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SUBGRADE STABILIZATION USING CEMENT AND RICE HUSK ASH

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ABSTRACT:

Subgrade acts as foundation for a pavement structure. Soil strength can be increased through addition of chemical additives like cement, lime, Rice Husk Ash (RHA), Fly Ash etc. depending on the availability of additives. Stabilization of soil using cement or lime only is not cost effective. The use of RHA may minimize cost as it can act as a stabilizing agent. The present study is carried out on the soil of Naguman-Shabqada Section of Provincial Highway, District Charsadda, KPK, Pakistan, to investigate its stabilization potential. A small amount of cement is mixed with varying percentages of RHA. The results achieved show that the increase in content of RHA increases the Optimum moisture content (OMC), but decreases the Maximum dry density (MDD). There is a considerable increase in the California bearing Ratio CBR value and unconfined compressive stress (UCS) UCS of soil with RHA content. After increase in a certain percentage of RHA content the strength of soil starts decreasing. Addition of 6% cement and 15% RHA content is recommended as an optimum amount to have maximumstrength improvement.

1. INTRODUCTION

Transport and communication infrastructure acts as a backbone for the economic and industrial development of a country. The pavement subgrade acts as an understructure for pavement. The strength of a subgrade layer is directly related to the life of pavement. If the subgrade is strong the overtopping layers thickness can be reduced which also saves cost. Cement is used as a main stabilizing agent but the rapidly increase in price because of the increment in the expense of vitality is presently deterrent in utilizing the cement. In this manner the utilization of agricultural waste will impressively lessen the expense of development and also decreases the environmental hazards they causes. RHA cannot be used alone with the soil because of scant cementious properties. Small amount of cement is mixed with RHA and the effect on soil properties like MDD, OMC, UCSand CBRis observed. In Pakistan, where there is weak soil, such stabilization can prove very effective `both in terms of engineering and cost. The repeated overlaying and maintenance of pavement can be circumvented and focus can be shifted to new alignments and roads.

2. RESEARCH OBJECTIVES

The research objectives are the stabilization of soil to improve subgrade layer of the pavement. The Target of study is to:

- Strengthen and escalate the load carrying capacity of subgrade soil using soil stabilization techniques.
- Reduce the swell potential of subgrade soil.
- Increase the durability of soil.
- Analyze the use of cement and RHA as a stabilizer.

3. LITERATURE REVIEW

Sub-base dependability is the strengthening of soil qualities under the rehashed stacking. In the properties of soil every property significantly influences the long haul capacity of asphalt under the street. Soil ought to be sufficiently stable to give such quality against weight improvement from asphalt at later times. It ought to additionally control the perpetual and over the top rutting of subsoil because of the weight advancement in the life time of asphalt. At the point when unique soil doesn't have such properties it is important to make that soil fit for this sort of result for the advancement of asphalt.

The fuse of cement to be used in the soils alone is indistinguishable to (Kedzi, 1979) and (Brown, 1996) announcement that cement will results in an expand MDD and demonstrate a decrease impact in OMC. It is associated that the expansion with cement clearly improved the fondness of cement for water and collection of particles which had come about the arrangement of bigger full scale pores inside of the soil.

Regarding compressive quality, cement yields unmistakable enhancement for the common soils. Quality increments continuously with period of curing. This is in concurrence with the result of (Bergado et al, 1996) that the rate of expansion of quality is by and large fast in the early stages and from there on reductions with time.

Due to its protecting properties, RHA has been utilized as a part of the assembling of obstinate blocks. Several studies have been completed to sanitize RHA for utilization in silicon chip fabricate. The systems are as yet being created, however seems promising. It is realized that ranchers in Asia will utilize RHA to avoid bug assault in put away nourishment stuffs, and a few investigative studies have been done to test the viability of this. Greenwich University are examining little scale paddy processing in Bangladesh and Vietnam, and the likelihood of utilizing RHA for water refinement. An organization in the USA have delivered a proto sort plant for assembling actuated carbon from RHA, and the real market for this is in water cleansing.

4. METHODOLOGY

The soil used in the research work was collected from Naguman-Shabqada Section of Provincial Highway, District Charsadda, KPK, Pakistan. Details are covered in section 3.3 of this chapter. All tests were performed on oven dried soil. Cement was used in the research as stabilizing agent. Bestway cement was used throughout the research work. RHA was obtained from Mardan. The Ash was in the fine form originally and was kept in airtight bags to avoid any moisture addition. Different tests were carried out to determine the properties of soil such as Grain Size Distribution, Atterberg's Limits, Moisture – Density Relationship of Untreated Soil

4.1 Moisture–Density Relationship of Cement Ash Treated Soil

Moisture-Density relationship of Cement Ash treated soil was determined to find optimum moisture content of the mix for different percentages. Modified proctor compaction test was performed according to ASTM 1557-10. Four percentages of RHA were used i.e. 5, 10, 15, 20% along with two percentages of cement 3 and 6% as shown in Table 1. OMC and MDD were found out for eight different mixes.

