

Stabilization of Locally Available Soil using CNSA and Glass Industry Waste



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Abstract: Soil is one of the most important components used in a variety of construction activities. The soil available in particular site may or not be suitable for the construction works mainly because of low bearing capacity. When soil is weak which creates many problems and it is difficult task for civil engineers to overcome this problems. In such case it is proposed to stabilize such soil so that it can be effectively used. There are various methods of soil stabilization such as physical stabilization, chemical stabilization etc. The present work is carried out to study the effect of industrial glass waste and Cashew nut shell-ash (CNSA) as a stabilizer in lateritic soil. The main objective of this study is to obtain a best percentage of Cashew nut shell ash and glass industry waste that can be added with locally available lateritic soil as a stabilizing agent for pavement sub-grades. The experimental program included grain-size analysis, specific gravity, heavy- compaction, unconfined compressive strength test (UCC) and California bearing ratio test (CBR) tests on soil mixture prepared with lateritic soil at various proportions of CNSA and glass industry waste (GIW). Specimens for CBR tests were prepared at optimum moisture content and soaked for 4 days before testing. From the experimental investigations, the optimum dosage of GIW and CNSA were obtained as dual blend of 2% GIW along with the addition of 4% CNSA by weight of the soil. But the result of this dosage is only a marginal improvement in the engineering properties of the soil. Thus, it can be concluded that there is no much effect of CNSA and GIW in the stabilization of the lateritic soil. However, if any a marginal improvement is expected, then it could be used as a stabilizer, since these two stabilizers are available in free of cost as they are the industrial by-products.

Index Terms: Lateritic soil, Subgrade, CBR, UCS, Stabilization.

I. INTRODUCTION

Soil stabilization is one of the low cost road construction methods by effectively utilizing the locally available material to increase in the engineering performance of soil by modifying some of the undesirable properties and retaining the desired minimum strength even after subjecting it to the extreme condition. The various methods are used to soil

stabilization are proportioning and mixing different good quality materials and there-by improving the material gradation, use of cementing agents, using modifying agents, using water proofing agents, using water repelling agents, using water retaining agents, by heat treatment and also by using chemical stabilization. In the present work, we have adopted the technique of proportioning and mixing locally available waste materials and checked its use as stabilizing agent for locally available soil near our campus. Thus, this study has been carried to stabilize the soil using the cashew-nut shell ash (CNSA) and glass industry waste (GIW) of 4 different proportions (0, 2, 4, 6% by the weight of soil) and conducting the certain experimental tests such as modified proctor test, un-confined compressive strength test, CBR in soaked and un-soaked condition. Finally, the discussion on the results obtained in stabilized soil by comparing it with the natural un-stabilized soil. Thus the specific objectives of this research includes the study of the basic geotechnical properties of locally available soil near NITTE campus, then to obtain the proportion and optimum dosage of cashew nut shell ash and glass powder by conducting various tests such as Heavy compaction, UCC and CBR test. Further, to evaluate the properties of stabilized soil using CNSA and GIW. Then to discuss the variation in the strength characteristics of soil based on the tests conducted. The study was also extended to know the suitability of this stabilized soil for the pavement application i.e., as a sub-grade material through FEM based KENPAVE software.

II. LITERATURE REVIEW

Lekha B M et al (2014) have studied the addition of 0.2 to 1% randomly spaced arecanut coir with an increments of 0.2% and fixed the cement content of 3% to lateritic soil which increase the unconfined strength 540 to 896 N/mm², CBR value 51 to 64% of 0.6% of coir and 3% of cement. They adopted cement stabilization method and they concluded that, there is an marginal improvement of lateritic soil properties. Further, evaluation was also carried out using KENPAVE software. The addition of coir fiber lead to an increase in the strength up to the dosage of 0.6%, but the further addition, it lead to a decrease in the strength.

Saikrishnamacharyulic et al (2017) have reported the studies on the improvement of the engineering properties of weak soil using the waste fiber materials and tire waste. The addition of 0.25 to 1% fiber with an increment of 0.25%; and 1 to 8% of tire waste with an increment of 1% (by weight) to lateritic soil.

