Geotechnical Data Analysis Contributing Rainfall Triggering Landslide Risk Assessment at Kawkhali Upazila of Rangamati District, Bangladesh

Md. Azahar Hossain[1*], Md. Ahsan Habib[1], Abu Syed Mohammed Faisal[1], Mohammad Anisur Rahman[1], Salma Akter[1]

[1]Environmental Geology and Natural Hazard Assessment Branch, Geological Survey of Bangladesh (GSB), Dhaka, Bangladesh

*(*Corresponding E-mail: azahargsb@gmail.com)*

Abstract: On 13 June 2017, a large-scale landslide hit the south-eastern Tertiary mountainous region of the country, surpassing all previous disaster records in Bangladesh. At least 165 people, including children and four army personnel, were killed in different landslides caused by deep landslides in different parts of the Rangamati, Bandarban, and Chittagong districts. In the fieldwork at Kawkhali Upazila of Rangamati district, the original slope angle is measured at different sites where landslides took place. Samples were gathered from various destinations of the field for grain size investigation and direct shear test individually. It was completed at the Engineering Geological Laboratory of the Geological Survey of Bangladesh (GSB), considering the ASTM Standard Test Strategy for particle size investigation of soils. The direct shear test is covered in ASTM D 3080 - standard test method for direct shear test of soils under consolidated drained conditions. Grain size, Hydrometer, Atterberg limit and shear strength parameter tests are executed to observe geo-information to determine the risk assessment. The test result obtained from sieve analysis shows that the amount of sand in the sample is 95.84 - 99.51% whereas the total amount of silt and clay is 0.49 - 4.13%. The uniformity coefficient Cu is 2.79-6.5 and the coefficient of curvature Cc is 0.55-1.96. From the hydrometer analysis result it is seen that sand particles vary from 0.44 to 58%, silt particles vary from 29.52-75.10%, and clay particles vary from 4.5- 42.5%. Samples can be categorized as 5 samples are silty sand, 6 samples are sandy silt, and 6 samples are clayey silt, depending on the particle sizes present in soil. The average liquid limit of the review region is 34.94%, demonstrating the high expansion potential of the soil. In this condition, the deformation of the slope is possible ultimately resulting in the slope being unsteady. Results from the direct shear test showed that the cohesion of slope materials ranges from 2.41 to 15.56 kPa, while the internal friction angle varies from 26.75° to 35.40°. Hence, a higher percentage of sandy materials, low cohesion value and greater original slope angle than internal friction angle were the main attributes that severely affected slope stability, which, in turn, triggered landslides in the study area.

Keywords: ***Kawkhali Upazila, Landslide, Geotechnical parameters, Shear strength, Particle size, Slope angle.***

Introduction

Landslides are a natural disaster in the mountainous region of southeastern Bangladesh. Landslides caused by heavy rains often result in loss of life and casualties. On 13 June 2017, a large-scale landslide hit the southeastern Tertiary mountainous region of the country, surpassing all previous disaster records in Bangladesh. At least 165 people, including children and four army personnel, were killed in different landslides caused by landslides in different parts of the Rangamati, Bandarban, and Chattogram districts. In July 2017, 21 people lost their lives due to landslides in Betbunia, Fatikchari, Ghagra, and Kalampati Union of Kawkhali Upazila. In this context, GSB's Environmental Geology and Natural Hazard Assessment branch have decided on the annual outdoor program in the said Kawkhali Upazila in the fiscal year 2021-2022.

Location, Extent, and Accessibility

Kawkhali Upazila under Rangamati District in the Chattogram Division of Bangladesh located between 22°29’ to 22°44’N latitude and 91°56’ to 92°80’E longitude (Figure 1). The area is bounded by Naniarchar and Loxmichari Upazila of Rangamati to the north, Rangunia and Raozan of Chattogram district to the south, Rangamati Sadar and Kaptai Upazila of Rangamati to the east and Fatikchari and Raozan Upazila of Chattogram to the west. The study area encompasses 04 Union i.e., Ghagra, Fatikchari, Kalampati and Betbunia with the total surface area of approximately 339.29 km^2.

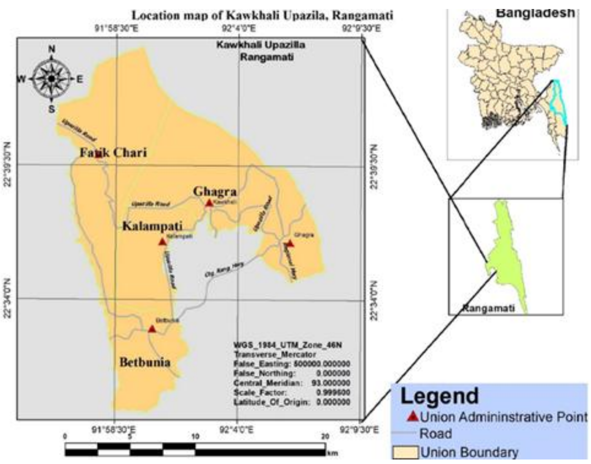

Figure 1, Locations of the study area. (Source: LGED, Bangladesh).

