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Expansive Soil Stabilization Using Marble Dust and Bagasse Ash

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Abstract: ***This research is an attempt to investigate the effect of marble dust and bagasse ash on the stabilization of expansive soils. Expansive soils are always characterized by their high expansion, high moisture content, high compressibility, high shrinkage on drying along with wide polygonal cracks and sufficient swelling on wetting. Expansive soils (problematic soil) are present in different parts of the world and extensively found in many locations particularly in Pakistan. In KPK province we select five different sites and collect soil sample and determine their index properties. While selecting sites we visually inspect the soil and collect soil sample from area having wide cracks in soil in dry condition. From the index properties of all the soil samples, district Bannu soil were classified as expansive soil having liquid limit greater than 50% and plasticity index greater than 30%. Currently different techniques are in use for improvements of expansive soil but most of them are uneconomical. For expansive soil improvement we use marble dust and baggase ash which are already burden on our natural environment. Utilizing these wastes for the improvement of expansive soil will be the best alternative. Different lab tests on expansive soil without the addition of these waste and with the addition of these waste were performed and their effect on swelling and other properties were determined. Finally, marble dust and baggase ash can be utilized to treat and stabilize the expansive soil as economical alternative to Portland cement and other (expensive) chemical stabilizers. The use of baggase ash and marble dust for stabilization applications is an economical and environmental solution of the problems associated with its disposal process.***

Keywords: Expansive soil, Expansive index, Swell pressure, Bagasse ash, marble dust.

1. Introduction

Expansive soils are those that experience significant volume changes associated with changes in water contents. It expands when water is added and shrinks when they dry out. An expansive soil expands due to the presence of highly reactive clay minerals such as montmorilonite and smectite. This continuous change in soil volume can cause light structure built on this soil to move unevenly and crack. This damage is more than twice the damage from floods, hurricanes, tornadoes, and earthquakes combined (Jones and Holtz, 1973). Problem of expansive soils has appeared as cracking and break-up of pavements, roadways, building foundations, slab-on-grade members, channel linings, irrigation systems, water pipelines, sewer lines and gas pipeline. Soils sample were collected from five different districts including district Swat, Bannu, Mardan and Peshawar (Site 1 & 2) and their index properties were determined. From the index properties of the entire soil sample district Bannu soil were considered as expansive soil having liquidlimit greater than 50% and plasticity index greater than 30%. Generally main properties of expansive soil are swelling properties which affect both the long and short term stability of the structure foundation built on this soil. Therefore it is necessary to improve the soil properties to avoid damages to the structure. Bagasse ash and marble dust are used to improve the properties of expansive soil which are available in large amount and are produced in huge amount by the sugar cane and marble industry. Bagasse ash is high in silica, calcium, and other minerals. Bagasse ash and marble dust are added in 0%, 4%, 8% and 12% separately and the results were compared.

2. Materials and Methods

In this study marble dust are used which are taken from marble industry (Haji khan marble industry) located near Rashakai interchange motorway. Similarly bagasse ash is collected from the sugar mills Mardan. Expansive soil are collected from kosha village, tehsil domail, district Bannu.

Figure 1: Satellite image of kosha village, tehsil domail, district Bannu

3. Selection of Sites

While selecting sites for collecting expansive soil sample we visually inspect the ground surface. Expansive soils can be easily recognized in the dry season by the deep cracks (a yardstick can be easily inserted), soil is rock hard when dry,

but very stiff and sticky when wet and the crack width exceed 1 inch and resemble the shape of polygon as shown in the figure 02.

Figure 02: [a] width of the crack, [b] depth of the crack
Crack pattern of expansive soil

4. Damage to Structure Foundation Due to Expansive Soil

Problems of expansive soil has appeared as cracking of building foundations, channel, break-up of pavements, sewer lines, water pipe lines, gas pipe lines and irrigation systems. In the United States damage caused by expansive clays exceeds the combined average annual damage from floods, earthquakes, hurricanes and tornadoes (Jones and Holtz, 1973). Expansive soils damage foundation by uplift pressure when moisture increase and lift up lightly loaded and result cracks in continuous strip footings. Such uneven movement and cracking of foundation can cause distress to the rest of the structure.

Figure 3: Crack pattern in [a]ground floor and [b]pavement due to expansive soil

5. Preparation of Samples

The index properties of the soil are first determined in their natural form and then marble dust and bagasse ash were mixed at different percentage (4%, 8% and 12%).
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6. Test Program

Atterberg liquid limit test, plastic limit, shrinkage limit, specific gravity, expansive index and dry density test were carried out for both natural soils and with the addition of marble dust and bagasse ash with three different percentages (4%, 8% and 12%) the following laboratory test were carried out.

