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SOIL STABILIZATION WITH CEMENT

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Abstract:

This paper presents the classification of soil and modification or stabilization of soil with cement. Soil samples are taken at about 3 ft depth from Mawlamyine which are denoted by soil A. Laboratory tests are conducted to determine the engineering properties and strength characteristics of studied soil with and without cement. Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The soil from site place are performed for laboratory tests and moisture content test, grain-size analysis, atterberg limit test, sieve analysis standard proctor compaction tests and California bearing ratio (CBR) test. The above tests are also carried out the classification of soil and modification or stabilization of soil.

***Keywords*- Moisture Content, Atterberg Limit, Cement, Compaction, CBR**

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I. INTRODUCTION

Soil is used as a construction material in various civil engineering projects and its supports structural foundation. Soils are sediments or other unconsolidated accumulation of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.Soil has distinct advantages as a construction material, including its relative availability, low cost, simple construction techniques, and materials properties which can be modified by mixing, blending and compaction. However, there are distinct disadvantages to the use of soil as a construction material, including its non-homogeneity, variation in properties in space and time, changes in stress-strain response with loading, erodability, weathering, and difficulties in transitions between soil and rock.

Civil engineering works in highways, buildings, dams and other structures have strong relationship with soil. These structures need a strong and stable layer of foundation soil to build on. Therefore, soil must be able to carry imposed loads from any structure placed upon it without shear failure or destructive unallowable settlements. Thus, proper estimation of bearing strength of foundation soil is very essential for safety and performance of the structures. The poor engineering properties of soil create problems for construction projects. The soil requires be stablilized. Soil stabilizations are implemented for improving soils, which have inadequate engineering properties. Soil stabilization refers to the process of changing soil properties to improve engineering properties of soil. Soil can be stabilized by mechanically or chemically. Mechanical stabilization means improving the soil properties by rearrangement of particles and densification by compaction, or by changing the gradation through addition or removal of soil particles. Chemical stabilization means improving the soil properties with chemical stabilizers such as cement, lime, fly ash, natural pozzolan, bitumen and enzyme etc. This paper described the addition of cement to the studied soils will change the strength behaviour of these soils. The objective of the stabilization is to increase the bearing capacity of the soil, its resistance to wearing process and soil permeability.

II. PERFORMED TEST RESULTS OF NATURAL SOILS

In order to determine the properties of natural soil before adding cement, the following tests are performed. They are water-content determination, grain-size analysis of soil,atterberg limit test, compaction test and California Bearing Ratio (CBR) test are performed.

Soil samples are taken at about 3 ft depth from Mawlamyine Region which are denoted by soil A. The studied soils excavated, placed in plastic bags, and transported to the laboratory for preparation and testing. Laboratory test were carried out to classify soil sample.

A. Water-Content Determination

Water-content determination is a routine laboratory test to determine the amount of water present in a quantity of soil in terms of its dry weight. The water-content determination of soil A is 20.24%.

B. Grain-Size Analysis of Soil

The grain-size characteristics of soil are evaluated by a mechanical analysis. It is the determination of the size range of particles presented in a soil, and can't be expressed as a percentage of the total dry weight. The following methods are generally used to find the particle size distribution of soil.

1. Sieve analysis is used for particle size larger than 0.075 mm in diameter.
2. Hydrometer analysis is used for particle size smaller than 0.0075 mm in diameter.

C. *Atterberg Limit Test*

The water content levels at which the soil change from one state to the other are the Atterberg Limit.

They are the plastic limit (PL), liquid limit (LL), and shrinkage limit (SL). These limits are referred to as Atterberg Limits. The plasticity index is the difference of liquid limit and plastic limit. The following equation is used to find the plasticity index.

$$PI=LL-PL \quad (1)$$

D. *Compaction Test*

Compaction is the densification of soil by removal of air, which requires mechanical energy. This test is used for determining optimum moisture content and maximum dry density.

