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Evaluation of Dispersion Potential for Some Problem Soils in Central Myanmar

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ABSTRACT
Dispersive soils which occur in central region of Myanmar are easily erodible and serious problem of stability of embankments, earth dams, earths and earth retaining structures. These soils are found in regions where the annual rainfall is less than 800 mm. Dispersive soil is structurally unstable and the presence of dispersive soil is indicated by occurrence of erosion gullies, sink holes, spew holes and piping. In some parts of the central Myanmar, dispersive soils have to be used for construction purpose since no other soil material is available. Dispersion only occurs in non-saline or rain water. If dispersive soils have been used in the construction of earth-dams and embankments, serious piping and failures are occurred. In Myanmar, some problems are found in central region of Myanmar. The study soil is investigated by emersion test in field and then physical tests are done in Yangon Technological University and chemical tests are done in Irrigation and Management of Water Utilization Department in Myanmar. According to these tests results, most of the study soils are dispersive. This paper presents the results of study soils, soil structural problems along Yangon-Mandalay Express Way, dispersive potential rating for the study soils and the correlation between Exchangeable sodium percentage (ESP) and Atterberg's limits.

Keywords: *Atterberg's Limit Test, Exchangeable sodium percentage (ESP), Cation exchange capacity (CEC)*

I. INTRODUCTION
Many earth dams, hydraulic structures and other structures like road way embankments have suffered serious erosion problems and have failed due to the presence of the dispersive soils. Though the problem has been identified in many parts of the world in recent times, design advances and technical preventive measures are yet to be fully developed and practiced. As the scope and magnitude of the problem which can result from the use of dispersive soil is very high, preventing the failures caused by the dispersibility of the soils has become one of the major concerns of the geotechnical engineers.

In the past, clay soils were considered to be highly resistant to erosion by flowing water, however, in the last few years it was recognized that highly erodible clay soils exist in nature. The tendency for dispersive erosion in a given soil depends on variables such as mineralogy and chemistry of the clay, as well as dissolved salts in the water in soil pores and in the eroding water. Such clays are eroded rapidly by slow-moving water, even when compared to cohesionless fine sands and silts. When dispersive clay soil is immersed in water, the clay fraction behaves like single-grained particles; that is, the clay particles have a minimum of electrochemical attraction and fail to closely adhere to, or bond with, other soil particles. Thus, dispersive clay soil erodes in the presence of flowing water when individual clay platelets are split off and carried away. Such erosion may start in a drying crack, settlement crack, hydraulic fracture crack, or other channel of high permeability in a soil mass. Dispersive soils are clayey and silty soils which are highly susceptible to erosion. The dispersion occurs when the repulsive forces between individual clay particles exceed the attractive forces (Vander Waals attraction) so that when the clay mass is even in contact with still water individual clay particles are progressively detached from the surface & go into suspension.

The principal difference between dispersive clays and ordinary erosion resistant clays appears to be the nature of the cations in the pore water of the clay mass. Dispersive clays have a preponderance of sodium cations, whereas ordinary clays have a preponderance of calcium, potassium, and magnesium cations in the pore water.

II. PROBLEMS DUE TO DISPERSIVE SOIL IN STUDY AREA

The problems related to dispersive soils are common throughout the world. In Myanmar, some of the problems due to dispersive soil are occurred in central region of Myanmar and on the Yangon-Mandalay Express Way embankment. In the past, clay soils were considered to be highly resistant to erosion by flowing water, however, in the last few years it is recognized that highly erodible clay soils exist in nature. Some natural clay soils are dispersed or deflocculated in the presence of relatively pure water and are, therefore, highly susceptible to erosion and piping. Piping failure in embankment is caused by water flowing through the pores of the soil. The erosion occurs mainly in cohesionless soils which have little resistance to the plucking forces of seeping water. With dispersive clay, piping is due to a deflocculating process where water travels through a concentrated leakage channel then occurs along the entire length at the same. Erosion damage in embankments constructed with dispersive soils have generally occurred in areas of high crack potential such as long conduits, in areas of large differences in compressibility of foundation materials. When a concentrated leak starts through embankment constructed of dispersive clay, either of falling two actions may occur: (a) .If the velocity is sufficiently low, the clay surrounding the flow channel swells and progressively seals off the leak. (b) If the initial velocity is sufficiently rapid, the dispersed clay particles are carried away, enlarging the flow channel at faster channel at faster rate than it is closes by swelling leading to progressive piping failure. Some of the failures due to dispersive soil on Yangon-Mandalay Express Way embankment are shown in Figure (1), (2) and (3).

