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EFFECT OF SUGAR CANE BAGASSE ASH ON THE PHYSICAL PROPERTIES OF SUBGRADE LAYER

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Abstract: in pavement, subgrade layer must be has enough strength in order to withstand and support the other layers. Availability of waste materials from industry and agriculture and the need to employing the use of this material in the field of roadworks instead of traditional stabilizing agents has encouraged an investigation into stabilizing the soil by sugar cane bagasse Ash (SCBA). Sugar cane bagasse Ash has beneficial engineering purposes of using it as stabilizer material. Work of this paper is aimed to evaluate the potential benefits of bagasse ash, which is considering pozzolana material, as stabilizer material for subgrade layer. The laboratory work involved soil stabilized with varying percentages of sugar cane bagasse ash (3%, 5%, 7%, 10%, 15%, 20%, 25% and 30%) by dry weight of the soil individually. The used soil shows that it belongs to A-7-6 class of soil in the AASHTO soil classification system and the soil under this class is generally of poor engineering use. Analysis of the results shows that slight improvement on the geotechnical properties of bagasse ash stabilized soil, where increasing the addition of bagasse ash reduces plastic limit (P.L), liquid limit (L.L), specific gravity (Gs) and maximum dry density (MDD) values, while increase the optimum moisture content (OMC) value for soil stabilized by bagasse ash. The results of conducted tests show that initially OMC of soil is (21.9%) and for addition of bagasse ash up to (30%) it becomes (34.52%) and the increase is about (57.6%), to the contrary the initially MDD of soil is (1.59 gm/cm3) and for addition of bagasse ash up to (30%) it has become in decrease upto (1.11 gm/cm3) where the reduction is about (30.2%). For liquid limits, plastic limits and plasticity index the results of it at 30% bagasse ash is slightly lower than it for nature soil and the reduction is about (4.9%) for liquid limit , (2%) for plastic limit and (2.9%) for plasticity index. Finally, for the specific gravity (Gs) the initial value of it for soil is (2.7) and for (30%) bagasse stabilized soil decrease to be (2.5) with reduction about (0.2%).

Keywords: *Sugar cane bagasse Ash (SCBA), pozzolana, pozzolanic activity, calcination temperatures*

تأثير رماد قصب السكر على الخصائص الفيزيائية للطبقة الوسادية

الخلاصة: في التبليط، طبقة التربة الوسادية يجب أن يكون لديها ما يكفي من القوة من أجل الصمود ودعم الطبقات الأخرى. لقد شجع توفر المخلفات من الصناعة والزراعة والحاجة إلى توظيف استخدام هذه المواد في مجال أعمال الطرق بدلا من مضافات التثبيت التقليدية التحري في تثبيت التربة برماد قصب السكر(SCBA). رماد قصب السكر يملك استعمالات هندسية مفيدة عندما يستخدم كمادة تثبيت . ان الهدف من هذه الدراسة هو تقييم الفائدة الكامنة لرماد القصب ، والذي يعتبر مادة بوزولانية ، كمادة مثبتة لطبقة التربة الوسادية . تضمن العمل المختبري تثبيت التربة بنسب متنوعة من رماد قصب السكر (3% ، 5%، 7 %، 10% ، 15% ، 20% ، 25% و 30%) من الوزن الجاف للتربة على حدة. وتبين ان التربة المستخدمة تنتمي إلى فئة A-7-6 في نظام تصنيف التربة ال (AASHTO) والتربة تحت هذه الفئة عادة ما تكون ذات استخدام هندسي رديء. من تحليل النتائج تبين ان هناك تحسن طفيف في الخصائص الجيوتكنيكية للترب المثبتة بواسطة رماد القصب، حيث ان زيادة إضافة رماد القصب يقلل من قيمة حد اللدونة ، حد السيولة ، الوزن النوعي و قيمة الكثافة الجافة العظمى ، بينما يزيد من قيمة نسبة المحتوى المائي الأمثل للترب المثبتة برماد القصب . وقد بينت نتائج التجارب التي أجريت ان القيمة الاوليه للمحتوى المائي الأمثل للتربة هو (21.9%) ولاضافة رماد القصب الى حد (30%) تصبح (34.52%) والزيادة حوالي (57.6٪)، وعلى العكس من ذلك القيمة الأولية لقيمة الكثافة الجافة العظمى للتربة هي (1.59 غم / سم ^{3}) ولاضافة رماد القصب الى حد (30%) يكون في قلة تصل الى (1.11 غم / سم ^{3}) حيث نسبة النقصان تكون تقريبا

