SLOPE STABILITY ANALYSIS USING GEO-STUDIO SOFTWARE

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Abstract : Analyzing the stability of earth structures is the oldest type of numerical analysis in geotechnical engineering. The idea of discretizing a potential sliding mass into slices was introduced early in the 20th Century. Even to this day, stability analyses are by far the most common type of numerical analysis in geotechnical engineering. This is in part because stability is obviously a key issue in any project – will the structure remain stable or collapse? This, however, is not the only reason. Concepts associated with the method of slices are not difficult to grasp and the techniques are rather easy to implement in computer software – the simpler methods can even be done on a spreadsheet. Consequently, slope stability software became available soon after the advent of computers. In this study, we use "GEOSTUDIO" Software for analysis of slope stability, seepage in both saturated and unsaturated

IndexTerms **- Component,formatting,style,styling,insert.**

I. 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 is the main problem and it passes through the dam material and it also carrying dam materials. 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 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. The properties of embankment soil shall conform to the Borrow area soil whose properties are specified in the table furnished in the drawing of the earth dam section. The work shall be started only after locating the borrow areas within the economical lead for the total required quantity of soils the engineering properties of which are given in the drawing of the earth dam section.Proper soil testing arrangement must be made at the site and proper records shall be maintained. So that the soil properties laid for the embankment conform to the designed density and shear parameters.

Unconsolidated fat clays all loose pockets, sods, roots, trees, stumps and loose boulders shall be removed. Soil containing vegetables matter shall be removed. Stripping may be done up to minimum of 0.3m depth or as specified

in the drawing so as to ensure complete removal of loose material, vegetable matter etc. The soils from borrow areas for embankments shall be free from
calcareous, organic impurities and soluble salts. Soluble salts if present shall not be more than 0.2%.
The density and moisture content of the placed fill shall be checked for every layer of embankment and for each 3550 m3 of fill to ensure the required densities achieved at site either by core cutter method or by sand replacement method.For every 10500m3 compacted fill tests may be conducted to evaluate shear parameters, permeability and consolidation characteristics, by collecting undisturbed samples from the fill to ensure that assumed properties are achieved on the bank. The in situ permeability test may be conducted by open trench method as the embankment is raised the record of such tests with the results obtained shall be properly maintained.

3.2. FOUNDATION TREATMENT

Earth dam may be founded on soil over burden or rock. If the foundation is on soil i.e. non rocky strata, vegetation like bushes, grass roots, trees etc. shall be completely removed after removal of these materials the foundation surface shall be moistened to the required extent and adequately rolled before placing embankment material.For rocky foundation, the face shall be cleaned of all loose/fragments including semi detached and over hanging surface blokes of rocks. Proper bond shall be established between the embankment and the rock surface prepared, key trenches may be provided

Figure 3.2.Embankment Slope

In the place of earth dam where the sub-strata consists of fat clay possessing free swelling greater than 100% and time bound ultimate settlement characteristics exceeding 25%-35%, it is better to preload the sub-strata in such case the design office may be consulted for the treatment of sub-strata after testing the swelling and settlement characteristics of sub-soil samples at laboratories.The minimum bottom width of cut –off shall be 4m. a bottom width of 10% to 30% of hydraulic head may be provided to satisfy requirements of piping. This may suitably be increased to satisfy other requirements of mechanical equipment and curtain grouting.Cut -off trench is not necessary in the reach of earth dam where the ground level is higher than F.R.L and where the sheet rock is exposedat ground level, key trenches 4m wide and 1m depth shall be provided.The cut -off in the flanks on either side shall normally be extended up to top of impervious core. The back fill material for cutoff trench shall have same properties as those prescribed for the impervious core. Impervious soils are generally suitable. However soil having high compressibility and high liquid limit are not advisable to be used as they are prone to swelling and formation of cracks.

3.3.EMBANKMENT

Rising of embankment shall be uniform in all reaches of earth dam and in no circumstances level deference of embankment either in cross section or in longitudinal section shall be greater than 10mEmbankment shall be formed by placing soil in layers which after compaction are 20cm thick. The new layer shall overlap by0.5m on either side of the previous layer. The material brought on the filled, shall be directed to the proper zone. Cobbles and rock fragments greater in size than the specified thickness shall be picked and removed from the embankment. After the material has been placed it may be spread to the desired thickness and over sized cobbles and rock fragments disposed off. The next important step is application of water through and uniform wetting of soil during or immediately prior to compaction is essential.

