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## APPENDICES

### Appendix A – Basic Characteristics data

#### Particle size distribution for Bottom Ash sample S1

Sieve Size (mm)	Mass of Bottom ash (g)	Cumulative mass (g)	Percent Retained (%)	Percent Passing (%)
10	91.0	91.0	8.99	91.01
5	84.5	175.5	8.35	82.66
2.36	237.7	413.2	23.49	59.17
1.18	257.5	670.7	25.44	33.73
0.6	159.3	830.0	15.74	17.98
0.425	86.0	916.0	8.50	9.49
0.3	47.7	963.7	4.71	4.77
0.15	34.4	998.1	3.40	1.37
0.075	9.1	1007.2	0.91	0.47

#### Particle size distribution of sample S2

Sieve Size (mm)	Mass of Bottom ash (g)	Cumulative mass (g)	Percent Retained(%)	Percent Passing (%)
10	14.3	14.3	1.43	98.57
5	55.1	69.4	5.51	93.06
2.36	656.5	725.9	65.69	27.37
1.18	161.6	887.5	16.17	11.20
0.6	60.6	948.1	6.06	5.13
0.425	25.8	973.9	2.58	2.55
0.3	15.6	989.5	1.56	0.99
0.15	6.8	996.3	0.68	0.31
0.075	2.4	998.7	0.24	0.07

#### Particle size distribution of S3

Sieve Size (mm)	Mass of Bottom ash (g)	Cumulative mass (g)	Percent Retained (%)	Percent Passing (%)
10	21.7	21.7	2.17	97.83
5	87.7	109.4	8.77	89.06
2.36	584.0	693.4	58.41	30.65
1.18	63.9	757.3	6.39	24.26
0.6	102.4	859.7	10.24	14.02
0.425	71.5	931.2	7.15	6.87
0.3	43.8	975.0	4.38	2.49
0.15	16.9	991.9	1.69	0.80
0.075	6.2	998.1	0.62	0.18

Liquid Limit by cone Penetration method for sample S3

Sample No	Can No	Mass of Can	Mass of Wet soil+ Can	Mass of Dry soil+ Can	mc %	Penetration mm
1	5A	16.82	39.62	32.23	47.96	25
2	GPI	19.27	40.95	33.87	48.49	32.5
3	500	19.46	44.66	36.24	50.18	36.5
4	B6	16.88	37.69	30.52	52.57	42

Table for Specific Gravity of types of bottom ash

Sample Name	Specific Gravity
Bottom Ash Sample S1	2.19
Bottom Ash Sample S2	1.8
Bottom Ash Sample S3	1.91
Fly Ash Sample ( FA)	2.18
75% FA+25% BA	2.0

Tables of Dry Density and Moisture content relations

Bottom Ash Sample S1 (Gs = 2.19)

Procedure	4.5 kg Hand Rammer, 5 Layers, 27Blows per Layer, 1L Mould,	Mould Diameter (cm)								
		Mould Height (cm)								
Test Number	I	Mould Volume (cm <sup>3</sup> )								
		2	3	4	5	6	7	8	9	
Volume of adding water	ml	250	450	650	850	1050	1250	1450	1650	
Mass of Mould + Base + Com. Specimen(m <sub>s</sub> )	g	4450.3	4508.4	4616.6	4728.4	4777.7	4804.6	4793.7	4819.7	
Mass of Mould + Base(m <sub>0</sub> )	g	3217.0	3217.0	3217.0	3217.0	3217.0	3217.0	3217.0	3217.0	
Mass of the Com. Specimen (m <sub>w</sub> -m <sub>0</sub> )	g	1181.3	1291.4	1399.6	1511.4	1560.7	1587.6	1576.7	1602.7	
Bulk Density p = (m <sub>w</sub> -m <sub>0</sub> )/V	g/cm <sup>3</sup>	1.185	1.24	1.40	1.52	1.57	1.59	1.58	1.61	
Moisture Content Container No:	3	4	5	6	7	4	5	6		
Mass of Container	g	42.5	41.0	42.3	45.8	38.9	38.3	40.4	39.6	
Mass of Container + Wet Soil	g	157.0	144.3	158.6	163.5	142.3	163.4	190.4	213.9	
Mass of Container + Dry Soil	g	155.0	136.0	143.4	140.7	116.6	127.5	141.6	155.1	
Moisture Content (w)	%	1.78	8.74	15.03	22.16	33.08	40.25	48.22	50.91	
Dry Density P <sub>d</sub> = 100p/(100+w)	g/cm <sup>3</sup>	1.164	1.138	1.126	1.149	1.176	1.135	1.067	1.065	
	kg/m <sup>3</sup>	1164.16	1137.62	1126.00	1149.18	1176.32	1135.41	1066.95	1065.23	

Bulk Density (kg/m <sup>3</sup> ) p = (m <sub>2</sub> -m <sub>1</sub> )/V	m/c %	Dry Density (kg/m <sup>3</sup> ) Pd = 100p/(100+w)	Zero air Void		5% air Void		10% air Void	
			A=0 Pd = G <sub>s</sub> Y <sub>w</sub> [1-A] 1+wG <sub>s</sub>	A=0.05 Pd = G <sub>s</sub> Y <sub>w</sub> [1-A] 1+wG <sub>s</sub>	A=0.05 Pd = G <sub>s</sub> Y <sub>w</sub> [1-A] 1+wG <sub>s</sub>	A=0.1 Pd = G <sub>s</sub> Y <sub>w</sub> [1-A] 1+wG <sub>s</sub>		
1184.85	1.78	1164.16	2107.93	2002.53	1897.14			
1237.01	8.74	1137.62	1838.27	1746.36	1654.44			
1295.29	15.03	1126.00	1647.54	1565.16	1482.78			
1403.81	22.16	1149.18	1474.50	1400.78	1327.05			
1515.95	29.53	1170.35	1329.94	1263.44	1196.95			
1565.40	33.08	1176.32	1270.03	1206.53	1143.03			
1592.38	40.25	1135.41	1164.03	1105.82	1047.62			
1581.44	48.22	1066.95	1065.15	1011.89	958.64			
1607.52	50.91	1065.23	1035.51	983.73	931.95			

Dry Density and Moisture content relations BA Sample S2 (Gs = 1.8)

Procedure	Mould Diameter (cm)			Mould Height (cm)			Mould Volume (cm <sup>3</sup> )						
	10.300	11.400	997	10.300	11.400	997	10.300	11.400	997				
4.5 kg Hand Rammer, 5 Layers, 27Blows per Layer, 1L Mould,													
<b>Test Number</b>	<b>B7</b>	<b>B6</b>	<b>B5</b>	<b>B8</b>	<b>B1</b>	<b>B2</b>	<b>B3</b>	<b>1</b>	<b>2</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
Mass of Mould + Base + Com. Specimen(m <sub>s</sub> )	4953.0	4953.0	4978.0	5006.0	5015.0	5031.0	5069.0	4424.0	4498.8	4700.0	4703.2	4720.0	4704.8
Mass of Mould + Base(m <sub>i</sub> )	4013.0	4013.0	4013.0	4013.0	4013.0	4013.0	4013.0	3224.8	3224.8	3224.8	3224.8	3224.8	3224.8
Mass of the Com. Specimen (m <sub>s</sub> -m <sub>i</sub> )	940	940	965	993	1002	1018	1056.0	1199.2	1274	1475.2	1478.4	1495.2	1480
Bulk Density p = (m <sub>s</sub> -m <sub>i</sub> )/V	0.94	0.94	0.97	1.00	1.01	1.02	1.06	1.203	1.28	1.48	1.48	1.50	1.48
<b>Moisture Content Container No:</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>6</b>	<b>7</b>	<b>3</b>	<b>4</b>	<b>6</b>	<b>7</b>	<b>6</b>	<b>7</b>
Mass of Container	14.99	16.94	17.51	14.21	14.02	15.22	29.00	37.9	38.4	44.4	44.4	37.1	26.0
Mass of Container + Wet Soil	46.16	40.42	69.45	44.69	40.38	44.68	58.31	175.7	235.3	157.5	146.3	89.1	246.3
Mass of Container + Dry Soil	45.26	39.46	66.56	42.57	38.14	41.87	55.13	151.7	192.4	125.5	111.4	67.6	165.6
Moisture Content (w)	2.97	4.26	5.89	7.48	9.29	10.54	12.17	21.09	26.56	39.46	46.97	51.68	67.42
Dry Density P <sub>d</sub> = 100p/(100+w)	0.908	0.904	0.914	0.927	0.920	0.924	0.944	0.993	1.010	1.061	1.009	0.989	0.887

Bulk Density (kg/m <sup>3</sup> ) p = (m <sub>s</sub> -m <sub>i</sub> )/V	m/c	%	Dry Density Pd = p/(1+w/100)	Zero air Void		5% air Void		10% air Void	
				A=0 Pd = $\frac{G_s Y_w [L-A]}{1+wG_s}$	A=0.05 Pd = $\frac{G_s Y_w [L-A]}{1+wG_s}$	A=0.05 Pd = $\frac{G_s Y_w [L-A]}{1+wG_s}$	A=0.1 Pd = $\frac{G_s Y_w [L-A]}{1+wG_s}$		
934.80	2.97		907.81	1708.56	1623.13	1537.70	1537.70		
942.83	4.26		904.28	1671.73	1588.14	1504.55	1504.55		
967.90	5.89		914.05	1627.41	1546.04	1464.66	1464.66		
995.99	7.48		926.71	1586.52	1507.20	1427.87	1427.87		
1005.02	9.29		919.61	1542.20	1465.09	1387.98	1387.98		
1021.06	10.54		923.67	1512.87	1437.22	1361.58	1361.58		
1059.18	12.17		944.26	1476.55	1402.72	1328.89	1328.89		
1202.81	21.09		993.32	1304.71	1239.48	1174.24	1174.24		
1277.83	26.56		1009.68	1217.82	1156.93	1096.04	1096.04		
1479.64	39.46		1061.00	1052.49	999.86	947.24	947.24		
1482.85	46.97		1008.93	975.35	926.58	877.82	877.82		
1499.70	51.68		988.71	932.50	885.88	839.25	839.25		
1484.45	67.42		886.67	813.18	772.52	731.86	731.86		

Dry Density and Moisture content relations BA Sample S3 (Gs = 1.91)

Procedure	4.5 kg Hand Rammer, 5 Layers, 27Blows per Layer, 1L.Mould.		Mould Diameter (cm)							
			Mould Height (cm)							
			Mould Volume (cm <sup>3</sup> )							
Test Number	1	2	3	4	5	6	7	8	9	
Volume of adding water	ml	250	450	650	850	1050	1250	1450	1650	
Mass of Mould + Base + Com. Specimen(m <sub>2</sub> )	g	4377.9	4454.7	4524.0	4648.6	4754.9	4801.5	4805.3	4805.3	
Mass of Mould + Base(m <sub>1</sub> )	g	3222.8	3222.8	3222.8	3222.8	3222.8	3222.7	3222.8	3222.8	
Mass of the Com. Specimen (m <sub>2</sub> -m <sub>1</sub> )	g	1155.1	1231.9	1301.2	1425.8	1532.1	1578.8	1582.5	1582.5	
Bulk Density p = (m <sub>2</sub> -m <sub>1</sub> )/V	g/cm <sup>3</sup>	1.159	1.24	1.31	1.43	1.54	1.58	1.59	1.59	
<b>Moisture Content Containr No:</b>		3	4	5	6	7	5	6	6	
Mass of Container	g	33.7	30.0	41.0	42.3	39.3	40.0	38.4	38.4	
Mass of Container + Wet Soil	g	80.0	88.5	108.4	133.1	130.8	108.1	131.8	131.8	
Mass of Container + Dry Soil	g	79.2	83.8	99.9	117.2	110.8	88.8	101.7	101.7	
Moisture Content (w)	%	1.76	8.74	14.43	21.23	27.97	39.55	47.55	47.55	
Dry Density P <sub>d</sub> = 100p/(100+w)	g/cm <sup>3</sup>	1.139	1.136	1.141	1.180	1.201	1.135	1.076	1.076	
	kg/m <sup>3</sup>	1138.56	1136.34	1140.52	1179.67	1200.82	1134.76	1075.74	1075.74	

