eISSN: 2721-5717; pISSN: 2747-2124 https://journal.unhas.ac.id/index.php/zonalaut

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JURNAL INOVASI SAINS DAN TEKNOLOGI KELAUTAN

STIFFENED PLATE ANALYSIS BY CONSIDERING FOLLOW-UP PLATES IN THE EFFECT OF ONE-WAY AXIAL LOAD ON FPSO VESSELS

Rati Ahmad, Firman Husain, and Muhammad Zubair Muis Alie
Department of Ocean Engineering, Hasanuddin University
*ratiahmad051200@gmail.com

Abstract

Floating Production Storage and Offloading (FPSO) is the portable offshore structure. The material configuration used is the most important aspect in the FPSO structure design criteria. Plates and Stiffened and plates experience local buckling due to the external load when the hull girder collapsed. The objective of the present study is to analyze the stiffened plates taking the attached plate thickness into consideration on the FPSO in term of plate deformation and deflection located of the bottom area under tension and compression stages. In this study the attached plating thickness is varied according to FPSO data and BKI Rule. The stiffened plate elements located at the bottom are modelled by Tee-Bar element. The simply supported condition is applied to the model and the Non-Linier Finite Element Method (NLFEM) is used for the analysis. The result obtained by NLFEM shows that under tension and compression the stiffened plate of model of the thickened plate of the FPSO, the deflection are 1.75 mm and -1.75 mm, respectively. While for model of corrugated plates with BKI minimum intervening plate thickness the deflection are 1.8 mm and -1.8 mm under tension and compression, respectively.

Keyword: FPSO, Stiffened plate, Deflection, NLFEA

1. INTRODUCTION

One of the technical aspects that affect the level of ship safety is the strength of the ship's construction structure. The ship construction must be able to withstand the loads acting on the ship both under normal and extreme conditions. The material configuration used is the most important aspect in the floating production storage and offloading (FPSO) structure design criteria. Plates and stiffened and plates experience local buckling due to the external load when the hull girder collapsed. When the hull is subjected to a vertical bending moment, the deck structure or bottom plate mainly exhibits buckling produce behavior. The consequence of buckling is basically a basic geometric problem, where large deflections will change the shape of the structure. In the buckling phenomenon, the structure as a whole does not necessarily fail. This is because the buckling process occurs in the elastic region, so that when the compressive load is removed, the structure will return to its original state. Plates are the main horizontal elements that transmit live and dead loads to the vertical support frame of a structural system. Stiffener are stiffening pads (plates) used at the fulcrum of a beam when the beam does not have the ability in the profile body to support the ultimate reaction or centered load. Deformation in a beam can be very easily explained by the deflection of the beam from its position before loading. Deflection is measured from the neutral surface after deformation has occurred. As for what affects the deflection, namely the stiffness of the rod, the size of the force exerted on the structure, the type of support and the shape of the rod. The purpose of this study is to determine the effect of variations in the thickness of the accompanying plate on the one-way axial load on the stiffened plate.

2. METHODS

This research uses the Non-Limit Finite Element Method (NLFEM), with data collection techniques, namely literature studies and modeling of the object under study is the bottom area plate on the FPSO ship from PT Irvine Engineering Dubai. Structure modeling and running analysis using ANSYS™ software.

2.1. Structure Model

The modeled stiffened plate at the bottom area of the FPSO ship is the T (Tee-Bar) stiffener model. This model variation uses three stiffeners on the plate. The model variation can be seen in the following figure 1.

