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Seafastening for Cargo Transportation Offshore

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ABSTRACT: Seafastening for cargo securing transportation offshore is to secure the heavy module GTC Gas Turbine Compressore module P1 and module S1 during transported by using Flat Top Barge BS 27 Barge Transporter is safely. The analysis of Seafastening should consider for the transverse force and Longitodinal force in roll, pitch and heaving. The weight of P1 is 511.48 mt metric ton and S1 429.18 mt metric ton will transported by BS 27 with length 100.58m, witdht 30.48m draft, 1.87m, and height 5.49m, has period of motion 10 second, roll 5 degree, pitch 2.5 deg. And heave acceleration 0.1 g m/s^2. The environment condition is the wind speed is 15 m/s. The capacity of wire lashing is 22 mt. The result from the site activity of the transportation of Module P1 and S1 with using BS 27is succsessfuly and safely. The module P1 has the total transverse securing force 124.92 greater than total transverse sliding force 110.45, the longitudinal securing force 59.01 is greater than total longitudinal sliding force 54.92 mt. The module S1 has the total transverse securing force is 109.28 greater than total transverse sliding force 100.62 mt, and total longitudinal securing force 77.89 mt greater than total longitudinal sliding force 49.72 mt.

KEYWORDS: Seafastening, Transverse, Longitudinal, BS 27.

I. INTRODUCTION

The content of this document forms the Seafastening [1] for Cargo Transportation Offshore for the Heavy Module GTC Gas Turbine Compressor. Its weight is 511 ton, it will be transported by using BS 27, this is the Barge, it has dimension 330 feet length, 100 feet width and 18 feet height.

The aim of this document is to provide an overview on the proposed concept of handling to enable the safe and smooth transportation of the cargo. Details of the cargo are stated in this document.

Lashing analysis [2] of the transportation is included in this document. All relevant studies have been performed for the cargo transportation for the above-mentioned analysi

This report summarises the acceleration results caused by the motion of the trailer with cargo during transportation. The analysis is to ensure that the lashing is adequate to resist the accelerations during the transportation.

The growth of renewable energy sources, particularly solar and wind energy, and the decreasing use of non-renewable sources in electricity production. The European Union has set targets for renewable energy usage, and off shore wind energy is expected to play a significant role in achieving these targets. Off shore wind energy is becoming increasingly cost-effective and is expected to play a significant role in the future development of renewable energy technologies. The article also discusses the challenges of installing off shore wind turbines, including the complexity of raising and anchoring them to the sea floor and the various types of foundations required for different depths of water [3]. Marine operations for transporting large and heavy objects. The study focuses on estimating the failure probability of seafastening and uses two methods to calculate wave-induced barge motions. The design check is based on a simplified method, while the structural reliability analyses use a 3D panel model. The study also considers the uncertainty in weather forecasts for both weather-restricted and weather-unrestricted operations. Other research has focused on installation operations, hull girder capacity, and the correlation between global and local wave loads. The study provides an indication of the reliability level for marine operations [4].

The amount of energy produced by offshore wind turbines is expected to increase significantly in the coming years, with their share of the total global offshore installations expected to exceed 10% by 2025. China is promoting a gradual transition from conventional energy sources to renewable energy sources, and has taken the lead in offshore wind market by installing 1.8 GW offshore wind turbines in 2018. However, the construction period and costs of offshore wind turbines are still much greater than those of onshore wind turbines due to the limitation of the window periods for offshore construction. A new type of wide-shallow foundation and one-step transportation and installation method for the foundation, called the large-scale composite bucket foundation (CBF), has been proposed by Tianjin University and Daoda Company, which has great advantages for bearing the large bending moment loads from wind turbines. The first CBF for a fully operational wind turbine was installed in Qidong City, in the eastern part of Jiangsu Province in 2010 [5].

The transportation of offshore structures, specifically the topside and lower supporting structure, which are usually transported by a transportation vessel. The topside structure, however, cannot be transported by buoyancy as it contains equipment unfamiliar with water, so a seafastening structure is used to fix the topside and protect it from damage during transportation. The study focuses on the fixing technique using the seafastening structure and uses a numerical model for analysis. The motion of the transportation vessel, loads on the topside, and stresses loaded on the seafastening structure are estimated numerically to assess the safety of the seafastening structure. The study uses the boundary condition transfer method and coupled analysis to analyze the transportation vessel, the topside, and the seafastening structure as an integrated analysis method [6].