Bulk Density (kg/m <sup>3</sup> ) p = (m <sub>2</sub> -m <sub>1</sub> )/V	m/c %	Dry Density Pd = p/(1+w/100)	Zero air Void			5% air Void			10% air Void		
			A=0			A=0.05			A=0.1		
			Pd = G <sub>s</sub> Y <sub>w</sub> [1-A]			Pd = G <sub>s</sub> Y <sub>w</sub> [1-A]			Pd = G <sub>s</sub> Y <sub>w</sub> [1-A]		
1158.58	1.76	1138.56	1+wG <sub>s</sub>			1+wG <sub>s</sub>			1+wG <sub>s</sub>		
1235.61	8.74	1136.34	1847.94			1755.54			1663.15		
1305.12	14.43	1140.52	1636.87			1555.03			1473.19		
1430.09	21.23	1179.67	1497.29			1422.43			1347.56		
1536.71	27.97	1200.82	1358.99			1291.04			1223.09		
1564.89	34.48	1163.69	1244.90			1182.65			1120.41		
1583.55	39.55	1134.76	1151.64			1094.06			1036.48		
1587.26	47.55	1075.74	1088.08			1033.67			979.27		
			1000.93			950.88			900.83		



Comparison of Dry Density and optimum Moisture content Bottom Ash sample S1,  
sample S2, sample S3

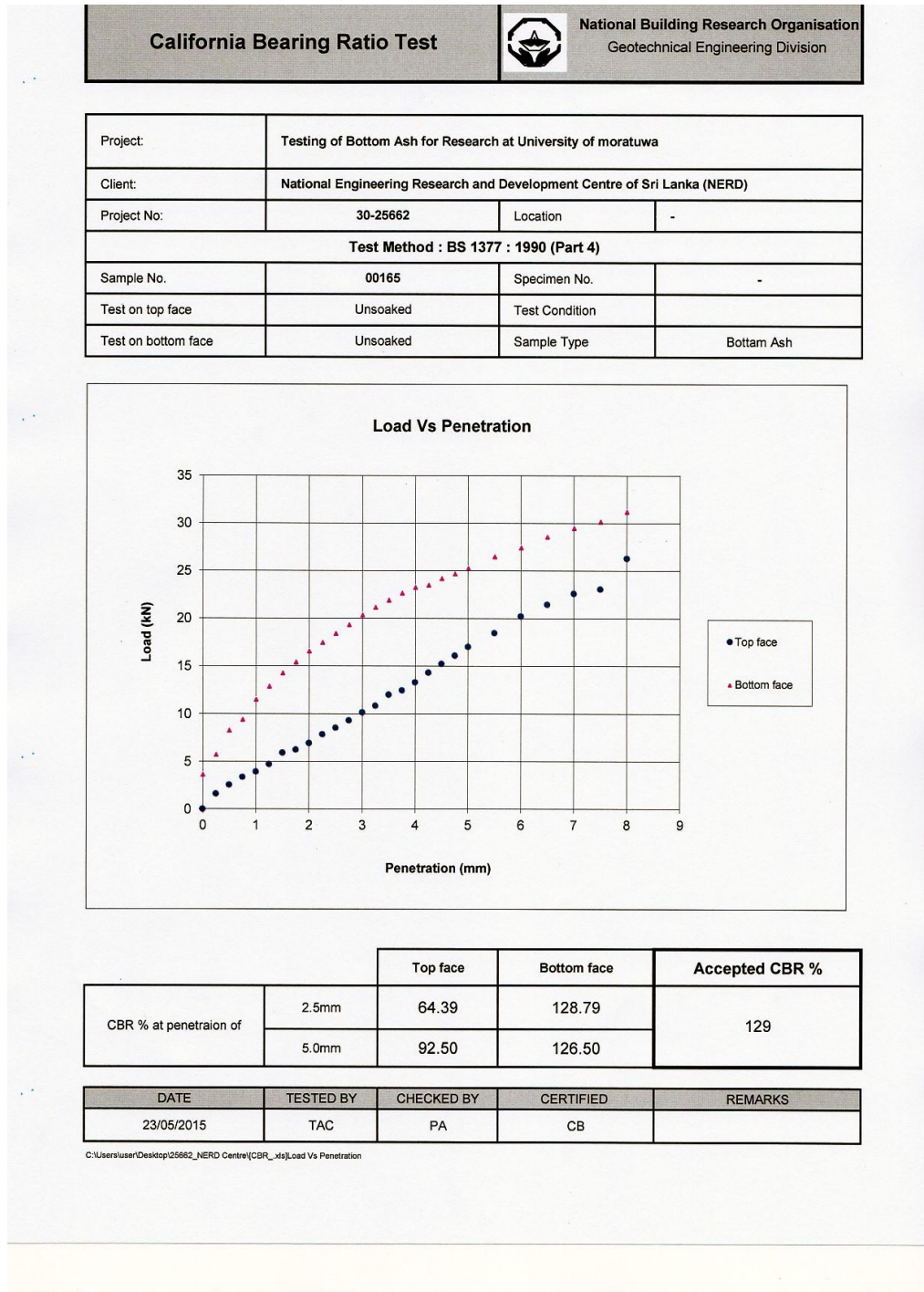
Sample S1 - 100% BA		Sample S2 - 100% BA		Sample S3 - 100% BA	
Maximum Dry Density	1177 kg/m <sup>3</sup>	Maximum Dry Density	1060 kg/m <sup>3</sup>	Maximum Dry Density	1177 kg/m <sup>3</sup>
Optimum Moisture content	32%	Optimum Moisture content	39.5%	Optimum Moisture content	32%
Y <sub>w</sub>	1000	Y <sub>w</sub>	1000	Y <sub>w</sub>	1000
G <sub>s</sub>	2.19	G <sub>s</sub>	1.8	G <sub>s</sub>	2.19
m/c %	Dry Density (kg/m <sup>3</sup> ) Pd = 100p/(100+w)	m/c %	Dry Density (kg/m <sup>3</sup> ) Pd = 100p/(100+w)	m/c %	Dry Density (kg/m <sup>3</sup> ) Pd = 100p/(100+w)
1.78	1164.16	3.0	907.8	1.8	1138.6
8.74	1137.62	4.3	904.3	8.7	1136.3
15.03	1126.00	5.9	914.0	14.4	1140.5
22.16	1149.18	7.5	926.7	21.2	1179.7
29.53	1170.35	9.3	919.6	28.0	1200.8
33.08	1176.32	10.5	923.7	34.5	1163.7
40.25	1135.41	12.2	944.3	39.5	1134.8
48.22	1066.95	21.1	993.3	47.6	1075.7
50.91	1065.23	26.6	1009.7		
		39.5	1061.0		
		47.0	1008.9		
		51.7	988.7		
		67.4	886.7		

Permeability Test

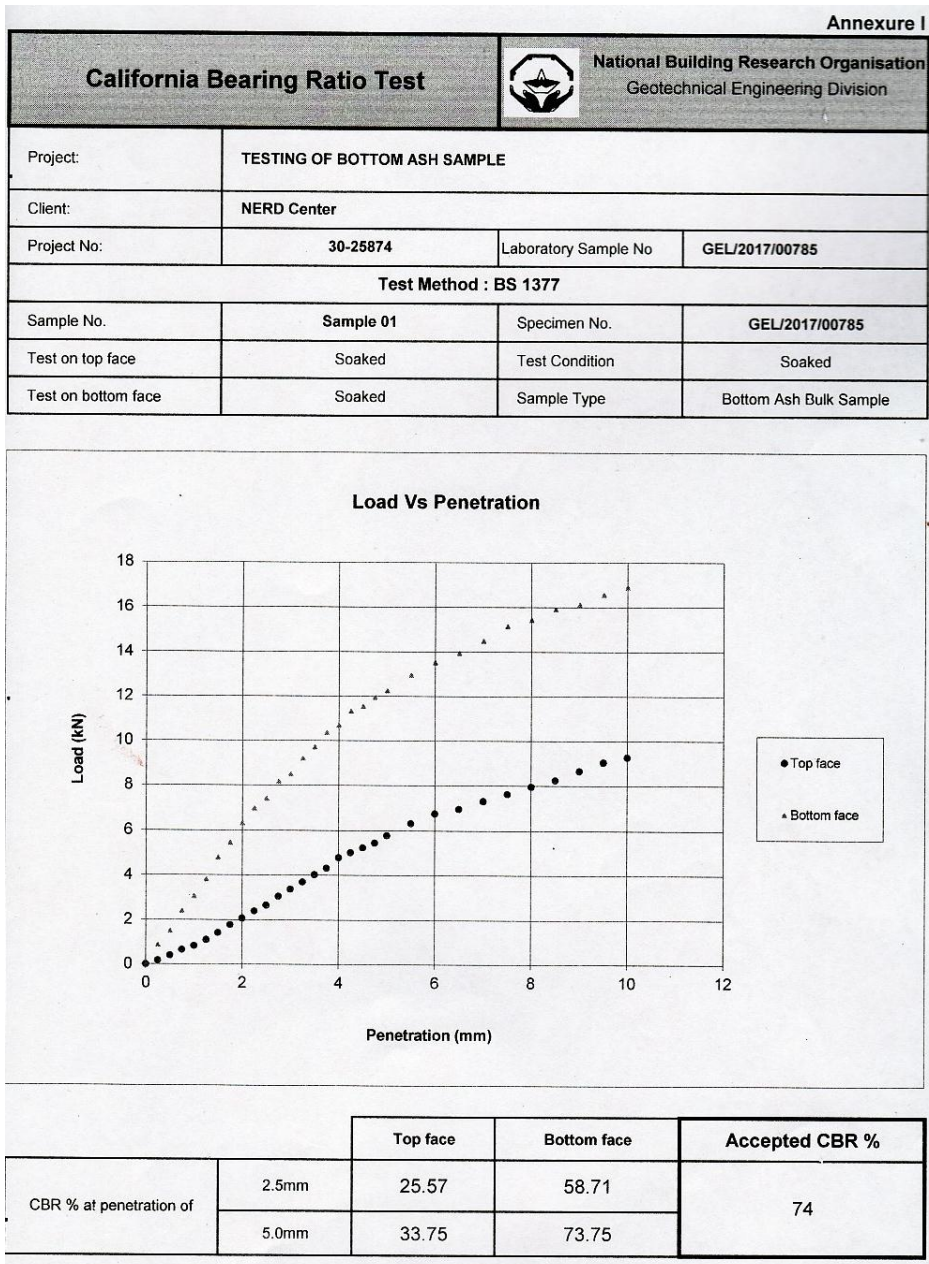
Rate of flow from 8 number of trial sets of constant head perimeter for Sample S3

Set No	Time to collect 1000 ml water (Sec)	h <sub>1</sub> (cm)	h <sub>2</sub> (cm)	h <sub>3</sub> (cm)	h <sub>1</sub> -h <sub>2</sub> (cm)	h <sub>1</sub> -h <sub>3</sub> (cm)	h <sub>2</sub> -h <sub>3</sub> (cm)	Rate of Flow (m <sup>3</sup> /s)
1	218.0	97.8	82.3	62.5	15.5	35.3	19.8	4.5872E-06
2	235.0	96.1	81.6	62.8	14.5	33.3	18.8	4.2553E-06
3	243.0	91.5	77.5	59.0	14.0	32.5	18.5	4.1152E-06
4	245.0	88.6	74.7	56.3	13.9	32.3	18.4	4.0816E-06
5	250.5	86.8	73.2	55.1	13.6	31.7	18.1	3.9920E-06
6	253.0	84.8	71.3	53.4	13.5	31.4	17.9	3.9526E-06
7	261.0	82.3	69.2	51.7	13.1	30.6	17.5	3.8314E-06
8	269.0	79.9	67.2	50	12.7	29.9	17.2	3.7175E-06

