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Slope Stability Analysis Using Ansys Software

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ABSTRACT

In this paper, we introduce a slope stability analysis method based on the finite element method in Open pit mining this mining which accounts for about 95% of India's total coal production. As a result, open pit mines are reaching deeper mining depths. This complicates the stability of the working slope and the final design of the pit slope. As a result, 18% of open cast mining accidents are due to slope failure. These failures result in loss of production, loss of life, additional tailings costs for recovery and handling, and potential mine abandonment/early closure. Slope stability analysis is used for safer operating conditions in mining and has increased its importance.

The basic objectives of this project are mainly: a) Understanding the different types and causes of slope failures. b) Analyzing the slope safety factor. We also collect information on slope parameters and types of slope failures that occurred at open pit mines, as well as knowledge about the causes of slope failures. The main goal is to find solutions to control slope failure and maintain slope stability. The finite element method is one of the best methods for analyzing gradient parameters. Literature review revealed that the finite element method using ANSYS software is the best numericalmethod for slope stability analysis

KEYWORDS: Open pit, Factor of safety, ANSYS, Numerical method;

I. INTRODUCTION

At present, there are many methods for slope stability analysis to solve the slope failure problems in mines. There are two types of mining: open pit mining and underground mining.

This means open pit mines are going to deeper mining depths. This means that mining slope stability and the final design of the slope are difficult to achieve. For example, 18% of accidents in surface mining can be traced to slope failures. Slope failures are primarily due to the effects of gravity and soil infiltration forces. Failures can also be caused by excavation, gradual dissolution of the soil/rock structure, and improper design of the pit slope angle. The pit embankment should be sloped at a certain angle to prevent falling rocks. This angle is determined by the geo-mechanicalconditions of the particular mine. The actual slope angle used in a mine will depend on the presence of haul roads, ramps required to transport the blasted ore out of the pit, ore grade, and economic constraints. Slope failures cause production losses, fatalities, additional overburden costs for recovery and treatment, and in some cases lead to mine abandonment/premature closure. On stable slopes, the term safety factor plays an important role. The minimum factor of safety considered in the design of pits, cases and stockpile cases shall be at least 1.50 for permanent or permanent cases and at least 1.30 for all other cases. Quantitative analysis methods are mostly preferred, This method provides limit equilibrium and numerical analysis methods. Due to advances in computer technology, numerical analysis methods have been mainly applied to the calculation of slope safety factors. In other words, the finite element method analyses the geometry of each shape and considers the stress-strain relationship of the soil mass and results in more accurate. This project explores finite element strength reduction methods for slope stability analysis using ANSYS software.

A. *ANSYS*

Ansys is a simulation software used for engineering simulation, it is also used to determine the safety factor of open cast benches in open cast mines. This software is very use full to determine the different types of stress analysis with less time, now a days ANSYS is become more use full software to determine the slope stability of open cast benches.

II. OBEJECTIVE OFTHIS PAPER

To study the slope stability analysis by using ANSYS software. The main objective is to determine the stability of benches by varying the bench height and slope angle and also the width of benches to analyse the factor of safety

III. FACTOR OF SAFETY

The factor of safety of slope is defined as the ratio of total force available force available to resist sliding to the total force tending to induce sliding. Practical experience suggests that factor of safety of 1.3 will generally be adequate for mine slopes which are not required to remain stable for long periods. For critical slopes adjacent to haul roads or important installations, A factor of safety of 1.5 is usually preferred (Hook and bray, 1977) for evaluating the factor of safety, the analysis will consider mode of failures. (7)

Figure1: - bench plane with discontinuity

$$FOS = \frac{\mathrm{AC} + \mathrm{Wcos} \propto \tan\emptyset}{\mathrm{Wsin} \propto}$$

W= weight of sliding block

w= $\frac{\gamma h^2 (cot \propto - cot\beta\ )}{2}$

A= area of contact of sliding block is= $\frac{\mathrm{h}}{\sin \propto} \times 1^2$

α = dip angle of discontinuity

β= overall slope angle

c= cohesive force in Pascal

∅ = angle of internal friction

γ= unit weight of sliding block

h = actual virtual height of the slidingblock

v= volume of failure plane

IV. METHODOLOGY

This paper can show that the methodology is done by approaching the numerical modeling using ANSYS.

