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A Comparison Study on Stability of Kuranchery Slopes Using GEO5 and PLAXIS 2D Software

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***Abstract*: In Kerala majority of the hilly or steep slope regions are under the elevated risk of soil erosion. It is one form of soil degradation induced mainly by the actions of wind or rain. The factors affecting erosion include land use, geomorphology, geology, climate, soil texture, soil structure, vegetation etc. Soil erosion may be a slow process that continues relatively unnoticed causing loss of fertile top layer soil which is good for plant growth and it may reduce the soils ability to absorb and store water which is in increased rate results in landslide, debris flow, rock fall, etc., in sloped regions. So it is essential to put as much as effort as possible into action especially in slopes, that will stop the soil from washing away by suggesting methods to control it after the analysis of the stability of that slope.**

Kuranchery slope is one of land slide prone area in Thrissur district. An analysis on that region is necessary. In this project, two different software (GEO5 and PLAXIS 2D), analysis were carried out and stability characters were observed. Using these software, we can solve most geotechnical tasks, from the basic ones that is verification of foundation, walls, slope stability up to highly specialized program such as analysis of tunnel, building damage due to tunneling etc. both software adopts unique system on implementing standards and partial factors, hence it is used around the world. By using software output factor of safety and comparing it with the standards we can analyze the stability of slope against sliding. A comparison study based on results of both software carried out and mitigation methods for reducing landslides are also discussed.

***Keywords*: Land slide, Soil stabilization, GEO5, PLAXIS 2D.**

1. Introduction

Soil erosion is one of the major environmental problems especially in the case of hilly regions or slopes. Erosion is the natural process induced mainly by the wind or rain. It causes the loss of fertile top layer soil which is good for plant growth and it may reduce the soil's ability to absorb and store water which is in increased rate causes rock fall, debris fall etc. The determinant factor for erosion is water content in the soil. Other factors that induce soil degradation are rainfall and rain water runoff, agricultural activities, vegetative cover, slope of the land etc. The term landslide refers to several forms of mass wasting that include a wide range of ground movements such as rock falls, deep seated slope failures, mud flows and debris flows. It is necessary to analyze the slope stability. It is carried out to analyze the safe design of all type of natural or manmade slopes. Slope stability is the resistance of inclined surface to failure by sliding or collapsing. The increasing demand for engineered cut and fill slopes on construction projects has only increased the need to understand analytical methods, investigative tools, and stabilization methods to solve slope stability problems. The need of slope stability in the slopes along with highway is more than other slopes. It is because that the chances of failure of the slopes and unexpected accidents are high. Slope stabilization methods involve specialty construction techniques that must be understood and modeled in realistic ways. An understanding of geology, hydrology, and soil properties is central to applying slope stability principles properly.

In older times the stability analysis is carried out by using graphs or hands itself. The conventional methods used for the analysis are limit equilibrium methods. The method is mainly 3 types. Swedish circle method, Friction circle method and Bishop's method. Nowadays everything advanced and lot of possibilities to use software. In that GEO5 and PLAXIS 2D are advanced software's suitable for solving geotechnical problems based on traditional analytical method and finite element method. Basic geotechnical approaches implemented in the GEO5 programs are applicable all over the world. Nevertheless, most countries adopt their own standards and conventions. GEO5 offers a unique way of applying standards which significantly simplifies the work of a designer and at the same time allows for complying with all required approaches. It is an accurate and easy to use tool in all geotechnical problems.

The output of both software analysis is factor of safety, defined as the ratio of the shear strength to the shear stress required for equilibrium. The factor of safety is determined for different slopes. If the value of factor of safety is less than 1.5, the slope is unstable. For the safe standing of slopes, it is necessary to maintain the factor of safety. In most applications, the primary purpose of slope stability analysis is to contribute to the safe and economic design of excavations, embankments, earth dams, landfills, and spoil heaps. Slope stability evaluations are concerned with identifying critical geological, material, environmental, and economic parameters that will affect the project, as well as understanding the nature, magnitude, and frequency of potential slope problems. When dealing with slopes in general and slope stability analysis in particular, previous geological and geotechnical experience in an area is valuable.

