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STUDY ON ENGINEERING PROPERTIES OF SOIL USING BAGASSE ASH AND SISAL FIBER Shazad

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Abstract - In a well-organized environment, disposal of waste poses a great threat as regards where and how to effectively dispose the waste material without any harmful effect to society. In the recent times, utilization of solid waste materials in soil stabilization has gained eminence as an effective means to manage wastes generated from various industries. In this paper, a review is given on utilization of different solid waste materials which have been used to stabilize soft soils. Though, there are lots of methods and techniques are available to stabilize these soil. This study provides how waste materials can be used to stabilize the soft soil. The increasing construction cost of conventional stabilizers as well as requirement for the cheap consumption of industrial and agricultural wastes for valuable trade has provoked an exploration into the stabilizing prospective of Bagasse Ash and Sisal Fiber for highly compressible clayey soil. Today, sustainable construction is in demand hence the new studies focused on trends of sustainable utilization of resources. To achieve we can use waste products, natural and biodegradable resources. In this study an extensive lab work have been done to investigate the utilization of agricultural, industrial waste and natural fibers for enhancing the engineering properties of the moderately compressible clay obtained from Mohali Airport Road, Punjab (India). This study aimed to access the appropriateness of Bagasse Ash and Sisal Fiber for stabilization of clayey soil. Consistency limits, Maximum Dry Density, Optimum Moisture Content, UCS and (soaked) CBR tests have determined by using Bagasse Ash (2%, 4%, 6% and 8%) and Sisal Fibers in different lengths (2mm, 4mm, 6mm) with percentages (1%, 1.5%, 2%) by weight of dry soil.

Key Words: **Soil, Sisal fibre, bagasse ash, Optimum Moisture Content, Maximum dry density, unconfined compressive test (UCS), California bearing ratio (CBR)**

1. INTRODUCTION

The increasing construction cost of conventional stabilizers as well as requirement for the cheap consumption of industrial and agricultural wastes for valuable trade has provoked an exploration into the stabilizing prospective of bagasse ash and Polypropylene fiber for highly compressible clayey soil. This study aimed to assess the appropriateness of bagasse ash and Polypropylene fiber for stabilization of clayey soil. Many researchers resolute more on utilize cost effectual resources which are available locally from industrial and agricultural waste so that we are able to enhance the properties of poor soil. In excess of addiction of industrially made stabilizing agents (cement, lime etc.) had kept construction cost of stabilized structure high. Up till now have persistent to prevent the small and deprived countries of the world for improving reachable road networks to meet necessitate of their countryside dwellers that compose great fraction of their residents which are mainly farmers. Therefore, the probable utilization of waste from agricultural like bagasse ash will significantly decrease the rate of erection as well as decrease environmental hazards due to these wastes. Bagasse ash is an agricultural waste obtained from sugarcane mills. Soils which are expansive in nature are found in several continents of the world. Though, the dilemma of increase and decrease is related by elevated wetness change. Therefore, it is restricted in places where the variation of climate is more. The high change of volume with the intermittent phase of wetting and drying can interpret large damage in structures; mostly on low rise buildings, low depth foundations and light structures like pavements and water supply lines etc. The usually utilized stabilizing agents for compressible clays are bitumen, lime and cement. Researchers had suggested that the stabilization of soft soil by lime or cement is efficient. But, costs of stabilizing agents are so high which make them inexpensively unappealing as stabilizers. Current style to investigate facility in the soil engineering and building materials focuses excess on the explore for economical and nearby accessible resources like bagasse ash, fly ash, RHA, coconut fibers etc. as stabilizers for the full or partial substitute of conventional stabilizing agents like cement as well as lime. However, in view of the fact that in recent time, numerous studies have established utilization of these wastes as a cement replacing substance in concrete technology. Though, their use as a separate stabilizer is still doubtful. So, this study will be used for evaluating various engineering properties of bagasse ash with reinforced expansive soil with Polypropylene fibers. If study will give good results, then these additives can be used as soil stabilizers by replacing the quite expensive chemicals like lime, cement, etc.

