Comparative Slope Stability Analysis for Cut Slope of Marble made Terrain of Markhu Formation at Chandram Bhir and Bhaisedobhan Formation at Ghaghare Bhir of Central Nepal

Ujjwal Krishna Raghubansha[1*] and Ranjan Kumar Dahal[1]

[1]Central Department of Geology, Tribhuvan University

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

Abstract: Slope stability is a major concern in mountainous regions, influenced by topography, geology, shear strength, groundwater, and external loads. Internal factors such as rock type, weathering, and geological structures, and external factors like rainfall, melting, earthquakes, and blasting affect slope behavior. Although marble is a hard rock, its jointed nature and chemically reactive minerals make marble terrains highly vulnerable to landslides. The Markhu and Bhaisedobhan Formations, both Proterozoic marble units, have experienced significant rock slides due to discontinuities. Soil thickness, slope angle, and water saturation further control stability. This study compares slope stability characteristics of these two marble formations.

Keywords: ***Slope stability, Marble, Landslide, Geological factors, Soil thickness*****.**

Introduction

Slope stability is the major problem in mountainous countries, either natural or engineered slopes (Abramson et al., 2002). The detailed study of topography, geology, shear strength, groundwater conditions, external loading and plan curvature of the slope are important parameters for slope stability analysis. Slope stability is affected by internal factors such as rock types, weathering, internal behavior of soil and rock, geological structure, etc. and external factors such as rainfall, melting, earthquake, blasting, surcharging of external loads etc. (Koirala and Dahal, 2025; Malla, 2025). Marble is a hard rock but due to excessive joints and the chemical behavior of minerals of Marble, Marble terrain is vulnerable to slope failure issues. Chandram Bhir belongs to Markhu Formation and Ghaghare Bhir belongs to Bhaisedobhan Formation (both Proterozoic Age). Marble is sensitive to chemical weathering and vulnerable to Landslides.

There are numerous rock slides in marble terrain due to discontinuity properties and huge rock slides have also occurred in both terrains. Slope stability analysis of a hillslope as effects of soil thickness depend on the slope angles, the vertical depth of the soil, and saturation of water in soil. The thickness of soil is also a controlling factor of slope stability (Pantha et al., 2025). In this study, comparative study of slope stability is done for two marble rock formations i.e. Markhu Formation and Bhaisedobhan Formation based on geological, geo-mechanical and mineralogical properties.

Methodology

Based on field data, rock mass rating and discontinuity analyses were carried out. Representative samples were collected for petrographic analysis, and laboratory tests were performed to determine key geotechnical parameters. Landslide inventories were prepared to document the spatial distribution and characteristics of slope failures. Using both field observations and laboratory results, a comparative study of slope stability was conducted on terrains underlain by two different marble formations. The study also examined the influence of geological structures and weathering intensity on slope behavior, providing insights into potential landslide susceptibility in the region.

Results

At Chandram Bhir is located at the landform made by earthquake induced landslide forming agglomerate of Marble of Markhu formations. It comprises of very coarse to medium grained marble with more than 95% of calcium carbonate minerals (Table 1). At this part most of the slide mass are found to be recemented forming stable agglomerate slopes. Whereas the Gharghare Bhir is also located at the landform made by earthquake induced landslide on Marble of Bhaisedobhan formations. It comprises of fine to medium grained marble with about 65% of calcium carbonate minerals. At this part recementation process is found to be very negligible and repeated occurrence of slope failures are found.

Conclusions

In the comparative analysis of two Marble Formations i.e. Markhu Formation dominantly consists of coarse to medium-grained calcium carbonate whereas Bhaisedobhan Formation consists of various minerals like pyrites, biotite, quartz and with dominant calcium carbonate (50-90%). Markhu formation consists of about 95% calcium carbonate.

Due to high calcite content, even after the occurrence of landslides disintegrated blocks of marble get recemented as agglomerate in Markhu Formation whereas the disintegrated part of the Bhaisedobhan Marble due to high silica and other minerals content has less cementation and binding processes (Figure 1). There is more vulnerability to landslides in Gharghare Bhir than Chandram Bhir. The Marble terrain along the Kanti Rajpath is composed of various minerals coarse to fine-grained calcite that have variable shape, size, strength and same chemical compositions. The rate of mechanical breakdown and chemical degradation is very high in Marble as compared to other metamorphic rocks in its vicinity. There are numerous uphill and downhill slope failures along the cut slopes of the Kanti Rajpath at Gharghare Bhir.

Table 1, Comparison of geotechnical parameters of two rock formations.

Parameters	Density (g/cc)	Water Absorption (%)	Porosity (%)	UCS (MPa)	Cohesion (MPa)	Friction Angle	Modulus of Elasticity (GPa)	Poisson's Ratio	Rock Type
Markhu Formation	2.91	0.33	0.01	90	0.44	42	31.45	0.2	Bluish white, thickly bedded, highly jointed, non-foliated, coarse-grained marble.
Bhaisedobhan Marble	2.67	0.23	0.37	77.7	0.21	40.17	28.72	0.22	Light to dark grey, thin to medium bedded, fine to coarse grained, highly jointed and foliated.

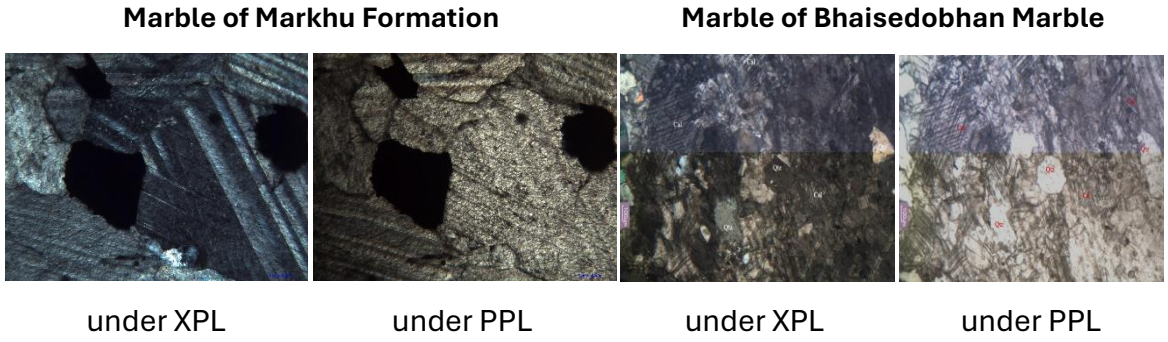

Figure 1, Microscope view of marble under XPL and PPL.

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