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EXPERIMENTAL STUDY ON STABILISED GRAVEL FOR ROAD SUB-BASE

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ABSTRACT:- The quality of a pavement depends on the strength of its sub-grade. The sub-grade acts as a support for the entire pavement system. In case of flexible pavement the sub- grade must be uniform in terms of geotechnical properties like shear strength, compressibility etc. Materials selected for construction of sub-grade must have to be of adequate strength and at the same it must be economical for use. They must also be ensured for the quality and compaction requirements. If the natural soil is very soft and weak it needs some improvement for use as sub-grade. It is, therefore, needed to stabilize the existing weak soil to achieve increased strength and reduced compressibility.

In view of this the present investigation has been carried out with easily available materials like lime and rice husk ash mixed individually and in combinations with different proportions. The different percentages of lime with respect to weight of dry soil were 2%, 4%, 6%, 8% 10% and for rice husk ash (RHA) were 3%, 6%, 9% and 12%. In each case the stabilized soil was compacted at optimum moisture content (OMC), 2% above and 5% above optimum moisture content (OMC+2, OMC+5). In each case California Bearing Ratio (CBR) tests and in case of compaction at OMC Unconfined Compressive Strength (UCS) tests were performed. The effect of curing on UCS samples up to 180 days with the intervals of 30 days was also studied.

It was found that CBR of original soil improved from 4.25% to a maximum value 28.25% when mixed with combination of 6% lime and 9% rice husk ash (RHA) under unsoaked conditions and from 3.5% to 29.82% when mixed with a combination of 6% lime and 9 % rice husk ash (RHA) with respect to dry weight of soil under soaked conditions at optimum moisture content (OMC). The unconfined compressive strength (UCS) of original soil improved by 253% when mixed with 6% lime and 6% rice husk ash (RHA), however the maximum value of UCS is attained by a value of 285% when mix proportion of 4% lime and 9% rice husk ash.

Based on the laboratory test results correlations have been developed between California Bearing Ratio (CBR) for different placement of moisture contents and also respective values of Unconfined Compressive Strength (UCS) considering each of them as function of different soil parameters. In this respect statistical analyses have been done by multiple linear regression models. Standard error has been found to be minimum when the model includes index properties (LL, PL & PI) and compaction characteristics (OMC & MDD) of the soil. This is in comparison with the models done separates with either of the sets of property.

The study incorporates an exhaustive and systematic experimental programmer. This helps in searching the most cost effective design mix of rice husk ash and lime admixtures with near surface alluvial soil, extensively used for construction of sub- grade.

It is concluded from this study that desired CBR and UCS values may be obtained on mixing a limited quantity of lime with soil when rice husk ash is also used as an auxiliary stabilizer making the mix cost effective.

1. INTRODUCTION

Out of many stabilizing materials lime improves the soil much with its little addition by pozzolanic reaction. Lime reduces the plasticity index of soil making it more friable and easy for handling and pulverized. There are generally an increase in Optimum Moisture Content and decrease in

Maximum Dry Density but the strength and durability increases. Hydrated (slaked) lime is very useful in treating heavy, plastic clayey soils. Lime may be used alone or in combination with cement, fly ash, or other pozzolanic materials like rice husk ash etc. Lime has been mainly used for stabilizing the road bases and sub grades.

Rice husk is an agricultural waste material obtained from milling of the rice. About 770 million tons of rice husks are produced annually in Asia. In India it is approximately 120 million tons per annum. In developed countries, where the mills are typically large, disposal of the husks is a big problem for the environment and also burning them in an open place is not desirable, so the majority of the husk is currently used for land filling. This waste material, if suitable, can be used for the economic utilization in construction of road system. Therefore a systematic detailed investigation should be undertaken to make possible use of rice husk ash (RHA) to improve the quality of weak subgrade soil so that it can be used with desired improvement for cost effective construction of good quality of subgrade.

The present investigation has been carried out to study the strength improvement of soft subgrade with the lime and rice husk ash because they are easily available. Both the materials-lime and rice husk ash have been mixed individually and also in combination in different proportions with a locally available clayey soil. The major parameter for determining the improvement of soil is California Bearing Ratio (CBR) under soaked and unsoaked conditions at the different moisture contents and corresponding Unconfined Compressive Strengths (UCS). Effect of curing period on improvement of strength of soil has also been examined. This has been carried out at the optimum moisture content (OMC) of soil and above it. Based on the laboratory test data an attempt has been made to develop an equation of CBR considering it as a function of different soil parameters such as atterberg limits, compaction characteristics and strength by multiple linear regression analysis.