2. EXPERIMENTAL STUDY

2.1 Materials

Following are the materials which are used for stabilization of Clay soil:

a) Soil: - The soil sample for study is collected from Saha, Haryana, i.e. named as PR9 by using disturbed sampling method. Fig.1 shows collected soil sample.

Fig.1: Disturbed soil sample

Table 1: Properties of soil used in study

Sr. No.	Characteristics	Value
1	Specific gravity	2.54
2	Atterbergs limits: a) Liquid limit (%) b) Plastic limit (%) c) Plasticity index (%)	 37.1 26.3 10.8
3	Colour	Light brown
4	IS classification	CI
5	Standard Proctor compaction test result:- Optimum moisture content (%) Maximum dry density(g/cc)	 15.42 1.82
6	Unconfined compressive strength(Kg/cm^2)	2.98
7	California Bearing Ratio (soaked):- At 2.5 mm penetration (%) At 5.0 mm penetration (%)	 1.81 1.51

b) Bagasse Ash: - Bagasse is a fibrous dry pulpy residue which obtained after crushing to extract juice from sugarcane or sorghum stalks. After extracting the juice from the sugarcane, bagasse is kept for drying as shown in Fig 2

Fig. 2: Dried Bagasse

The dried bagasse is then burnt to generate heat in boiler to convert water into steam. This steam is then used to rotate a turbine-generator system at high pressure to produce electricity. From the combustion process bagasse ash is generated, that has grey-black color as shown in Fig 3.

Fig. 3: Bagasse Ash

Table 2: Physical properties of Bagasse Ash

Sr.no.	Properties	Value
1	Colour	black
3	Specific gravity	0.78

Table 3: Chemical composition of Bagasse Ash

Sr.no	Constituents	%age
1	Sio_2	62.43
2	Al_2o_3	4.38
3	Fe_2o_3	6.98
4	CaO	11.80
5	MgO	2.51
6	SO_3	1.48
7	K_2O	3.53
8	Loss of ignition(LOI)	4.73

c) Sisal Fiber: In India Sisal plant was brought by the Portuguese in the fifteenth century and first time cultivated in Goa and later on in Orissa and now found throughout the country. Sisal grows in semi-arid regions around the world Sisal fiber is a type of natural fiber also acts as reinforcement in clay sisal mix soil. Sisal fibers are cellulose-rich (> 65%) and show tensile strength. Sisal is a natural fiber material, cheap, easy laying in field and biodegradable. Sisal has low moisture absorption, excellent durability and high initial tensile strength Sisal is not like as fiber as coir or jute. Sisal fiber was obtaining from the Indian market. The fiber strands are .8mm to 1.2 mm in diameter is adopted. The sisal fiber shown in figure 4.

Fig. 4: sisal fibre

Table 4: Physical properties of sisal fibre

Sr.no.	Properties	Value
1	Average Diameter (mm)	0.8 to 1.2
2	Average Tensile Strength (N/mm^2)	385 to 728
3	Density (g/cc)	1.58
4	Nature	Natural

2.2 Experimental Investigation

The following were tests performed for the present study in laboratory:-

1. Atterberg limits (MDD,OMC)
2. Standard Proctor Test for determination of O.M.C and MDD.
3. Unconfined Compression Test.
4. California Bearing Ratio Test

2.2.1 Maximum Dry Density and Optimum Moisture Content: - The clayey soil samples blended with bagasse ash and reinforced with sisal plant fibers have been tested by using Heavy compaction test at different values of moisture content for the analysis of MDD and OMC as shown below.

2.2.1.1 Proportions of Materials with Clay Soil:

I) SPT test conducted on soil by different mix proportion of bagasse ash:-

1. Plain Soil +BA (0%)
2. Soil + BA (2%)
3. Soil + BA (4%)
4. Soil + BA (6%)
5. Soil+ BA (8%)

From the above proportion result of MDD (Maximum dry density) & OMC (Optimum moisture content) is calculated:

Table 5: MDD and OMC of soil with variations in % of BA

S.No.	Percentage Of Bagasse Ash (%)	Maximum Dry Density(g/cc)	Optimum Moisture Content (%)
1	0	1.82	15.42
2	2	1.8	14.62
3	4	1.75	14.36
4	6	1.68	16.24
5	8	1.68	16.63

Chart-1 & 2 showing the variation of curves MDD and OMC with %age of BA obtained from the result of SPT test.

