Proceeding_ICSOT_Muhammad_Zubair_Muis_Alie.pdf

by

THE HULL GIRDER STRENGTH ANALYSIS DUE TO EQUIPMENT LOAD UNDER LONGITUDINAL BENDING

Muhammad Zubair Muis Alie, Juswan, Wahyuddin Mustafa, Kevin Gabriel Pangalinan and **Nurul Inda Pratiwi,**
Universitas Hasanuddin, Indonesia

SUMMARY

The objective of the present study is to analyze the hull girder strength due to the equipment load of FSO after being converted into FPSO under longitudinal bending. There is no change of the ship's construction; however, much additional equipment after conversion is conducted. One of them is the processing module, where the equipment is placed at the deck part. This additional equipment should be analyzed including their influence to the ultimate strength. The cross-section of FPSO is taken by considering one-frame space. The application of Multi-Point Constraint (MPC) in the numerical method is used. The MPC is placed at the neutral axis position as a reference point on both sides of the cross-section. The cross-section is assumed to remain plane. The midship section is modeled with one frame space. The element type of shell 181 is used on the model. As a simple calculation, the initial imperfections, cracks, and residual welding stress are not taken in the analysis. The ultimate strength obtained by the numerical method is therefore compared with the analytical method and the behavior of the ship in terms of stress distribution and deformation are also presented in this study.

1. INTRODUCTION

The conversion of a ship is now implemented primarily for offshore structure, namely Floating Storage Offloading (FSO) or Floating Production Storage Offloading (FPSO). The purpose of the conversion is to obtain the advantage of the ship payload. Besides, the conversion is also conducted to change the ship function. One of the ship conversion, which is commonly performed, is the ship conversion from FSO to FPSO. Nowadays, about 70% of FPSO is produced from the conversion result. Time-consuming is shorter than a new design that is one of the reasons. Due to this reason, the analysis of the ultimate strength of being converted from FSO to FPSO must be taken into consideration.

The ultimate strength analysis of the ship had been presented by some papers like; The residual strength of an Aframax-class double hull oil tanker damaged in the collision had been assessed by Parunov [1] by considering the influence of the rotation of the neutral axis. The impact of nonlinear finite element method models on the ultimate bending moment for hull girder was studied by Xu [2]. There was two analysis performed; those were implicit static analysis and explicit dynamic analysis. A structural reliability analysis model based on a Bayesian belief network was proposed by Li and Tang [3] for the hull girder collapse risk after accidents. The Bayesian belief network was used to represent random states of variable risk events after accidents, as well as the dependencies between activities, and the structural reliability analysis was used to evaluate the failure probability hull girder for each possible accident conditions. The incidence of collision damage models on an oil tanker and bulk carrier reliability was investigated by Campanile [4] considering the IACS deterministic model against GOLADS/IMO database statistics for collision events, substantiating the probabilistic model. The safety of an oil tanker in intact condition was performed by Campanile [5] to investigate the incidence of load combination methods on hull girder sagging/hogging time-variant failure probability. The simplified approach to the ultimate hull girder strength of asymmetrically damaged ships was conducted by Muis Alie [6] considering the critical element under sagging condition. The residual hull girder strength in intact and damage condition under longitudinal bending moment using nonlinear finite element was conducted by Muis Alie [7], and damages were modelled simply by removing the element on the damaged part. The ultimate hull girder strength considering section modulus under longitudinal bending was analysed by Muis Alie and Latumahina [8] and the cross-section of Ro-Ro ship was taken to be analysed.

In the present study, the analysis of hull girder strength due to the equipment load of FSO after being converted into FPSO under longitudinal bending is conducted. There is no change of the ship's construction, but much additional equipment after conversion. One of them is the processing module, where the equipment is placed at the deck part. For the simple calculation, the one-frame space of FPSO's cross-section is considered. The cross-section is assumed to remain plane. The element type of shell 181 is used on the model. The initial imperfections, cracks, and residual welding stress are not taken into account. The ultimate strength obtained by the numerical method is therefore compared with the analytical method and the behavior of the ship in terms of stress distribution and deformation are also shown in this study.

