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Stabilization of Clayey Soil Using Waste Plaster of Paris and Groundnut Shell Ash

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ABSTRACT
Soil is generally utilized in the field of Civil engineering and has applications in structures, foundations, and pavements, etc. when achieved with adequate stabilization. The purpose of this analysis was to stabilize the clayey soil when coalesced with waste plaster of Paris and groundnut shell ash in different proportions. Two types of scales - Unconfined compression and California bearing ratio were performed for analysis of the specimens prepared. The findings of this analysis revealed an 11.52 percent ascend in the California bearing value of soil admixtures, of which ground shell ash and waste plaster of Paris had been combined at 6% and 18% respectively. However afterward, the value perpetuates to decrease. In the case of unconfined compressive strength when 18% of waste plaster of Paris is added in the mixture of clayey soil the maximum value of is 2.84 Kg/cm^2 is achieved, which reveals that the shear strength of the mixture increase with the addition of 18% of waste plaster of Paris. The investigation uncovered the fact that that ground shell ash and waste. Plaster of Paris can be used as an admixture if properties of the clayey soil are to be amended.
Keywords - California Bearing Ratio (C.B.R), Groundnut Shell Ash (GSA), Unconfined Compressive Strength (UCS), Waste Plaster of Paris (POP).

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I. INTRODUCTION

When we use soil in construction purposes it is very important to check its stability so that it does not fail the adequate specifications required in civil engineering. There is a reliance on industrially processed soil containing additives such as lime, geopolymer, etc., however, the use of these additive materials contributes to higher costs and eventually expensive roads [1]. Various waste materials are now being added to engineering materials [2] as well as admixtures in soil and are tested whether they are successful to produce desired properties. The World Bank has spent considerable money on research into the exploitation of industrial waste products to reduce the environmental problem as well as help in waste management [3]. In this direction, we consider improvements in soil by adding various admixtures in soil and opting adequate techniques like compaction, proportioning, etc. so that the structure made is long-lasting, economical, and safe [4]. Considering these reasons, this work assesses the strength characteristics of clay soil reinforced with waste POP and groundnut shell ash as a viable economic alternative for stabilizing clay soil that can be further used in road construction.

II. STUDY AREA

In this study, the clayey soil which was used is taken from the Nabha town which is situated in Patiala Punjab. This soil is commonly known as “Chikane Mitti” [5]. It is also commonly used for making houses in villages as well as road construction.

In this study waste Plaster of Paris is used and has been thus utilized. In **Table 2** the chemical composition of waste Plaster of Paris is mentioned.

Table 1. Index properties of clayey soil.

Properties	Value
Colour	Light Brown
Liquid Limit (%)	51
Plastic Limit (%)	18
Specific Gravity	2.65
Gravel Size (>4.75mm)	0
Sand Size (0.075-4.75mm)	17.4%
Silt Size (0.002-0.075)	34.3%
Clay Size (<0.002mm)	48.3%
Maximum Dry Density	1.63

(gm/cc)	
O.M.C. (%)	21
U.C.S. (kg/cm²)	0.58
C.B.R Value (%) soaked	3.8

Table 2. Chemical compositions of plaster of paris [6].

Composition	Waste POP (%)
CaO	38.5
SiO_2	1.5
Al_2O_3	0.2
Fe_2O_3	Nil
MgO	0.8
P_2O_5	Nil
SO_3	49.6
CO_3	6.02%
TiO_2	0.01
LOI	9.3
CaO	38.5

Groundnut Shell, which is an agriculture waste, is used in a concrete mixture in civil engineering and as an additional stabilizer in soil [7]. Here in this study, the groundnut shell is taken from procured locally from the Industrial area Patiala State, Punjab, India. The coordinates are 30° 20' 24.0000" North latitude and 76° 22' 47.9892" East latitude. In winter, the temperature goes from 5^0 to 0^0 Celsius, and in summer, it goes from 40^0 to 45^0 Celsius. In **Table 3** the chemical composition of a groundnut shell is mentioned:

Table 3. Chemical compositions of groundnut shell ash [8].

Composition	Waste POP (%)
CaO	10.91
SiO_2	33.36
Al_2O_3	6.73
Fe_2O_3	2.16
MgO	4.72%
$K_2O + Na_2O$	25.38%
SO_3	6.40%
CO_3	6.02%
LOI	0.1
CaO	10.91
SiO_2	33.36

III. METHODOLOGY

3.1. Soil Stabilization

Soil stabilization ensures that it must blend more than one type of component and then test its properties through mechanical and chemical methods [9]. The purpose of doing this is to improve the desired engineering property so that soil material can be improved [10]. This may also be the reason for stabilizing the soil so that its strength, as well as durability, can be increased.

