

PRESENTASI

TUGAS AKHIR

JURUSAN TEKNIK KELAUTAN FTK ITS

**Studi Respon Dinamis Spar Platform
dengan Variasi Rasio Diameter dan
Jarak Heave Plate**

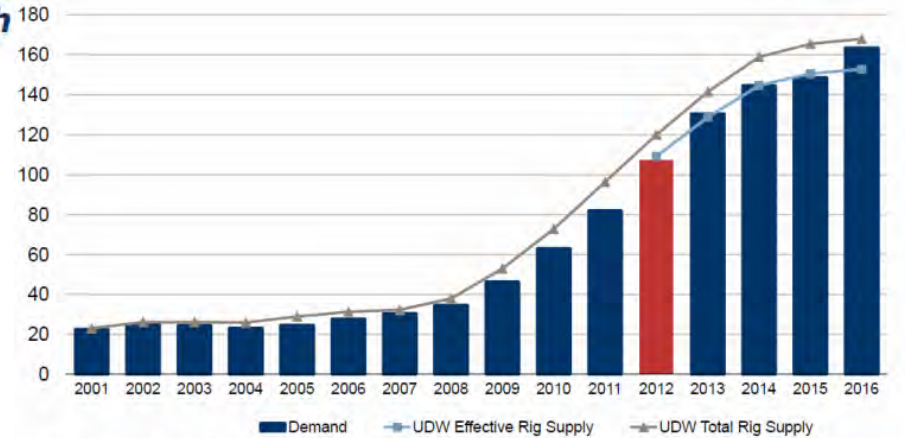
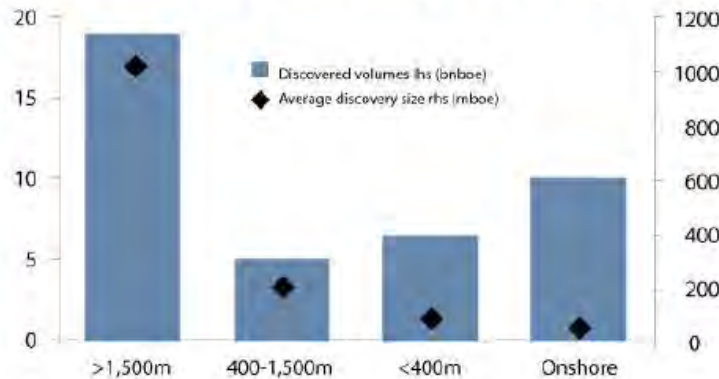
Ryan Ciputra
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Dosen Pembimbing :
Yoyok Setyo H. S.T., MT., Ph.D
Ir. Joswan J.S., M.Sc.

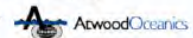
LATAR BELAKANG

T U G A S A K H I R

Discovered reserves in 2010, by water depth



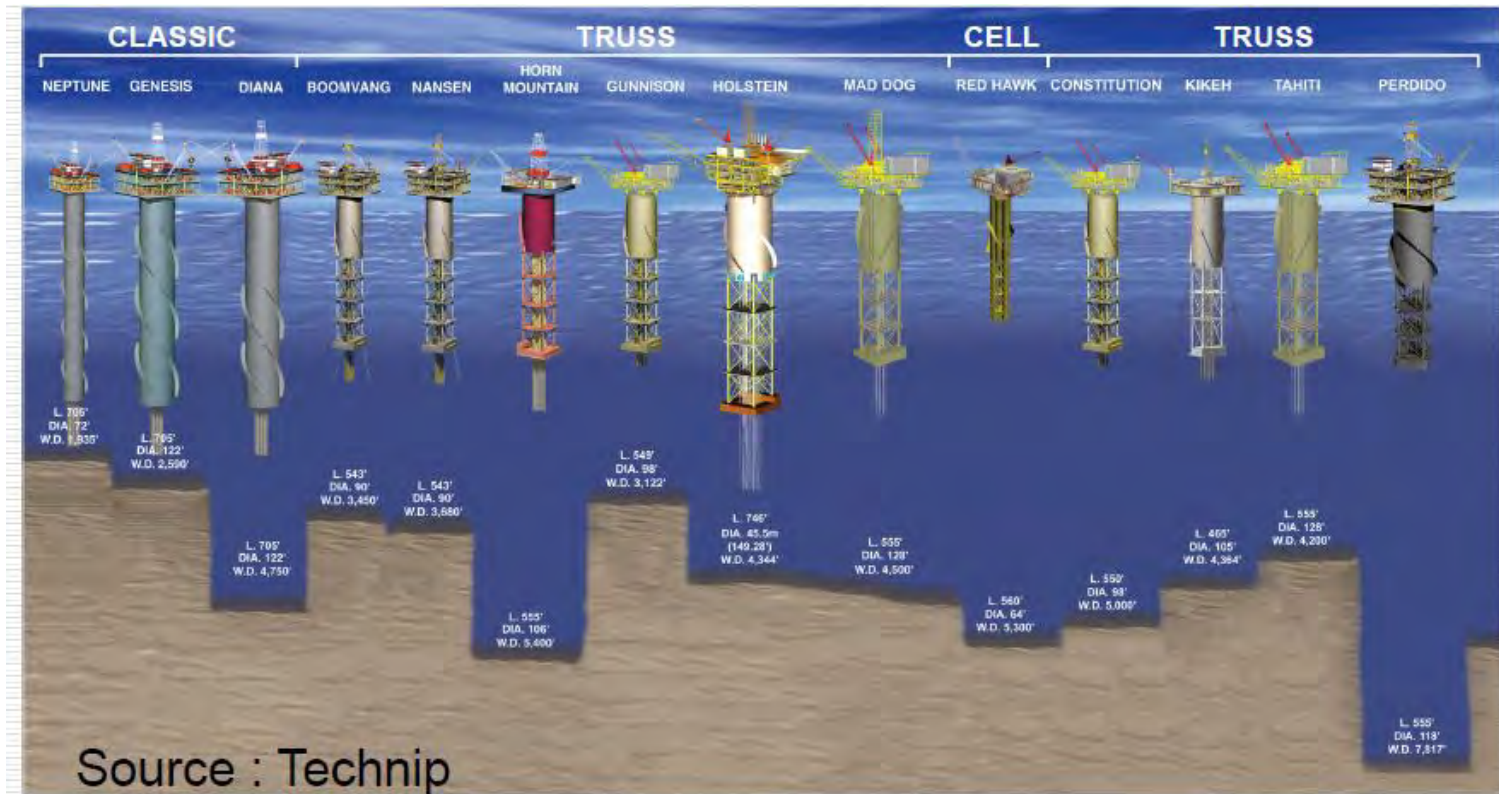
Note: Effective supply reflects reduction in fleet capacity due to required maintenance and mobilization activities.
Source: ©2012 ODS-Petrodata, a company which has been acquired by IHS.



1. Produksi minyak dan gas bumi mulai bergerak ke perairan dalam yang mempunyai kondisi laut yang lebih ganas dan bergelombang besar dibandingkan perairan dangkal.

S P A R

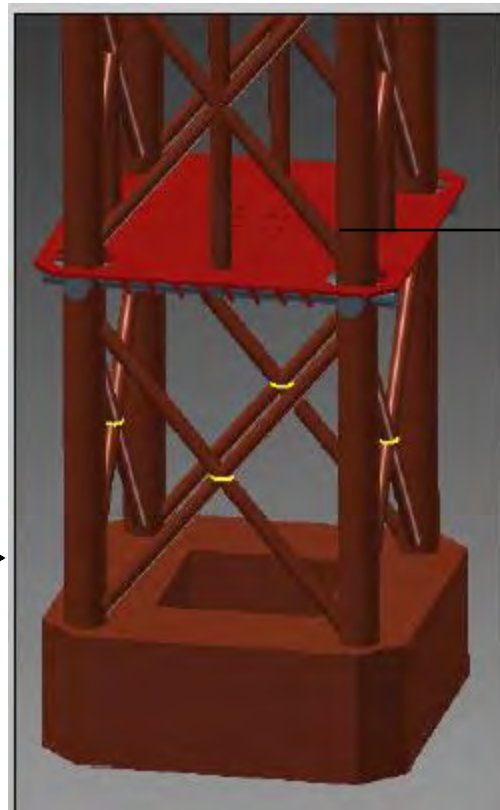
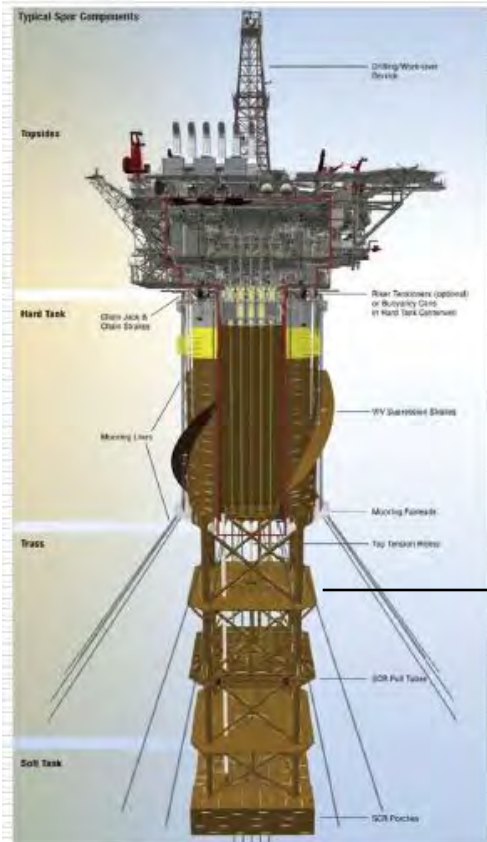
SINGLE POINT ANCHOR RESERVOIR



Source : Technip

HEAVE PLATE

SINGLE POINT ANCHOR RESERVOIR



RUMUSAN MASALAH

T U G A S A K H I R

1. Bagaimana respon gerakan spar platform karena variasi rasio diameter heave plate?
2. Bagaimana respon gerakan spar platform karena variasi jarak antar heave plate?
3. Manakah Spar Platform dengan performance terbaik?

T U J U A N

T U G A S A K H I R

1. Menganalisa respon gerakan spar platform karena variasi rasio diameter heave plate.
2. Menganalisa respon gerakan spar platform karena variasi jarak antar heave plate.
3. Menganalisa Spar Platform dengan performance terbaik.

M A N F A A T

T U G A S A K H I R

Dari hasil analisa dapat diketahui model SPAR dengan variasi rasio diameter dan jarak antar *heave plate*, sehingga dapat digunakan sebagai referensi dalam pengembangan dan inovasi dalam desain SPAR terutama pada *heave plate* untuk mendapatkan optimasi desain SPAR dalam efisiensi operasi.

BATASAN MASALAH

T U G A S A K H I R

1. Ukuran utama variasi *spar platform* akan divariasikan dengan mengacu pada parameter utama Design of Floating Structure Spar Design.
2. Variasi *spar platform* hanya dilakukan terhadap rasio diameter *heave plate* dan jarak.
3. Daerah operasi SPAR ditetapkan di Teluk Meksiko
4. Prediksi gerakan pada gelombang acak dilakukan dengan menerapkan analisis spectra, dengan menggunakan formulasi spectra JONSWAP ($\gamma = 3$).

BATASAN MASALAH

T U G A S A K H I R

5. Prediksi gerakan pada gelombang reguler dilakukan dengan menerapkan teori difraksi 3-dimensi.
6. Analisa dinamis pada struktur SPAR menggunakan analisa frekuensi domain.
7. Beban yang digunakan adalah beban angin dan beban gelombang
8. Analisa *free floating* dilakukan pada heading angle 0 deg.