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The optimum dosage was obtained upon the addition of 2% of tyre and 1% of coir to the soil, which lead to an 50% increased UCC strength values, and soaked CBR value from 1.95% to 3.19%.

Behrouz et al (2015) studied flexibility of lateritic soil using the tire powder and micro silica. The first-class overall performance changed into determined using 6% of additives, 3% of micro silica and 3% of tyre driven aggregates. The mix containing the micro silica in the soil which controlled the seepage flow, which further lead to an increased strength value. The increasing flexibility of the mix will lead to a decrease in the modulus of elasticity value which was found to be 15284 kPa.

Jeeja et al (2012) evaluated the strength properties of problematic soil to modified by addition of polymer fiber like polyethylene terephthalate bottle fiber and polypropylene sack fiber. The dosage was from 0 to 0.2% by weight of soil with increment of 0.05%. The addition of 0.1% and 0.15% of PET fibers and SACK fibers to obtain the better engineering performance.

Pallavi et al (2017) have studied on geotechnical properties of lateritic soil by the addition of thermal power plant industrial waste (i.e., fly-ash) and coir fiber. Soil mixed with various proportion of thermal industrial waste 5, 10, 15% by the weight of lateritic soil and coir fibres with varied dosages of 0.25, 0.50, 0.75, and 1% by the weight of soil. Several tests were conducted in unmodified as well as modified soil. The tests for consistency limit, modified proctor test, and unconfined compressive strength were the major tests. The optimum dosage of 5% of fly ash and 0.1% of fibers were suggested to be used as stabilizers.

Marathe et al (2015): Studied on modification of shedi soil using cement and rubber tyre chips. They have used ordinary Portland cement of 53 grades as binding material addition to shredded tire-chips to modify the shedi soil (lithomargic soil). They have determined the geotechnical properties such as specific gravity, consistency limit, grain size distribution, unconfined compressive strength, and California Bearing Ratio test. The results showed that maximum of 4% of rubber tire chips +2% of cement showed the better engineering behavior of this weak soil. The CBR value increased from 19.04% to 37.57%. The compaction results indicated that, the maximum dry density (MDD) increases initially, and then further addition had lead to a decrease in the MDD values. The UCC strength increased from 61.01kPa for 0 day curing period to 193.21 kPa for 28 day curing period.

Kumar et al (2015) studied on amendment of lithomargic soil the usage of industrial waste product together with fly ash and ground granulated blast furnace slag, sodium hydroxide flakes. Evaluation carried out UCC and CBR for various percentage of fly ash (0,10,15,20,25,30%) GGBS (0,10,15,20,25,30%) and sodium hydroxide flakes of 14M at the curing period of 0,1,3 and 4 weeks. They concluded that 14M of NaOH + 20% of fly ash + 20% of GGBS found the optimum strength for 28 days of curing.

III. MATERIALS AND METHODOLOGY

The current investigation was carried out on modification of locally available lateritic soil using CNSA and GIW. The details of the soil used and the details on the stabilizers along with the methodology followed are presented in this section.

A. Lateritic soil

The present study soil was carried out near campus and then passing through 20 mm sieve. The results from the wet sieve analysis have shown that the soil contained very less amount of clay and silt particles. The course grained particles were dominating. Further, the soil was classified as well graded sand (SW) as per the results from Indian Standard Soil Classification System. The soil was reddish brown in colour. Figure 1 shows the site from which the soil is collected.

B. Cashew nut shell ash (CNSA)

Cashew nut shell ash is a waste product which is obtained from the burning of raw cashews in cashew production industry. For the present investigations the CNSA was obtained from M/s Gayathri export cashew industry, Karkala Tq., of Karnataka. The ash was passed through 75microns IS sieve and used for the study. The specific gravity of CNSA was found to be 0.963 (through density bottle method). Figure 2 shows the CNSA which was used in this study. It was greyish white in colour.

C. Glass industry waste (GIW)

The glass industry waste (GIW) used in this research work was the combination of fine glass powder along with fine sand particles, in their gradation the mix was passing through 425micron and retained on 75micron. It was obtained from glass manufacturing industry from Bikampadi Industrial Area of Mangalore, Karnataka. Figure 3 shows the white colored GIW which was used in this study. This also readily obtained as a waste product, which the industry officials were used to dump on the fertile land.