3.2. Standards of Soil Stabilization

- Deciding the property of soil which should be adjusted to get the plan esteem and pick the compelling and practical/economical strategy for adjustment.
- Designing the Stabilized soil blend test and testing it in the lab for proposed stability and durability values.

3.3. Mechanical Stabilization

The physical process can be resorted to by the Mechanical stabilization of the local soil by the physical ideas, which can be done through compacting or with vibration [11]. It can also be done through the fusion of other physical soil features like boundaries and nailing. The primary purpose of conducting this survey is not at all mechanical adjustments, nor will it be discussed further.

3.4. Chemical stabilization

Chemical Stabilization of soil chiefly relies upon compound responses between stabilizer (cementitious material) and soil minerals (pozzolanic materials) to accomplish the ideal impact [12]. Chemical compound adjustment technique is the center of this examination and, in this manner, all through the remainder of this report, the word soil adjustment will imply for synthetic amendment.

IV. EXPERIMENTATION AND RESULTS

Various percentages (3%, 6%, 9%, and 18 %) of waste POP were initially added to the clayey soil to obtain the highest values of strength characteristics. Following were the experimentation:

4.1. Unconfined Compression Test

It is also called uniaxial compression tests it is used for triaxial tests for in specials cases and the lithostatic pressure is zero [13-14]. If the UC test is compared with a triaxial test, it is a much easier test and happens quickly and UC test doesn't require any sophisticated triaxial setup. In this test, a cylinder that is made from the soil is tested without any lateral support during the failure in simple compression and the strain is a constant rate [15]. The unconfined compression strength of the soil is defined as compressive loads per unit area applied on the specimen until it fails.

Table 4. UCS test for different percentage waste pop mixed with clay soil.

S.No	Specimen	1-Days		4-Days		7-Days		28-Days	
		Strength kg/cm^2	*% Strain*	*Strength kg/cm^2*	*% Strain*	*Strength kg/cm^2*	*% Strain*	*Strength kg/cm^2*	*% Strain*
1	100% Soil	0.53	21.3	1.09	16.5	0.97	15	1.32	13.5
2	97% Soil + 3% of waste POP	0.79	17.5	1.12	16	1.18	14.5	1.35	13
3	94% Soil + 6% of waste POP	0.95	16.4	1.28	14	1.45	14	1.36	12.5
4	91% Soil + 9% of waste POP	1.68	12	1.58	13	1.82	12	1.85	12
5	88% Soil + 12% of waste POP	1.81	10.5	1.61	9	1.87	11	1.93	10
6	85% Soil + 15% of waste POP	1.95	10	1.83	8	1.98	10.5	2.01	8
7	82% Soil + 18% of waste POP	2.09	9.41	1.98	8	2.10	10	2.14	7

Fig. 1. Shows that maximum increases in unconfined compressive strength of the clayey are achieved when 18% of waste POP when added to the specimen. On the other hand, it has been observed that the strength has been elevated by 3% for waste POP, in the case of untreated soil it was attained at is on 28 days of curing. **Fig. 1(d)** shows that as waste POP content increases, this leads to an increase in the rate of strength. This study has shown that as the waste POP content increases to 18%, which impacts on soil stiffness. The performance of soil which is treated with waste POP was found to be better to that of soil without waste POP content.

