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

ZONA LAUT

JOURNAL OF OCEAN SCIENCE AND TECHNOLOGY INNOVATION

Comparative Analysis of Mooring System Performance with Variations in 4, 6, and 8 Point Configurations on Accommodation Work Barges

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Abstract

In the maritime industry, an effective mooring system is essential to ensure the stability and safety of offshore operations. A mooring system is a collection of equipment and techniques used to maintain the position and stability of a structure at sea or on an accommodation work barge. In practice, there are still various challenges and problems in the use of mooring systems on accommodation work barges. Factors such as weather conditions, sea depth, and the type of anchor used must be considered. This study will focus on analyzing the factors that affect the mooring system, analyzing the ship's RAO, and evaluating the weight of the anchor and tension wire. This study aims to produce recommendations for the best mooring system and configuration based on four types of seabed. The analysis was carried out using Ansys AQWA software and criteria set by ABS, DNV, and API. The factor that most influences the tension wire is the environmental load received by the ship (currents, waves, wind). Differences in environmental loads will also result in different tension values. In holding power analysis, mud seabeds produce the lowest holding power, while rock seabeds produce the highest holding power but are difficult to anchor. The 8 mooring system configuration is suitable for floating hotel operations because it has a good motion response, while 6 mooring is recommended for well intervention work because it is more efficient during the work process. The best anchor placement is located at 45° - 60° from the ship's centerline because it has an even load distribution.

Keywords: Accommodation Work Barge, RAO, Mooring Analysis, Mooring Tension, Holding Power

1. INTRODUCTION

Increased activity in the shipping and offshore construction sectors requires reliable and efficient mooring systems. Mooring systems play a vital role in maintaining the position and stability of floating structures to ensure safety during operations in dynamic marine environments. Inefficiencies in these systems can lead to various risks, such as barge displacement, structural damage, disruption to work safety, and potential environmental pollution, which can cause significant losses.[1]

An accommodation work barge (AWB) is a type of ship or barge specifically designed to provide accommodation and work facilities for crews or workers involved in offshore operations[2].This vessel serves as a support facility for offshore activities, such as construction, drilling, inspection, and maintenance of offshore facilities[3]. During operation, the AWB must remain stable so that workers and equipment on deck can operate safely. Therefore, the mooring system used must be able to withstand environmental forces such as currents, wind, and waves optimally.[4]

However, in practice, the performance of the mooring system on the AWB is greatly influenced by various factors, including environmental conditions, the type and capacity of the anchor, and the configuration of the number of mooring lines used. Variations in the number of mooring points—for example, 4, 6, and 8 points—can result in different force distributions and stability. Therefore, a comparative analysis is needed to evaluate the effect of these configuration variations on the performance of the mooring system, both in terms of tether forces and barge position stability. The results of this study are expected to serve as a reference in selecting the most efficient and safe mooring configuration for Accommodation Work Barge operations in various water conditions.

2. METHODS

Numerical methods in analysis and modeling for accommodation work barges were performed using ANSYS AQWA and MaxSurf software. MaxSurf software was used to model the main dimensions of the ship in accordance with the target full-scale model. The MaxSurf mesh marker model is then taken and used as a reference model for the barge in the ANSYS AQWA software, which will be used to analyze the motion and mooring system.

2.1. Research Object

The object of this study is accommodation work barges that will operate in offshore working areas in Indonesia. This barge was selected based on its size, which is considered to be similar in shape and size, so that it can represent barges in actual working areas. The data presented as the object of the study consists of Barge Technical Information, Mooring Wire Specifications, and Anchor Specifications.

Table 1. Barge the Technical Information

No	Parameter	Value	Unit
1	Length Overall (LOA)	100,58	m
2	Breadth Moulded (B)	31,70	m
3	Depth (H)	7,31	m
4	Draft (T)	4,51	m
5	Displacement	14149,55	Ton
6	Deadweight	7859,00	Ton
7	Gross Tonnage	11087	GT
8	Net Tonnage	3327	GT
9	Crew Capacity	300	Person

