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EFFECT OF DENSITY AND MOISTURE ON THE SLOPE STABILITY OF HIGHWAY EMBANKMENT

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ABSTRACT

An experimental study has been carried out to observe the effect of density and moisture on property of cohesive (expansive) soil. At a constant grading of a soil its effect on strength, swelling pressure, permeability and CBR value has been undertaken, as soils are to be used for making road pavement, embankments, dams etc. The stability of an embankment will greatly be influence by the shear parameters which are depend upon the degree of compaction. This paper deals with slope stability evolutions by limit equilibrium (LE) methods and compared with the results from GEOSLOPE software. The LE based methods are compared based on the factor of safety (FOS) obtained from various conditions with simplified slope geometry and shear strength parameters. The slope stability analysis of cohesive soil has been done by SLOPE/W software and is used in under different conditions to evaluate slope stability. Analysis of embankment at different heights of each slope with Bishop Method. In the present study the effect of varying the density and moisture has been studied to determine the properties of cohesive soil namely expansive black cotton soil. It has been concluded that by increasing the dry density, the undrained shear parameters (C & Φ) are improved.

KEYWORDS: Cohesive expansive soil, factor of safety, limit equilibrium, cohesion , friction angle etc.

INTRODUCTION

The most common type of natural soil on the earth's surface is the cohesive expansive soil. This type of soil can be found in various regions of country and causes several problems like settlement of the structure, cracks and liquefaction. The liquefaction is most important problem in geotechnical engineering. The ability of liquefaction is concern to the several factors. The pore water pressure is an important factor in liquefaction and slope geometry design. The author made an investigation on slope behavior subjected to underground water level. The slope models developed under compacted and optimum moisture content (OMC) condition with different ground water levels and geometries. In this regard using Geo-slope software several models have been analyzed. The result revealed pore water pressure ability has correlation with slope geometry and soil mechanical properties, it means pore water force at any earthen structure or area is specific.

EXPERIMENT SETUP AND METHODOLOGY ADOPTED

The objective of the study is to observe the variation in shear parameters (C,Φ), for expensive black cotton soil by varying its dry density and moisture content for the experimental study the soil samples were procured from the campus of the institute the sample so collected was divided in equal parts and grading of each part was done. It was observed that the grading was more or less constant for all parts so an average grading pattern was found.

After grading the used geotechnical properties of the soil was determined. These properties are tabulated in Table 1. The soil particles retained on particular sieve were kept in separate bottles for mixing the required properties of different parts for conducting the test on a varying dry density required proportion of water was added to this soil mass for making a soil paste and samples were prepared for conducting the desired tests. After finding out the required parameters (shear parameters for a constant dry density on a constant moisture content, the same set of tests were conducted on another samples prepared at same dry density but another moisture content. In this way the required set of experiments were conducted. The following dry density and moisture content values were adopted.

(A) Dry Density:- 1.4gm/cm^3 , 1.5gm/$cm^{3,}$ 1.6gm/cm^3 and 1.64(i.e MDD)

(B) Moisture Content:- 10%,15%, 20% and 25%

The shear parameters C and Φ were determined by conducting the Triaxial compression test of UU type (i.e. by performing quick test) test for different density and moisture content are tabular in Table 2. For creating slope models the mixed soils angle of friction (Φ), unit weight (γ) and cohesion (C) have been used at different height of embankment. The 48 slope models geometry were prepared on dry, partially saturated, optimum moisture content and fully saturated condition of soil by using geoslope at the foundation levels as shown in fig 1,2,3,4. The Geo-Slope was used for studying models characteristics and finding possibility improvement factor of safety from local and economical material. In application of the Geo-slope software Bishop method with limit equilibrium was used to solving slope problem to calculate normal stress, shear stress, shear strength and Factor of Safety.

Table: Properties Soils

S.No	Name of Test	Test Results														
1	Gradation IS 2720 part III	sieve size	4.75	2.36	1.18	0.6	0.425	0.3	0.212	0.15	0.075	0.06	0.02	0.006	0.002
		% passes	99.8	99.7	98.4	95.7	92	87.9	87.9	78.5	70.3	19.7	19	11.9	6.33
		Gravel												0.25	
		Sand												29.44	
		Silt												63.98	
		Clay												6.33	
2	Aterbergs limits IS 2720 part V				liquid limit				plastic limit			shrinkage limit			
					61				39			16			
3	Specific Gravity IS: 2720 Part III													2.45	
4	IS classification													MH	
5	Free Swell Index													61%	
6	Compaction Parameters IS :2720 Part VIII				Optimum Moisture Content						Maximum Dry Density				
					20%						1.64g/cc				

RESULTS AND DISCUSSION OF HIGHWAY EMBANKMENT SLOPE STABILITY ANALYSIS

Factor of Safety in Short-Term Analysis (Homogeneous Embankments at different heights on different water content and different density) Table 2 Results show the Angle of Internal Friction and cohesion value at different Moisture content and different density.

