International Journal of Current Engineering and Technology
ISSN 2277 - 4106

Available at http://inpressco.com/category/ijcet

Research Article

Stabilization of Expansive Soil of Surat Region using Rice Husk Ash & Marble Dust

Khushbu S. Gandhi[a*]

[a]Department of Civil Engineering , Sarvajanik College of Engineering and Technology, Surat, Gujarat, India

Accepted 20 October 2013, Available online 25 October 2013, **Vol.3, No.4 (October 2013)**

Abstract

Expansive clay soils are extensively distributed worldwide, and are a source of great damage to infrastructure and buildings. The problem with expansive soils has been recorded all over the world. These soils can cause heavy economic losses, as well as being a source of risk to the population. In monsoon they imbibe water and swell and in summer they shrink on evaporation of water there from. The wetting and drying process of a sub grade layer composed of black cotton soil result into failure of substructures in form of settlement and cracking. And because of this alternative swelling and shrinkage, lightly loaded civil engineering structures like residential buildings, pavements and canal linings are severely damaged. It is, therefore, necessary to mitigate the problems posed by expansive soils and prevent cracking of structures. Many innovative foundation techniques have been devised as a solution to the problem of expansive soils. There are numerous soil stabilization techniques for improving the strength of the in-situ soil, and one of the techniques is using chemical additive. Chemical improvement is a time saving method that enables sub grade or sub-base layer and otherwise unsatisfactory materials in-situ to obtain higher density and strength, obviating the need for costly excavation and replacement with borrow material. Surat is located on highly expansive soil. This work is based on an experimental study in the stabilization of an expansive soil in Surat, consisting of the changes of its various properties and its mechanical capacities by the addition of by-products and waste materials of industrial origin such as rice husk ash and marble dust. This may achieve the double objective of reducing the problems of this type of soil, and also of providing a use for the additives, thus eliminating the economic and environmental cost involved in managing them. And also regression analysis for quick prediction of swelling pressure and CBR value of soil with regarding to the other properties of soil is also carried out.

Keywords: *Expansive soil, stabilization, swelling, shrinkage, rise husk ash, marble dust.*

1. Introduction

Black cotton soils are problematic for Civil Engineers, because of their unconventional behavior. These soils show large volume changes with respect to variation of seasonal moisture content. These soils when subjected vehicular traffic, road pavement gets heaved and cracked due to swelling and shrinkage. Hence, these soils are to be stabilized before constructing the roads in order to have very effective and efficient and very long lasting road. Considerable research has been taken place using different stabilizing materials such as lime, fly-ash, cement, industrial wastes and geo-synthetics etc. and proved to be useful in stabilization of black cotton soils.
[1]From the past study it has been concluded that Surat is covered with black cotton soil. Figure 1 map of soil deposits in Gujarat State shows that the majority of South Gujarat area having black cottons soil as top layer.

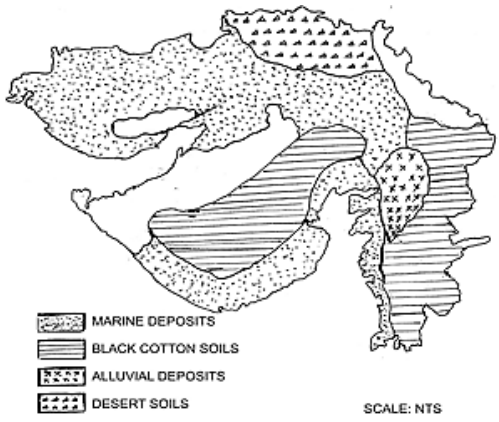

Fig. 1 Map of Soil Deposits in Gujarat State

2. Problem description

There are three basic types of soil naturally occurring in this area: sand, silt and clay. Clay soils are generally classified as expansive. This means that a given amount of

*Corresponding author **Khushbu S. Gandhi**

clay will tend to expand (increase in volume) as it absorbs water and it will shrink (lessen in volume) as water is drawn away. The effects can be dramatic if expansive soils supporting structures are allowed to become too wet or too dry. Building structures, foundations, driveways and walkways may crack and heave as the underlying expansive soils become wet and swell. Sometimes the cracking and heaving appear temporary as the soils dry and shrink back to their original position.