OBJECTIVES

The main objectives of the present study are as follows:-

- To examine the applicability, effectiveness and suitability of mixing lime and some locally available agricultural waste materials such as Rice Husk Ash(RHA) in isolation and in different combinations as ground improving materials for use in soft cohesive sub-grade of a flexible pavement.
- To find out the best possible design mix proportion of the chosen soil and admixtures used which gives maximum strength of stabilized soil compared to that of the original soil.

Table. 1: Engineering Properties of Soil

Basic Properties of Soil	Value
Sand (%)	5
Silt (%)	68
Clay (%)	27
Liquid Limit (%)	51
Plastic Limit (%)	28
Plasticity index (%)	23
IS Classification	CH
Specific Gravity	2.65
Maximum Dry Density(gm/cc)	1.630
Optimum Moisture Content (%)	15.92
CBR at OMC Unsoaked (%) at OMC	4.25
CBR at OMC Soaked (%) at OMC	3.50
Unconfined Compressive Strength(U (kN/m2)	98

Table 2: Physical Properties of RHA

Basic Properties of RHA	Value
Liquid Limit (%)	NP
Plastic Limit (%)	NP
Plasticity index (%)	NP
Specific Gravity	1.96
Maximum DryDensity(gm/cc)	0.85
Optimum Moisture Content (%)	32

Angle of internal friction(°)	38
CBR at OMC Unsoaked (%)	8.75
CBR at OMC Soaked (%)	8.15

APPLICATIONS AND USE OF RICE HUSK ASH:- RHA has got numerous applications in silicon based industries. Substantial research has been carried out on the use of RHA as a mineral admixture in the manufacture of concrete. RHA, in amorphous form, can be used as a partial substitute for Portland cement and as an admixture in high strength and high performance concretes and also for soil stabilization and ground improvement.

METHODOLOGY

All the tests of soil before and after stabilization with different RHA and lime contents were carried out as per the procedures recommended in the relevant IS codes. For laboratory tests, specimens of soil with and without admixtures were prepared by thorough mixing the required quantity of soil and stabilizers in pre-selected proportions in dry state and then required quantity of water was added and mixed thoroughly to get a homogeneous and uniform mixture of soil and admixtures. The California Bearing Ratio tests were performed under both soaked and unsoaked conditions, with different water content such as OMC, OMC+2 and OMC+5. The 2%, 4%, 6%, 8% and 10% proportions were used in cases of lime and 2%, 4%, 6%, 8 %, 10% for RHA

EXPERIMENTAL PROGRAM:-

The detailed experimental programme of the present study was undertaken to investigate the changed behavior of the available cohesive soil when mixed with easily available local stabilizing admixtures like lime and rice husk ash in different proportions individually or in combinations. This will enable to examine not only suitability of these composite materials in the construction of sub-grade for flexible pavement, but also to decide the optimum mixing proportion for cost effective construction.

Initially the geotechnical properties like Atterberg limit, grain size distribution and specific gravity of the soil and stabilized soil had been determined. The necessary experiment on made to determine the compaction characteristics i.e. optimum moisture content (OMC) and maximum dry density (MDD) by conducting Standard Proctor Compaction tests of those soils.

Thereafter the effect of strength characteristics of the original soil and stabilized soils had been made by conducting California Bearing Ratio (CBR) test and unconfined compressive strength (UCS) test on the stabilized soil. Furthermore, the effect of curing has also been studied by conducting unconfined compressive strength test at different intervals during a curing period of 180 days. At the outset discussion on the test results had been done to bring out the effect of stabilization on soil strength at different curing periods for various proportions of admixtures. Searching had also been done to find the optimize proportion of admixtures, lime and rice husk ash to obtain maximum strength.

MECHANISM OF STABILIZATION WITH RICE HUSK ASH (RHA) :-Rice Husk Ash is a pozzolanic material which contains 80-85% silica. This is therefore highly reactive and depending upon the temperature of incineration. Pozzolanic are defined as siliceous or siliceous and aluminous materials which in themselves process little or no cementing property, but will in a finely dispersed form in the presence of water chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementations properties. When water is added to a mixture with pozzolanic material it acts as cement, in some cases providing a stronger bond than cement alone.

