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SAFETY FACTOR COMPARISON OF DIFFERENT METHODS OF SLOPE STABILITY ANALYSIS BY GEOSTUDIO SOFTWARE

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ABSTRACT:

Embankment dam are common in any other type of dams because of various reason like the use of ordinary construction technology method using the cheep raw soil material and subsurface materials, no need of a particular valley shape etc. one of the important factor causing failure of embankment dam by seepage and hence seepage analysis of embankment dam is of greater importance. Due to these, Calculation of seepage in earthen dam by the analytical approach, Calculation of slope stability analysis in earthen dam by analytical approach. Most of natural slope failure occurs during rainy season, as the presence of water causes both increased stresses and the loss of strength with the development of modern method of technique of stability analysis, a safe and economical design of a slope have a thorough knowledge various methods for checking the stability of slope and their limitations. Two types of slope problems occur in clays, short term stability and long term stability (steady seepage case). Based on field observation and laboratory analysis, it is conducted that for short term stability analysis the $\phi = 0$ total stress method is satisfactory. The effective stress method of analysis should be used for long term stability analysis. Stability analysis determines using the different method of slope stability analysis such as Taylor's method, Swedish slip circle method, bishop's method and Morgenstern method.

KEY WORDS: *IS soil classification, Atterberg's limits, permeability, shear strength, seepage, slope stability analysis.*

1. INTRODUCTION:

Dams are constructed for various purpose like flood control, navigation, water sources, recreation, power generation and irrigation etc. earth dams have always been associated with seepage as they impound water it. The water seeks paths of least resistance through the dam and its foundation. Seepage must be controlled to save the erosion of embankment or its foundation. Embankment dam are common in any other type of dams because of various reason like the use of ordinary construction technology method using the cheep raw soil material and subsurface materials, no need of a particular valley shape etc. one of the important factor causing failure of embankment dam by seepage and hence seepage analysis of embankment dam is of greater importance. The slide

is nothing but failure of mass of soil in downward direction. It is usually caused by a gradual disintegration of the soil structures, by an increase of the pore water pressure in a few exceptionally permeable layers, or by a shock that liquidizes of soil. The main factor for increasing of pore-water pressure is loss of shear strength of soil. The loss of shear strength may occur due to shock loads, increase in water content, increase in pore water pressure, weathering or any other cause. "Most of natural slope failure occurs during rainy season, as the presence of water causes both increased stresses and the losses of strength with the development of modern method of technique of stability analysis, a safe and economical design of a slope have knowledge various methods for checking the stability of slope and their limitations". Two types of slope problems occur in clays, short term stability and long term stability (steady seepage case). Based on field observation and laboratory analysis, it is conducted that for short term stability analysis the $\phi = 0$ total stress method is satisfactory. Stability analysis determines using the different method of slope stability analysis such as Taylor's method, Swedish slip circle method, bishop's method and Morgenstern method. The Geostudio computer software is used to estimate the seepage and slope stability analysis of utakur summer storage tank. This soft ware solves the underground water problems for stable, unstable, saturated and unsaturated conditions. This software not only the superiority to the graphic method and manual calculations, but also regarding the time we can gain good results. This software has many applications which helps designers in best designing of dams and analyzing the weak or strength points of dams and also designing of the construction which dealing with the seepage problems.

2. OBJECTIVES:

- Study the earthen dam details
- Study the failures of earthen dam
- Study the problems of earthen dam
- Calculation of seepage in earthen dam by the analytical approach
- Calculation of slope stability analysis in earthen dam by analytical approach
- Determining the seepage analysis by using geo-studio software in earthen dam
- Determine the slope stability analysis by using geo-studio software in earthen dam

3. METHODOLOGY:

In the present study seepage and slope stability analysis is done in two ways:

Analytical approach: The analytically the seepage analysis is calculated by using Darcy's law, and the slope stability analysis is done by using Bishop Method. This analytical approach is done based on the earthen dam details and with their material properties.

