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STABILITY AND LONGITUDINAL STRENGTH ANALYSIS ON BARGE 400 FT DURING SEA TRANSPORTATION DECOMMISSIONING JACKET

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ABSTRACT

Transporting a dismantled offshore platform has its challenges in the process. The stability and longitudinal strength of the decommissioning barge used are common problems in this process. Stability analysis will be carried out in intact and damaged conditions while longitudinal strength analysis will be carried out during still water, hogging, and sagging conditions. This paper discusses the calculation of stability and longitudinal strength on a 400 feet long barge used for decommissioning jacket transportation. From the results of the stability analysis that occurred, the initial GM value was obtained in the intact condition of 52.29 m and damage of 47.72 m, 47.69 m, 47.83 m, and 47.81 m. Then, the intact range value that occurred in intact condition was 86° and damage of 82°, 82°, 83.04°, and 82.9°. Next, the ratio area value that occurred in intact condition was 11.22 and damage of 37.24, 43.09, 36.95, and 47.59. Then, from the results of the longitudinal strength analysis, the bending moment value was obtained in still water, hogging, and sagging conditions respectively of 16410 Ton.m, 52740 Ton.m, and 37210 Ton.m and the value of shear forces in still water, hogging, and sagging conditions respectively of 619.092 Ton, 1552.973 Ton, and 1391.362 Ton. The results of stability and strength analysis meet their respective criteria of (GL, 2023)

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1. INTRODUCTION

Recorded in April 2020, there were 630 offshore platforms in Indonesia. As many as 522 units are operating, 102 units are not operating and 6 units have been abandoned (Wiratno, 2020). The number of offshore platforms that are not operating and have been abandoned will continue to increase over time and can cause many negative impacts on the environment. Offshore platforms that have been abandoned for quite a long time will cause high corrosion or rust and this corrosion will cause poisoning impacts on marine biota (ITS News, 2019). Therefore, post-operation offshore platforms must be dismantled (decommissioning).

Decommissioning of the offshore platform is a series of processes aimed at moving part or all of the post-operation offshore platform for recycling. Decommissioning is one alternative handling of post-operation offshore platforms apart from converting the platform into artificial coral reefs (Rig to Reef). There are four method to decommissioning offshore platform, complete removal, partial removal, topple-in-place method, and leace in place (Saujana, Mulyadi, & Rosyid, 2022). The decommissioning process can be done in whole (complete removal) or by cutting per part (peace small decommissioning) depending on the ability of the transport vessel (heavy lifting vessel) used (Eisses, 2016).

Not only stability, knowing the capacity of the maximum load that can be carried from the hull girder of the ship is very important in designing the limits of a floating building, namely the longitudinal strength of the ship which is usually referred to from the maximum strength of the ship's hull girder (Wang, Wu, & Wang, 2019). The longitudinal structural strength of the midship part of the ship is an important strength that ensures the safety of the ship's structural behavior.

To make this calculation, many things must be considered such as differences in loading types, cargo weight, and wave loads (Salazar-Domínguez, Hernández-Hernández, Rosas-Huerta, Iturbe-Rosas, & Herrera-May, 2021). The purpose of this research is to analyze the stability and longitudinal strength of decommissioning barge during transportation decommissioned offshore platforms.

2. METHOD

2.1 BARGE MODELING

The decommissioning barge is the ship that used in this research. A decommissioning barge can be said to be a ship that has been modified in such a way to be specialized in the decommissioning process. The main dimensions of the decommissioning barge to be modeled are shown in Table 1:

Table 1 : Barge main dimensions

Information	Dimension (m)
Length Overall	122
Breadth Moulded	36.6
Depth Moulded	7.625
Draft Moulded	5.8

From modeling results, visualization of the decommissioning barge in form of a general arrangement and three-dimensional modeling was obtained. The decommissioning barge modeling was carried out using MOSES Modeler software. This software allows for detailed and accurate representations of the barge, which can be crucial in planning and executing the decommissioning process.

2.2 LOADCASES

Loadcase made to differentiate intact and damaged analysis. Loadcase intact performed when the barge transports the jacket in the intact condition, while loadcase damage perform when the barge transports the jacket structure in a damaged case (leakage). Loadcase damage will divided into several leakage scenarios. These scenarios are distinguished based on the tank that has a leak. The selection of these tanks is perform using the deterministic damage stability method.

a. Intact loadcases

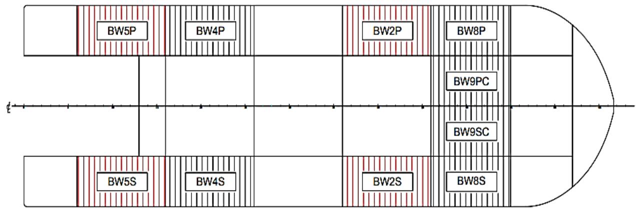
Intact condition is cases where the decommissioning barge is good condition (no leaks). The amount of loading that occurs is the sum of the weight of the load being lifted, the weight of the tank, and the weight of the decommissioning barge itself.