2. FINITE ELEMENT MODELING

In the present study, the numerical method to analyze the hull girder strength due to load equipment of change function from FSO to FPSO before and after being converted is conducted. The ship has 172 m, 30 m and 18.4 m of length, breadth, and depth of ship, respectively. The midship section consists of two kinds of longitudinal stiffeners those are flat-bar and angle-bar. There is also the inner hull in the cross-section. The element type is shell-181. The shell-181 element applied to all of the cross-section as shown in figure 1.

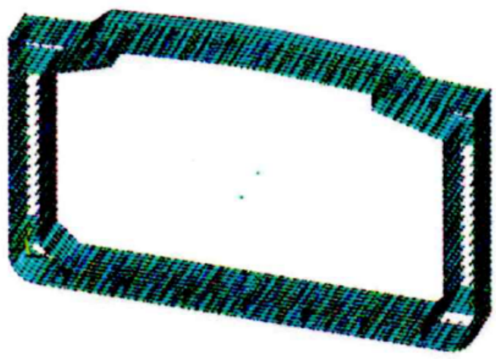


Figure 1. Finite element model of cross section

According to figure 1, there are two points located at the neutral axis. These two points are placed at both sides of the cross-section, and those are used to place the MPC (Multi-Point Constraint) for representing the behavior of the cross-section. The ultimate strength analysis, including the effect of change function from FSO to FPSO, is calculated using the numerical method under sagging condition. The rigidly linked corresponding with the boundary condition where MPC is applied to both sides of the cross-section, as shown in figure 2.

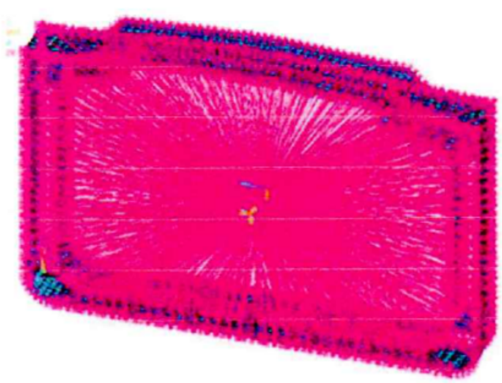
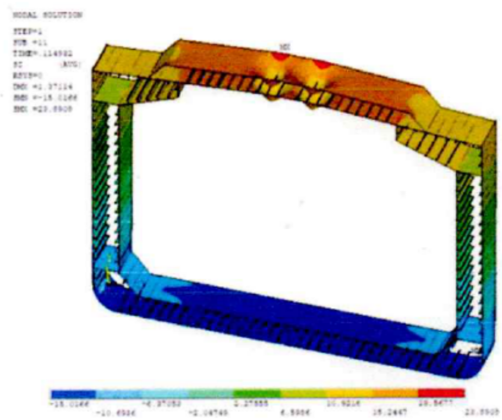


Figure 2. Boundary condition

3. RESULTS AND DISCUSSIONS

The behavior of the ultimate strength analysis is described in terms of working stress distribution. Figures 3 and 4 show the working stress and deformation under the sagging condition. The tension and compression take place at the deck and bottom part since the hull cross-section is under sagging condition.



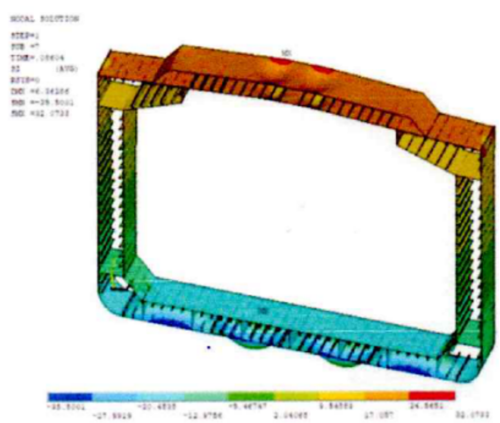


Figure 3. Working stress in sagging

Figure 4. Deformation in sagging

According to figures 3 and 4, the maximum stress and deformation are located in the middle of the cross-section. There are two layers at the deck part of the ship's cross-section. This will be contributed to the ultimate strength since the cross-section is under hogging or sagging condition.