Computer approach: The Geo-studio software is mainly based on finite element method that can be used for evaluate the performance of dams. The product SLPOE/W is calculate the analysis of slope stability and pore-water pressure conditions, soil properties, analysis of methods and loading conditions. For analysis of slope stability having a several methods such as Bishop, Ordinary, janbu, Morgenstern-price, Spencer.

4. SOIL PROPERTIES

The soil properties are determined by the conducting the different tests and obtaining the different values as follows:

Table.1 Soil properties for Foundation and Embankment

Foundation		Embankment	
Liquid limit	53.0%	Liquid limit	45%
Clay content	89 (fines)	Clay content	83 (fines)
Specific gravity	2.59	Specific gravity	2.62
Void ratio	0.62	Void ratio	0.59
Water content	26.7	Water content	19.32
Density	1752 kg/cm^3	Density	1903 kg/cm^3
Shear strength	c = 3600 kg/cm^2 $\phi = 6^0$	Shear strength	c = 3800 kg/cm^2 $\phi = 7^0$
IS classification	CH	IS classification	CI

4.1 CALCULATION OF SEEPAGE:

From the Earth dam dimensions Total height of dam is 11.5m,Up stream and Downstream slope is 2:1,Top width of the dam is 5.5m and length of the Blanket is 4.0m and coefficient of permeability is x =1.89 x 10^{-6} cm/sec, y = 4.256 x 10^{-6}cm/sec and free board is 1.5m.

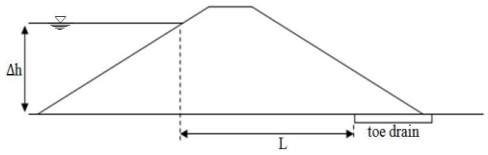

Fig.1 Homogenous earth dam profile.

From the Darcy's law equation, q= k. s

k=$\sqrt{kx \, . ky}$

= 0.24759 x 10^{-6} m/sec

Maximum storage level H = total height of dam – free board

= 10 m.

Focal distance S = $\sqrt{(D^2}$+H^2)-D

Length of the Upstream

horizontal projection L = horizontal slope x M.S.L

= 18.2 m.

Length of the water surface = 0.3 L

= 0.3 x 18.2

= 5.46 m.

Distance of the water surface to blanket D = addition of water surface length, horizontal slopes of u/s and d/s and, width of the dam and length of the d/s slope

D = 27.5 m.

Focal distance S = 4.88 m.

Therefore discharge q = k x s

q= 1.074 x 10^{-6} m^3/sec/m

seepage through the earth dam is **1.208 x $10^{-6}$$m^3$/sec/m.**

4.2 CALCULATION OF SLOPE STABILITY

From the soil properties table 4.1 of embankment, the unit weight of soil γ = 19.03 KN/m^3 cohesion C= 40 kpa, angle of internal friction ϕ =7^0, Total height of the dam h=11.5m and angle of slope β=49^0 by using bishop method and ordinary ,Morgenstern method.

$\sum N$ = 1882.994 kN $\sum T$ = 612.401 kN,

Factor of safety $F_s = \frac{Cr\theta + \sum N \tan\phi}{\sum T}$

Therefore the factor of safety is **1.63**

4.3 SEEPAGE ANALYSIS (SEEP/W)

Analysis of seepage is done by Geo-studio software step by step procedure as, For seepage analysis open the Geo-studio SEEP/W define module, Identify the individual toolbars available.

Earthen Dam dimensions : Top Width 5.5 m, Bottom width 40 m, Total height of the dam is 11.5 m, Maximum water level is 9.2 m, Slope of dam is 1.5 in 1 both U/S and D/S, Sand blanket 4 m.

Soil properties: permeability of soil is 1.89 x 10^{-6} cm/sec, unit weight of soil is 19.03 KN/m^3, cohesion 40 kpa, angle of internal friction 7^0, liquid limit 45%.

