[TH-01] IDENTIFICATION OF DISPERSIVE SOIL USING TURBIDITY

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ABSTRACT: Dispersive soils occur in many parts of the world are easily erodible and deflocculated in water causing serious problems of stability of earth and earth retaining structures. Earth dams constructed on dispersive soils have suffered internal and surface erosion. The failure of slopes due to dispersion of clay particles by seepage water along cracks, fissures and root holes are initiated by erosion of soil. The mechanism of dispersivity of soils is reasonably well understood. Many of the proposed methods like pinhole, double hydrometer, crumb and chemical tests suffer few limitations. In Emerald’s test and Atkinson’s test the turbidity of soil with water has been mentioned. So this paper deals with the identification of dispersive soils based on turbidity from double hydrometer test. Turbidity is the cloudiness or haziness of a fluid caused by suspension of large numbers of individual particles that are generally invisible to the naked eye. As dispersion of soil particles creates turbidity in water, it can be used as one of the parameter for the identification of dispersive soils. Turbidity value for the water collected during the test at various time intervals are found out using turbidity meter and a graph between turbidity verses time is obtained. The results of this study can serve as an effective tool in quick and easy identification of dispersive potential of various soils in laboratory based on Turbidity.

KEYWORDS: turbidity, dispersive potential, crumb test, double hydrometer, suspension

1 INTRODUCTION

Dispersive soils are highly susceptible to erosion and piping phenomenon as it deflocculates in the presence of flowing water. It rapidly erode forming tunnels and deep gullies by a process in which the individual clay particles go into suspension in slow-moving water (colloidal erosion), damaging roads, earth dams, canals, and other hydraulic structures. Many slope and earth dam failures, foundation and pavement failures have been observed in these types of soils.

Many of the proposed methods like Crumb Test, Pinhole Test, SCS Double Hydrometer Test and Chemical Analysis are being identify the dispersive soil. These are generally used in combination to obtain the most reliable outcome.

Pinhole test and crumb test are only qualitative and not useful for correlation studies. Thus there is a need to prepare a method to identify the dispersive soil. In Emerald’s test and Atkinson’s test the turbidity of soil with water has been mentioned. So this paper deals with the identification of dispersive soils based on turbidity from double hydrometer test.

Turbidity is an optical determination of water clarity. Turbid water will appear cloudy, murky, or otherwise coloured, affecting the physical look of the water. Suspended solids and dissolved coloured material reduce water clarity by creating an opaque, hazy or muddy appearance. Hence it is decided in the present study to use Turbidity as one of the parameter to identify the dispersive nature of a soil.

2 LITERATURE REVIEW

The dispersive mechanism has been reported by various researchers such as Sherard et al(1976), Heinzen and Arulalandan(1977), Holmgren and Flanagan(1977). The importance of this subject in civil engineering practice was not recognized till 1960's. In Australia Aitchinson and Wood, (1965), found that many failures of small dams were due to dispersive soil. Sherard et al (1972) proposed that dispersive soil cannot be identified by the conventional laboratory index tests and visual classification. Hence pinhole test was proposed for qualitative identification of dispersive soils.

Sherard et al (1976), proposed the pinhole test. In this test, distilled water is allowed to flow through a 1.0 mm diameter hole drilled through a compacted specimen. The water passing through the hole is collected on the other end. This water becomes muddy and the diameter of the hole rapidly enlarges due to erosion in dispersive soil. In non-dispersive soil the water is clear and there is no change in the hole diameter. Thus the water will be turbid in case of dispersive soil.

According to Sherard and Decker (1977), the tendency for dispersive erosion 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. Field identification of dispersive soils is based on the behaviour of air dried aggregates in distilled water or rainwater and the above method is the simplification of Emerson crumb test (Emerson 2002).

The performance of a range of analytical procedures for the prediction of soil dispersion has been conducted by a number of authors including; Bell and Maud (1994), Bell and Walker (2000), Moore et al. (1985) and Elges (1985). Review of these studies generally indicate that the Emerson crumb test (Emerson 2002) and the Pinhole test are the most reliable tests for predicting dispersive behaviour of soils.

3 METHODS AND MATERIALS

Soil samples were collected from six different locations of Tamil Nadu based on visual appearance such as colour of the stagnated water and eroded marks on its surface, for the present study. The physical appearances like colour and texture are different for each of the samples. Number of tests was conducted on these soil samples and they are grouped as Primary, Secondary and Tertiary test.