Figure 1 Channel Erosion

Figure 2 Channel and Piping Erosion

Figure 3 Channel and Piping Erosion

III. METHODOLOGY

The flow chart for the study plan is as shown in the Figure (4)

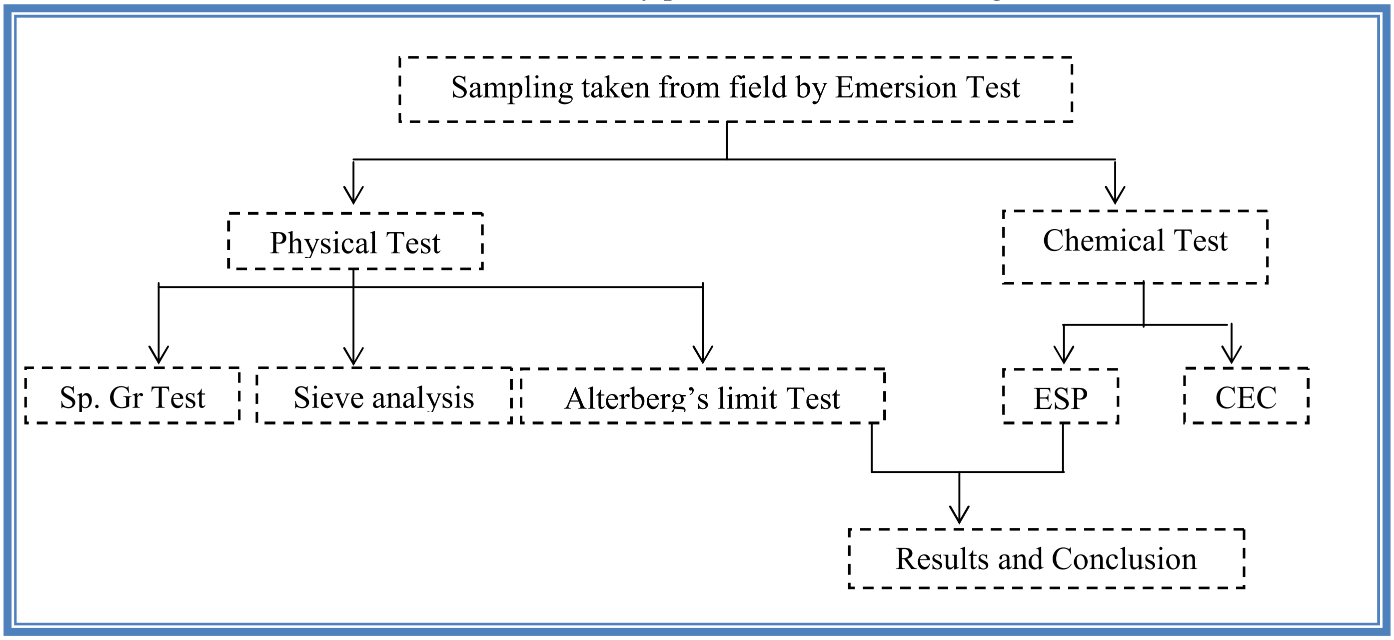

Figure 4 Flow Chart of the Study Plan

1. *Exchangeable Sodium Percent (ESP)*

The Exchangeable Sodium Percent (ESP)is the most common analytical technique used to identify sodic or dispersive soils. The ESP is determined from the ratio of exchangeable cations

$$ESP(\%) = \frac{Na^{+}}{Na^{+} + Mg^{2+} + K^{+} + Ca^{2+}} \times 100$$

Table1. Relationship between degree of dispersion and percentage of exchangeable sodium

