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IMPROVING THE ENGINEERING PROPERTIES OF EXPANSIVE SOIL BY USING SOLID PLASTIC WASTE WITH BRICK POWDER

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ABSTRACT

Expansive soil covers more than 20% of India's land area. It can be found throughout India, including Madhya Pradesh, Maharashtra, Andhra Pradesh, Gujarat, Tamil Nadu, and Karnataka. Excessive amounts of clay and open space in a soil might cause unfavorable changes in volume. The volume of the soil varies along with variations in the amount of water present.

The quantity of water in expanding soil has long been a source of concern for engineers. This stress manifests itself for geotechnical engineers as a persistent concern about expansive soil uplift brought on by variations in the moisture content of foundation soil. Longitudinal fractures on pavements are a major concern for pavement engineers when the subgrade soil is expansive and has significant seasonal moisture fluctuations.

This article presents the findings from an experiment anchoring loose soil with brick powder and solid plastic wastes to enhance its geotechnical qualities. Basic properties like strength, stiffness, and permeability are anticipated of all materials, even those that don't make the cut. Engineers are expected to devise solutions to improve the ground if these claims are untrue. Researchers are examining if Brick Powder can be used to stabilize very expansive clay soil due to the growing cost of standard stabilizing agents like lime and cement and the necessity to employ industrial and agricultural wastes in engineering in a cost-effective way. Brick powder is an industrial waste with potential applications in building materials provided it meets the necessary mechanical, chemical, and physical requirements. The purpose of this study is to determine the binding power of brick powder and solid plastic waste for clay soil. The soil samples were sorted using index qualities as part of the lab procedure. The soils in this class are typically not suitable for construction. The geotechnical characteristics of stabilized soil will be assessed and compared to standards using several methods, including Atterberg limits, grain size analysis, specific gravity, free swell test, compaction, and CBR testing. To stabilize the soil, brick powder was added at 5, 10%, 25%, and 50% of its dry weight. The soil was improved by adding 0.25 %, 0.5%, 0.75 %, and 1% of plastic waste strips.

KEYWORDS

Brick Powder, plastic Strips, CBR, Proctor test, Liquid Limit, Soil Stabilization.

I. INTRODUCTION

Expanding Soil expands when it has more water in it and contracts when it has less. This is due to a kind of clay mineral known as montmorillonite. Small or light structures with low overburden pressure are more vulnerable to deterioration. The structure becomes less functional due to uneven shrinking and growing, which can also result in little cracks or even massive cracks that allow the structure to collapse. It has been demonstrated that extensive soil can lead to economic loss and property damage. In places with expansive soil, the appropriate action should be done to address the issue before construction begins. Expansion soil can be worked with more easily and its natural swelling and expansion can be reduced in a variety of ways.

Expansive soils also contract or become compacted when they dry out. A house or other structure may become less stable as a result, sinking and sustaining damage. Large cracks and fissures may also appear in the soil.

For a long time, geotechnical engineers have faced difficulties in performing lightly laden foundations on expanding clays due to the large volume changes these soils experience with variations in water content. When wet, this volume change manifests as swelling or collapsing, and when dry, it manifests as shrinking. Uneven variations in soil moisture can result in significant ground movement, which can lead to cracks and other damage.

Numerous research have examined the significance of utilizing lime as a binder to modify the characteristics of expansive soils, including decreasing their flexibility, decreasing their propensity to inflate and collapse, and increasing their shear strength. The majority of this research demonstrates the beneficial effects of lime on soil strength and decreasing edema. Under these circumstances, the primary issue is the failure to consider the behavior of the soil under various operational stressors and the dry side of OMC (the unsaturated zone). Here, the question is if there is a chance of collapse or if, in the event that a soil is stabilized with lime at the OLC and prepared with less water than is ideal, there will be almost no swelling potential. It is currently unclear whether results from one state of unsaturated soil can be utilized to anticipate how unsaturated soil would behave at varied moisture contents and operating loads. Some research has examined a specific state on the dry side of the OMC.

II. MATERIALS

a) Collection of brick work

b) Collection of water bottle

c) Water

III. METHODOLOGY

A. Prior to treatment and testing

The sample was prepared in accordance with ASTM D421, thus that is how it was done. This procedure involves breaking up the dirt lumps using a mallet wrapped in rubber. Sieve analysis is then used to divide the dried soils into two groups. For the Atterberg limits and the free swell test, the first group is creating uniform samples. For the California bearing ratio test and the compaction test, the second group is creating uniform samples. To ensure that the mix ratio is the same in every test, the soil and Brick Powder are then manually combined. Here, the laboratory data from the gathered samples are combined and examined for both the subgrade soil that is naturally occurring and the soil that has been marble-treated. This facilitates the process of viewing the outcomes and drawing conclusions.

