A Review of Landslide Hazard Mapping and Development of Rockfall Hazard Rating System along CPEC Route in Northern Pakistan

Muhammad Farooq Ahmed[1], and Ehtesham Mehmood[2]
[1]*Department of Geological Engineering,*
[2]*Department of Civil Engineering, UET, Lahore, Pakistan*
[*]*Email: mfageo@uet.edu.pk*

The Karakorum Highway (KKH) serves as a vital transportation link between China and Pakistan, traversing some of the world's most challenging terrain, characterized by complex geological forces including crustal closure, forcing compression, tectonic uplift, and fragile geological settings. Consequently, this region is prone to significant rock avalanches, deep-seated bedrock slides, and rockfall activities, posing potentially destructive consequences. Thus, conducting comprehensive studies on landslide hazard mapping and slope failure assessment is crucial for effective hazard mitigation. Initial efforts aimed at developing a comprehensive indigenous rockfall hazard and rating system along the KKH. Regional-level hazard maps, incorporating landslide inventories and susceptibility assessments, were prepared as a foundational step towards this endeavor. Utilizing anomalous topographic protocols and hillshade maps, the hazard mapping exercise effectively delineated various types of landslide-related features, including landslide complexes, translational bedrock slides, retrogressive slumps, and rock avalanches. These regional-level hazard maps laid the groundwork for the development of an indigenous rockfall hazard rating system covering a 285 km section from Thakot to Raikot bridge. The area was subdivided into 129 smaller sections based on local geological settings and rockfall potential. Field visits facilitated the measurement and estimation of various parameters to refine the Pierson (2005) model and develop a Rockfall Hazards Rating System tailored to the region's conditions. This modified version incorporated a novel parameter and upgrades from the Pierson model, as well as additional parameters from other rockfall hazard rating systems, reflecting local site conditions. The developed hazard maps demonstrated compliance with local site conditions and were deemed satisfactory for the selected areas. Additionally, a separate prediction

model was formulated for high-hazard sites in the Tatta Pani area, leveraging extensive laboratory testing and field validation exercises to predict rainfall-triggered rockfall. High-risk road sections were identified to prepare local risk maps and design safety barriers against rockfall hazards. This comprehensive study represents the initial step towards establishing an indigenous rockfall hazard rating system. Its aim is to assist local authorities in implementing cost-effective and sustainable mitigation measures for vulnerable rockfall hazard zones, while also formulating guidelines for an early warning system to mitigate associated risks.