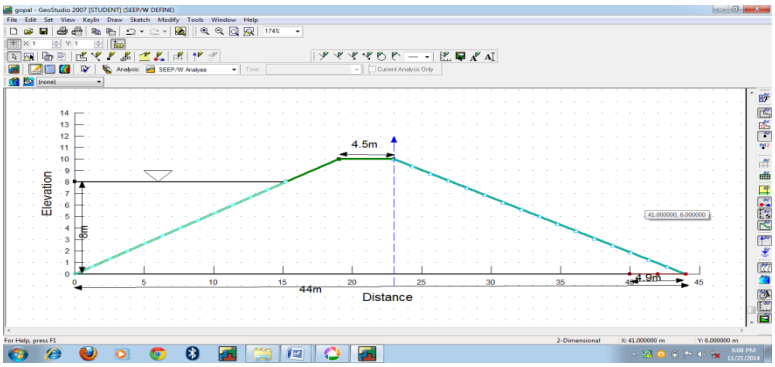

Fig.2 sketching of the seepage problem

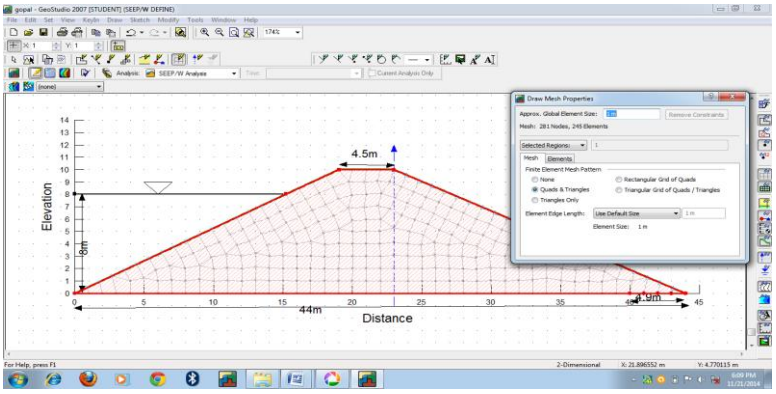

Fig.3 mesh properties

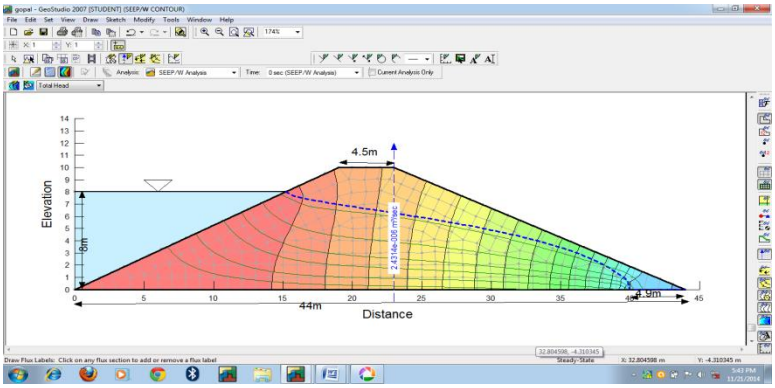

Fig.4 seepage analysis

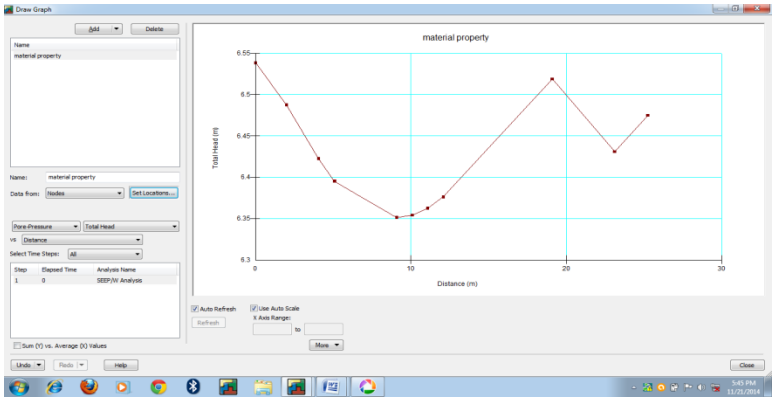

Fig.5 Pore-pressure and total head

The above fig 4.6 shows the graph between pore pressure and total head of the dam. In the seepage condition the pore pressure and material properties of the soil is changes, depending upon the total head.

