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The Study of Tandem Offloading Performance and Operability on The Cylindrical Hull FPSO Sevan Stabilized Platform with Variation in Mooring System Configuration

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ABSTRACT

This study has been carried out to evaluate the dynamic behavior of the Cylindrical FPSO Sevan Stabilized Platform (SSP) and the LNG Carrier (LNGC) during the process of tandem offloading. The study includes hydrodynamics modellings, computations, and simulations of both cases SSP and LNGC operated individually and in combination for offloading operations. The SSP is moored with two variations of mooring, namely taut and catenary. Environmental loads are waves with the incorporated winds and currents propagating 90^o, 210^o, and 330^o relative to the SSP headings. Excitation of random waves up to Hs = 4.50 m instigates the relatively low SSP motions in standalone condition. In offloading condition, when LNGC is connected, the SSP motion could magnify as much as 2.0 up to 5.0 times higher than that in standalone condition, but still considered in an acceptable level. The motion quality of LNGC in offloading operation is comparable with the SSP. For various random wave headings with Hs = 4.50 m during offloading operation may generate maximum tensions between 1,600 kN up to 2,600 kN in the casse of catenary mooring, and between 4,700 kN up to 7,000 kN in the case of taut mooring. Even then, this largest tension preserves a safety factor of 2.05 which is well above the limit of 1.67 as required by the governing standards. Finally, the study conclude an operability of as much as 90% could be achieved on SSP and LNGC offloading operation in the Masela Block of the Abadi Gas Field.

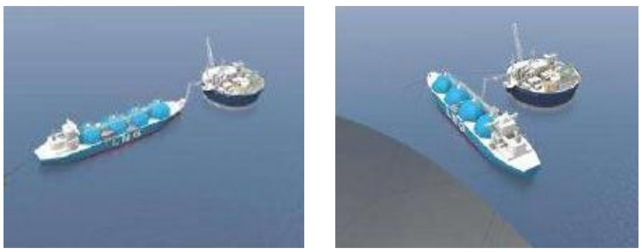
Keywords: *Sevan Stabilized Plarform, tandem offloading, catenary, taut, motion, tension, operability*

1. INTRODUCTION

As the time pass by, the development of offshore exploration and exploitation technology is also advancing. Right now, the cylindrical floating production storage and offloading (FPSO) or also well known as Sevan Stabilized Platform (SSP) is commonly used as a new concept in offshore technology to ensure profitability in deep water and ultra deep water fields. It is also considered as a lower-cost option for large, deep water projects compared with other conventional FPSO. Its cylindrical hull is also considered as a new promising and effective concept for deep water because of the huge capacity of storage and offloading capability that can reduce the necessity of pipe-line uses. The other advantage of this cylindrical structure, is its flexible design dan has a greater characteristic motion when used in a deep or shallow water. This structure use a spread mooring system without turret and swivel. The study of the interaction of hidrodinamic of SSP and LNGC has been developed as explained in this paper, remembe-ring the fact that this structure is a new innovation in offshore drilling [1].

In an offloading process, mooring system is an important part that hold the role in holding the structure position from the wind, wave, and current loads. Chakrabarti [2] concluded that the design of mooring system is a balance combination to make a compliant system that can resist an overposition of the structure, and make it stiff enough so there will not be over friction. Djatmiko [3] is also concluded that the motion of a floating structure causes the force that works in a mooring system, as well as the mooring system gives a restoring force to the structure so the motion will be significantly restrained. By that, the hidrodinamics analysis on the mooring system is important to do in order to anticipate the operability of a structure that operate and to make sure that the mooring system has sufficient capacity and ability to hold the SSP and LNGC in the right position when the offloading process is carried out.

The current study is conducted to evaluate the offloading performance and operability on the cylindrical hull FPSO Sevan Stabilized Platform (SSP) with variation in mooring system configuration. There are actually two types of offloading from SSP to LNGC according to the relative position between the two vessels, namely tandem and side by side, as shown in Fig. 1 [4]. The current study is dedicated to explore the case of tandem offloading for operation in the Abadi Gas Field of Masela Block [5].



(a) (b)

Figure 1. Offloading between SSP and LNGC: (a) tandem and (b) side by side [4]

2. MATERIALS AND METHODS

The flow and procedure of the study is conducted by the stages as follow. Firstly, a literature review is performed by referring to the materials as contained in text books, journal and conference papers, codes and standards, rules and regulations, and so on. This stage also cover an effort in comprehending the hydrodynamic software MAXSURF [6] and OrcaFlex [7].

2.1 Data Collection

The data collection is carried out through a field study, comprises of the direct observation to the object to be evaluated and also acquiring a number of data related to the study. Beside this exploration to the supporting data is made as the preparation for the analysis and evaluation. The primary data which are required includes:

- Hydrosatic data of 160,000 DWT LNG carrier,
- Data of Sevan Stabilized Platform type S400 [4]
- Environmental data [8], and
- Data on the mooring configuration.

2.2 Modeling and Computation using MAXSURF

The modeling of FPSO structure is commenced by employing the software MAXSURF to derive the hydrostatic peculiar of the vessel. This is further to be validated against the stability booklet made available by the operator. In the next step the software is utilized to perform the hydrodynamic analysis in frequency-domain to obtain the data of FPSO motion RAOs, wave drift, added mass and damping forces.