Offshore transportation planning, which is divided into regular and non-regular liners based on the regularity of the plan. Persistence analysis is used to find the proper timing for offshore operations, taking into account wave, wind, and current observation data over an 18-year period. The percentage of weather windows versus the threshold and duration is presented. However, persistence analysis has limitations, such as using a limited number of waypoints and not considering tow behavior under such weather conditions. The paper presents a simulation that considers weather conditions and tow behavior on the detailed route. The study is focused on long-term planning, which considers the transportation route, weather conditions on the route, and ship behavior under such weather conditions. The great circle route is assumed to be the route in this study, but detailed route optimization can be conducted for short-term planning [7].

The problem of monitoring multi-phase flow in offshore oil and gas pipelines, which consists of oil, water, and gas. Subsurface instrumentation is difficult, and expensive, so measurements are often reduced to the top of the vertical riser-pipeline. Poor measurements can lead to significant errors in the oil recovery process, affecting various aspects such as model prediction, flow patterns, separation, chemical injection, emulsion layer, corrosion-rate, and produced water treatment. The article focuses on the importance of accurate and reliable measurements of multi-phase flow in the upstream transportation pipelines and how it can optimize the produced water treatment process. The Danish Environmental Protection Agency has regulations on the amount of dispersed oil discharged into the ocean, and the amount of produced water and discharged dispersed oil is increasing, supporting the importance of accurate measurements of multi-phase flow. The article will evaluate the respective methods based on how they can be implemented and applied to benefit the entire oil recovery process [8].

As a highly motivated individual with a strong passion for engineering, I am excited to apply for the Teknik Sipil program offered by Fakultas Teknik Universitas 17 Agustus 1945 Cirebon. With a background in mechanical engineering and experience in offshore cargo transportation, I believe that this university and program are the best fit for me to achieve my future goals.

II. METODS

The method used is to compare the analysis calculations with the facts in the project field. The results of the calculations are applied in the project field to ensure that the results of the Hirungan are safely used for project work in the fiel

This document [9] is to provide a plan for the transportation of the GTC Gas Turbine Compressor with BS 27. The Module that will be transported are two piecies, namely GTC P1 and GTC S1.

This document will clarify the various phases and steps of the transportation wich is scured by lashing. It should be demonstrated that lashing for transportation in accordance with code and specification will not impart overload or cause damage to the lashing system.

This document will provide confirmation that the transportation will be a controlled operation leading to an as lashing system comparable to the approved design and that sufficient means of inspection, measurement and recording are performed to confirm the actual lashing configuration.

2.1 Prototype and Instrumentation

The transportation plan with the lashing arrangement can be seen in fugure Figure 1, 2.3,4,5 and Table 1,2,3,4 and 5.

