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Research Paper

Stabilization of black cotton soil by using cement, lime and rice husk in flexible pavements

Sajja Satish [1] *, Shyam Prakash Koganti [2], Kommineni Hemantha Raja [3], Kaza Raaga Sai [4]

[1] Assistant Professor, Department of Civil Engineering, VR Siddhartha Engineering College
[2] Assistant Professor, Department of Civil Engineering, PVP Siddhartha Institute of Technology
[3] Assistant Professor, Department of Civil Engineering, K L University
[4] Assistant Professor, Department of Civil Engineering, Lingaya's Institute of Management and Technology
**Corresponding author E-mail: satish.sajja@gmail.com*

Abstract

Expansive soil (Black cotton soil) is very weak and does not have enough stability for any type of construction work. To make the subgrade soil stable, by improving its engineering properties is very essential. In the present work, stabilization of subgrade soil by using Sand and Cement varying percentage of cement as 2%, 3%, 5% and constant percentage of sand by weight of soil, Rice Husk of 5%, 7%, 10%, and Lime is used to enhance the strength of subgrade soil. The purpose of this study is to determine the optimum dose of the stabilizer, which improves the strength and bearing capacity of soil less which is suitable for pavement structure. To evaluate the strength of soil, various tests have been performed such as Sieve analysis, Liquid limit, Plastic limit, Specific gravity, Compaction (OMC, MDD) and CBR test in the laboratory. The result shows that the use of the above materials in combination increases the California Bearing Ratio values (CBR). By using the CBR value the design of pavements to carry traffic in the range of 1 to 10 msa and 10 – 150 msa is calculated as per IRC: 37 – 2001.

Keywords: *Cement; Lime; Rice Husk; Sand; CBR.*

1. Introduction

From past few years there has been an extensive utilization of land for various purposes. This resulted in the decrease in the available land. Also there has been a gradual increase in population day-by-day, due to the increase in birth rates and decreases of death rates. With the increase of population, there is need for the available land for various construction purposes. This phenomenon created an increase in the demand of sand. This resulted in construction of buildings and other civil engineering structures on weak or soft soil. Because of soft soils having low shear strength and high swelling, ground improvement techniques such as soil stabilization and reinforcement are employed to improve mechanical behavior of soil.

After a few researches, it was found that stabilization of soil is a way-out for all the problems. Soil stabilization is the addition of external materials to soil to improve the properties of soil. Soil stabilization is one of the most suitable alternatives which are widely used in pavement construction. Generally lime and cement are used as additive to black cotton soils to improve its geotechnical properties. But, in recent days, many of the waste materials are tested to improve the black cotton soil properties. [8] Few of such waste materials are fly ash, municipal waste, egg shell powder, quarry dust, rice husk, ground nutshell powder, construction waste etc. It is already known that, owing to the construction of capital city Amravati, there will be large civil constructions, infrastructure, and road networks constructed in future 10-20 years in Andhra Pradesh. As it is already discussed that most parts of Amravati are covered by BCS, if we use soil stabilization techniques for road network construction, large amount of economy will be saved.

1.1. Black cotton soil

This type of soil is made up of volcanic rocks and lava. Black soil is also known as 'regur' which is derived from a Telugu word 'reguda'. Black soil is also known as Black Cotton Soil as cotton is an important crop which is grown in this type of soil. The soil content is rich in calcium carbonate, potash, lime and magnesium carbonate but has poor phosphorus content. It is mostly found in areas such as Gujarat, Madhya Pradesh and Maharashtra. It is also found in states like Tamil Nadu, Andhra Pradesh and Karnataka.

1.1.1. Stabilization of black cotton soil

Replacement of expansive soil with a non-expansive material is a common method of reducing shrink-swell risk. However, often the soil or stratum extends too deep and in that case this method is not economically efficient. The best method is to saturate and prevent potential expansion if the high moisture content can be maintained. [6].

1.2. Cement

Cement is a binder, a substance used in construction that sets, hardens and adheres to other materials, binding them together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete. An increase in Cement content generally causes increase in strength and durability. Both normal and air entraining cement give almost the same results of stabilization. [7].

1.2.1. Soil - cement stabilization

Soil cement is an intimate mix of soil, cement and water which is well compacted and cured to form a strong base course. The terms “Cement treated soil” and “Cement modified soil” refer to the compacted mixes when cement is used in small proportions to impart some strength or to modify the properties of the soil and these mixes do not full fill the mix design requirements specified for soil- cement. [3].
Degree of stabilization depends on nature of soil, proportion of cement, efficiency of mixing, compacting moisture content and dry density of compacted mix. By the increasing percentage of cement added, there is an increase in the strength and the durability of soil-cement and a decrease in volume change, moisture movement and plasticity of the fine grained soils.

1.3. Lime

Lime is a calcium-containing inorganic material in which carbonates, oxides, and hydroxides predominate. In the strict sense of the term, lime is calcium oxide or calcium hydroxide. An increase in the lime content causes a slight change in liquid limit and a considerable increase in plastic limit resulting in reduction in plasticity index. With proper lime treatment it is possible to make the clay almost non-plastic with plasticity index reducing to practically zero. [4] There is also considerable reduction in swelling and increase in shrinkage limit due to lime treatment of clayey soils. All these changes are desirable for stabilization of clay [2].

