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CASE STUDY PROBLEMS ON DISPERSION POTENTIAL FOR YANGON-MANDALAY EXPRESS WAY EMBANKMENTS

Khin Win Nwe[1]
Nyan Myint Kyaw [2]
[1,2]Department of Civil Engineering, Yangon Technological University (YTU), The Union of the Republic of Myanmar

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 Yangon-Mandalay Express Ways (Nay Pyi Taw- Mandalay portion) embankment. The embankment 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. For these tests results, most of the embankment soils are dispersive. This paper presents the soil structural problems along Yangon-Mandalay Express Way and dispersive potential rating for the studied soil

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

INTRODUCTION

Dispersive soils are highly susceptible to erosion and containing high percentage of exchangeable sodium ions. These soils are found extensively in Central region of Myanmar. In appearance, they are like normal clays that are seen stable and somewhat resistance to erosion but in reality they can be highly erosive and subject to severe damage or failure. It is important to understand the nature of these soils and to be able to identify them so they can be treated or avoided. Soil dispersion is mainly related to the presence of exchangeable sodium percentage. Firstly, soil samples are taken from some locations on Yangon-Mandalay Express Way embankments by Emersion field test. And then, the physical test for the soil samples are tested in the Soil Laboratory, Yangon Technological University and Chemical tests are tested in Soil Survey Section, Soil and Water Analytical Laboratory, Irrigation and Management of Water Utilization Department, Ministry of Agriculture, Livestock and Irrigation. Most of the failures of embankments on Yangon-Mandalay Express way (Nay Pyi Taw to Mandalay portion) were composed of dispersive clays with low-to-medium plasticity (CL, SC and CH). This paper presents about the nature of dispersive soil, visual features of dispersive soil locations and test results for Yangon-Mandalay Express Way (Nay Pyi Taw to Mandalay portion).

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 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 disperse or deflocculate 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 Fig. (1.1), (1.2) and (1.3).

Figure 1.1 channel erosion

Fig. 2: Channel and Piping Erosion

Fig. 3: Channel and Piping Erosion

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The implementation for this study is shown in Figure 1.4 as a flow chart diagram.

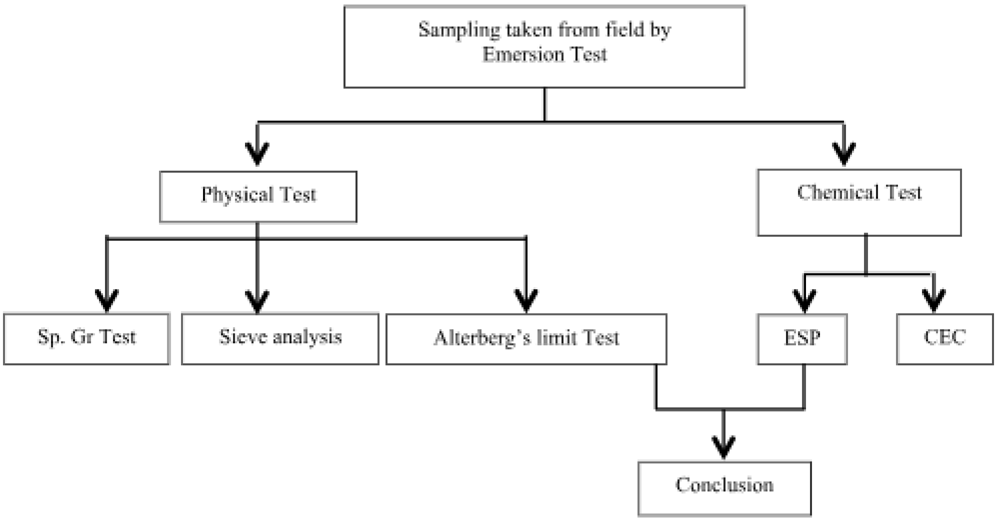

Figure 1.4 flow chart

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

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

Table: 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

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 dry soil. Alternatively equivalent amount of another cation (Al^{3+} or 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)

Identification of Dispersive Soil by Emerson Field Test

Field testing is able to identify dispersive soils by observing the behavior 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.

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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 below)