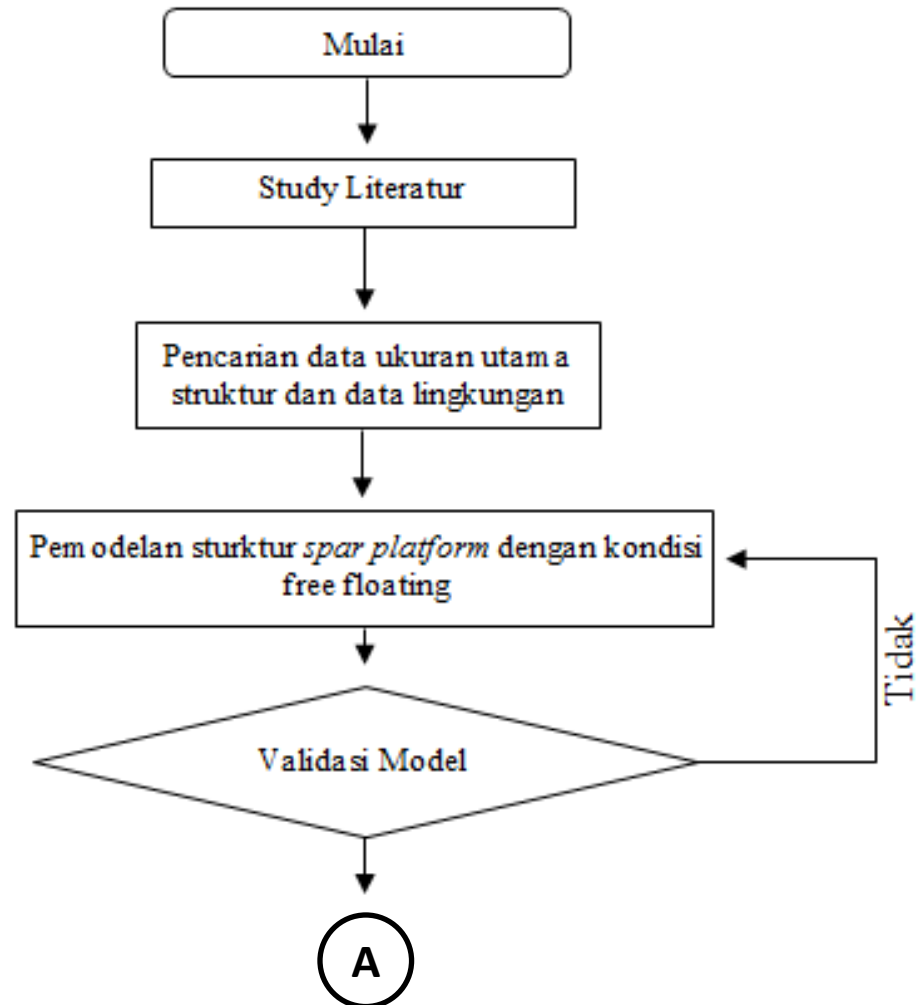
BATASAN MASALAH

T U G A S A K H I R

9. Sistem tambat bertipe taut mooring dengan jumlah 4 buah, sudut tambat 45 deg.
10. 10. Analisa pada kondisi tertambat dilakukan pada heading angle 0, 45, 90 deg
11. Analisa vortex akibat beban yang terjadi tidak dilakukan.

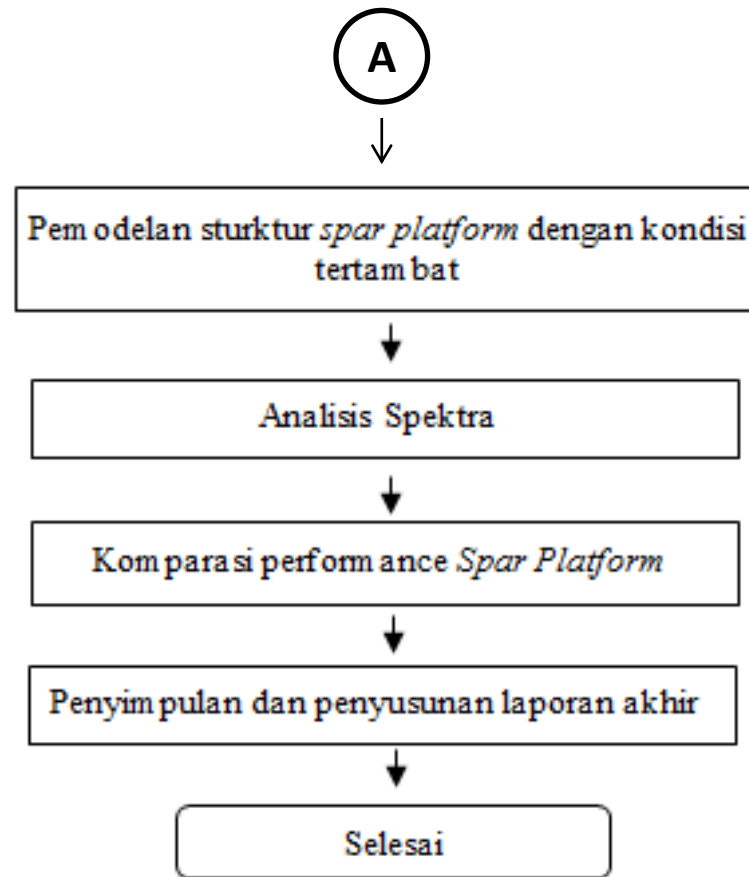
METODOLOGI PENELITIAN

T U G A S A K H I R



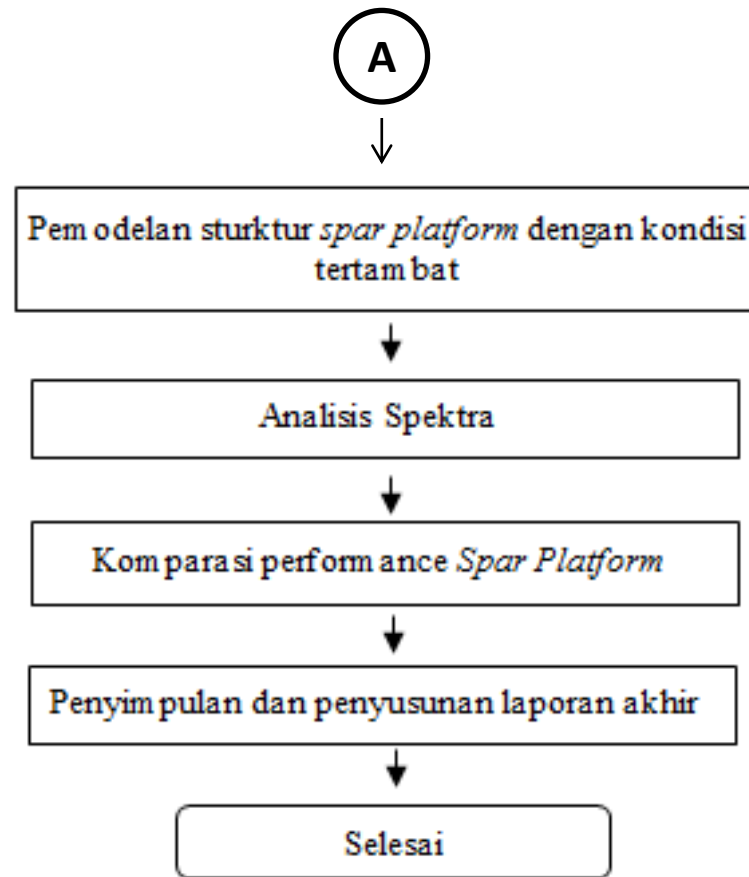
METODOLOGI PENELITIAN

T U G A S A K H I R



METODOLOGI PENELITIAN

T U G A S A K H I R



D A T A

UKURAN STRUKTUR SPAR

Deskripsi	Satuan	SPAR
Kedalaman air	m	590
Diameter Hull	m	21.945
Panjang Hull	m	215
Freeboard	m	16.88
KG	m	95.71
KB	m	99.06
Jumlah Mooring Line	buah	4
hard tank	m	198.12
G from msl	m	102.41
B from msl	m	99.12

SUMBER : Design of Floating Structure Spar Design.

D A T A

L I N G K U N G A N

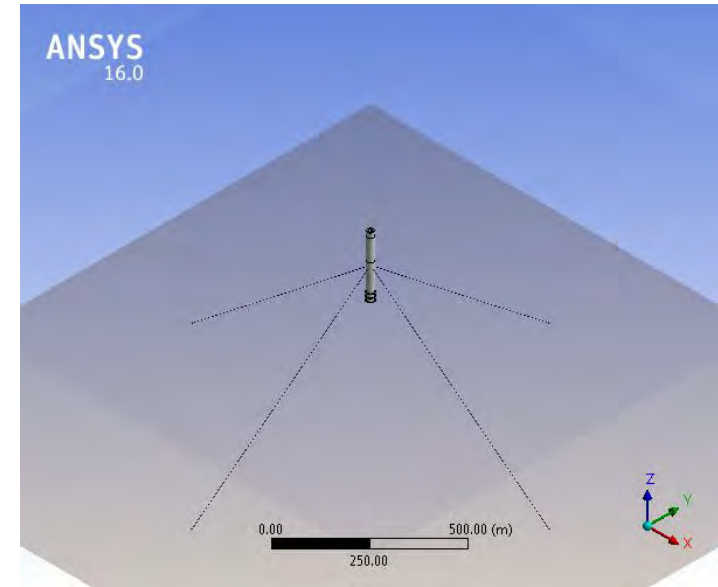
Deskripsi	Satuan	Quantity
Gelombang		
Gelombang Signifikan, Hs	m	12.19
Peak Period, Tp	sec	14
Wave Spectrum	JONSWAP ($\gamma = 3$)	
Direction	deg	180 ⁰
Wind		
Velocity	m.s	41.12 m/s @ 10m
Spectrum	API RP 2T	
Direction	deg	210 ⁰
Current		
Profile		
At surface (0m)	m/s	1.0668
At 60.96 m	m/s	1.0688
At 91.44 m	m/s	0.0914
On the sea bottom	m/s	0.0914
Direction	deg	150 ⁰

SUMBER : Dynamic Analysis of Multiple Body Floating Platforms Coupled with Mooring Lines and Riser

D A T A

M O O R I N G L I N E

	Units	Value
GMBL	Ton	1000
Elongation at break	%	24
Drift Stiffness	MN	42
Strom Stiffness	MN	126
Diameter	Mm	210
Weight in air	Kg/m	26
Weight submerged	Kg/m	22
Mooring line length	m	738.68



PARAMETER

G E O M E T R I

<i>Configures heave plate</i>	<i>Parameter Geometry (m)</i>	<i>Heave Plate Diameter Ratio (m)</i>				
		120%Dh	122%Dh	124%Dh	128%Dh	130%Dh
Spar dengan 3 Heave Plate	Spar Diameter Hull			21.945		
	Total Draft			198.12		
	Heave Plate Thickness			0.3		
	Heave Plate Diameter	26.334	26.776	27.211	28.089	28.528
	Relative Spacing	13	13	13	13	13

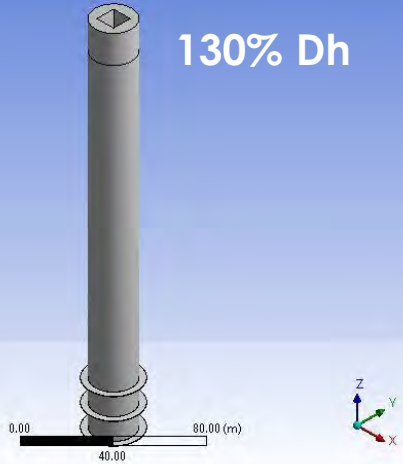
Tabel 2. Parameter geometri spar model (b)

<i>Configures heave plate</i>	<i>Parameter Geometry (m)</i>	<i>Heave Plate Diameter Ratio (m)</i>		
		130% Dh		
Spar dengan 3 Heave Plate	Spar Diameter Hull			21.945
	Total Draft			198.12
	Heave Plate Thickness			0.3
	Heave Plate Diameter	28.528	28.528	28.528
	Relative Spacing	4	8	16

