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Evaluation of Compaction and Strength Behaviour of Different Expansive Soils Stabilized with Lime

B.Varaprasada Rao[1], K. Padma Kumari[2], N. Darga Kumar[3]
[1]*Research Scholar, Department of Civil Engineering, JNT University-Kakinada, Andhra Pradesh, India, 533003*
[2]*Professor, Department of Civil Engineering, JNT University-Kakinada, Andhra Pradesh, India, 533003*
[3]*Professor, Department of Civil Engineering, JNT University-Manthani, Telangana, India, 505184*
Corresponding Author: B.Varaprasada Rao

Abstract: *Abstract: Expansive soils are one of the major soil deposits along the coastal area of East Godavari District, Andhra Pradesh, India. Such soils are predominantly clayey soils or very fine silts exhibit swell-shrink behaviour when subjected to moisture changes and do not have enough strength for any type of construction work. In the process of improving, the engineering properties that means to improve bearing capacity, to increase in soil strength, and durability under adverse moisture conditions of expansive soils, an experimental investigation is carried out to evaluate the effect of lime on various expansive soils and its impact on compaction and strength characteristics. To obtain an optimum percentage of lime content for stabilization of expansive soil thereby reducing the differential free swell index (DFSI) by less than 50%. The lime content was varied at 0%, 1%, 2%, 4%, 6% by the dry weight of the soil. Based on DFSI values, soils were categorized into five ranges and performed a comparative evaluation on compaction and strength behaviour of various expansive soils before and after stabilization.*

Keywords: *Compaction, expansive soils, lime, unconfined compressive strength*

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I. Introduction

The problem with expansive soil is universal, which has a high potential for swelling and shrinkage due to moisture variations [1]-[4]. Consequently, this peculiar property of swell-shrink behavior of expansive soil has created several problems due to highly unpredictable upward movement causes severe cracking in residential buildings and other civil engineering structures such as highways, bridges, canals, and reservoir linings, airports, seaports, pavements, etc. [5], [6]. Of all the several advanced methods and innovative techniques, stabilization of expansive soils with various additives such as fly ash, lime, cement, magnesium oxide, and calcium chloride, etc. has also met with considerable success in controlling volume changes in expansive soils [7]-[10]. Lime stabilization has been documented as an effective method to control the volumetric changes in expansive soils among the other chemical treatment methods because of its cost-effective usage [11]-[15]. In the present work, an attempt is made to study the influence of lime on compaction and strength characteristics before and after stabilization on different lime-soil mixes.

II. Experimental Programme

2.1 Materials

The materials used in this study for experimentation are different expansive soils with different expansive nature and hydrated lime was used as an additive in this investigation. The collected soils were dried and sieved through 425-micron I.S. sieve before its use in experimental studies.

2.1 Tests performed

Proctor compaction tests were conducted as per the standard test procedure (ASTM 2000, D 698a) for all the virgin expansive soils and soil-lime mixes. Oven-dry water content was determined and the compaction curves are plotted.

The unconfined compressive strength (UCS) tests were conducted for all the untreated expansive soils and soil-lime mixes to study the effect of lime on the values of compaction and UCS used in this investigation as per the I.S. code of practice (I.S. 2720, 1964). The collected expansive soils were stabilized at their respective optimum lime contents and tested after 1day as presented in Table.1.

III. Results and discussion

Differential free swell index (DFSI) tests were conducted for all the untreated expansive soil samples and grouping was done as five ranges based on the DFSI value. Range 1 being (50% -70% DFSI), Range 2 (71% -90% DFSI), Range 3 (91% -110% DFSI), Range 4 (111% -130% DFSI) and Range 5 (131% -150% DFSI). The tests were conducted in two series. In the first series compaction and strength, tests were performed for all the untreated soil samples and have taken the average values of Maximum Dry Density (MDD), Optimum Moisture Content (OMC) and Unconfined Compressive Strength (UCS) are shown in Table1.

In the second series the compaction and strength characteristics of lime stabilized samples of all expansive soils were determined at optimum lime content (percentage of lime at which swelling was arrested) and have taken the average values of MDD, OMC and UCS (After stabilization) are shown in Table1. The graphs are plotted between Range Vs average values of MDD and OMC before and after stabilization and the results are represented in Figs.1&2 for all the five ranges. Graph for Range Vs average values of UCS also drawn before and after stabilization and represented in Fig.3 for all the five ranges.