Table: Result s show the Angle of Internal Friction and cohesion value

S. No.	moisture content (%)	(KN/m3)	Φ Degree	C (KN/m2)
1	10	1.4	26	0.36
2		1.5	27	0.7
3		1.6	35	0.7
4	15	1.4	15	0.63
5		1.5	16	1.12
6		1.6	18	1.2
7	20	1.4	0	0.7
8		1.5	0	1.26
9		1.6	15	1.33
10	25	1.4	0	0.91
11		1.5	0	1.28
12		1.6	10	1.33

Table: Results Shows the FOS of Embankment at Different water content and Different Density

S.No.	Height of Embankment	Model No. 1 (Dry Soil)		Model No. 2 (Partly Saturated Soil)		Model No. 3 (Optimum Moisture Content)		Model No. 4 (Fully Saturated Soil)	
		Density	FOS	Density	FOS	Density	FOS	Density	FOS
1	10	1.4	1.934	1.4	1.567	1.4	1.061	1.4	0.896
2		1.5	2.279	1.5	1.821	1.5	1.416	1.5	1.427
3		1.6	2.543	1.6	2.326	1.6	2.314	1.6	2.507
4	15	1.4	1.855	1.4	1.449	1.4	0.936	1.4	0.869
5		1.5	2.01	1.5	1.567	1.5	1.11	1.5	1.26
6		1.6	2.279	1.6	2.154	1.6	2.091	1.6	2.066
7	20	1.4	1.78	1.4	1.384	1.4	0.5	1.4	0.641
8		1.5	1.8	1.5	1.529	1.5	1.064	1.5	0.981
9		1.6	2.332	1.6	2.18	1.6	2.047	1.6	1.982
10	25	1.4	1.553	1.4	0.967	1.4	0.384	1.4	0.316
11		1.5	1.7	1.5	1.44	1.5	1.06	1.5	0.971
12		1.6	2.253	1.6	2.14	1.6	2.018	1.6	0.954

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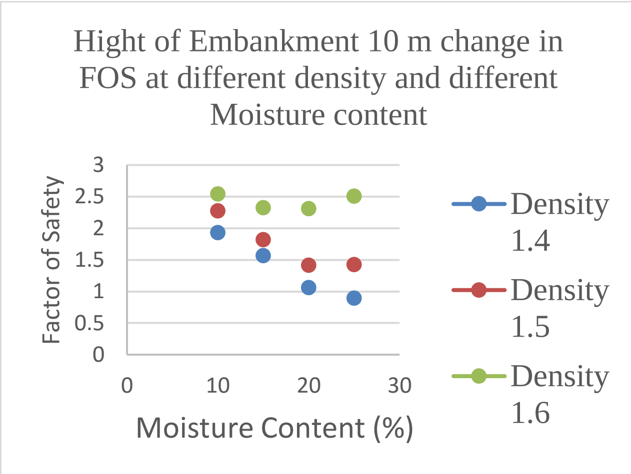