Fig. 2 Cracks in expansive soil when soil is dry due to shrinkage

Fig. 3 Vertical cracks on walls due to expansion of soil

To get rid of this problem, we need to take preventive measures such as soil stabilization, draining of the excess water or by making soil moist based on condition of soil.

There are various additive materials used as stabilizers to stabilize the expansive soil. Purpose of this work is to find the additives as stabilizers which are economical as well as advantageous in other possible ways. Based on visits to various industries finally additives has been decided as soil stabilizers for chemical soil stabilization considering economic advantage and waste disposal problems.

3. Working Simulation

3.1 Selection of site

In Surat city, it has been analyzed that the swelling pressure of soils from different zones. And it has been found that Vesu area of Surat region has higher swelling pressure than any other area. So the disturbed and undisturbed soil sample has been collected from Vesu region from 2 m depth to carry out various laboratory tests in order to evaluate various properties of soil.

3.2 Selection of materials as soil stabilizers

After studying the literatures on soil stabilization using various additives, it has been decided to choose the materials as soil stabilizers which are economic and which are the waste products of industries. After visiting various industries and observing the waste products they produce, we found **rice husk ash** and **marble dust** as best suitable to experiment with expansive soil for stabilization. The main reasons for choosing these materials are

1. They are economical as they are the waste products
2. They do not have significant use in any productive work
3. They have disposal problem
4. They are locally available.

4. About Rice Husk Ash

4.1 Production of rice husk

Rice husk is produced in the first step in the milling process when the husk is removed from the grain in the husking stage of the rice mill**.** India is a major rice producing country. The annual rice husk ash produce in India amounts is generally approximately 120 million tons.

4.2 Characteristics of rice husk ash

Rice husk ash is difficult to ignite and it does not burn easily with open flame unless air is blown through the husk. It is highly resistant to moisture penetration and fungal decomposition. Husk therefore makes a good insulation material. Rice husk ash has a high silica (SiO_2) contents which means that it decomposes slowly when brought back to the field. Handling of rice husk ash is difficult because it is bulky and dusty. It has angle of repose is about 40-45° which means that it's flow ability, e.g. in feed hoppers is very poor. Rice husk ash has low bulk density of only 70-110 kg/m³, 145 kg/m³ when vibrated or 180kg/m³ in form of brackets or pellets. It thus requires large volumes for storage and transport, which makes transport over long distances un-economical. Because of the high silica contents rice husk ash is very abrasive and wears conveying elements very quickly.

4.3 Chemical properties of rice husk ash

The chemical composition of raw rice husk ash is shown in Table 1.

5. About Marble Dust

In the world, marble (natural stone) production amount was 21.7 million tons in the year of 1986; however in 1998 this amount increased to 51 million tons. Increasing demand for marble product rises the generation of waste

marble material. The proportion of marble discharged as waste during block production at the quarries is equal to 40 - 60 % of the overall production volume. Large pieces of marble waste can be used as embankment or pavement material, and waste marble dust can be used as additives in some industries (paper, cement, ceramic etc.). But, only small portion of the waste marble products is utilized economically, most of them are stored on lands. Increasing of usage fields of waste marble products will eliminate the potentially harmful effects of them on environment and minimize the cost due to storage.