Fig 1: lateritic soil site



Fig 2: Cashew nut shell ash



Fig 3: Glass powder

D. METHODOLOGY

The stabilization of lateritic soil certain tests were conducted to investigate the strength characteristics and the engineering behaviour. Initially, the unmodified soil was tested for Grain size distribution, consistency limits, specific gravity, compaction characteristics as per IS : 2720 (part IV) 1985, IS : 2720 (part V) 1985, IS : 2720 (part VI) 1972, IS : 2720 (part II /section I) 1980, IS : 2720 (part VII) 1980, respectively. For the present study, the soil is then tested for determining its engineering properties i.e., tests for strength parameters such as UCS and penetration resistance in-terms of California Bearing Ratio (i.e., CBR value) for the soil stabilized using the mixture of CASA and GIW. The obtained results were compared with un-stabilized soil. The analysis is further carried out using KENPAVE software for both modified and unmodified soils to study the maximum stress and sub-grade modulus.

IV. RESULTS AND DISCUSSIONS

A. Test Results on Un-stabilized Soil

The basic test results on un-stabilized locally available lateritic soil is presented in Table I below. All the tests in this investigation were carried-out as per the relevant Indian Standards. From the results it can be noted that it is a cohesive friction soil. The soaked CBR value was about 3.35% which can be considered as low for pavement sub-grade applications.

Table- I: Properties of Un-stabilized soil

Sl. No	Test Details	Particulars	Test Results
1	Specific Gravity of soil (IS 2720 (part III sec 1) (1980))	--	2.59
2	Classification of Soil according to IS soil classification system (IS 2720-Part IV (1985))	Cu = 12.21	Well Graded Sand (SW)
		Cc = 1.07	
3	Modified proctor test (IS 2720-Part 8 (1983))	MDD	18.07 KN/m ³
		OMC	15.67%
4	Unconfined Compression Test (IS 2720-Part 10(1991))	Angle of friction (Φ)	26°
		Cohesion (C)	20 KN/m ²
5	California Bearing Ratio Test (IS 2720-Part 16 (1987))	Soaked	3.35%
		Un-soaked	10.11%

The initial stabilization with using only GIW was carried out by studying its compaction, unconfined compressive strength (UCS), and CBR properties. The dosage was given from 0 to 6% with 2% increment (by weight). The test for heavy compaction is shown in table II, UCS is shown in table III, CBR is shown in table IV. The results indicated that the 2% of GIW can be used as an optimum dosage which gives better compaction and strength values.

Table- II: Compaction Properties of GIW stabilized soil

Sl. No	GIW Dosage (%)	MDD (kN/m ³)	OMC (%)
1	0	18.07	15.67
2	2	18.40	17.04
3	4	17.97	17.61
4	6	17.82	17.73

Table- III: UCS Properties of GIW stabilized soil

Sl. No	GIW Dosage (%)	Cohesion (kN/m ²)	Angle of friction
1	0	20	26°
2	2	22.4	34°
3	4	21.6	33°
4	6	20.2	31°

Table- IV: CBR Properties of GIW stabilized soil

Sl. No	Dosage (%)	Soaked CBR (%)	Un-Soaked CBR (%)
1	0	3.35	10.61
2	2	5.80	11.21
3	4	5.34	11.08
4	6	5.31	11.05

The further, in next level, the stabilization of the soil was done only by using CNSA. The test was carried out by studying its compaction, unconfined compressive strength (UCS), and CBR properties. The dosage was given from 0 to 6% with 2% increment (by weight). The test for heavy compaction is shown in table V, UCS is shown in table VI, CBR is shown in table VII. The results indicated that the 4% of CNSA can be used as an optimum dosage which gives better compaction and strength values.

