Flow-Like Landslide Triggered by Extreme Rainfall of July 2002 in Southwest Kathmandu, Nepal

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1. INTRODUCTION

Slope failure broadly described as landslide is a consequence of a large mass surges down slope in response to the gravity. The style of mass movement is generally defined according to flow velocity, volume of the material involved, shear rates, and shear strength of the materials. Experiences show that landslide occurrences on hill slopes have very close relationship with availability of water. As a result, many varieties of landslides occur as a consequence of heavy rainfall in tropical and temperate climatic zones. Keeping view of these contexts, this paper will describe scenario of rainfall triggered flow-like landslide occurred in Kathmandu, Nepal (Figure 1).

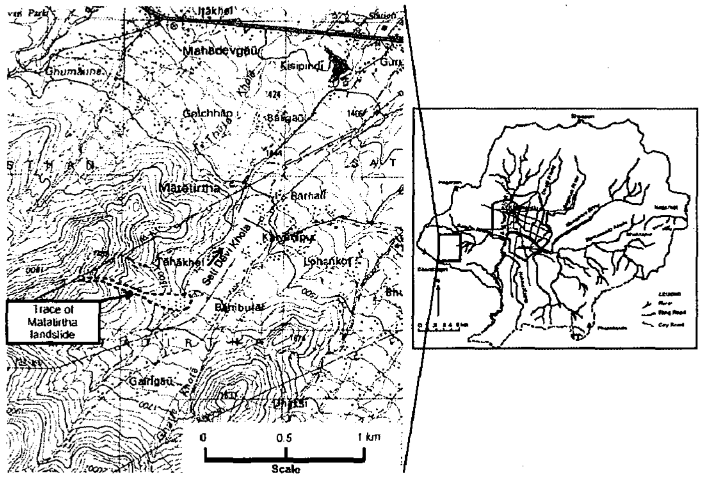

Figure 1: Location Map of Matatirtha flow-like landslide

2. RAINFALL TRIGGERED FLOW-LIKE LANDSLIDE IN NEPAL AND SOUTH OF KATHMANDU

Nepal is situated in the center of the long Himalayan concave chain, and is almost rectangular in shape with about 870 km length in the NWW-SEE and 130 to 260 km in N-S direction. The Himalaya has one of the most dynamic and fragile mountain landscapes. It is a live mountain with active tectonics. The seasonal monsoon rains, intense but improper land use practices both for cultivation and construction ensure that the Nepalese Himalayas are among the most unstable landscapes worldwide. The shallow landslide that generally flows down to slope in very high velocity is found to be most devastating landslide in Nepal. According to UN, in Nepal, on an average 260 people lost their lives every year and about 30,000 families affected annually. Ministry Home Affairs, HMG/Nepal confirmed that in 2002, from mid July to late September, 52 districts affected by landslides and floods, 444 people were killed, about 44 were missed, more than 100 were injured, more than 55,000 families were affected. In Nepal, it is felt that flow-like landslides affect human settlements, bridge and roads by destroying and burying. In the year 2002, many flow-like landslides occurred along southern marginal hills of Kathmandu and damaged many infrastructures. Single flow-like landslide occurred in a village Matatirtha situated at the southwest of the capital city Kathmandu killed 18 people inhabiting on the base of the hill (Figure 2).

Figure 2: Flow-like landslide of Matatirtha, July 2002, site after 40 hours

3 NATURE OF SLIDES AT MATATIRTHA

3.1 Precipitation of the area

From the meteorological point of view, the month of July is very critical for the southern hills of Kathmandu. Most nearest rain gauge station from the failure area is in Thankot (situated at about 1.5 km aerial distance from Matatirtha. Rainfall data recorded by the Department of Hydrology and Meteorology (DMG) at its Thankot station is 300.1 mm at 24 hr in the day of major failures, i.e. 23 July 2002 (Figure 3).

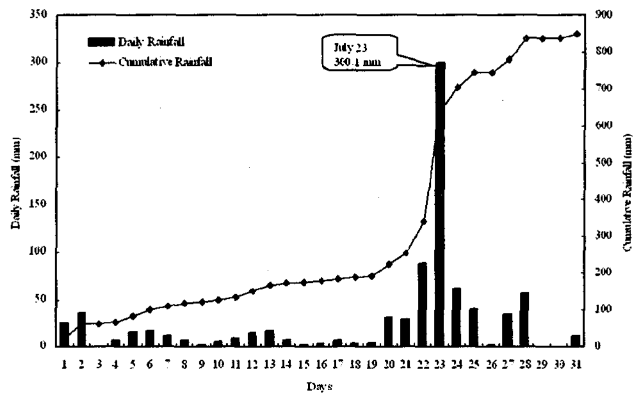

Figure 3: Rainfall pattern of Thankot area in July 2002

3.2 Geological and geotechnical characteristics

Southern hills of Kathmandu valley mainly consist of limestone rocks of Phulchauki Group (Stöcklin and Bhattarai, 1977) and mainly are covered by weathered debris deposit. During study, geotechnical properties of the both deposited debris and colluvial materials of the slope are identified as far as practicable. The altered and reworked soils, which formed the original soil cover at the heads of gullies, have wide grain size distributions (Figure 4) and have significant clay fractions.The thickness of soil is also varied from crown part to lowest part of

