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Stiffened Plate Analysis by Considering the Effect of Uniaxial Load on FPSO Vessels

***Indah Melati Suci[1], Nur Fatima Dwi Putri[2], Firman Husain[2], and Muhammad Zubair Muis Alie[2]**

[1]Naval Architecture of Polytechnic Batulicin, Indonesia
[2]Department of Ocean Engineering, Hasanuddin University, Indonesia
*Correspondence author: indahmelati27011@gmail.com ; Tel.: +62 823-9416-9827
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Abstract

Plates are a very important part of shipbuilding and offshore structures. The reinforced plate is used to withstand loads acting in the axial and bending directions. The structure of the deck or bottom plate exhibits buckling or yielding behavior. Thus, it is very important to analyze the ultimate bearing capacity of a plate structure subjected to compressive loads for safe ship structure design. The material configuration used is the most important aspect in the FPSO structure design criteria. Plates and stiffened plates experience local buckling due to the external load when the hull girder collapsed. The objective of the present study is to analyze the effect of flange and web thickness to the ultimate strength on the FPSO in terms of plate deformation located of the bottom and deck area under compression stages. In this study, the attached plate thickness is varied according to FPSO data and BKI Rule. The stiffened plates element located at the bottom and deck area are modelled by Tee-Bar and Angle-Bar element. The simply supported condition is applied to the model and the anon-liniear Finite Element Method is used for the analysis. The result obtained by NLFEM shows that under tension and compression, the stiffened plate of Tee-Bar model, the deformations are 1,75 mm and 1,8 mm respectively. While for Angle-Bar model the deformation are 12,4 mm and 13 mm under compressing respectively.

Keywords: Angle-bar, Deformation, FPSO, Plates, Stiffened, Tee-bar

1. Introduction

FPSO are portable offshore oil drilling and storage structures. FPSOs are generally floaters with simultaneous oil storage and offloading supplies. FPSOs may be designed to drydock so that they always face the weather, minimizing turning and lifting movements. Plates are very important elements in shipbuilding and offshore structures.

In this study, we will discuss the effect of variation in the thickness of the stiffened plate on the one-way axial load and the amount of deformation that will occur in the stiffened plate due to the optimal load given under compressive conditions. The stiffener on the plate functions as a reinforcement. So, in this study, the thickness of the plate used is constant and the thickness of the web and flange used is varied to determine the strength of the stiffener.

The purpose of this study is to determine the effect of variations in the thickness of the stiffening plate on the one-way axial load of the FPSO ship stiffened plate at the bottom and deck, to determine the deformation that occurs in the FPSO ship stiffened plate and to determine the comparison of the strength of the stiffened plate shape against the one-way axial force.

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2. Materials and Methods

In this study, the object to be studied is the stiffened plate on the bottom and deck of the PT Irvine Dubai FPSO ship. The stiffened plates to be studied are stiffeners with Tee-Bar and Angle-Bar shapes. This research uses the Finite Element Method. In this study, the focus of research lies on the stiffened plates of the Bottom and Deck of the FPSO ship. Where at the bottom there is a Tee-bar type stiffened plate and on the deck of the ship there is an Angle-Bar type stiffened plate. Structural modeling and analysis using ANSYS.

2.1 Presentation of Data

This study uses an FPSO vessel with the following main sizes:

1. Main Dimension
   a. LOA : 256,5 m
   b. B : 70,2 m
   c. D : 20,7 m
   d. Cb : 0,83
2. Materials
   a. Type of material : MILD STELL CLASS D
   b. Elastic modulus : 210000 N/mm^2
   c. Density : 7,07 × 10-5 N/mm^3
   d. Yield strength : 235 N/mm^2
   e. Poisson ration : 0.33