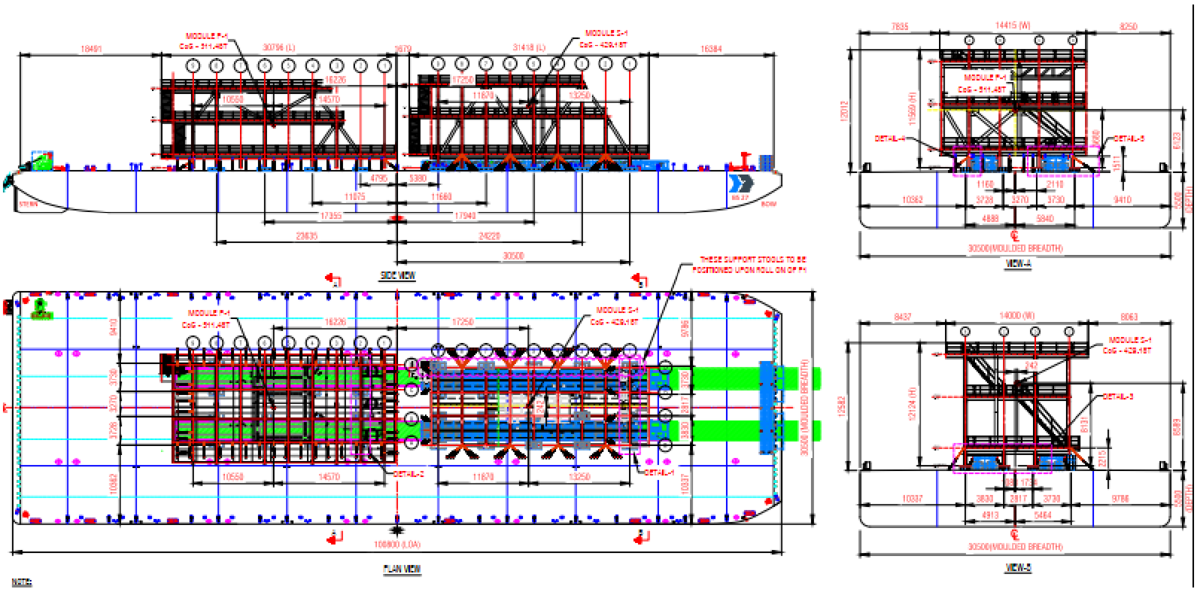

Figure 1. Module P1 and S1 Seafastening Plan

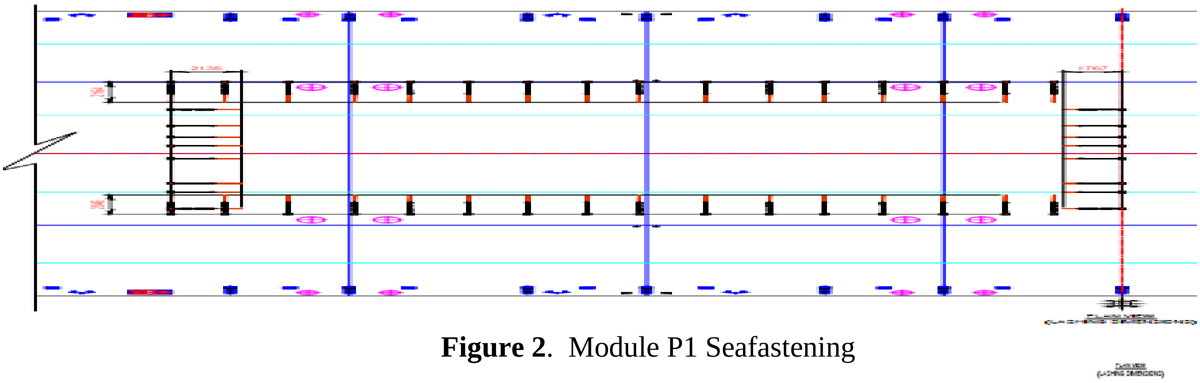

Figure 2. Module P1 Seafastening

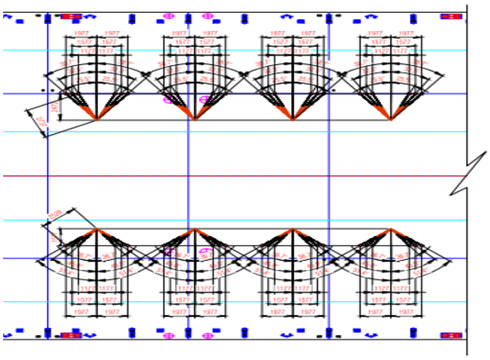

Figure 3 . Module S1 Seafastening

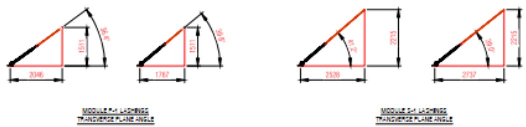

Figure 4. Deatail Seafastening P1 and S1

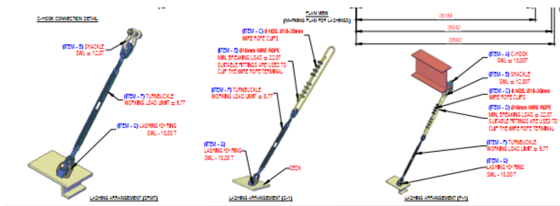

Figure 5. Wire Seafasteing Module P1 and S1

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2.2 Acceleration Calculation Module P1

The acceleration calculation as below;
The Cargo detail, cargo dimension, Trailer Detail , Road Inclination as shown in Table 1.

