Plate deformation analysis on deck structure of jack-up

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Abstract. Any kind of deck on an offshore structure is very important to place everything and doing anything on it. The deck must be strong to withstand any load acting on it not only in vertical but also in a horizontal direction. Besides, many equipment placed in the deck, so that needs to be evaluated for the safety activities. The objective of the present study is to analyze the deck structure of jack-up under axial life load. The small section of the deck is taken and modeled consists of a plate and stiffened plate. The boundary condition is applied to the model including axial compression load. The thickness of the attached plating is simulated and analyzed to obtain the behavior of the model. The behavior of the model is represented by stress and deformation. For the simple analysis, the welding residual stress, crack, and initial imperfection are not taken. There are four cases for boundary conditions with different thickness of the model is analyzed. The result obtains by the numerical analysis is presented together with the behavior in term of stress and deformation.

1. Introduction
Jack-up like fixed jacket offshore platform consists of some decks such as drilling, production, storage, helipad, and accommodation. The deck plays an important role to place and allocate anything according to the function of the deck. The deck must be strong to withstand any loads acts to the deck structure. Therefore, the analysis of deck structure to the ultimate strength of the jack-up structure must be taken into account for structural strength and safety.

Fixed offshore structure such as jacket, jack-up, and concrete gravity platform have been studied by some researches. Guede [1] presented a method for risk assessment and inspection plan development as part of the risk-based structural integrity management of offshore jacket platform. Yang [2] conducted the seismic collapse performance of jacket offshore platforms with time-variant zonal corrosion model. Muis Alie [3] 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. Eldin [4] conducted the sensitivity analysis on 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. Muis Alie [5] discussed the configuration effect of fixed offshore structure with symmetrical and unsymmetrical shape toward buckling failure. Two kinds of offshore structure were analyzed. The numerical analysis was adopted to calculate buckling failure under axial and lateral load. Hezarjaribi [6] performed the
The nonlinear response of jacket-type platforms against extreme waves was examined utilizing sensitivity analyses.

The objective of the present study is to analyze the deck structure of jack-up under axial life load. The small section of the deck is taken and modeled consists of a plate and stiffened plate. The boundary condition is applied to the model including axial compression load. The thickness of the attached plating is simulated and analyzed to obtain the behavior of the model. The behavior of the model is represented by stress and deformation. For the simple analysis, the welding residual stress, crack, and initial imperfection are not taken. There are four cases for boundary conditions with different thickness of the model is analyzed. The result obtained by the numerical analysis is presented together with the behavior of the model in term of stress and deformation.

2. Methodology
The deck structure of jack-up is modeled by the finite element method, as shown in figure 1. The dimension of the plate and stiffened plate and material properties are described in table 1 and table 2, respectively.
**Figure 1.** Deck structure of jack-up

**Table 1.** The dimension of the model

|                     |        |
|---------------------|--------|
| Length (mm)         | 5000   |
| Breadth (mm)        | 7000   |
| Thickness (mm)      | 65, 70, 75 |

**Table 2.** Material properties

|                                |        |
|--------------------------------|--------|
| Young’s modulus (N/mm$^2$)     | 210000 |
| Yield strength (N/mm$^2$)      | 690    |
| Tensile strength (N/mm$^2$)    | 938    |

**Figure 2.** Boundary conditions of the plate and stiffened plate

Figure 2 shows the boundary conditions of the plate and the stiffened plate in four cases. The boundary conditions are simulated with the thickness of the model. The ratio between the length and
breadth of the model is constant. The axial compression load acts vertically perpendicular to the surface of the attached plating.

3. Results and discussion

Figure 3 shows the deformation of the stiffened plate for four cases those are Case 1, Case 2, Case 3 and Case 4 with different thickness namely, 65 mm, 70 mm and 75 mm with different thickness. It is observed that the effect of boundary conditions gives significant influence to the deformation with some constraints on the stiffened plate. Every case provides different deformation, and the maximum deformation is located in the center of the model. The deformation for Case 1 and Case 2 is almost identical. On the other hand, for Case 3 and Case 4, there is three and six buckling modes, respectively. This happens because of the constraint of the model placed at the stiffened plate in the transversal direction, as shown in figure 3(c) Case 3. The additional constraint is situated at the center of the model in a longitudinal direction, according to figure 3(d) Case 4.

The Von-Mises stress distribution is described in figure 4 of the stiffened plate for four cases those are Case 1, Case 2, Case 3 and Case 4 with different thickness namely, 65 mm, 70 mm and 75 mm with different thickness. It is found that the stress distribution also gives significant influence to the stress distribution due to the constraint of the stiffened plate.
Figure 3. Deformation of stiffened plate

(a) Case 1

(b) Case 2

(c) Case 3

(d) Case 4

Figure 4. Von-Mises stress distribution of stiffened plate
For the case of Von-Mises stress distribution, only the 75 mm thickness of the model is taken as a sample in the analysis. The stress concentration located among the stiffener due to the constraint as the boundary condition applied to the model as shown in Figure 4. Figure 5 shows the stress-strain relationship of the stiffened plate model. It is observed that all cases are almost identical for elastic and plastic behavior.

4. Conclusion
The plate deformation analysis has been conducted using the nonlinear finite element method. The following conclusion can be summarized; the effect of the constraint of boundary conditions applied to the model with some variation of cases give significant influence to the Von-Mises stress distribution and deformation of the stiffened plate model.

References
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