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IMPROVEMENT OF SOFT SOIL WITH DIFFERENT MATERIALS

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I. ABSTRACT

The strength of a pavement's sub-grade determines its quality. The entire pavement system is supported by the sub-grade. In the case of flexible pavement, the sub-grade must have consistent geotechnical parameters like as shear strength and compressibility. The materials chosen for the building of the sub-grade must have sufficient strength while also being cost-effective. They must also meet the requirements for quality and compaction. If the natural soil is soft and weak, it will need to be improved before it can be used as a sub-grade. To achieve improved strength and lower compressibility, it is necessary to stabilise the current weak soil.

As a result, the current study was conducted using readily available materials such as lime and rice husk ash, which were mixed separately and in different quantities..

The compressive force is un constrained The original soil's strength (UCS) enhanced by 253 percent when mixed with 6 percent lime and 6 percent rice husk ash (RHA), but the maximum value of UCS was achieved when a mixture of 4 percent lime and 9 percent rice husk ash was added .Based on the findings of laboratory tests, correlations have been established between the California Bearing Ratio (CBR) for various moisture content placements and the related values of Unconfined Compressive Strength (UCS), each of which is a function of various soil properties. Multiple linear regression models were used to conduct statistical studies in this case. When the model contains the soil's index properties (LL, PL, and PI) as well as compaction characteristics (OMC and MDD), the standard error is minimised.

This is in contrast to the models created separately using any of the property sets. The microfabric structure of soil and soil-lime-RHA mixes has also been identified in an attempt to get insight into the reasons for strength enhancement.This study found that by mixing a little amount of lime with soil and adding rice husk ash as an auxiliary stabiliser, desirable CBR and UCS values can be achieved, making the mix cost effective.

II. INTRODUCTION

Alternative materials are increasingly being used in building around the world in recent years. This is to address the need for soil stabilisation to improve the earth. In this regard, readily available and inexpensive materials, notably recycled trash such as fly-ash and rice husk ash, are increasingly being used for road subgrade construction. The inclusion of proper admixtures helps to improve the subgrade.India has a road network of more than 33 lakh kilometres, making it the world's second largest road connecting system[2]. The quantitative density of India's road network is similar to that of the United States, at 0.66 kilometres per square kilometre of land (0.65). The highways carry about 65 percent of freight and 80 percent of passenger traffic[2]. Despite having the world's largest railway network, vehicle transportation has remained the predominant mode of transportation in our country. This is due to its adaptability to changes, flexibility, and accessibility to remote places for accomplishing the desired connectivity goal. A solid and well-connected road network is essential for every country's overall development. Roads are one of the most powerful indicators of a country's economic activity and progress. A vast amount of waste materials (agricultural, industrial, and other) are generated as a result of rapid economic growth and industrialization around the world, having a huge detrimental influence on the environment, as well as public health and the ecology system.

Environmentalists are increasingly concerned about the accumulation of various waste materials[3]. As a result, the secure disposal of these Engineers and technicians have a critical challenge and a difficult task in dealing with waste materials. The bulk usage of such waste materials, primarily in the field of Civil Engineering, might considerably alleviate this situation. With its small addition by pozzolanic reaction, lime outperforms several other stabilising elements in terms of soil improvement. Lime lowers the plasticity index of soil, making it more friable and easily crushed.

Although the Optimum Moisture Content rises and the Maximum Dry Density falls, the strength and durability of the material improves. The use of hydrated (slaked) lime in the treatment of heavy, plastic clayey soils is quite beneficial. Lime can be used alone or in conjunction with cement, fly ash, or other pozzolanic materials such as rice husk ash and other pozzolanic materials. Lime has traditionally been used to stabilise road bases and subgrades. Rice husk is an agricultural waste product obtained from rice milling. In Asia, some 770 million tonnes of rice husks are generated each year. It is around 120 million tonnes per year in India. Because disposal of the husks in developed countries, where mills are often enormous, is a major environmental issue, and burning them in an open area is not acceptable, the majority of the husk is currently used for land infill. If suitable, this waste material can be utilised for the cost-effective construction of a road system.

As a result, a thorough investigation should be conducted to see if rice husk ash (RHA) may be used to improve the quality of weak subgrade soil, allowing it to be used with the desired improvement for cost-effective subgrade building.

III SCOPE OF WORK

The following is a list of the study's objectives:

1) Conduct normal laboratory tests such as specific gravity, grain size analysis, and Atterberg Limits to characterise both unstabilized and stabilised soil.

2) Determination of soil compaction parameters such as optimal moisture content (OMC) and maximum dry density (MDD).

3) To determine the strength of sub-grade soil in terms of California Bearing Ratio (CBR), test for both unsoaked and soaked conditions at optimum moisture content (OMC), 2 percent above optimum moisture content (OMC+2 percent), and 5 percent above optimum moisture content (OMC+5 percent) for both unstabilized and stabilised soil.

