Site Characterization and Rainfall Induced Landslide Risk Assessment at Balukhali Rohingya Refugee Camps of Ukhiya, Bangladesh

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Abstract: This research is mainly focused on landslide hazards of the world's largest refugee camp of Ukhiya, Cox's Bazar Bangladesh. The whole area mainly small hillocks and hills of Ukhiya area are at great risk especially during monsoon. Several case studies result of recent slope failures is presented to understand the risk during monsoon in the camp area. From numerical seepage and stability modeling of slope at different locations of Ukhiya camps, it is established that Ukhiya hill slopes and the temporary shelters of Rohingyas are at great risk during monsoonal heavy rainfall for sustainable community-based living in the camp area. This study will ultimately help to manage hazards for sustainable hill management and settlement on hills. Based on the rainfall threshold (140 mm to 280 mm) line, warning system can be developed to save lives and properties of the camp inhabitants for further study.

Keywords: Landslide, *Slope stability, Geo-hazard, Rainfall threshold*.

Introduction

Landslides have become most frequent geologic hazard in the southeastern part of Bangladesh remarkably on Chittagong Division. In the last decades, due to climate change along with other anthropogenic causes such as high population density, unplanned land use, and fierce hill cutting are triggering devastating landslides in the hilly regions of the country (Chen et al., 2017; Sultana, 2020). Under the current conditions of global climate change, the Ukhiya hills is very susceptible to landslide dangers during monsoonal precipitation. The Rohingya refugee camps of Balukhali highlands frequently experience shallow landslides and monsoonal slope collapses (Figure 1). Most landslides occur during the monsoon season in the CHA due to extreme rainfall events (>40 mm/day) within a short period (2-7 days) (Khan et al., 2012).

The study targets site characterization, geotechnical evaluation of soil properties, investigations of the stability risk and vulnerability of rainfall-induced landslides and slope failures that occurred in several locations around the Balukhali Rohingya refugee camp region, Ukhiya.

Figure 1, Landslide event in Balukhali Camp.

Methodology

The study employs three major approaches: Field Methodology, Laboratory Methodology, and Modeling.

Field Methodology

Detailed site investigations were conducted, including surface and subsurface sample collection and landslide data recording. Subsurface samples were obtained using the Wash Boring method with light cable percussion drilling. Disturbed and undisturbed samples were collected using a split spoon sampler and U100 Shelby tube, respectively, following BS 5930 (1981) standards.

Laboratory Methodology

Soil samples were tested for various geotechnical properties (moisture content, specific gravity, Atterberg limits, shear strength, swelling, shrinkage, and pore water pressure) according to BS 1377 (1990) and ASTM (1974). Additional tests, including triaxial and Oedometer tests (per K.H. Head, 1982; ASTM IS, 2720; BS, 1377) and direct shear tests (ASTM D3080, 2011), were conducted to evaluate soil strength parameters.

Modeling

Climate data, particularly rainfall records (2008–2020) from the Bangladesh Meteorological Department, were analyzed. Slope stability modeling was performed using the Bishop Simplified Method in Seep/W and Slope/W software (Geo-Slope, Canada).

Conclusion

Several case studies results of recent slope failures are presented to understand the risk during monsoon in the camp area. From numerical seepage and stability modeling of slope at different locations of Balukhali camps, it is established that Ukhiya hill slopes and the temporary shelters of Rohingyas are at great risk during monsoonal heavy rainfall for sustainable community-based living in the camp area. The variation of factor of safety values with different rainfall amount are considered to see the impacts of rainwater on stability. Landslide Risk zonation map based on Factor of Safety (Fs) values of the camp area is established and some sustainable solutions are recommended to reduce the landslide risk. From the recent precipitation pattern, it is established that rainfall pattern is changing in the Ukhiya Teknaf region of Cox's bazar district, Bangladesh. This is significantly influencing on the pore water pressure (P.W.P.) development and Ground water level (G.W.L.) fluctuations values of the Rohingya camp area. Based on calculated Factor of safety (Fs) values, landslide risk maps of the Rohingya refugee camp area have been prepared based on calculated factor of safety values at different points of hills slopes. A rainfall thresh hold line has been established to understand risk during raining. From the three decades data, it is established that 140 to 280 mm. rainfall is sufficient to cause any landslide in the Ukhiya hills including Rohingya camp area.

Based on all the observed Fs values, four landslide risk zones are identified. They are very high-risk zones with a Fs value range of 0.18 to 0.46, a high-risk zone with a value 0.56 to 0.75, medium risk zone with a Fs value range of 0.76 to 1.0, and a marginally stable zone with a Fs value close to 1. It has also been proven that when rainfall seeps into the subsurface, the majority of it drains out towards the northeastern portion of the hills, where there are massive P.W.P. builds up. Suction can play vital role in case of stability.

This study will ultimately help to manage hazards for sustainable hill management and settlement on hills. Based on the rainfall threshold line, warning system can be developed to save lives and properties of the camp and local inhabitants for further study. Model development results and risk maps may help policy makers, city dwellers, engineers and other concerned authorities to understand the landslide risks of the investigated area. Some recommendations and sustainable mitigation measures are recommended to reduce the risk.

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