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Experimental & Numerical Studies of Vertical Motion Acceleration Analysis in Helideck on a Catamaran Floating Crane

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ABSTRAK

This research discusses the operability of vertical acceleration in the helideck. The experiment was carried out at the Maneuvering and Ocean Engineering Basin (MOB) facility of the BPPT-ITS Hydrodynamics Technology Center. The model being tested is the catamaran type with a scale of 1:36 to the original scale. Experimental testing using random waves with a Pierson-maskowitz spectrum with Hs = 2.5 and Hs = 6.37 m. The helideck only performs surge sway and heave tests. Meanwhile, numerical analyzes the effects of regular waves at heading 0^0 45^0 90^0 135^0 180^0 and obtained RAO for Heave, Roll, Pitch movements. For the analysis of landing operability at Helideck using the Olson and Marine criteria, where the limit of wave height according to Olson is obtained, namely for the incoming wave direction of 0^0, 90^0,180^0, it should not be done more than 3 meters of wave height, while for conditions 450 and 1350 should not be above 4 meters. . For the HCA category, the critical condition when the direction of the wave of 900 with a wave height of 2 meters. At an altitude of 4 meters is the limit of the wave direction 0^0 45^0 135^0 180^0.

Keywords: *floating crane catamaran, operability, helideck.*

1. INTRODUCTION

The vast territory of Indonesia which is dominated by the ocean is very beneficial for the whole, coupled with the existence of a very strategic area. Indonesian waters also have a variety of marine potentials that are very abundant, so a transportation medium in the form of support vessels is needed to explore these territorial waters, in this case, cargo ships are much needed. One of them is a floating crane that can codify and connect the transfer of goods from one city to another. Also, in the operation at sea, a support facility is required for the transportation of the crew from land to sea, in the form of a helideck, before making a landing at the helideck to see what conditions the ocean boundary looks like and minimize damage due to helicopter landings [1]. During helicopter landing operations, environmental factors are the most challenging for pilots [2] and also the greatest risk from all aspects [3] so as not to endanger the continuity of operations at sea, especially in conditions of erratic and often changing marine environments. It also relates to the operability analysis of helicopter operations so that they can be successful if the operation is carried out with various uncertain environmental conditions. [4]

For this reason, the author analyzes the motion characteristics of the catamaran floating crane to determine the operational limits of the helicopter so that it can land safely.

2. METHODOLOGY

2.1 Literature Study

This literature study is done by searching, studying, and understanding journals, books, and alumni final project report from both the institution itself and from other institutions that discuss operability and experimentation. These works of literature are also used as references for conducting this research.

2.2 Structural Modelling

For modelling that was carried out experimentally, the geometric, kinematic, and dynamic aspects were considered, the scale used was 1:36. Here is scaling according to Froude:

Table 1. Principal Dimension FCC

Catamaran Properties (Scale 1:36)			
Parameter	**Full scale**	**Scale factor**	**Scale Model**
Loa (m)	111	λ	3.08
Lwl (m)	111	λ	3.08
Lpp (m)	108	λ	3.00
B (m)	37.8	λ	1.05
H (m)	14.4	λ	0.4
T (m)	4.7	λ	0.13
Displacement (kg)	846400	λ^3	181

This floating catamaran experiment was carried out at the MOB BTH-BPPT Surabaya test pool facility with the following pool data:

Table 2. Pool Data

Dimensions	Size	Unit
Length	45	meter
Breadth	30	meter
Dept	1.5	meter
Maximum Waves Period	0.5-3	second
Waves Direction	0° - 90°	*degree*

2.3. Validation

Catamaran Floating Crane modelling in the numerical section using MOSES software which is to compare with the experimental results. Due to the experiment results in Surge, Sway, Heave movements on the helideck so for validation only these three movements.

2.4 Seakeeping Criteria

Some of the seakeeping criteria in the helicopter landing category that are widely used in the reference to evaluating ship operability have been put forward by Olson (1978), and by Marin (2015) where there are limitations in which the helicopter can land safely in the helideck section.