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(30,2%).نتائج حدود السيولة، حدود السيولة و مؤشر اللدونة عند إضافة نسبة 30% من رماد القصب هي اقل قليلا مما هي عليه بالنسبة لقيمها للتربة الطبيعية ونسبة النقصان تقريبا (4,9%) بالنسبة لحد السيولة ، (2٪) لحد السيولة و (2.9٪) لمؤشر اللدونة. أخيرا ، للوزن النوعي فان القيمة الأولية له بالنسبة للتربة هي (2.7) و لل(30%) من رماد القصب المثبت للتربة تقل لتصبح (2.5) مع نسبة نقصان حوالي (0.2٪).

1. Introduction

Today world is facing serious problem of disposal of agricultural waste. Some regions in the southern of Iraq are popular in production of sugar cane nearly in enough quantity that may be cause problems to environment and to the health. Sugar factories produces waste after extraction of sugar cane in machines that waste when burnt, the resultant ash is known as 'Bagasse Ash'. Bagasse ash is an agricultural waste fibrous material with presence of silica (SiO_2), at high percentage, and can be used to improve the existing properties of soil [1].

Sugar cane is one of the most significant economic products for many countries like Brazil, India, Pakistan and few of Arab countries like Egypt, Sudan and Iraq [2]. Brazil is the one of the most countries of the world in the production of sugarcane, followed by India, China, Thailand, Mexico, Pakistan, Australia and Cuba. For Arab countries, sugar cane is grown in a few of them, and Egypt is one of the most Arab countries production of sugar cane, followed by Sudan, while grown in limited areas in Iraq, Morocco, Lebanon [2].

One of the conditions for the material to be used as cement replacing materials, it contains large amount of silica and bagasse ash found to be has large amount of silica that make it as an replacing material but after prove its efficiency. Despite this abundance and silica content, relatively little has been done to examine the potential of this material for soil stabilization. Even though little, the conducted researches conform the suitability of this material for soil stabilization as an admixture with lime and cement but its suitability as a standalone material is still questionable and this encourage the work on this material [3].

Sugar cane entered Iraq for the first time in 1969, in Al-Majarr-Al-Kabir fields in Maysan city for the state company for sugar industry a subsidiary of Iraq ministry of industry and minerals. In Maysan, sugar cane implants in Maysan's project and gives the sum of $ 80 ton / ha and sugar by (10%). Table 1 shows the evolution of the cultivation, production and productivity of sugar cane for the period 1970-2008 [2]. Finally, from this table realize that we have resources of waste materials produced from sugar industry which may be invested in roadwork for these days.

Table 1: Evolution of the Cultivation and Production of Sugar Cane (1970-2008)[2].

الانتاجية كغم / هكتار	الانتاج / الف طن متري	المساحة/ الف هكتار	السنة
45108	144.12	3.1950	1970
28572	110.29	3.8600	1971
31036	75.268	2.4250	1972
34944	97.840	2.8000	1973
34944	978.42	28.000	1974
2716.0	104.16	38.375	1975
42700	128.10	3.0000	1976
47220	153.35	3.2475	1977
47436	200.65	4.2300	1978
34964	**221.36**	**9.9050**	متوسط المدة
23332	70.000	3.0000	1991
22388	68.000	3.0375	1995
22440	69.000	3.0750	1996
23332	70.000	3.0000	1997
22873	**69.250**	**3.02825**	* متوسط المدة
9484.0	55.000	5.8000	2007
21244	3.7000	0.1750	2008
15314	**29.350**	**2.9875**	متوسط المدة

2. Study Objective

Disposal of Agricultural waste by safe way is a big problem and the engineers take challenge for safe disposal of these waste materials. Various attempts have been made to improve the strength of soil using different additives and this research work has been focused on use cheaper and locally available waste material (bagasse ash) as additive in soil stabilizing and takes the maximum benefit from it finally try to used it as alternate for traditional additives.

