DESIGN OF STABLE SLOPES FOR DUMPS ADMIXTURE WITH FLYASH

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

IN

MINING ENGINEERING

BY

DEBASHIS RAO

111MN0622

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CERTIFICATE

This is to certify that the thesis entitled, "***Design of stable slopes for dumps admixture with fly ash***" submitted by Sri **Debashis Rao, 111MN0622** in partial fulfilment for the award of Bachelor of Technology in Mining Engineering at National Institute of Technology Rourkela, is a record of original research work carried out under our supervision.

The contents of this thesis have not been submitted elsewhere for the award of any degree what so ever to the best of our knowledge.

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Date:

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ABSTRACT

The waste dump has been a major issue in mining industries in recent years since there is a huge demand of minerals. With a limited availability of land there is more waste material to dump, Huge amount of fly ash is generated in India by coal fired thermal power plants. Here is a question about their disposal which leads to adverse effect on local environment. As per Ministry of Environment and Forests (MOEF) guidelines, at least 25% fly ash is used as back filled material in mine which is located within 50km from the power plant.

In this project the stability of overburden dumps mixed with fly ash of JPOCCM mine of JPL Tamnar (Raigarh) was carried out by field monitoring using total station and monitoring stations.

For the stability of OB dump, it was proposed to use fly ash mixtures. Different geo technical parameters such as cohesion, frictional angle and density were found out and were used to model the dumps in FLAC SLOPE software and OASYS software to find out the value of FOS.

The safe slope angle for 30m OB bench height for OB, OB+15% fly ash, and OB+30% fly ash were found out to be 29°, 26°, and 28° respectively.

From the analysis it is concluded that with increase in slope angle of the deck and height, the factor of safety decreases. With the addition of 15% fly ash the safe bench angle decreases by 2° due to partial filling of void space but when 30% fly ash were added then there will be an increase in 1° of safe bench angle. This is due to more void spaces that were filled with again 15% fly ash. Thus, the Factor of safety as well as safe slope angle are increased.

On comparison between OASYS and FLAC, they show same slope angle but different factor of safety. It is due to the change in grid size from medium to fine. Hence the results were changed. More over in OASYS it is assumed that the failure of surface to be moving in a direction lying in the arc of a circle. But in FLAC SLOPE the direction of failure may be in any direction.

From the analysis of total station monitoring it was found that both pits are stable due to the admixture of fly- ash and OB dump to be used.

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

In recent years open cast mining is a major challenge in the mining industries as it contributes maximum portion of total production. In open cast mine, Investigations are going on due to the maximum working flexibility within a short span of period. For the coal winning operation, the removal of overburden is the primary purpose. As the overburdened material is a waste material, it should be dumped safely and economically. There is a major problem of availability of land for mining industries to store maximum overburdened material within a limited space of land. Therefore the analysis of stable slopes of dump and ultimate pit slope designs are the major concerns.

Dump slope failures affects the production, loss of watering in the pits, additional stripping cost of recovery, excessive handling of failed material, hazards, may cause mine abandonment/premature closure. In recent years, the numbers of land slide have taken place in most of the mines.

Keeping this in mind, the Ministry of Environment and Forests (MoEF) has issued notifications stipulating targets for 100% utilization of fly ash in a phased manner. Proper scientific studies are necessary to evaluate the stability of such dumps. Problems of slope instability occur frequently and are a source of major concern in the mining industry. For the mining industry, it has directed that the mines lying within 50 km of a thermal power plant (by road) to use at least 25% of the backfill material as fly ash on a weight to weight basis subject to the approval of DGMS [1]. These are caused either due to improper design of slopes or an incorrect assessment of the existing ones and pose a danger to the safety of people, equipment and other property. Geological structure, angle of the slope, weight acting on the slope, water content are some of the factors that affect slope stability and must be considered while analyzing the stability of slopes.

In this context the purpose of this project is to study the stability of overburdened dumps mixed with fly ash at Jindal Power Open Cast mine (JPOCM) of Tamnar (Raigarh), Chhattisgarh. Jindal Power Limited, Tamnar already have a captive thermal power plants of 1000 MW and generate fly ash, a solid coal combustion residue formed due to the burning of coal, of nearly 16000 tons per day. Therefore, quantity of fly ash generated requires large area for its dumping. In last two decades, it was realized that fly ash is no more a waste and hence its utilisation has increased by several folds, and particularly in mining industries.

1.1 Objectives of the Project

This project has the following objectives:

- ➔ To determine the geo-technical parameters and to propose safe slope angle of three different mixtures i.e. OB, OB+15% fly ash and OB+30% fly ash.
- ➔ To model the stable dump slopes in FLAC SLOPE and OASYS software to evaluate the factor of safety (FOS) for different slope angles.
- ➔ Reduced level analysis by field monitoring of different pit slopes done by total station monitoring.

1.2 Methodology of the Project

The project methodology is described below in a flow- chart:

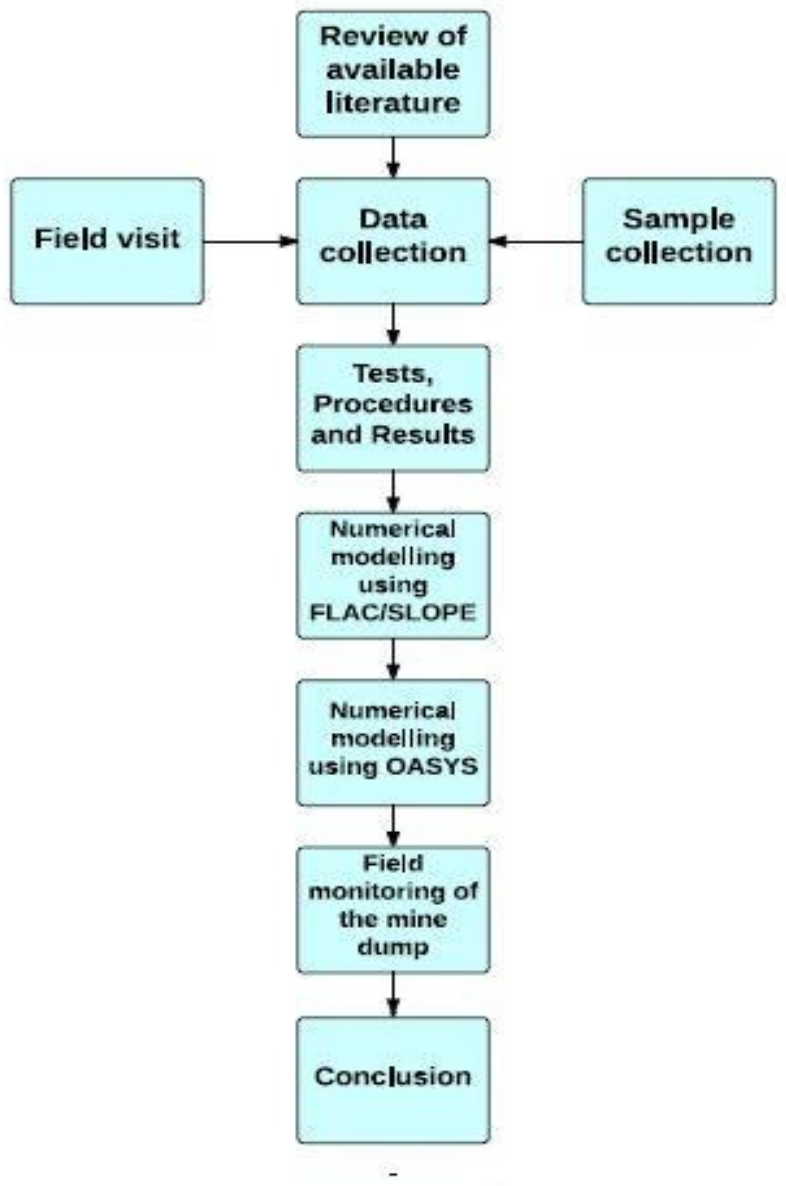

Fig.1.1 Flow chart showing different project methodology

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 Dump Failure and Stability Analysis

The failure of a dump mass of soil located beneath a slope is called a dump slide. It involves a downward and outward movement of the entire mass of soil that participates in the dump slope failure. Dump slide may occur in almost every possible manner, slowly or suddenly and with or without any apparent provocation. Usually, slides are due to excavation or undercutting the foot of an existing dump slope. However, in some instances, they are caused by a gradual disintegration of the structure of an overburdened dump.

There are basically 3 types of dumps. They are:-

2.1.1 External dumps: External dumps are the dumps where wastes are dumped outside the excavation. It is suitable for thick and moderately dipping upto steep seams. Mostly, in hilly terrains external dumps are preferred.

2.1.2 Internal dumps: Internal dumps, as the name suggests, are the dumps where wastes are dumped inside the excavation. It is suitable for horizontal deposits having dip angle of 5° – 12°. In coal mines, 40% of the overburden must be dumped within the pit even during mining.

2.1.3 Mixed dumps: Combination of the above two types of dumps.

2.2 Factors Affecting Dump Slope Stability

2.2.1 Gravitational force

The movement of soil from high points to low points is due to the gravitational force. Hence it is an important consideration for the dump failure which acts in the direction of probable motion.

2.2.2 Erosion of dump caused by flowing water

There are two aspects of erosion which are to be considered for the effect which causes dump slope stability. The first is the river erosion occurring at the base of a slope which is large scale erosion. The second one is caused by ground water or surface runoff which is relatively localised erosion. In the first type, the geometry of the potentially unstable rock mass changes due to erosion. At the toe of a potential slide, with the reduction of confining stress may stabilise the slope due to removal of material. The second localised erosion is of joint filling materials or the zones of weathered rock that can effectively decrease interlocking between adjacent rock blocks.

2.2.3 Geological discontinuities

The stability of slopes is significantly influenced by the structural discontinuity in the rock in which the slope is excavated. The physical and chemical characteristics of a soil or rock mass may change due to the discontinuity of the plane or surface. Bedding plane, schistosity, foliation, joint, cleavage, fracture, fissure, crack or fault plane are the different forms of discontinuity. This controls the type of failure which may occur is a rock slope. Properties of discontinuities such as persistence, orientation, roughness and infilling are very important for the stability of jointed rock slope.

2.2.4 Effect of water

The effect of water on the slope can be considered into two folds. One is the generation of pore water pressure, which is caused by ground water or aquifer below the surface while the other is rain water infiltration that seeps through surface and flows along the slope generating water pressure. It is caused due to the surrounding precipitation levels, topography, nearby water masses, and the geo-hydrological characteristics of the rock mass (Sjöberg, 1999).

2.2.5 Material properties of the dump slope.

The material properties affecting the stability of slope are particle size distribution, density, moisture content, plasticity, density, and shear strength of material, particle size and angle of repose. The rock mass strength is also a very important factor that affects the stability of slopes.

2.2.6 Inclination of the dump slope.

The overall dump angle is measured from crest of the uppermost platform to the toe. 26° to 37° is the normal range of dump slopes. The upper value corresponds to the free dumped cohesion rock fill where as the lower value is commonly adopted for reclamation. The dump material containing appreciable fines or cohesive material or consists of very large, angular boulders with the slopes steeper than 37° may also be considered.

2.2.7 Seismic effect

The fracturing in the rock mass occurs due to the seismic waves passing through rock ads stress. They are tarred apart which may include liquefaction due to friction which is reduced in unconsolidated masses as a result. Due to earthquakes, landslide is one of the major hazards. With different time scales, blasting and earthquakes affect rock slopes in two distinct ways. The first effect causing co-seismic detachment of rock from a slope face and the second effect occurs over a layer time frame involving opening of fissures and rock fracturing that may result in rock dislodgements in the future. Hence the rock slopes strongly depend on load conditions of the rock mass due to such effects of seismicity.

2.3 Factors Controlling the Dump Failures

Various factors are responsible for the instability of dump and major factors are given below as described in (Das, 2008).

2.3.1 Dump slope angle

For slope stability it is one of the most important factors. Increase in the bench angle (& so the overall slope angle) keeping bench width and height constant, the factor of safety (FOS) decreases. So, it is necessary to maintain the dump slope angle so as to increase FOS. The dumping area and hence the dumping cost can be determined with the use of overall slope angle.

2.3.2 Natures of the dump materials

The natures of the dump materials have direct impacts on its stability and potential size of failures. When the natural dump materials with low durability weather which are exposure to atmospheric moisture, high particle load, freezing and thawing, wetting and drying in the natural dump environment are applied rapidly then materials are changed to finer particles .With the co-incident reduction in friction angle for the material, the dump also degrades the material and results in a rounded rather than angular shaped rock. The rock types and its composition, respective particle sizes, weathering, slaking potential, unconfined compressive strength affects the shear strength of dump material. As a result it will directly control the dump slope stability.

2.3.3 Dump height

The dump height is generally defined as the vertical distance from the dump crest to the ground surface of the dump toe. Typically the dump height ranges from 20m to more than 400m.Greater the dump height, lesser will be the Factor of safety (FOS). The relation between FOS with the dump height can be discussed later in the modelling.

2.3.4 Changes in cohesion of interface materials

The resistance force per unit area is called as cohesion and its unit is Pascal (Pa). The soil mainly contains two particles i.e. clay and silt, in which cohesion exists in between two particles. If these two particles are absent then there will be no cohesion. Generally rock has more cohesion than soil. So, by changing the cohesion value of both interface materials, dump slope stability can be controlled. More the value of cohesion, higher will be the FOS.

2.3.5 Different methods of dump construction

Different methods of dump construction include either OB + fly ash mixture in the alternate layer of different thickness or whole dump will be constructed with only OB + fly ash mixture. Hence the dump slope stability can be increased.

