MICROSTRUCTURAL MODIFICATION AND STABILIZATION OF DISPERSIVE SOILS USING BAGASSE ASH

[1]ABENEAZER ALEMAYEHU KOSHIMA, [2]ELEYAS ASSEFA, [3]YITAYOU ESHETE

Addis Ababa Science and Technology
Department of Civil Engineering College of Architecture and Civil Engineering
E-mail: [1]koshimaabeneazer@gmail.com

Abstract - Dispersive sub grade soils are one of the known causes of road failure. Replacement of dispersive soils with natural construction materials is an expensive and sometimes not economically viable solution. On the other hand, commonly used chemical stabilizations of dispersive soils are either costly or not environmentally friendly. This work investigates the use of SCBA as a stabilizer for dispersive soils. The results show increasing the amount of SCBA up to 20% and the curing period to 21 days reduce the high plastic property of dispersive soils and improve the Atterberg limits of these soils. Besides, SCBA stabilization enhances the strength and reduces dispersive potentials of dispersive subgrade soils. SCBA stabilization also modifies and enhances the microstructure of dispersive soils.

Keywords - Dispersive Soils, SCBA Stabilization, Subgrade Improvement, Soil Engineering, Road Integrity, Atterberg Limits, CBR Enhancement, Soil Modification, Microstructural Analysis, Sustainable Stabilization

I. INTRODUCTION

Transportation is a flow of people and goods from one location to another to accomplish ba- sic needs or tasks. Road transportation is the most popular and fundamental system that supports the economic growth of a nation by contributing an essential role in different sec- tors (Eichengreen and Gupta, 2011; Mushir and Hailemariam, 2015). The performance of roads depends on the nature of subgrade soils (Paige-Green, 2008; Singh et al., 2016). Dispersive subgrade soils are one of the known causes of road failure. Dispersive clay particles are easily detached and eroded by rainwater due to having a small mass and very small particle size. As a result, these soils have extremely low erosion resistance (Pa, 1991). On the contrary, normal clays have aggregated structures with high inter-particular attractions and with water. Besides, normal clay soils have a sufficient balance of electrochemical forces of attraction among particles, which is very strong, cohesive, and non-dispersive (Ismail et al., 2008). Dispersive clay soils predominantly contain sodium cations (Vakili et al., 2018). These soils have an imbalance of electrochemical forces raised from having one positive charge of sodium ions in steady of two positive charges of magnesium and calcium ions like normal clay soils. This imbalance of electrochemical force causes particles to be repulsive with each other (Abbaslou et al., 2016). As a result, these soils are susceptible to erosion due to water with low ion concentrations (Vakili et al., 2013). Dispersive soils are not suitable subgrade material to construct pavement structures, and these soils can cause serious engineering challenges if the soils are not identified and treated appropriately (Singh et al., 2018). However, dispersive clay soils sometimes create fewer problems than ex- pected since eroding water might balance ionic compositions of the soil (Edgar, 1991). Soil replacement is one of the techniques used to mitigate problems raised by dispersive soils, but it is very expensive and sometimes not economically viable. On the other hand, chemical treatment method adds chemical ad- ditives like fly ash, gypsum, alum, and lime to stabilize dispersive soils. Vakili et al. (Vakili et al., 2013) studied stabilization of dispersive clays using pozzolan. Their study shows a re- duction in dispersivity potential, which has significantly altered upon the percentage of se- lected admixtures and curing time. Addition of pozzolan followed by curing reduced the sample's dispersivity potential. The pozzolan stabilization led to a decreasing index of plas- ticity and sodium percentage, and an increase of conductivity of electricity and unconfined compressive strength. The pozzolan replaced sodium ions with calcium and aluminium ions, which have higher valences and reduces thick- ness of the double layer. The study also indi- cates an increase in curing day could improve the unconfined compressive strength.