Primary test includes the test for classification of soils, differential free swell test and standard proctor compaction test. Secondary Test includes Double Hydrometer test and Crumb Test. The measurement of Turbidity at different time interval from the double hydrometer test is termed as Tertiary test.

The Primary test results of the collected samples are presented in Table 1.

Table 1 Primary test results

Test/Sample	**1**	**2**	**3**	**4**	**5**	**6**
Specific gravity	2.60	2.69	2.32	2.76	2.63	2.71
Gravel, %	8	10	6	2	0	0
Sand, %	43	24	28	32	72	42
Silt, %	10	20	22	18	26	24
Clay, %	39	46	44	48	2	34
Liquid limit, %	31.5	57.0	38.0	46.0	24.0	31.0
Plastic limit %	21.6	19.2	16.4	19.7	18.4	7.9
Plasticity index, %	9.9	37.8	21.6	26.3	5.6	23.1
Soil Classification	SC	CH	CI	CI	SM	CL
DFS,%	12.5	48.0	24.2	10.0	0.0	13.0
Swell classification	L	H	M	L	L	L
OMC, %	10.2	11.5	9.4	12.2	9.4	8.0
γ_d, g/cc	1.76	2.00	2.06	1.85	1.94	1.90

From Table 1 it can be observed that the collected soil's classification ranges from SM to CH. The OMC ranges from 8% to 12.2% and dry density ranges from 1.76 g/cc to 2.06 g/cc.

3.1 Measurement of Turbidity

The sample preparation for the turbidity test is similar to the method adopted in double hydrometer test. The soil samples with and without dispersing agent are prepared in two hydrometer jars and it is pipetted out at a constant depth (pipettable height) from the jar. The solutions are collected at various time intervals such as 0.15, 0.25,1,2,4,8,15,30,60, 120 and 240 minutes and placed in the Turbidometer. There is no disturbance in the soil sample while pipetting the sample out for the readings.

A turbidity meter is used to measure the turbidity of the samples with respect to time. The turbidity meter consist of a light emitting setup, with a sensor that can read the amount of light reflected or scattered when the light is passed through a solution. The readings in NTU are displayed on a digital screen.

Finally a graph between Turbidity vs time for different soil types was obtained.

4 RESULTS AND DISCUSSION

The results of secondary and tertiary test are discussed in this section.

4.1 Secondary test results

The results of double hydrometer test and crumb test and the range of dispersion for different soil samples are presented in Table 2.

Table 2 Secondary test results

Sample No.	Dispersion percentage	Degree of Dispersion based on SCS test and Crumb test
1	7.3	Non dispersive (ND)
2	50	Intermediate dispersive (ID)
3	61.64	Highly dispersive(HD)
4	59.57	Highly dispersive (HD)
5	8.32	Non dispersive (ND)
6	52.28	Intermediate dispersive (ID)

From the double hydrometer test and Crumb test it is identified that Samples 3 and 4 are highly dispersive, Samples 2 and 6 are Intermediate dispersive and Samples 1 and 5 are Non-dispersive.

4.2 Tertiary test results

The results of turbidometer are presented in Fig.1 and Fig 2 which shows the time vs. turbidity for soil samples with and without dispersing agent. It can be observed from both the figures that the turbidity increases with time for all the soil types for both conditions, i.e., with and without dispersing agent. But in the test without dispersing agent, the turbidity decreases for all soils after attaining a peak, except for highly dispersive soil.

For highly dispersive soil the turbidity is almost same at initial state for both the testing conditions such as with dispersing agent and without dispersing agent. For intermediate dispersive soil with dispersing agent, the turbidity increases with time and for without dispersing agent also the turbidity increases but after sometime it decreases. But the increment is very less for the soil sample with dispersing agent when compared with soil sample without dispersing agent. For non-dispersive soil with dispersing agent, the turbidity increases with time and for without dispersing agent there is very less increment in turbidity.

For the experimental time of 4 hours, these non-dispersive soils when added with dispersive agent show lesser turbidity than intermediate dispersive soils and highly dispersive soils.