2.3.6 Condition of ground water

The ground water generally decreases the effective normal stress as it is present in cracks, fractures, joints and it always changes the shear strength parameters and will give a thrust in upward direction. Hence it has a tendency to reduce frictional angle and cohesion of the particles. As a result, factor of safety will be reduced to a greater extent..

2.3.7 Impact by heavy earth moving machineries

Due to the movement of heavy earth moving machineries, the compaction occurs with the dump material causing more stability of the dump slope. Hence FOS increases.

2.3.8 Degree of compaction.

A dozer is used for the compaction of the dump material. Due to compaction the void space will be suppressed i.e. void ratio will decrease and degree of compaction will increase. Hence the FOS of the dump slope will be increased.

2.3.9 Plantation

Plantation is very much important now days for the stability of dump material. Generally the roots of the tree hold the dump material and increase the stability. There is a plant called Vertebrae grass which is in demand these days. As its above portion is small but its roots grow below the surface and spread very deep. This will hold the dump material and the surface run off will be prevented during rainy season.

2.3.10 Grain size

Grain size means the particle size which is very much important for the slope stability as it will determine the unit weight, permeability, porosity etc. More grain size will increase the porosity causing more seepage of water through the dump material. Therefore, FOS will reduce. So as to increase the FOS, porosity has to be decreased and this will be done by adding fly-ash with the dump material. In this thesis, the grain size analysis will show how the FOS increases in addition to fly ash.

2.4 Different Types of Slope Failure

There are mainly 4 types of slope failure occur i.e.

- Wedge failure
- Toppling failure
- Plane failure
- Circular failure/ non circular failure

2.4.1 Wedge failure

When different sock masses slides along two intersections, discontinuities which is dip out of the cut slope at an oblique angle to the cut face, forming a wedge- shaped block. The movement of rock mass either in the direction of maximum dips of the striper of the two planes or along planes simultaneously. The wedge failure mainly depends upon the ratio of peak to the residual shear strength. This occurs rapidly or for some minutes or it may take longer time which may be a month. The range between the sizes of the wedge failure is from a few cubic metres to a very large extending of slides, with which the destruction potential can be enormous. [8]

2.4.2 Toppling failure

The series of columns of a rock mass which are formed by a set of fractures and the strike is approximately parallel to the dip steeply into the face as well as to the slope face. Toppling failures occur in these types of rock masses. The rock slab or the rock column rotates at or near the base of the slope about a fixed point due to which at the same time slippage occur at the layers. This mode of failure is occurred in metamorphic rocks, columnar basalts, and sedimentary rocks. The different types of toppling failures include flexural, block or a combination of block toppling. As a secondary failure mode toppling can also occur and it is similar to block sliding. [10]

2.4.3 Plane failure

These types of failures generally doesn't exist for dump slopes and in rock slopes, rather it is rare. In this failure the sliding plane is nearly parallel (within ±20°) or must strike parallel to the slope face and sliding plane must "day light" in the slope face, which means that the plane dip must be lower than slope face. Due to this interaction, the geometric conditions are complex in reality. However, the slope sensitivity causes changes in ground water and shear strength.

2.4.4 Circular failure

If the size of individual particles in a rock mass or in a soil are very small as compared with the size of slope and the inter-lock is developed in between the particle than this type of failure occurs. These failures occur only for unjointed rock masses, homogeneous material containing properties of uniform strength, altered weak rock masses or highly jointed rock masses. As the name suggests, the slide surface takes the form of a circular shape. If the dimensions of the rock fragments are smaller than the slope dimensions then the circular failure will occur. Even it has a height of few metres, smaller particle sizes, sand, silt will exhibit circular slide surface. [9]

The above discussed types of failures have been depicted diagrammatically (Fig. 2.1).

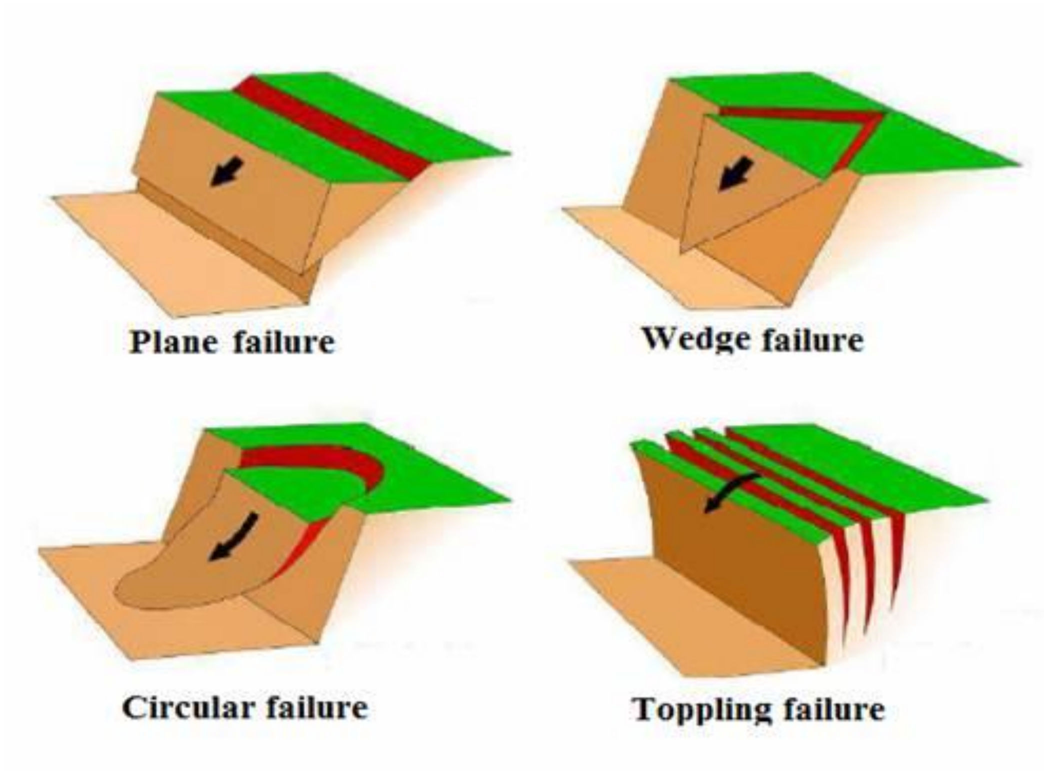

Fig.2.1 Different types of slope failures

2.5 Analysis of Slope Stability

2.5.1 Limit equilibrium method for slope stability

The rock slope stability depends on the sliding surface along with the shear strength. To analyse the shear failures, the study of Mohr coulomb material is to be carried out in which the shear strength can be calculated by the value of cohesion (c), angle of internal friction (Φ). [6]

Generally for a sliding surface, if an effective normal stress (σ) is acting then the value of shear strength is given by $\boldsymbol{\tau = c + \sigma \tan \upsilon}$.

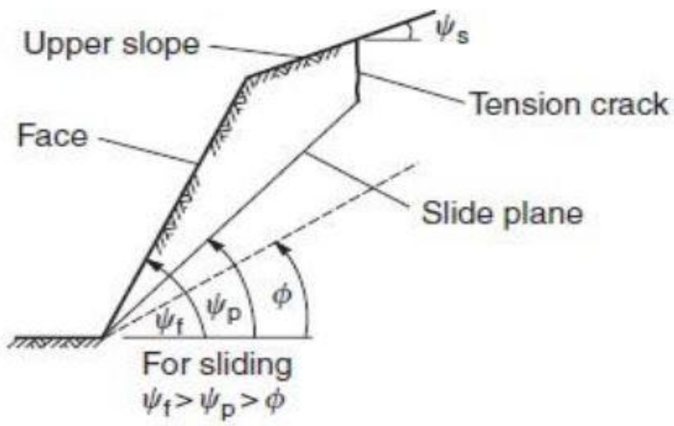

Figure 2.2: Cross-sectional view of a plane failure (Wyllie and Mah, 2005)

Factor of Safety (FOS) = Resisting force/Driving force

Resisting force = cA + W cos (ψ_p) tan φ

Driving force = W sin (ψ_p)

Therefore, FOS= [cA + W cos (ψ_p) tan φ] / [W sin (ψ_p)] (1)

If water forces in the sliding plane and in the tension crack is taken then the above equation for FOS becomes, FOS= [cA + (W cos ψ_p − U − V sin ψ_p) tan φ] / [W sin ψ_p + V cos ψ_p]

Where,

U is water force acting on the sliding plane = .5 $\gamma_w z_w$ (H + b tan ψ_s – z) cosec ψ_p

V is water force in the tension crack= .5 $\gamma_w z_w^2$

The cohesion will be approximately zero if the surface is clean and dry. Then in equation (1), FS = 1 if $\psi_p = \upsilon$. The block of rock will slide when the dip angle of the sliding surface equals the friction angle of this surface, and that stability is independent of the size of the sliding block. That is, the block is at a condition of "limiting equilibrium" when the driving forces are exactly equal to the resisting forces and the factor of safety is equal to 1.0. Therefore, the method of slope stability analysis described in this section is termed limit equilibrium analysis.

2.5.2 Analysis of sensitivity

In sensitivity analysis, for calculation of factor of safety it can take the range of those parameters which are used for the calculation of FOS in limit equilibrium. The sensitivity analysis is actually about the parameters which has the greatest influence upon the factor of safety. The calculation of factor of safety becomes very difficult when the problem contains more than 3 parameters are taken into consideration. Therefore, taking appropriate value of parameters for determining the factor of safety by usual techniques.

2.5.3 Probabilistic design method

The slope stability will be affected by varying each influencing parameters. From the probability distribution of FOS, the slope failure probability can be determined. It is applicable for the large number of samples. By the different opinion of the experts, the accurate analysis of distribution function can be done by spending much more time in analysis. After which the probability density function of each parameter gets prepared. These parameters are the value of mean by the binomial distribution curve, and then the probability of failure can be calculated by the two parameters.

- Margin of safety method
- Monte- Carlo method

2.6 Guidelines for Design of Dump Slopes

2.6.1 CMR guidelines [8]

Section 98 of The Coal Mine Regulations (CMR), 1957 stipulates that:

- ➢ In alluvial soil, morum, clay, gravel, debris or any other similar structure the overall slope angle shouldn’t exceed 45°. The figure is flexible to the decision of the regional inspector.

- The bench height of the above mentioned structures shouldn't be greater than 1.5 metre and width of the bench should always be greater than the height.
- For coal slopes the overall slope angle shouldn't exceed 45°and the height of each bench shall be less than 3 metres.
- In any kind of hard excavation, the sides must be suitably benched, sloped and secured so as to prevent any danger from falling material.
- If undercutting any side causes overhanging, than such undercuts must be avoided.

2.6.2 DGMS guidelines

- As per the DGMS permission for fly-ash filling in opencast working along with overburden, height of dump is limited to 30m. The height of dump at study sites was about 25m.
- Stability of dump slopes was monitored with total station and monitoring stations fixed at an interval of 20-30m on the dumps at a distance of about 5m from the crest of the dump slopes.
- The height should be planned in such a way that it is within the reach of excavation machines.
- The topsoil removed during mining shall be stacked separately. In future this can be used for reclamation purpose.

2.7 Slope Stability Analysis by other Investigators

Table 2.1: Work done by other investigators

Year	Author	Title	Description
1987	Alistair Kent et al	Coal mine waste dumps in British Colombia stability issues and recent development	Proposed two dump slope monitoring technique in British Colombia coal mine. The two methods are using simple wire-line Extensometer on the dump crests

			and wire line monitor record. Both this techniques are till now prevalent in British Colombia mines. After the installation of wire-line extensometer on the dump crest accidents due to dump failure have greatly reduced. Another experimental technique successfully implemented was an Automate wire-line extensometer, making use of truck dispatch and telemetry system.
2005	Neal Harries, et al.	Case studies of slope stability radar used in open cut Mines	Carried out an investigation in South- African metal mines, for dump and slope stability analysis. It was done in the year 2005. The monitoring technique used was slope stability radar (SSR). Four alarms were set in the SSR, namely- red, orange, yellow and green, to make the pit superintendent aware of various conditions. A rock fall was seen on the SSR visual, which was concluded from the SSR deformation plot, to be a result of 54mm for over 240 minutes. As the SSR system provided an hour of warning with a small movement of the rock mass, so all the machinery and personnel could be cleared from the place.
2011	Shad M. et al	Feasibility of using cone spectrometer truck to install Time domain reflectometry and fibre optic slope failure Detectors in pavement structures	Time domain reflectometry (TDR) Technique was used by a RUSS professor of civil engineering, Ohio University, to monitor the slope stability of embankments in the year 2011. His study also included the use of Fibre optic slope failure detectors. The main objective of this study was to compare Optical time domain reflectometry (OTDR) with electrical TDR and to demonstrate a new method of installation of fibre optic or co-axial cables in earthen slopes, to monitor slope stability problems.
2012	Singam Jayanthu	Field monitoring of stability of dump with 25% fly-ash	Carried out stability analysis of overburden mixed with 25% fly-

		and 75% overburden Materials related to JPOCCM mine, JPL.	ash in alternate layer. Dry density, Cohesion and friction angle value as obtained by them through experimental analysis for OB material were 1.87g/cc, 41.8 KN/m^2 and 28.5° respectively. Similarly dry density, Cohesion and friction angle value as obtained by them through experimental analysis for OB+25% fly-ash mixture were 1.74g/cc, 89.6 KN/m^2 and 22.9^0 respectively. With this value they modelled the dump in PLAXIS software, with 4 decks and each deck is of 30 metre height and 32^0 Deck angle. The overall slope angle was fixed at 22^0. A factor of safety of 1.75 was obtained. When a top soil layer of 2 metre
2014	Vinoth, et al	Applying real time seismic monitoring technology for Slope stability assessment- An Indian open cast coal mine perspective.	Carried out real time monitoring of a high wall mine to identify the impact of seismic activity on high-wall slope. He prepared seismic event impact contours and seismic clusters to know the impact of underground development work on the high-wall slope. During his monitoring period he found out that, the overall impact of the micro-seismic activity on the slope was negligible and no high-wall slope stability problem was created.