4.6 SLOPE STABILITY (SLOPE/W):

Analysis of slope stability of earthen dam in dry condition the above procedure is followed but in this dam in dry condition and the region is selected as a single why because total entire dam is dry.

Earthen dam dimensions : Top width of dam is 5.5m, downstream side slope 1.5 in 1, base width of the dam is 40 m, height of the dam is 11.5 m.

Soil properties: unit weight of soil 19.03kn/m^2, cohesion 40kPa, angle of internal friction 7^0.

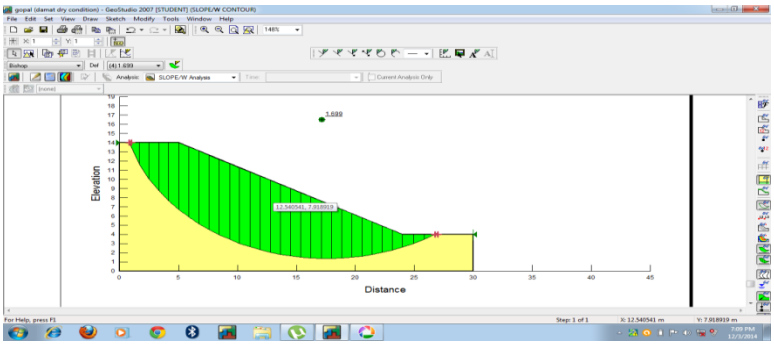

Fig.6 Solution for Slope stability analysis with factor of safety

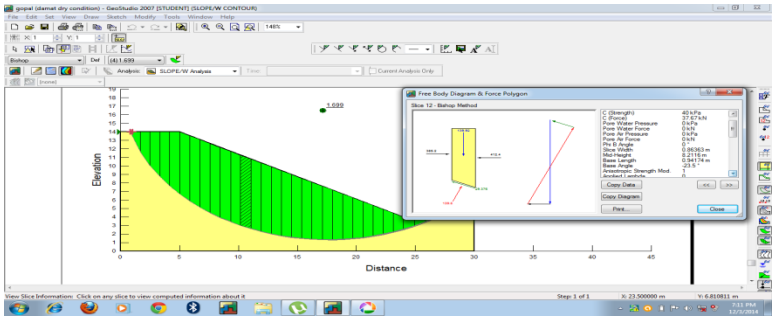