Figure 3.3.1 Upstream side of Embankment

The engineering properties of the soils to be laid for the embankment are as furnished in the table of drawing of earth dam section. These properties are assigned based on the test results furnished by field officers for the purpose of design.Earth work in embankment shall be carried 1m extra in width on side of slopes to ensure compaction for the full section of dam. After the compaction, trimming shall be done to the designed dimensions of the dam section.Compaction index shall be maintained at 0.98. the central portion between u/s casing soils and sand filter has to be carried out with extra moisture content of about 2.6 of OMC and compacted to the required density In the reaches of earth work embankment, where rollers are not accessible compaction shall be done by compressed air tampers to achieve required density or by any other means suitable.There shall be extra provision of 1% to 2% in embankment height of the dam to accommodate embankment compression and foundation settlementsPosition of the borrow areas in the fore shore as well as on the downstream shall be at a distance greater than 10 times the depth of storage from u/s side and d/s side toes of the embankment. The minimum distance from toes shall not be less than 500m Effective field control envisaged to satisfy the parameters i.e. density, moisture content, shear strength for every layer height of embankment. The test results shall be recorded and maintained for inspecting authorities' perusal.In case of homogeneous embankment where casing cover is provided, the casing cover shall also be laid simultaneously and compacted with rising of embankment.

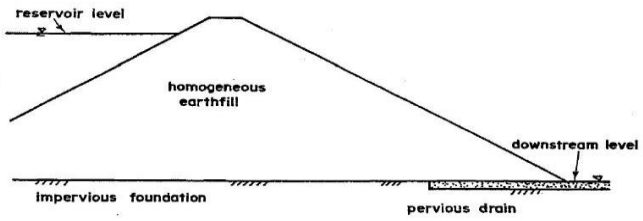


Figure 3.3.2 homogeneous earth fill dam

3.4.MISCELLANEOUS

The placed riprap shall consist of one mass stones laid on edge starting at the bottom of the slope. The stone shall be laid completely with staggered joint and so matched and interlocked that they shall be keyed together with a minimum of joint space. Rock fragments and spalls shall be driven in to interstices' to wedge the riprap in place the wedging shall be done with the largest chip practicable. Each chip being well driven home with a hammer so that no chip can be removed by hand. Very irregular projections shall be knocked off so that the riprap presents a reasonably uniform surface free or loose stones. The finished surface shall be convex towards water side so that in case of settlement the individual stones will be under compression and press against each other**.Sand needed for the** material shall be hard, strong, dense, durable, clean and free from veins and adherent coating and free from injurious

amount of disintegration pieces, alkali vegetable matter and other deleterious substances. As far as possible, flaky, scorious and elongated pieces shall be avoided Rock toe shall be provided to facilitate drainage of seepage water and to protect the lower part of d/s slope from tail water erosion and sloughing shall be provided in all reaches where the storage depth is greater than 3m. The maximum and minimum heights of rock toe shall be 4m. and 1m respectively and the height of rock toe shall be maintained at 15% of the depth of storage in between these maximum and minimum limitations.Material used for rock toe shall be well graded broken rock shall range in size from 25mm to 900mm. No load shall contain more than 15% by volume of rock fragment smaller than 25mm and volume of fragment less than 25mm shall not exceed 25% of the total.In the case of standing tail water due to back water of lower reservoir etc. or M.F.L. rock toe shall be provided up to the level to which tail water stands for duration of few months. Hand placed riprap 30cm thick shall be provide above the rock toe up to 1m above the highest tail water level during/floods.and rock toe are not necessary in the reach of earth dam where ground level is at or higher than F.R.L. A system of open paved drains (chutes) along the sloping surface terminating in to the longitudinal collecting drains at the junction of berm and slope shall be provided at 90m center to center, to drain the rain water. The drains may be formed in riprap masonry or with precast concrete sections as shown in the

MATERIALS AND METHODOLOGY

4.1. MATERIALS

Summer storage tank is constructed in the year of 2009 and it is located at Nandyal, Kurnool (dist) A.P. The purpose of S.S. tank is constructed for drinking of water. The S.S. tank is constructed mainly clay, sand, gravel materials. The clay soils are filled on upstream side and gravel soil is filled on downstream side and the sand layer is used for the purpose of to drain out the seepage of water from the embankment.