The paper contains 10 major steps which are used to analysis of factor of safety.

Step1: Open the ANSYS, select static structural

Step2: Go to engineering data and give material properties like

Table1: The physio-mechanical properties used for numerical modelling (8)

Step3: Go to geometry and draw a 2D model with having parameters like bench height and width and slope angle.

Step4: After getting a 2D model, then convert it into 3D by clicking selecting sketch and extrude then generate. Finally, the 2D model convert into a 3D model

Step5: Go to model, then assign the materials to the model

Step6: Select meshing and click on generate mesh

Step7: Select static structural solution for applying the supports to the model like fixed supports and friction less supports and standard earth gravity. The supports are attached to model to restrict the model movement

Step8: Select static structural solution, click on insert then go for total deformation

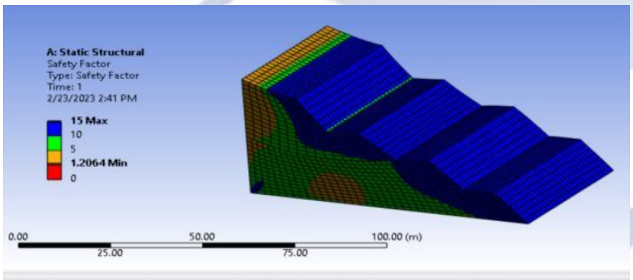
Step9: After total deformation select a static solution and click on insert and go for stress tool

Step10: Click on the stress tool then go for safety factor, click on safety factor, analysis of safety factor is done by the ANSYS

V. RESULTS AND DISCUSSIONS

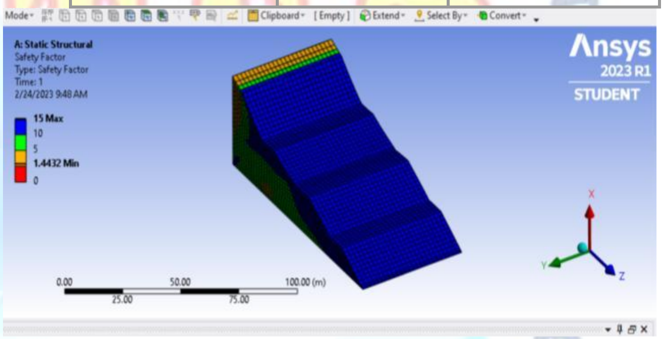
Results are discussed from the analysis of FOS by using ANSYS software by creating some models are shown below:

A. By varying slope angle of the benches:

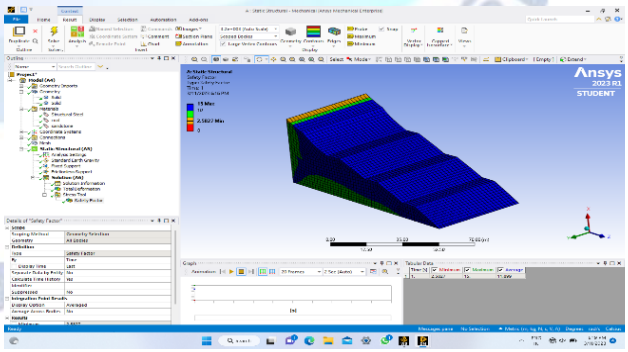


Model 1: the modelis stimulated with bench height of 10m, width of 10m, slope angle is 45°

