Jack-up foundation analyses

This example simulates a jack-up rig on a sand foundation subjected to alternating wind loading.

This page discusses:

Products: Abaqus/Standard Abaqus/Aqua

Geometry and model

The model—a simplified planar model for the analysis of a multiple leg, portal frame-type structure—is intended for the analysis of 3-leg jack-up rigs with shallow foundation supports. Figure 1 is a schematic of a 3-leg jack-up, as represented by the model. The jack-up hull is assumed to be rigid and triangular, and the connection between the hull and the legs is also taken to be rigid. The jack-up has two windward legs and one leeward leg; the model is projected onto the vertical symmetry plane that passes through the leeward leg and between the windward legs. Elastic beam columns are used to model both the upper and lower segment of each leg. The soil model is chosen to be macro-yield sand. Three degrees of freedom—vertical, horizontal, and rotational—are assumed at each spud can at the base of each leg. Mass is assumed to be concentrated at the center of the hull. The horizontal degree of freedom at the center is assumed to represent the motion of the rig for analysis purposes. Wind loading on the rig is applied as a horizontal force above the center of gravity of the hull.

The leg segments are modeled using B21 elements, and the general beam section is used to define the structural properties of the beam. The interaction between the spud can and the soil is modeled through JOINT2D elements and the joint elasticity and joint plasticity definitions. Rigid beam elements, RB2D2, are used to model the rigid hull.

The dimensions of the rig and the material properties of the sand and the spud can are as follows (force units are in kN, and length units are in meters):

Leg length upper segment	49.4
Leg length lower segment	13.5
Leg EI upper segment	2.7×10^8

Leg EI lower segment	2.7×10^9
Leg AE upper segment	2.2×10^8
Leg AE lower segment	2.2×10^9
Leg GA upper segment	8.1×10^7
Leg GA lower segment	8.1×10^8
Horizontal distance from platform	
center of gravity to leeward leg	23.4
Horizontal distance from platform	
center of gravity to windward leg	11.7
Spud can diameter	10.9
Spud can cone angle	180°
Foundation preload per spud can	50600
Foundation tensile capacity	0
Operational vertical load (weight)	62700
Vertical distance from center of gravity	
to load application point	7.1
Soil submerged unit weight	10.0
Soil friction angle	33°
Soil Poisson's ratio	0.2
Foundation elastic shear moduli, $G_{\nu\nu}$	5.14×10^4

G_{hh}	3.87 × 10^3
G_{rr}	2.04 × 10^3
Constant coefficient, Λ_1	1.0
Constant coefficient, Λ_2	0.5

Boundary conditions and loading

The base nodes of the JOINT2D elements are always fixed. The required preload is applied to each spud can using an initial condition. In the first step the weight loading is applied at the center of gravity of the hull. The rig is then subjected to an alternating horizontal wind loading applied at the specified location above the center of gravity of the hull.

The rig is loaded from zero to 5370 kN, unloaded to zero and then to 6440 kN in the opposite direction, reloaded to 9130 kN in the initial direction, unloaded and reloaded to 9770 kN in the opposite direction, and unloaded to zero again. Each of these loadings is done in a separate step and is ramped from zero to the specified magnitude at the end of the step.

Results and discussion

The estimated load path for the leeward spud can foundation is plotted in a graph of equivalent horizontal load, $R = \sqrt{(M/D)^2 + \Lambda_1 H^2}$, versus V/V_c. The plot is shown in Figure 2 and is in good agreement with the load path predicted by an independent analysis, as detailed in the reference below. The moment-horizontal load response (i.e., M/D versus *H*) for the leeward spud can foundation, shown in Figure 3, compares well with the independent analysis.

Input files

jackup.inp

Input data for this example.

References

Wong, P. C. and J. D. Murff, "Dynamic Analysis of Jack-Up Rigs Using Advanced Foundation Models," Proceedings, 13th International Conference on Offshore Mechanics and Arctic Engineering (OMAE), vol. 2 - Safety and Reliability, Houston, pp. 93–109, February 1994.

Figures

Figure 1. Schematic representation of jack-up rig.