Table 1 Chemical analyses of rice husk ash

Constituent	Content (%)
Organic material and Moisture	73.87
Al_2O_3	1.23
Fe_2O3	1.28
CaO	1.24
MgO	0.21
SiO_2	22.12
MnO_2	0.074

4.2 Production of marble dust

For the production of fine particles (<2 mm), while cutting marble is one of the major problems for the marble industry. When 1 m³ marble block is cut into 2 cm thick slabs, the proportion of fine particle production is approximately 25 % .While cutting of marble blocks water is used as cooler. But, the fine particles can be easily dispersed after losing humidity, under atmospheric conditions, such as wind and rain. Thus, fine particles can cause more pollution than other forms of marble waste.

5.2 Characteristics of marble dust

Table 2: Characteristics of marble dust

Element	Chemical Composition (%)
C	37.9
O	47
Ca	8.5
Mg	6.6

Table 3: Mineral composition of marble dust

Mineral	Marble dust
Calcite	present
Dolomite	present

5. Experimental Study

6.1 Preparation of test samples

Soil has been tested to find properties using additives such as marble dust and rice husk ash. The soil samples were prepared by adding the marble dust to the prepared sample from 0% to 30% at an interval of 10% (by weight). On other side risk husk ash is added to natural soil to prepare the sample from 0% to 30% at an interval of 10% (by weight). Total six different samples were analyzed in this study. Firstly, all the materials viz. soil, rice husk ash and marble dust were oven dried at 60° C for 24 hours. Before mixing all different materials all of them were sieved through 2.36mm sieve. So that homogenous sample can be prepared. For the preparation of each specimen, all the materials were mixed thoroughly by trowel and passing the mixture by 20mm sieve.

6.2 Test results and Analysis

Soil has been tested with the admixture at different proportion to find the basic index properties like Liquid Limit, Plastic Limit, Shrinkage Limit etc and swelling properties like Free swell index, Swelling Pressure and also to find California Bearing Ratio(CBR). The result analysis is carried out for both admixtures as shown in figure.

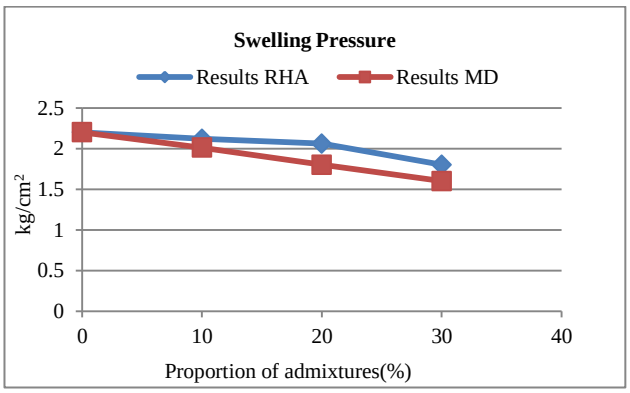

Fig. 4 Comparison of swelling pressure for RHA and MD

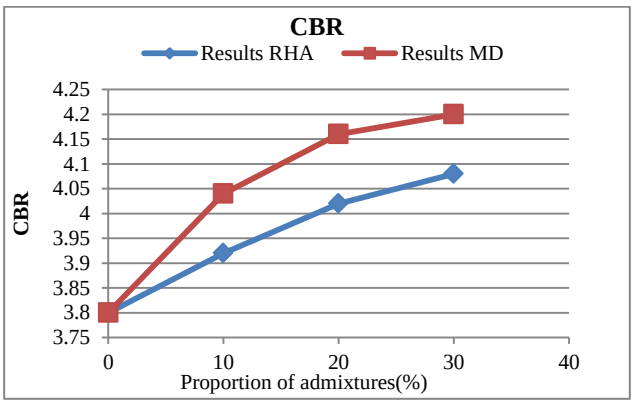

Fig. 5 Comparison CBR value for RHA and MD

From fig 4 , it has been concluded that swelling pressure decreases at about constant rate with increasing proportion of admixtures. But with the increase proportion of marble

dust, swelling pressure decrement is more than that of rice husk ash.

The value of CBR constantly increases with the increase proportion of admixtures. The effect of marble dust on CBR is more than the rice husk ash.