4) To estimate the strength of sub-grade soil using the Unconfined Compressive Strength (UCS) test for various curing times up to 180 days at optimum moisture content (OMC) in order to analyse the effect of curing on stabilisation of soil strength.

5) Using X-ray diffraction (XRD) and X-ray fluorescence (XRF) spectra, determine the semi-quantitative elemental analysis of soil samples, lime, and rice husk ash (RHA) and their few particular mixtures.

6) Using multiple regression analysis, build a correlation between CBR and various soil factors.

7) To determine the optimal soil, lime, and rice husk ash combination for maximal strength enhancement in stabilised soil.

IV MATERIALS USED

The materials employed in this investigation were clayey soil, lime, and rice husk ash, all of which were readily available in the area. The following is a list of the physical qualities of these materials, one by one:

SOIL

The soil for this study was gathered using the disturbed sample method at a depth of 2.5 to 3.5 m below ground level. It appears that the beginning soil sample comprises crystalline quartz, mica, and clinochlore, based on the X-ray diffraction (XRD) patterns

LIME

Lime is a fantastic tool for modifying and stabilising soil beneath roads and other construction projects. Lime can improve the sub-grade soil's stability, impermeability, and load-bearing capacity significantly[4]. Lime can be used to change some of the physical qualities of soil and so improve its quality, or it can be used to stabilise the soil and increase its strength and longevity

RUSK

Rice husk is an agricultural waste product obtained from rice milling, with an estimated 120 million tonnes produced in India[5]. If suitable, this waste material can be utilised for the cost-effective construction of a road system. A systematic, extensive investigation should be conducted to see if rice husk ash (RHA) may be used to improve the quality of weak soils, particularly in weak soils, so that such improved soil can be cost effective for construction projects.

Silica is the most prominent component in RHA. The addition of RHA raises the quantity of Silica in the soil, which improves the sample's strength and stability.

V METHOLODGY

All soil tests were performed according to the techniques suggested in the relevant IS regulations before and after stabilisation with various RHA and lime levels.

For laboratory tests, specimens of soil with and without admixtures were prepared by thoroughly mixing the required quantity of soil and stabilisers in pre-determined proportions in a dry state, then adding and thoroughly mixing the required quantity of water to obtain a homogeneous and uniform mixture of soil and admixtures. The California Bearing Ratio testing were conducted in both wet and dry conditions.OMC, OMC+2, and OMC+5 are examples of varied water content situations. 2% of the population .In the case of lime, the proportions were 4 percent, 6 percent, 8 percent, and 10%, and 3 percent, 6 percent, 9 percent, and 10%, 12% for RHA. They were mixed with original soil individually and also in combination of both the admixtures

VI EXPERINMENTS

The soil sample from the location was oven dried and sieved through a 2.36 mm IS sieve before being dried for 24 hours at 105°C. RHA was processed in the same way as dirt was processed. The needed quantity of sieved, oven dried soil was first weighed and thrown into a mechanical combination to mix the rice husk ash and lime with soil. The needed amount of lime and RHA were then applied to the soil and thoroughly mixed. A consistent blend of soil-lime-RHA was achieved with great care. The soil or altered soil samples were examined in accordance with the test protocol

LIQUID LIMIT

When a pat of soil in a standard cup is subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus (Casagrande's apparatus) operated at a rate of two shocks per second, the liquid limit is defined as the water content, in percent, at which a pat of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm.

In this test, 200g of air-dried soil was combined with water to make a thick homogenous paste after passing through an IS 425 sieve. Different soil-lime-RHA combinations were used in the liquid limit test.

PLASTIC LIMIT

The Plastic Limit is the percentage of water in a soil that can no longer be bent into 3 mm diameter threads without collapsing. About 50g of the oven dry sample from the 425 material was taken and combined with water until homogeneous and pliable enough to be formed into a ball. The sample was rolled on a glass plate to create threads that cracked at a diameter of around 3 mm. In compliance with IS 2720, the plastic limit test was performed on several soil-lime-RHA combinations (part5)

STANDARD PROCTOR TEST

A total of 2.5 kg of air-dried soil sample passed through a 4.75 mm screen was thoroughly mixed with a modest amount of water. At first, the sample was combined with an appropriate amount of water of 5%, which was gradually increased to 10%, 15%, 20%, and so on. Proctor's specimens had a diameter of 100 mm and a height of 127.5 mm. The material was placed in this mould in three layers, each of which was compressed with 25 blows from a 2.6 kg hammer at a 310 mm drop. In line with IS 2720, a standard compaction test was performed on several soil-lime-RHA mixtures with various combinations to determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD). CALFORNIA BARING RATIO