PEMODELAN

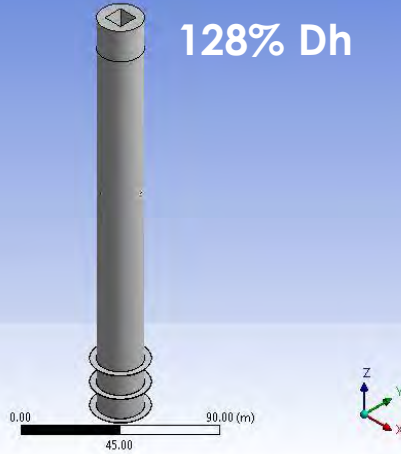
ANSYS
16.0

130% Dh



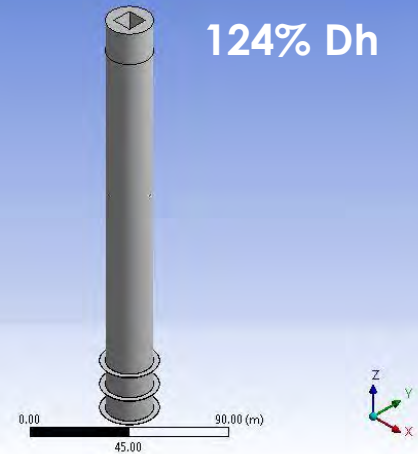
ANSYS
16.0

128% Dh



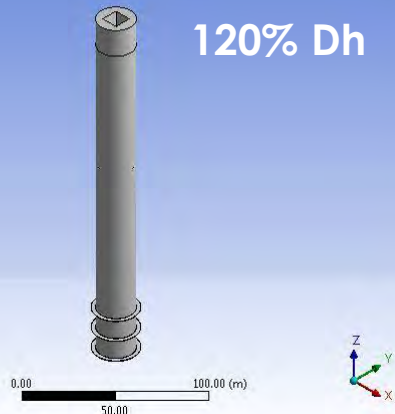
ANSYS
16.0

124% Dh



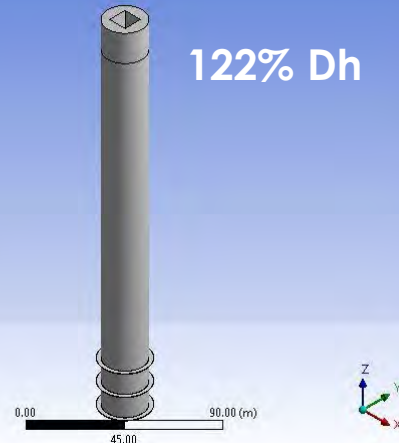
ANSYS
16.0

120% Dh

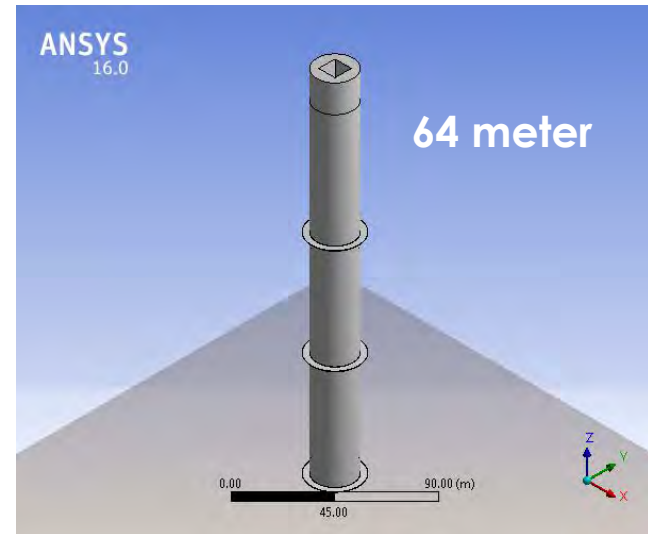
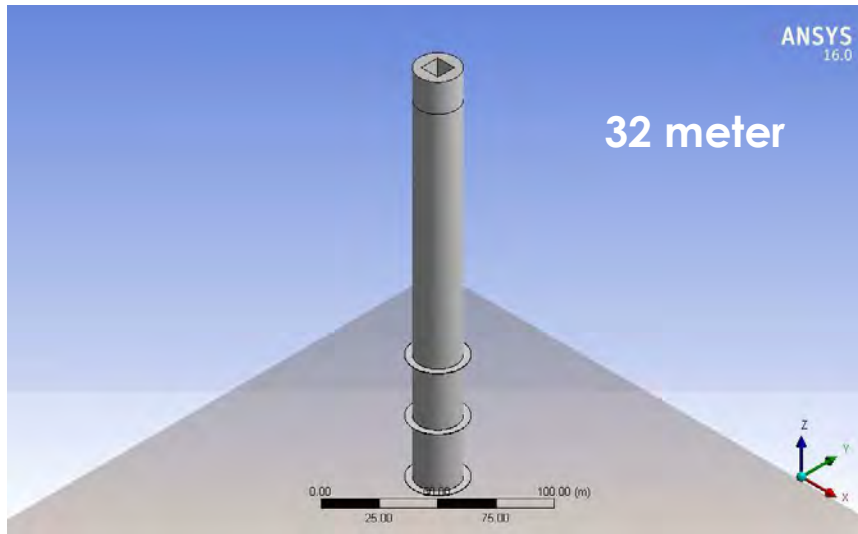
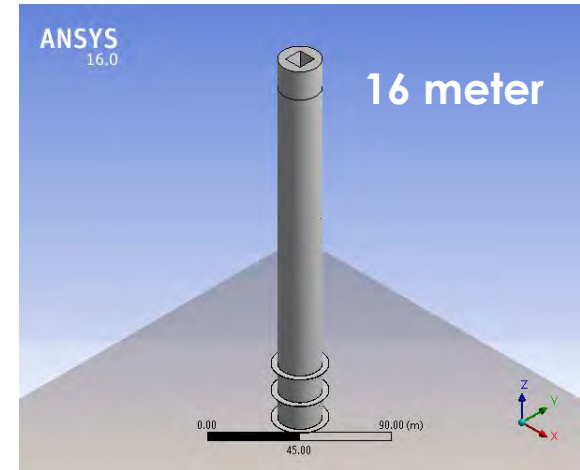
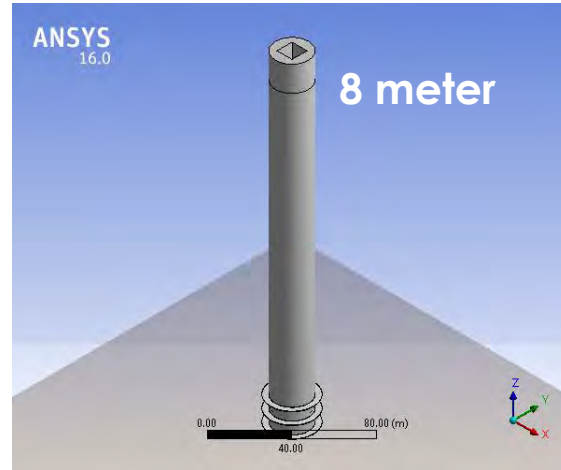
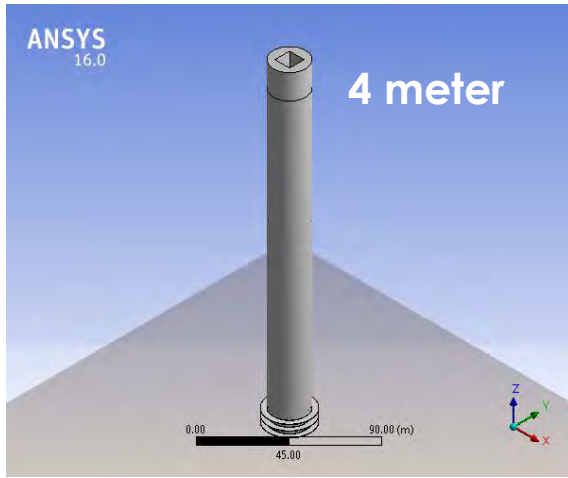


ANSYS
16.0

122% Dh



PEMODELAN



ANALISIS

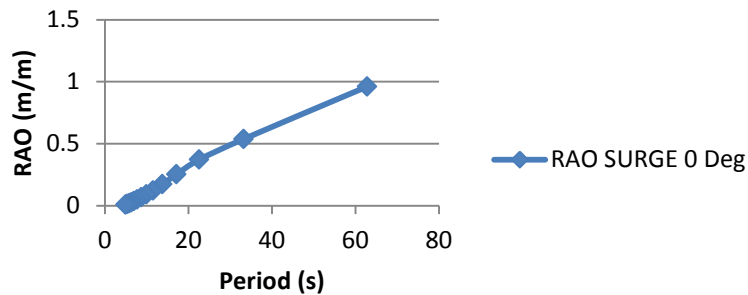
P E M B A H A S A N

ANALISA RAO
FREE FLOATING

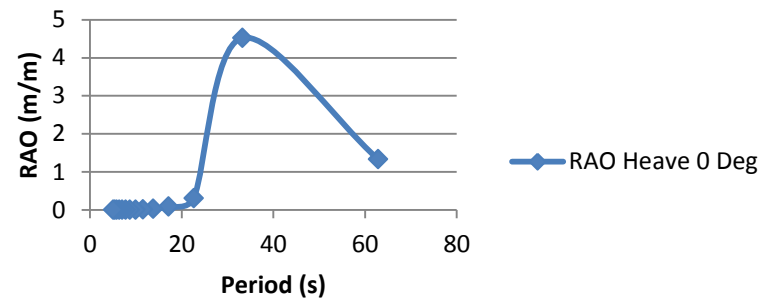
ANALISIS

KONDISI FREE FLOATING

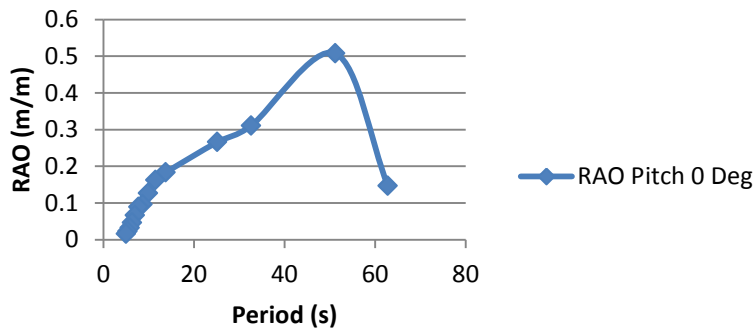
Surge Motion SPAR Tanpa Heave Plate



Heave Motion SPAR Tanpa Heave Plate



Pitch Motion SPAR Tanpa Heave Plate



RAO Puncak :

Surge : 0.96 m pada , $T > 62$ s

Heave : 4.5 m pada, $T = 33.24$ s

pitch : 0.507 deg, pada $T = 51.24$ s

VALIDASI

PERIODE NATURAL

DNV F-205

Surge	Heave	Pitch
> 100 s	20-35 s	50-90 s

MODEL

Surge	Heave	Pitch
>62 s	33.24 s	51.24 s

ANALISIS

P E M B A H A S A N

K O M P A R A S I

H A S I L R A O

F R E E F L O A T I N G

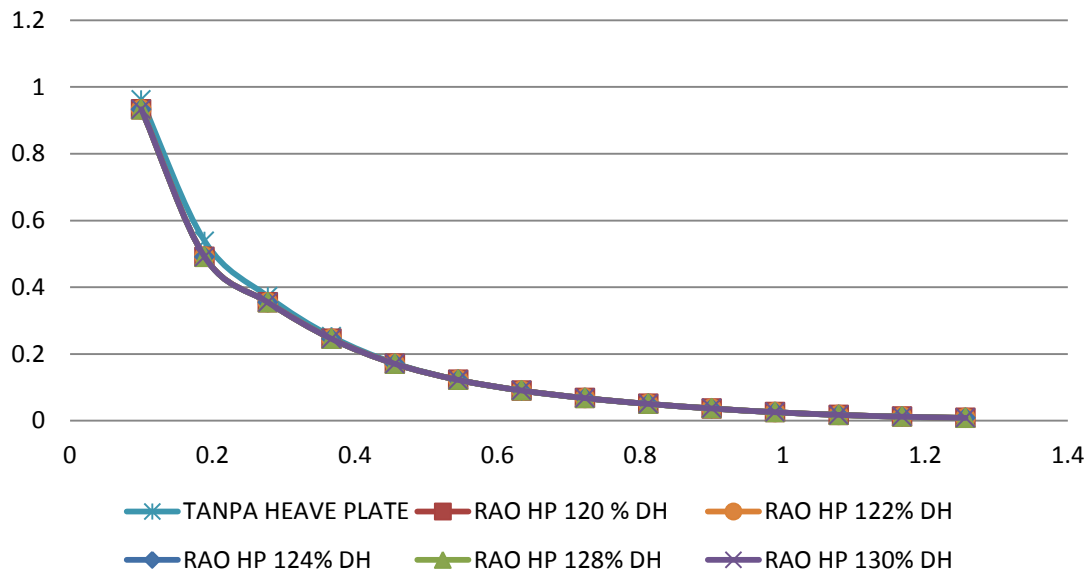
V A R I A S I R A S I O D I A M E T E R

ANALISIS

P E M B A H A S A N

S U R G E

RAO SURGE 0 Deg



RAO MAKSIMUM :

