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Pengaruh Derajat Kejenuhan terhadap Stabilitas Lereng Highwall Tambang Batu Bara Berdasarkan Pendekatan Deterministik dan Probabilistik
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INTISARI

Kestabilan lereng *highwall* tambang batu bara sangat dipengaruhi oleh keberadaan air atau derajat kejenuhan (Sr) yang menurunkan kekuatan geser batuan dan memicu kelongsoran. Penelitian ini mengevaluasi kualitas massa batuan, menganalisis dampak perubahan Sr terhadap stabilitas desain awal lereng ditinjau dari *Factor of Safety* (FS) dan *Probability of Failure* (PF), serta merumuskan rekomendasi geometri aman sesuai standar KEPMEN ESDM No. 1827 K/30/MEM/2018 di Luwe Hulu, Kalimantan Tengah. Metode penelitian meliputi klasifikasi massa batuan menggunakan *Rock Quality Designation* (RQD), *Rock Mass Rating* (RMR), dan *Geological Strength Index* (GSI). Analisis stabilitas dimodelkan pada software berbasis *Limit Equilibrium Method* dengan pendekatan deterministik dan probabilistik menggunakan kriteria keruntuhan Mohr-Coulomb serta Generalized Hoek-Brown. Hasil klasifikasi menunjukkan kualitas massa batuan secara umum tergolong sangat baik, didominasi oleh kelas *Excellent* (RQD) dan *Good* (RMR). Litologi *coal* dan *claystone* teridentifikasi sebagai lapisan terlemah yang berpotensi menjadi bidang gelincir. Pada kondisi Sr aktual, desain awal lereng terbukti aman. Namun, pada skenario peningkatan Sr sebesar 20%, kestabilan lereng menurun drastis hingga gagal (FS < 1) dengan probabilitas kelongsoran (PF) melonjak mencapai 82,76% hingga 98,61% akibat tingginya sensitivitas lapisan *silt* dan *claystone* terhadap air. Guna menanggulangi potensi kegagalan, direkomendasikan rekayasa geometri dengan mengurangi tinggi bench pada material tanah *silt* dan *clay* dari 10 meter menjadi 5 meter, serta melandaikan sudut lereng keseluruhan (*overall slope angle*) dari 34° dan 32° menjadi 18° dan 15° pada masing-masing sayatan. Evaluasi geometri rekomendasi membuktikan lereng berhasil mencapai kondisi aman yang disyaratkan regulasi, yaitu FS statis > 1,3, FS dinamis > 1,1, serta PF ditekan di bawah 5% meskipun pada kondisi ekstrem Sr +20% dan beban gempa.

Kata kunci: derajat kejenuhan, kestabilan lereng highwall, klasifikasi massa batuan, *Factor of Safety* (FS), *Probability of Failure* (PF).

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ABSTRACT

The stability of coal mine highwall slopes is strongly influenced by the presence of water or the degree of saturation (Sr), which reduces rock shear strength and triggers slope failure. This study evaluates rock mass quality, analyzes the effect of changes in Sr on the stability of the initial slope design in terms of Factor of Safety (FS) and Probability of Failure (PF), and formulates safe geometry recommendations in accordance with KEPMEN ESDM No. 1827 K/30/MEM/2018 in Luwe Hulu, Central Kalimantan. Rock mass classification was conducted using Rock Quality Designation (RQD), Rock Mass Rating (RMR), and Geological Strength Index (GSI). Stability analysis was modeled using Limit Equilibrium Method-based software with deterministic and probabilistic approaches, applying the Mohr-Coulomb and Generalized Hoek-Brown failure criteria. Results show that rock mass quality is generally very good, dominated by the Excellent (RQD) and Good (RMR) classes, while coal and claystone were identified as the weakest layers with potential to act as slip surfaces. Under actual Sr conditions, the initial slope design proved stable. However, under a 20% increase in Sr, slope stability decreased drastically to failure (FS < 1), with PF rising sharply to 82.76%–98.61%, reflecting the high sensitivity of silt and claystone to water. To mitigate this, a geometric redesign is recommended: reducing bench height in silt and clay materials from 10 m to 5 m, and flattening the overall slope angle from 34° and 32° to 18° and 15°. The recommended geometry successfully achieves the required safety criteria static FS > 1.3, dynamic FS > 1.1, and PF below 5% even under extreme Sr +20% and seismic loading conditions.

Keywords: degree of saturation, highwall slope stability, rock mass classification, Factor of Safety (FS), Probability of Failure (PF).