	100	100	99	93	88	83	79	76	73	0.39	2390	1876		53.5	27.8	25.7	12.30	0	27.0	73.0	A-7-6	(19)	CH
	5.0m	100	100	100	100	100	100	99	98	98	97	97	94	87	82	78	74	70	67	0.54	2393	1843	2.45	53.9	26.4	27.5		2	31.0	67.0	A-7-6	(18)	CH
	6.0m	100	100	100	100	100	100	100	100	100	100	100	98	91	86	82	79	76	73	0.41	2785	2234		60.6	30.0	30.6	10.40	0	27.0	73.0	A-7-5	(23)	CH
	8.0m	100	100	100	100	100	99	98	96	95	91	90	85	77	73	69	65	63	60	0.77	2171	1692		55.6	27.4	28.2		5	35.0	60.0	A-7-6	(15)	CH
	10.0m	100	100	100	100	100	100	97	94	92	89	87	86	80	77	73	70	67	64	0.72	2088	1670	2.48	57.7	31.6	26.1	11.90	8	28.0	64.0	A-7-5	(16)	CH
	11.0m	100	100	100	100	100	98	96	91	90	85	83	78	71	67	63	59	56	53	0.97	1981	1479	2.65	57.5	29.6	27.9		10	37.0	53.0	A-7-6	(12)	CH
	12.0m	100	100	93	85	81	76	74	67	63	51	50	46	38	35	31	29	27	26	1.89	996	681		50.8	24.6	26.2		37	37.0	26.0	A-2-7	(0)	SC
	15.0m	100	100	100	100	100	100	100	98	97	83	81	72	61	57	55	53	51	49	1.13	1336	1073	2.61	53.2	31.3	21.9		3	48.0	49.0	A-7-5	(8)	SC
	16.0m	100	100	100	100	100	100	100	100	100	98	97	91	78	73	69	65	63	61	0.69	1841	1440		59.1	35.5	23.6		0	39.0	61.0	A-7-5	(14)	MH
	18.0m	100	100	100	100	100	100	99	98	98	96	95	89	77	72	68	64	63	61	0.72	2017	1598		59.5	33.3	26.2		2	37.0	61.0	A-7-5	(15)	MH
	20.0m	100	100	100	100	100	100	99	96	94	90	89	82	72	67	64	60	59	57	0.87	1526	1208	2.61	57.1	35.9	21.2		6	37.0	57.0	A-7-5	(11)	MH
	24.0m	100	100	100	100	100	100	100	100	100	96	94	83	71	67	64	59	57	52	0.87	1037	759		44.3	29.7	14.6		0	48.0	52.0	A-7-6	(5)	MH
	25.0m	100	100	100	100	100	100	100	100	99	98	97	89	78	73	69	65	62	56	0.74	1225	879		43.0	27.3	15.7		1	43.0	56.0	A-7-6	(7)	MH
	27.0m	100	100	100	100	100	100	100	100	99	98	97	91	76	71	67	62	59	56	0.76	965	711		43.7	31.0	12.7		1	43.0	56.0	A-7-5	(6)	MH
	30.0m	100	100	100	100	100	100	100	99	99	98	98	89	74	68	62	55	50	43	0.91	1332	774	2.55	42.1	24.1	18.0		1	56.0	43.0	A-7-6	(4)	SC

LL: Liquidity Limit; PL: Plastic Limit; PI: Plasticity Index; GM: Grading Modullus; PM: Plasticity Modullus; PP: Plasticity Product; GS: Specific Gravity; LS: Linear shrinkage

Appendix 5: Chemical Test

SOIL PH CONTENT RESULTS REPORT						
Project: Kawaala Substation						
Sampling Date: 01/12/2015 to 03/12/2015						
Site Location: Kawaala Substation						
Testing Date: 15 December, 2015						
Test Method: ASTM G 51						
TEST NO	DEPTH (m)	TRIAL 01	TRIAL 02	AVERAGE PH VALUE	SAMPLE DESCRIPTION	REMARKS
BH01	5	**6.6**	**6.6**	**6.6**	Stiff, Moderate yellowish Brown, moist Sandy Fat CLAY	Slightly Acidic
	10	**6.86**	**6.7**	**6.8**	Stiff, moderate Reddish Brown, moist, Sandy Fat CLAY soils	Slightly Acidic
	15	**6.94**	**6.91**	**6.9**	Medium Dense, Moderate Yellow, Coarse grained Clayey SAND with cobbles soils	Slightly Acidic
	20	**6.86**	**6.86**	**6.9**	Hard, Mottled Moderate yellow, Sandy Elastic SILT soil.	Slightly Acidic

CHLORIDE CONTENT RESULTS REPORT				
Project: Kawaala Substation				
Sampling Date: 01/12/2015 to 03/12/2015				
Site Location: Kawaala Substation				
Testing Date: 15 December, 2015				
Ref. Test Method: ASTM D 512				
BOREHOLE NO.:	DEPTH (M)	CHLORIDE CONTENT (%)	VISUAL SAMPLE DESCRIPTION	REMARKS
BH - 01	5	**0.073**	Stiff, Moderate yellowish Brown, moist Sandy Fat CLAY	Mild Concentrations of Chlorides
	10	**0.061**	Stiff, moderate Reddish Brown, moist, Sandy Fat CLAY soils	Mild Concentrations of Chlorides
	15	**0.061**	Medium Dense, Moderate Yellow, Coarse grained Clayey SAND with cobbles soils	Mild Concentrations of Chlorides
	20	**0.044**	Hard, Mottled Moderate yellow, Sandy Elastic SILT soil.	Mild Concentrations of Chlorides

SULPHATE CONTENT RESULTS REPORT				
Project: Kawaala Substation				
Sampling Date: 01/12/2015 to 03/12/2015				
Site Location: Kawaala Substation				
Testing Date: 15 December, 2015				
Ref. Test Method: ASTM D 516				
BOREHOLE NO.:	**DEPTH (m)**	**SULPHATE CONTENT (%)**	**VISUAL SAMPLE DESCRIPTION**	**REMARKS**
BH - 01	5	**0.61**	Stiff, Moderate yellowish Brown, moist Sandy Fat CLAY	Moderate Concentrations
	10	**1.32**	Stiff, moderate Reddish Brown, moist, Sandy Fat CLAY soils	Severe Concentrations
	15	**1.77**	Medium Dense, Moderate Yellow, Coarse grained Clayey SAND with cobbles soils	Severe Concentrations
	20	**2.14**	Hard, Mottled Moderate yellow, Sandy Elastic SILT soil.	Very Severe Concentrations

Appendix 6: Specific Gravity

Specific Gravity Test Report										
Project: Kawaala Substation										
Date: 20/12/2015										
Location: Kawaala Substation										
Test Method: ASTM D 854										
Depth (m)		5	10	11		15		20	30	
Pyknometer label		1	2	TS	KB	MA	KN	AK	NM	TS	LG
Mass of bottle +Soil + Water (g)	m_3	185.1	196.1	87.4	85.1	87.5	84.8	86.3	85.4	87.7	84.8
Mass of bottle +Soil + Water (g)	m_2	95.7	102.4	38.0	36.9	37.3	37.1	35.3	38.1	40.4	36.5
Mass of bottle full of water (g)	m_4	159.8	171.4	81.2	78.9	81.3	78.7	80.1	79.3	81.6	78.7
Mass of density bottle (g)	m1	52.9	61.0	28.0	27.0	27.3	27.1	25.2	28.1	30.4	26.4
Mass of soil sample alone (g)	m_2-m_1	42.8	41.4	10.0	9.9	10.0	10.0	10.1	10.0	10.0	10.0
Mass of water in full bottle (g)	m_4-m_1	106.9	110.4	53.2	51.9	54.0	51.6	54.9	51.2	51.2	52.3
Mass of water used (g)	m_3-m_2	89.4	93.7	49.4	48.2	50.2	47.7	51.0	47.4	47.3	48.3
Volume of soil particle(g)	$(m_4-m_1)-(m_3-m_2)$	17.5	16.7	3.8	3.7	3.8	3.9	3.9	3.8	3.9	3.9
Particle Density (specific Gravity)	$GS=[(m_2-m_1)]/[(m_4-m_1)-(m_3-m_2)]$	2.45	2.48	2.63	2.68	2.63	2.59	2.61	2.62	2.55	2.55
Average Particle Density (specific Gravity)		2.45	2.48	2.65		2.61		2.62		2.55	

Appendix 7: Natural moisture content

Depth (m)	3	5	6	10	11	12	15	16	18	20	24	25	27	30
Natural Moisture Content (%)	26.2	22	22.7	19	21.5	10.9	19.3	25.8	24.2	25.8	22.6	20.7	22	17.6

Appendix 8: One-Dimensional Consolidation (Oedometer test)

Consolidation test – calculations

Project : Kawaala Substation | Job ref. | | Borehole No.: **BH01** | Sample No. **1** | Depth 5m | Date 10/12/2015

Soil description :

Test method: ASTM D 2435

Machine no. | Specimen diameter: **75** mm | Height H_s 20 mm

Cell no.3 | Height of solids H_s 12.19674141

Ring no.3 | Initial voids ratio e_o 0.639782244

Increment no.	Pressure P kPa	Cumulative compression (DH) mm	Consolidated height H=H_o-(DH)	$e=\frac{H-H_s}{H_s}$ Voids ratio	Incremental: Height change dH mm	Incremental: Pressure change dP kPa	$m_v=\frac{\delta H}{H_1}\cdot\frac{1000}{\delta P}$ m^2/MN	$\overline{H}=\frac{H_1+H_2}{2}$	$c_v=\frac{0.111\overline{H}^2}{t_{90}}$ m^2/year	Permeability $k_w=c_v\rho_w g m_v$ m/sec
0	0	0	20	0.640	0	0	-	-	-	
1	20	0.874	19.126	0.568	0.874	20	2.285	19.563	-	
2	40	1.501	18.499	0.517	1.501	20	4.057	18.8125	11.50	1.4513E-08
3	80	1.839	18.161	0.489	0.338	40	0.465	18.3300	5.57	8.0618E-10
4	160	2.402	17.598	0.443	0.563	80	0.400	17.8795	8.95	1.1134E-09
5	320	3.025	16.975	0.392	0.823	160	0.229	17.2865	5.35	3.8175E-10
6	640	3.736	16.264	0.333	0.711	320	0.137	16.6195	3.68	1.5639E-10
7	1280	4.456	15.544	0.274	0.720	640	0.072	15.9040	3.15	7.0919E-11

Consolidation test – calculations

Project : Kawaala Substation | Job ref. | | Borehole No.: **BH01** | Sample No. **1** | Depth 10m | Date 10/12/2015

Soil description :

Test method: ASTM D 2435

Machine no. | Specimen diameter: **75** mm | Height H_s 20 mm

Cell no.3 | Height of solids H_s 11.74503418

Ring no.3 | Initial voids ratio e_o 0.702847323

Increment no.	Pressure P kPa	Cumulative compression (DH) mm	Consolidated height H=H_o-(DH)	$e=\frac{H-H_s}{H_s}$ Voids ratio	Incremental: Height change dH mm	Incremental: Pressure change dP kPa	$m_v=\frac{\delta H}{H_1}\cdot\frac{1000}{\delta P}$ m^2/MN	$\overline{H}=\frac{H_1+H_2}{2}$	$c_v=\frac{0.11\overline{H}^2}{t_{90}}$ m^2/year	Permeability $k_w=c_v\rho_w g m_v$ m/sec
0	0	0	20	0.703	0	0	-		-	
1	20	0.301	19.699	0.677	0.301	20	0.764	19.8495	-	
2	40	0.712	19.288	0.642	0.712	20	1.846	19.4935	11.97	6.87257E-09
3	80	1.052	18.948	0.613	0.340	40	0.449	19.1180	10.23	1.42756E-09
4	160	1.543	18.457	0.571	0.491	80	0.333	18.7025	5.80	5.99958E-10
5	320	2.092	17.908	0.525	0.549	160	0.192	18.1825	9.26	5.51926E-10
6	640	2.775	17.225	0.467	0.683	320	0.124	17.5665	13.50	5.20382E-10
7	1280	3.510	16.490	0.404	0.735	640	0.070	16.8575	3.54	7.66924E-11

Consolidation test – calculations

Project : Kawaala Substation | Job ref. | | Borehole No.: **BH01** | Sample No. **1** | Depth 15m | Date 10-20/12/2015

Soil description :

Test method: ASTM D 2435

Machine no. | Specimen diameter: **50.47** | Height H_s 20 mm

Cell no. | Height of solids H_s 10.59003831

Ring no. | Initial voids ratio e_o 0.888567294

Increment no.	Pressure P kPa	Cumulative compression (DH) mm	Consolidated height H=H_o-(DH)	$e=\frac{H-H_s}{H_s}$ Voids ratio	Incremental: Height change dH mm	Incremental: Pressure change dP kPa	$m_v=\frac{\delta H}{H_1}\cdot\frac{1000}{\delta P}$ m^2/MN	$\overline{H}=\frac{H_1+H_2}{4}$	$c_v=\frac{0.197\overline{H}^2}{t_{90}}$ m^2/year	Permeability $k_w=c_v\rho_w g m_v$ m/sec
0	0.00	0	20	0.889	0	0	-	-	-	
1	73.52	0.136	19.864	0.876	0.136	73.52	0.093	9.966	64.2751895	1.86197E-09
2	147.05	0.242	19.758	0.866	0.242	73.53	0.167	9.9395	48.71148439	2.52407E-09
3	294.10	0.344	19.656	0.856	0.102	147.05	0.035	9.914	10.1769915	1.11718E-10
4	588.19	0.472	19.528	0.844	0.128	294.09	0.022	9.882	20.22279957	1.40209E-10

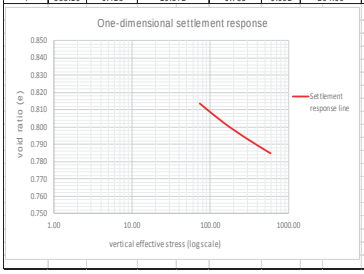
0.079

Consolidation test – calculations

Project :	**Kawaala Substation**	Job ref.	
		Borehole No..	**BH01**
Soil description :		Sample No.	**1**
		Depth	20m
		Date	10-20/12/2015

Test method:	ASTM D 2435		
Machine no.	Specimen diameter: **50.47**	Height H.	20 mm
Cell no.	Height of solids H.	10.96551724	
Ring no.	Initial voids ratio e_o	0.823899371	

VOIDS RATIO					COMPRESSIBILITY				COEFFICIENT OF		
					Incremental						
Increment no.	Pressure P kPa	Cumulative compression (DH) mm	Consolidated height H=H_s+(DH)	$e = \frac{H - H_s}{H_s}$ Voids ratio	Height change dH mm	Pressure change dP kPa	$m_v = \frac{\delta H}{H_1} \frac{1000}{\delta P}$ m^2/MN	$\bar{H} = \frac{H_1 + H_2}{4}$	$c_v = \frac{0.197\ \bar{H}^2}{t_{50}}$ m^2/year	Permeability $k_v = c_v \rho_w g m_v$ m/sec
0	0.00	0	20	0.824	0	0	-	-	-	
1	73.52	0.114	19.886	0.814	0.114	73.52	0.078	9.9715	128.692306	3.12153E-09
2	147.05	0.234	19.766	0.803	0.234	73.53	0.161	9.9415	25.58382202	1.28133E-09
3	294.10	0.336	19.664	0.793	0.102	147.05	0.035	9.916	12.72637253	1.39647E-10
4	588.19	0.428	19.572	0.785	0.092	294.09	0.016	9.893	8.444935848	4.19886E-11

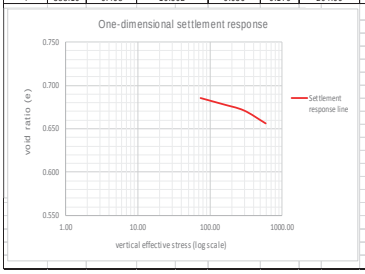


Consolidation test – calculations

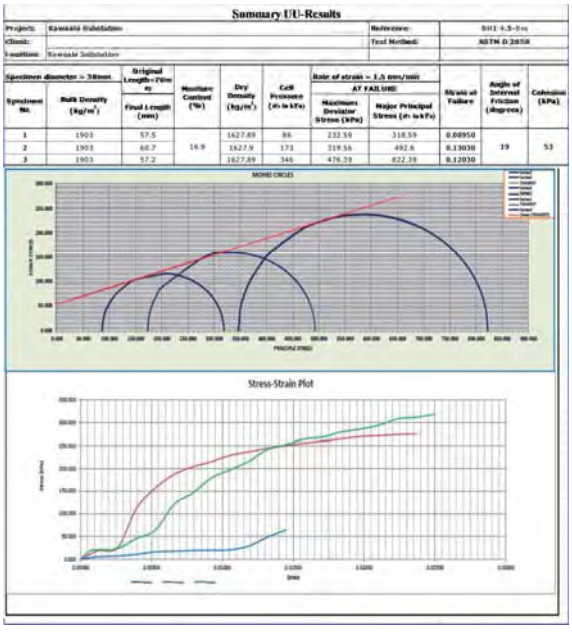
Project :	**Kawaala Substation**	Job ref.	
		Borehole No..	**BH01**
Soil description :		Sample No.	**1**
		Depth	30m
		Date	10-20/12/2015

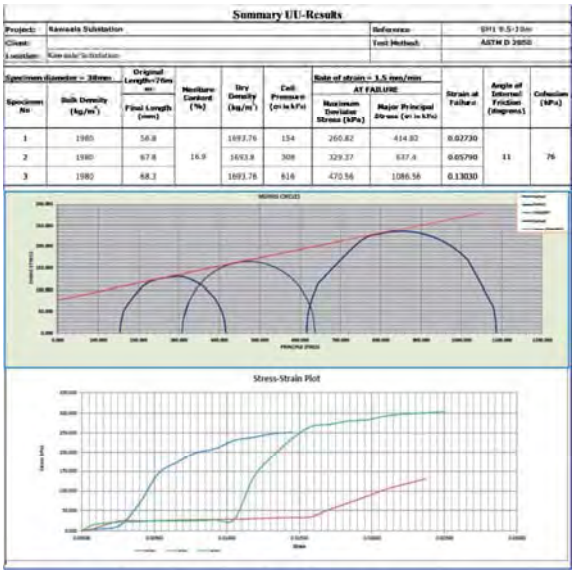
Test method:	ASTM D 2435		
Machine no.	Specimen diameter: **50.47**	Height H.	20 mm
Cell no.	Height of solids H.	11.83141762	
Ring no.	Initial voids ratio e_o	0.690414508	