Unsoaked CBR Value for the bottom ash Sample S3



Soaked CBR Value for the bottom ash Sample S3



**Appendix B – Compressibility characteristics data of bottom ash**

Consolidation settlement for Bottom Ash sample S1

for loading 25kN/m<sup>2</sup>, 50kN/m<sup>2</sup>, 100kN/m<sup>2</sup> and 200kN/m<sup>2</sup>

Time Elapsed (min)	Root time min <sup>1/2</sup>	25kN/m <sup>2</sup>		50kN/m <sup>2</sup>		100kN/m <sup>2</sup>		200kN/m <sup>2</sup>	
		Dial Reading	Settlement (mm)	Dial Reading	Settlement (mm)	Dial Reading	Settlement (mm)	Dial Reading	Settlement (mm)
0	0.00	12.000	0.000	11.900	0.000	11.693	0.000	11.430	0.000
0.1	0.32	11.824	-0.176	11.697	-0.204	11.542	-0.151	11.418	-0.012
0.17	0.41	11.804	-0.196	11.696	-0.204	11.534	-0.159	11.412	-0.018
0.25	0.50	11.790	-0.210	11.696	-0.204	11.530	-0.163	11.406	-0.024
0.5	0.71	11.778	-0.222	11.696	-0.204	11.522	-0.171	11.398	-0.032
1	1.00	11.770	-0.230	11.695	-0.205	11.514	-0.179	11.390	-0.040
2	1.41	11.762	-0.238	11.694	-0.206	11.504	-0.189	11.382	-0.048
4	2.00	11.756	-0.244	11.694	-0.206	11.494	-0.199	11.374	-0.056
8	2.83	11.746	-0.254	11.694	-0.206	11.486	-0.207	11.368	-0.062
15	3.87	11.740	-0.260	11.694	-0.207	11.478	-0.215	11.360	-0.070
30	5.48	11.734	-0.266	11.693	-0.207	11.470	-0.223	11.352	-0.078
60	7.75	11.726	-0.274	11.693	-0.207	11.462	-0.231	11.348	-0.082
120	10.95	11.720	-0.280	11.693	-0.207	11.454	-0.239	11.340	-0.090
240	15.49	11.712	-0.288	11.693	-0.207	11.445	-0.248	11.334	-0.096
480	21.91	11.700	-0.300	11.693	-0.207	11.435	-0.258	11.328	-0.102
1440	37.95	11.900	-0.100	11.693	-0.208	11.430	-0.263	11.314	-0.116

Calculated value for coefficient of consolidation and volume compressibility

for sample S1

Current load increment	0 kN/m <sup>2</sup> 25kN/m <sup>2</sup>	25kN/m <sup>2</sup> 50kN/m <sup>2</sup>	50kN/m <sup>2</sup> 100kN/m <sup>2</sup>	100kN/m <sup>2</sup> 200kN/m <sup>2</sup>
At the Beginning Sample Thickness (H) mm	20.000	19.900	19.693	19.430
Sample settlement from each load (Δh) mm	0.300	0.208	0.263	0.116
Coefficient of Volume Compressibility (m <sub>v</sub> ) (10 <sup>-4</sup> m <sup>2</sup> /kN)	6.00	2.09	1.30	0.30
√ t <sub>90</sub> (min <sup>1/2</sup> )	1.80	1.60	1.40	1.15
t <sub>90</sub> (min)	3.24	2.56	1.96	1.32
d = H/2 (mm)	10.00	9.95	9.85	9.72
T <sub>90</sub>	0.848	0.848	0.848	0.848
Coefficient of Consolidation (C <sub>v</sub> ) (mm <sup>2</sup> /min)	26.17	32.79	41.95	60.52
Coefficient of Consolidation (C <sub>v</sub> ) (m <sup>2</sup> /year)	13.8	17.2	22.0	31.8

Void ratios with relevant applied pressure for sample S1

Applied Pressure ( $\sigma$ ) kN/m <sup>2</sup>	Void Ratio e
	0.86
25	0.85
50	0.83
100	0.81
200	0.79

Consolidation settlement for Bottom Ash sample S2

for time elapsed data for loading 25kN/m<sup>2</sup>, 50kN/m<sup>2</sup>, 100kN/m<sup>2</sup> and 200kN/m<sup>2</sup>.

Time Elapsed (min)	Root time min <sup>1/2</sup>	25kN/m <sup>2</sup>		50kN/m <sup>2</sup>		100kN/m <sup>2</sup>		200kN/m <sup>2</sup>	
		Dial Reading (mm)	Settlement (mm)	Dial Reading (min)	Settlement (mm)	Dial Reading (min)	Settlement (mm)	Dial Reading (min)	Settlement (mm)
0	0.00	12.000	0.000	11.890	0.000	11.778	0.000	11.586	0.000
0.1	0.32	11.921	-0.079	11.822	-0.068	11.682	-0.096	11.538	-0.048
0.17	0.41	11.919	-0.081	11.820	-0.070	11.676	-0.102	11.526	-0.060
0.25	0.50	11.918	-0.082	11.818	-0.072	11.668	-0.110	11.522	-0.064
0.5	0.71	11.916	-0.084	11.816	-0.074	11.661	-0.117	11.512	-0.074
1	1.00	11.914	-0.086	11.813	-0.077	11.656	-0.122	11.502	-0.084
2	1.41	11.912	-0.088	11.810	-0.080	11.648	-0.130	11.491	-0.095
4	2.00	11.910	-0.090	11.807	-0.083	11.640	-0.138	11.479	-0.107
8	2.83	11.908	-0.092	11.804	-0.086	11.634	-0.144	11.472	-0.114
15	3.87	11.906	-0.094	11.802	-0.088	11.628	-0.150	11.464	-0.122
30	5.48	11.904	-0.096	11.799	-0.091	11.622	-0.156	11.456	-0.130
60	7.75	11.902	-0.098	11.796	-0.094	11.617	-0.161	11.444	-0.142
120	10.95	11.900	-0.100	11.792	-0.098	11.610	-0.168	11.436	-0.150
240	15.49	11.898	-0.102	11.789	-0.101	11.603	-0.175	11.428	-0.158
480	21.91	11.896	-0.104	11.785	-0.105	11.595	-0.183	11.415	-0.171
1440	37.95	11.890	-0.110	11.778	-0.112	11.586	-0.192	11.398	-0.188

Calculated values for coefficient of consolidation and volume

compressibility for sample S2

Current load increment	0 kN/m <sup>2</sup> 25kN/m <sup>2</sup>	25kN/m <sup>2</sup> 50kN/m <sup>2</sup>	50kN/m <sup>2</sup> 100kN/m <sup>2</sup>	100kN/m <sup>2</sup> 200kN/m <sup>2</sup>
At the Beginning Sample Thickness (H) mm	8.000	8.000	8.000	8.000
Sample settlement from each load ( $\Delta h$ ) mm	0.110	0.112	0.192	0.188
Coefficient of Volume Compressibility ( $m_v$ ) ( $10^{-4}$ m <sup>2</sup> /kN)	2.20	1.13	0.97	0.48
$\sqrt{t_{90}}$ (min <sup>1/2</sup> )	2.50	2.40	2.30	2.20
$t_{90}$ (min)	6.25	5.76	5.29	4.84
d = H/2 (mm)	10.00	9.95	9.89	9.79
T <sub>90</sub>	0.848	0.848	0.848	0.848
Coefficient of Consolidation ( $C_v$ ) (mm <sup>2</sup> /min)	13.57	14.56	15.68	16.80
Coefficient of Consolidation ( $C_v$ ) (m <sup>2</sup> /year)	7.1	7.7	8.2	8.8

Void ratios with relevant applied pressure

for sample S2

Applied Pressure kN/m <sup>2</sup>	Void Ratio e
	0.696
25	0.687
50	0.678
100	0.661
200	0.645

Calculated value for coefficient of consolidation and volume compressibility for higher load case for sample S2

Current load increment	0kN/m <sup>2</sup> 250kN/m <sup>2</sup>	250kN/m <sup>2</sup> 500kN/m <sup>2</sup>	500kN/m <sup>2</sup> 1000kN/m <sup>2</sup>	1000kN/m <sup>2</sup> 2000kN/m <sup>2</sup>
At the Beginning Sample Thickness (H) mm	20.00	19.732	19.502	19.170
Sample settlement from each load ( $\Delta h$ ) mm	0.268	0.230	0.332	0.480
Coefficient of Volume Compressibility ( $m_v$ ) ( $10^{-5}$ m <sup>2</sup> /kN)	5.4	2.3	1.7	1.3
$\sqrt{t_{90}}$ (min <sup>1/2</sup> )	1.40	1.30	1.20	1.00
$t_{90}$ (min)	1.96	1.69	1.44	1.00
d = H/2 (mm)	10.00	9.87	9.75	9.59
T <sub>90</sub>	0.848	0.848	0.848	0.848
Coefficient of Consolidation ( $C_v$ ) (mm <sup>2</sup> /min)	43.27	48.84	55.99	77.91
Coefficient of Consolidation ( $C_v$ ) (m <sup>2</sup> /year)	22.7	25.7	29.4	40.9

Consolidation settlement for Bottom Ash sample S2 for Higher loads

for loading, Unloading and Reloading and relevant void ratios for the applied pressure.

Time Elapsed (min)	Root time min <sup>1/2</sup>	Loading						Unloading						ReLoading						
		250 kN/m <sup>2</sup>		500 kN/m <sup>2</sup>		1000 kN/m <sup>2</sup>		2000 kN/m <sup>2</sup>		3000-1000 kN/m <sup>2</sup>		1000 - 100 kN/m <sup>2</sup>		500 kN/m <sup>2</sup>		1000 kN/m <sup>2</sup>		2000 kN/m <sup>2</sup>		
		Dial Reading (mm)	Settlement (mm) for 250kN/m <sup>2</sup>	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	
0	0.00	11.732	0.000	11.732	0.000	11.732	0.000	11.732	0.000	11.732	0.000	11.732	0.000	11.732	0.000	11.732	0.000	11.732	0.000	
0.1	0.32	11.780	-0.230	11.580	-0.152	11.268	-0.234	10.790	-0.380	10.716	0.026	11.210	0.492	11.210	0.492	11.210	0.492	11.210	0.492	11.210
0.17	0.41	11.778	-0.222	11.560	-0.172	11.260	-0.242	10.784	-0.386	10.716	0.026	11.218	0.500	11.218	0.500	11.218	0.500	11.218	0.500	11.218
0.25	0.50	11.774	-0.226	11.556	-0.176	11.250	-0.252	10.774	-0.396	10.716	0.026	11.220	0.502	11.220	0.502	11.220	0.502	11.220	0.502	11.220
0.5	0.71	11.770	-0.230	11.552	-0.180	11.242	-0.260	10.768	-0.402	10.716	0.026	11.226	0.504	11.226	0.504	11.226	0.504	11.226	0.504	11.226
1	1.00	11.764	-0.236	11.548	-0.184	11.234	-0.268	10.764	-0.406	10.716	0.026	11.228	0.508	11.228	0.508	11.228	0.508	11.228	0.508	11.228
2	1.41	11.760	-0.240	11.542	-0.190	11.228	-0.274	10.754	-0.416	10.716	0.026	11.230	0.512	11.230	0.512	11.230	0.512	11.230	0.512	11.230
4	2.00	11.754	-0.246	11.538	-0.194	11.220	-0.282	10.746	-0.424	10.716	0.026	11.234	0.516	11.234	0.516	11.234	0.516	11.234	0.516	11.234
8	2.83	11.750	-0.250	11.532	-0.200	11.216	-0.286	10.736	-0.434	10.716	0.026	11.238	0.520	11.238	0.520	11.238	0.520	11.238	0.520	11.238
15	3.87	11.748	-0.252	11.528	-0.204	11.210	-0.292	10.728	-0.442	10.716	0.026	11.242	0.524	11.242	0.524	11.242	0.524	11.242	0.524	11.242
30	5.48	11.746	-0.254	11.524	-0.208	11.204	-0.298	10.718	-0.452	10.718	0.028	11.244	0.526	11.244	0.526	11.244	0.526	11.244	0.526	11.244
60	7.75	11.742	-0.258	11.520	-0.212	11.196	-0.306	10.710	-0.460	10.718	0.028	11.246	0.530	11.246	0.530	11.246	0.530	11.246	0.530	11.246
120	10.95	11.740	-0.260	11.516	-0.216	11.190	-0.312	10.710	-0.470	10.718	0.028	11.250	0.532	11.250	0.532	11.250	0.532	11.250	0.532	11.250
240	15.49	11.738	-0.262	11.512	-0.220	11.186	-0.316	10.694	-0.476	10.718	0.028	11.252	0.534	11.252	0.534	11.252	0.534	11.252	0.534	11.252
480	21.91	11.736	-0.264	11.508	-0.224	11.179	-0.322	10.690	-0.480	10.718	0.028	11.254	0.536	11.254	0.536	11.254	0.536	11.254	0.536	11.254
1440	37.95	11.732	-0.268	11.502	-0.230	11.170	-0.332	10.690	-0.480	10.718	0.028	11.270	0.552	11.270	0.552	11.270	0.552	11.270	0.552	11.270