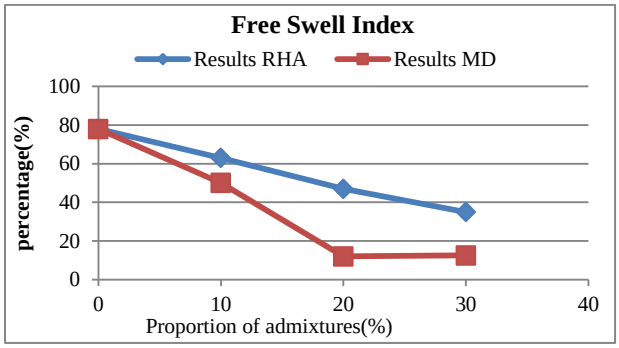

Fig. 6 Comparison FSI (%) for RHA and MD

From the graph, it has been concluded that with increase in proportion of rice husk ash, free swell decreases at nearly constant rate and with increase in proportion of marble dust, free swell decreases at nearly constant rate up to 20% which further shows no changes and the free swell for the same remains constant.

6. Regression Analysis

Correlation

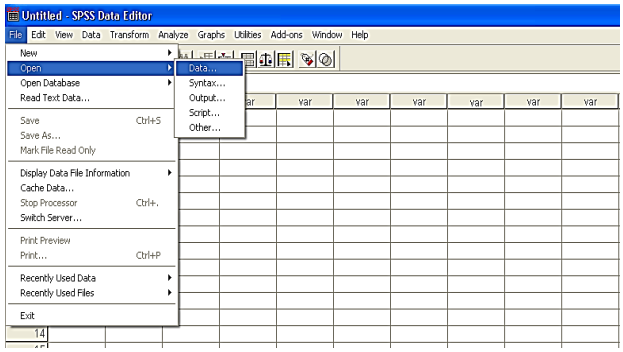

Fig. 7 SPSS data editor window

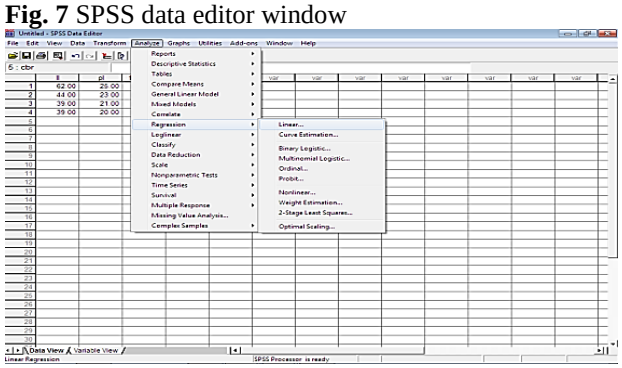

Fig. 8 SPSS data analysis window

From the fig 6, we can conclude that marble dust is more effective than rice husk ash for soil stabilization as with the increase proportion of marble dust, the value of atterberg limit, CBR, swelling pressure tends to go towards the normal value of these properties of stabilized soil. On account of establishment of correlation between various properties of soil. We have used spss 13 software for performing regression analysis.

Output:

Now the output of spss13 of the above statistic regression analysis is given below.

Model Summary

Table 4: Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000(a)	1	.	.

a Predictors: (Constant), FSI, PI, MD

Table 5 Unstandardized & Standardized Coefficients

Coefficients(a)				
Model		Unstandardized Coefficients		Standardized Coefficients
		B	Std. Error	Beta
1	(Constant)	4.251840888	0	
	PI	-0.010027752	0	-0.496983701
	FSI	-0.001036078	0	-0.184137247
	MD	0.005054579	0	0.362524086

a Dependent Variable: CBR

Table 6 Unstandardized & Standardized Coefficients

Excluded Variables(b)						
Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	LL	.(a)	.	.	.	0
	SL	.(a)	.	.	.	0