4.2.METHODOLOGY

In this project the seepage and slope stability analysis is done in two ways (i) Analytical approach (ii) Computer approach.

i.Analytical approach

The analytically the seepage analysis is calculated by using Darcy's law, and the slope stability analysis

approach is done based on the earthen dam details and with their material properties.

ii. Computer approach

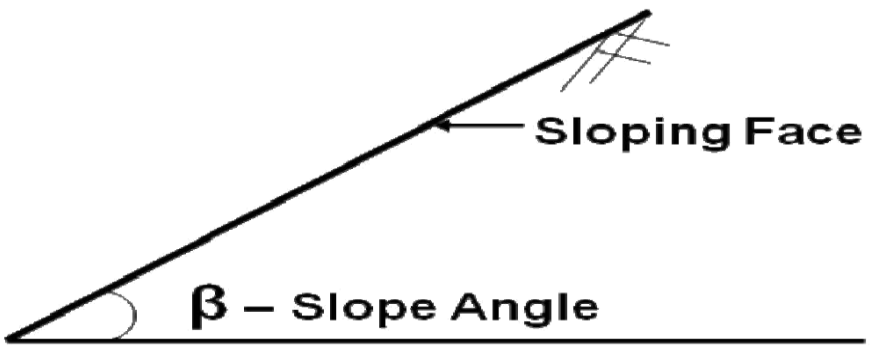
In order to achieve the objectives of this study, Geo-studio software is used. The Geo-studio software is mainly based on finite element method that can be used for evaluate the performance of dams. The Geo-studio software is SLOPE/W for slope stability, SEEP/W for ground water seepage, SIGMA/W for stress-deformation, QUAKE/W for dynamic earthquake, TEMP/W for geothermal, CTRAN/W for contaminant transport, AIR/W for air flow, VADOSE/W for vadose zone & covers. On this research SLOPE/W and SEEP/W is used. 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. The product SEEP/W is used for the analysis of seepage. Calculate the leak using partial differential equations makes the water flow.

4.2.1. ANALYSIS OF SEEPAGE IN EARTH DAM BY ANALYTICAL METHOD

The quantity of seepage passing through the body or foundation of the earth dam can be estimated by usin Mttheoryof porous media. The analysis is based on the following assumptions.

4.2.3. ANALYSIS OF SLOPE STABILITY IN EARTH DAM BY ANALYTICAL METHOD

An exposed ground surface that stands at an angle ( ) with the horizontal is called slope. Slopes are requireinthe construction of highway and railway embankments, earth dams, levees and canals. These are constructeby sloping the lateral faces of the soil because slopes are generally less expensive than constructing walls. Slopes can be natural or manmade. When the ground surface is not horizontal a component of gravity will try to move the sloping soil mass downwards. Failure of natural slopes and manmade slopes has resulted in much death and destruction.



Slope stability analysis consists of determining and comparing the shear stress developed along the potential rupture surface with the shear strength of the soil.

4.3. TYPES OF SLOPES

Slopes are classified into two types (1) Infinite slope (2) Finite slopeInfinite slope: they have dimensions that extend over great distances and the soil mass is inclined to the horizontal.Finite slope: a finite slope is one with a base and top surface, the height being limited faces of earth dam, embankments and excavation and the like are all finite slopes.

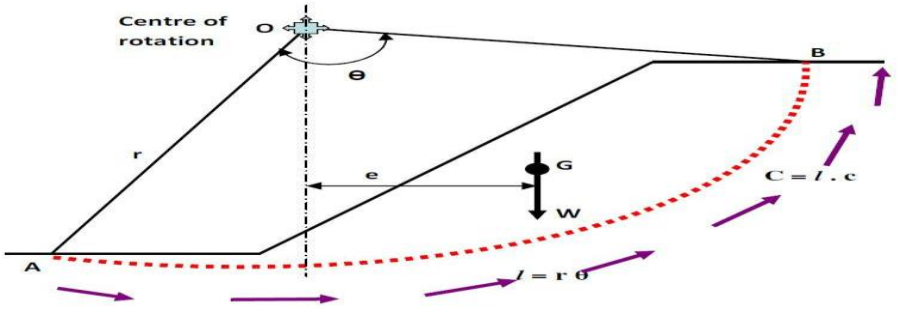


Figure 4.3.2.Finite slope

4.4. FACTOR OF SAFETY

Factor of safety of a slope is defined as the ratio of shear strength of a soil to the average shear stress developed along the potential surface

4.5.1. SLOPE STABILITY ANALYSIS BY BISHOP'S METHOD

Bishop (1955) gave an effective stress analysis of which he took into account, at least partially, the effect of the forces on the vertical sides of the slices in the Swedish method.The figure explains the trail failure surface and all the forces on vertical slices which tend to keep it in equilibrium.