After the development reappear again in industry of sugar in Maysan factory, this means that the environment will getting more agricultural waste material. With the new approach of science which include recycle these waste materials and use it friendly to environment in different approaches especially in highway approach, this has been encouraged the researchers to investigate using these materials.

Using this waste material either to treat the materials used to construct pavement layers or to increase or improve the quality of traditional additive material or reduce the cost of additive by replace a part or all of additives with these waste materials. Therefore and based on this development, the objective of this work is to show the possibility of using sugar cane bagasse ash (SCBA) in road works by utilize the effectiveness of sugar cane bagasse ash to enhance the properties of natural soil that's used to construct subgrade layer in pavement structure and then specify starting point in exploitation these waste materials in road works.

3. Pozzolanic Material

The name pozzolan comes from the town Pozzuoli in Italy. Pozzolans are a broad class of siliceous or siliceous and aluminous materials which, in themselves, possess little or no cementitious value but in finely divided form and in the presence of water it react chemically with calcium hydroxide [$Ca(OH)_2$] at ordinary temperature to form compounds having cementitious properties. The quantification of the capacity of a pozzolan to react with calcium hydroxide and water is given by measuring its pozzolanic activity [4].

The pozzolanic activity of a material primarily depends on two factors: the amount of calcium hydroxide [$Ca(OH)_2$] available for the reaction with the pozzolan and the reaction rate that this combination occurs. The amount of available calcium hydroxide depends on the nature of pozzolan's active phase, pozzolan's chemical properties, SiO_2 content in the pozzolan and the $Ca(OH)_2$/pozzolan ratio in the mixture. The reaction rate depends on physical factors, such as the surface area of pozzolan, the solid/water ratio of the mixture and the temperature [5].

ASTM C 618 [6] requires minmum sum of "SiO_2, Al_2O_3 and Fe_2O_3" for natural pozzolans is greater than 70% and the greater amount of these, the greater its activity. Pozzolanic activity is determined by "strength activity index". For chemical reaction the pozzolans must be amorphous and bagasse ash which considered as pozzolanic material rich in amorphous silica [7].

The benefits of pozzolanic materials is attributed to their physical and chemical characteristics, such as their effects on particle packing and their ability to provide amorphous silica to react with calcium hydroxide during the cement hydration reactions. Amorphous silica solubilizes into an alkaline solution and reacts with Ca^{+2} ions when it comes into contact with water then forming hydrated calcium silicates similar to those produced through cement hydration reactions. Sugar cane bagasse ash has high levels of silica under normal conditions and using suitable calcination parameters (such as controlled calcination temperatures, heating rate and burn time) will keep the silica in the amorphous state [8].

Cement, lime and asphalt or bituminous are most commonly stabilizers used for a long time ago but the high cost of processing it made them expensive and in order to mitigate this problem alternatives to traditional stabilizers is being considered. Several materials such as rice husk ash, pulverized fuel ash, sugar cane bagasse Ash, volcanic ash, silica fume, etc are in use in many countries according to its availability. Natural and artificial pozzolanas are the two types of pozzolanas where, natural pozzolanas are essentially volcanic ashes from geologically recent volcanic activity and artificial pozzolanas result from various industrial and agricultural processes, usually as by-products [9].

4. Bagasse Ash

Bagasse ash is an abundant fibrous waste product derived from sugar-refining industry and readily available for use with low costs. This material requires more attention on its safe disposal and for opportunities to use as recycled material because it poses a risk to the environment increasingly, while bagasse is defined as fibrous residue of sugar cane stalks that remains after extraction of sugar" [10] and that is the difference between bagasse and bagasse ash.

Bagasse is burnt as a fuel in sugar factories and bagasse ash is the result of this burning. This bagasse ash causes environmental problems where dusts from the processing of bagasse and can cause the chronic lung condition pulmonary fibrosis (bagassosis) .As well as bagasse when it is left in the open it ferments and decays; this needs safe disposal of the pollutant, which when inhaled in large doses can result in respiratory disease [11].

Cheapness in produce, ease of use, need for simple equipment and lower or negligible capital inputs all these represent the benefits of using bagasse ash. Bagasse ash as explained above has a high proportion of fiber and to using it as pozzolanic material it became necessary to recondition the samples by re-ashing again at controlled calcination temperature in the laboratory, to exclude the high carbon content.