2. Objectives and Scope

The study was undertaken to investigate the stability of slopes in landslide prone area using GEO5 and PLAXIS 2D software. The determination of index properties using geotechnical investigations are carried out first and hence the values to be assigned to corresponding software. Finally, the results of both software's are compared to know the trend in factor of safety values. Demarcation of risk zones and slip circle formation to be checked, stability assessment is necessary on risky slopes. Defect orientation measurement and their interpolation with recent available software done. This project is limited with the study of slope stability in kuranchery and suggesting suitable remedial measures based on analysis result. To ensure future safety and as a part of encouraging sustainable development more eco-friendly methods are adopted.

3. Material

A. Soil

The soil considered in the study is laterite soil collected from the selected landslide affected slopes of Kuranchery, Thrissur, Kerala. On 8th August 2018, severe flood affected the south Indian state of Kerala, over 483 people died as an after effect of this calamity. Kuranchery was one of the most flood affected region in Thrissur. 2 landslide affected slopes considered for this study are shown in figure 1 and 2.

Fig. 1. Landslide affected slope 1

Fig. 2. Landslide affected slope 2

Evaluated properties of the soil are shown in the table 1

Table 1
Initial properties of soil

Soil properties	Slope 1	Slope 2
Specific Gravity	2.708	2.679
Liquid limit	36	38
Plastic limit	21	23
Plasticity index	15	15
Classification	SC	SC
Density	18.4	19
Bulk density	17	17
Cohesion	15.7	13.2
Angle of internal friction	21^0	18^0

4. Methodology

Initial step was data collection about the flood affected regions based on damages and reason behind the landslide. The soil samples were collected from corresponding slopes. Then the index properties of soil were determined as per the respective IS Codes to know the characteristics. Tests conducted are Specific gravity, Sieve analysis, Atterberg limits, Light compaction and Direct shear test. Two geotechnical software GEO5 and PLAXIS 2D are used in this study. Using index properties and collected data as per the required parameters both software studies were conducted and the corresponding factor of safety values were observed and compared. Finally, as a mitigation method suitable remedial measures are suggested.

5. Software Used

Slope stability problems are frequently encountered in the construction of roads, canals and dams as well as some natural slopes are or may become unstable due to the presence of water which may weak the soil characters or due to an excavation. The slip of a slope can be catastrophic and causes human losses in addition to considerable natural damages. The two different geotechnical software used here for the slope stability analysis are GEO5 and PLAXIS 2D.

Input parameters for slope stability software include,

- Geometry; Slope, inclination, & height
- Zoning; identification of zones of different soils within
- Slope and beneath it including depth to hard stratum
- Properties; soil parameters for soil in each zone
- Water levels; level of water adjacent to slope

A. GEO5

GEO5 software is a very intuitive and easy to use tool. Users mostly do not need any extensive tutorial before using programs; they can work confidently with it within a few minutes. But you can use variety of training and documentation resources though whenever needed. Basic geotechnical approaches implemented in the GEO5 programs are applicable all over the world. GEO5 offers a unique way of applying standards which significantly simplifies the work of a designer and at the same time allows for complying with all required approaches.

B. PLAXIS 2D

PLAXIS 2D is a powerful and user friendly finite element package that has been developed specifically for the analysis of deformation, stability and flow in geotechnical engineering. The input procedures enable the enhanced output facilities provide a detailed presentation of computational results. PLAXIS enables new users to work with the package after only a few hours of training. Its applications range from excavations, embankments and foundation to tunneling & mining and reservoir geo mechanics.

6. Results and Discussion

A. GEO5 Analysis

Figure 3 and 4 shows the analysis of cross section of corresponding slopes 1 and 2 in GEO5 software.

