p

BACHELOR THESIS – (ME 141502)

ANALYSIS OF MOORING SYSTEM DESIGN ON FLOATING PLATFORM OF OCEAN CURRENT POWER PLANT USING CFD (COMPUTATIONAL FLUID DYNAMICS) METHOD

Muhamad Arif Budiman Rivai
NRP. 4212101037

Supervisors:
Irfan Syarif Arief, S.T, M.T
Ir. Tony Bambang Musrijadi, PGD

Marine Engineering Department
Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember
Surabaya

2016

(This page intentionally left blank)

SKRIPSI – (ME 141502)

ANALISA PERENCANAAN *MOORING SYSTEM* PADA *FLOATING PLATFORM* PEMBANGKIT LISTRIK TENAGA ARUS LAUT DENGAN MENGGUNAKAN METODE CFD (*COMPUTATIONAL FLUID DYNAMICS*)

Muhamad Arif Budiman Rivai
NRP 4212101037

Dosen Pembimbing :
Irfan Syarif Arief, S.T, M.T
Ir. Tony Bambang Musrijadi, PGD

Jurusan Teknik Sistem Perkapalan
Fakultas Teknologi Kelautan
Institut Teknologi Sepuluh Nopember
Surabaya

2016

(This page intentionally left blank)

Approval Sheet

ANALYSIS OF MOORING SYSTEM DESIGN ON FLOATING PLATFORM OF OCEAN CURRENT POWER PLANT USING CFD (COMPUTATIONAL FLUID DYNAMICS) METHOD

BACHELOR THESIS

Submitted to Comply One of The Requirements
To Obtaine a Bachelor Engineering Degree
on
Laboratory of Marine Manufacture and Design (MMD)
Bachelor Degree Program of Marine Engineering Department
Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember

Prepared by :

Muhamad Arif Budiman Rivai
4212 101 037

Approved by
Supervisor of Bachelor Thesis :

1. Irfan Syarif Arief, S.T., M.T. ( )
   NIP. 1969 1225 1997 02 1001

2. Ir. Tony Bambang Musrijadi, PGD ( )
   NIP. 1959 0410 1987 01 1001

Surabaya,
Juli 2016

(This page intentionally left blank)

Approval Sheet

ANALYSIS OF MOORING SYSTEM DESIGN ON FLOATING PLATFORM OF OCEAN CURRENT POWER PLANT USING CFD (COMPUTATIONAL FLUID DYNAMICS) METHOD

BACHELOR THESIS

Submitted to Comply One of The Requirements
To Obtaine a Bachelor Engineering Degree
on
Laboratory of Marine Manufacture and Design (MMD)
Bachelor Degree Program of Marine Engineering Department
Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember

Prepared by :

Muhamd Arif Budiman Rivai
4212 101 037

Approved by
Head of Marine Engineering Department

Dr. Eng. M. Badrus Zaman, ST. MT.
NIP. 1977 0802 2008 01 1007

APPROVAL FORM

ANALYSIS OF MOORING SYSTEM DESIGN ON FLOATING PLATFORM OF OCEAN CURRENT POWER PLANT USING CFD (COMPUTATIONAL FLUID DYNAMICS) METHOD

BACHELOR THESIS

Proposed to One of Requirements Obtaining a Bachelor Engineering Degree
On
Laboratory of Marine Manufacture and Design (MMD)
Study Program Bachelor Double Degree Marine Engineering Department
Institut Teknologi Sepuluh Nopember Surabaya

Proposed by :
Muhamad Arif Budiman Rivai
NRP. 4212 101 037

Approved by
Representative Hoschschule Wismar in Indonesia

Dr.-Ing Wolfgang Busse

ANALYSIS OF MOORING SYSTEM DESIGN ON FLOATING PLATFORM OF OCEAN CURRENT POWER PLANT USING CFD (COMPUTATIONAL FLUID DYNAMICS) METHOD

Name	: Muhamad Arif Budiman Rivai
NRP	: 4212101037
Department	: Marine Engineering
Supervisor	: 1. Irfan Syarif Arief, S.T, M.T
	2. Ir. Tony Bambang Musrijadi, PGD

Abstract

Floating platform of ocean current power plant requires good stability against sea waves, ocean currents, wind and other external force. Stability of Floating Platform is greatly influenced by the selection of mooring system. The precise selection of mooring system will reduce the degree of free movement (Surge, Sway, Heave, Pitch, Sway, and Roll) on Floating Platform. Degree of free movement can be observed by RAO and Spectrum response. Mooring system that are safe, strong, effective and economic must consider the number of line, line spacing, diameter of line, material of line, and the tension that can be hold. Selection of mooring systems that are safe, effective and economic are absolutely required in order to maintain the stability of Floating Platform so that all components of the equipment which are above Floating Platform can operates optimally.

Keywords : Floating platform , RAO, Spectrum Response

(This page intentionally left blank)

ANALISA PERENCANAAN *MOORING SYSTEM* PADA *FLOATING PLATFORM* PEMBANGKIT LISTRIK TENAGA ARUS LAUT DENGAN MENGGUNAKAN METODE CFD (*COMPUTATIONAL FLUID DYNAMICS*)

Nama	: Muhamad Arif Budiman Rivai
NRP	: 4212101037
Jurusan	: Marine Engineering
Dosen Pembimbing	: 1. Irfan Syarif Arief, S.T, M.T
	2. Ir. Tony Bambang Musrijadi, PGD

Abstrak

Floating platform pada pembangkit listrik tenaga arus laut membutuhkan stabilitas yang baik untuk melawan gelombang laut, arus laut, angin, serta gaya luar lainnya. Stabilitas dari *Floating platform* sangat dipengaruhi oleh *mooring system* yang dipilih. *Mooring system* yang tepat akan mengurangi derajat gerakan kebebasan (*Surge, Sway, Heave, Pitch, Sway, dan Roll)* pada derajat gerakan kebebasan dapat dilihat melalui grafik RAO dan spectrum Response. Mooring System yang aman, effisien dan ekonomis harus mempertimbangkan jumlah *line*, jarak antar *line*, *diameter line*, *material line*, serta *tension* yang dapat ditahannya. Pemilihan mooring system yang aman, efektif dan ekonomis mutlak hukumnya agar menjaga stabilitas *Floating platform* sehinga semua komponen peralatan yang berada diatas *Floating platform* dapat berkerja secara optimal.

Kata Kunci *: Floating platform,RAO, Spectrum Response*

(This page intentionally left blank)

Preface

Author praise Allah SWT the Almighty who has given the grace and guidance so that author can finish bachelor thesis report well and smoothly. The author would like to thank those who have helped the implementation of bachelor thesis report :

1. Allah SWT
2. My Parents who always support me.
3. Mr. Dr. Eng. M. Badrus Zaman, ST. MT. as Head of Marine Engineering Department
4. Mr. Semin ,ST ,MT ,Ph.D as in secretary of Marine Engineering Department
5. Irfan Syarif Arief, S.T., M.T. as my Bachelor Thesis Supervisor Lecturer
6. Ir. Tony Bambang Musrijadi, PGD as my Bachelor Thesis Supervisor Lecturer
7. My friend in Marine engineering department
8. All member at marine manufacturing and design laboratory
9. Everyone who help me in making the bachelor thesis

The authors recognize that the preparation of the bachelor thesis Report may be a deficiency for readers. Thus the authors expect criticism and suggestions from readers for better report. The authors hope that this bachelor thesis can be useful to the reader.

Surabaya, 30 July 2016

M. Arif Budiman Rivai
4212 101 037

(This page intentionally left blank)

Contents

(This page intentionally left blank)

Figures

Tables

Chapter 1
Introduction

1.1 Background

Ocean current energy utilization is one of the energy resources diversify activities to ensure the availability of energy, as clarify in Government Law No. 30/2007 about Energy resource. research and development of science and technology provision and utilization of energy is directed mainly to the development of new energy and renewable energy to support the development of an national energy industry independently. the energy of ocean currents as one of the new and renewable energy can be utilized to solve the problem of electric energy in the isolated archipelago in order to support efforts towards Indonesia became an independent archipelago nation

The energy potential which available in Indonesia, ocean current energy resources are a potential resource to be converted into electrical energy. This is because of the Indonesian archipelago has many narrow strait, which will increase the velocity of water flow to be the heavy sea currents. The technology which can be used to facilitate its geographical conditions is to install turbines that utilize the movement of heavy water flow to rotate the turbine blades that can be converted into electrical energy. Turbines and all other supporting equipment is installed on Floating Platform that built on the deep waters strait

Floating platform of ocean current power plant is located in deep water requires good stability against sea waves, ocean currents, wind and other forces. The stability of Floating Platform is greatly influenced by the selection of mooring system. The right selection of mooring system will reduce the six degree of free movement (Surge, Sway, Heave, Pitch, Sway, and Roll) on Floating Platform. the great, efficient and economic of Mooring system must consider the number of line, line spacing, line diameter, line material, and tension of line.

1.2 Problem Formulation and Scope

Problem Formulation

1. What kind of Mooring line that is safe, efficient, and Economic to maintain the stability of the Floating Platform (Wire rope , fiber or chain system).
2. How many diameter of the mooring line / cable that precise to maintain the stability of the Floating Platform
3. Where the position of mooring line / cable that precise to maintain the stability of the Floating Platform
4. How stability of floating platform based on RAO and Spectrum Response graph on pitch, roll, heave, Surge, sway and Yaw Condition
5. What is anchoring type that is safe, efficient, and Economic to maintain the stability of the Floating Platform

Scope

- Currents, waves and winds Force are constant (steady)
- tide force is not calculated and considered
- Viscosity is not calculated and considered
- construction of platform is very rigid and isn't any deflection

- fluid are incompressible, Inviscid, and irrotational
- Analysis using Ansys Aqwa

1.3 Objective

1. Find out the value of external force/load that acting on the Floating Platform
2. Selecting the kind of Mooring line that are safe, strong, and cheap on the Floating Platform to Reduce 6 degrees of freedom movement
3. Find out line position, line diameter, material line and the tension of line on the Floating Platform mooring system
4. Find out stability of floating platform using RAO and Spectrum Response graph on pitch, roll, heave, Surge, sway and Yaw Condition
5. Find out the weight and type of Anchor include its accessories

1.4 Benefit

Results of the research will be useful in selecting Mooring system that is safe, strong, cheap, and efficient then Floating platform of ocean current power plant to be more stable and all machinery component above platform can operate optimally

(This page intentionally left blank)

Chapter 2

Literature Review

2.1 Floating Platform Of Ocean Current Power Plant

A Floating platform of ocean current power plant is a buoyant platform held in place by a mooring system. The mooring system is a set of tension legs or tendons attached to the platform and connected to a template or foundation on the seafloor.[1]

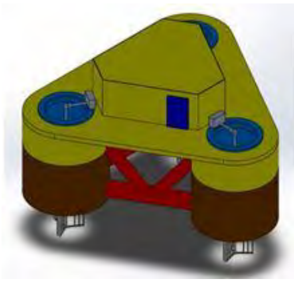


Figure 2.1. Floating platform of ocean current power plant

The mooring system of floating platform is vertically oriented and consists of tubular steel members called tendons. The group of tendons at each corner of the structure is called a tension leg. The tendon system is highly tensioned due to excess buoyancy of the platform hull. The high tension limits horizontal offsets to a small percentage of water depth. Vertical motions of the Floating platform are nearly non-existent due to the tendon's high axial stiffness (low elasticity). Roll and pitch motions are also negligible.[2] 58

Floating Platform of ocean current plant has many limitation like as,

- Water depth / payload limited
- Cost of tendon system

- Vertical mooring system does not provide active control of horizontal position (e.g., for well access)[2]58

2.2 Environment Loads

Environmental loads are those caused by environmental phenomena. The different loads to be considered while designing the structure are wind loads, wave load, mass, damping, ice load, seismic load, current load, dead load, live load, impact load, etc. [1)]

2.2.1 Wind Force

Wind forces on offshore structures are caused by complex fluid-dynamics phenomenon, which is generally difficult to calculate with high accuracy[1)]. the wind force on a plate orthogonal to the wind flow direction can be determined by the net wind pressure as given below:

$$p_w = \frac{1}{2}\rho_a C_w v^2 \qquad (2.1)$$

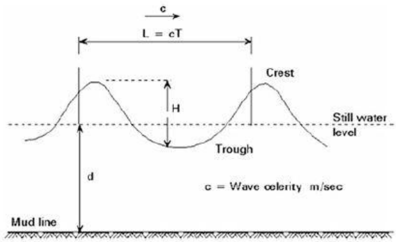
where ρ_a is mass density of air (1.25 kg/m3), and C_w is wind pressure coefficient. It is important to note that the mass density of air increases due to the water spray (splash) up to a height of 20–20 m above MSL. Hence, the total wind-induced force on the plate is given by:

$$F_w = p_w A \qquad (2.2)$$

If the plate has an angle (θ) with respect to the wind direction, then the appropriate projected area, normal to the flow direction, should be used in the above equation. The wind pressure coefficient C_w is determined under controlled stationary wind flow conditions in a wind tunnel. [1)]

2.2.2 Wave Force

Wind-generated sea surface waves shall be represented as a combination of series of regular waves. Regular waves of different magnitude and wave lengths from different directions are combined to represent the sea surface elevation[1)].



Wave theories serve to calculate the particle velocities, accelerations, and the dynamic pressure as functions of the surface elevation of the waves. For long crested regular waves, the flow can be considered two-dimensional and are characterized by parameters such as wave height (H), period (T) and water depth (d). k ¼ 2p=L denotes the wave number, x ¼ 2p=T denotes the wave circular frequency, and f ¼ 1=T denotes the cyclic frequency **Error! Reference source not found.**.

Figure 2.2 Regular sea wave

The wave particle kinematics can now be used to calculate the loads on a structure with the Morison Equation.