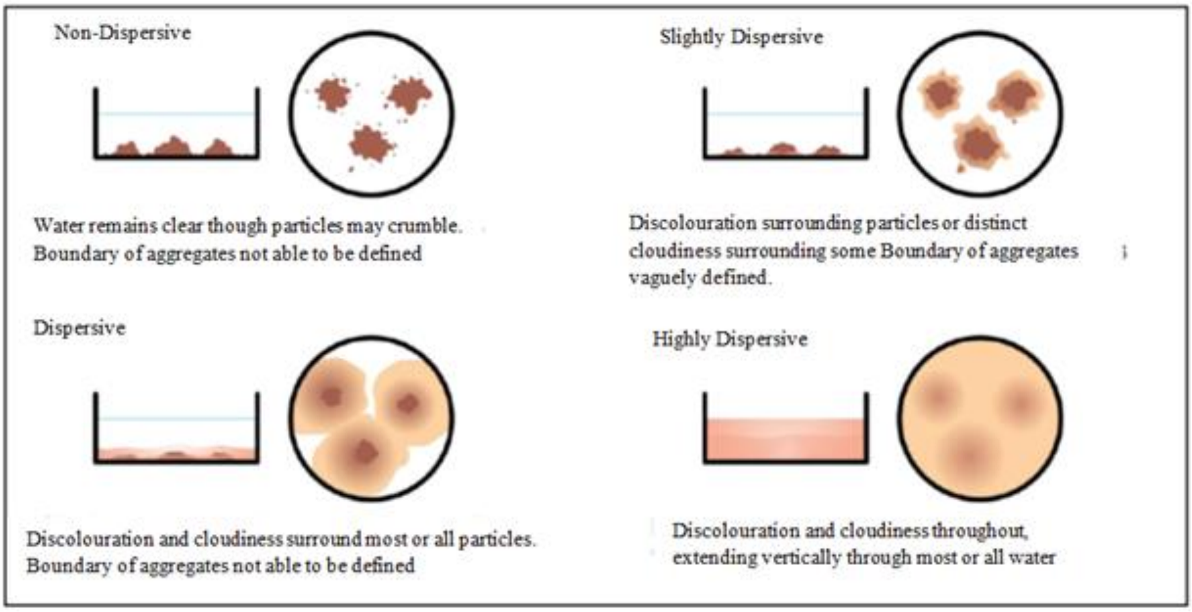

Figure 1.5 emerson field test

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Sample Location

The following table is the location of study soil samples on Yangon-Mandalay Express Way embankments

Table: Sample Locations

Sample No	Locations
1	325/4-5
2	337/6
3	311/7
4	297/6-7
5	325/5-6(YGN to MDY)near underpass
6	327/5-6(MDY to YGN)
7	333/6-7 (YGN to MDY)
8	334/4-5(MDY to YGN)
9	324/2-3(MDY to YGN)
10	333/1-2(MDY to YGN)
11	325/4-5(MDY to YGN)
12	326/1-2(YGN to MDY)
13	327/5-6(YGN to MDY)
14	328/2-3(YGN to MDY)
15	329/6-7(YGN to MDY)
16	330/5-6(YGN to MDY)
17	331/0-1(YGN to MDY)
18	332/5-6(YGN to MDY)
19	333/6-7(YGN to MDY)
20	334/1-2(YGN to MDY)
21	335/4-5(YGN to MDY)
22	340/0-1
23	359/6-7

Classification of Study Soil by USCS

The study soils are classified by Unified Soil Classification System and the results are shown in Table (3). Specific gravity for study soils are between 2.53 to 2.8. Minimum liquid limit is 29% and maximum is 61%. Minimum plasticity index is 16.7 % and the maximum is 43%. Therefore, dispersive soils are low to high

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plasticity. Most of the study soils are CL, CH and SC. Percentage of clay containing in studied soils are greater than 10 and maximum percentage is 65.

Table: Sample Locations

Sample no.	% of sand	% of silt	% of clay	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Specific Gravity	Type of soil by USCS
1	15	20	65	10.4	29.5	19.1	2.65	CL
2	43	10	47	19.6	61.8	42.2	2.68	CH
3	49	11.5	39.5	18	40.5	22.5	2.67	CL
4	55.5	5	39.5	23	59	36	2.66	CH
5	57	10	33	13.5	39	25.5	2.64	SC
6	40.5	20	39.5	12.3	35	22.7	2.7	CL
7	44	6.5	49.5	20	54	34	2.7	CL
8	74	6.5	19.5	19.5	48	28.6	2.66	SC
9	60	5	35	18.5	45	26.5	2.78	SC
10	44	6.5	49.5	20	57	39	2.53	CH
11	43	2	55	15.7	37	21.3	2.7	CL
12	41	2	57	15.5	56	40.5	2.59	CH
13	38	2	60	14	38	22	2.61	CL
14	38	2	60	13	45	32	2.68	CH
15	44	2	54	14.7	33	18.6	2.65	CL
16	39	2	59	16.3	37	20.7	2.63	CL
17	42	2	56	17	51	34	2.71	CH
18	42	2	56	16	50	34	2.67	CH
19	40	2	58	13.4	55	41.7	2.69	CH
20	40	2	58	13	50	37.2	2.69	CH
21	43	2	55	18.4	61	42.3	2.64	CH
22	67	12	21	22	42	20	2.75	SC
23	62	15.5	22.5	24	51	27	2.8	SC

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Analytical Data for Soil Sample

Dispersive rating for study soils are classified by chemical test and these results are shown in Table 4.