E. *California Bearing Ratio (CBR) Test*

The CBR test is a simple strength test that compares the bearing capacity of a material with that of a well-graded crushed stone (thus, a high-quality crushed stone material should have a CBR of 100%). It is primarily intended for, but not limited to, evaluating the strength of cohesive materials having maximum particle sizes less than 0.75 inches. The CBR method is probably the most widely used methods for designing pavement structures. The CBR is a comparative measure of the shearing resistance of soil. Classification system on the basis of CBR number is described Table I.

TABLE I
CLASSIFICATION SYSTEM ON THE BASIC OF CBR NUMBER

CBR%	Material	Rating
>80	Sub base	Excellent
50 to 80	Sub base	Very Good
30 to 50	Sub base	Good
20 to 30	Subgrade	Very Good
10 to 20	Subgrade	Fair-good
5 to 10	Subgrade	Poor-fair
<5	Subgrade	Very poor

TABLE II
CBR VALUE FOR SOIL A

Penetration (mm)	Penetration Resistance (unsoaked)		Penetration Resistance (soaked)	
	Load 5.678 N/d	Stress (KPa) x 100	Load 5.678 N/d	Stress (KPa) x 100
0	0	0	0	0
0.5	110	6.23	58	1.70
1	180	5.28	93	2.73
1.5	250	7.34	128	3.76
2	320	9.39	163	4.78
2.5	390	11.44	198	5.81
3	490	14.38	248	7.28
4	592	17.37	299	8.77
5	689	20.22	347	10.18
6	799	23.45	401	11.77
7.5	869	25.50	437	12.82
9	1039	30.49	522	15.32
10	1139	33.42	572	16.78
12.5	1409	41.35	707	20.75

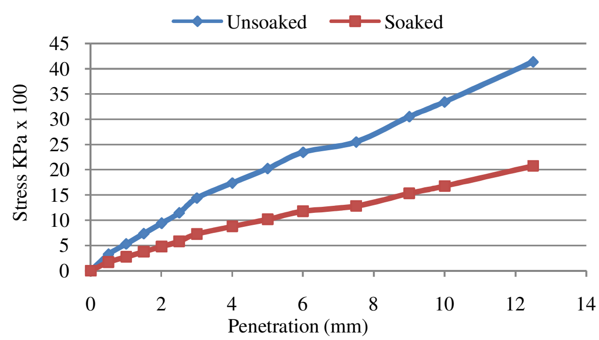

Fig.1 CBR Value for untreated soil A

TABLE III
CBR TEST RESULTS OF UNTREATED SOIL A

Samples	CBR (%)		General Rating	Uses
	Unsoaked	Soaked		
Soil A	16.57 (10 -20)	-	Fair-Good	Subgrade
	-	8.42 (5 - 10)	Poor-Fair	Subgrade

F. *Soil Classification*

To classify the soil, laboratory tests including sieve analysis, water content analysis. Atterberg Limits, compaction and CBR tests are required.

TABLE IV

PHYSICAL PROPERTIES OF SOIL STUDIED

Sr. No	Properties	Soil Sample A
1	Liquid Limit (%)	28.36
2	Plastic Limit (%)	21.39
3	Plasticity Index (%)	6.97
4	Gravel (%)	0
5	Sand (%)	42.8
6	Silt (%)	10.86
7	Clay (%)	-
8	Natural Moisture Content (%)	20.24
9	Maximum Dry Density lb/ft^3	100.2
10	Optimum Moisture Content (%)	21.12

III. DESIGN RESULTS OF SOIL STABILIZATION WITH CEMENT

A. *Cement Stabilization*

Portland cement is used widely for stabilization low-plasticity clays, sandy soils, and granular soils to improve the engineering properties of strength and stiffness. At low cement contents, the product is generally termed cement-modified soil. A cement-modified soil has improved properties of reduced plasticity or expansive characteristics and reduced frost susceptibility. At higher cement contents, the end product is termed soil-cement. Higher cement contents will unavoidably include higher incidences of shrinkage cracking caused by moisture changes.

The particles may be bound together by the action of the stabilization agent itself or may be cemented by products of chemical reactions between the soil and stabilization agent as in the case of cement. Although, there is not test requirement for the optimum cement content when using cement to modify the subgrade. An amount of cement 5%,6% and 7% by dry weight of the soil should be used for the modification of the subgrade.