Exchangeable Sodium Percentage (ESP)	Rating
<6	Non-sodic
6-10	Slightly sodic
10-15	Moderately sodic
>15	Highly sodic

2. Cation Exchange Capacity(CEC)

CEC is the number of positive charges(cations)that a representative sample of soil can hole. It is usually described as the number of hydrogen ions(H^{+}) necessary to fill the soil cation holding sites per 100 grams of drysoil. Alternatively equivalent amount of another cation ($Al3^{+}Ca^{2+}$) can be used in the measured.CEC expressed as centimoles of positive charge per kilogram of soil(cmol(+)/kg) or meq/100g(milli-equivalent/100g of soil).

3. *Identification of Dispersive Soil by Emerson Field Test*

Field testing is able to identify dispersive soils by observing the behaviour of air dried aggregates soil samples in distilled water or rainwater. The Emerson crumb test is used as an initial test to identify dispersive soil in the field.

Step 1 Collect soil aggregates (2 or 3 pea sized soil aggregates / 1-2cm in diameter) from each layer in the soil profile representative of the soil layers.

Step 2 If moist, dry the aggregates in the sun for a few hours until air-dried (Note: aggregates may not disperse when they should if they have not been sufficiently dried).

Step 3 Gently place the selected aggregates in a shallow glass or jar of distilled water or rain water.

Step 4 Leave the soil aggregates on a stable surface without shaking or disturbing them for 2 hours.

Step 5 Record the results to determine the level of dispersion observed (refer to Figure (5))

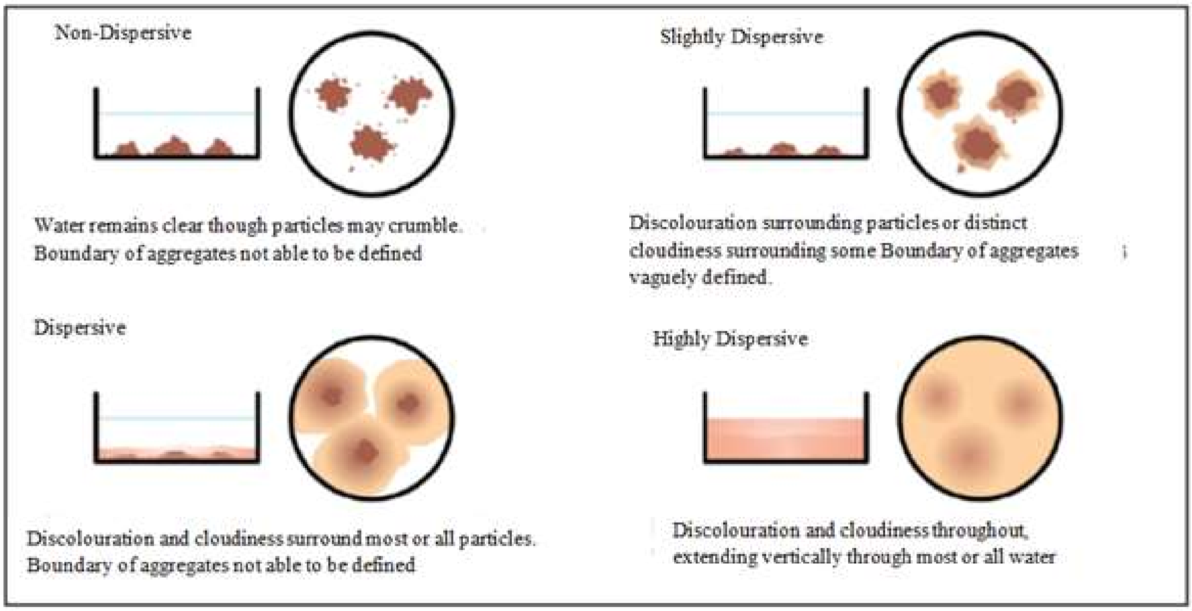

Figure 5 Emerson Field Test

4. Classification of Study Soil by USCS

The study soils are classified by Unified Soil Classification System and the results are shown in Table (2).

