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Embankment Analysis and Design by Using Soil and Flyash Composite

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***Abstract:* -- Fly ash a fine powder thrown out in large quantities from thermal power plants as a waste material, we have used this material in our project. Since its the cheapest material available at Satpura Thermal Power Station, Sarni. The problems associated with fly ash are the large area of land required for disposal and toxicity. Fly ash, being treated as waste and a source of air and water pollution till recent past, is, in fact, a resource material and also proven its worth over a period of time. Fly ash is having the potential for gainful utilization till is put to right use. It has now emerged not only as a resource material but also as an environment savior. Fly ash is also being used in the cement production and precast products as a fill material etc. Ministry of environment and forest had made compulsory to use fly ash for any construction project within 100 km of the power plant. Slope stability is the potential of soil covered slopes to withstand and undergo movement. We followed the analysis to make embankment stable enough to resist against failures and could resist external forces like the earthquake. The composite of soil and fly ash will exhibit the strength as properties of fly ash have proved favorable in the embankment. Fly ash is used as a borrow material to construct fills and embankments. Fly ash has been used in the construction of structural fills and embankments from small fills for road shoulders to large fills for interstate highway embankments. So we proposed slope stability analysis using composite of soil and fly ash.**

***Keywords* — OMC - Optimum moisture content, MDD -Maximum dry density CPT - Cone penetration test SPT - Standard cone penetration test MORTH – Ministry of road, transportation and highway SM – Silty sand CH – Clay of high plasticity CI – clay of medium plasticity FSI – Free swell index BC – Black cotton soil CBR – California bearing ratio.**

I. INTRODUCTION

Waste transformations is the powerful term used in effective solid waste management technique. The thermal power plants in India consume more than 300 million-tons of coal and generate nearly 100,000 MW power. This produces fly-ash around 163.56 Million-tons out of which only 61.37% is being utilized. Though fly ash has wide variety of applications in civil engineering industries but bulk utilization of fly ash is possible only if it is used as an embankment material. Direct use of fly ash in highway embankment projects consumes large volumes of fly ash and provides a promising solution to the disposal problem, but also an economic alternative to the use of traditional materials. Since the intended use of these materials is as embankment construction materials, emphasis is given to the determination of their mechanical characteristics, including compaction, permeability, strength, stiffness, and compressibility.

II. METHODOLOGY

The aim of an embankment design i.e. the slope stability analysis is to ensure that the slopes remain stable. For this, when a slope tends to slip or fail, the embankment material must offer resistance to prevent the failure. The stability analysis is a procedure to find the ratio of resistance offered and forces acting. This will be clear from following illustration: Referring to figure, consider a slope A-B-C-D, failing along an arc B-E. While failing, the slipping wedge B-C-E rotates around centre O and moves to B'C'E'. The force acting "F" will be moment of weight of wedge around O i.e. the sliding mass.

The Embankment material, however offer resistance against sliding. This comprise of two components:

a) Bond between soil particles, and
b) Friction btween soil particles

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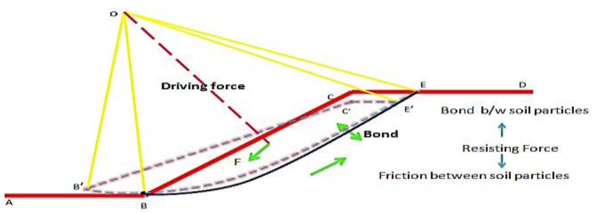

Fig 1: Analysis Concept

It is this force produced due to the bond between soil particles and friction between soil particles together (along the slip circle) offer resistance to total driving force. It follows that, for a slope to remain stable, resistance force must be greater than acting force. Thus, during analysis one has to find the ratio of resisting force and acting force. The ratio is what we call as FACTOR OF SAFETY (FOS).

Hence, FOS= RESISTING FORCE / ACTING FORCE

This whole philosophy is utilized in the embankment design. As per IRC: 75-1979, minimum factor of safety shall be 1.25.

There are three main properties required for founding stratum and embankment material.