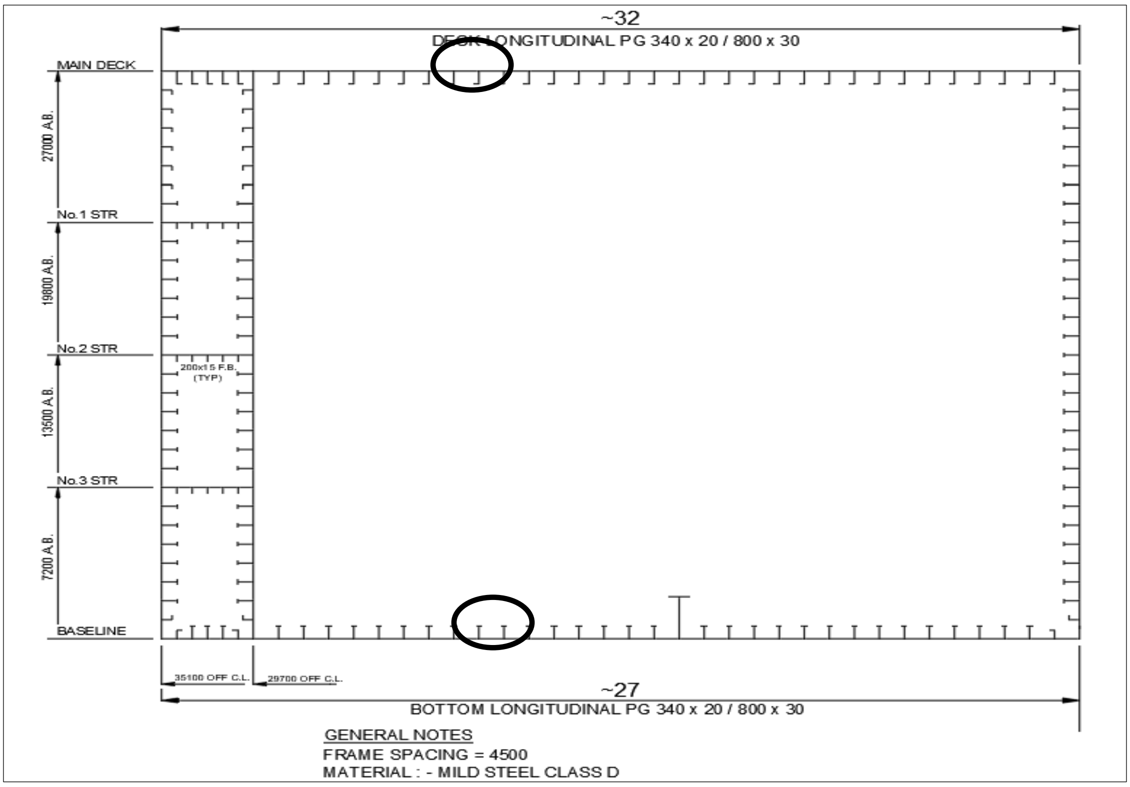

Fig. 1. Half Midship of FPSO Vessel

Fig. 1 shows the midship half of the FPSO vessel and the circled part is the part to be modeled. The stiffeners used in the modeling are dimensioned based on the data in the following table. The dimensions were selected based on the original data of the observed FPSO vessel's stiffened plate size.

Table 1. Dimension of Stiffened Plate

Type plate	Plate		Web		Flange	
	Long	Thickness	Long	Thickness	Long	Thickness
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

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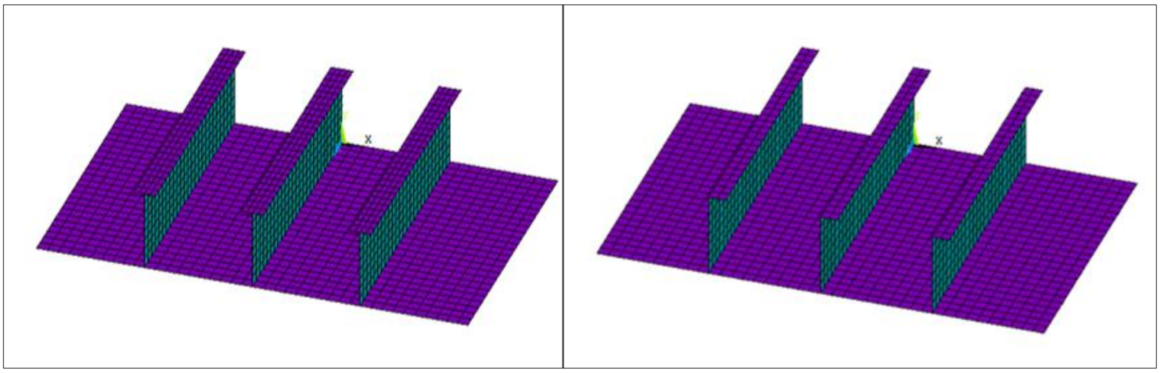

Fig. 2. Stiffened Plates Model

Modeling of reinforced plates using ANSYS™ software with 3 stiffeners where the thickness of the stiffening plate varies, namely the thickness of the original data and the thickness that has been varied. An overview of the modeling of the reinforced plate to be analyzed can be seen in Fig. 2.

