Strength Characteristics Of Expansive Soil Mixed With Quarry Residue And Cement

Jemal Aliy Gobena, S. Suppiah

Abstract*: construction should repose on the soil. All soils will not have good vigor and bearing capacity. So, the soil bearing capacity plays a dynamic role in constructions, accordingly, the soil vigor and carrying capacity should be modified. The ebony cotton soils bring many quandaries in construction. The present work is done in stabilizing the expansive soils gathered from Wol aita Sodo, Ethiopia, by utilizing quarry dust and cement and fixes the optimum percentage of quarry sand and cement addition to the black cotton soil in refining the strength characteristics of the soil. Utilization of blend of quarry residue and cement were arranged by method of a resource to potentially giving workable, financially savvy yet strong sub grades in high plasticity soils. In this paper an endeavor is made for the usage of quarry dust and cement by adding quarry dust and cement to expansive soil at various percentages and tests like plasticity, grain size distribution, swell, compaction, unconfined compressive strength, direct shear and CBR tests were performed. From the outcomes of the tests, it is known that, addition of cement and quarry residue decreases plasticity and improving strength characteristics.

Index Terms*: Black cotton Soil, Quarry dust, Cement, Unconfined compressive strength.

I. INTRODUCTION

Difficult soils are amongst the most problematic soils from Civil Engineering construction point of view. Of the several factors that affect the swelling behavior of these soils, the basic mineralogical composition is very important. Most expansive soils are rich in mineral montmorillonite and a rare in illite. Black cotton soil is heavy clay soil, changing from clay to loam; it is generally dark grey to light in color. The most important characteristic of the expansive soil is, when dry, it shrinks and is hard like stone and has very high bearing capacity. The uncommon properties of the soil make it difficult to construct foundation. Special way of construction of foundation is mandatory in such soil.

Shear strength of soils is necessary for many stability problems of the geotechnical engineering, including prediction of the stability of slopes and embankments, design of foundations, and earth pressures calculation against retaining structures.

Mixing of expansive soils with cement has optimistic effect on the environment [2]. Mechanical properties and carrying capacity of the soils are connected with the effectiveness' of the cement and with the mineralogical arrangement of fine grained soil [8]. Components, for instance, budget and accessibility of replaceable materials, the choice of the type of stabilizers is logically attainable and typical. The blending of at least two materials and compressing those with stabilizers increases the quality of the treated soil, this improvement is known as stabilization [7]. In this exploration, the expansive soil was stabilized with quarry-residue and cement.

Expansive soils contain (bentonite) or kaolinite (kaolin) mineral. These minerals act absolutely extraordinary perform under working burden. Additionally, impact of these minerals on hydration of cement and solidifying manner are likewise extraordinary. Kaolinite shows little impact on solidifying process in inverse to montmorillonite, which needs a lot of cement to get reasonable strength [6]. The primary motivation behind this investigation was to get different properties of stabilized soil in assorted quarry residue and percentage of cement.

Swelling soils, for example, clayey soils are exposed to modifying of their properties to get the best physically stabilized conditions. One of numerous approaches to get this interest is adjustment. Feeble soils mixed out chemically with different materials such as lime or cement can highly improve mechanical characteristics of soil for example, carrying capacity and liquid retention. Tragically effect of soil physical behavior on stabilization process is as yet vague [1]. The soil stabilization agents such as quarry sand and cement should not be underestimated, because it may cause lowering of mechanical properties or shrinkage cracks. Meager research work has been done on black cotton soils. However, this rather useful information is spattered in various publications and the need to bring this spattered information together has long been felt.

The magnitude of shrinkage properties of a soil increases with the amount of fine grained particles in the soil. Sand and silt sized particles reduce total shrinkage because they dilute the clay and decrease the volume of water held by the soil. Generally, a soil deposit having illite layer or montmorillonit e layer as the dominant clay mineral shrinks more than the clay minerals.