Moravej et al. (Moravej et al., 2015) studied the use of microbial calcite as bio-stabilization of dispersive clays. Bacillus spherics bacteria were used in the study. Curing time with bac- terial cell density was the target variable for the study, and the result showed sample's dis- persivity decreases as bacterial cell density in- creases and curing time increases. However, this technique needs strong biological knowl- edge and complex for engineers. Gidday et al. (Gidday and Mittal, 2020) applied lime to im- prove dispersive subgrade characteristics. The result indicates an increase in the CBR values and unconfined compressive strength. Besides, dispersive property decreased with increasing lime content and different curing conditions. The study shows the optimum lime content should be 7% to 9% so as to provide high qual- ity and strength of subgrade rating. However, this amount of lime by soil mass is expensive compared to other industrial wastes that

could potentially be a stabilizer. In this study, we used SCBA for microstruc- tural modification and stabilization of GidoleWozeka's failed road due to dispersive sub- grade soil. Gidole-Wozeka road project passes through the western escarpment of the south- ern segment of the Ethiopian central rift. We will study the effects of SCBA on index and engineering properties, and microstructure of the soil using various laboratory equipment.

II. METHODOLOGY

XRF test on SCBA performed for determining the pozzolanic properties of SCBA and specific gravity of SCBA ws determined. Index properties tests that are grain size analysis, Atter- berg limits tests and specific gravity test were performed to analayze the effect of SCBA and curing on dispersive subgrade soil. Index prop- erty tests were performed for both natural and treated subgrade soil with varying percentages of SCBA 0%, 5%, 10%, 15%, and 20% and curing period of 0, 7, 14, and 21 days were per- formed. On the other hand, chemical tests of SAR and PS are performed to determine the dispersive potential of natural and treated sub- grade soils.

Strength tests that are modified compaction, California Bearing Ratio (CBR) and unconfined compression strength (UCS) tests were per- formed with varying percentages of SCBA 0%, 5%, 10%, 15%, and 20% and curing period of 0, 7, 14, and 21 days to analyze the effect of SCBA and curing on dispersive subgrade soil. SEM was also used to study the micostructural changes after the stabilization of subgrade soil.

III. RESULT

Table 1 presents laboratory test results of AASHTO, LL (Liquid Limit) , MDD (Maximum Dry Density), OMC (Optimum Moisture Con- tent), PI (Plastic Index), PL (Plastic Limit), CBR (California Bearing Ratio), GI (Group Index), Gs (Specific Gravity) and qu (Unconfined Com- pressive Strength) test results. Figure 1 shows the SEM result.