Table.1 The MDD, OMC, and UCS average (Avg.) values before and after stabilization

S. No	Avg. DFSI (%)	Range	Avg. Lime Content	Before Stabilization			After Stabilization		
				MDD (g/cc)	OMC (%)	UCS (kPa)	MDD (g/cc)	OMC (%)	UCS (kPa)
1	61.02	1	1.2	1.636	23.38	107	1.806	16.72	114.84
2	81.5	2	3	1.617	24.65	99.5	1.755	18.5	117.9
3	101.34	3	3.73	1.569	26.52	86.54	1.68	20.18	120.05
4	116.74	4	5.2	1.49	28.7	63.4	1.622	21.12	143.22
5	140	5	6	1.43	30.4	50	1.57	22.3	155.9

3.1 Effect of Additive on Compaction Characteristics

The impact of lime on compaction characteristics before and after stabilization of expansive soils in all ranges 1 to 5 are presented in Fig 1. The graph shows that the average MDD has improved from 1.636 to 1.806 g/cc in range-1 soils, from 1.617 to 1.755 g/cc in range – 2 soils, from 1.569 to 1.86 g/cc in range -3 soils, from 1.49 to 1.622 g/cc in range-4 soils, from 1.43 to 1.57 g/cc in range – 5 soils.

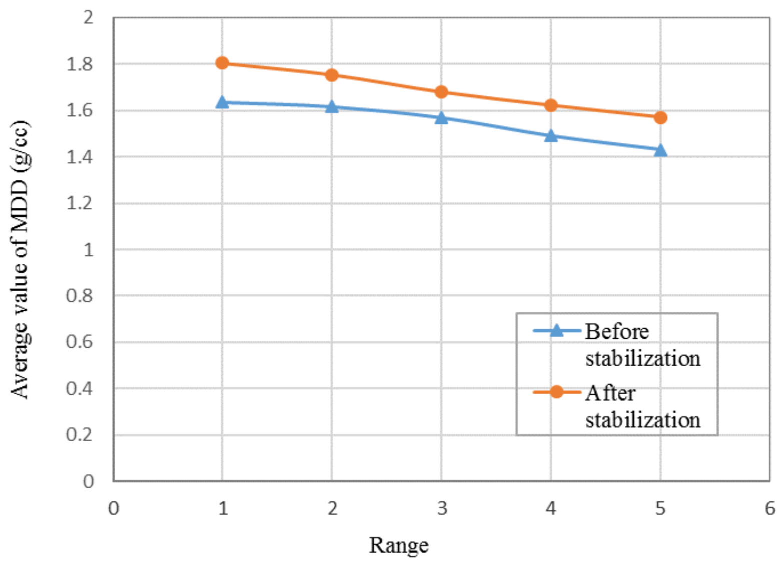

Fig.1 Effect of lime on MDD before and after stabilization.

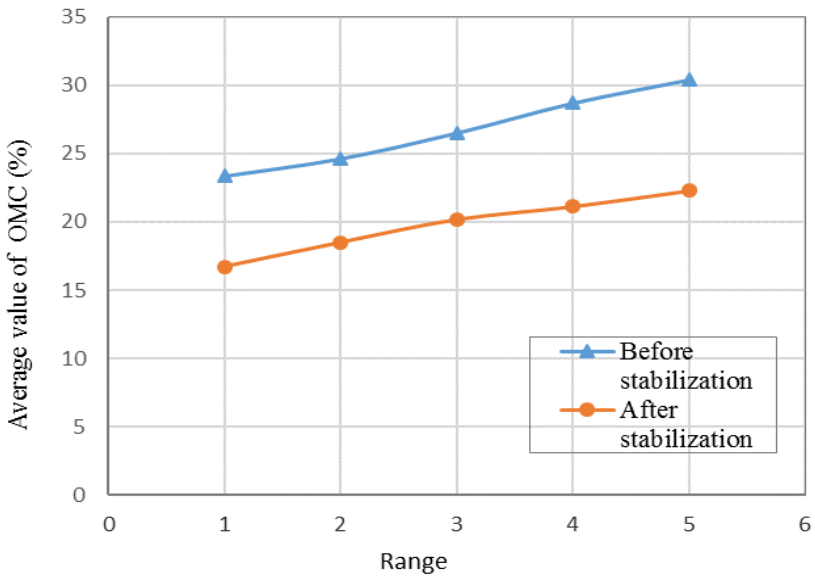

Fig.2 Effect of lime on OMC before and after stabilization.