Loading Pattern	Applied Pressure		Final Dial Gauge Reading	Change in Dial Gauge reading	Thickness of soil sample H <sub>i</sub> / mm	Equivalent height of voids (H <sub>i</sub> -H <sub>s</sub> )/mm	Void Ratio e=(H <sub>i</sub> -H <sub>s</sub> )/H <sub>s</sub>
	kg	kN/m <sup>2</sup>					
Loading	0.0	12.000	12.000	0.000	20.000	8.178	0.692
	5.0	250.0	11.732	0.268	19.732	7.910	0.669
	10.0	500.0	11.502	0.230	19.502	7.680	0.650
	20.0	1000.0	11.170	0.332	19.170	7.348	0.622
	40.0	2000.0	10.690	0.480	18.690	6.868	0.581
Unloading	40.0	2000.0	10.690	1.310	18.690	6.868	0.581
	20.0	1000.0	10.718	-0.028	18.718	6.896	0.583
	2.0	100.0	11.270	-0.552	19.270	7.448	0.630
Rebating	2.0	100.0	11.270	0.730	19.270	7.448	0.630
	5.0	250.0	11.014	0.256	19.014	7.192	0.608
	10.0	500.0	10.902	0.112	18.902	7.080	0.599
	20.0	1000.0	10.784	0.118	18.784	6.962	0.589
	40.0	2000.0	10.610	0.174	18.610	6.788	0.574

Calculated value for void ratios for sample S3-1

Consolidation settlement for Bottom Ash sample S3-1 for loading, Unloading and Reloading and the table of relevant void ratios for the applied pressure.

Time Elapsed (min)	Loading	12.5 kN/m <sup>2</sup> (250g)		25 kN/m <sup>2</sup> (500g)		50 kN/m <sup>2</sup> (1 kg)		100 kN/m <sup>2</sup> (2kg)		200 kN/m <sup>2</sup> (4 kg)		400 kN/m <sup>2</sup> (8kg)	
		Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)
0	0.00	0.00	0.000	15.00	-0.030	36.20	-0.042	71.00	-0.070	27.00	-0.048	14.00	-0.080
0.1	0.32	5.00	-0.010	31.50	-0.033	56.50	-0.041	8.50	-0.075	91.00	-0.128	99.00	-0.170
0.17	0.41	5.50	-0.011	31.70	-0.033	57.00	-0.042	9.00	-0.076	92.00	-0.130	100.00	-0.172
0.25	0.50	6.10	-0.012	31.80	-0.034	57.50	-0.043	10.00	-0.078	95.00	-0.132	1.00	-0.174
0.5	0.71	6.50	-0.013	31.90	-0.034	58.50	-0.045	11.50	-0.081	95.00	-0.136	4.00	-0.180
1	1.00	6.80	-0.014	32.10	-0.034	59.00	-0.046	13.20	-0.084	97.00	-0.140	6.80	-0.186
2	1.41	7.20	-0.014	32.30	-0.035	60.00	-0.048	14.50	-0.087	99.00	-0.144	9.00	-0.190
4	2.00	7.50	-0.015	32.50	-0.035	61.00	-0.050	16.00	-0.090	1.00	-0.148	12.00	-0.196
8	2.83	8.00	-0.016	32.80	-0.036	61.80	-0.051	17.20	-0.092	2.00	-0.150	14.00	-0.200
15	3.87	8.50	-0.017	33.10	-0.036	62.80	-0.053	18.20	-0.094	4.00	-0.154	16.00	-0.204
30	5.48	9.20	-0.018	33.50	-0.037	63.50	-0.055	20.00	-0.098	6.00	-0.158	18.00	-0.208
60	7.75	10.00	-0.020	34.00	-0.038	64.50	-0.057	21.50	-0.101	8.50	-0.163	20.00	-0.212
120	10.95	11.00	-0.022	34.50	-0.039	65.50	-0.059	23.00	-0.104	10.00	-0.166	22.00	-0.216
240	15.49	12.00	-0.024	35.00	-0.040	67.00	-0.062	24.00	-0.106	12.00	-0.170	24.00	-0.220
480	21.91	13.00	-0.026	35.50	-0.041	68.00	-0.064	25.00	-0.108	14.00	-0.174	25.00	-0.222
1440	37.95	15.00	-0.030	36.20	-0.042	71.00	-0.070	27.00	-0.112	14.00	-0.174	27.20	-0.226

Time Elapsed (min)	Unloading	400 kN/m <sup>2</sup> - 100kN/m <sup>2</sup> (2kg)		100 kN/m <sup>2</sup> - 25kN/m <sup>2</sup> (500g)	
		Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)
0	0.00	27.20	0.000	64.00	0.000
0.1	0.32	71.00	0.112	17.50	0.093
0.17	0.41	70.00	0.114	17.20	0.094
0.25	0.50	69.50	0.115	17.00	0.094
0.5	0.71	69.00	0.116	16.80	0.094
1	1.00	68.80	0.117	16.50	0.095
2	1.41	67.20	0.120	16.00	0.096
4	2.00	67.00	0.120	14.80	0.098
8	2.83	66.50	0.121	14.50	0.099
15	3.87	66.20	0.122	14.00	0.100
30	5.48	66.10	0.122	13.70	0.101
60	7.75	66.10	0.122	13.70	0.101
120	10.95	65.50	0.123	12.30	0.103
240	15.49	64.50	0.125	11.50	0.105
480	21.91	64.00	0.126	8.00	0.112
1440	37.95	64.00	0.126	8.00	0.112



Time Elapsed (min)	Root time min <sup>1/2</sup>	50 kN/m <sup>2</sup> (1kg)			100 kN/m <sup>2</sup> (2kg)			200 kN/m <sup>2</sup> (4 kg)			400 kN/m <sup>2</sup> (8kg)			800 kN/m <sup>2</sup> (16 kg)		
		Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)
0	0.00	8.00	11.584	0.000	22.60	11.555	0.000	72.50	11.455	0.000	9.50	11.381	0.000	58.00	11.284	0.000
0.1	0.32	20.00	11.560	-0.024	30.20	11.540	-0.015	3.00	11.394	-0.061	44.50	11.311	-0.070	80.00	11.240	-0.044
0.17	0.41	20.20	11.560	-0.024	39.50	11.521	-0.034	3.50	11.393	-0.062	45.00	11.310	-0.071	93.00	11.214	-0.070
0.25	0.50	21.00	11.558	-0.026	46.00	11.508	-0.047	4.00	11.392	-0.063	46.00	11.308	-0.073	96.00	11.208	-0.076
0.5	0.71	21.00	11.558	-0.026	58.00	11.484	-0.071	4.00	11.392	-0.063	46.20	11.308	-0.073	99.00	11.202	-0.082
1	1.00	21.50	11.557	-0.027	66.00	11.468	-0.087	4.00	11.392	-0.063	47.00	11.306	-0.075	45.00	11.110	-0.174
2	1.41	21.80	11.556	-0.028	67.00	11.466	-0.089	4.80	11.390	-0.065	49.00	11.302	-0.079	56.00	11.088	-0.196
4	2.00	21.90	11.556	-0.028	67.60	11.465	-0.090	5.00	11.390	-0.065	49.50	11.301	-0.080	60.00	11.080	-0.204
8	2.83	22.00	11.556	-0.028	68.00	11.464	-0.091	6.00	11.388	-0.067	50.00	11.300	-0.081	61.00	11.078	-0.206
15	3.87	22.00	11.556	-0.028	72.00	11.456	-0.099	6.50	11.387	-0.068	51.00	11.298	-0.083	64.00	11.072	-0.212
30	5.48	22.10	11.556	-0.028	72.00	11.456	-0.099	7.00	11.386	-0.069	51.30	11.297	-0.084	67.00	11.066	-0.218
60	7.75	22.20	11.556	-0.028	72.00	11.456	-0.099	7.20	11.386	-0.069	53.80	11.292	-0.089	68.50	11.063	-0.221
120	10.95	22.30	11.555	-0.029	72.00	11.456	-0.099	8.50	11.383	-0.072	54.00	11.292	-0.089	70.60	11.059	-0.225
240	15.49	22.40	11.555	-0.029	72.00	11.456	-0.099	9.00	11.382	-0.073	55.00	11.290	-0.091	73.00	11.054	-0.230
480	21.91	22.60	11.555	-0.029	72.50	11.455	-0.100	9.00	11.382	-0.073	55.00	11.290	-0.091	73.00	11.054	-0.230
1440	37.95	22.60	11.555	-0.029	72.50	11.455	-0.100	9.50	11.381	-0.074	58.00	11.284	-0.097	76.50	11.047	-0.237

Load Pattern	Applied Pressure kg	Applied Pressure kN/m <sup>2</sup>	Final Dial Gauge		Change in Dial Gauge Reading	Thickness of soil Sample H <sub>1</sub> /(mm)	Equivalent height of voids (H <sub>1</sub> -H <sub>s</sub> )/(mm)	Void Ratio e=(H <sub>1</sub> -H <sub>s</sub> )/H <sub>s</sub>	
			Reading	Reading				e=(H <sub>1</sub> -H <sub>s</sub> )/H <sub>s</sub>	e=(H <sub>1</sub> -H <sub>s</sub> )/H <sub>s</sub>
Loading	0.00		12.000		0.000		7.446	0.593	
	0.25	12.50	11.970		0.030		7.416	0.591	
	0.50	25.00	11.928		0.042		7.374	0.587	
	1.00	50.00	11.858		0.070		7.304	0.582	
	2.00	100.00	11.746		0.112		7.192	0.573	
	4.00	200.00	11.572		0.174		7.018	0.559	
8.00	400.00	11.346		0.226		6.792	0.541		
Unloading									
	8.00	400.00	11.346		0.654		6.792	0.541	
	2.00	100.00	11.472		-0.126		6.918	0.551	
	0.50	25.00	11.584		-0.112		7.030	0.560	
Re - Loading									
	0.50	25	11.584		0.416		7.030	0.560	
	1.00	50.00	11.555		0.029		7.001	0.558	
	2.00	100.00	11.455		0.100		6.901	0.550	
	4.00	200.00	11.381		0.074		6.827	0.544	
	8.00	400.00	11.284		0.097		6.730	0.536	
16.00	800.00	11.047		0.237		6.493	0.517		

Consolidation settlement for Bottom Ash sample S3-2for loading, Unloading and Reloading and the table of relevant void ratios for the applied pressure.

