ResearchNote

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Executive Summary

- A single degree-of-freedom system loaded by ambient white noise was investigated by statistical assessment of dynamic modal parameters such as natural frequency and damping factors of Offshore Wind Turbine(OWT).
- The UNISON's U4 (4MW) OWT system of was simulated using advanced Finite Element modelling considering soil-structure interaction was validated and updated using a series of centrifuge experiments, which can account for the influence of soil's confining pressure and blade-rotor-nacelle assembly and tower's mass scale effects.
- Using state-of-art statistical techniques such as correlation functions estimated by both Random Decrement Analysis (RDA) and Perturbation Wavelet Analysis (PWA) and Chi-squared Hypothesis Tests as a basis for system parameter identification, the OWT system was assessed by a threshold estimation procedure, developed with machine learning model fed with scour-damaged response data correlated with foundation's ULS, SLS, and FLS performances.
- The model's accuracy was further enhanced by supervised learning from large amount of virtual data produced by the updated FEM model to be able to predict for a long term (20 years) Remaining Useful Life (RUL) or to classify Scour Health Index based on current system parameters.
- The outcome of the study will lead to improved timing of maintenance and reduced offshore investigation and maintenance jobs, resulting in reduced risk of failure for the OWT. The system's dynamic property parameters can be monitored to ensure its safe operation.

4. Proposal Doc

4.1. Choices

4.2. Proposal Details

4.3. ChatGPT Output

4.4. Literature Review (200 papers)

Part I

Proposal

1 Choices

1.0.1 Soil Choice

- Material model choice
  - Mohr-Coulomb Model
  - Hardening Mohr-Coulomb Model
  - Cyclic SANISAND Model
- Young's modulus and Poisson ratio
- Critical State Properties
- Nonlinear Parameters
- cohesion and tensile properties
- Cycllic strength parameters

1.0.2 Structure Choice

- Rigid or Linear Elastic Material
- Young's modulus and Poisson ratio
- Fatigue properties (SN Curve)
- Hardness properties (BHN)

1.0.3 SSI Choice

- Interface friction coefficient
  - Horizontal / Vertical
- Modulus of subgrade reaction of soil
  - Horizontal / Vertical / Rotational

1.0.4 Loading Choice

- Actuators

Static vs Cyclic

- Vibrations

Forced vs Ambient FFT vs FDD and EFDD

For experimental investigation, means and location of excitation, the density of the measurement point grid, the sampling rate and the length of time window must be optimized for good quality results.

Method	Advantages	Disadvantages
Forced	Provides “scaled” results	Artificial vibration required
Excites all (broad) range of natural frequencies	First mode can be too low to be excited	
Known force and mass, which allows FE updating		
Ambient	No artificial excitation	Lack of stationarity (not controllable). scatter may occur.
Better for low frequency (large and complex structures)	Not all natural frequency may be excited	
Cheap (no shaker)	Non-linearity of structure itself (assumption of cross section)	
Can be performed without embarrassing normal user (stopping traffic or humans)	Requires long cables	
Requires reference points >1 (3D or 1D sensors)		
Time window must be selected > 1000~2000 times f_n		
Requires manual techniques for FE updating		

1.0.5 Software Choice

- ABAQUS
  - UMAT implementation

- Plaxis 3D
- ARTeMIS Modal Pro
  - Operational Modal Analayis
  - Structural Health Monitoring
- SAP 2000
  - natural frequency for 3D structure on Winkler foundation

1.1 Verification Plan

- Winkler model limitations
- Mass-spring model limitations
- Accelerometer locations
- Sensor Sensitivity and Capacity
- Clear damage detection (condition chart)

1.2 Deployment Process

- anomaly detection
- sesnsor deployment
- model validation
- threshold check
- damage detection