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Experiential Investigation on the Stabilization of Expansive Soil with Lime

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Abstract – **Subgrade is an important component in the pavement structure. The performance and durability of pavement also depends on type of subgrade soil and its engineering properties. Expansive soil is one of the major soil deposits of Myanmar. In this research, expansive soil is taken from East and West sides of Mandalay-Madayar Road. Based on Atterberg limit values and particles size analysis, the group symbol of research soil is CL according to Unified Soil Classification System (USCS). The plasticity index of research soil is about 25% and has high degree of expansion. Stabilization is needed for research soil to reduce the expensive potential. Lime increases the optimum water content for compaction, which is an advantage when dealing with wet soil and also increases the strength of clayey soil. In this study, stabilization of expansive soil has been carried out using lime. The plasticity index decreases with increase in lime content which varies from 24.66 to about 10.95 in East side and from 26.5 to about 10.64 in West side. This shows that the degree of expansion decreases to low range when increase in lime content. From the unsoaked CBR test results, the CBR values for natural soil in east and west sides are 44.5 and 20 respectively. When expansive soil treated with lime, the peak value of CBR occurs at 3% and 7% of lime in east side of soil and the CBR value decreases as increase in addition of lime in west side of soil. Therefore, the both sides of soil are suitable for sub- base material in dry condition.***Keywords***- –Bio concrete, bacteria, bacillus subtilise, Polymers, carbonate producing bacteria.**

Keywords **- CBR , Expansive Soil, , Lime , Stabilization.**

I. INTRODUCTION

Expansive soil is soil that expands when water is added, and shrinks when they dry out. Clay soils are generally classified as "expansive". This means that a given amount of clay will tend to expand (increase in volume) as it absorbs water and it will shrink (lessen in volume) as water is drawn out. Expansive soils are unsaturated clayey soils that exhibit considerable volume changes, both swelling and shrinking under moisture content fluctuation.

Volume changes of these soils can cause damage on structure resting on them which are shown in Fig. 1. It is important to identify the existence of expansive soil at proposed construction site so that undesirable consequences can be properly predicted and controlled at minimum. The existing soil at a construction site may not always be totally suitable for supporting structure such as building, bridges, highways and dams.

So the soil needs to be densified to increase its unit weight and thus the shear strength. There are general principles of soil improvement such as compaction and chemical stabilization. Soil compaction is generally the cheapest method of soil stabilization available. Soil stabilization is improving the undesirable physical properties of a soil to achieve the desired shear strength, structure and void ratio.

Stabilization of expansive clay can be effectively carried out with the use of admixtures generally known as chemical stabilization. In this study lime is used as stabilizer and introduced in varying percentage to study the properties of soil.

Fig.1 Cause of Damage on Structures

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II.OBJECTIVES OF RESEARCH

- To investigate the basic properties of expansive soil.
- To classify the expansive potential of soil sample by some classification methods.
- To understand the engineering behavior of expansive soil stabilized with various lime contents.
- To choose the suitable lime content for improving the expansive potential and strength of soil.

III.PROPERTIES OF EXPANSIVE SOIL

1. Grain-Size Analysis

Soils are generally characterized as gravel, sand, silt or clay depending upon the predominant sizes of particles within the soil. In determination of grain-size distribution of the soil, sieve analysis is carried out for particles greater than 0.075 mm and hydrometer analysis is used for particles smaller than 0.075 mm. In hydrometer analysis,

ASTM 152H hydrometer and 50 grams of soil passing No.200 sieve (0.075 mm opening) are used. In the analysis, zero correction (-3.0) and meniscus correction (1) are taken. Fig. 2 and 3 show particle-size distribution curve for soil in east and west sides of Mandalay-Madayar Road.

2. Atterberg Limit Tests

The state of soil depends on the amount of water present in the soil. The water content levels at which the soil change from one state to the other are the Atterberg limits. They are the liquid limit (LL) and plastic limit (PL). Table I shows the typical soil classification based on plasticity index and Table II shows the Atterberg limit test results for research soil

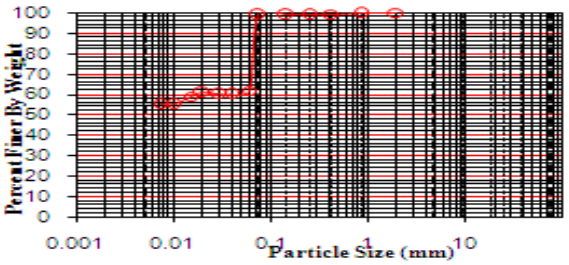

Fig.2 Particle- Size Distribution Curve East.