2.2.3 Current Force

The presence of current in water produces the following distinct effects: Current velocity should be added vectorially to the horizontal water particle velocity before computing the drag force, because drag force depends on the square of the water particle velocity **Error! Reference source not found.**. Current decreases slowly with the increase in depth, but even a small magnitude of current velocity can cause significant drag force. This effect is insignificant and generally neglected. Current makes the structure itself to generate waves, which in turn creates diffraction forces. [2)]

the current on a floating structure can be calculated from[2)]:

$$X_c = \frac{1}{2}\rho \cdot V_c^2 \cdot C_{Xc}(\alpha_c) \cdot A_{TS} \quad (2.3)$$

$$Y_c = \frac{1}{2}\rho \cdot V_c^2 \cdot C_{Yc}(\alpha_c) \cdot A_{LS} \quad (2.4)$$

$$N_c = \frac{1}{2}\rho \cdot V_c^2 \cdot C_{Nc}(\alpha_c) \cdot A_{LS} \cdot L \quad (2.5)$$

Where,

X_c = steady longitudinal current force (N)

Y_c = steady lateral current force (N)

N_c = steady yaw current moment (Nm)

ρ = density of water (kg/m^3)

V_c = current velocity (m/s)

α_c = current direction, from astern is zero (rad)

$A_{TS} \approx B \cdot T$ = submerged transverse projected area (m^2)

$A_{LS} \approx L \;\; T$ = submerged lateral projected area (m^2)

2.3 Mooring Line

2.3.1 Chain rope

Figure 2.3 Chain rope

Chains are the most common used mooring lines and are available in different diameters and grades. The most commonly used type of chain mooring line is the stud link chain, which is used for moorings that have to be reset numerous times during their lifetime, for instance semi-submersibles. The other chain design which is used frequently is a studless chain, which is often used for permanent moorings, like FPSO's, buoys etcetera.[3]

Chain system has an advantage in overcoming the abrasion, because it has a very strong grip anchor. But, the disadvantage is the heavy chain itself. In the deep water is often to be problem because of the heavy of chain that is too large. [3]

2.3.2 Wire rope

Figure 2.4 Steel wire rope

Wire ropes are common used in offshore mooring liens in two different designs, namely a six strand and spiral strand. Compared to a chain a wire rope a lower weight is needed for the same breaking load and a higher elasticity. To connect the wire rope to other components of the mooring system a socket is used. A downside of a wire rope is that it is generally more prone to damage and corrosion. [3]

Wire rope must be protected against corrosion, either by coating or by cathodic protection or both

2.3.3 Synthetic Fibre rope

Synthetic Fiber ropes have a number of advantages over steel-wire rope in deep-water platform mooring systems, including weight savings, durability and reduced platform offset. [3]

Figure 2.5 Synthetic Fiber ropes

The principal advantage is weight. Wire rope in the form of a catenary is the traditional way of mooring platforms. In deeper water, the weight of suspended wire rope increases and the downward angle of the catenary at the platform becomes steeper. This results in a large downward pull on the platform, which decreases payload or increases required buoyancy.[3]

The use of lightweight fiber rope mooring line eliminates these problems. It is a misnomer to call this a catenary mooring. The fiber rope extends essentially as a straight taut line from the platform down to the anchor point. Thus this is called a taut-leg mooring.[3]

The slope of the synthetic line at the platform is much less than with a wire-rope catenary. The weight of suspended mooring line is much less. These features reduce the downward pull on the platform. More payload can be carried by the platform. Or alternatively, platform buoyancy can be decreased, thus reducing wave and current forces. Wire rope must be protected against corrosion, either by coating or by cathodic protection or both. Synthetic fiber does not corrode. This is an obvious advantage. **Error! Reference source not found.**

2.4 Mooring System

2.4.1 Catenary mooring

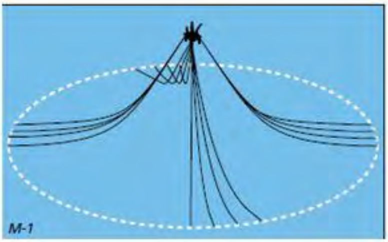


Figure 2.6 Catenary mooring System

When oil and gas exploration and production was conducted in shallow to deep water, the most common mooring line configuration was the catenary mooring line consisting of chain or wire rope. For exploration and production in deep to ultra-deep water, the weight of the mooring line starts to become a limiting factor in the design of the floater. To overcome this problem new solutions were developed consisting of synthetic ropes in the mooring line (less weight) and/or a taut leg mooring system.[3)]

2.4.2 Taut Leg Mooring

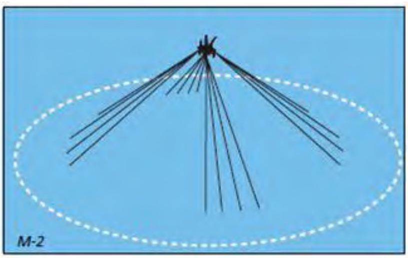


Figure 2.7 Taut leg mooring system

The major difference between a catenary mooring and a taut leg mooring is that where the catenary mooring arrives at the seabed horizontally, the taut leg mooring arrives at the seabed at an angle. This means that in a taut leg mooring the anchor point has to be capable of resisting both horizontal and vertical forces, while in a catenary mooring the anchor point is only subjected to horizontal forces. In a catenary mooring, most of the restoring forces are generated by the weight of the mooring line. In a taut leg mooring, the restoring forces are generated by the elasticity of the mooring line.[3)]

An advantage of a taut leg mooring over the catenary mooring is that it has a smaller footprint, i.e. the mooring radius of the taut leg mooring will be smaller than for a catenary mooring for a similar application. This reduces the material quantity, cost and weight of the total mooring system.[3)]

2.4.3 Tendon / Tension Leg mooring

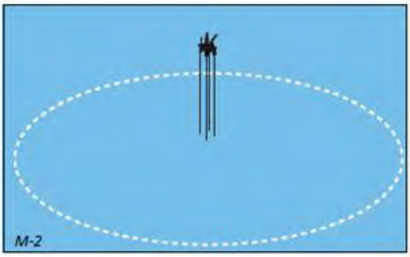


Figure 2.8 Tension leg mooring

This mooring system was developed to moor extreme large production units in very deep water. More recently it is also applied to small TLP unit moorings. Generally suction anchors are applied, however with the availability of vertical loaded gravity installed anchors this system might become more popular for relatively small floating units that are unable to carry large weight from the deep water mooring system.[3)]

2.5 Anchor

The mooring and anchor or foundation design used for mooring systems and subsea equipment plays a very important role in the lifecycle. All over the world their exist difference in bottom soil conditions. These soil conditions have a big influence on the load capacity of any anchor system. A greater load capacity of any anchor can be achieved by a deeper embedding, also the greater quantity of affected soil. Therefore permanent anchors can be designed for different types of soils.[3)]

Weight of anchor able to be calculated by the formula below: [(1)]

$$W \geq \frac{T_M(S_f \sin\varphi + \mu\cos\varphi)}{\mu(1 - w_0/\sigma_G)} \qquad (2.6)$$

Where

W = Weight of anchor

σ_G = Weight per Structure volume unit

W_0 = Weight per water volume unit

φ = angle between mooring and structure

μ = Friction Coefficient between anchor and sea bed (0.5-0.6)

S_f = Safety factor

T_m = Tension of line

Anchor design requires some information, like as

- Soil Data

The type of soil will determine the type of anchir that can be used and how it will be set

- Load Data

Typically anchors are designed based on the calculated maximum intact and damaged design loads

- Mooring Line Configuration

Configuration of mooring line based on installation type of mooring (Catenary, taut leg mooring, etc) and type of mooring line (chain, wire, or fiber). [3)]

A deeper the embedment, the greater the pull-out load, which is the key to maximize the load. Since horizontal loads can embed themselves deeper, vertical loads will take more effort to get deeper. Vertical loaded anchors are therefore more expensive to install. Finding a relatively cheap anchoring system with a high vertical load capacity that is easy to install will be very challenging. types of seafloor is listed below.[3]

2.5.1 Gravity-Base anchor

Figure 2.9 Gravity-base anchors

Gravity-base anchors are mainly used in TLPs. The heavy dead weight ensures a safe capacity force in the vertical or horizontal direction. The material of the anchor is cheap, but a large amount of material is needed to achieve the demanded capacity. The difference between its weight and its buoyancy defines the load carrying capacity. [3]

2.5.2 Drag-Embedded Anchor

Figure 2.10 Drag embedded anchors

This anchor type are dropped to the seabed and wired or dragged to achieve a deeper embedment. Movement over time may not be a high risk or critical. The weight of the mooring lines will cause a line tension to drive the anchor deeper. The advantages of this anchor are: [3]

- Low anchor type cost
- Suitable for catenary moored systems because precise placement is not needed.
- Horizontal mooring forces exist

Besides a high horizontal load capacity for anchors, also a high vertical load design capacity is developed. A class of drag embedded anchors are developed called vertical-load anchors (VLAs). These are more suitable for anchoring wind turbine platforms. [3]

2.5.3 Driven Pile Anchor

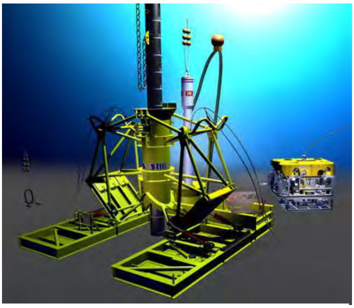


Figure 2.11 Driven pile anchor

Driven pile anchor has been proven as very reliable and can achieve a very high load capacity. This anchor has been developed over the years of experience in the oil and gas industry. Because the reliable is very high, these anchors are the most commonly used for offshore oil production.

The advantages are:

- They are permanent
- Precisely located
- Piles will not creep
- Well suited to take vertical loading

A disadvantage can be the high cost. By using a vibratory or impact hammer, the drivepile anchor is driven into the seafloor. [3]

2.5.4 Suction Anchor

Figure 2.12 Suction anchors

Suction anchors have a physical look of a long pipe, which is open at the bottom end and closed at the top. These are a good alternative for the drivenpile anchor. In order to evacuate the water and sucking the pipe into the bottom soil, the closed end is outfitted with pump fittings. A transverse tension direction is achieved on the pipe by attaching an anchor line to a pad eye near the midpoint of the pipe. In this way the tension line are placed well down in the deeper soil allowing a large wedge of soil to support the line load. A suction anchor is the most effective for vertical loading compared to drag embedded anchors. [3]

2.5.5 Driven Anchor Plate

Figure 2.13 Driven anchor plate

A driven anchor plate uses the same principle as the suction anchor, but uses less material, which lowers the costs. It can resist a large wedge of soil when tension loads are applied to the plate, in this way it will rotate in the soil. The advantages are: [3]

- It can be precisely located

- Can sustain high vertical loads
- Not likely to creep

A suction anchor, jetted, or vibration can be used for embedment.

2.5.6 Drilled and Grouted Pile

Figure 2.14 Drilled and grouted pile

The seabed does not always have a permeable soil conditions where an anchor can be embedded in. If the seabed contains a rocky surface, an anchor can be attached by drilling into the rock and grout a pile into the hole. The used pile will contain of similar in size and shape as the driven pile. The advantages of drilled and grouted pile compared to driven piles are: [3]

- More reliability
- Can achieve higher vertical loads

A disadvantage is the higher cost because it requires heavy installation equipment. [3]

2.5.7 Deadweight Anchor

Figure 2.15 deadweight anchor

A deadweight anchor is any heavy object placed on the seafloor to resist vertical and/or lateral loading. It can be fabricated from concrete and steel and configured to enhance lateral capacity. Deadweight anchors are often used because they are inexpensive and readily sized for most seafloor and loading conditions. In general they are not very efficient (ratio of holding capacity to weight) compared to the other anchor types, thus they may require heavy lift capabilities for installation and they are a poor choice on sloping seafloors. However, on very hard bottoms they might provide the only reasonable anchoring option[3)]

2.6 Response Amplitude Operator (RAO)

In the field of ship design and design of other floating structures, a response amplitude operator (RAO) is an engineering statistic, or set of such statistics, that are used to determine the likely behavior of a ship when operating at sea. Known by the acronym of *RAO*, response amplitude operators are usually obtained from models of proposed ship designs tested in a model basin, or from running specialized CFD computer programs, often both. RAOs are usually calculated for all ship motions and for all wave headings.[4]

RAOs are effectively transfer functions used to determine the effect that a sea state will have upon the motion of a ship through the water, and therefore, for example, whether or not (in the case of cargo vessels) the addition of cargo to the vessel will require measures to be taken to improve stability and prevent the cargo from shifting within the vessel. Generation of extensive RAOs at the design phase allows shipbuilders to determine the modifications to a design that may be required for safety reasons (i.e., to make the design robust and resistant to capsizing or sinking in highly adverse sea conditions) or to improve performance (e.g., improve top speed, fuel consumption, stability in rough seas). RAOs are computed in tandem with the generation of a hydrodynamic database, which is a model of the effects of water pressure upon the ship's hull under a wide variety of flow conditions. Together, the RAOs and hydrodynamic database provide (inasmuch as this is possible within modelling and engineering constraints) certain assurances about the behavior of a proposed ship design. They also allow the designer to dimension the ship or structure so it will hold up to the most extreme sea states it will likely be subjected to (based on sea state statistics).[5]

2.7 Ocean Wave Spectrum Response

Ocean waves are produced by the wind. The faster the wind, the longer the wind blows, and the bigger the area over which the wind blows, the bigger the waves. In designing ships or offshore structures we wish to know the biggest waves produced by a given wind speed. Suppose the wind blows at 20m/s for many days over a large area of the North Atlantic. [5]

It is important to realise that the spectra presented in the section are attempts to describe the ocean wave spectra in very special conditions, namely the conditions after a wind with constant velocity has been blowing for a long time.[8)] A typical ocean wave spectrum will be much more complicated and variable. For example it may have two peaks, one from distance swell and the other generated by the local wind. [5]

The nature of ocean waves is random, both large and direction, so because of the nature of the energy wave is random difficult to measure. Random wave is a combination of sinusoidal waves with wave periods long and very varied. The size of the random wave component intensity is generally expressed in terms of spectrum amplitude density, wave energy density, or commonly abbreviated to be wave energy spectrum. [5)]

Based on DNV RP C205 (2010), The Pierson-Moskowitz spectra is given by[14)]:

$$S_{PM}(\omega) = \frac{5}{16} \cdot H_S^2 \omega_p^4 \cdot \omega^{-5} \exp\left(-\frac{5}{4}\left(\frac{\omega}{\omega_p}\right)^{-4} \right) \quad (2.8)$$

where $\omega_p = 2\pi/T_p$ is the angular spectral peak frequency

The *JONSWAP* spectrum is formulated as a modification of the Pierson-Moskowitz spectrum for a developing sea state in a fetch limited situation:

$$S_J(\omega) = A_\gamma S_{PM}(\omega)\ \gamma^{\exp\left(-0.5\left(\frac{\omega-\omega_p}{\sigma\ \omega_p}\right)^2 \right)} \quad (2.7)$$

Where,

$S_{PM}(\omega)$ = Pierson-Moskowitz spectrum
γ = non-dimensional peak shape parameter
σ = spectral width parameter
$\sigma = \sigma_a$ for $\omega \leq \omega_p$
$\sigma = \sigma_b$ for $\omega > \omega_p$
A_γ = 1- 0.287 ln(γ) is a normalizing factor

2.8 Ansys AQWA

ANSYS AQWA provides an engineering toolset for the investigation of the effects of wave, wind and current on floating and fixed offshore and marine structures, including: spars; floating production, storage, and offloading (FPSO) systems; semi-submersibles; tension leg platforms (TLPs); ships; renewable energy systems; and breakwater design.[15)]

AQWA Hydrodynamic Diffraction provides an integrated environment for developing the primary hydrodynamic parameters required for undertaking complex motions and response analyses. AQWA Hydrodynamic Diffraction can also generate pressure and inertial loading for use in a structural analysis as part of the vessel hull design process. [15)]

AQWA Hydrodynamic Time Response provides dynamic analysis capabilities for undertaking global performance assessment of floating structures in the time domain. A wide range of physical connections, such as mooring lines, fenders, and articulations, are provided to model the restraining conditions on the vessels. In addition, sea-keeping simulation may be undertaken with the inclusion of forward speed effects. Slow-drift effects and extreme-wave conditions may be investigated, and damage conditions, such as line breakage, may be included to study any transient effects that may occur. [15)]

Chapter 3
Research Methodology

1. Literature Studies

Find out a general overview of the mooring system, 6 degrees of freedom movement, and stability on the Floating Platform Effectively and efficiently. Literature is obtained from books, journal maritime, audit reports of companies, and the official website which can be responsible its information

2. Searching and Inputting data

Searching and Inputting data such as Design Platform, General Arrangement Platform, depth and contour of the trough, the current velocity, wind velocity, and Wave velocity

3. Redrawing And Editing

Design of floating platform is edited using maxsurf, solidwork and autocad software. Its mean to measure dimension of platform and then to equate the file extension to be processed in mooring software.