The analysis has been carried out for the case of environmental loads propagating from a number of directions, namely 0°, 45°, 90°, 135° and 180°. The data so generated subsequently will be implemented as the input for next modeling using the OrcaFlex.

2.3 Modeling and Computation using OrcaFlex

The modeling carried out using software OrcaFlex is aimed at obtaining the tension intensities which develop on the FPSO's mooring lines. In this respect the modeling requires input data as resulted from running the MAXSURF.

The running of OrcaFlex yields a time-domain simulation of tension elevation for a period of times, typically within three (3) hours or 10,800 seconds. In the next step analysis is performed on the tension time history to derive the maximum tension expected to occur on the critical mooring line.

3. RESULTS AND DISCUSSION

3.1 Modeling of SSP and LNG Carrier

The modeling of both floating structures, ie. the SSP and the LNGC is established by using MAXSURF software, by inputting the data such as environmental load, breadth, height, draught, displacement and the coordinate of the station used in the ship modeling.

The modeling of SSP is carried out as follow. First, it has to be modeled by inputting all the parametric data of the structure, such as breadth, draught, diameter and the displacement. In this study, the SSP is designed by using 2 condition of storage, namely full load and ballast load. Fig. 2 gives the model of SSP structure designed using MAXSURF software.

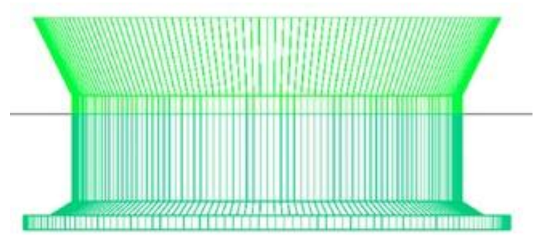


Figure 2. Model of SSP hull

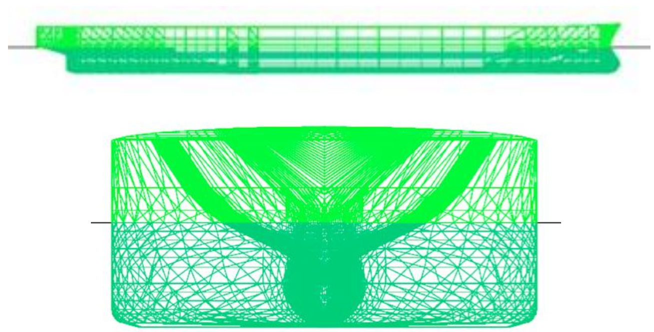


Figure 3. Hull model of LNG Carrier

In this study, the LNGC is designed by having three (3) conditions of storage, which are full load, half load, and ballast load. Results of running the MASURF software generate the hull model of the LNGC as shown in Fig. 3.

3.2 Hull Model Validation

Model validation is conducted to examine the appropriateness and suitability of the structural modeling that has been done in relation to the actual structure. The validation is made on 10 primary parameters for SSP and 7 primary parameters for the LNGC. Tables 1 and 2 presents the validation of SSP and LNGC primary parameters.

Table 1. Results of model validation for SSP

	MODEL	Data	ERROR (%)
Displacement (ton)	88404.9	87900	0.57
Displacement volume (ton)	86248.7	85756.1	0.57
WPA m2	3847.65	3840	0.2
KMT (m)	23.35	23.34	0.04
KML (m)	23.35	23.34	0.04
BMT (m)	13.67	13.61	0.44
BML (m)	13.67	13.61	0.44
VCB (m)	9.69	9.73	0.41
GMT (m)	5.11	5.14	0.58
GML (m)	5.11	5.14	0.58

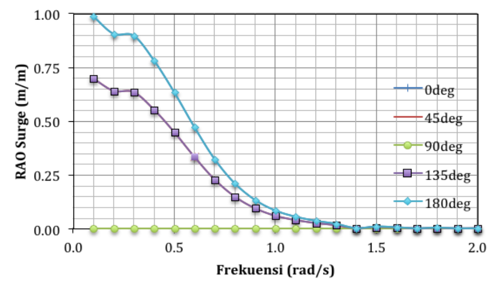
Table 2. Results of model validation for LNG carrier

ITEM	DATA	MODEL	ERRO
Displacement (ton)	184710.3	181291	1.9
Block coeff. (Cb) (t)	0.8	0.8	2.4
Max Sect. area coeff. (Cm)	1.0	1.0	0.0
Cp	0.8	0.8	1.2
KB (m)	8.3	8.3	0.1
BMt (m)	12.3	12.7	2.9
BML (m)	346.3	364.0	4.9

According to ship classifications the difference or error between the model and actual vessel parameters should not exceed 5.0% [9]. As shown in in Table 1, the SSP model has the largest error of 0.58% for GML. Whereas in Table 2 the LNGC model is considered satisfactory as the errors are below 5.0%, with the largest is for BML of 4.9%.

3.3 Motion Characteristics of SSP and LNG Carrier in Free Floating Condition

The 6-DOF FPSO motions comprise of 3-DOF translationnal modes, i.e. surge, sway, and heave, and 3-DOF rotational modes, i.e. roll, pitch, and yaw, are computed using software MAXSURF. Computation is conducted for SSP in stationary free floating condition, namely no mooring system is installed. SSP is evaluated with the 3 condition of storage that is full load, half load, and ballast load.