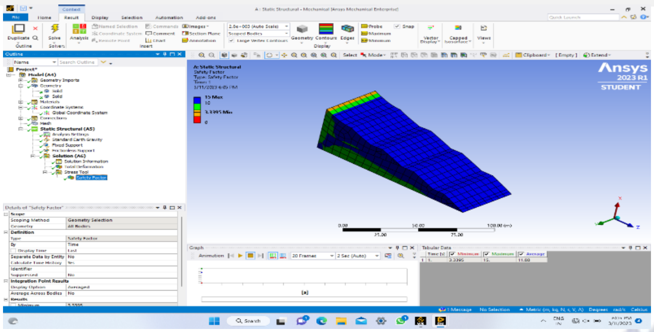
PROPER TIES	COAL	SANDSTONE
Density (Kg/m^3)	1400	2810
Cohesion (MPa)	0.70	1.74
Friction Angle (º)	24º	34º
Young's Modulus	1641 MPa	3530 MPa
Poisson's Ratio	0.35	0.373
Tensile Yield Strength	1.128 MPa	1.796 MPa
Compressive Yield Strength	7.647 MPa	18.14 MPa



Model 2: the model is stimulated with bench height of 10m, width of 10m, slope angle is 30°



Model 3: the model is stimulated with bench height of 10m, width of 10m, slope angle is 29°



Model 4: The modelis stimulated with bench height of 10m , width of 10m, slope angle is 28°

The following table and graph shows comparison between slope angle and factor of safety when height and width of benches constant

TABLE 2:

Model .No	Bench Width (in meters)	Bench Height (in meters)	Bench slope Angle (in degrees)	Factor of Safety
1	10	10	45	1.2064
2	10	10	30	1.4432
3	10	10	29	2.5827
4	10	10	28	3.3395

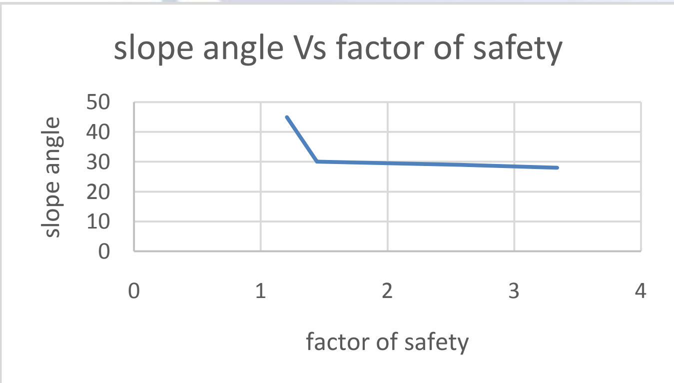
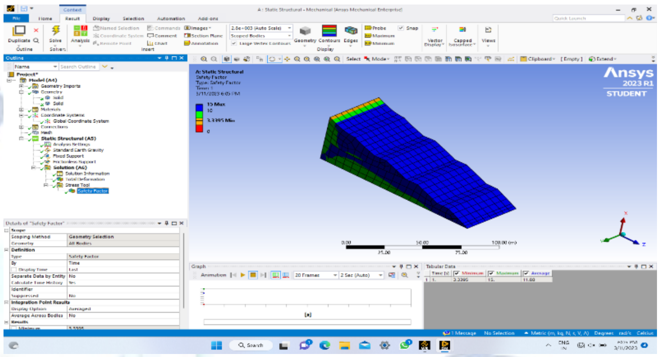


Figure 2: Slope angle vs factor of safety

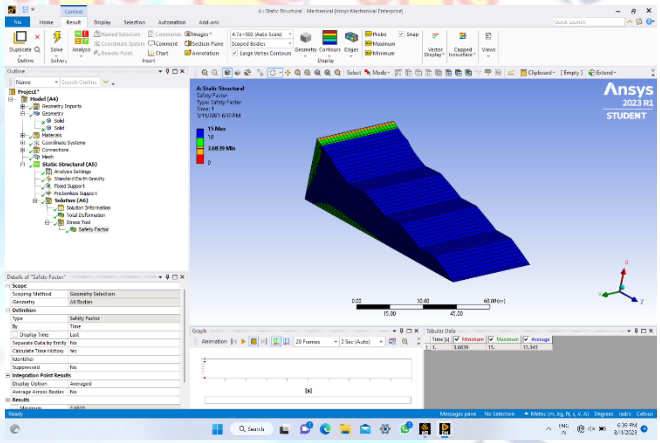
The above models clearly gives that when bench angle increasing the factor of safety decreasing. High bench angle requires more capital to develop and it is unsafe.