Table2. Soil Sample Classification

Sample no.	% of sand	% of silt	% of clay	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Specific Gravity	Type of soil by USCS
1	59	11.5	29.5	13	20	7	2.69	SC
2	45	11.5	43.5	10	33	23	2.64	CL
3	49	23	28	17	33	16	2.67	CL
4	52	8.5	39.5	14	30	16	2.6	SC
5	15	20	65	10	29	19	2.65	CL
6	43	10	47	20	61	41	2.68	CH
7	49	11.5	39.5	18	40	22	2.67	CL
8	55.5	5	39.5	23	59	36	2.66	CH
9	79	1.5	19.5	11	24	13	2.64	SC
10	29	21.5	49.5	25	102	77	2.58	CH
11	29	11.5	59.5	20	63	43	2.8	CH
12	43.5	11.5	45	20	52	32	2.79	CH
13	57	10	33	13	39	26	2.64	SC
14	40.5	20	39.5	12	35	23	2.7	CL
15	44	6.5	49.5	20	54	34	2.7	CL

Sample no.	% of sand	% of silt	% of clay	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Specific Gravity	Type of soil by USCS
16	74	6.5	19.5	19	48	29	2.66	SC
17	60	5	35	18	45	27	2.78	SC
18	44	6.5	49.5	20	57	37	2.53	CH
19	43	2	55	16	37	21	2.7	CL
20	41	2	57	15	56	41	2.59	CH
21	38	2	60	21.3	38	16.7	2.61	CL
22	38	2	60	13	45	32	2.68	CH
23	44	2	54	15	33	18	2.65	CL
24	39	2	59	16	37	21	2.63	CL
25	42	2	56	17	51	34	2.71	CH
26	42	2	56	16	50	34	2.67	CH
27	40	2	58	13	55	42	2.69	CH
28	40	2	58	13	50	37	2.69	CH
29	43	2	55	18	61	43	2.64	CH
30	67	12	21	22	42	20	2.75	SC
31	62	15.5	22.5	24	51	27	2.8	SC
32	17	34	49	40	19	21	2.73	CL
33	22	27	51	46	23.5	22.5	2.69	CL

Specific gravity for study soils are between 2.53 to 2.8.
Minimum liquid limit is 20% and maximum is 102%.
Minimum plasticity index is 7 %and maximum is 77%.
Therefore dispersive soils are low to high plasticity.
Most of the study soils are CL, CH and SC.

5. Analytical Data for Soil Sample

Dispersive rating for study soils are classified by chemical tests and these results are shown in Table 3.

Table3. Analytical Data for Soil Sample

Sample No	pH	CEC (cmol/kg)	ESP(%)	Rating	Remark
1	8.2	15.78	26.43	Highly Sodic	Dispersive
2	9.1	30.44	20.57	Highly Sodic	Dispersive
3	8.4	47.84	6.54	Slightly Sodic	Margin
4	8.1	42.44	9.87	Slightly Sodic	Dispersive
5	8.6	21.12	35.42	Highly Sodic	Dispersive
6	8.9	19.49	38.38	Highly Sodic	Dispersive