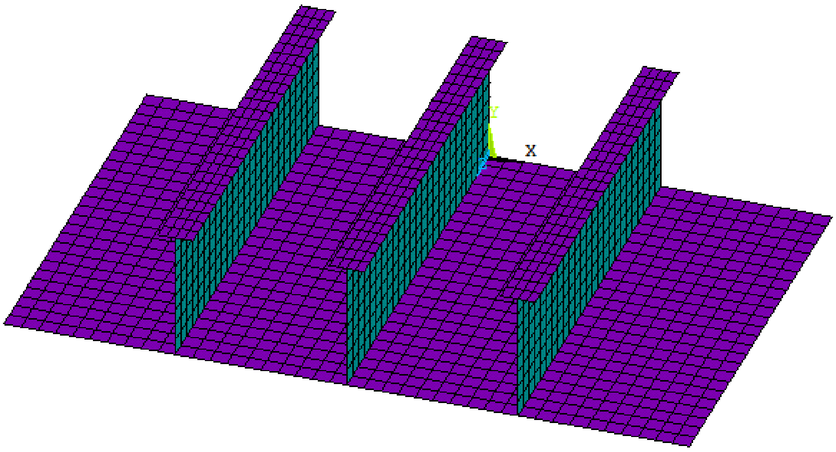


Figure 1 Stiffened plate model

As for the boundary conditions on the model, a pinch support is given at the back of the model and a y-direction rotation joint support at the front of the model. An overview of the boundary conditions can be seen in the following figure 2.

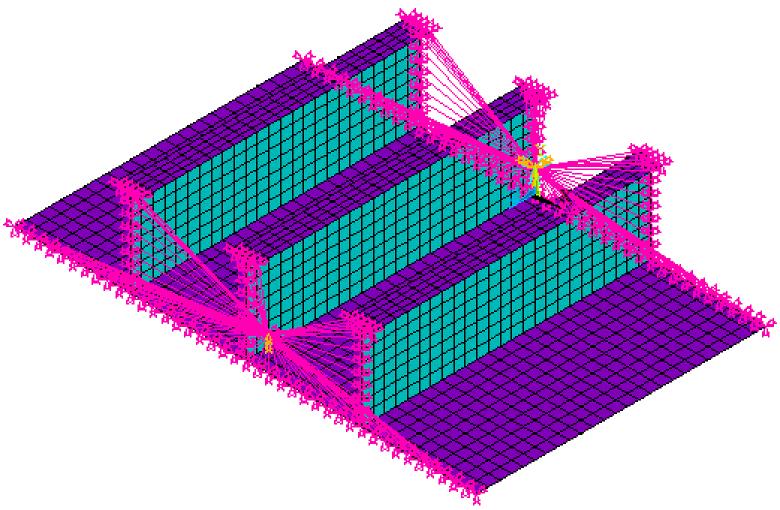
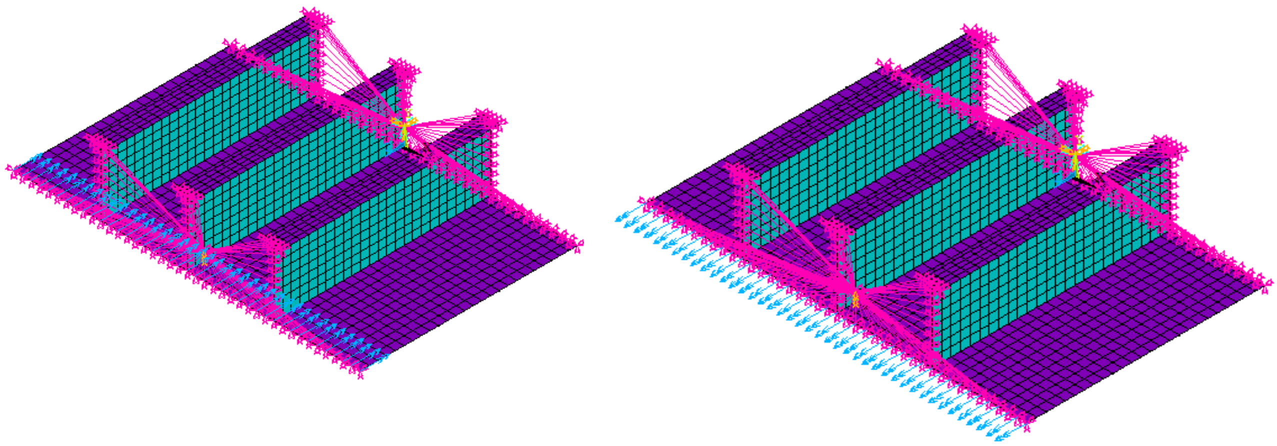


Figure 2 Support on the model

The loads acting on the stiffened plates analyzed are one-way axial loads in compressive and tensile conditions. The load acting on the compressive condition can be seen in the following figure 3.