1.3.1. Soil-lime stabilization

When soils are treated with lime, either modification in soil properties or binding or both actions may take place. In the case of clayey soils with high plasticity the predominant action is generally modification resulting benefits such as reduction in plasticity and volume changes due to variation in moisture content. [9]Other benefits are soil- lime mixes become friable and easy to be pulverized having less affinity with water; also there could be pozzolanic action resulting in slow rate of increase in strength with curing period.

1.4. Rice husk

Rice hulls (or rice husks) are the hard protecting coverings of grains of rice. In addition to protecting rice during the growing season, rice hulls can be put to use as building material, fertilizer, insulation material, or fuel [1] [10].
The performance of soft subgrades interms of CBR and DCPI can be improved using robosand, flyash and even in combination. Field DCPI and CBR are also improved.

2. Collection of black cotton soil

The soil of the capital region of Andhra Pradesh including Guntur and Krishna districts consists of similar soil i.e. Black cotton soil. In the present study, soil is required for various tests like, sieve analysis, liquid limit, plastic limit, compaction and C.B.R. for Soil and for combinations of all materials, is collected from ‘Kanuru’ region which is near to the Vijayawada city for experimental usage. Geologically, a major part of the Krishna river basin is composed of Archaen crystalline rocks with charnockites, charnockite gneiss, hypersthene-diopside gneiss, hornblende gneiss and hornblende- biotite and quartz-mica gneiss (composite) rock types.

2.1. Collection of cement

In the present study, the cement required for the various tests is collected from our concrete laboratory of PVPSIT which is 53 grade KCP cement.

2.2. Collection of rice husk and lime

The Rice Husk and Lime that was used in our experimental study is collected from “Kanuru” region which is near to the Vijayawada city.

3. Experimental work

Expansive soil (Black cotton soil) is very weak and does not have enough stability for any type of construction work. In pavement, sub grade layer is the bottom most layer underlying the base course or surface course. To make the sub grade soil stable, by improving its engineering properties is very essential. In the present work, stabilization of sub grade soil by using Sand and Cement (varying percentage of sand as 10%, 20%, 30% and constant percentage of cement by weight of soil), Quarry Dust, Rice Husk and Lime (of 10%, 20%, 30%) is used to enhance the strength of sub grade soil. The purpose of this study is to determine the optimum dose of the stabilizer, which improves the strength and bearing capacity of soil (CBR less than or equal to 2% to more than 7%) which is suitable for pavement structure. To evaluate the strength of soil, various tests have been performed such as Sieve analysis, Liquid limit, Plastic limit, Specific gravity, PH, Standard proctor test and CBR test in the laboratory. The result shows that the use of the above materials in combination increases the California Bearing Ratio (CBR) values i.e. the strength of soil to a great extent. Based on the results obtained from the CBR values, pavement thicknesses were calculated. Thus calculated pavement thicknesses were compared with the pavement thickness soil CBR.

4. Objectives of project

To improve the strength, reduce the swelling index and to increase the bearing capacity of the black cotton soil, it is stabilized using different materials like Cement, Rice Husk and Lime The purpose of this study is to determine the optimum dose of the stabilizer, which improves the strength and bearing capacity of soil which is suitable for pavement structure. Various composition of samples taken are as shown in the Table 1.

Table 1: Composition of Materials

Sl. No.	Material	Composition
1		2% cement + Sand 10% + Soil
2	Cement	3% cement + Sand 10% + Soil
3		5% cement + Sand 10% + Soil
4		Soil + 10% Lime
5	Lime	Soil + 20% Lime
6		Soil + 30% Lime
7		Soil + 5% Rice Husk
8	Rice Husk	Soil + 7% Rice Husk
9		Soil + 10% Rice Husk

5. Pavement thickness

There are 4 types of flexible pavements with bituminous course as surfacing. For easy understanding these are named as type 1, 2, 3 and 4.
Pavement thicknesses are calculated for 2, 5, 10, 20, 30, 50, 100 and 150 msa (million standard axles).
Type 1: Bituminous surfacing using granular base & sub base.
Type 2: Bituminous surfacing using cemented base & sub base.
Type 3: Bituminous surfacing using cemented granular base & sub base.
Type 4: Bituminous surfacing using

RAP (Reclaimed Asphaltic Pavement) & cemented sub base. (As per clause no: 10.1, 10.2, 10.3 and 10.4 of IRC 37:2012).

By using the CBR value obtained at 2.5mm penetration, pavement thicknesses for the soil and other samples for type 1, 2, 3 and 4 are calculated. The Pavement thicknesses of various material composition for traffic range from 1 to 10 msa given in Table 2. The Pavement thicknesses of various material composition for traffic range from 10 to 150 msa given in Table 3. Also it is shown in the Figure 1 and 2.