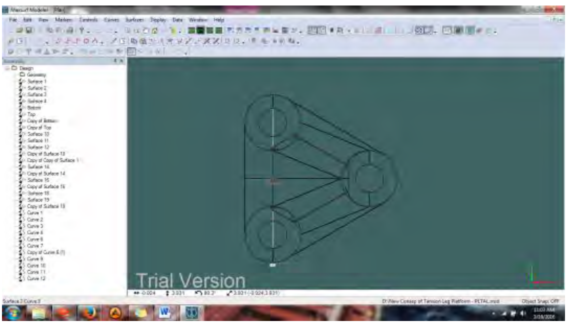


Figure 3.16 Redrawing and editing

4. Analysis of External Force

Analyzing and calculating the value of force which are received by the platform as a result of currents, waves and wind force. Calculation based on DNV rules for Offshore operational

5. Mooring System Selection

Mooring Line types to be tested consists of chain, wire rope and fiber. The most Strongest type, and efficient which is then selected. After that, the position of mooring line is simulated at many different position.

6. Stability Analysis

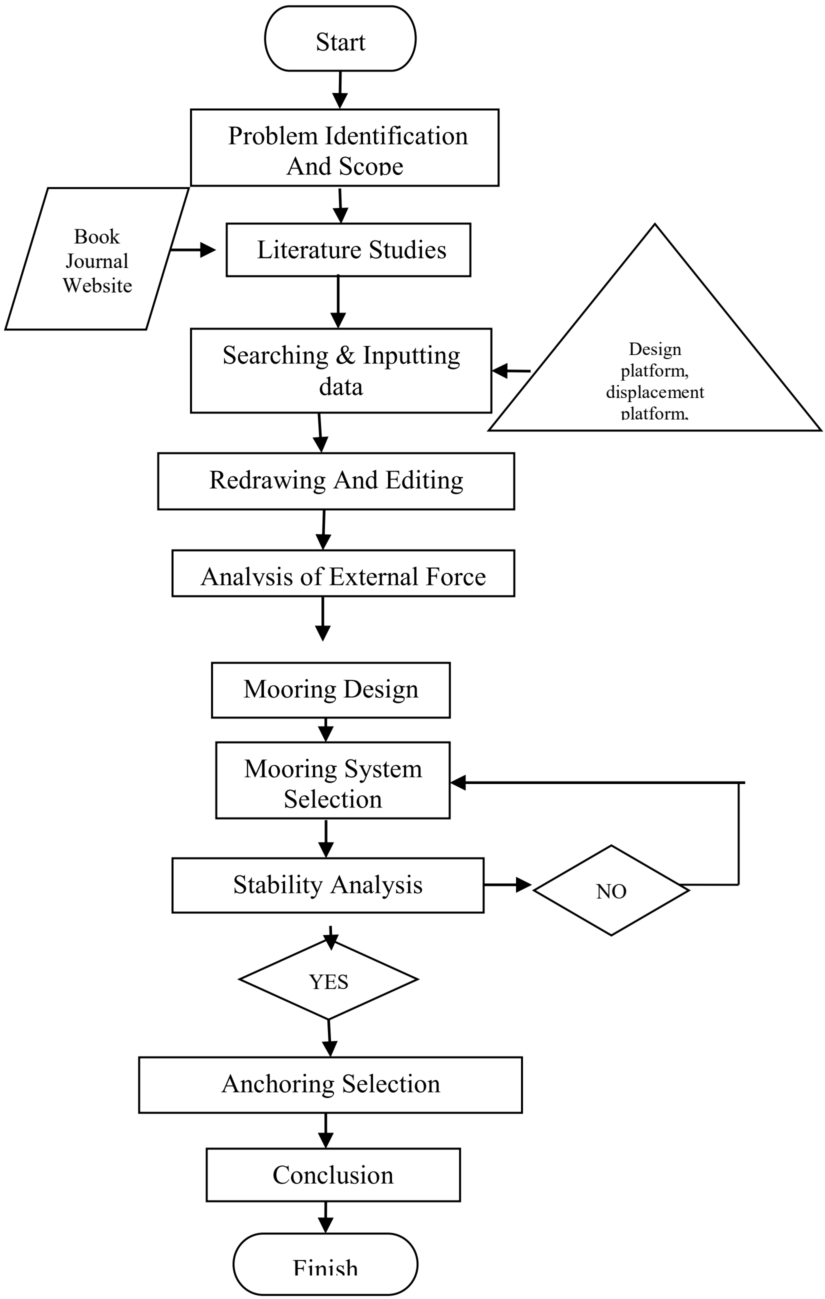
Floating platform stability is tested using Ansys AQWA Software. The best stability can be observe from

1) low RAO value in 6 degree free movement (heave, roll, pitch, surge, sway, and yaw) at sea wave direction from 0^0 ,30^0 ,60^0 ,90^0 ,120^0, 150^0, 180^0, 210^0, 240^0, 270^0, 300^0, and 330,)
2) RAO smooth graph

The best RAO will be change to be spectrum response to determine energy frequency received by floating platform.

7. Anchoring selection

Anchor weight is calculated based on mooring system selection results. after that, type of anchor is selected based on contour of sea bed. The last, anchor will be simulated used software.


Start
Problem Identification And Scope
Book
Journal
Website
Literature Studies
Searching & Inputting data
Design platform, displacement platform.
Redrawing And Editing
Analysis of External Force
Mooring Design
Mooring System Selection
Stability Analysis
NO
YES
Anchoring Selection
Conclusion
Finish

(This page intentionally left blank)

Chapter 4

Research Results

4.1 Geographic Condition

The Ocean current power plant will be placed around the Toyapakeh Strait. Toyapakeh Strait is located between the Nusa Penida and Nusa Lembongan and nusa Ceningan having a length of 6 km and a width up to 1.5 km in the east, 700 meters in the center and 1 km in the southwest. Morphology of the Toyapakeh strait relatively steep. In areas near the coastline has a contour pattern is very tight and the sea depth is getting deeper nerly central of Strait.

Figure 4.17 Toyapakeh Maps

Viewed from the bathymetric contour maps in the Strait Toyapakeh. Sea bed of Strait Toyapakeh have a contour increasingly steep near center of strait . So the water flow velocity will be higher in these conditions. When the position of water is low at some point, water flow have a maximum current speed around 1.62 m/s. When the position of water is normal, water flow have a maximum current speed around 2.7 m/s.

Table 4.1. Geographic condition

Depth	27	m
Current Velocity	2.7	m/s
Wind Velocity	16.46	m/s
Wave Hight	2	m
Sea water Density	1025	Kg/m^3
Air Density	0.0023668	Slug/Ft^3
	1.219	Kg/m^3

4.2 Platform Design

Principle Dimension

Length : 12 m
Breadth : 10.4 m
Height : 6.7
Draft : 2.8 m
Tendon Diameter : 4 m

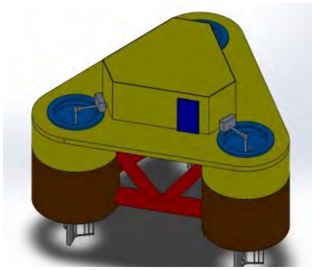


Figure 4.18 Floating Platform Design

Platform Design is re-drawn used Autocad 3D. Design is analyzed used Solidwork Software to knowing moment inertia and center of mass of floating platform. This is very important to final process using Ansys Aqwa

Table 4.2. Moment Inertia

Axis	Tipe 1		Tipe 2	
Ixx	2,015,883.34	kg.m2	2,015,883.34	kg.m2
Iyy	2,015,300.98	kg.m2	2,015,300.98	kg.m2
Izz	3,350,651.40	kg.m2	3,350,651.40	kg.m2
Ixy	540.01	kg.m2	540.01	kg.m2
Ixz	-680.27	kg.m2	-680.27	kg.m2
Iyz	-1,127.21	kg.m2	-1,127.21	kg.m2

4.3 Mooring Line Type

Type of mooring system for Ocean Current power plan is tension leg mooring type. Selection process consider many various Requirement and things, like as :

1. The geographical conditions
2. Easy installation
3. Turbines require good stability when it absorbs the energy of ocean currents
4. Able to Reduce heave, roll and pitch movement well. That are generally the most dominant movement occurs on floating platform
5. More popular for relatively small floating units that are unable to carry large weight

Table 4.3 Advantages and disadvantages of Tension Leg mooring and catamaran

Criteria	Tesion leg mooring	Catamaran
Stability	+	-
structural strength	+	-
life service	+	-
metode load out	-	+

Position of mooring line is simulated in 2 locations, between tendon and peak of tendon. the positions consider many advantages likes:

type 1 : (+) floating platform is more light
(+) Mooring line isn't disturb current flow that will rotate blade inside turbine (Reduce blade rotation)

Type 2 : (+) following offshore rules for large floating platform
on deep water (ocean current power plant is small
floating platform and is located on swallow water)

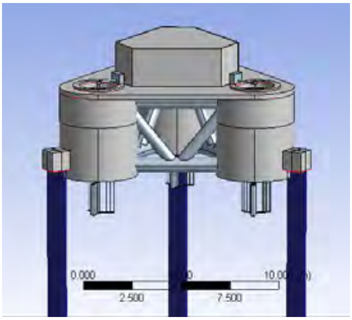


Figure 4.20 Mooring line position Type 1

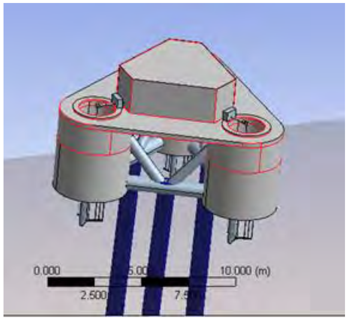


Figure 4.19 Mooring line position Type 2

4.4 Environment Force

Environment force is formed by wind force, current force, and wave force. Environment force will influence diameter and anchor selection.

4.4.1 Wind Force

Based on DNV rules wind force can be calculated using formula:

$$q = \frac{1}{2} \rho_a U_{T,z}^2 \qquad (2.8)$$

$$F_W = C\, q\, S \sin\alpha \qquad (2.9)$$

Where,

q = the basic wind pressure or suction

ρ_a = the mass density of air; to be taken as 1.226 kg/m^3
For dry air at $15^{o}C$.

$U_{T,z}$ = the wind velocity averaged over a time
C = shape coefficient
q = basic wind pressure or suction,
S = projected area of the member normal to the direction of the force
α = angle between the direction of the wind and the axis of the exposed member or surface.

From These formula, after calculation is known that total wind force is 0.86 kN

4.4.2 Current Force

Current force can be calculated using Morison equation, like is shown below :

$$F = F_D + F_I = C_D \frac{w}{2g} A\ U|U| + C_m \frac{w}{g} V \frac{\delta U}{\delta t} \qquad (2.10)$$

Where,

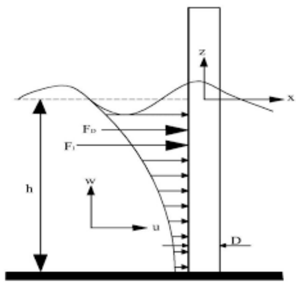


Figure 21 Drag and inertia force

F = Current force
F_d = drag force
F1 = inertia force
C_d = Inertia coefficient
C_m = Inertia coefficient
W = weight density of water
A = projected area normal to the cylinder (= D for circular cylinders)
V = displaced volume of the cylinder (= πD^2/4 for circular cylinders)
g = gravitational acceleration

After calculation is known drag force about 367.12 N, inertia force about 2101.88 N , so current force about 2468.995 N or 2.47 kN

4.4.3 Wave Force

Sea wave is difficult to predicted, many method to calculated wave force. Difficulty in calculation is caused by sea wave is categorized as irregular wave. Based on ocean and polar research is known method to calculate wave force as shown below

$$\begin{aligned} &\text{when } F_M > 2F_D \\ &\{(F_w)_{\max}, (F_w)_{\min}\} = \pm F_M \\ &\text{when } F_M \leq 2F_D \\ &\{(F_w)_{\max}, (F_w)_{\min}\} = \pm\left(F_D + \frac{F_M^{\,2}}{4F_D}\right) \end{aligned} \qquad (2.11)$$

Where,

F_d = Drag force

F_m = Inertia Force

F_w = Wave force

Based on regulation above ,then :

1. Wave force is equals Inertia force, if total value of inertia force is greater than 2 times of drag force

2. Wave Force is equals $= \pm\left(F_D + \frac{F_M^{\,2}}{4F_D}\right)$

If inertia force is smaller than 2 times of drag force.

<u>Calculation based rules Above</u>:

Fm = 2101.88 N

Fd = 367.12 N 2Fd = 734.23 N

Result : $Fm \geq 2FD$

Summary : wave force = Fm = 2101.88 N

= 2.1 kN

4.4.4 Environment Force

Environment force or load is equal total load of wind force, current force and wave force.

Tf = Wind force + current force + wave force

= 0.84 kN + 2.47 kN + 2.1 kN

= 5.41 kN

This calculation on normal condition and wave,wind and current comes from same directSion

4.5 Mooring Line Material

There are 3 types of mooring line that will be consider to be Selected for floating platform: chain, wire rope dan Fibre rope.

