Visakhapatnam Chapter

Proceedings of Indian Geotechnical Conference 2020
December 17-19, 2020, Andhra University, Visakhapatnam

Mechanical Stabilization of Subgrade using Sand-Cement Mixture

Mainak Majumder[1][0000-0003-1501-2744] and Sayan Bhattacharyya[2] [0000-0002-7214-8958]

[1] Engineering Research Manager, Research & Development, L&T Construction, Mumbai, India
[2] Post Graduate Fellow, SMEC India, Gurugram, India
lncs@springer.com

Abstract. An attempt to stabilize the Black-cotton soil (BCS) using locally available sand with cement mixture is been presented in this study. The soil in western part of the India is predominated by the Black-cotton soil which causes lot of problems for the road construction. Replacement with well graded borrow soil for subgrade is not economical solutions for the road construction. In India, several road constructions have been proposed on this problematic terrain. For this purpose, different proportion of sand-cement mixture has been used to improve the engineering properties of the BCS. The mixture of 60% sand and 2% cement resulted in increase in the CBR value by about 120% as compared to the lime stabilized BCS.

Keywords: Subgrade stabilization, Black-Cotton Soil, Sand-Cement Mix.

1 Introduction

Black-cotton soil (BCS) is an expansive fine grained soil found in several parts of India mostly in western region notably, Maharashtra, Karnataka, Andhra Pradesh. BCS is found to be very problematic for the road construction due to its nature of swelling during monsoon and shrinking during summer. This phenomenon leads to several stabilization techniques to improve its engineering properties especially when road/highways are planned to construct on the BCS. The swelling of BCS happens when polar water or organic molecules absorb onto the inter particle space of soil. The expansion of the interlayer happens when any type of exchangeable cations come into contact with the clay [1].

The subgrade of the pavement represents the weakest layer in the pavement systems, and poor subgrade can significantly affect the pavement performance. Several attempts have been made to stabilize the subgrade constructed on the BCS. The most commonly used techniques are like addition of lime, fly ash, cement to improve engineering properties as a result of flocculation and pozzolanic reaction [2]. Other different additives like saw dust ash, reinforced ash fibre, shell ash have been used in recent times by several researchers [3]. Balancing the economy and environment, two contradictory aspect is very difficult in the actual project site. In the present study, locally available pit sand with the very minor content of cement have been implemented as

the alternative stabilization material. The BCS soil has been characterized experimentally by different physical and chemical properties. Suitability of the subgrade layer by using sand-cement mixture has been checked as per MORTH [4] specifications through experimentation.

2 Black-Cotton Soil Characterization

Black cotton soil used in this study is sampled from the Aurangabad region of Maharashtra, India. Extensive laboratory tests have been performed to characterize the physical and chemical properties of the soil. All the tests have been performed as per Indian standard procedures; their respective codes and properties are tabulated in Table 1. The soil sample has been taken from the 1.5m depth after chopping off top organic content. The Table 1 shows that the soil is high plasticity clay (CH) with very high free swell index (>40) and very low CBR values, which is unsuitable as the subgrade material as per MORTH specifications. Hence, it genuinely requires stabilization or replacement.

Table 1. Physical and Chemical Properties of Black-Cotton Soil (BCS).

Properties		Testing Standards	Symbols	Units	Values
Gravel			-	%	0
Sand		IS: 2720- Part 4	-	%	7
Fines	Silt		-	%	34
	Clay		-	%	59
Water Content		IS: 2720-Part 2	w	%	7.52
Liquid Limit		IS: 2720-Part 5	LL	%	81
Plasticity Index			PI	%	61
Soil Classification		IS:1498	-		CH
Specific Gravity			G_s		2.69
Free Swell Index		IS: 2720-Part 40	*FSI*	%	80
Optimum Moisture Content		IS: 2720-Part 7	OMC	%	23.15
Maximum Dry Density			MDD	gm/cc	1.73
California Bearing Ratio (Soaked)		IS: 2720-Part 31	*CBR*	%	3.2
California Bearing Ratio(Unsoaked)			*CBR*	%	4.0
Angle of Internal Friction		IS: 2720-Part 10	φ	°	4
Cohesion			c	kPa	28
pH		IS: 2720-Part 26	-	-	7.6
Cation Exchange Capacity		IS: 2720-Part 24	TCE	meq/100g	22
Chloride Content		IS: 2720-Part 27	cl	ppm	5.4

3 Properties of Sand-Cement

The Sand collected from the Krishna River is essentially uniformly graded loose fine sand (SP) with angle of internal friction 28°. The gradation characteristics have been represented in Fig. 1, which shows that 425 micron passing is more than 80% which indeed helps in reducing the FSI and plasticity of the BCS. In the present study OPC 53 grade cement has been used to mix with the fine sand.

