Stability of slope Along Abha-Darb Road

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***Abstract*— The study work comprises of the stability analysis of Slope Along Abha-Darb Road, Asir Region, Kingdom of Saudi Arabia. The area is vulnerable to landslide to avoid this problem. Geotechnical study was carried out along the road cut slopes to determine the various properties of soil mass. Which act as input parameters for the numerical simulation of Slope (Fast Lagrangian Analysis of Continua). The result is checked for displacements and FOS .The result shows that the slope is unstable showing circular failure at the upper height and is quite stable at the lower height of the slope.**

***Keywords*— Deformation, Landslide, FLAC-3D, Circular Failure**

I. INTRODUCTION

Population growth and accompanying economic developments have meant that civil engineering projects are increasingly being carried out in mountainous region. In the last decade there are various landslides problems culminating in tragedies (Leh, 2003). The reason behind this fact is that, the slopes are inherently unstable. Moreover the erosion as soil runoffs occurs regularly; slopes can fail and result in landslides problems.

Slope failures increase when a naturally occurring weak zone or what is called a fault plane, in geological terminology, is present. Landslide or mass movements problems are important and costly problem, and it should be of prime importance so for geotechnical engineers and engineering geologists throughout the world, preferably in geologically active regions. Landslide problem occurs globally and rated as sudden, short lived geomorphic hazard that comprise the rapid to slow descent of soil or rock in sloping terrains. It can occur on any terrain, given the right condition of soil, moisture and angle of slope.

Risks of landslides are enhanced in the tropics, where thick, loose residual soil, the result of deep weathering, can be easily eroded. Until and unless a holistic stance in tackling landslides is taken, lives and properties will be at stake and taxpayer' money will be wasted on rescue missions.

Although many mitigation works had been planned and designed, there still exist many uncertainties associated with the material, spanning from its complex origin. Hence, it's come the importance to analyze the stability of the existing slopes. However, most of the times it is too costly or impossible to monitor the slope for the whole of its service life

In hilly areas of the southern Saudi Arabia, many urban areas, highways, roads, and escarpment roads that is vulnerable to different types of landslides (Youssef et al., 2014a). Landslide problems were occurred in the different parts of Saudi Arabia such as rock falls, debris flows, and sliding (planar, wedge, and circular failures) (Youssef et al., 2012). Among these landslide problems; Al-Hada debris flow in August 2012 (Youssef et al., 2013) and Al- Raith debris flow in March 2013 (Youssef et al., 2014b). These landslides problems occur due to natural triggering factors such as rain storm events and anthropogenic effects (rock cuts and dumping materials along the gullies and streams).

II. OBJECTIVE

The objective of this study is to determine stability of slope along Abha-Darb Road. The stability analysis of slope is carried out based on computer modelling software FLAC3D, a finite difference package. A real case study of slope failure is chosen in fulfilling the objective of study for the simplicity of the analysis the soil is assumed to be homogeneous. Stresses of the soil mass along the critical slip surfaces as well as the displacements are all the three directions are determined using finite difference scheme. In order to judge the failure surface FOS is calculated at critical section to show the behaviour of failure.

III. STUDY AREA

The project work was carried out on Slope 20 km from Abha towards Darb. For Geotechnical study,the soil sample is collected from the location **18°4 '6.8"N,42 ° 30'18.6" E**. The area is particularly taken into study work as it is regularly damaged and there is huge probability of landslide occurrence in future which can cause loss of human lives and property.

Fig.1 Site of Study Area

Fig. 2 Affected Area

IV. MODELLING

Three dimensional nonlinear analyses were carried out by making use of finite difference code FLAC3D to study the effects of static response of Slope. FLAC3D contains an automatic 3D grid generator in which grids are created by manipulating and connecting pre-defined shapes such as brick, wedge, pyramid and cylinder. In the present study, the geometry of the soil domain is created using no of brick shape element Figure shows the element numbering for a brick shape used for creating the soil domain. In this figure, p0, p1….p7 specify the reference (corner) points of the shapes, n1, n2 and n3 specify the number of zone in their respective directions and r1, r2 and r3 specify ratios that is used to space zones with increasing or decreasing geometric ratio. Similarly figure shows the wedge element which is used to create toe of the hill.

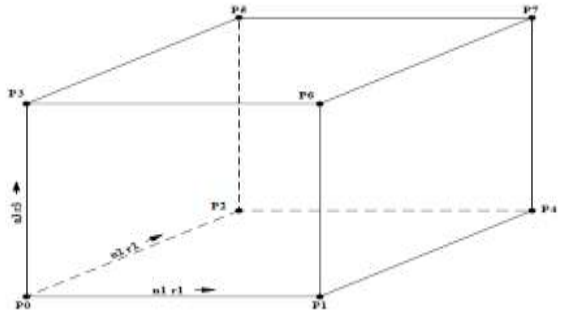

Fig. 3 Brick Element

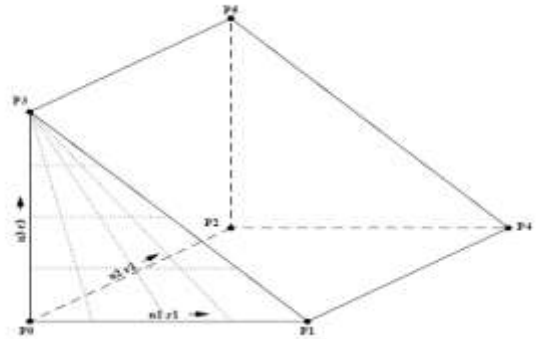

Fig. 4 Wedge Element

The whole grid is discretized into 6540 number of zones and 8482 number of grid points.