MECHANISM OF LIME STABILIZATION:- Lime stabilized soils are generally used as sub-bases and bases of pavements to improve the bearing capacity of soft clay soil. It has also been used as a stabilizer for soils on embankment slopes and canal lining. When lime is added to clayey soils it lowers the liquid limit of soil and reduces the plasticity index. This

renders clayey soil friable, easy to be pulverized, reduces swelling, decreases the OMC required for compaction. Normally 2 - 8% of lime may be required for coarse grained soils and 5 - 10% for plastic soils. It has been found that the strength of soil lime mix increases with addition of materials lime cement, rice husk ash (RHA),fly ash etc. Lime stabilization with hydrated lime or fat lime is an effective measure in improving the engineering properties of soft clay soils. It improves the strength, stiffness and durability of fine grained soils. Lime has also been used as a stabilizer for soils on embankment slopes and canal lining, in the base courses of pavements, under concrete foundations. Introduction of lime to soils produces a maximum density under higher optimum moisture content than in the untreated soil. Lime stabilization has extensively been used for stabilizing highly unstable plastic and swelling clayey soils such as black cotton soils. Treatment with lime helps in decreasing the swelling potential and swelling pressures of such clayey soils

RESULTS:-

MAXIMUM DRY DENSITY:- The maximum dry density (MDD) is generally reduced with the increase in combined amount of lime and rice husk ash (RHA) combination. The decreasing trend of maximum dry density (MDD) can be attributed to the cationic exchange of the lime which induces flocculation and agglomeration of the clay particles. Again decrease in maximum dry density (MDD) with addition of rice husk ash (RHA) may be attributed to the replacement of soil with the rice husk ash (RHA) which have relatively low specific gravity (1.95) as compared to that of original soil, (specific gravity = 2.63). The decrease in maximum dry density (MDD) may also be attributed to coating of the soil particles by rice husk ash (RHA)which results in larger particles with larger voids and hence lesser density.

OPTIMUM MOISTURE CONTENT:-

The increase in optimum moisture content (OMC) in spite of the reduced the surface area is caused by flocculation and agglomeration, which is due to the additional fine contents requiring more water in addition to the free lime that needs more water for the pozzolanic reactions.

The possible cause of increased water demand with increase of lime content may be the requirement of more water for dissociation of lime into Ca++ ions and OH- ions to supply more Ca++ ions for the cation exchange reaction. The increase in OMC due to addition of RHA may be attributed to the fact that RHA decreases the quantity of free silt and clay fraction and as a result quantity of coarser materials with greater surface area increases. Hence more water is required to compact the soil-RHA mixtures.

CALIFORNIA BEARING RATIO (CBR) AT OMC, (OMC+2%), AND (OMC+5%)

The maximum California Bearing Ratio (CBR) value at OMC of 28.25% is found to occur with the combination of 6% of lime and 9% rice husk ash (RHA) contents under un-soaked condition and the maximum value increases to 29.82% for 6% of lime and 6% rice husk ash (RHA) combination under soaked condition. The California Bearing Ratio (CBR) value is found to increase appreciably with addition of rice husk ash (RHA) at lower lime content when compared with the original soil. This is probably due to the chemical action of lime.

CBR AT WATER CONTENT ABOVE OMC (OMC+2%, OMC+5%)

The maximum California Bearing Ratio (CBR) value of 22.14 % is found to occur with the combination of 6% of lime and 9% rice husk ash (RHA) contents under un-soaked condition and the maximum value increases to 24.10 % for 6% of lime and 9% rice husk ash (RHA) combination under soaked condition. When water content is increased further i.e. 5% more than the optimum moisture contents (OMC+5%) maximum California Bearing Ratio (CBR) value of 20.33% occurs under un-soaked condition and in soaked condition the maximum value obtained is 21.73% for 6% of lime and 9% rice husk ash (RHA) combination.

CONCLUSION:-

1. The treatment of soil with addition of admixtures such as lime and RHA has a general trend of decrease in liquid limit and increase in plastic limit and decrease of plasticity index.
2. The specific gravity decreases with increase of addition of lime up to 2% irrespective of RHA content. But with addition of lime more than 2%, it again
3. increases asymptotically to a constant value and further increase in RHA content it decreases for any lime content,
4. The liquid limit decreases for all soil-lime-rice husk ash combinations and the stabilized soils appear to be suitable for construction as pavement materials for the flexible pavements as is seen from CBR values.
5. The optimum moisture content increases with increasing lime content up to 6% and RHA content up to 12% and then decreases.
6. The strength characteristics in terms of CBR value is found to increase appreciably with addition of RHA at lower lime content when compared to the original soil. This is due to the pozzolanic action of lime and RHA.
7. Soil, when mixed with lime and RHA combinations the CBR values increase appreciably both under soaked and un-soaked conditions.
8. The maximum CBR value of 28.25% is found to occur with the combination of 6% of lime and 8% RHA contents under un-soaked condition and this value increases up to 29.82% for 6% of lime and 6% RHA combination under soaked condition at the optimum moisture content. This should be considered for estimation of optimum quantity of lime rice husk ash to be used for working in the field.
9. The curing period has the influence on the UCS value of admixture contained soil.
10. The UCS value increases with the curing period for a fixed lime and RHA content, up to 9% of RHA and 8% of lime individually and beyond these limiting values the unconfined compressive strength decreases.

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