CHAPTER 3

DESCRIPTION OF THE STUDY AREA

3.0 Description of the Study Area

3.1 Introduction

The JPL coal mine is under Tamnar tahsil of Raigarh District, Chhattisgarh. Jindal Power Open Cast Coal Mine which is captive mine of Jindal's 1000 MW (4 x 250 MW) thermal power plant. The block is located between Longitudes - 83°29'40" to 83°32'32" (E) and Latitude - 22°09'15" to 22°05'44" (N) falling in the topo sheet number 64 N/12 (Survey of India). The block is well connected by Road. It is about 60 km from Raigarh town, which is district head quarter and nearest railway station is on Mumbai - Howrah Main Line.

3.2 Geomining condition

In general, area of the coal block - Jindal Power Open Cast Coal Mine is almost flat with small undulations from surface. The lithological section comprises about 3-4 m unconsolidated loose soil/alluvium. Below the top soil there is weathered shale/sandstone up to 6–8 m depth. The weathered shale and sandstone are comparatively loose in nature and can be excavated without blasting. Below weathered zone (which varies from 3 – 10 m), the rock is hard, compact and massive in nature and can be excavated only after blasting. Thus the average depth of the excavation of these excavations, which can be removed, is about 16 m.

In the sub-block IV/2 & IV/3 only lower groups of Gondwana sediments have been deposited. Strata are gently dipping by 2 to 5° south-westerly. The general strike of the sediments is in NW -SE, and almost uniform throughout the block. Two normal faults of small magnitude have been deciphered based on the level difference of the floor of the seams, though the presence of some minor faults of less than 5 m throw cannot be overruled.

3.3 Method of Dumping fly ash and OB

It was proposed earlier to have internal overburden dumps of maximum height of 30 m in each individual deck with four decks up to 120 m overall dump height. Presently overburden dump height is about 72 m with a maximum deck height up to 25 m in this mine. These dumps and slopes are observed to be stable at present. Stability analyses for the proposed dumps were undertaken using various techniques for the maximum dump height of 120 m, which is the ultimate depth of the mine. Ground Water level conditions are below the 13 m from the surface and benches are generally dry. Jindal Power Limited, Tamnar has already have captive thermal power plants of 1000 MW and generating fly ash, a solid coal combustion residue form due to the burning of coal, of nearly 16000 tons per day. Therefore, quantity of fly ash generated requires large area for its dumping. In last two decade it was realized that fly ash is no more a waste. Its utilization has increased by several folds, and particularly in mining industries.

Fly ash is being used at JPL along with overburden material for backfilling in the mine as per the guide line. The following methodology was adopted for the dumping process:

Section of the dumping of fly ash at Jindal Power Open Cast Coal Mine, Tamnar is shown in Figure 3.1. Initially a row of overburden was dumped forming an embankment with a width of greater than 15 m and height up to 5 m all around the proposed area for fly ash dump. A number of such areas were formed in a layer wherein the fly ash was dumped so that each dump of fly ash was separated by another overburden dump of 15 m wide in order to control the airborne quality of the fly ash. Fly ash was dumped within this area surrounded by overburden in alternate layers of height not exceeding 5 m in each layer. Therefore, each layer of overburden was followed by a layer of mixture of fly ash and overburden (fly ash

25%) and so on up to the height of 30 m.

The side of the overburden dump is benched and the angle of slope is about 28^{o}. Dump is compacted; width of the dump is about 40 m and the overall slope is about 21^{o} from the horizontal. The toe of the dump is protected by putting the compact rocks (Overburden material) in order to restrict the possibility of any failure. Fig 3.2 to 3.5 illustrates dumping of fly ash through truck in the dump, sprinkling of water in the dump area, dozing of fly ash and OB material at the dump site, top soil on the dump area respectively. Fig 3.6 shows plantation over top soil on the dump area.

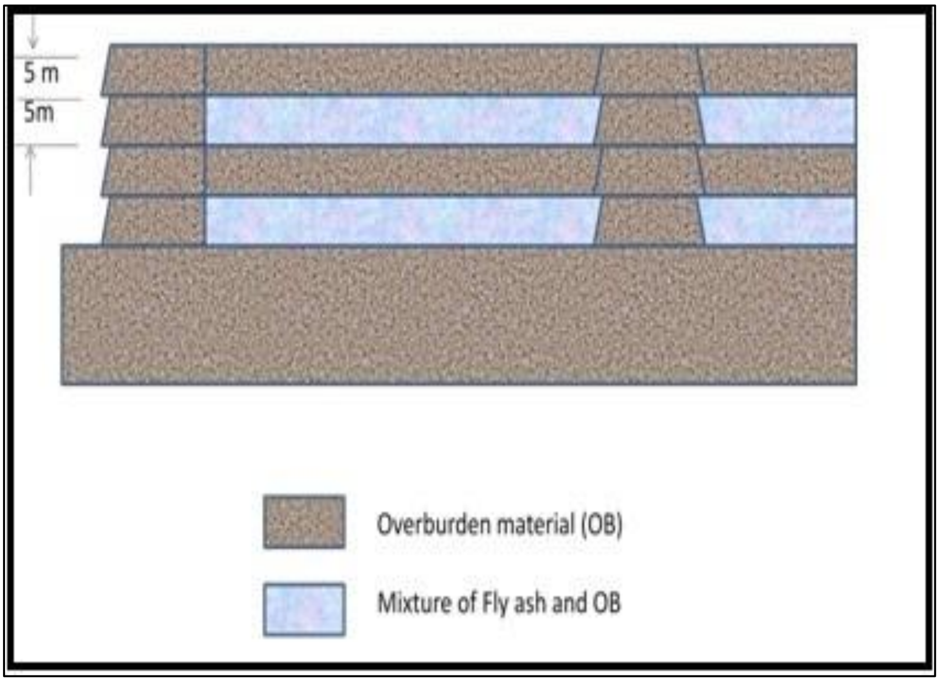

Figure 3.1 Section of the dump

Figure 3.2 Fly ash and OB mixed dump at dumps

Figure 3.3 Sprinkling of water in the dump area

Figure 3.4 Dozing of fly ash and OB material at the dump site

Figure 3.5 Top soil on the dump area

Figure 3.6 Plantation over Top soil on the dump area

3.4 Sample Preparation and Collection

Various samples of overburden, soil and fly ash from the dump site of Jindal Open Cast Coal Mine, Tamnar were collected from two different pits i.e. Pit-1 and Pit-2 in two different season (autumn and spring).At first the locations were selected where the appropriate samples (overburden) could be taken. The soft soil cover war cleaned off at first then ground was dug up to half meter to take samples of proper moisture content. A trench of 2 to 3m deep was dug and a hollow cylindrical mould of 15cm length and 10cm internal diameter was put into the ground. Then carefully hammering was done. Along with the soil inside the cylindrical mould was carefully taken out from the ground which was properly packed to prevent exposure to air. An air tight packing was done with the help of plastic gunning bags. Fly ash sample was collected from the ash pond of Jindal Power Limited, Tamnar.

Different geotechnical tests were conducted for the overburden and the fly ash samples collected from the site. Laboratory geotechnical investigation was carried out for determination of grain size distribution, specific gravity, compaction characteristics (optimum moisture content and maximum dry density), and shear strength characteristics following Bureau of Indian standard (BIS) methods. The parameters like density, and shear parameters cohesion (C) and (angle of repose) are determined for both overburden and fly ash to analyze stability of dumped slope. Fig 3.7 shows the process of collection of field sample for testing of Physico mechanical Properties of dump material.

Figure 3.7 Collection of field sample for testing of Physico mechanical Properties of dump material

CHAPTER 4

EXPERIMENTAL ANALYSIS

4.0 Experimental Analysis

In experimental analysis various tests were conducted to evaluate factor of safety (FOS) by taking the following geo-technical parameter.

- Density (kg/m^3)
- Cohesion (Pa)
- Angle of Internal Friction (°)

So in order to determine the above values the tests which were conducted on OB, OB+15% fly ash, OB+30% fly ash are mentioned below.

- Grain size analysis
- Procter hammer test (this test is carried out to determine density)
- Direct Shear test (this test is carried out to determine cohesion ‘C’ and angle of internal friction ‘Φ’)

4.1 Test for analysis of Grain size [12]

Objective

(a) Sieves sizes are to be selected as per *I.S* specifications and sieving performances are to be observed

(b). Obtain percentage of soil retained on each sieve.

(c) graph between log grain size of soil and % finer is to be plotted

Test Procedure

Generally soil contains particles of different shape and sizes, which is a porous mass. Inter-particulate electrochemical forces exist in between the particles of the soil. Hence the classification of soils can be determined using this variation of grain sizes. Grain size analysis predicts the classification of coarse grain or fine grained of soil.

Table 4.1 Different Fractions of Soil According to the Particle Size

Particle Size	Fraction
> 4.75 mm	Gravel
0.075 mm – 4.75 mm	Sand
0.002 mm – 0.075 mm	Silts
< 0.002 mm	Clay

As per Indian standard (IS 2720(IV)-1985, the sieves were arranged in such a way that the finest one was to be placed at the bottom and the coarsest one was placed at the top. Then at The coarsest sieve, 1kg of oven dried sample was taken. Hence the entire assembly of sieve was placed on the mechanical sieve shaker machine shown in figure 3.8 and shaken for about 10 min. After 10 min, the assembly was taken out and the weight of sample retained in each sieve size was taken. Calculation of percentage along with the plotting of graph between grain size and cumulative percentage of fines were carried out.

Fig.4.1 Assembly of different sieve size placed on mechanical sieve shaker

The observations of different samples were obtained as follows.

Sample: OB material

Amount of sample taken: 1000 gm

Table 4.2 Grain Size Analysis of OB material

Sieve Size (mm)	Weight Retained (gm)	Cumulative weight (gm)	% age weight retained	%age finer
4.75	129.5	129.5	12.95	87.05
2	74.5	204	20.4	92.55
1	112.5	316.5	31.65	88.75
0.425	139	455.5	45.55	86.1
0.212	365	820.5	82.05	63.5
0.15	122.5	943	94.3	87.75
0.075	47	990	99.0	95.3

0.01	4	4	99.4	0

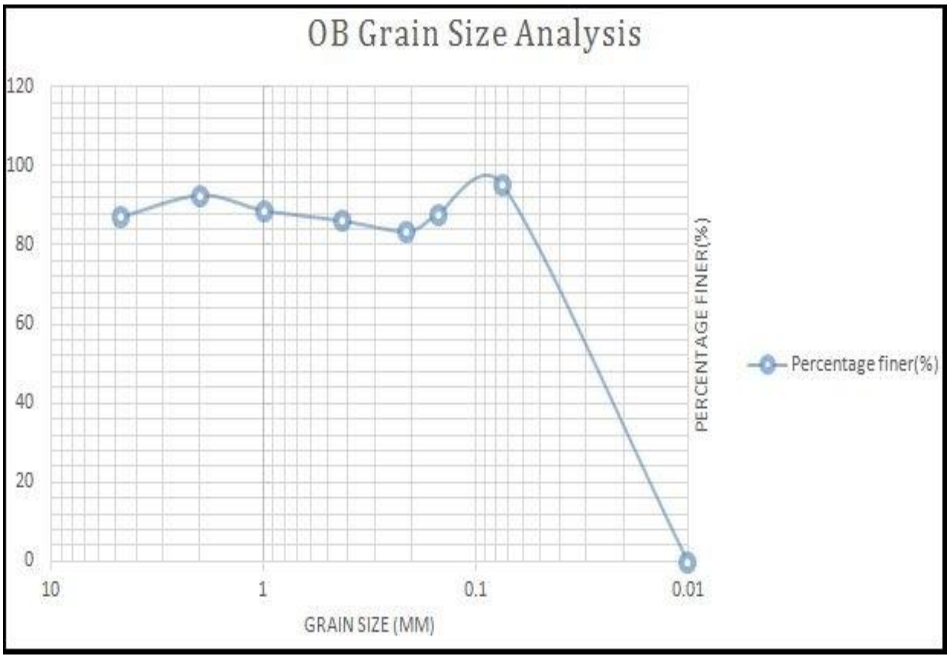

Fig 4.2 Grain Size Curve of OB material

Sample: OB + 15% fly ash material

Amount of sample taken: 998 gm (848 gm OB + 150 gm fly ash)

Table 4.3 Grain Size Analysis of OB + 15% Fly ash material

Sieve Size (mm)	Weight Retained (gm)	Cumulative weight (gm)	% age weight retained	%age finer
4.75	81.5	81.5	8.15	91.85
2	55.5	137	13.7	94.45
1	67.5	204.5	20.45	93.25
0.425	6.5	211	21.1	99.35
0.212	74.5	285.5	28.55	92.55

