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Derivation of Fragility Functions of Marine Drilling Risers Under Ocean Environment

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Abstract : The performance of marine drilling risers is crucial in the offshore oil and gas industry to ensure safe drilling operation with minimum downtime. Experimental investigations on marine drilling risers are limited in the literature owing to the expensive and exhaustive test setup required to replicate the realistic riser model and ocean environment in the laboratory. Therefore, this study presents an analytical model of marine drilling riser for determining its fragility under ocean environmental loading. In this study, the marine drilling riser is idealized as a continuous beam having a concentric circular cross-section. Hydrodynamic loading acting on the marine drilling riser is determined by Morison's equations. By considering the equilibrium of forces on the marine drilling riser for the connected and normal drilling conditions, the governing partial differential equations in terms of independent variables z (depth) and t (time) are derived. Subsequently, the Runge Kutta method and Finite Difference Method are employed for solving the partial differential equations arising from the analytical model. The proposed analytical approach is successfully validated with respect to the experimental results from the literature. From the dynamic analysis results of the proposed analytical approach, the critical design parameters peak displacements, upper and lower flex joint rotations and von Mises stresses of marine drilling risers are determined. An extensive parametric study is conducted to explore the effects of top tension, drilling depth, ocean current speed and platform drift on the critical design parameters of the marine drilling riser. Thereafter, incremental dynamic analysis is performed to derive the fragility functions of shallow water and deep-water marine drilling risers under ocean environmental loading. The proposed methodology can also be adopted for downtime estimation of marine drilling risers incorporating the ranges of uncertainties associated with the ocean environment, especially at deep and ultra-deepwater.

Keywords : drilling riser, marine, analytical model, fragility
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