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Sommario/riassunto	This thesis presents a numerical model capable of simulating offshore wind turbines exposed to extreme loading conditions. External condition-based extreme responses are reproduced by coupling a fully nonlinear wave kinematic solver with a hydro-aero-elastic simulator. First, a two-dimensional fully nonlinear wave simulator is developed. The transient nonlinear free surface problem is formulated assuming the potential theory and a high-order boundary element method is implemented to discretize Laplace's equation. For temporal evolution a second-order Taylor series expansion is used. The code, after validation with experimental data, is successfully adopted to simulate overturning plunging breakers which give rise to dangerous impact loads when they break against wind turbine substructures. Emphasis is then placed on the random nature of the waves. Indeed, through a domain decomposition technique a global simulation framework embedding the numerical wave simulator into a more general stochastic environment is developed. The proposed model is meant as a contribution to meet the more and more pressing demand for research in the offshore wind energy sector as it permits taking into account dangerous effects on the structural response so as to increase the global structural safety level.