Table 1: Proportion of different mixes

Serial No	Mixture	With addition of Cement (C)
1	5%RHA in Soil	(05%RHA+3%C) in Soil
		(05%RHA+6%C) in Soil
2	10%RHA in Soil	(10%RHA+3%C) in Soil
		(10%RHA+6%C) in Soil
3	15%RHA in Soil	(15%RHA+3%C) in Soil
		(15%RHA+6%C) in Soil
4	20%RHA in Soil	(20%RHA+3%C) in Soil
		(20%RHA+6%C) in Soil

4.2 Sample Fabrication

The test specimens were prepared following ASTM D 5102-09 for UCS testing. The samples were fabricated using a mould having 6 inches height and 3 inches diameter. After calculations it was found 22 blows were needed for the compaction of single layer. The cement-ash-soil mix was prepared at OMC and kept for at least 1 hour for hydration. The specimen prepared after 2 hours of mixing developed cracks after removal from mould. Two specimens were prepared for each cement-ash-soil percentage.

4.3Curing of Samples

Samples were sealed through plastic sheets making them air tight to avoid removal of moisture. Samples were cured for a 7 days period in an oven at 40oC. Curing arrangements are shown in Figure 1. and Figure 2.


Figure 1 and Figure 2: Curing arrangements for sealed samples

4.4Soaking of Samples

After the curing of samples for 7 days, they were wrapped in porous cloth and placed over a porous stone in a container to apply soaking. The samples were kept in the container for 24 hours. After removing from container, samples were tested.

4.5Unconfined Compressive Strength (UCS) Testing

In UCS testingthe machine applies the load to produce an axial deformation rate of approximately 0.5 to 2% per minute. The values of load (KN) and displacement (mm) were noted at equal time intervals. The sudden drop in load value indicated the failure of specimen. The peak values were noted down. The test arrangements are shown in Figures 3.

Figures 3: Unconfined compression testing of samples

4.6 CBR Testing of Untreated and Treated Soils

CBR is a simple penetration test performed for the assessment of subgrade strength.

4.6.1Untreated soil

The test was carried out according to ASTM D 1883-07. Three CBR samples were prepared for untreated soil. 1st at 90% of MDD on the dry side of optimum, 2nd atOMC and 3rd at 90% of MDD on the wet side of optimum. Samples were soaked for 96 hours. Swelling gauge was attached with samples to note the swell after soaking.

4.6.2Treated soil

CBR samples were prepared according to the mix percentages including soil cement and Rice Husk Ash. Three samples were prepared in the same way as that for untreated. The samples were cured in the oven for 7 days at 40^{o}C. After curing, samples were soaked for a period of 96 hours. Swell was noted for each sample.

5.TEST RESULTS AND DISCUSSIONS

Subgrade soil along Naguman-Shabqada Section of Provincial Highway, District Charsadda, KPK, Pakistanrepresents a nonstop issue to the performance of highway. Total 20 samples were prepared according to the specified percentages of mix to find the unconfined compressive strength. Two samples were tested for each combination and the average strength was considered. Similarly 12 tests were performed to find the CBR value for different combination of mix. These tests included both treated and untreated soil. All tests were carried out after soaking. Soil reacted well to both stabilizing agents. There was a considerable increase in the UCS and CBR value with the addition of stabilizing agents. Soaked strength increased almost 42 Times (from 6.55 psi to 278 psi) when stabilized with both cement and RHA. The swell potential of soil was reduced to almost zero.

5.1 Soil Characterization

Soil characterization is shown in Table.2

5.1.1Soil classification

Sieve analysis and Atterberg's limits helped in the classification of soil. The results obtained from above tests classified the soil as Silt as per Unified Soil Classification System and A-4 as per AASHTO classification system.

Table 2: Summary of Soil Characterization Result

USCSClassification		Silt
AASHTO Classification		A-4
Liquid limit (%)		13
Percent Passing Sieve No. 200		26.8
Specific Gravity		2.81
MDD, (g/cm3)		2.14
OMC, (%)		7.0
UCS, psi	Soaked	6.35
	Un-soaked	41
CBR, %	Soaked	13
	Un-soaked	23
Swell, (%)		2.12

5.1.2 Strength and durability characteristics of soil

Unconfined compressive strength tests results indicate that there is a large decrease in strength of soil after soaking for only 24 hours. Swell of soaked sample came out to be 2.1 %. Soil under soaked conditions gets so weak that it is unable to even manage its self-weight. There were little cracks developed after soaking.