TABLE V

THE CBR RESULTS OF TREATED SOIL WITH CEMENT 5%

Penetration (mm)	Penetration Resistance (unsoaked)		Penetration Resistance (soaked)	
	Load 5.678 N/d	Stress (KPa) x 100	Load 5.678 N/d	Stress (KPa) x 100
0	0	0	0	0
0.5	132	3.87	70	2.05
1	212	6.22	106	3.11
1.5	292	8.57	146	4.28
2	396	11.62	198	5.81
2.5	580	17.02	290	8.51
3	660	19.37	330	9.68
4	770	22.59	385	11.30
5	850	24.94	425	12.47
6	930	27.29	465	13.64
7.5	1101	32.31	550	16.14
9	1250	36.68	625	18.34
10	1380	40.49	690	20.25
12.5	1764	51.76	882	25.88

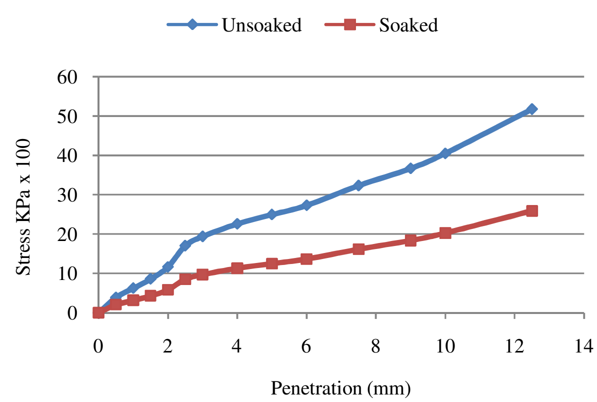

Fig.2The Result of Soil Treated with Cement 5%

TABLE VI

THE CBR RESULTS OF TREATED SOIL WITH CEMENT 6%

Penetration (mm)	Penetration Resistance (unsoaked)		Penetration Resistance (soaked)	
	Load 5.678 N/d	Stress (KPa) x 100	Load 5.678 N/d	Stress (KPa) x 100
0	0	0	0	0
0.5	148	4.34	72	2.11
1	232	6.81	116	3.40
1.5	320	9.93	158	4.64
2	460	13.5	227	6.66
2.5	620	18.19	318	9.33

3	760	22.30	376	11.03
4	900	26.41	445	13.06
5	1040	30.52	518	15.20
6	1190	34.92	590	17.31
7.5	1340	39.32	667	19.57
9	1598	46.89	790	23.18
10	1680	49.30	836	24.53
12.5	2020	59.27	1018	29.87

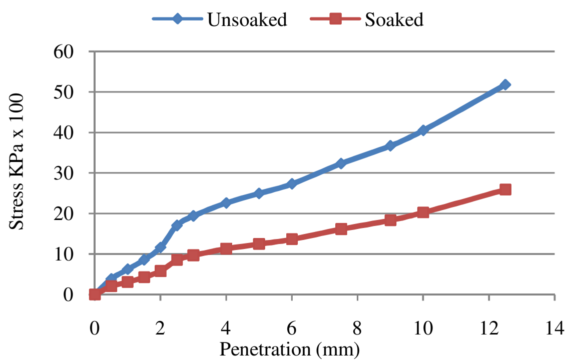

Fig. 3 The Results of Soil Treated with Cement 6%

TABLE VII
THE CBR RESULTS OF TREATED SOIL WITH CEMENT 7%

Penetration (mm)	Penetration Resistance (unsoaked)		Penetration Resistance (soaked)	
	Load 5.678 N/d	Stress (KPa) x 100	Load 5.678 N/d	Stress (KPa) x 100
0	0	0	0	0
0.5	158	4.64	81	2.38
1	236	6.93	119	3.49
1.5	360	10.56	189	5.55
2	520	15.26	262	7.69
2.5	656	19.25	328	9.62
3	820	24.06	410	12.03
4	1158	33.98	568	16.67
5	1424	41.79	711	20.86
6	1656	48.59	818	24.00
7.5	1980	58.10	978	28.70
9	2304	67.61	1052	30.87
10	2535	74.42	1168	34.27
12.5	2860	83.92	1340	39.32