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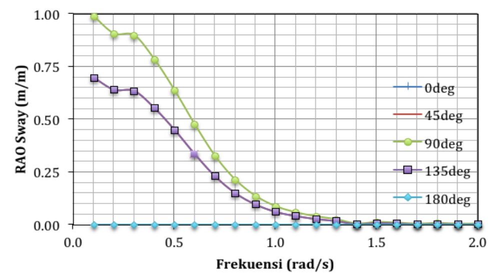

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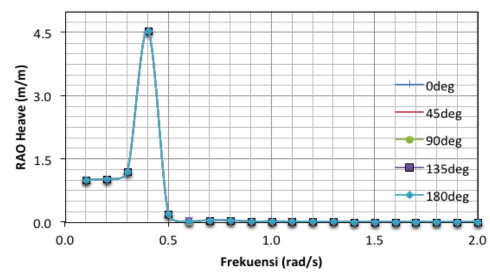

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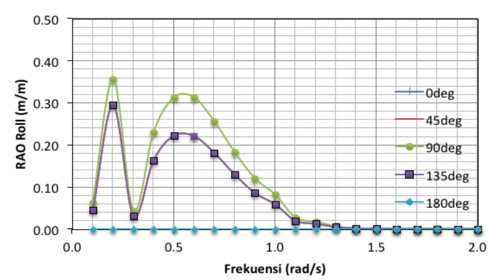

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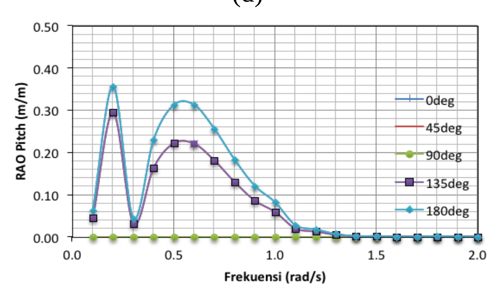

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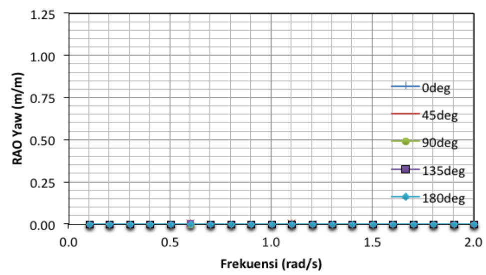
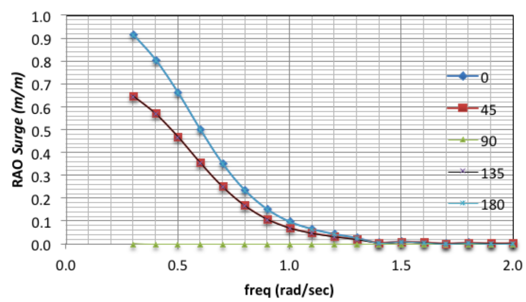


(f)

Figure 4. RAO graphs of the SSP: (a) surge, (b) sway, (c) heave, (d) roll, (e) pitch, (f) yaw

Computation using MAXSURF yields the response amplitude operators (RAOs) of SSP for the 6-DOF due to regular wave excitations as exhibited in Figs. 4a-f. Based on the RAOs, it can be said that the motion characteristic of SSP has the similarity between surge and sway, and between roll and pitch brought about the symmetric form of the cylindrical hull.



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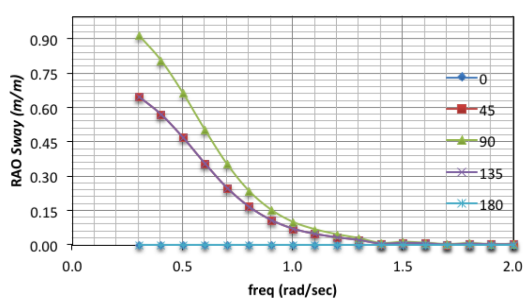

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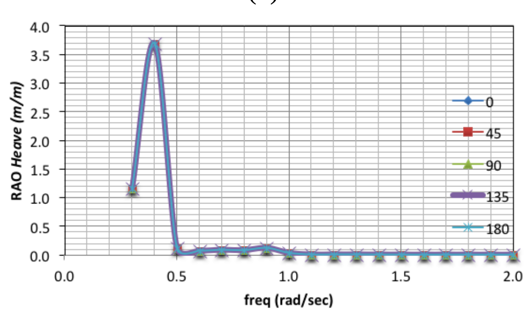

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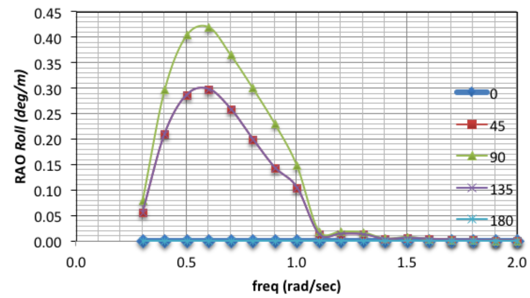

