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EFFECT OF MOULDING WATER CONTENT ON GEOTECHNICAL PROPERTIES OF RICE STRAW ASH STABILIZED EXPANSIVE SOIL

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ABSTRACT

Effects of moulding water contents on some geotechnical properties of an expansive soil stabilized with optimum (20%) amount of rice straw ash (RSA) have been discussed in this paper. Standard Proctor compaction, unconfined compressive strength, soaked California bearing ratio, hydraulic conductivity and swelling pressure tests were conducted on expansive soil-RSA mixes, by preparing the samples at maximum dry density but having five different moulding water contents, Optimum moisture content (OMC), and dry and wet sides of OMC. From the test results it is found that moulding water contents have significant effects on the geotechnical properties of this stabilized expansive soil.

Keywords: moulding water contents, expansive soil, rice straw ash, California bearing ratio.

1. INTRODUCTION

Expansive soil is a term generally applied to any soil or rock material that has a potential for shrinking or swelling under changing moisture conditions [1]. Pavement, light buildings, retaining walls etc. founded on expansive soil are severely damaged by its alternate swell-shrink behaviour. Stabilization using agricultural solid wastes is one of the different methods of treatment of this soil to improve its engineering properties for counteracting the swell-shrink behaviour. Some prominent agricultural solid wastes which have been successfully utilized for stabilization of expansive soil are, Rice husk ash [2-7], Bagasse ash [8-9], Groundnut shell ash [10-11], and Olive cake residue [12]. Rice Straw Ash (RSA) is an agricultural solid waste produced from burning of rice straw. Burning of 1000 kg of rice straw produces 150 kg of ash [13].The silica content of RSA is very high.RSA can also be used to stabilize expansive soil.

Anupam *et al.* [14] had found some positive effects on engineering properties of a non expansive clayey soil by stabilizing it with RSA. The tests conducted were, shrinkage limit, standard Proctor compaction and soaked CBR. The optimum amount of RSA was found to be 20%. From the review of literature it is found that the study regarding, stabilization of expansive soil using RSA has not been studied by any researcher. The water content at which a stabilized soil is likely to be compacted in the field may be slightly different from the water content at which it is compacted in the laboratory, in preparing samples to find different geotechnical properties. Hence, it is necessary to study the properties like unconfined compressive strength (UCS), soaked California bearing ratio (CBR), hydraulic conductivity, swelling pressure etc. of a stabilized soil at different moulding water content to evaluate the effectiveness of stabilization.

The objective of the present investigation is to study the effect of moulding water content on engineering properties of an expansive soil stabilized with optimum amount of RSA.

2. MATERIALS AND METHODS

2.1 Materials

Expansive soil and RSA are the two materials used in the experiment.

Expansive soil

The geotechnical properties of a local expansive soil used in the experimental programme are:

a) Grain Size Analysis :i) Sand size -9%
   ii)Silt size -23 % iii) Clay Size: 68%
b) specific gravity-2.67
c) Consistency Limits: i) Liquid Limi-61% ii) Plastic Limit-29% iii) Shrinkage Limit-11%
d) Compaction Properties i) Optimum Moisture Content (OMC)-22%
   ii) Maximum dry density (MDD)-16.2 kN/m^3
e) UCS-102 kN/m^2
f) Soaked CBR-1.72%
g) Hydraulic Conductivity-$2.87 x 10^{-7}$ cm/sec
h) Swelling Pressure-132 kN/m^2

Rice Straw Ash (RSA)

RSA was made by burning rice straw. Rice straw was brought from an agricultural field of Odisha. The straw ash was grinded, the residue passing 75μ sieve was

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used in the experimental programme. The specific gravity of RSA is 1.89. The major chemical compositions of RSA are: SiO_2 -65.36%, Al_2O_3-2.62%, Fe_2O_3-15.28%, CaO-2.89%.