Table- V: Compaction Properties of CNSA stabilized soil

Sl. No	CNSA Dosage (%)	MDD (kN/m ³)	OMC (%)
1	0	18.07	15.67
2	2.0	17.77	18.58
3	4.0	17.85	18.67
4	6.0	17.80	17.98

Table- VI: UCS Properties of CNSA stabilized soil

Sl. No	CNSA Dosage (%)	Cohesion (kN/m ²)	Angle of friction
1	0	20	26°
2	2.0	34	26°
3	4.0	36.6	24°
4	6.0	36.4	23°

Table- VII: CBR Properties of CNSA stabilized soil

Sl. No	Dosage	Soaked CBR (%)	Un-Soaked CBR (%)
1	0	3.35	10.61
2	2	3.80	10.30
3	4	3.34	11.21
4	6	3.31	11.02

The investigation is further extended to study the effect of stabilization using optimum CNSA and optimum glass powder content. The test was carried out by studying its compaction, unconfined compressive strength (UCS), and CBR properties. The dosage was given from 4% CNSA and 2% fly-ash content. The test for heavy compaction, UCS, and soaked and un-soaked CBR test results is shown in table VIII. The results indicated that there is an marginal increment of the strength values. Thus making this stabilization is not so much effective.

Table VIII: Stabilized Lateritic Soil Using 4% of CNSA and 2% of GIW

Compaction		UCC		CBR	
MDD (kN/m ³)	OMC (%)	Cohesion (kN/m ²)	Angle of friction (Degree)	Soaked (%)	Un soaked (%)
17.86	16.74	43.33	37.67°	5.54%	10.01%

The pavement analysis is carried using KENPAVE software and by referring pavement selected literatures. The KENPAVE results are as follows: Figure 4 and figure 5 gives the results for with-out (un-stabilized soil) and with optimum stabilization.

UNSTABILIZED SOIL

Young’s modulus = 27600000 kPa
 Depth of sub grade = 25 cm
 Sub grade modulus = 30.45 kN/m³
 Poison’s ratio = 0.15
 Max. Stress = -838.396 kPa

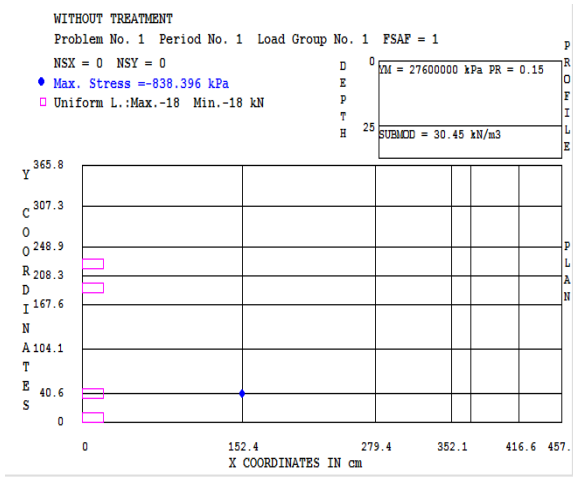


Fig 4: KENPAVE results for un-stabilized Soil

STABILIZED SOIL (Using Optimum dosage)
 Young’s modulus = 27600000 kPa
 Depth of sub grade = 25 cm
 Sub grade modulus = 44.44 kN/m³
 Poison’s ratio = 0.15
 Max. Stress = 737.603 kPa