THP : 0.961 m

120 % Dh : 0.932 m

122 % Dh : 0.933 m

124 % Dh : 0.932 m

128 % Dh : 0.932 m

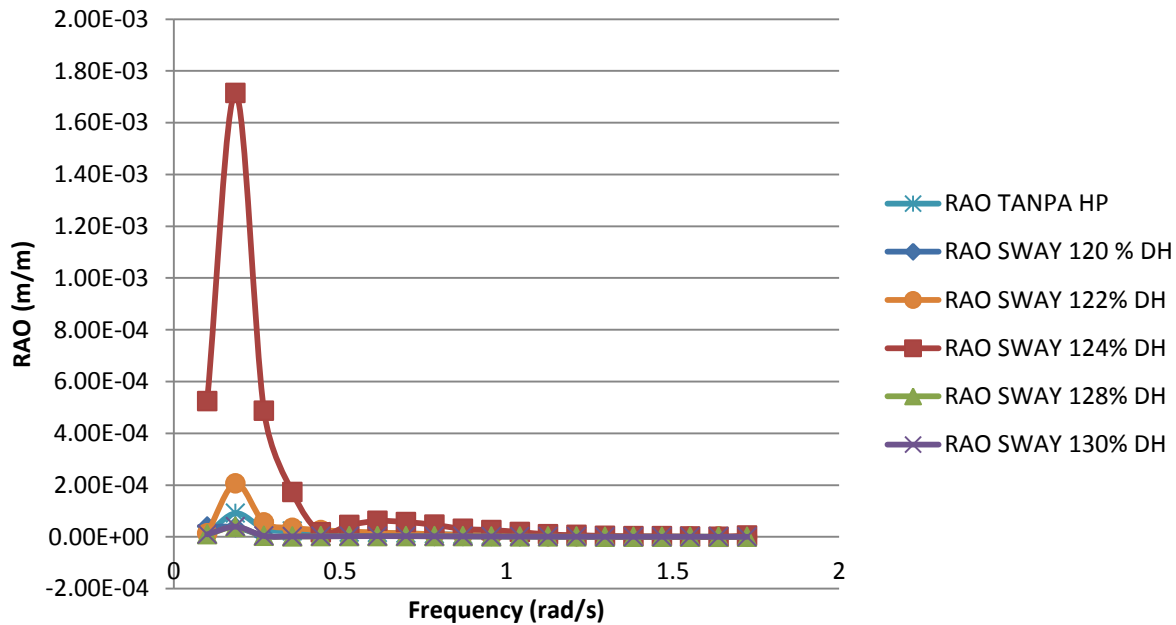
130 % Dh : 0.933 m

ANALISIS

P E M B A H A S A N

S W A Y

RAO SWAY 0 deg



RAO MAKSIMUM :

THP : $6.9E-5$ m

120 % Dh : $2.2E-5$ m

122 % Dh : $1.4E-5$ m

124 % Dh : $1.2E-5$ m

128 % Dh : $2.6E-5$ m

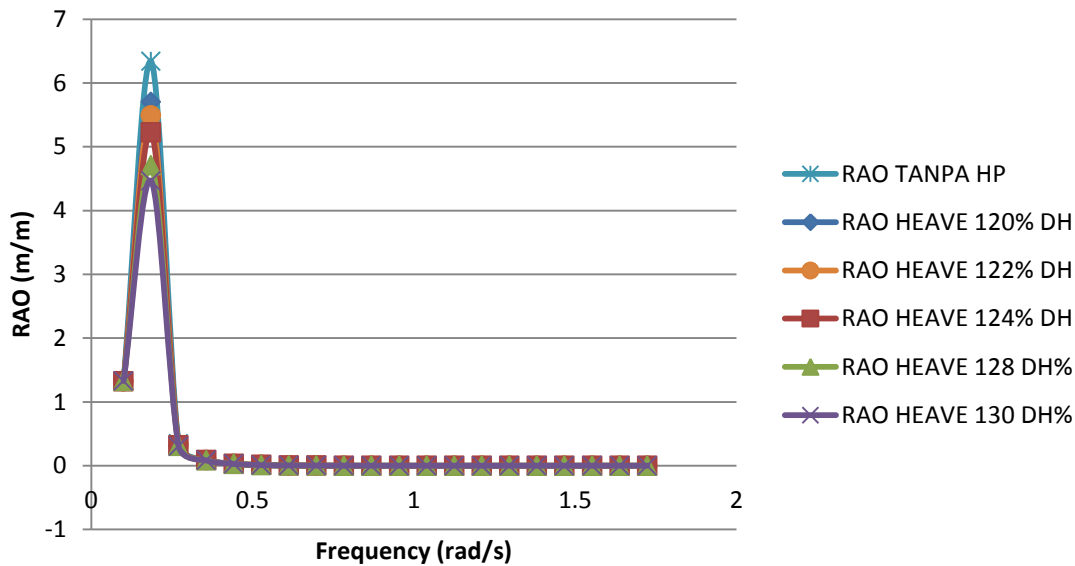
130 % Dh : $2.7E-5$ m

ANALISIS

P E M B A H A S A N

H E A V E

RAO HEAVE 0 deg



RAO MAKSIMUM :

THP : 4.52 m

120 % Dh : 4.13 m

122 % Dh : 4.02 m

124 % Dh : 3.86 m

128 % Dh : 3.55 m

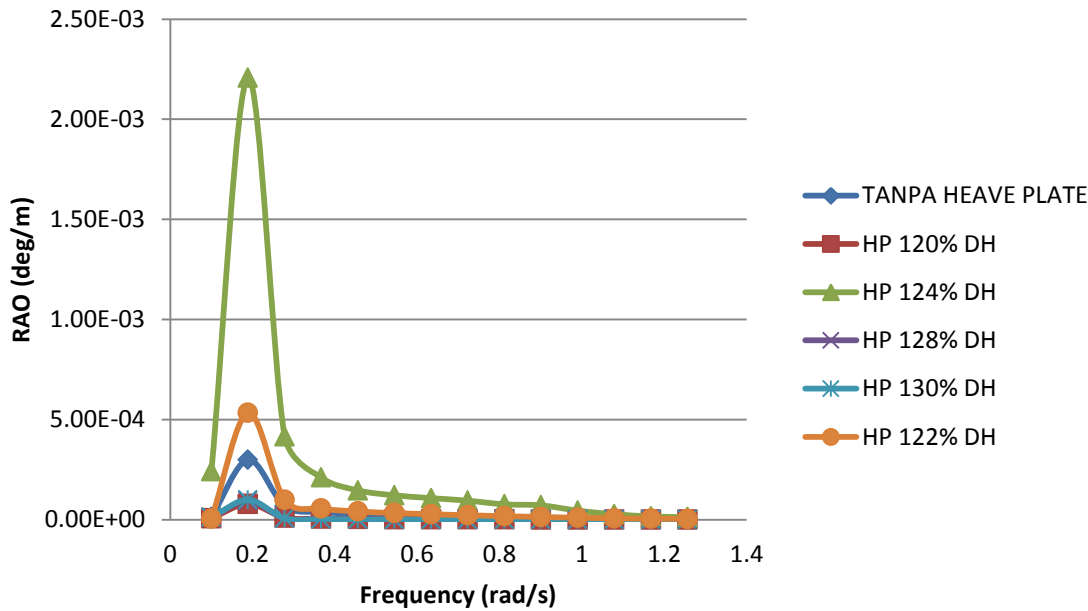
130 % Dh : 3.40 m

ANALISIS

P E M B A H A S A N

R O L L

RAO ROLLING 0 deg



RAO MAKSIMUM :

THP : 2.9E-4 deg

120 % Dh : 7.8E-5 deg

122 % Dh : 5.3E-5 deg

124 % Dh : 2.2E-3 deg

128 % Dh : 9.4E-5 deg

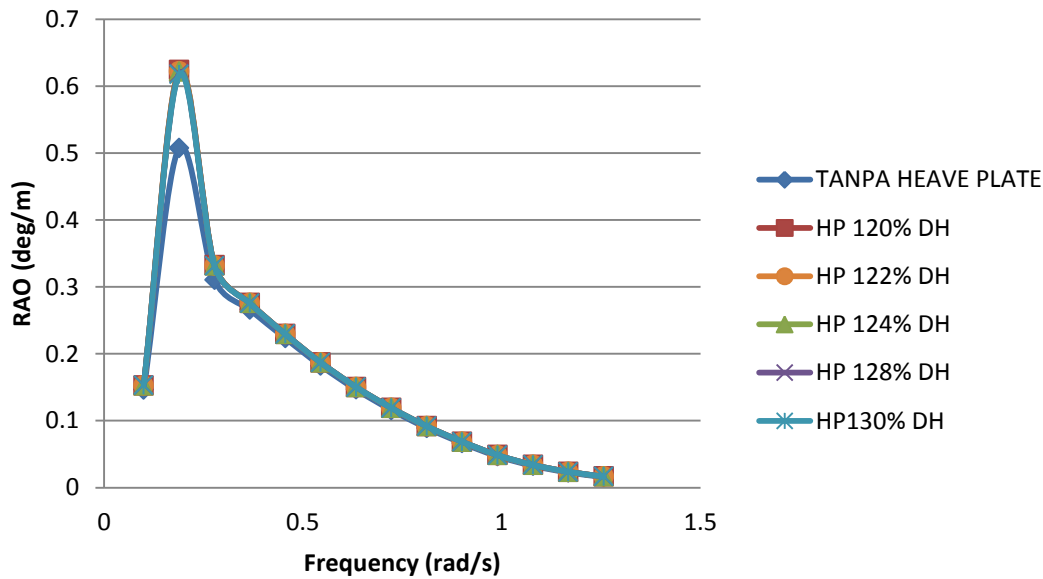
130 % Dh : 9.9E-5 deg

ANALISIS

P E M B A H A S A N

P I T C H

RAO PITCHING 0 deg



RAO MAKSIMUM :

THP : 0.507 deg

120 % Dh : 0.623 deg

122 % Dh : 0.622 deg

124 % Dh : 0.621 deg

128 % Dh : 0.618 deg

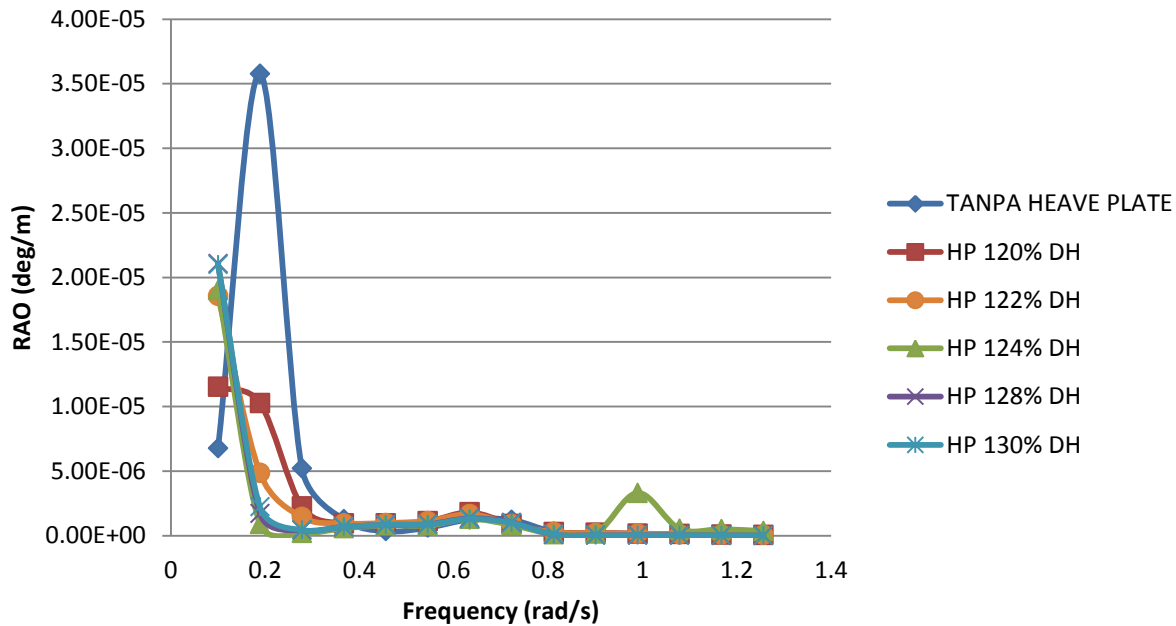
130 % Dh : 0.617 deg

ANALISIS

P E M B A H A S A N

Y A W

RAO YAWING 0 deg



RAO MAKSIMUM :