As the angle decreases, factor of safety increases, thereby it is safe it is economically feasible to design the slopes.

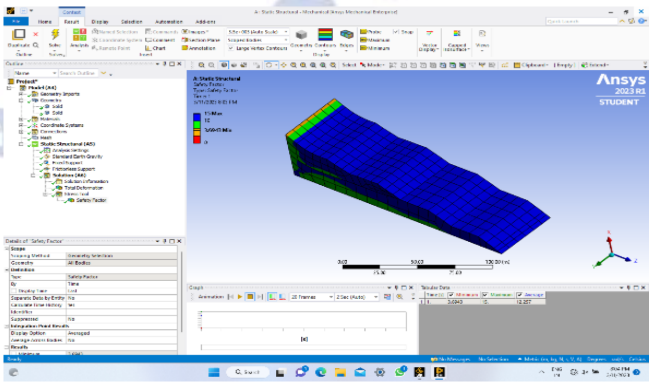
B. By varying the height of the benches for feasible angle:



Model 5: the modelis stimulated with bench height of 10 m , width of 10m, slope angle is 28°



Model 6: the model is stimulated with bench height of 7.5m , width of 10m, slope angle is 28°



Model 7: The model is stimulated with bench height of 5 m, width of 10m, slope angle is 28°

The following table and graph shows comparison between bench height and factor of safety when slope angle and width of bench is constant

TABLE 3:

Model No	Bench Width (in meters)	Bench Height (in meters)	Bench Slope Angle (in degrees)	Factor of safety
5	10	10	28	3.3395
6	10	7.5	28	3.6839
7	10	5	28	6.4282

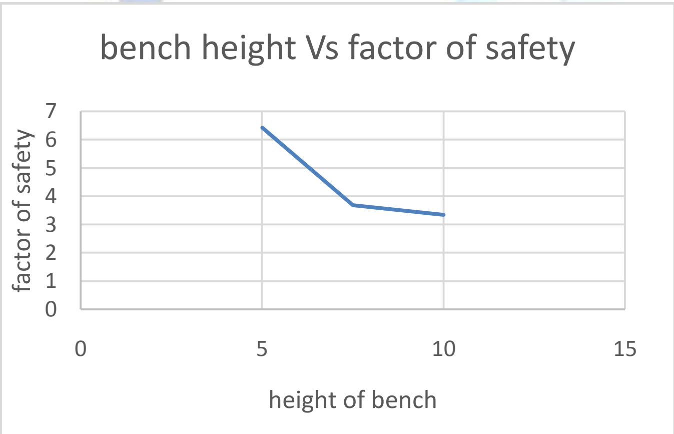
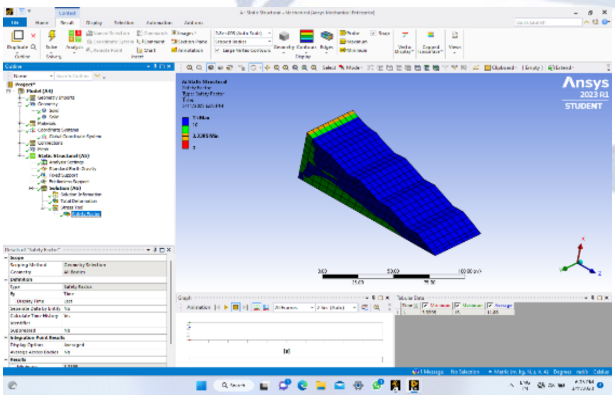
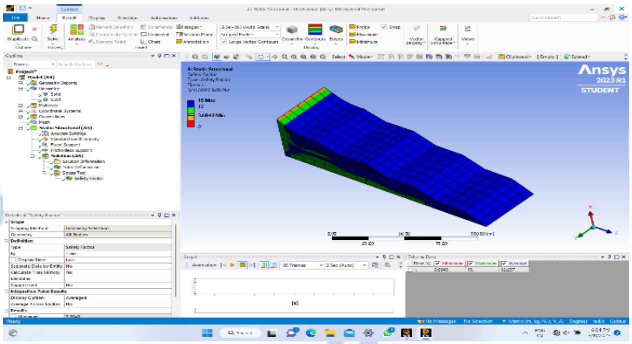


