Geotechnical Innovation for Offshore Wind: Building Canada’s Foundations with Global Expertise

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Abstract ID: 9
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What Theme Are You Submitting for?: Operation, Maintenance, and Reliability
Keywords: Design and optimization of devices and systems; geotechnical engineering; soils and foundations

Electrical power generated from wind continues to grow rapidly in many global regions. Recent technological advances have led to a sharp increase in wind turbine capacity and the development of large offshore farms with both fixed-bottom and floating turbines. The resulting increases in offshore tower sizes require larger and more robust foundations to support turbines subjected to significant accumulations of cyclic loads from wind, waves, and currents over their lifespans. This translates into higher capital costs—offshore foundation construction alone can account for 20–30% of total capital costs in typical offshore wind farms.

Optimising turbine foundation design and construction can therefore significantly reduce capital costs and mitigate risks through sound geotechnical engineering. Effective foundation design typically follows four distinct, interlinked steps: (a) identifying seabed materials and near-surface profiles; (b) observing and characterising their behaviour; (c) creating conceptual and analytical models of structure–seabed interactions; and (d) applying engineering judgement, experience, and empirical procedures to finalise the design. A successful process must be coherent, well-integrated, and tailored to site-specific ground conditions and constraints.

This presentation explores geotechnical design approaches for optimising monopile foundations in offshore wind farms, with examples drawn from the authors’ project portfolio. These include offshore in-situ testing, cyclic laboratory testing, finite element simulations, and scaled physical modelling using centrifuge technology. The role of international expertise—particularly from more mature offshore wind markets—is emphasised as a catalyst for development in emerging regions. In the context of the Canadian offshore wind sector, early investment in geotechnical research, soil testing infrastructure, and academic–industry partnerships is highlighted as essential. Building a foundation of local capability while engaging global collaborators will help address regional challenges, improve design efficiency, and support Canada’s path towards sustainable offshore wind development.