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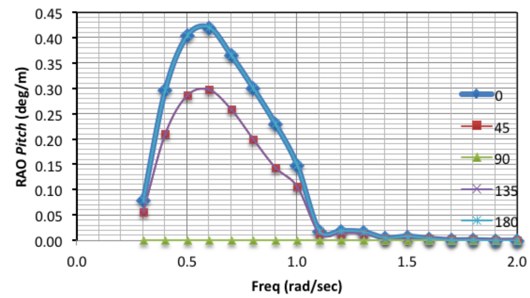

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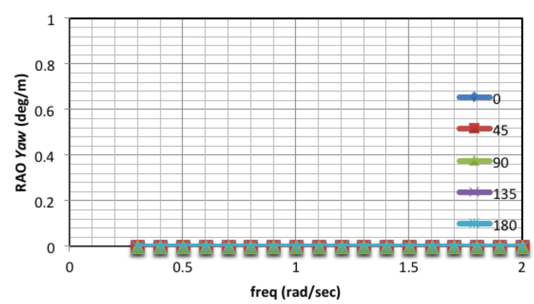


(f)

Figure 5. RAO graphs of the LNG carrier: (a) surge, (b) sway, (c) heave, (d) roll, (e) pitch, (f) yaw

The basic shape cylindrical hull also causes the RAO of heave has the same value in every directions of loading, hence the yaw has no significant value to the SSP in almost every directions of loading. After finish analyzing the motion of SSP, we can proceed to analyze the motion of the LNGC. RAO graphs of LNGC obtained from running the MAXSURF software imposed by regular waves are presented in Figs. 5a-f.

LNGC has different characteristics of motion with SSP. The highest surge motion is happened in the direction loading of 0^o and 180^o, hence sway has no value in the direction of 0^o and 180^o. Different from SSP, LNGC has different value of heave from every different direction of loadings.

Overall, the motions of SSP and LNGC in free floating condition under excitation of regular wave are presented in the form of RAO graphs. For all 6-mode of motions the two vessels may be considered as having good characteristics, with no indication of excessive intensities.

3.4 Motion Characteristics of SSP in Standalone Moored Condition

In order to keep the SSP stays in its intended position, the vessel is moored to the seabed. In this study, it uses two (2) types of mooring configuration, namely catenary and taut, as depicted in Figs. 6 and 7. Both types of mooring are modeled with the same anchor and fairlead position but with different pretension and length of mooring line. Figure 8 illustrate the top view of mooring configuration for both taut and catenary types.

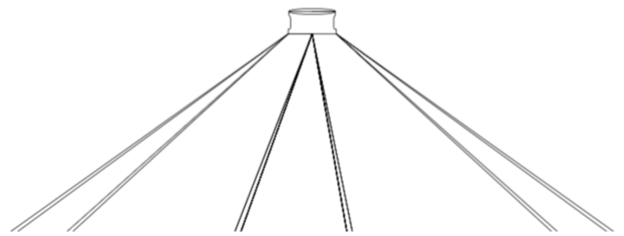


Figure 6. Side view of taut mooring system for the SSP

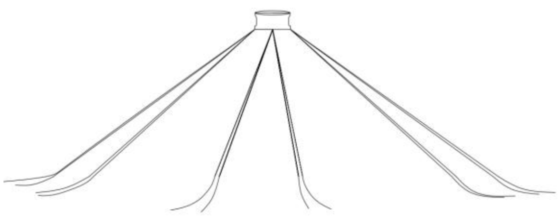


Figure 7. Side view of catenary mooring system of SSP

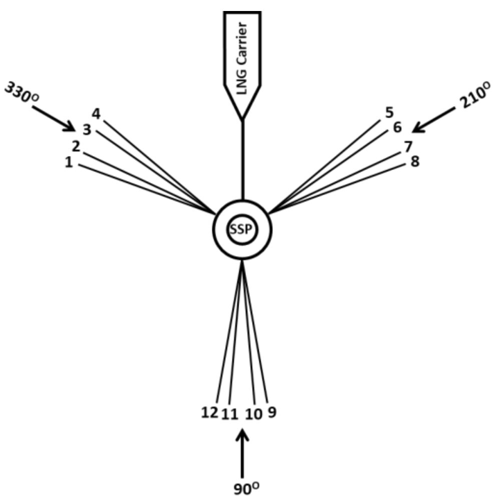


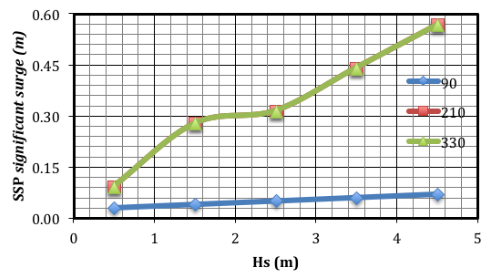
Figure 8. Top view of the SSP mooring system configuration

There are 12 mooring lines extend from each connection point on the vessel, and are divided into 3 points at connection on the SSP base, with each point contains 4 mooring lines, as shown in Figure 8. In the current study the SSP and the corresponding mooring system is subjected to environmental load propagating in three directions relative to the vessel, namely 90°, 210° and 330°. The significant wave heights considered in this study are obtained from the wave scatter data of Masela Block, as listed in Table 3 [8].