Table 2. Loadcase intact

Item	Mass (ton)	Quantity	Percentage (%)
Lightship	4055.440	1	
Jacket Leg	315.868	1	
Topside	76.498	1	
Accommodation Room	30	1	
Girder 1	35	1	
Girder 2	35	1	
Beam 1	0.2	1	
Beam 2	0.2	1	
Beam 3	0.2	1	
Beam 4	0.2	1	
Beam 5	0.2	1	
BW8P	369.12		31.37
BW9PC	369.12		31.37
BW9SC	369.12		31.37
BW8S	369.12		31.37
BW2P	335.61		25.67
BW2S	335.61		25.67
BW4P	265.27		20.29
BW4S	265.27		20.29
BW5P	232.04		19.95
BW5S	232.04		19.95
Total	7691.14		

b. Damage loadcase

In load case damage, four leak scenarios occurred, namely in tanks BW2P, BW2S, BW5P, BW5S. Visualization of the scenario of a ballast tank experiencing a leak is shown in Picture 1:



Picture 1. Damage case scenario

In load case damage, the amount of the loading that occurs vary from intact conditions due to leaks in the tank. This leak will cause main changes in loading that occurs in each scenario. The amount of loading that occurs in the BW2P, BW2S, BW5P, and BW5S tank leak scenarios is 7726.16 tons, 7730.88 tons, 7812.56 tons, and 7817.80 ton respectively.

2.3 ALLOWABLE SHEAR FORCES AND BENDING MOMENT CALCULATION

The allowable bending moment value obtained using the equation:

$$BMallow = \sigma allow \ x \ SM \qquad (1)$$

Where BM allow is the bending moment limit value permitted to occur, σ allow is the allowable bending stress of ship material (17.5 kN/cm^2) (GL, 2023), and SM is the section modulus value that occur in each decommissioning barge frame. The section modulus value of the barge frame varies depending on its shape. From the calculation results, the allowable bending moment value is 296158 ton.m.

The allowable shear force value obtained using the equation:

$$SFallow = \tau allow \ x \ A \quad (2)$$

Where SF allow is the allowable shear force limit value permitted to occur, τ allow is the allowable bending stress of ship material (11 kN/cm^2) (GL, 2023) and A is the area of the barge decommissioning frames. The area value will also vary depending on the shape of the barge decommissioning frame. From the calculation results, the allowable shear force value is 26933.4 tons.

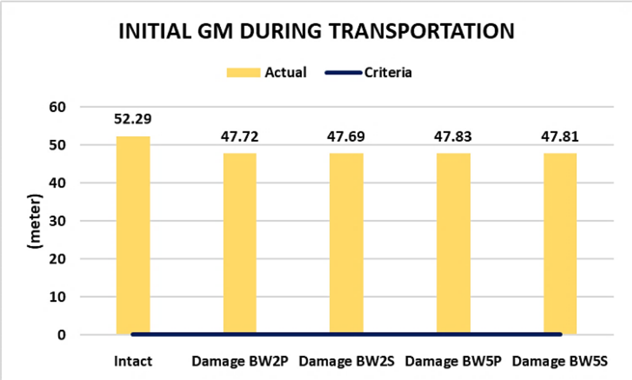
The allowable bending moment and shear force values will used as limiting values for the actual bending moment and shear force. The actual values of the bending moment and shear force must not exceed the permitted limits in the allowable bending moment and shear forces. Bending moment and shear force values will be analyzed in three conditions: still water, hogging and sagging.