Table 1. Cargo P1, BS27, Detail

Description	**Unit**	**Quantity**
Cargo Detail		
Weight	MT	511.48
Lashing Capacity	MT	5
Coeficient of friction		0.1
Cargo Dimension		
Length	m	30.80
Width	m	14.42
Height	m	12.57
BS 27 Deatail		
Type BS 27	EA	1
Length	m	100.58
Width	m	30.48
Height	m	5.5

The Wind Force shown in Table 2

Table 2. Wind Force

Descrption			Unit		Quantity	
Wind Speed			m/s		15	
Air Specific Gravity			ton/m^3		0.00129	
Longitudinal Wind Force			kN		32.77	
Transverse Wind Force			kN		70.01	
Area	Cs	Ch	Trans	Longi	Trans	Long
WL-13.5m	1	1	471.18	220.55	68.38	32.01
15.3-30.5m	1	1.1	10.23	4.79	1.63	0.76
30.5-46m	1	1.2	0.00	0.00	0.00	0.00
46-61m	1	1.3	0.00	0.00	0.00	0.00
61-76m	1	1.37	0.00	0.00	0.00	0.00
76-1000m	1	1.43	0.00	0.00	0.00	0.00
Total			481.41	225.34	70.01	32.77

The Input Parameters as shown in Table 3;

Table 3. Input Parameters

Description	Unit	Quantity
Max. Roll Angle	deg	5
Max. Ptch Angle	deg	2.5
Heave Acceleration	m/s^2	0.1 g
Period of Motion	S	10
Draft of Barge	m	1.87
Transverse Dist. To Barge CL	m	0
Longitudinal Dist. To Pitch CL	m	16.23
Cargo VCG to Deck	m	6.12
Cargo Height to Deck	m	12.58
Min. Uplift arm in Transverse	m	4.72
Min Uplift arm in Longitudinal	m	7.58

Total Force as shown in Table 4.

Table 4. Total Force

Description		Unit	Quantity
Total Force		Unit	Quantity
Roll+Heave+Wind	Transverse	kN	722.35
	Vertical	kN.m	5498.38
Roll-Heave+Wind	Transverse	kN	634.88
	Vertical	kN.m	4498.67
Pitch+Heave+Wind	Longitudinal	kN	359.17
	Vertical	kN.m	5656.76
Pitch-Heave+Wind	Longitudinal	kN	315.39
	Vertical	kN.m	4654.19
UP Lift Momen			
Transverse Momen	Max	kN.m	-16376.82
	No Transverse Tipping		
Longitudinal Momen	Max	kN.m	-32859.47
	No Longitudinal Tipping		

2.3 Acceleration Calculation Module S1

5T lashings will be used to secure [1] the cargo in both transverse and longitudinal directions. Lashing calculation [10] is based on 2x20 axle lines BS 27. Proposed lashing arranggement as shown in figure 7.

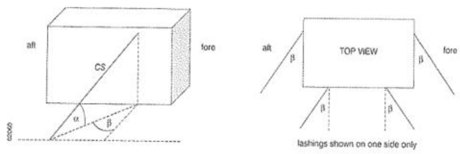

Figure 7. Lashing arrangement

The Cargo detail, cargo dimension, Trailer Detail , Road Inclination as shown in Table 5.

Table 5. Cargo P1, BS27, Detail

Description	Unit	Quantity
Cargo Detail		
Weight	MT	429.18
Lashing Capacity	MT	5
Coeficient of friction		0.1
Cargo Dimension		
Length	m	31.42
Width	m	14
Height	m	11.12
BS 27 Deatail		
Type BS 27	EA	1
Length	m	100.58
Width	m	30.48
Height	m	5.5

The Wind Force shown in Table 6.

Table 6. Wind Force

Descrption			Unit		Quantity	
Wind Speed			m/s		15	
Air Specific Gravity			ton/m^3		0.00129	
Longitudinal Wind Force			kN		33.10	
Transverse Wind Force			kN		74.29	
Area	Cs	Ch	Trans	Longi	Trans	Long
WL-13.5m	1	1	480.70	214.20	69.76	31.09
15.3-30.5m	1	1.1	28.34	12.63	4.52	2.02
30.5-46m	1	1.2	0.00	0.00	0.00	0.00
46-61m	1	1.3	0.00	0.00	0.00	0.00
61-76m	1	1.37	0.00	0.00	0.00	0.00
76-1000m	1	1.43	0.00	0.00	0.00	0.00

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Total	509.04	226.83	74.29	33.10

The Input Parameters as shown in Table 7.