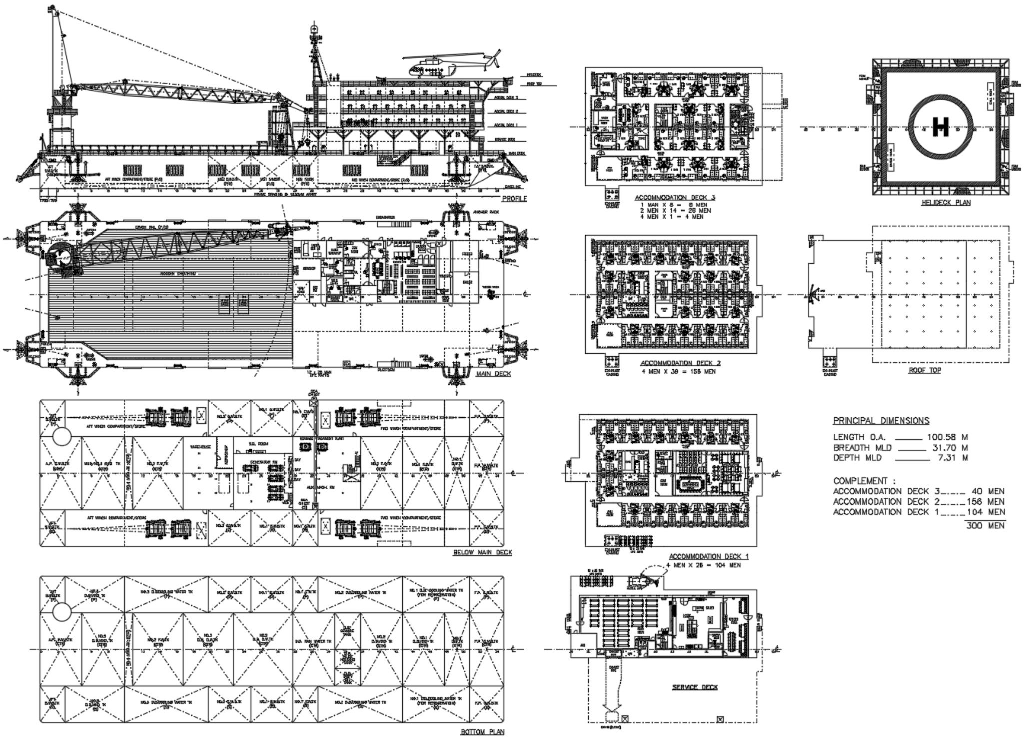


Figure 1. General Arrangement Accomodation Work Barge

Table 2. Mooring Wire Specifications

No	Parameter	Value	Unit
1	Rope Diameter	58	Mm
2	Rope Mass (Air)	14,80	Kg/m
3	Rope Mass (Submerge)	12,50	Kg/m
4	Minimum Breaking Load	2430	kN

Table 3. Anchor Specifications

No	Parameter	Value	Unit
1	Anchor Weight	10 9,81	MT kN
2	Holding Capacity	132 1295	MT kN
3	Type : Flipper Delta	-	-

2.2. Research Method

1. Maximum Tension Mooring

Maximum mooring stress analysis can be performed using a frequency domain approach that refers to Rules API RP 2 SK [5].

$$T_{Max} = T_{Mean} + T_{wfmax} + T_{lfsig} \tag{1}$$

where $T_{Max}$is the maximum mooring line tension (kN), $T_{Mean}$is the mean tension component (kN), $T_{wf,max}$is the maximum wave-frequency tension component (kN), and $T_{lf,sig}$is the significant low-frequency tension component (kN).

2. Mooring Safety Factor Criteria

Mooring safety factor criteria are safety limits (permitted limits) for the operation of moored offshore floating structures, taking into account the maximum stress occurring in the mooring system. The mooring stress value must meet the safety factor criteria/limits. The mooring safety factor criteria in this study are based on API RP 2 SK regulations [5].

Table 4. Anchor Specifications

No	Conditions	Analysis Method	Safety Factor
1	Intact	Dynamic	≥ 1,67
2	Damage	Dynamic	≥1,25

The mooring safety factor value can be obtained by comparing the minimum breaking load value of the mooring line with the maximum tension value of the mooring line [6]:

$$Maximum\ Tension = \frac{Minimum\ Breaking\ Load}{Safety\ Factor} \tag{2}$$

3. Anchor Holding Capacity

Determining the anchor holding capacity required to hold a ship can refer to the factor of safety (FOS) and the maximum tension of the mooring line at the anchor point using the following equation [7]:

$$H_{Anchor} = S_f \times W \tag{3}$$

where H_{Anchor}denotes the required anchor holding capacity (kN), Wrepresents the anchor weight (kN), and $S_f$is the soil factor.

Table 5. Soil Factor

No	Seabed Type	Value of factor (kN/m^2)
1	Clay (Soft)	5 – 10
2	Clay (Stiff)	10 – 20
3	Sand (Loose)	10 – 15
4	Sand (Dense)	15 – 30
5	Grave	30 – 50
6	Rock	> 50 (difficult to embed)

4. Wave Load Calculation

Wave forces can be calculated based on the Moorison equation, which is commonly used for floating structures [1]:

$$F(Wv) = \frac{1}{2}\rho C_D A u(t) + \rho C_m V \frac{du(t)}{dt} \tag{4}$$

where $F(W_v)$is the total wave load acting on the structure (N), $\rho$is the density of seawater (1.025 ton/m^3), $C_d$is the drag coefficient (1.0–1.4 for a barge hull), $C_m$is the mass coefficient (2.0–2.5 for a barge hull), $A$is the area affected by the wave (m^2), $V$is the submerged volume in water (m^3), $u(t)$is the wave particle velocity (m/s), and $\frac{du}{dt}$is the wave particle acceleration (m/s^2).

5. Wind Load Calculation

The load value generated by wind acting on the barge body can be calculated using the following formula [1]:

$$F_W = \frac{1}{2}\rho\alpha V W^2 A w C d w \tag{5}$$

where $F_w$is the wind load (N), $C_{dw}$is the drag coefficient, $\rho_a$is the density of air (1.29 kg/m^3), $A_w$is the vertical area exposed to wind (m^2), and $V_w$is the average wind speed (m/s).

Table 6. Drag Coefficient

No	Wind direction	Type structure	Value
1	Head	Superstructure (Flat)	0,8 – 1,2
2	Beam Seas	Side Hull & Superstructure	1,2 – 1,4
3	Quartering (45°)	Campuran	1,1 – 1,3
4	From Aft	Deck Open Superstructure	0,6 – 1,0

6. Seawater Current Load Calculation

The load value generated by the ocean current acting on the barge body can be calculated using the following formula [1]:

$$F_W = \frac{1}{2}\rho w V W^2 A w C d w \tag{6}$$

where $F_w$is the seawater current load (N), $C_{dw}$is the drag coefficient, $\rho_w$is the density of seawater (1025 kg/m^3), $A_w$is the submerged area under water (m^2), and $V_w$is the average current velocity (m/s).

3. RESULTS AND DISCUSSION

In this study, the barge will have three different configurations, namely 4, 6, and 8 mooring systems with a caternary spread type. This mooring system was chosen because it provides good flexibility in dealing with strong waves and ocean currents, making it ideal for areas with dynamic environmental conditions[8]. The anchor distribution position is adjusted according to the anchor pattern data that has been adjusted to the actual conditions of the barge. In each mooring system configuration, there will be three external load directions, namely head seas /0°, beam seas/90°, and following seas/180°, and the tension of the mooring wire will be analyzed under two conditions, namely ULS (Ultimate Limited State), which is when the mooring system is not damaged, and ALS (Accidental Limited State), which is when the mooring system is damaged[9]. In this analysis, it is assumed that the wire is broken.

