

Perbandingan Desain Rencana dan Alternatif Desain Perlindungan Kaki Lereng Timbunan pada *Overpass Abutment Ramp 3 Junction STA 3+550* Proyek Pembangunan Jalan Tol Yogyakarta-Solo Seksi 2.2.

INTISARI

Pembangunan Jalan Tol Yogyakarta–Solo Seksi 2.2 *Ramp 3 Junction STA 3+550* membutuhkan perlindungan kaki lereng timbunan yang andal untuk menjaga stabilitas *overpass abutment*. Desain eksisting menggunakan dinding penahan tanah tipe kantilever beton bertulang. Struktur tersebut mampu menahan tekanan tanah, tetapi membutuhkan biaya konstruksi relatif tinggi. Penelitian ini bertujuan menghitung alternatif desain berupa dinding penahan tanah tipe gravitasi berbahan batu kali dengan memperhatikan aspek teknis, stabilitas struktur, serta efisiensi biaya. Analisis dilakukan melalui perhitungan statis konvensional dan pemodelan numerik dua dimensi menggunakan metode elemen hingga (*Finite Element Method/FEM*). Data yang digunakan berasal dari hasil uji tanah, parameter desain dalam dokumen DED, serta kondisi geometri eksisting. Evaluasi stabilitas mencakup faktor keamanan terhadap geser, guling, dan daya dukung tanah.

Hasil perhitungan statis menunjukkan tipe kantilever memiliki faktor keamanan geser 2,47, guling 3,89, dan daya dukung tanah 3,38. Tipe gravitasi menunjukkan nilai lebih tinggi dengan geser 2,61, guling 4,49, dan daya dukung tanah 3,72. Analisis FEM memperlihatkan pada fase setelah konstruksi, kantilever memiliki faktor keamanan sebesar 1,99, sedangkan gravitasi mencatat nilai 2,10. Pada kondisi gempa, kantilever menunjukkan faktor keamanan 1,16, sementara gravitasi mencapai 1,21. Keduanya memenuhi persyaratan faktor keamanan minimum, dengan tipe gravitasi lebih unggul pada stabilitas guling dan daya dukung tanah, sedangkan kantilever memberikan deformasi yang relatif lebih kecil.

Evaluasi biaya konstruksi menunjukkan perbedaan signifikan. Pembangunan dinding penahan tanah tipe kantilever memerlukan biaya Rp106.260.706,70, sedangkan tipe gravitasi hanya Rp45.430.069,62. Selisih biaya yang besar memperlihatkan bahwa tipe gravitasi lebih efisien secara ekonomi. Pertimbangan teknis dan ekonomis menegaskan bahwa tipe gravitasi dapat dipilih sebagai alternatif desain perlindungan kaki lereng timbunan pada proyek ini. Hasil penelitian diharapkan menjadi referensi untuk pengambilan keputusan desain struktur penahan tanah pada proyek infrastruktur serupa.

Kata kunci: dinding penahan tanah, tipe kantilever, tipe gravitasi, stabilitas lereng, FEM 2D, efisiensi biaya.

***Comparison of Planned and Alternative Slope-Foot Protection Designs for the
Overpass Abutment Ramp 3 Junction STA 3+550, Yogyakarta–Solo Toll Road***

Section 2.2.

ABSTRACT

The construction of the Yogyakarta–Solo Toll Road Section 2.2 Ramp 3 Junction STA 3+550 requires reliable slope-foot protection to ensure the stability of the overpass abutment. The existing design employs a reinforced concrete cantilever retaining wall. While this structure is capable of resisting lateral earth pressures, it involves relatively high construction costs. This study aims to evaluate an alternative design using a gravity retaining wall made of stone masonry by considering technical performance, structural stability, and cost efficiency. The analysis was carried out through conventional static calculations and two-dimensional numerical modeling using the Finite Element Method (FEM). The input data were derived from soil investigation results, design parameters in the Detailed Engineering Design (DED), and the existing geometric conditions. Stability evaluation focused on safety factors against sliding, overturning, and soil bearing capacity.

The results of the static calculation indicate that the cantilever wall achieves a sliding safety factor of 2.47, overturning of 3.89, and soil bearing capacity of 3.38. The gravity wall demonstrates higher values, with sliding at 2.61, overturning at 4.49, and soil bearing capacity at 3.72. FEM analysis shows that after construction, the cantilever wall records a safety factor of 1.99, while the gravity wall reaches 2.10. Under seismic loading, the cantilever wall achieves a safety factor of 1.16 compared to 1.21 for the gravity wall. Both alternatives satisfy the minimum stability requirements, with the gravity wall performing better in terms of overturning and soil bearing capacity, whereas the cantilever wall provides slightly smaller deformations.

The cost evaluation highlights a substantial difference between the two alternatives. The construction of a cantilever retaining wall requires Rp106,260,706.70, whereas the gravity wall requires only Rp45,430,069.62. This significant cost gap demonstrates that the gravity wall is more economically efficient. Considering both technical and economic aspects, the gravity retaining wall can be recommended as an alternative design for slope-foot protection in this project. The findings are expected to serve as a useful reference for decision-making in the design of retaining structures for similar infrastructure projects.

Keywords: retaining wall, cantilever type, gravity type, slope stability, FEM 2D, cost efficiency.