B. Tests Executed On Sub Grade Soil

a) Grain size analysis

b) Atterberg limits

c) Standard Proctor Compaction Test

d) California Bearing Ratio Test (CBR Test).

a) Grain Size Analysis

Grain size analysis is used to calculate the percentage of soils that can pass through different sieve holes with different dimensions. The standard (ASTM D6913M-17, 2017) was followed in conducting a wet sieve test to return sticky soil particle size to initial dimensions. This was achieved by first immersing and cleaning the soil particles in water, and then utilizing a mechanical device to sieve the residue.

b) Atterberg limits

The goal of the Atterberg limit test is to measure the soil's flexibility so that the findings can be used as an index parameter to categorize the soil. The cone penetration method was applied to ascertain the soil's liquid limit. The amount of water in the soil that causes it to change from being soft to semisolid and lose its ability to be classified as plastic is known as the "plastic limit." This can be ascertained by rolling a dirt paste on a 3 millimeter-diameter piece of glass until it starts to crumble.

c) Compaction characteristics

A traditional soil compaction test was performed to ascertain the ideal soil moisture content as well as the maximum feasible dry density. A minimum of three experiments were conducted wherein air-dried soil samples were exposed to 25 blows per trial at three distinct strata. The top of the mold is removed once the dirt has been compacted, and the weight of the soil is calculated by calculating how much it has grown. Furthermore, the volume of water confined in the compacted earth is determined. Using the densities and moisture contents discovered in the compacted soil trials, a graph of dry density vs moisture content is produced.

d) Californian bearing ratio (CBR)

CBR is the percentage of force per unit area needed to penetrate a mass of soil using a typical 50 mm diameter circular plunger moving at a 1.25 mm/min pace. This is contrasted with the force needed to complete the identical operation in a material that is thought to be standard. Usually, the ratio is calculated with a penetration that ranges from 2.5 to 5 millimeters.

e) Direct shear box test

The direct shear apparatus, also referred to as the direct shear device, was employed to perform tests on soil plastic waste composite specimens that were divided in half horizontally and measured 100 millimeters by 30 millimeters in height, as seen in Figure 3.10 below.

The shear box's inner side, or what may be considered its diameter, as well as its area were measured. Care was taken to make sure that the top and bottom halves of the shear box were brought into contact with one another and fixed in place. For every specimen, the weight of the soil or the soil mixed with PET plastic waste was measured and found to be 150g. The sample was thoroughly and uniformly mixed with the necessary amount of water to reach the specimen's ideal water content after the compaction test results were obtained. The funnel was used to put three layers of saturated soil or soil-PET plastic waste mixture in the shear box. Each layer was compacted using a manual tamper. There were fifteen blows delivered to each stratum. The top of the soil or the soil-PET plastic waste composite in the shear box was carefully covered before being transferred to the direct shear box machine. The goal of doing this was to avoid any contamination (digishear).

IV. RESULTS AND DISCUSSION

RESULTS AND OBSERVATION TABLE FOR PROCTOR TEST:-

Table 1 Liquid limit results for Normal soil

Sample No	1	2	3	4
Penetration	16	19	23	25
M1	30.71	35.73	39.35	40.92
M2	26.937	30.627	33.967	34.29
M1-M2	3.773	5.103	5.383	6.63
M3	13.44	14.09	18.58	16.44
M2-M3	13.497	16.537	15.387	17.85
w	27.95	30.86	34.98	37.14
AVERAGE	32.73			

Table 2 Liquid limit results for Mix 1

Sample No	1	2	3	4
Penetration	17	20	22	23
M1	33.5775	36.5575	37.8175	41.2775
M2	29.47	31.65	32.36	35.28
M1-M2	4.1075	4.9075	5.4575	5.9975
M3	13.05	14.4	14.6	16.54
M2-M3	16.42	17.25	17.76	18.74
w	25.02	28.45	30.73	32.00
AVERAGE	29.05			

Table 3: Liquid limit results for Mix 2

Sample No	1	2	3	4
Penetration	16	18	22	25
M1	31.21	34.77	38.85	41.38
M2	27.89	30.93	34.22	35.24
M1-M2	3.32	3.84	4.63	6.14
M3	14.1	16.2	18.69	16.54
M2-M3	13.79	14.73	15.53	18.7
w	24.08	26.07	29.81	32.83
AVERAGE	28.20			

Table 4 Liquid limit results for Mix 3

Sample No	1	2	3	4
Penetration	15	17	20	25
M1	32.28	35.87	36.81	42.03
M2	28.81	31.79	33.05	36.51
M1-M2	3.47	4.08	3.76	5.52
M3	14.05	15.06	18.4	16.54
M2-M3	14.76	16.73	14.65	19.97
w	23.51	24.39	25.67	27.64
AVERAGE	25.30			