Fig.7 Bishop method

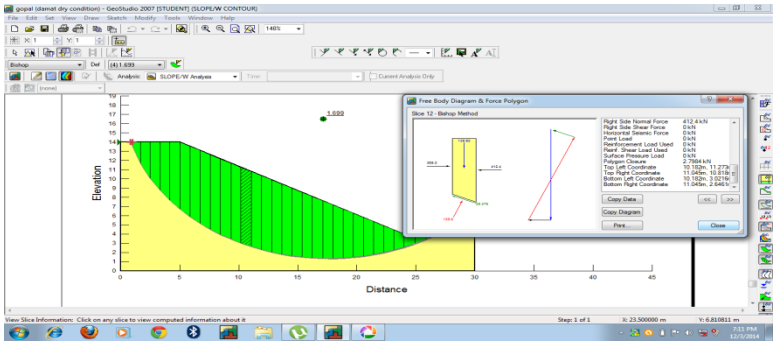

Fig.8 Slice information

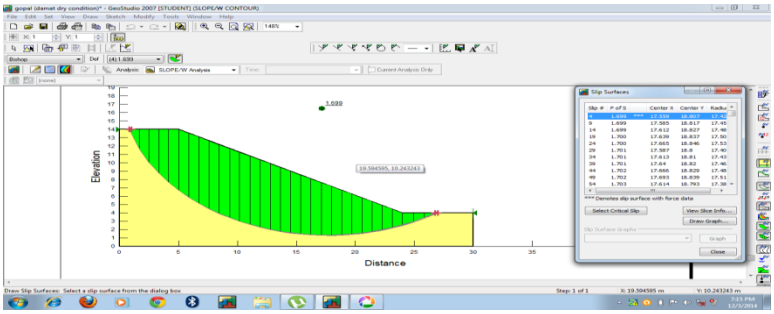

Fig.9 critical slip circle

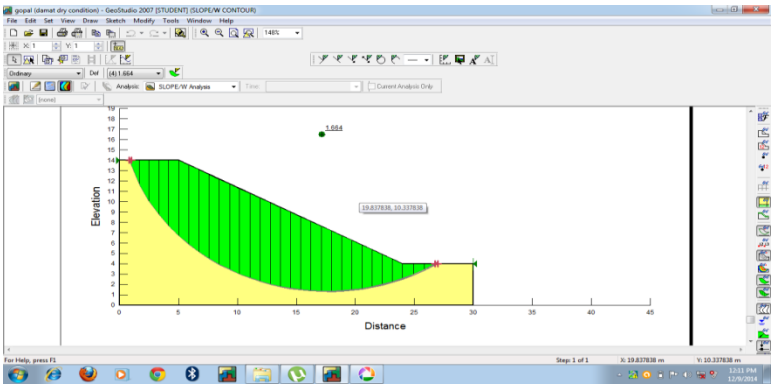

Fig.10 Ordinary method

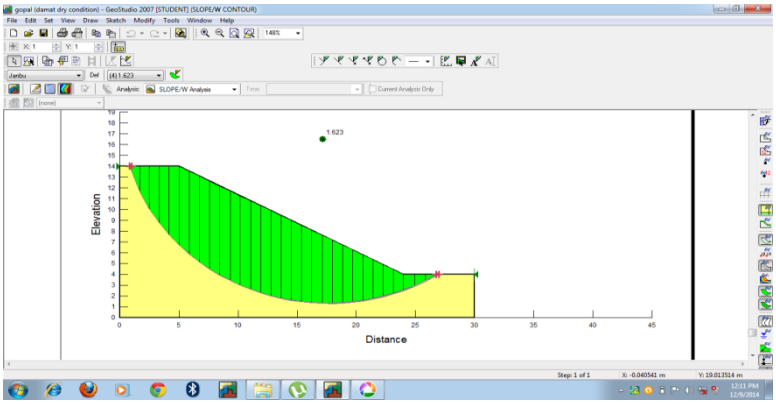

Fig.11 Jambu method

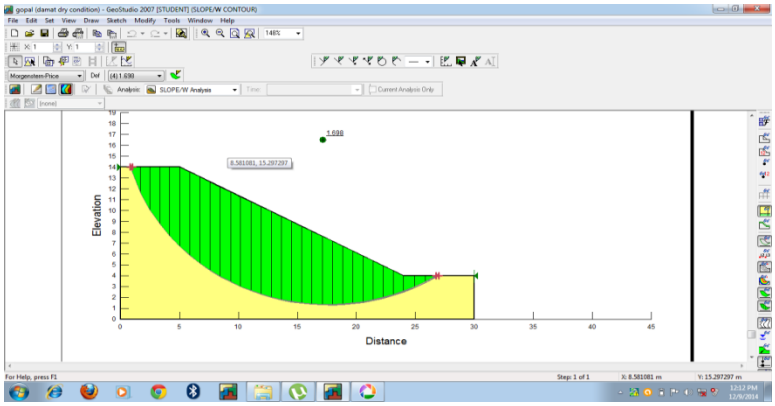

Fig.12 Morgenstern method

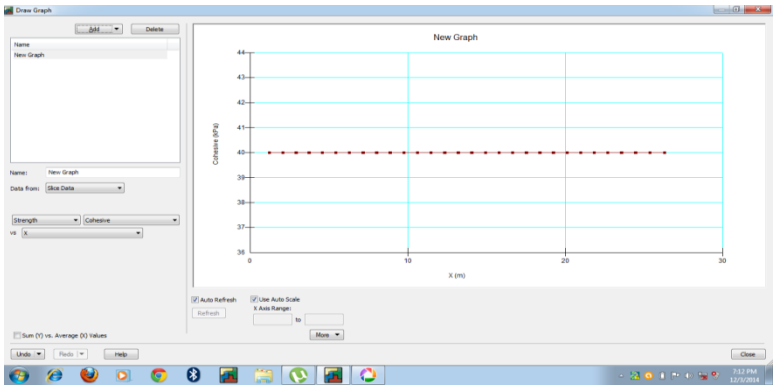

Fig.13 Graph for strength and cohesion

The above 5.4 shows the graph between strength and cohesion in dry condition. In dry condition strength and cohesion no change it will be same condition.