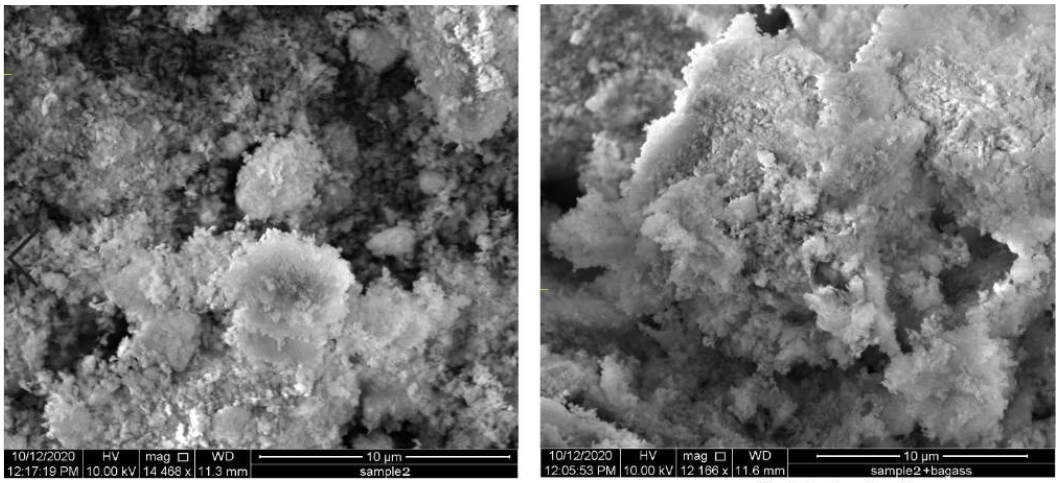


Figure 1: SEM test result

SCBA (%)	Curing day	%pass #200	LL	PL	PI	GI	AASHTO	Gs	MDD	OMC	CBR	qu
0	0	67.05	46.16	27.5	18.66	10	A-7-6	2.85	1.77	17.92	1.98	41.34
	7	67.05	46.83	27.42	19.4	11	A-7-6	2.85	1.78	17.67	2.31	43.12
	14	67.05	46.46	27.78	18.69	10	A-7-6	2.85	1.8	17.14	2.64	43.96
	21	67.05	46.39	27.38	19.01	11	A-7-6	2.85	1.82	16.78	2.97	45.47
5	7	56.7	44.07	29.05	15.03	6	A-7-6	2.83	1.85	15.84	5.16	84.44
	14	47.3	42.57	32.48	10.09	2	A-5	2.82	1.88	15.54	8.24	99.3
	21	41.5	41.25	34.34	6.91	1	A-5	2.78	1.9	14.91	9.67	113.81
10	7	49.8	43.79	31.31	12.47	4	A-7-5	2.78	1.87	15.29	7.8	91.56
	14	40.2	41.82	32.48	9.34	1	A-5	2.76	1.9	14.88	11.86	133.06
	21	33.5	39.12	35.04	4.08	0	A-2-4	2.74	1.93	14.55	15.08	160.93
15	7	46.4	41.31	32.22	9.09	2	A-5	2.74	1.89	15.04	10.65	120.65
	14	38.1	39.39	34.72	4.67	0	A-4	2.68	1.92	14.62	14.26	150.55
	21	32.7	38.51	35	3.51	0	A-2-4	2.67	1.95	14.12	16.07	171.08
20	7	42.7	40.21	33.33	6.88	1	A-4	2.66	1.93	14.23	15.71	164.79
	14	34.1	38.49	35	3.49	0	A-2-4	2.66	1.96	13.86	17.05	181.42
	21	28.4	36.85	36.57	0.28	0	A-2-4	2.65	1.99	13.31	18.2	203.42

Table 1: Overall laboratory test results summary of treated subgrade soils

IV. DISCUSSION

As shown in Table 1, SCBA and curing period have impacts on index properties of dispersive subgrade soils. SCBA and curing period could increase soil particle sizes, improve the Atter berg limits, and reduces the high plastic property of dispersive soils. Besides, it enhances the subgrade soil index.

SCBA and curing period have impacts on strength properties of dispersive subgrade soils. As the result shows (see Table 1), the treated subgrade soils have high MDD and low OMC compared to the natural subgrade soils that mean that SCBA stabilization with curing periods can improve the strength of dispersive subgrade soils. The results also show the CBR values increased above 15% and improved the soil's consistency to stiff with increasing the SCBA amounts up to 20% and the curing pe riod to 21 days, which indicates the treated subgrade soils are very good. SCBA could also reduce the dispersion potential and alter the microstructure of dispersive soils. It forms numerous well-defined patterns on the soil sur- face that minimizes the dispersed nature of the subgrade soils (see Figure 1).

REFERENCES

[1] H Abbaslou, H Hadifard, and A Poorgohardi. Characterization of dispersive problematic soils and engineering improvements: a re- view. Comput. Mater. Civ. Eng, 1:65–68, 2016.

[2] H Nelson Edgar. Soil mechanics note no. 13: Dispersive clays. Soil Conservation Service, United States Department of Agriculture, Wash- ington, DC, pages 11–12, 1991.

[3] Barry Eichengreen and Poonam Gupta. The service sector as india's road to economic growth. Technical report, National Bureau of Economic Research, 2011.

[4] Bisrat Gissila Gidday and Satyendra Mittal. Im- proving the characteristics of dispersive sub- grade soils using lime. Heliyon, 6(2):e03384, 2020.

[5] Fauzilah Ismail, Zainab Mohamed, and Mazi- dah Mukri. A study on the mechanism of internal erosion resistance to soil slope insta- bility. Electronic Journal of Geotechnical Engi- neering, 13(A):1–12, 2008.

[6] S Moravej, E Nikooee, G Habibagahi, and A Ni- azi. Bio- stabilisation of dispersive soils. 2015.

[7] Ali Mushir and Meaza Hailemariam. Geo- graphical analysis of road transportation of ethiopia. Ethiopian Journal of Environmental Studies and Management, 8:846–845, 2015.

[8] Chester Pa. 1 no. copies i. 1991.

[9] P Paige-Green. Dealing with road subgrade problems in southern africa. In The 12th Inter- national Conference Of International Association For Computer Methods And Advances In Geome- chanics (IACMAG)(India, 1-6 October 2008), pages 4345–53, 2008.

★★★