The numerical analysis was conducted using ANSYS AQWA based on linear potential flow theory with the assumption of small-amplitude vessel motions. The AWB was modeled as a rigid body with six degrees of freedom, while the mooring system was represented by non-linear catenary lines to account for geometric nonlinearity. Anchors were assumed to be fully fixed on a rigid seabed and embedded 2.5 m below the seabed surface at a water depth of 50 m, representing the deepest operational condition, with fairleads fixed relative to the vessel hull. Hydrodynamic damping was obtained from AQWA radiation damping, with viscous effects implicitly included. Environmental loads were applied as combined wave, current, and wind actions, with wave excitation modeled using irregular JONSWAP spectra for head, beam, and following seas.

Table 7. Anchor Patern Data

No	Lines	Bearing Relative (Deg.)	Horizontal Distance (m)	Pre tension (MT)	Mid Bouy Position From Anchor (m)	Length of Pennant Wire (m)
1	S1	154	650	8	-	-
2	S2	135	650	8	-	-
3	S3	260	600	8	-	-
4	S4	320	650	8	-	-
5	P1	206	650	8	-	-
6	P2	225	650	8	-	-
7	P3	319	650	8	-	-
8	P4	346	650	8	-	-

3.1. Barge Modelling

Initial modeling on the barge will be performed using Maxsurf software, while advanced modeling for the addition of the mooring system will use Ansys AQWA software.

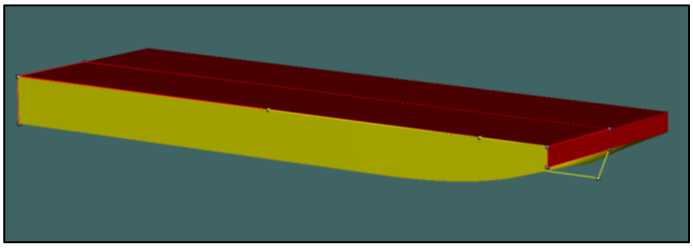


Figure 2. Initial Modeling of The Barge Hull

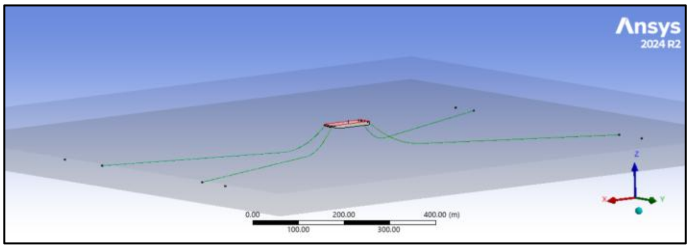


Figure 3. Configuration 4 Mooring System Modeling

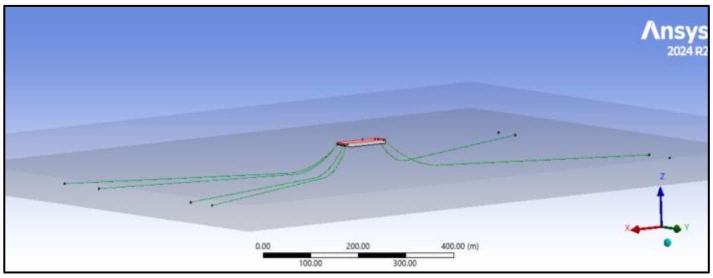


Figure 4. Configuration 6 Mooring System Modeling

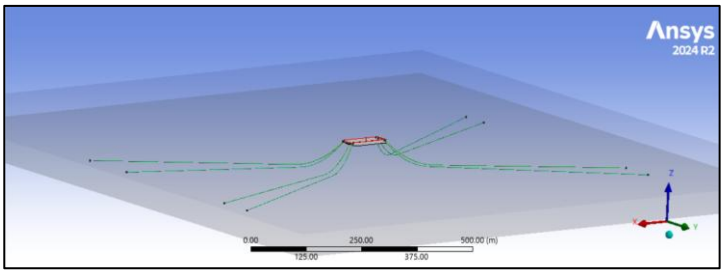
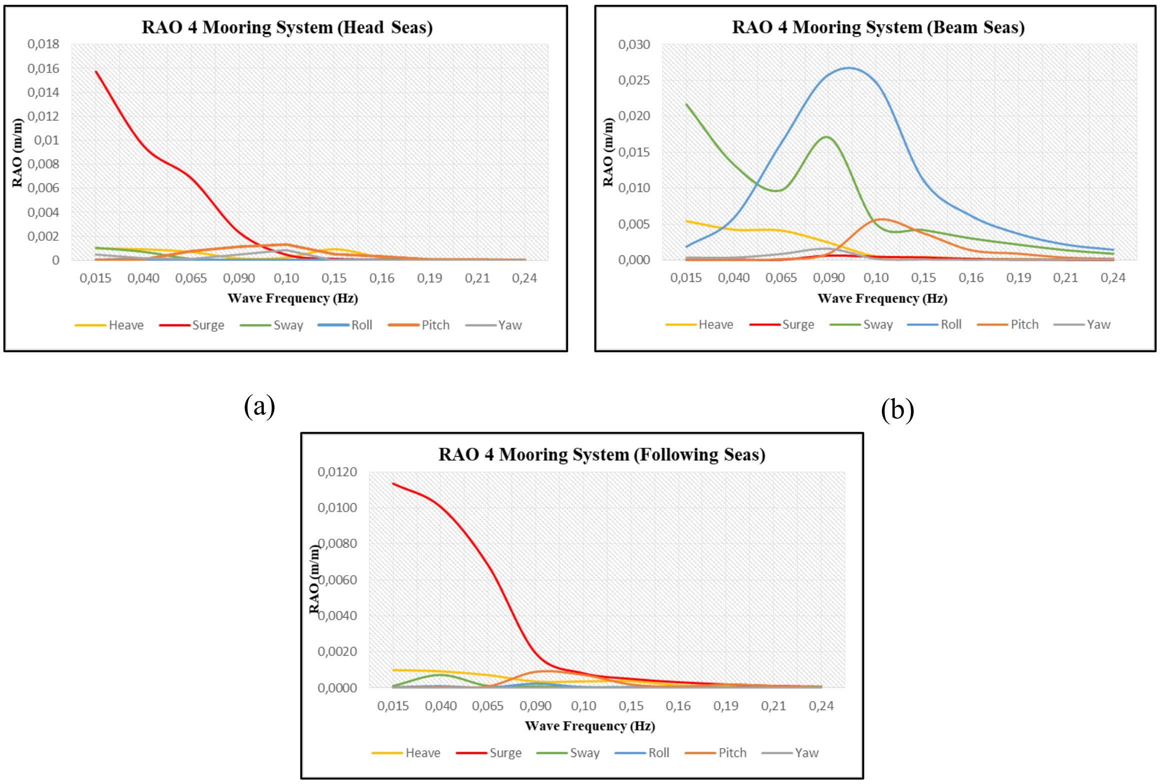