Table 3. Wave scatter data of Masela Block [8]

		Hs (m)					Total
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	
Tp (s)	0.1-2.0	0.00	0.00	0.00	0.00	0.00	0.00
	2.1-4.0	0.58	0.00	0.00	0.00	0.00	0.58
	4.1-6.0	9.51	4.43	0.00	0.00	0.00	13.94
	6.1-8.0	5.12	6.90	4.74	0.05	0.00	16.81
	8.1-10.0	8.20	3.50	5.70	0.79	0.05	18.24
	10.1-12.0	10.80	20.8	0.15	0.04	0.02	31.81
	12.1-14.0	9.30	2.68	0.02	0.02	0.00	12.02
	14.1-16.0	2.93	2.46	0.04	0.00	0.00	5.43
	16.1-18.0	0.42	0.77	0.03	0.00	0.00	1.22
	18.1-20.0	0.05	0.09	0.00	0.00	0.00	0.15
Total		46.91	41.44	10.68	0.90	0.07	100
Cumulative		46.91	88.35	99.03	99.93	100	

The evaluation of the SSP motion on the standalone moored condition has to be done before moving to the offloading condition. The evaluation of the SSP motion is done based on the scenario where the SSP with full load and ballast load storage is imposed by a variety of environmental load and also the configuration of taut and catenary mooring system. The results of which are exemplified in Figs. 9a-f.



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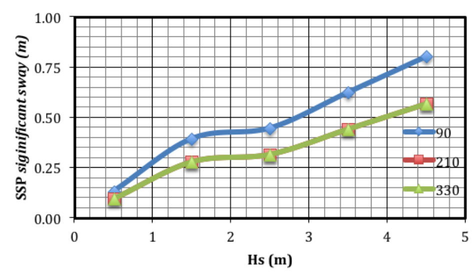

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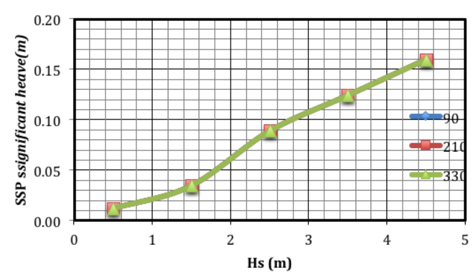

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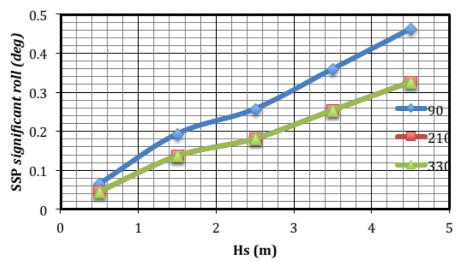

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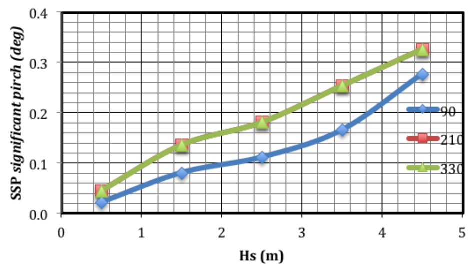

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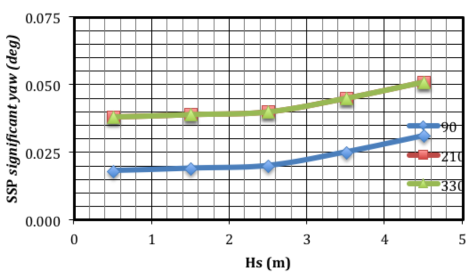


(f)

Figure 9. The significant motion responses of the SSP in standalone moored condition: (a) surge, (b) sway, (c) heave, (d) roll, (e) pitch, (f) yaw

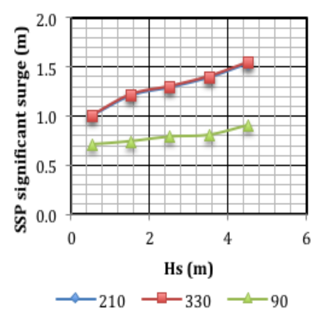
On the standalone moored condition, the load scenario is divided into 4 conditions that is: (1) full load SSP with catenary type of mooring, (2) ballast load SSP with catenary type of mooring, (3) full load SSP with taut type of mooring, and (4) ballast load SSP with taut type of mooring. The statistical values of the SSP motions due to significant wave heights ranging from 0.5 m up to 4.5 m are presented in Figs. 9a-f. The graphs exhibit variation in environmental heading will affect the differences in motion response intensities.

The motion intensities of SSP in standalone condition induced by random waves increase in parallel to the increasing of significant wave height *Hs*. At the level of *Hs* = 4.5 m the largest significant values of motions reaching 0.56 m for surge, 0.80 m for sway, 0.16 m for heave, 0.46^o for roll, 0.32^o for pitch, and 0.05^o for for yaw. These values indicate excellent characteristics of SSP motion in standalone condition.

3.5 Motion Characteristics of SSP and LNG Carrier in Offloading Operations

After modeling and analyzing the SSP structure in stand-alone condition with both mooring system configurations, the next stage is to model and analyze the SSP structure when conducting offloading activities with LNGC. Similarly with the evaluation of SSP operating in standalone, for offloading operation observations are also made into several scenarios. In this occasion, the evaluation is performed by dividing into 6 scenarios, as follows:

a) 1st Condition: SSP with catenary mooring is fully loaded combined with LNGC in ballast loaded;
b) 2nd Condition: SSP with catenary mooring is ballast loaded combined with LNGC in half loaded;
c) 3rd Condition: SSP with catenary mooring is ballast loaded combined with LNGC in fully loaded;
d) 4th Condition: SSP with taut mooring is fully loaded combined with LNGC in ballast loaded;
e) 5th Condition: SSP with taut mooring is ballast loaded combined with LNGC in half loaded;
f) 6th Condition: SSP with taut mooring is ballast loaded combined with LNGC in fully loaded.