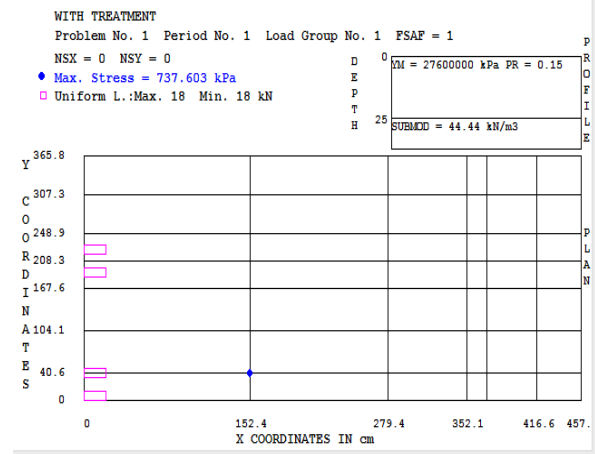


Fig 5: KENPAVE results for stabilized Soil

V. CONCLUSIONS AND FUTURE SCOPE

A. Conclusions

- From the results obtained by experimental study it was observed that addition of glass powder increases the max. Dry density and also increases the optimum moisture content of the lateritic soil, but the MDD reduced due to the fineness of particles.
- With the addition of glass powder cohesion increases by 12%, and angle of frictions increases by 30.76%.
- The CBR values also improved both in soaked and unsoaked condition i.e. soaked CBR increased by 73.13% and unsoaked CBR increased by 5.65%.
- The addition of CNSA decreases the Max. dry density by 1.68%
- With the addition of CNSA cohesion increases by 83% and angle of friction decreases by 8.33%
- There was no much variation in soaked CBR values but un-soaked CBR decreased by 5.65%.
- With the addition of combined mix, the MDD was observed was slightly less than the MDD of natural soil.
- With the addition of combined dosage of CNSA and GIW angle of frictions increases by 44.86%.
- Soaked CBR increased by 5.54% and unsoaked CBR decreased by 5.99%.
- Hence it can be concluded that there is no much effect of CNSA and glass powder on lateritic soil

B. Conclusions

- Similar kind of studies can be performed on other types of soil such as red soil, black cotton soil, lithomargic soils etc.
- Shear parameters can be determined by tri-axial test.
- Durability studies can be performed on these stabilized soils.
- The effect of these Industrial glass waste and CNSA on soil can be examined using XRD and SEM.
- Kenpave analysis can be carried on flexible pavement.

REFERENCES

1. B M Lekha, S Goutham and A U R Shankar, "evaluation of laterite soil stabilized with arecanut coir for low volume road", Indian geo tech 2, 2015 (20-29).
2. Saikrishnamacharyulu, V K B Rao and H Kumara "experimental study on soil stabilization using waste fibre materials", International journal for technological research in engineering , volume 4, Issue 10 , 2017
3. B Gordan and A Adnan "strength performance based on flexibility from laterite soil using tire powder and micro silica", Hindawi publishing corporation journal of materials, 2015.
4. S Marathe ,B S Rao and Anilkumar "stabilization of lithomargic soil using cement and randomly distributed waste shredded rubber tyre chips", International journal of engineering trends and technology , volume 23,2015.
5. P A Padalkar, T A Kulkarni and A J Chavan , "study on properties of laterite soil using fly ash and coir fibres", International journal of engineering in mechanical and civil engineering, ISSN 2456-1290, 2018.
6. J Menon and M S Ravikumar " strength evaluation of laterite soil stabilized using polymer fibres", Internatinal journal of civil engineering and technology , volume 9,Issue 2, 2018 pp-227-234.
7. Anilkumar, S Marathe, Vikram ,N Shenoy, Vaishnavi and Venkatesh "stabilization of lithomargic soil using alkali activated fly ash with GGBS", International journal of constructive research in civil engineering volume 1,Issue 1,2015.
8. IS 2720 Part 16 (1987), "Indian standard methods of test for soils: Determination CBR", Bureau of Indian Standards, New Delhi, pp 1-16.
9. IS 2720 Part III (1964), "Indian Standard methods of Test for soils: Determination of specific gravity." SP 36 (Part 1) : 1987, Compendium of Indian Standards on soil Engineering: Part 1: Laboratory Testing of soils for Civil Engineering purposes, Bureau of Indian Standards, New Delhi, pp. 65-67.
10. IS 2720 Part IV (1985) , "Indian Standards Methods of Test of soil for Grain Size Analysis", Compendium of Indian Standards on soil Engineering, part 1 laboratory testing of soil for civil engineering purpose, Bureau of Indian Standards, New Delhi, pp 73-91.
11. IS 2720 Part VIII (1983), "Indian Standard Methods of Test for Soils: Part 8: Determination of water content. Dry density Relation Using Heavy compaction, "Compendium of Indian Standard on Soil Engineering: Part 1: Laboratory Testing of soils for Civil Engineering purpose, Bureau of Indian Standard, New Delhi.
12. IS 2720 Part X (1973),"Indian Standard Methods of Test for Soils: Determination of Unconfined Compressive Strength," Compendium of Indian Standards on Soil Engineering purposes, Bureau of Indian Standards, New Delhi, pp. 202-205.

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