Figure 5. Configuration 8 Mooring System Modeling

3.2. Motion Analysis

RAO (Response Amplitude Operator) analysis was performed to assess vessel motion response under three wave headings: head seas (0°), beam seas (90°), and following seas (180°).

1. Configuration 4 Mooring System



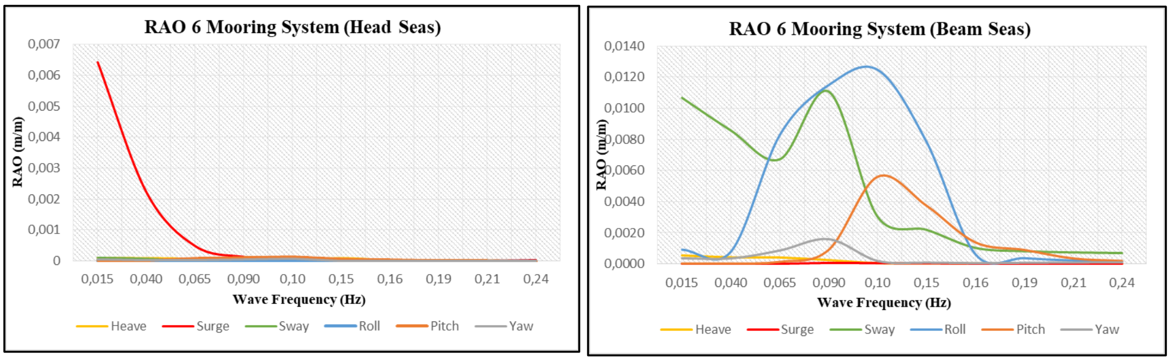
(a) (b)

(c)

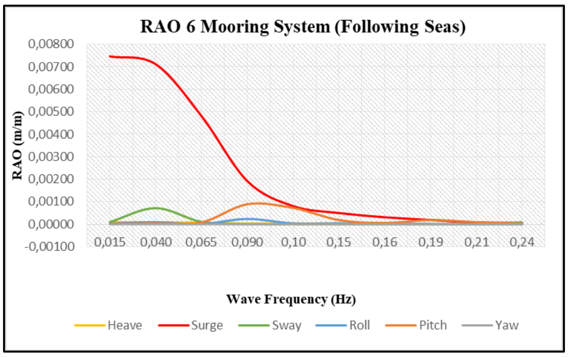
Figure 6. RAO respons value of the 4 mooring system configuration (a) 0°, (b)90°, (c)180°

For the 4-point mooring configuration, the RAO results indicate that in head seas (Figure 6a), surge motion dominates at low frequencies (<0.05 Hz), reflecting a strong longitudinal response while other motion components remain relatively small. Under beam seas (Figure 6b), sway and roll exhibit the highest amplitudes around 0.09 Hz, indicating reduced transverse stability due to lateral wave excitation. In following seas (Figure 6c), the response pattern is similar to head seas, with surge remaining dominant but slightly reduced as waves approach from the stern. Overall, the largest vessel motions occur under beam sea conditions, where elevated sway and roll responses increase vessel excursion and impose higher demands on the mooring system. This behavior confirms that, for the 4-mooring configuration, beam seas represent the most critical condition for vessel stability and mooring performance, contributing to the elevated mooring tensions observed in the corresponding load analysis.

2. Configuration 6 Mooring System



(a) (b)

