EXPERIMENTAL STUDY OF SURAT REGION EXPANSIVE SOIL MODIFIED USING BAGASSE ASH AND WOOD ASH

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ABSTRACT

In India large surface deposits are covered by Expansive soil which have tendency to undergo volume change due to change in water content with seasonal variation. 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. Civil engineering structure constructed on such soils experience damage due to uneven movement caused by swelling and shrinkage process of the soil. The wetting and drying process of a subgrade layer composed of black cotton soil result into failure of substructures in form of settlement and cracking. It is, therefore, necessary to mitigate the problems posed by expansive soils and prevent cracking of structures. Surat is located on highly expansive soil. This paper is based on an experimental study in the stabilization of an expansive soil in Surat, consisting of the changes of its various properties by the addition of waste materials of industrial origin such as Bagasse ash and Wood ash. It's a comparative study also for stabilization using different waste material. So that we can conclude which waste material stabilize the Surat region soil effectively based on its selling properties. This may achieve the double objective of reducing the problems of this type of soil, and also of providing a use for the waste product, thus eliminating the economic and environmental cost involved in managing them. The empirical correlation of basic soil properties with swelling property also developed using regression analysis for the quick result for stabilized soil.

KEYWORDS:

Bagasse ash, Expansive soil, Regression analysis, Stabilization, Swelling, Shrinkage , Wood ash.

1. INTRODUCTION

Expansive soils are soils that expand when water is added, and shrink when they dry out. This continuous change in soil volume can damages the foundation causes cracks in superstructure. Surat city situated in South Gujarat region of India having expansive soil called black cotton soil as top layer. This soil being expansive required special attention for road construction as well as pavement design. To improve the engineering properties of such a soil, chemical stabilization is one of the most effective methods. The growing cost of traditional stabilizing agents and the need for the economical utilization of industrial and agricultural waste for beneficial engineering purposes has prompted. Investigation has been

carried out to check the stabilizing potential of bagasse ash & wood ash in highly expansive clay soil **(**black cotton soil). In many situations, soils in natural state do not present adequate geotechnical properties to be used for foundation. In Order to adjust their geotechnical parameters to meet the requirements of technical specifications of construction industry, studying soil stabilization is more emphasized. Soil stabilization is the permanent physical and chemical alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and control the shrink-swell properties of a soil, thus improving the load-bearing capacity of a sub-grade to support pavements and foundations. Stabilization can be used to treat a wide range of sub-grade materials from expansive clays to granular materials. Stabilization can be achieved with a variety of chemical additives including lime, fly ash, and Portland cement, as well as by-products such as lime-kiln dust (LKD) and cement-kiln dust (CKD). Proper design and testing is an important component of any stabilization project. This allows for the establishment of design criteria as well as the determination of the proper chemical additive and admixture rate to be used to achieve the desired engineering properties. Benefits of the stabilization process can include: Higher resistance (R) values, Reduction in plasticity, Lower permeability, Reduction of pavement thickness, Elimination of excavation - material hauling/handling - and base importation, Aids compaction, Provides "all-weather" access onto and within projects sites.

2. WORKING SIMULATION

By taking the number of samples from the different zones of Surat region; identification and classification of the soil has been carried out. It is found that the soil available in this region is high to medium plastic clay and it is expansive in nature. High plastic clay which shows maximum swelling pressure from central zone of Surat region has been selected for stabilization.

2.1. Material Selection for Soil Stabilization:

Bagasse ash and wood ash have been selected as chemical stabilizer after checking their chemical properties for the Surat region because both the product are locally available and waste product of agriculture and industry which may gave us economical solution.

Baggase ash:

Figure 1. Baggase ash

Bagasse, also called Megass, fibre remaining after the extraction of the sugar-bearing juice from sugarcane. Sugar cane bagasse is an industrial waste which is used worldwide as fuel in the same sugar-cane industry. The combustion yields ashes containing high amounts of

unburned matter, silicon and aluminium oxides as main components. These sugar-cane bagasse ashes (SCBA) have been chemically, physically and mineralogically characterized, in order to evaluate the possibility of their use as a cement-replacing material in the concrete industry.