0.15	125.5	411	41.1	87.45
0.075	342.5	753.5	75.35	65.75
0.01	175	175	17.5	0

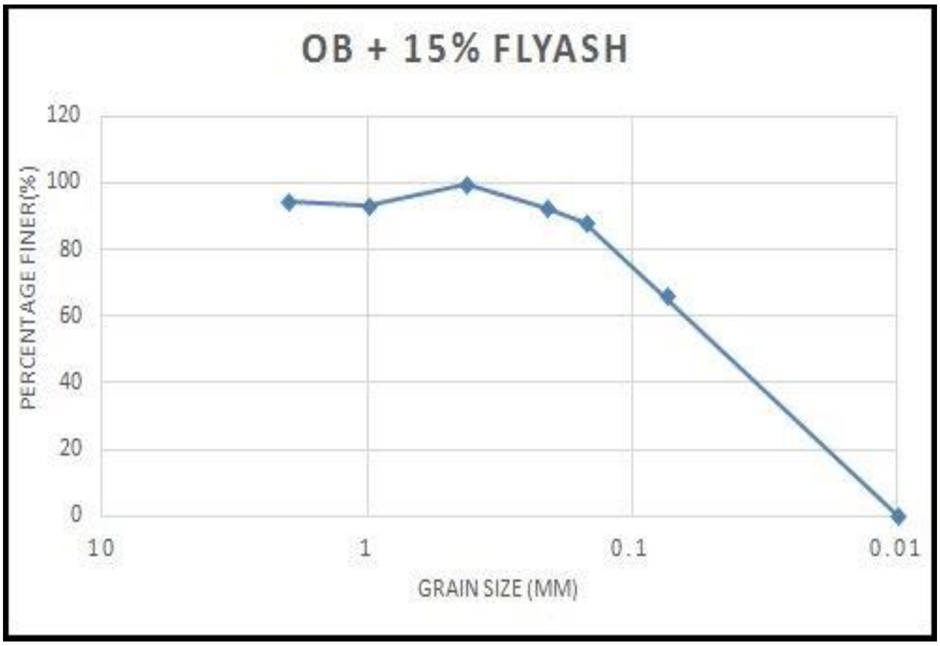

Fig 4.3 Grain Size Curve of OB + 15 % Fly ash material

Sample: OB + 30% fly ash material

Amount of sample taken: 1000 gm (700 gm OB + 300 gm fly ash)

Table 4.4 Grain Size Analysis of OB + 30% Fly ash material

Sieve Size (mm)	**Weight Retained (gm)**	**Cumulative weight (gm)**	**% age weight retained**	**%age finer**
4.75	80	80	8.0	92
2	48	128	12.8	95.2
1	74.5	202.5	20.2	92.55

0.425	108.5	311	31.1	89.15
0.212	313.5	624.5	62.45	68.05
0.15	215	839	83.95	78.5
0.075	120.5	960	96.0	87.95
0.01	29.5	29.5	2.95	0

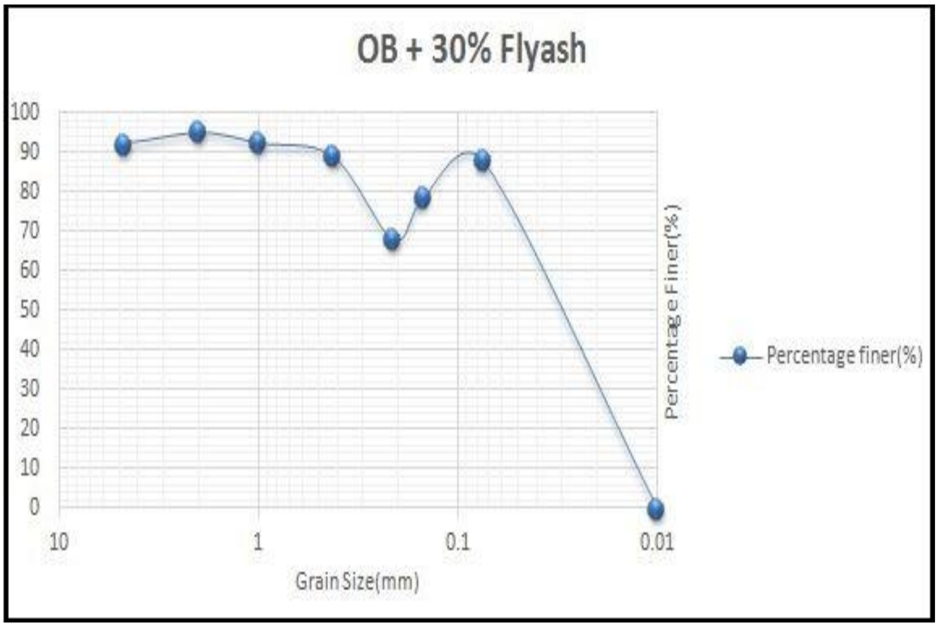

Fig. 4.4 Grain Size Curve of OB + 30% Fly ash material

Result

From the above test it is evident that the maximum %finer of particle size lie between 0.075mm-4.75 mm. Hence the natures of the samples were sandy.

4.2 Test for standard proctor hammer [13]

Objective

This test was carried out to determine

- Optimum moisture content
- Maximum dry density

When maximum compaction is given to the sample then due to strength and deformation of the sample, it will give the maximum dry density accurately. After finding the value of maximum dry density we can easily find out the value of optimum moisture content. The procedure can be discussed as follows.

Procedure

A 0.5mm size of air dried sample (2.5kg) was taken in a container. 5% of the sample i.e.125 ml of water is added to it and was thoroughly mix with the sample. At first the weight of empty mould (W_m) was taken then the base plate was attached to it and there after the collar was fixed. 1/3rd of the mixture of water and samples was taken and put it into the empty mould. 25 numbers of blows were applying to the samples for compaction. After giving blows again 1/2nd of sample was taken and was given 25 numbers of blows. The same procedure was adopted for the remaining sample. Collar was removed and the above part of the sample within the mould was trimmed. Carefully not disturbing the sample, the mould was detached from the base plate and small amount of samples from the compacted samples were taken. The weight of the small sample was taken and put it in the oven. After 24 hour the sample was taken out and again weight was taken. First step was completed. Now again in the fresh sample of same material was taken and mix more 5% of water i.e.50 ml and the whole procedures were carried out and complete tabulation was done. These procedures were same for OB, OB+15% fly ash, OB+30% fly ash.

Fig.4.5 Proctor Compaction Apparatus

Fig.4.6 Application of blows

The observations obtained from the above test were tabulated below.

Sample: OB material

Sample weight ($\mathbf{W_m}$) = 2.5 kg

Empty mould weight ($\mathbf{W_E}$) =1.9 kg

Internal diameter of mould (**d**) = 10cm

Mould height (**h**) = 12.5 cm

Mould volume (**v**) = 982.14 cc

Fig.4.7 Sample: OB material

Table 4.5 Procter Compaction Test for OB material

PARAMETER	1	2	3	4	5
Weight Of Mould + Soil, **W1** (gm)	3791	3901	4043	4210	4021
Weight Of Compacted Soil, **Wc** (Gm)	1884	1912	2031	2321	2104
Wet Density, **Dw** = Wc/V (G/Cc)	1.918	1.946	2.067	2.363	2.142
Weight Of Container, **X1** (Gm)	19.95	20.12	19.62	21.23	21.52
Weight Of Container + Wet Soil, **X2** (Gm)	115.6	75.20	116.8	124.3	112.4
Weight Of Container + Dry Soil, **X3** (Gm)	111.8	73.02	110.2	115.5	103.4
Weight Of Dry Soil, X3 - X1 (Gm)	91.85	50.09	93.58	94.27	81.88
Water , X2 - X3 (Gm)	3.8	2.18	6.6	8.8	9.0
Water Content, **W** = (X2 - X3)/(X3 - X1) (%)	4.13	4.35	7.05	9.33	10.99
Dry Density, **Dd** = Dw/(1 + 0.01W) (G/Cc)	1.841	1.864	1.930	2.161	1.929

From the above tests, it was observed, the maximum dry density (MDD) of OB material was found to be 2.161 and the optimum moisture content (OMM) was found to be 9.33. The graphical study between these two parameters can be shown as follows.

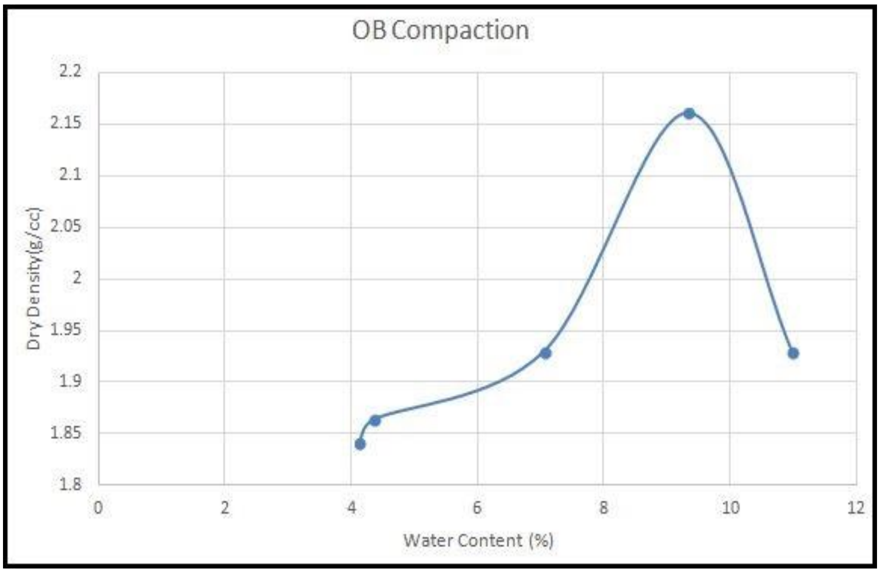

Fig. 4.8 Compaction Curve for OB material

Sample: OB + 15% fly ash material

Sample weight (**W_m**) = 2.5 kg

Empty mould weight (**W_E**) =1.85 kg

Internal diameter of mould (**d**) = 10cm

Mould height (**h**) = 12.7 cm

Mould volume (**v**) = 997.26 cc

Fig.4.9 Sample: OB + 15% fly ash material

Table 4.6 Procter Compaction Test for OB + 15% Fly ash material

PARAMETER	1	2	3	4
Weight of Mould + Soil, **W1** (gm)	3699	3782	3892	3984
Weight of Compacted Soil, **Wc** (gm)	1801	1912	2001	2062
Wet Density, **dw** = Wc/V (g/cc)	1.805	1.917	2.006	2.067
Weight Of Container, **X1** (gm)	19.02	19.67	20.31	21.06
Weight Of Container + Wet Soil, **X2** (gm)	94.92	102.12	92.04	106.72
Weight of Container + Dry Soil, **X3** (gm)	92.01	94.98	86.38	95.70
Weight of Dry Soil, X3 - X1 (gm)	72.99	75.31	66.07	74.64
Water , X2 - X3 (gm)	2.91	7.14	5.66	11.02
Water Content, **W** = (X2 - X3)/(X3 - X1) (%)	3.98	9.4	8.56	14.76
Dry Density, **dd** = dw/(1 + 0.01W) (g/cc)	1.735	1.752	1.847	1.8011

From the above tests, it was observed, the maximum dry density (MDD) of OB+15 % fly ash material was found to be 1.847 and the optimum moisture content (OMM) was found to be 11.23. The graphical study between these two parameters can be shown as follows.

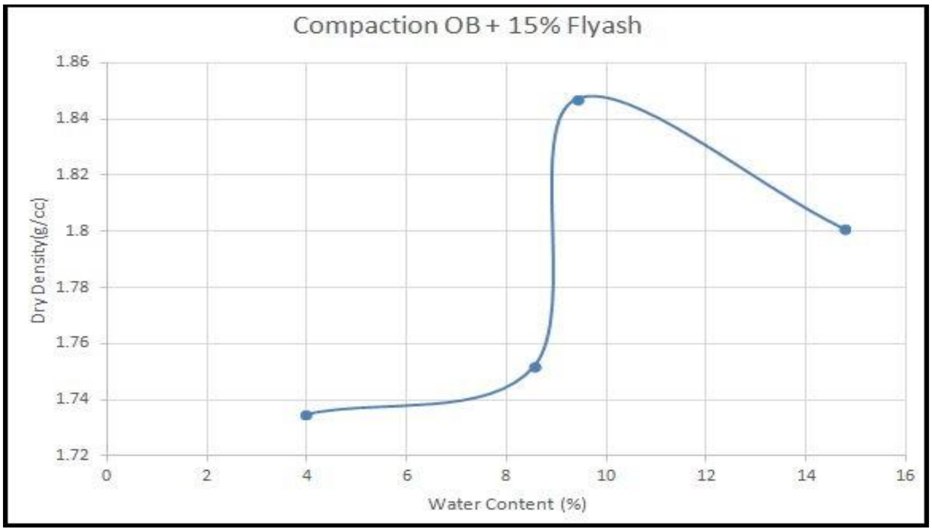

Fig. 4.10 Compaction Curve for OB + 15% Fly ash material

Sample: OB + 30% fly ash material

Sample weight ($\mathbf{W_m}$) = 2.5 kg

Empty mould weight ($\mathbf{W_E}$) =1.92 kg

Internal diameter of mould (**d**) = 10cm

Mould height (**h**) = 12.6 cm

Mould volume (**v**) = 990 cc

Fig.4.11 Sample: OB + 30% fly ash material

Table 4.7 Procter Compaction Test for OB + 30% Fly ash material

PARAMETER	1	2	3	4	5	6
Weight of Mould + Soil, **W1** (gm)	3423	3581	3640	3672	3752	1827
Weight of Compacted Soil, **Wc** (gm)	1562	1621	1748	1798	1893	1968
Wet Density, **dw** = Wc/V (g/cc)	1.577	1.637	1.759	1.816	1.912	1.987
Weight Of Container, **X1** (gm)	19.32	19.82	20.66	21.72	22.12	10.23
Weight Of Container + Wet Soil, **X2** (gm)	86.91	94.12	98.23	98.00	94.18	104.6
Weight Of Container + Dry Soil, **X3** (gm)	83.41	88.23	91.49	90.23	86.32	92.45
Weight Of Dry Soil, X3 - X1 (gm)	64.09	68.41	70.83	68.51	64.2	72.22
Water , X2 - X3 (gm)	3.5	5.89	6.74	7.77	7.86	12.16
Water Content, **W** = (X2 - X3)/(X3 - X1) (%)	5.46	8.609	9.515	11.341	12.24	16.837
Dry Density, **dd** = dw/(1 + 0.01W) (g/cc)	1.495	1.507	1.606	1.631	1.703	1.7006

From the above tests, it was observed, the maximum dry density (MDD) of OB+15 % fly ash material was found to be 1.847 and the optimum moisture content (OMM) was found to be 11.23. The graphical study between these two parameters can be shown as follows.