VOIDS RATIO					COMPRESSIBILITY				COEFFICIENT OF		
					Incremental						
Increment no.	Pressure P kPa	Cumulative compression (DH) mm	Consolidated height H=H_s+(DH)	$e = \frac{H - H_s}{H_s}$ Voids ratio	Height change dH mm	Pressure change dP kPa	$m_v = \frac{\delta H}{H_1} \frac{1000}{\delta P}$ m^2/MN	$\bar{H} = \frac{H_1 + H_2}{4}$	$c_v = \frac{0.197\ \bar{H}^2}{t_{50}}$ m^2/year	Permeability $k_v = c_v \rho_w g m_v$ m/sec
0	0.00	0	20	0.690	0	0	-	-	-	
1	73.52	0.062	19.938	0.685	0.062	73.52	0.042	9.9845	29.49213281	3.88037E-10
2	147.05	0.144	19.856	0.678	0.144	73.53	0.099	9.964	6.42493943	1.97123E-10
3	294.10	0.232	19.768	0.671	0.088	147.05	0.030	9.942	9.304143825	8.76181E-11
4	588.19	0.408	19.592	0.656	0.176	294.09	0.031	9.898	17.48994679	1.6619E-10



Appendix 9: Undrained Triaxial Results

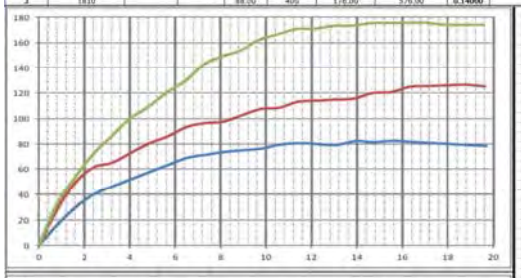


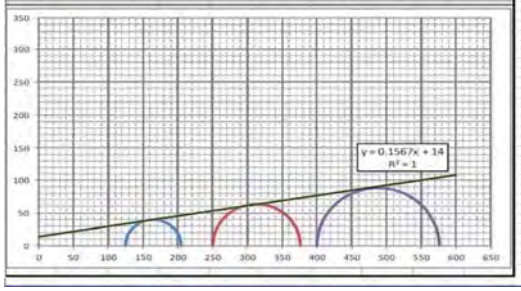


Summary UU-Results

Project:	Kawaala Substation	Reference:	BH1 15-15.5m
Client:		Test Method:	ASTM D 2850
Location:	Kawaala Substation		

Specimen No	Bulk Density (kg/m³)	Original Length=76mm Final Length (mm)	Moisture Content (%)	Shear stress (kpa)	Cell Pressure (σ₃ in kPa)	Rate of strain = 1.287 mm/min AT FAILURE: Maximum Deviator Stress (kPa)	Rate of strain = 1.287 mm/min AT FAILURE: Major Principal Stress (σ₁ in kPa)	Axial Strain	Angle of Internal Friction (degrees)	Cohesion (kPa)
1	1810			40.00	125	80.00	205.00	0.14000	9	14
2	1810			83.0	250	126.00	376.0	0.14000		
3	1810			88.00	400	176.00	576.00	0.14000		

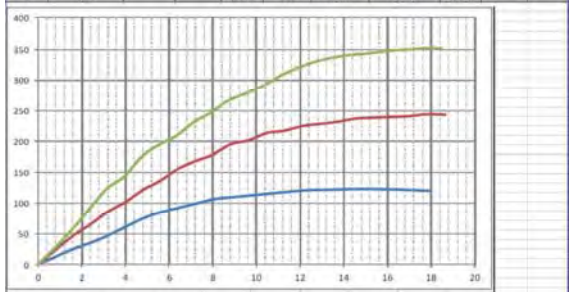


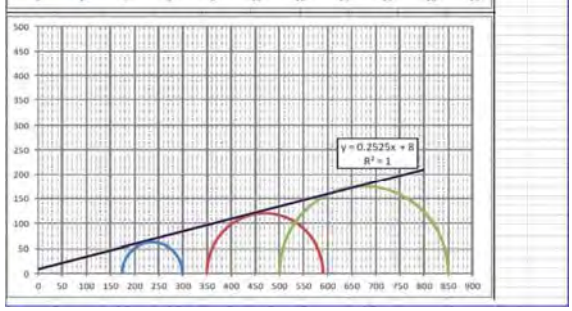


Summary UU-Results

Project:	Kawaala Substation	Reference:	BH1 20-20.5m
Client:		Test Method:	ASTM D 2850
Location:	Kawaala Substation		

Specimen No	Bulk Density (kg/m³)	Original Length=76mm Final Length (mm)	Moisture Content (%)	Shear stress (kpa)	Cell Pressure (σ₃ in kPa)	Rate of strain = 1.287 mm/min AT FAILURE: Maximum Deviator Stress (kPa)	Rate of strain = 1.287 mm/min AT FAILURE: Major Principal Stress (σ₁ in kPa)	Axial Strain	Angle of Internal Friction (degrees)	Cohesion (kPa)
1	1841			62.00	175	124.00	299.00	0.15000	14	8
2	1841			120.00	350	240.00	590.00	0.15000		
3	1841			175.00	502	350.00	850.00	0.15000		

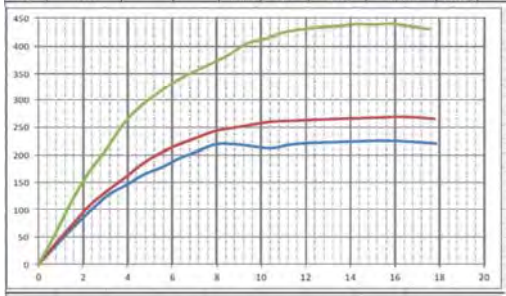


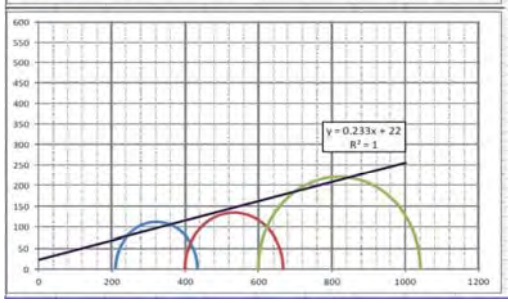


Summary UU-Results

Project:	Kawaala Substation	Reference:	BH1 25-25.5m
Client:		Test Method:	ASTM D 2850
Location:	Kawaala Substation		

Specimen No	Bulk Density (kg/m³)	Original Length=76mm Final Length (mm)	Moisture Content (%)	Shear stress (kpa)	Cell Pressure (σ₃ in kPa)	Rate of strain = 1.287 mm/min AT FAILURE: Maximum Deviator Stress (kPa)	Rate of strain = 1.287 mm/min AT FAILURE: Major Principal Stress (σ₁ in kPa)	Axial Strain	Angle of Internal Friction (degrees)	Cohesion (kPa)
1	1851			112.00	210	224.00	434.00	0.15000	13	22
2	1851			134.00	400	268.00	668.00	0.15000		
3	1851			220.00	600	440.00	1040.00	0.15000		

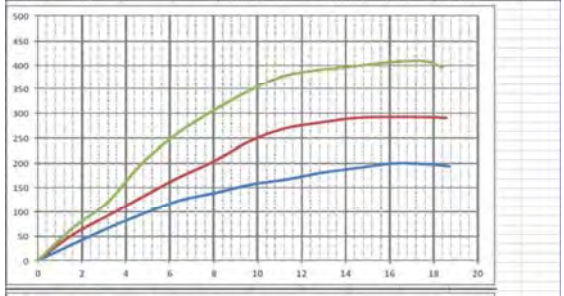


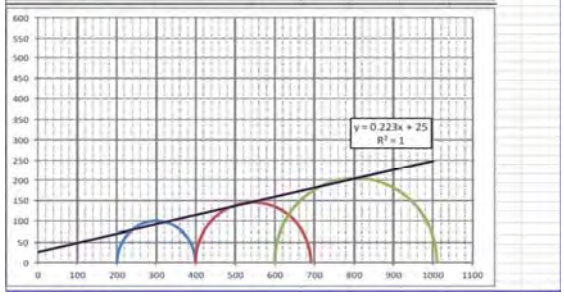


Summary UU-Results

Project:	Kawaala Substation	Reference:	BH1 30-30.5m
Client:		Test Method:	ASTM D 2850
Location:	Kawaala Substation		

Specimen No	Bulk Density (kg/m³)	Original Length=76mm Final Length (mm)	Moisture Content (%)	Shear stress (kpa)	Cell Pressure (σ₃ in kPa)	Rate of strain = 1.287 mm/min AT FAILURE: Maximum Deviator Stress (kPa)	Rate of strain = 1.287 mm/min AT FAILURE: Major Principal Stress (σ₁ in kPa)	Axial Strain	Angle of Internal Friction (degrees)	Cohesion (kPa)
1	1893			100.00	200	200.00	400.00	0.15000	13	25
2	1893			145.00	400	290.00	690.00	0.15000		
3	1893			205.00	600	410.00	1010.00	0.15000		



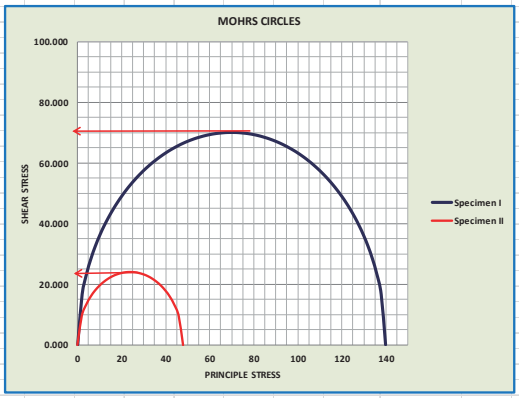


Appendix 10: Unconfined compressive Results

Summary UC Results

PROJECT:		Kawaala Substation			
Client:					**Location:** Kawaala Substation
BH No:	**BH 01**	DEPTH:	4.5-5.0	m	**Date:**3/12/2015

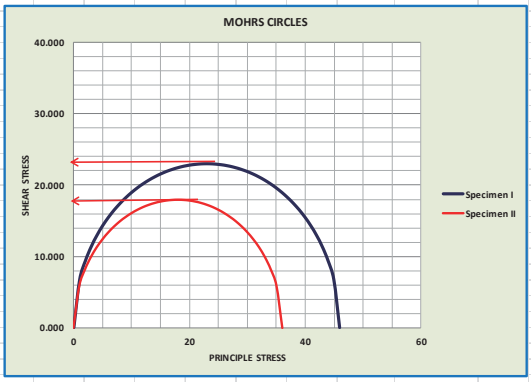
Specimen diameter = 38mm			**Original Length=76mm**	**Moisture Content**
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	**Final Length (mm)**	**%**
Specimen I	70	35	70.5	22.8
SpecimenII	24	12	69.5	
Average	**47**	**24**	**70**	



Summary UC Results

PROJECT:		Kawaala Substation			
Client:					**Location:** Kawaala Substation
BH No:	**BH 01**	DEPTH:	9.5-10	m	**Date:**3/12/2015

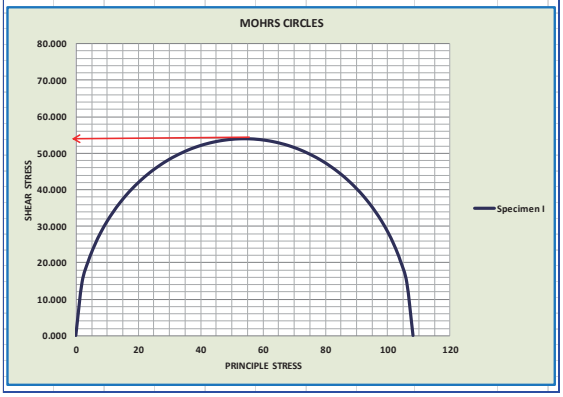
Specimen diameter = 38mm			**Original Length=76mm**	**Moisture Content**
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	**Final Length (mm)**	**%**
Specimen I	23	12	73.6	18.7
SpecimenII	18	9	72.8	
Average	**21**	**11**	**73**	



Summary UC Results

PROJECT:		Kawaala Substation			
Client:					**Location:** Kawaala Substation
BH No:	**BH 01**	DEPTH:	11-11.5	m	**Date:**20/12/2015

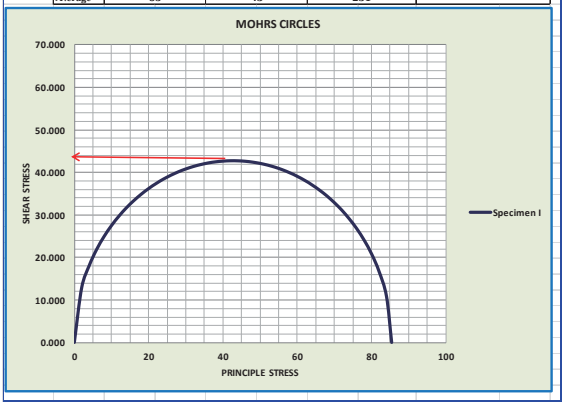
Specimen diameter = 38mm			**Original Length=192mm**	**Moisture Content**
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	**Final Length (mm)**	**%**
Specimen I	108	54	180.45	20.4
Average	**108**	**54**	**180**	



Summary UC Results

PROJECT:		Kawaala Substation			
Client:					**Location:** Kawaala Substation
BH No:	**BH 01**	DEPTH:	15-15.5	m	**Date:**20/12/2015

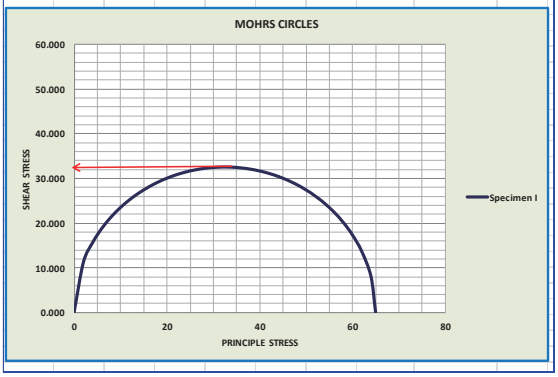
Specimen diameter = 38mm			**Original Length=255mm**	**Moisture Content**
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	**Final Length (mm)**	**%**
Specimen I	85.3	42.7	231	27.4
Average	**85**	**43**	**231**	



Summary UC Results

PROJECT:		Kawaala Substation			
Client:					**Location:** Kawaala Substation
BH No:	**BH 01**	DEPTH:	20-20.5	m	**Date:**20/12/2015

Specimen diameter = 38mm			**Original Length=195mm**	**Moisture Content**
	Unconfined compresive strength,qu(in kpa)	Undrained cohesion,Cu (in kpa)	**Final Length (mm)**	**%**
Specimen I	65.0	32.5	177	28.5
Average	**65**	**33**	**177**	



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GREATER KAMPALA TRANSMISSION NETWORK PROJECT IN THE REPUBLIC OF UGANDA

MUKONO SUBSTATION DRAFT DETAIL

GEOTECHNICAL REPORT

YACHIYO ENGINEERING CO.,LTD.
Consulting Engineers & Architects

Revision **00**
Date **21.04.2016**
Prepared by **DA/LN**
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EXECUTIVE SUMMARY

This report mainly deals with the geological and geotechnical investigation findings of Mukono Substation. In this report the governing soil properties are considered based on the geological and geotechnical site investigation which was executed in March, 2016. In addition, relevant non-geotechnical parameters are outlined. The evaluation of the field and laboratory investigations is included in this report.

Mukono substation is located in Mukono district, Central Uganda that encircles Kampala, Uganda's capital city. It is located approximately 26km by road from the capital centre, Kampala. The approximate centroid of the project area coordinates is UTM WGS 84 36N 480723.000mE 42566.000mN. The elevation of the project area varies between 1170 to 1100amsl.

Mukono substation is a non-existing substation without developments on the site. The project area incorporated within the site boundary is approximately 397,128.44m^2. The site investigation confirmed that the geological sequence at the site generally comprises of a inorganic Sandy Lean CLAY from ground level to a depth of 1.5m, overlying inorganic Sandy SILT up to a depth of 7.5m, underlain by Poorly Graded SAND with Clay and Gravel up to a depth of 13.5m, overlying Silty SAND with Gravel up to a depth of 16.5m underlain by Silty SAND up to a depth of 28.5m.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BGL	Below Ground Level
BH	Borehole
DGSM	Department of Geological Survey and Mines
JICA	Japan International Cooperation Agency
km	Kilometer
m	Meter
masl	Above Mean Sea Level
SPT	Standard Penetration Test
UTM	Universal Transverse Mercator
YEC	Yachiyo Engineering Company Ltd
^{0}C	Degrees Celsius

1 INTRODUCTION

1.1 About report

This report mainly deals with the geotechnical investigation finding for Mukono substation. It discusses the index and engineering properties of soil based on the geotechnical field investigation and laboratory which was conducted in March, 2016. Relevant non-geotechnical parameters are outlined including the analysis and calculation results are given as part of this report (i.e. bearing capacity and settlements). Finally, recommendations were made for design and construction of the proposed development foundation.

1.2 Background

Yachiyo Engineering Company Ltd (YEC) were commissioned by the Japan International Cooperation Agency (JICA) to carry out a preparatory survey for the improvement of the greater Kampala metropolitan area transmission system in the republic of Uganda. Yachiyo Engineering Company Ltd plans to construct a new substation and associated infrastructure at the proposed site. Geotechnical investigations were required to determine the suitability of the site for the proposed developments and to guide the design of the proposed infrastructure.

Following decision of conducting Geotechnical investigation at Mukono substation and transmission line, Newplan limited have been contracted by Yachiyo Engineering Company Ltd to carry out a Topographic surveying and Geotechnical investigation.

1.3 The Consultant

Following a competitive bidding procedure Newplan Limited was appointed by Yachiyo Engineering Company Ltd to carry out topographic surveying and geotechnical investigation for the proposed site. The Contract was signed on 11th March 2016 and the assignment commenced on 12th March, 2016.