THP : 3.5E-5 deg

120 % Dh : 1.1E-5 deg

122 % Dh : 1.8E-5 deg

124 % Dh : 1.9E-5 deg

128 % Dh : 2.1E-5 deg

130 % Dh : 2.1E-5 deg

ANALISIS

P E M B A H A S A N

K O M P A R A S I

H A S I L R A O

F R E E F L O A T I N G

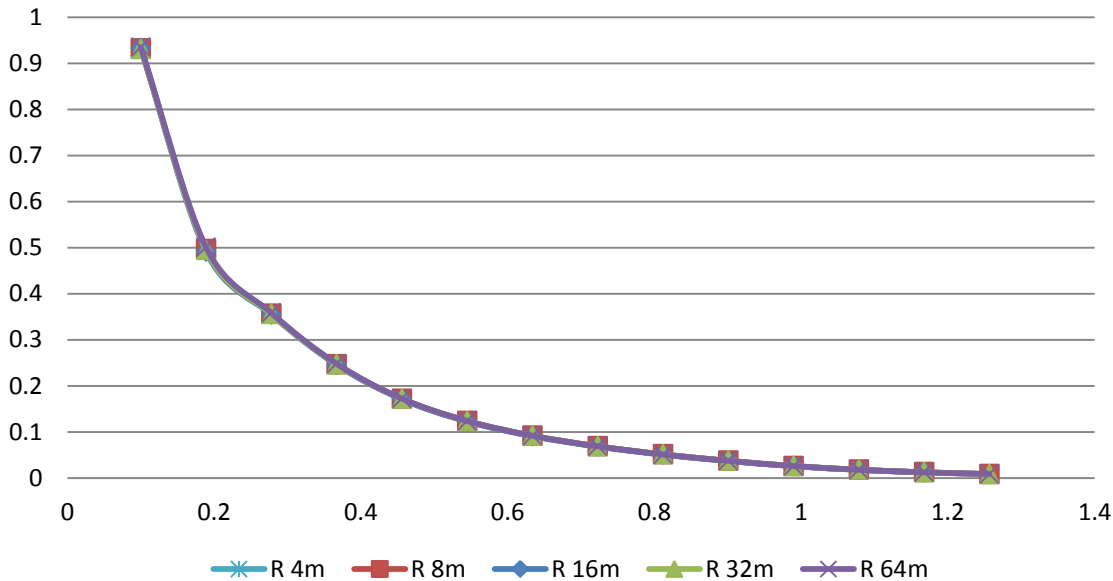
V A R I A S I J A R A K

ANALISIS

P E M B A H A S A N

S U R G E

RAO SURGE 0 deg



RAO MAKSIMUM :

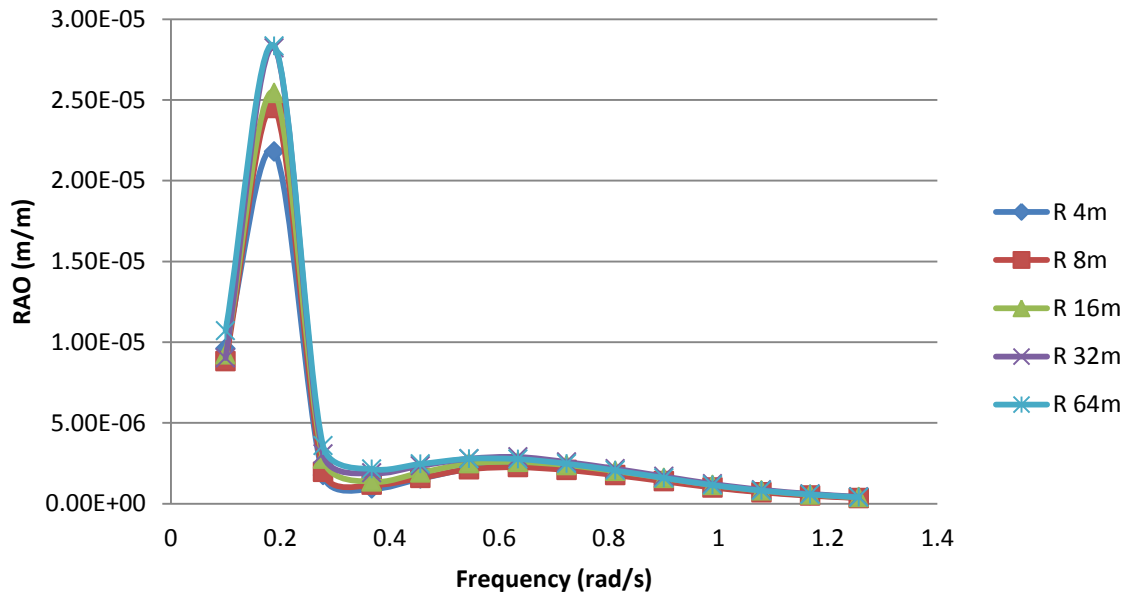
4 meter : 0.933 m
8 meter : 0.931 m
16 meter : 0.932 m
32 meter : 0.930 m
64 meter : 0.934 m

ANALISIS

P E M B A H A S A N

S W A Y

RAO SWAY 0 deg



RAO MAKSIMUM :

4 meter : 2.1E-5 m

8 meter : 2.4E-5 m

16 meter : 2.5E-5 m

32 meter : 2.8E-5 m

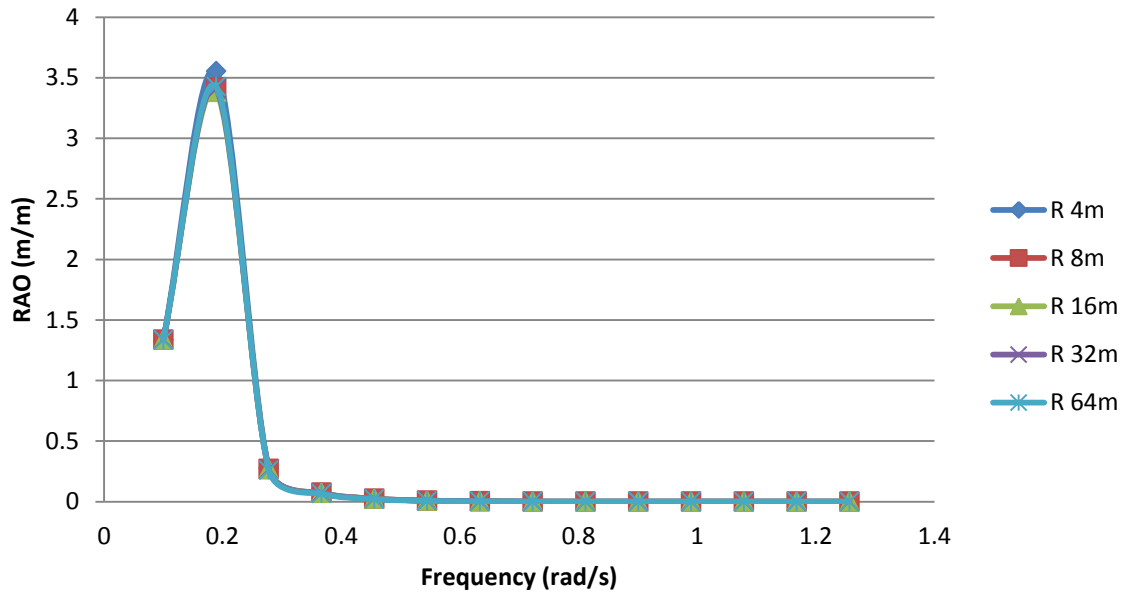
64 meter : 2.8E-5 m

ANALISIS

P E M B A H A S A N

H E A V E

RAO HEAVE 0 deg



RAO MAKSIMUM :

4 meter : 3.55 m

8 meter : 3.42 m

16 meter : 3.38 m

32 meter : 3.40 m

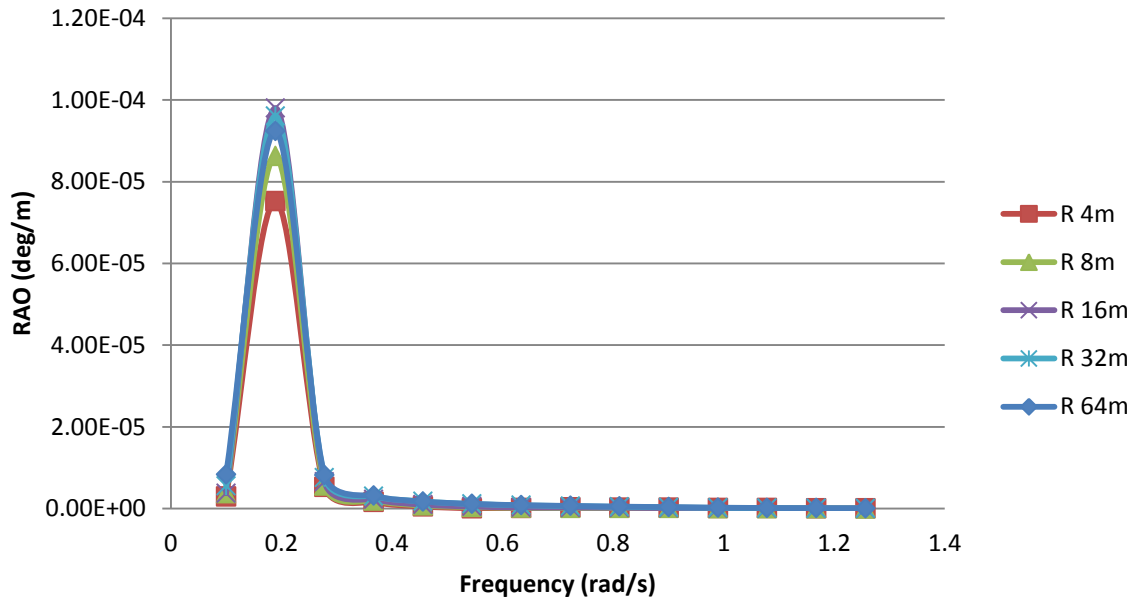
64 meter : 3.42 m

ANALISIS

P E M B A H A S A N

R O L L

RAO ROLLING 0 deg



RAO MAKSIMUM :

4 meter : 7.5E-5 deg

8 meter : 8.6E-5 deg

16 meter : 9.8E-3 deg

32 meter : 9.6E-5 deg

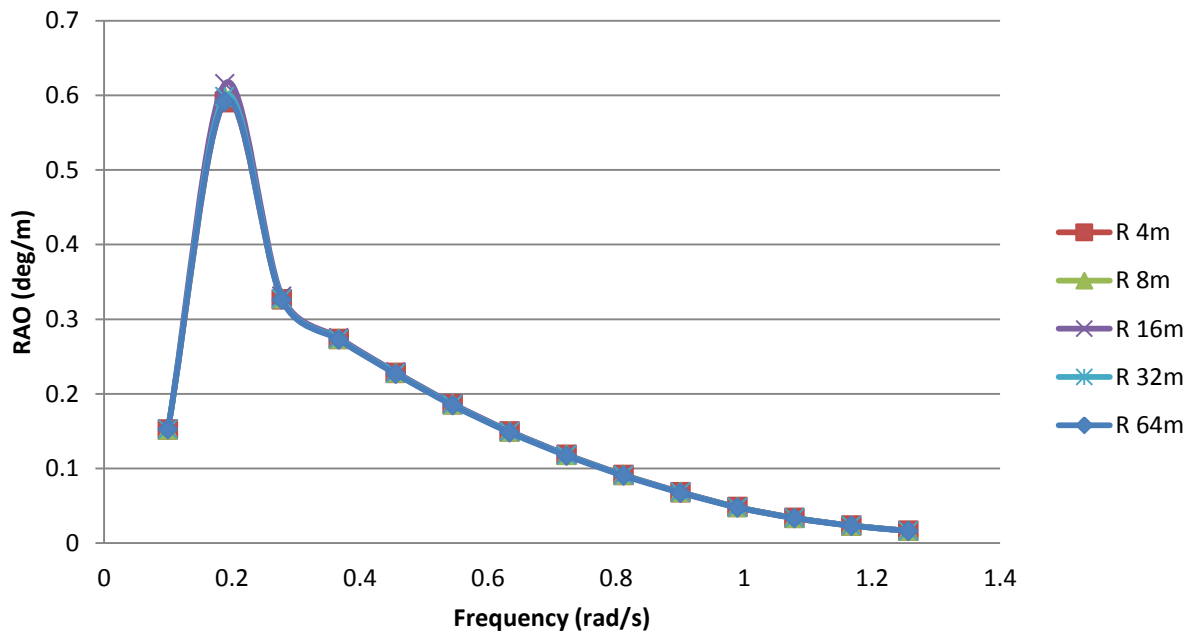
64 meter : 9.2E-5 deg

ANALISIS

P E M B A H A S A N

P I T C H

RAO PITCHING 0 deg



RAO MAKSIMUM :

