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Analisis Pengaruh Sistem Pelapisan Tanah SC dan SM terhadap Stabilitas Lereng Timbunan Disposal Tambang
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ABSTRAK

Kegiatan penambangan terbuka (*open-pit mining*) menghasilkan material tanah penutup dalam jumlah besar yang harus ditimbun pada area *disposal*. Stabilitas lereng *disposal* menjadi aspek penting karena berkaitan dengan keselamatan kerja dan keberlangsungan operasi penambangan. Material penyusun timbunan pada kondisi lapangan umumnya bersifat heterogen, sedangkan analisis stabilitas lereng sering mengasumsikan material yang homogen. Perbedaan tersebut dapat memengaruhi perilaku lereng, terutama dalam pembentukan bidang gelincir. Penelitian ini bertujuan menganalisis pengaruh penerapan sistem *soil layering* menggunakan tanah SC (*clayey sand*) dan SM (*silty sand*) terhadap stabilitas lereng timbunan *disposal*.

Penelitian diawali dengan pengujian karakteristik tanah yang meliputi kadar air, batas Atterberg, berat jenis, distribusi ukuran butir, dan *California Bearing Ratio* (CBR). Berdasarkan klasifikasi *Unified Soil Classification System* (USCS), Sampel F termasuk tanah SC dan Sampel B termasuk tanah SM. Selanjutnya dilakukan *soil mixing* untuk memperoleh komposisi campuran optimum. Analisis stabilitas lereng dilakukan menggunakan metode elemen hingga dua dimensi (*Finite Element Method/FEM*) dengan model Mohr-Coulomb pada kondisi *undrained*. Simulasi dilakukan secara *staged construction* pada lereng setinggi 40 m dengan variasi sudut lereng 30° dan 25°.

Hasil penelitian menunjukkan bahwa komposisi FB 6.4 (60% SC : 40% SM) merupakan campuran optimum dengan nilai CBR *soaked* sebesar 9,19%, meningkat dibandingkan Tanah F sebesar 3,57%. Pada analisis stabilitas lereng, kondisi eksisting mengalami *collapse* pada elevasi +30 m. Modifikasi geometri dengan sudut lereng 25° tanpa sistem pelapisan hanya mampu menunda *collapse* hingga elevasi +37 m. Penerapan sistem *soil layering* pada sudut lereng 30° menghasilkan nilai *Factor of Safety* (FoS) sebesar 1,163, sedangkan kombinasi sistem *soil layering* dan modifikasi geometri pada sudut lereng 25° menghasilkan nilai FoS sebesar 1,343 sehingga memenuhi kriteria desain minimum (>1,3). Selain meningkatkan faktor keamanan, sistem pelapisan tanah juga mengubah lintasan bidang gelincir ke zona dengan kuat geser yang lebih tinggi. Dengan demikian, sistem *soil layering* berpotensi menjadi alternatif yang efektif untuk meningkatkan stabilitas lereng *disposal* pada pertambangan terbuka.

Kata Kunci : Pelapisan tanah, Stabilitas lereng, Timbunan disposal, Penimbunan berlapis.

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ABSTRACT

Open-pit mining operations generate large volumes of overburden material that must be placed in disposal areas. Disposal slope stability is a critical aspect as it directly affects occupational safety and the continuity of mining operations. In practice, disposal materials are generally heterogeneous, whereas conventional slope stability analyses often assume homogeneous material conditions. This discrepancy may influence slope behavior, particularly in the development of critical slip surfaces. This study aims to analyze the effect of applying a soil layering system using SC (clayey sand) and SM (silty sand) soils on the stability of disposal slopes.

The study began with laboratory testing to determine the soil characteristics, including water content, Atterberg limits, specific gravity, particle size distribution, and California Bearing Ratio (CBR). Based on the Unified Soil Classification System (USCS), Sample F was classified as SC soil, while Sample B was classified as SM soil. Subsequently, a soil mixing process was carried out to obtain the optimum mixture composition. Slope stability analysis was performed using the two-dimensional Finite Element Method (FEM) with the Mohr-Coulomb constitutive model under undrained conditions. Simulations were conducted using a staged construction approach on a 40 m high slope with slope angles of 30° and 25°.

The results indicate that the FB 6.4 mixture (60% SC : 40% SM) was the optimum composition, producing a soaked CBR value of 9.19%, compared with 3.57% for Soil F. The existing slope condition experienced collapse at an elevation of +30 m. Geometric modification by reducing the slope angle to 25° without a soil layering system only delayed the collapse until an elevation of +37 m. The application of the soil layering system at a 30° slope angle resulted in a Factor of Safety of 1.163, while the combination of soil layering and geometric modification at a 25° slope angle produced the highest FoS of 1.343, meeting the minimum design criterion (>1.3). In addition to improving the safety factor, the soil layering system altered the critical slip surface toward zones with higher shear strength. Therefore, the proposed soil layering system has the potential to serve as an effective alternative for improving disposal slope stability in open-pit mining.

Keywords: *Soil layering, slope stability, disposal embankment, layered dumping.*