The study was carried out in two phases i.e.: initial geotechnical investigation and detailed investigation study. The initial geotechnical investigation was concluded on 14th March, 2016. Following that, detailed investigations commenced on 16th March, 2016. The field and laboratory tests were conducted by Comat lab limited. This report together with the Topographic report are deliverables that signify the conclusion of the Mukono substation Topographic surveying and Geotechnical investigations contract.

1.4 Scope of services

In order to facilitate the substation foundation design, a detailed geotechnical investigation was performed. Newplan limited conducted the geotechnical investigations as per the general guidance proposed in the American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. The scope of the services was as summarized below:

1. Drilling exploratory holes and recovering soil samples;
2. Determination of subsurface soil profile or logging borehole for strata profiles;
3. Carrying out standard penetration tests;
4. Conducting relevant laboratory tests on the recovered samples (i.e. Moisture Content, Particle Size Distribution, Atterberg limits (Consistency), consolidation tests and Triaxial tests for undisturbed samples);
5. Monitoring ground water occurrence (depth of water table);
6. Propose recommendations for foundation design; and
7. Preparation of a geotechnical interpretative report.

2 SITE DESCRIPTION

2.1 Location

The proposed Mukono substation is located in Mukono district, Central Uganda that encircles Kampala, Uganda's capital city. It is located approximately 26km by road from the capital centre, Kampala. The approximate centroid of the project area coordinates is UTM WGS 84 36N 480723.000mE 42566.000mN.

The project area incorporated within the site boundary is approximately 397,128.44m^2. It is mainly farm land and forest which is sparsely populated with a few habited settlements.

Figure 2. 1: Site location

2.2 Topography

A detailed topographic survey was carried out by Newplan in March 2016. This indicated the topography of the site is undulating with the elevation of the project area varying between 1170 and 1100amsl.

2.3 Climate

The project area is classified under tropical climate with temperatures ranging from 15 to 29 ^{0}C. The project area receives rain in in two different season, March to May and in August to December. The mean annual rainfall is between 1125 and 1350mm.

3 GEOTECHNICAL INVESTIGATION

3.1 Methodology

Geotechnical investigation were conducted in two main phases of investigation.

1. Initial geotechnical investigation
   - Desk study (Reviewing useful sources of geological, historical and topographic information)
   - Site reconnaissance (Sampling, description and visual field identification)
2. Detailed geotechnical investigation
   - Preliminary design stage investigation
   - Final design stage or phase investigation

Initial geotechnical investigation was concluded in March, 2016. This investigation was limited to detail geotechnical investigation mainly for preliminary design stage investigation.

This preliminary design detailed geotechnical investigation typically includes four borings and relevant soil testing for defining the general stratigraphy, soil and rock characteristics, groundwater conditions, and other existing features important to foundation design. Further final design stage investigation stages can be considered if there are significant design changes or if local subsurface anomalies warrant further study.

The investigation was conducted in accordance with American Society for Testing and Materials (ASTM) D 420 - Standard Guide to Site Characterization for Engineering Design and Construction Purposes. It consists of the following components:

- Field Investigations; these were intrusive and included drilling exploratory holes, SPTs and groundwater observation.
- Laboratory tests on samples recovered from borehole.

3.2 Field Investigations

The site work was executed on the basis of ASTM D 420 recommendation (i.e. ASTM D 1586, ASTM D 1587, ASTM D 2488, and ASTM D 5783). The field work comprised of the following;

- Rotary drilling of one boreholes to a maximum depth of 30m;
- Collecting disturbed and undisturbed samples;
- In-situ Standard Penetration Testing (SPT) within the boreholes. These were undertaken at 1.5m intervals. SPTs were based on a 65kg driving hammer falling ‘free’ from a height of 760mm;
- Driving the standard split-barrel sampler of internal and external diameters 35mm and 50mm respectively to reach a distance of 450 mm into the soil at the bottom of the boring after the chosen interval.
- Counting the number of blows to drive the sampler each 75 mm increment of a total of 450 mm penetration. The blow count for the first 150 mm increment was discarded and the sum of the blow counts for the second and the third 150 mm increment was recorded as the SPT ‘N’ value.

3.2.1 Borehole

One borehole were drilled as per ASTM D 5783 and terminated to depths 30mBGL. Location of the borehole GPS coordinate is summarized in below Table 3.1 (WGS84 Geographic coordinate system). The drilled borehole log were prepared as per ASTM D 2488. The exploratory borehole records and log is included in Appendix 1 and should be read in conjunction with the accompanying general notes therein. The records also give details of the samples taken together with the observations made during boring.

Table 3- 1: Borehole location coordinates

Borehole	X	y
Borehole 1 (BH1)	480723.000mE	42566.000mN

3.2.2 Soil profile

The site investigation confirmed that the geological sequence at the site generally comprises of a inorganic Sandy Lean CLAY from ground level to a depth of 1.5m, overlying inorganic Sandy SILT up to a depth of 7.5m, underlain by Poorly Graded SAND with Clay and Gravel up to a depth of 13.5m, overlying Silty SAND with Gravel up to a depth of 16.5m underlain by Silty SAND up to a depth of 28.5m. (See Appendix 1 up to 4).

3.2.3 Ground water

To determine the elevation of the ground water table, observations were carried out during the drilling. These groundwater observations in the boreholes were conducted as per ASTM D 4750.

The ground water table was not encountered within a depth of 28.5m depth from ground surface. This indicates the ground water table is deep far from the lowest foundation footing and free from hydrostatic uplift. The Ground water observation result is presented in the borehole logs Appendix 1.

3.2.4 The Standard Penetration Test (SPT)

The standard penetration test (SPT) were performed during the advancement of a soil boring to obtain an approximate measure of the dynamic soil resistance, as well as a disturbed drive sample (split barrel type) to determine the arrangement of different layers of the soil with relation to the proposed foundation elevation. The test was conducted as per Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils, American Society for Testing and Materials (ASTM) D 1586. One borehole was drilled and 19 standard penetration tests over 28.5m depth of borehole were conducted. SPTs test were carried out at 1.5m intervals.

Information obtained from SPT combined with other geotechnical laboratory test results, on site topography and area climatic records, provides basic planning material essential

to the logical and effective development of substation and other infrastructure.

The observed field standard penetration values (N) were corrected to the average energy ratio of 60% (N_{60}) on basis of field observation as function of the input driving energy and its dissipation around the sampler into the surrounding soil. SPT correction were applied as per Seed *et al.* (1985) and Skempton (1980). Furthermore, the undrained shear strength (c_u) of the soil was determined using the corrected standard penetration values (N_{60}) as per Hara *et al.* (1971) and Peck *et al.* (1974) empirical relationship respectively. Finally, the approximate ultimate bearing capacity (Q_{ult}) and approximate allowable bearing capacity (Q_{all}) were computed using the derived undrained shear strength (c_u) of the soil. Overconsolidation (OCR) was determined using Mayne and Kemper (1988).

A factor of Safety (FoS) of 3.0 was used irrespective of the site conditions for computation of allowable bearing capacity (Q_{all}). Detailed bearing capacity results are attached as Appendix 1 and the summary of undrained shear strength (c_u) given in Table 3.2.

Depending on the standard penetration value (N_{60}) and unconfined shear strength result, the insitu soil comprises of soft to loose consistency Sandy Lean CLAY soil from the ground surface to a depth of 7.5m, underlain by denes to very stiff consistency Clayey SAND soil up to a depth of 10.5m, overlying by firm to loose consistency Clayey SAND with Gravel up to a depth of 18m, underlain by hard weathered rock up to a depth of 28.5m. Furthermore, the insitu soil is over consolidated.

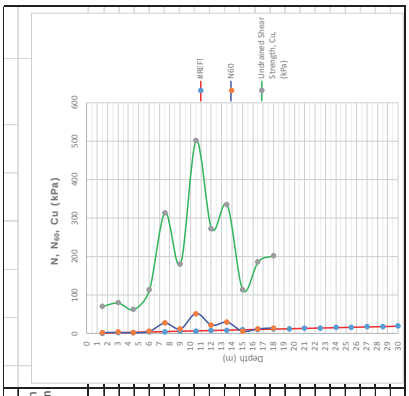


Table 3- 2: Standard penetration test result for BH1

	BH1					
Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	N	N_{60}	Undrained Shear Strength, C_u, (kPa)	Overcon soldation ratio (OCR)
0						
1.5	0.03	0.59	6	4	72	5
3	0.06	0.59	7	4	81	4
4.5	0.09	0.59	5	3	63	2
6	0.12	0.67	10	7	114	3
7.5	0.15	0.67	41	27	315	7
9	0.18	0.75	17	13	181	4
10.5	0.21	0.75	70	52	501	9
12	0.24	0.75	30	22	272	4
13.5	0.26	0.75	40	30	335	5
15	0.29	0.75	9	7	114	2
16.5	0.32	0.79	17	13	188	3
18	0.35	0.79	19	15	203	3
19.5	0.38	0.79	Refusal			
21	0.41	0.79	Refusal			
22.5	0.44	0.79	Refusal			
24	0.47	0.79	Refusal			
25.5	0.50	0.79	Refusal			
27	0.53	0.79	Refusal			
28.5	0.56	0.79	Refusal			
30	0.59	0.79	Refusal			

3.3 Laboratory Investigations

Samples from the exploration works were labelled, protected and taken to the laboratory with the aim of carrying out tests as per American Society for Testing and Materials (ASTM) D 4220. All undisturbed samples were collected as per Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes (ASTM) D 1587. The testing was scheduled by Comatlab limited. The following lab tests have been carried out on samples taken from the different boreholes:

- Moisture content
- Liquid limit
- Plastic limit & plasticity index
- Linear shrinkage
- Particle density determination/Specific Gravity Test
- Particle size distribution
- Unconfined compression
- Consolidation test-Oedometer/Undisturbed
- Triaxial test/Undisturbed (i.e. Unconsolidated Undrained (UU) Test)
- pH value
- Chemical test (sulphates and chlorides)

3.3.1 Moisture content

Moisture content test was conducted to determine the amount of water present in a quantity of soil in terms of its dry weight and to provide general correlations with strength, settlement, workability and other properties. The moisture content test was conducted on more than 19 samples collected from borehole (i.e. both disturbed and undisturbed) as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 2216. The test result is presented in Figure 3.1 and Appendix 6 with respect to depth. Natural moisture content of the insitu soil varied between 5.5 and 31%.

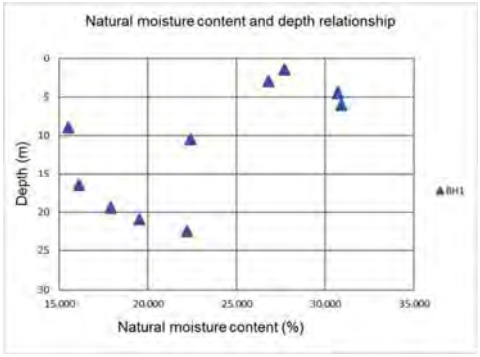


Figure 3- 1: Trend of Natural Moisture Content

3.3.2 Atterberg Limits

To describe the consistency and plasticity of fine-grained soils with varying degrees of moisture, liquid limit and plastic limit tests were conducted on samples collected from borehole as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 4318. A total of 19 atterberg limit tests were conducted. The test result is presented in Appendix 11. All the result obtained from atterberg laboratory tests were used for soil classificatio.

Shrinkage limit tests were also conducted on samples recovered from the boreholes as per Standard Test Methods for American Society for Testing and Materials (ASTM D) 427 and D 4943. The test result for shrinkage limit tests is presented in appendix 11. All Shrinkage limit test results were less than 15 percent, this indicates that Kaolinite clay mineral is dominant or high in insitu soil and the project area is not prone to swelling or expansive soil.

3.3.3 Particle size distribution

To determine the percentage of various grain sizes, sieve analysis tests were conducted. Results from grain size distribution were used to determine the textural classification of soils (i.e. gravel, sand, silt, and clay) which in turn is useful in evaluating the engineering characteristics such as permeability, strength, and swelling potential. A total of 19 sieve analysis tests were conducted as per Standard Test Methods for American Society for Testing and Materials per (ASTM) D 422. The test results are presented in Figure 3-2 and Appendix 4.

Borehole No.	Depth (m)	Sample Description	Group Name (USCS)	Particle Size Distribution: Percentage Passing Given Sieve (%)																		Grading modulus	Atterberg Limits				
				75 (mm)	63 (mm)	50 (mm)	37.5 (mm)	28 (mm)	20 (mm)	14 (mm)	10 (mm)	6.3 (mm)	5.0 (mm)	2.36 (mm)	2.0 (mm)	1.18 (mm)	0.600 (mm)	0.425 (mm)	0.300 (mm)	0.150 (mm)	0.075 (mm)		Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	NMC
01	1.5	Inorganic Sandy Lean **CLAY**	CL	100	100	100	100	100	100	98	95	92	89	80	77	72	66	63	60	55	51	1.1	49.8	28.0	21.8	10.0	27.7
	3.0	Inorganic Sandy **SILT**	ML	100	100	100	100	100	95	94	93	92	91	87	87	84	77	73	70	65	62	0.8	47.1	29.0	18.2	9.3	26.8
	4.5	Inorganic Sandy Elastic **SILT**	MH	100	100	100	100	100	100	100	100	100	100	99	99	96	85	80	75	68	63	0.6	51.8	30.3	21.5	10.7	30.7
	6.0	Inorganic Sandy **SILT**	ML	100	100	100	100	100	100	100	100	99	98	95	94	90	80	75	70	62	57	0.7	45.8	28.3	17.5	10.0	30.9
	7.5	Inorganic Sandy **SILT**	ML	100	100	100	100	100	100	100	100	100	100	99	99	95	85	79	74	65	58	0.6	45.0	27.3	17.8	10.0	13.2
	9.0	Poorly Graded **SAND** with Clay and Gravel	SP-SC	100	100	100	89	81	78	76	75	75	74	64	60	43	34	31	27	18	10	2.0	27.0	20.2	6.8	5.0	15.5
	10.5	Silty **SAND** with Gravel	SM	100	100	100	100	100	96	93	89	82	77	66	64	58	50	46	41	34	29	1.6	41.2	30.5	10.6	6.4	22.4
	12.0	Poorly Graded **SAND** with Silt and Gravel	SP-SM	100	100	100	100	92	89	86	84	76	68	42	37	25	18	15	13	10	9	2.4	28.1	22.2	5.9	3.6	5.5
	13.5	Poorly Graded **SAND** with Clay and Gravel	SP-SC	100	100	100	100	96	96	94	94	93	91	63	52	29	20	18	16	13	10	2.2	29.5	21.3	8.2	4.3	11.3
	15.0	Silty **SAND** with Gravel	SM	100	100	100	90	90	86	84	84	83	83	72	68	51	41	38	34	24	16	1.8	30.1	22.6	7.5	4.3	9.3
	16.5	Silty **SAND** with Gravel	SM	100	100	100	100	100	100	99	98	91	80	55	54	49	44	42	38	31	23	1.8	36.3	28.4	7.9	3.6	16.1
	18.0	Silty **SAND**	SM	100	100	100	100	100	100	100	100	99	99	78	67	38	27	24	22	17	13	2.0	32.6	25.4	7.2	3.6	9.4
	19.5	Clayey **SAND**	SC	100	100	100	100	100	100	100	100	100	99	97	95	85	69	64	57	49	42	1.0	36.4	24.0	12.4	6.4	17.9
	27.0	Silty **SAND**	SM	100	100	100	100	100	100	100	100	100	99	86	81	61	37	29	23	17	14	1.8	41.0	30.8	10.2	4.3	19.5
	28.5	Silty **SAND**	SM	100	100	100	100	100	100	99	99	98	97	92	89	80	67	60	53	43	36	1.1	35.3	25.7	9.6	6.4	22.2

Figure 3- 2: Particle distribution curve for BH1

3.3.4 Specific Gravity

To determine the specific gravity of the soil grains specific gravity test was conducted as per Standard Test Methods for American Society for Testing and Materials (ASTM) D 854. The specific gravity of the project area soil varies between 2.59 and 2.79 and the average specific gravity is 2.68.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

4.2 Recommendations

5 REFERENCES

1. AMERICAN SOCIETY FOR TESTING AND MATERIALS: Annual Book of ASTM international Standards. 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, United States.

- D 420 Standard Guide to Site Characterization for Engineering Design and Construction Purposes
- D 421 Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
- D 427 Standard Test Method for Shrinkage Factors of Soils by the Mercury Method
- D 422 Test Method for Particle-Size Analysis of Soils
- D 512 Standard Test Methods for Chloride Ion In Water
- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 1586 Test Method for Penetration Test and Split-Barre Sampling of Soils
- D 2113 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
- D 2434 Standard Test Method for Permeability of Granular Soils (Constant Head)
- D 2435 Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading
- D 2487 Classification of Soils for Engineering Purposes
- D 2216 Test Method for Laboratory Determination of Water Moisture) Content of Soil and Rock (Unified Soil Classification System).
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
- D 2850 Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
- D 3740 Practice for Minimum Requirements of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction Plasticity Index of Soils
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

- D 4750 Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
- D 4767 Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils
- D 4943 Standard Test Method for Shrinkage Factors of Soils by the Wax Method
- G 51 Test Method for pH of Soil for Use in Corrosion Testing

2. Bowles Joseph E; Foundation Analysis and Design, Second Edition. McGraw Hill Companies, Tokyo, 1997.
3. California Department of Transportation, 2012. Corrosion Guidelines version 2.0.
4. Department of Geological Surveys and Mines, 2012. Geological Map of Uganda sheet No 70.
5. VICKERS, BRIAN (1978); Laboratory work in Civil Engineering Soil Mechanics. Granada Publishers, London.
6. G.E Barney; Principles and Practice of Soil Mechanics, First Edition. Macmillan Press Ltd, London, 1995
7. Department of US Army Corps of Engineers, CECW-EG Engineer Manual 1110-1-1904 Engineering and Design of SETTLEMENT ANALYSIS, Washington, DC 20314-1000, 1990.
8. MJ Tomlinson; Foundation Design & Construction, Sixth Edition. Addison Wesley Longman Limited, Edinburgh Gate, Harlow Essex CM20 2JE, 1998.
9. R.F.Craig. E & FN Spon, 2004. CRAIG'S SOIL MECHANICS. Seventh Edition, London.