Soils are made out of an assortment of materials, the greater part of which doesn't enlarge within the sight of dampness. Be

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that as it may, various expansive soil minerals are black cotton soils. There are additionally some sulfate salts that will expand with changes in temperature. Use of such mixing technique must fulfill high guidelines of soil test standards. Experts should make sure about mechanical properties and performing of stabilized material under moving wheel load. Another kind of issue is properties of clayey soils. In inverse to non-strong soils this kind of material has poor strength properties and its use as building material makes numerous inquiries concerning performing under certain stacking even after adjustment.

At the point when a black cotton soils contains a lot of extensive minerals, it has the capability of huge expansion. At the point when the expansive soil contains next to no broad minerals, it has minimal for reaching to swell potential.

II. TESTING PROGRAM

A. Material

In this study, two types of soils were used. These soils are clayey soil (black cotton soil) brought from inside a Wolaita Sodo University in the South nations and nationalities and people's region of Ethiopia. Second soil is a quarry dust, which is taken from Wolaita Sodo town. The geotechnical properties of clayey soils and quarry dusts are shown in Table 1. Different soil investigations such as specific gravity, Liquid limit, plastic limit, and particle size distribution were tested in accordance with ASTM test procedures.

Table.1: Properties of Clayey soil and quarry residue.

Sr. No	Parameter	Clayey soil	Quarry dust
1	Grain size distribution Coarse sand (2mm– 4.75 mm) % Medium sand (0.425mm – 2mm)% Fine sand (0.075mm – 0.425mm)% Silt (0.002mm – 0.075mm) and Clay content (grain size <2μ mm), %	- 3 5 46 46	2 43 45 10 -
2	Atterberg limit Liquid limit, LL, % Plastic limit, PL, % Plasticity index, PI, %	78 44 34	12 NP -
3	Specific gravity of solids	2.64	2.72
4	Differential free swell index (%)	123	0
5	Compaction characteristics Maximum dry density (MDD)(g/cc) Optimum moisture content (OMC) (%)	1.48 24.8	1.96 14.2
6	Classification Effective size D10(μm) Uniformity coefficient(Cu) Coefficient of curvature(Cc) AASHTO soil classification USCS soil classification	- - - A 7-5 CH	75 6.4 1 A-2-4(0) SW
7	Shear parameters Angle of shearing resistance(deg) Cohesion(c)(KN/m2)	0 21	35 0
8	California bearing ratio value @2.5 mm penetration @5 mm penetration	1.86 1.62	32.4 29.6
9	Unconfined compressive strength(KN/m2)	112	-

B. Quarry dust

Sample of quarry dust used for this work is clean and fine to medium course sand. This was to be properly passed through 4.75mm sieve and oven dried for 24 hours to remove its moisture before the initiation of tests.

C. Methods

In this research work, the specified experiments were done on untreated soil to determine its properties. Soil was mixed with quarry dust and cement to improve its quality. The amount of quarry dust was taken in varying percentage such as 10%, 20%, and 30% by dry weight of soils whereas amount of cement was taken as varying percentage such as 2%, 4%, and 6% by dry weight of soil .According to this methodology, mix sample were formed then, all experiments were done as per ASTM specification to analyze engineering properties and swelling behavior on both natural and mixed soil.

D.Particle size distribution.

According to the AASHTO classification chart, it came under the range of A-7 group and A-7-5 sub-group. By unified soil classification system (USCS) classification system, natural expansive soil and quarry dust were clearly categorized as CH and SW respectively.

E. Atterberg limit test.

The liquid limits, and plastic limits tests are a fundamental proportion of the critical water contents of a fine grained soil, for example its shrinkage limit, plastic limit and liquid limit. Contingent on the dampness substance of soil, it might show up in four phases, for example, Solid, Semi-solid, plastic and fluid.

