Enhancing Structural Integrity of Offshore Wind Turbine Monopiles through Particle Damping: A Numerical and Experimental Study

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INTRODUCTION

Wave- and current-induced motions of supporting structures of offshore wind turbines (OWT) can impact their efficiency. These motions also induce large stresses that impact their service life. This study focuses on improving the efficiency and longevity of OWT through passive damping of the monopile motions.

METHODS

Data Collection: ANSYS simulations were performed to model the monopile response, and stress and strain distributions. A multi-layer spring system at the monopile base was incorporated to simulate soil-structure interaction under various soil conditions.

Experimental Validation: Experiments will be conducted in the wave tank of the Davidson Lab. Optical fiber sensors will be used to measure strain, load cells will be used to measure the forces and high-speed cameras will be used to measure the monopile motions.

RESULTS

1. **Wave-Induced Force (Morison's Equation):** Graphs illustrate the wave induced force on the monopile, calculated using Morison's equation, for different wave amplitudes and wave periods (based on model parameters).
2. **Stress-Strain Distribution (ANSYS Simulation):** Detailed visuals show the stress and strain on the monopile under operational loads, providing insights into areas of high stress/strain concentration.
3. **Particle Damping Effect:** Above results are being used to design the validation and control experiments. The design includes the base structure, monopile model, and particle damping box.

DISCUSSION

Based on previous results on floating bases of OWT, the integration of particle damping should significantly decrease the monopile's motion and, thus, enhance the structural integrity and performance of offshore wind turbine, thereby extending their service life and improving their operational efficiency.

Next Steps: Validate simulations by performing experiments in wave tank and optimize particle damping parameters. Establish a collaboration with industry partners to implement these findings in real-world applications.

AUTHOR AFFILIATIONS: Stevens Institute of Technology

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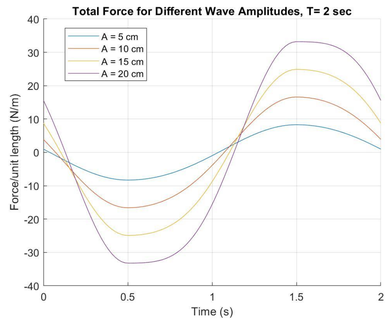
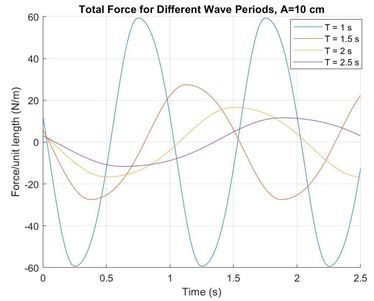
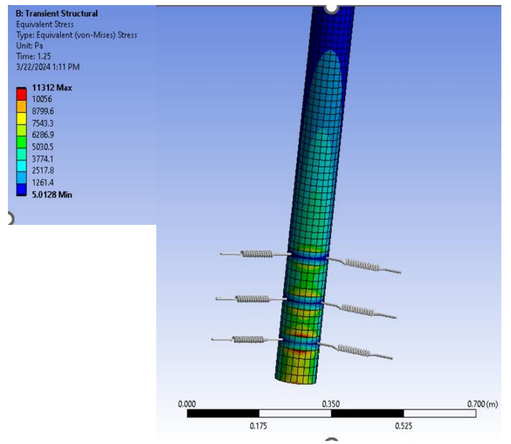


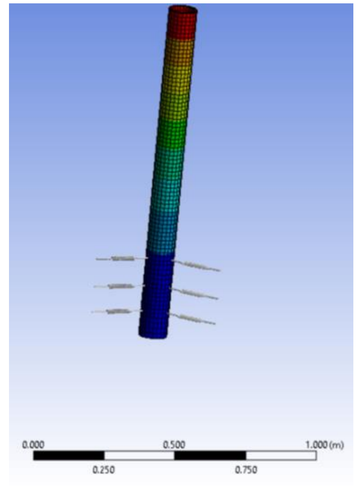
Wave-induced force under varying wave amplitudes between 5 and 20 cm



Wave-induced force under varying wave periods between 1 and 3 sec

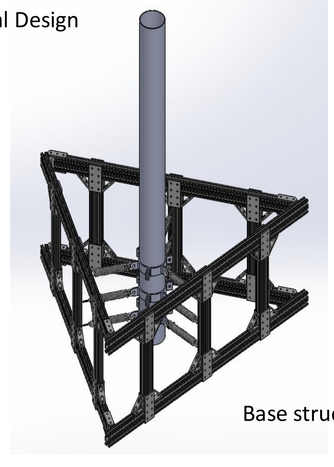


Stress/Strain Distribution



Deformation Distribution

Experimental Design



Base structure

Particle Damping Box