These are:

a) Shear Strength: This are required to determine the resistance offered. Shear strength is represented by two parameters: Cohesion-C (Bond) and angle of internal friction-ϕ (friction). These are determining by conducting laboratory shear tests such as: direct shear or tri-axial shear test. For embankment material (borrow-area) these tests shall be conducted at 95% OMC/MDD; while for founding layer, either in undisturbed state or at 97% compaction. These compaction limits are as specified by MORTH Table no. 300.2.

b) Compressibility: This is necessary to estimate settlement of embankment- especially if the founding layer is clayey in nature. The test involved is consolidation test. Here also two parameters are determined: 1) Compression Index using settlements are worked-out, and 2) Coefficient of Consolidation which predicts rate of settlements i.e. how much settlements are expected after different time interval of say 1 year, 2year, 5 year, 10 year and so on.

c) Compaction: From this test, two values are determined: Maximum Dry Density and Optimum Moisture Content (OMC & MDD). Compaction test is required for two reasons: 1) to calculate weight of falling mass (i.e. volume of falling mass x its density) 2) And more importantly, for compaction control at site. It should be understood here that, will all the parameters equal, it is the proper compaction ensures the performance of an embankment. How inadequate compaction can lead to major failure.

III. STABILITY ANALYSIS

The purpose of stability analysis is two-fold.

a) For a given slope i.e. if the slope is already fixed (say 1V:1.5H) verifying factor of safety.

b) If the slope is not fixed (say for a new embankment) then deciding economical slope for the specified factor of safety.

There are number of analysis methods available to ascertain the FOS for embankments; such as

a) Taylors Stability Chart: Taylor has given graphs between angle of friction, angle of slopes and cohesion. Using three parameters FOS is determined. This method is applicable to limited soil types and always do not give correct FOS.

b) Friction Circle Method: In this method it is assumed that while failing, centre of slip circle lie on another circle whose radius is rSinϕ, where, r is the radius of failing circle.

c) Swedish Circle Method: This method was future extended by Fillenius and assumes that centre of slip circle lie on a straight-line passing through a fixed point.

d) Bishop's Method: This is tedious but most accurate and often used where higher degree of precision is required or maximum optimization is necessary.

Any of the above methods can be used; the basic aim is to determine the factor of safety. Amongst four methods briefed above, Swedish Circle Method is simplest and most easy to understand.

IV. DATA COLLECTION AND ANALYSIS

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Bore log data of foundation:

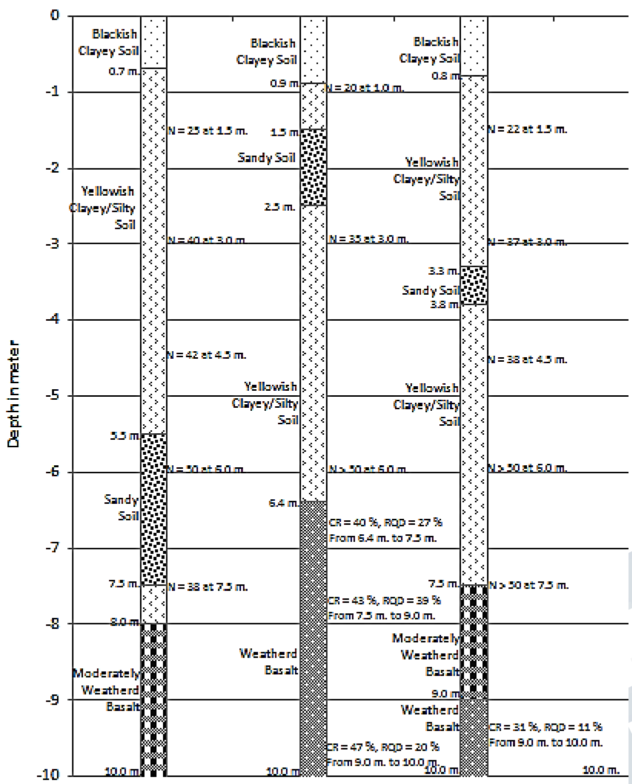

Fig 2: Bore log data

Slope Stability Analysis:

a) Manual Slope Stability Analysis:-

The embankment we have analyzed is composite type of embankment constructed by using sandwich type construction by laying alternate layers of flyash and soil of appropriate thickness. Cross section of this composite road embankment is as follows.