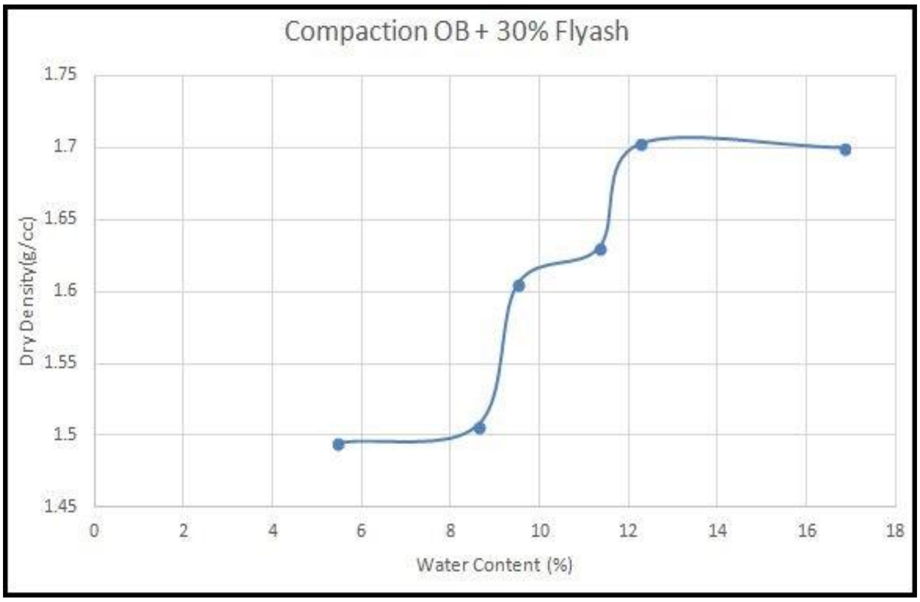

Fig. 4.12 Compaction Curve for OB + 30% fly ash material

Result:

The maximum dry density and the corresponding optimum moisture content can be denoted in the maximum compaction curve. The results were summarised below table 4.8.

Table 4.8 Results of Procter Compaction Test

Sample	MDD (g/cm^3)	OMC (%)
OB	2.161	9.33
OB + 15% fly ash	1.847	11.23
OB + 30% fly ash	1.703	12.24

4.3 Direct shear test [14]

Sample: OB material

Table 4.9 Normal Stress vs. Shear Stress for OB material

Normal stress N, kg/cm^2	Shear stress τ , kg/cm^2
0.5	0.328
1.0	0.724

1.5	0.843
2.0	1.172
2.5	1.621

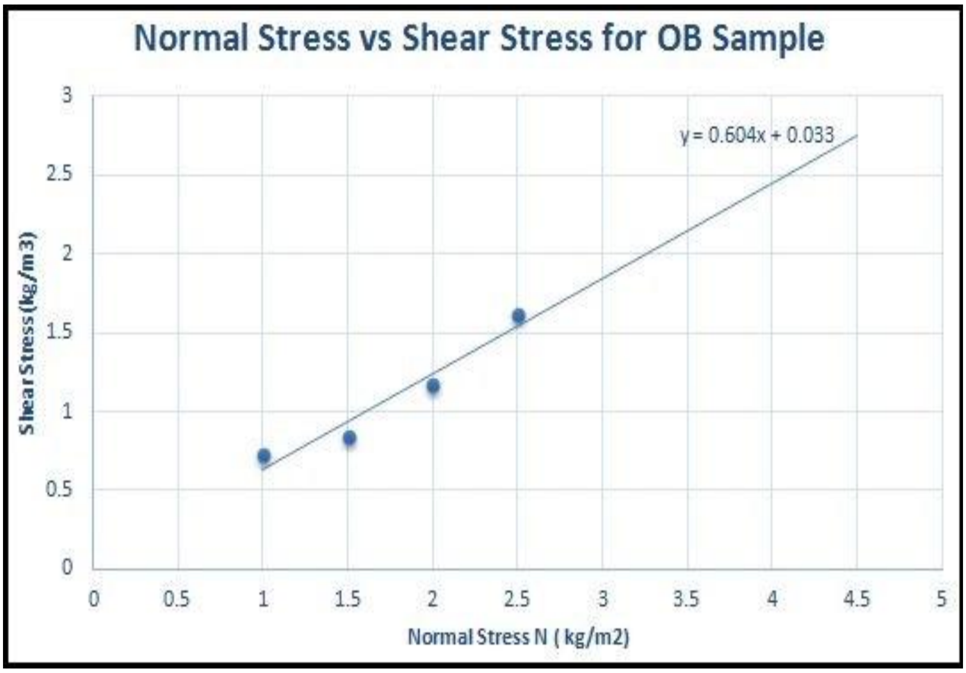

Fig. 4.13 Normal Stress applied vs. Shear Stress for OB material

As per Mohr-Coulomb expression $\tau = c + \sigma \tan \Phi$,

From the graph, y= 0.60x + 0.033,

Cohesion = y intercept of the line

= 0.033 kg/cm²

= 3230.1945 Pa

Angle of internal friction (Φ) = slope of the line = tan-1 (0.60)

= 30.963^0

OB + 15% fly ash material

Table 4.10 Normal Stress vs. Shear Stress for OB + 15% fly ash material

Normal stress N, kg/cm²	**Shear stress τ , kg/cm²**
0.5	0.382
1.0	0.635
1.5	0.720
2.0	1.161
2.5	1.312

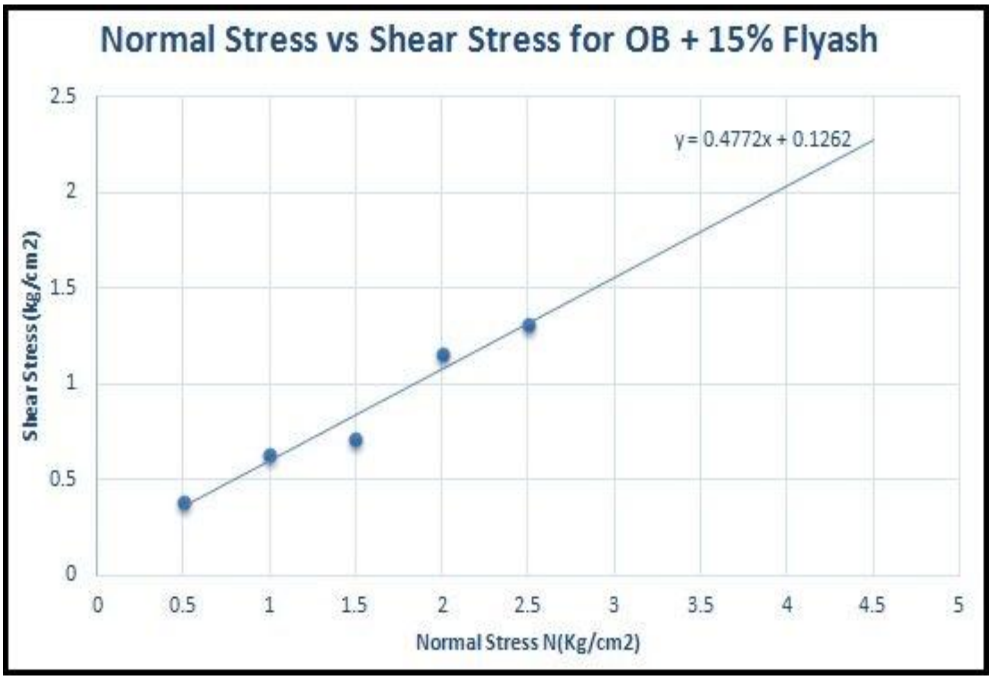

Fig. 4.14 Normal Stress applied vs. Shear Stress for OB + 15% fly ash material

The Mohr-Coulomb expression $\tau = c + \sigma \tan \Phi$,

From the graph, y= 0.4772x + 0.1262,

Cohesion = y intercept of the line

= 0.1262 kg/cm²

= 12375.9923 Pa

Angle of internal friction (Φ) = slope of the line = tan-1 (0.4772)

= 25.51^0

OB + 30% fly ash material

Table 4.11 Normal Stress vs. Shear Stress for OB + 15% fly ash material

Normal stress N, kg/cm²	Shear stress τ , kg/cm²
0.5	0.374
1.0	0.698
1.5	0.819
2.0	1.182
2.5	1.267

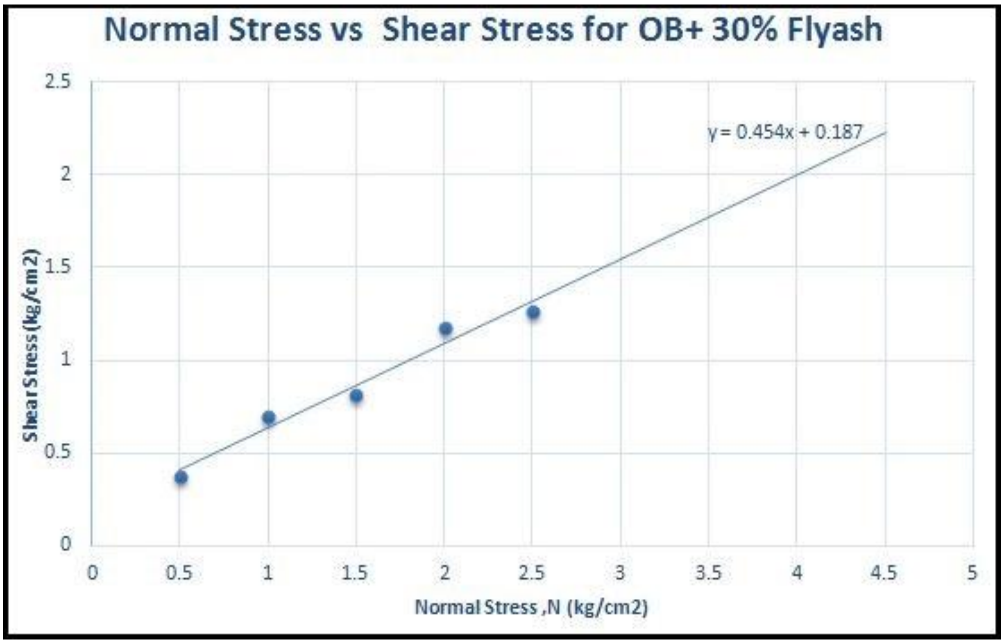

Fig. 4.15 Normal Stress applied vs. Shear Stress for OB + 30% fly ash material

As per Mohr-Coulomb expression τ = c + σ tan Φ,

From the graph, y= 0.454x + 0.187,

Cohesion = y intercept of the line

= 0.187 kg/cm²

= 18338.4355 Pa

Angle of internal friction (Φ) = slope of the line = tan-1 (0.454)

= 24.41

Result

The values of cohesion and internal frictional angles are listed below table

Table 4.12 the values of cohesion and internal angle of friction of different samples

Sample	Cohesion (kg/cm^2)	Angle of internal friction (Φ)
OB	0.033	30.963
OB + 15% fly ash	0.1262	25.51
OB + 30% fly ash	0.187	24.41

Fig. 4.16 Apparatus showing direct shear test

Fig. 4.17 the above samples showing failure profile

CHAPTER 5

NUMERICAL MODELLING

5.0 Numerical Modelling using FLAC/SLOPE

FLAC/SLOPE is used for the calculation of factor of safety (FOS) automatically and graphical interface can be done with variety conditions of slope, it is used as eco-friendly which models the stable slopes or detects the stability problems. Various conditions such as soil properties of heterogeneous, multiple layers, conditions of pore pressure, slope geometry at arbitrary, structural reinforcement and surface loading.

FLAC/slope is facilitated to the analysis of stable slopes and simplified modelling is done using different calculation method. Rapid development of model is being done using some code by analysis and reporting fast solution.

FLAC/slope can perform difficult parametric studies along with multiple analyses for rock slope and dump slope project. The programs are so developed that different models can be simulated, accessed and stored. The results can be compared with different model analysis. The simulation is done using four stages.

- 1st stage will show model stage
- 2nd stage will show build stage
- 3rd stage will show solving stage
- 4th stage will show plotting stage

5.1 Different dumps design using FLAC

The purpose of the project is to design the stable overburden dump to be economic and safe. The overburden handling and working condition for stable overburden dump design in the primary work. Accidents can be prevented by designing good overburden dumps. The poor construction of dumps and its design will leads to failure. So in order to construct a stable and safe overburden dump.[10]

In the first two trials of two benches/decks of 30m and 20m of overburden dump height and keeping the height of sandstone at 30m of different slope angles varies from 26^0 to 35^0 were taken. The overburden bench width was keeping constant at 40m. These procedures were adopted accordingly for OB +15% fly ash and OB + 30% of fly ash.

5.1.1 OB material

The parameters responsible for the calculation of factor of safety (FOS) and safe slope angle were listed below.