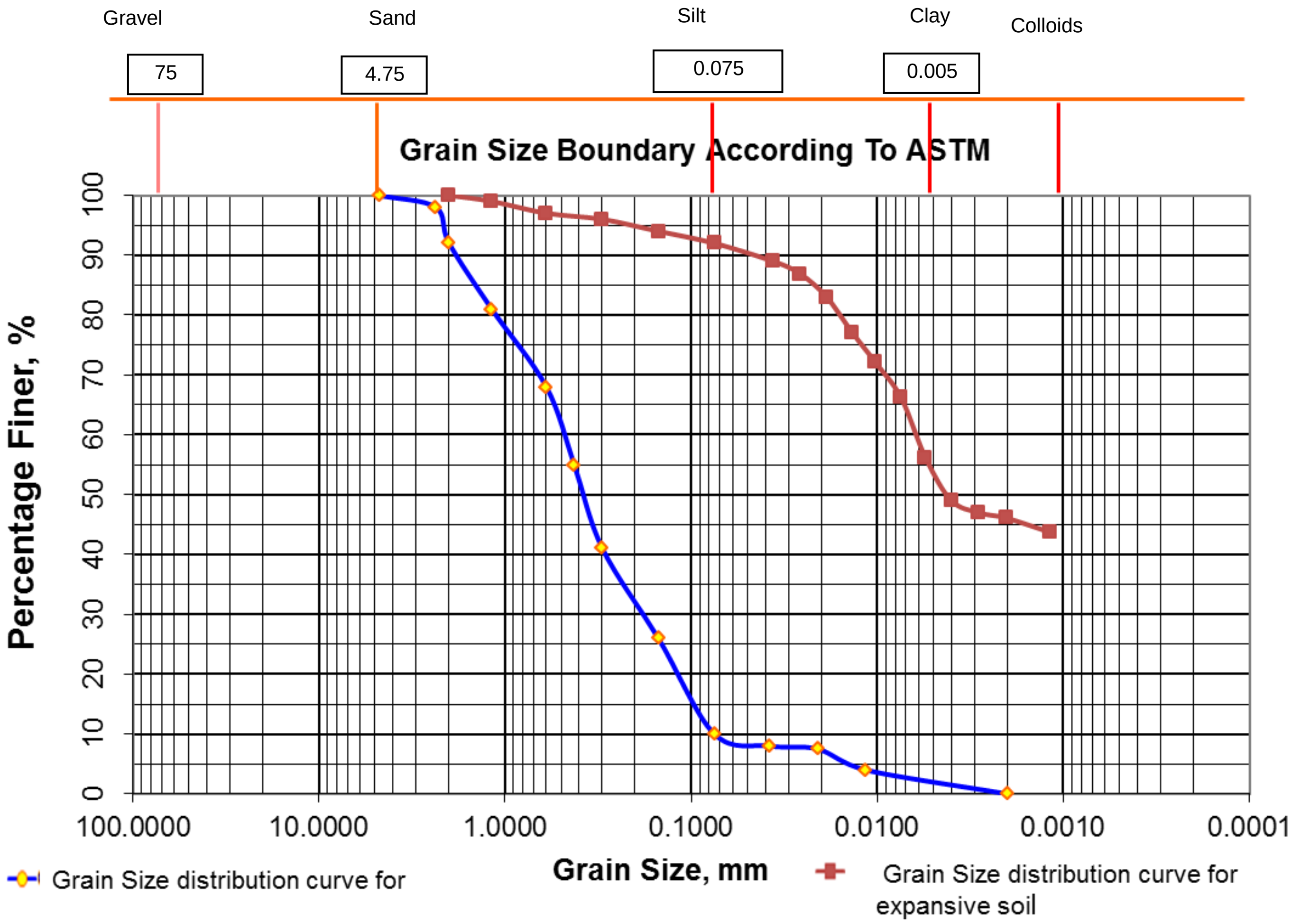

Fig.1: Grain size distribution curve for expansive soil and quarry dust.

Table 2: Atterberg limits and free swell index of expansive soil at different percentage of cement and quarry dust.

