STABILIZING EFFECTS OF THE COMBINATION OF BAGASSE ASH AND BAMBOO FIBER ON THE STRENGTH PROPERTIES OF EXPANSIVE SOIL

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ABSTRACT

A wide area of India is covered with expansive soils. Such soil possesses a greater threat to any type of structure. To treat expansive soil with admixtures is mostly expensive. In this present study, the utilization of waste products and their effect on engineering properties of soil is determined. As bagasse ash with more than 70% silica shows cementitious behaviour and is an industrial waste is a replacement for many other expensive admixtures and bamboo fiber which is a natural fiber is used as reinforcement to soil. The combinations of both the products have shown the maximum bearing capacity and shear strength to the soil by performing different tests including Standard proctor test, California bearing ratio and direct shear test. Samples are prepared with different percentages of bagasse ash (3%, 6%, and 9%) to find the maximum optimum value then the tests were performed with optimum value of bagasse ash and bamboo fiber with different percentages (0.25%, 0.5%, 0.75%, 1%, 1.25%). It is found that with 6% of optimum value of bagasse ash and 1% of bamboo fiber, the soil shows the maximum stability for structures.

KEYWORDS: Expansive Soil, Bagasse Ash, Bamboo Fiber, CBR, Direct Shear Test

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INTRODUCTION

Construction land conditions vary with different soil types. Some of these types vary with different weather conditions. Expansive soils are one of the few types, which shrink and swell with hot and cold weather conditions. Due to the adverse behaviour of these soils, construction on them without any distinct treatment could result in shear failure of any structure. With passing time, the demand for more construction is high on the rise and soil conditions like these needs a better treatment. Use of good admixtures for stabilizing the soil is as important as utilizing of waste materials and both can be done by the usage of sugarcane bagasse ash and bamboo fiber. Bagasse ash is the waste product of sugar industries that has more than 70% silica which shows binding properties and can be used as a replacement to any cementitious product where as usage of bamboo fiber reinforces the soil in the strongest way. With the increase in the properties of soil, it is important to have a discrete type of fiber with proper length and proper content. Bamboo fiber is a natural fiber and has the tendency of reducing the crack formation on the top layer. The introduction of natural waste (bagasse ash) and a natural fiber (bamboo fiber) reduces the cost efficiency and available near various construction sites. In this study how the combination of these two materials effect both the physical and chemical properties of soil and their stabilizing effect has been studied.

Many different researchers have studied the various stabilizing effects on the soil. As to use different stabilizers including different types of fibers or any type of binding materials could help the soil gain its maximum strength.

Akansha & Mittal (2018) worked on the combination of bagasse ash and coir fiber to check the bearing capacity of soil by performing standard proctor test and California bearing ratio for both soaked and unsoaked conditions.

Paul and Sneha (2016) determined the effect of random inclusion of bamboo fiber on strength behavior of fly ash treated black cotton soil.

Reddy et al. (2017) worked on the duo of sugarcane straw ash and polypropylene fiber and conducted different tests included SPT, CBR & UCS to check the compressibility of soil.

MATERIAL USED

Expansive Soil

It is a clayey soil found in many parts of India. It is commonly found in agricultural land. This soil can be easily recognized in summer or rainy seasons as it shrinks and swell. A lot of construction sites have major problems with this soil. Construction on this type of soil results in shear failure of the structures. The soil used in the tests is collected from district Punch of J&K. This particular type of soil selected is on the basis of its less bearing capacity and a lack in shear strength.

Bagasse Ash

It is the waste removal of sugarcane industries as the raw waste left of sugarcane used to burn the boilers. The ash left after it is bagasse ash which is usually dumped at fields or any pit as a waste as this ash shows cementitious properties can be used for stabilizing the soil. The ash used in the tests is obtained from the sugar factory in Morinda, Punjab. As bagasse ash has more than 70% silica and silica has the binding properties. So on this basis bagasse ash is selected for the test purposes to see its effects on the stabilization of soil the chemical composition of bagasse ash is shown below.