Table 1. A Typical Chemical Analysis of Bagasse Ash

Description	Abbreviation	Percentage (%)	Description	Abbreviation	Percentage (%)
Silica	Sio_2	60.26	Sulphate	So_4	1.30
Iron	Fe_2o_3	5.03	Phosphorus	P_2o_5	2.69
Calcium	Cao	8.35	Loss of Ignition	-	3.39
Magnesium	Mgo	0.40	Alumina	Al_2o_3	10.73
Sodium	Na_20	1.33	Titanium	Tio_2	0.13
Potassium	K_2o	5.57	Manganese	Mn	0.078
Chloride	Cl	0.20	Wax Content	-	Nil

Wood ash :

Wood ash is the inorganic and organic residue remaining after the combustion of wood or unbleached wood fiber. The physical and chemical properties of wood ash vary significantly depending on many factors. Hardwoods usually produce more ash than softwoods and the bark and leaves generally produce more ash than the inner woody parts of the tree.

Table 2. Range in elemental composition of industrial wood ash samples.

Element	Wood Ash	Element	Wood Ash
Calcium	15 (2.5-33)	Arsenic	6 (3-10)
Potassium	2.6 (0.1-13)	Boron	123 (14-290)
Aluminum	1.6 (0.5-3.2)	Cadmium	3 (0.2-26)
Magnesium	1.0 (0.1-2.5)	Chromium	57 (7-368)
Iron	0.84 (0.2-2.1)	Copper	70 (37-207)
Phosphorus	0.53 (0.1-1.4)	Lead	65 (16-137)
Manganese	0.41 (0-1.3)	Mercury	1.9 (0-5)
Sodium	0.19 (0-0.54)	Molybdenum	19 (0-123)
Nitrogen	0.15 (0.02-0.77)	Nickel	20 (0-63)

After selecting material for stabilization, Bagasse ash and wood ash as chemical stabilizer in different percentage of soil is used. Test such as plastic limit, liquid limit, shrinkage limit, free swell index, specific gravity has been carried out for soil sample with stabilizer.

3. RESULT ANALYSIS

3.1. Test Results Using Bagasse Ash : Bagasse ash mixed with high plastic clay in 10%, 20%, 30% and 40% of soil and following results found.

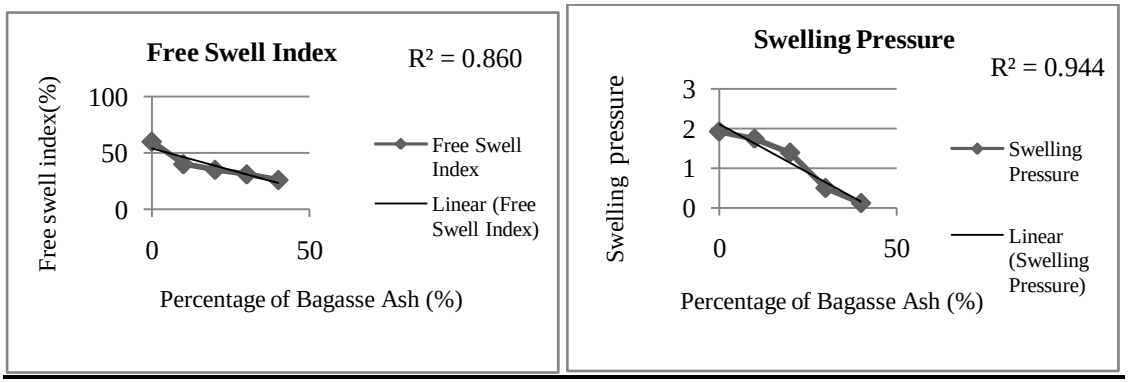
Table 3. Test results using Bagasse Ash

Mixture Proportion	PL(%)	LL(%)	PI(%)	SL(%)	FSI(%)	SG	Swelling Pressure (kg/cm^2)
S	30	72	42	21	60	2.51	1.92
S+10%	25	52	27	12	40	2.53	1.74
S+20%	23	44	21	10	35	2.54	1.39
S+30%	22.5	39	16.5	9	31	2.2	0.5
S+40%	19	34	15	7	26	2.04	0.12