Cohesion (c): 3236.194 Pa

Angle of internal friction (Φ): 30.963

Density: 2.161 g/cm^3

Table 5.1 variation of FOS with bench slope angle for OB material using FLAC

Slope Angle (^{o})	Factor of safety (30m OB)
26	1.35
27	1.30
28	1.25
29	**1.21**
30	1.18

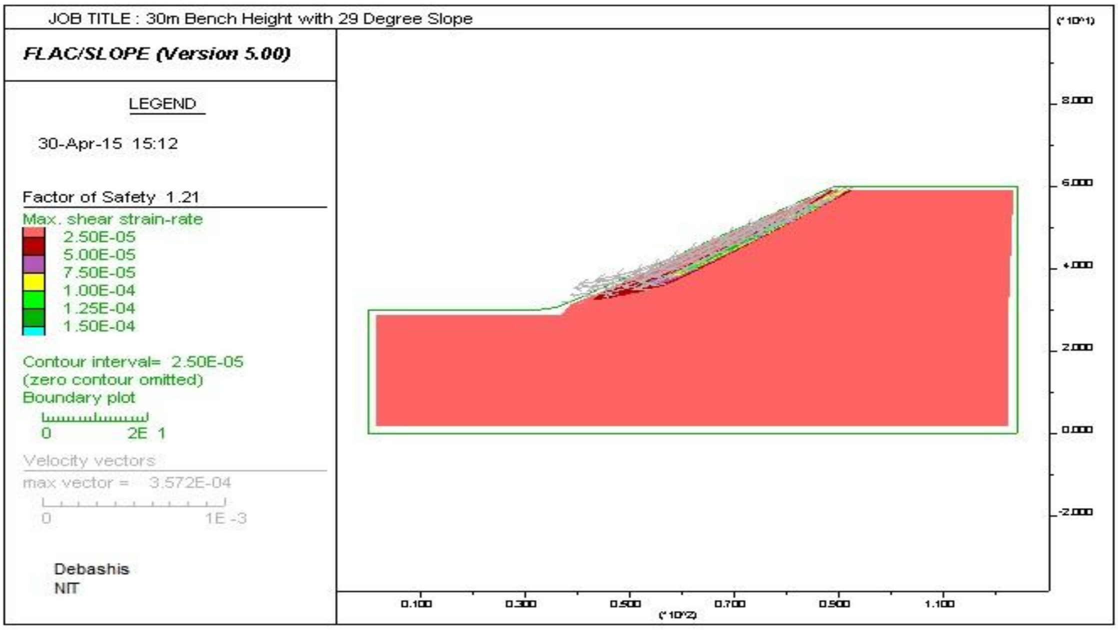

Fig.5.1 Model for 30m OB material, at 29^0 slope angle using FLAC (FOS is 1.21)

5.1.2 OB Material + 15% fly ash

The parameters responsible for the calculation of factor of safety (FOS) and safe slope angle were listed below.

Cohesion (c): 12375.9927 Pa

Angle of internal friction (Φ): 25.51

Density: 1.847 g/cm^3

Table 5.2: variation of FOS with bench slope angle for OB material+15% fly ash using FLAC

Slope Angle (^{0})	Factor of safety (30m OB)
25	1.27
26	**1.22**
27	1.17
28	1.13
29	1.10
30	1.07

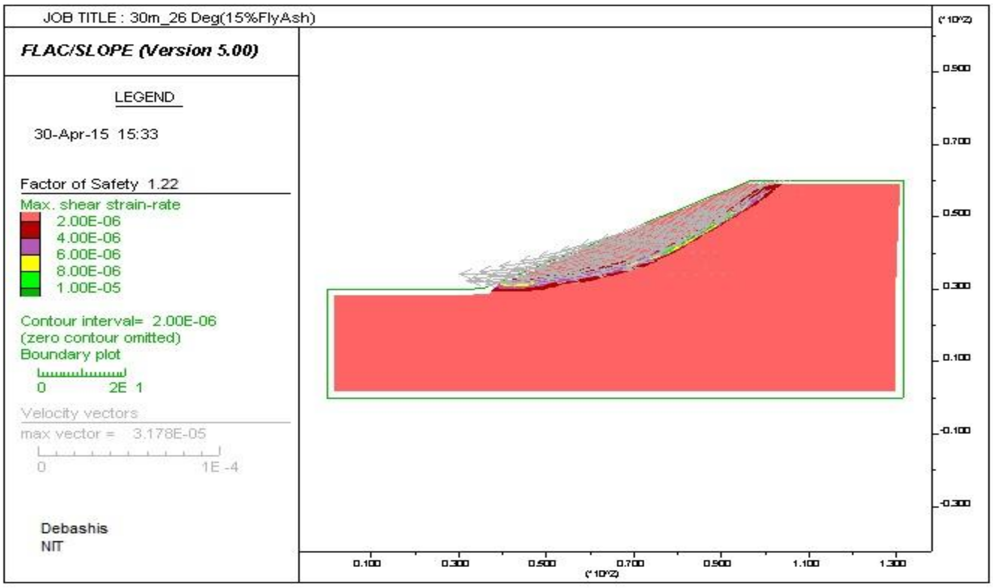

Fig.5.2 Model for 30m OB + 15% fly ash material, at 26^0 slope angle using FLAC (FOS is 1.22)

5.1.3 OB Material + 30% fly ash

The parameters responsible for the calculation of factor of safety (FOS) and safe slope angle were listed below.

Cohesion (c): 18338.4355 Pa

Angle of internal friction (Φ): 24.41

Density: 1.703 g/cm³

Table 5.3: variation of FOS with bench slope angle for OB material+30% fly ash using FLAC

Slope Angle (^{0})	Factor of safety (30m OB)
25	1.41
26	1.34
27	1.27
28	**1.22**
29	1.17
30	1.12

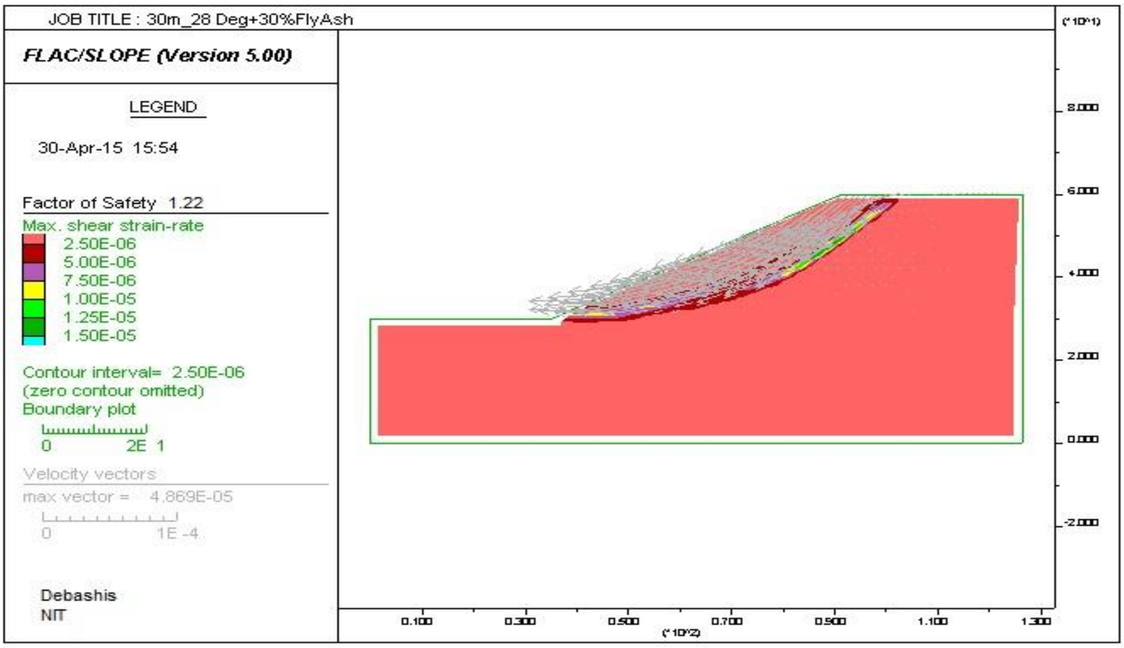

Fig.5.3 Model for 30m OB + 30% fly ash material, at 28^0 slope angle using FLAC (FOS is 1.22)

As per DGMS the slope of an overburden dump is usually determined by the angle of repose of the material, but in no case it should exceed 37.50. Alternately we can say, bench angle shouldn't exceed the natural angle of repose or 37.50, whichever is less.

For OB dump as per DGMS

Cohesion (c): 12375.9927 Pa

Angle of internal friction (Φ): 25.51

Density: 1.847 g/cm^3

Fig.5.4 Variation of FOS with bench slope angle for OB material as per DGMS

Slope Angle (^{0})	Factor of safety (30m OB)
30	1.35
33	1.29
37.5	**1.21**
39	1.18
42	1.15

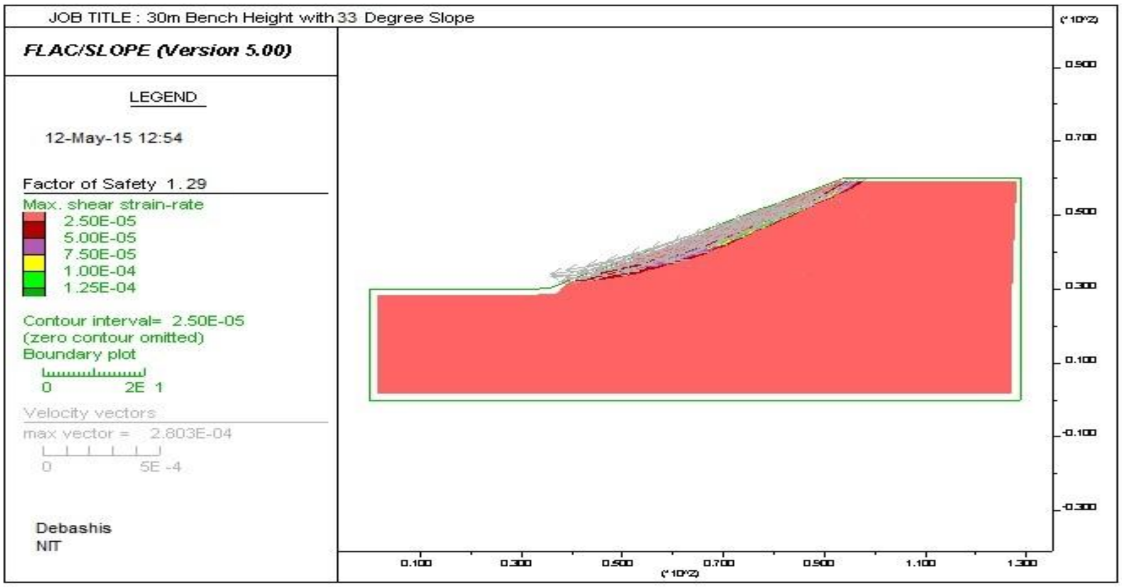

Fig.5.4 Model for 30m OB material, at 33^0 slope angle using FLAC as per DGMS (FOS is 1.29)

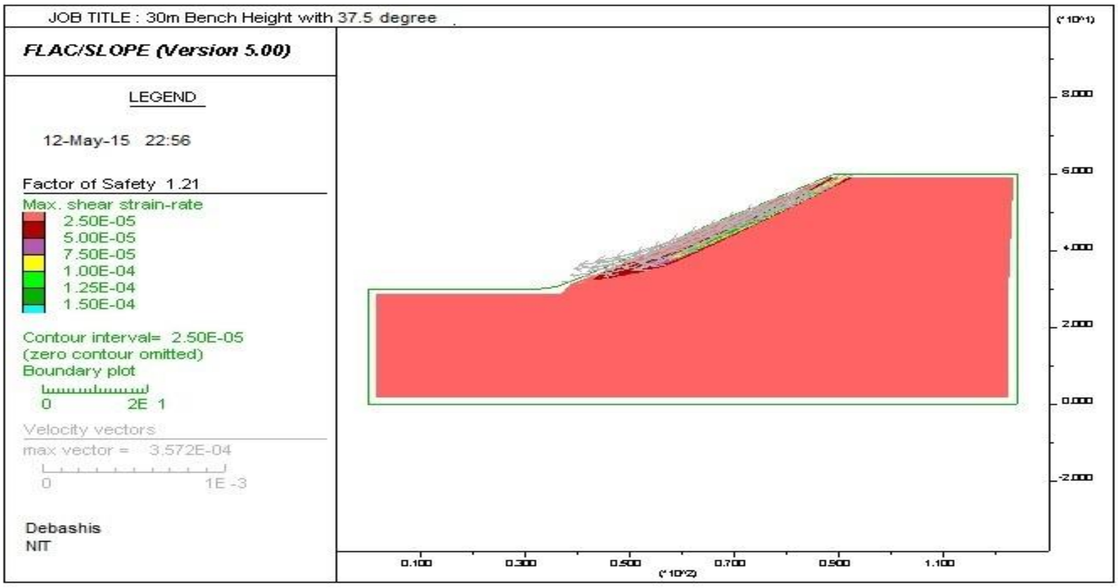

Fig.5.5 Model for 30m OB material, at 37.5^0 slope angle using FLAC as per DGMS (FOS is 1.21)

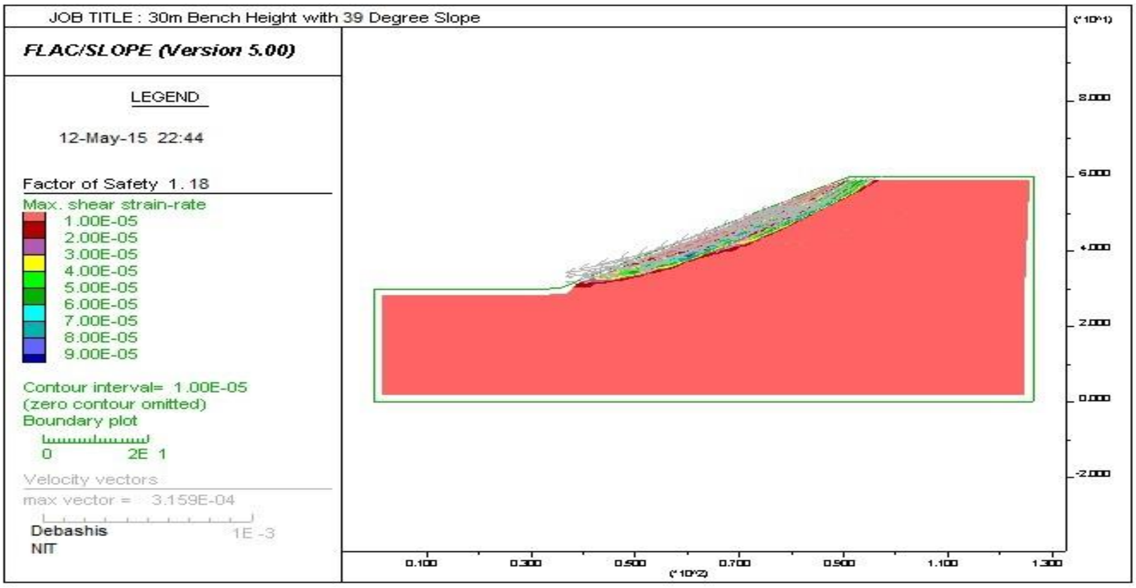

Fig.5.6 Model for 30m OB material, at 39^0 slope angle using FLAC as per DGMS (FOS is 1.18)

5.1.4 Result

The steepest angle for which the FoS > 1.2 was accepted as the safe slope angle. The slope angles for the models were 25^0, 26^0, 27^0, 28^0 and 29^0 for different OB dump material and admixture of fly ash.