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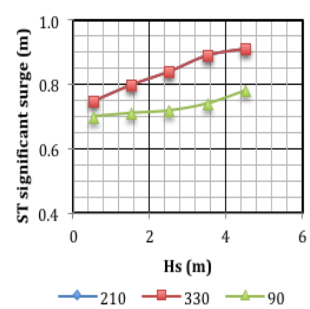
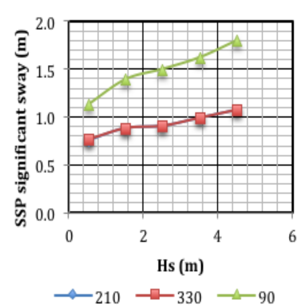


(b)

Figure 10. The surge responses during offloading under 1st condition: (a) SSP and (b) LNGC



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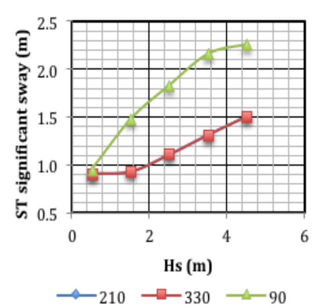
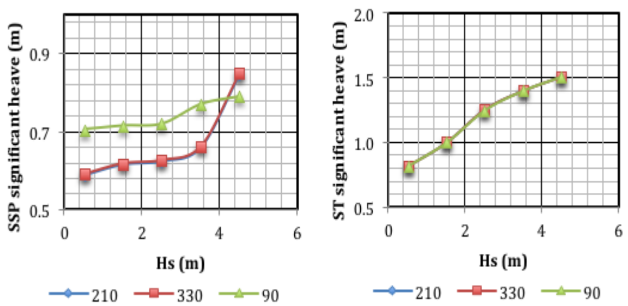


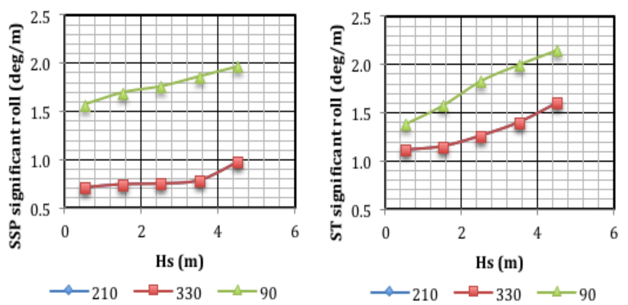
(b)

Figure 11. The sway responses during offloading under 1st condition: (a) SSP and (b) LNGC



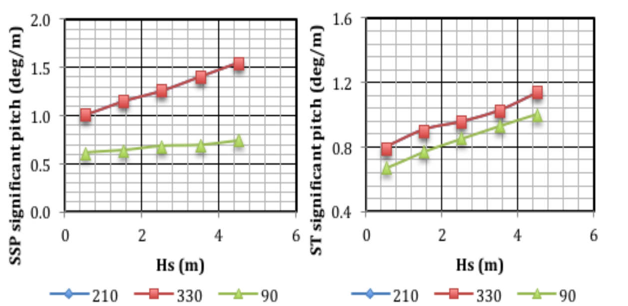
(a) (b)

Figure 12. The heave responses during offloading under 1st condition: (a) SSP and (b) LNGC



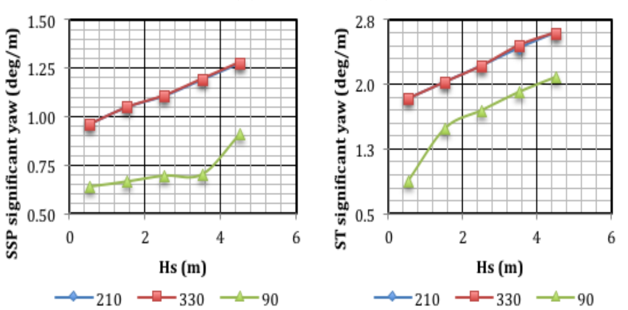
(a) (b)

Figure 13. The roll responses during offloading under 1st condition: (a) SSP and (b) LNGC



(a) (b)

Figure 14. The pitch responses during offloading under 1st condition: (a) SSP and (b) LNGC



(a) (b)

Figure 15. The yaw responses during offloading under 1st condition: (a) SSP and (b) LNGC

The evaluation scenarios were also carried out by varying the direction of the LNGC, ie 30°, 150°, and 270°, and the loading direction of 210°, 330°, and 90°. Results of SSP and LNGC motion responses during offloading process is typified in Figures 10 to 15. These are statistical values of the all 6-mode of motions for offloading with scenario of the 1st condition.

In general as it is expected, the responses are increasing in parallel to the augmentation of the significant wave height. Even though the trend of the increasing responses are not linear. Differences in the responses of SSP and LNGC due to variations in angle of environmental load propagation are quite high in certain mode of motions but may also relatively small for other modes.