6 APPENDIX

Appendix 1: Borehole logs

Appendix 2: Drilling pictorial logs

Appendix 3: Borehole layout

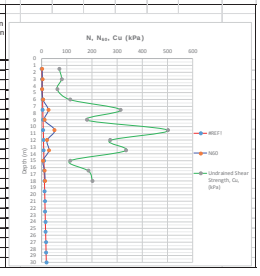
Appendix 4: Soil Profile

Appendix 5: Standard Penetration test result

CLIENT: YACHIYO ENGINEERING COMPANY LTD
PROJECT: GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION
CONTRACTOR: NEWPLAN LIMITED

SUMMARY FOR STANDARD PENETRATION TEST (SPT) RESULTS

			BH1			
Depth (m)	Vertical stress (MN/m2)	Over all Efficiency	N	N_{60}	Undrained Shear Strength, C_u (kPa)	Overconsolidation ratio (OCR)
0						
1.5	0.03	0.59	6	4	72	5
3	0.06	0.59	7	4	81	4
4.5	0.09	0.59	5	3	63	2
6	0.12	0.67	10	7	114	3
7.5	0.15	0.67	41	27	315	7
9	0.18	0.75	17	13	181	4
10.5	0.21	0.75	70	52	501	9
12	0.24	0.75	30	22	272	4
13.5	0.26	0.75	40	30	335	5
15	0.29	0.75	9	7	114	2
16.5	0.32	0.79	17	13	188	3
18	0.35	0.79	19	15	203	3
19.5	0.38	0.79	Refusal			
21	0.41	0.79	Refusal			
22.5	0.44	0.79	Refusal			
24	0.47	0.79	Refusal			
25.5	0.50	0.79	Refusal			
27	0.53	0.79	Refusal			
28.5	0.56	0.79	Refusal			
30	0.59	0.79	Refusal			



	CLIENT:	YACHIYO ENGINEERING COMPANY LTD						
	PROJECT:	GEOTECHNICAL INVESTIGATION FOR BULOOBA SUBSTATION						
	CONTRACTOR:	NEWPLAN LIMITED						
	SUMMARY FOR EVALUATION OF ALLOWABLE BEARING CAPACITY BASED ON FIELD SPT 'N' VALUES							

BH No.	Depth (m)	Predominant Soil Fraction	Measured SPT 'N' Value N	Over all Correction factor C_N	*Corrected SPT 'N' Value* N_{60}	Undrained Cohesion C_u (kPa)	Ultimate Bearing Capacity Q_{ult} (kPa)	Allowable Bearing Capacity Q_{all} (kPa)
BH01	0.00							
	1.00		6	0.59	4	72	371	124
	2.00		7	0.59	4	81	414	138
	3.00		5	0.59	3	63	325	108
	4.00		10	0.67	7	114	586	195
	5.00		41	0.67	27	315	1618	539
	6.00		17	0.75	13	181	930	310
	7.00		70	0.75	52	501	2577	859
	8.00		30	0.75	22	272	1400	467
	9.00		40	0.75	30	335	1722	574
	10.00		9	0.75	7	114	588	196
	11.00		17	0.79	13	188	965	322
	12.00		19	0.79	15	203	1046	349
	13.00		Refusal	0.79				
	14.00		Refusal	0.79				
	15.00		Refusal	0.79				
	16.00		Refusal	0.79				
	17.00		Refusal	0.79				
	18.00		Refusal	0.79				
	19.00		Refusal	0.79				
	20.00		Refusal	0.79				

*The undrained shear strength (cu) of the soil is determined using the corrected standard penetration values (N_{60}) as per Hara et al. (1971) and Peck et al. (1974) empirical relationship respectively.Cu = Pa*0.29*N60^0.72, where Pa is Atmospheric presure and qult = 5.14 x Cu. Qall is evaluated usinga factor of safety of 3*

Appendix 6: Natural Moisture Content

Appendix 7: Summary of Texture Classification

Borehole No.	Depth (m)	Sample Description	Group Name (USCS)	75 (mm)	63 (mm)	50 (mm)	37.5 (mm)	28 (mm)	20 (mm)	14 (mm)	10 (mm)	6.3 (mm)	5.0 (mm)	2.36 (mm)	2.0 (mm)	1.18 (mm)	0.600 (mm)	0.425 (mm)	0.300 (mm)	0.150 (mm)	0.075 (mm)	Grading modulus	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	NMC
				Particle Size Distribution: Percentage Passing Given Sieve (%)																			Atterberg Limits				
01	1.5	Inorganic Sandy Lean **CLAY**	**CL**	100	100	100	100	100	100	98	95	92	89	80	77	72	66	63	60	55	51	**1.1**	49.8	28.0	21.8	10.0	27.7
	3.0	Inorganic Sandy **SILT**	**ML**	100	100	100	100	100	95	94	93	92	91	87	87	84	77	73	70	65	62	**0.8**	47.1	29.0	18.2	9.3	26.8
	4.5	Inorganic Sandy Elastic **SILT**	**MH**	100	100	100	100	100	100	100	100	100	100	99	99	96	85	80	75	68	63	**0.6**	51.8	30.3	21.5	10.7	30.7
	6.0	Inorganic Sandy **SILT**	**ML**	100	100	100	100	100	100	100	100	99	98	95	94	90	80	75	70	62	57	**0.7**	45.8	28.3	17.5	10.0	30.9
	7.5	Inorganic Sandy **SILT**	**ML**	100	100	100	100	100	100	100	100	100	100	99	99	95	85	79	74	65	58	**0.6**	45.0	27.3	17.8	10.0	13.2
	9.0	Poorly Graded **SAND** with Clay and Gravel	**SP-SC**	100	100	100	89	81	78	76	75	75	74	64	60	43	34	31	27	18	10	**2.0**	27.0	20.2	6.8	5.0	15.5
	10.5	Silty **SAND** with Gravel	**SM**	100	100	100	100	100	96	93	89	82	77	66	64	58	50	46	41	34	29	**1.6**	41.2	30.5	10.6	6.4	22.4
	12.0	Poorly Graded **SAND** with Silt and Gravel	**SP-SM**	100	100	100	100	92	89	86	84	76	68	42	37	25	18	15	13	10	9	**2.4**	28.1	22.2	5.9	3.6	5.5
	13.5	Poorly Graded **SAND** with Clay and Gravel	**SP-SC**	100	100	100	100	96	96	94	94	93	91	63	52	29	20	18	16	13	10	**2.2**	29.5	21.3	8.2	4.3	11.3
	15.0	Silty **SAND** with Gravel	**SM**	100	100	100	90	90	86	84	84	83	83	72	68	51	41	38	34	24	16	**1.8**	30.1	22.6	7.5	4.3	9.3
	16.5	Silty **SAND** with Gravel	**SM**	100	100	100	100	100	100	99	98	91	80	55	54	49	44	42	38	31	23	**1.8**	36.3	28.4	7.9	3.6	16.1
	18.0	Silty **SAND**	**SM**	100	100	100	100	100	100	100	100	99	99	78	67	38	27	24	22	17	13	**2.0**	32.6	25.4	7.2	3.6	9.4
	19.5	Clayey **SAND**	**SC**	100	100	100	100	100	100	100	100	100	99	97	95	85	69	64	57	49	42	**1.0**	36.4	24.0	12.4	6.4	17.9
	27.0	Silty **SAND**	**SM**	100	100	100	100	100	100	100	100	100	99	86	81	61	37	29	23	17	14	**1.8**	41.0	30.8	10.2	4.3	19.5
	28.5	Silty **SAND**	**SM**	100	100	100	100	100	100	99	99	98	97	92	89	80	67	60	53	43	36	**1.1**	35.3	25.7	9.6	6.4	22.2

Appendix 8: Specific Gravity

Appendix 9: Chemical Test

Appendix 10: One-Dimensional Consolidation (Oedometer test)

Appendix 11: Atterbeg Test Results

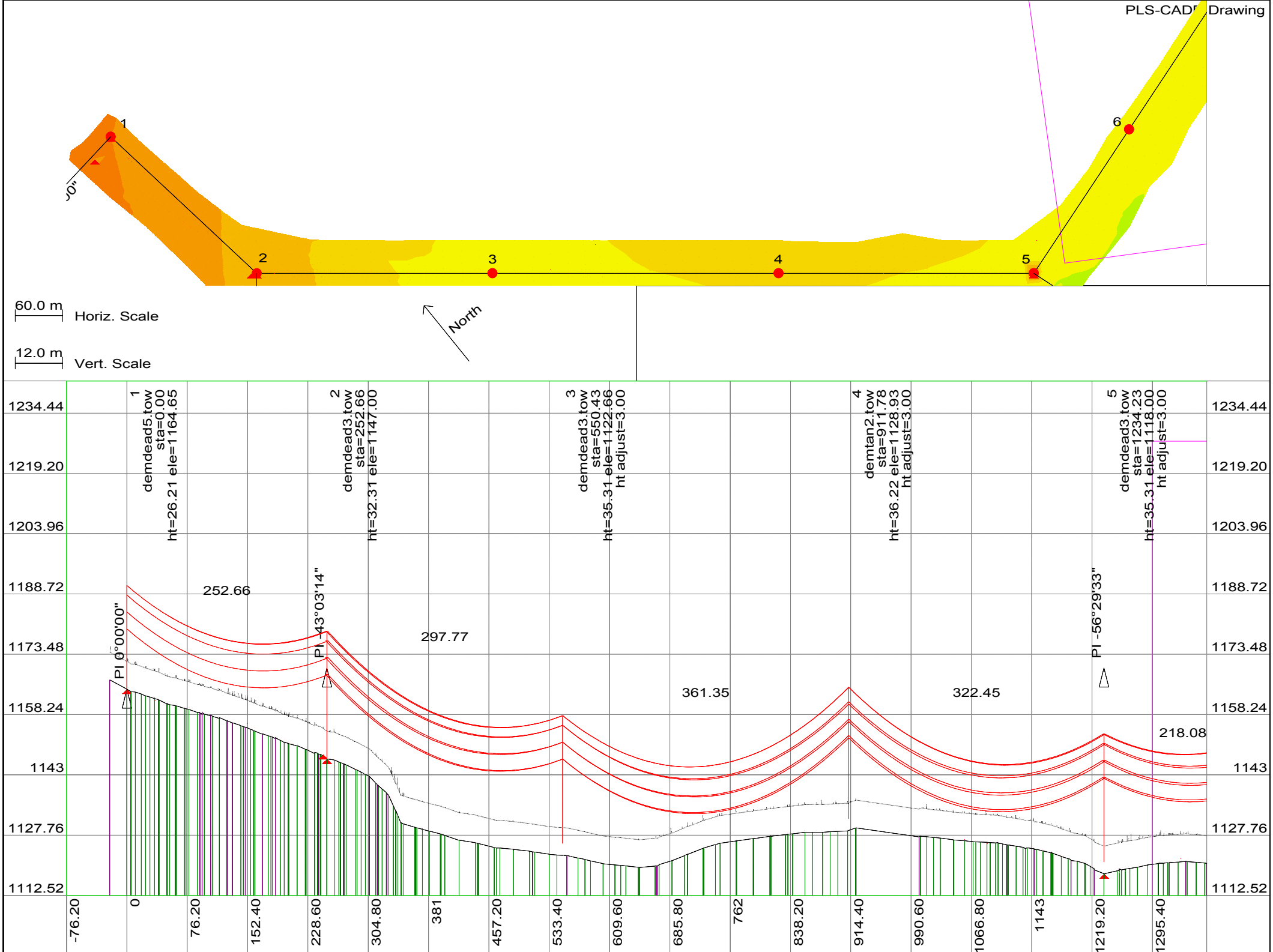
Borehole No.	Depth (m)	Sample Description	Atterberg Limits				
			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	NMC
01	1.5	Inorganic Sandy Lean **CLAY**	49.8	28.0	21.8	10.0	27.7
	3.0	Inorganic Sandy **SILT**	47.1	29.0	18.2	9.3	26.8
	4.5	Inorganic Sandy Elastic **SILT**	51.8	30.3	21.5	10.7	30.7
	6.0	Inorganic Sandy **SILT**	45.8	28.3	17.5	10.0	30.9
	7.5	Inorganic Sandy **SILT**	45.0	27.3	17.8	10.0	13.2
	9.0	Poorly Graded **SAND** with Clay and Gravel	27.0	20.2	6.8	5.0	15.5
	10.5	Silty **SAND** with Gravel	41.2	30.5	10.6	6.4	22.4
	12.0	Poorly Graded **SAND** with Silt and Gravel	28.1	22.2	5.9	3.6	5.5
	13.5	Poorly Graded **SAND** with Clay and Gravel	29.5	21.3	8.2	4.3	11.3
	15.0	Silty **SAND** with Gravel	30.1	22.6	7.5	4.3	9.3
	16.5	Silty **SAND** with Gravel	36.3	28.4	7.9	3.6	16.1
	18.0	Silty **SAND**	32.6	25.4	7.2	3.6	9.4
	19.5	Clayey **SAND**	36.4	24.0	12.4	6.4	17.9
	27.0	Silty **SAND**	41.0	30.8	10.2	4.3	19.5
	28.5	Silty **SAND**	35.3	25.7	9.6	6.4	22.2

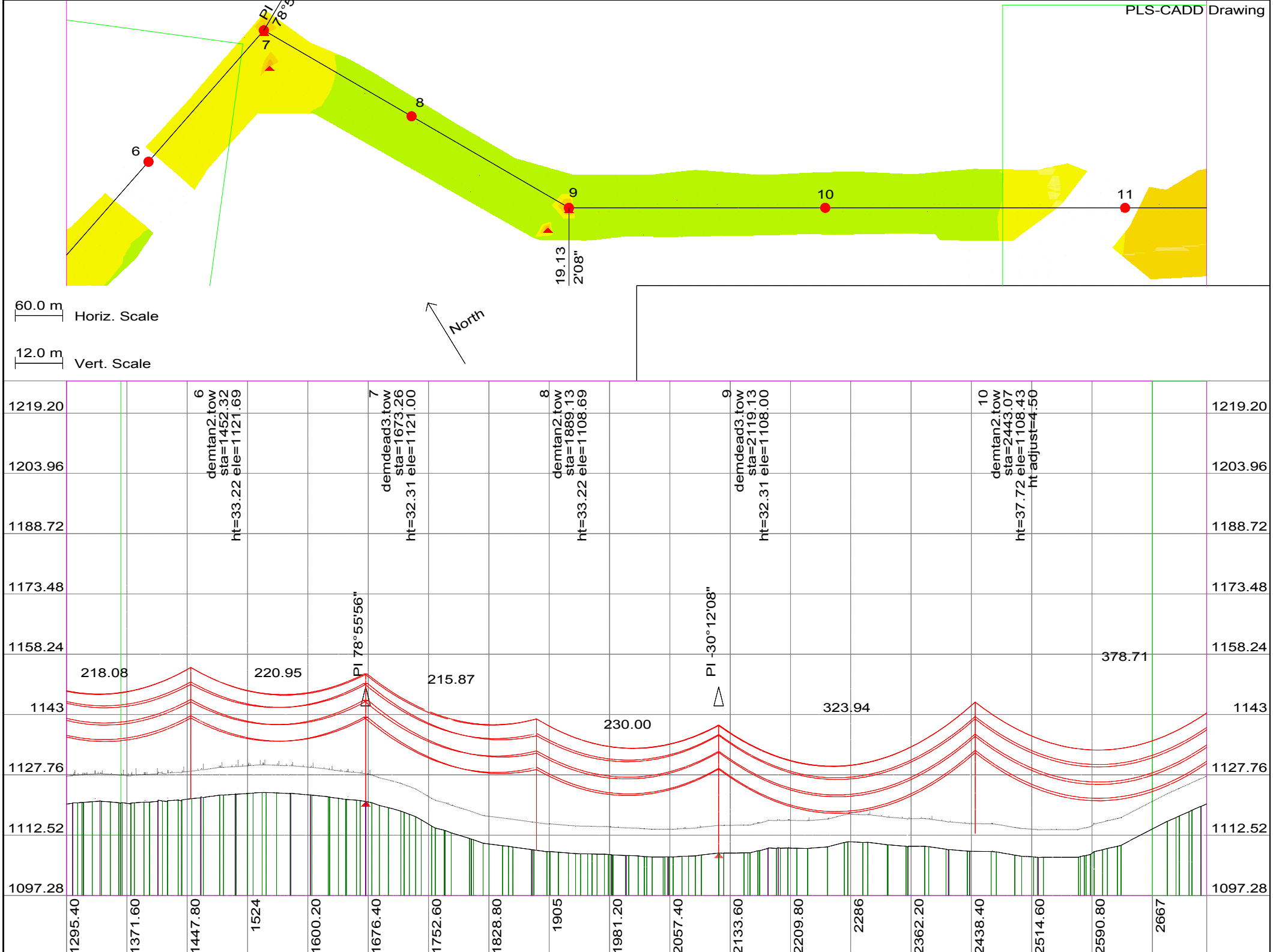
Appendix 12: Bulk Density

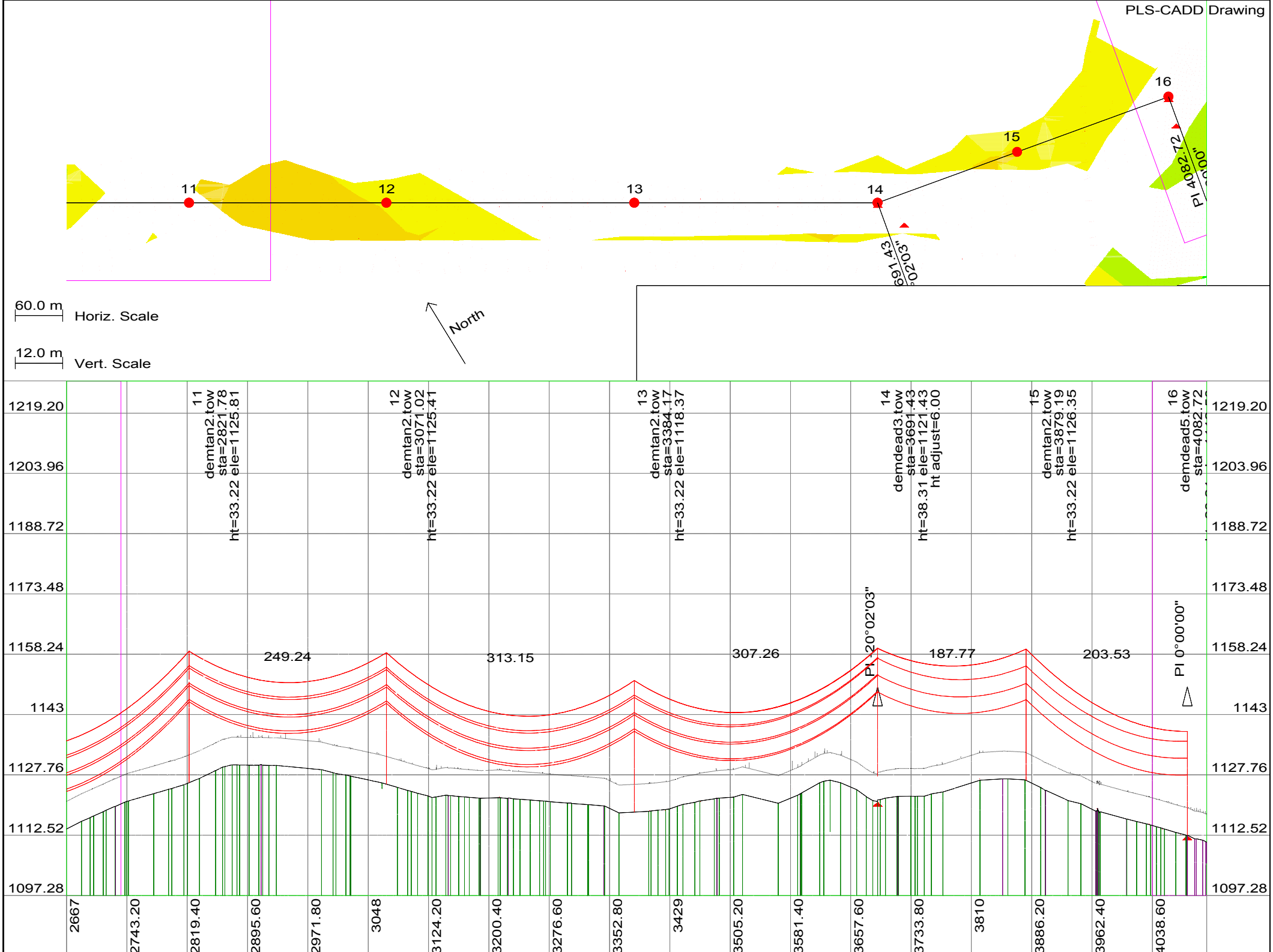
Appendix 13: Unconsolidated undrained triaxial tests result