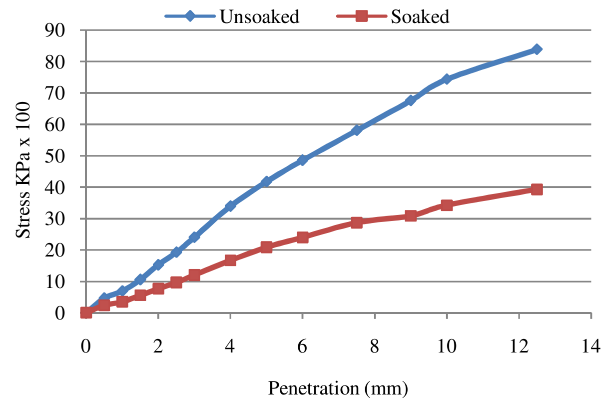

Fig.4The results of Soil Treated with Cement 7%

TABLE VIII
CBR TEST RESULTS OF TREATED SOIL A (CEMENT 5%)

Samples	CBR (%)		General Rating	Uses
	Unsoaked	Soaked		
Soil A	24.67 (20-30)	-	Very-Good	Subgrade
	-	12.38 (10-20)	Fair-Good	Subgrade

TABLE IX
CBR TEST RESULTS OF TREATED SOIL A (CEMENT 6%)

Samples	CBR (%)		General Rating	Uses
	Unsoaked	Soaked		
Soil A	26.36 (20-30)	-	Very-Good	Subgrade
	-	13.52 (10-20)	Fair-Good	Subgrade

TABLE X
CBR TEST RESULTS OF TREATED SOIL A (CEMENT 7%)

Samples	CBR (%)		General Rating	Uses
	Unsoaked	Soaked		
Soil A	27.89 (20-30)	-	Very-Good	Subgrade

	-	13.94 (10-20)	Fair-Good	Subgrade

From the test results, soaked CBR values of treated soil range from 10 to 20 and general rating are Fair-Good. Therefore, both types of studied soil is suitable for subgrade course before application of cement with 5%, 6% and 7%.

IV. DISCUSSION AND CONCLUSIONS

From this research works, the following facts can be discussed.

1. With respect to moisture content measurements and specimen size, the recommended amount of soil required to obtain an accurate measurement increases with increasing maximum particle size.
2. The sieve sizes recommended for mechanical sieving in this laboratory exercise (No.4, No.10, and No.40) are based on the assumption that the soil contains little or no gravel-size particles (i.e.; particles retained by the No4 sieve).
3. Plasticity index is a qualitative measure of the swell potential of soil. Clays with high exchange capacity, including bentonite, montmorillonite, and smectite, have high swell potentials. Liquid limit is defined as the water content at which the groove close at exactly 25 cranks. Most likely, it will required either more or less than 25 craks to close the crack for the first test. To derive liquid limit using the multipoint method, the procedure is repeated at three different water contents, and the data are plotted on semi-log graph.
4. Compaction of subgrade soils is a basic subgrade detail and is one of the most fundamental geotechnical operations for any pavements project. The purpose of compaction is generally to enhance the strength or load-carrying capacity of the soil, while minimizing long-term settlement potential. Compaction also increase stiffness and strength, and reduces swelling potential for expansive soils.
5. The CBR test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these test are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement. This instruction sheet covers the laboratory method for the determination of CBR of undisturbed and remold compacted soil specimens, both in soaked as well as unsoaked state.

As a result of testing, the CBR value of untreated soil in soaked condition is 8.42. Therefore, soil condition is Poor-Fair for subgrade. After stabilization with cement 5%, 6% and 7%, the CBR value of treated soil in soaked condition is 12.38, 13.52, 13.94. CBR values of treated soils range from 10 to 20 and general rating are Fair-Good. So, the studied soil is suitable for subgrade course after stabilization with cement.

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