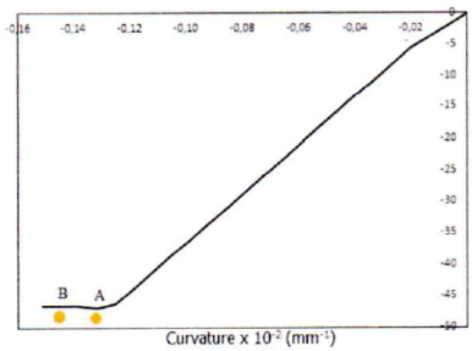


Figure 5. Moment-curvature relationship

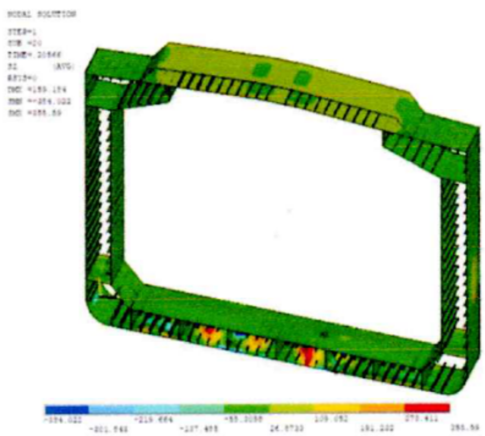


Figure 6. Deformation of FSO at ultimate strength

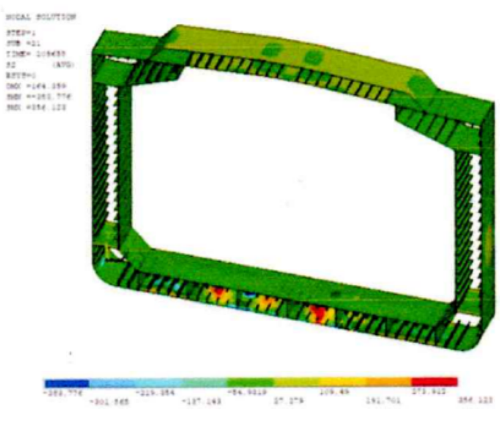


Figure 7. Deformation of FSO at the collapse

Figure 5 shows the moment-curvature relationship of FSO under sagging condition. There are two points at the line, and those point A and B at the ultimate strength and collapse stages. Figures 6 and 7 show the deformation of FSO at point A and B on the ultimate strength and collapse regime, respectively.

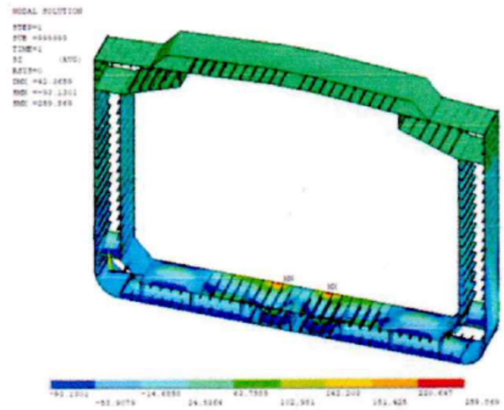


Figure 8. Deformation of FPSO at ultimate strength

According to figures 6 and 7, it is observed that the behavior of deformations is almost similar. It can be seen from figure 5 for the relationship of the moment-curvature curve, where points A and B are almost in a straight line. Therefore, the hull girder behavior of the cross-section at those points is almost similar. Figures 8 and 9 show the deformation of FPSO at ultimate and collapse stages. It is observed that the behavior of the FSO is completely different with FSPO after being converted with additional equipment.