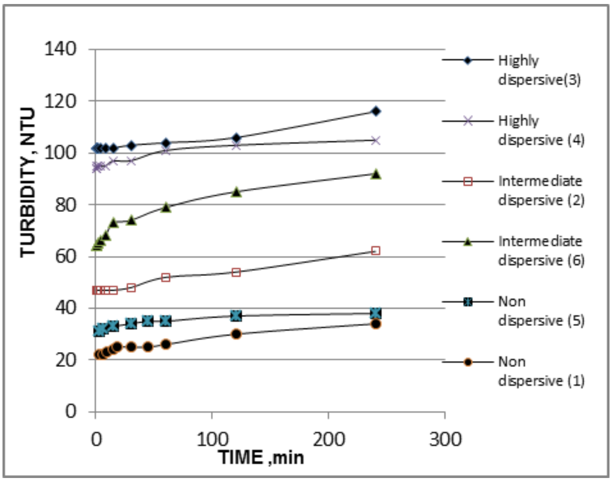

Fig. 1 Time vs. Turbidity for soil samples with dispersing agent

From Fig.1, the observed turbidity values for the different soil samples at time, t=0 and time, t=240 minutes are determined and presented in Table 3.

Table 3.Turbidity (NTU) values for different soils with dispersing agent

Turbidity in NTU	@t=0	@t=240min
Non dispersive (1)	31	38
Non dispersive (5)	22	34
Intermediate dispersive(2)	64	92
Intermediate dispersive(6)	47	62
Highly dispersive (3)	102	116
Highly dispersive (4)	94	105

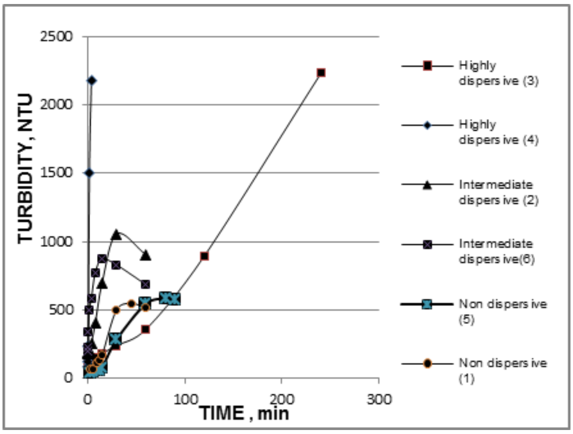

Fig. 2 Time vs. Turbidity for soil samples without dispersing agent

From Fig 2, values of turbidity at time, t=0, time at which peak is attained and at t=60 minutes, are determined and presented in Table 4.

Table 4 Turbidity values in NTU for soil samples without dispersing agent

Time	ND(1)	ND(5)	ID(2)	ID(6)	HD(3)	HD(4)
t=0	68	41	183	196	119	88
Peak	550 @45m	582 @80m	1057 @30m	873 @15m	2230 @240m	2174 @4m
t=60	514	545	905	686	-	358

Therefore from both the test results, the range of turbidity was identified for different degree of dispersiveness, with and without dispersing agent and presented in Table 5.

Table 5 Range of turbidity (NTU) for identification of degree of dispersiveness

Degree Of Dispersion	With Dispersing Agent	Without Dispersing Agent
Non dispersive	20-40	500-700
Intermediate dispersive	40-90	700-1300
Highly dispersive	90-120	1300-above

The above table can be used as tool to identify the dispersive nature of soil using Turbidometer.

5 CONCLUSION

Dispersion soils are highly susceptible to erosion due to its high reactivity with water. It is observed from the previous study that Turbidity-time curve changes with dispersivity of soil. So it is proven in this paper that there is a scope to use turbidity as one of the parameter in identification of degree of dispersiveness of soils.

The important observations made from the present study are given below:

1. The dispersiveness of different soils can be identified based on Turbidity i.e. by quantitative approach and not by qualitative approach.

2. The Turbidity ranges are identified for different degree of dispersiveness with and without dispersing agents and the ranges are identified. The range of turbidity (NTU) for non-dispersive, intermediate dispersive and highly dispersive soils with dispersing agent is 20-40, 40-90 and 90-120 respectively. The range of turbidity (NTU) for non-dispersive, intermediate dispersive and highly dispersive soils without dispersing agent are 500-700, 70-1300 and above 1300 respectively.

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