3. RESULTS AND DISCUSSION

3.1 Experiment

In the Catamaran modelling that is made and modelled for experiments using balsa wood for the whole mode. The main deck is covered by plywood so that when the water is tested, it does not enter the deck. The topside helideck is given a qualisys sensor to capture xyz motion. The model of the experimental test is as follows:

Figure1. Model Floating Crane Catamaran

As for the modelling carried out experimentally, the geometric, kinematic, and dynamic aspects are considered, the scale used is 1:36, and will be placed in the MOB pool facility of the Hydrodynamics Technology Center, so that the results of the model parameters are as follows:

Table 3. Parameter Model Experiment

Parameter	Size	Unit
Length overall (LOA)	3.08	m
Length between perpendicular (LPP)	3.08	m
Breadth (B)	3.00	m
Depth (H)	1.05	m
Draft (T)	0.40	m
Displacement	181	kg

3.2 Result Experiment

The results obtained in the experiments carried out at the MOB facility by transforming from the time domain after that using fft and producing the following comparisons:

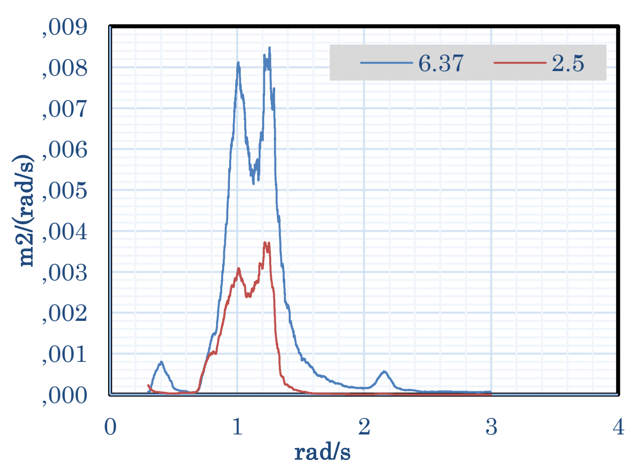

Figure 2. Surge Spectra Response at Helideck

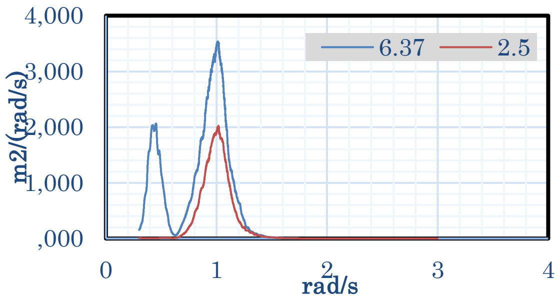

Figure 3. Sway Spectra Response at Helideck

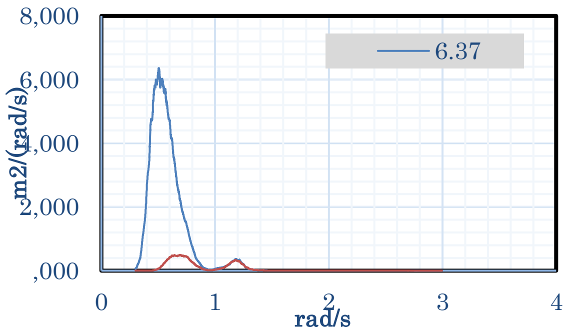

Figure 4. Heave Spectra Response at Helideck

3.3 Numerical

Numerical modelling for FCC uses the MOSES software and the following are the results:

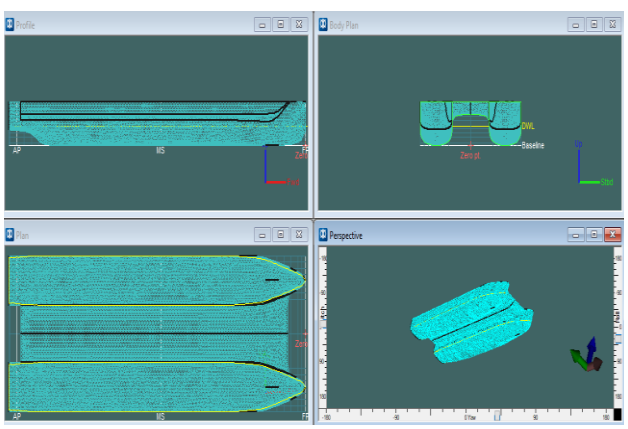

Figure 5. The Modelling of Vessel

After that, comparing the analysis of the response spectra of the helideck motion when tethered between numerical and experimental results in the following results:

1. Intact condition in wave height of 6.37 m.

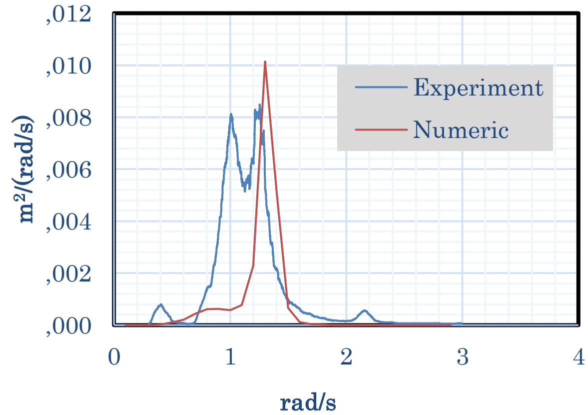

Figure 6. Comparison of Surge Spectra Response

Here are the differences between the two graph:

Table 4. Comparison spectra response surge Hs=6.37m

Stochastic	Experiment	Numeric	Comparison
Mo	0.0039	0.0021	48%
zs =	0.1253	0.0907	28%

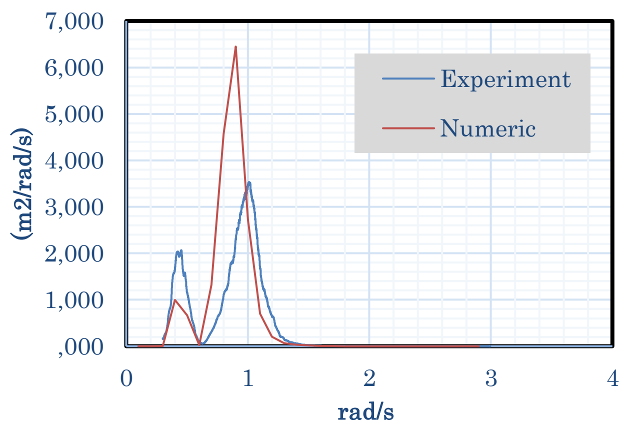

Figure 7. Comparison of sway Spectra Response

Here are the differences between the two graphs:

Table 5. Comparison of Sway Spectra Response Hs= 6.37m

Stochastic	Experiment	Numeric	Comparison
Mo	1.311	1.757	-34%
zs =	2.290	2.651	-16%

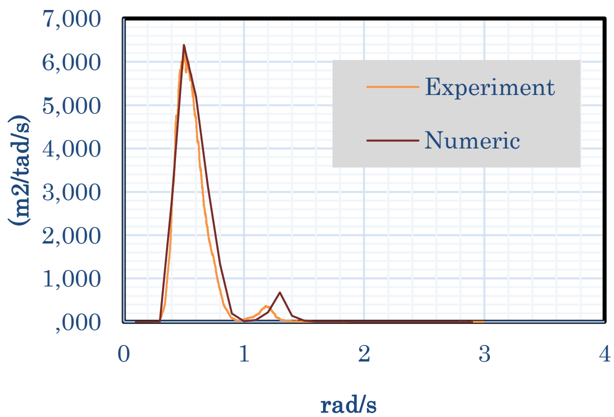

Figure 8. Comparison of Heave Spectra Response

Here are the differences between the two graphs:

Table 6. Comparison of Heave Spectra Response Hs= 6.37 m

Stochastic	Experiment	Numeric	Comparison
Mo	1.738	1.991	-15%
zs =	2.636	2.822	-7%

2. Intact condition in wave significant height of 2.5 meter

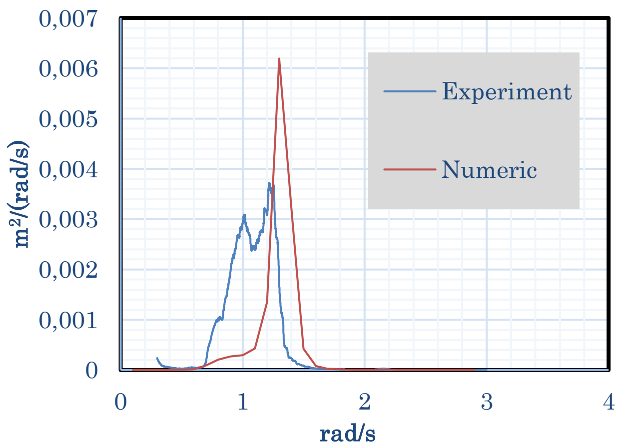

Figure 9. Comparison of Surge Spectra Response

Here are the differences between the two graphs:

Table 7. Comparison of Surge Spectra Response Hs= 2.5 m

Stochastic	Experiment	Numeric	Comparison
Mo	0.0015	0.0012	19%
□s =	0.077	0.069	10%

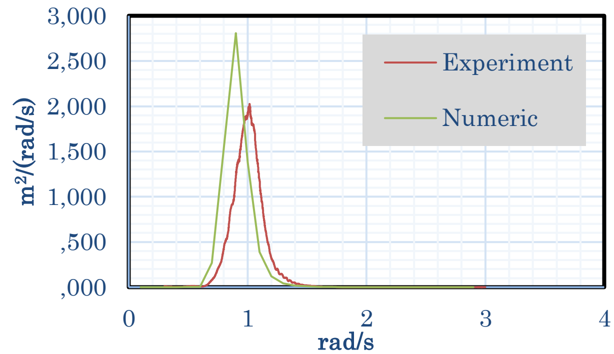

Figure 10. Comparison of Sway Spectra Response

Here are the differences between the two graphs:

Table 10. Comparison of Sway Spectra Response Hs= 2.5 m

Stochastic	Experiment	Numeric	Comparison
Mo	0.547	0.642	-17%
□s =	1.479	1.603	-8%

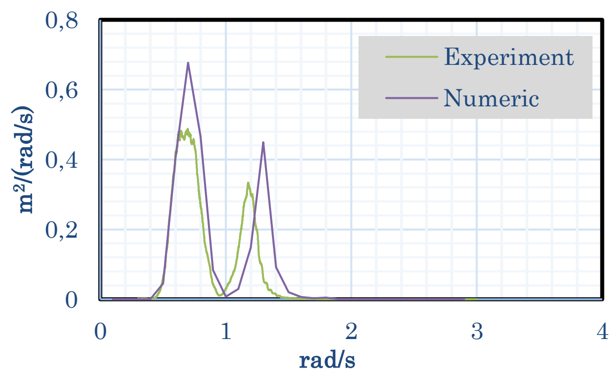

Figure 11. Comparison of Heave Spectra Response

Here are the differences between the two graphs:

Table 11. Comparison of Heave Spectra Response Hs= 2.5 m

Stochastic	Experiment	Numeric	Comparison
Mo	0.188	0.238	-27%
□s =	0.867	0.977	-13%

After validating the experimental and numerical conditions on sway, surge and heave, it is continued to vary the wave height between 0 -10 meters with the following wave incidence angles:

1. *following seas* (0^0)
2. *quarter stern seas* (45^0)
3. *beam seas* (90^0)
4. *bow quartering seas* (135^0)
5. *head seas* (180^0)

3.4. Operability Analysis

For the operation and landing of helicopters in marine buildings, criteria is operating limits where if these criteria exceed the helicopter landing process on the helideck cannot be carried out. This is because it avoids slips, bumps and accidents in the helicopter landing operation at the helideck. Then it is necessary:

1. Olson's criteria (1977 & 1978) [5] [6]. To determine the limits that can be done by helicopters to land, namely using *double amplitude significant roll, double amplitude significant pitch, double amplitude significant heave* dan *significant vertical velocity*. The following are the limitations on the headings 0^0, 45^0, 90^0, 135^0 dan 180^0 with the height vary within 1 until 10 meter.