4.5.1 Chain

Type : Studless chain

Consideration : - Low cost compared Studlink Chain

- Weight is not predominantly important
- Long lifetime

4.5.2 Wire

Type : Wire Rope, Six Strand

Consideration : 1. Low Cost

2. Easy Maintenance
3. Light

4.5.3 Fiber

Type : Polyester Fiber

Consideration : 1. Low Cost
2. Providing superior abrasion resistance
3. Light

4.6 Nominal Diameter

Nominal diameter is regulated on DNV rules as shown below:

$$f = \frac{1}{2}\rho C_D D \cdot v \cdot |v| \qquad (2.12)$$

Where,

F = drag force
ρ = Sea water density
C_d = Drag Coefficient
D = Nominal diameter

Regulation also about drag coefficient, like as table below:

Table 4.4 Coefficient drag regulation

	Transverse	Longitudinal
Stud chain	2.6	1.4
Stud less chain	2.4	1.15
Stranded rope	1.8	*
Spiral rope without plastic sheathing	1.6	*
Spiral rope with plastic sheathing	1.2	*
Fibre rope	1.6	*

After calculation using formula 2.12, is known nominal diameter like as shown below:

Chain : Transverse, D = 40.94 mm
Longitudinal, D = 85.44 mm
Wire : D = 57.8 mm
Fiber : D = 61.41 mm

4.7 Mooring line Specification

after knowing the nominal diameter, rope specifications can be searched through a brochure with matching line diameter rope, function, and geography conditions.

a. Chain

Merk	: ASAC
Type	: Studless Chain
Grade	: R3
Diameter	: 42 mm
Weight	: 39.4 kg/m
Weight total	: 973.18 kg/m
Breaking load	: 1400 kN
Prof load	: 981 kN

b. Wire

Merk	: Lankhorst
Diameter	: 58 mm
Weight	: 17 Kg/m
Total Weight	: 419.9 Kg
Breaking Strength	: 2350 kN

c. Fiber

Merk	: Supermax
Diameter	: 64 mm
Weight	: 236 Kg/100m
Total Weight	: 58.29 Kg
Breaking Strength	: 3024 kN

4.8 Axial Stiffness

axial stiffness has a different value depending on the type of rope. axial stiffness can be determined with knowing diameter of line. Ansys AQWA determine the axial stiffness calculation like as shown below:

a. Chain

$$EA = 0.854 \times 10^8\ D^2\ kN\ (studless)\ or\ 1.01 \times 10^8\ D^2\ kN\ (studlink). \tag{2.13}$$

Chain type is studless, then known axial stiffness about 178164 kN

b. Wire

$$E = 1.13 \times 10^8\ kN/m^2\ (\textit{for Wire ropes with wire core}). \tag{2.14}$$

$$E = 1.03 \times 10^8\ kN/m^2\ (\textit{for Wire ropes with fibre core}). \tag{2.15}$$

Wire rope type is wire ropes with Fibre core, then known axial stiffness about 123458 kN

c. Fiber

$$\text{Axial Stiffness} = 1.18 \times 10^5\ D^2\ kN\ (\text{for Nylon ropes}). \tag{2.16}$$

$$\text{Axial Stiffness} = 1.09 \times 10^6\ D^2\ kN\ (\text{for Polyester ropes}). \tag{2.17}$$

$$\text{Axial Stiffness} = 1.06 \times 10^6\ D^2\ kN\ (\text{for Polypropylene ropes}). \tag{2.18}$$

Fiber type is fiber that produced by polyester ropes, then known axial stiffness about 4464.6 kN

4.9 Maximum Tension

To calculate maximum tension, normal force and buoyancy must be determined. Normal force that acting on floating platform can be known using formula below:

$$N = F_a - W \tag{2.19}$$

And for Buoyancy force able to determined using formula, below

$$F_A = \rho\, g\, V_a \tag{2.20}$$

Maximum tension able to known using formula below:

$$T_m = \frac{N}{\cos \varphi} + F_{w\,(max)} \tag{2.21}$$

Where,

N = Normal force

F_A = Buoyancy

ρ = Density of seawater

V_a = Floating platform Volume

W = Floating platform Weight

φ = Angle between mooring

T_m = Maximum tension

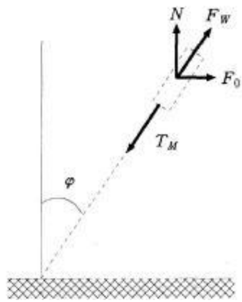


Figure 4.22 Mooring Line Force Distribution

From These calculation maximum tension on each mooring line able to determining as shown below:

a. Chain

Type 1 : N = 932.07 kN
Tm = 934.17 kN

Type 2 : N = 918.87 kN
Tm = 920.98 kN

b. Wire

Type 1 : N = 932.07 kN
Tm = 934.17 kN

Type 2 : N = 918.87 kN
Tm = 920.98 kN

b. Wire

Type 1 : N = 932.07 kN
Tm = 934.17 kN

Type 2 : N = 918.87 kN
Tm = 920.98 kN

4.10 Safety Factor and Breaking Condition

Mooring line is categorized safe for operation if the minimum breaking load (MBL) which divided the safety factor is smaller than the maximum tension, and the mooring line would break otherwise.

$$\frac{MBL}{safety\,factor} \geq \text{Maximum tension} \quad (2.22)$$

Safety factor is regulated by DNV rules based on geographic condition and assumption user. If assumption that mooring line will be break because of loss of life time, then safety factor range is controlled based on table below.

Table 4.5. Safety factor based on geographic condition

Consequence Class	*Type of analysis of wave frequency tension*	*Partial Safety factor on mean tension* γ_{mean}	*Partial Safety factor on dynamic tension* γ_{dyn}
1	Dynamic	1.10	1.50
2	Dynamic	1.40	2.10
1	Quasi-static	1.70	
2	Quasi-static	2.50	

- *Class 1* : where mooring system failure is unlikely to lead to unacceptable consequences such as loss of life,
collision with an adjacent platform, uncontrolled outflow of oil or gas, capsize or sinking.

- *Class 2* : where mooring system failure may well lead to unacceptable consequences of these types.

Based on these table 4.5, safety factor is 1.10 because mean tension and dynamic is often used for swallow seawater. Using formula (2.22) Breaking condition each mooring line type able to is determined as shown below :

a. Chain

Minimum breaking : 1400kn

Safety Factor : 1.10

Breaking condition : 44^0

Table 4.6 Breaking condition of chain

φ	MBL/Safety factor	Maximum Tension (Tipe 1)	Maximum Tension (Tipe 2)	Status (tipe 1)	Status (Tipe 2)
0	1272.73	934.17	920.98	Safe	Safe
10	1272.73	948.55	935.15	Safe	Safe
20	1272.73	993.99	979.95	Safe	Safe
30	1272.73	1078.36	1063.00	Safe	Safe
40	1272.73	1218.83	1201.61	Safe	Safe
44	1272.73	1297.83	1279.49	Break	Break

b. Wire

Minimum breaking : 2350kn

Safety Factor : 1.10

Breaking condition : 65^0

Table 4.7 Breaking condition of wire

φ	MBL/Safety factor	Maximum Tension (tipe 1)	Maximum Tension (tipe 2)	Status (Tipe 1)	Status (Tipe 2)
0	2136.36	934.72	921.53	Safe	Safe
10	2136.36	949.11	935.71	Safe	Safe
20	2136.36	994.58	980.54	Safe	Safe
30	2136.36	1079.00	1063.76	Safe	Safe
40	2136.36	1219.55	1202.33	Safe	Safe
50	2136.36	1453.00	1432.48	Safe	Safe
60	2136.36	1867.34	1840.95	Safe	Safe
65	2136.36	2208.87	2177.65	Break	Break

c. Fiber

Minimum breaking : 3024kn

Safety Factor : 1.10

Breaking condition : 71^0

Table 4.8 Breaking condition of fiber

φ	MBL/Safety factor	Maximum Tension (tipe 1)	Maximum Tension (tipe 2)	Status (Tipe 1)	Status (Tipe 2)
0	2749.09	935.08	921.89	Safe	Safe
10	2749.09	949.48	936.08	Safe	Safe
20	2749.09	994.96	980.92	Safe	Safe
30	2749.09	1079.42	1064.18	Safe	Safe
40	2749.09	1220.02	1202.8	Safe	Safe
50	2749.09	1453.57	1433.04	Safe	Safe
60	2749.09	1868.07	1841.68	Safe	Safe
70	2749.09	2729.96	2691.38	Safe	Safe
71	2749.09	2867.81	2827.28	Break	Break

4.11 Response Amplitude Operator (RAO)

Based on simulation results using Ansys AQWA known that RAO on mooring line type of chain, wire and fiber is almost the same and there is little bit Difference in distance/rotation. Mooring line type chain has smaller RAO if compared with fiber RAO or Wire RAO. These results conclude that Chain better than Wire and Fiber in maintaining the stability of the Floating platform.

Table 4.9 RAO - Heave - Chain - Type 1

Encounter	Heave RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011
0.446	1.069	1.069	1.068	1.068	1.068	1.069	1.069	1.069	1.068	1.068	1.068	1.069
0.703	1.252	1.249	1.243	1.240	1.243	1.249	1.252	1.249	1.243	1.241	1.243	1.249
0.959	1.011	1.134	1.362	1.471	1.362	1.134	1.010	1.128	1.355	1.464	1.356	1.129
1.216	6.045	6.158	6.307	6.373	6.305	6.156	6.043	6.091	6.280	6.393	6.280	6.093
1.473	0.511	0.541	0.534	0.524	0.534	0.541	0.510	0.498	0.536	0.570	0.536	0.499
1.730	0.027	0.088	0.033	0.074	0.033	0.088	0.027	0.068	0.036	0.096	0.036	0.068
1.986	0.061	0.071	0.057	0.044	0.057	0.071	0.061	0.049	0.059	0.070	0.060	0.049
2.243	0.031	0.027	0.030	0.032	0.030	0.027	0.031	0.033	0.030	0.026	0.030	0.033
2.500	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020
2.756	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006
3.013	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004
3.270	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008
3.527	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009
3.783	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011
4.040	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002
4.297	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003
4.553	0.001	0.003	0.001	0.003	0.002	0.003	0.001	0.003	0.001	0.003	0.001	0.003
4.810	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004
5.067	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003

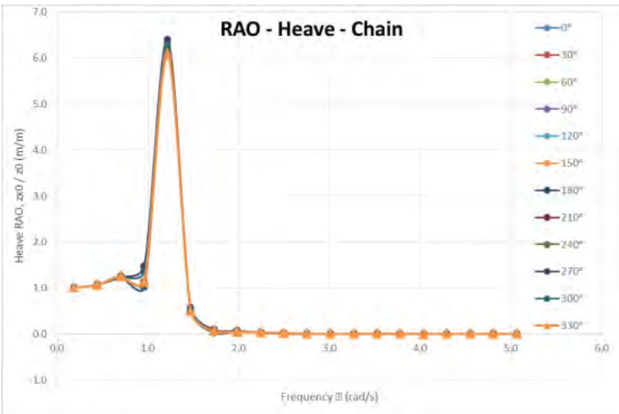


Figure 4.23 RAO - Heave - Chain - Type 1

Table 4.10 RAO - Heave - Wire - Type 1

Encounter	Heave RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.011	1.011	1.010	1.010	1.010	1.011	1.011	1.011	1.010	1.010	1.010	1.011
0.446	1.069	1.069	1.068	1.067	1.068	1.069	1.069	1.069	1.068	1.067	1.068	1.069
0.703	1.250	1.247	1.241	1.238	1.241	1.247	1.250	1.247	1.242	1.239	1.241	1.247
0.959	1.008	1.132	1.360	1.468	1.359	1.131	1.007	1.126	1.352	1.461	1.353	1.127
1.216	6.155	6.270	6.421	6.489	6.420	6.268	6.153	6.202	6.394	6.509	6.394	6.204
1.473	0.515	0.545	0.539	0.528	0.538	0.545	0.514	0.502	0.540	0.574	0.540	0.502
1.730	0.027	0.088	0.033	0.074	0.033	0.088	0.027	0.068	0.036	0.096	0.036	0.068
1.986	0.061	0.071	0.057	0.045	0.058	0.071	0.061	0.049	0.060	0.070	0.060	0.050
2.243	0.031	0.027	0.030	0.032	0.030	0.027	0.031	0.033	0.030	0.026	0.030	0.034
2.500	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020
2.756	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006
3.013	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004
3.270	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008
3.527	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009
3.783	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011
4.040	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002
4.297	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003
4.553	0.002	0.003	0.001	0.003	0.002	0.003	0.001	0.003	0.002	0.003	0.001	0.003
4.810	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004
5.067	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003

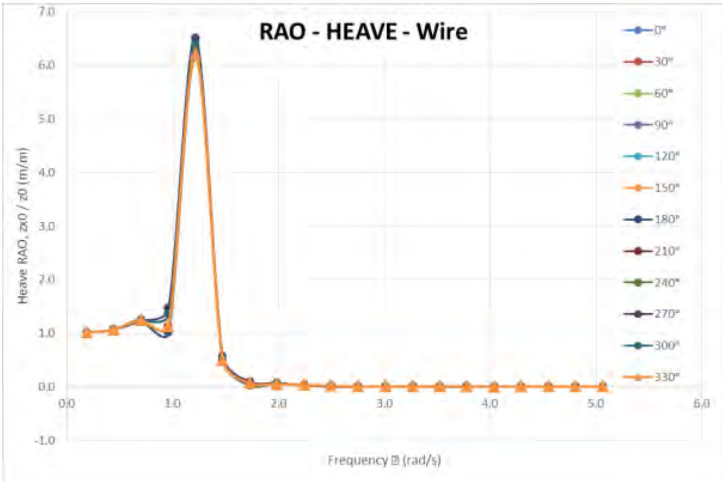


Figure 4.24 RAO - Heave - Wire - Type 1

Table 4.11 RAO - Heave - Fiber - Type 1

Encounter	Heave RAO, z_{x0}/z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.011	1.011	1.010	1.010	1.010	1.011	1.011	1.011	1.010	1.010	1.010	1.011
0.446	1.069	1.068	1.067	1.067	1.067	1.068	1.069	1.068	1.067	1.067	1.067	1.068
0.703	1.249	1.246	1.240	1.237	1.240	1.246	1.249	1.246	1.240	1.237	1.240	1.246
0.959	1.007	1.130	1.358	1.466	1.357	1.129	1.006	1.124	1.350	1.459	1.351	1.125
1.216	6.225	6.341	6.494	6.562	6.493	6.339	6.223	6.272	6.466	6.583	6.467	6.274
1.473	0.517	0.548	0.541	0.531	0.541	0.548	0.517	0.505	0.543	0.577	0.543	0.505
1.730	0.027	0.088	0.033	0.074	0.033	0.088	0.027	0.068	0.036	0.097	0.036	0.068
1.986	0.061	0.071	0.058	0.045	0.058	0.072	0.061	0.050	0.060	0.070	0.060	0.050
2.243	0.031	0.027	0.030	0.032	0.030	0.027	0.031	0.033	0.030	0.026	0.031	0.034
2.500	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020
2.756	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006
3.013	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004
3.270	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008
3.527	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009
3.783	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011
4.040	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002
4.297	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003
4.553	0.002	0.003	0.001	0.003	0.002	0.003	0.001	0.003	0.002	0.003	0.001	0.003
4.810	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004
5.067	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003

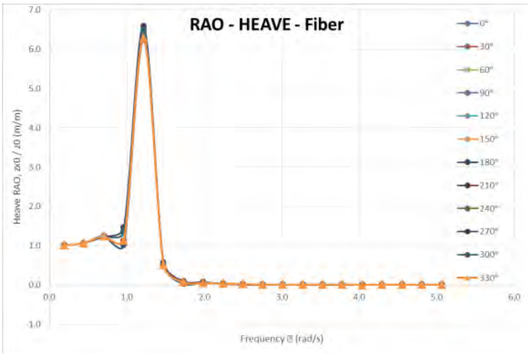


Figure 4.25 RAO - Heave - Fiber - Type 1

Based on simulation results using Ansys AQWA known that RAO on Type 1 and Type 2 has a shape that is almost same but has a significant heights differ greatly, so the mooring line type 2 better than type 1 in maintaining the stability of the Floating platform.

