Rock Cut Slope Stability Analysis Using Slope Mass Rating and Kinematics Analysis along Kanti Rajpath from Kalche to Chapeli, Central Nepal

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Abstract: Cut slopes along the Kanti Rajpath between Kalche and Chapeli are prone to monsoon-triggered instability. Sixteen representative slopes were analyzed using Rock Mass Rating (RMR), Slope Mass Rating (SMR), and kinematic assessments. Predominantly schist with interbedded quartzite and granite, the slopes exhibit moderate to high weathering. Findings reveal a mix of stable and unstable conditions, with multiple potential failure mechanisms. The study proposes prioritized mitigation measures, including drainage, scaling, reinforcement, and monitoring.

Keywords: ***RMR, SMR. Kinematics, Slope.***

Introduction

The Kanti Rajpath, a vital mountain highway in central Nepal, traverses' terrain characterized by steep slopes and complex geological conditions. During the monsoon, heavy rainfall frequently triggers instability in road-cut slopes, posing risks to traffic safety and infrastructure integrity. This study provides a concise engineering geological evaluation of sixteen representative cut slopes between Kalche and Chapeli, aiming to quantify stability, identify potential failure mechanisms, and recommend risk-reduction strategies.

Geological and Geotechnical Setting

The road cuts predominantly expose schist with interbedded quartzite and occasional granite intrusions. Weathering is moderate to high, influencing rock-mass strength and deformation behavior. Structural features, including foliation, joints, and fractures, control potential failure modes. Slope heights vary between 8 and 22 meters, with inclination angles ranging from 45° to 70°, creating a complex interaction between intrinsic rock quality and geometric factors affecting stability.

Methodology

The engineering geological analysis combined three complementary approaches:

Rock Mass Rating (RMR)

Quantifies rock-mass quality based on uniaxial compressive strength, rock quality designation, spacing and condition of discontinuities, groundwater conditions, and slope orientation.

Slope Mass Rating (SMR)

Adjusts RMR for slope orientation and kinematics to assess stability more realistically.

Kinematic Analysis

Evaluates potential failure mechanisms, including planar, wedge, and toppling modes, based on the orientation of discontinuities relative to the slope.

Results

RMR classification indicates that 50% of slopes fall in the ‘good rock’ category (RMR 61–80), while the other 50% are ‘fair’ (RMR 41–60). SMR results show a broader spectrum: approximately 6% are completely stable, 50% stable, 31% partially stable, and 12% unstable to critically unstable. Kinematic analysis highlights multiple susceptibility types: planar failure 38%, toppling 31%, and wedge 31%. The discrepancies between RMR and SMR results emphasize the controlling influence of structural orientation and slope geometry beyond inherent rock-mass quality.

Discussion

The combination of RMR, SMR, and kinematic analysis allows identification of slopes requiring urgent attention. Stable slopes require routine maintenance, while partially stable and unstable slopes need targeted interventions. Recommended measures include:

- Improving drainage to reduce pore-water pressure during monsoon.
- Scaling to remove loose or potentially hazardous rock blocks.
- Selective reinforcement using rock bolts, anchors, or retaining structures.
- Continuous monitoring to detect early signs of instability.

Conclusion

The study demonstrates that slope stability along Kanti Rajpath is governed not only by rock-mass quality but also by structural orientation and slope geometry. Implementation of prioritized mitigation measures can enhance safety and reduce maintenance costs on this important mountain route.

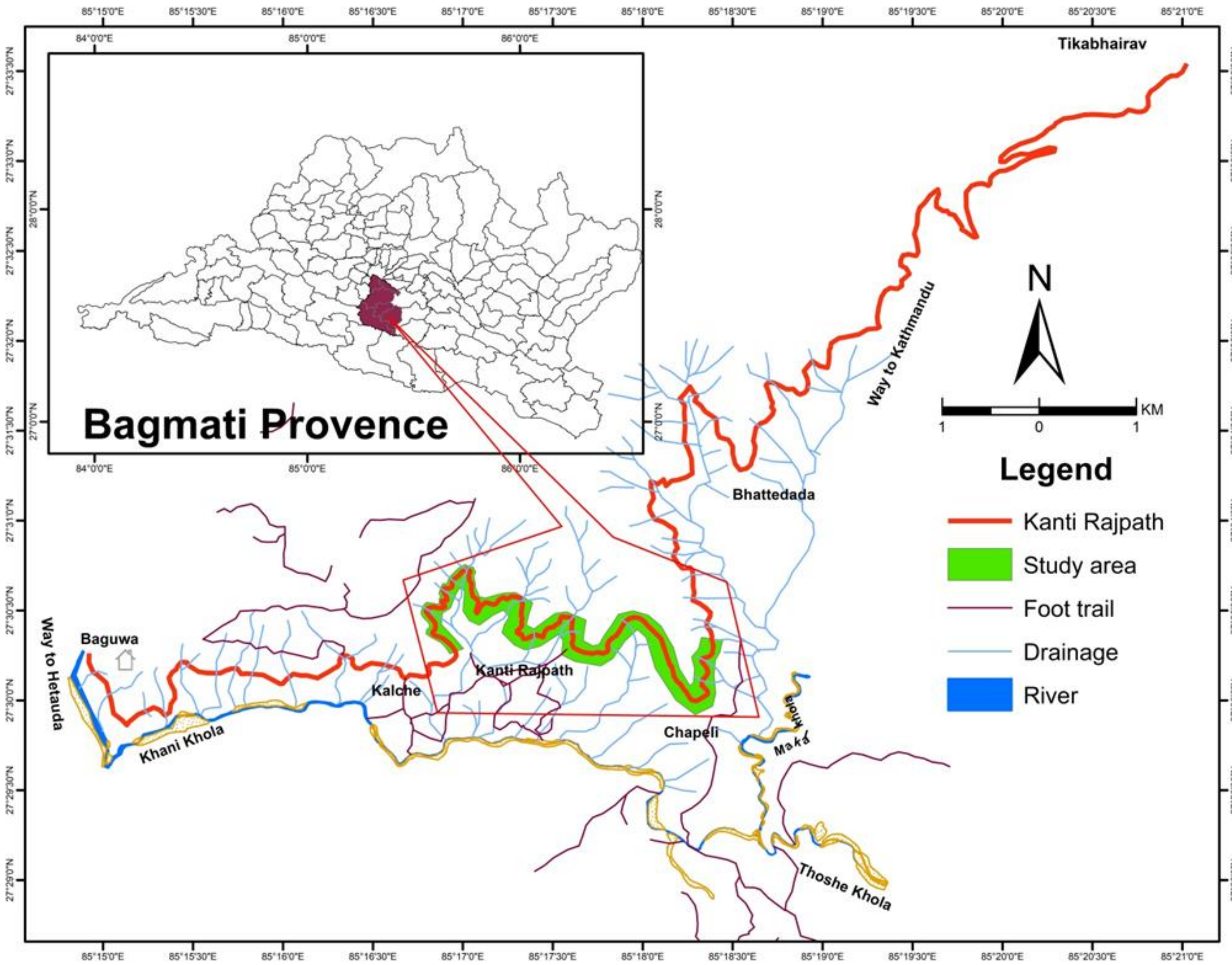

Figure 1, Study area map of Kanti Rajpath.