LL: Liquid Limit PL: Plastic Limit PI: Plasticity Index
SL: Shrinkage Limit FSI: Free Swell Index SG: Specific Gravity

Bagasse ash mixed with the soil in four different proportions (10%, 20%, 30 %, 40 %) and carried out the test as per IS code. In test data analysis as per figure 2 and figure 3, it is found that with the increase in proportion of Baggase ash it shows the linear correlation and corresponding swelling pressure decreases. On increasing Bagasse-ash content free swell index decreases steadily to a lowest value at 20% Bagasse-ash and then it decreases slightly and same at 20%, 30% and 40% Bagasse-ash content respectively.

Figure 2. FSI v/s % of Bagasse Ash Figure 3. SP v/s % of Bagasse Ash



Test Result Using Wood Ash: : Wood ash mixed with high plastic clay in 20%, 40%, 60% and 80% of soil and following results found.

Table 4. Test results using Wood Ash

Mixture Proportion	PL(%)	LL(%)	PI(%)	SL(%)	FSI(%)	SG	Swelling Pressure (kg/cm^2)
S+20%	27	69	42	18.5	44	2.54	1.67
S+40%	23	54	31	16	37	2.47	1.51
S+60%	20	47	27	14.3	30	2.38	1.37
S+80%	18	38	20	11	27	2.29	0.7

LL: Liquid Limit PL: Plastic Limit PI: Plasticity Index
SL: Shrinkage Limit FSI: Free Swell Index SG: Specific Gravity

From Figure 4 and figure 5, it has been shown that by adding 20% Wood Ash the value of swelling Pressure slowly decreases and with increases in content of wood ash to 60% it decreases gradually. On increasing Wood-ash content free swell index decreases steadily to a lowest value, then it decreases slightly and same at 40%,60% and 80% Wood-ash content respectively.

Figure 4. F.S.I. v/s % of Wood Ash

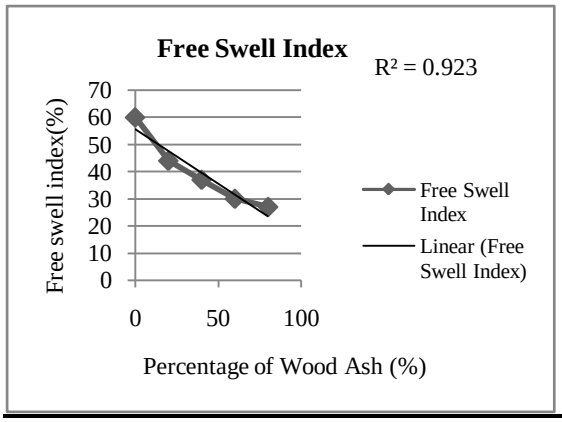
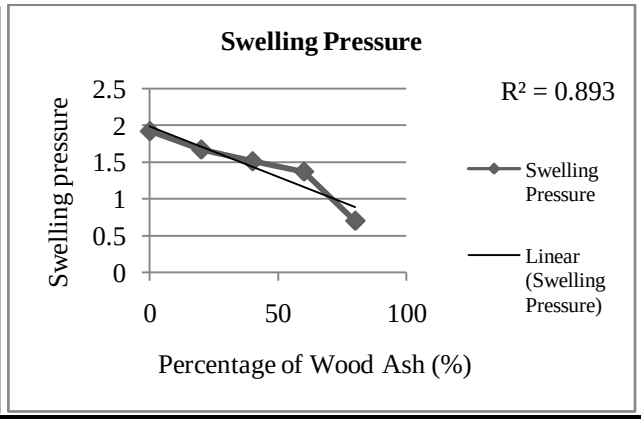