Table 7. Input Parameters

Description	Unit	Quantity
Max. Roll Angle	deg	5
Max. Ptch Angle	deg	2.5
Heave Acceleration	m/s^2	0.1 g
Period of Motion	s	10
Draft of Barge	m	1.87
Transverse Dist. To Barge CL	m	0.24
Longitudinal Dist. To Pitch CL	m	17.25
Cargo VCG to Deck	m	8.59
Cargo Height to Deck	m	12.58
Min. Uplift arm in Transverse	m	5.12
Min Uplift arm in Longitudinal	m	12.04

Total Force as shown in Table 8.

Table 8. Total Force

Description		Unit	Quantity
Total Force		Unit	Quantity
Roll+Heave+Wind	Transverse	kN	658.03
	Vertical	kN.m	4617.23
Roll-Heave+Wind	Transverse	kN	584.64
	Vertical	kN.m	3778.38
Pitch+Heave+Wind	Longitudinal	kN	325.17
	Vertical	kN.m	4754.11
Pitch-Heave+Wind	Longitudinal	kN	288.44
	Vertical	kN.m	3912.86
UP Lift Momen			
Transverse Momen	Max	kN.m	-13233.70
	No Transverse Tipping		
Longitudinal Momen	Max	kN.m	-44090.11
	No Longitudinal Tipping		

2.3 Acceleration Calculation SMPT

The acceleration calculation [11] is as below.

Table 9. Barge Information

Description	Unit	Quantity
Length	m	100.58
Width	m	30.48
Depth	m	5.49

The Input parameters, as shown in Table 10.

Table 10. Input Parameters

Description	Unit	Quantity
Max. Roll Angle	deg	5
Max. Ptch Angle	deg	2.5
Heave Acceleration	m/s^2	0.1 g
Period of Motion	S	10
Draft of Barge	M	1.87
Cargo Weight	mton	87.20
Transverse Dist. To Barge CL	M	3.6
Longitudinal Dist. To Pitch CL	M	18.58
Cargo VCG to Deck	M	0.71
Cargo Length	M	32.2
Cargo Width	M	2.43
Cargo Height to Deck	M	1.25
Min. Uplift arm in Transverse	M	1.20
Min Uplift arm in Longitudinal	M	13.29

The Wind Force shown in Table 11

Table 11. Wind Force

Descrption			Unit		Quantity	
Wind Speed			m/s		15	
Air Specific Gravity			ton/m^3		0.00129	
Longitudinal Wind Force			kN		33.10	
Transverse Wind Force			kN		74.29	
Area	Cs	Ch	Trans	Longi	Trans	Long
WL-13.5m	1	1	156.82	11.83	22.76	1.72
15.3-30.5m	1	1.1	0.00	0.00	0.00	0.00
30.5-46m	1	1.2	0.00	0.00	0.00	0.00
46-61m	1	1.3	0.00	0.00	0.00	0.00
61-76m	1	1.37	0.00	0.00	0.00	0.00
76-1000m	1	1.43	0.00	0.00	0.00	0.00
Total			156.82	11.83	22.76	1.72

Total Force as shown in Table 12.

Table 12. Total Force

Description		Unit	Quantity
Total Force		Unit	Quantity
Roll+Heave+Wind	Transverse	kN	117.76
	Vertical	kN.m	948.18
Roll-Heave+Wind	Transverse	kN	102.85
	Vertical	kN.m	777.75
Pitch+Heave+Wind	Longitudinal	kN	49.26
	Vertical	kN.m	967.92
Pitch-Heave+Wind	Longitudinal	kN	41.79
	Vertical	kN.m	797.00
UP Lift Momen			
Transverse Momen	Max	kN.m	-834.99
	No Transverse Tipping		
Longitudinal Momen	Max	kN.m	-10556.66
	No Longitudinal Tipping		

2.4 Seafastening Calculation Module P1

5T lashings will be used to secure [1] the cargo in both transverse and longitudinal directions. Lashing calculation [10] is based on 2x20 axle lines BS 27. Proposed lashing arranggement as shown in figure 6.

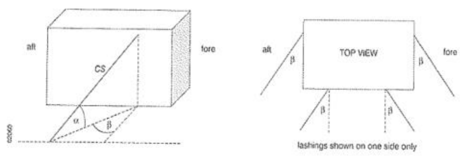

Figure 6. Seafastening arrangement

The transverse seafastening as shown in Table 13.