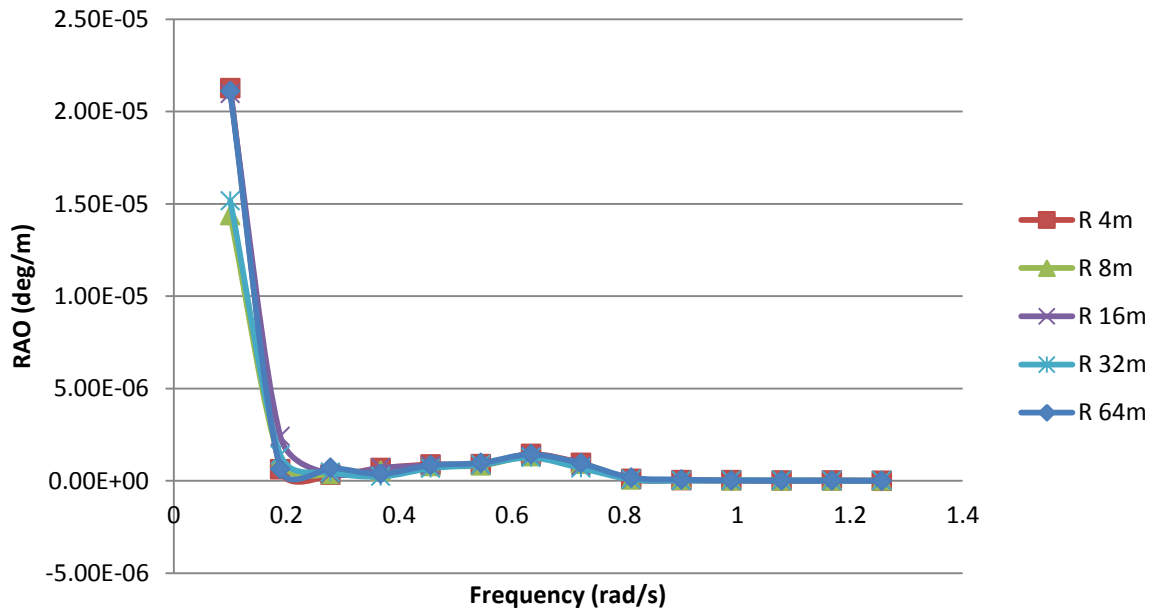
4 meter : 0.590 deg
8 meter : 0.598 deg
16 meter : 0.615 deg
32 meter : 0.598deg
64 meter : 0.691 deg

ANALISIS

P E M B A H A S A N

Y A W

RAO YAWING 0 deg



RAO MAKSIMUM :

4 meter : 2.1 E-5 deg

8 meter : 1.4 E-5 deg

16 meter : 2.1E-5 deg

32 meter : 1.5E-5 deg

64 meter : 2.1E-5 deg

ANALISIS

P E M B A H A S A N

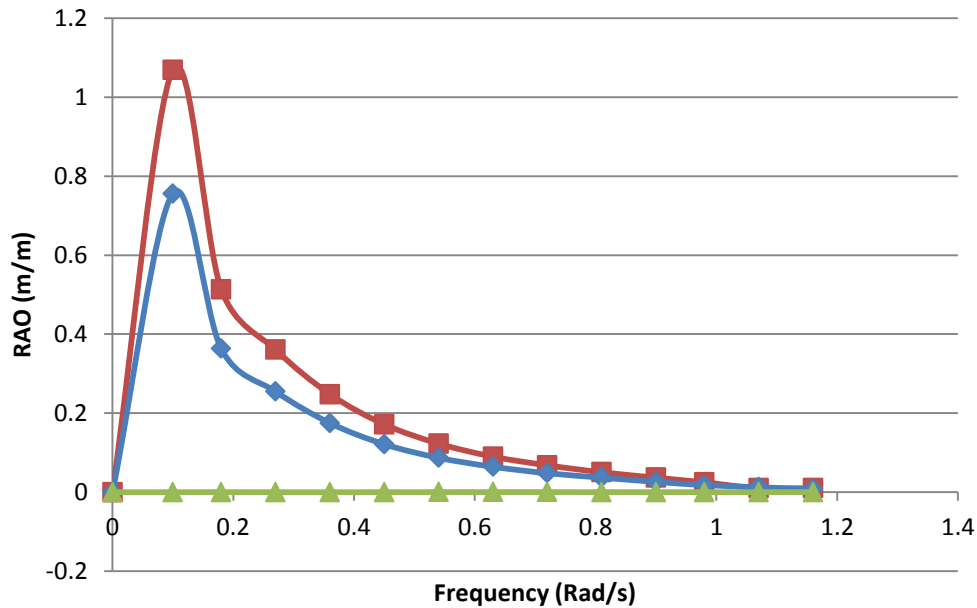
HASIL RAO
TERTAMBAT
VARIASI RASIO DIAMETER

ANALISIS

P E M B A H A S A N

S U R G E

RAO Surge kondisi tertambat variasi 130 % Dh



RAO MAKSIMUM :

0 deg : 1.06 m

45 deg : 0.7 m

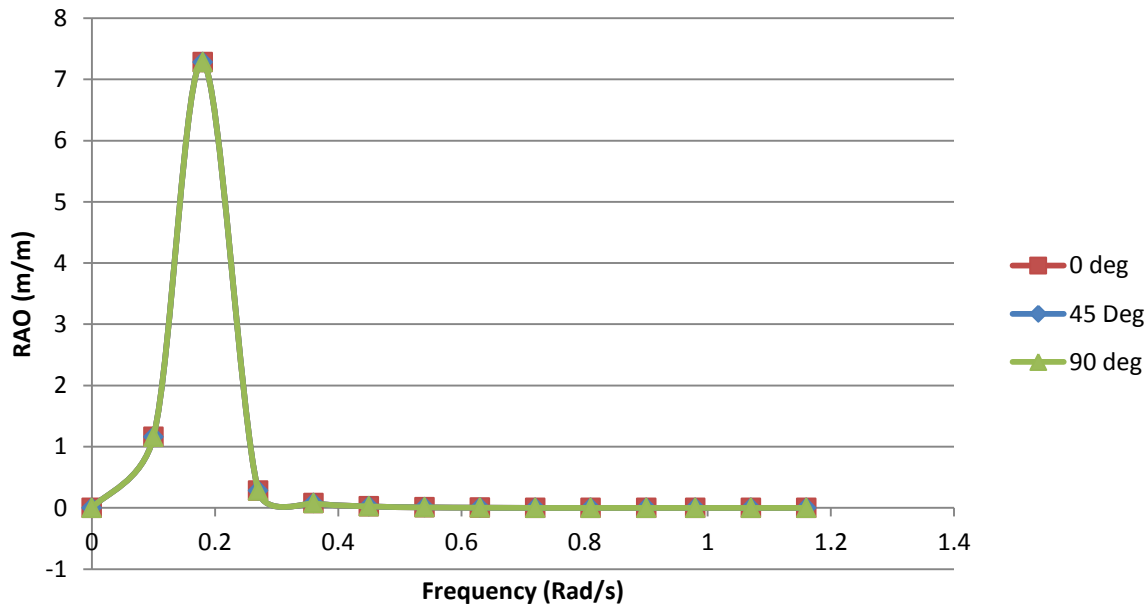
90 deg : 0.1 m

ANALISIS

P E M B A H A S A N

H E A V E

RAO Heave kondisi tertambat variasi 130 % Dh



RAO MAKSIMUM :

0 deg : 7.27 m

45 deg : 7.27 m

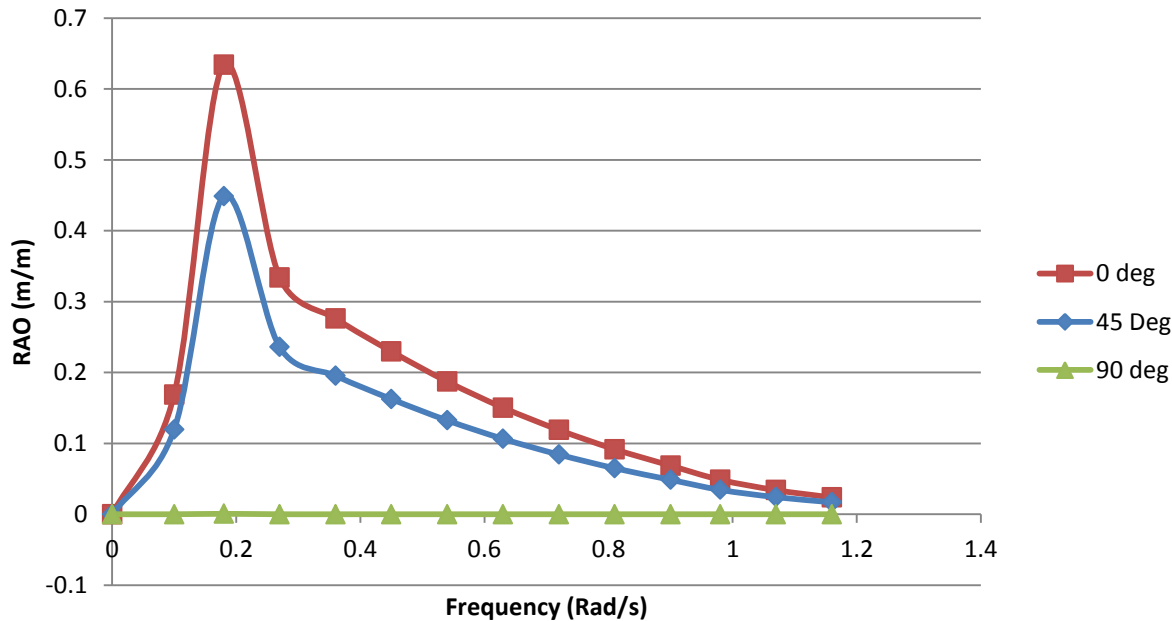
90 deg : 7.27 m

ANALISIS

P E M B A H A S A N

P I T C H

RAO Pitch kondisi tertambat variasi 130 % Dh



RAO MAKSIMUM :

0 deg : 0.63 deg

45 deg : 0.44 deg

90 deg : 0 deg

ANALISIS

P E M B A H A S A N

HASIL RAO

TERTAMBAT

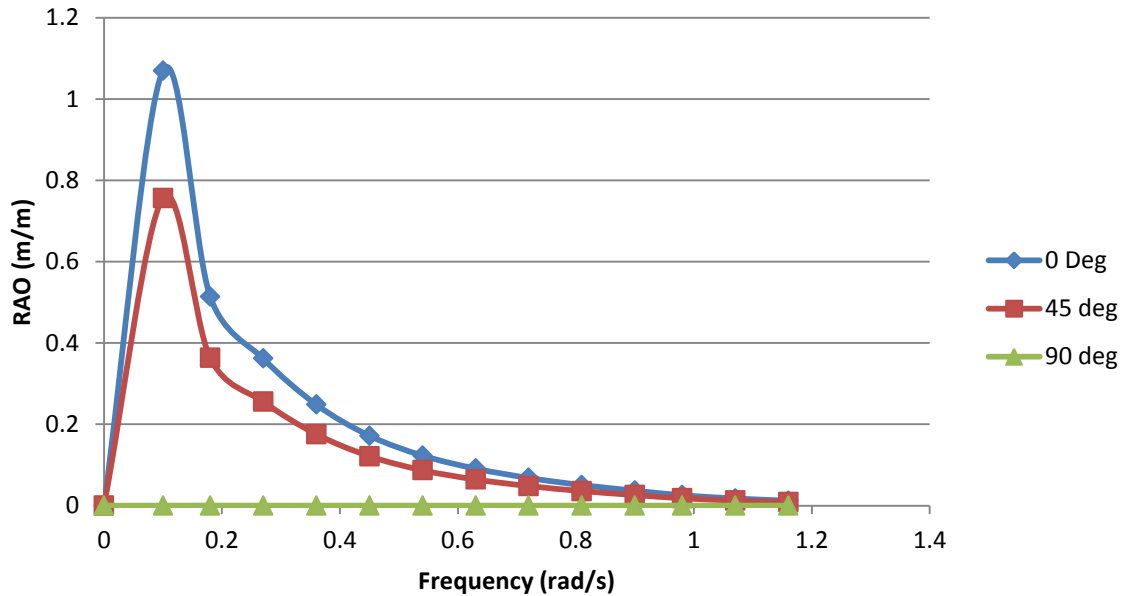
VARIASI JARAK

ANALISIS

P E M B A H A S A N

S U R G E

RAO Surge kondisi tertambat variasi jarak 16 m



RAO MAKSIMUM :