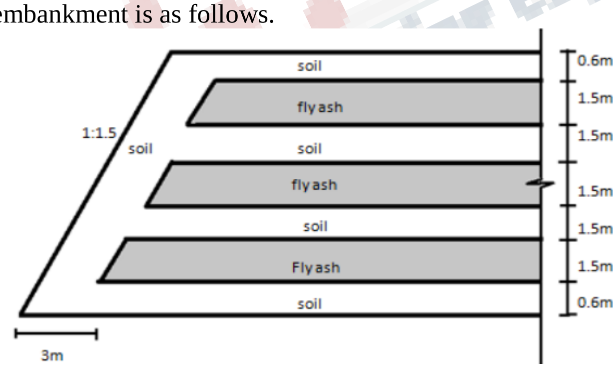

Fig 3: Cross section of embankment

We have analysed the embankment by using two methods

a) Fellenius procedure of critical circle

b) Swedish circle method

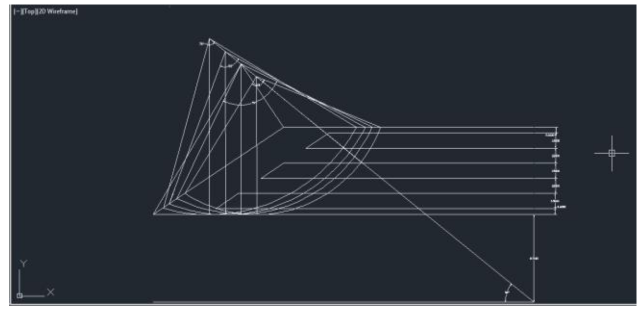

Fig 4: Analysis drawing in AutoCAD

V. ANALYSIS IN GALENA SOFTWARE

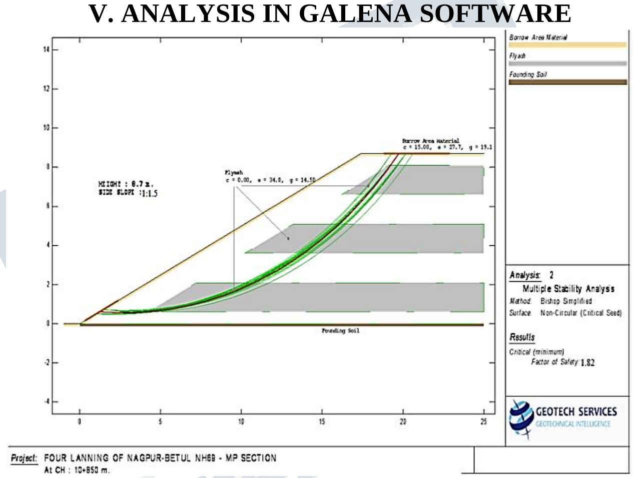

Fig 5 : Slope Stability Analysis in Galena Software

Galena software divides falling wedge into 44 slices and calculate the factor of safety and gives an output as factor of safety which is equal to 1.78. Curve shown in red colour is a critical circle of slope.

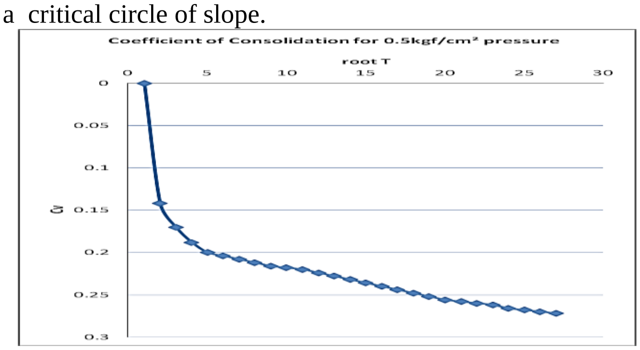

Fig 6 : Coefficient of Consolidation For 0.5kgf/cm² Pressure

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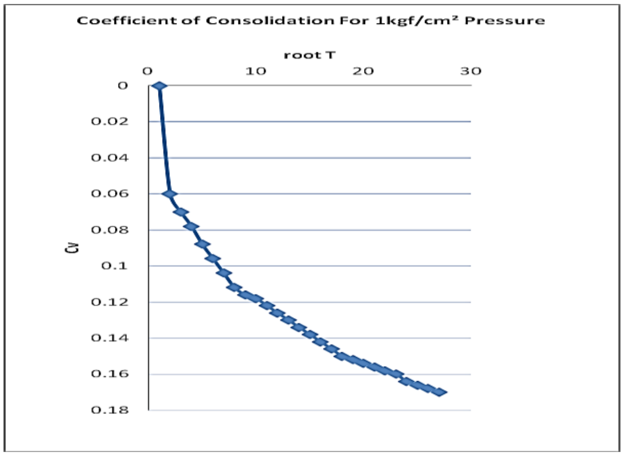