CBR test outcomes demonstrate that the soil has an incredible CBR when compacted to 90% of MDD on dry of optimum. On the other hand, the CBR value was reduced when the soil was compacted at OMC. The CBR further dropped when the soil was compacted to 90% of MDD on the wet side of optimum. Fig. 4.1 demonstrates the impact of dampness on CBR of characteristic soil.

As the soil belongs to the area of high rainfall and snow in winters, drainage also a problem, therefore appropriate measures should be taken before constructing any pavement in particular area.

5.2 Moisture-Density Relationship for Soil Cement RHA Mix

5.2.1 Effect of RHA on OMC

Figure 4. Show the effect of RHA on the OMC of mix. Increase in the RHA content resulted in the increase of OMC. This behavior is due to the water used by the pozzolanic material (RHA) in the hydration process. Therefore OMC would be the highest for the mix containing 6% cement and 20 % RHA as both stabilizing agents plays an important part in hydration process.

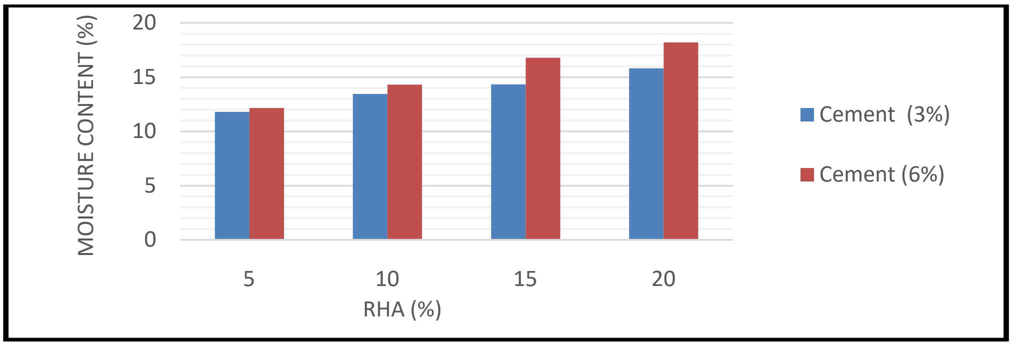

Figure 4: Variation in moisture content with increase of RHA

5.2.2 Effect of RHA on MDD

Figure 5.shows the effect of RHA on the MDD of mix. Increase in the RHA content resulted in the decrease of MDD. This trend is due to the lower specific gravity of RHA as compared to the soil and cement.

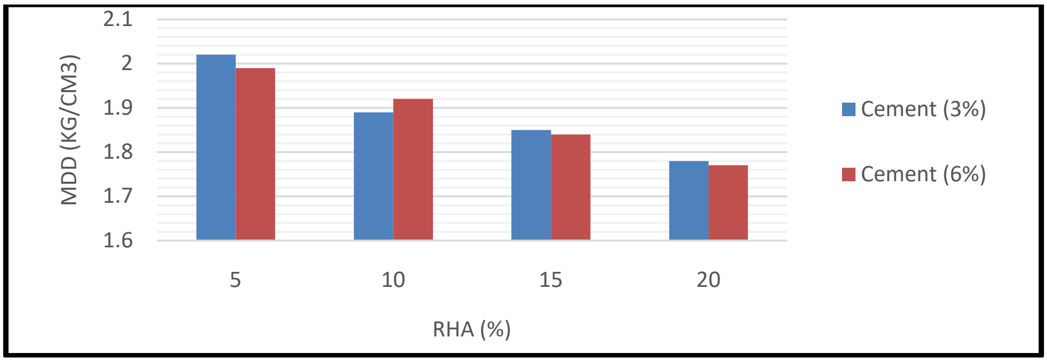

Figure 5: Variation in maximum dry density with increase of RHA

5.2.3 Unconfined Compressive Strength of Treated Soil

UCS is the most common and versatile technique for assessing the quality of stabilized soil. Variation of UCS with increment in RHA from 5% to 20% along with 3 & 6% cement was investigated and the results are indicated. The gain in strength with the addition of cement and RHA is shown in Figure 6. The maximum strength is achieved at the addition of 6% cement and 15% RHA. The UCS is increased 42 times. Further increase in RHA content decreases UCS, because after the addition of 15% RHA may results in forming weak bonds between the soil and the cementitious compounds.

