Structural response analysis of jack-up during system jacking lifting process

Rian Burnang Purba, Juswan, and Muhammad Zubair Muis Alie

Department of Ocean Engineering, Engineering Faculty, Universitas Hasanuddin, Makassar, Indonesia

Email: ryanburnang@pp-epc.com

Abstract. One of the offshore structures which may be categorized as a column structure where the axial compression and lateral pressure take place is jack-up. The internal and external loads make the structure becomes deformable, leading to failure. For this reason, the structure must be analyzed for the internal and external response. In the present study, the structural response analysis of the jack-up structure during the system jacking lifting process is conducted using a nonlinear finite element method for three cases of the conditions to be analyzed for the structural response. The result obtained by nonlinear finite element is presented in terms of stress and deformation.

1. Introduction
Jack-up, like a fixed jacket offshore platform, consists of many elements such as braces and piles. Braces and piles have played a significant role to withstand axial and lateral loads in vertical and horizontal directions. When the structure moves in a vertical direction, especially during the operation, the structure must be analyzed for the structural response.

Ji [1] presented the experimental and numerical study on the collapse of aged steel jackets, caused by corrosion or fatigue crack. Pisanò [2] emphasized the potential of 3D continuum simulations to capture nonlinear soil-structural interaction in jack-up units. Muis Alie [3] discussed the configuration effect of fixed offshore structure with symmetrical and unsymmetrical shape toward buckling failure. Two kinds of the offshore structure were analyzed. The numerical analysis was adopted to calculate buckling failure under axial and lateral load. Hezarjaribi [4] performed the nonlinear response of jacket-type platforms against extreme waves that were examined utilizing sensitivity analyses. Guede [5] presented a method for risk assessment and inspection plan development as part of the risk-based structural integrity management of the offshore jacket platform. Muis Alie [6] analyze the effect of symmetrical and unsymmetrical configuration shapes on buckling and fatigue strength analysis of the fixed offshore platform. Two models of the fixed offshore structure were taken to be analyzed with the same dimension but different configuration shapes. The numerical calculation was performed to investigate the buckling and fatigue strength of both structures. Yang [7] conducted the seismic collapse performance of jacket offshore platforms with a time-variant zonal corrosion model. Eldin [8] conducted the sensitivity analysis on the seismic life-cycle cost of a fixed-steel offshore platform structure. The sensitivity analysis was performed using different methods such as tornado diagram analysis, first-order second moment, and Latin hypercube sampling.

This study aims to analyze the structural response of the jack-up structure during the system jacking the lifting process. The nonlinear finite element is adopted to analyze the structure, and the result is presented for stress and deformation.
2. Methodology
The nonlinear finite element method is used to model and analyze the jack-up structure for structure response during the system jacking lifting process. The finite element model of the jack-up structure is illustrated in figure 1. The legs of the jack-up structure at sea bottom are assumed to be fixed.

![Figure 1. The jack-up structure FE model.](image)

(a). Case 1.

(b). Case 2.
Figure 2. Three conditions of jack-up for analyses.

Three conditions of the jack-up structure to be analyzed, as shown in figure 2. The deck module moves in a vertical direction. The existing condition is illustrated in figure 2(a). The deck module of structure moves in the vertical direction for case 2 and case 3, as described in figure 2(b) and (c).

3. Results and discussion

The unity check, i.e., interaction ratio (IR) for three cases of the jack-up structures obtained by the finite element method, is illustrated in figure 3.
According to figure 3 that there are some elements where the interaction ratios are more than 1, especially the elements located at deck hull. These are caused by the equipment on the deck part so that the stress concentration takes place on it. These phenomena are found in all cases.
Figure 4. Deformations of jack-up.

Figure 4 shows the deformation of the jack-up structure for three cases. In the existing condition figure 4(a), the deformation takes place around the deck hull only. The jack-up structure becomes deformable in case 2 and case 3 figures 4(b) and (c).
4. Conclusion
The structural response of the jack-up structure during the system jacking lifting process is performed using the finite element method. It is found that the interaction ratios takes place around the deck hull due to the stress concentration. For the present case, the deformation just located at the deck hull. On the other hand, the deformation starts in case 2 and case 3.

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