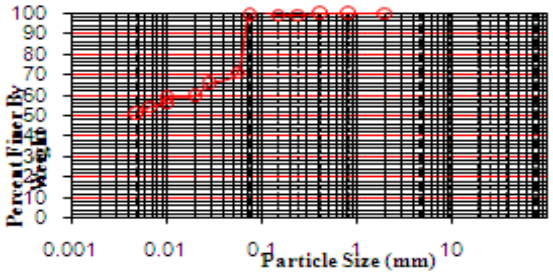

Fig.3 Particle- Size Distribution Curve West

Table1. Typical Soil Classification Based On Plasticity Index.

Plasticity Index	Probable Expansion (% total volume change)	Degree of expansion
>32	> 30	Very high
23-32	20-30	High
12-23	10-20	Medium
<12	< 10	Low

Source Braja M Das. (1998).

Table2. Atterberg Limit Test Results.

Atterberg limit	East	West
LL	39	49
PL	14.34	22.5
PI	24.66	26.5

It can be seen that the research soils are high in degree of expansion according to Table I. Therefore, the research soil needed to stabilize for reducing swell-shrinkage potential.

3. Compaction Test

Compaction is one kind of densification that is realized by rearrangement of soil particles without outflow of water. It is realized by application of mechanic energy.

Standard proctor compaction test is used to obtain the maximum dry density and optimum moisture content of the soil sample. Test result for research soils are shown in Table III and Fig.4 shows the water content and dry unit weight relationship for east side of expansive soil.

Table3.Compaction Test Results.

Type	East	West
Optimum moisture content (%)	20	13.5
Maximum dry unit weight (kN/m^3)	15.8	16.19

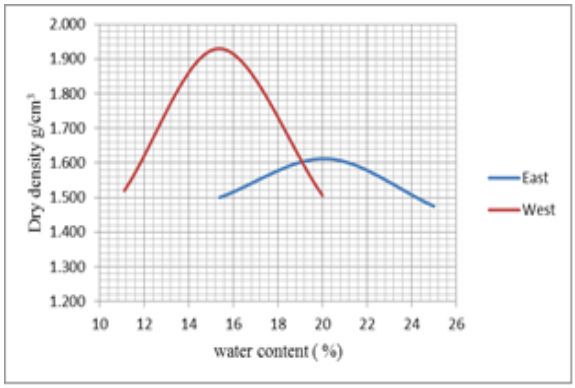

Fig. 4 Water Content and Dry Density Relationship for Expansive Soil (East & West).

Based on the test results of research soil, the optimum water contents of 20 and 13.5% should be added to achieve the maximum dry unit weight of about 16kN/m^3 for east and west sides of soil respectively.

4. California Bearing Ratio (C.B.R.) Test

California bearing ratio is the ratio of force per unit area required to penetrate in to a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm/min. Following table shows typical classification on the basic of CBR.

Table4.Typical classification System On The Basic of CBR

CBR number	General rating	Uses
0-3	Very poor	Sub-grade
3-7	Poor to fair	Sub-grade
7-20	Fair	Sub-base
20-50	Good	Base, sub-base
> 50	Excellent	Base

Source Joseph E. Bowels. (1978).

CBR test is carried out under unsoaked condition. CBR results for research soils of east and west sides are 44.5 and 20 respectively. According to Table 4, it can be seen that east soil is good rating and west soil is fair rating. Both sides of soils can be used as sub-base material.

5. Summary for engineering properties of expansive soil

To know the engineering properties of expansive soil, grain-size analysis, Atterberg limit test, standard proctor compaction test and CBR test are performed by using the soil taken from east and west sides of Mandalay-Madayar Road. The properties of research soil for east and west sides of Mandalay-Madayar Road are summarized in Table 5 and 6 respectively.