2.2 Methods

In the first phase of the experimental programme the optimum amount of RSA for stabilization of expansive soil was found out. For that purpose RSA was added to expansive soil. The RSA added was up to 30%. The increment of addition was 5%. Different geotechnical properties of the RSA stabilized expansive soil were found out. The tests conducted were standard Proctor compaction, UCS, soaked CBR, hydraulic conductivity and swelling pressure. Tests were conducted by preparing the samples at MDD and OMC. Based on these properties the optimum amount of RSA for stabilization was found out. The optimum amount was 20%. In the second phase of the experimental programme, the same properties of the expansive soil stabilized with optimum amount (20%) of RSA were determined by preparing the samples at MDD but at four different moulding water contents these are, 2% and 4% more than OMC, and 2% and 4% less than OMC. Except compaction tests, samples for other tests were cured for 7 days. The tests were conducted according to procedures given in the Indian Standard Codes.

3. ANALYSIS OF TEST RESULTS AND DISCUSSIONS

The results of standard proctor compaction test conducted on expansive soil-RSA mixes have been shown in Figure-1(a) and Figure-1(b).

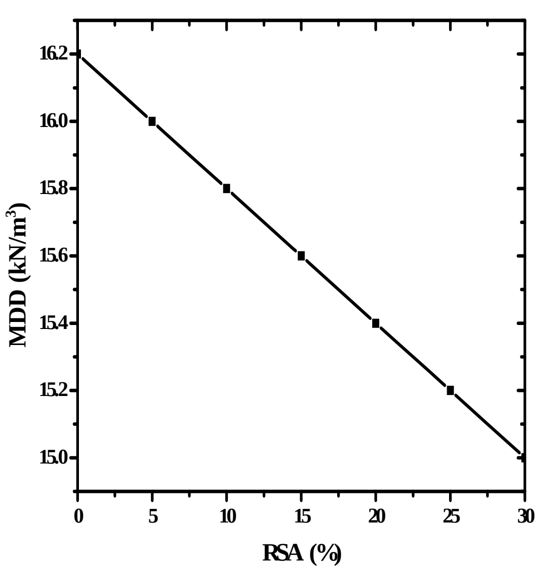

Figure-1(a). Effect of RSA on MDD of expansive soil.

From the Figure-1(a) it is found that decrease in MDD of expansive soil occurs with increase in RSA percentage. The MDD decreased to 15 k N/m^3 from 16.2 kN/m^3 when RSA addition is 30%.

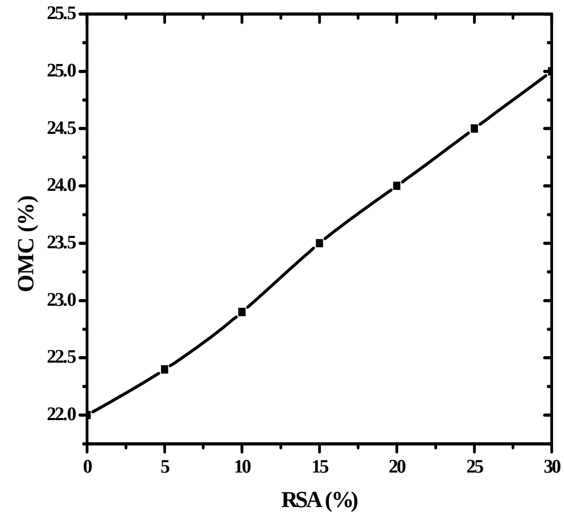

Figure-1(b). Effect of RSA on OMC of expansive soil.

From the Figure-1(b) it is observed that increase in OMC of expansive soil occurs with increase in RSA percentage. The OMC increased to 25 % from 22 %, at 30% addition of RSA.

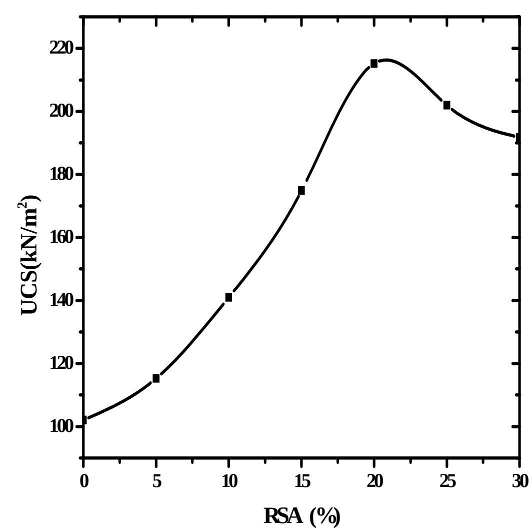

Figure-2. Effect of RSA on UCS of expansive soil.