Fig 7 : Coefficient of Consolidation For 1kgf/cm² Pressure

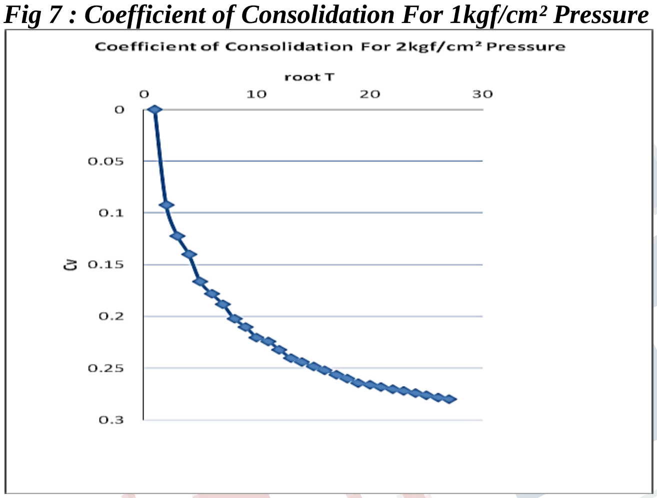

Fig 8: Coefficient of Consolidation For 2kgf/cm² Pressure

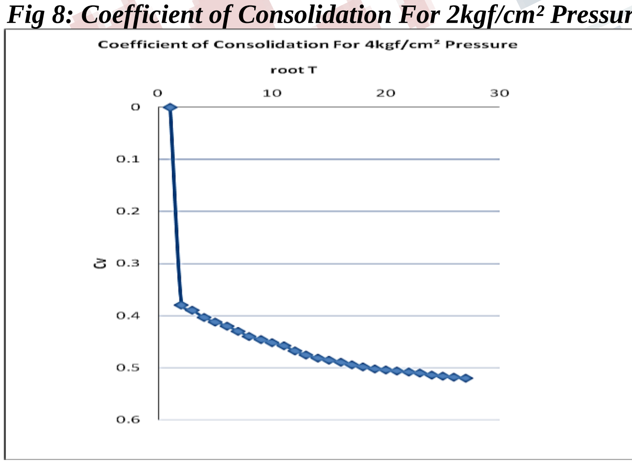

Fig 9: Coefficient of Consolidation For 4kgf/cm² Pressure

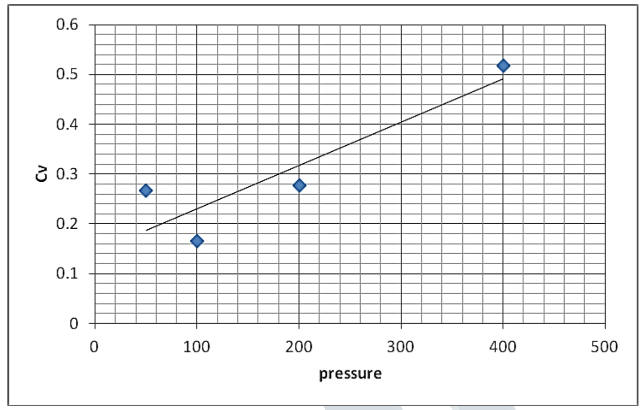

Fig 10: Graph of Coefficient of Consolidation Cv

VI. RESULTS

From the above analysis, we get the following results

1. Using manual slope stability analysis, fellenius and Swedish method we obtained factor of safety to be 1.54.
2. Using galena software for slope stability analysis factor of safety obtained is to be 1.78.
3. From settlement analysis, we obtained 298mm settlement for 99% consolidation.
4. Total time required for settlement is 11years.
5. Settlement per year = 2 to 5cm.

VII. CONCLUSION

The embankment we are going to analyze is composite type of embankment constructed by using sandwich type construction by laying alternate layers of flyash and soil of appropriate thickness. We have done analysis of embankment by using two methods Fellenius procedure of critical circle and Swedish circle method. According to Fellenius and Swedish for critical circle we constructed an analysis drawing in AutoCAD software. For more accuracy result we have used Galena software which gives as infinite number of critical circle and gives out the most accurate value for the factor of safety for the design on embankment. In our design analysis we got the factor of safety as 1.78 which we then compared the results with IRC-75 and the results were safe and economical for the design purposes of view. The manually factor of safety was calculated as 1.54, this factor of safety can be used at site for manual start of work when software result are not analysed

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