A Predictors in the Model: (Constant), MD, PI, FSI

B Dependent Variable: CBR

Using following regression equation, the correlation is derived from the above statistics.

$$Y = \beta 0 + \beta 1 X 1 + \beta 2 X 2 + \ldots\ldots\ldots\ldots \beta n Xn$$

SP = 2.21556 – 0.00124 (PI) + 0.000389 (FSI) - 0.0199 (MD)

Where, SP = swelling pressure (kg/cm^2)
PI = plasticity index (%)

FSI = free swell index (%)
MD = marble dust in percentage (%)

CBR = 4.251840888 – 0.10027752 (PI) – 0.001036078 (FSI) + 0.005054579 (MD)

Where, SP = swelling pressure (kg/cm^2)
PI = plasticity index (%)
FSI = free swell index (%)
MD = marble dust in percentage (%)

Here the swelling pressure and California Bearing Ratio are taken as dependent variable and other properties are taken as independent variables.

7. Results and Discussion:

We have selected soil in Vesu region for laboratory tests. We have used marble dust and rice husk ash a stabilizers and performed various tests for determining the soil properties. The various tests results are mentioned below.

Results using marble dust:

Table 7 :Soil properties using Marble dust

Proportion of MD(%)	0	10	20	30
Swelling Pressure(kg/cm^2)	2.2	2.01	1.8	1.6
Liquid Limit(%)	62	44	39	39
Plastic Limit(%)	25	23	21	20
Shrinkage Limit(%)	22.16	20	17.5	16.5
Free swell index(%)	78	50	12	12.5
CBR	3.8	4.04	4.16	4.2

Results using rice husk ash:

Table 8 : Soil properties using Rice husk ash

Proportion of RHA(%)	0	10	20	30
Swelling Pressure(kg/cm^2)	2.2	2.12	2.06	1.8
Liquid Limit(%)	62	53	49	46
Plastic Limit(%)	25	24	22	21
Shrinkage Limit(%)	22.16	22.08	18	17.04
CBR	3.8	3.92	4.02	4.08
Free swell index(%)	78	63	47	35

From the above results, it has been concluded that swelling pressure decreases with the increasing proportion of stabilizers. Somehow marble dust is more effective as stabilizing agent than rice husk ash.

Also equation has been derived for quick prediction of CBR and swelling pressure regarding with other properties of soil and proportion of marble dust as independent variable.

CBR = 4.251840888 – 0.10027752 (PI) – 0.001036078 (FSI) + 0.005054579 (MD)

SP = 2.21556 – 0.00124 (PI) + 0.000389 (FSI) - 0.0199 (MD)

Where, SP = swelling pressure (kg/cm^2)
PI = plasticity index (%)
FSI = free swell index (%)
MD = marble dust in percentage (%)
CBR = California Bearing Ratio

The merits of Marble dust over Rice husk ash are discussed below.

Index properties

- The decrease in Liquid limit of soil is about 30% with the addition of 20% of marble dust whereas, in case of rice husk ash with the same proportion the decrease in LL is only 26%
- It was observed that the plastic limit of the expansive soil is decreased by18 % with the addition of 30 % MD. While in RHA the decreased was nearly same.
- It was noticed that the shrinkage limit of the expansive soil is decreased by 23% with the addition of 30% MD. While in RHA decrease was noticed to be only 17.5%
- It has been observed that there is remarkable influence of marble dust on free swell index. The decrease of about 80 % is noted with the addition of only 20% of MD. Whereas in RHA with the same proportion the reduction was only about 38%
- The remarkable influence was also seen on the results of CBR with the addition of MD i.e Increase of 40% of CBR values on addition of 30 % MD. While the increment was normal in case of RHA.
- The decrease in swelling pressure of soil is about 30.5% with the addition of 30% of marble dust whereas, in case of rice husk ash with the same proportion the decrease in LL is only23 %