From the Figure-2 it is observed that UCS has maximum value, 215 kN/m^2 when the percentage addition of RSA is 20%, thereafter it decreases. The maximum increase in UCS is 111% as compared to the UCS of

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unstabilized soil when the percentage addition of RSA is 20%.

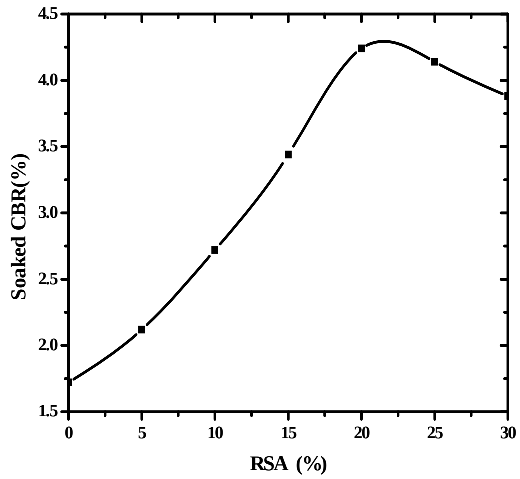

Figure-3. Effect of RSA on soaked CBR of expansive soil.

From the Figure-3 it is observed that, the maximum value of soaked CBR achieved is 4.24% when addition of RSA is 20%, further increase in RSA content decreases the soaked CBR. The increase in percentage of soaked CBR is 146.51% as compared to the soaked CBR of unstabilized expansive soil, when the percentage addition of RSA is 20%.

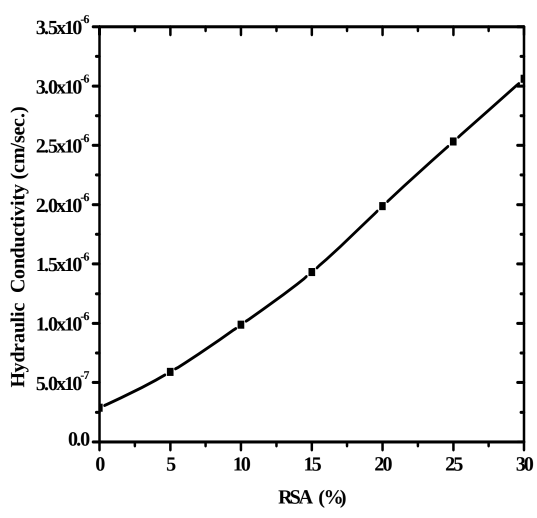

Figure-4. Effect of RSA on hydraulic conductivity of expansive soil.

From the Figure-4 it is observed that increase in amount of RSA there is increase in hydraulic conductivity of expansive soil. Hydraulic conductivity increases to 19.87 x 10^{-7} cm/sec. and 30.61x 10^{-7} cm/sec. from a value of 2.87x10^{-7} cm/sec. when the percentage addition of RSA is 20% and 30%, respectively.

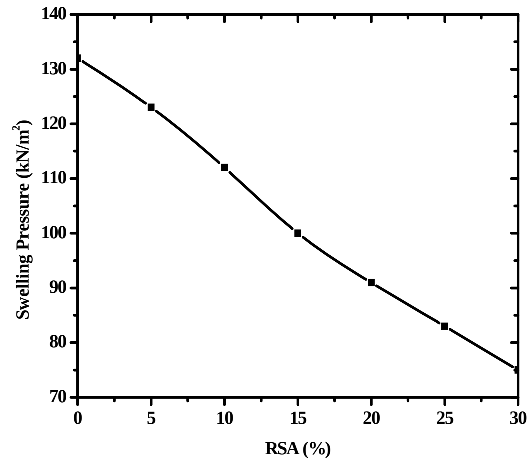

Figure-5. Effect of RSA on swelling pressure of expansive soil.

