Ph.D. DISSERTATION DEFENSE

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Title:	Monopiles in sloping sandy ground under scour condition
Chairperson:	Dr. Raju Datla, Department of Civil, Environmental and Ocean Engineering, Charles V. Schaefer, Jr. School of Engineering and Science
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ABSTRACT

Offshore wind farms play a pivotal role in the renewable energy sector, yet the stability of their monopile foundations is challenged by scour and sloping seabed conditions. While most monopile designs assume a flat seabed, real-world installations often occur on submarine slopes where complex soil-structure interactions significantly influence lateral behavior. Scour, caused by sediment erosion around the pile, further reduces lateral capacity and threatens structural integrity. This study investigates the combined effects of scour and seabed slope on monopile performance through comprehensive 3D finite element analyses and proposes an improved p–y model to account for sloping ground effects. The new model incorporates modified formulations for initial stiffness, ultimate soil resistance, and a depth correction factor within a hyperbolic framework, showing strong agreement with available experimental and field data. Numerical results reveal that downslope loading on a 20° slope reduces lateral load capacity by up to 35%, while upslope loading enhances stiffness and ultimate resistance. Global scour conditions further decrease load capacity by as much as 47%, though increasing the embedment length effectively mitigates these effects. In addition, machine learning techniques—MLR, DT, RF, and ANN—were applied to predict lateral load capacity reduction (LLCR), with the ANN model achieving superior accuracy (RMSE = 0.018, MAE = 0.013). Normalized embedment length, scour depth, and slope angle were identified as the most influential parameters governing LLCR. The outcomes of this research emphasize the necessity of incorporating both sloping ground and scour effects into monopile design and provide a practical framework for more resilient offshore wind foundation systems.