ANALISIS VARIASI TEBAL TANAH LUNAK TERHADAP *NEGATIVE SKIN FRICTION* FONDASI TIANG PANCANG MENGGUNAKAN METODE ANALITIK DAN METODE ELEMEN HINGGA

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ABSTRAK

Fondasi tiang pancang yang dibangun pada tanah lunak berpotensi mengalami *negative skin friction* (NSF) akibat terjadinya penurunan tanah yang lebih besar dibandingkan penurunan tiang. Kondisi tersebut menyebabkan timbulnya gaya gesek negatif pada selimut tiang yang bekerja sebagai beban tambahan aksial (dragload), sehingga dapat mengurangi kapasitas daya dukung efektif fondasi. Penelitian ini bertujuan untuk mengevaluasi pengaruh variasi ketebalan tanah lunak terhadap besarnya NSF, posisi titik netral (*neutral plane*), dan kapasitas daya dukung aksial tiang pancang. Analisis dilakukan berdasarkan data investigasi tanah dari beberapa titik bor dengan ketebalan lapisan tanah lunak berkisar antara 11 m hingga 15 m. Pendekatan yang digunakan meliputi metode analitik dan metode elemen hingga. Metode analitik digunakan untuk memperkirakan nilai NSF, kedalaman titik netral, dan kapasitas daya dukung berdasarkan formulasi teoritis, sedangkan metode elemen hingga digunakan untuk mensimulasikan perilaku tanah dan interaksi tanah–tiang dengan mempertimbangkan pengaruh deformasi, distribusi tegangan, serta proses konsolidasi tanah. Hasil analisis menunjukkan bahwa peningkatan ketebalan lapisan tanah lunak cenderung meningkatkan besarnya penurunan titik netral, sehingga nilai NSF yang bekerja pada tiang juga mengalami peningkatan. Konsekuensinya, kapasitas daya dukung efektif fondasi mengalami penurunan. Selain itu, kedalaman titik netral yang diperoleh dari metode elemen hingga berada pada kisaran 1,23–1,32 kali panjang lapisan tanah yang mengalami konsolidasi (Lc), lebih dalam dibandingkan hasil metode analitik yang menggunakan pendekatan 0,75Lc. Perbedaan tersebut menunjukkan bahwa analisis numerik mampu menggambarkan mekanisme interaksi tanah–tiang secara lebih rinci sehingga memberikan hasil yang lebih representatif terhadap kondisi lapangan.

Kata Kunci: Daya Dukung Aksial, Metode Elemen Hingga, *Negative Skin Friction*, Tanah Lunak, Titik Netral

ANALYSIS OF THE EFFECT OF SOFT SOIL THICKNESS VARIATION ON NEGATIVE SKIN FRICTION OF PILE FOUNDATIONS USING ANALYTICAL AND FINITE ELEMENT METHODS

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ABSTRACT

Pile foundations constructed on soft ground are susceptible to negative skin friction (NSF) due to the occurrence of soil settlement exceeding pile settlement. This condition induces negative shaft resistance acting as an additional axial load (dragload), which may reduce the effective bearing capacity of the foundation. This study aims to evaluate the influence of soft soil thickness variation on NSF, neutral plane depth, and axial bearing capacity of pile foundations. The analysis was carried out using subsurface investigation data obtained from several boreholes with soft soil thicknesses ranging from 11 m to 15 m. Both analytical and finite element approaches were employed in this study. The analytical method was used to estimate NSF, neutral plane depth, and bearing capacity based on theoretical formulations, while the finite element method was applied to simulate soil behavior and pile–soil interaction by considering deformation characteristics, stress redistribution, and consolidation effects. The analysis results show that an increase in the thickness of the soft soil layer tends to increase the magnitude of the neutral point settlement, causing the NSF value acting on the pile to also increase. Consequently, the effective bearing capacity of the pile foundation decreases. Furthermore, the neutral plane predicted by the finite element analysis was found to be located at approximately 1.23–1.32 times the thickness of the consolidating soil layer (Lc), which is deeper than the value estimated by the analytical approach of 0.75Lc. These findings suggest that numerical analysis provides a more detailed representation of pile–soil interaction mechanisms and yields result that are more representative of actual field conditions.

Keywords: *Axial Bearing Capacity, Finite Element Method, Negative Skin Friction, Neutral Plane, Soft Soil.*