Figure 5. SP v/s % of Wood Ash



3.2. Data Analysis and Comparative Study of Bagasse Ash and Wood Ash Mixed with Soil :

Figure. 6. SP v/s % of Wood Ash

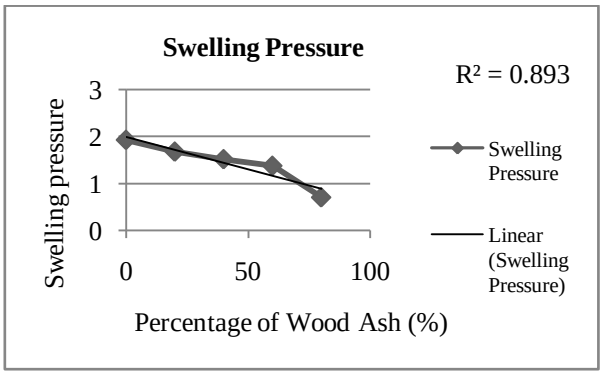
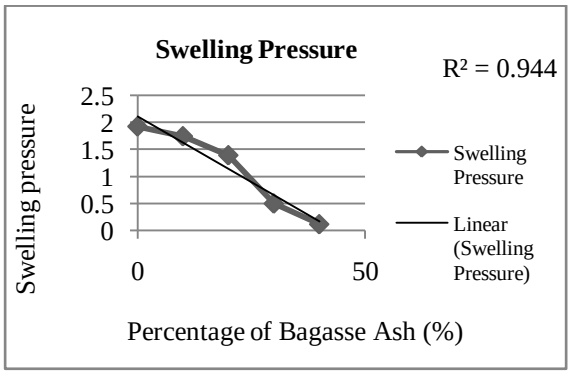


Figure 7. SP v/s % of Bagasse Ash



From the graph it has been shown that by adding bagasse ash in %(10,20,30,40) & wood ash in %(20,40,60,80)the swelling pressure of soil decreases.

It has been shown that bagasse ash is added in lower percentage it gives good results than wood ash which is added in more proportion. It has been seen that bagasse ash is more effective than wood ash .

From the test data analysis, it has been shown that Baggase Ash is more effective than Wood ash for soil stabilization of highly plastic soil of Surat region as with the increase proportion of Baggase Ash, the value of Liquid Limit, Plastic Limit, Plasticity Index, Shrinkage Limit, Free Swell Index, Specific Gravity & Swelling Pressure tends to go towards the normal value of these properties of stabilized soil.

4. LINEAR REGRESSION ANALYSIS

On account of establishment of correlation between various properties of soil, we have done regression analysis with the use of "spss13" software. The stepwise modal analysis is mentioned below.

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

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \beta nXn \quad \text{---------- (1)}$$

$$SP\ (kg/cm^2) = 3.827 - 0.47\ (FSI) + (PI)\ 0.21\text{-}(0.71)\ (\%\ Bagasse\ Ash) \quad \text{---------- (2)}$$

where, SP = Swelling Pressure
FSI = Free Swell Index
PI = Plasticity Index

Table 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.996(a)	.992	.967	.14375

a Predictors: (Constant), PERCENT, PI, PL

Table 6. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.460	3	.820	39.683	.116(a)
	Residual	.021	1	.021		
	Total	2.481	4			

a Predictors: (Constant), PERCENT, PI, PL
b Dependent Variable: SP

Table 7. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		Value	B	Std. Error	Beta	
1	(Constant)	6.111	1.987		3.075	.200
	PL	-.128	.087	-.655	-1.469	.380
	PI	-.009	.025	-.124	-.357	.782
	PERCENT	-.085	.016	-1.715	-5.272	.119