The motion intensities of SSP in offloading operation, where the LNGC is connected to the SSP, brought about *Hs* = 4.5 m have largest significant values of 1.55 m for surge, 1.80 m for sway, 0.85 m for heave, 1.95° for roll, 1.55° for pitch, and 1.28° for yaw. If compared to the standalone the increasing of motion intensities for surge, sway, heave, roll, pitch and yaw in offloading operation are, correspondingly, 2.77, 2.25, 5.3, 4.23, 4.84, and 25.6 times higher. These suggest the presence of LNGC generate significant coupled motion effects induced by the hydrodynamics interference among SSP and LNGC.

The motion intensities of SSP in offloading operation imposed by random wave with *Hs* = 4.5 m are 0.90 m, 2.25 m, 1.50 m, 2.15°, 1.14°, and 2.85° for mode of surge, sway, heave, roll, pitch, and yaw, respectively. These could be considered in acceptable level.

3.6 Tension Characteristics on the SSP Mooring Lines in Offloading Operations

Based on motion data from computation as contained in Figs. 4-15, then simulation in time-domain to evaluate the tension developed on each mooring line is conducted. The simulations are performed for all six scenarios as explained in sub-section 3.5. Significant wave heights *Hs* is varied between 0.5 m up to 4.5 m at every interval of 1.0 m incurporated to the JONSWAP spectra with peakedness parameter γ = 2.5 to establish the time-series of random wave excitation. JONSWAP spectra with peakedness parameter γ = 2.5 is selected as it is considered appropriate to model the wave characteristics in Indonesia [10]. An example of simulation result of in the form of effective tension elevation graph on line number 9 due to wave *Hs* = 4.5 m for 1st condition is shown in Fig. 16.

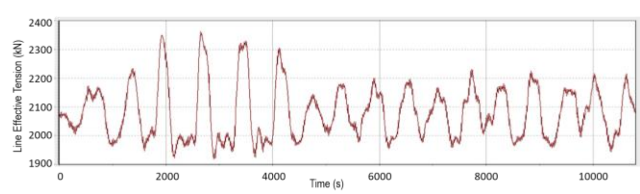


Figure 16. Effective tension on line-9 due to wave *Hs* = 4.5 m and direction 90° for operation scenario of the 1st condition

From this evaluation, there are 90 set of data on mooring line tension has been produced from combination of 6 operational conditions, 5 variations of *Hs*, and 3 wave directions. Further, if one consider overall 12 mooring lines, then there are 1,080 individual mooring tension time-histories have been produced. For each time history is sequentially processed to obtain the maximum tension on each line. Referring to the very large number of data that has been generated, not all the data could be presented in this paper. Only examples which are considered appropriate to represent in the explanation are put forward. In this respect data from catenary and taut mooring systems are described separately.

Table 4. SSP catenary mooring line maximum tensions (kN) due to wave *Hs* = 4.5 m and direction 90^o for the 1st, 2nd and 3rd offloading operational conditions

Line	1st Cond	2nd Cond	3rd Cond	% diff from 1st Cond	
				2nd Cond	3rd Cond
1	1821	2024	2125	11.15	16.69
2	1825	2022	2123	10.79	16.33
3	1778	2021	2122	13.67	19.35
4	1774	2025	2126	14.15	19.84
5	1772	1979	2080	11.68	17.38
6	1776	1974	2075	11.15	16.84
7	1776	1972	2073	11.04	16.72
8	1777	1977	2078	11.25	16.94
9	2290	2490	2591	8.73	13.14
10	2288	2489	2590	8.78	13.20
11	2287	2487	2588	8.75	13.16
12	2292	2492	2594	8.73	13.18
Avrg =	1955	2163	2264	10.82	16.06

In Table 4 it is shown an example of results on the maximum tension on each mooring line for SSP catenary mooring configuration when operated in 1st, 2nd, and 3rd conditions due to wave height *Hs* = 4.5 m and direction 90^o. In this particular case the highest tensions are found to occur the line group of 9, 10, 11 and 12. The overall maximum are on line-12 with intensities of 2,292 kN, 2,492 kN, and 2,594, respectively, for the 1st, 2nd, and 3rd condition. Average increase of tensions on 2nd and 3rd conditions when compared to the 1st condition are some 10.82% and 16.06%.

Table 5 gives an example of results on the maximum tension on each mooring line for SSP taut mooring configuration when operated in 4th, 5th, and 6th conditions due to wave height *Hs* = 4.5 m and direction 90^o. In this particular case the highest tensions are found to occur the line group of 9, 10, 11 and 12. The overall maximum are on line-12 with intensities of 6,605 kN, 6,834 kN, and 6,648 kN, respectively, for the 4th, 5th, and 6th condition. Average increase of tensions on 5th, and 6th conditions when compared to the 4th condition are some 3.66% and 4.82%.