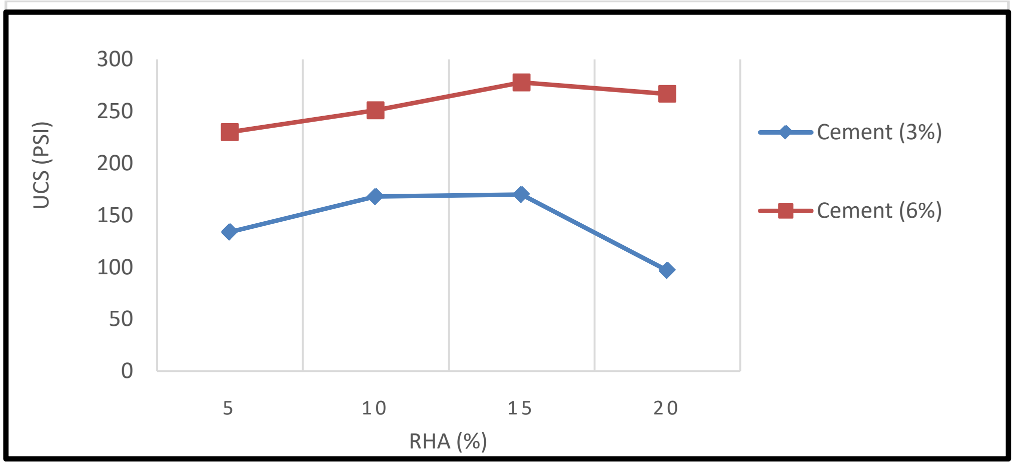

Figure 6: Variation in UCS with increase of RHA

5.2.4 California Bearing Ratio Of Treated Soil

The variation of CBR with increase percentage of RHA from 5% to 20% mixed with soil and 3% to 6% cement is shown in Figure 7. The maximum value of CBR is obtained at 6% cement and 15% RHA. Gain in strength is due to the reactions between the RHA and CaOH present in the soil and cement. The CBR value is increased 21 times at optimum percentages of stabilizing agents. Further increase in RHA content reduces the CBR value which may be due to the formation of weak bonds in the mixture.

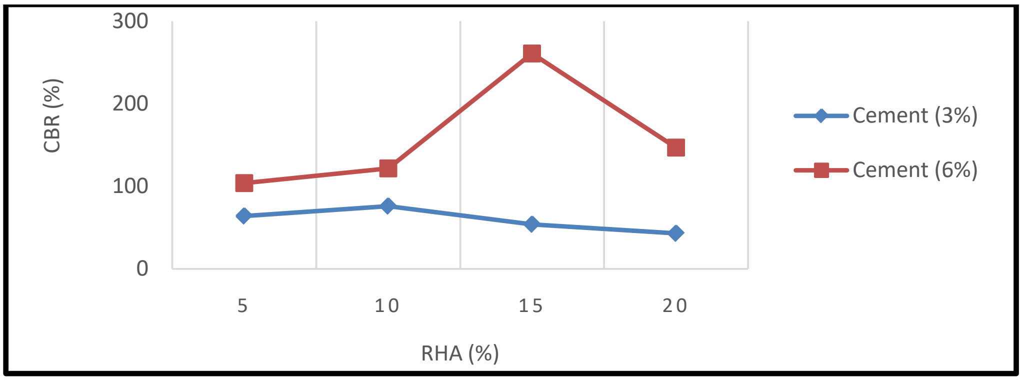

Figure 7: Variation in CBR with increase of RHA

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the test results, following conclusions are drawn:

- Soil is very reactive to both stabilizing agents i.e. cement and RHA, therefore better strength results have been achieved.
- A large improvement in UCS and CBR is noted. UCS and CBR of soaked soil is increased up to 42 times and 21 times respectively after treating with 6% cement and 15% RHA.
- For achieving maximum strength, soil stabilization using 15% RHA Content with 6% cement is suggested as an optimum amount.
- Compaction of soil within two hours after mixing is likely to provide maximum strength in the field and swell potential of soil is also reduced to almost zero.

6.2 Recommendations

- Use of soil stabilization procedures in expressway development is not exceptionally basic in Pakistan. Soil stabilization offers in fact and monetarily practical solutions for some highway designing issues. This technique needs to be utilized all the more as often as possible to enhance the quality properties of silty subgrade.
- Composition of agro-based waste items differs with soil (because of silica accessible in soil). There is have to analyze the Rice Husk Ash from different sources everywhere throughout the nation to institutionalize its utilization as a pozzolan in soil stabilization.
- Comparison of cost may additionally be mulled over to find out the monetary impacts of stabilizing out granular soil utilizing cement RHA.

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