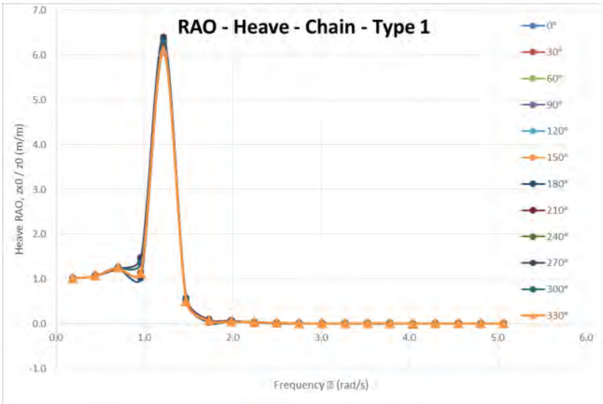


Figure 4.26 RAO - Heave - Chain - Type 1

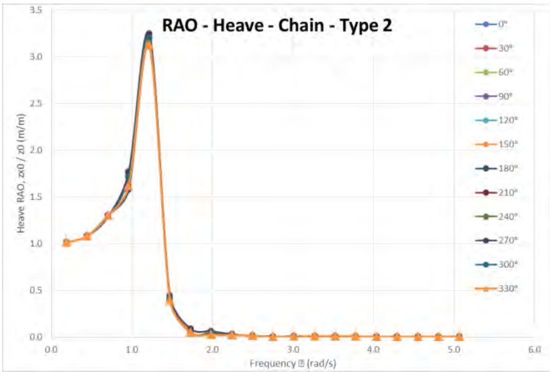


Figure 4.27 RAO - Heave - Chain - Type 2

Conclusions from the simulation is that mooring line type 2 using chain line is the best in maintaining the stability of floating platform.

Below is the RAO on mooring line that using Chain materials and placement type 2 at each 6 degrees of freedom movement:

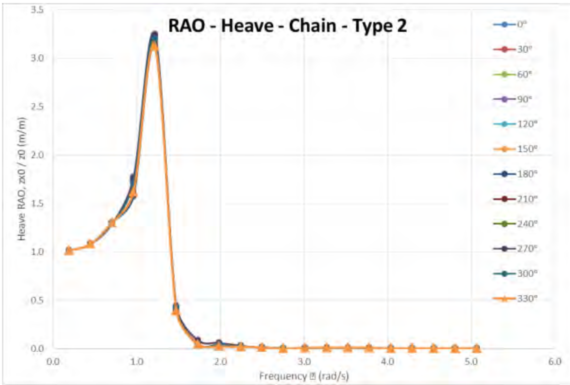


Figure 4.28 RAO - Heave - Chain - Type 2

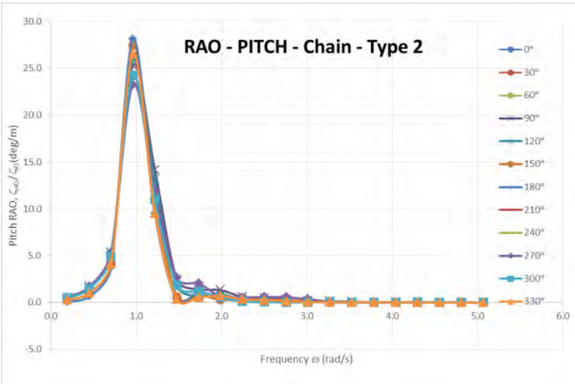


Figure 4.29 RAO - Pitch - Chain - Type 2

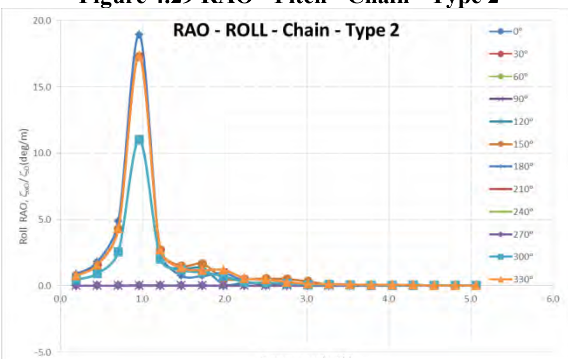


Figure 4.30 RAO - Roll - Chain - Type 2

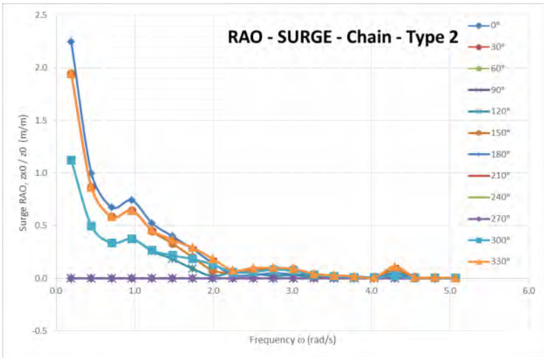


Figure 4.31 RAO - Surge - Chain - Type 2

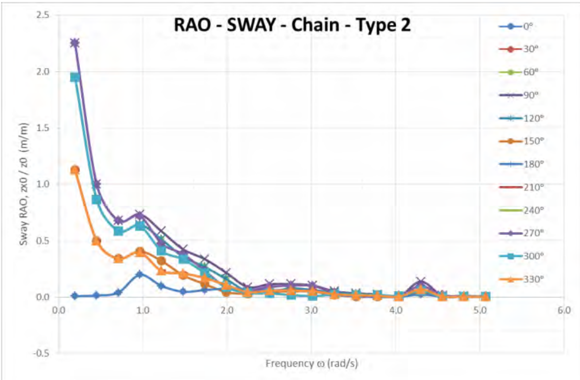


Figure 4.32 RAO - Sway - Chain - Type 2

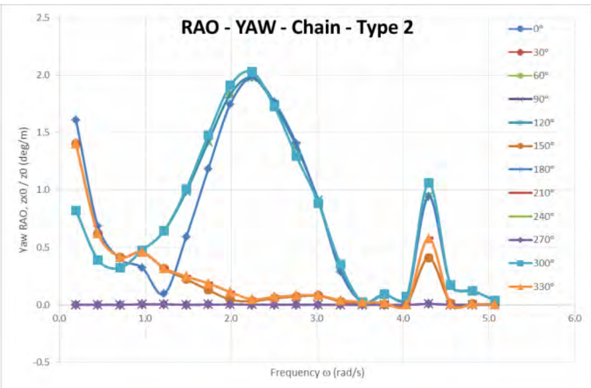


Figure 4.33 RAO - Yaw - Chain - Type 2

4.12 Response Spectrum

In Reality, the sea waves are random waves type so that the platform response that expressed in RAO can't clarify the real platform response at sea. To get a platform response movements in random sea waves condition can be to identified with using response spectrum. Response spectrum can be calculated by multiplying the wave spectrum (S_ζ) with RAO^2.

Calculation of Spectrum Response is regulated by DNV Offshore regulation are as follows:

$$S_R(\omega) = \left|\xi^{(1)}(\omega)\right|^2 S(\omega) \qquad (2.23)$$

This formula can be simplified to be,

$$S_{\zeta r}(\omega) = RAO^2 \times S_\zeta(\omega) \qquad (2.24)$$

Wave spectrum (S_ζ) can be determined using JONSWAP Equation.

$$S_J(\omega) = A_\gamma S_{PM}(\omega)\ \gamma^{\exp\left(-0.5\left(\frac{\omega-\omega_p}{\sigma\ \omega_p}\right)^2\right)} \qquad (2.25)$$

Below is the graph from the calculation results of RAO type chain on the placement of type 2 after converted into a spectrum of responses :

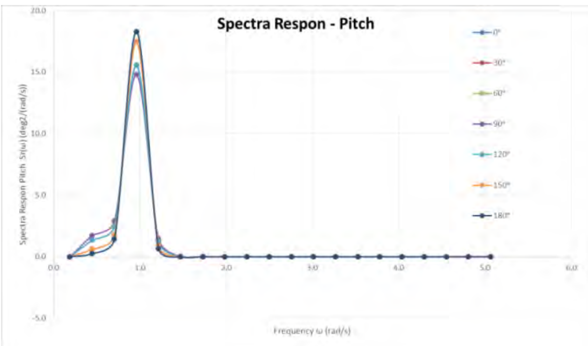


Figure 4.34 Spectra Response - Pitch - Chain - Type 2

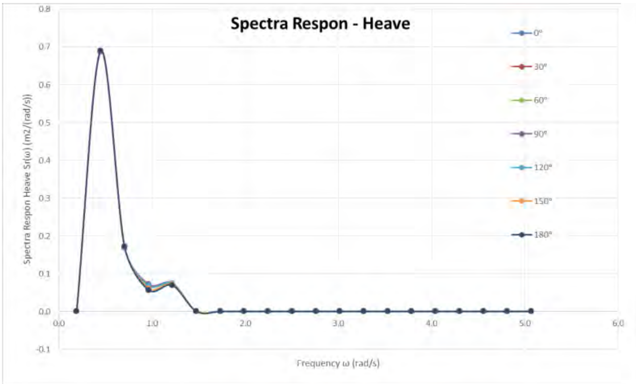


Figure 4.35 Spectra Response - Heaving - Chain - Type 2

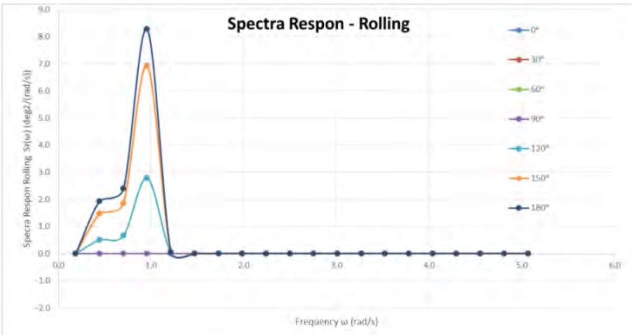


Figure 4.36 Spectra Response - Rolling - Chain - Type 2

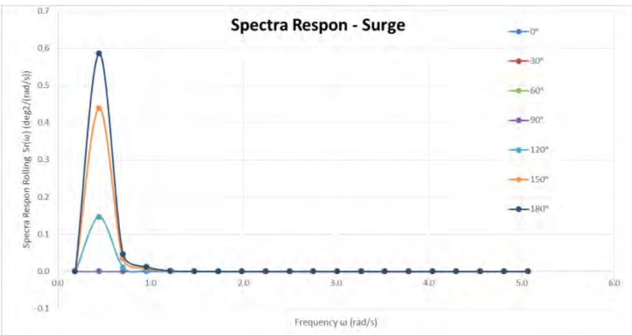


Figure 4.37 Spectra Response - Surge - Chain - Type 2

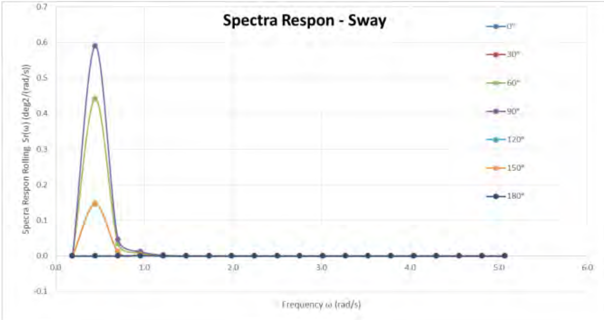


Figure 4.38. Spectra Response - Sway - Chain - Type 2

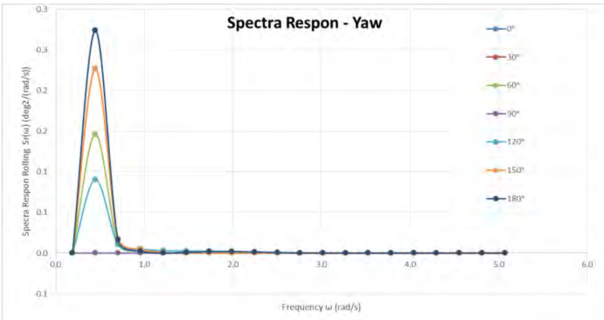


Figure 4.39. Spectra Response - Yaw - Chain - Type 2

From these Graph is known that average heaving movement is 0.685 m, maximum pitching movement is 18° at sea wave coming prom 180 °, And maximum rolling is 8.3° at sea wave coming prom 180 °

4.13 Anchor

4.13.1 Anchor Type

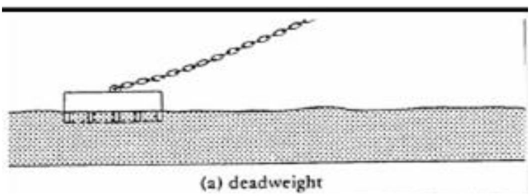


Figure 4.40 Deadweight anchor

Type : Deadweight Anchor

Consideration :

1. Inexpensive
2. Mooring line connection easily to inspect and service
3. Material for construction readily available and economical
4. Reliable on thin sediment over rock
5. Easy installation (low cost installation)
6. Lateral load resistance is low compared to most anchors except for very hard bottom conditions
7. Large vertical reaction component, permitting shorter mooring line scope

4.13.2 Anchor Shackle

Shackle leg diameter is regulated by DNV rules, as shown below:

$$d_s = 1.4 \cdot D_{nom} \qquad (2.26)$$

Based on these formula, Shackle leg diameter is determine about 80.9 mm. Shackle pin diameter is regulated by DNV rules, as shown below:

$$d_p = 1.5 \cdot D_{nom} \qquad (2.27)$$

Based on these formula, Shackle pin diameter is determine about 86.7 mm.

4.13.3 Anchor Pad Eye

Based on Offshore Standart , anchor pad eye is regulated that design load is equals characteristic breaking strength of mooring line. Breking strength od chain is equal 1400 kN, so total load of pad eye must be greater then 1400 Kn.

