Characterization of Engineering Properties of Active Soils Stabilized with Nanomaterial for Sustainable Infrastructure Delivery

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APPENDIX

TABLE A-1 Percentage changes in percent swell (%) and water absorption (source: analysis of laboratory results)

SAMPLE	PERCENT IN SWELL (%)	CHANGE IN WATER ABSORPTION (%)
Loc 1R	0.00	0.00
1:250	-9.93	-53.87
1:200	-24.94	-57.20
1:150	-38.01	-65.31
1:100	-64.89	-76.75
1:50	-69.73	-83.39
Loc 2R	0.00	0.00
1.250	-21.96	-16.78
1.200	-37.40	-53.02
1:150	-56.56	-58.39
1:100	-66.59	-63.09
1:50	-68.50	-67.79
Loc 3B	0.00	0.00

1.250	-18.21	-43.36
1.200	-36.41	-54.36
1:150	-57.26	-57.19
1:100	-64.12	-80.08
1:50	-68.34	89.45
Loc 4B	0.00	0.00
1.250	-20.45	-6.54
1.200	-37.50	-15.89
1:150	-37.50	-15.89
1:100	-44.32	-13.08
1:50	-48.11	-12.15
Loc 5D	0.00	0.00
1.250	-12.97	-31.34
1.200	-20.00	-32.84
1:150	-32.97	-22.39
1:100	-37.30	-61.94
1:50	-42.16	-23.88

TABLE A-2: 1 & 7-Day Unconfined Compressive Strength

Loc	**Mix**	**Weight (kg) Before Curing**	**Weight (kg) After Curing**	**Crushing Load (kg)**		**Compressive strength (KN/m^2)**	
				1 day	**7 days**	**1 day**	**7 days**
	0	1.732	1.601	14	45	21.1	69.0
	1:250	1.612	1.550	18	53	27.8	80.5
	1:200	1.772	1.566	27	85	41.2	129.3
1	1:150	1.785	1.678	31	99	46.9	151.4
	1:100	1.742	1.609	38	118	58.4	180.1
	1:50	1.742	1.600	35	122	53.7	185.9
	0	1.698	1.575	15	54	23.0	82.4
	1:250	1.709	1.614	23	76	35.5	115.9
	1:200	1.694	1.639	36	114	54.6	173.4
2	1:150	1.723	1.629	39	116	59.4	177.2
	1:100	1.754	1.667	37	117	56.5	178.2
	1:50	1.750	1.640	41	120	62.3	
	0	1.765	1.624	23	85	35.5	129.3
	1:250	1.760	1.604	33	106	50.8	161.9
	1:200	1.714	1.538	41	130	62.3	198.3
3	1:150	1.728	1.571	37	133	56.5	203.1
	1:100	1.733	1.580	40	135	61.3	205.0
	1:50	1.757	1.616	45	154	69.0	221.3
	0	1.736	1.552	15	40	23.0	61.3
	1:250	1.747	1.563	20	62	30.7	94.8
4	1:200	1.760	1.592	32	102	48.9	155.2
	1:150	1.749	1.600	36	105	54.6	160.0
	1:100	1.766	1.609	40	124	61.3	188.7

	1:50	1.760	1.578	44	140	67.1	213.6
	0	1.799	1.669	28	92	43.1	139.9
5	1:250	1.739	1.620	35	112	53.7	170.5
	1:200	1.081	1.652	31	117	46.9	178.2
	1:150	1.783	1.662	39	125	59.4	149.5
	1:100	1.792	1.675	43	130	65.1	198.3
	1:50	1.799	1.637	45	142	69.0	216.5

TABLE A-3: Durability test (source: analysis of laboratory results)

SAMPLE	Weight Before Test (g)	Weight After Test (g)				Percentage Weight Loss After 4 Cycles %
		1	2	3	4	
LOC 1- R	1762	0	0	0	0	100
1:250	1716	1026	620	25	0.629	62.9
1:200	1777	1126	596	106	0.551	55.1
1:150	1785	1272	623	36	0.559	44.1
1:100	1756	1632	1260	826	0.250	25.0
1:50	1743	1608	1461	890	0.196	19.6
LOC 2- R	1698	0	0	0	0	100
1:250	1710	1111	520	180	0.470	47.0
1:200	1717	1201	580	96	0.454	45.4
1:150	1732	1062	796	126	0.289	28.9
1:100	1754	1621	1201	620	0.241	24.1
1:50	1767	1682	1362	300	0.210	21.0
LOC 3-B	1745	0	0	0	0	100
1:250	1752	1216	720	123	0.519	51.9
1:200	1732	1086	680	204	0.510	51.0
1:150	1750	1080	962	360	0.470	47.0
1:100	1745	1460	1160	820	0.438	43.8
1:50	1765	1621	1262	980	0.286	28.6
LOC 4-B	1736	0	0	0	0	100
1:250	1747	1029	420	33	0.541	541