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Table 13. Transverse Seafastening

Description	Unit	Quantity
Transverse plan angle, α	deg	36.40
Longitudinal plan angle, β	deg	0
Transverse Force Value, fy		0.8
Wires number	EA	16
Wire heighr	m	1.51
Wire Horizontal Distance	m	2.05
Sling MBL	MT	22
Sling CS	MT	9.78
Other Lashing SWL	MT	9.7
CS	MT	9.7
Shackle SWL	MT	12
Turnbuckle	MT	9.7
Wire Securing Force	MT	124.92
Total Securing Force	MT	124.92
Skew Load Factor		1.5
Total Transverse Sliding Force	MT	110.45
Anti Tipping Momen	kN.m	1357.56
Tipping Momen	kN.m	-16376.82
Conclusion		SAFE

Longitudinal seafastening, shown in Table 14.

Table 14. Longitudinal Seafastening

Description	Unit	Quantity
Transverse plan angle, α	deg	40.50
Longitudinal plan angle, β	deg	90.00
Longitudinal Force Value, fy		0.76
Wires number	EA	8
Wire heighr	m	1.51
Wire Horizontal Distance	m	1.77
Sling MBL	MT	22
Sling CS	MT	9.78
Other Lashing SWL	MT	9.7
CS	MT	9.7
Shackle SWL	MT	12
Turnbuckle	MT	9.7
Wire Securing Force	MT	59.01
Total Securing Force	MT	59.01
Skew Load Factor		1.5
Total Transverse Sliding Force	MT	54.92
Anti Tipping Momen	kN.m	613.90
Tipping Momen	kN.m	-32859.47
Conclusion		SAFE

2.4 Seafastening Calculation Module S1

5T lashings will be used to secure [1] the cargo in both transverse and longitudinal directions. Lashing calculation [10] is based on 2x20 axle lines BS 27. Proposed lashing arranggement as shown in figure 7.

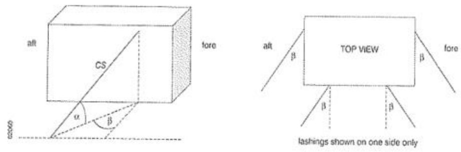

Figure 7. Lashing arrangement

The transverse seafastening as shown in Table 15.

Table 15. Transverse Seafastening

Description	Unit	Quantity
Transverse plan angle, α	deg	41.20
Longitudinal plan angle, β	deg	51.40
Transverse Force Value, fy		0.47
Wires number	EA	24
Wire heighr	m	2.22
Wire Horizontal Distance	m	2.23
Sling MBL	MT	22
Sling CS	**MT**	**9.78**
Other Lashing SWL	MT	9.7
CS	MT	9.7
Shackle SWL	MT	12
Turnbuckle	MT	9.7
Wire Securing Force	MT	109.28
Total Securing Force	MT	109.28
Skew Load Factor		1.5
Total Transverse Sliding Force	MT	100.62
Anti Tipping Momen	kN.m	1031.92
Tipping Momen	kN.m	-13233.70
Conclusion		SAFE

Longitudinal seafastening, shown in Table 16.

Table 16. Longitudinal Seafastening

Description	Unit	Quantity
Transverse plan angle, α	deg	39.00
Longitudinal plan angle, β	deg	25.50
Longitudinal Force Value, fy		0.33
Wires number	EA	24
Wire heighr	m	2.22
Wire Horizontal Distance	m	2.74
Sling MBL	MT	22
Sling CS	MT	9.78
Other Lashing SWL	MT	9.7
CS	MT	9.7
Shackle SWL	MT	12
Turnbuckle	MT	9.7
Wire Securing Force	MT	77.89
Total Securing Force	MT	77.89
Skew Load Factor		1.5
Total Transverse Sliding Force	MT	49.72
Anti Tipping Momen	kN.m	543.30
Tipping Momen	kN.m	-44090.11
Conclusion		SAFE

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III. Result And Discussion

Result

3.1 Lashing analysis of Module P1

The modul P1 has weitgh 511.48 ton can be secured with 24 pieces Sling with 5 ton capacity. The arrangement of lasing has transverse plan anggle 36.40 deg and longitudinal plan angle 90 deg. During traveling [14] with BS 27 with max roll [12] angle 5 degree, max pitch angle 2.5 deg and heave [13] acceleration [14] 0.1g m/^{s} affected the total transverse sliding force 110.45 MT,ton.and the total securing force 124.92 MT. The Conclusion is Safe.

Summary of forces for securing module Pi on trailer as shown in Table 17.