Table 2: Pavement Thickness of Various Material Composition for Traffic Range 1-10 MSA

Cummulative Traffic in MSA	Soil	3% Cement	5% Cement	10% Cement	10% Lime	20% Lime	30% Lime	5% Huck	7% Huck	10% Huck
1	680	410	395	400	395	385	374	680	653	680
2	735	469	445	453	445	414	404	735	620	735
3	770	509	470	490	478	460	454	770	655	770
5	795	534	475	515	499	470	461	795	663	795
10	850	614	542	592	574	514	501	850	751	850

Table 3: Pavement Thickness of Various Material Compositions for Traffic Range 10-150 MSA

Cummulative Traffic in msa	Soil	3% Cement	5% Cement	10% Cement	10% Lime	20% Lime	30% Lime	5% Huck	7% Huck	10% Huck
10 msa	850	614	542	592	574	540	540	700	751	700
20 msa	880	639	571	620	603	568	565	730	781	730
30 msa	900	654	586	638	622	583	580	750	801	750
50 msa	925	674	606	658	642	603	600	780	823	780
100 msa	975	719	636	690	668	633	630	800	851	800
150 msa	975	719	656	703	688	653	650	820	880	820

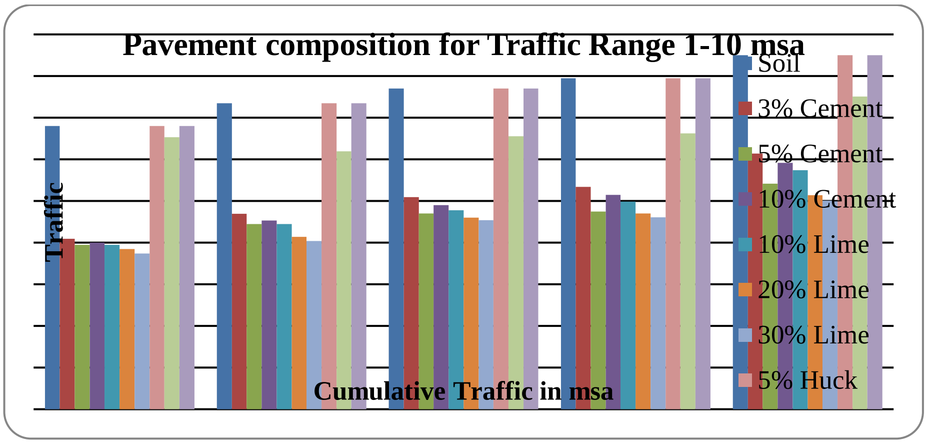

Fig. 1: Pavement Composition of for Traffic Range 1-10 MSA.

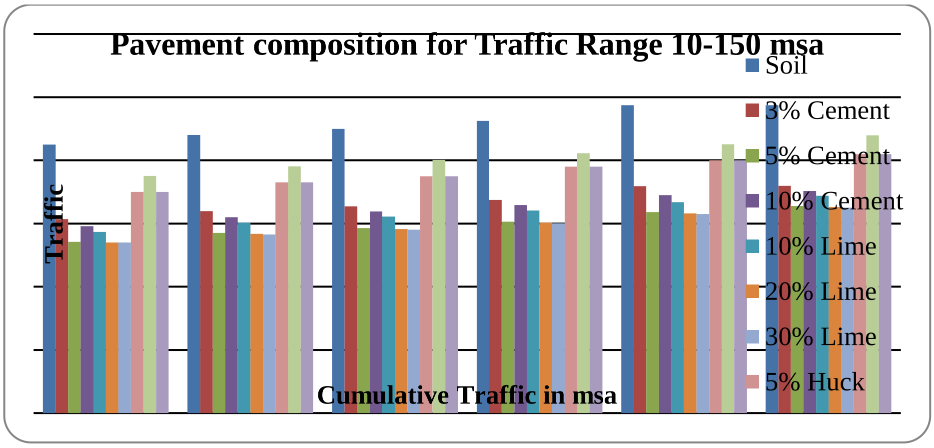

Fig. 2: Pavement Composition of for Traffic Range 10-150 MSA.

6. Conclusions

From the work done it was found that, Free swell index of black cotton soil was found to be 85%. Plastic limit of soil is found to be 12.35%. Liquid limit for black cotton is 56.35%. Plasticity index for black cotton soil was found to be 44.50%. Soil classification was found out to be CH (Inorganic Clays of high plasticity). The OMC and MDD values are found to be 28.5 % and 1.51 g/cc. The CBR value is found to be 1.08 %. The pavement thickness is drawn from the CBR value for the Traffic range of 1-10 msa and 10-150 msa as per IRC: 37-2001. The pavement thicknesses are drawn and it was found that with increase in the percentage of cement, quarry dust and lime, the strength increases, therefore the thickness of the pavement decreases for the range 1-10 msa. But the thickness is increased for the range of 10- 150 msa. The pavement thicknesses are drawn and it was found that with increase in the percentage of rice husk, the strength increases upto 7% and then it decreases for 10%. Therefore the thickness of the pavement decreases only for certain level for the range 1-10 msa. But the thickness is increased for the range of 10- 150 msa. Hence the final conclusion is that Rice husk is not suggested for stabilization with soil. Whereas Quarry Dust is the best suitable when compared with cement, lime, rice huck for the stabilization of road bases.

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