Structure and Tectonics of the Study Area

The folds of the CTFB comprise the youngest structural subdivision of the western flank of the Indo-Burma Ranges (Hossain et al., 2014). The geological studies completed in this western collapsed flank area show that the CTFB has not been grown simultaneously; rather, this fold-thrust belt has grown dynamically toward the west (Hossain et al., 2018). The deformation force of the belt changes from west to east. In the western part of the CTFB, a significant number of folds have been dynamic just from the Late Pliocene or even later (Khan et al., 2018). The CTFB has created linear NNW-SSE to N-S to NNE-SSW oriented doubly plunging folds, which are lined up with the general pattern of the IBR. In view of the shape and folding intensity, Bakhtine (1966) separated the CTFB into three divisions. From east to west, these are eastern highly compacted disturbed zone, center asymmetric thrust faulted zone, and western quite zone.

Methodology

At the beginning of the program, all the baseline studies including the identification of landslide-prone areas with the help of Landsat, Sentinel, and Google Earth images are done. The topographical map of the said Upazila is prepared by analyzing the Sentinel image before the outdoor survey and then every aspect is confirmed in the field survey. Through surface inspection the size, shape, and mass movement of landslides are determined, and samples are collected for analyzing geo-engineering properties. In addition, necessary information is collected through focus group discussions (FGD) among concerned institutions and landslide-prone areas. GIS software was used for different map preparation and analysis. Geographic Information System (GIS), as a computer-based system for data capture, input, manipulation, transformation, visualization, combination, query, analysis, modeling, and output, with its excellent spatial data processing capacity, has attracted great attention in natural disaster assessment (Carrara et al., 1999). Different thematic maps were prepared from different satellite images and validated by checking the landslide point data collected from the field. A landslide hazard zoning map is prepared by applying the Knowledge-based rating and weighting method in GIS.

Geotechnical Data Analysis

Atterberg limit test, hydrometer test, grain size distribution, sieve analysis and direct shear test was executed at the Engineering Geological laboratory of GSB. From the test results obtained from sieve analysis shows that the amount of sand in the sample is 95.84 - 99.51% whereas total amount of silt and clay is 0.49 - 4.13%. From the hydrometer analysis result it is seen that sand particles vary from 0.44 to 58%, silt particles vary from 29.52- 75.10%, and clay particles varies from 4.5- 42.5%. Samples can be categorized as 5 samples are silty sand, 6 samples are sandy silt, and 6 samples are clayey silt depending on the particle sizes present in soil. Average Liquid limit of the review region is 34.9412%, demonstrating the high expansion potential of the soil. In this condition the deformation of the slope is possible and ultimately resulting in the slope being in an unsteady condition. As per the field perception, the original slope and angle of the landslide locales is similarly high, and it differs from 24° to 84° and around 40% of sites have slope angle more than 45°. Results from the direct shear test show that cohesion of sediment taken from landslide destinations is exceptionally low. It changes from 2.41 to 15.56 kPa. This is because of the high level of sand size particles and the nonappearance of conspicuous sand and clay proportions. In addition, internal friction angle estimated at eight distinct landslide destinations shifts from 25.70° to 35.40°.

Acknowledgment

The authors acknowledge the Geo-information for the Implementation of a Climate-Change-Resilient Urbanization (GICU) project, a German–Bangladesh cooperation funded by the Federal Ministry for Economic Cooperation and Development (BMZ) and the Ministry of Power, Energy and Mineral Resources (MPEMR). The project is jointly implemented by the Federal Institute for Geosciences and Natural Resources (BGR) and the Geological Survey of Bangladesh (GSB). The authors sincerely appreciate the valuable support and collaboration provided.

References

Bakhtine, M. I. (1966). Major tectonic features of Pakistan: Part II. The Eastern Province. Science and Industry, 4 (2), 89–100.

Hossain, M. S., Khan, M. S. H., Chowdhury, K. R., and Abdullah, R. (2018). Synthesis of the tectonic and structural elements of the Bengal Basin. In S. Mukherjee (Ed.), Tectonics and Structural Geology: Indian Context (pp. 135–218). Springer International Publishing AG, Cham. https://doi.org/10.1007/978-3-319-99341-6_6

Hossain, M. S., Khan, M. S. H., Chowdhury, K. R., and Afrooz, M. (2014). Morpho-structural classification of the Indo-Burman Ranges and the adjacent regions. In National Conference on Rock Deformation and Structures (RDS-III), Assam, India. Abstract volume, p. 31. https://doi.org/10.13140/RG.2.1.3769.6240

Khan, M. S. H., Hossain, M. S., and Uddin, M. A. (2018). Geology and active tectonics of the Lalmai Hills, Bangladesh – An overview from Chittagong–Tripura Fold Belt perspective. Journal of the Geological Society of India, 92, 713–720. https://doi.org/10.1007/s12594-018-1093-5