3. RESULTS AND DISCUSSION

3.1 STABILITY ANALYSIS

a. Initial GM

The initial GM value indicates the range from the actual center of mass (G) to the metacentric point (M). The greater the GM value, the shorter the roll period during barge decommissioning, which is good for the barge stability. From the results of the analysis on intact and damaged conditions, the initial GM values that occur shown in Picture 2:

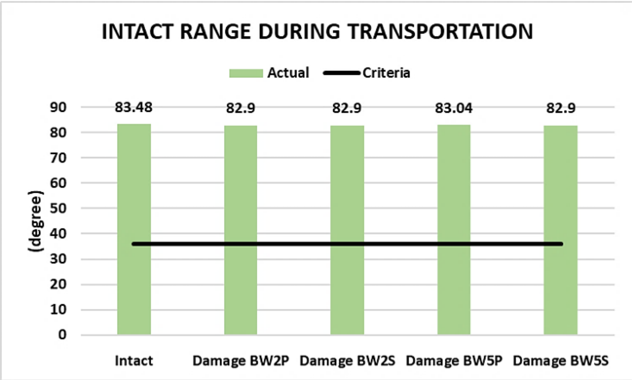


Picture 2. Actual Initial GM

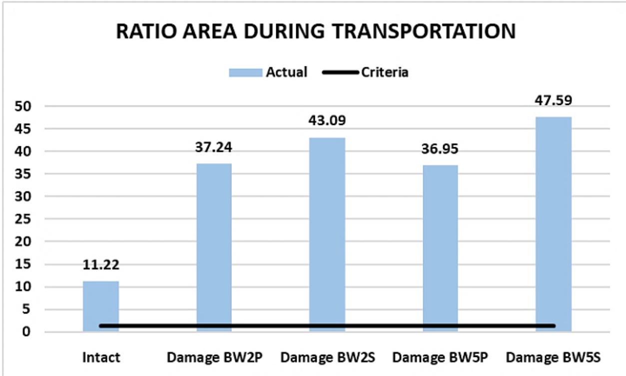
Picture 2 shows the initial GM value that occurs in each condition. The highest value occurs at 52.29 m in the intact conditions, and the smallest result occurs at 47.69 m in the BW2S damaged condition. All results that occur meet the requirements given to (GL, 2023), where the initial GM must be greater than 0.15 m. The value that occurs in the initial GM affected by the location of the center of mass (G). G value is affected by the amount of loading that occurs. The initial GM value increases with an increasing DWT value (Alamsyah et al., 2023). This proven in the intact condition. Result of the actual load is the smallest of all and has the highest initial GM value.

b. Intact Range

The intact range value shows that in the stability analysis, the decommissioning barge will reach the static equilibrium point where the center of mass (G) and center buoyancy (B) are on the same line. At this moment, the force value that occurs is zero, and the barge will return to its original position. From the analysis results, the actual intact range values in intact and damaged conditions shown in Picture 3:



Picture 3. Actual Intact Range



Picture 4. Actual Ratio Area

Picture 3 shows the actual intact range values in each condition, where the highest value occurs on intact condition and the lowest value on the damaged condition on BW2P, BW2S, and BW5S. All results that occur meet the requirements given in DNV, where intact range must be greater than 36°.

The values that occur on intact and damaged conditions is slightly different. It is was happen because during the analysis, decommissioning barge draft at intact and damage conditions is not much different. The value of the intact range will be higher with increasing water load (Daeng Paroka, 2018). In intact condition, the actual draught load was 2.12 m, and the damage was 2.13 m, 2.14 m, 2.06 m, 2.12 m. This slight difference in values means that the intact range values that occur are not much different

c. Ratio Area

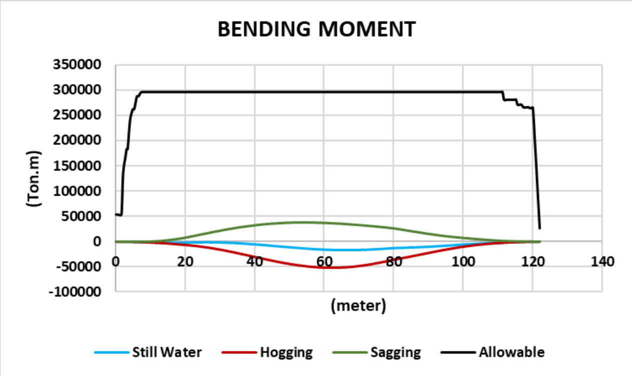
The area under wind overturning arm ratio shows that the area under the GZ curve must not be less than 40% of the area under the wind overturning arm area curve. From the results, the value of the under wind overturning arm ratio that occurs in both intact and damaged conditions shown in Picture 4:

Picture 4 shows the under wind overturning arm ratio values that occur in each condition, where the values at range 11.22 to 47.59. All result that occurs meet the requirements given in (GL, 2023), where the value of the area under wind overturning arm ratio must be greater than 1.4. Based on analysis results, the smallest value area under the wind overturning arm ratio occurred when the condition was intact. It is was happen because the value in the intact condition was higher than in the damaged case, so the resulting ratio value was small. The area ratio value that occurs in BW2P and BW5P damage conditions has a slight difference, 0.29. It is suspected because both tanks are in the portside position. Likewise, the area ratio value for the BW2S and BW5S tanks has a difference of 4.5. It is also suspected because these two tanks are in the starboard position.