Table: Analytical Data for Soil Sample

Sample No	pH	CEC (cmol/kg)	ESP (%)	Rating	Remark
1	8.6	21.12	35.42	Highly Sodic	Dispersive
2	8.9	19.49	38.38	Highly Sodic	Dispersive
3	8.9	20.5	34.34	Highly Sodic	Dispersive
4	9.7	18.44	13.67	Moderately Sodic	Dispersive
5	9.0	14.59	34.82	Highly Sodic	Dispersive
6	8.8	17.43	35.92	Highly Sodic	Dispersive
7	8.7	17.92	37.17	Highly Sodic	Dispersive
8	8.8	19.27	24.39	Highly Sodic	Dispersive
9	8.8	16.65	30.51	Highly Sodic	Dispersive
10	8.8	20.33	34.88	Highly Sodic	Dispersive
11	8.9	12.03	15.88	Highly Sodic	Dispersive
12	9.0	11.55	24.85	Highly Sodic	Dispersive
13	9.4	12.11	20.07	Highly Sodic	Dispersive
14	9.0	18.17	15.30	Highly Sodic	Dispersive
15	8.8	19.68	16.36	Highly Sodic	Dispersive
16	9.2	13.99	15.51	Highly Sodic	Dispersive
17	9.2	35.54	40.6	Highly Sodic	Dispersive
18	8.8	19.78	10.11	Moderately Sodic	Dispersive
19	8.9	12.45	16.87	Highly Sodic	Dispersive
20	9.3	11.33	25.33	Highly Sodic	Dispersive
21	9.0	11.76	17.01	Highly Sodic	Dispersive
22	8.25	14.17	35.51	Highly Sodic	Dispersive
23	9.12	26.09	20.01	Highly Sodic	Dispersive

In study soils, pH values are between 8.6 to 9.4. But most of the soil samples of pH values is greater than 8. From the analytical results, increasing pH with the number of negative charges on the colloids increases. Therefore, CEC also increase. pH greater than 8 indicates possible high levels of exchangeable sodium or magnesium, and therefore a tendency for the clay to disperse.

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RESULT AND DISCUSSION

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

$$ESP = a + b\ PL$$

Where,

ESP = Exchangeable sodium percentage

PL = Plastic 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.

$$ESP = 24.385 + 0.005\ PL2$$

The relationship curve for Exchangeable sodium percentage (ESP) and Plastic Limit (PL) is shown in Figure 1.6.

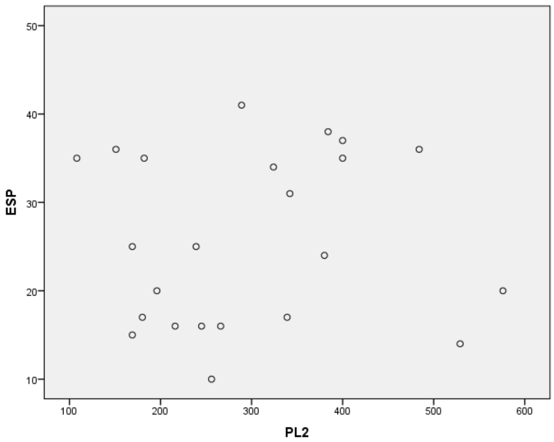

Figure 1.6 the relationship curve for ESP and PL

Samples were collected from some locations in the Yangon-Mandalay Expressway embankment. First, the studied soils were classified by Unified Soil Classification System and then, Atterberg's Limit Test was conducted. These tests were conducted in the Geotechnical Laboratory, Department of Civil Engineering, and Yangon Technological University.

- Chemical properties of dispersive soil were tested in Irrigation and Management Utilization Department, Ministry of Agriculture, livestoke and Irrigation, Yangon.
- From Atterberg's Limit results, the studied soils are low to high plasticity.
- From the chemical test results, most of the studied soils are high dispersive rating.
- So, tunnel erosion mostly occurs in dispersive soils which typically contain greater than 6% exchangeable sodium (ESP).

CONCLUSION

- Tunnel erosion and gully erosion have been found in central region of Myanmar on some locations of Yangon-Mandalay Express Way Embankments.
- Most of the collected samples are found in highly dispersive soil potential by the results of chemical tests.
- Tunnel erosion results from both physical and chemical processes.

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- Dispersion can occur if clay soils coming in contact with fresh water (rain or runoff, etc.). Soil cracks and pores enable runoff and dispersed clays to flow through the soil. Loss of top soil through erosion or excavation exposes dispersive soils to rainfall.
- From this study, twenty three samples are collected from Yangon – Mandalay Express Way Embankment in August, 2016. All of the samples are tested in the laboratories from August to December, 2016.
- From the Alterberg's Limit test and sieve analysis results, the soil samples are CH, CL and SC by Unified Soil Classification System.
- From the chemical test results, most of the soil samples of dispersive potential rating are high.
- The observed behaviour 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.
- This problem is worldwide, and structural failures attributed to dispersive soils have occurred in many countries

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