5. Related Study

Suliman and Fudi Almola [12] presented a general notion describing the relation between the sugar cane bagasse ash and coal fly ash. The notion is as follows: in their study they have been used sugar cane bagasse ash from Kinana & Guenaid sugar factory and they found that, the chemical composition of the sugar cane bagasse ash is similar to class F coal fly ash especially in terms of the total of alumina, silica, and ferric oxide content then it may behave like class F fly ash in its engineering properties. Therefore and according to this study, sugar cane bagasse ash may be successfully used as an engineering material for a wide variety of engineering applications. Table 2 shown chemical composition of fly ash according to ASTM C 618 [6] classification (ASTM C 618 explain that, class F & C fly ashes are commonly used as pozzolanic admixtures for general purpose concrete) and a comparison between chemical compositions of Kinana & Guenaid sugar cane bagasse ash with pulverized coal fly.

Table 2: Comparsion between Chemical Composition of Kinana & Guenaid Sugar Cane and Coal Fly Ash (Class F and C) [12].

Oxide	Guenaid sugarcane bagasse ash (%)	Kinana sugarcane bagasse ash (%)	Class F fly ash (%)	Class C fly ash (%)
SiO_2	56.70	58.03	40 - 63	32 - 42
Al_2O_3	15.52	4.56	17 - 28	15 - 20
Fe_2O_3	6.81	9.69	3 - 12	5 - 7
MgO	9.30	13.71	0.6 - 2	4.1 - 6.1
CaO	4.50	5.85	2 - 8	15 - 35
LOI	6.40	8.66	0 - 5	0 - 0.5

6. Experimental Work

6.1. *Materials*

6.1.1. *Natural Soil*

The natural soil sample used in this research for current experimental tests was collected from the north of Iraq (Duhook) at depth (1.5-2) meter below the natural ground surface. Physical and chemical properties of the soil sample are shown in Table 3 and the specific gravity (Gs) of soil is (2.7). The soil is classified (CH) according to unified soil classification system (USCS) and A-7-6 class according to american association of state highway and transportation officials (AASHTO) soil classification system and the soils under this class are generally of poor engineering use.

Table 3: Physical and Chemical Properties of Soil Sample

Index Property	Index Value
Liquid limit, L.L	71.9
Plastic Limit, P.L	24
Plasticity Index, PI	47.9
Specific Gravity, G_S	2.7
Maximum Moisture Content, % OMC	21.9
Maximum Dry Density, MDD (gm/cm^3)	1.59
Soil Symbols (USCS)	CH
Soil Symbols (AASHTO)	A-7-6
pH	8.45
Total Soluble Salts, T.S.S	0.35

6.1.2. *Sugar Cane Bagasse Ash (SCBA)*

Sugar cane bagasse ash which is utilized in this project is taken from Maysan factory for sugar production which is located in Al-Majarr-Al-Kabir in Maysan about 30 Km southing Amarah city. The burning of bagasse of sugar cane produces bagasse ash.

The sugar cane bagasse ash (SCBA) used in this study was made from sugar cane bagasse. Firstly, sugar cane bagasse was washed by water to remove unwanted materials such as sand grains and dried in air for 3 to 4 days then calcining it. Thermo oven is used and calcination temperature setting at 600°C, which produces an increase in the pozzolanic activity index as shown by Cordeiro et al. [8, 13]. Bagasse ash obtained was pulverized and passed firstly through sieve No. 40, for check by removing unburnt and large size particles, and finally through sieve No. 200 to obtain final bagasse ash stabilizer. Production stages, especially stages of the burning and pulverizing, were made by special sector and helping from some person all contributed to produced this production as final step.

Specific gravity of bagasse ash is found to be very less (1.93) and this may be due to its fibrous nature and very light in weight, Fig. 1 shows a sample of bagasse ash used in this study, (a) for bagasse before drying stage and (b) for bagasse ash.

Figure 1 (a): Bagasse before Drying Stage.

Figure 1 (b): Sample of Bagasse Ash Stabilizer.

The chemical composition analysis of the ash was carried out by national center for construction laboratories and researches and Table 4 shows this chemical compositions.