Loading			12.5 kN/m <sup>2</sup> (25kg)		25 kN/m <sup>2</sup> (50kg)		50 kN/m <sup>2</sup> (1 kg)		100 kN/m <sup>2</sup> (2kg)		200 kN/m <sup>2</sup> (4 kg)		400 kN/m <sup>2</sup> (8kg)			
Time Elapsed (min)	Root time min <sup>1/2</sup>	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement t (mm)	Dial Reading (mm)	Settlement t (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	
0	0.00	0.00	0.000	5.00	11.990	-0.010	11.972	31.00	11.938	-0.034	61.50	11.877	-0.048	14.00	11.772	-0.080
0.1	0.32	3.50	11.993	7.10	11.986	-0.004	11.956	50.00	11.900	-0.038	98.50	11.803	-0.074	70.00	11.660	-0.112
0.17	0.41	3.50	11.993	7.50	11.985	-0.005	11.955	51.00	11.898	-0.040	99.00	11.802	-0.075	71.00	11.658	-0.114
0.25	0.50	3.60	11.993	7.70	11.985	-0.005	11.954	51.20	11.898	-0.040	99.50	11.801	-0.076	73.00	11.654	-0.118
0.5	0.71	3.70	11.993	7.90	11.984	-0.006	11.954	52.00	11.896	-0.042	1.00	11.798	-0.079	74.00	11.652	-0.120
1	1.00	3.80	11.992	8.10	11.984	-0.006	11.953	52.80	11.894	-0.044	2.00	11.796	-0.081	77.00	11.646	-0.126
2	1.41	3.90	11.992	8.35	11.983	-0.007	11.952	53.50	11.893	-0.045	3.50	11.793	-0.084	79.00	11.642	-0.130
4	2.00	4.00	11.992	8.60	11.983	-0.007	11.951	54.20	11.892	-0.046	4.50	11.791	-0.086	81.00	11.638	-0.134
8	2.83	4.10	11.992	8.90	11.982	-0.008	11.950	55.10	11.890	-0.048	6.00	11.788	-0.089	83.10	11.634	-0.138
15	3.87	4.20	11.992	9.30	11.981	-0.009	11.949	55.80	11.888	-0.050	7.00	11.786	-0.091	84.00	11.632	-0.140
30	5.48	4.30	11.991	9.80	11.980	-0.010	11.948	56.50	11.887	-0.051	8.50	11.783	-0.094	86.00	11.628	-0.144
60	7.75	4.40	11.991	10.30	11.979	-0.011	11.946	57.50	11.885	-0.053	9.80	11.780	-0.097	88.00	11.624	-0.148
120	10.95	4.50	11.991	10.80	11.978	-0.012	11.944	58.60	11.883	-0.055	11.00	11.778	-0.099	89.50	11.621	-0.151
240	15.49	4.60	11.991	11.20	11.978	-0.012	11.942	60.10	11.880	-0.058	12.00	11.776	-0.101	91.30	11.617	-0.155
480	21.91	4.70	11.991	11.50	11.977	-0.013	11.940	61.50	11.877	-0.061	13.20	11.774	-0.103	93.50	11.613	-0.159
1440	37.95	5.00	11.990	14.00	11.972	-0.018	11.938	61.50	11.877	-0.061	14.00	11.772	-0.105	93.50	11.613	-0.159

Unloading			400 kN/m <sup>2</sup> - 100kN/m <sup>2</sup> (2kg)		100 kN/m <sup>2</sup> - 25kN/m <sup>2</sup> (50kg)		
Time Elapsed (min)	Root time min <sup>1/2</sup>	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)
0	0.00	93.50	11.613	0.000	58.00	11.684	0.000
0.1	0.32	70.00	11.660	0.047	29.00	11.742	0.058
0.17	0.41	69.00	11.662	0.049	28.70	11.743	0.059
0.25	0.50	68.80	11.662	0.049	28.50	11.743	0.059
0.5	0.71	68.50	11.663	0.050	28.50	11.743	0.059
1	1.00	68.80	11.662	0.049	28.20	11.744	0.060
2	1.41	67.80	11.664	0.051	28.00	11.744	0.060
4	2.00	67.20	11.666	0.053	28.00	11.744	0.060
8	2.83	67.00	11.666	0.053	27.50	11.745	0.061
15	3.87	67.00	11.666	0.053	27.50	11.745	0.061
30	5.48	67.00	11.666	0.053	27.20	11.746	0.062
60	7.75	67.00	11.666	0.053	27.00	11.746	0.062
120	10.95	62.00	11.676	0.063	27.00	11.746	0.062
240	15.49	58.00	11.684	0.071	26.50	11.747	0.063
480	21.91	58.00	11.684	0.071	20.00	11.760	0.076
1440	37.95	58.00	11.684	0.071	20.00	11.760	0.076

Time Elapsed (min)	Reloading Root time min <sup>1/2</sup>	50 kN/m <sup>2</sup> (1kg)		100 kN/m <sup>2</sup> (2kg)		200 kN/m <sup>2</sup> (4 kg)		400 kN/m <sup>2</sup> (8kg)		800 kN/m <sup>2</sup> (16 kg)	
		Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)
0	0.00	20.00	11.760	32.00	11.736	44.50	11.711	67.50	11.665	8.50	11.583
0.1	0.32	26.00	11.748	34.60	11.731	63.50	11.673	94.50	11.611	15.00	11.570
0.17	0.41	26.80	11.746	36.10	11.728	64.00	11.672	95.00	11.610	28.00	11.544
0.25	0.50	26.80	11.746	38.30	11.723	64.50	11.671	95.20	11.610	60.00	11.480
0.5	0.71	26.80	11.746	42.00	11.716	65.00	11.670	96.00	11.608	65.00	11.470
1	1.00	27.00	11.746	43.00	11.714	65.00	11.670	96.00	11.608	76.00	11.448
2	1.41	27.00	11.746	43.10	11.714	65.20	11.670	96.50	11.607	81.00	11.438
4	2.00	27.20	11.746	43.30	11.713	65.50	11.669	97.50	11.605	90.00	11.420
8	2.83	27.50	11.745	43.30	11.713	65.50	11.669	98.00	11.604	90.00	11.420
15	3.87	27.80	11.744	43.30	11.713	65.60	11.669	98.20	11.604	90.20	11.420
30	5.48	27.90	11.744	43.30	11.713	65.70	11.669	98.40	11.603	90.20	11.420
60	7.75	28.00	11.744	43.40	11.713	65.90	11.668	99.00	11.602	90.20	11.420
120	10.95	30.00	11.740	43.60	11.713	66.10	11.668	100.00	11.600	91.90	11.416
240	15.49	30.00	11.740	43.60	11.713	67.00	11.666	6.50	11.587	94.50	11.411
480	21.91	30.00	11.740	43.60	11.713	67.00	11.666	6.50	11.587	94.50	11.411
1440	37.95	32.00	11.736	44.50	11.711	67.50	11.665	8.50	11.583	96.50	11.407

Load Pattern	Applied Pressure kg	Applied Pressure kN/m <sup>2</sup>	Final Dial Gauge Reading		Change in Dial Gauge Reading	Thickness of soil Sample Ht/(mm)	Equivalent height of voids (H1-Hs)/(mm)	Void Ratio e=(H1-Hs)/Hs
			Final Dial Gauge Reading	Final Dial Gauge Reading				
Loading	0.00		12.000		0.000	20.000	7.419	0.590
	0.25	12.50	11.990		0.010	19.990	7.409	0.589
	0.50	25.00	11.972		0.018	19.972	7.391	0.588
	1.00	50.00	11.938		0.034	19.938	7.357	0.585
	2.00	100.00	11.877		0.061	19.877	7.296	0.580
	4.00	200.00	11.772		0.105	19.772	7.191	0.572
	8.00	400.00	11.613		0.159	19.613	7.032	0.559

Unloading	Applied Pressure kg	Applied Pressure kN/m <sup>2</sup>	Final Dial Gauge Reading		Change in Dial Gauge Reading	Thickness of soil Sample Ht/(mm)	Equivalent height of voids (H1-Hs)/(mm)	Void Ratio e=(H1-Hs)/Hs
			Final Dial Gauge Reading	Final Dial Gauge Reading				
	8.00	400.00	11.613		0.387	19.613	7.032	0.559
	2.00	100.00	11.684		-0.071	19.684	7.103	0.565
	0.50	25.00	11.760		-0.076	19.760	7.179	0.571

Re - Loading	Applied Pressure kg	Applied Pressure kN/m <sup>2</sup>	Final Dial Gauge Reading		Change in Dial Gauge Reading	Thickness of soil Sample Ht/(mm)	Equivalent height of voids (H1-Hs)/(mm)	Void Ratio e=(H1-Hs)/Hs
			Final Dial Gauge Reading	Final Dial Gauge Reading				
	0.50	25	11.760		0.240	19.760	7.179	0.571
	1.00	50.00	11.736		0.024	19.736	7.155	0.569
	2.00	100.00	11.711		0.025	19.711	7.130	0.567
	4.00	200.00	11.665		0.046	19.665	7.084	0.563
	8.00	400.00	11.583		0.082	19.583	7.002	0.557
	16.00	800.00	11.407		0.176	19.407	6.826	0.543

Consolidation settlement for Bottom Ash sample S3-3 for loading, Unloading and Reloading and the table of relevant void ratios for the applied pressure.

Time Elapsed (min)	Root time min <sup>1/2</sup>	12.5 kN/m <sup>2</sup> (25g)		25 kN/m <sup>2</sup> (50g)		50 kN/m <sup>2</sup> (1 kg)		100 kN/m <sup>2</sup> (2 kg)		200 kN/m <sup>2</sup> (4 kg)		400 kN/m <sup>2</sup> (8 kg)		
		Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	
0	0.00	0.00	12.000	0.000	12.60	11.975	-0.025	28.50	56.00	11.888	-0.065	71.00	11.654	-0.080
0.1	0.32	9.00	11.982	-0.018	23.00	11.954	-0.021	44.00	86.00	11.828	-0.060	53.00	11.694	-0.150
0.17	0.41	9.50	11.981	-0.019	23.50	11.953	-0.022	44.20	87.00	11.826	-0.062	54.00	11.692	-0.154
0.25	0.50	9.80	11.980	-0.020	23.50	11.953	-0.022	45.00	88.00	11.824	-0.064	56.00	11.688	-0.156
0.5	0.71	10.00	11.980	-0.020	23.70	11.953	-0.022	45.70	88.80	11.821	-0.066	57.00	11.686	-0.160
1	1.00	10.50	11.979	-0.021	24.00	11.952	-0.023	46.00	90.00	11.820	-0.068	58.50	11.683	-0.164
2	1.41	11.00	11.978	-0.022	24.30	11.951	-0.023	46.80	91.20	11.818	-0.070	60.20	11.680	-0.168
4	2.00	11.50	11.977	-0.023	24.60	11.951	-0.024	47.50	92.00	11.816	-0.072	61.30	11.677	-0.172
8	2.83	11.80	11.976	-0.024	24.80	11.950	-0.024	48.50	93.00	11.814	-0.074	63.00	11.674	-0.175
15	3.87	11.90	11.976	-0.024	25.10	11.950	-0.025	49.50	94.00	11.812	-0.076	64.00	11.672	-0.178
30	5.48	12.00	11.976	-0.024	25.50	11.949	-0.026	50.20	95.00	11.810	-0.078	65.70	11.669	-0.181
60	7.75	12.10	11.976	-0.024	26.00	11.948	-0.027	50.80	96.00	11.808	-0.080	68.00	11.664	-0.186
120	10.95	12.20	11.976	-0.024	26.50	11.947	-0.028	51.50	97.50	11.805	-0.083	70.00	11.660	-0.188
240	15.49	12.30	11.975	-0.025	27.00	11.946	-0.029	52.50	98.20	11.804	-0.084	70.80	11.658	-0.191
480	21.91	12.40	11.975	-0.025	27.50	11.945	-0.030	54.00	99.30	11.801	-0.087	71.50	11.657	-0.193
1440	37.95	12.60	11.975	-0.025	28.50	11.943	-0.032	56.00	1.20	11.798	-0.090	73.00	11.654	-0.197

