Slope Failure in Lateritic Soils - An Analytical approach

Aswathy Mohan Chenchery   Dr. K. Balan

Abstract - During the recent floods of August 2018 Kerala witnessed a large number of landslides which created great loss of life and property. Slope collapses abruptly under the influence of rainfall or an earthquake. Laterite soil is well known in Asian countries as building material. Intense southwest monsoon rainfall, high temperature and lush vegetation promote the formation of laterite soils. Failures occur in lateritic soil due to several reasons such as change in slope geometry, uncertainty of erratic ground profile, presence of water table on site and presence of an unrecognized soft soil layer. Strength of laterite varies with time because of the losses of cohesion and angle of internal friction, ineffectiveness of iron oxide to coalesce and loss of strength due to fully saturated soil condition. In this paper an attempt has been made to analyze the failure in lateritic soil using geostudio slope stability software. The minimum factor of safety and critical slip surface was obtained. The pore water pressure was also considered during the analysis.

Keywords – Geostudio, Laterite soil, lithomargic clay, slope stability, tropical soil

1. INTRODUCTION

Slope collapses abruptly under the influence of rainfall or an earthquake. There is a mass downward movement of rock debris and soil in response to gravitational stresses. Slopes are sometimes gently rounded, sometimes extremely steep. The mass wasting can be classified into three major types on the basis on down slope movement as falls, slides and flows.

* *Aswathy Mohan Chenchery is currently pursuing master's degree program in Geotechnical Engineering in Kerala Technological University, India, PH – 8390990790. E-mail : aswathychenchery@gmail.com*
* *Dr. K. Balan is currently professor and head of civil engineering department, India. E- mail – drkbalan@gmail.com*

Laterite is well known in Asian countries as a building material. It is excavated from the soil and cut in form of large building blocks.

It was first described by English surgeon Francis Buchanan who was travelling along the western coast of Southern India.

These are highly weathered soils and contain extremely variable proportions of iron and aluminum oxides. Laterite soils are commonly found in tropic and sub tropic region with intense southwest monsoon rainfall, high temperature and lush vegetation.

2. METHODOLOGY

This research is intended to analyse the failures occurring in lateritic soil slopes analytically using geostudio software. The values used in this study such as the shear strength properties were obtained from literatures.

Geostudio has a rigorous analytical capability and is provided with CAD like functionality. This helps tographically represent the soil conditions of the laterite soil. The limit equilibrium method was adopted.

A slope of 12 m height was considered having two layers of soil. The top layer consisted of laterite soil for a height of 5 m and the bottom layer consisted of lithomargic clay for a height of 7 m. Mohr – Coulomb failure criterion was used for defining the material properties. The properties of laterite soil and lithomargic clay are shown in Table 1.

TABLE I. TABLE SHOWING PROPERTIES OF LATERITE AND LITHOMARGIC CLAYS

Properties	Laterite	Lithomargic Clay
Young's modulus	40000 kPa	10000 kPa
Poisson's ratio	0.33	0.33
Cohesion	35 kP	27 kPa
Angle of internal friction	30	20
Material type	Drained	Undrained
Hydraulic conductivity	0.1 m/day	0.0321 m/day

The calculation was carried out for wet and dry conditions as we know that laterite soil behave differently when subjected to wet and dry conditions.

3. RESULTS AND DISCUSSION

A slope of height 12 m was considered for the study and the input values were cohesion, angle of internal friction and unit weight. Two different layers of soil were considered as shown in Figure 1.

The analysis was carried out for finding out the minimum factor of safety.

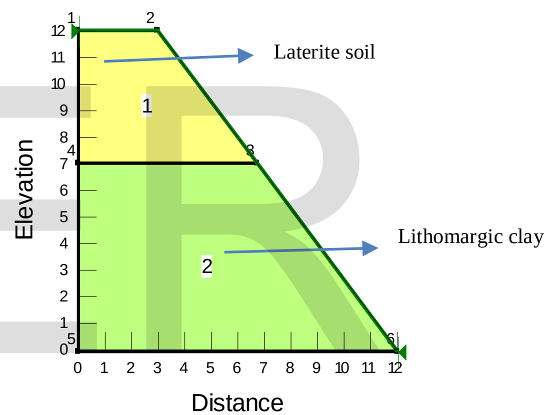

Fig.1. Soil profile showing height and layers of soil

The analysis was carried out and the slip circle was obtained showing minimum factor of safety as shown in figure 2. The factor of safety was 2.280 which mean the slope was stable. The graph was obtained as shown in Figure 3 for total normal stress versus the slice of the slip circle.