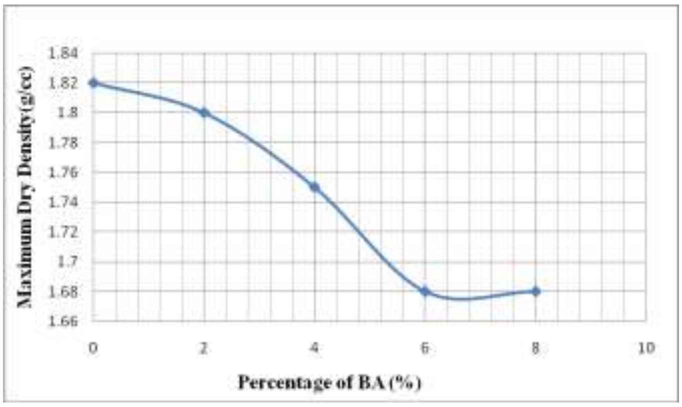

Chart-1: Variation of MDD with % of BA

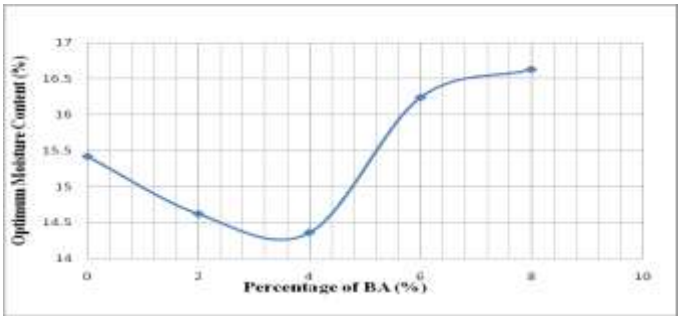

Chart-2: Variation of OMC with % of BA

From the result of Atterberg limits best proportions are selected from their MDD & OMC (soil +BA 4%) is 1.75g/cc & 14.36%. Now Standard proctor test and unconfined compressive strength, California Bearing Ratio Test is performed on best proportion of soil.

II) SPT test conducted on soil by different mix proportion of BA and sisal fibre:

1). Soil +BA (4%) +sisal fibre (1%) of 2cm

2). Soil + BA (4%) + sisal fibre (1.5%) of 2 cm

3). Soil + BA (4%) sisal fibre (2%) of 2 cm

4) Soil +BA (4%) +sisal fibre (1%) of 4cm

5) Soil + BA (4%) + sisal fibre (1.5%) of 4 cm

6) Soil + BA (4%) sisal fibre (2%) of 4 cm

7) Soil +BA (4%) +sisal fibre (1%) of 6cm

8) Soil + BA (4%) + sisal fibre (1.5%) of 6 cm

9) Soil + BA (4%) sisal fibre (2%) of 6 cm

From the above proportions result of MDD (Maximum dry density) & OMC (Optimum moisture content) is calculated:

Table 6: MDD and OMC for soil with 4% BA reinforced Sisal Fiber

S.No.	% of SF= 1%		% of SF= 1.5%		% of SF= 2%	
	MDD g/cc	OMC %	MDD g/cc	OMC%	MDD g/cc	OMC%
Length of SF 2cm						
1	1.81	13.87	1.81	13.67	1.79	13.4
Length of SF 4cm						
2	1.87	13.13	1.86	13.09	1.85	12.67
Length of SF 6cm						
3	1.83	13.64	1.82	14.52	1.81	14.62

Chart-3 & 4 showing the variation of curve MDD and OMC with the %age of BA and sisal fibre obtained from the SPT test:

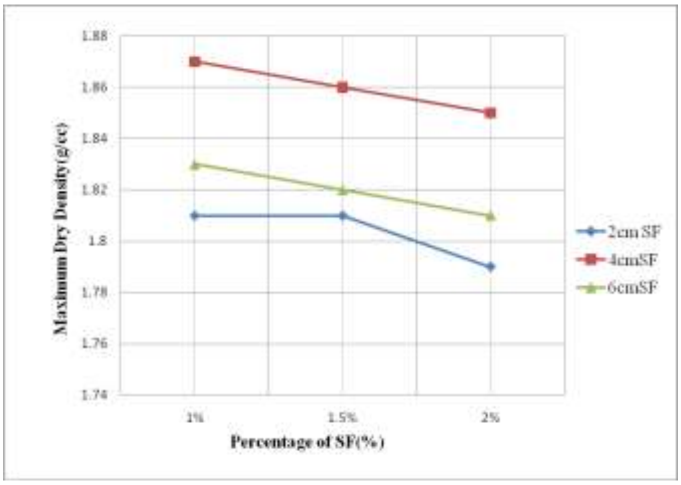

Chart-3: Variation of MDD with % of 4% BA reinforced Sisal Fiber

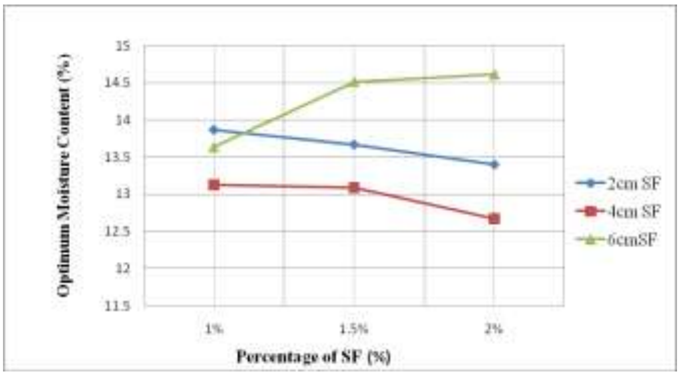

Chart-4: Vibration of OMC with % of 4% BA reinforced Sisal Fiber

2.2.2 Unconfined Compressive Strength: - The clayey soil samples blended with bagasse ash and reinforced with sisal plant fibers have been tested by using UCS test at different percentages and length of fibers for the analysis of California Bearing Ratio as shown below.

2.2.2.1 Proportions of Materials with Clay Soil:

I) UCS test conducted on soil by different mix proportion of bagasse ash:

1. Plain Soil +BA (0%)

2. Soil + BA (2%)

3. Soil + BA (4%)

4. Soil + BA (6%)

5. Soil+ BA (8%)

From the above proportion result of UCS (unconfined compressive strength) is obtained for soil and BA:

Table 7: Result of UCS test (Soil-BA)

S.No.	% of BA	UCS (Kg/cm^2)
1	0	2.98
2	2	3.07
3	4	3.12
4	6	2.95
5	8	2.81

Chart-5 showing the variation of curve with % of BA obtained from the result of UCS test.

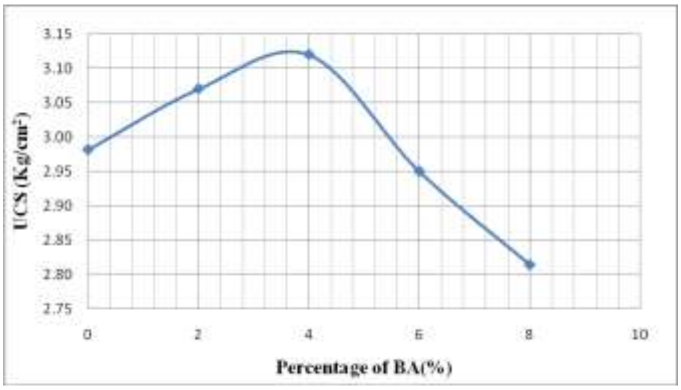

Chart-5: Variation of UCS with % BA

1I) UCS test conducted on soil by different mix proportion of BA and Sisal Fibre:-