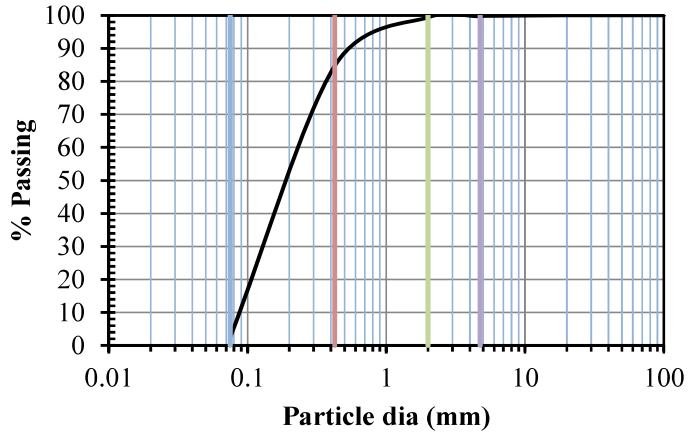

Fig. 1. Gradation characteristics of the pit sand.

4 Stabilization Scheme and Results

In the present study, six different trials have been used to check the applicability of the sand-cement mixes. The main purpose of use the high content of sand is to reduce the plasticity and swelling index of the BCS, whereas the cement has been used to increase the CBR value and durability of the subgrade. The pulverization and degree of mixing determines the quality of improvement. In addition to that adequate moisture content must be retained in order to accelerate the strength of the subgrade. In Table 2 the improvement with different proportioning BCS: Sand: Cement mixes have been shown along with the improved engineering properties. It can be observed from the results that 65% Sand mixes (Case-1) followed in 67% increase in FSI, 74% increase in the Pl, and 64% increase in the unsoaked CBR. As per MORTH clause 305.2.1.2 the FSI and CBR values must be less than 50% and 8% respectively for the soil to be used as subgrade material. The fineness of sand gives more interlocking effect in the BCS's clay fraction whereas the cement content (2%) gives pozzolanic

effect to improve the CBR values. The results shown in Fig. 2 cases-1-5, all trials are applicable for BCS stabilization with proper quality control at the project site.

Table 2. Improvement of engineering properties with different mixes of Sand-Cement.

	Proportioning (Soil: Sand: Cement)	FSI (%)	LL (%)	PI (%)	MDD (gm/cc)	OMC (%)	Unsoaked CBR (%)	
							95% OMC	97% OMC
Without Stabilization	100:00:00	80	81	61	1.73	23.75	3.2	3.8
Case-1	33:65:02	26.5	24	16	1.92	13.6	16	28
Case-2	38:60:02	28.66	26	20	1.91	12.8	13	26
Case-3	43:55:02	32	29	23	1.87	12.2	12	24
Case-4	48:50:02	36	32	25	1.86	11.7	11	20
Case-5	53:45:02	40	37	27	1.85	11.4	10	16
Case-6	58:40:02	45	42	29	1.78	11.2	9	12

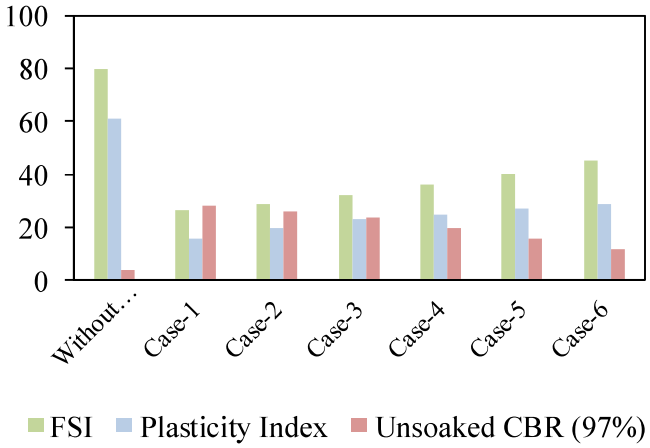

Fig. 2. Comparative representations of the improved properties.

5 Conclusions

In the present experimental work different proportion of the sand-cement mixture has been used as an alternate stabilization material for the black cotton soil. The propor-

tion of sand in the mixes controls the plasticity and swell potential and cement controls the strength characteristics of the black cotton soil. It has been found out that usage of more than 40% sand (by weight) can increase the plasticity of the subgrade soil significantly whereas the quantity of cement has been kept limited due to the cost and environmental aspects.

References

1. Zhou, Z.: Construction and application of clay-swelling diagrams by the use of XRD methods. Technol. 474, 306 (1995).
2. Gadzama, E.W.: Lateritic soil and other problems of soils of Africa; Properties of tropical black clay/black cotton soil as Applied to Construction work. Masters Dissertation, Federal University of Technology, Yola, Nigeria. (2004).
3. Ikeagwuani, C.C., Obeta, I.N, and Agunwamba, J.C.: Stabilization of black cotton soil subgrade using sawdust ash and lime. Soils and Foundations, 59, 162-175 (2019).
4. Ministry of Road Transport and Highways (MORTH): Specifications for road and bridge works, 3. 305.2.1.2. (2000)