Mine dump slope stability and failure behaviour analysis under geo-mining condition using hybrid numerical modelling

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Dump slope stability and failure behaviour analysis under actual geo-mining conditions is tedious for mining engineers. Therefore, the present study presents a novel hybrid numerical modelling for dump slope stability and failure behaviour analysis, from initiation and transport to overburden (OB) deposition. Mixed and broken material matrix slope stability was analysed using finite discrete element method (FDEM). The present study used absorbing boundary conditions under gravity force. The shear strength reduction approach was used for slope strength analysis. Newton's second law is incorporated to simulate rock boulder kinematics accurately during the progressive failure. The results of the present study indicate that hybrid numerical modelling can evaluate dump stability and simulate the complete failure process, including crack initiation, propagation in slope, failure surface, OB transport and deposition. Finally, the role of mixed materials (soil and rock boulders) in the dump slope stability and failure behaviour was analysed. FDEM is a powerful visualisation tool for solving a numerical model under real geo-mining conditions. This will be helpful for the safe working distance analysis from the dump slope toe.

Keywords: Geo-mining condition, hybrid numerical modelling, mine dump, progressive failure, slope stability.

failure cases were reported in India, resulting in the loss of miner's lives and machinery stuck in debris flow (Figure 1). Dump slope stability plays a vital role in sustainable mining practices. Therefore, the broken and discrete material slope stability analysis is essential for optimum geometry parameters design and failure mitigation.

Limit equilibrium analysis is widely employed for the mine OB dump slope factor of safety (FOS) calculation[4,5]. However, many researchers have conducted exhaustive studies related to mine dump slope failure mechanism analysis, deformation and FOS assessment[6], parametric studies for dragline dump[7] and the role of the weak ground floor[8]. Various modelling approaches have been used for the dump slopes stability evaluation and deformation analysis, such as finite element method (FEM)[9], finite difference method (FDM)[10], and discrete element method (DEM)[11]. Chand and Koner[12] used the limit equilibrium method (LEM) integrated with the Monte Carlo approach for the dump slope failure probability analysis. Mohanty *et al.*[13] used universal distinct element code (UDEC) to analyse the dump slope stability. The particle flow code simulation approach was used for the dump slope displacement and failure behaviour analysis under static and dynamic loading[11,14]. The limitation of the particle flow code-based simulation approach is each particle will be