CEMENT (%)	QUARRY DUST (%) 0%			10%			20%			30%		
	LL (%)	PL (%)	FSI (%)	LL (%)	PL (%)	FSI (%)	LL (%)	PL (%)	FSI (%)	LL (%)	PL (%)	FSI (%)
0	78	44	123	72	41	114	62	36	96	48	19	82
2	81	31	109	63	28	103	51	9	74	39	6	58
4	72	18	88	44	16	76	34	5	46	28	NP	34
6	61	11	61	38	8	34	11	NP	29	6	NP	12

Table 3: Various Characteristics of cement Stabilized Expansive soil mixed with quarry dust

CEMENT (%)	QUARRY DUST (%) 0%			10%			20%			30%		
	OMC (%)	MDD (g/cc)	FSI (%)	OMC (%)	MDD (g/cc)	FSI (%)	OMC (%)	MDD (g/cc)	FSI (%)	OMC (%)	MDD (g/cc)	FSI (%)
0	24.8	1.28	120	23.7	1.36	100	22.10	1.38	95	20.80	1.41	87
2	23.8	1.56	95	21.2	1.60	82	20.00	1.64	74	18.60	1.66	63
4	22.9	1.57	78	18.6	1.62	67	17.00	1.65	58	16.20	1.68	42
6	18.2	1.59	62	16.3	1.66	53	15.17	1.69	45	12.40	1.73	34

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F. Proctor compaction test

Compaction test provides most favorable moisture content and extreme dry density of soil that requires in the field. The relationships of dry density and moisture content of the expansive soil was determined at different
Percentages of cement and quarry dust as (2%, 4%, and 6%), (10%, 20%, and 30%) respectively as per the

Mould of 944cm3 was utilized and the soil sample compressed in three strata with 25 blows individually, using a rammer of 2.5kg dropping from the height of 300mm. Samples were taken from each test and dehydrated in the oven for one day. For the determination of optimum moisture content and maximum dry density, the dry density was plotted against the mean moisture content. The outcomes of the optimum moisture content and maximum dry density are shown in the tables 3.