a Dependent Variable: SP

$$\mathbf{SP\ (kg/cm^2) = 6.111\text{-}0.128\ (PL) - 0.09\ (SL)\ \text{-}0.85\ (\%\ Bagasse\ Ash)} \quad \text{---------- (3)}$$

where, SP = Swelling Pressure
SL = Shrinkage Limit
PL = Plasticity Limit

5. RESULT AND CONCLUSION

5.1. Results:

After studying all the data and curves from the graphs, it can be concluded that both the materials i.e. Bagasse Ash and Wood Ash are effective for stabilizing the expansive soil and the result is shown as under:

Table 8. Test results using Bagasse Ash

Mixture Proportion	PL(%)	LL(%)	PI(%)	SL(%)	FSI(%)	SG	Swelling Pressure (kg/cm^2)
S	30	72	42	21	60	2.51	1.92
S+10%	25	52	27	12	40	2.53	1.74
S+20%	23	44	21	10	35	2.54	1.39
S+30%	22.5	39	16.5	9	31	2.2	0.5
S+40%	19	34	15	7	26	2.04	0.12

Table 9. Test results using Wood Ash

Mixture Proportion	PL(%)	LL(%)	PI(%)	SL(%)	FSI(%)	SG	Swelling Pressure (kg/cm^2)
S+20%	27	69	42	18.5	44	2.54	1.67
S+40%	23	54	31	16	37	2.47	1.51
S+60%	20	47	27	14.3	30	2.38	1.37
S+80%	18	38	20	11	27	2.29	0.7

LL: Liquid Limit PL: Plastic Limit PI: Plasticity Index
SL: Shrinkage Limit FSI: Free Swell Index SG: Specific Gravity

Equation to find out swelling pressure without test:

SP = 3.827 - 0.47 (FSI) + (PI) 0.21 - (% Percentage of Bagasse Ash) (0.71) ---------- (4)
SP = 6.111 - 0.128 (PL) - 0.09 (SL) - 0.85 (% Percentage of Bagasse Ash) ---------- (5)

5.2. Conclusion:

In the Surat city situated in South Gujarat region of India having black cotton soil. The majority of South Gujarat area having black cottons soil which is unstable and have to be stabilized for that we have used bagasse ash and wood ash. In Surat city, we have analyzed the swelling pressure of soils from different zones. And we found that North Zone has higher swelling pressure than any other Zone. So we collected the soil sample from a site in Katargam region from 2 m depth.

After studying all the data and curves from the graphs, it can be concluded that both the materials i.e. Bagasse Ash and Wood Ash are effective for stabilizing the expansive soil. Hence is proved to be economical and easy solution to stabilize the various expansive soils and preventing the damage caused to different structural elements and buildings.
Moreover over use of bagasse as a binding agent is very beneficial:

- waste product
- eco-friendly,

- Better functional efficiency.
- Cost effectiveness.
- Better durability.
- Minimum waste.

From the Test results we can known that by adding bagasse ash in %(10,20,30,40) swelling pressure decreases & by adding wood ash also in %(20,40,60,80)the swelling pressure of soil decreases.

We can conclude that bagasse ash is added in lower percentage it gives good results than wood ash which is added in more percentage. So we can conclude that bagasse ash is effective .

From the above graphs, we can conclude that Baggase Ash is more effective than Wood ash for soil stabilization as with the increase proportion of Baggase Ash, the value of Liquid Limit, Plastic Limit, Plasticity Index ,Shrinkage Limit, Free Swell Index, Specific Gravity & Swelling Pressure tends to go towards the normal value of these properties of stabilized soil. And as these materials are locally and cheaply available it becomes the first choice of stabilization when there comes the matter of economic solution. So instead of dumping it why not use in this way so the industrial problem is also solved.

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