3. Results and Discussion

The modeling of the stiffened plate is carried out using ANSYS™ software starting from the stage of defining the element type to the stage of giving loads and mounting the support. Deformation of the stiffened plate can be easily observed based on the deflection before loading. Based on the running analysis of the model in ANSYS software, the relationship between the force and deflection acting on the FPSO ship's stiffened plate is obtained by considering the thickness of the stiffened plate in the Tee-Bar and Angle-Bar models using the NLFEA method in ANSYS.

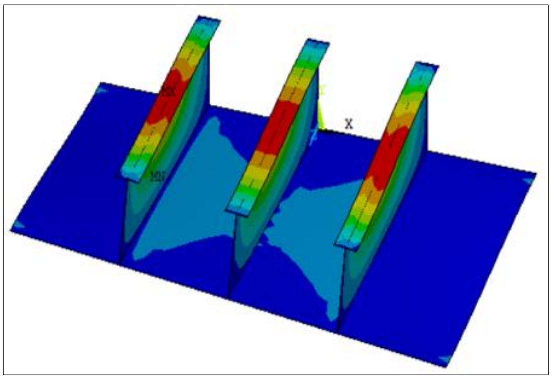

Fig. 3. Deformation of the 1st Tee-Bar Model

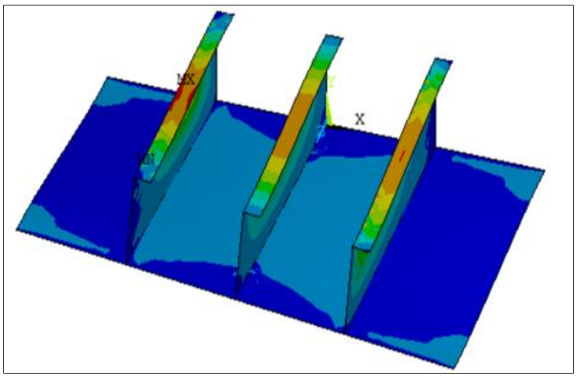

Fig. 4. Deformation of the 1st Angle-Bar Model

In Fig. 3 It is known that the maximum deflection requirement for the bottom area reinforced plate does not exceed, where L for Tee-Bar is 5 meters, so that a maximum deflection limit of 13.8 mm or 0.0138 meters is obtained. From the results of the analysis on the Tee-Bar Model 1, the deflection value obtained does not exceed the maximum deflection requirement, which is 1.75 mm, which means the structure is safe. In Fig. 4, Model 1 Angle-Bar has a requirement that the maximum deflection for reinforced plates not exceed the deck area, where L for Model 1 Angle-Bar is 5 meters and the maximum deflection limit for Model 1 Angle-Bar is 20.83 mm or 0.02083 meters. From the analysis results it can be seen that the deflection value obtained does not exceed the maximum deflection requirement, which is 12.4 mm.

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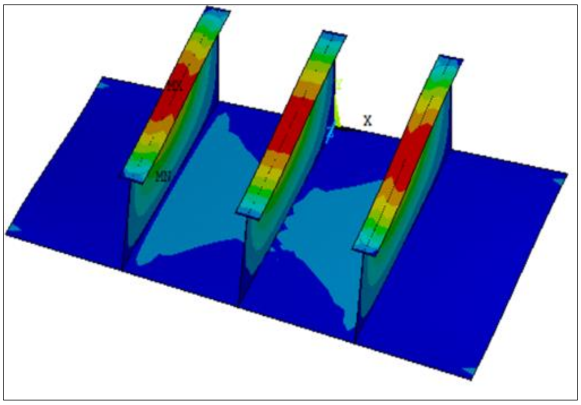