1). Soil +BA (4%) +sisal fibre (1%) of 2cm

2). Soil + BA (4%) + sisal fibre (1.5%) of 2 cm

3). Soil + BA (4%) sisal fibre (2%) of 2 cm

4) Soil +BA (4%) +sisal fibre (1%) of 4cm

5) Soil + BA (4%) + sisal fibre (1.5%) of 4 cm

6) Soil + BA (4%) sisal fibre (2%) of 4 cm

7) Soil +BA (4%) +sisal fibre (1%) of 6cm

8) Soil + BA (4%) + sisal fibre (1.5%) of 6 cm

9) Soil + BA (4%) sisal fibre (2%) of 6 cm

From the above proportion result of UCS (unconfined compressive strength) is obtained for soil BA and Sisal Fibre is calculated:

Table 8: Result of UCS for (BA +Sisal Fiber)

S.No.	Percentage of SF%	Length of SF		
		2cm	4cm	6cm
		UCS (kg/cm^2)		
1	1	3.44	3.47	3.47
2	1.5	3.55	3.73	3.56
3	2	3.40	3.58	3.51

Chart-6 showing the variation of curve with % of BA and Sisal fibre:-

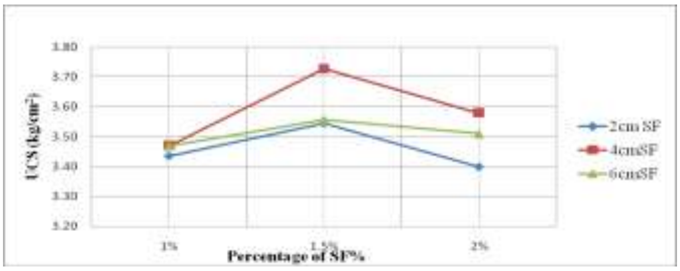

Chart-6: Variation of UCS for BA soil reinforced with Sisal Fiber

2.2.3 California Bearing Ratio (soaked):- The clayey soil samples blended with bagasse ash and reinforced with sisal plant fibers have been tested by using CBR test at different percentages and length of fibers for the analysis of California Bearing Ratio as shown below.

2.2.3.1 Proportions of Materials with Clay Soil:

I) CBR test conducted on soil by different mix proportion of bagasse ash:

1. Plain Soil +BA (0%)

2. Soil + BA (2%)

3. Soil + BA (4%)

4. Soil + BA (6%)

5. Soil+ BA (8%)

From the above proportion result of CBR (California Bearing Ratio**)** is obtained for soil and BA:

Table 9: Result of CBR test (Soil-BA)

S.No.	of BA %	CBR%
1	0	1.81
2	2	2.04
3	4	2.59
4	6	2.36
5	8	2.30

Chart-7 showing the variation of curve of CBR with % of BA obtained from the result of CBR test.

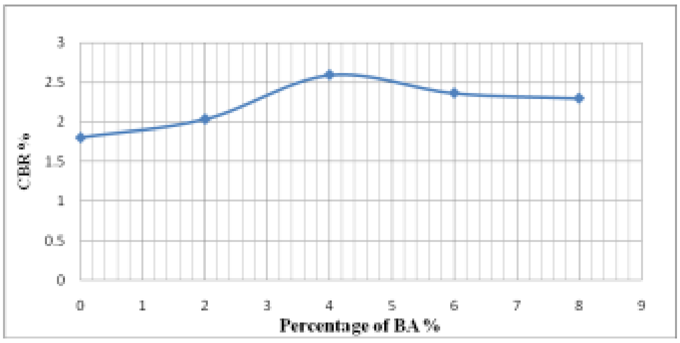

Chart-7: Variation of CBR with % of BA

1I) CBR test conducted on soil by different mix proportion of BA and Sisal Fibre:-