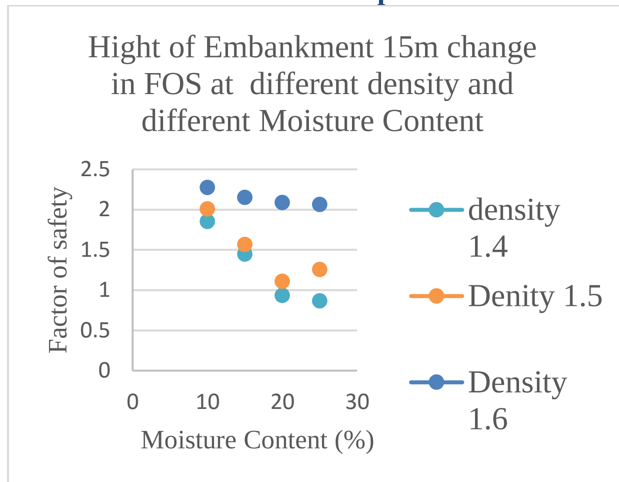

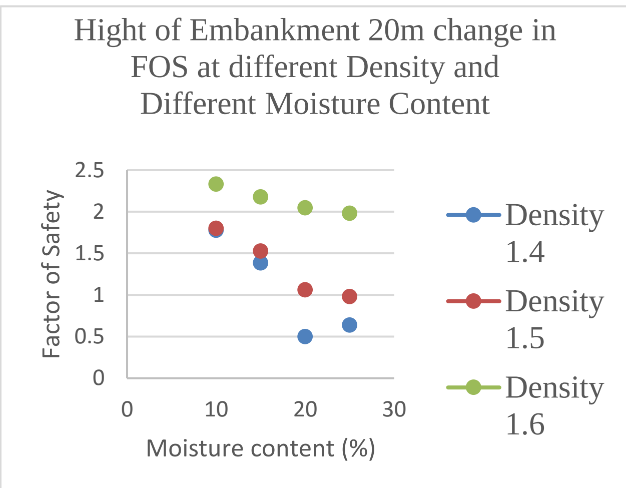

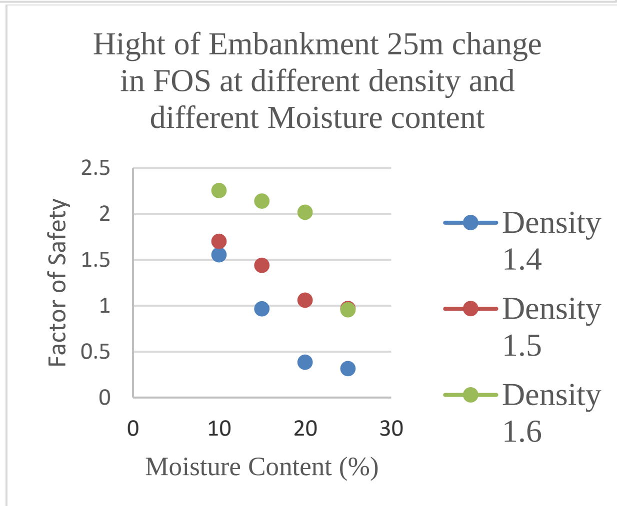

CRITICAL FAILURE OF SLOPE ON EXPANSIVE SOIL AT DIFFERENT HEIGHTS OF (HOMOGENEOUS EMBANKEMENT)

This section presents the results of the short-term and long-term analyses performed on the embankments built with expansive soils by using GEO-SLOPE software. After the demonstration of each group of data, a Fig. is prepared the failure arc with MDD and OMC at 10 m height of embankment. And, the second Fig. reveals the stress of the heaviest slice in that failures circle.