Table 4: Oxide Composition of Bagasse Ash.

description	*abbreviation*	*Ash (%)*
Silica	SiO_2	64.22
Iron	Fe_2O_3	3.85
Calcium	CaO	4.05
Magnesium	MgO	2.30
Alumina	Al_2O_3	4.50

(*) Tests are carried out by NCCL

The standard requirement according to ASTM C 618[6] for pozzolanic materials that the combined percent composition of SiO_2, Al_2O_3 and Fe_2O_3 is as below:
Fly Ash (class C & F)

- ✓ Class C → from lignitide or subbituminous coals (SiO_2+Al_2O_3+Fe_2O_3>50%)
- ✓ Class F→ from bituminous coals (SiO_2+Al_2O_3+Fe_2O_3>70%)
- ✓ Class N→ from natural (SiO_2+Al_2O_3+Fe_2O_3>70%)
- ✓ While in silica fume → $SiO_2 \approx$ 85-98%

The results indicate that bagasse ash regarded as pozzolanic materials because (SiO_2+Al_2O_3+Fe_2O_3>70%) and this sumution is adequate to meet the requirement of ASTM C 618 [6] for pozzolanic materials as class N (natural pozzola) as shown in Table 5 according to ASTM C 618[6].

Table 5: Chemical Requirements for Pozzolana Materials [6].

	Class		
	N	F	C
Silicon dioxide (SiO_2) plus aluminum oxide (Al_2O_3) plus iron oxide (Fe_2O_3),min, %	70.0	70.0	50.0
Sulfur trioxide (SO_3),max, %	4.0	5.0	5.0
Moisture content, max, %	3.0	3.0	3.0
Loss on ignition,max, %	10.0	6.0[A]	6.0

7. Sugar Cane Bagasse Ash Calcination

Calcination changes some characteristics of the powder that might affect its reactivity. By controlled calcinations it is possible to keep silica of sugar cane bagasse ash in the amorphous state especially it has high levels of silica. Cordeiro et al. [8, 13] showed that burning ashes between 400°C and 600°C produces an increase in the pozzolanic activity index due to the loss of carbon during the calcination process. At a firing temperature of 800°C formation of crystalline silica compounds is observed and these compounds causing a drop in the pozzolanic activity index.

Paula et al [14] noted that: for a calcination temperature of 600°C for a period of 6 hours, it is possible to obtain ash with Sio_2 content 84 wt%. They suggest that the optimal temperature for the production of pozzolanic sugar cane bagasse ash is 600°C because at this temperature it is possible to generate predominantly amorphous silica with a good pozzolanic activity index.

8. Sample Preparation

Basic laboratory test like compaction (OMC and MDD) was carried out on soil sample (with and without bagasse ash) to determine the basic properties of all samples. Laboratory tests samples of soil with and without admixtures prepared by mixing the required quantity of soil and stabilizer in preselected proportions in dry state and all results are discusses by graph and tables below. The samples used in the research work are soil and soil stabilized with varying percentages i.e. (3, 5, 7, 10, 15, 20, 25 & 30%) of SCBA individually. All the materials are taken in dry form and mixed manually. Before mixing process, soil was air dried and broken into pieces in the laboratory then kept in an oven at 110°C temperature for 24 hrs to remove water and then drying. Agricultural waste bagasse ash is also kept in oven for maintaining the dry form of the ash finally the test procedure is conducted. Soil properties with addition of SCBA are tested to determine the following.

A. *Index Properties (LL, PL, PI And Specific Gravity)*
B. *Compaction Properties (OMC And MDD)*

9. Test Results

A. Index Properties Test Methods

The results of index properties tests on the soil without and with different percentage of SCBA are shown in Table 6. All tests made according to standard tests. The liquid limit test was conducted using Casagrande's liquid limit apparatus as per the procedures laid down in ASTM D 4318-00 [15] and plastic limit as per the specifications laid down in ASTM D 4318-00 [15]. Finally, specific gravity test was done according to ASTM D 854- 00 [16].