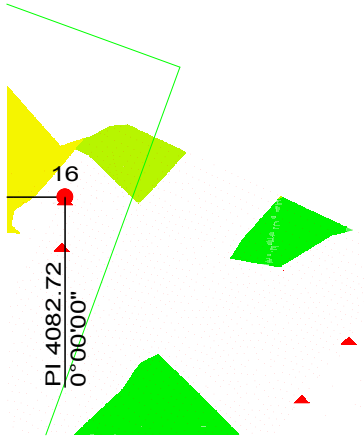
Appendix 14: Unconfined Compressive Strength

資料－１０　220 kV 送電線縦断図（新ムコノ変電所）


PLS-CADD Drawing
1
2
3
4
5
6
60.0 m
Horiz. Scale
12.0 m
Vert. Scale
North
1 demdead5.tow sta=0.00 ht=26.21 ele=1164.65
2 demdead3.tow sta=252.66 ht=32.31 ele=1147.00
3 demdead3.tow sta=550.43 ht=35.31 ele=1122.66 ht adjust=3.00
4 demtan2.tow sta=911.78 ht=36.22 ele=1128.93 ht adjust=3.00
5 demdead3.tow sta=1234.23 ht=35.31 ele=1118.00 ht adjust=3.00
PI 0°00'00"
PI 43°03'14"
PI -56°29'33"
252.66
297.77
361.35
322.45
218.08
1234.44
1219.20
1203.96
1188.72
1173.48
1158.24
1143
1127.76
1112.52
-76.20
0
76.20
152.40
228.60
304.80
381
457.20
533.40
609.60
685.80
762
838.20
914.40
990.60
1066.80
1143
1219.20
1295.40


PLS-CADD Drawing
PI 78°55'56"
6
7
8
9
10
11
19.13
2'08"
60.0 m
Horiz. Scale
12.0 m
Vert. Scale
North
6 demtan2.tow sta=1452.32 ele=1121.69 ht=33.22
7 demdead3.tow sta=1673.26 ele=1121.00 ht=32.31
8 demtan2.tow sta=1889.13 ele=1108.69 ht=33.22
9 demdead3.tow sta=2119.13 ele=1108.00 ht=32.31
10 demtan2.tow sta=2443.07 ele=1108.43 ht=37.72 ht adjust=4.50
PI 78°55'56"
PI -30°12'08"
218.08
220.95
215.87
230.00
323.94
378.71
1219.20
1203.96
1188.72
1173.48
1158.24
1143
1127.76
1112.52
1097.28
1295.40
1371.60
1447.80
1524
1600.20
1676.40
1752.60
1828.80
1905
1981.20
2057.40
2133.60
2209.80
2286
2362.20
2438.40
2514.60
2590.80
2667


PLS-CADD Drawing
11
12
13
14
15
16
PI 4082.72
°00'00"
691.43
°02'03"
60.0 m
Horiz. Scale
North
12.0 m
Vert. Scale
1219.20
1203.96
1188.72
1173.48
1158.24
1143
1127.76
1112.52
1097.28
11 demtan2.tow sta=2821.78 ele=1125.81 ht=33.22
12 demtan2.tow sta=3071.02 ele=1125.41 ht=33.22
13 demtan2.tow sta=3384.17 ele=1118.37 ht=33.22
14 demdead3.tow sta=3691.43 ele=1121.43 ht adjust=6.00 ht=38.31
15 demtan2.tow sta=3879.19 ele=1126.35 ht=33.22
16 demdead5.tow sta=4082.72
249.24
313.15
307.26
187.77
203.53
PI 20°02'03"
PI 0°00'00"
2667
2743.20
2819.40
2895.60
2971.80
3048
3124.20
3200.40
3276.60
3352.80
3429
3505.20
3581.40
3657.60
3733.80
3810
3886.20
3962.40
4038.60



60.0 m Horiz. Scale

12.0 m Vert. Scale

North

16
demdead5.tow
sta=4082.72
ht=26.21 ele=1112.50

PI 0°00'00"

1219.20
1203.96
1188.72
1173.48
1158.24
1143
1127.76
1112.52
1097.28

4038.60
4114.80

資料－１１　他ドナー支援事業の遅延による本事業の影響について

11. 他ドナー支援事業の遅延による本事業の影響について

他ドナーが融資する事業のうち本事業と関連のあるものは，現時点では本事業の運用開始よりもかなり前に運用開始している予定である。しかし，可能性は低いものの想定外の事由によりこれらの運用開始が本事業の完工よりも遅延することも考えられる。したがって，その場合の影響について負のリスク管理の一環としてまとめた。

１．中国輸出入銀行が融資する事業（ムコノ変電所新設工事）が遅延した場合の影響

ムコノ変電所はナマンベ南変電所およびルジラ変電所の新設と同一契約対象であるため，遅延する場合は次の２ケースが考えられる。しかしながら，両ケースとも運用上の問題は生じない。

（ケース１）ムコノ変電所だけが遅延する

新ムコノ変電所がナルバレ変電所～ナマンベ変電所間の 132kV 送電線に接続できないことから，ナルバレ発電所～ナマンベ変電所間の 132kV 送電線の系統構成が本事業のコンポーネントが適用されない現在の系統構成とほぼ同じ状態になるため，2022 年断面では，通常時は問題ないが，ナルバレ変電所～ムコノ変電所間の 132kV 送電線の N-1 故障時にカンパラ北変電所～ルゴゴ変電所間の 132kV 送電線が 125%，カワラ変電所～ムトゥンドゥエ変電所間の 132kV 送電線が 121%の過負荷となる。しかし，これら過負荷となる送電線の電線は本事業で HTLS 電線に増強されるため，実際には過負荷は生じないものと考えられる。

（ケース２）ムコノ変電所と他の変電所も同時に遅延する

ムコノ変電所，ナマンベ南変電所およびルジラ変電所は主に周辺の工業団地への供給用に新設されるが，変電所新設遅延に伴い工業団地も新設が遅延することとなり，負荷が軽減されるため，ケース１よりも潮流条件は緩和される。

【まとめ】

系統運用面：

2022 年断面までは，過負荷等の運用上の問題は発生しない。

本事業(JICA)で実施する工事：

・新ムコノ変電所（132kV 母線）からムコノ変電所（132kV 母線）間の接続ケーブルおよび保護リレーおよび通信線の据付

11. 他ドナー支援事業の遅延による本事業の影響について

・新ムコノ変電所（132kV 母線）からナマンベ南変電所用 132kV フィーダー間の接続ケーブルおよび保護リレーおよび通信線の据付

中国輸出入銀行の融資で実施する工事：

・上記の JICA の融資で実施する工事に関するケーブルの接続と保護リレーの調整。

２．世界銀行が融資する事業（カワンダ変電所～マサカ変電所 220kV 送電線新設工事）が遅延した場合の影響

ブロバ変電所は 220kV 設備が利用できないため，132kV 1 回線送電線(110MVA)によりカブラソケ変電所とともにムトゥンドゥエ変電所から供給を受ける配電用変電所(132/33kV, 40MVA*2)としてのみ利用可能となる。

【まとめ】

系統運用面：

2022 年断面までは，過負荷等の運用上の問題は発生しない。

本事業(JICA)で実施する工事：

・ブロバ変電所から 220kV 分岐用鉄塔までの鉄塔，電線および OPGW の設置。

世界銀行の融資で実施する工事：

・電線および OPGW を 220kV 分岐用鉄塔で接続。

・保護リレーの設定変更など運用開始に向け必要な作業の実施。

以　上

資料－１２　UETCL と NFA 間の協議議事録

THE REPUBLIC OF UGANDA

MEMORANDUM OF UNDERSTANDING

BETWEEN

UGANDA ELECTRICITY TRANSMISSION COMPANY (UETCL)

AND

NATIONAL FORESTRY AUTHORITY

FOR THE ESTABLISHMENT OF A TRANSMISSION LINE IN A CENTRAL FOREST RESERVE UNDER THE KAMPALA METROPOLITAN TRANSMISSION PROJECT

Drawn By:
UETCL
Legal Office
P.O.Box 7625
Kampala

THE REPUBLIC OF UGANDA

MEMORANDUM OF UNDERSTANDING

THIS MEMORANDUM OF UNDERSTANDING is made this 19th day of July 2016 By And Between **THE UGANDA ELECTRICITY TRANSMISSION COMPANY LIMITED (UETCL)** of P. O. Box 7625 Kampala (hereinafter referred to as "the Licensee" and shall where the context so admits include its successors and assignees) of the one part, And **NATIONAL FORESTRY AUTHORITY** of P. O. Box 70863 Kampala a Statutory Corporation duly established under the laws of Uganda (hereinafter referred to as "the Authority") and shall where the context so admits, include its successors and assignees) both collectively referred to as "the parties"

WHEREAS: -

A. The Authority is statutorily charged with the management of Central Forest Reserves and is duly entitled to regulate activities in forest reserves and to receive compensation towards mitigation measures for any activities in the Forest Reserve.

B. The Licensee is the owner and developer of a proposed high voltage electricity transmission line under the Kampala Metropolitan Transmission Project that will traverse the Central Forest Reserves Listed in Clause 2 of this Memorandum of Understanding.

C. The Project will traverse the Acreage to be determined during a joint inventory/survey and assessment of the affected forest reserve by the Authority and the Licensee (**Appendix 1**).

D. The Authority shall grant a License to the Licensee to develop a high voltage electricity transmission line to traverse the central forest reserve referred to in **Appendix 1** of this Memorandum of Understanding after the Licensee meeting all conditions set by the Authority and after obtaining all requisite approvals and clearances incidental to the project.

E. The Parties have reached an understanding in respect of their mutual obligations and responsibilities in relation to the management of and compensation for the impacts of the aforesaid Electricity Transmission Line on the Forest Reserves Listed in Clause 2 and Appendix 1 herein.

F. UETCL is the authorized Licensee for purposes of making all due payments and coordinating all necessary activities for and on behalf of the Licensee;

THE PARTIES HAVE AGREED AS FOLLOWS:

1. In consideration of Paying to the Authority the sum that will be agreed and computed as compensation for "The Benefit Stream Foregone", upon detailed forest biomass and biodiversity survey and valuation, the Licensee shall have the concession and right to establish a high voltage electricity transmission line through the Listed Reserves and shall dispose of the growing Stock in the Listed Forest Reserves in accordance with License that will be issued by the Authority.

2. The Forest Reserve affected by the Kampala Metropolitan Transmission Project that is subject of this Memorandum of Understanding herein Referred to as the "Listed Reserve" is: Nandagi Central Forest Reserves (**Appendix 1**).

UGANDA ELECTRICITY TRANSMISSION CO LTD P. O. BOX 7625, KLA

3. The Benefit Stream Foregone for purposes of Computation of the consideration payable to the Authority will be determined and attached hereto and shall be the Biodiversity and Economic Valuation of Compensation to the Authority for Way-leaves and Line Construction in the Listed Reserves. The sum specified shall be the Agreed Total Compensation due to the Authority is full and final compensation to the Authority for the Benefit Stream Foregone and shall exclude license holders.

4. The Licensee shall compensate the private tree farmers and license holders found in the path of the way leave separately from and independent of the Authority.

5. Upon Signing of this Memorandum of Understanding the Authority shall grant the Licensee and any of its agents and contractors leave to traverse the affected forest area and land to carry out preliminary investigations.

6. The Licensee shall exercise the various rights that shall be stipulated in the license conditions to be issued by the Authority upon compensation for the Benefit Stream Foregone.

7. The Authority shall provide technical assistance to the Licensee for purposes of carrying out the necessary Forest Clearance activities and disposing of growing stock in the Affected Areas.

8. The licensee warrants that acquisition of rights to set up the electricity Transmission Installations in the Listed Reserves and other use and occupancy rights shall be subject to the license.

9. This Memorandum shall not apply to Private Tree Farmers or private forests in any other location along the proposed line route. The Licensee agrees and understands that compensation for growing stock to private tree farmers with Licenses from the Authority shall be negotiated and concluded directly with such Private Tree Farmers.

10. All Appendices hereto shall be read as one and fully binding as part of this Memorandum of Understanding.

11. The Licensee shall before possession of the land obtain an Environmental Impact Assessment Certificate and/or approval from the National Environment Management Authority and all other requisite approvals and clearances incidental to the project.

12. Both parties shall carry out a joint biomass and biodiversity assessment and ground survey of the substation and associated transmission corridors at the cost of the Licensee.

UGANDA ELECTRICITY TRANSMISSION CO LTD
P. O. BOX 7625, KLA

In the presence of:

Managing Director/CEO

In the presence of:

DENNIS L. WAMALA
ADVOCATE
COMMISSIONER FOR OATHS
P. O. BOX 7026, KAMPALA

COMPANY SECRETARY

The Common Seal of the
NATIONAL FORESTRY AUTHORITY was affixed hereto:

NATIONAL FORESTRY AUTHORITY
NFA
05 JUL 2016
OFFICE OF THE EXECUTIVE DIRECTOR

In the presence of:

Executive Director

In the presence of:

LEGAL MANAGER

APPENDIX 1

LISTED CENTRAL FOREST RESERVES

S.No	Forest Reserve	Substation Site (Acres)	Transmission Line (Acres)	Total Area affected in Acres
1	Nandagi	TBV	TBV	TBV
	TOTAL	**TBV**	**TBV**	**TBV**

TBV: To Be Verified during a joint biomass and biodiversity inventory and survey in the affected forest reserve

UGANDA ELECTRICITY TRANSMISSION CO LTD
P. O. BOX 7625, KLA

資料－１３　環境モニタリングフォーム

Environmental Monitoring Form

1. Pre-construction phase

(1) Comments from the public and NEMA regarding the EIA

Monitoring item	Comments	Response of UETCL
Contents of formal comments from the public on the EIA		
Contents of formal comments from NEMA on the EIA		

(2) Nandagi Forest Reserve

Monitoring item	Status
Progress of compensation measures	
Replantation progress of endangered flora (e.g. *Jacaranda mimosifolia*)	

2. Construction phase

(1) Noise (L_{Aeq})

Location	Results (LAeq)	Reference standard*	Compliance status	Measures implemented in case of non-compliance
		75 dB (day) 50 dB (night)		

*: Maximum Permissible Noise Levels for Construction Site (commercial area), Part IV of Firste Schedule of National Environment (Noise Standards And Control) Regulations, 2003

(2) Air quality (PM_{10}, $PM_{2.5}$)

Location	Results	Reference standard*	Compliance status	Measures implemented in case of non-compliance
		PM10: 50 μg/m^3 (24hr average)		
		PM2.5: 20 μg/m^3 (24hr average)		

*: WHO Air Quality Guideline

(3) Water quality (pH, DO, COD, SS, turbidity, T-N, T-P, oil and grease)

Location	Results	Reference standard*	Compliance status	Measures implemented in case of non-compliance

*: Baseline data

(4) Soil pollution

Location	Record of soil pollution	Action taken

(5) Waste

Location	Record of inappropriate waste management	Action taken

(6) Occupational safety

Location	Record of occupational accidents	Action taken

(7) Ecosystem

Location	Satus	Actions taken
	Describe if any adverse impacts occurred due to construction activities such as accidental animal kills, incidents of poaching, destruction of habitats outside project area, finding of endangered species, intrusion of invasive species	

3. Operation phase

(1) Water quality (SS, turbidity)

Location	Results	Reference standard*	Compliance status	Measures implemented in case of non-compliance

*: Baseline data

(2) Waste

Location	Record of inappropriate waste management	Action taken

(3) Ecosystem

Location	Satus	Actions taken
	Describe if any adverse impacts occurred such as bird kills, intrusion of invasive species	

資料－１４　ステークホルダーミーティング議事録

1. Meeting with National Forest Authority (NFA)

Week	**11**	Meeting date	**16 March 2016**
		Recorded by	**BA**
Meeting/subject	**Meeting with National Forestry Authority (NFA) - Consultation on GKMA Transmission Line Improvement Project**	Total pages	**2**

Present	Apology	Copy	Name	Organisation	Designation
☒	☐	☐	List attached	NFA	
☒	☐	☐	Denis Mutaryebwa	NFA	Coordinator Plantations
☒	☐	☐	Takeshi Sato	JICA Study Team	ESIA Specialist
☒	☐	☐	Kazu Nogami	JICA Study Team	
☒	☐	☐	Dr. Isa Kabenge	JICA Study Team	Engineer
☒	☐	☐	Brenda Amanda (BA)	JICA Study Team	Engineer

Item	Update
1.	**Introduction**
	The JICA study team was welcomed by Tom Rukundo, the NFA EIA Specialist and self-introductions made. A presentation of the Project details was made by the JICA study team. The presentation included: • Project Background • Project Location • Project and activities components • The ESIA process • Potential Environmental and Social Impacts (construction and operation phase) • Mitigation Measures for identified impacts (construction and operation phase) • Resettlement Action Plan (land survey and valuation survey procedures, compensation process, grievance mechanism, and disturbance allowance)
2.	**Question and Answer Session**
2.1.	**Comment:** Nandagi is located outside the nursery bed, the land was given to tree farmers by NFA, so the land belongs to NFA, but the trees belong to individual farmers. It is also managed by NFA. Since it is government land, an offset fee is paid. NFA will dialogue with UETCL regarding the offset.
2.2.	**Comment:** Biodiversity evaluation should be part of the ESIA study. For the transmission line through Mabira, UETCL got a consultant to do the biodiversity evaluation.
2.3.	**Comment:** Purpose of the forest reserve is mostly as a catchment area where streams pass.
2.4.	**Comment:** Uncoordinated planning is a major problem for the forest reserves example, Standard Gauge Railway and Oil Pipeline. The cumulative impacts can be great, such that the forest reserves are lost.
2.5.	**Comment:** Minimal impact would be going through the sugarcane plantation. Why isn't the line going through the plantation and instead through the forest reserve. The 16 acres obtained for the substation were already acquired by UETCL. This project is only dealing with the transmission line corridor for the new proposed substation, since it was found that this 16 acres was sufficient for two substations.

