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Potential Usage of Fillers in Improving Geotechnical Properties of Expansive Soil–A Review

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Abstract—*Considerable interests have been developed in posing problems for black cotton with the usage of different types of fillers to improve its geotechnical properties. However, one has to understand whether the filler type or filler content that affects the soil responses such as California Bearing Ratio (CBR), Maximum Dry Density (MDD) and Plasticity Index (PI) which are of utmost important. Thus, the aim of this paper is to present a review on the potential usage of fillers and filler content that could improve these soil properties. Here, based on the previous studies the four different fillers such as Fly-ash, Foundry sand, Bagasse ash and Rice husk ash which were used to stabilize the moderately expansive soil were chosen and a statistical analysis were performed using Analysis of Variance (ANOVA). The results presented helps in choosing appropriate filler and its dosage based on the properties that are required to be modified.*

1. INTRODUCTION

The major problems for lightly loaded structures, including pavements are the clays. They consolidate under load and change volumetrically along with seasonal moisture variation [1]. Here, in our country the black cotton soil is of same kind having a highest clayey behavior causing a major problem for construction. In India, around 20 percent is covered with expansive soils which includes almost the entire Deccan plateau, Western Madhya Pradesh, parts of Gujarat, Andhra Pradesh, Uttar Pradesh, Karanataka, and Maharastra [2]. This expansive behavior of black cotton soil is due to presence of clay mineral i.e. Montmorillonite [3] which leads to swelling and shrinking with the presence of moisture. The results of this type of soil could cause excessive deflections and differential movements resulting in damage to foundation, structural element and architectural features. The black cotton soil exhibit poor strength, high volumetric instability and experience durability problems [4]. Therefore, it has become a challenge for the engineers to do more to develop our knowledge of proven methods to deal with expansive soils, improvement of these methods and work towards better quality control and quality assurance of their application. The conventional practice is that we go for stabilization. Suitable stabilization technique is adopted to reduce the volume change behavior of this highly sensitive and compressible material [5]. There are various types of stabilization such as mechanical stabilization, chemical stabilization, lime stabilization, cement stabilization, admixture stabilization and so on.

In the present research, the suitability and the effect of different type of fillers and the effect of filler content on the geotechnical responses such as CBR, MDD and PI has been reviewed based on the previous literature findings.

2. LITERATURE REVIEW

Several researchers have proposed different type of fillers based on their experimentation for stabilization of expansive soil. However, only few findings could be found which suggests the suitability that maps the requirement of the properties that need to be improved. Here in the present review, the findings from [6-7] which falls under the category of moderately expansive soils were used to find the effect of filler content and filler type on various properties of expansive soil. The fillers studied are Flyash, Foundry sand, Rice husk ash and Bagasse ash.

2.1. Maximum Dry Density Characteristics

It is reported in Udayashankar and Puranik (2012) that addition of flyash brings in an improvement in the compaction parameters of the study of the soils, by increasing the maximum dry density of the soils with decrease in corresponding values of optimum moisture content. However, the study doesn't say anything about whether the filler content influenced the changes or the filler type.

The major conclusion drawn by Sanjeev and Sushma (2014) were the value of maximum dry density is increased continuously after addition of foundry sand; Maximum increased by 4.30 percent at 40 percent addition of foundry sand. It was said that the improvement in maximum dry density helps us to provide stable working platform mainly in rainy season.

However, the above findings doesn't say whether the filler content or the filler type is influencing the Maximum Dry Density characteristics of the soil.

2.2. Plasticity Index Characteristics

The findings [6] concludes that with the increase in Flyash content the plasticity index of the soils decreased thereby the workability is enhanced.

It could be seen from findings [7] that after addition of 40 percent Foundry sand the liquid limit of the soil and the plasticity Index considerably reduced and it was said that the drainage properties could be improved with the decrease in liquid limit.

However, the study nowhere tells about the effect of fillers on the Plasticity Index properties of the soils.