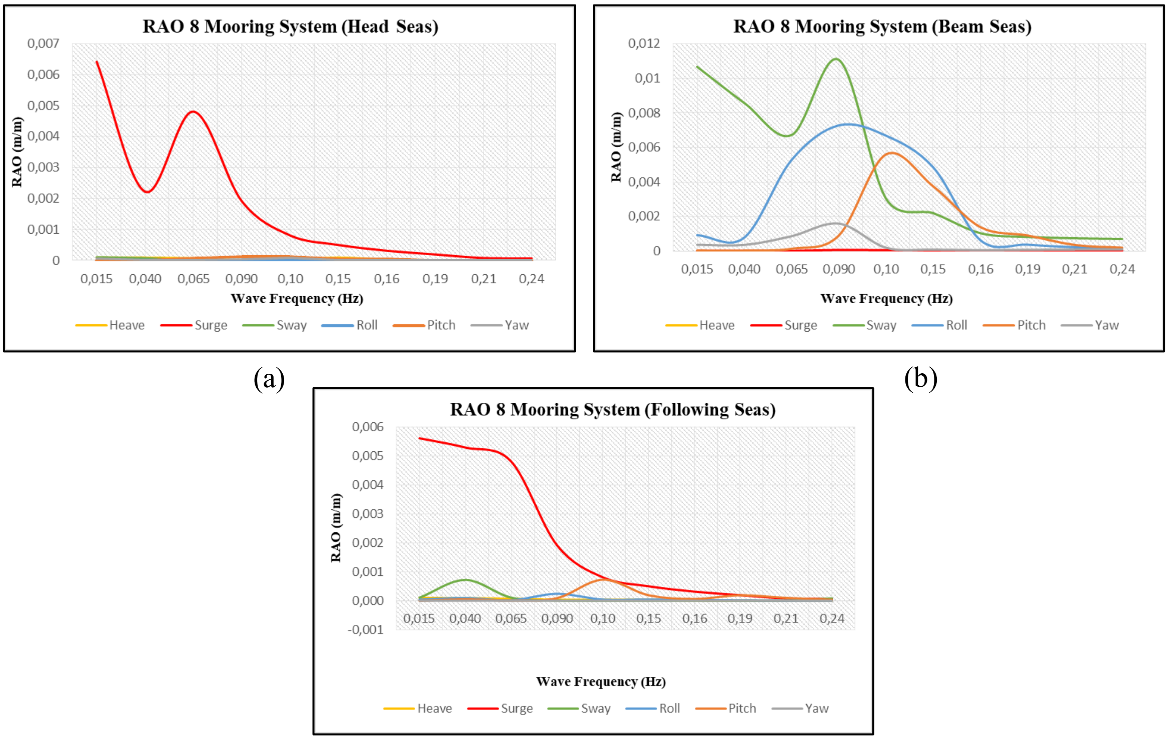


(c)

Figure 7. RAO respons value of the 6 mooring system configuration (a) 0°, (b)90°, (c)180°

For the 6-point mooring configuration, the RAO results show that in head seas (Figure 7a), surge remains the dominant motion at low frequencies (<0.05 Hz); however, its amplitude is lower than that observed in the 4-mooring configuration, indicating improved longitudinal restraint due to the additional mooring lines. Under beam seas (Figure 7b), sway and roll still peak around 0.09 Hz, similar to the 4-mooring case, but with significantly reduced amplitudes, demonstrating enhanced transverse stability and more effective control of lateral and rotational motions. In following seas (Figure 7c), the motion response resembles that of head seas, with surge remaining dominant but further reduced relative to the 4-mooring system. Overall, the 6-mooring configuration provides improved motion control in all wave directions, particularly under beam sea conditions, which are critical for operational safety. This reduction in vessel motions contributes to lower mooring line tension and improved station-keeping performance, supporting the suitability of the 6-mooring configuration for AWB operational use.

3. Configuration 8 Mooring System



(a) (b)

(c)

Figure 8. RAO respons value of the 8 mooring system configuration(a) 0°, (b)90°, (c)180°

For the 8-point mooring configuration, the RAO results indicate that in head seas (Figure 8a), surge remains the dominant response at low frequencies, consistent with previous configurations, but with the lowest amplitude among all cases, indicating a significant improvement in longitudinal stability. Under beam seas (Figure 8b), sway and roll continue to dominate around 0.09 Hz; however, their amplitudes are further reduced compared to the 4- and 6-mooring configurations, demonstrating enhanced transverse and rotational restraint. In following seas (Figure 8c), the vessel motion remains minimal, with surge responses slightly reduced relative to the other configurations. Overall, the progressive reduction in RAO amplitudes from the 4- to 8-mooring systems confirms that increasing the number of mooring lines substantially improves vessel stability, reduces motion sensitivity to wave excitation, and provides the most favorable motion control performance, particularly under critical beam sea conditions.

3.3. Tension & Holding Power Analysis

Based on the requirements of API RP 2SK, DNV, and ABS, the tension acting on the mooring wire shall not exceed the allowable tension determined by the prescribed safety factors, as presented in Table 4. The corresponding allowable tension limits are as follows: for the Ultimate Limit State (ULS), the maximum allowable tension is $2430/1.67 = 1455.090$; meanwhile, for the Accidental Limit State (ALS), the maximum allowable tension is $2430/1.25 = 1944.000$.

1. Configuration 4 Mooring System

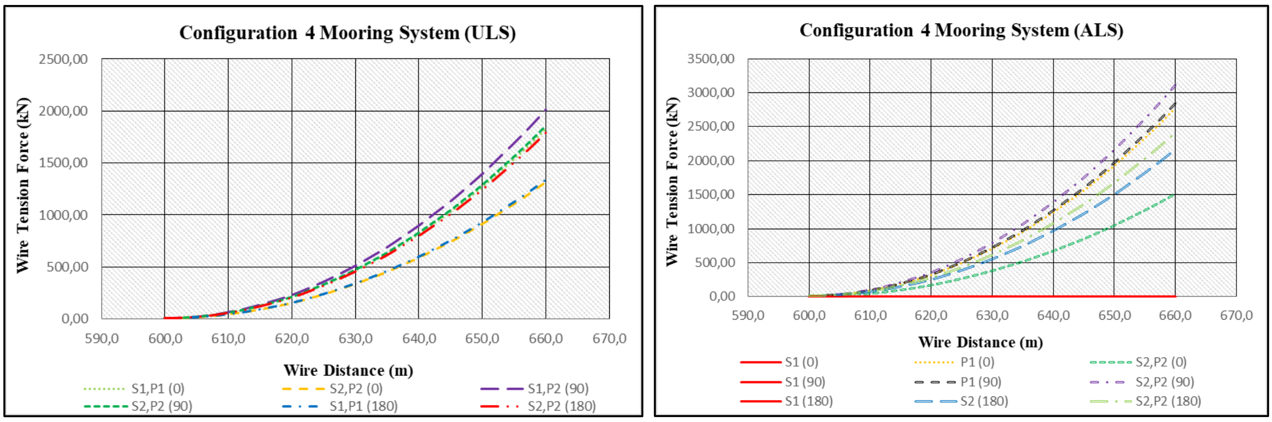


Figure 9. Wire Tension value of the 4 mooring system configurations

Under ULS conditions, the 4-point mooring system remains fully intact; however, the maximum tension recorded on wires S1 and P1 at 90° reached 2011.711 kN, exceeding the allowable limit. Under ALS conditions, where one mooring line (S1) is assumed to fail, a pronounced redistribution of load occurs, resulting in peak tensions of 3117.755 kN on the remaining lines. These results indicate the limited redundancy and poor load-sharing capability of the 4-mooring configuration, as excessive tension is observed even in normal conditions and is further amplified under accidental scenarios. Consequently, this configuration is not suitable for AWB operational use and can only be considered for survival conditions, where operations are suspended and shortened wire lengths are applied to temporarily maintain station.