6.1 Liquid Limit Test

The test procedures of liquid limit is performed by ASTM D 4318-05

6.2 Expansion Index

The test procedures of expansion index is performed by ASTM D 4829

Figure 4: Expansion index test

6.3. Permeability Test

The test procedures of falling head test is performed by ASTM D 2166

6.4. Dry Density Test

The test is performed according to standard Proctor test.

7. Stabilization Material

Sugarcane bagasse ash and marble dust are used as stabilization material. Bagasse ash was collected from sugar mills, district Mardan. On visual inspection bagasse ash were appeared as black color. Chemical properties of bagasse ash are determined and are expressed as:

Table 1: Chemical properties of bagasse ash

Chemical properties of bagasse ash		
S.No	Chemical element	Percent by weight
1	Sio_2	63.45
2	Al_2o_3	10.34
3	Fe_20_3	7.68
4	K_2o	2.64
5	Cao	8.84
6	So3	1.0
7	Mn	0.4
8	Cu	0.2
9	Zn	0.3
10	Na_2o	1.77
11	P_2o_5	2.23

Marble dust was obtained from local marble industry near Rashaki interchange district Mardan. White marble dust waste was obtained from the industry having water absorption value 0.93%. Chemical properties were determined and are expressed as:

Table 2: chemical properties of marble dust

Chemical properties of marble dust	
Oxide compounds	Marble dust percent by weight
Sio_2	26.53
MgO	18.31
CaO	38.45
Fe_20_3	13.70
Al_20_3	0.39
Density	2.83 (gm/cm^3)

Figure 5: Stabilization material (bagasse ash, marble dust) collected from local factory,

8. Properties of Stabilized Soil

The soil sample was collected from kosha village,tehsil domail district Bannu region. Various tests like liquid limit, plastic limit, plasticity index, expansive index, dry density, direct shear test and swell potential were determined. The percentage of bagasse ash is kept 0%, 4%, 8% and 12% respectively and the entire tests are conducted. The results show that when the percentage of bagasse ash and marble dust is increased in the soil sample, all the index properties decrease whereas is dry density increased. The table shows the laboratory test.

Table 3: Test result

Marble dust	LL	PL	PI	EI	SP (psi)	r_d(gm/cm^3)
0%	54	23	31	13	9.02	1.51
4%	48	21	27	11	7.64	1.51
8%	41	20	21	94	6.94	1.627
12%	36	18	18	83	5.56	1.564
Bagasse ash						
4%	42	23	19	12	6.25	1.6
8%	39	22	17	12	4.86	1.61
12%	37	20	17	10	4.72	1.507

LL=Liquid limit
PL= Plastic limit
PI= Plasticity index
EI=Expansive index
Sp=Soil uplift pressure
r_d = Dry density

9. Graphical Representation of Liquid Limit Test Result"

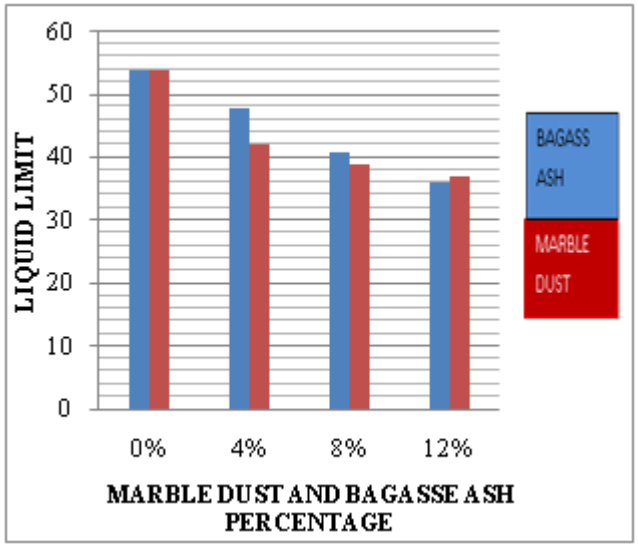

Figure 6: Relationship between liquid limit and percentage of marble dust and bagasse ash

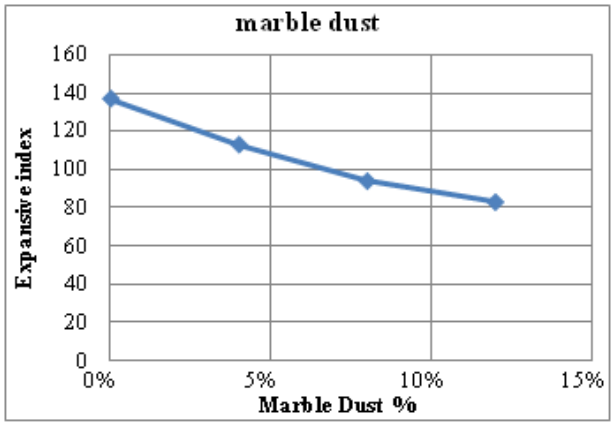

Figure 7: Relation between expansive index and percentage of marble dust.