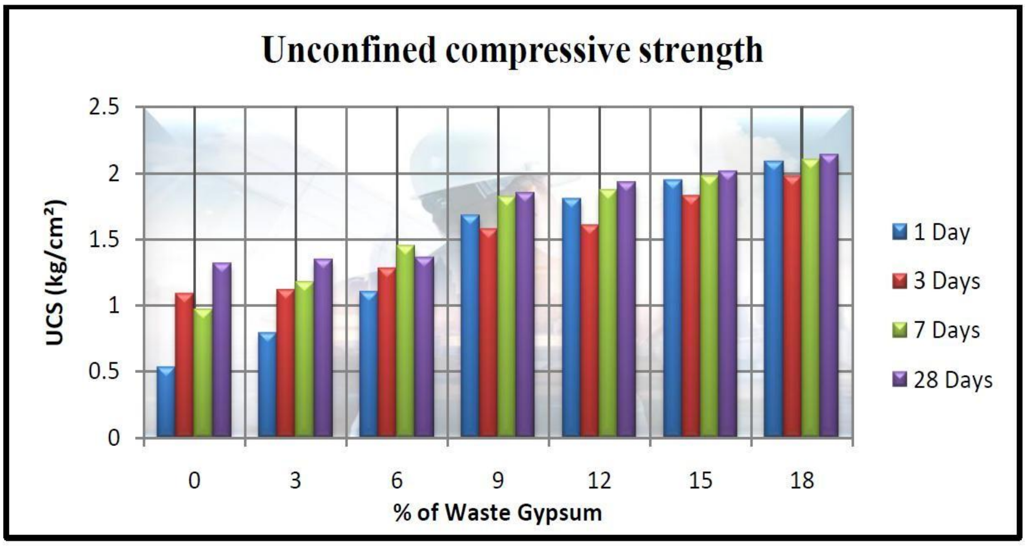

Fig. 1. Graph of UCS (Unconfined Compressive strength) for different % of waste POP mix with clayey soil for 28 days curing.

4.2. California Bearing Ratio Test

It is mandatory to implement certain conditions such as controlled density and moisture conditions to perform this California bearing ratio test [5]. This test is used for the evaluation of resistance of a material to penetration of standard plunger [16]. This test is used performed on either natural or compacted soils that can be present in water soaked or un-soaked conditions [17]. The results which are obtained further compared with the curves of a standard test to have clarity of the strength of the subgrade soil.

Table 5. California bearing ratio test.

S. No	Specimen	Soaked CBR (%)
1.	100% Soil	3.8
2.	97% Soil + 3% of waste POP	5.9
3.	94% Soil + 6% of waste POP	6.78
4.	91% Soil + 9% of waste POP	6.1
5.	88% Soil + 12% of waste POP	5.81
6.	85% Soil + 15% of waste POP	5.63
7.	82% Soil + 18% of waste POP	5.33

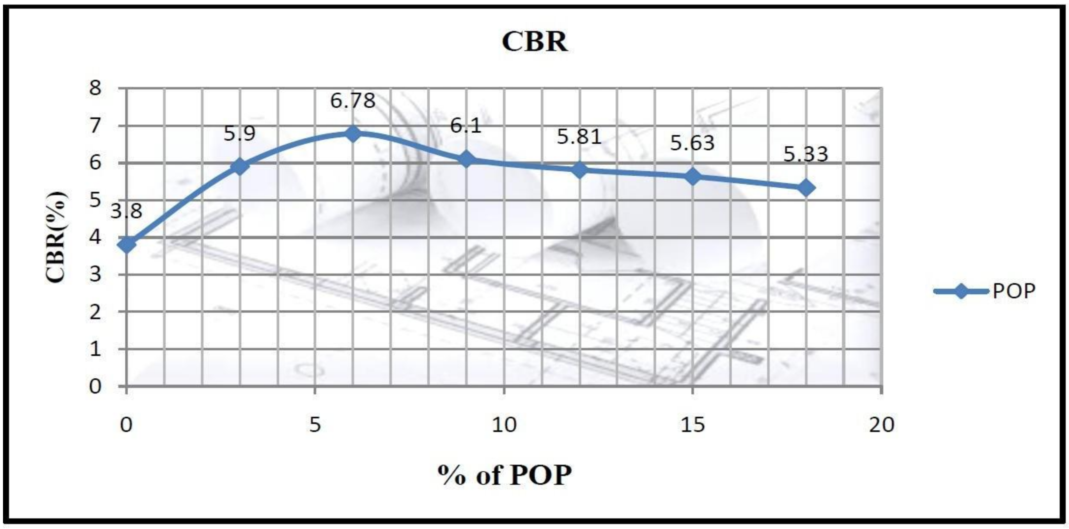

Fig. 2. Graph for CBR of different % of waste POP mix with clayey soil.

Fig. 2 based on the waste POP treated clayey soil for the soaked C.B.R at different periods. If it talks about the CBR value of natural Soil, it came out 3.8%. The figure is shown above showcase that the CBR value for 6% waste POP content comes out to be 6.78%. Through this, it was analyzed that the improvement is going well. The reason its improvement is that it can also be said that it might be due to the quantity of calcium required for the development of calcium silicon hydrate (CSH) is formed and that is a very essential element to increase strength.