3.2 LONGITUDINAL STRENGTH ANALYSIS

a. Bending Moment

A bending moment is a moment caused by one or more forces that cause a change in the shape of the barge. From the results of the analysis, the bending moment values that occur in each still water, hogging, and sagging conditions shown in Picture 5:



Picture 5. Actual bending moment compare to permitted limit

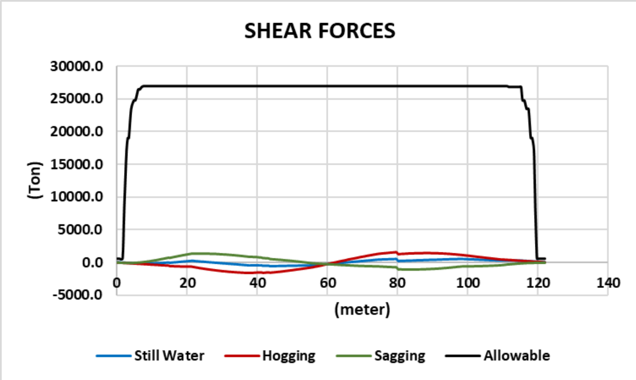
Picture 5 shows the bending moment values that occur in each condition. The bending moment will have a positive value if the bending moment causes an upward curve (sagging) and a negative value if the bending moment causes a downward curve (hogging) (Engineering LibreTexts, 2023).

In still water conditions, the maximum bending is 16410 tons.m. From the graph, it can be seen that in still water conditions, the bending moment that occurs makes the barge slightly concave downwards. In hogging conditions, it is -52740 ton.m.

Hogging conditions cause the decommissioning barge to have a concave downward tendency. In sagging conditions, it is 37210 ton.m. The sagging condition causes the decommissioning barge to have a concave upward proclivity. These values still meet the bending moment permit limits granted, namely 296158 ton.m. Therefore, results value describes the value of the bending moment that occurs when the barge is decommissioned during structure transportation.

b. Shear Force

Shear forces are forces that occur on a barge and can cause deformation of the barge shape. From the results of the analysis, the shear force values that occur in each still water, hogging, and sagging conditions shown in Picture 6:



Picture 6. Actual shear force compare to permitted limit

Picture 6 shows the shear force values that occur in each condition. From the results of previous research, it can be concluded that the shear force value is obtained from the integration of the load curve value, and the load curve is obtained from the results of subtracting the weight curve and buoyancy curve.

The shear force will be positive if the shear force tends to move from top left to bottom (sagging) and negative if the shear force that occurs tends to move from bottom left to top right (hogging) (Engineering LibreTexts, 2023).

In still water conditions, the maximum bending that occurs is 619,092 tons. In hogging conditions, it is 1591.05 tons. Hogging conditions cause the decommissioning barge to have a shear force that tends to be negative. In sagging conditions, it is 1391,362 tons. The sagging condition causes the decommissioning barge to have a shear force that tends to be positive.

These values still meet the shear forces permit limits granted 26933.4 tons. Therefore, the value that occurs describes the magnitude of the shear forces that occur when decommissioning the barge during structure transportation.

4. CONCLUSION

From the results of the stability analysis, the initial GM values in the intact condition, BW2P damage, BW2S damage, BW5P damage, and BW5S damage respectively were; 52.29 m, 47.72 m, 47.69 m, 47.83 m, 47.81 m, then the intact range values are 83.48°, 82.9°, 82.9°, 83, 04°, 82.9° and the area under wind overturning arm ratio values are 11.22, 37.24, 43.09, 36.95, and 47.59 respectively.

Because the initial GM value, intact range, and ratio under wind overturning arm pass the stability criteria proposed in (GL, 2023), the stability of the 400 ft barge decommissioning during the decommissioning platform transportation assumed safe.

The results of the longitudinal strength analysis showed that the bending moment values that occurred in still water, hogging, and sagging conditions were respectively 16410 ton.m, 52740 ton.m, 37210 ton.m, then the shear force values that occurred in the same conditions respectively, 619,092 tons, 1591.05 tons, and 1391,362 tons. The result of bending moment and shear forces are still below the permitted limits that the longitudinal strength of a 400 ft decommissioning barge during decommissioning platform transportation assumed to be safe.

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