Table 6: The Results of Index Properties of Soil with and without SCBA

%	%L.L	%P.L	%PI	Gs
0	71.9	24.0	47.9	2.7
3	70.8	23.6	47.2	2.69
5	68.0	21.1	46.9	2.67
7	67.3	21.0	46.3	2.65
10	65.8	20.0	45.8	2.64
15	64.1	19.0	45.1	2.61
20	62.9	18.3	44.6	2.57
25	64.8	19.8	45	2.53
30	67.0	22.0	45	2.50

The reduction in plasticity index and increases in durability plus strength is the most common quality improvements which are achieved through stabilization [17]. Reduction in plasticity index gives higher workability for stabilized soil and Table 6 shows slightly reduction in plasticity index for addition bagasse ash and this mean positive indicator from using bagasse ash as stabilizer for soils having problem in its workability. The effect of bagasse ash on the liquid and plastic limit of the soil is shown in Fig. 2 and 3.

As shown in Fig. 2 liquid limit (L.L) slightly decreased with increment in bagasse ash content until 20% bagasse ash at which the reduction is about (9%) after that L.L increase to (67%) for 30% bagasse ash stabilized soil. The addition of bagasse ash also decreases the plastic limit (P.L) of stabilized soil as shown in Fig. 3. The decrease is observed to be more with the increase in the quantities of bagasse ash up to 20% by about (5.7 %) reduction and then P.L increase to be (22%) for 30% bagasse ash.

Finally For both liquid and plastic limits, the final value at 30% bagasse ash is slightly lower than it for nature soil and the reduction is about (4.9%) for liquid limit , (2%) for plastic limit and (2.9%) for plasticity index all at 30% bagasse ash. These reductions are due to the partial replacement with bagasse ash which is non plastic material and flocculation and agglomeration of clay particles caused by cation exchange may be the other test results [3].

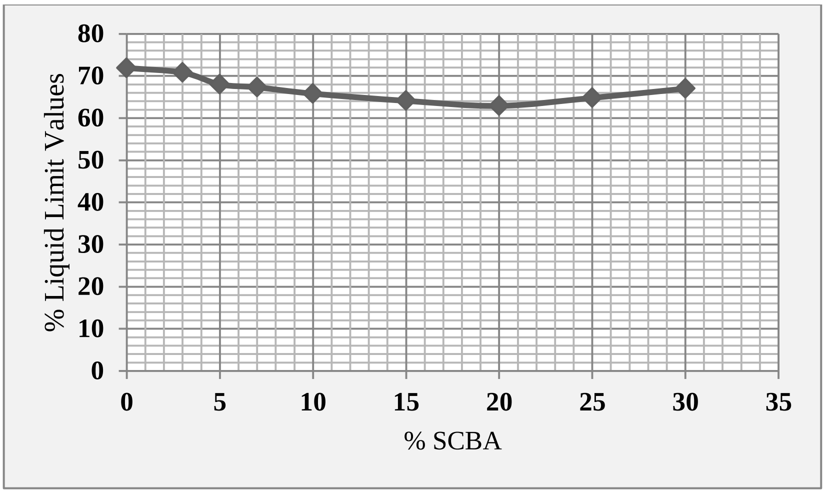

Figure 2: The Effect of Bagasse Ash on Liquid Limit (L.L)

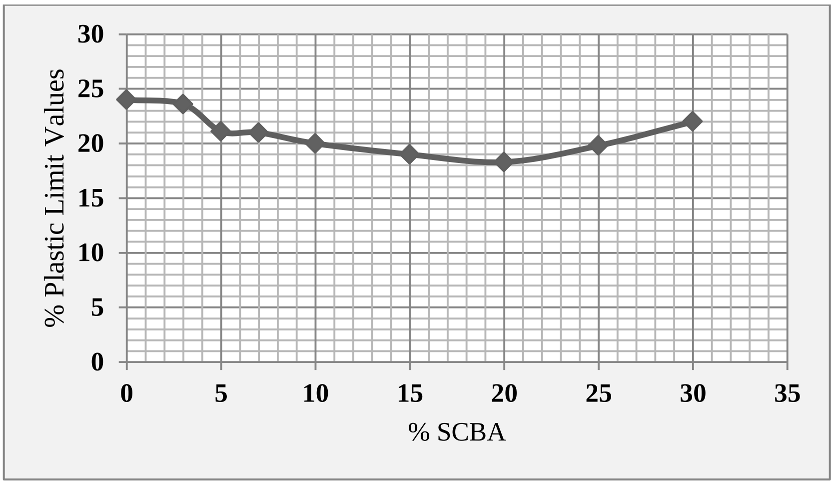

Figure 3: The Effect of Bagasse Ash on Plastic Limit (P.L)