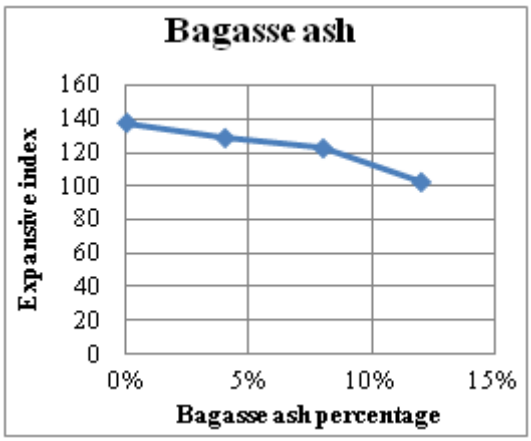

Figure 8: Relation between expansive index and percentage of bagasse ash.

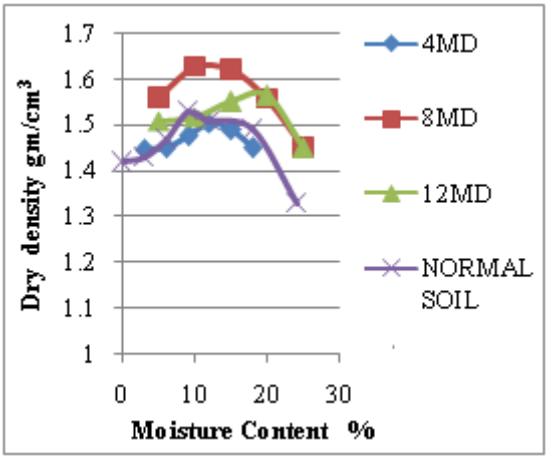

Figure 9: Moisture - dry density relationship with the addition of 4%, 8% and 12% marble dust

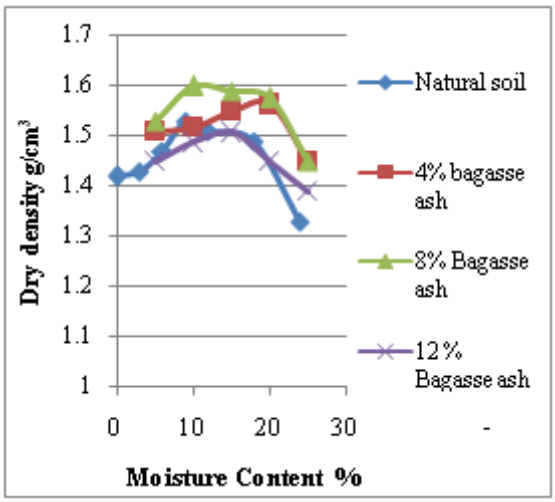

Figure 10: Moisture - dry density relationship with the addition of 4%, 8% and 12%bagasse ash

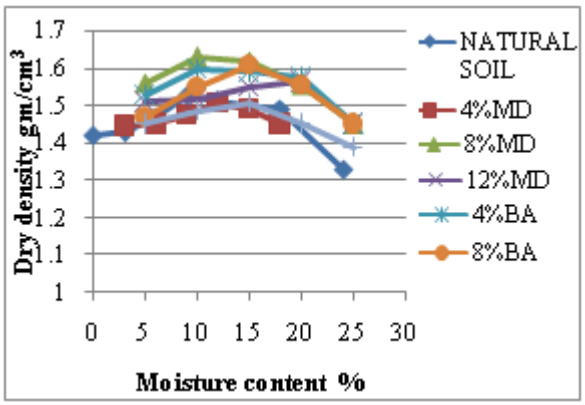

Figure 11:.Moisture – Dry density relationship with the addition of marble dust and bagasse ash

10. Conclusion and Discussion

According to Unified Soil Classification System (USCS), the Bannu soil classified as CH group. Stabilization of soil by using industrial waste such as marble dust and bagasse ash is successfully improving the poor properties of expansive soil. Marble dust and bagasse ash are available locally in large quantity, thus it is an economical way of soil stabilization. Marble dust and bagasse ash are directly disposed off into the river which affect the aquatic life and are already burden on our natural environment. Thus it is best alternative to utilize these wastes for the improvement of local expansive soil. Addition of 4%, 8% and 12% marble dust and bagasse ash are led to reduce the liquid limits, plastic limits, plasticity index and expansive index.Thus increasing in marble dust and bagasse ash reduce the index properties of expansive soil. Addition of 12% marble dust reduce soil uplift pressure from 9.02psi to 5.56psi where as 12% bagasse ash reduce soil uplift pressure from 9.02 psi to 4.72psi which shows that bagasse ash is more effective in decreasing the soil uplift pressure. Dry density of expansive soil also increase with the addition of marble dust and bagasse ash and remain maximum approximately at 8% addition but again decline with the addition of 12% marble dust and bagasse ash.

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