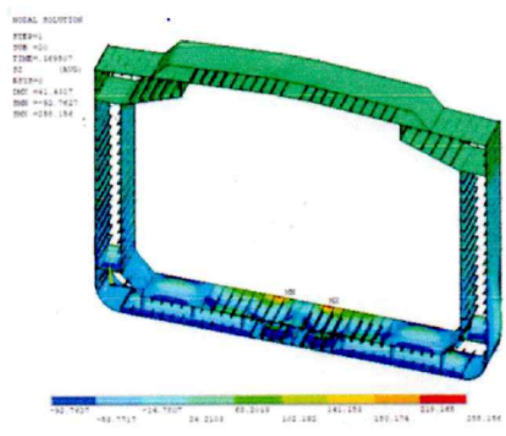


Figure 9. Deformation of FPSO at the collapse

Figure 10 shows the moment-curvature relationship of FPSO under sagging condition. Points A and B are the ultimate strength and collapse regime, respectively.

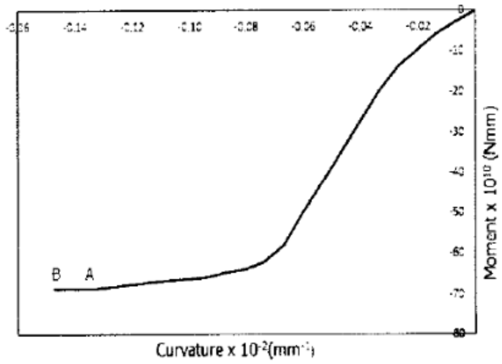


Figure 10. Moment-curvature relationship of FPSO

Figure 11 describes the comparison of the moment-curvature relationship between the analytical method and FEM of FSO under sagging condition. The dashed line represents the result obtained by the analytical method, while a solid line for FEM.

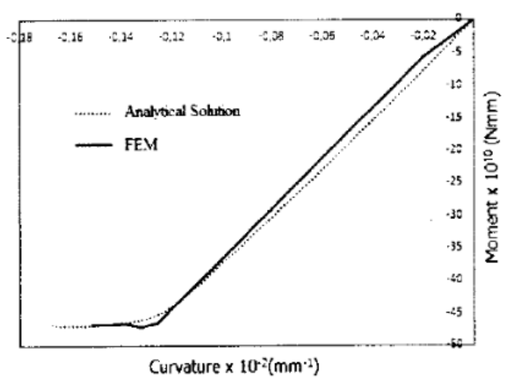


Figure 11. Comparison of moment-curvature FSO

According to figure 11 that the ultimate strength obtained by FEM is a little bit larger than the analytical method. This may be due to the constraint at the cross-section and the load redistribution that is effect to the stress in the elements.

Figure 12 shows the comparison of the ultimate strength obtained by FEM between FSO and FPSO. The solid line represents the ultimate strength of FSO, while FPSO is represented by the dashed line. According to figure 12 that the bending stiffness of FSO and FPSO is different from one another. This behavior is due to the effect of additional equipment and change function where the FSO is converted to FPSO. The effect of the additional equipment which corresponds to loading gives significant influence to the ultimate strength before and after being converted from FSO to FPSO.

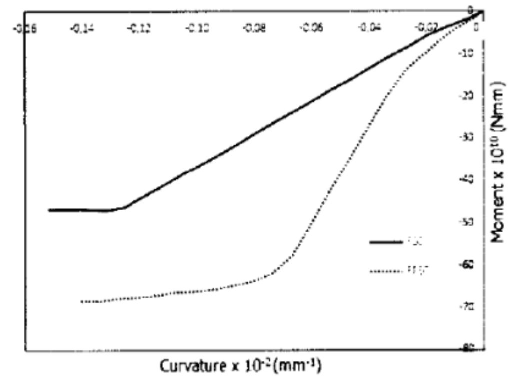


Figure 12. Comparison of moment-curvature between FSO and FPSO

4. CONCLUSIONS

The effect of change function to the ultimate strength from FSO to FPSO is conducted using the nonlinear finite element analysis. The following conclusion is summarized; the impact of change function, namely additional equipment after being converted from FSO to FPSO, is significant to the ultimate strength under sagging condition. Due to additional equipment, the bending stiffness is different between FSO and FPSO. Also, the ultimate strength obtained by nonlinear finite element analysis for FPSO is larger than FSO.