Table5. Summary For Engineering Properties of Expansive Soil (East)

S. No.	Property	Values
1.	Consistency limits	
	Liquid limit (%)	39
	Plastic limit (%)	14.34
	Plasticity index (%)	24.66
2.	Compaction characteristics	
	Standard proctor test	
	OMC (%)	20
	Max dry unit weight (kN/m^3)	15.8
3.	California bearing ratio test (CBR)	
	Unsoaked condition	44.5

Table6.Summary For Engineering Properties of Expansive Soil (West)

S. No.	Property	Values
1.	Consistency limits	
	Liquid limit (%)	49
	Plastic limit (%)	22.5
	Plasticity index (%)	26.5
2.	Compaction characteristics	
	Standard proctor test	
	OMC (%)	13.5
	Max dry unit weight (kN/m^3)	16.19
3.	California bearing ratio test (CBR)	
	Unsoaked condition	20

IV. EXPERIMENTAL INVESTIGATION ON EXPANSIVE SOIL STABILIZES WITH LIME

The consistency limits, compaction characteristics and CBR values of black cotton soil treated with 2%, 3%, 5% and 7% of lime by weight of soil are evaluated by performing the tests.

1. Consistency Limits

Atterberg limit test is performed on expansive soil treated with various percentage of lime. The test results for east and west sides of soil are described in Table VII and VIII respectively. Fig. 5 and 6 show the variation of consistency limits with various percentage of lime content.

Table7.Results of Consistency Limits (East)

Type	EPS	EPS + 2%	EPS + 3%	EPS + 5%	EPS + 7%
LL	39	37	48	45	58
PL	14.34	24.52	36.94	33.74	47.05
PI	24.66	12.48	11.06	11.26	10.95

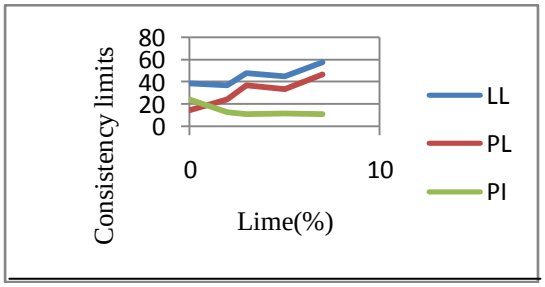

Fig. 5 Variation of Consistency Limits (East)

Table8.Results of Consistency Limits (West.)

Type	EPS	EPS + 2%	EPS + 3%	EPS + 5%	EPS + 7%
LL	49	61	41.5	51	53.5
PL	22.5	36.67	26.19	38.75	42.86
PI	26.5	24.33	15.31	12.25	10.64

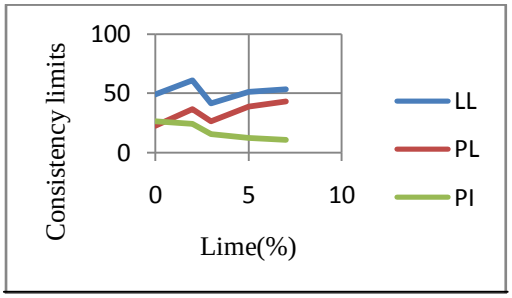

Fig. 6 Variation of Consistency Limits (West)

From the above figures, it can be found that, plasticity index decreases with increasing lime content. Liquid limit and plastic limit are fluctuation when increasing the dosage of lime. Therefore, the degree of expansion decrease when increase in lime content.

2. Compaction Characteristics

The standard proctor compaction test is carried out to investigate the variation in relation between water content and maximum dry unit weight. Table IX and X show the test results for research soil treated with various percentage of lime and Fig. 7 and 8 show the variation of compaction characteristic for untreated and lime treated expansive soil east and west respectively.

Table9.Compaction Test Results of EPS Treated With Lime (East

Type	EPS	EPS +2%	EPS +3%	EPS +5%	EPS +7%
Optimum moisture content (%)	20	15	19.5	23.7	24
Maximum dry unit weight(kN/m^3)	15.8	16.9	16.4	15.01	15.107

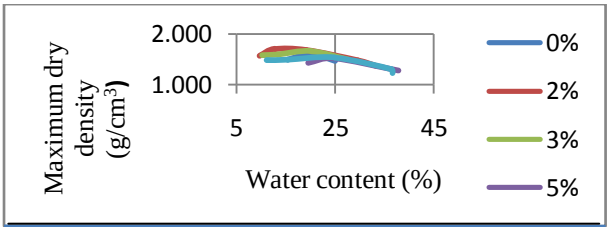

Fig. 7 Compaction Characteristics (East).

