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Assessment of Jack-up Survival in Severe Storms

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Abstract

This paper reports on a study to assess the performance of two LeTourneau 116-C Jack-up Rigs, the GSF Adriatic III and GSF Adriatic VII, under extreme storm loading conditions in the northern Gulf of Mexico during Hurricane Rita.

The objective of this study was to provide a demonstration of pushover methodology for the assessment of the performance of LeTourneau 116-C Jack-up Rigs during extreme storm loading by way of comparison of analysis results to actual field experience. This objective was pursued using nonlinear pseudo-static pushover analysis within the framework of SNAME Bulletin 5-5, but incorporating more realistic foundation performance parameters including recommendations of a SAGE Study of Spud Can Fixity in Cohesive Soils for the International Association of Drilling Contractors (IADC). See Templeton, Lewis and Brekke (2003), Templeton, Brekke and Lewis (2005), and Templeton (2006).

In the cases checked in this study, foundation collapse always occurred prior to any indication of nonlinear structural overload. This indicates that nonlinear foundation pushover analysis (with a linear treatment of the structure) is a useful method for survival analyses in cases of deep penetration in clay. By contrast, it also indicates that pushover analyses using a nonlinear structural model with linear (or linearized) treatment of the foundation would not be expected to produce useful results in similar cases of deep penetration in clay soils.

The results for the case of the Adriatic III in Hurricane Rita are that, consistent with the actual outcome, the Adriatic III can be shown theoretically to have withstood the hindcast environmental loads. However, an aggressive treatment of foundation performance and dynamic amplification is necessary to show this. More specifically, the following analysis assumptions are necessary:

- In addition to Bulletin 5-5 recommendations, the additional SAGE recommendations regarding spud can ultimate rotational and horizontal capacity as well as spud can rotational stiffness are necessary.
- It is also necessary to use an allowance for foundation hysteretic damping. In the case of deep penetrations in clay, foundation hysteretic damping limits dynamic amplification to modest amounts.
- It is further necessary to account for lateral soil reactions on the legs. Application of lateral soil reactions via p-y curves for all 4 chords was required. Additionally, the use of enhanced p-y formulations based on results of newly published work (see Templeton, 2009) was required.

The results for the Adriatic VII show that the rig should not have withstood the storm loads during Hurricane Rita, consistent with the actual outcome, even with the application of the aggressive foundation assumptions used for the Adriatic III rig in the same hurricane. The results indicate foundation collapse for Adriatic VII in Rita.

On the basis of the analysis results presented in this report, the Adriatic III should have been expected to survive the loads corresponding to hindcast conditions for its exposure to Hurricane Rita. The Adriatic VII, however, according to results of similar analysis should have experienced collapse during the same hurricane - triggered by the foundation. Both of these expected outcomes are consistent with the actual outcomes during the hurricane. Combined, these results provide a very useful calibration of the best present methods for nonlinear foundation pushover analysis of the ability of independent leg jack-up rigs to survive extreme storm loading, particularly for cases of deep penetration in clay.