5. REFERENCES

1. Parunov J, Rudan S and Bužančić Primorac B, 'Residual ultimate strength assessment of double hull oil tanker after collision', *Eng. Struct,* 2017.
2. Xu M C, Song Z J and Pan J, ' Study on influence of nonlinear finite element method models on ultimate bending moment for hull girder', *Thin-Walled Struct,* 2017.
3. X and Tang W, 'Structural risk analysis model of damaged membrane LNG carriers after grounding based on Bayesian belief networks', *Ocean Eng,* 2019.
4. Campanile A, Piscopo V and Scamardella A, 'Conditional reliability of bulk carriers damaged by ship collisions', *Mar. Struct,* 2018.
5. Campanile A, Piscopo V and Scamardella A, 'Incidence of load combination methods on time-variant oil tanker reliability in intact conditions', *Ocean Eng,* 2017.
6. Muis Alie M Z, 'Simplified approach on the ultimate hull girder strength of asymmetrically

damaged ships', *Int. J. Offshore Polar Eng,* 2018.
7. Muis Alie M Z, Sitepu G, Sade J, Mustafa W, Nugraha A M and Bin Muh. Saleh A, 'Finite Element Analysis on the Hull Girder Ultimate Strength of Asymmetrically Damaged Ships', 2016.
8. Muis Alie M Z and Latumahina S I, 'The Ultimate Hull Girder Strength Analysis Considering Section Modulus Under Longitudinal Bending',2018.

6. AUTHORS BIOGRAPHY

[Muhammad Zubair Muis Alie] Associate Professor at Department of Ocean Engineering, Engineering Faculty, Hasanuddin University. He is the Head of Ocean Structure Analysis Research Laboratory (OSAREL). His previous experience includes the ultimate strength of ship and offshore structures, structural mechanics, finite element analysis and other subjects related to structural strength.

[Juswan] Lecturer at Department of Ocean Engineering, Engineering Faculty, Hasanuddin University. His previous experience includes the planning, design, and construction of the ship and offshore structures.

[Wahyuddin Mustafa] Lecturer at Department of Naval Engineering, Engineering Faculty, Hasanuddin University. He is a member of Ship Construction Laboratory. His previous experience includes the construction and production of the ship and offshore structures.

[Kevin Gabriel Pangalinan] Graduate Student at the Department of Ocean Engineering, Engineering Faculty, Hasanuddin University. He finished his study at Ocean Structure Analysis Research Laboratory (OSAREL). His previous research related to the ultimate strength of Floating Production Storage Offloading (FPSO).

[Nurul Inda Pratiwi] Graduate Student at the Department of Ocean Engineering, Engineering Faculty, Hasanuddin University. She finished her study at Ocean Structure Analysis Research Laboratory (OSAREL). Her previous research related to ultimate strength of Floating Production Storage Offloading (FPSO).

Proceeding_ICSOT_Muhammad_Zubair_Muis_Alie.pdf

ORIGINALITY REPORT

14%	12%	10%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	worldwidescience.org Internet Source	3%
2	shellbuckling.com Internet Source	2%
3	repository.unhas.ac.id Internet Source	1%
4	publications.isope.org Internet Source	1%
5	trid.trb.org Internet Source	1%
6	Muhammad Roestam, Ashury, Muhammad Zubair Muis Alie. "The analysis of the main deck subjected to deaerator load", IOP Conference Series: Earth and Environmental Science, 2020 Publication	1%
7	onepetro.org Internet Source	1%
8	en.wikipedia.org Internet Source	

		1%
9	investor.cimbniaga.co.id Internet Source	<1%
10	teknikkelautan.unhas.ac.id Internet Source	<1%
11	Jialu Zhang, Haojie Ren, Hao Ren, Yi Chai, Zhaodong Liu, Xiaojun Liang. "Comprehensive Review of Safety Studies in Process Industrial Systems: Concepts, Progress, and Main Research Topics", Processes, 2023 Publication	<1%
12	discovery.ucl.ac.uk Internet Source	<1%
13	hdl.handle.net Internet Source	<1%
14	Yin Zhang, Jun Guo, Jiang Xu, Shun Li, Junjie Yang. "Study on the unequivalence between stiffness loss and strength loss of damaged hull girder", Ocean Engineering, 2021 Publication	<1%

Exclude quotes On

Exclude bibliography On

Exclude matches < 5 words