Table 8. Comparison Tension and Holding Power in 4 Mooring System

No	Seabed Type	Tension Min (kN)	Tension Max (kN)	Comparison Tension and Holding Power in 4 Mooring System (kN)				
				Heading (Deg)	Ultimate Limited State (ULS)			
1	Clay	981,00	1962,00		S1	P1	S2	P2
				0	1828,196	1828,196	1314,488	1314,488
				90	2011,771	2011,771	1864,458	1864,458
2	Mud	490,50	981,00	180	1339,418	1339,418	1790,424	1790,424
				Tension Max	2011,771	2011,771	1864,458	1864,458
				Heading (Deg)	Accidental Limited State (ALS)			
3	Sand	1475,5	2943		S1	P1	S2	P2
				0	0,000	2775,534	1508,942	1508,942
				90	0,000	2846,547	3117,755	1864,458
4	Rock	4905	>4905,0	180	0,000	2169,208	2417,450	2417,450
				Tension Max	0,000	2846,547	3117,755	2417,450

2. Configuration 6 Mooring System

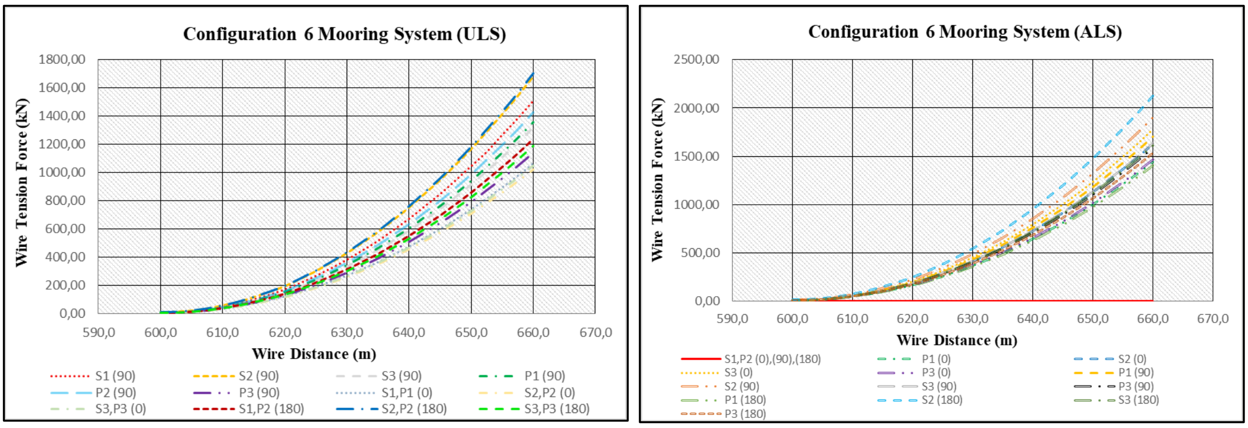


Figure 10. Wire Tension value of the 6 mooring system configuration

For the 6-point mooring configuration, the maximum line tension under ULS conditions occurs on wires S2 and P2 at 180°, reaching 1704.302 kN, which is notably lower than that of the 4-mooring system. Under ALS conditions, following the failure of one mooring line, the highest tension is observed on S2, increasing to 2124.863 kN. The reduction in peak tension under ULS conditions demonstrates the improved load distribution achieved by the additional mooring lines at the bow. However, relatively high tension persists at the stern where no additional lines are installed, leading to localized load amplification under accidental conditions. Despite this limitation, the tension levels remain within acceptable operational limits, indicating that the 6-mooring configuration offers a balanced compromise between load reduction and system efficiency, and is therefore suitable for AWB operational use, particularly for well maintenance activities and emergency scenarios such as platform blowout events

Table 9. Comparison Tension and Holding Power in 6 Mooring System

No	Seabed Type	Tension Min (kN)	Tension Max (kN)	Comparison Tension and Holding Power in 6 Mooring System (kN)						
					Ultimate Limited State (ULS)					
1	Clay	981,00	1962,00	Heading (Deg)	S1	P1	S2	P2	S3	P3
				0	1067,304	1067,304	1020,829	1020,829	1048,191	1048,191
				90	1507,431	1353,772	1680,883	1428,785	1319,021	1140,885
2	Mud	490,50	981,00	180	1239,943	1239,943	1704,302	1704,302	1187,572	1187,572
				Tension Max	1507,431	1353,772	1704,302	1704,302	1187,572	1187,572
					Accidental Limited State (ALS)					
3	Sand	1475,5	2943	Heading (Deg)	S1	P1	S2	P2	S3	P3
				0	0,000	1444,200	1628,530	0,000	1779,847	1467,271
				90	0,000	1704,075	1901,475	0,000	1637,218	1591,891
4	Rock	4905	>4905,0	180	0,000	1401,592	2124,863	0,000	1610,701	1535,156
				Tension Max	0,000	1704,075	2124,863	0,000	1779,847	1591,891