0 deg : 1.06 m

45 deg : 0.75 m

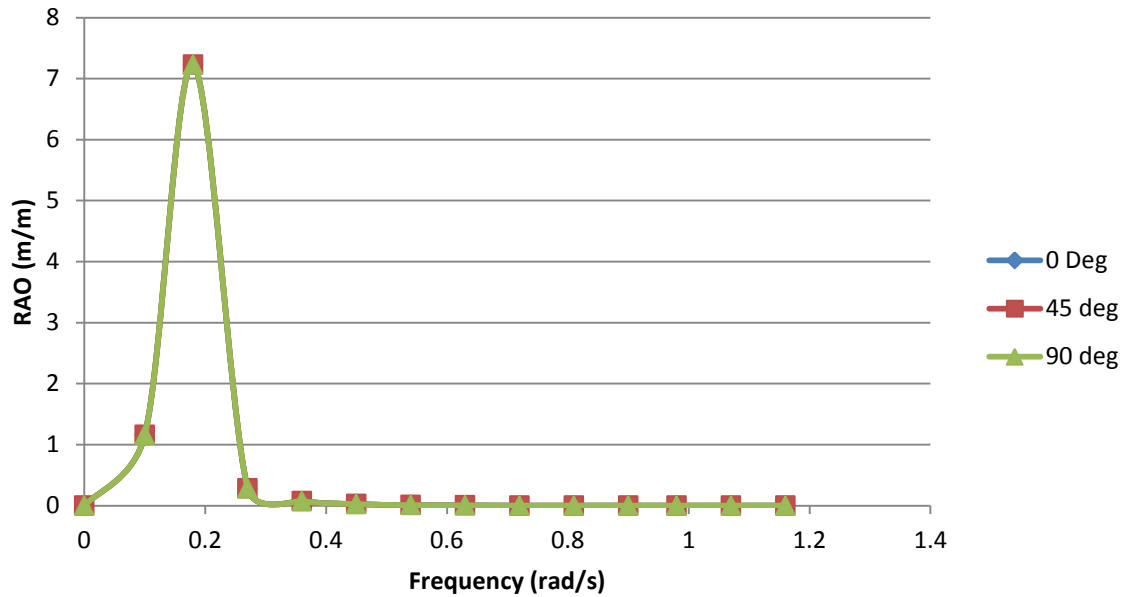
90 deg : 0.1 m

ANALISIS

P E M B A H A S A N

H E A V E

RAO Heave kondisi tertambat variasi jarak 16 m



RAO MAKSIMUM :

0 deg : 7.22 m

45 deg : 7.22 m

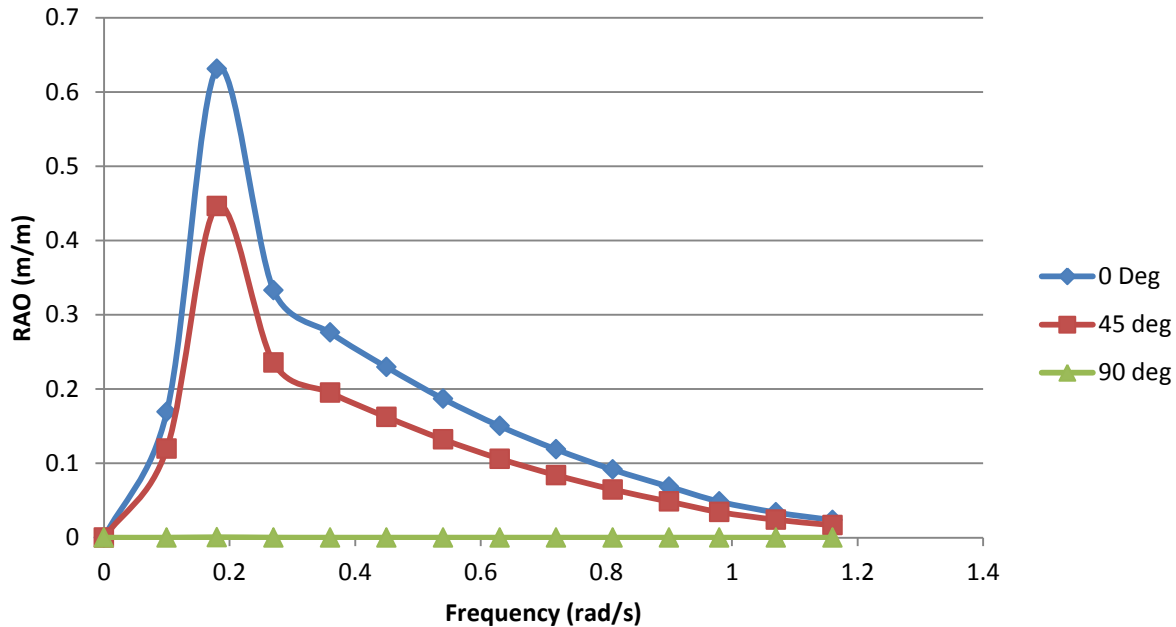
90 deg : 7.22 m

ANALISIS

P E M B A H A S A N

P I T C H

RAO Pitch kondisi tertambat variasi jarak 16 m



RAO MAKSIMUM :

0 deg : 0.63 deg

45 deg : 0.44 deg

90 deg : 0 deg

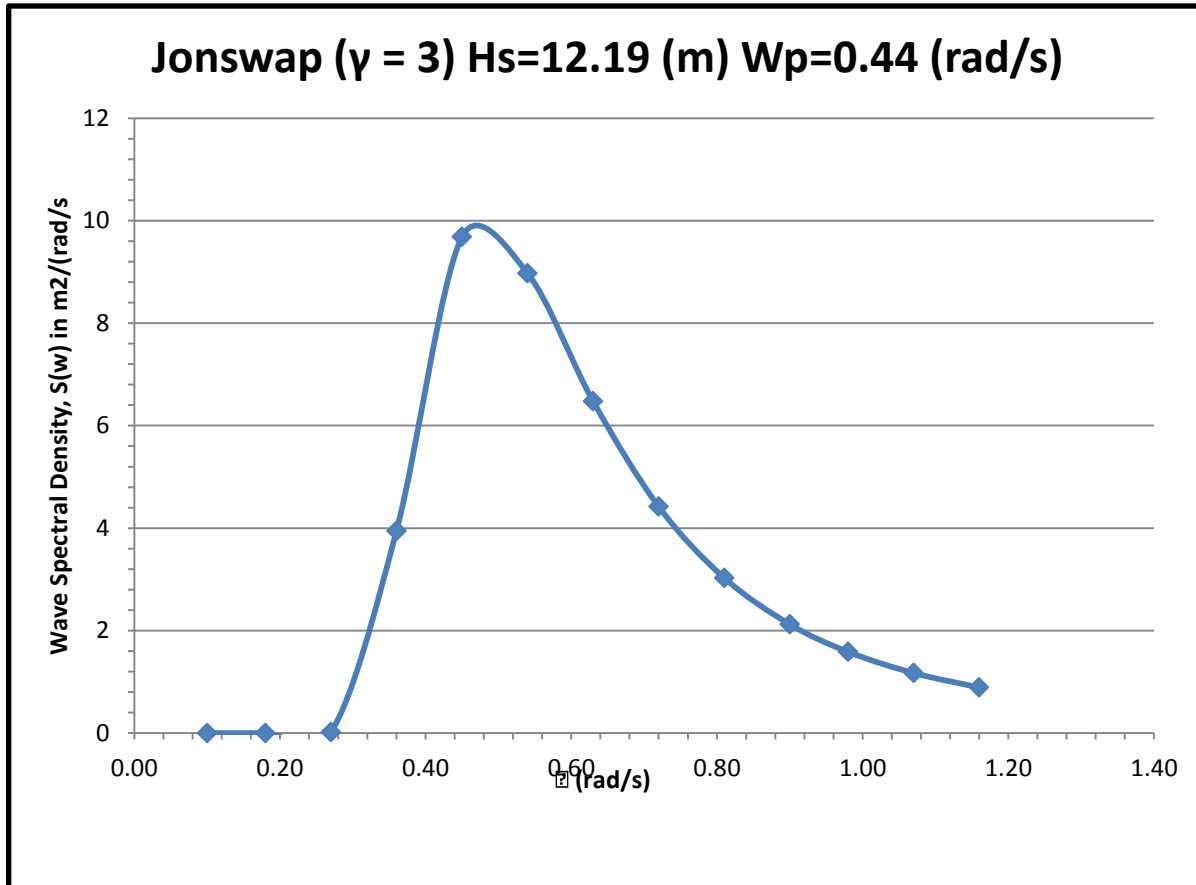
ANALISIS

P E M B A H A S A N

S	P	E	K	T	R	A
J	O	N	S	W	A	P

ANALYSIS

P E M B A H A S A N



ANALISIS

P E M B A H A S A N

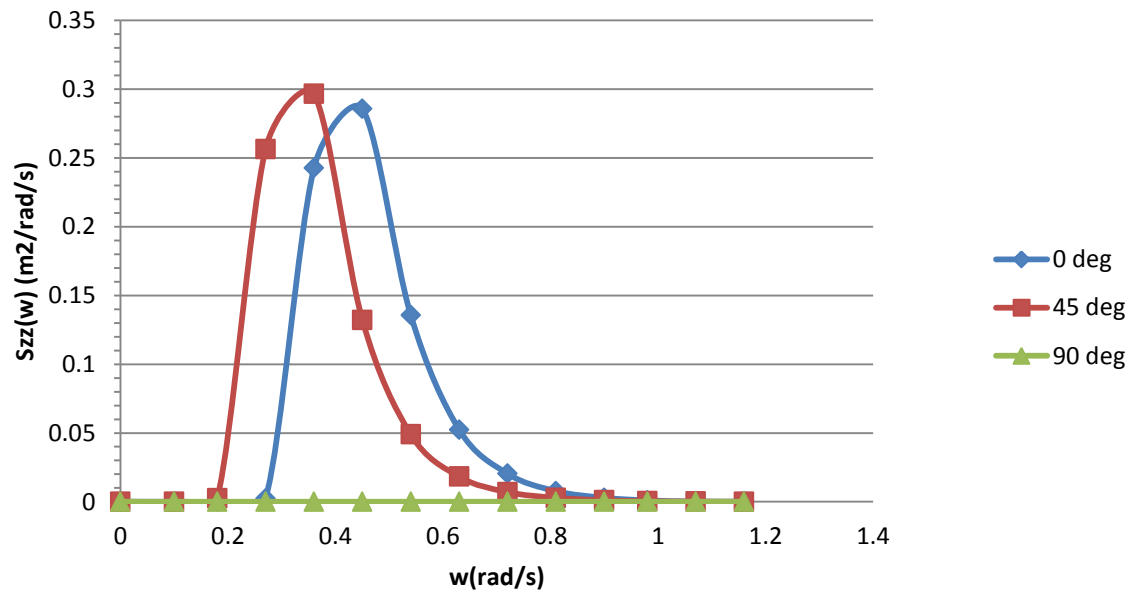
H A S I L
SPEKTRA RESPON
RASIO DIAMETER

ANALISIS

P E M B A H A S A N

S U R G E

Surge Spectral Respos



AMPLITUDO

MAKSIMUM :

0 deg : 0.28 m

45 deg : 0.29 m

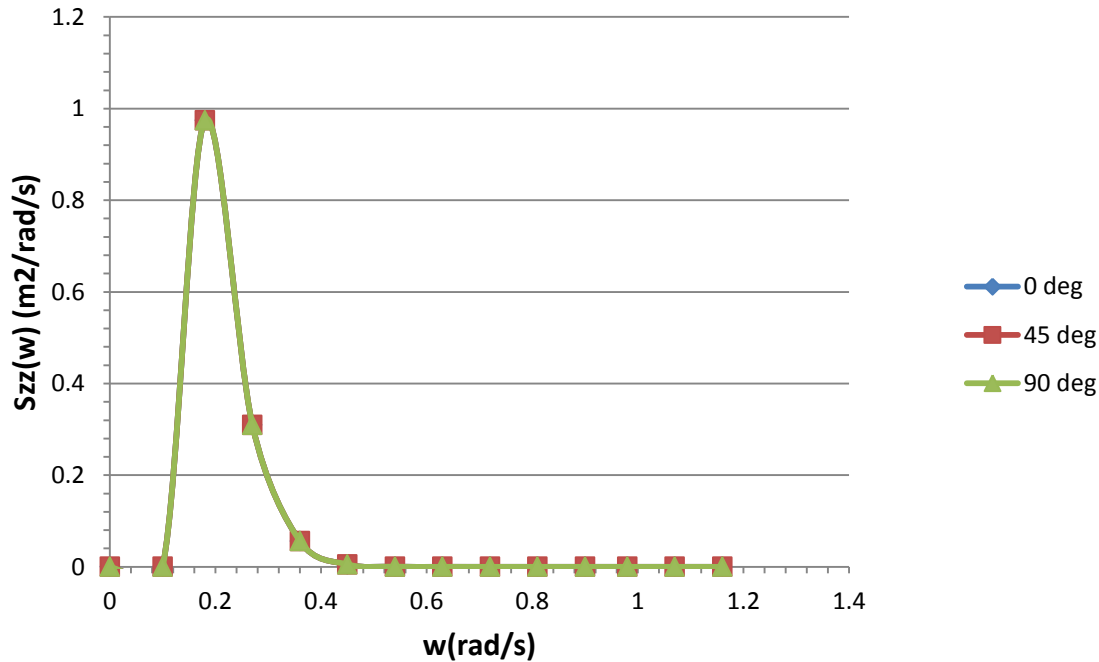
90 deg : 0 m

ANALISIS

P E M B A H A S A N

H E A V E

Heave Spectral Respons variasi 130% Dh



AMPLITUDO

MAKSIMUM :