Availability

In the world, marble (natural stone) production amount was 65 million tons in the year. The annual rice husk ash produce in India amounts is generally approximately 120 million ton

Cost

Usually both the materials are the waste products from the industries or manufacturing plants so can be used economically. Though the production of rice husk is more

than marble dust, but the procedure for burning the rice husk and to convert it into the ash makes the overall method of using rice husk ash as a soil stabilizer more costly

Ease of Use

Mixing of marble dust with the soil is found to be more easy and effective as compared to rice husk ash. The workability of marble dust while mixing it with wet expansive soil is more. The procedure of mixing rice husk ash with the wet soil is found to be tedious and bit hard.

Eco-friendly

There is no problem of degradation in case of marble dust with the passage of time whereas rice husk ash degrades at very slow rate with time. The problems of germination are also noticed with rice husk ash in certain conditions.

8. Conclusion

After analyzing all the data, it has been concluded that both the materials i.e. marble dust and rice husk ash are effective for stabilizing the expansive soil. Hence it's proved to be economical and easy solution to stabilize the expansive soils and preventing the damage caused to different structural elements and buildings. And as these materials are locally and cheaply available it becomes the first choice of stabilization when the matter of economic solution comes. Moreover it has been concluded that Marble dust is more effective than Rice husk ash for stabilization of expansive soil with all aspects.

References

Ali Jawaid S.M., Shukla. V.K., (1996) Stabilization of silty sand using RHA and Gypsum *Indian Geotechnical Conference*, Madras.PP 419_421.

Chee-Ming Chan and Meei-Hoan Ho, The Potential of Using Rubberchips as a Soft Clay Stabilizer Enhancing Agent, Postgraduate Incentive Research Grant, University Tun Hussein Onn , Malaysia, Vol. 4, No. 10; October 2010, PP 122-131.

K. Harishkumar. and K. Muthukkumaran,2011; Study on swelling soil behavior and its improvements , *International Journal of Earth Sciences and Engineering*, Volume 04, No 06 SPL, October 2011, pp. 19-25.

K. S. Berawala and C. H. Solanki (2010); Empirical Correlations of Expansive Soils Parameters for the Surat Region, *Indian Geotechnical Conference*- December 16–18, IIT Bombay, PP 933-936.

Mohammed Ali and Sreenivasulu. V. (2004), An experimental study on the influence of Rice husk ash and Lime on properties of Bentonite, *IGC, Warangal*, PP 468-471.

N. V. Nayak and R. W. Christensen (1971); Swelling Characteristics of Compacted Expansive Soils, *Clays and Clay Minerals* Vol. 19, PP 251-261.

R. K. Katti (1978), Search for solutions to problems in black cotton soils, First I.G.S. Annual Lecture, Indian Geotech. Society at I.I.T., Delhi

R. Rama Rao. and P. V. Satyanarayana (2003) Use of RHA, Lime and Gypsum in strengthening sub-grade and sub base in low cost roads, *National conference on modern cement and bituminous roads*, Vizng PP 374-379.

Rao Sriram A. (1984), A study of swelling characteristics and behavior of expansive soils, Ph.D Thesis submitted to the *Kakatiya University, Warangal*.

Raymond N. Yong and Benno P. Warkentin (1975) Soil Properties and Behavior roads *National conference on modern cement concrete and bituminous roads, Vizag* PP 374-379.

Robert M Brooks (Dec 2009), Soil stabilization with flyash and rice husk ash , *International Journal of Research and Reviews in Applied Sciences*, Volume 1, Issue 3, December, PP 209-217.

S. Bhuvaneswari, R. G. Robinson and S. R. Gandhi, (2005), Stabilization of Expansive Soil Using Fly Ash , Fly Ash Utilization Programme (FAUP), TIFAC, DST, New Delhi.

W.G. Holtz and Gibbs, 1956; Engineering properties of expansive clays, Transactions, *ASCE* , Vol.121, pp 641-677.