2.6.	**Comment:** A 'no-objection' letter about the Chinese Project was obtained by UETCL. NFA does not have an official confirmation about this. NFA will follow-up the matter with UETCL.
2.7.	**Comment:** Booklet on management of forest reserves regarding activities acceptable within the reserves is available and can be shared with the Consultant.
2.8.	**Recommendation:** Send kmz file of Project area to NFA John Diisa (Coordinator GIS) and Tom Rukundo so that extent of Project area within forest reserves is known.

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community: NATIONAL FOREST AUTHORITY (NFA)					
Purpose of consultation (tick appropriate box):	Scoping			ESIA	✓
	Sensitisation			RAP	✓
	Environmental Audit			Other (specify)	
Date: 16th March 2016					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name of person/ official met:	Designation	Contact (Tel/email)	Sign/ initial		

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2. Meeting with National Forest Authority (NFA)

Week	**13**	Meeting date	**5 April 2016**
		Recorded by	**BA**
Meeting/subject	**Meeting National Forestry Authority - Consultation on GKMA Transmission Line Improvement Project**	Total pages	**2**

Present	Apology	Copy	Name	Organisation	Designation
☒	☐	☐	List attached	NFA	
☒	☐	☐	Paul Okiror	UETCL	Safeguard Officer
☒	☐	☐	Takeshi Sato	JICA Study Team	ESIA Specialist
☒	☐	☐	Dr. Isa Kabenge	Air Water Earth	Engineer
☒	☐	☐	Brenda Amanda (BA)	Air Water Earth	Engineer

Item	Update
1.	**Introduction**
	The JICA study team was welcomed and self-introductions made. A presentation of the Project details was made by the JICA study team. The presentation included: • Project Background • Project Location • Project and activities components • The ESIA process • Potential Environmental and Social Impacts (construction and operation phase) • Mitigation Measures for identified impacts (construction and operation phase) • Resettlement Action Plan (land survey and valuation survey procedures, compensation process, grievance mechanism, and disturbance allowance)
2.	**Question and Answer Session**
2.1.	**Comment:** First project-Electrification of Mukono industrial parks project. More two substations connecting Iganga to Mayuge.
2.2.	**Comment:** The Mukono industrial parks project affects Nandagi project. Options/ alternatives considerations include social, environmental and economic alternatives analysis.
2.3.	**Comment:** Negotiations are still on-going with NFA so the transmission line corridor and substation sites are not yet confirmed.
2.4.	**Comment:** The Chinese require 30m corridor, while JICA transmission line requires 75m corridor. That is a total of 105m. The substation is 3 acres, 6 ha as approximate transmission line length inside the substation. Access road is 1.2km (8m wide).
2.5.	**Comment:** NFA needs to see the option selection reports showing the alternatives and why the forest reserve area was selected.
2.6.	**Question:** What distance was left for the river protection? River Kasala which joins Sezibwa downstream.
2.7.	**Question:** Standard gauge railway and other proposed roads. Has UETCL found out about any other projects that are planned for the near future within the project area? Standard gauge railway to be 2m from the ground. This project needs to be harmonised with other government projects e.g. Railway, Jinja Expressway.

2.8.	**Comment:** NFA needs to know that UETCL has confirmed that there are no projects planned or existing that can share a wayleave with the UETCL projects.
2.9.	**Concern:** UETCL needs to own the projects, as opposed to pseudo names like Chinese substation or Japanese substation.
2.10.	**Comment:** Bujagali substation will be intended to increase switch from 132kV (existing) to 220kV, although without need for more land requirement.
2.11.	**Comment:** Another meeting will be held in which the documents submitted by UETCL will be arranged. A field visit of the area will then be held.
2.12.	**Concern:** The width of the corridor is wide and yet it is a protected area.

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community:	NATIONAL FORESTRY AUTHORITY (NFA)				
Purpose of consultation (tick appropriate box):	Scoping			ESIA	✓
	Sensitisation			RAP	✓
	Environmental Audit			Other (specify)	
Date: 5th April 2016					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name of person/ official met:	Designation	Contact (Tel/email)	Sign/ Initial		

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STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community:	NATIONAL FORESTRY AUTHORITY (NFA)				
Purpose of consultation (*tick appropriate box*)	Scoping			ESIA	✓
	Sensitisation			RAP	✓
	Environmental Audit			Other (specify)	
Date: 5th August 2015					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name of person/ official met:	Designation	Contact (Tel/email)	Sign/ initial		

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Mukono Project Area

1. Meeting with National Forestry Authority (NFA) private foresters

Week	**11**	Meeting date	**10 May 2016**
		Recorded by	**IKK**
Meeting/subject	**Meeting with National Forestry Authority (NFA) Private foresters- Consultation on GKMA Transmission Line Improvement Project**	Total pages	**2**

Present	Apology	Copy	Name	Organization	Designation
☒	☐	☐	List attached	NFA Foresters	
☒	☐	☐	Mercy Nampurira	NFA	Nandagi Forest Supervisor
☒	☐	☐	Ian Kakuru Kahigi (IKK)	Air Water Earth Ltd	Valuation Surveyor
☒	☐	☐	Edward Okot Omoya (EOO)	Air Water Earth Ltd	Ecologist

1.	**Introduction**
	The NFA Nandagi Forest Supervisor welcomed the team and the foresters that managed to make it for the sensitization meeting. Introductions of the Consultant team present for the meeting were made. A presentation of the 'ESIA and RAP for The Preparatory Survey for the Greater Kampala Metropolitan Area Transmission System Improvement Project' was made to the PAPs present who comprised registered NFA foresters, their managers and a few unregistered share croppers. The presentation included: • Project Background • Project Location • Project and activities components • The ESIA process • Potential Environmental and Social Impacts (construction and operation phase) • Mitigation Measures for identified impacts (construction and operation phase) • Resettlement Action Plan (land survey and valuation survey procedures, compensation process, grievance mechanism, and disturbance allowance)
2.	**Question and Answer Session**
2.1.	**Question:** What is the project duration and when is it expected to commence? **Response:** The project duration is not certain at the moment, since this is still at the preparatory stage, although surveying and valuation is expected to commence as soon as possible.
2.2.	**Comment:** The NFA forest supervisor should be included on the grievance committee as she knows the affected people personally and would be better able to assist in addressing their issues.
2.3.	**Question:** Will the project be able to provide certain additional services that are lacking in the community e.g health centre, drug store? **Response:** The consultant is not privy to that information but will ensure to convey to the project proponent.

2.4.	**Question:** Will share croppers who are planting their crops in the forest be compensated for their loss of livelihood? **Response:** According to the NFA forest supervisor, no croppers are permitted within the forest reserve and therefore any croppers therein are operating illegally. On this basis, no croppers will be compensated.

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community: NANDAGI FOREST FARMERS					
Purpose of consultation (tick appropriate box):	Scoping			ESIA	✓
	Sensitisation	✓		RAP	✓
	Environmental Audit	✓		Other (specify)	
Date: 10/05/2016					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name	Village/Parish	Contact (Telephone)	Sign/ initial		

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STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community: NANDAGI FOREST FARMERS					
Purpose of consultation (*tick appropriate box*):	Scoping			ESIA	✓
	Sensitisation	✓		RAP	✓
	Environmental Audit	✓		Other (specify)	
Date: 10/05/2016					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name	Village/Parish		Contact (Telephone)		Sign/ initial

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STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community: NANDAGI FOREST FARMERS					
Purpose of consultation (*tick appropriate box*):	Scoping			ESIA	✓
	Sensitisation	✓		RAP	✓
	Environmental Audit	✓		Other (specify)	
Date: 10/05/2016					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name	Village/Parish		Contact (Telephone)		Sign/ initial

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STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community: NANDAGI FOREST FARMERS					
Purpose of consultation (*tick appropriate box*):	Scoping			ESIA	✓
	Sensitisation	✓		RAP	✓
	Environmental Audit	✓		Other (specify)	
Date: 10/05/2016					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name	Village/Parish		Contact (Telephone)		Sign/ initial

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2. Meeting with Community in Mukono Project Area - Nama II, Buyuki and Luwunga villages

Week	**11**	Meeting date	**30 April 2016**
		Recorded by	**IKK**
Meeting/subject	**Meeting with Communities in Mukono - Nama II, Buyuki and Luwunga villages - Consultation on GKMA Transmission Line Improvement Project**	Total pages	**2**
Project Proponent	**UETCL**		

Present	Apology	Copy	Name	Organisation	Designation
☒	☐	☐	List attached	Nama II, Buyuki and Luwunga	Project Affected Persons
☒	☐	☐	List attached	Nama II, Buyuki and Luwunga	Chairpersons
☒	☐	☐	Ian Kakuru Kahigi (IKK)	Air Water Earth Ltd	Valuation Surveyor
☒	☐	☐	Isa Kabenge	Air Water Earth Ltd	Engineer

1.	**Introduction**
	The LC1 Chairman of Luwunga zone welcomed the team. Introductions of the consultant team and chairpersons present for the meeting were made. A presentation of the **'ESIA and RAP for The Preparatory Survey for the Greater Kampala Metropolitan Area Transmission System Improvement Project'** was made to the chairpersons and a few PAPs present, including but not limited to: The presentation included: • Project Background • Project Location • Project and activities components • The ESIA process • Potential Environmental and Social Impacts (construction and operation phase) • Mitigation Measures for identified impacts (construction and operation phase) • Resettlement Action Plan (land survey and valuation survey procedures, compensation process, grievance mechanism, and disturbance allowance)
2.	**Question and Answer Session**
2.1.	**Comment:** Projects take place but compensation delays for a long time and this affects the PAPs because their plans are put on hold and they incur losses in the process.
2.2.	**Comment:** L.C1s are a vital part of any project implementation and yet they are usually not compensated for their time and effort yet they are fully involved in the project from start to finish. This should be given consideration so that they may be enlisted on project implementation teams in some capacity. **Response:** The LCs will be facilitated for their involvement, especially when they have to walk with the Surveyors and Valuers.

2.3.	**Concern:** If assessment has been done but compensation is eventually not done and the project is aborted. How would the PAPs be compensated after sacrificing their properties and not undertaking any developments as a result? **Response:** The principle in Uganda is to compensate for affected properties. Therefore, no injury or damage is realised if the project is aborted and hence no compensation payment can be advanced.
2.4.	**Question:** Who constitutes the grievance committee? **Response:** The grievance committee constitutes a member of the Local Council, a member of the project proponent organisation and an identified NGO from the project area.
2.5.	**Concern:** In some instances, PAPs' structures get old and collapse before compensation is done. How will these be handled if re-assessment is done subsequently? **Response:** In the event that a PAP's structure collapses before compensation, the PAP will get the compensation due him as his property information will have already been captured.
2.6.	**Question:** Will PAPs be permitted to use the land after the project has been implemented? **Response:** The project proponent intends to fully compensate and acquire the project area and therefore no work or developments by PAPs will be allowed subsequent to project implementation.
2.7.	**Concern:** How will kibanja holders and title owners be compensated? **Response:** Kibanja owners and title holders will be equitably compensated in their individual holding capacities on pro rata basis.
2.8.	**Concern:** Wives may not receive any money and the husbands claim it all and squander it. How will their interests be put into consideration? **Response:** Wives especially those who are legally or traditionally married will be put into consideration by having their information captured during the payment exercise and as much as possible, husbands will be encouraged to present joint accounts for payment. This will be done with the help of the L.C1 to identify such risk prone relationships.

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community:	Nama II, Buyuki & Luwunga			
Purpose of consultation (*tick appropriate box*):	Scoping		ESIA	✓
	Sensitisation	✓	RAP	✓
	Environmental Audit		Other (specify)	
Date:	30/04/2016			
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT				
Proponent: YACHIYO ENGINEERING COMPANY LTD.				

Name	Village/Parish	Contact (Telephone)	Sign/ initial
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STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community:	Nama II, Buyuki & Luwunga			
Purpose of consultation (*tick appropriate box*):	Scoping		ESIA	✓
	Sensitisation	✓	RAP	✓
	Environmental Audit		Other (specify)	
Date:	30/04/16			
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT				
Proponent: YACHIYO ENGINEERING COMPANY LTD.				

Name	Village/Parish	Contact (Telephone)	Sign/ initial
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STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community:	Nsw. II, Bugabi & Luwunga				
Purpose of consultation (*tick appropriate box*):	Scoping		ESIA	✓	
	Sensitisation	✓	RAP	✓	
	Environmental Audit		Other (specify)		
Date: 30/9/16					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name	Village/Parish	Contact (Telephone)	Sign/ Initial		

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3. Meeting with Community in Mukono Project Area - Wanjeyo, Kivuvu and Bwefulumya villages

Week	**11**	Meeting date	**30 April 2016**
		Recorded by	**IKK**
Meeting/subject	**Meeting with Communities in Mukono - Wanjeyo, Kivuvu and Bwefulumya villages - Consultation on GKMA Transmission Line Improvement Project**	Total pages	**2**
Project Proponent	**UETCL**		

Present	Apology	Copy	Name	Organisation	Designation
☒	☐	☐	List attached	Wanjeyo, Kivuvu and Bwefulumya	Project Affected Persons
☒	☐	☐	List attached	Wanjeyo, Kivuvu and Bwefulumya	Chairpersons
☒	☐	☐	Ian Kakuru Kahigi (IKK)	Air Water Earth Ltd	Valuation Surveyor
☒	☐	☐	Isa Kabenge	Air Water Earth Ltd	Engineer

1.	**Introduction**
	The LC1 Chairman of Bwefulumya zone welcomed the team. Introductions of the consultant team and chairpersons present for the meeting were made. A presentation of the **'ESIA and RAP for THE Preparatory Survey for the Greater Kampala Metropolitan Area Transmission System Improvement Project'** was made to the chairpersons and a few PAPs present, including but not limited to: The presentation included: • Project Background • Project Location • Project and activities components • The ESIA process • Potential Environmental and Social Impacts (construction and operation phase) • Mitigation Measures for identified impacts (construction and operation phase) • Resettlement Action Plan (land survey and valuation survey procedures, compensation process, grievance mechanism, and disturbance allowance)
2.	**Question and Answer Session**
2.1.	**Question:** Where exactly is the project going to pass within this particular area? **Response:** The project route is outlined in the google earth image on the presentation slides. The transmission lines will commence from the intersection with the chinese lines in Nama, Luwunga downhill up to Bwefulumya where they meet the substation. The substation will predominantly affect commercial foresters in Nandagi Forest reserve
2.2.	**Comment:** It has been said that community members will be given opportunities for employment during project works. That will be a good initiative.

2.3.	**Question:** Are the power lines going to be connected from existing lines to the new sub-station? **Response:** Yes, there will be a 132 kV line connecting from the substation to the existing transmission lines along the highway.
2.4.	**Question:** Will power supply from the new lines and sub-stations be able to connect for community domestic use? **Response:** Yes, from the 132 kV connection to existing transmission lines but not directly to the high voltage lines or the substation.
2.5.	**Concern:** Can the local leaders write to project so that any projects being implemented within this community give job opportunities especially labourers to community members first? **Response:** As a principle, project contractors are encouraged to utilise community members of the project community for some lay jobs to help raise the economic status of the project community. This is done in conjunction with the local leaders. However, the local leaders are at liberty to write to the project contractors to request for such job opportunities for their community.
2.6.	**Question:** If the corridor to be acquired borders with someone's house, would that person's house be affected and can they be compensated for that house? **Response:** In such an event, the person would not be compensated unless if he suffered injurious affection as a result of project works.
2.7.	**Question:** Since a sub-station is to be constructed within the community, can UMEME and UETCL make some effort to increase the density of power supply and connections in this area? **Response:** It is not within the mandate of the consultant to advise UMEME or UETCL on how to distribute power resources but the consultant shall present the concerns of the community for their discretionary review.

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community:	Namawojjolo West, Kasenge, Bwefulumya,			
Purpose of consultation (*tick appropriate box*):	Scoping		ESIA	✓
	Sensitisation	✓	RAP	✓
	Environmental Audit		Other (specify)	
Date: 30/04/16				
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT				
Proponent: YACHIYO ENGINEERING COMPANY LTD.				