As the most suitable results were obtained in soil samples containing waste POP content of 18 %, so keeping it as constant groundnut shell ash was added on different ratios of 3%, 6%, 9%, 12%, and 18 %.

Table 6. Obtained UCS and C.B.R values of properties of soil, waste P.O.P and groundnut shell ash admixture.

S. No.	Specimen	UCS (kg/cm^2)	C.B.R (%)
1	100% Soil	0.58	3.8
2	79% Soil + 18% of waste POP+3% of groundnut shell ash	2.28	10.46
3	76% Soil + 18% of waste POP+6% of groundnut shell ash	1.98	11.52
4	73% Soil + 18%of waste POP+9% of groundnut shell ash	1.85	10.61
5	70% Soil + 18% of waste POP+12% of groundnut shell ash	1.71	9.45
6	67% Soil + 18% of waste POP+15% of groundnut shell ash	1.59	8.56
7	64% Soil + 18% of waste POP+18% of groundnut shell ash	1.42	7.81

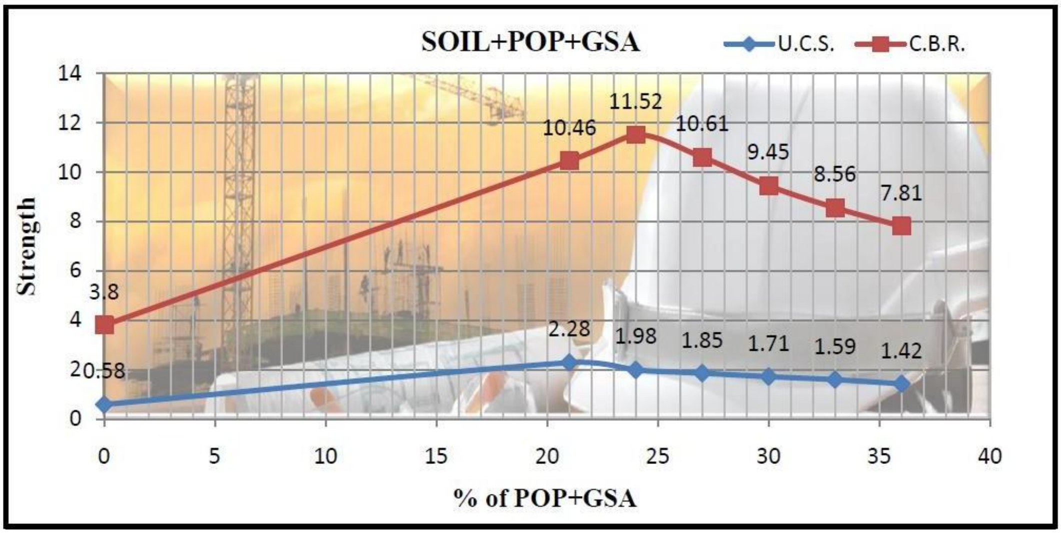

Fig. 3. Comparison between UCS and C.B.R for different % of groundnut shell ash, 18% of waste Plaster of Paris mixed with clayey soil.

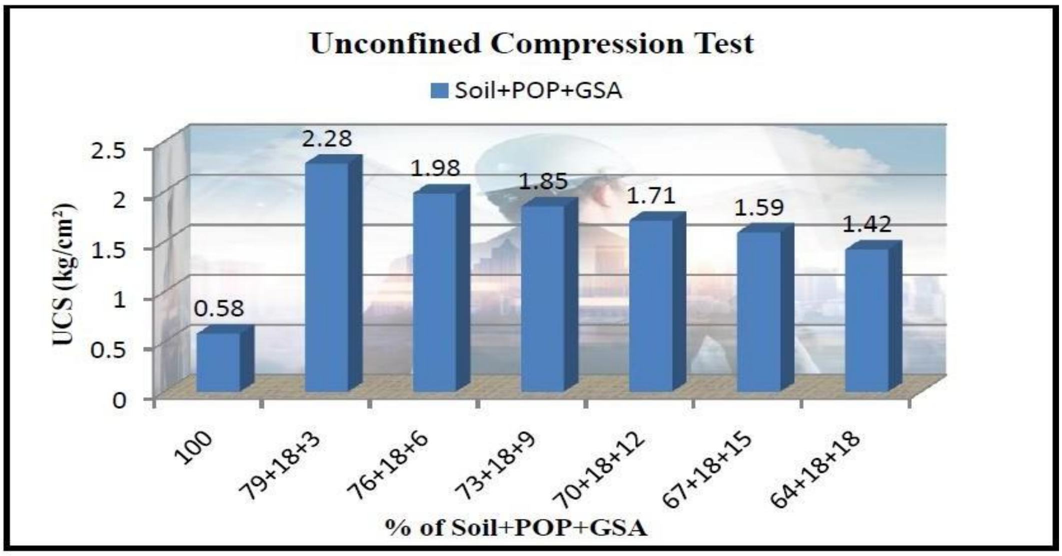

Fig. 4. Graph of UCS for different % of groundnut shell ash, 18% of waste POP mixed with clayey soil.