The maximum dimensions of the zones in X and Y and Z are coming out to be less than 8.123 m. Thus the mesh size of the *FLAC3D* model used ensures the accurate wave transmission

V. BOUNDARY CONDITION

For the slope stability analysis, the boundary conditions of slope model were as follows: At the base of the grid all movements are restrained. The planes at X = 0 m can freely move in Y and Z directions and not in the X direction. In the same way, the planes Y= 0 and Y= 5m are free to move in X and Z directions but not in the Y direction.

VI. MATERIAL PROPERTIES

The parameters used for the soil modelling are summarized in the following table.

TABLE I

Density (kg/m^3) ρ	1860
Poissons ratio μ	0.25
Young's modulas (N/m^2) E	137.5 x 106
Shear modulas (N/m^2) G	55 x 106
Bulk modulas (N/m^2)	91 6 x 106
Cohesion N/m^2 c	2 x 104
Internal friction angle φ	7°

VII. RESULTS

The results obtained from static analysis are summarized in table. The result given by static analysis is in the form of displacement magnitude contours, x-displacement, y-displacement, z-displacement; Finally FOS is obtained which is shown by contours with respect to x- axis and z- axis (elevation). Also variation of FOS along the height of the slope at various location of the hill has been plotted.

The displacement in x direction is found to be 0.183m while the displacement in y direction is found to be negligible in the power of 10^{-5}m and in z direction it is found to be 0.095 m. respectively

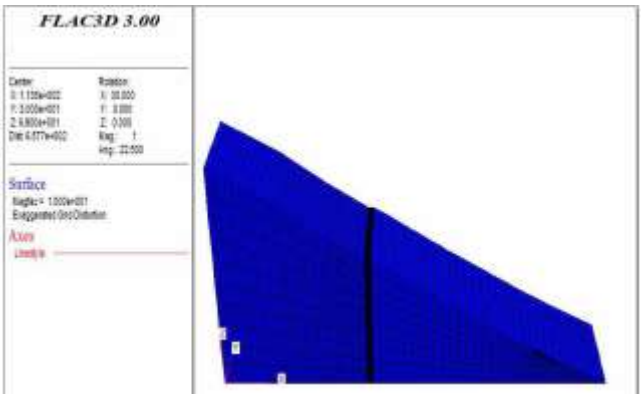

Fig. 5 Model of Slope

The factor of safety with respect to Elevation and Height which is shown in the form of contour line is plotted which is showing that slope is unstable at higher height and is very stable at lower height. Moreover the factor of safety contour line is showing trends of circular failure.

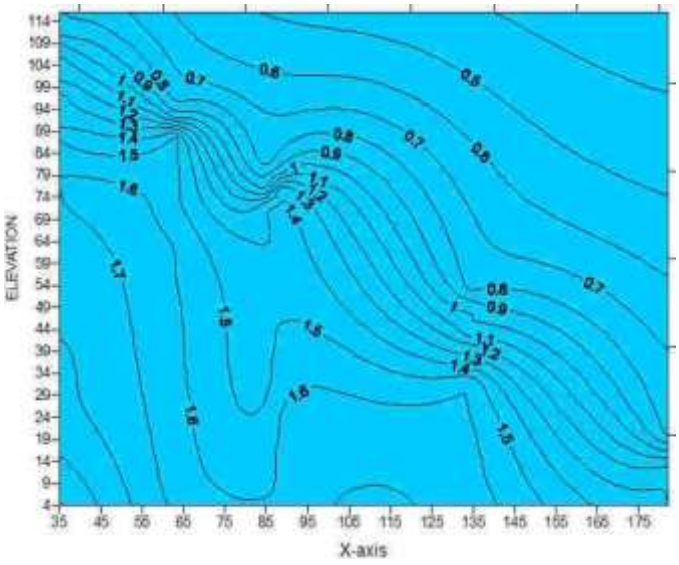

Fig. 5 Factor of safety wrt X-axis and Elevation

VIII. CONCLUSION

The study work analyses the stability of slope along Abha Darb Road Asir region which are often prone to landslide. The slope was investigated for the stability using three dimensional finite difference codes. The specific maximum displacement computed in the slope in X – direction is 0.18295 m in static case the specific maximum displacement computed in the slope in Z – direction is 0.094675 m in static case Thus we can definitely conceive that the slope is undergoing large deformations. The result of factors of safety of the slope at different location confirms the unstability of slope of slope which is showing the pattern of circular slope failure. Keeping in mind the shortcomings of the present study, extensive study should be made on the study area to know about the properties of whole mass. In our case whole mass is considered to have same properties, while the soil contains rocks also. Seepage force, which is one of the important causes of instability, must be considered in addition to full or partial saturation of rock mass.

Alternative calibration strategies and the integration of the Finite difference-model into a knowledge based alert system can be subject of further investigations. It is essential however that quality/quantity of both input data and instrumentation data for modelling purposes be improved concomitantly in order to provide the requisite validation

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