DNV standard regulated that Pad eye Diameter must be greater than Diameter of shackle leg. Diameter of shackle leg is equals 80.9 mm, so Pad eye Diameter is 82 mm

4.13.4 Anchor Weight

Weight of deadweight Anchor for tension leg mooring type able to be determined using formula as shown below

$$W \geq \frac{T_M(S_F \sin\varphi + \mu\cos\varphi)}{\mu(1 - w_0/\sigma_G)} \qquad (2.28)$$

Where,

T_m = Maximum tension

S_f = Safety factor

σ = Weight per unit volume structure

φ = Angle between anchor and mooring line

μ = Friction coefficient between anchor and seabed

W_σ = Weight per unit volume water

Force that acting on connection between mooring line and anchor is shown a figure below

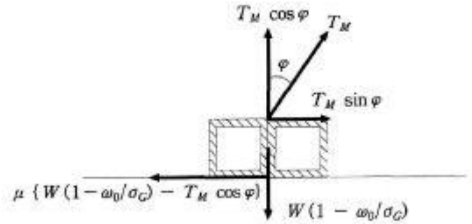


Figure 41 Force distribution that acting on Deadweight Anchor

Using formula (2.28), Anchor weight is determined must be greater than 926.08 Ton for maintain position of floating platform

4.13.4 Anchor Horizontal and Vertical Force

Based on Figure. 41 ,horizontal force able to determine using formula

$$F_h = \mu \{W.(1-\frac{\omega_o}{\sigma_G}) - T_m . \cos\varphi\} \qquad (2.29)$$

Using formula 2.29, Horizontal force is known about 607843.52 N or 607.84 kN.

Based on Figure. 41, vertical force able to determine using formula

$$F_v = W.(1-\frac{\omega_o}{\sigma_G}) \qquad (2.30)$$

Using formula 2.30, Horizontal force is known about 920975.03 N or 920.97 kN.

4.14 Simulation

Based on simulation results using Ansys AQWA is known Floating platform that using chain and placement type 2 have a good resultant displacement with maximum value (distance) about 1,79 m so that sea water doesn’t enter until platform deck. Pressure is received by floating platform at the bottom of tendon is not too high about 1294.4 N/m2

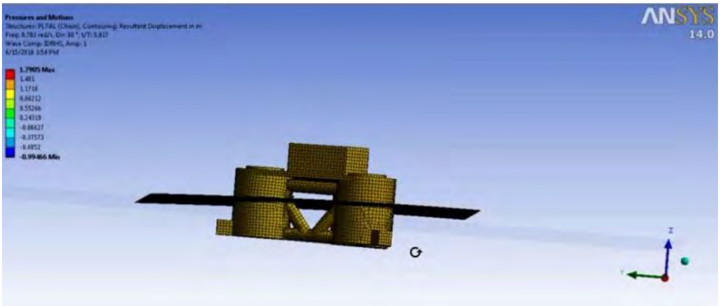


Figure 4.42 Resultant displacement simulation

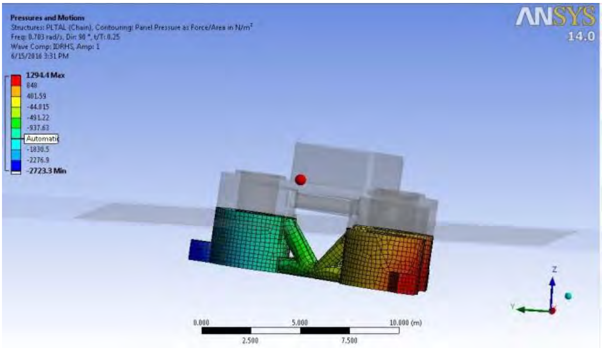


Figure 4.43 Pressure testing simulation

The simulations performed at conditions where the currents, wind and waves coming from the same direction, so that it provides a greater load on one side.

Hydrostatic displacement properties simulation result on floating platforms is shown below

AQWA Hydrostatic Results

Structure		PLTAL (Chain)				
Hydrostatic Stiffness						
Centre of Gravity Position:	X:	0. m	Y:	0. m	Z:	-7.e-2 m

	Z	RX	RY
Heave(Z):	293459.53 N/m	-1920.7898 N/°	-1.3228786 N/°
Roll(RX):	-110053.15 N.m/m	37296.395 N.m/°	3.5707347 N.m/°
Pitch(RZ):	-75.795364 N.m/m	3.5707347 N.m/°	36571.238 N.m/°

Hydrostatic Displacement Properties						
Actual Volumetric Displacement:		94.468277 m³				
Equivalent Volumetric Displacement:		181.53839 m³				
Centre of Buoyancy Position:	X:	3.1761e-4 m	Y:	-0.3757095 m	Z:	-1.4709059 m
Out of Balance Forces/Weight:	FX:	-3.8151e-8	FY:	-2.1327e-8	FZ:	-0.4796232
Out of Balance Moments/Weight:	MX:	-0.1955104 m	MY:	-1.6501e-4 m	MZ:	2.0357e-7 m
Cut Water Plane Properties						
Cut Water Plane Area:		29.194675 m²				
Centre of Floatation:	X:	2.5828e-4 m	Y:	-0.3750199 m		
Principal 2nd Moment of Area:	X:	340.79028 m^4	Y:	340.83478 m^4		
Angle Principal Axis makes with X (FRA):		3670.1665 °				
Small Angle Stability Parameters						
C.O.G. to C.O.B.(BG):		1.4009058 m				
Metacentric Heights (GMX/GMY):		2.2065516 m		2.2070224 m		
COB to Metacentre (BMX/BMY):		3.6074574 m		3.6079283 m		
Restoring Moments/Degree Rotations (MX/MY):		638.26251 N.m/°		638.39868 N.m/°		

Figure 4.44. AQWA hydrostatic results

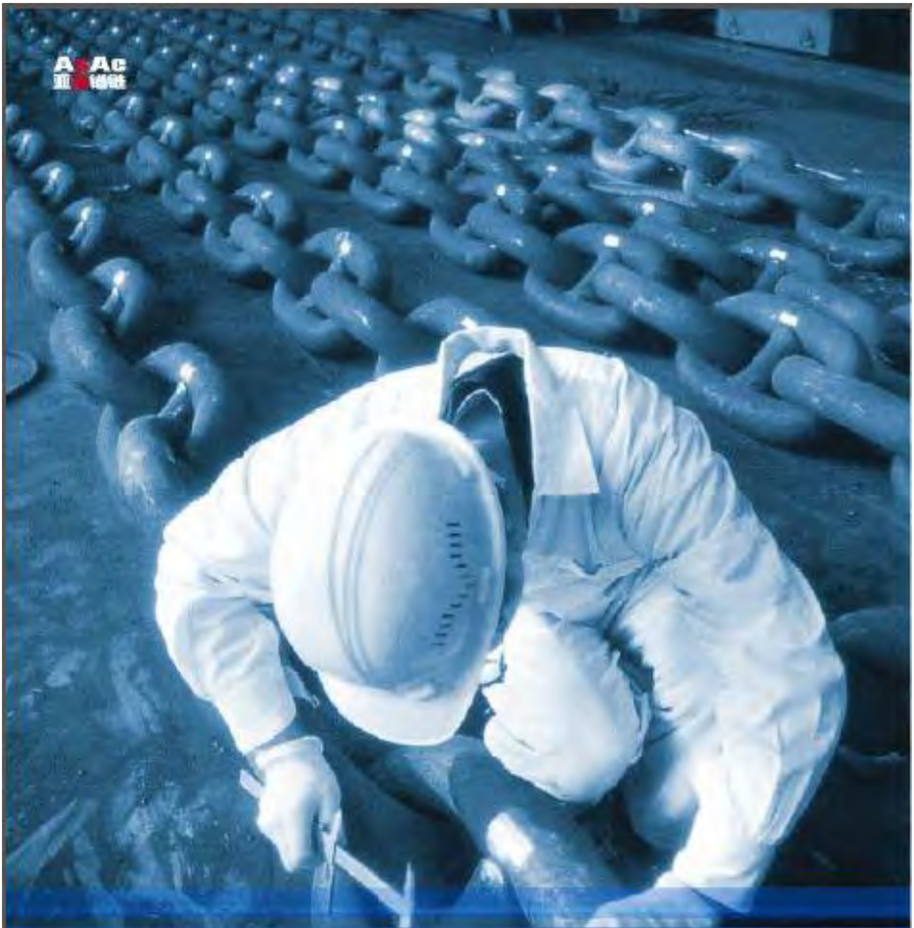
Attachment 1

MOORING LINE SPECIFICATION

Asian Star

Anchor Chain & Mooring Chain

江苏亚星锚链股份有限公司 Asian Star Anchor Chain Co., Ltd. Jiangsu(AsAc)



国际认可证书

International Approval Certificates

AsAc

国际认可证书 | International Approval Certificates

质量&健康、安全和环境管理体系认可证书
Quality & HSE Approval Certificates

ISO9001, API-Q1, ISO14001, OHSAS18001 and HSE

国际认可证书 International Approval Certificates

船用链认可证书
Anchor Chain Approval Certificates

ABS, BV, CCS, CR, DNV, GL, KR, LR, NK, RINA, RMRS

注： The certificat is to be subject to the latest edition.

系泊链认可证书
Mooring Chain Approval Certificates

ABS、BV、DNV、LR、API-2F

注：The certificate is to be subject to the latest edition

链径 Diameter Of Chain mm	锚链 ANCHOR CHAIN			
	等级 Grade 2		等级 Grade 3	
	拉力负荷 PL	破断负荷 BL	拉力负荷 PL	破断负荷 BL
	KN	KN	KN	KN
14	82	116	---	---
16	107	150	---	---
17.5	127	179	---	---
19	150	211	---	---
20.5	175	244	---	---
22	200	280	---	---
24	237	332	---	---
26	278	389	---	---
28	321	449	449	642
30	368	514	514	735
32	417	583	583	833
34	468	655	655	937
36	523	732	732	1050
38	581	812	812	1160
40	640	896	896	1280
42	703	981	981	1400
44	769	1080	1080	1540
46	837	1170	1170	1680
48	908	1270	1270	1810
50	981	1370	1370	1960

重 量 Weight(Kg)

链径 Chain Diameter (mm)	有档锚链 Stud Link Chain kg/27.5m	普环 Common Link	加大环 Enlarged Link	末端环 End Link	肯特卸扣 Kenter Shackle	连接卸扣 Joining Shackle	末端卸扣 End Shackle	转环 Swivel	A型转环卸扣 Anchor Swivel Shackle A.SW.S(a)	B型转环卸扣 Anchor Swivel Shackle A.SW.S(b)
14	128	0.26	0.39	0.32	0.6	0.67	1.5	1.05	—	—
16	150	0.35	0.49	0.57	0.65	0.95	1.52	1.34	—	—
17.5	197	0.50	0.66	0.67	0.88	1.34	2.05	1.73	—	—
19	236	0.66	0.85	1.06	1.13	1.84	2.41	2.17	—	—
20.5	268	0.80	1.02	1.06	1.36	2.2	3.25	2.2	—	—
22	324	1.04	1.30	1.58	1.64	2.66	3.95	3.5	21	7.6
24	370	1.30	1.65	1.84	2.13	3.4	5.12	4.53		9.9
26	431	1.64	2.03	2.74	2.58	4.5	6.7	5.79	42	12.5
28	496	2.04	2.48	3.23	3.3	5.19	8.1	7.25		15.7
30	563	2.48	3.58	3.74	4.15	6.32	10	9	97	19.4
32	635	2.98	4.45	4.74	5.06	8.24	11.77	10.03		23.4
34	712	3.54	5.21	5.54	6.01	9.56	14.2	12.75	116	28
36	800	4.23	5.99	6.95	6.89	11.31	16.55	14.96		33.4
38	888	4.96	6.15	7.66	8.4	13.45	19.55	17.44		39.4
40	1033	6.04	8.01	8.2	9.63	15.5	22.8	20.25	135	46
42	1084	6.65	9.04	9.92	11	18.1	26	25.4		53
44	1197	7.73	10.25	11.42	12.45	20.25	29.71	26.6		61
46	1310	8.80	11.54	13.92	14.1	23.33	34.3	30.67	156	70
48	1438	10.06	14.44	15.67	16.7	27.5	38.0	35.0		79
50	1546	11.28	16.06	17.7	19.0	31.6	45.2	40.5	284	89
52	1661	12.68	17.85	18.97	20.3	34.0	50.9	49.5		101

Lankhorst | *Ropes*

Offshore
Steel Wire Ropes

OFFSHORE DIVISION

WireCo

www.lankhorstropes.com

QUALITY SYSTEM & CERTIFICATION

Quality system


Lloyd's Register LRQA

CERTIFICATE OF APPROVAL

Royal Lankhorst
Euronete Group B.V.
Prinsengracht 2
8607 AD Sneek
The Netherlands

Lankhorst Euronete
Portugal, SA
Rua da Cerfil
(Capitão Gramaxo)
PO Box 1029
Maia 4471-909
Portugal

ISO 9001 : 2008

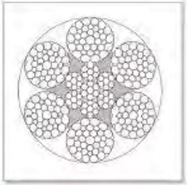
Research, development, production and supply of natural- and synthetic yarns, ropes, netting and fabric. Supply of steel wire, combination ropes and hardware. Testing and product certification.

Certification

WireCo WorldGroup

OFFSHORE DIVISION

6x36 WS+IWRC



Galva-nized | Greased | 1960 | RHRL

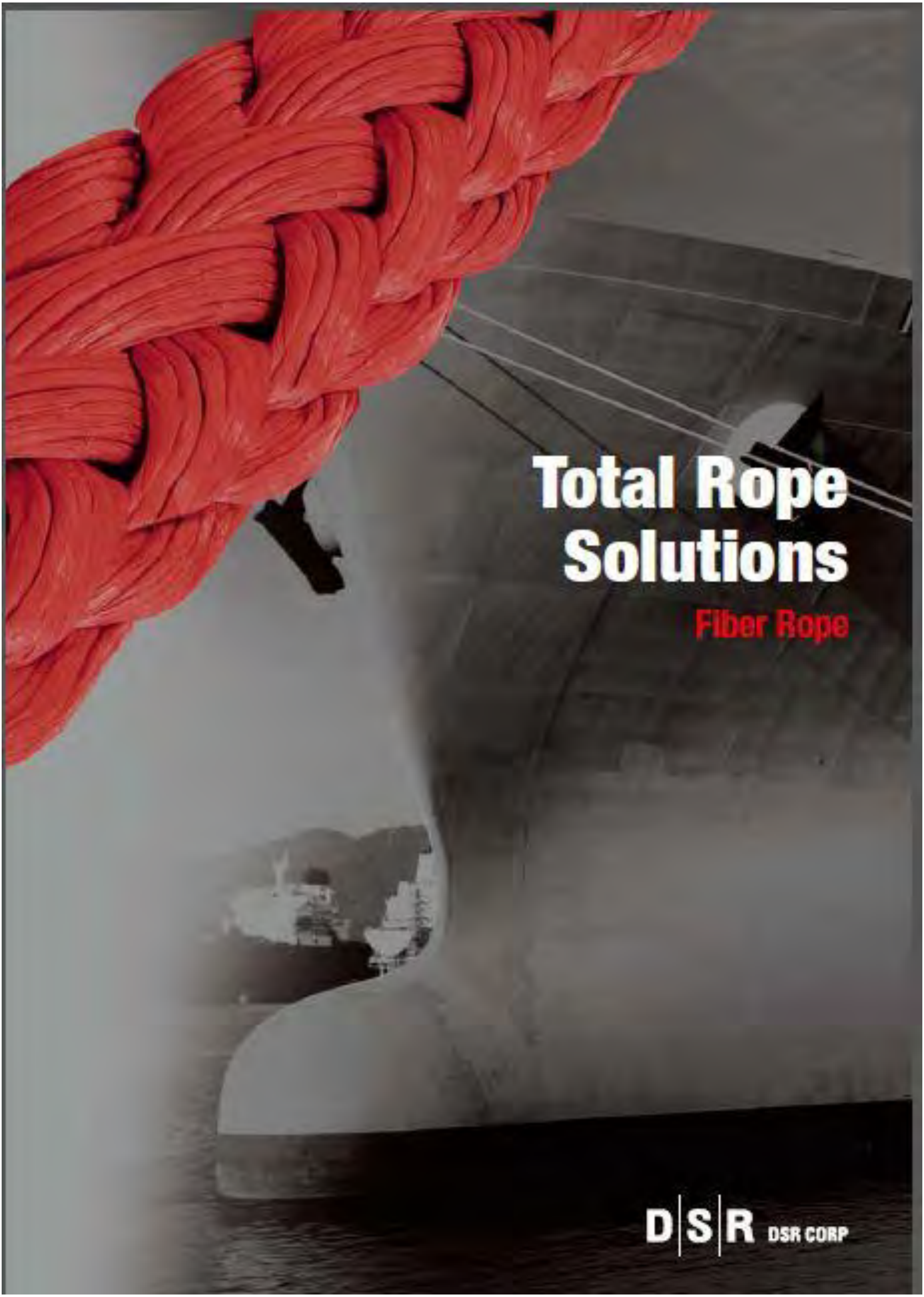
Optional:

GALFAN® coating

Standard wire rope with higher breaking strength. Used for all kinds of purposes, i.e. luffing, mooring, towing, anchoring and coupling push barges. The independent wire rope core provides more strength and stability to the wire rope compared to fibre core. Construction according to ISO standard.