Figure 3: bench height vs factor of safety

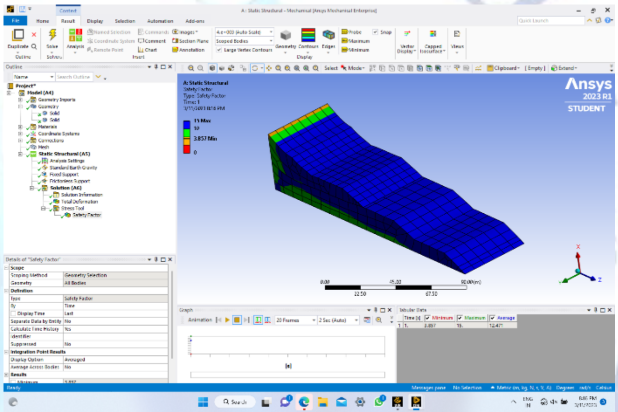
C. *By varying width of the benches for feasible angle:*



Model8: The model is stimulated with bench height of 10 m, width of 10m, slope angle is 28°



Model9: The modelis stimulated with bench height of 10 m, width of 25m, slope angle is 28°



Model10: The model is stimulated with bench height of 10 m, width of 30m, slope angle is 28°

The following table and graph shows comparison between bench width and factor of safety when slope angle and height of bench is constant

TABLE 4:

Model No	Bench Width (in meters)	Bench Height (in meters)	Bench Slope Angle (in degrees)	Factor of safety
8	10	10	28	3.3395
9	25	10	28	3.6943
10	30	10	28	3.857

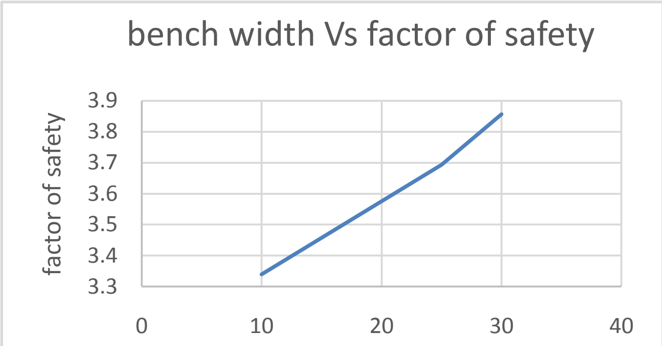


Figure 4: bench width vs factor of safety

The above models clearly gives that when bench width increasing the factor of safety also increasing. More bench width leads to high factor of safety, having more factor of safety is safe. So if the bench width is less the factor of safety also decreases, due to more width movement of vehicles is easy and flexible.

VI. CONCLUSIONS

The following conclusions are obtained:

When width and height of bench keeping constant and varying slope angle, the FOS is decreasing significantly.

And also, when varying height , width and slope angle is keeping constant, the FOS is decreasing significantly.

And also, when varying width, height and slope angle is keeping constant, the FOS is increasing significantly.

The study has clearly demonstrated the effect of slope angle on factor of safety. The factor of safety decreased considerably with increasing slope angle. And study clearly demonstrated the design of benches with less slope angle having more FOS.

From parametric analysis it is clear that by comparing the ANSYS models, the factor of safety is decreasing by increasing the bench height. And factor of safety is increasing along with increasing the width of the benches.

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