Table 5. SSP taut mooring line maximum tensions (kN) due to wave *Hs* = 4.5 m and direction 90^o for the 4th, 5th and 6th operational conditions

Line	4th Cond	5th Cond	6th Cond	% diff from 4th Cond	
				5th Cond	6th Cond
1	6237	6470	6543	3.74	4.91
2	6235	6468	6540	3.74	4.89
3	6234	6467	6539	3.74	4.89
4	6238	6471	6543	3.74	4.89
5	6192	6425	6497	3.76	4.93
6	6187	6420	6493	3.77	4.95
7	6185	6418	6491	3.77	4.95
8	6190	6423	6495	3.76	4.93
9	6603	6832	6908	3.47	4.62
10	6601	6830	6906	3.47	4.62
11	6600	6829	6905	3.47	4,62
12	6605	6834	6910	3.47	4,62
Avrg =	6342	6574	6648	3.66	4,82

Furthermore, the comparison of results in Tables 4 and 5 indicate the tensions of SSP with taut mooring configuration will be averagely 3.10 times higher than that for the case of SSP with catenary mooring. This finding is typical in the comparison by considering other significant wave heights, i.e. 0.5 m, 1.5 m, 2.5 m, and 3.5 m, as well as other wave headings, i.e. 210^o and 330^o. It is necessary to mention herein, the largest tensions when wave heading is 210^o take place in the mooring line group of 5, 6, 7 and 8, while when the wave heading is 330^o the largest tensions happen to be in the mooring line group of 1, 2, 3, and 4. Nonetheless, the largest tensions due to 210^o and 330^o wave directions are generally lower than that in the case of 90^o.

3.7 Operability of the SSP and LNG Carrier during Offloading Operations

The operability of offloading operation is evaluated based on the motion criteria and mooring tension criteria. The motion criteria requires, firstly, the relative motion between SSP and LNGC should not be less than 20.0 m, and, secondly, the maximum rotational motion should be less than 5^o [11]. The relative motion criteria is related mainly with the surge and sway mode of motions. Whereas the rotational motion criteria is primarily connected to the roll and pitch mode of motions.

The mooring tension criteria requires the maximum line tension should not be larger than 1.67 of minimum breaking load (MBL) [12]. In this case, the lowest MBL of the mooring system eventually is 14,336 kN, i.e. the specific value of the polyester rope component.

After analyzing overall the derived simulation data, and those are subsequently checked against the criteria, the results of operability matrix is shown in Table 6. The green shading indicates the all the wave joint occurrence of significant wave height *Hs* and peak period *Tp* where the offloading operation could be safely operated, i.e. when *Hs* is less than 3.0 m for all *Tp* variations. The operation would not be safely operated for all waves with Hs > 3.0 m. This eventually due to the relative motion criteria which is exceeded to a certain degree.

Table 6. Results of operability analysis (red shading indicate criteria is exceeded)

		Hs (m)					Total
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	
Tp (s)	0.1-2.0	0.00	0.00	0.00	0.00	0.00	0.00
	2.1-4.0	0.58	0.00	0.00	0.00	0.00	0.58
	4.1-6.0	9.51	4.43	0.00	0.00	0.00	13.94
	6.1-8.0	5.12	6.90	4.74	0.05	0.00	16.81
	8.1-10.0	8.20	3.50	5.70	0.79	0.05	18.24
	10.1-12.0	10.80	20.8	0.15	0.04	0.02	31.81
	12.1-14.0	9.30	2.68	0.02	0.02	0.00	12.02
	14.1-16.0	2.93	2.46	0.04	0.00	0.00	5.43
	16.1-18.0	0.42	0.77	0.03	0.00	0.00	1.22
	18.1-20.0	0.05	0.09	0.00	0.00	0.00	0.15
Total		46.91	41.44	10.68	0.90	0.07	100
Cumulative		46.91	88.35	99.03	99.93	100	

Considering the results in Table 6, it may be observed that the offloading operation between SSP and LNGC could be performed in the extent of 99.03% of all wave occurrence. In other words, the operability of offloading operation may reach as high as 99.03% in the Masela Block of Abadi Gas Field.

4. CONCLUSIONS

A study has been conducted for the case of the hydro-dynamics interaction between SSP and LNG carrier under the excitation of environmental loads. The findings of the study could be portrayed as follows:

- The motions of SSP and LNGC in free floating condition under excitation of regular wave as presen-ted in the form of RAO graphs may be considered as having good quality, with no indication of excessive intensities.
- The motion characteristic of SSP in standalone condi-tion is excellent as shown by the low motion inten-sities for all the 6-mode of motions when induced by a random wave with *Hs* = 4.5 m.
- The motion intensities of SSP in offloading operation, where the LNGC is connected to the SSP, brought about *Hs* = 4.5 m may escalate between 2.0 up to 5.0 times of that in in the case of standalone. Even for yaw the escalation could be as much as 26.0 times. These are caused by the hydrodynamics interference among SSP and LNGC lead to augmentation in coupled motion.
- The motion intensities of SSP in offloading operation imposed by random wave with *Hs* = 4.5 m are respected within acceptable level.
- For the case of offloading operation where the SSP is moored with catenary configuration imposed by random wave having *Hs* = 4.5 m may give tensions of 1,600 kN at the lowest up to some 2,600 kN at the highest. For the case of SSP is moored with taut configuration the tension may intensify as much as 3.1 times higher than that of catenary configuration. The magnitudes may range from 4,700 kN at the lowest up to 7,000 kN at the highest. The safety factor of the maximum tension that is predicted to occur is some 2.05, which is well above the minimum required safety factor of 1.67.
- Considering the motion and tension criteria, the SSP and LNGC operability could be expected to reach as high as 99.0% for offloading operation at Masela Block of the Abadi Gas Field.

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