Table 10.Compaction Test Results of EPS Treated With Lime (West)

Type	EPS	EPS + 2%	EPS +3%	EPS +5%	EPS + 7%
Optimum moisture content (%)	13.5	21	27	27	28.8
Maximum dry unit weight (kN/m^3)	16.19	18.84	18.74	14.5	13.73

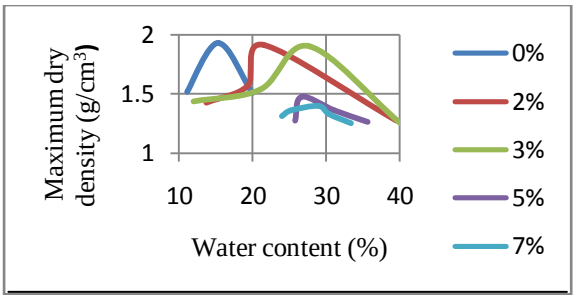

Fig.8 Compaction Characteristics (West).

It can be observed that, the maximum dry unit weight decreases and optimum moisture content increases as an increase of lime percentage. Because of the soil particles are slowly cemented, increasing the particle resistance and compactive effort leading to reduction in the unit weight of soil.

3. California Bearing Ratio (C. B. R.) for EPS Treated with Lime

East and west sides of CBR results for EPS treated with various percentage of lime are described in Table XI and XII respectively. Fig. 9 shows the variation of CBR values untreated and treated lime. The CBR samples are treated with 2, 3, 5 and 7% of lime are tested under unsoaked condition.

Table11.CBR Test Results of EPS Treated With Lime (East)

Samples	CBR value
EP Soil	44.5
EP Soil + 2% Lime	43.4
EP Soil +3% Lime	43.07
EP Soil + 5% Lime	29.96
EP Soil + 7% Lime	22.47

Table12.CBR Test Results of EPS Treated With Lime (West)

Samples	C.B.R value
EP Soil	20
EP Soil + 2% Lime	18.72
EP Soil +3% Lime	63.67
EP Soil + 5% Lime	46.81
EP Soil + 7% Lime	63.66

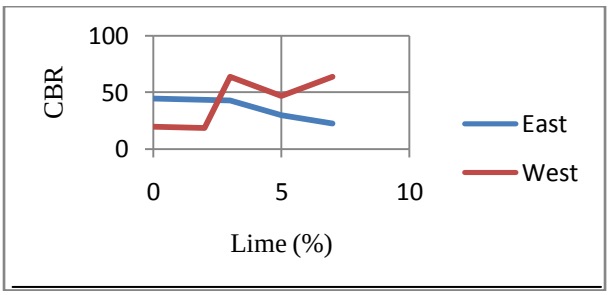

Fig.9 California Bearing Ratio.

The maximum CBR values are found at 3% and 7% of lime in west soil. However, the value of CBR decreasesas the lime content increase in east soil.

V.CONCLUSIONS

This research deals with experimental investigation on stabilization of expansive soil with lime. The grain size analysis, consistency limits, compaction characteristics and CBR of untreated and lime treated expansive soil are investigated. The group symbol of research soil is CL and group name is sandy lean clay classified according to USCS. This soil also shows high degree of expansion based on the plasticity index value of 24.66 in east soil and 26.5 in west soil obtained by performing Atterberg limit tests. When expansive soil treated with lime, the degree of expansion decrease from medium to low based on the results of plasticity index. The plastic nature and expansive potential of the soil decrease as the lime content increases. The addition of lime leads to slight reduction in the maximum dry unit weight and this is due the resistance offered by the compactive effort of the soil-lime mix against impact. The soil in east side of Mandalay-Madayar Road, it is appropriate to use as base soil and west side can be used as sub-base soil according to their CBR test results. The CBR values of the lime treated expansive soil are increased in west side and decreased in east side when compared to untreated expansive soil.

To conclude this investigation, the expansive soil in east and west sides of Mandalay-Madayar Road should be stabilized with 3% of lime to reduce the expansive potential in low degree and also can be used as base/ sub-base soil. Therefore, for improving the expansive potential and strength of the soil, the optimum lime content is found to be in the range of 2.5% to 4%.

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