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Theoretical and Experimental Investigation of a Landslide Occurred in Idukki District, Kerala

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Abstract - *Kerala experienced extreme rainfall from 1st to 20th of August, 2018. This extreme rainfall event resulted in flooding and landslide hazards leading to 483 deaths and severe destruction of property. This disastrous floods and landslides caused extensive damage to houses, roads, railways, bridges, power supplies, communications networks, and other infrastructure; washed away crops and livestock and affected the lives and livelihoods of millions of people in the state. In this project a study is being conducted to identify the reasons of one of the landslides occurred in Idukki district through different laboratory investigations such as Natural Moisture Content (NMC), specific gravity, grain size distribution, shear parameters etc. The stability analysis of the slope was conducted and the failure plane was determined.*

***Key Words*: Landslides, Slope stability analysis, Friction circle method, factor of safety, rainfall induced slides, soil properties.**

1. INTRODUCTION

Kerala experienced the worst ever floods in its history since 1924 between June 1 and August 18, 2018. During this period, the state received more than 2428.9 mm of rain which was 42% more than the normal average. The torrential rains triggered several landslides. Idukki, the worst-hit district, was ravaged by 143 landslides [1]. The magnitude of the floods and landslides has underscored the need for research and knowledge generation activities. Slope stability analysis is conducted to assess the possibility of landslides involving natural or existing engineered slopes, to analyze occurred landslides, and to understand the failure mechanism and the influence of environmental factors [2]. The landslides that occurred in the Idukki district can be classified as shallow seated landslides, deep-seated landslides, soil piping, and partially failed landslides [3]. In this study, a deep-seated landslide occurred on the Thodupuzha-Puliyanmala road at chainage 45/900 was analyzed. This paper presents the geotechnical investigation and stability analysis of the landslide.

1.1 Objective

The objective of this study was to establish the reasons of failure of the landslide and to obtain the factor of safety of the slope.

2. METHODOLOGY

Undisturbed samples were collected from the landslide site. A sampling tube of 10 cm diameter and 30 cm length was used to collect the samples. The samples were then fully saturated in order to simulate the rainfall condition. The slope geometry is such that the slope angle was 60° and the height of the slope was 10 m. the photograph of the site is shown in fig -1.

Fig -1: Photograph of the site

The soil samples were tested in the geotechnical laboratory to identify the classification of soil, to determine the grain size distribution of the soil and to obtain the shear parameters of the soil sample. Five samples were collected from different heights of the slip surface of the slope. To classify the soil atterberg limits test were conducted. Hydrometer analysis and sieve analysis were carried out to develop the gradation curve of the soil. To attain the shear strength parameters such as cohesion and angle of internal friction, triaxial (unconfined undrained) test was conducted. The slope stability analysis was done theoretically using the friction circle method.

3. RESULTS AND DISCUSSIONS

3.1 Geotechnical Investigation

The basic properties, particle size distribution and shear strength parameters of the soil samples were found out from geotechnical laboratory tests. The results are shown in table -1.

Table -1: Basic properties of soil samples.

Sample No:	1	2	3	4	5
Water content (%)	31	42	39	49	45
Specific gravity	2.64	2.65	2.65	2.70	2.67
Field density (g/cc)	1.85	1.85	1.82	1.77	1.83
Liquid limit (%)	43	45	43	43	45
Plastic limit (%)	26	27	27	26	26
Void ratio	0.87	1.02	1.02	1.27	1.12
Percentage of sand particles (%)	56	51	56	57	57
Percentage of clay particles (%)	43	48	43	42	42
Percentage of silt particles (%)	1	1	1	1	1
Cohesion (c)	28	27	25	23	28
Angle of internal friction (φ)	20	17	16	16	18.5

The sample no: 4 have the highest water content and lowest shear strength values. This sample was collected from a depth of 5 m from the crown portion of the landslide. The flow curve and gradation curve of the sample 4 is shown in chart -1 and chart -2 respectively.

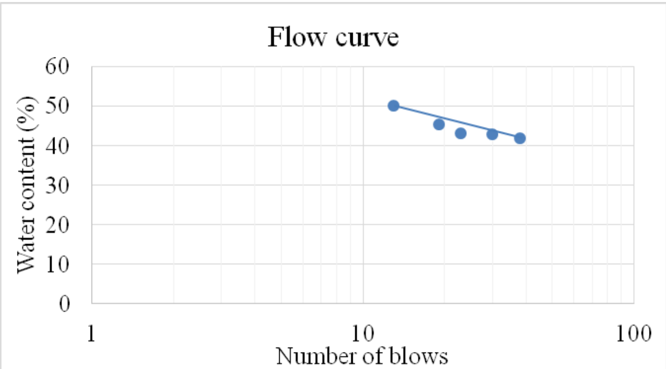

Chart -1: Flow curve of soil sample 4

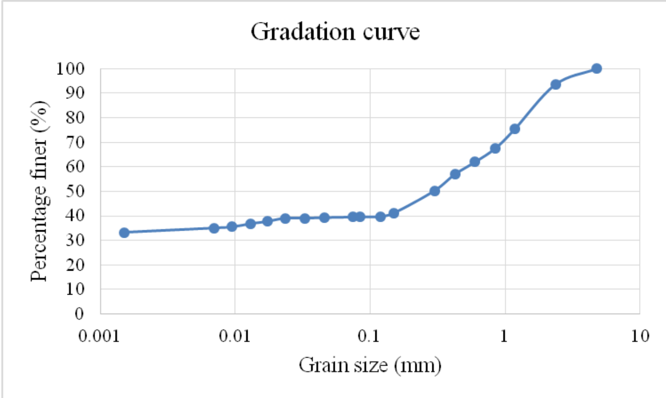

Chart -2: Gradation curve of soil sample 4

The Mohr's circle of the sample 4 is shown in fig -2.