Diameter (mm)	Weight (kg/m)	MBF (kN)	MBF (MT)
32	4,19	715	72,9
34	4,73	807	82,3
36	5,30	904	92,2
38	5,91	1008	103
40	6,54	1116	114
42	7,22	1231	126
44	7,92	1351	138
46	8,65	1476	151
48	9,42	1608	164
50	10,2	1744	178
51	10,6	1815	185
52	11,1	1887	192
54	11,9	2030	207
56	12,8	2188	223
58	13,8	2350	240
60	14,7	2512	256
62	15,8	2680	273
64	17	2858	292
66	17,9	3039	310
68	19	3226	329
70	20	3419	349
72	21,2	3617	369
74	22,4	3821	390
76	23,6	4030	411
80*	26,2	4466	455

CASAR · Union · OLIVEIRA · camesa · drumet



Total Rope Solutions

Fiber Rope

D|S|R DSR CORP

In the bed giving you cozy sleep,

With fisherman's dream of full net,

In the beautiful piano melody,

Together with calm rest of ships mooring at harbor,

As cranes lift up cargos,

At the busy elevators you are using everyday,

Inside of a car taking you wherever you want to go,

DSR is always with you anytime and anywhere.

CONTENTS

FIBER ROPE

Offshore

Oil industry, Gas industry, Offshore Plant

Fishing

Drag net fishery, Surrounded net, Fixed shore net, Gill net fishing, Stow net, Trawl net, Pots etc.

Sling

Container Bag, Rope Sling, General use in home, Farm and industry etc.

Shipping

Mooring/Hawser, Cargo-working, Towing-working etc.

Leisure

Yacht, Climbing

SuperMax® Plus Rope

SuperMax® Plus Rope consists of SuperMax®(UHMWPE) braided rope core inside and Polyester fiber braided jacket. This combination offers the property of non-rotating and anti-kinking while maintaining higher strength than normal 12 S/T braided rope. Braided jacket providing superior abrasion resistance makes the rope round shape and protects the core from foreign matter.

SuperMax® Plus Rope 12-S/T

Dia		Circ.	Weight			Breaking Strength	
mm	Inch	Inch	KGS/100M	LBS/100FT	LBS/100FM	Ton	kN
26	1-1/32	3-1/4	43.50	29.23	175.4	54.0	530.3
28	1-1/8	3-1/2	50.00	33.60	201.6	63.0	618.6
30	1-3/16	3-3/4	54.20	36.42	218.5	68.0	667.7
32	1-1/4	4	64.00	43.01	258.0	74.0	726.6
34	1-11/32	4-1/4	71.80	48.25	289.5	84.0	824.8
36	1-7/16	4-1/2	78.90	53.02	318.1	93.0	913.2
38	1-1/2	4-3/4	86.10	57.86	347.1	102.0	1,002
40	1-19/32	5	94.80	63.70	382.2	114.0	1,119
42	1-21/32	5-1/4	104.6	70.29	421.7	127.0	1,247
44	1-3/4	5-1/2	111.0	74.60	447.5	135.0	1,326
48	1-7/8	6	137.0	92.06	552.3	165.0	1,620
52	2-1/16	6-1/2	160.0	107.5	645.1	195.0	1,915
56	2-1/4	7	183.0	123.0	737.8	230.0	2,258
60	2-3/8	7-1/2	205.0	137.8	826.5	263.0	2,583
64	2-1/2	8	236.0	158.6	951.5	308.0	3,024
68	2-11/16	8-1/2	264.0	177.4	1,064	345.0	3,388
72	2-7/8	9	295.0	198.2	1,189	380.0	3,731
76	3	9-3/8	331.0	222.4	1,335	429.0	4,213
80	3-5/32	10	359.0	241.2	1,447	458.0	4,497
88	3-7/16	11	421.0	282.9	1,697	540.0	5,303
96	3-13/16	12	511.0	343.4	2,060	626.0	6,147
104	4-1/8	13	598.0	401.8	2,411	745.0	7,316
112	4-7/16	14	694.0	466.3	2,798	833.0	8,180
120	4-3/4	15	786.0	528.2	3,169	955.0	9,378

Manufactured and tested according to ISO and BSEN standard
Warning : The minimum breaking strength should never be considered as the safe working load of the rope

- Material : Inside - UHMWPE / Outside - Polyester fiber
- Melting Point : 150℃ / 265℃
- Elongation at break : 4 ~ 5%
- Abrasion resistance : Very Good
- UV resistance : Good

Characteristics

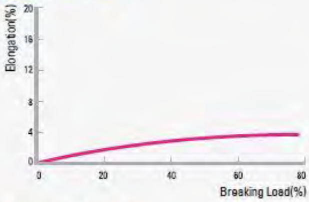
- High Strength
- Lowest elongation
- Dry & Wet conditions : Wet strength equals dry strength
- Non-rotating and anti-kinking
- Longer life and easy handling

Applications

- Mooring Lines
- Anchor Lines
- Towing Rope
- Tug Rope

Maximum strength to weight ratio, and strength comparable to steel wire rope

■ Elongation Table



■ Breaking Strength

Attachment 2

RESPONSE AMPLITUDE OPERATOR (RAO)

RAO – Chain – Type 1 - Heave

Encounter	Heave RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011
0.446	1.069	1.069	1.068	1.068	1.068	1.069	1.069	1.069	1.068	1.068	1.068	1.069
0.703	1.252	1.249	1.243	1.240	1.243	1.249	1.252	1.249	1.243	1.241	1.243	1.249
0.959	1.011	1.134	1.362	1.471	1.362	1.134	1.010	1.128	1.355	1.464	1.356	1.129
1.216	6.045	6.158	6.307	6.373	6.305	6.156	6.043	6.091	6.280	6.393	6.280	6.093
1.473	0.511	0.541	0.534	0.524	0.534	0.541	0.510	0.498	0.536	0.570	0.536	0.499
1.730	0.027	0.088	0.033	0.074	0.033	0.088	0.027	0.068	0.036	0.096	0.036	0.068
1.986	0.061	0.071	0.057	0.044	0.057	0.071	0.061	0.049	0.059	0.070	0.060	0.049
2.243	0.031	0.027	0.030	0.032	0.030	0.027	0.031	0.033	0.030	0.026	0.030	0.033
2.500	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020
2.756	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006
3.013	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004
3.270	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008
3.527	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009
3.783	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011
4.040	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002
4.297	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003
4.553	0.001	0.003	0.001	0.003	0.002	0.003	0.001	0.003	0.001	0.003	0.001	0.003
4.810	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004
5.067	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003

RAO – Chain – Type 1 - Pitch

Encounter	Pitch RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.080	0.307	0.519	0.597	0.519	0.306	0.080	0.307	0.519	0.597	0.519	0.306
0.446	0.591	1.016	1.555	1.766	1.555	1.016	0.591	1.016	1.555	1.766	1.555	1.016
0.703	3.067	3.655	4.672	5.135	4.673	3.656	3.067	3.643	4.654	5.115	4.655	3.645
0.959	47.815	47.547	47.132	47.428	47.064	47.454	47.776	45.915	44.247	44.091	44.197	45.880
1.216	21.687	24.360	26.990	28.098	26.987	24.355	21.681	20.235	20.540	21.148	20.543	20.240
1.473	0.525	1.000	2.594	3.469	2.596	1.001	0.526	0.593	2.567	3.640	2.569	0.595
1.730	1.616	1.093	1.050	1.846	1.051	1.092	1.616	0.752	1.592	2.612	1.594	0.751
1.986	0.783	0.518	0.819	1.238	0.818	0.517	0.785	0.763	0.558	0.818	0.555	0.759
2.243	0.302	0.407	0.362	0.524	0.361	0.407	0.302	0.351	0.275	0.714	0.273	0.350
2.500	0.030	0.309	0.156	0.329	0.155	0.309	0.030	0.217	0.148	0.596	0.147	0.217
2.756	0.136	0.218	0.048	0.189	0.048	0.219	0.136	0.110	0.099	0.446	0.098	0.110
3.013	0.100	0.128	0.112	0.146	0.111	0.129	0.099	0.064	0.083	0.281	0.083	0.065
3.270	0.047	0.036	0.100	0.101	0.100	0.036	0.047	0.041	0.059	0.091	0.059	0.041
3.527	0.032	0.011	0.052	0.082	0.052	0.011	0.032	0.036	0.013	0.031	0.014	0.036
3.783	0.022	0.024	0.029	0.045	0.029	0.024	0.021	0.044	0.027	0.047	0.027	0.044
4.040	0.024	0.016	0.025	0.073	0.024	0.016	0.023	0.031	0.027	0.037	0.028	0.032
4.297	0.045	0.028	0.052	0.092	0.052	0.028	0.045	0.050	0.078	0.047	0.077	0.048
4.553	0.025	0.009	0.006	0.019	0.007	0.009	0.025	0.006	0.026	0.013	0.026	0.006
4.810	0.023	0.014	0.007	0.031	0.007	0.014	0.023	0.007	0.018	0.020	0.018	0.007
5.067	0.023	0.003	0.014	0.010	0.014	0.003	0.023	0.006	0.012	0.011	0.012	0.005

RAO – Chain – Type 1 - Rolling

Encounter	Rolling RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.866	0.751	0.436	0.000	0.435	0.751	0.866	0.751	0.436	0.000	0.435	0.751
0.446	1.869	1.627	0.949	0.000	0.949	1.627	1.869	1.627	0.949	0.000	0.950	1.627
0.703	4.878	4.283	2.539	0.002	2.542	4.284	4.878	4.285	2.541	0.002	2.543	4.286
0.959	57.152	51.706	32.278	0.114	32.070	51.566	57.150	51.829	32.385	0.104	32.192	51.696
1.216	4.065	4.072	2.875	0.022	2.855	4.045	4.027	4.037	2.842	0.022	2.884	4.078
1.473	1.477	2.151	1.798	0.005	1.805	2.157	1.477	1.960	1.662	0.005	1.670	1.965
1.730	1.067	2.121	1.788	0.003	1.794	2.126	1.070	1.492	1.371	0.004	1.374	1.492
1.986	0.873	0.749	0.470	0.003	0.473	0.749	0.874	1.143	0.758	0.001	0.757	1.141
2.243	0.442	0.642	0.251	0.002	0.254	0.642	0.443	0.502	0.231	0.000	0.230	0.501
2.500	0.225	0.519	0.042	0.001	0.041	0.518	0.226	0.313	0.088	0.001	0.087	0.313
2.756	0.091	0.380	0.086	0.001	0.085	0.380	0.091	0.171	0.145	0.001	0.145	0.172
3.013	0.115	0.233	0.065	0.000	0.066	0.233	0.115	0.119	0.113	0.001	0.113	0.119
3.270	0.094	0.072	0.025	0.001	0.027	0.072	0.095	0.079	0.076	0.001	0.075	0.079
3.527	0.034	0.024	0.012	0.001	0.013	0.024	0.035	0.065	0.048	0.000	0.047	0.065
3.783	0.022	0.040	0.022	0.000	0.022	0.041	0.022	0.049	0.029	0.000	0.029	0.050
4.040	0.026	0.031	0.028	0.001	0.028	0.030	0.027	0.061	0.020	0.000	0.019	0.061
4.297	0.079	0.044	0.062	0.001	0.062	0.044	0.079	0.073	0.026	0.000	0.026	0.073
4.553	0.015	0.012	0.030	0.000	0.030	0.012	0.015	0.014	0.015	0.000	0.015	0.013
4.810	0.008	0.019	0.025	0.000	0.025	0.019	0.008	0.022	0.015	0.000	0.015	0.021
5.067	0.008	0.008	0.019	0.000	0.019	0.008	0.008	0.006	0.021	0.000	0.020	0.006

RAO – Chain – Type 1 - Surge

Encounter	Surge RAO, z_{x0}/z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	2.310	2.000	1.155	0.000	1.155	2.000	2.310	2.000	1.155	0.000	1.155	2.000
0.446	1.024	0.887	0.512	0.000	0.512	0.887	1.024	0.887	0.512	0.000	0.512	0.887
0.703	0.697	0.603	0.348	0.000	0.348	0.603	0.697	0.603	0.348	0.000	0.348	0.603
0.959	1.009	0.877	0.513	0.001	0.512	0.876	1.009	0.885	0.521	0.001	0.520	0.884
1.216	0.544	0.467	0.267	0.000	0.267	0.467	0.544	0.476	0.277	0.000	0.276	0.476
1.473	0.415	0.341	0.188	0.000	0.188	0.341	0.415	0.380	0.226	0.000	0.226	0.380
1.730	0.290	0.207	0.094	0.000	0.094	0.207	0.290	0.303	0.192	0.000	0.193	0.303
1.986	0.151	0.078	0.025	0.000	0.025	0.078	0.150	0.195	0.137	0.000	0.137	0.195
2.243	0.036	0.049	0.061	0.000	0.061	0.050	0.035	0.079	0.063	0.000	0.063	0.080
2.500	0.031	0.080	0.048	0.000	0.048	0.080	0.032	0.100	0.062	0.000	0.062	0.100
2.756	0.054	0.091	0.023	0.000	0.023	0.091	0.054	0.104	0.088	0.000	0.088	0.104
3.013	0.039	0.092	0.034	0.000	0.034	0.092	0.039	0.095	0.077	0.000	0.077	0.095
3.270	0.036	0.036	0.013	0.000	0.013	0.035	0.036	0.047	0.036	0.000	0.036	0.047
3.527	0.028	0.009	0.008	0.000	0.008	0.009	0.028	0.030	0.020	0.000	0.020	0.030
3.783	0.021	0.008	0.011	0.000	0.011	0.008	0.021	0.021	0.010	0.000	0.010	0.021
4.040	0.012	0.012	0.004	0.000	0.004	0.012	0.012	0.008	0.008	0.000	0.008	0.008
4.297	0.061	0.096	0.063	0.001	0.063	0.096	0.061	0.134	0.026	0.001	0.026	0.134
4.553	0.004	0.015	0.004	0.000	0.004	0.015	0.004	0.011	0.002	0.000	0.002	0.011
4.810	0.005	0.009	0.003	0.000	0.003	0.009	0.005	0.007	0.002	0.000	0.002	0.007
5.067	0.005	0.006	0.003	0.000	0.003	0.006	0.005	0.006	0.002	0.000	0.002	0.006