Minerals	Percentages
SiO ₂	73
Al ₂ O ₃	6.7
Fe ₂ O ₃	6.3
CaO	2.8
MgO	3.2
P ₂ O ₃	4.0

Figure 1

Bamboo Fiber

Bamboo fiber is a natural fiber can be used effectively for stabilizing the soil. The bamboo fiber used in the tests is collected from a small scale industry in Ghaziabad, Delhi. The size of the bamboo fiber used is 30mm in length and 1.2mm in diameter. The properties of bamboo fiber are shown below.

• Properties of bamboo fibre	Values
• Elongation (%)	14
• Fibre length (mm)	30
• Moisture (%)	4.8
• Break force (N)	6.1
• Youngs Modulus (GPA)	14.2
• Tensile strength(MPA)	180

Figure 2

EXPERIMENTAL WORK AND RESULTS

Experimental work that is conducted is as follows:

- Water content of virgin soil
- Specific gravity of the virgin soil
- Liquid limit by Casagrande's apparatus
- Plastic limit
- Standard proctor test to find Maximum dry density and Optimum moisture content
- California bearing ratio test for virgin soil in both soaked and unsoaked condition
- Preparation of soil samples mixed with bagasse ash
- SPT on soil samples mixed with bagasse ash at different percentages (3%, 6%, and 9%)
- CBR test on soil samples mixed with bagasse ash for both soaked and unsoaked condition
- Preparation of soil samples mixed with bagasse ash and bamboo fiber
- SPT on samples mixed with bagasse ash and bamboo fiber at different percentages (0.25%, 0.5%, 0.75%, 1%, 1.25%)
- CBR test on samples mixed with both bagasse ash and bamboo fiber at different percentages (0.25%, 0.5%, 0.75%, 1%, 1.25%)
- Direct shear test on samples mixed with both bagasse ash and bamboo fiber at different percentages (0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%)

Representation of index properties of soil

Table 1: Representation of Index Properties of Soil

Property	Value
Water Content	17.52%
Specific Gravity	2.57
Liquid Limit	47
Plastic Limit	23.76
Plasticity index	23.24
OMC	17%
MDD	1.61
CBR(soaked)	3.243
CBR(unsoaked)	7.6
Direct Shear Test (kg/cm ²)	14.86

Figure 3: Graph Showing Value of OMC (%) at 3%, 6% & 9% Bagasse Ash.

Fig 3 shows the variation of OMC with different percentages of bagasse ash. The results show that on adding bagasse ash from 3 to 9% OMC got increased from 18 to 21.

Figure 4: Graph Showing Value of MDD (%) at 3%, 6% & 9% Bagasse Ash.

Fig 4 shows the variation of MDD w.r.t to the percentages of bagasse ash. The results show that on adding bagasse ash from 3 to 9% MDD initially got decreased and then got increased. The reason for such behavior is the low weight of bagasse ash than the soil particles, at same volume.

Figure 5: Graph Showing Values of CBR (Unsoaked) and CBR (Soaked) at 3%, 6% & 9% Bagasse Ash.

Fig 5 shows the variation of CBR on adding different percentages of bagasse ash. The results show that there is a constant increase in the CBR value of the soil stabilized with bagasse ash. The CBR got increased by 1.2 times. As seen in the results, the CBR initially increases up to the addition of 6% of bagasse ash and decreases thereupon. The reason for such behavior is that replacing bagasse ash with the soil up to certain limits results in the increase of the internal friction of the soil particles. Further decreases in the strength might be due the reduction in the cohesion between the soil particles.

Table 2: Shows the Comparison of OMC, MDD & CBR for Different Percentages of Bagasse Ash

S. No.	Tests	Expansive soil	With 3% BA	% Increase/Decrease	With 6% BA	% Increase/Decrease	With 9% BA	% Increase/Decrease
1.	OMC (%)	17	18	5.88% Increase	19	11.76% Increase	21	23.52% Increase
2.	MDD	1.61	1.584	1.61% Decrease	1.562	2.981% Decrease	1.571	2.422% Decrease
3.	CBR (us)	7.6	8.743	15.03% Increase	9.62	26.57% Increase	9.04	18.94% Increase
4.	CBR (S)	3.243	3.524	8.66% Increase	3.93	21.18% Increase	3.24	0.09% Decrease

Figure 6: Graph Showing Value of OMC (%).