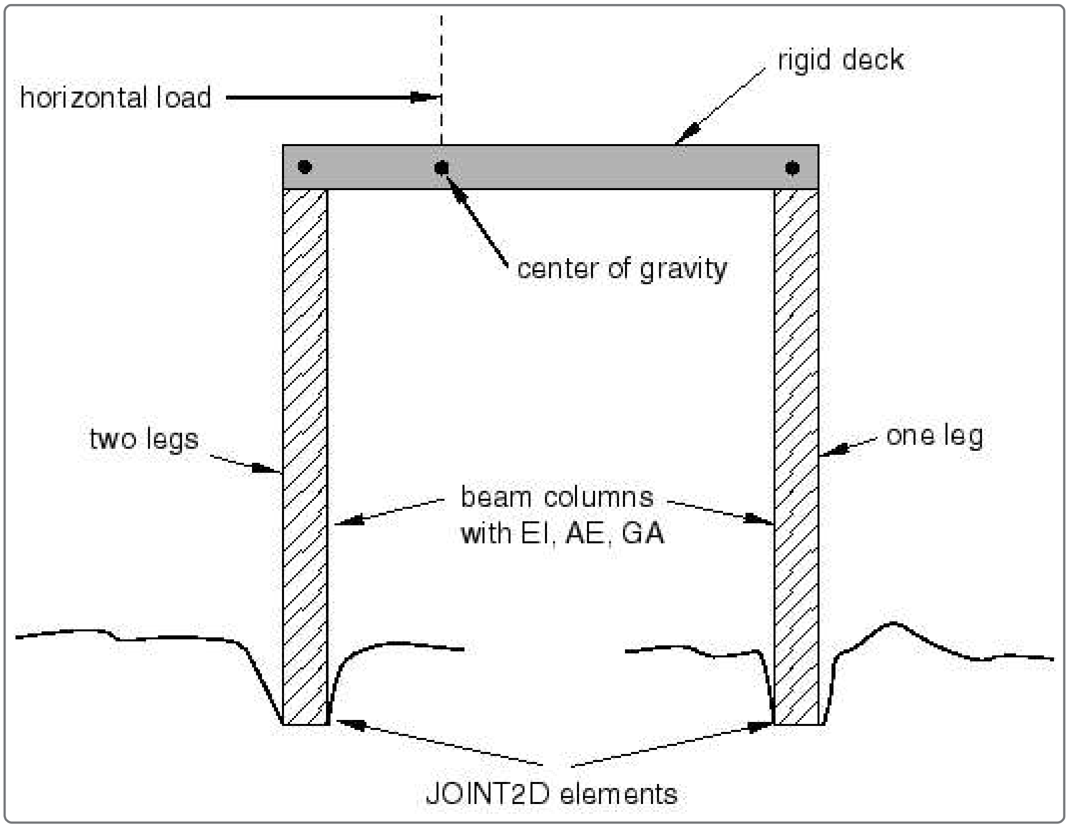


Figure 2. Load path for leeward spud can.

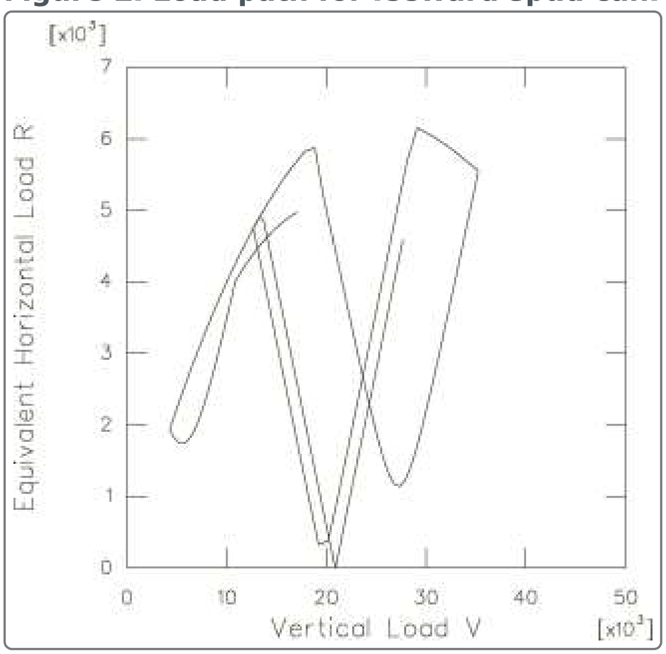
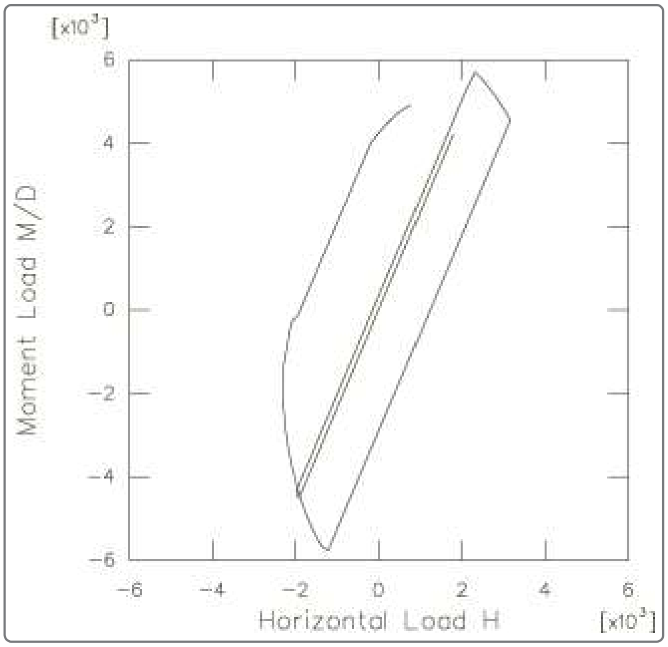


Figure 3. Moment versus horizontal load for leeward spud can.


[x10^3]
6
4
2
0
−2
−4
−6
Moment Load M/D
−6
−4
−2
0
2
4
6
Horizontal Load H
[x10^3]