SARI

Kestabilan lereng merupakan salah satu aspek kritis dalam operasi tambang terbuka, karena kegagalan lereng dapat mengganggu keselamatan kerja, aktivitas produksi, serta keberlanjutan operasional tambang. Penelitian ini bertujuan untuk mengevaluasi kestabilan lereng pada area penambangan Pit "Z", PT Bukit Asam Tbk, berdasarkan karakteristik geologi dan geoteknik material penyusun lereng, serta menilai tingkat risiko kelongsoran melalui pendekatan deterministik dan probabilistik. Penelitian dilakukan melalui integrasi data geologi, data bor, hasil pengujian laboratorium dan lapangan, penilaian kualitas massa batuan menggunakan *Geological Strength Index* (GSI), serta data muka air tanah dari sumur pantau. Tujuh penampang geoteknik disusun pada seluruh sisi lereng aktif untuk merepresentasikan kondisi geometri aktual. Analisis kestabilan lereng dilakukan menggunakan metode kesetimbangan batas untuk memperoleh nilai Faktor Keamanan (FK), serta analisis probabilistik berbasis simulasi Monte Carlo untuk menghitung Probabilitas Kelongsoran (PK), dengan kriteria evaluasi mengacu pada Kepmen ESDM nomor 1827 (2018). Hasil analisis menunjukkan sebagian besar lereng berada pada kategori aman hingga menengah, namun dua segmen utama yaitu penampang A–A' (*lowwall*) dan G–G' (*highwall*) berada pada kondisi kritis dengan FK rendah (1,114 dan 0,998) serta PK tinggi (30,95% dan 41,28%). Kondisi ini dipengaruhi oleh kondisi litologi yang mengalami pelapukan, bidang diskontinuitas, serta tekanan air pori yang tinggi. Perbaikan geometri lereng melalui pelandaian, pembentukan jenjang, dan penambahan *berm* pengaman berhasil meningkatkan FK menjadi 1,524 dan 1,333, serta menurunkan PK menjadi 10,03% dan 3,55%. Hasil penelitian menegaskan bahwa pendekatan kombinasi deterministik dan probabilistik memberikan gambaran risiko yang lebih realistis dan komprehensif untuk menentukan desain geometri lereng yang aman, efisien, dan berkelanjutan pada operasi tambang terbuka.

Kata kunci: Kestabilan lereng, tambang terbuka, Faktor Keamanan, Probabilitas Kelongsoran, Monte Carlo

ABSTRACT

Slope stability is one of the most critical aspects in open-pit mining operations, as slope failures can disrupt workers safety, production activities, and overall operational continuity. This study aims evaluates the stability of slopes in Pit "Z", PT Bukit Asam Tbk. based on the geological and geotechnical characteristics of slope-forming materials, as well as to assess landslide risk using deterministic and probabilistic approaches. The analysis was conducted through the integration of geological data, borehole data, laboratory and field test results, rock mass quality assessment using the Geological Strength Index (GSI), and groundwater level data obtained from monitoring wells. In total, seven geotechnical cross-sections were constructed across all active slopes to represent the actual slope geometry. Deterministic analysis using the Limit Equilibrium Method was performed to obtain the Factor of Safety (FoS), while probabilistic analysis using Monte Carlo simulations was used to estimate the Probability of Failure (PoF). The evaluation criteria follow the guidelines from the Regulation of the Minister of Energy and Mineral Resources number 1827 (2018). The results show that most slopes fall within the safe to moderate category, however, two critical sections, A–A' (lowwall) and G–G' (highwall), exhibited low FoS values (1.114 and 0.998) and high PoF values (30.95% and 41.28%). These conditions are primarily influenced by weathered lithology, the presence of discontinuities, and elevated pore-water pressure. Slope improvements through cutback, bench reconstruction, and the addition of safety berms successfully increased the FoS to 1.524 and 1.333, and reduced the PoF to 10.03% and 3.55%, respectively. The results highlight that combining deterministic and probabilistic approaches provides a more realistic and comprehensive understanding of slope behavior and risk. This integrated approach is essential for determining safe, efficient, and sustainable slope geometry designs for open-pit coal mining operations.

Keywords: *slope stability, open-pit mine, Factor of Safety, Probability of Failure, Monte Carlo*