Sample No	pH	CEC (cmol/kg)	ESP(%)	Rating	Remark
7	8.9	20.5	34.34	Highly Sodic	Dispersive
8	9.7	18.44	13.67	Moderately Sodic	Dispersive
9	8.7	10.73	26.28	Highly Sodic	Dispersive
10	9.1	13.42	62.59	Highly Sodic	Dispersive
11	8.9	16.15	53.87	Highly Sodic	Dispersive
12	8.8	30.66	18.17	Highly Sodic	Dispersive
13	9.0	14.59	34.82	Highly Sodic	Dispersive
14	8.8	17.43	35.92	Highly Sodic	Dispersive
15	8.7	17.92	37.17	Highly Sodic	Dispersive
16	8.8	19.27	24.39	Highly Sodic	Dispersive
17	8.8	16.65	30.51	Highly Sodic	Dispersive
18	8.8	20.33	34.88	Highly Sodic	Dispersive
19	8.9	12.03	15.88	Highly Sodic	Dispersive
20	9.0	11.55	24.85	Highly Sodic	Dispersive
21	9.4	12.11	20.07	Highly Sodic	Dispersive
22	9.0	18.17	15.30	Highly Sodic	Dispersive
23	8.8	19.68	16.36	Highly Sodic	Dispersive
24	9.2	13.99	15.51	Highly Sodic	Dispersive
25	9.2	35.54	40.6	Highly Sodic	Dispersive
26	8.8	19.78	10.11	Moderately Sodic	Dispersive
27	8.9	12.45	16.87	Highly Sodic	Dispersive
28	9.3	11.33	25.33	Highly Sodic	Dispersive
29	9.0	11.76	17.01	Highly Sodic	Dispersive
30	8.25	14.17	35.51	Highly Sodic	Dispersive
31	9.12	26.09	20.01	Highly Sodic	Dispersive
32	8.2	29.27	8.17	Slightly Sodic	Dispersive
33	7.57	16.09	30.83	Highly Sodic	Dispersive

In study soils, pH values are between 7.57 and 9.4.But most of the soil samples of specific gravity is greater than 8. From the analytical results, increasing pH with the number of negative charges on the colloids increases. So CEC also increases.pH greater than 8 indicates possible high levels of exchangeable sodium or magnesium, and therefore a tendency for the clay to disperse.

IV. RESULTS AND DISCUSSION

The relation between the Exchangeable sodium percentage and Liquid limit is calculated by SPSS software based on Linear Regression Analysis.

$$ESP = a + b\ LL$$

Where,

ESP = Exchangeable sodium percentage
LL = Liquid limit
a = constant
b = the slope of the line

In mathematical modeling, 95% confidence interval is considered from thirty three samples and the following equation is obtained.

$$ESP = 6.68 + 0.421\ LL$$

The relationship curve for Exchangeable sodium percentage (ESP) and Liquid Limit (LL) is shown in Figure 6.

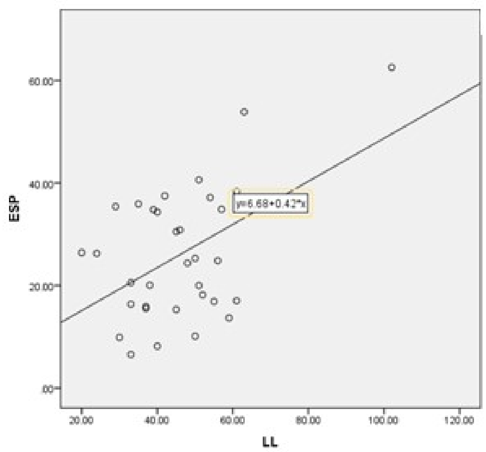

Figure 6 The Relationship Curve for ESP and LL

IV. CONCLUSION

1. In this study, thirty three samples are collected from central region of Myanmar. All of the samples are tested in the laboratories from August to December, 2016.
2. According to the Alterberg's Limit test and sieve analysis results, the soil samples are CH, CL and SC by Unified Soil Classification System.
3. According to the chemical test results, most of the soil samples of dispersive potential rating are high.
4. The observed behavior of the clays and the tests carried out demonstrate that the clays from these locations are dispersive and would not be suitable for use in embankment. This soil should be stabilized with lime or cement to be used for road construction
5. This problem is worldwide, and structural failures attributed to dispersive soils have occurred in many countries.

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