Slope 1:

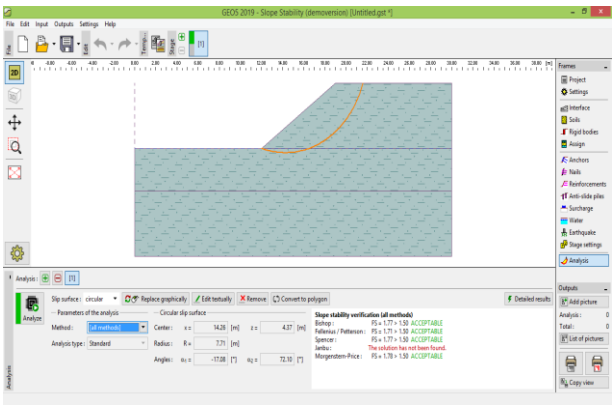

Fig. 3. Analysis of section of slope 1 using GEO5

Factor of Safety = 1.71

Slope 2:

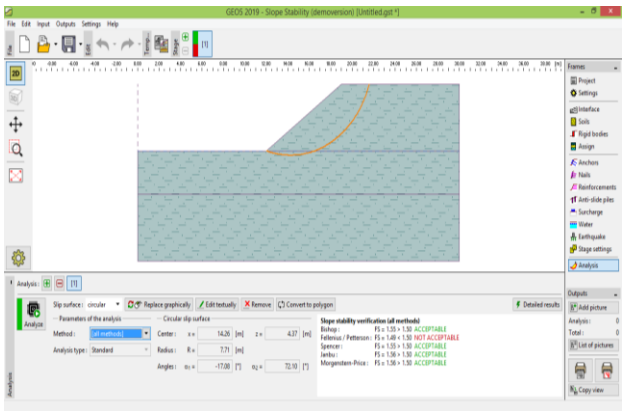

Fig. 4. Analysis of section of slope 1 using GEO5

Factor of Safety = 1.49

Height of the slope was 183m and angle of inclination was 35^0 according to the collected data from responsible authorities. It is observed that factor of safety value is greater for slope 1 as compared to slope 2. This indicates that slope 1 has greater resistance against a sudden slip or failure.

B. PLAXIS 2D Analysis

The total displacement profile and factor of safety are obtained from software analysis using PLAXIS 2D. Finite element models may be either Plane strain or Axisymmetric. The slope is analyzed as a plane strain model. Displacements and strains in z-direction are assumed to be zero. However, normal stresses in z-direction are fully taken into account.

In PLAXIS, soil properties are stored in the material data set. Mohr-Columb model was selected as the material model and the soil properties obtained from the tests were given as input parameters.

Slope 1:

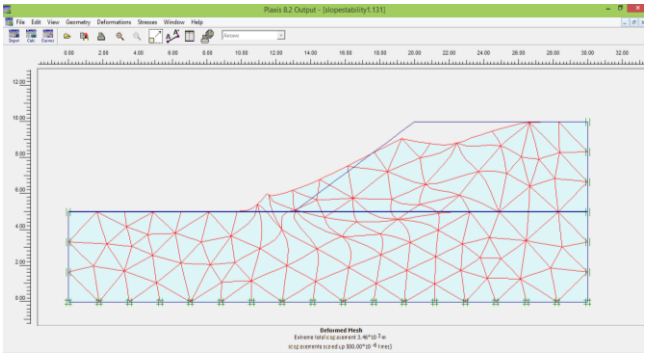

Fig. 5. Deformation mesh of Slope 1 using Plaxis 2D

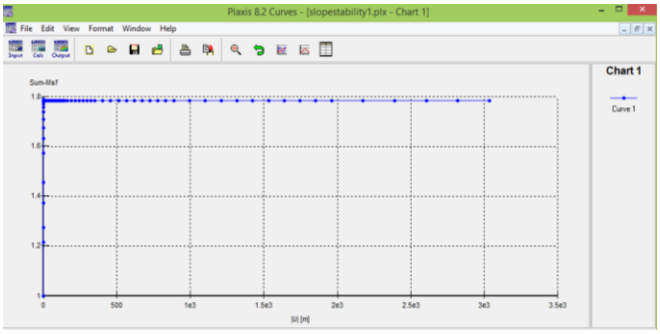

Fig. 6. Factor of Safety of Slope 1

Factor of Safety = 1.78

Figure 5 and 6 shows corresponding deformation mesh and factor of safety value of slope 1. Height and inclination angle are taken as 183m and 35^0 correspondingly. Reduced scale values are preferred. Water table is assumed to be at ground level. Corresponding slope was drawn using drawing tool and required parameters are assigned, hence proceeded to analysis phase. The initial phase is defined with the excavated slope geometry. Initial stresses are generated in this phase using the gravity loading. Safety analysis was done in the next phase. Medium coarseness was chosen for mesh generation.