The CBR test is essentially a penetration test in which a cylindrical plunger with a 5 cm diameter is inserted into the soil mass enclosed in a 15 cm diameter and 175 cm high compaction mould. A detachable perforated base plate with a thickness of 1 cm and a diameter of 23.5 cm is included with the CBR mould. CBR is defined as the ratio of force necessary to pierce a soil sample with a cylindrical plunger of 5 cm diameter at a rate of 1.25 mm / min to the force required to penetrate a standard material at the same rate. About 5 kg of air-dried soil sample was maintained on a 4.75 mm filter after being combined with a reasonable amount of water (at optimum moisture content) of its weight. The sample was placed in the CBR mould in three layers, each of which was crushed with 55 blows from a 2.6 kg hammer at a drop of 310 mm (standard proctor test). Following usual practise, the compacted soil and mould were weighed and placed beneath the CBR testing machine. At penetrations of 0.0, 0.50, 1.0, 1.5, 2.00, 2.5, 3.0, 4.0, 5.0, 7.5, 10, and 12.5mm, the load was measured. CBR values are typically calculated for 2.5 mm and 5.0 mm penetration.

The CBR value at 2.5 mm penetration is usually higher than that at 5.0 mm penetration, hence the former should be used for design purposes.

In compliance with IS 2720, the CBR test was performed on several soil-lime-RHA combinations under both unsoaked and wet conditions (part16). The experiments were carried out at Optimum Moisture Content (OMC), 2% higher than Optimum Moisture Content (OMC +2%), and 2% higher than Optimum Moisture Content (OMC +5%).

SPECIFIC GRAVITY

To get a notion of the unit weight of different mixes, the specific gravity of the soil must be determined. It's the weight in air of a certain volume of soil solids at a specified temperature divided by the weight in air of an identical amount of distilled water at the same temperature. The original soil specimen was subjected to a specific gravity test in line with IS 2720 (part3/Sec1).

GRAIN SIZE ANALYSIS

This experiment was carried out to determine the grain size of several soil-lime-RHA mixtures.The results of grain size analysis are graphically represented as grain size distribution curves, which plot the cumulative % finer than known corresponding grain sizes versus these sizes on a logarithmic scale.

UNCONFINED COMPRESSION TEST

A cylindrical soil sample with no lateral confinement was used in the unconfined compression test. The soil specimen is

gradually subjected to an axial compressive load until it fails. The load is applied quickly, with little provision for drainage, resulting in flooded circumstances. In the laboratory, a remoulded soil sample with a diameter of 38 Samples that had been allowed to cure for up to 180 days. Different curing periods were investigated on the samples

VII.RESULT AND DISCUSSION

For soil, lime, and rice husk ash, the results of XRD and XRF analysis are presented and described as follows:

The X-ray diffraction (XRD) patterns of the used soil sample reveal the presence of crystalline quartz, mica, and clinochlore in the initial soil sample. Silica is the major component of RHA. The addition of RHA increases the quantity of Silica in the soil, which improves the sample's strength and stability. Extra Cristobalite phase is obtained with the existing phases with the addition of rice husk (RHA) to the soil. Calcite (Calcium Carbonate), Silica (Quartz), Calcium Hydroxide, and Sulphur dioxide are all found in the XRD pattern of the used lime (SO2). When lime was added to the soil rice husk ash combination, a new phase called Gismondine developed alongside the other phases. The weight percentages of crystalline phases were calculated using the Rietveld method from X-ray diffraction line profile analysis, and the results are reported in Table 7. Figure 7.3 shows the 2 and XRD patterns of soil lime and RHA combinations. A full-pattern fit method

mm and a length of 76 mm was made from soil compacted in a Proctor mould as part of the Standard Proctor Compaction test.

In line with IS 2720, the UCS test was performed on the soil specimen and various soil-lime-RHA mixes with corresponding optimal moisture content values (part10). UCS values were determined for samples made immediately and

is the Rietveld method. This is a non-linear least squares algorithm in essence. The disparity between the two profiles is minimised by varying numerous factors. and the calculated profiles are compared, with least squares refinements applied until the residuals are minimised and the best fit between the full observed powder diffraction pattern and the entire calculated pattern based on simultaneously revised crystal structure models is attained. Modeling of instrumental factors, diffraction optics effects, and other specimen features, such as size and strain parameters, is possible. The profile residual factor (Rp), the weighted residual factor (Rwp), the anticipated residual factor (Rexp), weighted- statistics (Dws), and the goodness of fit (GOF), all obtained from Rietveld analysis, were used to measure the quality of fitting. The values of the fitting's reliability parameters during Rietveld refining are listed in Table. 7.4. The X-Ray Fluorescence (XRF) spectrum was used to assess the chemical makeup of the soil and other tested samples. For elemental analysis, XRF spectrums were recorded in AXIOS XRF (PANalytical), and element concentrations are given in Table 1