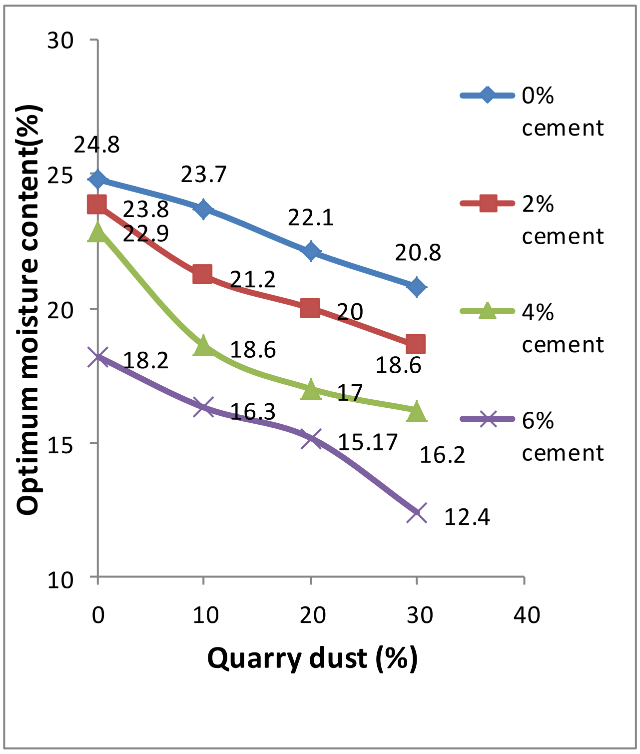

Fig. 5: Disparity of OMC (%) of soil - cement mixtures with varying quarry dust

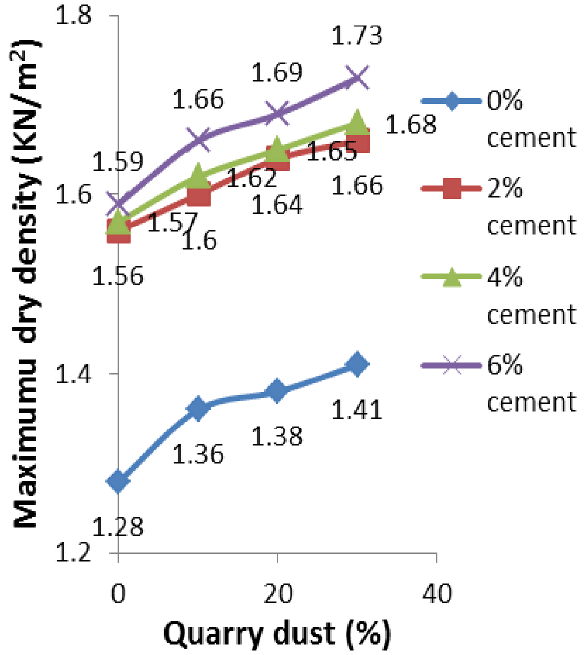

Fig. 6: Disparity of MDD (g/cc) of stabilized soil – cement - quarry dust mixtures.

G. Unconfined Compressive Strength

The unconfined compressive strength test (UCS) was conducted in accordance with ASTM D2166.
Thoroughly mixed air dried expansive soil – quarry dust – Cement mixtures were compacted at optimum moisture contents (OMC) by means of the Standard Proctor compaction energy. The compacted expansive soil – quarry dust –Cement mixtures were prepared at step concentrations of 0, 10, 20, and 30 % for the quarry dust and 0, 2, 4, and 6 % for the Cement respectively. The compacted samples were extruded from the mold using a cylindrical steel measuring 76 mm by 38 mm diameter. The conducted samples were closed in polythene baggage and kept in the damp room at a continual temperature of 250 C for 7, 14 and 28 curing period days. The samples were then located in a weight frame driven at a continual strain of 0.10 % /min until miscarriage occurred. Three varieties of samples were used for each test and the middling result was taken and

Table 4: Results of UCS (KN/m^2) (7 days curing) for

CEMENT	QUARRY DUST (%)			
(%)	0	10	20	30
0	122	303	305	371
2	205	411	495	549
4	369	483	661	725
6	505	807	902	984

cement – quarry dust stabilized soil

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Table 5: Results of UCS (KN/m^2) (21 days curing) for Cement – Quarry dust Stabilized Soil

CEMENT (%)	QUARRY DUST (%) 0	10	20	30
0	122	353	378	474
2	255	481	547	599
4	471	583	783	815
6	658	907	10522	1134

Table 6: Results of UCS (KN/m^2) (28 days curing) for Cement – Quarry dust Stabilized Soil

CEMENT (%)	QUARRY DUST (%) 0	10	20	30
0	122	371	402	503
2	279	504	576	607
4	476	586	798	828
6	665	938	1094	1146

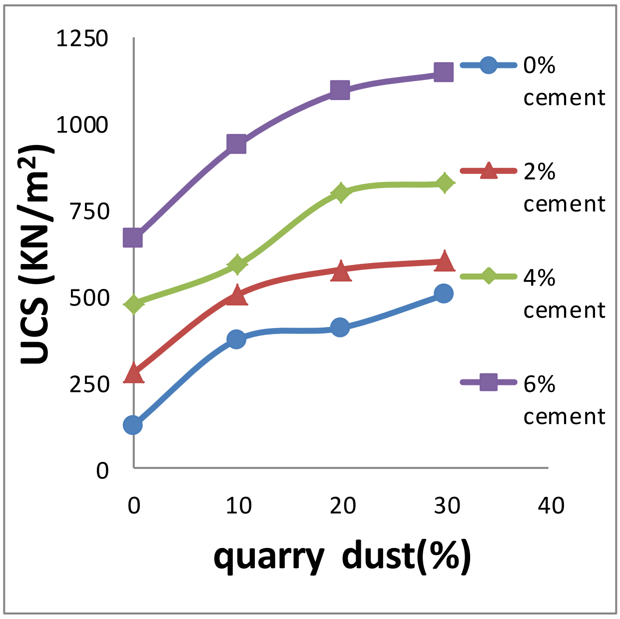
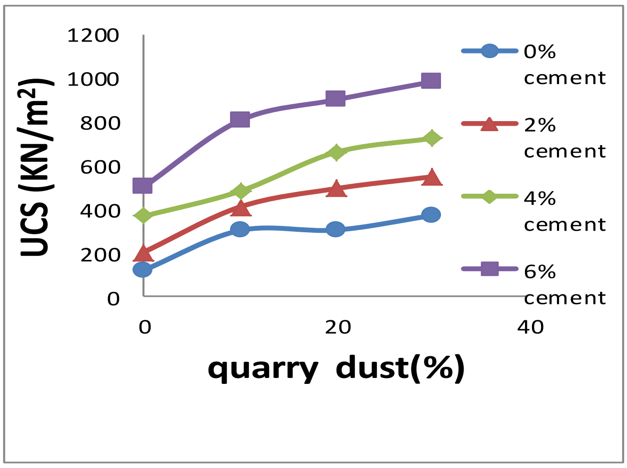