3. Configuration 8 Mooring System

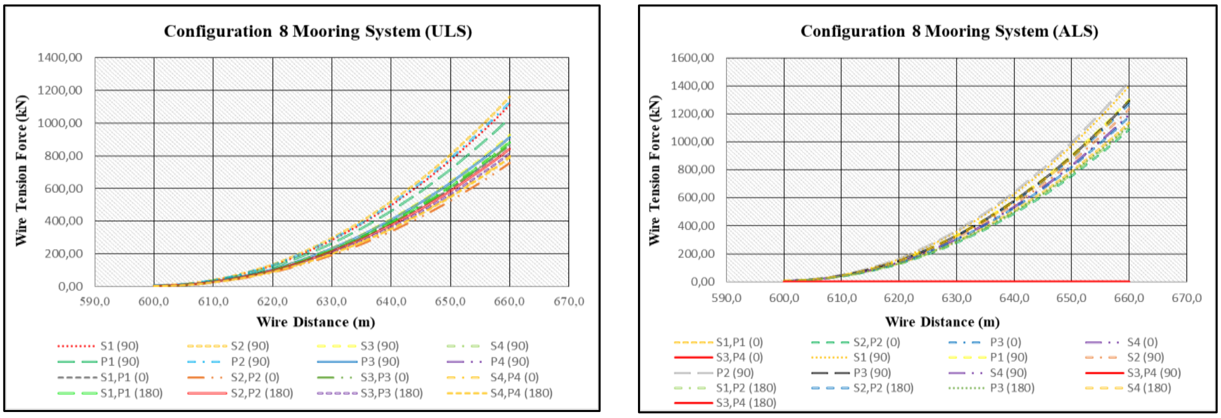


Figure 11. Wire Tension value of the 8 mooring system configuration

For the 8-point mooring configuration, the system exhibits the most favorable performance among all evaluated layouts. Under ULS conditions, where all mooring lines remain intact, the maximum tension occurs on S2 at 90°, reaching 1164.909 kN, which is substantially lower than the peak values observed in the 4- and 6-mooring configurations and well below the allowable ULS limit. Under ALS conditions, assuming the failure of two mooring lines (S3 and P4), the highest tensions are recorded on P2 at 90° (1433.513 kN) and S4 at 180° (1283.936 kN), both of which remain within permissible ALS limits. These results indicate a high level of redundancy and effective load redistribution, minimizing tension amplification even under degraded conditions. Consequently, the 8-mooring configuration is highly recommended for AWB applications requiring continuous operation and enhanced comfort, such as floating hotel functions, as it ensures low line tension and reduced vessel motions compared to the 4- and 6-mooring systems.

Table 10. Comparison Tension and Holding Power in 8 Mooring System

No	Seabed Type	Tension Min (kN)	Tension Max (kN)	Perbandingan Tension 8 Mooring System dengan Holding Power (kN)								
				Heading (Deg)	Ultimate Limited State (ULS)							
1	Clay	981,00	1962,00		S1	P1	S2	P2	S3	P3	S4	P4
				0	867,789	867,789	755,453	755,453	871,793	871,793	799,269	799,269
				90	1114,293	1033,082	1164,909	1130,158	928,905	914,778	890,679	870,282
2	Mud	490,50	981,00	180	880,858	880,858	843,086	843,086	816,947	816,947	791,261	791,261
				Tension Max	1114,293	1033,082	1164,909	1130,158	928,905	914,778	890,679	870,282
				Heading (Deg)	Accidental Limited State (ALS)							
3	Sand	1475,5	2943		S1	P1	S2	P2	S3	P3	S4	P4
				0	1135,672	1135,672	1088,683	1088,683	0,000	1270,672	1195,202	0,000
				90	1397,254	1303,308	1234,086	1433,513	0,000	1294,755	1169,104	0,000
4	Rock	4905	>4905,0	180	1106,077	1106,077	1179,520	1179,520	0,000	1119,166	1283,936	0,000
				Tension Max	1397,254	1303,308	1234,086	1433,513	0,000	1294,755	1283,936	0,000

4. Configuration 6 Mooring System with angle changes

The 6 mooring system is a widely used configuration during well intervention operations because it is the recommended configuration in operational standards and is more efficient during well intervention and when a blowup occurs on the platform [10]. Therefore, analyzing angle changes is important to obtain an effective and efficient angle when used on barges.

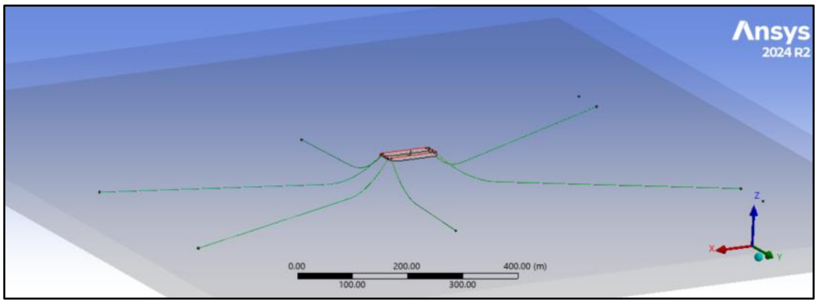


Figure 11. Configuration 6 Mooring System with Angle Changes Modeling

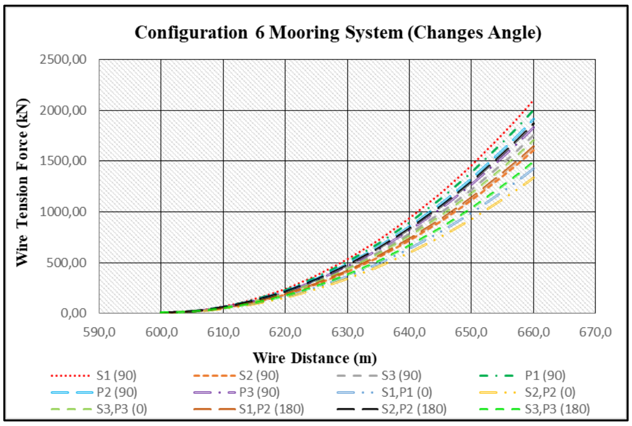


Figure 11. Configuration 6 Mooring System with Angle Changes Modeling

Angle changes at S3 and P3 to 90° from the barge centerline significantly disrupt the load-sharing mechanism of the mooring system. From an engineering standpoint, mooring line angles in the range of 45–60° provide an optimal balance between longitudinal and transverse force components, allowing environmental loads to be distributed more uniformly among the lines. When mooring angles exceed 60°, particularly approaching 90°, the effectiveness of the affected lines in resisting longitudinal loads is reduced, causing the remaining lines to carry a disproportionate share of the load and resulting in increased line tension.