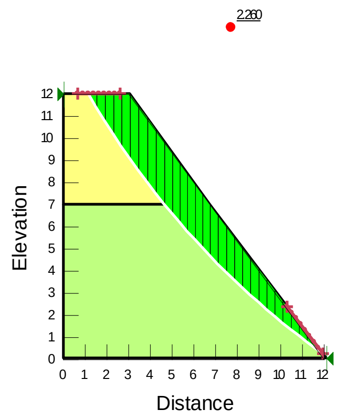

Fig.2 .Figure showing critical slip surface

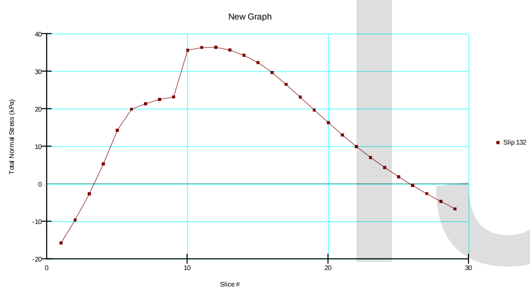

Fig.3. Graph of total normal stress versus slice

Now a piezometric line was introduced passing through both the soil layers indicating the line of water passing through the soil as shown in figure 4. It can be seen that as soon as the soil comes in contact with water the factor of safety is reduced to 1.159. The minimum factor of safety is assumed to be atleast 1.3 for the slopes to be stable. From the graph shown in figure 5 it can be seen that the total normal stress is decreasing upto a point.

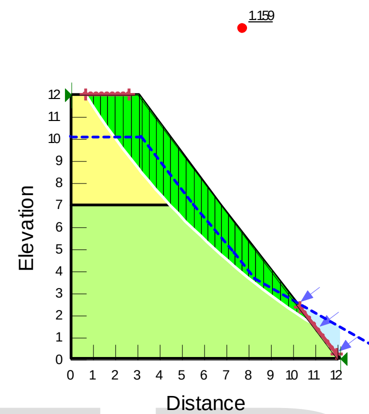

Fig .4. Figure showing piezometric line

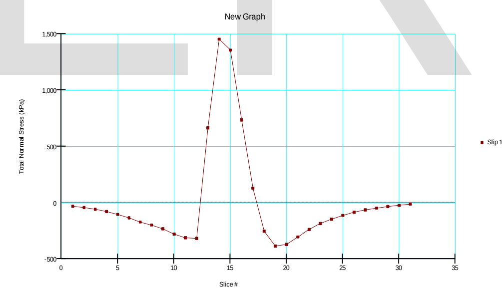

Fig.5. Graph of total normal stress versus slice

Different stabilization measures can be adopted depending on the profile of the slope. Here soil nailing has been adopted and it can be seen that as soon the stabilization method is adopted the factor of safety increases. It is shown in Figure 6. Graph shown in figure 7 again show an increase in total normal stress values.

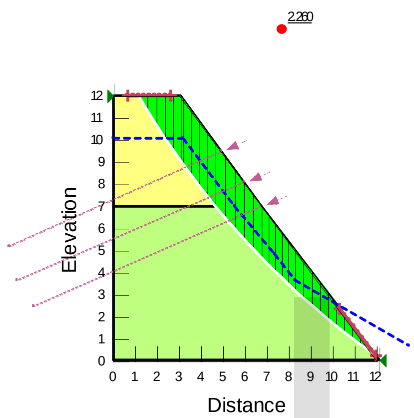

Fig.6. Figure showing reinforcement details

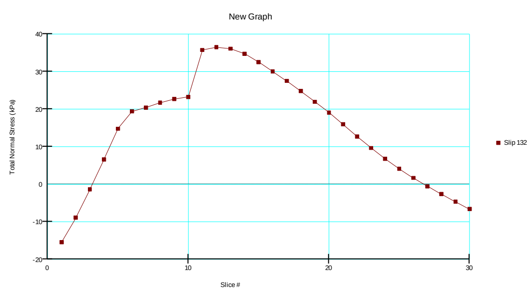

Fig.7. Graph of total normal stress versus slice

4. CONCLUSION

In this study the slope has been analysed analytically and the following conclusions can be made

1. Lateritic soils are affected by the presence of water and can show instability of slopes when heavy rains hit the area.
2. Even though the factor of safety was more than 1.3 which is required for the stability of the slopes it was observed that the factor of safety reduces as soon as the soil comes in contact with water.
3. When necessary stabilization measures are taken the factor of safety can be increased and the slopes can be stabilized to some extend

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