Slope 2:

Figure 7 and 8 shows deformation mesh and factor of safety value of slope 2. It is observed that deformation is more in case of slope 2 and hence the factor of safety value is lower. This

indicates that slope 1 has greater resistance against a sudden slip or failure.

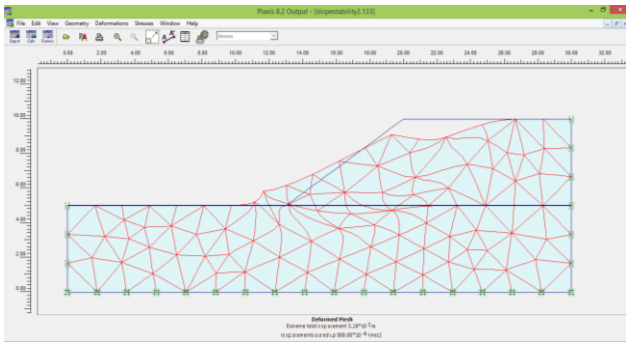

Fig. 7 Deformation mesh of Slope 2 using Plaxis 2D

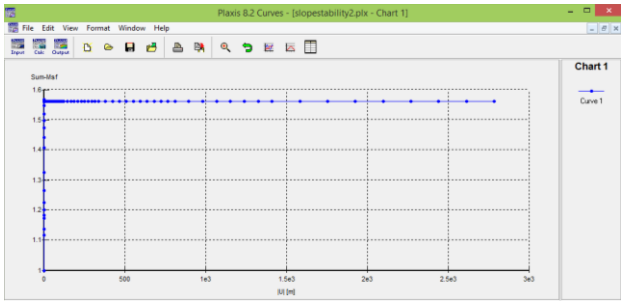

Fig. 8. Factor of Safety of Slope 2

Factor of Safety = 1.56

C. Result comparison

The stability of both the slopes from kuranchery flood affected region is analyzed with the help of slope stability tool in Geo5 and Plaxis 2D software. The corresponding results of analysis is obtained from the analysis output. The obtained results are tabulated below in table 2.

Table 2
Factor of safety corresponding to slopes

Software	Factor of Safety	
	Slope 1	Slope 2
GEO5	1.71	1.49
Plaxis 2D	1.78	1.56

It can be concluded from both the results Plaxis 2D provides more precise value than Geo5. Plaxis 2D also having an upper hand over Geo5 as it provides total displacement values (i.e., the amount of deformation on corresponding slope). From the observed conditions, it is clear that slope 2 analysed from GEO5. shows a value of 1.49 which is just beyond basic safety factor value. It was known to a forest fire which occurred before 2 years lead some forest area burn and which eventually made the sand property being less stable at the top. Vegetation could be an effective and environmental friendly method on top surfaces to reduce the intensity of erosion from top surface, hence reduce damage.

7. Conclusion

Based on the analysis carried out, the conclusions of the study can be summarized as follows,

- For the 1st slope the FOS is 1.78 from plaxis 2D and 1.71 from geo5 and for the 2nd slope the FOS is 1.56 from plaxis 2D and 1.49 from geo5.
- The water table was assumed to be at Ground level, any change of rise of water table, would result in a reduced factor of safety.
- It can be predicted that the slopes near the failed slopes are prone to failure because of similar soil properties.
- With increase in c and φ values Factor of safety increases.
- Methods like geogrids, anchoring, stone columns etc. could be adopted to avoid failure of the existing slopes near the failed slopes.
- Vegetation could be an effective and environmental friendly method on top surfaces and proper drainage is a nature friendly approach.

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