Fig.2 shows the influence of lime on compaction characteristics before and after stabilization of expansive soils in all ranges 1 to 5. The graph shows that the average OMC has decreased from 23.38 to 16.72 % in range-1 soils, from 24.65 to 18.5 % in range-2 soils, from 26.52 to 20.18 % in range-3 soils, from 28.7 to 21.12 % in range-4 soils, from 30.4 to 22.28 % in range-5 soils.

3.2 Effect of Additive on Strength Characteristics

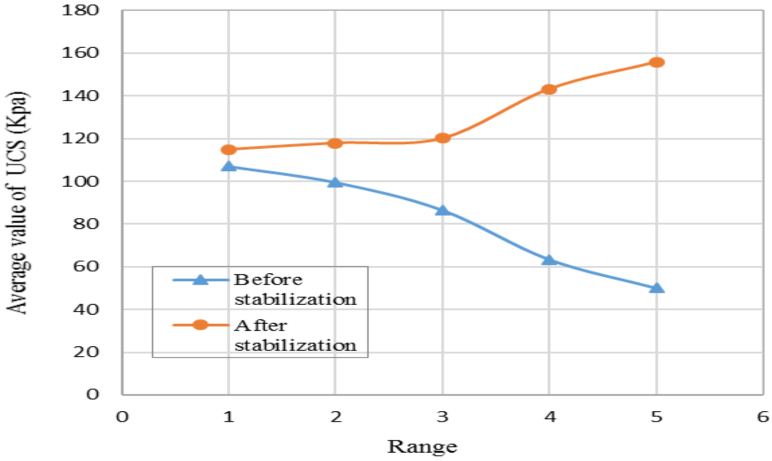

Fig. 3 Effect of lime on UCS before and after stabilization.

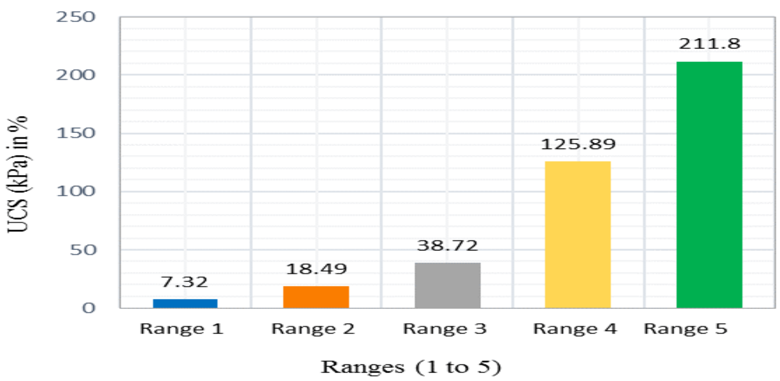

Fig. 4 Strength improvement after stabilization with lime.

The influence of lime on strength characteristics before and after stabilization of expansive soils in all ranges from 1 to 5 is represented in Fig.3. The graph shows that the average strength has increased from 107 to 114.84 kPa in range-1 soils, from 99.5 to 117.9 kPa in range-2 soils, from 86.54 to 120.05 kPa in range-3 soils, from 63.4 to 143.22 kPa in range-4 soils, from 50 to 155.9 kPa in range-5 soils. This data reveals that the strength increased by about 7.32% in lower range soils and about 211.8% in higher range soils.

Fig. 4 represents the strength of five ranges of expansive soils after stabilization and their variation on the strength characteristics. Lime stabilization was pronounced, for the higher range of expansive soils (Fig. 3 and 4). Moreover, it is manifest that less range expansive soils needed a lesser optimum lime content and vice versa, inferring that lime utilization can be optimized.

IV. Conclusion

The main conclusions that can be drawn from the laboratory test program on the efficiency of lime treatment for different ranges of expansive soils to establish the average compaction and strength characteristics are discussed. The data reveals that the average MDD improved by 10.39% in lower range soils and 9.79% in higher range soils and the average OMC decreased by 39.38% in lower range soils and 36.44% in higher range soils.

Considerable improvement in strength characteristics was observed when stabilized with their respective optimum lime contents for 1 to 5 ranges of expansive soils. The strength behaviour improved by about 211.8% for the higher range expansive soils (i.e.) in range-5, whereas it was only 7% for the lower range expansive soils (i.e.) range-1. Finally, it can be concluded that the efficiency of lime treatment on different expansive soils revealed that the higher range expansive soils yield better improvement when compared with lower range expansive soils.

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