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A Case Study on Cloud burst induced Landslide

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Abstract— **The devastating landslide which took place at Kadavoor, Kothamangalam on August 17, 2012 shook the lives of many. More than seven families lost their homes and the death toll touched seven in this catastrophic incident. In order to find out the root cause of the landslide, many site visits were conducted and soil samples were collected from 4 different cordon points, with an objective to classify the soil type and determine its cohesion and angle of internal friction. The soil parameters were found out by conducting laboratory tests. Simultaneously, the longitudinal profile of the slope was surveyed and. slip circles were plotted for various sections and soil types and minimum factor of safety is determined.**

Keywords-landslide, cloud bursting, slip circle

I. INTRODUCTION

Landslides are primarily the result of shear failure along the boundary of moving soil or rock mass. If natural slope fails, it is more probable that failure has been caused by gradual decrease of shear strength than by extreme condition at the time of failure. Presence of water increases the weight of the soil mass and leads to the reduction in shear strength. Hence water has been implicated as the main controlling factor in most of the slides. Studies conducted in the state have revealed that prolonged and intensive rainfall resulting in pore water pressure variations are the most important trigger for landslides. The process leading to landslide was accelerated by anthropogenic disturbances such as deforestation and cultivation of crops lacking capability to add to root cohesion in steep slopes.

Some other alternative mechanisms can be invoked to explain the phenomenon. For instance, the mechanism of gradual ‘‘smoothing’’ of the sliding surface was proposed by Kokusho (not for the Kadavoor landslide). He supposed that when a soil layer of significant thickness underneath the sliding surface liquefies, and the soil directly on top is of low permeability (both conditions might also apply to the Kadavoor landslide), then the natural tendency of the liquefied layer to settle could produce a very slim ‘‘film’’ of water, only a few centimeters or even millimeters in thickness. The development of this water film along the sliding surface could explain the extent of the runoff (about 100 m). Figure 1 shows the site at Kadavoor where the land slide occurred.

Figure 1 Site at Kadavoor

II. LITERATURE REVIEW

It is generally recognized that rainfall induced landslides are caused by increased pore pressures and seepage forces during the periods of intense rainfall (Terzaghi 1950; Sidle and Swanston 1982; Sitar et al.1992; Anderson and Sitar 1995). It is the increased pore pressure that decreases the effective stress in the soil and thus reduces the soil shear strength eventually resulting in slope failure (Brand 1981; Brenner et al. 1985). Further studies have illustrated that in some cases of rainfall induced landslides movement along the sliding surface leads to crushing of soil grains, which results in liquefaction along its surface finally resulting in rapid movement and long run out distance (Sassa 1996; Sassa 1998a, b); thus high pore pressure is the result of shearing along the sliding surface. Liquefaction, a process by which soil suddenly loses a large proportion of its shear resistance due to the generation of high pore pressure is a reason for fluidised landslide. Liquefaction triggered by dynamic effects , such as earthquakes or by static effects such as rainfall, snowmelt has been studied extensively (Eg: Terzaghi 1956; Seed 1966 , 1979; Bishop 1967,1973; Castro 1969, Casagrande 1971; Castro and paulose 1977; Sassa

1984,1996,1998a,1998b; Eckersley 1985,1986; Hird and Hassona 1990, Ishihara et al 1990) and much knowledge has been accumulated about mechanism of liquefaction.

The major objective of the study is to identify the root cause of the landslide by assessing the soil type and determining the shear strength parameters. The factor of safety is determined by Swedish Circle method. The stability of the existing slope is judged there by.

III. METHODOLOGY

Soil sample was taken from 4 cordon points Figure 2. The fourth sample was taken at a point located in the top right corner of the slope which hadn't slide off due to the landslide. The soil samples were classified after conducting wet sieve analysis. Important soil parameters like cohesion and angle of internal friction was found out from direct shear test. The longitudinal profile of the slope was obtained after conducting survey.