In addition, larger mooring angles increase the effective spacing between adjacent lines, reducing system stiffness and symmetry. This condition leads to uneven restoring forces and localized tension amplification, as observed in the head seas, beam seas, and following seas cases, where peak tensions reached 1705.813 kN, 2004.066 kN, and 1873.523 kN, respectively. Therefore, a mooring angle range of 45–60° is technically preferred, as it ensures balanced force distribution, adequate system stiffness, and reduced peak tension, thereby enhancing overall mooring system reliability.

Table 11. Comparison Change Angle In 6 Mooring System

<table>
<tr><th>No</th><th>Seabed Type</th><th>Tension Min (kN)</th><th>Tension Max</th><th colspan="7">Comparison Tension and Holding Power in 6 Mooring System (kN)</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Clay</td><td rowspan="2">981</td><td rowspan="2">1962</td><td rowspan="2">Heading (Deg)</td><td colspan="6">With No Changes Angle</td></tr>
<tr><td>S1</td><td>P1</td><td>S2</td><td>P2</td><td>S3</td><td>P3</td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">Mud</td><td rowspan="4">490,5</td><td rowspan="4">981</td><td>0</td><td>1067,304</td><td>1067,304</td><td>1020,829</td><td>1020,829</td><td>1048,191</td><td>1048,191</td></tr>
<tr><td>90</td><td>1507,431</td><td>1353,772</td><td>1680,883</td><td>1428,785</td><td>1319,021</td><td>1140,885</td></tr>
<tr><td>180</td><td>1239,943</td><td>1239,943</td><td>1704,302</td><td>1704,302</td><td>1187,572</td><td>1187,572</td></tr>
<tr><td>Tension Max</td><td>1507,431</td><td>1353,772</td><td>1704,302</td><td>1704,302</td><td>1187,572</td><td>1187,572</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Sand</td><td rowspan="2">1475,5</td><td rowspan="2">2943</td><td rowspan="2">Heading (Deg)</td><td colspan="6">With Change Angle</td></tr>
<tr><td>S1</td><td>P1</td><td>S2</td><td>P2</td><td>S3</td><td>P3</td></tr>
<tr><td rowspan="4">4</td><td rowspan="4">Rock</td><td rowspan="4">4905</td><td rowspan="4">>4905,0</td><td>0</td><td>1429,045</td><td>1429,045</td><td>1334,908</td><td>1334,908</td><td>1705,813</td><td>1705,813</td></tr>
<tr><td>90</td><td>2004,066</td><td>2004,066</td><td>1609,105</td><td>1917,551</td><td>1758,906</td><td>1830,312</td></tr>
<tr><td>180</td><td>1643,110</td><td>1643,110</td><td>1873,523</td><td>1873,523</td><td>1493,606</td><td>1493,606</td></tr>
<tr><td>Tension Max</td><td>2004,066</td><td>2004,066</td><td>1873,523</td><td>1917,551</td><td>1758,906</td><td>1830,312</td></tr>
</table>

The observed tension characteristics can be explained by the combined effects of vessel motion response and mooring configuration geometry.The excessive mooring tensions observed in the 4-point configuration are primarily caused by limited load-sharing capability and low system redundancy, where environmental loads are concentrated on a small number of lines. This condition is further amplified under beam sea excitation, which induces large lateral motions and increases line tension beyond allowable limits. In contrast, the 6-point configuration distributes environmental loads more evenly, reducing peak tension to acceptable levels under operational conditions, although localized overload may still occur under accidental scenarios. The 8-point configuration exhibits the most effective load distribution and redundancy, maintaining mooring tensions within allowable limits even under degraded conditions. These findings directly inform AWB operational decisions, where the 4-point system should be restricted to survival conditions, the 6-point system is suitable for normal operations, and the 8-point system is recommended for long-term or accommodation-based operations.

4. CONCLUSION

The factor that most affects the performance of the AWB ship mooring system is the environmental load received by the ship (currents, waves, wind). The angle of the mooring line also affects the distribution of load on each mooring wire. The greater the difference in the angle of the mooring wire, the less effective the distribution of load on each wire will be. Based on the analysis results, the 4 mooring system configuration can only be used in survival conditions, the 6 mooring configuration can be recommended for AWB operations, while the 8 mooring configuration is highly recommended when AWB is to be used as a floating hotel. The best anchor placement obtained based on research is at an angle of 45–60° from the centerline of the ship. This is proven in the angle change analysis in the 6 mooring configuration, where angles greater than 60° result in uneven load distribution.

For Designers To achieve consistent load distribution, mooring systems should be constructed to minimize fluctuation in the mooring line angle. For AWB operating circumstances, a minimum of six mooring lines are advised, with anchor placement kept between 45 and 60 degrees from the barge centerline. For work barge operator to increase safety and redundancy, an eight-mooring configuration is advised for long-term lodging or floating hotel applications.AWB operational practices should be aligned with the installed mooring configuration. Four-mooring systems should be limited to survival conditions, while routine operations should be conducted using at least six mooring lines. Continuous inspection and monitoring of mooring line tension are required, for offshore project planer Site-specific environmental conditions should be integrated into mooring system selection during the planning stage. Projects requiring prolonged station-keeping or accommodation functions should allocate adequate capacity for eight-mooring systems and optimized anchor layouts to ensure long-term operational safety and reliability.

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