Table 17. Forces Securing Module P1

	Transverse	Longitudinal
Total Secuting Forces (MT)	124.92	59.01
Total Sliding Forces (MT)	110.45	54.92

Conclusion

Total Transverse Securing Forces > Total Transver Sliding Fore (Safe)
Total Longitudinal Securing Forces > Total Longitudinal Sliding Fore (Safe)
Conclusion Safe

Modul P1 Transported on Trailer BS 27 onshore moving, shown in Figure 8.

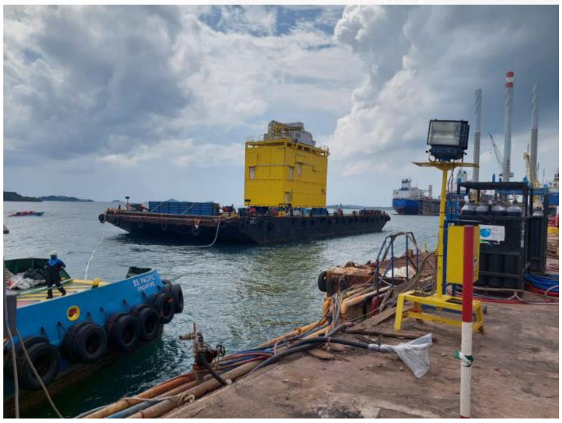

Figure 8. Modul P1 on BS 27

3.2 Lashing Analysis modul S1

The modul S1 has weitgh [15] 429.18 ton can be secured with 48 pieces Sling with 5 ton capacity. The arrangement [16] of lasing has transverse plan anggle 41.20 deg and longitudinal plan angle 51.40 deg. During traveling with BS 27 with max roll [17] angle 5 deg , max pitch angle 2.5 and heave [18] acceleration 0.1 g m/^{s} affected the total transverse sliding force 100.62 MT, ton.and the total transverse securing force 109.28 MT. The Conclusion is Safe.

Summary of forces for securing module S1 on trailer as shown in Table 18.

Table 18. Forces Securing Module S1

	Transverse	Longitudinal
Total Secuting Forces (MT)	109.28	77.89
Total Sliding Forces (MT)	109.62	49.72

Conclusion:
Total Transverse Securing Forces > Total Transver Sliding Fore (Safe)
Total Longitudinal Securing Forces > Total Longitudinal Sliding Fore (Safe)
Conclusion Safe

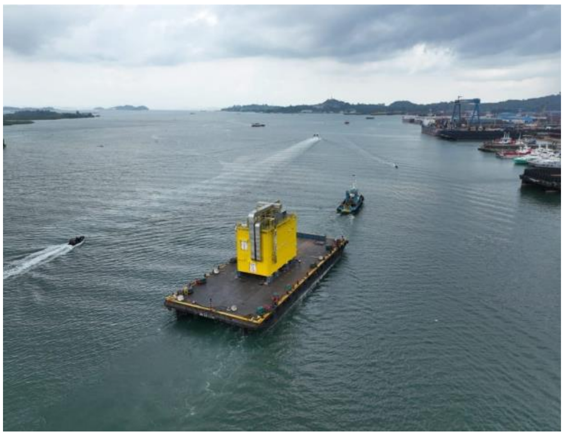

Figure 8. Module S1 On BS27

Discussion

It depends on the specific application [19] and context of the lasing arrangement. If the lasing arrangement is used in a controlled environment with proper safety precautions, it may be considered safe. However, if the lasing arrangement is used in an uncontrolled environment or with improper safety precautions, it could potentially be dangerous. It's important to always follow proper safety guidelines when working with lasers. The safety of a lasing arrangement depends on the specific application and context, as well as the adherence to safety precautions. In controlled environments with proper safety measures, lasers can be considered safe. However, in uncontrolled environments or without proper safety precautions, lasers can pose potential dangers [20]. It is crucial to always follow safety guidelines when working with lasers to minimize the risk of eye and skin exposure to laser radiation [3]. Failure to have proper labels, signage, and protective clothing can result in hazardous situations [1][2]. Overprotection or under-protection should be avoided, and the selection of appropriate protective clothing should consider the integration of components and ease of use without compromising performance [2].

IV. Conclusion

Based on analysis above, The concluson is:

a. Total Transverse Securing Forces > Total Transverse Sliding Fore , for turning condition it is Safe.
b. Total Longitudinal Securing Forces > Total Longitudinal Sliding Fore, for breaking condition , it is Safe.

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