Time Elapsed (min)	Root time min <sup>1/2</sup>	400 kN/m <sup>2</sup> - 100kN/m <sup>2</sup> (2kg)		100 kN/m <sup>2</sup> - 25kN/m <sup>2</sup> (50g)			
		Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)		
0	0.00	71.50	11.457	0.000	17.20	11.566	0.000
0.1	0.32	24.00	11.552	0.095	86.00	11.628	0.062
0.17	0.41	23.50	11.553	0.096	85.50	11.629	0.063
0.25	0.50	23.20	11.554	0.097	85.00	11.630	0.064
0.5	0.71	23.00	11.554	0.097	84.80	11.630	0.065
1	1.00	22.80	11.554	0.097	84.20	11.632	0.066
2	1.41	22.50	11.555	0.098	83.50	11.633	0.067
4	2.00	22.20	11.556	0.099	83.20	11.634	0.068
8	2.83	22.00	11.556	0.099	82.50	11.635	0.069
15	3.87	22.00	11.556	0.099	82.00	11.636	0.070
30	5.48	21.50	11.557	0.100	81.80	11.636	0.071
60	7.75	20.50	11.559	0.102	81.20	11.638	0.072
120	10.95	20.00	11.560	0.103	80.80	11.638	0.073
240	15.49	17.80	11.564	0.107	79.50	11.641	0.075
480	21.91	17.20	11.566	0.109	77.50	11.645	0.079
1440	37.95	17.20	11.566	0.109	77.50	11.645	0.079

Time Elapsed (min)	Reloading Root time min <sup>1/2</sup>	50 kN/m <sup>2</sup> (1kg)		100 kN/m <sup>2</sup> (2kg)		200 kN/m <sup>2</sup> (4 kg)		400 kN/m <sup>2</sup> (8kg)		800 kN/m <sup>2</sup> (16 kg)						
		Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)	Dial Reading (mm)	Settlement (mm)					
0	0.00	77.50	11.645	0.000	86.80	11.626	0.000	7.00	11.586	0.000	35.50	11.529	0.000	95.00	11.410	0.000
0.1	0.32	85.00	11.630	-0.015	89.00	11.622	-0.004	30.00	11.540	-0.046	69.00	11.462	-0.067	10.00	11.380	-0.030
0.17	0.41	85.20	11.630	-0.015	93.00	11.614	-0.012	30.50	11.539	-0.047	70.00	11.460	-0.069	20.00	11.360	-0.050
0.25	0.50	85.20	11.630	-0.015	99.00	11.602	-0.024	31.00	11.538	-0.048	70.50	11.459	-0.070	50.00	11.300	-0.110
0.5	0.71	85.50	11.629	-0.016	1.00	11.598	-0.028	32.00	11.536	-0.050	71.00	11.458	-0.071	70.00	11.260	-0.150
1	1.00	85.80	11.628	-0.017	4.00	11.592	-0.034	32.20	11.536	-0.050	71.20	11.458	-0.071	75.00	11.250	-0.160
2	1.41	85.90	11.628	-0.017	4.00	11.592	-0.034	32.50	11.535	-0.051	72.00	11.456	-0.073	83.00	11.234	-0.176
4	2.00	86.00	11.628	-0.017	4.10	11.592	-0.035	33.00	11.534	-0.052	73.00	11.454	-0.075	86.00	11.228	-0.182
8	2.83	86.00	11.628	-0.017	4.90	11.590	-0.036	33.10	11.534	-0.052	73.50	11.453	-0.076	87.00	11.226	-0.184
15	3.87	86.00	11.628	-0.017	5.00	11.590	-0.036	33.50	11.533	-0.053	74.00	11.452	-0.077	89.00	11.222	-0.188
30	5.48	86.10	11.628	-0.017	5.00	11.590	-0.036	34.00	11.532	-0.054	74.00	11.452	-0.077	92.00	11.216	-0.194
60	7.75	86.50	11.627	-0.018	5.10	11.590	-0.037	34.10	11.532	-0.054	75.00	11.450	-0.079	93.00	11.214	-0.196
120	10.95	86.60	11.627	-0.018	5.70	11.589	-0.038	34.50	11.531	-0.055	76.00	11.448	-0.081	95.90	11.208	-0.202
240	15.49	86.70	11.627	-0.018	6.00	11.588	-0.038	35.00	11.530	-0.056	92.00	11.416	-0.113	98.30	11.203	-0.207
480	21.91	86.70	11.627	-0.018	6.00	11.588	-0.038	35.00	11.530	-0.056	92.00	11.416	-0.113	98.30	11.203	-0.207
1440	37.95	86.80	11.626	-0.019	7.00	11.586	-0.040	35.50	11.529	-0.057	95.00	11.410	-0.119	1.50	11.197	-0.213

Load Pattern	Applied Pressure kg	Applied Pressure kN/m <sup>2</sup>	Final Dial Guage Reading		Change in Dial gauge Reading	Thickness of soil Sample H <sub>L</sub> /(mm)	Equivalent height of voids (H <sub>L</sub> -H <sub>s</sub> )/(mm)	Void Ratio e=(H <sub>L</sub> -H <sub>s</sub> )/H <sub>s</sub>
			Final Dial Guage Reading	Change in Dial gauge Reading				
Loading	0.00		12.000	0.000		20.000	0.603	
	0.25	12.50	11.975	0.025		19.975	0.601	
	0.50	25.00	11.943	0.057		19.957	0.601	
	1.00	50.00	11.888	0.065		19.920	0.597	
	2.00	100.00	11.798	0.090		19.829	0.590	
4.00	200.00	11.654	0.144		19.686	0.578		
8.00	400.00	11.457	0.197		19.489	0.562		

Applied Pressure kg	Applied Pressure kN/m <sup>2</sup>	Final Dial Guage Reading		Change in Dial gauge Reading	Thickness of soil Sample H <sub>L</sub> /(mm)	Equivalent height of voids (H <sub>L</sub> -H <sub>s</sub> )/(mm)	Void Ratio e=(H <sub>L</sub> -H <sub>s</sub> )/H <sub>s</sub>
		Final Dial Guage Reading	Change in Dial gauge Reading				
Unloading	8.00	400.00	11.457	0.543		7.015	0.562
	2.00	100.00	11.566	-0.109		7.123	0.571
	0.50	25.00	11.645	-0.079		7.203	0.577

Applied Pressure kg	Applied Pressure kN/m <sup>2</sup>	Final Dial Guage Reading		Change in Dial gauge Reading	Thickness of soil Sample H <sub>L</sub> /(mm)	Equivalent height of voids (H <sub>L</sub> -H <sub>s</sub> )/(mm)	Void Ratio e=(H <sub>L</sub> -H <sub>s</sub> )/H <sub>s</sub>
		Final Dial Guage Reading	Change in Dial gauge Reading				
Re-Loading	0.50	25	11.645	0.355		7.203	0.577
	1.00	50.00	11.626	0.019		7.184	0.576
	2.00	100.00	11.586	0.040		7.144	0.573
	4.00	200.00	11.529	0.057		7.087	0.568
	8.00	400.00	11.410	0.119		6.968	0.559
16.00	800.00	11.197	0.213		6.755	0.542	

Calculated value for coefficient of consolidation and volume compressibility for load cases for sample S3-1

Current load increment	0kN/m <sup>2</sup>	12.5kN/m <sup>2</sup>	25kN/m <sup>2</sup>	50kN/m <sup>2</sup>	100kN/m <sup>2</sup>	100kN/m <sup>2</sup>
	12.5kN/m <sup>2</sup>	25kN/m <sup>2</sup>	50kN/m <sup>2</sup>	100kN/m <sup>2</sup>	200kN/m <sup>2</sup>	400kN/m <sup>2</sup>
At the Beginning Sample Thickness (H) mm	20.00	19.970	19.928	19.858	19.746	19.572
Sample settlement from each load ( $\Delta h$ ) mm	0.030	0.042	0.070	0.112	0.174	0.226
Coefficient of Volume Compressibility( $m_v$ )(10 <sup>-5</sup> m <sup>2</sup> /kN)	12.0	8.5	7.0	5.6	4.4	2.9
$\sqrt{t_{90}}$ (min <sup>1/2</sup> )	2.80	2.20	2.00	1.80	1.50	1.10
$t_{90}$ (min)	7.84	4.84	4.00	3.24	2.25	1.21
d = H/2 (mm)	10.00	9.99	9.96	9.93	9.87	9.79
T <sub>90</sub>	0.848	0.848	0.848	0.848	0.848	0.848
Coefficient of Consolidation ( $C_v$ ) (mm <sup>2</sup> /min)	10.82	17.47	21.05	25.80	36.74	67.12
Coefficient of Consolidation ( $C_v$ ) (m <sup>2</sup> /year)	5.7	9.2	11.1	13.6	19.3	35.3

Calculated values for coefficient of consolidation and volume compressibility for load case for sample S3-2

Current load increment	0kN/m <sup>2</sup>	12.5kN/m <sup>2</sup>	25kN/m <sup>2</sup>	50kN/m <sup>2</sup>	100kN/m <sup>2</sup>	100kN/m <sup>2</sup>
	12.5kN/m <sup>2</sup>	25kN/m <sup>2</sup>	50kN/m <sup>2</sup>	100kN/m <sup>2</sup>	200kN/m <sup>2</sup>	400kN/m <sup>2</sup>
At the Beginning Sample Thickness (H) mm	20.00	19.990	19.972	19.938	19.877	19.772
Sample settlement from each load ( $\Delta h$ ) mm	0.010	0.018	0.034	0.061	0.105	0.159
Coefficient of Volume Compressibility( $m_v$ )(10 <sup>-5</sup> m <sup>2</sup> /kN)	4.0	3.6	3.4	3.1	2.6	2.0
$\sqrt{t_{90}}$ (min <sup>1/2</sup> )	3.20	2.50	2.00	1.50	1.20	0.90
$t_{90}$ (min)	10.24	6.25	4.00	2.25	1.44	0.81
d = H/2 (mm)	10.00	10.00	9.99	9.97	9.94	9.89
T <sub>90</sub>	0.848	0.848	0.848	0.848	0.848	0.848
Coefficient of Consolidation ( $C_v$ ) (mm <sup>2</sup> /min)	8.28	13.55	21.14	37.46	58.17	102.32
Coefficient of Consolidation ( $C_v$ ) (m <sup>2</sup> /year)	4.4	7.1	11.1	19.7	30.6	53.8

Calculated value for coefficient of consolidation and volume compressibility for load case for sample S3-3

Current load increment	0kN/m <sup>2</sup>	12.5kN/m <sup>2</sup>	25kN/m <sup>2</sup>	50kN/m <sup>2</sup>	100kN/m <sup>2</sup>	100kN/m <sup>2</sup>
	12.5kN/m <sup>2</sup>	25kN/m <sup>2</sup>	50kN/m <sup>2</sup>	100kN/m <sup>2</sup>	200kN/m <sup>2</sup>	400kN/m <sup>2</sup>
At the Beginning Sample Thickness (H) mm	20.00	19.975	19.943	19.888	19.798	19.654
Sample settlement from each load ( $\Delta h$ ) mm	0.025	0.032	0.055	0.090	0.144	0.197
Coefficient of Volume Compressibility( $m_v$ )(10 <sup>-5</sup> m <sup>2</sup> /kN)	10.0	6.4	5.5	4.5	3.6	2.5
$\sqrt{t_{90}}$ (min <sup>1/2</sup> )	2.80	2.30	1.90	1.40	1.10	0.90
$t_{90}$ (min)	7.84	5.29	3.61	1.96	1.21	0.81
d = H/2 (mm)	10.00	9.99	9.97	9.94	9.90	9.83
T <sub>90</sub>	0.848	0.848	0.848	0.848	0.848	0.848
Coefficient of Consolidation ( $C_v$ ) (mm <sup>2</sup> /min)	10.82	15.99	23.36	42.78	68.67	101.10
Coefficient of Consolidation ( $C_v$ ) (m <sup>2</sup> /year)	5.7	8.4	12.3	22.5	36.1	53.1

