INTEGRATION OF GEOTECHNICAL DATA AND 3D MODELING FOR STRATIGRAPHIC ANALYSIS IN A BREAKWATER AREA

(Case Study: Raja Kecik Beach, Bengkalis Regency)

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ABSTRACT

Raja Kecik Beach, directly facing the Malacca Strait, encounters severe coastal erosion threats, prompting the construction of a rubble-mound breakwater structure as a mitigation measure. The stability of this coastal protection structure heavily depends on the bearing capacity and subsurface soil stratigraphic conditions. This study aims to analyze the physical properties, soil acidity (pH), and micro-morphology of the subsoil, reconstruct topographies and 3D block stratigraphic models, and evaluate their impacts on breakwater foundation stability. Geotechnical investigations were conducted through hand boring at 9 station points (BH-01 to BH-09) with a penetration depth of 0.0–2.5 meters, in-situ soil pH measurements, and digital microscopic analysis using ImageJ based on the Wentworth Scale. Surface topographic mapping was executed via UAV Drone aerial photogrammetry (Agisoft Metashape), while the 3D stratigraphic block modeling was developed using RockWorks 17. Laboratory results revealed that the upper layer (0.0–0.8 m) in the open beach area is dominated by fine sand (d = 0.18–0.21 mm, circularity 0.72–0.75), whereas the subsurface deeper than 1.0 m is continuously dominated by soft clay (d < 0.0039 mm, circularity 0.38–0.41). Soil pH values ranged from 3.90–4.90 (strongly acidic) in the mangrove zone to 6.90–7.60 (neutral to weakly alkaline) in the marine zone. The 3D RockWorks 17 model demonstrated that the soft clay layer is thick and continuous beneath the entire breakwater footprint zone. These conditions indicate a high risk of differential settlement and limited shear bearing capacity of the subsoil, necessitating ground improvement techniques, such as geotextile reinforcement, to ensure the long-term sustainability of the breakwater structure.

***Keywords**: 3D Stratigraphy, Breakwater, Geotechnics, Hand Boring, ImageJ, Raja Kecik Beach, RockWorks 17.*