From the Figure-5 it is found that increase in the addition of RSA, swelling pressure decreases. Swelling pressure reduced to 76 kN/m^2 and 91 kN/m^2 when the percentage addition of RSA is 30% and 20% respectively from 132 kN /m^2. The maximum decrease in percentage reduction is 43.2% when the addition of RSA is 30% and 31.1% when the percentage addition of RSA is 20%.

From the analysis of test results, the optimum percentage of RSA for stabilization of expansive soil is found to be 20%.

4. EFFECT OF MOULDING WATER CONTENT ON GEOTECHNICAL PROPERTIES OF EXPANSIVE SOIL STABILIZED WITH OPTIMUM AMOUNT OF RSA

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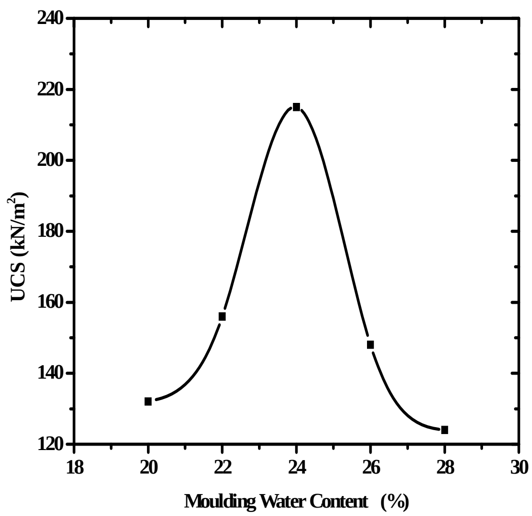

Figure-6. Effect of moulding water content on UCS of RSA stabilized expansive soil.

Figure-6 shows the variation of UCS of the expansive soil stabilized with optimum amount (20%) of RSA with moulding water content. The UCS has highest value when the moulding water content is at 24% (OMC). For equal variation of moulding water content on both sides (dry and wet) of OMC, the UCS is more when the moulding water content is at dry side of OMC than the corresponding moisture content on wet side of OMC. The UCS is 215 kN/m^2 when the moulding water content is at OMC, decreases to 124 kN/m^2 when the moulding water content changes to OMC-4%.

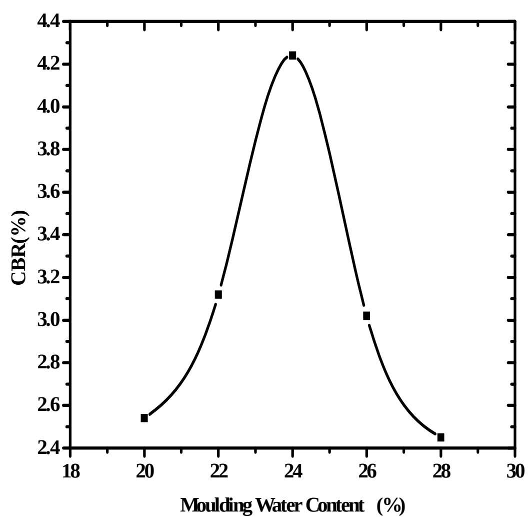

Figure-7. Effect of moulding water content on soaked CBR of RSA stabilized expansive soil.

Figure-7 shows the variation of soaked CBR of the expansive soil stabilized with optimum amount (20%) of RSA with moulding water content. The soaked CBR has highest value when the moulding water content is at 24% (OMC). For equal variation of moulding water content on both sides (dry and wet) of OMC, the soaked CBR is more when the moulding water content is at dry side of OMC than the corresponding moisture content on wet side of OMC. The soaked CBR is 4.24% when the moulding water content is at OMC, decreases to 2.45% when the moulding water content changes to OMC-4%.

Figure-8 shows the variation of hydraulic conductivity of the expansive soil stabilized with optimum amount (20%) of RSA with moulding water content. The hydraulic conductivity has lowest value when the moulding water content is at 26% (OMC+2%). The hydraulic conductivity is 9.68x 10^{-7} cm/sec. when the moulding water content is at OMC, it decreases to a value 4.28 x 10^{-7} cm/sec. when the moulding water content changes to OMC+2% and increases to 19.87x10^{-7} cm/sec. when the moulding water content changes to OMC-4%.