When 15%fly ash was added to OB material then from FLAC software analysis the factor of safety 1.21.and safe slope angle was 26^0. As a result according to the analysis of modelling it is evident that the admixture of 15% fly ash gave an effective result.

When again 30% fly ash was added to OB dump material the factor of safety and safe slope angle were increased and shown a result of 1.22, 28^0 respectively.

5.2 Numerical Modelling using OASYS SLOPE

This software has basically designed for modelling of soil nails in slopes. Different numerical modelling analysis can be done using OASYS. Such as

- Circular and non circular slip surface
- Soil modelled as being plastic.
- Perched water tables
- Piezometeric water pressure
- Surface loads and submerged slopes
- Uses a limited variety of methods
- Applied lateral body load for earthquakes

Here in this software it can be seen the minimum factor of safety for more than one slip surface.

In OASYS, again same parameters were taken as that of FLAC slope. [11] The modelling was done for the same OB material, OB +15% fly ash material and OB +30% fly ash. The width of the bench fixed at 40m in all cases.

5.2.1 OB Material

The parameters responsible for the calculation of factor of safety (FOS) and safe slope angle were listed below.

Cohesion (c): 3236.194 Pa

Angle of internal friction (Φ): 30.963

Density: 2.161 g/cm³

Table 5.5: variation of FOS with bench slope angle for OB material using OASYS

Slope Angle (^{0})	Factor of safety (30m OB)
25	1.41
26	1.39
27	1.34
28	1.25
29	**1.20**
30	1.16

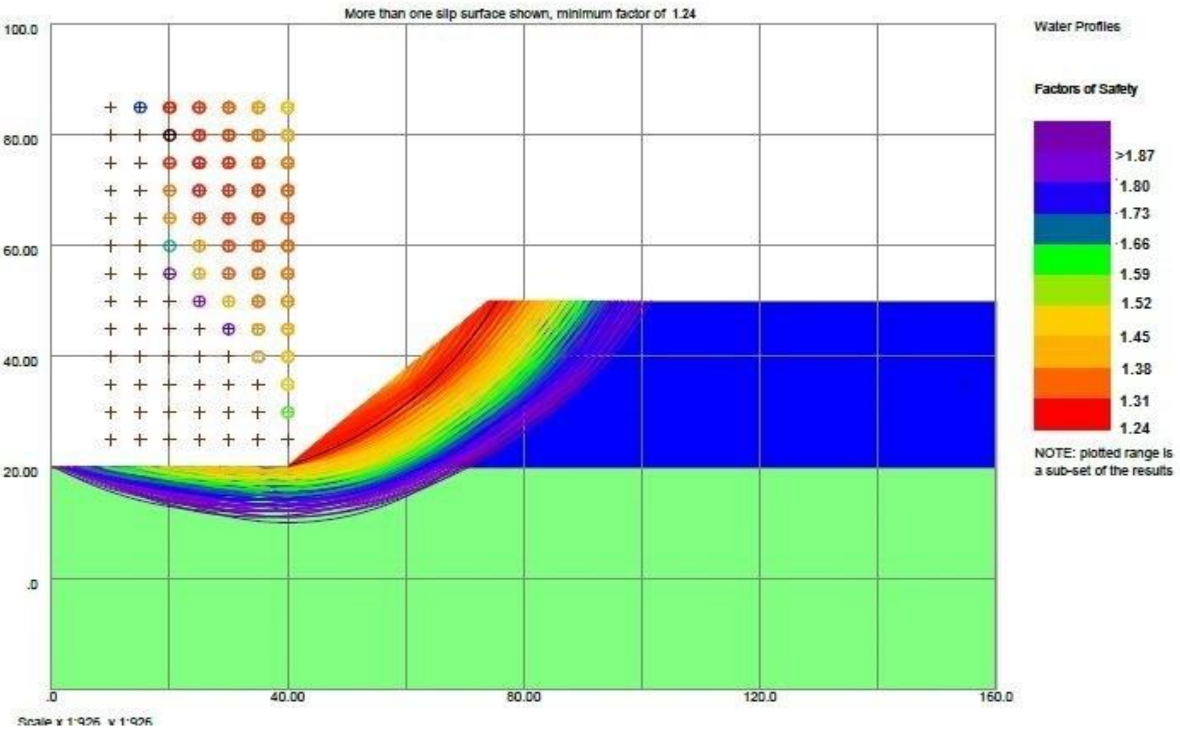

Fig.5.7 Factor of safety for 30m OB material, at 29^0 slope angle using OASYS (FOS is 1.24)

5.2.2 OB +15% fly ash material

The parameters responsible for the calculation of factor of safety (FOS) and safe slope angle were listed below.

Cohesion (c): 12375.9927 Pa

Angle of internal friction (Φ): 25.51

Density: 1.847 g/cm³

Table 5.6: variation of FOS with bench slope angle for OB material+15% fly ash using OASYS

Slope Angle (^{0})	Factor of safety (30m OB)
25	1.29
26	**1.21**
27	1.18
28	1.12
29	1.08
30	1.03

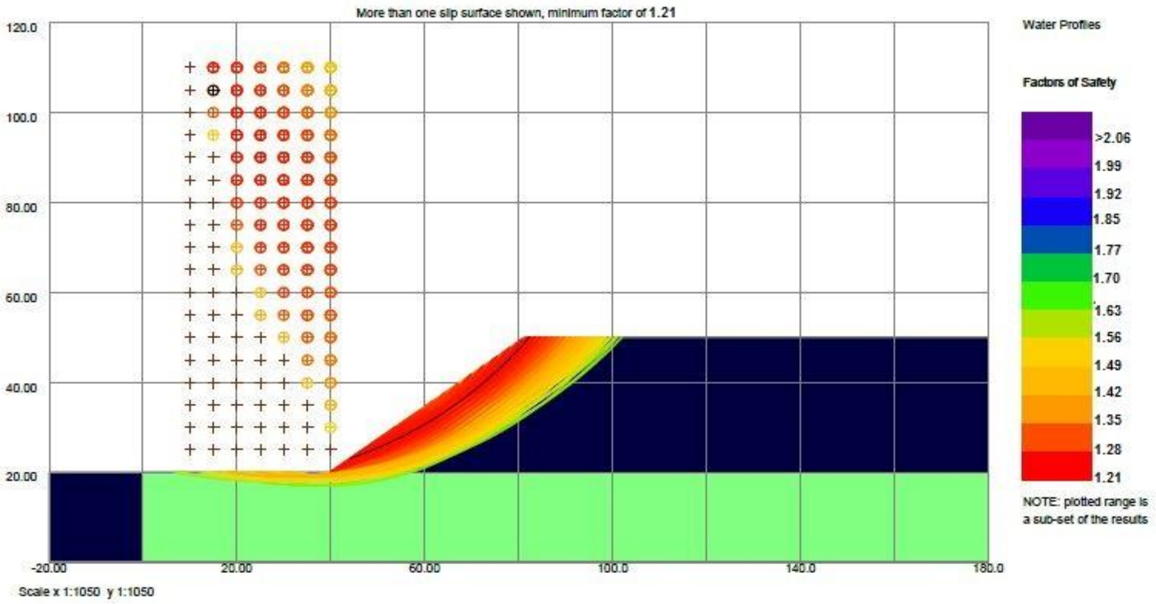

Fig.5.8 Factor of safety for 30m OB+ 15% fly ash material, at 26^0 slope angle using OASYS (FOS is 1.21)

5.2.3 OB +30% fly ash material

The parameters responsible for the calculation of factor of safety (FOS) and safe slope angle were listed below.

Cohesion (c): 18338.4355 Pa

Angle of internal friction (Φ): 24.41

Density: 1.703 g/cm³

Table 5.7: variation of FOS with bench slope angle for OB material+30% fly ash using OASYS

Slope Angle (^{0})	Factor of safety (30m OB)
25	1.40
26	1.33
27	1.27
28	**1.22**
29	1.17
30	1.12

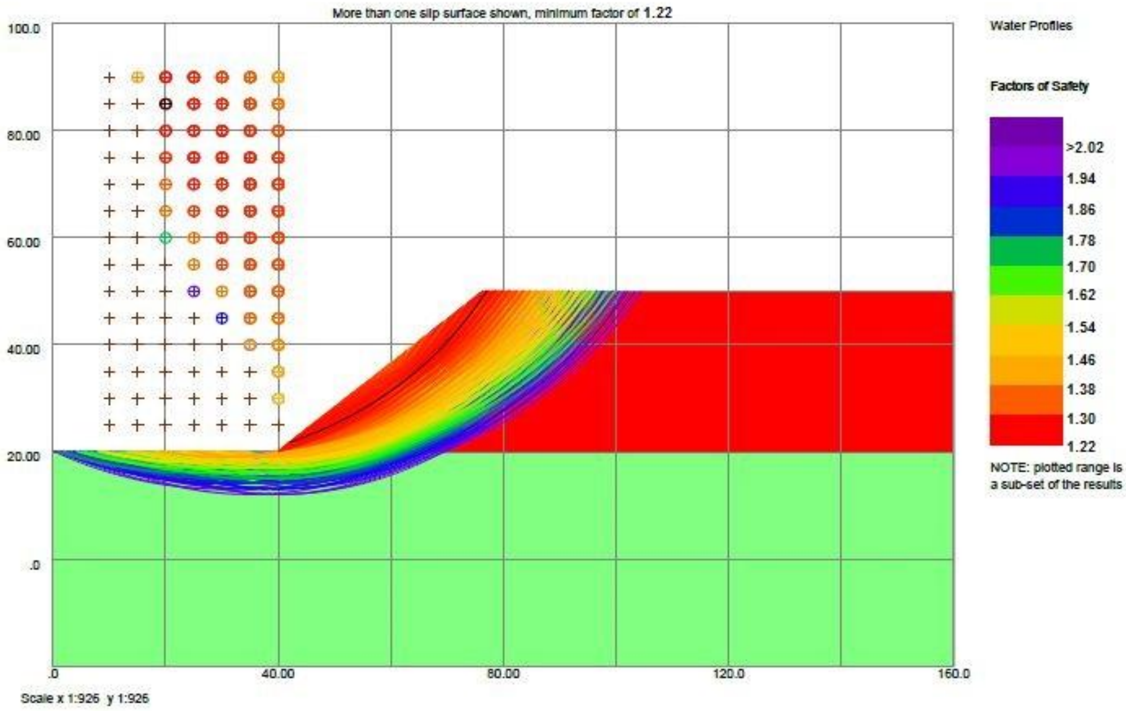

Fig.5.9 Factor of safety for 30m OB+ 30% fly ash material, at 28^0 slope angle using OASYS (FOS is 1.22)

For OB dump as per DGMS

Cohesion (c): 12375.9927 Pa

Angle of internal friction (Φ): 25.51

Density: 1.847 g/cm³

Table 5.8: variation of FOS with bench slope angle for OB material using OASYS

Slope Angle (^{0})	Factor of safety (30m OB)
30	1.37
33	1.29
37.5	**1.20**
39	1.17
42	1.14

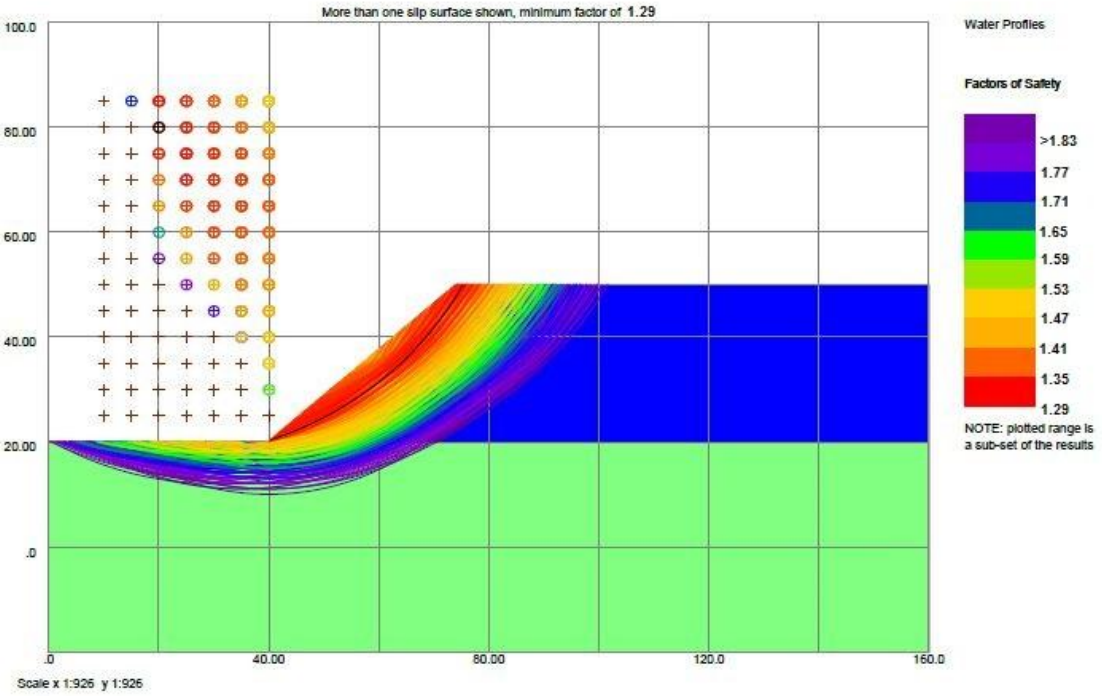

Fig.5.10 Factor of safety for 30m OB material, at 33^0 slope angle using OASYS as per DGMS (FOS is 1.29)