Fig. 5. Deformation of the 2nd Tee-Bar Model

The maximum deflection that occurs in the bottom plate as in Fig. 5 under pressure is 1.8 mm. The maximum deflection requirement shall not exceed L/360, where the maximum deflection limit value for the Model 2 Tee-Bar is 13.8 mm. so that the Model 2 Tee-Bar does not exceed the maximum deflection requirements

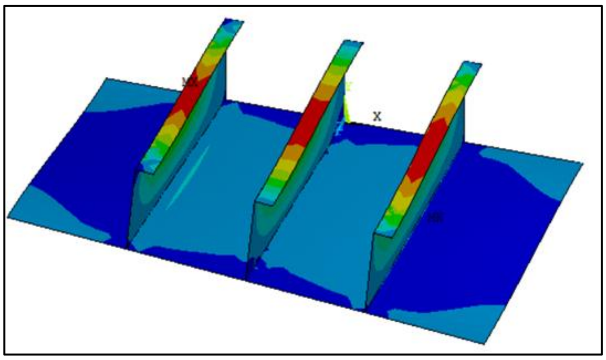

Fig. 6. Deformation of the 2nd Angle-Bar Model

The maximum deflection that occurs in the deck plate as in Fig. 6 under compression conditions is 13 mm. The maximum deflection requirement must not exceed L/360, where the maximum deflection limit value for Model 2 Angle-Bar is 20.83 mm. So Model 2 Angle-Bar does not exceed the maximum deflection requirements.

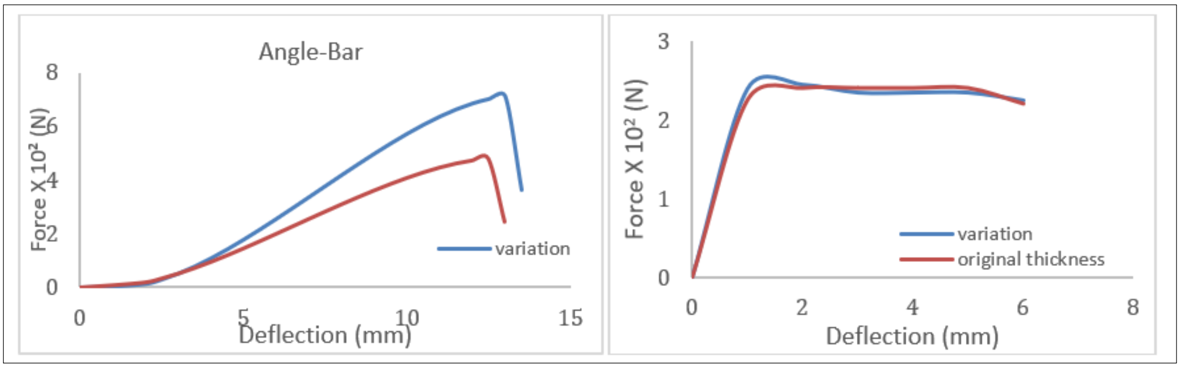

Fig. 7. Comparison of Deformation of Reinforced Plates

As can be seen in Fig. 7, the deflection that occurs in the Tee-Bar model is greater in reinforced plates with varying thicknesses. Meanwhile, it can be seen that the graph of the Angle-Bar model reinforced plate with varying thickness has greater deformation compared to the Angle-Bar model with FPSO ship thickness data.

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4. Conclusions

Based on the analysis of the response of the reinforced plate by considering the reinforced plate on the FPSO ship in the model under the influence of one-way axial load, it can be concluded that for the deformation that occurs in the reinforced plate in the bottom and deck area by considering the thickness of the reinforced plate, a deflection is obtained in Model 1 of the reinforced plate. The Tee-Bar is 1.75 mm in compression conditions and in Model 2 the Tee-bar reinforced plate uses a thickness that has been varied by 1.8 mm in compression conditions. Meanwhile, in Model 1, the plate is angle-bar reinforced, which is 12.4 mm in compression conditions, and in Model 2, the plate is angle-bar reinforced using a varied thickness, namely 13 mm in compression conditions.

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