An Unfortunate Rock Slope Failure at Torkham Border Facilities: Some Overlooked Facts, Stability Evaluation, and Remediation

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On April 18, 2023, a massive rockslide occurred, burying a long queue of containers awaiting clearance at the Pakistan-Afghan border crossing. The rockslide resulted in the displacement of over 40,000 cubic meters of debris, burying 28 containers and tragically claiming the lives of 13 individuals. Additionally, the newly constructed road and bridge infrastructure sustained damage. This incident unfolded along a recently established road segment, spanning approximately 140 meters with a maximum elevation of 70 meters. The event prompted concerns regarding the stability of adjacent rock slopes sharing similar geological characteristics. Consequently, a comprehensive site investigation was conducted in July 2023 to assess the condition of the neighboring rock slopes and ascertain the underlying causes of the failure, which could pose risks to adjacent areas. The investigation encompassed engineering geological mapping, discontinuity surveys, geotechnical explorations, and laboratory testing to determine reliable parameters for subsequent stability assessments. Kinematic analysis revealed a predominant plane failure mode in the rock slope instability, attributable to unfavorable joint orientations concerning the cut slope. Specifically, the limestone beds exhibited a steep dip towards the slope face, juxtaposed with a near-vertical cut at the toe, predisposing the slope to substantial plane failures, particularly during periods of heavy rainfall. The failed slope served as crucial evidence informing subsequent analyses. Back-analysis of the failed slope was undertaken to validate and extrapolate parameters for the forward assessment of adjacent slopes. Subsequent limit-equilibrium analyses were performed under both flooded and seismic loading scenarios, revealing marginal Factor of Safety (FOS) values

insufficient to ensure long-term slope stability. Consequently, measures such as rock reinforcement and construction of retaining walls were incorporated into the analyses, resulting in satisfactory FOS values. Based on the analysis outcomes, recommendations were made for stabilization measures, including the installation of 6-8-meter-long rock bolts at 3-meter intervals, equipped with weep holes, alongside the construction of rubble concrete retaining walls. These stabilization measures are presently undergoing implementation to mitigate risks associated with slope instability.