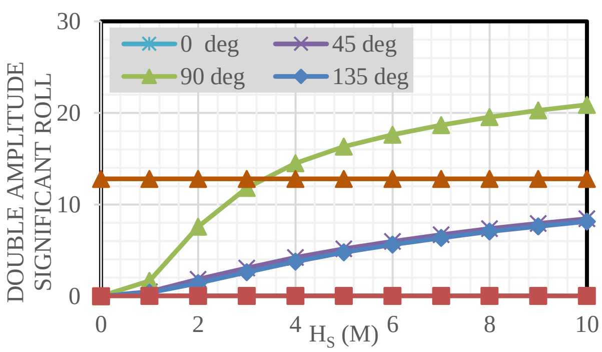

Figure 12. Double Amplitude Significant Roll

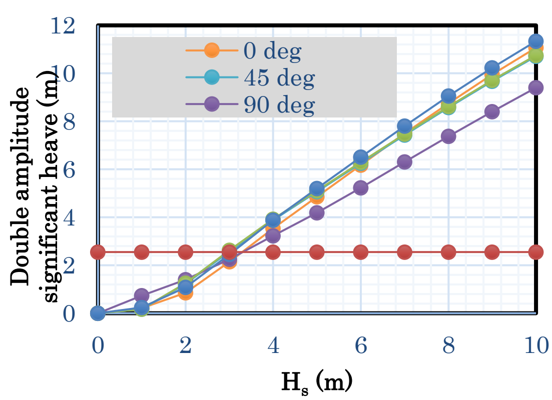

Figure 13. Double Amplitude Significant Heave

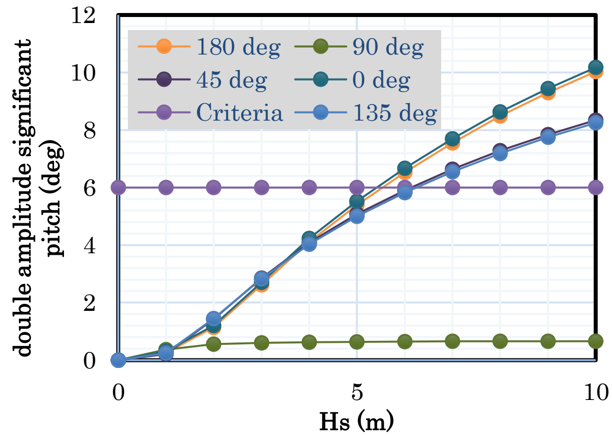

Figure 14. Double Amplitude Significant Pitch

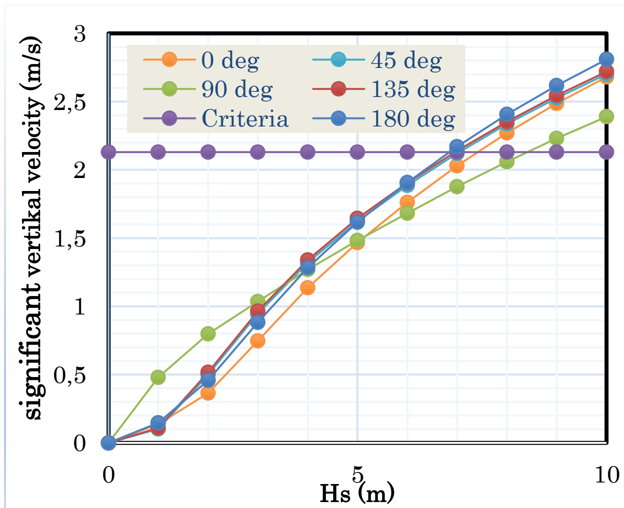

Figure 15. Significant vertical Velocity

From the graph above we can find out the criteria limit that exceeds 1-10 meters altitude. The following is the maximum value for each heading:

Table 12. The Olson's Criteria Maximum

Heading	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Limitation
0	> 10 m	6 m	4 m	8 m	4 m
45	> 10 m	7 m	3 m	8 m	3 m
90	4 m	> 10 m	4 m	9 m	4 m
135	> 10 m	7 m	3 m	7 m	3 m
180	> 10 m	6 m	4 m	8 m	4 meter

2. Criteria issued by the Norwegian Helideck Certification Association or HCA [7] considers roll motion, pitch, heave rate and double amplitude heave. The following are critical conditions in a landing:

Table 13. The Maximum Value of HCA Criteria Heading 0^0.

Aircraft		180			
Category		P/R	H/R	H/A	Limitation
Heavy	DAY	4	4	4	4
	NT	3	3	3	3
Medium	DAY	6	4	4	4
	NT	4	3	3	3

Table 14. The Maximum Value of HCA Criteria Heading 135^0.

Aircraft		135			
Category		P/R	H/R	H/A	Limitation
Heavy	DAY	4	4	4	4
	NT	3	3	3	3
Medium	DAY	7	4	4	4
	NT	4	3	3	3

Table 15. The Maximum value of HCA criteria heading 90^0.

Aircraft		90			
Category		P/R	H/R	H/A	Limitation
Heavy	DAY	2	3	4	2
	NT	2	2	3	2
Medium	DAY	2	3	4	2
	NT	2	2	3	2

Table 16. The Maximum value of HCA criteria heading 45^0.

Aircraft		45			
Category		P/R	H/R	H/A	Limitation
Heavy	DAY	5	4	4	4
	NT	3	2	3	2
Medium	DAY	7	4	4	4
	NT	4	2	3	2

Table 17. The Maximum value of HCA criteria heading 0^0.

Aircraft		0			
Category		P/R	H/R	H/A	Limitation
Heavy	DAY	4	4	4	4
	NT	3	2	3	2
Medium	DAY	7	4	4	4
	NT	4	2	3	2

4. CONCLUTION

Based on the research that has been done, the following conclusions are obtained:

1. Analysis of Fcc vertical motion response spectra obtained the greatest value from the experimental and numerical comparisons at 6.37 and 2.5 conditions, namely: for numerical 6.38 m2 / (rad / s) for heave motion, for experiments 6.35 m2 / (rad / s). For numerical 0.67 m2 (/ rad / s) and for experiments that is 0.488 m2 / (rad / s).
2. The operational limitation of Helicopter landing at Helideck at the FCC, according to Olson, is that for the incoming wave direction of 0^0, 90^0,180^0, it should not be done more than 3 meters high, while for conditions 45^0 and 135^0 should not be above 4 meters. For the category according to the HCA, the critical condition in the direction of the wave of 90^0 for a wave height of 2 meters. At an altitude of 4 meters is the limit of the wave direction 0^0 45^0 135^0 180^0.

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