For specific gravity, Fig. 4 shows a reduction in its value with addition of bagasse ash content from (2.7) of nature soil to (2.5) for 30% bagasse ash stabilized soil and the reduction is about (0.2%)

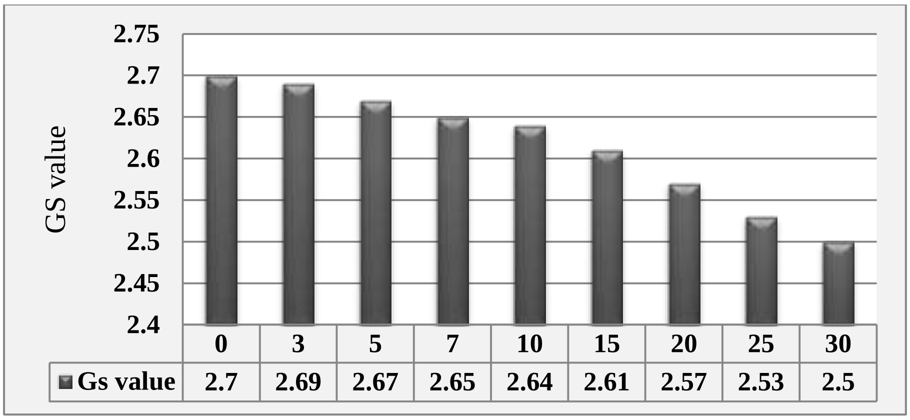

Figure 4: The Effect of Bagasse Ash on Specific Gravity (Gs)

B. Compaction Test Methods

The variation of OMC and MDD with the different percentages of SCBA is shown in Fig. 5 and 6 respectively below and their details are given in Table 7. The standard compaction tests were performed in accordance with (ASTM D 698) [18]. The moisture content determinations are performed in accordance with (ASTM D 2216 – 05) [19].

Table 7: The Variation of OMC and MDD with Bagasse Ash

%	%OMC	MDD g/cm^3
0	21.9	1.59
3	22.6	1.55
5	24.14	1.51
7	25.0	1.49
10	25.52	1.35
15	27.57	1.32
20	27.77	1.26
25	30.72	1.18
30	34.52	1.11

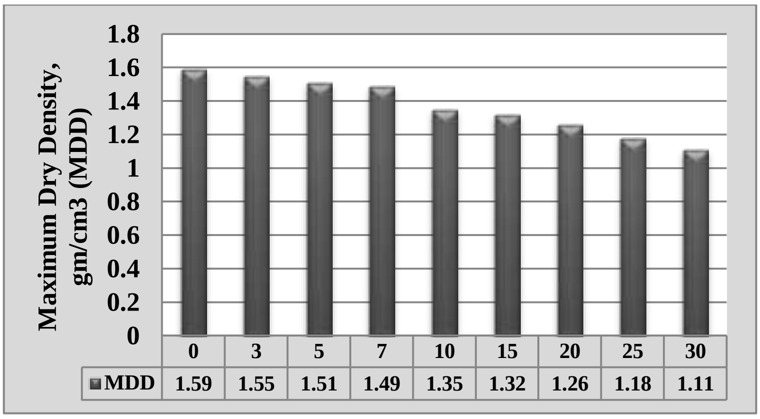

Figure 5: Variation of MDD with the Different Percentages of Bagasse Ash

The MDD values of the treated sample by SCBA decreased with the increasing of bagasse ash content while on the contrary with OMC values , where OMC increased with higher bagasse ash content as shown in Fig. 5 and 6. the addition of bagasse ash to soil decreases the MDD from (1.59) g/cm^3 for nature soil to (1.11) g/cm^3 for 30% bagasse ash stabilized soil where the reduction is about (30.2%) and increases the OMC from (21.9%) to (34.52%) and the increase is about (57.6%) .

The general drop in MDD could be a result of the flocculated and agglomerated of fine particles (caused by cation exchange) and then occupying larger spaces leading to corresponding decrease in dry density [20, 21]. Also, the drop in density with higher stabilizer content may be attributed to the replacement of soil particles with specific gravity of 2.7 in a given volume by particles of the stabilizer (SCBA) which has a comparatively lower specific gravity of 1.93.