Name	Village/Parish	Contact (Telephone)	Sign/ initial

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Stand. Doc No. AWE/036

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community:	Namawojjolo West, Kasenge, Bwefumunya			
Purpose of consultation *(tick appropriate box)*:	Scoping		ESIA	✓
	Sensitisation	✓	RAP	✓
	Environmental Audit		Other (specify)	
Date:	30/04/16			
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT				
Proponent: YACHIYO ENGINEERING COMPANY LTD.				

Name	Village/Parish	Contact (Telephone)	Sign/ initial
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Buloba Project Area

4. Meeting with Community in Buloba Project Area - Kaggaba, Mabuye and Nsujjwe villages

Week	**05**	Meeting date	**27 January 2016**
		Recorded by	**BA**
Meeting/subject	**Meeting with Buloba residents (Kaggaba, Mabuye and Nsujjuwe villages)- Consultation on GKMA Transmission Line Improvement Project**	Total pages	**2**

Present	Apology	Copy	Name	Village	Designation
☒	☐	☐	List attached	Buloba residents	
☒	☐	☐	Ian Kakuru	Air Water Earth Ltd.	Valuer
☒	☐	☐	Brenda Amanda	Air Water Earth Ltd.	Engineer

1.	**Introduction**
	The AWE team was welcomed and self-introductions made. A presentation of the Project details was made by the AWE team. The presentation included: • Project Background • Project Location • Project and activities components • The ESIA process • Potential Environmental and Social Impacts (construction and operation phase) • Mitigation Measures for identified impacts (construction and operation phase) • Resettlement Action Plan (land survey and valuation survey procedures, compensation process, grievance mechanism, and disturbance allowance)
2.	**Question and Answer Session**
2.1.	**Question:** Is the 15 acres mentioned only for the substation, or for the entire Project area? **Response**: The 15 acres mentioned is for the substation area.
2.2.	**Question:** How will the *kibanja* holders and title holders be catered for? **Response:** The compensation for such an area is split such that the kibanja holder receives 70% of the compensation sum while the title holder receives 30% of the compensation sum.
2.3.	**Comment:** Sometimes the Valuers don't give the right amount e.g. someone who deserves more money gets less, and vice versa. **Response:** The valuation process will be conducted in line with the laws of Uganda and the JICA Guidelines for Social and Environmental Considerations. In accordance with the Ugandan laws, the Valuation report will be submitted to the Chief Government Valuer for approval of the compensation values to be used for the Project.
2.4.	**Question:** How will the Grievance Committee be selected and where could it be found? **Response:** The Grievance Committee will be composed of the area local chairpersons such as LC I and LC II. Aside from the local chairpersons, the Committee will also include an elder on the village, an opinion leader, as well as a representative from UETCL. The Committee's office shall be at the LC Chairperson's office, or another location that the PAPs agree upon as being the most convenient. UETCL also has officers that are dedicated to handling the RAP issues that arise from their various Projects.

2.5.	**Question**: If a young fruit tree has been valued, will the future prospects be catered for e.g. the jack fruit trees or oranges that would have been reaped from the fruit tree? **Response:** No, valuations are done on as as-is basis. Projections are not done during the valuation exercise.
2.6.	**Suggestion:** Both the kibanja holder and title holder should be present during the Valuation exercise. **Response:** All PAPs will be notified when the fieldwork for surveying and valuation is taking place.
2.7.	**Comment:** Sometimes the cut-off date is announced but the Project takes long to start, yet the people have been asked to hold off on developments. **Response:** If a Project takes more than 2 years after the cut-off date, a re-evaluation is done to take into consideration any changes.
2.8.	**Complaint:** Towards the end of last year (2015), a team doing geo-technical surveys was in the area. The team ate fruits from community members' trees and also parked their vehicles in peoples' compounds without asking for permission. **Response**: It is regrettable that community members' property was not respected. All the Consultants involved will be informed to ensure that all field staff respect community members' property and make requests to use or purchase any individual or community resources.
2.9.	**Question:** The Graveyard for the Grail Sisters is within the Project area. Will these graves be relocated? **Response:** The Project route will try as much as possible not to affect any physical and cultural resources. However, the affected areas will be more accurately identified after the surveyors have started with field work and marked out the substation and corridor extents.
2.10.	**Question:** Some landowners do not live in the area and have to travel from far. Will facilitation be provided for this? **Response:** No, facilitation is not provided for the community members to attend meetings.

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community: KAGABA, MABUYE & NSUSUWE VILLAGES, MPIGI DISTRICT.					
Purpose of consultation (tick appropriate box):	Scoping			ESIA	✓
	Sensitisation	✓		RAP	✓
	Environmental Audit			Other (specify)	
Date: 27th January 2016					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name of person/ official met:	Designation (Village)		Contact (Tel/email)		Sign/ Initial

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community:	KAGGABA, MABUYE & NJUJJWE VILLAGES, MPIGI DISTRICT				
Purpose of consultation (*tick appropriate box*):	Scoping			ESIA	✓
	Sensitisation	✓		RAP	✓
	Environmental Audit			Other (specify)	
Date:	27th January 2016				
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name of person/ official met:	Designation (Village)	Contact (Tel/email)	Sign/ initial
[redacted]			

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5. Meeting with Community in Buloba Project Area - Kaggaba, Mabuye and Nsujjwe villages

Week	**13**	Meeting date	**30 March 2016**
		Recorded by	**BA**
Meeting/subject	**Meeting with Buloba residents (Kaggaba, Mabuye and Nsujjwe villages)- Consultation on GKMA Transmission Line Improvement Project**	Total pages	**2**

Present	Apology	Copy	Name	Village	Designation
☒	☐	☐	List attached	Buloba residents	
☒	☐	☐	Ian Kakuru	Air Water Earth Ltd.	Valuer
☒	☐	☐	Isa Kabenge	Air Water Earth Ltd.	Engineer
☒	☐	☐	Brenda Amanda	Air Water Earth Ltd.	Engineer
☒	☐	☐	Sato Takeshi	JICA Study Team	ESIA Specialist

1.	**Introduction**
	The AWE team was welcomed and self-introductions made. A presentation of the Project details was made by the AWE team. The presentation included: • Project Background • Project Location • Project and activities components • The ESIA process • Potential Environmental and Social Impacts (construction and operation phase) • Mitigation Measures for identified impacts (construction and operation phase) • Resettlement Action Plan (land survey and valuation survey procedures, compensation process, grievance mechanism, and disturbance allowance)
2.	**Question and Answer Session**
2.1.	**Concern:** It would be best to invite only those who are directly affected by the project so as not to waste too much time. Some people invited for the meeting will not lose land to the project.
2.2.	**Question:** Can't the surveyors and valuers come soon so that the affected people are identified? The most important thing is for the project area to be clearly marked. **Response:** The Surveyors and Valuers will start field work after they are informed that community sensitization meetings such as this one have been held.
2.3.	**Question:** Would the project come to a standstill if there were land wrangles within the project area? **Response:** The Project's Grievance Mechanism makes it possible to have dialogue with the ownership of the land that has wrangles. If the matters cannot be easily resolved, and no feasible alternative can be made to the Project design, there is the possibility of a hold-up in the Project progress.
2.4.	**Question:** Is it possible for the project route to change if it interacts with many other projects e.g. the Express highway? **Response:** Yes, the Project design can be changed at this point if major obstacles are met or identified.
2.5.	**Comment:** The contacts provided by the Consultants should be those of individuals and not general office numbers. Noted: Individual phone numbers will be provided, in addition to the office phone number.

2.6.	**Question:** When will the project start? **Response:** Towards the end of this year 2016, Government of Uganda and Japanese government are expected to sign an agreement. Project implementation will then probably take about two years.
2.7.	**Comment:** The time lag between the Surveyors and Valuers should not be long as this could result in people continuing to develop their land, sometimes dubiously.
2.8.	**Concern:** People's property should be adequately compensated.

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community:	KAGGABA, MABUYE & MUTUNWE VILLAGES				
Purpose of consultation (*tick appropriate box*):	Scoping			ESIA	✓
	Sensitisation	✓		RAP	
	Environmental Audit			Other (specify)	
Date:	30th March 2016.				
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name of person/ official met:	~~Designation~~ Village		Contact (Tel/email)	Sign/ initial	

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Air Water Earth
www.awe-engineers.com
ISO9001:2008

Stanc. Doc No. AWE/034

Kawaala Project Area

6. Meeting with Community in Kawaala Project Area - Namungoona residents

Week	**13**	Meeting date	**29 March 2016**
		Recorded by	**BA**
Meeting/subject	**Meeting with Namungoona residents- Consultation on GKMA Transmission Line Improvement Project**	Total pages	**2**

Present	Apology	Copy	Name	Village	Designation
☒	☐	☐	List attached	Namungoona residents	
☒	☐	☐	Isa Kabenge	Air Water Earth Ltd.	Engineer
☒	☐	☐	Brenda Amanda	Air Water Earth Ltd.	Engineer

1.	**Introduction**
	The AWE team was welcomed and self-introductions made. A presentation of the Project details was made by the AWE team. The presentation included: • Project Background • Project Location • Project and activities components • The ESIA process • Potential Environmental and Social Impacts (construction and operation phase) • Mitigation Measures for identified impacts (construction and operation phase) • Resettlement Action Plan (land survey and valuation survey procedures, compensation process, grievance mechanism, and disturbance allowance)
2.	**Question and Answer Session**
2.1.	**Question:** Can one remove some of their property such as roof or doors even after they have been paid? **Response:** Yes, as long as the information has been captured by the Valuer. All additions or subtractions from property after the cut-off date are not considered during compensation.
2.2.	**Question:** The cable, in some cases is passing through land that is undeveloped. Will such land owners be compensated? **Response:** Yes, all land owners will be compensated for their lost property. Developments on the land are also compensated for.
2.3.	**Question:** It is possible that the trench will affect some people even though it is not necessarily going through their land? Can such people volunteer to be compensated for relocation if they are uncomfortable having the cable so close to them? **Response:** No, one cannot volunteer to be affected by the Project. However, any damage to one's property during the course of the Project implementation can be compensated. The reporting of such cases would be done through the Local leaders and the Grievance Committee.
2.4.	**Question:** The land on which the current substation is located belonged to one of the meeting participants who was not compensated. Will the remaining land also be taken without compensation? **Response:** This Project will be implemented in line with JICA Guidelines and Ugandan laws. Therefore, all people whose land will be acquired will be compensated for both their land, and any property on the land affected.

2.5.	**Question:** Will the project give time for the brick making to be completed before the project can commence? **Response:** Yes, because notice to relocate will be given when the compensation money is paid. This notice period is always given, because it also has an impact on the amount of compensation given since the disturbance allowance is calculated based on the notice period.
2.6.	**Question:** Who gets compensated? The landowner or tenant? **Response:** Both the land owner and kibanja holder receive compensation. An example in this area that is on Kabaka's land is that on Kabaka's land, the Buganda Land Board receives 30% of the calculated compensation amount while the Kibanja holder will receive 70% of the compensation amount. A tenant occupying a house will not receive any part of the compensation sum because ample notice will be given and none can always move to another location.
2.7.	**Comment:** The entire compensation process should involve the LC chairman. **Response:** Noted. Chairpersons are always involved in the compensation process.

STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community: NAMUNGOONA LC1					
Purpose of consultation (*tick appropriate box*):	Scoping			ESIA	✓
	Sensitisation	✓		RAP	
	Environmental Audit			Other (specify)	
Date: 29th March 2016					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name of person/ official met:		Designation	Village	Contact (Tel/email)	Sign/ initial

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STAKEHOLDER CONSULTATION RECORD

Name of agency/stakeholder/community: NAMUNGOONA LC I					
Purpose of consultation (*tick appropriate box*):	Scoping			ESIA	✓
	Sensitisation	✓		RAP	✓
	Environmental Audit			Other (specify)	
Date: 29th March 2016					
Project name: PREPARATORY SURVEY FOR THE GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT					
Proponent: YACHIYO ENGINEERING COMPANY LTD.					
Name of person/ official met:	~~Designation~~ Village		Contact (Tel/email)		Sign/ initial

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資料－１５　RAP モニタリングフォーム

Table 1 Progress of land acquisition, compensation and resettlement

Resettlement activities	Planned total	Unit	Progress in quantity			Progress in %		Expected completion date	Responsible organization	Note
			Previous Quarter	Current Quarter	Remaining	Previous Quarter	Current Quarter			
Progress of land acquisition	50	ha	10	25	25	25	50	2016/12	UETCL	
Progress of land compensation (in cash)	10	No. of HHs	5	7	3	50	70	2016/12	UETCL	
Progress of land compensation (land for land)		No. of HHs								
Progress of asset compensation (in cash)		No. of HHs								
Progress of asset compensation (by replacement structure)		No. of HHs								
Progress of crop compensation		No. of HHs								
Progress of resettlement		No. of HHs								
Others										

Table 2 Grievance report

	Date received	Contents of grievance	Actions taken and status
1			
2			

資料－１６　外部モニタリングの TOR 案

TERMS OF REFERENCE FOR AN EXTERNAL MONITORING AGENCY FOR GREATER KAMAPALA METROPLITAN AREA TRANSMISSION SYSTEM IMPROVEMENT PROJECT

A. Project Background

The Republic of Uganda has been experiencing high economic growth and approximately 7% annual economic growth has been recorded over the past years. In line with this growth trend, the power demand has also been increasing rapidly at 9.7% on average per year from 2007 to 2012. The Project aims to increase the capacity of power supply through the upgrade of transmission and substation system in Kampala Metropolitan Area.

To implement the Project, land acquisition will be required at Buloba, New Mukono and Kawaala components. People affected by the land acquisition will be compensated and rehabilitaed by UETCL in accordance to the Resettlement Action Plan (RAP). UETCL seeks to engage an independent External Monitoring Agency (EMA) to undertake monitoring and evaluation of the RAP implementation process.

B. Key Objective of External Monitoring

Monitoring is an integral part of the resettlement process. The External Monitoring Agency (EMA) will review implementation process as per set policies and criterias in the RAPs report, assess the achievement of resettlement objectives, the changes in living standards and livelihoods, restoration of the economic and social base of the project affected people, the effectiveness, impact and sustainability of entitlements, the need for further mitigation measures if any, and to learn strategic lessons for future policy formulation and planning.

C. Scope of Work

The scope of work of the External Monitoring Agency (EMA) will include the following activities:-

1. To develop specific monitoring indicators for undertaking monitoring of the Resettlement Action Plan (RAP).
2. To review and verify the progress in land acquisition/resettlement implementation of the Project.
3. Identify the strengths and weaknesses of the land acquisition/resettlement objectives and approaches as well as implementation strategies.
4. Evaluate and assess the adequacy of compensation given to the APs and the livelihood opportunities and incomes as well as the quality of life of APs of project-induced changes.
5. Identification of the categories of impacts and evaluation of the quality and timeliness of delivering entitlements (compensation and rehabilitation measures) for each category

and how the entitlements were used and their impacts and adequacy to meet the specified objectives of the Plans. The quality and timeliness of delivering entitlements, and the sufficiency of entitlements as per approved entitlement matrix.

6. Provide a summary of whether involuntary resettlement was implemented (a) in accordancewith the RAPs, and (b) in accordance with the stated policy.
7. To review the quality and suitability of the relocation sites from the perspective of the both affected and host communities.
8. Verify expenditure & adequacy of budget for resettlement activities.
9. To analyze the pre-and post-project socio-economic conditions of the affected people. The methodology for assessment should be very explicit, noting any qualifications.
10. Review results of internal monitoring and verify claims through sampling check at the field level to assess whether land acquisition/resettlement objectives have been generally met.Involve the affected people and community groups in assessing the impacts of land acquisitionfor monitoring and evaluation purposes.
11. To monitor and assess the adequacy and effectiveness of the consultative process with affected people, particularly those vulnerable, including the adequacy and effectiveness ofgrievance procedures and legal redress available to the affected parties, and disseminationof information about these.
12. Identify, quantify, and qualify the types of conflicts and grievances reported and resolved andthe consultation and participation procedures.
13. Describe any outstanding actions that are required to bring the resettlement activities in line with the policy. Describe further mitigation measures needed to meet the needs of any affected person or families judged and/or perceiving themselves to be worse off as aresult of the Project. Provide a timetable and define budget requirements for these supplementary mitigation measures.
14. Describe any lessons learned that might be useful in developing the new national resettlement policy and legal/institutional framework for involuntary resettlement.
15. Verifying internal reports by field-checking delivery of compensation to PAPs, including the levels and timing of the compensation; readjustment of land; preparation and adequacy of resettlement sites; construction of houses; provision of employment, the adequacy of the employment, and income levels; training; special assistance for vulnerable groups; repair, relocation, or replacement of infrastructure; relocation of enterprises, compensation, and adequacy of the compensation; and transition allowances;
16. Interviewing a random sample of PAPs in open-ended discussions, to assess their knowledge and concerns about the resettlement process, their entitlements, and the rehabilitation measures;
17. Observing the functioning of the resettlement operation at all levels, to assess its effectiveness and compliance with the RAP;

18. Checking the type of grievance issues and the functioning of grievance redress mechanisms by reviewing the processing of appeals at all levels and interviewing aggrieved PAPs:
19. Advising TANROADS regarding possible improvements in the implementation of the RAP.

D. Methodology and Approach

The general approach to be used is to monitor activities and evaluate impacts ensuring participation of all stakeholders especially women and vulnerable groups. Monitoring tools should include both quantitative and qualitative methods. The external monitor should reach out to cover:

- PAPs who had property, assets, incomes and activities severely affected by Project works and had to relocate either to resettlement sites or who chose to self-relocate, or whosesource of income was severely affected.
- PAPss who had property, assets, incomes and activities marginally affected by Project works and did not have to relocate;
- PAPs by off-site project activities by contractors and sub-contractors, including employment, use of land for contractor's camps, pollution, public health etc.;

Supplemented by Focused Group Discussions (FGD) which would allow the monitors to consult arange of stakeholders (local government, resettlement field staff, NGOs, community leaders, and,most importantly, APs), community public meetings: Open public meetings at resettlement sites toelicit information about performance of various resettlement activities.