Fig 6 shows the variation of OMC on adding bamboo fiber as r/f to the soil stabilized with bagasse ash. The figure depicts a constant increase in OMC of the soil stabilized with bagasse ash and reinforced with bamboo fiber. The reason for such behavior is the greater water absorbs capacity of bamboo fiber.

Figure 7: Graph Showing Values of MDD.

Fig 7 shows the variation of MDD on adding bamboo fiber to the soil stabilized with bagasse ash. The results show that on adding bamboo fiber up to the 1%, there is a decrease in the MDD which further increases on adding the bamboo fiber up to 1.25%. The reason for such behavior is the low specific gravity of bamboo fiber than the soil particles. Also, there is reduction in the compactive effort due to the lubrication effect of absorbed moisture content.

Figure 8: Graph Showing Values of CBR (Unsoaked) and CBR (Soaked).

Fig 8 shows the variation of CBR value on adding bamboo fiber to the soil stabilized with the bagasse ash. The CBR for un soaked value increased 1.35 times and for soaked it got increased by 1.55 times. The reason for increase in CBR value is the mechanical bond which is developed between the fiber and the soil bagasse ash mix.

Figure 9: Graph Showing Values of Direct Shear Test with Respect to Bamboo Fiber Percentage.

Fig 9 shows the variation in the values of direct shear test on adding the bamboo fiber and bagasse ash mixture to the soil. The pattern in the values shows increasing trend up to the addition of 1 % bamboo fiber then suddenly shows the decreasing trend with further addition. As there is a very high increase in strength shown at 1 % addition of bamboo fiber with 517.49 % increase, it stabilizes the soil at maximum.

Table 3: Shows the Comparison Between Expansive Soil, Bagasse Ash and Bamboo Fiber

Test s	Expe nsive soil	Soil with 6% BA	% Inc/D ec	With 6% BA & 0.25 % BF	% Inc/D ec	With 6 % BA & 0.5% BF	% Inc/D ec	With 6% BA & 0.75 % BF	% Inc/De c	With 6% BA & 1% BF	% Inc/ Dec	With 6% BA & 1.25 % BF	% Inc/D ec
OM C (%)	17	19	11.76 % Inc	18.5	8.82 % inc	19.5	14.7 % inc	20	17.64 % inc	21	23. 52 % inc	23	35.29 % inc
MD D	1.61	1.56 2	2.981 % dec	1.543	4.16 % dec	1.525	5.27 % dec	1.487	7.63 % dec	1.423	11. 61 % dec	1.548	3.85 % dec
CBR (US)	7.6	9.62	26.57 % inc	9.98	31.31 % inc	10.52	38.42 % inc	12.47	64.07 % inc	13.03	71. 44 % inc	12.20	60.52 % inc
CBR (S)	3.243	3.93	21.18 % inc	4.12	27.16 % inc	4.91	52.46 % inc	5.55	147.76 % inc	5.92	164 .28 % inc	5.04	55.55 % inc
Dire ct Shea r Test	14.86	31.3 2	110.7 6 % inc	59.89	303 % inc	68.41	366 % inc	81.52	448.99 % inc	91.76	517 .49 % inc	53.31	258.7 6 % inc

CONCLUSIONS

- With the test conducted it is concluded that waste product like bagasse ash has a very effective impact on the binding properties of expansive soil, as it shows an immense growth in the bearing capacity of the soil.
- The addition of bamboo fiber results in varying the shear strength of the soil by a marginal increase.
- It is seen that there is 26 % increase in the CBR values of the Expansive soil when 6 % of the Bagasse ash is added to it.
- The combination of bagasse ash and bamboo fiber reduces the shear failure and help gain the maximum shear strength at their optimum values.
- With 6% bagasse ash and 1 % bamboo fiber the CBR values of the expansive soil increases by 71.44 % and the shear strength values increases by 517.4 %.
- The final conclusion is that both bagasse ash and bamboo fiber helps in many ways to stabilize the clayey soil.

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