Fig. 7: Disparity of UCS (7 day curing) of stabilized soil - cement - quarry dust mixtures.



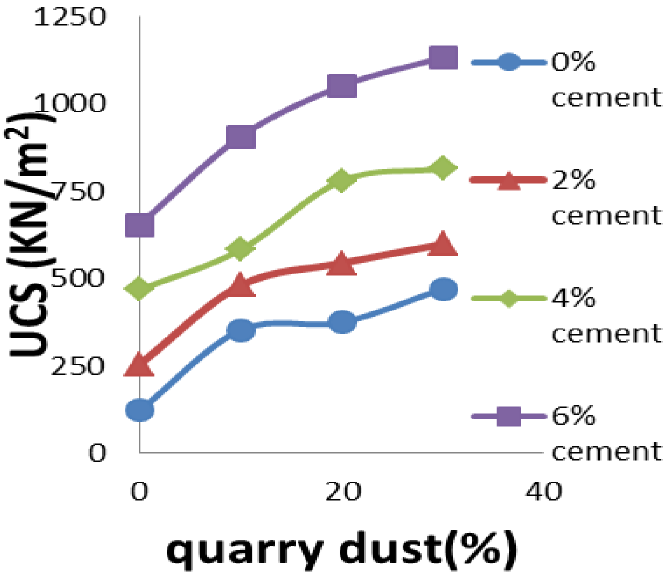


Fig. 8: Disparity of UCS (21 day curing) of stabilized soil - cement - quarry dust mixtures

Fig. 9: Disparity of UCS (28 day curing) of stabilized soil - cement - quarry dust mixtures.

III. CONCLUSION

Different research laboratory tests were conducted to contemplate the impact of cement and quarry residue on plasticity properties, compaction properties (MDD, OMC), differential free swell index, and compressibility characteristics of selected expansive soil. The black cotton soil was cured with the mixing in stepped concentration of 0, 2, 4, and 6% by dry weight of the soil. The outcomes obtained indicate that:

1 From the test results, the plasticity characteristics, optimum moisture content and differential free swell index are detected to decrease, however maximum dry density of soil admixture increased with increasing percentage of cement and quarry dust.

2 The soil treated by 2% cement and 10% quarry dust for maximum dry density meets the minimum requirement in accordance with AASHTO T 99.

3 Usual Cement Ranges for Stabilization (% by dry weight of soil) can be decreased by mixing expansive soil with quarry dust, as per AASHTO Classification.

4 From the test result, there is the decrease in free swell index of expansive soil with increase in quarry dust and cement percentage.

5 The investigation demonstrated that the stabilized soil blends like soils mixed out with different cementitious admixtures have the potential for a period subordinate increment in quality and in this manner with extra restoring time, further quality may create. Regarding this matter, further examinations in

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perspective on longer restoring occasions and conceivably higher quarry dust substance are vital

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