1:200	1756	1121	660	76	0.525	52.5
1:150	1745	1421	820	200	0.350	350
1:100	1760	1621	1226	820	0210	21.9
1:50	1768	1600	1321	1001	0.179	17.9
LOC 5-D	1717	0	0	0	0	100
1:250	1720	1212	786	46	0.544	54.4
1:200	1738	1306	840	201	0.481	48.1
1:150	1791	1436	1021	562	0.461	46.1
1:100	1782	1686	1314	1060	0.205	20.5
1:50	1796	1731	1456	1123	0.338	13.5

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TABLE A-4: Summary of ANOVA tests **on** effects on nanomaterial on engineering properties of active soil

S/N	Engineering Property	F Value	Conclusion
1	Clay Content	23.13	since the value of F (23.13) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on clay content at 95% confidence limit
2	Liquid Limit (LL)	10.29	since the value of F (10.29) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on the liquid limit (LL) of the soils at 95% confidence limit.
3	Silt and Fines	6.01	since the value of F (6.01) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on silt and fines content at 95% confidence limit
4	Soil Activity	11.48	since the value of F (11.48) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on activity of the soils at 95% confidence limit
5	Shrinkage Limit	14.69	since the value of F (14.69) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on shrinkage limit at 95% confidence limit
6	Moisture Content	2.66	since the value of F (2.66) is greater than $F_{critical}$(2.63), then the addition of different proportions of nanomaterial to the soil has significant effect on optimum moisture content at 95% confidence limit, however to a much smaller extent than other parameters analyzed.
7	Plastic Limit (PL)	3.2	since the value of F (3.2) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on plastic limit at 95% confidence limit, also to a smaller extent than other parameters apart from optimum moisture content.
8	Plasticity Index (PI)	25.88	since the value of F (25.88) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on plasticity index at 95% confidence limit
9	Maximum Dry Density (MDD)	1.01	Since the value of F (1.01) is less than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has **NO** significant effect on maximum dry density at 95% confidence limit. The analysis was repeated for only soil samples without nanomaterial and those with the highest content of nanomaterial (1:50). The result in the table below (Table 5.13j) shows that even with the highest amount of nanomaterial used (1:50), there was no significant difference between the maximum dry density of the natural soil and the amended soil. Hence addition of nanomaterial up to 1:50 did not significantly improve the soil maximum dry density
10	CBR	18.87	since the value of F (18.87) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on CBR at 95% confidence limit

11	Free Swell	20.42	since the value of F (20.42) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on free swell at 95% confidence limit
12	7-Day Unconfined Compressive Strength (UCS7)	2.4	since the value of F (2.4) is less than $F_{critical}$(2.64), then the addition of different proportions of nanomaterial to the soil has **NO** significant effect on 7 days unconfined compressive strength at 95% confidence limit. Hence, the analysis was repeated between the natural soil and the amended soil but only at nanomaterial content of 1:150 was a significant difference observed (see next table5.12n below). Addition of nanomaterial from 1:250 to 1:200 did not significantly improve the seven days compressive strength. This implies that for the purposes of improving compressive strength nanomaterial content should be greater than or equal to 1:50.
13	7-Day Unconfined Compressive Strength (1-Day UCS)	0.4	since the value of F (0.4) is less than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has **NO** significant effect on one day unconfined compressive strength at 95% confidence limit. Hence, the analysis was repeated between the natural soil and soils amended with different proportions of the nanomaterial. However, even at the maximum nanomaterial content of 1:50, there was no significant improvement in the 1 day compressive strength.
14	Percentage Swell (% Swell)	7.81	since the value of F (7.81) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on % swell at 95% confidence limit
15	Water Absorption	6.78	since the value of F (6.78) is greater than $F_{critical}$(2.62), then the addition of different proportions of nanomaterial to the soil has significant effect on water absorption at 95% confidence limit

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