	Sample Designations							
	Soil 100%	Lime	Soil +3%RHA	Soil +9%RHA	Soil +3%RHA+2%Lime	Soil +3%RHA +8%Lime	Soil +9%RHA+2%Lime	Soil+9%RHA +8%Lime
SiO2	59.113	38.271	59.187	59.528	59.193	58.549	58.819	59.261
Al2O3	21.358	_	20.596	18.496	20.519	19.534	19.515	19.23
Fe2O3	9.136	0.189	9.45	10.276	9.181	8.71	9.02	8.236
CaO	1.601	57.857	1.794	2.103	2.478	5.039	3.107	5.139
K2O	3.582	0.065	3.499	3.71	3.49	3.279	3.451	3.281
MgO	2.96	0.643	2.923	2.698	2.628	2.609	2.616	2.542
TiO2	1.047	0.026	1.011	1.092	1.037	0.985	1.001	0.936
Na2O	0.705	0.076	0.696	0.694	0.73	0.737	0.804	0.734
P2O5	0.107	_	0.136	0.19	0.153	0.119	0.148	0.441
SO2	0.295	2.873	0.605	1.084	0.492	0.347	1.449	0.1
MnO	0.095	_	0.105	0.128	0.099	0.093	0.105	0.1

VIII.EXPERMENTAL RESULTS

The current study's extensive experimental programme was designed to evaluate how the available cohesive soil behaved when mixed with readily available local stabilising admixtures such lime and rice husk ash in various quantities singly or in combination. This will allow researchers to assess not only the viability of these composite materials for use in the building of flexible pavement sub-grades, but also the best mixing proportion for cost-effective construction. The geotechnical parameters of the soil and stabilised soil, such as the Atterberg limit, grain size distribution, and specific gravity, were first determined. By conducting Standard Proctor Compaction tests on those soils, the essential experiment was done to identify the compaction parameters, i.e. optimum moisture content (OMC) and maximum dry density (MDD). See Table 2

After that, the effect of the original soil's strength properties on the stabilised soil was determined by performing California Bearing Ratio (CBR) and unconfined compressive strength (UCS) tests on the stabilised soil. Furthermore, the effect of curing was investigated by performing unconfined compressive strength tests at various intervals over the course of a 180-day curing period. The purpose of the initial discussion of the test findings was to highlight the influence of stabilisation on soil strength at various curing periods for varied admixture quantities. To get optimal strength, researchers looked for the best proportion of admixtures, lime, and rice husk ash.

TABLE 2

SI No	Test	No. of tests
1	Grain size distribution	5
2	Atterberg limits Liquid limit Plastic limit	 30 30
3	Standard proctor Compaction test OMC MDD	 30
4	CBR test at OMC Soaked condition Unsoaked condition	30 30
5	CBR test at OMC+2% Soaked Unsoaked	 30 30
6	CBR test at OMC+5% Soaked condition Unsoaked condition	 30 30
7	UCS with curing period at 0 -180 days with an intervals of 30 days	 210

IX.CONCLUSION

From the current investigation, the following findings can be drawn:

a) The addition of admixtures such as lime and RHA to soil results in a general drop in the liquid limit, an increase in the plastic limit, and a decrease in the plasticity index.

b) Regardless of RHA concentration, the specific gravity drops as the amount of lime added increases up to 2%. However, when more than 2% lime is added, it climbs asymptotically to a constant value, and as the RHA content increases, it decreases for any lime content.

c) The liquid limit reduces for all soil-lime-rice husk ash combinations, and CBR values indicate that stabilised soils are appropriate for use as paving materials for flexible pavements.

d) In general, the plastic limit increases as the amount of lime and rice husk ash content increases, up to 6% and 12% lime and RHA content, respectively. For all circumstances, it is more or less steady or displays a minor diminishing trend beyond these limits.

e) Adding admixtures to the soft sub-grade lowers the Maximum Dry Density while raising the Optimum Moisture content. Increases in lime and rice husk ash content, both sparingly, diminish the maximum dry density in almost all circumstances.

f) As the lime content and RHA content rise to 6% and 12%, respectively, the optimal moisture content rises and eventually falls.

g) When compared to the original soil, the strength characteristics in terms of CBR value are observed to rise significantly with the addition of RHA at reduced lime level. The pozzolanic activity of lime and RHA is responsible for this.

h) Soil CBR values increase significantly when lime and RHA combinations are combined, both under soaked and un-soaked conditions.

I) the maximum CBR value of 28.25 percent is found when 6 percent lime and 9 percent RHA contents are combined under un-soaked conditions, and this value increases to 29.82 percent when 6 percent lime and 6 percent RHA combinations are combined under soaked conditions at the optimum moisture content. This should be taken into account while determining the best amount of lime rice husk ash to use in the field.

CONFLICTS OF INTREST

The author declares that they have no conflicts of interest

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