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Table 5 Liquid limit results for Mix 4

Sample No	1	2	3	4
Penetartion	14	18	21	24
M1	26.792	29.772	33.032	34.492
M2	23.91	26.33	29.71	30.25
M1-M2	2.882	3.442	3.322	4.242
M3	11.05	12	16.5	14.12
M2-M3	12.86	14.33	13.21	16.13
w	22.41	24.02	25.15	26.30
AVERAGE	24.47			

Table 6 Grain size analysis results for normal soil

Sieve Size	Retained	Cumulative Retained	W.t. Retained	Passing (%)
19	0	0	0	100
4.75	0	0	0	100
2	2	2	0.4	99.6
0.425	1	3	0.6	99.4
0.075	356	359	71.8	28.2
Pan				
Total	359			
Gravel (%) 0%		Sand (%) 71.8	Silt and Clay (%) 28.2	

Table 7 Grain size analysis results for Mix1

Sieve Size	Retained	Cumulative Retained	W.t. Retained	Passing (%)
19	0	0	0	100
4.75	0	0	0	100
2	2	2	0.4	99.6
0.425	4	6	1.2	98.8
0.075	392	398	79.6	20.4

Pan				
Total	398			
Gravel (%) 0%		Sand (%) 79.6	Silt and Clay (%) 20.4	

Table 8 Grain size analysis results for Mix 2

Sieve Size	Retained	Cumulative Retained	W.t. Retained	Passing (%)
19	0	0	0	100
4.75	0	0	0	100
2	2	2	0.4	99.6
0.425	9	11	2.2	97.8
0.075	411	422	84.4	15.6
Pan				
Total	422			
Gravel (%) 0%		**Sand (%)** 84.4	**Silt and Clay (%)** 15.6	

Table 4.9 Grain size analysis results for Mix 3

Sieve Size	Retained	Cumulative Retained	W.t. Retained	Passing (%)
19	0	0	0	100
4.75	0	0	0	100
2	1	1	0.2	99.8
0.425	5	6	1.2	98.8
0.075	435	441	88.2	11.8
Pan				
Total	441			
Gravel (%) 0		Sand (%) 88.2	Silt and Clay (%) 11.8	

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Table 4.10 Grain size analysis results for Mix 4

Sieve Size	Retained	Cumulative Retained	W.t. Retained	Passing (%)
19	0	0	0	100
4.75	1	1	0.1	99.9
2	2	3	0.6	99.4
0.425	4	7	1.4	98.6
0.075	455	462	92.4	7.6
Pan				
Total	462			
Gravel (%)		Sand (%)	Silt and Clay (%)	
0%		92.4	7.6	

COMPACTION CHARACTERISTICS

Table 4.11 Moisture content with Dry density for normal soil

Moisture Content	1.94	7.99	9.16	10.80	12.69	14.58	16.57
Dry Density	1.570	1.651	1.669	1.697	1.715	1.704	1.623

Table 4.12 Moisture content with Dry density for Mix 1

Moisture Content	6.76	8.69	9.80	11.39	13.81	16.07
Dry Density	1.664	1.691	1.705	1.723	1.727	1.683

Table 4.13 Moisture content with Dry density for Mix 2

Moisture Content	5.34	6.54	8.66	10.20	13.11	15.06
Dry Density	1.688	1.701	1.720	1.735	1.748	1.697

Table 4.14 Moisture content with Dry density for Mix 3

Moisture Content	4.79	7.39	9.39	10.91	13.34	15.31
Dry Density	1.684	1.713	1.740	1.760	1.765	1.708

Table 4.15 Moisture content with Dry density for Mix 4

Moisture Content	5.25	6.59	8.74	10.13	13.21	15.11
Dry Density	1.736	1.748	1.774	1.788	1.752	1.705

CALIFORNIAN BEARING RATIO (CBR)

Table 4.16 CBR test results for normal soil

S.No.	Penetration (mm)		Proving Ring Reading (A)	Load(Kg) Calibration Factor x (A)	Corrected Load (Kg)
1	0.5		8	0	22.74
2	1.0		12	0	34.12
3	1.5		21	0	59.70
4	2.0		28	0	79.60
5	2.5		32	0	90.98
6	3.0		38	0	108.03
7	4.0		45	0	127.94
8	5.0		54	0	153.52
9	7.5		56	0	159.21
Penetration	Load	CBR %	CBR% Reported 7.47		
2.5	90.98	6.64			
5	153.52	7.47			