2.3. California Bearing Ratio Characteristics

The California bearing ratio of the study soils increase gradually with the addition of fly ash up to a certain percentage of fly ash, beyond which, further increase in fly ash percentage is observed to cause a decreasing trend in the California bearing ratio values. The improvement in the California bearing ratio value of the black cotton soil upon the addition of fly ash suggests that, it can be effectively used in bulk as sub-base material in combination with the study soils, for the road construction works [6].

The CBR value of black cotton soil increased after addition of all three waste material separately but for addition of 40% rice husk ash it increased maximum (10.04%) as compared to untreated soil (2.08%). Good CBR value increases the stability of soil [7]

Though the improvements in the properties could be found with the addition of these fillers, the findings limits to tell us about the individual effects which influences the geotechnical properties. Suppose, if the filler content that influences the MDD property of the soil, than any filler can be used and similarly if the filler type that influences the MDD property of the soil, than it is not required to study the effect by varying the filler content rather the study on chemical composition of the filler which is responsible for the change could be studied.

2.4. Statistical Analysis

The basic findings from both the researchers before the statistical analysis are as follows

- The PI values obtained from the experimental studies conducted by these two authors had the mean values varied from 31.3 to 15.5 percent. The addition of Bagasse Ash was found to decrease the PI value drastically till 50 percent. The interaction plot of filler content versus PI is as shown in Fig. 1.
- The MDD values were found to vary from 1.22-1.71 g/cc. Addition of flyash resulted in high MDD values. The interaction plot of filler content versus MDD is as shown in Fig. 2.
- The CBR values were varying from 3.00 to 10.04 percent. Rice husk ash improved the CBR characteristics as compared to other fillers. The interaction plot of filler content versus CBR is as shown in Fig. 3.

Further, the values obtained based on the experimental studies conducted by Udayashankar and Puranik (2012) and Sanjeev and Sushma (2014) were statistically analyzed using a statistical tool ANOVA in order to find the effect of filler type and content on the geotechnical properties of black cotton soil. The filler content in their study varied from 10 to 60 percent in interval of 10 percent each. A total of 24 values (4 filler * 6 varying percentages) were adopted for the analysis. The treatment factors considered for the study was BC soil+ filler type, filler content and the factor evaluated were PI, MDD and CBR.

Table 1 shows the test results of ANOVA which includes Degree of Freedom (DF), Sum of Squares (SS), Mean Square (MS), Fisher distribution statistics (F), p value and results of null hypothesis. The prime source of variation could be obtained using the MS value. Filler content is found to be the main source of variation with the highest MS value of 36.68 for the results of PI whereas filler type is the main source of variation for MDD and CBR values considered in the study having highest Mean square values of 0.1789 and 22.4172 respectively. The null-hypothesis was tested at a confidence level of 95 percent. The null-hypothesis was that the mean of the response variables do not vary with the variation in the treatment factors.

The major conclusions that could be drawn from statistical analysis are

- Filler content as a significant effect on the PI value. Therefore, from the experimental studies conducted by these two authors it could be strongly concluded that 40 percent filler content irrespective of the type considered in the study decreases the PI.
- Filler type as a significant effect on the MDD value. Therefore, the study indicates that Fly-ash could be effectively used to increase the MDD value.
- CBR value depends mainly on the filler type. Therefore, Rice-Husk ash could be effectively used to increase the CBR value as when compared to other fillers.
- Finally it could be strongly concluded that the chemical composition of the filler plays a major role in modifying the geotechnical properties of the soil such as MDD and CBR.