0 deg : 0.97 m

45 deg : 0.97 m

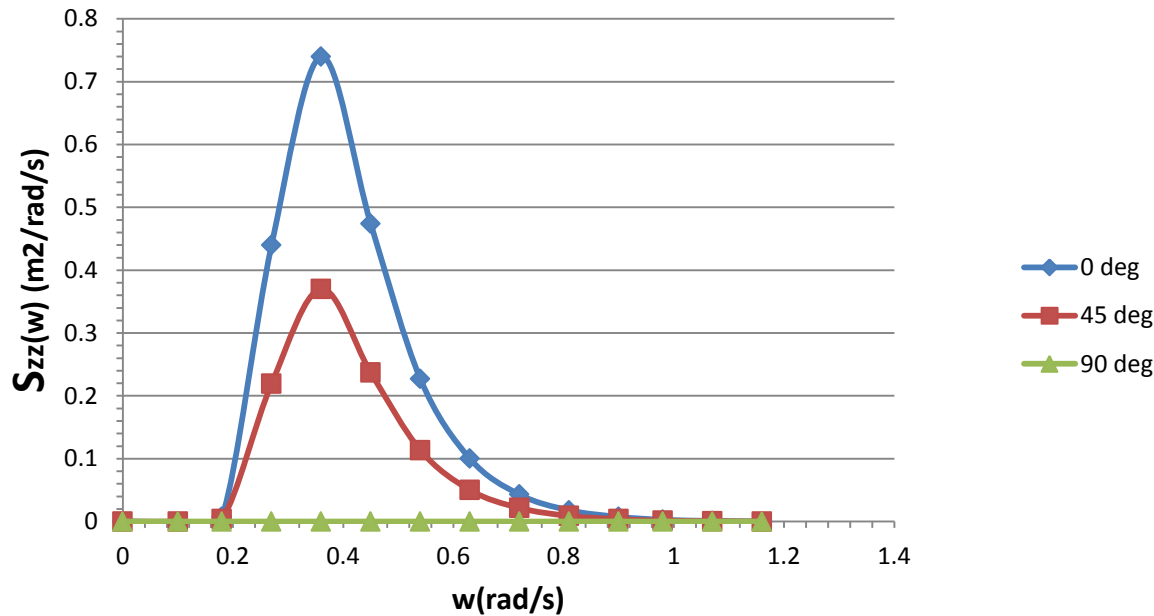
90 deg : 0.97 m

ANALISIS

P E M B A H A S A N

P I T C H

Pitch Spectral Respons



AMPLITUDO

MAKSIMUM :

0 deg : 0.73 deg

45 deg : 0.37 deg

90 deg : 0 deg

ANALISIS

P E M B A H A S A N

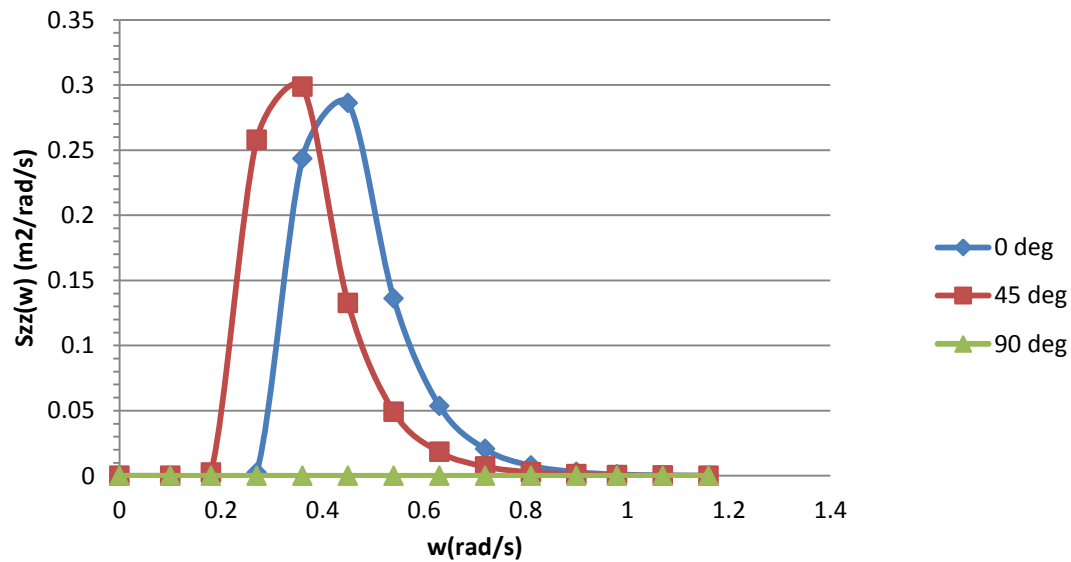
H A S I L
SPEKTRA RESPON
J A R A K

ANALISIS

P E M B A H A S A N

S U R G E

Surge Spectral Respos



AMPLITUDO

MAKSIMUM :

0 deg : 0.28 m

45 deg : 0.29 m

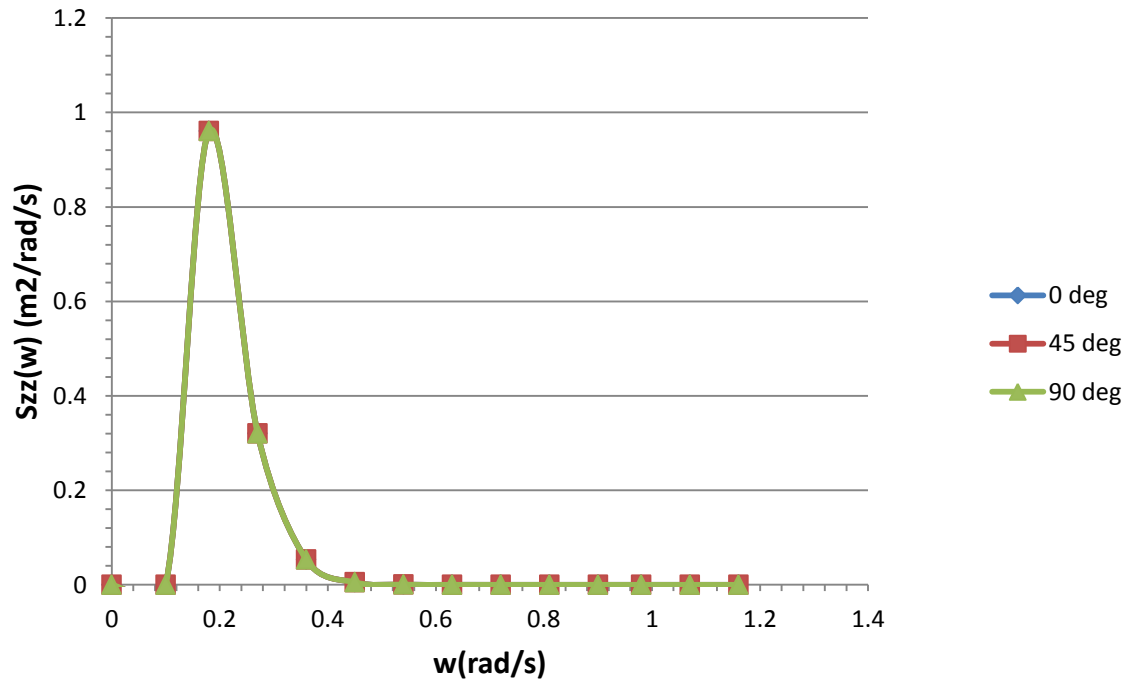
90 deg : 0 m

ANALISIS

P E M B A H A S A N

H E A V E

Heave Spectral Respons



AMPLITUDO

MAKSIMUM :

0 deg : 0.96 m

45 deg : 0.96 m

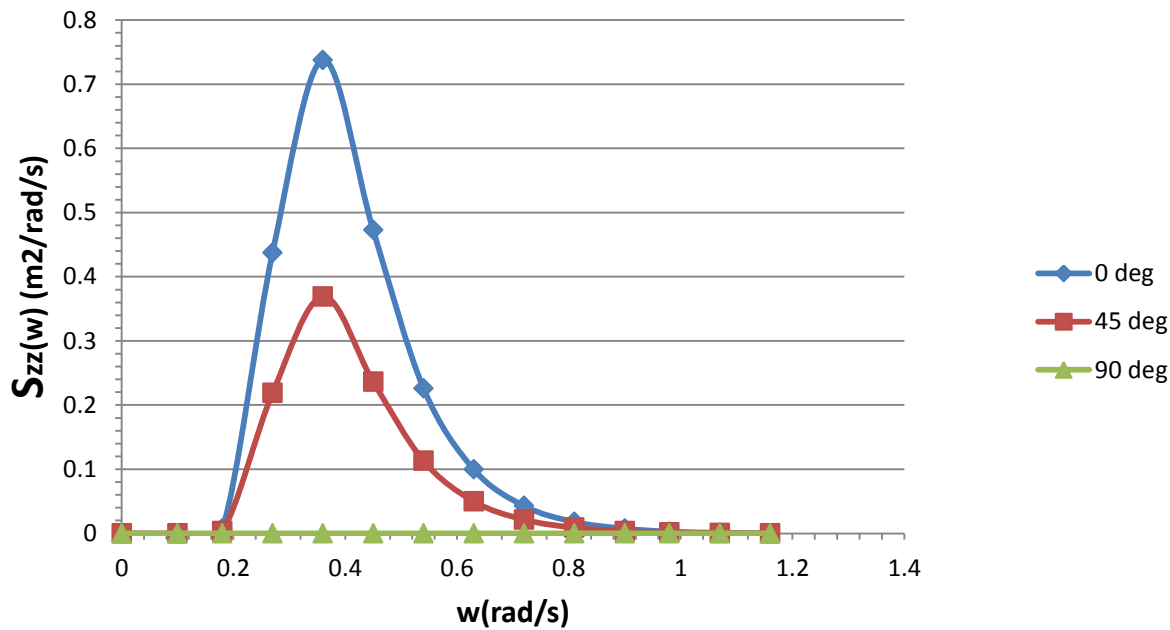
90 deg : 0.96 m

ANALISIS

P E M B A H A S A N

P I T C H

Pitch Spectral Respons



AMPLITUDO

MAKSIMUM :

0 deg : 0.73 m

45 deg : 0.36 m

90 deg : 0 m

KESIMPULAN

1. Perilaku gerak struktur SPAR dengan variasi rasio diameter dan jarak berdampak terdiri dari gerakan translasi *surge*, *sway* dan *heave* serta gerakan rotasional *roll* dan *pitch*, sedangkan untuk gerakan rotasional *yaw* sangat kecil atau mendekati 0.
2. Hasil analisis variasi rasio diameter *heave plate* dan variasi jarak antar *heave plate* menunjukkan bahwa penambahan rasio diameter *heave plate* dan jarak antar *heave plate* pada struktur SPAR secara umum akan memperkecil respon gerakan *heave*. Akan tetapi tidak berpengaruh terhadap gerakan *surge*.

KESIMPULAN

3. Nilai *amplitude maksimum* untuk *heave* terkecil diperoleh pada SPAR dengan ratio diameter 130% Diameter hull dengan nilai 0.97 meter. Untuk jarak nilai *amplitude maksimum* untuk *heave* terkecil diperoleh pada SPAR dengan jarak antar *heave plate* 16 meter dengan nilai 0.96 meter.



T	E	R	I	M	A
K	A	S	I	H	



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