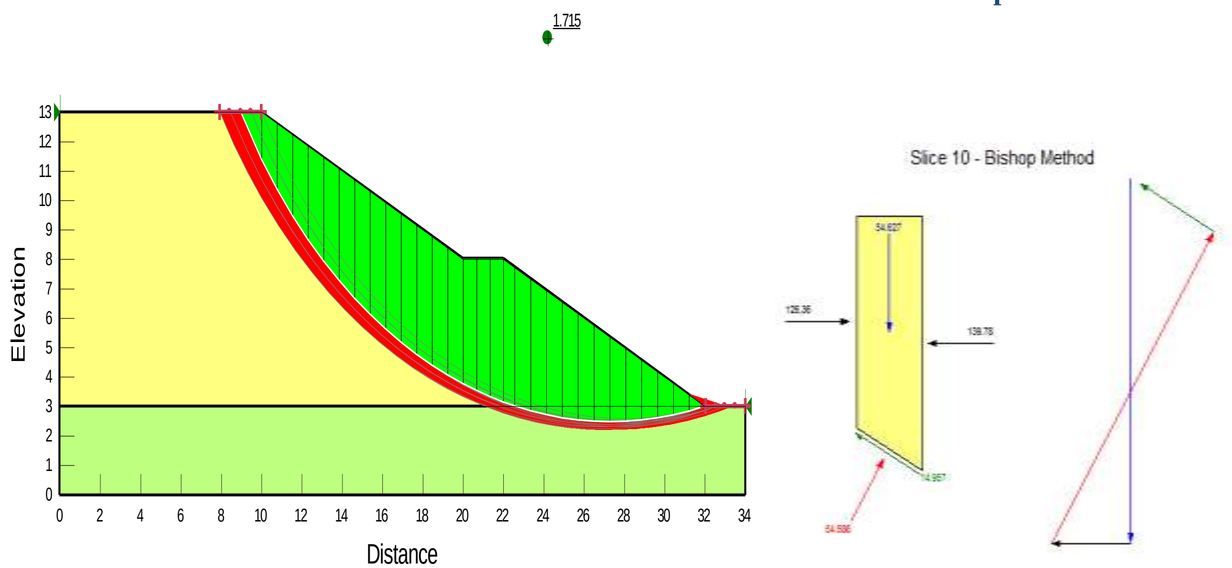

Fig: Most Critical Failure Arc in Short-Term Analysis and Stress in Each Slice (Homogeneous Embankment; Height 10m)

This section presents the results of the short-term and long-term analyses performed on the embankments built with Expansive soils. After the demonstration of each group of data, a Fig. is prepared the failure arc with MDD and OMC at 15 m height of embankment. And, the second Fig. reveals the stress of the heaviest slice in that failure circle

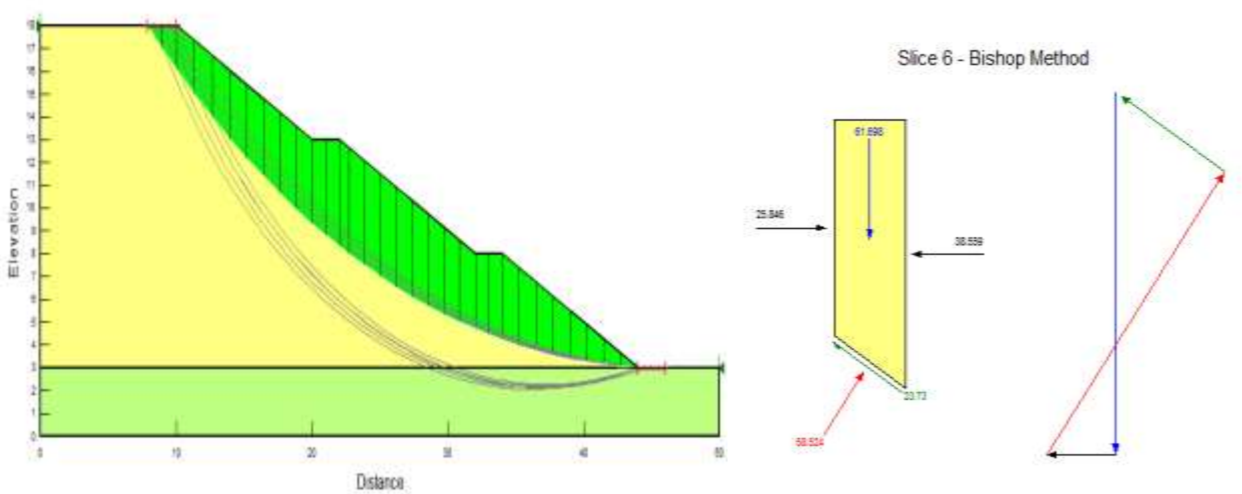

Fig: Most Critical Failure Arc in Short-Term Analysis and Stress in Each Slice (Homogeneous Embankment; Height 15m)

This section presents the results of the short-term and long-term analyses performed on the embankments built with expansive soils. After the demonstration of each group of data, a Fig. is prepared the failure arc with MDD and OMC at 20 m height of embankment. And, the second Fig. reveals the stress of the heaviest slice in that failure circle