(a) compressive loading conditions (b) tensile condition loading

Figure 3 Loading on the model

2.2. Material Properties

The material used in this analysis is steel with material specifications of mild still class D, young modulus (E) 210000 N/mm^2, poison ratio 0.3, density 7.07 x 10^{-5}, and yield strength 235 N/mm^2. The loads acting on the freshened plates analyzed are one-way axial loads in compressive and tensile conditions.

2.3. Case Study Analysis

In this study, the thickness of the stiffened plate on the stiffener is varied, namely the thickness of the original data of the FPSO ship with the minimum thickness of the BKI and the thickness of the web and flange is constant. Analysis of the reinforced plate using ANSYS software and the results obtained in the form of deflection and deformation shape that occurs due to variations in the thickness of the stiffened plate. The dimensions of the plate are detailed in the following table.

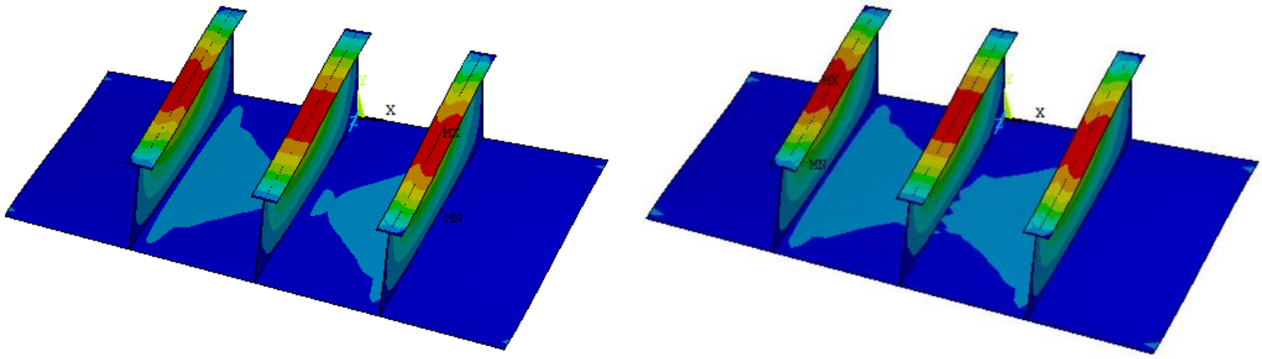
Table. 1 Dimension of the stiffened plate

Dimensions (mm)						
Type plat	Plat		Web		Flange	
	Long	Thick	Long	Thick	Long	Thick
Tee-Bar	711.2	25,4	1524	12,7	304,8	15,9
Tee-Bar (BKI)	711.2	23,14	1524	15,9	304,8	25,4

Table 1 shows the dimensions of the T (Tee-Bar) model plate where the plate that is varied is the follow-on plate. The thickness of the participating plate according to the FPSO ship data is 25.4 mm and the thickness of the participating plate according to the BKI minimum rule is 23.14 mm.

3. RESULTS AND DISCUSSION

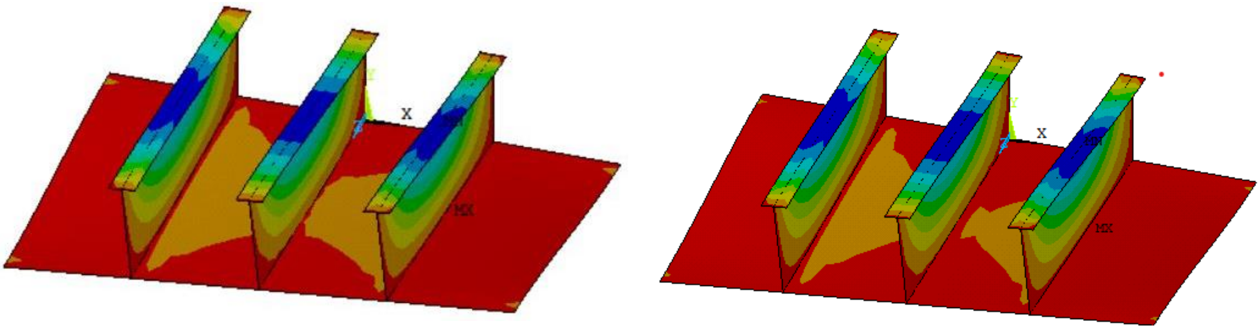
The results of the analysis using ANSYS software on compressive conditions and tensile conditions with the boundary conditions of the front joint of the model and clamp on the back of the model in the form of deformations that can be shown in the following figure:



(a) Deformation of the thickened plate of the FPSO under compressive conditions

(b) Deformation of corrugated plates with BKI minimum intervening plate thickness under compressive conditions

Figure 4 Deformation under compressive conditions



(a) Defomation of the thickened plate of the FPSO at tensile condition

(b) Deformations in corrugated plates with BKI minimum adhering plate thickness in tensile condition

Figure 5 Deformation at tensile condition

As can be seen in Figure 4a the maximum deflection that occurred in the bottom plate in the compressive condition under the influence of one-way axial load was 1.75 mm. In Figure 4b the maximum deflection that occurs in the bottom plate in the compressive condition with a one-way axial load of 1.8 mm. From the figure, it can be seen that the stiffener area is dominated by red color, which means that the maximum deflection occurs in the stiffener area.

The results of the analysis under tensile conditions can be seen in Figure 5a the maximum deflection occurring in the stiffened plate with the FPSO attached plate thickness of -1.75 mm. Figure 5b the maximum deflection that occurs on a plate with a BKI minimum plate thickness of -1.8 mm. From the figure, it can be seen that the participating plate area is dominated by red color, which means that the maximum deflection occurs in the plate area.

The maximum deflection requirement should not exceed $\frac{L}{360}$, where the maximum deflection limit value under compressive and tensile conditions is 13.8 mm. So that the structural model does not exceed the maximum deflection requirement. From Figure 2, it can be seen that the deformation that occurs in the stiffened plate with the FPSO participating plate thickness is smaller than the BKI minimum participating plate thickness.

Based on ANSYS analysis of the deflection of the bottom plate of the FPSO structure by considering the variation of the thickness of the accompanying plate under compressive conditions, the force-deflection curve is obtained as follows:

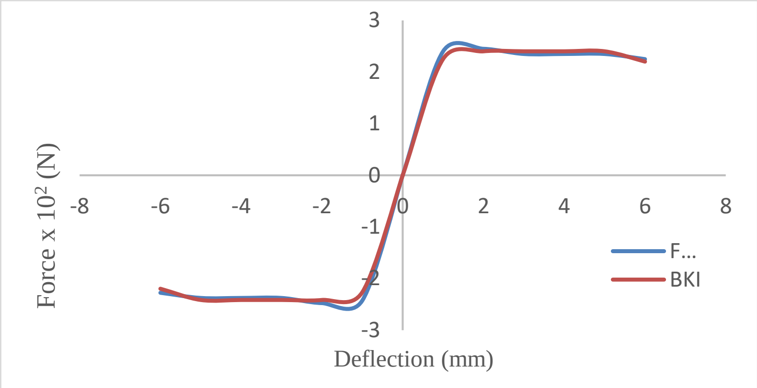


Figure 6 Force-deflection comparison curve of thickness variation of FPSO and BKI

Figure 6 shows a comparison curve of the deflection that occurs in the stiffened plate under compressive and tensile conditions. From the curve, it can be seen that the deflection occurring in the plate structure with the thickness of the accompanying plate according to the BKI minimum rule is greater than the deflection in the FPSO stiffener so that the FPSO stiffener structure is stronger than the stiffener structure with the thickness of the accompanying BKI minimum rule.

4. CONCLUSION

Based on the analysis of the response of the stiffened plate by considering the accompanying plate at the base of the FPSO ship under the influence of one-way axial load, it can be concluded that the effect of variation in the thickness of the accompanying plate on the stiffened plate is that the variation in the thickness of the larger accompanying plate is stronger than the smaller accompanying plate. It was found that the deflection of the Tee-Bar stiffened plate model with the thickness of the FPSO participating plate under compressive and tensile conditions was 1.75 mm and -1.75 mm. and the deflection that occurred in the Tee-Bar model according to the BKI minimum rules under compressive and tensile conditions was 1.8 mm and -1.8 mm. and the deflection that occurred in the stiffened plate did not exceed the maximum deflection requirement.

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