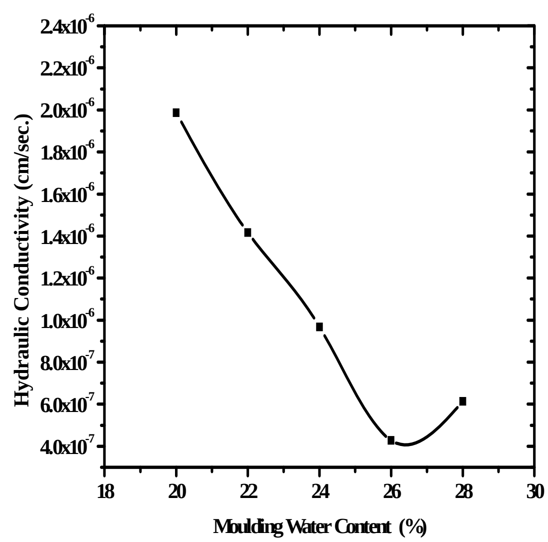

Figure-8. Effect of moulding water content on hydraulic conductivity of RSA stabilized expansive soil.

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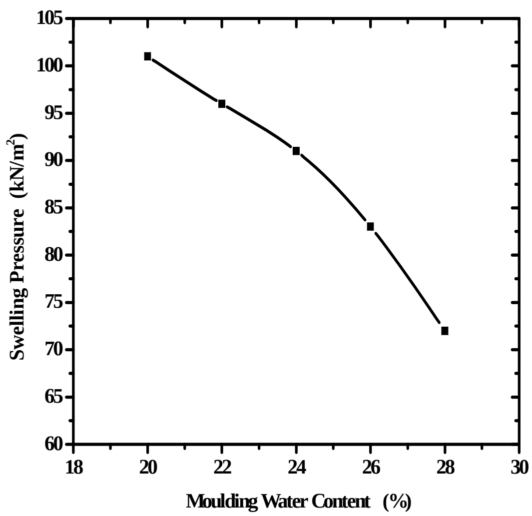

Figure-9. Effect of moulding water content on swelling pressure of RSA stabilized expansive soil.

Figure-9 shows the effect of moulding water content on swelling pressure of the expansive soil stabilized with optimum amount (20%) of RSA. From the figure it is observed that increase in moulding water content decreases the swelling pressure, the lowest value is observed, when the moulding water content is at 28% (OMC+4%). The swelling pressure is 91 kN/m^2 when the moulding water content is at OMC, increases to 101 kN/m^2 when the moulding water content changes to OMC-4% and decreases to 72 kN/m^2 when the moulding water content changes to OMC+4% .

5. CONCLUSIONS

The following conclusions are drawn from this study.

The optimum amount of RSA for stabilization of expansive soil is found to be 20%.

a) The UCS of the expansive soil stabilized with optimum amount (20%) of RSA has highest value when the moulding water content is at 24% (OMC). For equal variation of moulding water content on both sides (dry and wet) of OMC the UCS is more when the moulding water content is at dry side of OMC than the corresponding moisture content on wet side of OMC.
b) The soaked CBR of the expansive soil stabilized with optimum amount (20%) of RSA has highest value when the moulding water content is at 24% (OMC). For equal variation of moulding water content on both sides (dry and wet) of OMC the soaked CBR is more when the moulding water content is at dry side of OMC than the corresponding moisture content on wet side of OMC.
c) The hydraulic conductivity of the expansive soil stabilized with optimum amount (20%) of RSA goes on decreasing with increase in moulding water content, reaches lowest value when the moulding water content is at 26% (OMC+2%) and then increases.
d) The swelling pressure of the expansive soil stabilized with optimum amount (20%) of RSA goes on decreasing with increase in moulding water content, reaches lowest value when the moulding water content is at 28% (OMC+4%).
e) RSA alone should not be used to stabilize expansive soil because at 20% addition of RSA the swelling pressure is very high, it is also very high even when compacted at moulding water content of 28% (OMC+4%). Any binder like, lime, cement, lime sludge etc. should be added along with RSA to stabilize expansive soil to reduce the swelling pressure.

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