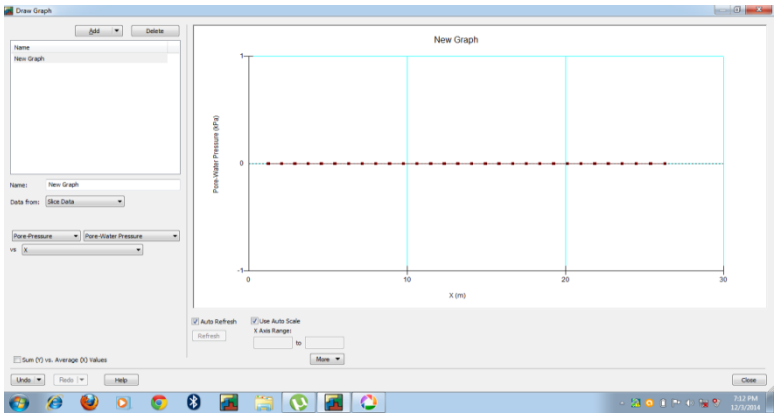

Fig.14 Graph for Pore pressure and pore-water pressure

The above fig 5.5 shows the graph between pore pressure and pore-water pressure in dry condition. In the dry condition there is no pore pressure and pore-water pressure, so it is constant.

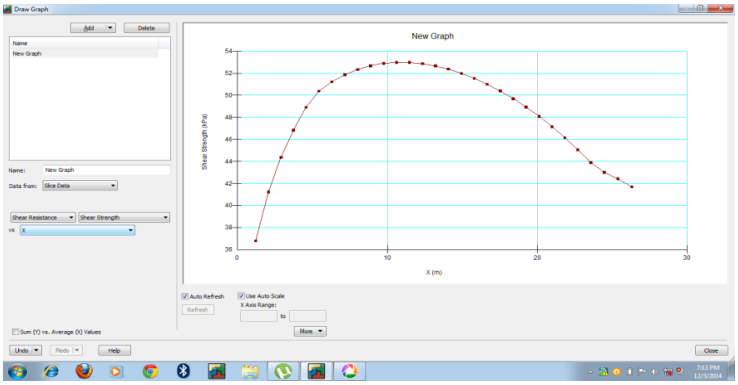

Fig15 Graph for Shear resistance and shear strength

The above graph shows the shear resistance and shears strength of the soil, the shear strength along y-axis and shear resistance along x- axis. When the shear resistance is increases the shear strength of the dam also is increases up to certain period, but finally the shear strength of the dam is decreases.

Table:4.3 Final results

Type of Analysis	Analytically	Geo-studio software	
Seepage	1.89 x 10^{-6} m^3/sec/m	2.4396 x $10^6$$m^3$/sec/m	
Slope stability Analysis of F.S	1.63	Morgenstern method	1.679
		Ordinary method	1.672
		Jambu method	1.773
		Bishop method	1.682

5.0 CONCLUSION:

1. Study the stability of the current earthen dam regularly .
2. To calculate the failures of the dams seepage failure by analytical approach 1.89 x 10^{-6} m^3/sec/m.
3. To calculate the safety measures of the dam by using Bishop Method. The factor of safety of the dam is obtained 1.63 with in permissible limit.
4. To calculate the seepage failure by using computer approach the value is 2.4396 x 10^{-6} m^3/sec/m.
5. To calculate the factor of safety of the dam by using computer approach using different methods and accuracy is obtained.
6. It is easy to estimate the stability using software and more precise value

7. It reduces time for calculation and increase the efficiency
8. For design of new structure using software help in prediction of failure

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