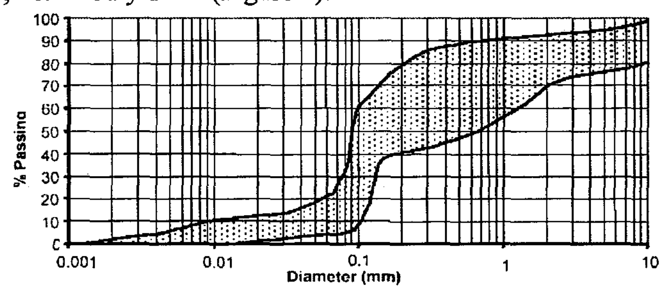

Figure 4: Grain size distribution of debris

failure in all failure. At crown part of failures, the thin veneer of porous silty gravel of thickness 0.5 m to 1.5 m is found over the extensively jointed calcareous rock. In the slides, the soil thickness at end of failure zone is 4 to 5.5 m. The calculated dry unit weight of the soil is ranged between 15 kN/m^3 to 19 kN/m^3. The shear strength test carried out on reconstituted specimen and variable friction angle value ranged from 25° to 30°. The value of apparent cohesion also ranged from 4 kN/m^2 to 7 kN/m^2.

4.4 Failure processes

During field investigation, it was noticed that steep slope of upper reaches of landslide had thin veneer of soil which was almost liquefied during rainfall and plucked from the underlain bed rock. Before failure at crown, the pervious soil continued infiltrating rainwater through highly fractured rocks also helped to generate almost saturation condition on the thick soil of down slope. The down slope has a gully and without any outlet system and it was realized that the saturation of slope materials was initiated from down to up. It is very clearly observed that debris slide first occurred at crown part and it scrape off the almost saturated thick soil of down hill and whole mass of the channel begins to flow, like a liquid as per the liquefaction flow rule (Darve, 1996) and debris flow hit the whole settlement of base and killed 18 people. The schematic view of the debris flow development pattern is shown in Figure 5. From the study of this flow-like landslide, it is felt that following are some parameters which caused the abrupt loss of shear strength of colluvium deposit.

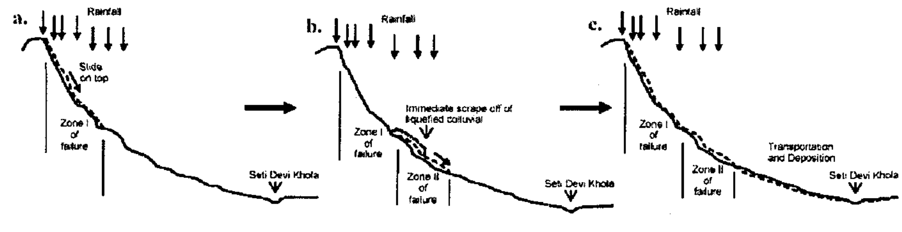

Figure 5. Schematic view of formation of flow at Matatirtha Landslide, an example of flow pattern in of flow-like landslide southern hills of Kathmandu

- High intensity of rainfall and steep slope of upper reaches covered by thin veneer of silty gravel cover
- High infiltration rate and localized slide at upper reaches
- Gully with thick clayey and silty gravel
- Encroachment of channel in lower reaches by cultivation practice

Due to large in nature, the flow velocity of Matatirtha landsilde is also approximately estimated by following equation by considering simple infinite model for liquefied debris and correcting value of g with slope angle (Hungr 2003 and Poudel 2004).

$$1/2mv^2 \geq m\ g\ \sin\beta\ h$$

Where, m is mass, v is velocity, g is gravitational acceleration, β is slope angle and h is height

From relationship, the minimum flow velocity of the Matatirtha before hitting the settlement was ≥40 m/s. According to landslide scale described by Cruden and Varnes in 1996, the Matatirtha landslide is Extremely Rapid Landslide. Similarly, time elapsed of flow is also estimated by simple equation of motion. It is predicted that after initiation of slide at upper reaches, minimum time taken to hit the first house settlement was just 8 sec. Interview with the villager who was able to escape during event also confirmed middling accuracy of the timing. In debris slide zone near to crown about 3100 m^3 of the debris was failed whereas materials rolled down from this zone entrained approximately 5860 m^3 of colluvial materials other failure zone of down slope. In the Zone I, the yield rate (Hungr, 2003) of landslide is 20.6 m^3/m and in Zone II it is 63.6 m^3/m. The yield rates support the quite widen gully resulted after landslide.

4. CONCLUSION

From this study following conclusions are made.

- The rainfall triggered flow-like landslide of Matatirtha shows us very critical and vital roles of landslide hazard mapping. It also shows us importance of hourly recorded rainfall data and from rainfall data, for south west Kathmandu, it can be predicted that if cumulative rainfall of 24-hours is more than 260 mm, flow like landslide can be occurred and for shallow debris slide, this value can be ranged between 230 to 250 mm.
- It is also felt that human inhabitation practice on old fan deposit and immediate base of hill should be regularized by government through separate law to decrease death from debris flow triggered by torrential rainfall.
- From this study, it is also concluded that landslide hazard map should be quantified towards landslide risk assessment and management for rainfall triggered flow-like landslide also which decisively provides fruitful upshot to early warning system of flow-like landslide disasters.

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