## Appendix C - Shear strength parameters of the Bottom Ash

Tabulation of direct shear test data for the bottom ash sample S2

Normal load 50 kN/m<sup>2</sup>

Shear Disp. Div	Proving Ring reading	Vertical Gauge reading	Vertical Dis. (mm) ΔH	Change in Void ratio Δe	Void ratio e=e <sub>0</sub> -Δe	Shear force (kg)	Shear Displac. (mm)	Shear Area (mm <sup>2</sup> )	Shear stress (kN/m <sup>2</sup> )
0	0.0	0.0	0.0000	0.0000	0.6981	0	0.00	3600	0.00
10	1.0	0.0	0.0000	0.0000	0.6981	0.174	0.10	3594	0.47
20	6.0	1.0	0.0254	0.0014	0.6968	1.044	0.20	3588	2.85
30	12.0	1.0	0.0254	0.0014	0.6968	2.088	0.30	3582	5.72
40	15.0	2.0	0.0508	0.0027	0.6954	2.610	0.40	3576	7.16
50	16.0	2.0	0.0508	0.0027	0.6954	2.784	0.50	3570	7.65
75	22.0	4.0	0.1016	0.0054	0.6927	3.828	0.75	3555	10.56
100	26.0	5.0	0.1270	0.0068	0.6913	4.524	1.00	3540	12.54
125	27.0	6.0	0.1524	0.0082	0.6900	4.698	1.25	3525	13.07
150	32.0	8.0	0.2032	0.0109	0.6872	5.568	1.50	3510	15.56
175	38.0	9.0	0.2286	0.0122	0.6859	6.612	1.75	3495	18.56
200	43.0	11.0	0.2794	0.0149	0.6832	7.482	2.00	3480	21.09
225	46.0	12.0	0.3048	0.0163	0.6818	8.004	2.25	3465	22.66
250	52.0	12.0	0.3048	0.0163	0.6818	9.048	2.50	3450	25.73
275	55.0	12.0	0.3048	0.0163	0.6818	9.570	2.75	3435	27.33
300	60.0	12.0	0.3048	0.0163	0.6818	10.440	3.00	3420	29.95
325	61.0	12.0	0.3048	0.0163	0.6818	10.614	3.25	3405	30.58
350	62.0	12.0	0.3048	0.0163	0.6818	10.788	3.50	3390	31.22
375	64.0	12.5	0.3175	0.0170	0.6811	11.136	3.75	3375	32.37
400	64.5	12.5	0.3175	0.0170	0.6811	11.223	4.00	3360	32.77
425	65.0	12.5	0.3175	0.0170	0.6811	11.310	4.25	3345	33.17
450	66.0	13.0	0.3302	0.0177	0.6805	11.484	4.50	3330	33.83
475	67.0	13.0	0.3302	0.0177	0.6805	11.658	4.75	3315	34.50
500	68.0	13.0	0.3302	0.0177	0.6805	11.832	5.00	3300	35.17
550	68.0	13.0	0.3302	0.0177	0.6805	11.832	5.50	3270	35.50
600	68.0	13.0	0.3302	0.0177	0.6805	11.832	6.00	3240	35.82
625	68.0	13.0	0.3302	0.0177	0.6805	11.832	6.25	3225	35.99
675	68.0	13.0	0.3302	0.0177	0.6805	11.832	6.75	3195	36.33

Normal load 100 kN/m<sup>2</sup>

Shear Disp. Div	Proving Ring reading	Vertical Gauge reading	Vertical Dis. (mm) ΔH	Change in Void ratio Δe	Void ratio e=e <sub>0</sub> -Δe	Shear force (kg)	Shear Displac. (mm)	Shear Area (mm <sup>2</sup> )	Shear stress (kN/m <sup>2</sup> )
0	0	0	0	0.0000	0.6981	0	0.0000	3600	0.00
10	11	1	0.0254	0.00136	0.6968	1.91400	0.1000	3594	5.22
20	25	2	0.0508	0.00272	0.6954	4.35000	0.2000	3588	11.89
30	34	3	0.0762	0.00408	0.6940	5.91600	0.3000	3582	16.20
40	41	3	0.0762	0.00408	0.6940	7.13400	0.4000	3576	19.57
50	47	4	0.1016	0.00543	0.6927	8.17800	0.5000	3570	22.47
75	64	5	0.127	0.00679	0.6913	11.13600	0.7500	3555	30.73
100	76	6	0.1524	0.00815	0.6900	13.22400	1.0000	3540	36.65
125	87	8	0.2032	0.01087	0.6872	15.13800	1.2500	3525	42.13
150	97	9	0.2286	0.01223	0.6859	16.87800	1.5000	3510	47.17
175	109	11	0.2794	0.01494	0.6832	18.96600	1.7500	3495	53.24
200	118	12	0.3048	0.01630	0.6818	20.53200	2.0000	3480	57.88
225	122	13	0.3302	0.01766	0.6805	21.22800	2.2500	3465	60.10
250	129	14	0.3556	0.01902	0.6791	22.44600	2.5000	3450	63.82
275	135	15	0.381	0.02038	0.6777	23.49000	2.7500	3435	67.08
300	140	16	0.4064	0.02174	0.6764	24.36000	3.0000	3420	69.87
325	140	16	0.4064	0.02174	0.6764	24.36000	3.2500	3405	70.18
350	141	16	0.4064	0.02174	0.6764	24.53400	3.5000	3390	71.00
375	141	17	0.4318	0.02309	0.6750	24.53400	3.7500	3375	71.31
400	142	18	0.4572	0.02445	0.6737	24.70800	4.0000	3360	72.14
425	144	18	0.4572	0.02445	0.6737	25.05600	4.2500	3345	73.48
450	144	18	0.4572	0.02445	0.6737	25.05600	4.5000	3330	73.81
475	144	18	0.4572	0.02445	0.6737	25.05600	4.7500	3315	74.15
500	144	19	0.4826	0.02581	0.6723	25.05600	5.0000	3300	74.48
550	141	20	0.508	0.02717	0.6709	24.53400	5.5000	3270	73.60
600	140	20	0.508	0.02717	0.6709	24.36000	6.0000	3240	73.76
625	143	19	0.4826	0.02581	0.6723	24.88200	6.2500	3225	75.69
675	141	20	0.508	0.02717	0.6709	24.53400	6.7500	3195	75.33

Normal load 300kN/m<sup>2</sup>

Shear Disp. Div	Proving Ring reading	Vertical Gauge reading	Vertical Dis. (mm) ΔH	Change in Void ratio Δe	Void ratio e=e <sub>0</sub> -Δe	Shear force (kg)	Shear Displac. (mm)	Shear Area (mm <sup>2</sup> )	Shear stress (kN/m <sup>2</sup> )
0	0	0	0	0.0000	0.6981	0.00	0.000	3600	0.00
10	30	0	0	0.0000	0.6981	5.22	0.100	3594	14.25
20	51	1	0.0254	0.00136	0.6968	8.87	0.200	3588	24.26
30	63	2	0.0508	0.00272	0.6954	10.96	0.300	3582	30.02
40	80	3	0.0762	0.00408	0.6940	13.92	0.400	3576	38.19
50	90	4	0.1016	0.00543	0.6927	15.66	0.500	3570	43.03
75	115	6	0.1524	0.00815	0.6900	20.01	0.750	3555	55.22
100	150	7	0.1778	0.00951	0.6886	26.10	1.000	3540	72.33
125	170	9	0.2286	0.01223	0.6859	29.58	1.250	3525	82.32
150	185	10	0.254	0.01358	0.6845	32.19	1.500	3510	89.97
175	202	12	0.3048	0.01630	0.6818	35.15	1.750	3495	98.66
200	212	13	0.3302	0.01766	0.6805	36.89	2.000	3480	103.99
225	235	14	0.3556	0.01902	0.6791	40.89	2.250	3465	115.77
250	249	15	0.381	0.02038	0.6777	43.33	2.500	3450	123.20
275	262	16	0.4064	0.02174	0.6764	45.59	2.750	3435	130.19
300	273	16	0.4064	0.02174	0.6764	47.50	3.000	3420	136.26
325	285	17	0.4318	0.02309	0.6750	49.59	3.250	3405	142.87
350	297	18	0.4572	0.02445	0.6737	51.68	3.500	3390	149.55
375	293	19	0.4826	0.02581	0.6723	50.98	3.750	3375	148.19
400	293	19	0.4826	0.02581	0.6723	50.98	4.000	3360	148.85
425	293	19	0.4826	0.02581	0.6723	50.98	4.250	3345	149.52
450	294	19	0.4826	0.02581	0.6723	51.16	4.500	3330	150.70
475	294	19	0.4826	0.02581	0.6723	51.16	4.750	3315	151.38
500	294	20	0.5080	0.02717	0.6709	51.16	5.000	3300	152.07



## Tabulation of direct shear test data for the bottom ash sample S3

Normal load 50kN/m<sup>2</sup>

Shear Disp. Div	Proving Ring reading	Vertical Gauge reading	Vertical Dis. (mm) ΔH	Change in Void ratio Δe	Void ratio e=e <sub>0</sub> -Δe	Shear force (kg)	Shear Displac. (mm)	Shear Area (mm <sup>2</sup> )	Shear stress (kN/m <sup>2</sup> )
0	0	0.0	0.0000	0.00000	0.5903	0	0.0	3600	0.0
10	11	0.0	0.0000	0.00000	0.5903	1.914	0.1	3594	5.2
20	17	0.0	0.0000	0.00000	0.5903	2.958	0.2	3588	8.1
30	20	1.0	0.0254	0.00141	0.5889	3.480	0.3	3582	9.5
40	23	1.0	0.0254	0.00141	0.5889	4.002	0.4	3576	11.0
50	27	1.0	0.0254	0.00141	0.5889	4.698	0.5	3570	12.9
75	35	2.0	0.0508	0.00282	0.5875	6.090	0.8	3555	16.8
100	46	3.0	0.0762	0.00424	0.5861	8.004	1.0	3540	22.2
125	56	4.0	0.1016	0.00565	0.5847	9.744	1.3	3525	27.1
150	65	5.0	0.1270	0.00706	0.5833	11.310	1.5	3510	31.6
175	73	6.0	0.1524	0.00847	0.5819	12.702	1.8	3495	35.7
200	79	6.0	0.1524	0.00847	0.5819	13.746	2.0	3480	38.7
225	86	7.0	0.1778	0.00988	0.5805	14.964	2.3	3465	42.4
250	90	8.0	0.2032	0.01130	0.5790	15.660	2.5	3450	44.5
275	95	8.0	0.2032	0.01130	0.5790	16.530	2.8	3435	47.2
300	98	9.0	0.2286	0.01271	0.5776	17.052	3.0	3420	48.9
325	99	9.0	0.2286	0.01271	0.5776	17.226	3.3	3405	49.6
350	100	10.0	0.2540	0.01412	0.5762	17.400	3.5	3390	50.4
375	100	10.0	0.2540	0.01412	0.5762	17.400	3.8	3375	50.6
400	100	10.0	0.2540	0.01412	0.5762	17.400	4.0	3360	50.8
425	100	10.0	0.2540	0.01412	0.5762	17.400	4.3	3345	51.0