1). Soil +BA (4%) +sisal fibre (1%) of 2cm

2). Soil + BA (4%) + sisal fibre (1.5%) of 2 cm

3). Soil + BA (4%) sisal fibre (2%) of 2 cm

4) Soil +BA (4%) +sisal fibre (1%) of 4cm

5) Soil + BA (4%) + sisal fibre (1.5%) of 4 cm

6) Soil + BA (4%) sisal fibre (2%) of 4 cm

7) Soil +BA (4%) +sisal fibre (1%) of 6cm

8) Soil + BA (4%) + sisal fibre (1.5%) of 6 cm

9) Soil + BA (4%) sisal fibre (2%) of 6 cm

Table 11: CBR for BA soil reinforced with Sisal Fiber

S.No.	% of Sisal Fiber	Length of SF		
		2cm	4cm	6cm
		CBR (%)		
1	1	2.76	2.99	2.63
2	1.5	2.89	3.09	2.86
3	2	2.66	2.96	2.76

From the above proportion result of CBR (California Bearing Ratio) is obtained for soil BA and Sisal Fibre is calculated:

Chart-8 showing the variation of curve with % of BA and Sisal fibre:-

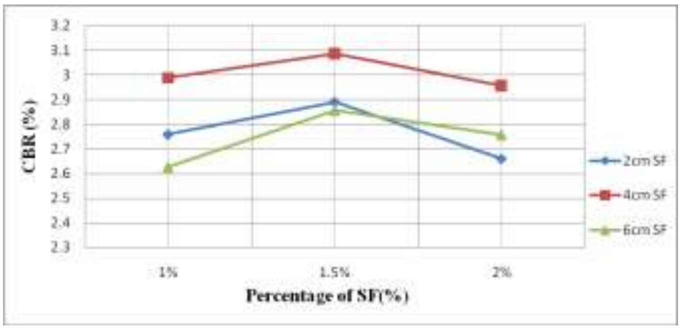

Chart-8: Fig.6.8: CBR for BA soil reinforced with Sisal Fibre

3. CONCLUSION

Based on analysis and interpretation of experimental investigations following conclusions are drawn.

3.1 Maximum Dry Density and Optimum Moisture Content

To study the effects of addition of Bagasse ash and Sisal Fibers in soil on MDD and OMC relationship different percentages of bagasse ash is added and optimized. Then this optimized bagasse ash soil is the mixed with the different lengths and different percentages of Sisal Fibers. It is interpreted that there is increase in OMC and decrease in MDD with addition of Bagasse Ash. But the values of CBR and UCS are increased with 4% of BA and Sisal Fiber length 4cm at 1.5%.

3.2 Unconfined Compressive Strength of Soil

i. There is increase in the percentage of UCS, when sample were prepared with 2%, 4% by 3.02%, 4.70% and decrease in percentage of UCS, when sample were prepared with 6%, 8% bagasse ash by 1.01%, 5.70% as compared to raw soil.
ii. The increase in UCS is maximum at 4% BA i.e. 4.70%.
iii. The experiments in combined sample of BA and Sisal fiber (2cm, 4cm, 6cm) shows that the maximum value of UCS are obtained at 4cm length with 1.5% by weight, which is found to be 3.73 kg/cm^2. The percentage increase as compared to the raw soil is 25.16%.

3.3. California Bearing Ratio (soaked)

i. The soaked CBR value of the raw soil is 1.81%
ii. The soaked CBR value of the raw soil with 4% BA is 2.59%, the percentage increase in CBR value as compared to raw soil is 43.10%,
iii. The soaked CBR value of combined soil sample with 4% BA, 1.5% of Sisal Fiber of 4cm length is

found to be 3.09%, the increase in CBR value as compared to raw soil is 70.16%.

4. FUTURE SCOPE

This study is confined to improve the properties of medium clayey soil (CI) by using bagasse ash and sisal fibers as stabilizer for compressibility, (MDD), UCS and CBR of soil. There is substantial scope of carrying out future research in this area. The possible research idea for future work:

1. A study can be conducted on other types of soils to investigate the consequences of adding fibers and ash on properties of soil.
2. A studied can be carried out with addition of other types of waste materials in addition to the waste of fibers to improve the engineering properties of soil.
3. The study can also be done by variations in the lengths and percentages of Sisal fiber.
4. The other engineering properties of soil like compressibility, and shear strength can be evaluated using fibers and bagasse ash.
5. A cost comparison can also be made to study the financial implementation by using such a technique over a particular project/ location.

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