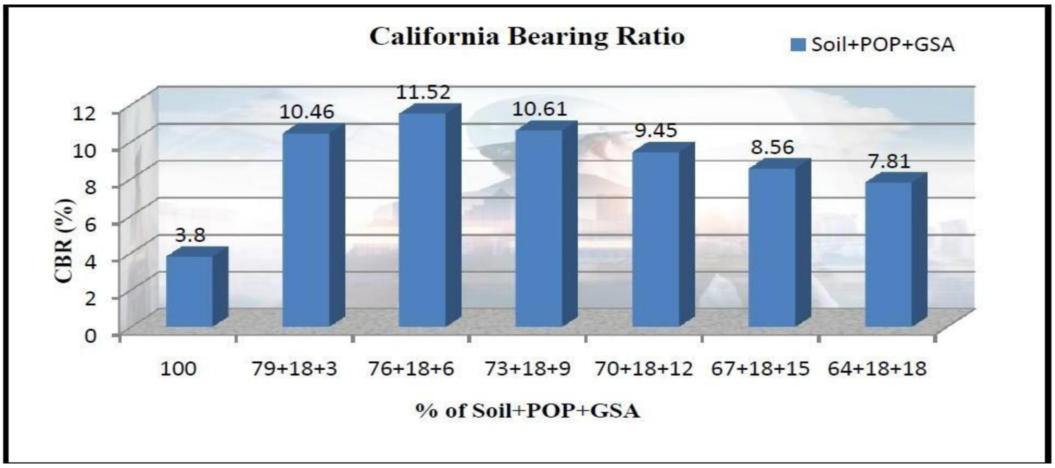

Fig. 5. Graph of C.B.R for different % of groundnut shell ash, 18% of waste Plaster of Paris mixed with clayey soil.

Table 4 demonstrates that the value of unconfined compressive strength is increasing, with an increase in the percentage of groundnut shell ash & 18% of waste Plaster of Paris in comparison to the clayey soil without admixture. This is because of the dimension of particles which is very small or attribute to ion exchange, which is present on the surface of the clay particles. Ca^{2+} is a lower valence metallic ion that is present in the clay microstructure which responsible for the formation of agglomeration and flocculation of the clay particles. This may be due to the growth in UCS, but after certain values, they will start declining which maybe because of the number of ions present is more than the soil particle. It is not able to form bonds among soil particles. The study has revealed that C.B.R values for the treated soil along with waste POP and groundnut shell ash increased up to 11.52%, further bifurcation reveals that when it comes to groundnut shell ash, it is 6% and waste POP which is 18% added in it. Hereafter C.B.R values start decreasing. It can be said that this happens because of the presence of calcium silicate hydrate, which is responsible for making bonds. But its C.B.R values start decreasing after certain values. This might be due to enabling to form the CSH bond with the soil particles. The results of the UCS test are shown in **Fig. 4** and the details of the results of the C.B.R test are shown in **Fig. 5.**

V. CONCLUSIONS

The following conclusions can be taken from the experiment conducted to test soil characteristics enhanced by waste Plaster of Paris and groundnut shell ash.

- Waste Plaster of Paris and groundnut shell which could be used in subgrade for flexible and rigid pavements.
- There relative increase in UCS value when 18% of the waste POP is combined with clay soil which reaches a maximum of 2.84 kg / cm^2. It indicates that the exordium of 18 % waste Plaster of Paris improves the shear strength of the mixes.
- The highest increase in UCS and CBR values is reported when 18 % of waste Plaster of Paris and 6 % of groundnut shell ash is amalgamated with clay soil and the soaked CBR value is between 3.82 and 11.52.

The findings thus demonstrate that 6% of the inclusion of groundnut shell ash and 18% of the waste Plaster of Paris mixed in the clay soil constitutes the optimum proportion of the content with maximum soaked CBR values.

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