Longitudinal section was taken in 7 directions and slip circles were drawn. Each circle was divided into 5 slices. Several slip circles were plotted changing the values of cohesion and angle of internal friction. The factor of safety (It is the ratio of available shear strength to that required to keep the slope stable) for each case was found out and it can be assumed that the landslide conformed to the soil parameters which gave the minimum factor of safety. Swedish circle method was adopted for finding the factor of safety. In this method, the sliding mass above the failure surface is divided into a no of slices. The force acting on each slice is obtained by considering the mechanical equilibrium of the slices.

Figure 2 Site spots for sampling

IV. OBSERVATION AND ANLYSIS

After conducting wet sieve analysis, sample 1, 2, 3 and 4 were reported as sandy type soil. The cohesion and angle of internal friction were determined as per the specification. The Factor of Safety for all the 7 sections were determined. A plot of factor of safety on all sections is given in Figure 3

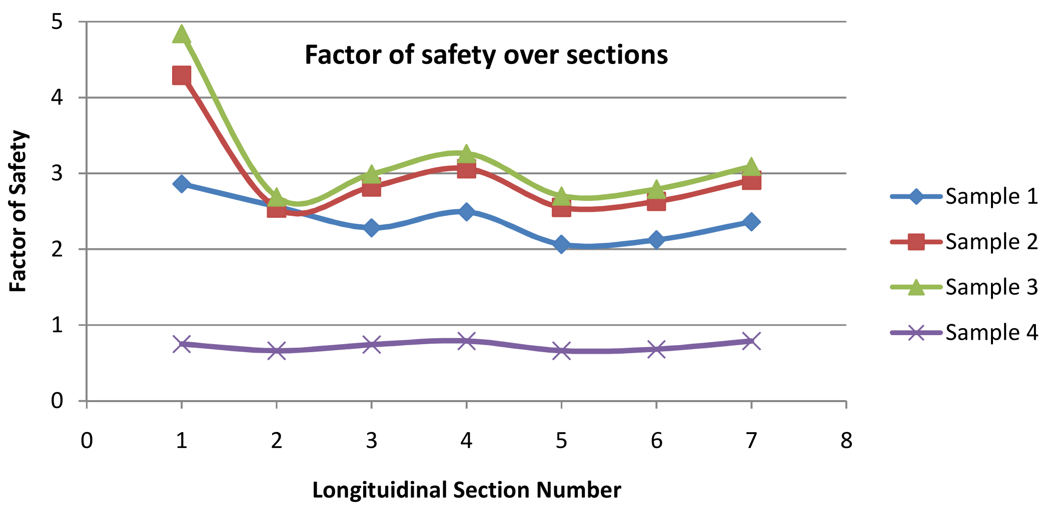

Figure 3 Factor of Safety on different Sections

It can be clearly seen that in each of the 7 sections taken, factor of safety falls below 1 if occupied by soil sample 4. All the other soil specimens gave a value of factor of safety higher than 1 which indicates stability of the slope. Hence it can be concluded that soil specimen 4 was responsible for the landslide trigger along with other several possibilities. It can also be suggested that after the heavy rain the pore water pressure at the slip surface increased, reducing the effective normal stress and thus diminishing the restraining friction along the slip line. This is combined with increased soil weight due to added groundwater. A shrinkage crack at the top of the slip would have also filled with rain water, pushing the slip forward.

V. CONCLUSION

From the factor of safety calculations it can be inferred that soil type 4(sandy soil) might be responsible for triggering the slide. Since saturated conditions existed at the top of the slope before the occurrence of the landslide, the increased unit weight of the soil also might have contributed to the slide. The combination of soil and topographic amplification could have played a major role in triggering the landslide. In such a case, the basic free field motion could have possibly been amplified within the sliding mass. With such an excitation, the developing shear stresses could possibly lead to liquefaction of even marginally sensitive soil layers which would have resulted in a catastrophe of this magnitude.

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