E. Other Stakeholders and their Responsibility

1. Responsibilityof the executing Agencies (EAs)

The EAs through their Project Implementation Unit (PIU) will ensure timely supply of background references, data and other necessary information to the EMA and provide access to project sites and relevant places to let the EMA implement external monitoring activity.

2. Responsibility of the Implementing organization(s)

Organizations that will assist EAs in implementing land acquisition and resettlement activities will provide information required by the EMA at site and at their Project Offices. It will on behalf of EAs ensure free access to project sites and related areas and the database on land acquisition and resettlement activities.

F. Team Composition of the External Monitoring Agency

The EMA should focus on, data collection, processing and analysis to pin point problem areas and weaknesses, and to light on deserving measures to achieve the objectives on schedule are the

special interest of the subject. Thus, there is a need for a dedicated monitoring team with adequate gender representation. Further, it is essential that the central team or field level coordinators responsible for monitoring, are skilled and trained in data base management, interview technique, and social and economic/finance. Keeping in mind these criteria, the team should ideally include:

Position/expertise	Qualification and experience
1. Team Leader/ Implementation Specialist	Master in social science with 10-year working experience in social impact assessment including census and socioeconomic surveys, stakeholders' consultation, and analyzing social impacts to identify mitigation measures in compliance with social safeguard policies of the international development financing institutions and national legislations. Experience of preparing resettlement framework and action plans and implementation of plans for externally financed projects is essential.
2. Social Impact Specialist	Master in social science with 5-year working experience in social impact assessment including census and socioeconomic surveys, stakeholders' consultation, and analyzing social impacts to identify mitigation measures in compliance with social safeguard policies of the international development financing institutions and national legislations. Experience of preparing resettlement framework and action plans and implementation of plans for externally financed projects is essential.
3. Data Analyst	Graduate with working experience and knowledge of software such as SPSS (Statistical Package for the Social Sciences)

G.Time Frame and Reporting

The EMA will be employed over a period of 3 years with intermittent inputs from the professionalteam to continue 2 years after completion of the RAP implementation.

Quarterly and annual monitoring reports should be submitted to UETCL with copies to JICA. An evaluation report at the end of the project should be submitted to UETCL and concerned parties with critical analysis of the achievement of the program and performance of EAs and implementingorganizations.

The external monitors will provide monitoring and evaluation report covering the following aspects:

- Whether the resettlement activities have been completed as planned and budgeted;

- The extent to which the specific objectives and the expected outcomes/results havebeen achieved and the factors affecting their achievement or non achievement;
- The extent to which the overall objective of the Resettlement Plan, pre project orimproved social and economic status, livelihood status, have been achieved and thereasons for achievement / non achievement;
- Major areas of improvement and key risk factors;
- Major lessons learnt; and
- Recommendations.

Formats for collection and presentation of monitoring data will be designed in consultation with EAs.

H. Qualification of the External Monitoring Agency

The EMA will have at least 10 years of experience in resettlement policy analysis and implementation of resettlement plans. Further, work experience and familiarity with all aspects of resettlement operations would be desirable. NGOs, Consulting Firms or University Departments (consultant organization) having requisite capacity and experience on the same can qualify for services

Interested agencies should submit a proposal to UETCL with a brief statement of the approach,methodology, and relevant information concerning previous experience on monitoring ofresettlement implementation and preparation of reports.

The profile of its agency, along with full signed CVs of the team to be engaged, must be submitted along with the technical proposal.

I. Budget and Logistics

The budget should include all expenses such as staff salary, office accommodation, training, computer/software, transport, field expenses and other logistics necessary for field activities, data collection, processing and analysis for monitoring and evaluation work. Additional expense claims whatsoever outside the proposed and negotiated budget will not be entertained. VAT, Income Tax and other charges admissible will be deducted at source as per Government laws.

資料－１７　環境チェックリスト

Environmental check list: Power transmission and distribution lines

Category	Item	Main Check Items	Yes: Y No: N Unknown: U	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) Y (b) N (c) N (d) N	(a) The EIA report is planned to be submitted to National Environment Management Authority (NEMA) around end of June 2016. (b) EIA approval is expected to be obtained from NEMA by mid-September 2016. (c) EIA not approved yet. (d) Since some sections of the Mukono component are located inside Nandagi Forest Reserve, a license must be acquired from National Forest Authority (NFA) as per the National Forestry and Tree Planting Act, 8/2003. The license is expected to be obtained by the end of September 2016. Other environment-related permits that may be required prior to construction are: ・ Traffic Management Permit from Uganda National Roads Authority (UNRA) ・ Wetland resource use permit from NEMA (if resource extraction from wetland is required) ・ Waste transport and storage license from NEMA
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) Y	(a) The Project has consulted relevant government agencies (e.g. NFA) and local communities (Mukono, Buloba and Kawaala) as per the EIA Regulation, 1998. NFA requested UETCL to compensate for the forest biomass and biodiversity that will be lost through land acquisition in Nandagi Forest Reserve in relation to the Mukono component. No objections on the project have been raised so far by the local communities. (b) So far, there have been no comments that will entail significant changes to the project design.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental	(a) Y	(a) An alternative analysis was conducted for the new substation sites (Buloba and Mukono), taking into

Category	Item	Main Check Items	Yes: Y No: N Unknown: U	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		considerations?		account social and environmental impacts.
2 Pollution Control	(1) Water Quality	(a) Is there any possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? If the water quality degradation is anticipated, are adequate measures considered?	(a) Y	(a) Soil runoff from the new substation and transmission line sites (Buloba and Mukono) could affect nearby surface water. Following are planned mitigation measures to minimize impacts: ・ Avoid removing short vegetation and grass along the transmission line corridor as far as it does not hinder construction and maintenance works. ・ Implementation of temporary erosion control measures (e.g. silt fence, erosion mats) especially where construction sites are near surface water. ・ Revegetation of exposed slopes immediately after construction is completed. ・ Construction of retaining walls for exposed slope protection if necessary. ・ Construction of runoff drainage channel. ・ Stockpiles and temporarily removed topsoil to be stored in a location and manner to prevent soil runoff into surface waters.
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) Y	(a) The Mukono substation and part of the associated transmission lines are located inside Nandagi Forest Reserve established under the National Forestry and Tree Planting Act, 8/2003. Around 15 ha of forest area will need to be cleared to secure the 220 kV transmission line corridor. UETCL will compensate for the forest biomass and biodiversity that will be lost based on the "Forest Biomass and Biodiversity Valuation" undertaken by National Forest Authority (NFA).The existing 132 kV Mukono branch point － Kampala North Substation transmission line, subject to reconductoring works, passes through Namyoya and Luvunya Forest Reserves. Impact on these forest reserves are expected to be

Category	Item	Main Check Items	Yes: Y No: N Unknown: U	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				negligible as the reconductoring works will be conducted within the existing transmission line corridor, hence no requirement for new forest clearance. Reconductoring works will also be short term and will not entail any activities that may have any adverse impacts to the forest.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Are adequate measures taken to prevent disruption of migration routes and habitat fragmentation of wildlife and livestock? (e) Is there any possibility that the project will cause the negative impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystem due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered? (f) In cases where the project site is located in undeveloped areas, is there any possibility that the new development will result in extensive loss of natural environments?	(a) Y (b) Y (c) Y (d) Y (e) Y (f) Y	(a) Part of the Mukono transmission line (around 2 km) will traverse through a natural/semi-natural forest inside Nandagi Forest Reserve. (b) A two-day ecological survey was conducted in Buloba and Mukono in April and May 2016 respectively. The following two bird species and one tree species were identified inside Nandagi Forest Reserve, which are classified as threatened under IUCN Red List. ・ Grey crowned crane (*Balearica regulorum*): EN ・ Grey parrot (*Psittacus erithacus*): VU ・ *Jacaranda mimosifolia*: VU In addition, the following three butterfly species were identified inside Nandagi Forest Reserve, which are classified as threatened under Uganda Red List prepared by Wildlife Conservation Society (WCS). ・ *Euphaedra rex* (VU) ・ *Neptis trigonophora* (VU) ・ *Caenides dacena* (EN) (c) The following measures will be implemented to minimize ecological impacts taking into account the identified threatened species. ・ Compensation of lost forest area in Nandagi Forest Reserve through reforestation works to be undertaken by UETCL and NFA. ・ Replantation of *Jacaranda mimosifolia* seedling. ・ Implementation of strict construction pollution control

Category	Item	Main Check Items	Yes: Y No: N Unknown: U	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				measures to minimize impacts on surrounding habitats. ・ Installation of bird flight diverters on the transmission lines to minimize bird collision. ・ Implementation of ecological monitoring during construction and operation phases. ・ In case important nesting sites of the threatened bird species are found during the ensuring stages, additional measures will be considered in consultation with experts (e.g. creation of artificial nesting area). (d) Measures described above should minimize disruption of migration routes and habitat fragmentation. (e) Introduction of invasive species will be prevented or minimized through the following measures: • Revegetation of exposed surfaces (e.g. cutting and filling slopes) to be done by native plant species only, and immediately after works is completed to minimize chance of colonization by invasive species. • Removal of invasive species if observed along the revegetation sites. (f) Around 15 ha of semi-natural and natural forest will be lost in Nandagi Forest Reserve. The loss of forest will be compensated through reforestation works to be undertaken by UETCL and NFA.
	(3) Topography and Geology	(a) Is there any soft ground on the route of power transmission and distribution lines that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed? (b) Is there any possibility that civil works, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to	(a) U (b) Y (c) Y	(a) A detailed geological survey will be conducted in the D/D stage. If necessary, adequate measures (e.g. revegetation, retaining walls) will be considered to prevent slope failures or landslides. (b) Cutting and filling works may be required for constructing the Buloba and Mukono substation. If necessary, adequate measures for preventing slope failures or landslides (e.g. revegetation, construction of

Category	Item	Main Check Items	Yes: Y No: N Unknown: U	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		prevent slope failures or landslides? (c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?		retaining walls) will be considered in the D/D stage. (c) Soil runoff from cut and fill areas is a possibility. If necessary, appropriate soil-runoff prevention measures (e.g. revegetation, retaining walls, silt fence, erosion mats) will be implemented.
	(4) Hydrology	(a) Is there a possibility that alteration of topographic features and installation of structures, such as tunnels will adversely affect surface water and groundwater flows?	(a) Y	(a) The Mukono access road will cross over two tributaries inside Nandagi Forest Reserve. Culverts will be installed at these location to avoid disturbance to their flow.
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement?	(a) U (b) Y (c) Y (d) Y (e) Y (f) Y (g) Y (h) Y (i) Y (j) Y	(a) The Project has made every effort to minimize land acquisition through corridor sharing of the transmission lines. Nevertheless, land acquisition will be required at Buloba (approx. 14 ha), Mukono (approx. 35 ha) and Kawaala (approx. 0.05 ha) sites. **Buloba:** According to the ongoing RAP study, the following 6 structures lie within the land acquisition area: ・Residential structure: 1 ・Incomplete structure: 3 ・Pit latrine: 1 ・Water tank: 1 Involuntary resettlement of the residential owner is unlikely to be required as there is sufficient land to rebuild the existing residential structure within his land boundary and no request for resettlement has been raised so far. Note that the owners of the incomplete structures currently live elsewhere so will not be subject to resettlement. **Mukono:** According to the ongoing RAP study, the following 4 structures lie within the land acquisition area: ・Residential structure: 1

Category	Item	Main Check Items	Yes: Y No: N Unknown: U	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?		・Incomplete structure: 1 ・Pit latrine: 2 Involuntary resettlement of the residential owner is unlikely to be required as there is sufficient land to rebuild the existing residential structure within his land boundary and no request for resettlement has been raised so far. Note that the owners of the incomplete structures currently live elsewhere so will not be subject to resettlement. **Kawaala:** According to the ongoing RAP study, only 1 pit latrine lie within the land acquisition area. No resettlement will hence be required. (b) The Project held consultation meetings with the communities in Buloba (2 times), Mukono (2 times) and Kawaala (once), and explained about the project and compensation policies. All affected landowners were also consulted during the land and asset valuation surveys. No objections were raised by the community or landowners. (c) The ARAP will be developed based on the ongoing socioeconomic studies. Compensation will be made at full replacement costs. Livelihood restoration programs will be developed based on the ongoing socioeconomic studies. Possible livelihood restoration programs may include among others provision of employment opportunities (e.g. construction labor) and other alternative income generating sources (e.g. poultry) depending on the interests of the affected communities. (d) Compensation and necessary assistance will be provided prior to resettlement in accordance to Section 42(7)(b) of the Land Act. (e) The Project's compensation policies were developed

Category	Item	Main Check Items	Yes: Y No: N Unknown: U	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				in accordance to Ugandan laws and JICA requirements. The policies are described in the Inception report of the ARAP study, which has been submitted to the Office of the Chief Government Valuer on April 1st, 2016. (f) The Project will conform to the requirements of WB OP 4.12 and best practices in regards to the needs of the vulnerable groups if any (e.g. women, orphans, people with physical disabilities). These may include for example provision of resettlement houses and giving priority for livelihood restoration assistance. (g) If resettlement is required, UETCL will provide necessary assistance (e.g. transport allowance, support to find new location) depending on needs of the PAPs. (h) UETCL will establish RAP unit to handle all RAP-related activities of the Project. The RAP unit will consists of 7 expert staffs of UETCL. Budget will be secured after cost estimation made through ARAP study. (i) Internal and external monitoring will be implemented throughout the RAP implementation period and until assistance for livelihood restoration are no more required. (j) A Grievance Resolution Committee (GRC) will be established to resolve issues quickly so as to expedite receipt of entitlements and smooth resettlement without resorting to expensive and time-consuming legal action. GRC will consist of UTECL staff, local leaders and third party representatives. If the grievance procedure fails to provide a settlement, complainants can still seek legal redress.
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered	(a) Y (b) Y (c) N	(a) According to the ongoing RAP study, seven and twenty landowners will lose part of their farmland in Buloba and Mukono respectively due to land acquisition.

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		to reduce the impacts, if necessary? (b) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary? (c) Is there any possibility that installation of structures, such as power line towers will cause radio interference? If any significant radio interference is anticipated, are adequate measures considered? (d) Are the compensations for transmission wires given in accordance with the domestic law?	(d) Y	Owners of these farmland will be compensated for their growing crops in accordance to the District Compensation Rates plus 30% disturbance allowance. They will also be provided necessary assistance (e.g. transition support, livelihood restoration program) depending on their interests. There are also some private farmers operating under NFA lease in Nandagi Forest Reserve, which will lose part or fully their leased land due to land acquisition. These private farmers grow mainly commercial trees and will be compensated for their growing trees in accordance to the District Compensation Rates plus 30% disturbance allowance. They will also be provided necessary assistance (e.g. transition support, livelihood restoration program) depending on their interests. (b) The risk of infectious diseases spreading is considered low as most workers will be employed locally. Nevertheless, the project will hold awareness programs (e.g. HIV/AIDS prevention program) and prepare a Code of Conduct to be strictly followed by the workers. (c) Radio interference is unlikely as the new transmission lines traverse through open land. (d) All landowners under the new transmission line corridor will be compensated in accordance to Ugandan Law.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) There are no heritages in the project affected areas.
	(4) Landscape	(a) Is there a possibility that the project will	(a) Y	(a) There will be slight changes to current landscape at

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		adversely affect the local landscape? Are necessary measures taken?		the new substation sites (Buloba, Mukono) and associated transmission lines. To minimize landscape impacts, the construction sites will be restored as close as possible to the original landscape (e.g. through revegetation) and green belt created, if necessary.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N (b) N	(a) & (b) There are no ethnic minorities and indigenous peoples in the project affected areas.
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) N (b) Y (c) Y (d) Y	(a) Working conditions will be managed in accordance to Ugandan labor laws (e.g. The Employment Act, 2006). (b) Safety of workers will be managed in accordance to: ・ UETCL's Safety Health and Environmental Policy ・ The Workman's Compensation Act, 2000 ・ The Occupational Safety and Health Act, 2006 ・ The Electricity (Safety Code) Regulations 2003 ・ JICA's "The Guidance for the Management of Safety for Construction Works in Japanese ODA Projects" Safety measure among other will include: ・ Implementation of safety training programs for all workers. ・ Assignment of safety officer ・ Provision of Personal Protective Equipment (PPE). ・ Holding of regular tool box meeting to discuss safety. ・ Lock out-tag out procedures to be clearly displayed on site and followed. ・ The construction contractor will be required to submit an Occupational Health and Safety Plan (OHSP) to UETCL and other necessary organizations for approval.

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				(c) See (b). (d) Security guards will be required to strictly follow the Code of Conduct.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) Y (b) Y (c) Y	(a) An Environment and Social Management Plan (ESMP) is developed to minimize impacts (e.g. noise, air pollution, water pollution, wastes) during construction. (b) The following measures are planned to minimize impacts on the natural environment in particular for Buloba and Mukono: ・ Revegetation of exposed surfaces (e.g. cut and fill slopes) to be done by native plant species only, and immediately after works are completed to minimize chance of colonization by invasive species. ・ Implementation of environmental awareness programs for the construction workers, with special focus on threatened species. ・ Strictly prohibit hunting and poaching of wild life and cutting of trees. ・ Prevention and minimization of pollution (e.g. noise, water) through strict implementation of planned pollution control measures. (c) Construction activities may cause temporary power outage and traffic disruption and accidents. Adequate measures are planned in the ESMP to minimize impacts/risks of power outage and traffic disruption and accidents.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate	(a) Y (b) (c) Y (d) Y	(a) An Environment and Social Monitoring Plan (ESMoP) has been developed covering both construction and operation stages. (b) The ESMoP includes internal and external monitoring of PAPs, field measurements (air, noise, water), ecosystem monitoring, progress of offset programs for

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		monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?		Nandagi Forest Reserve, regular site inspection and so on. See ESMoP for more details. (c) The monitoring responsibility and cost are outlined in the ESMoP. The monitoring cost will be incorporated into the Project budget. During the construction stage, the construction contractor and supervisor will be required to assign an Environment, Health and Safety officer to implement and oversee the monitoring requirements. The environmental department of UETCL will be responsible for implementing their monitoring requirements. (d) Monitoring report will be submitted to NEMA in accordance to their requirements. The monitoring results will also be reported to JICA on a regular basis.
	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Road checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	(a) Y	(a) Road checklist (Hydrology) was referred for the access road construction.
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) There are no transboundary impacts.