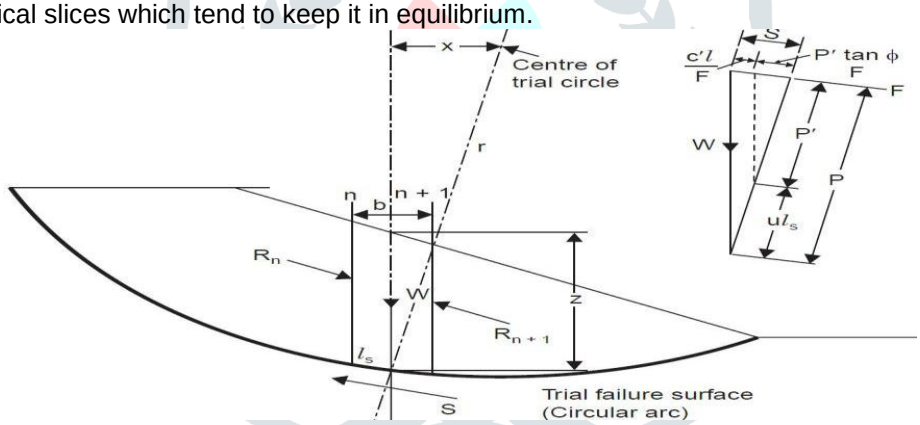


Figure 4.5.1.Bishop method

4.6. GEOSTUDIO SOFTWARE

Geo-studio software is mostly used in used in varies civil engineering applications and their problem analysis by considering different consideration. Now days it's widely used this are mostly for finite element analysis, slope stability, seepage analysis and so on other applications. Following are steps for used Geo-studio 2007 software

RESULTS AND DISCUSSIONS

5.1. DETERMINATION OF SOIL PROPERTIES

The soil properties are determined by the conducting the different tests and obtaining the different values as follows. The Table 5.1.1 shows the foundation soil properties and table 5.1.2 shows the Embankment soil properties.

5.1.1 PROPERTIES OF SOIL FOR FOUNDATION

The following soil properties shows the analysis for both seepage and slope stability in analytically and computer approach.

Liquid limit	47.5%
Clay content	83 (fines)
Specific gravity	2.52
Void ratio	0.55
Water content	18.60
Density	1921 kg/cm$_3$
Permeability	1.685 x 10^{-6} cm/sec
Shear strength	c = 4000 kg/cm$_2$

The above Table 5.1.2 shows the engineering properties of soil for embankment purpose. The liquid limit also ranges from 50% to 120%, the specific gravity will also ranges from 2.44 to 2.92 and permeability less than 10-6cm/sec from these properties the above soil is classified as CI i.e. inorganic clays of medium plasticity, gravelly clays. The soil is a impervious permeability and shear resistance strength is fair, compressibility is in medium

CALCULATION OF SEEPAGE THROUGH THE EARTH DAM BY ANALYTICALLY

From the Earth dam dimensions table (3.5.3) Total height of dam is 9.8m,Up stream and Downstream slope is 2:1,Top width of the dam is 4.5m and length of the Blanket is 4.9m and coefficient of permeability is x =1.685 x 10-6 cm/sec, y = 3.638 x 10-6cm/sec and free board is 2m.

				Weight (	**N=Wcos**	**T=Wsin**
No.	**slice (z)**	**slice (B)**	m^2	kN/m$_2$	kN	kN

	m	m					
1	2.2	2	2.2	42.262	-25	38.302	-17.86
2	3.5	2	7	134.47	-20	126.36	-45.99
3	4.5	2	9	172.89	-10	170.263	-30.02
4	5.5	2	11	211.31	-5	210.50	-18.41
5	6	2	12	230.52	-3	230.20	-12.064

CONCLUSIONS

Study the existence problems in the earthen dam.
To calculate the failures of the dams seepage failure by analytical approach 1.074 x 10-6 m3/sec/m.
To calculate the safety measures of the dam by using Bishop Method. The factor of safety of the dam is obtained 1.465 with in permissible limit.
To calculate the seepage failure by using computer approach the value is 1.6625 x 10-2 m3/sec/m.
To calculate the factor of safety of the dam by using computer approach 1.494 with water table and 1.699 without water table.

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