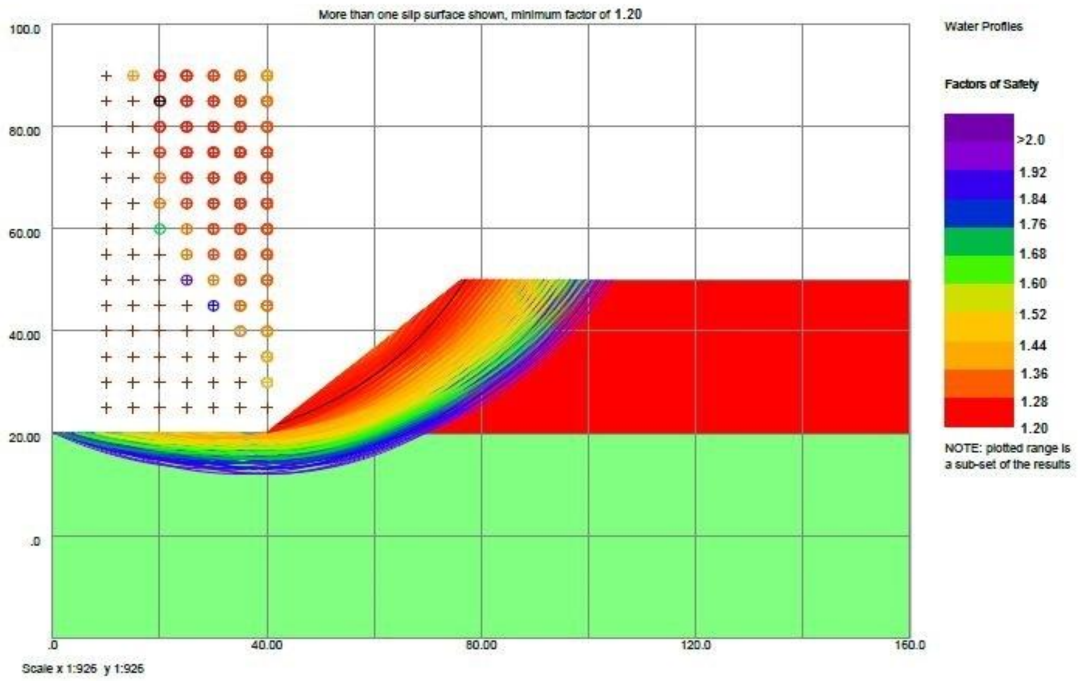

Fig.5.11 Factor of safety for 30m OB material, at 37.5^0 slope angle using OASYS as per DGMS (FOS is 1.20)

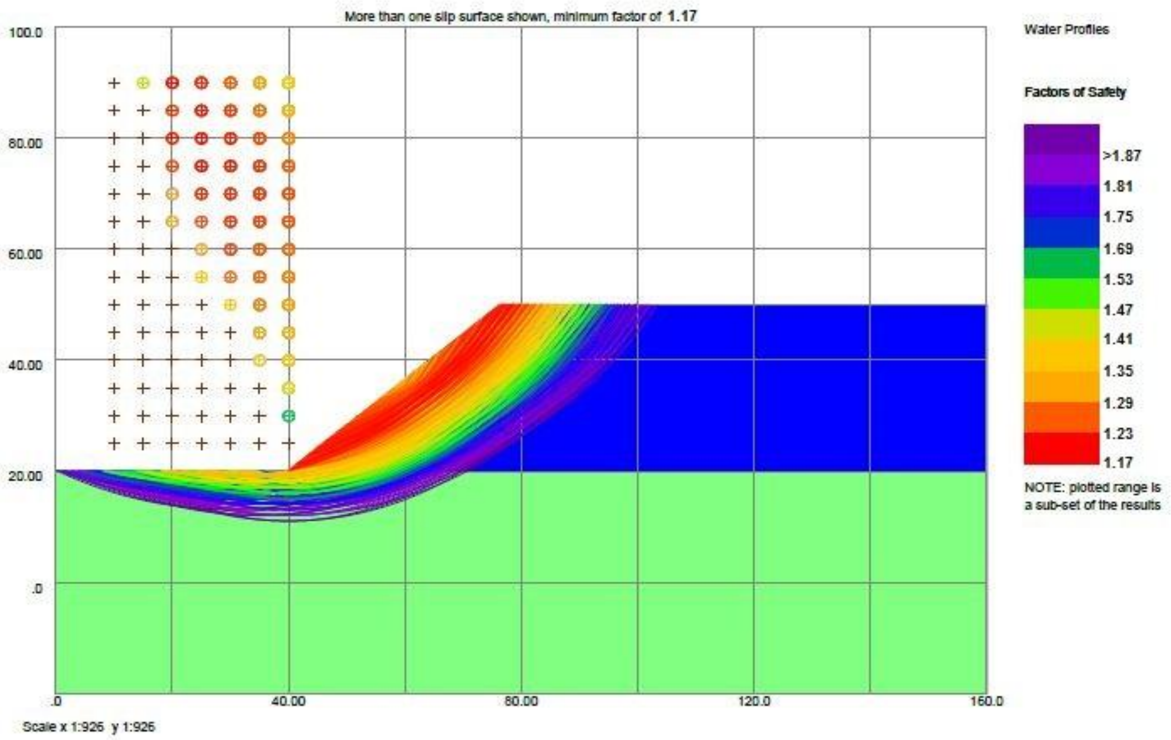

Fig.5.12 Factor of safety for 30m OB material, at 39^0 slope angle using OASYS as per DGMS (FOS is 1.17)

5.2.4 Result

Generally the minimum factor of safety for more than one slip surface can be analysed using the above simulation model. The slope angles for the models were 25^0, 26^0, 27^0, 28^0, 29^0, and 30^0 for different OB dump material and admixture.

When fly ash was added to OB material then from OASYS software analysis, the minimum factor of safety for 30m OB were less as compared to OB+15% fly ash and OB+30% fly ash. When again 30% fly ash was added to OB dump material the minimum factor of safety for 30m OB was showing more than OB + 15% fly ash .

CHAPTER 6

FIELD MONITORING OF THE DUMP

6.0 FIELD MONITORING OF THE MINE DUMP

Two different pits (Pit1 and Pit2) of JPL mine dump were monitored using total station and monitoring station. The total station at 20m – 30m intervals 5 m behind the crest of the dump was installed. The vertical displacement readings were taken in 3 months interval from March 2014 to Nov 2014.

Fig.6.1 Total station monitoring at JPL mine

6.1 Total station reading

6.1.1 Total station monitoring of Pit1

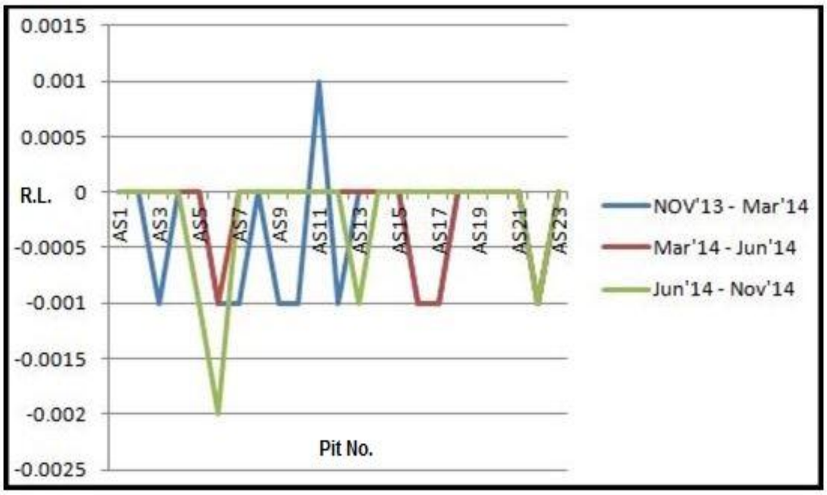

Fig.6.2 Graphical representation of reduced levels of Pit1

5.1.2 Total station monitoring of Pit2

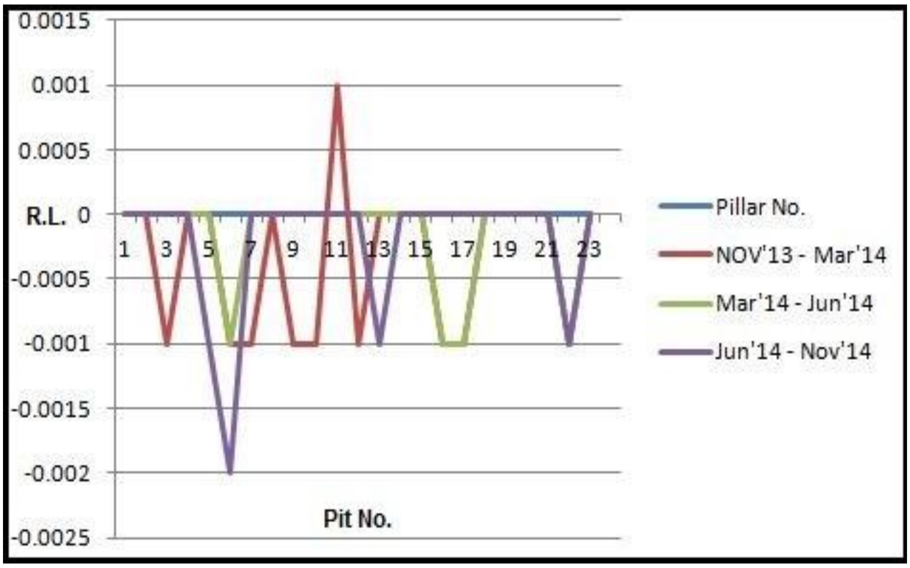

Fig.6.3 Graphical representation of reduced levels of Pit2

CHAPTER 7

ANALYSIS OF RESULTS

7.0 RESULTS

- For Pit1 at places AS6, AS7, AS9, AS10, AS11, AS12, AS16, AS17, AS22 showed the displacement of 0.001mm on march'2014. After three months in the month of Jun'2014 the reduce level of only AS6, AS16, AS17, AS22 showed the same displacement but for others it was zero. This was due to the effect of admixture of fly ash material with OB material. Due to some disturbances the places AS5, AS13, AS22 only showed a reduced level of 0.001mm and for AS6 it was 0.002mm in the month of Nov'2014. From the graphical representation of Fig.6.2 it can been seen that, as time increases the total number of reduced level also decrease. Hence the total reduced level can be suppressed by the application of fly ash admixture with OB material.

- For Pit2 at places KJS3, KJS8, KJS10, KJS12, KJS14, KJS18, KJS19, KJS21, KJS22 showed a displacement of 0.001mm at first in the month of March'14. After three months in the month of Jun'2014, the vertical displacement of places KJS3, KJS6, KJS10, KJS12, and KJS22 showed same and for others it was zero. Hence for the total reduced levels of Pit2 suppressed. Hence from the effect is lower after the passing of time. From the graphical representation of Fig.6.3 It can be seen that, as time increases the total number of reduced level also decrease. Due to the admixture of fly ash, the stability becomes high and showed a comparatively less displacement.

CHAPTER 8

CONCLUSION

8.0 CONCLUSION

For the stability of OB dump, it was proposed to use fly ash mixtures. Different geo-technical parameters such as cohesion, frictional angle and density were found out and were used to model the dumps in FLAC SLOPE software and OASYS software to determine the value of FOS.

1. The safe slope angle for 30m OB bench height for OB, OB+15% fly ash, and OB+30% fly ash were found out to be 29^0, 26^0, and 28^0 respectively. As per DGMS the slope of an overburden dump is usually determined by the angle of repose of the material, but in no case it should exceed 37.50. Alternately we can say, bench angle shouldn't exceed the natural angle of repose or 37.50, whichever is less. Hence the OB material was found to be stable.

2. From the analysis, it was concluded that with increase in slope angle of the deck and height, the factor of safety decreases. With the addition of 15% fly ash the safe bench angle decreases by 2^0 due to partial filling of void space but when 30% fly ash were added then there will an increase of 1^0 in safe bench angle. This is due to more void spaces that were filled with again 15%fly ash. Hence with the increase in Factor of safety the safe slope angle increase.

3. Comparing, OASYS and FLAC with same slope angle, different factor of safety is obtained. It is due to the change in grid size from medium to fine. Hence the results had changed. More over in Oasys it is assumes the failure surface to be moving in a direction lying in the arc of a circle. But in FLAC SLOPE the direction of failure may be in any direction.

4. From the analysis of total station monitoring it was found that both pits are stable due to the admixture of fly- ash and OB dump.

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