Table 4.17 CBR test results for Mix 1

S.No.	Penetration (mm)		Proving Ring Reading (A)	Load(Kg) Calibration Factor x (A)	Corrected Load (Kg)
1	0.5		4	0	11.37
2	1.0		11	0	31.27
3	1.5		22	0	62.55
4	2.0		29	0	82.45
5	2.5		32	0	90.98
6	3.0		45	0	127.94
7	4.0		49	0	139.31
8	5.0		56	0	159.21
9	7.5		59	0	167.74
Penetration	Load	CBR%	CBR% Reported		

2.5mm	90.98	6.64	7.75
5.0mm	159.21	7.75	

Table 4.18 CBR test results for Mix 2

S.No.	Penetration (mm)		Proving Ring Reading (A)	Load(Kg) Calibration Factor x (A)	Corrected Load (Kg)
1	0.5		5	0	14.22
2	1.0		11	0	31.27
3	1.5		22	0	62.55
4	2.0		28	0	79.60
5	2.5		34	0	96.66
6	3.0		50	0	142.15
7	4.0		57	0	162.05
8	5.0		61	0	173.42
9	7.5		72	0	204.70
Penetration	Load	CBR%	CBR% Reported 8.44		
2.5mm	96.66	7.06			
5.0mm	173.42	8.44			

Table 4.19 CBR test results for Mix 4

S.No.	Penetration (mm)	Proving Ring Reading (A)	Load(Kg) Calibration Factor x (A)	Corrected Load (Kg)
1	0.5	6	0	17.06
2	1.0	11	0	31.27
3	1.5	22	0	62.55
4	2.0	32	0	90.98
5	2.5	40	0	113.72
6	3.0	50	0	142.15
7	4.0	66	0	187.64
8	5.0	67	0	190.48

9	7.5		73	0	207.54
Penetration	Load	CBR%	CBR%		
2.5 mm	113.72	8.3	Reported		
5.0mm	190.48	9.27	9.25		

Table 4.20 CBR test results for Mix 4

S.No.	Penetration (mm)		Proving Ring Reading (A)	Load(Kg) Calibration Factor x (A)	Corrected Load (Kg)
1	0.5	9	0	25.59	1
2	1.0	13	0	36.96	2
3	1.5	21	0	59.70	3
4	2.0	34	0	96.66	4
5	2.5	43	0	122.25	5
6	3.0	53	0	150.68	6
7	4.0	67	0	190.48	7
8	5.0	71	0	201.85	8
9	7.5	75	0	213.23	9
Penetration	Load	CBR%	CBR% Reported		
2.5mm	122.25	8.92	9.82		
5.0mm	201.85	9.82			

DIRECT SHEAR BOX TEST

Table 4.21 DST results for Mix 2

Normal Stress (Kg/cm)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (Kg/cm^2)
0.50	36.00	137.52	14.03	0.39
1.00	44.00	168.08	17.15	0.48
1.50	56.00	213.92	21.83	0.61

Table 4.22 DST results for Mix 3

Normal Stress (Kg/cm)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (Kg/cm^2)
0.50	32.00	122.24	12.47	0.35

1.00	49.00	187.18	19.10	0.53
1.50	63.00	240.66	24.56	0.68

Table 4.23 DST results for Mix 4

Normal Stress (Kg/cm)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (Kg/cm^2)
0.50	31.00	118.42	12.08	0.34
1.00	46.00	175.72	17.93	0.50
1.50	58.00	221.56	22.61	0.63

V. CONCLUSION

This study aims to reduce pollution and strengthen weak soils by utilizing old plastic strips as the subgrade layer for road pavements. There are two applications for the study. Finding a sustainable method for disposing of plastic garbage is one thing; improving the subgrade layer beneath road pavements is another. The analysis and interpretations lead to the following results. When plastic strips of varying sizes and ages were introduced to the soil, MDD and OMC decreased. There are certain engineering applications where a reduction in the density of the materials in the pavement layers is advantageous, such as the construction of light embankments.

The soil's capacity to swell considerably decreases with increasing strip count. This may be the result of replacing a similar quantity of dirt with a plastic strip. It has been demonstrated that applying brick dust to black cotton soil improves all of its geotechnical characteristics.

- The greatest frictional angle was found at Mix 3 almost to 33° 57', and it subsequently dropped at 29° 23'.At greater doses of brick powder, there is only a modest connection observed.
- Based on the evaluation, the maximum corrected load for replacing soil with brick powder and plastic strips was raised from 153 kg to 201.85 kg.
  It is noted that the liquid limit test can be used to estimate the compression index, which is utilized in settlement analysis, and that the index varies with the amount of brick and plastic.
- On top of that soil compaction curve, the saturation curve assists in superimposing dry unit weights. Figure shows that Mix 3 had the highest measured dry density due to the usage of plastic strips and more brick powder.
- The soil's increased ability to support weight was caused by the increase in sand particles brought about by the brick elements.