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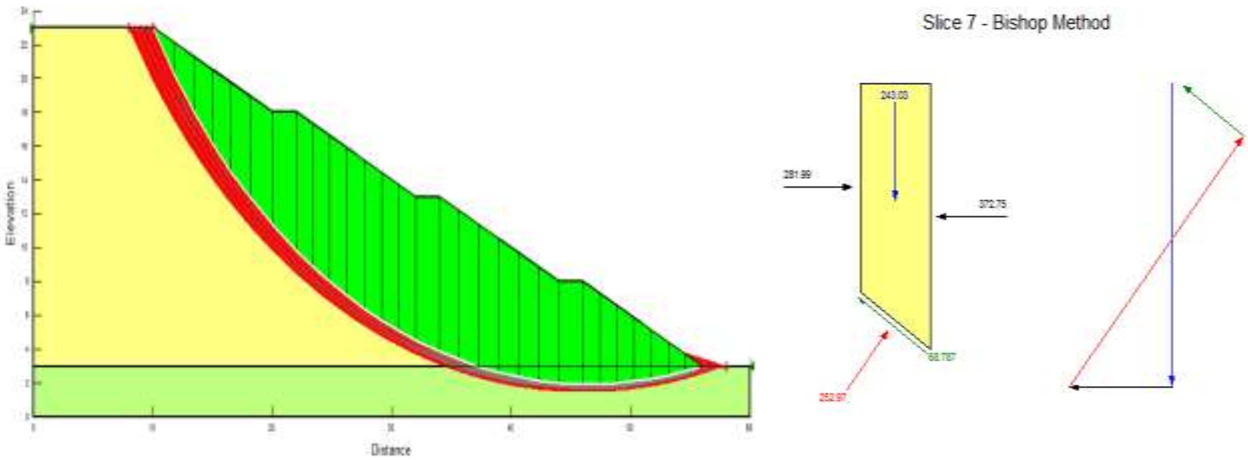

Fig: Most Critical Failure Arc in Short-Term Analysis and Stress in Each Splice (Homogeneous Embankment; Height 20m)

This section presents the results of the short-term and long-term analyses performed on the embankments built with expansive soils. After the demonstration of each group of data, a Fig. is prepared the failure arc with MDD and OMC at 25 m height of embankment. And, the second Fig. reveals the stress of the heaviest slice in that failure circle.

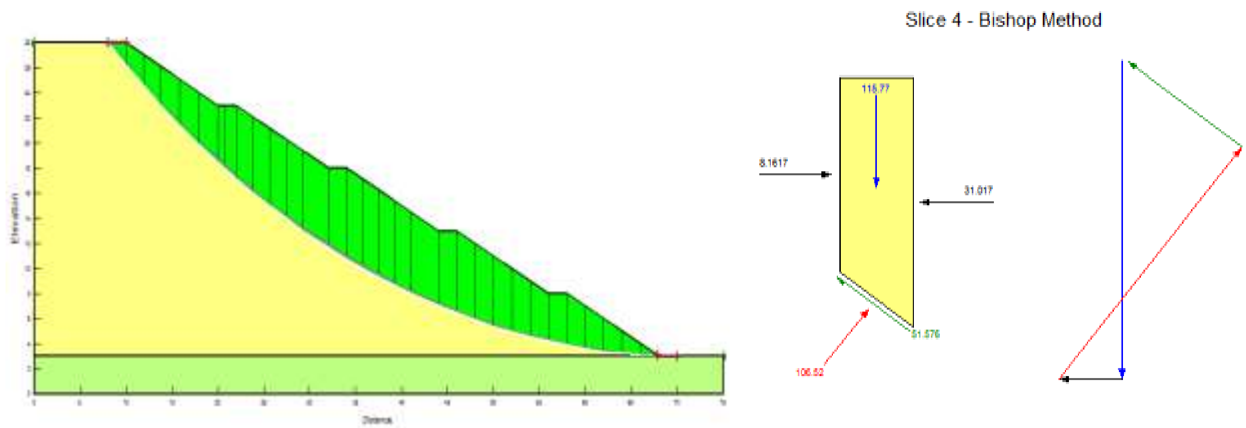

Fig: Most Critical Failure Arc in Short-Term Analysis and Stress of Each Slice (Homogeneous Embankment; Height 25m)

CONCLUSIONS

1) The Cohesion value of expansive soil increases with increase in dry density and increase in moisture content both.
2) The angle of internal friction increases with increase in dry density but decreases with increase in moisture content. The angle of internal friction reduces to zero on saturation (i.e.20% and 25%) moisture content at low density of 85% and 95% of compaction value. whereas at high density 98% and 100% compaction the angle of internal friction as good value
3) FOS increases with increase dry density for given moisture content and height of embankment.
4) FOS decreases with increase in moisture content for a given density and height of embankment.
5) The FOS decreases with increase in height of embankment for given MC and dry density for both soil.
6) The constant grading of soil is technique for modification the geotechnical properties and improving slope stability of embankment.

7) The type of failure is depend on slope geometric property, shear parameter and mechanical properties of soil.

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