Normal load 100kN/m<sup>2</sup>

Shear Disp. Div	Proving Ring reading	Vertical Gauge reading	Vertical Dis. (mm) ΔH	Change in Void ratio Δe	Void ratio e=e <sub>0</sub> -Δe	Shear force (kg)	Shear Displac. (mm)	Shear Area (mm <sup>2</sup> )	Shear stress (kN/m <sup>2</sup> )
0	0	0.0	0.0000	0.00000	0.5903	0	0.0	3600	0.0
10	21	0.0	0.0000	0.00000	0.5903	3.65400	0.1	3594	10.0
20	30	0.0	0.0000	0.00000	0.5903	5.22000	0.2	3588	14.3
30	40	1.0	0.0254	0.00141	0.5889	6.96000	0.3	3582	19.1
40	46	1.0	0.0254	0.00141	0.5889	8.00400	0.4	3576	22.0
50	51	2.0	0.0508	0.00282	0.5875	8.87400	0.5	3570	24.4
75	61	4.0	0.1016	0.00565	0.5847	10.61400	0.8	3555	29.3
100	69	5.0	0.1270	0.00706	0.5833	12.00600	1.0	3540	33.3
125	78	7.0	0.1778	0.00988	0.5805	13.57200	1.3	3525	37.8
150	82	8.0	0.2032	0.01130	0.5790	14.26800	1.5	3510	39.9
175	90	9.0	0.2286	0.01271	0.5776	15.66000	1.8	3495	44.0
200	92	10.0	0.2540	0.01412	0.5762	16.00800	2.0	3480	45.1
225	98	11.0	0.2794	0.01553	0.5748	17.05200	2.3	3465	48.3
250	101	12.0	0.3048	0.01694	0.5734	17.57400	2.5	3450	50.0
275	102	12.0	0.3048	0.01694	0.5734	17.74800	2.8	3435	50.7
300	104	13.0	0.3302	0.01835	0.5720	18.09600	3.0	3420	51.9
325	105	13.0	0.3302	0.01835	0.5720	18.27000	3.3	3405	52.6
350	106	13.0	0.3302	0.01835	0.5720	18.44400	3.5	3390	53.4
375	106	14.0	0.3556	0.01977	0.5706	18.44400	3.8	3375	53.6
400	106	14.0	0.3556	0.01977	0.5706	18.44400	4.0	3360	53.8
425	106	14.0	0.3556	0.01977	0.5706	18.44400	4.3	3345	54.1

Normal load 150kN/m<sup>2</sup>

Shear Disp. Div	Proving Ring reading	Vertical Gauge reading	Vertical Dis. (mm) ΔH	Change in Void ratio Δe	Void ratio e=e <sub>0</sub> -Δe	Shear force (kg)	Shear Displac. (mm)	Shear Area (mm <sup>2</sup> )	Shear stress (kN/m <sup>2</sup> )
0	0	0.0	0.0000	0.00000	0.5903	0.00000	0.0	3600	0.0
10	25	0.0	0.0000	0.00000	0.5903	4.35000	0.1	3594	11.9
20	39	0.0	0.0000	0.00000	0.5903	6.78600	0.2	3588	18.6
30	49	0.0	0.0000	0.00000	0.5903	8.52600	0.3	3582	23.4
40	60	2.0	0.0508	0.00282	0.5875	10.44000	0.4	3576	28.6
50	69	3.0	0.0762	0.00424	0.5861	12.00600	0.5	3570	33.0
75	89	5.0	0.1270	0.00706	0.5833	15.48600	0.8	3555	42.7
100	107	7.0	0.1778	0.00988	0.5805	18.61800	1.0	3540	51.6
125	122	9.0	0.2286	0.01271	0.5776	21.22800	1.3	3525	59.1
150	132	10.0	0.2540	0.01412	0.5762	22.96800	1.5	3510	64.2
175	144	12.0	0.3048	0.01694	0.5734	25.05600	1.8	3495	70.3
200	154	13.0	0.3302	0.01835	0.5720	26.79600	2.0	3480	75.5
225	163	14.0	0.3556	0.01977	0.5706	28.36200	2.3	3465	80.3
250	168	15.0	0.3810	0.02118	0.5692	29.23200	2.5	3450	83.1
275	176	16.0	0.4064	0.02259	0.5678	30.62400	2.8	3435	87.5
300	182	16.0	0.4064	0.02259	0.5678	31.66800	3.0	3420	90.8
325	189	17.0	0.4318	0.02400	0.5663	32.88600	3.3	3405	94.7
350	195	17.0	0.4318	0.02400	0.5663	33.93000	3.5	3390	98.2
375	200	17.0	0.4318	0.02400	0.5663	34.80000	3.8	3375	101.2
400	204	17.0	0.4318	0.02400	0.5663	35.49600	4.0	3360	103.6
425	206	17.0	0.4318	0.02400	0.5663	35.84400	4.3	3345	105.1
450	207	16.0	0.4064	0.02259	0.5678	36.01800	4.5	3330	106.1
475	207	16.0	0.4064	0.02259	0.5678	36.01800	4.8	3315	106.6
500	208	15.0	0.3810	0.02118	0.5692	36.19200	5.0	3300	107.6
550	206	14.0	0.3556	0.01977	0.5706	35.84400	5.5	3270	107.5
600	206	14.0	0.3556	0.01977	0.5706	35.84400	6.0	3240	108.5
525	206	14.0	0.3556	0.01977	0.57057	35.84400	5.3	3285	107.0
575	206	14.0	0.3556	0.01977	0.57057	35.84400	5.8	3255	108.0

Normal load 200kN/m<sup>2</sup>

Shear Disp. Div	Proving Ring reading	Vertical Gauge reading	Vertical Dis. (mm) ΔH	Change in Void ratio Δe	Void ratio e=e <sub>0</sub> -Δe	Shear force (kg)	Shear Displac. (mm)	Shear Area (mm <sup>2</sup> )	Shear stress (kN/m <sup>2</sup> )
0	0	0.0	0.00	0.00000	0.5903	0.0000	0.0	3600	0.0
10	26	1.0	0.03	0.00141	0.5889	4.5240	0.1	3594	12.3
20	43	2.0	0.05	0.00282	0.5875	7.4820	0.2	3588	20.5
30	57	3.0	0.08	0.00424	0.5861	9.9180	0.3	3582	27.2
40	69	4.0	0.10	0.00565	0.5847	12.0060	0.4	3576	32.9
50	80	5.0	0.13	0.00706	0.5833	13.9200	0.5	3570	38.3
75	103	6.0	0.15	0.00847	0.5819	17.9220	0.8	3555	49.5
100	130	8.0	0.20	0.01130	0.5790	22.6200	1.0	3540	62.7
125	150	10.0	0.25	0.01412	0.5762	26.1000	1.3	3525	72.6
150	171	11.0	0.28	0.01553	0.5748	29.7540	1.5	3510	83.2
175	185	13.0	0.33	0.01835	0.5720	32.1900	1.8	3495	90.4
200	201	15.0	0.38	0.02118	0.5692	34.9740	2.0	3480	98.6
225	216	16.0	0.41	0.02259	0.5678	37.5840	2.3	3465	106.4
250	229	17.0	0.43	0.02400	0.5663	39.8460	2.5	3450	113.3
275	245	18.0	0.46	0.02541	0.5649	42.6300	2.8	3435	121.7
300	259	19.0	0.48	0.02683	0.5635	45.0660	3.0	3420	129.3
325	269	20.0	0.51	0.02824	0.5621	46.8060	3.3	3405	134.9
350	269	20.0	0.51	0.02824	0.5621	46.8060	3.5	3390	135.4
375	266	20.0	0.51	0.02824	0.5621	46.2840	3.8	3375	134.5
400	266	20.0	0.51	0.02824	0.5621	46.2840	4.0	3360	135.1
425	266	20.0	0.51	0.02824	0.5621	46.2840	4.3	3345	135.7

Normal load 300kN/m<sup>2</sup>

Shear Disp. Div	Proving Ring reading	Vertical Gauge reading	Vertical Dis. (mm) ΔH	Change in Void ratio Δe	Void ratio e=e <sub>0</sub> -Δe	Shear force (kg)	Shear Displac. (mm)	Shear Area (mm <sup>2</sup> )	Shear stress (kN/m <sup>2</sup> )
0	0	0.0	0.0000	0.00000	0.5903	0.00000	0.0	3600	0.0
10	29	0.0	0.0000	0.00000	0.5903	5.04600	0.1	3594	13.8
20	46	0.0	0.0000	0.00000	0.5903	8.00400	0.2	3588	21.9
30	64	1.0	0.0254	0.00141	0.5889	11.13600	0.3	3582	30.5
40	81	3.0	0.0762	0.00424	0.5861	14.09400	0.4	3576	38.7
50	96	4.0	0.1016	0.00565	0.5847	16.70400	0.5	3570	45.9
75	129	7.0	0.1778	0.00988	0.5805	22.44600	0.8	3555	61.9
100	151	10.0	0.2540	0.01412	0.5762	26.27400	1.0	3540	72.8
125	174	11.0	0.2794	0.01553	0.5748	30.27600	1.3	3525	84.3
150	191	13.0	0.3302	0.01835	0.5720	33.23400	1.5	3510	92.9
175	202	15.0	0.3810	0.02118	0.5692	35.14800	1.8	3495	98.7
200	222	16.0	0.4064	0.02259	0.5678	38.62800	2.0	3480	108.9
225	240	18.0	0.4572	0.02541	0.5649	41.76000	2.3	3465	118.2
250	250	19.0	0.4826	0.02683	0.5635	43.50000	2.5	3450	123.7
275	266	20.0	0.5080	0.02824	0.5621	46.28400	2.8	3435	132.2
300	282	23.0	0.5842	0.03247	0.5579	49.06800	3.0	3420	140.7
325	296	23.0	0.5842	0.03247	0.5579	51.50400	3.3	3405	148.4
350	307	24.0	0.6096	0.03389	0.5565	53.41800	3.5	3390	154.6
375	320	25.0	0.6350	0.03530	0.5550	55.68000	3.8	3375	161.8
400	330	26.0	0.6604	0.03671	0.5536	57.42000	4.0	3360	167.6
425	340	27.0	0.6858	0.03812	0.5522	59.16000	4.3	3345	173.5
450	350	27.0	0.6858	0.03812	0.5522	60.90000	4.5	3330	179.4
475	351	27.0	0.6858	0.03812	0.5522	61.07400	4.8	3315	180.7
500	358	28.0	0.7112	0.03953	0.5508	62.29200	5.0	3300	185.2
550	362	28.0	0.7112	0.03953	0.5508	62.98800	5.5	3270	189.0
600	365	28.0	0.7112	0.03953	0.5508	63.51000	6.0	3240	192.3
650	365	28.0	0.7112	0.03953	0.5508	63.51000	6.5	3210	194.1
700	158	26.0	0.6604	0.03671	0.5536	27.49200	7.0	3180	84.8

## Appendix D - Toxicity Characteristics leaching Procedure (TCLP) for Bottom Ash Sample S3

# TEST REPORT

Report No: (7417)202-0317(R)(SL) Sep 06, 2017  
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**TEST RESULTS**

Parameters	Test Results	LOQ	Requirement	Unit	Method
<b>TCLP Heavy metal Analysis</b>					
Arsenic (As)	ND	0.04	5	mg/L	USEPA Method 1311-TCLP with ICP-MS
Chromium (Cr)	0.08	-	5		
Cadmium (Cd)	ND	0.04	1		
Copper (Cu)	ND	0.06	Not Given		
Lead (Pb)	0.04	-	5		
Manganese (Mn)	1.01	-	Not Given		
Zinc (Zn)	0.04	-	Not Given		
Thallium (Tl)	ND	0.04	Not Given		
Selenium (Se)	ND	0.04	1		
Nickel (Ni)	ND	0.04	Not Given		
Mercury (Hg)	ND	0.007	0.2		
Barium(Ba)	3.26	-	100		
Iron(Fe)	0.04	-	Not Given		
Silver(Ag)	ND	0.04	5		
Sulphur	ND	0.01	Not Given		
Sulfite content (SO <sup>2-</sup> <sub>3</sub> )	ND	1.0	Not Given		
Sulfate content (SO <sup>2-</sup> <sub>4</sub> )	ND	1.0	Not Given	mg/kg	

**Note:**  
 ND - Not Detected  
 mg/L - milligrams per Litter  
 TCLP-Toxicity Characteristics Leaching Procedure  
 ICP-MS - Inductively Coupled Plasma - Mass Spectrometry  
 USEPA- United States Environmental Protection Agency  
 LOQ- Limit of Quantification

**Remark:**  
 Test report (7417)202-0317(SL) has been replaced with (7417)202-0317(R)(SL) to add test as per the vendors request.

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