Numerical study of irregular breaking wave forces on a monopile for offshore wind turbines

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Introduction

• Wave spectrum is used to define irregular breaking waves. •Irregular breaking waves and breaking wave forces: an important parameter in designing substructures of offshore wind turbines.

•REEF3D to study the regular and irregular wave forces

Numerical Model

Grid Convergence Study for Irregular Breaking Wave Force

Three different grid sizes are tested and compared with experimental results. Case 2: Hs = 0.330m, Tp=2.9s. For grid refinement study, different grid sizes dx = 0.05m, 0.025m and 0.01mare tested.



- •Reynolds Averaged Navier-Stokes (RANS) equations are the governing equations of computational fluid dynamics (CFD).
- •Explicit TVD third-order Runge-kutta scheme and fifth-order finite difference WENO scheme in multi-space dimensions are used.
- •k-w model is used to model the turbulence.
- •Level set method (LSM) is used for modelling the free surface
- •The relaxation method is used in the present numerical model to generate the waves.
- Bretschneider spectrum is used for the wave generation.

Grid Convergence Study for Wave Surface Elevation

Three different grid sizes are tested and compared with experimental results. Case 1: Hs = 0.457m, Tp=2.9s. For grid refinement study, different grid sizes dx = 0.05m, 0.025m and 0.01mare tested.

x=-12.38m	=-12.38m x=-2.00m 0.00m		11.59m 12.50m13.41m 15.59m	18.62m	
	WG1		WG2 WG3 WG4		

A good match between experimental and numerical results.

Study With Different Wave Steepnesses

Case No.	Significant wave height, H_s (m)	Peak Period, T_p (s)	Grid size, dx (m)	Significant force, F_s (N)
Case 3	0.400 m	2.9 s	0.010 m	18.87
Case 4	0.500 m	2.9 s	0.010 m	22.88
Case 5	0.330 m	2.0 s	0.010 m	17.23
Case 6	0.330 m	3.8 s	0.010 m	19.36

Spectral wave density





•Contribution of secondary peak towards higher harmonics.

Fig. 2: Comparison of numerical and experimental spectral wave density (m^2/Hz) over frequency (Hz) for three different grid sizes for case 1 at a)

(c)

WG2 b) WG3 c) WG4

(b)

•The numerical model REEF3D can be used as a good tool to study irregular breaking wave forces. •Longer periods lead to more than one secondary peaks in force spectrum.