The increase of OMC with higher bagasse ash content may be as result to the lime in bagasse ash where it's dissociated in the presence of water into calcium and hydroxyl ions either of two situations arose. The calcium ion either replaced cations of other elements present at the exchange sites in the soil or the calcium ions were absorbed by the soil if there were other unattached anions apart from hydroxyl ions on the soil surface. Finally the increase in OMC was mostly due to pozzolanic reaction of lime in bagasse ash with clay fraction of the soil in conformity with Ola [20]. Also it may relate to decrease of dry density which means more voids is available for water (or higher water content). The increase in OMC has positive effect which is explained in using bagasse ash stabilizer for soils that having high water content and problems in compaction process.

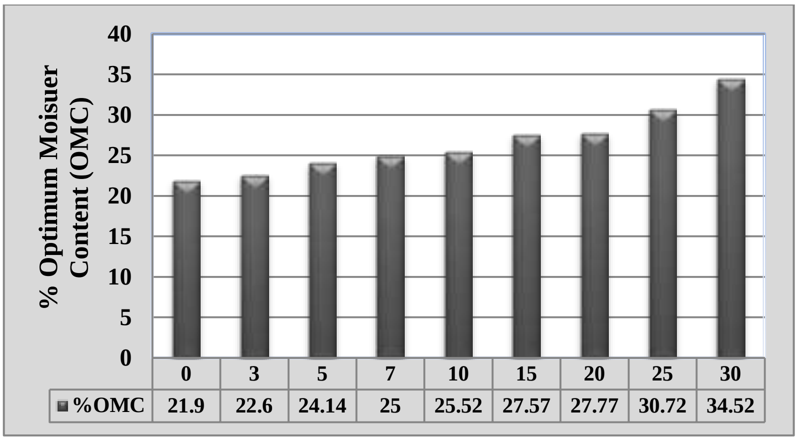

Figure 6: Variation of OMC with the Different Percentages of Bagasse Ash

10. Conclusions

1. Bagasse ash can be used as stabilizer materials especially in the sugar production areas where its availability is high and the south of Iraq flourishes in cultivation of sugar cane.
2. The MDD and OMC of the treated sample generally showed trends of decrease and increase, respectively, with higher bagasse ash content. The addition of bagasse ash to soil decreases the MDD from (1.59) g/cm^3 for nature soil to (1.11) g/cm^3 for 30% bagasse ash stabilized soil where the reduction is about (30.2%) and increases the OMC from (21.9%) to (34.52%) and the increase is about (57.6%) .
3. For both liquid and plastic limits, the final value at 30% bagasse ash is slightly lower than it for nature soil and the reduction is about (4.9%) for liquid limit , (2%) for plastic limit and (2.9%) for plasticity index all at 30% bagasse ash.
4. Bagasse ash may be used as stabilizer for soils of higher water content and or soils having problems in its workability where, using it as stabilizer reduce plastic limit, liquid limit and plasticity index and this reduction in plasticity index gives higher workability so that using it provides the possibility to compact the soils of higher water content with lower efforts.
5. The chemical test results indicate that bagasse ash regarded as pozzolanic materials because (SiO_2+Al_2O_3+Fe_2O_3>70%) and this sumution is adequate to meet the requirement of ASTM C 618 for pozzolanic materials as class N (natural pozzola).

11. Recommendation

1. Complete the research work with strength test (like unconfined compressive strength test, triaxial test, CBR test and others) and durability test (like wet & dry and vacuume tests) to specified the possibility of use waste materials (bagasse ash) as stabilizer for roads with high traffic and if the results was positive this means probability of significant evolution will appear in country by availability cheaper additive materials.
2. Repeat all this research work on southern soils and show the effect of sugar cane bagasse ash on these soils, availability bagasse ash in this region means low or neglected cost for transport and this mean another benefit appear for using bagasse ash.

12. Notation Used in This Study

Table 8: Used Notation

SCBA	*Sugar Cane Bagasse Ash*
OMC	Optimum Moisture Content
MDD	Maximum Dry Density
G_S	Specific Gravity
CBR	California Bearing Ratio

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