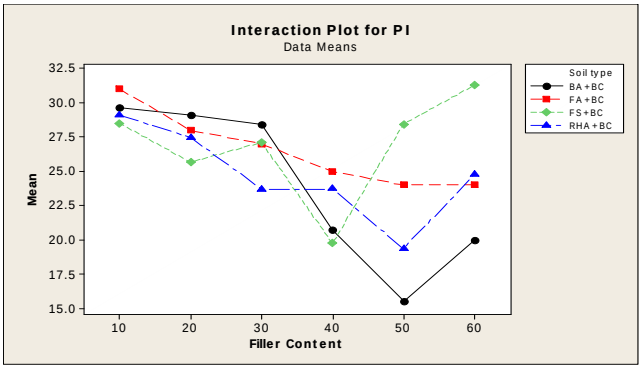

Fig. 1: Interaction plot of filler content and type versus Plasticity Index

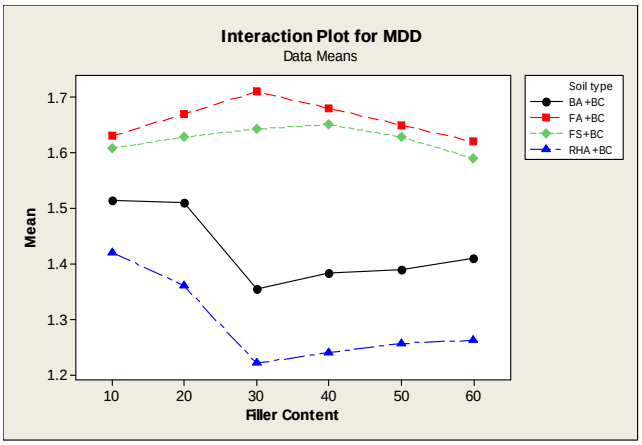

Fig. 2: Interaction plot of filler content and type versus Maximum Dry Density

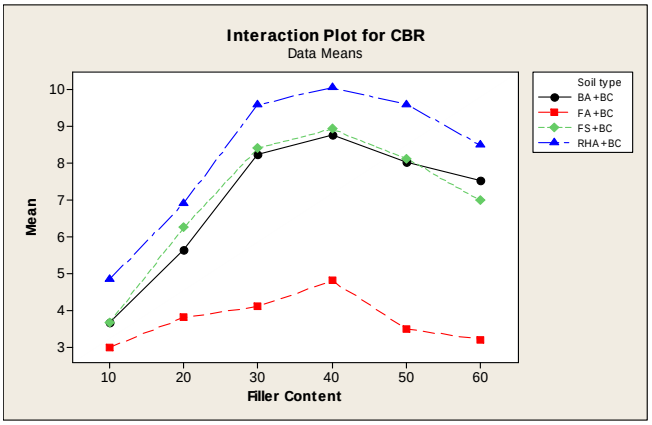

Fig. 3: Interaction plot of filler content and type versus California Bearing Ratio

Here, the difference between the conclusions drawn before the statistical analysis and after statistical analysis could be seen. Hence, it is highly recommended to perform statistical analysis before interpreting the results.

3. SUMMARY AND RECOMMENDATIONS

The study based on the review and statistical analysis summarizes the few important factors that are being neglected in considering the soil modification and also few recommendations have been suggested and are as follows

- Filler content as a significant impact on the plasticity index of the soil with a highest Mean square value of 36.68.
- Filler type as a significant effect on the MDD and CBR characteristics of the soil considered in the study with the MS value of 0.1789 and 22.4172 respectively. Hence the selection of the type of filler should be given a high priority than its dosage in order to improve the MDD and CBR characteristics.
- Prior to the usage of filler, a knowledge on its chemical composition supports the major findings and helps interpreting the results effectively.
- It could be seen that the statistical tool helps to draw more proper conclusions than the simple analysis and therefore it is recommended to perform statistical analysis before interpreting the results.

Overall, for all the soil modification hereafter, it is recommended to find the effect of filler type and filler content on the geotechnical responses of the soil with the thorough understanding of the chemical composition of the fillers being used.

Table 1: ANOVA test results

Source	DF	SS			MS			F			p		
		PI	MDD	CBR	PI	MDD	CBR	PI	MDD	CBR	PI	MDD	CBR
Filler type	3	35.718	0.53674	67.252	11.9059	0.1789	22.4172	1.08	64.99	34.53	0.387	0.000	0.000
Filler content	5	183.426	0.02121	50.046	36.6853	0.0042	10.0091	3.33	1.54	15.42	0.032	0.236	0.000
Error	15	165.117	0.04129	9.7370	11.0078	0.0027	0.6491						
Total	23	384.261	0.59925										

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