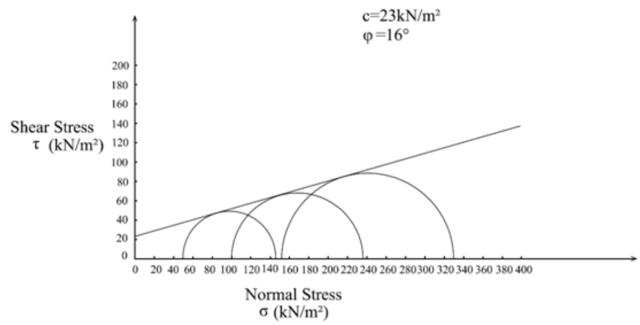

Fig -2: Mohr's circle of sample 4

3.2 Slope stability analysis

The slope stability analysis was done using Taylor's friction circle method. Several trial slip surfaces were drawn to obtain the most critical sliding surface, along which the developed cohesion is maximum. Here the toe circle AC passing through a point 10m from B is the critical sliding surface. The factor of safety of the samples with respect to effective cohesion (c') and effective angle of internal friction (φ') i.e. F_c (factor of safety with respect to cohesion) and F_φ (factor of safety with respect to friction angle)for different values of $\varphi'_d \leq \varphi'$ were found out using Taylor's stability number. Then a graph was plotted between $F_{c'}$ (factor of safety with respect to effective cohesion) and $F_{\varphi'}$ (factor of safety with respect to effective friction angle) and then the factor of safety of the slope, F_s was determined by $F_{c'} = F_{\varphi'} = F_s$. The lowest factor of safety found out was 0.70 and it can be said that the slope failed through the plane in which the factor of safety was lowest which is same as the slip circle AC shown in fig -3. The graph showing the factor of safety = 0.70 is shown in fig -4.

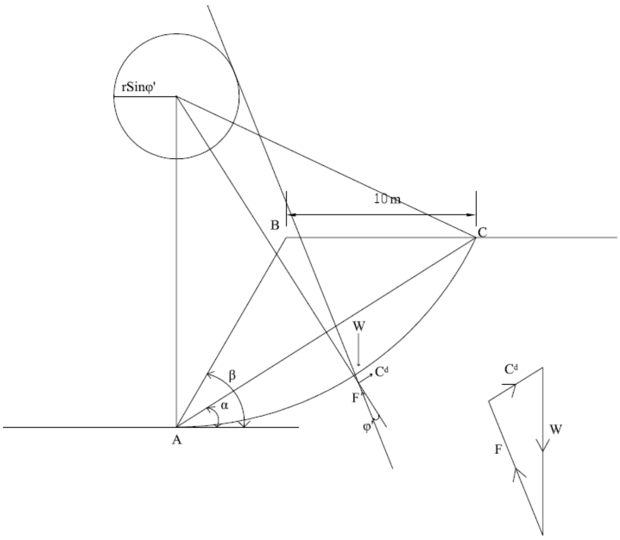

Fig -3: Slip circle of the slope

Here φ'= 11°, α = 32°, β = 60°.

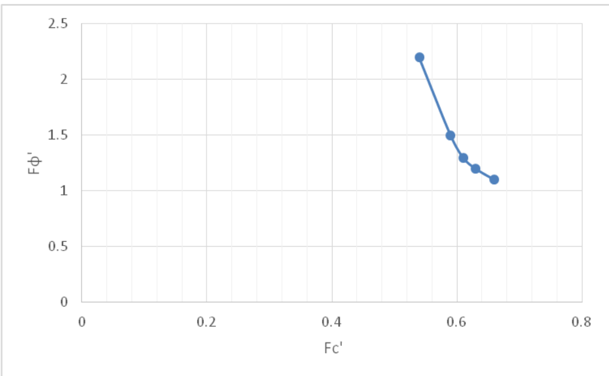

Fig -4: Graph showing $F_{c'} = F_{\varphi'} = F_S$.

4. CONCLUSIONS

The district of Idukki was very much affected by the landslides occurred during the months of June, July and August in the year 2018. Several lives were lost, many houses were destroyed, agricultural lands were affected, infrastructure facilities were damaged and many hazards took place due to the devastating landslides.

- In this project, a study about one of the landslides occurred in Idukki district were done.
- It was found that the toe circle AC was the critical sliding surface along which the developed cohesion (c'_d) is maximum.
- The factor of safety of slope was found out, which was 0.70<1.
- This shows that the slope failed through the critical surface where the factor of safety was less than1.

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