RAO – Chain – Type 1 - Sway

Encounter	Sway RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.006	1.158	2.005	2.316	2.005	1.158	0.006	1.158	2.005	2.316	2.005	1.158
0.446	0.011	0.513	0.889	1.027	0.889	0.513	0.011	0.513	0.889	1.027	0.889	0.513
0.703	0.031	0.350	0.605	0.698	0.605	0.350	0.031	0.350	0.605	0.698	0.605	0.350
0.959	0.318	0.520	0.786	0.891	0.786	0.519	0.318	0.522	0.780	0.881	0.779	0.521
1.216	0.160	0.430	0.637	0.715	0.637	0.430	0.160	0.134	0.315	0.382	0.315	0.134
1.473	0.045	0.200	0.372	0.441	0.372	0.200	0.045	0.218	0.346	0.392	0.346	0.218
1.730	0.063	0.119	0.278	0.351	0.278	0.119	0.063	0.174	0.221	0.241	0.221	0.174
1.986	0.079	0.046	0.167	0.226	0.167	0.046	0.079	0.112	0.090	0.089	0.090	0.112
2.243	0.070	0.028	0.049	0.093	0.049	0.028	0.070	0.046	0.039	0.057	0.039	0.046
2.500	0.059	0.046	0.049	0.116	0.049	0.046	0.059	0.058	0.035	0.092	0.035	0.058
2.756	0.064	0.053	0.082	0.119	0.082	0.053	0.064	0.060	0.020	0.105	0.019	0.060
3.013	0.065	0.053	0.067	0.110	0.067	0.053	0.064	0.055	0.007	0.106	0.007	0.055
3.270	0.024	0.021	0.041	0.054	0.041	0.021	0.024	0.027	0.022	0.041	0.023	0.027
3.527	0.008	0.005	0.027	0.035	0.027	0.005	0.008	0.018	0.020	0.010	0.020	0.018
3.783	0.001	0.005	0.018	0.025	0.018	0.005	0.001	0.012	0.019	0.009	0.019	0.012
4.040	0.002	0.007	0.011	0.009	0.011	0.007	0.002	0.004	0.009	0.014	0.009	0.005
4.297	0.029	0.060	0.054	0.166	0.054	0.059	0.028	0.083	0.069	0.120	0.069	0.082
4.553	0.003	0.009	0.003	0.013	0.002	0.009	0.003	0.006	0.005	0.018	0.005	0.006
4.810	0.001	0.005	0.004	0.008	0.004	0.005	0.001	0.004	0.005	0.010	0.005	0.004
5.067	0.001	0.004	0.004	0.006	0.004	0.004	0.001	0.003	0.004	0.007	0.004	0.003

RAO – Chain – Type 1 - Yaw

Encounter	Yaw RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.609	1.403	0.822	0.002	0.819	1.402	1.609	1.403	0.822	0.002	0.819	1.402
0.446	0.685	0.620	0.389	0.001	0.388	0.619	0.685	0.620	0.389	0.001	0.388	0.619
0.703	0.409	0.419	0.317	0.001	0.315	0.418	0.409	0.419	0.317	0.001	0.315	0.418
0.959	0.520	0.611	0.540	0.006	0.548	0.617	0.521	0.617	0.546	0.006	0.554	0.622
1.216	0.061	0.310	0.597	0.008	0.613	0.325	0.046	0.331	0.618	0.008	0.604	0.317
1.473	0.526	0.225	0.923	0.002	0.924	0.226	0.526	0.251	0.948	0.002	0.948	0.250
1.730	1.101	0.131	1.343	0.001	1.341	0.129	1.102	0.190	1.402	0.002	1.403	0.190
1.986	1.670	0.045	1.758	0.000	1.759	0.046	1.671	0.114	1.838	0.001	1.839	0.116
2.243	1.933	0.029	1.933	0.001	1.935	0.030	1.934	0.048	1.985	0.000	1.985	0.048
2.500	1.757	0.054	1.728	0.001	1.730	0.055	1.758	0.068	1.716	0.000	1.716	0.067
2.756	1.425	0.071	1.399	0.002	1.401	0.072	1.425	0.080	1.317	0.001	1.318	0.079
3.013	0.955	0.082	0.964	0.001	0.962	0.083	0.953	0.085	0.935	0.001	0.935	0.085
3.270	0.293	0.031	0.324	0.000	0.324	0.031	0.292	0.040	0.355	0.000	0.354	0.042
3.527	0.042	0.007	0.026	0.000	0.026	0.007	0.042	0.025	0.021	0.000	0.022	0.025
3.783	0.112	0.006	0.107	0.000	0.107	0.006	0.111	0.016	0.106	0.000	0.106	0.016
4.040	0.063	0.009	0.073	0.000	0.073	0.008	0.063	0.005	0.075	0.000	0.075	0.005
4.297	0.984	0.465	0.868	0.009	0.866	0.473	0.988	0.648	1.032	0.007	1.033	0.658
4.553	0.182	0.015	0.184	0.001	0.184	0.015	0.183	0.010	0.180	0.000	0.181	0.011
4.810	0.133	0.008	0.129	0.001	0.128	0.008	0.133	0.007	0.128	0.000	0.128	0.006
5.067	0.038	0.005	0.041	0.000	0.041	0.006	0.038	0.005	0.040	0.000	0.040	0.004

RAO – Wire – Type 1 - Heave

Encounter	Heave RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.011	1.011	1.010	1.010	1.010	1.011	1.011	1.011	1.010	1.010	1.010	1.011
0.446	1.069	1.069	1.068	1.067	1.068	1.069	1.069	1.069	1.068	1.067	1.068	1.069
0.703	1.250	1.247	1.241	1.238	1.241	1.247	1.250	1.247	1.242	1.239	1.241	1.247
0.959	1.008	1.132	1.360	1.468	1.359	1.131	1.007	1.126	1.352	1.461	1.353	1.127
1.216	6.155	6.270	6.421	6.489	6.420	6.268	6.153	6.202	6.394	6.509	6.394	6.204
1.473	0.515	0.545	0.539	0.528	0.538	0.545	0.514	0.502	0.540	0.574	0.540	0.502
1.730	0.027	0.088	0.033	0.074	0.033	0.088	0.027	0.068	0.036	0.096	0.036	0.068
1.986	0.061	0.071	0.057	0.045	0.058	0.071	0.061	0.049	0.060	0.070	0.060	0.050
2.243	0.031	0.027	0.030	0.032	0.030	0.027	0.031	0.033	0.030	0.026	0.030	0.034
2.500	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020
2.756	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006
3.013	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004
3.270	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008
3.527	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009
3.783	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011
4.040	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002
4.297	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003
4.553	0.002	0.003	0.001	0.003	0.002	0.003	0.001	0.003	0.002	0.003	0.001	0.003
4.810	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004
5.067	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003

RAO – Wire – Type 1 - Pitch

Encounter	Pitch RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.080	0.307	0.519	0.598	0.519	0.306	0.080	0.307	0.519	0.598	0.519	0.306
0.446	0.590	1.015	1.555	1.767	1.556	1.016	0.590	1.016	1.555	1.767	1.555	1.016
0.703	3.056	3.647	4.670	5.134	4.671	3.649	3.056	3.636	4.652	5.115	4.653	3.637
0.959	47.659	47.412	47.064	47.400	46.996	47.319	47.620	45.796	44.210	44.102	44.160	45.760
1.216	22.093	24.759	27.347	28.431	27.344	24.754	22.087	20.582	20.791	21.352	20.793	20.587
1.473	0.520	1.006	2.602	3.477	2.604	1.007	0.522	0.596	2.573	3.647	2.576	0.599
1.730	1.616	1.093	1.051	1.847	1.053	1.092	1.616	0.752	1.593	2.613	1.595	0.751
1.986	0.783	0.517	0.818	1.236	0.817	0.517	0.784	0.762	0.557	0.817	0.554	0.759
2.243	0.303	0.407	0.361	0.524	0.360	0.407	0.302	0.351	0.275	0.714	0.273	0.350
2.500	0.029	0.309	0.156	0.328	0.155	0.309	0.030	0.217	0.148	0.595	0.147	0.216
2.756	0.136	0.218	0.047	0.188	0.048	0.218	0.136	0.109	0.099	0.445	0.098	0.109
3.013	0.100	0.128	0.111	0.145	0.111	0.129	0.099	0.064	0.083	0.280	0.083	0.065
3.270	0.047	0.036	0.100	0.100	0.100	0.036	0.047	0.041	0.058	0.091	0.059	0.041
3.527	0.032	0.011	0.052	0.082	0.052	0.011	0.032	0.036	0.013	0.031	0.014	0.036
3.783	0.022	0.024	0.029	0.045	0.029	0.024	0.021	0.044	0.027	0.047	0.027	0.044
4.040	0.024	0.016	0.025	0.073	0.024	0.016	0.023	0.031	0.027	0.037	0.028	0.032
4.297	0.045	0.027	0.052	0.093	0.052	0.028	0.045	0.050	0.078	0.047	0.077	0.049
4.553	0.025	0.009	0.006	0.019	0.007	0.009	0.025	0.006	0.026	0.013	0.026	0.006
4.810	0.023	0.014	0.007	0.031	0.007	0.014	0.023	0.007	0.018	0.020	0.018	0.007
5.067	0.023	0.003	0.014	0.010	0.014	0.003	0.023	0.006	0.012	0.011	0.012	0.005

RAO – Wire – Type 1 - Roll

Encounter	Rolling RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.866	0.752	0.436	0.000	0.436	0.751	0.866	0.752	0.436	0.000	0.436	0.751
0.446	1.870	1.628	0.950	0.000	0.950	1.628	1.870	1.628	0.950	0.000	0.950	1.628
0.703	4.882	4.287	2.541	0.002	2.544	4.288	4.882	4.288	2.543	0.002	2.545	4.290
0.959	57.260	51.800	32.332	0.114	32.124	51.660	57.259	51.922	32.439	0.105	32.245	51.789
1.216	4.072	4.078	2.878	0.022	2.857	4.049	4.033	4.042	2.844	0.023	2.886	4.083
1.473	1.481	2.153	1.799	0.005	1.806	2.159	1.481	1.962	1.663	0.005	1.671	1.967
1.730	1.069	2.122	1.789	0.003	1.795	2.127	1.072	1.492	1.371	0.004	1.375	1.493
1.986	0.872	0.748	0.470	0.003	0.473	0.748	0.873	1.142	0.757	0.001	0.756	1.140
2.243	0.441	0.642	0.252	0.002	0.254	0.642	0.443	0.502	0.230	0.000	0.230	0.500
2.500	0.225	0.519	0.042	0.001	0.041	0.518	0.227	0.313	0.088	0.001	0.087	0.313
2.756	0.092	0.380	0.086	0.001	0.085	0.379	0.092	0.171	0.144	0.001	0.144	0.171
3.013	0.115	0.233	0.065	0.000	0.066	0.232	0.115	0.119	0.112	0.001	0.112	0.119
3.270	0.094	0.072	0.025	0.001	0.027	0.071	0.095	0.079	0.076	0.001	0.075	0.079
3.527	0.034	0.024	0.012	0.001	0.014	0.024	0.035	0.065	0.048	0.000	0.047	0.065
3.783	0.022	0.040	0.022	0.000	0.022	0.041	0.022	0.049	0.029	0.000	0.028	0.049
4.040	0.026	0.031	0.028	0.001	0.028	0.030	0.027	0.061	0.019	0.000	0.019	0.061
4.297	0.079	0.044	0.062	0.001	0.062	0.044	0.079	0.073	0.026	0.000	0.026	0.073
4.553	0.015	0.012	0.030	0.000	0.030	0.012	0.015	0.014	0.015	0.000	0.015	0.013
4.810	0.008	0.019	0.025	0.000	0.025	0.019	0.008	0.022	0.015	0.000	0.015	0.021
5.067	0.008	0.008	0.019	0.000	0.019	0.008	0.008	0.006	0.021	0.000	0.020	0.006

RAO – Wire – Type 1 - Surge

Encounter	Surge RAO, z_{x0}/z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	2.314	2.004	1.157	0.000	1.157	2.004	2.314	2.004	1.157	0.000	1.157	2.004
0.446	1.026	0.888	0.513	0.000	0.513	0.888	1.026	0.888	0.513	0.000	0.513	0.888
0.703	0.698	0.604	0.349	0.000	0.349	0.604	0.698	0.604	0.349	0.000	0.349	0.604
0.959	1.012	0.879	0.514	0.001	0.513	0.879	1.012	0.887	0.522	0.001	0.521	0.886
1.216	0.545	0.467	0.268	0.000	0.268	0.468	0.546	0.477	0.277	0.000	0.277	0.477
1.473	0.416	0.342	0.188	0.000	0.189	0.342	0.416	0.381	0.227	0.000	0.226	0.380
1.730	0.291	0.207	0.094	0.000	0.095	0.208	0.291	0.303	0.193	0.000	0.193	0.303
1.986	0.151	0.078	0.025	0.000	0.025	0.078	0.151	0.195	0.138	0.000	0.138	0.195
2.243	0.036	0.050	0.061	0.000	0.061	0.050	0.035	0.080	0.063	0.000	0.063	0.080
2.500	0.031	0.080	0.048	0.000	0.048	0.080	0.032	0.101	0.063	0.000	0.062	0.101
2.756	0.054	0.091	0.023	0.000	0.023	0.091	0.054	0.104	0.088	0.000	0.088	0.104
3.013	0.039	0.092	0.034	0.000	0.034	0.092	0.039	0.095	0.077	0.000	0.077	0.095
3.270	0.036	0.036	0.013	0.000	0.013	0.036	0.036	0.047	0.036	0.000	0.036	0.047
3.527	0.028	0.009	0.008	0.000	0.008	0.009	0.028	0.031	0.020	0.000	0.020	0.031
3.783	0.021	0.008	0.011	0.000	0.011	0.008	0.021	0.021	0.010	0.000	0.010	0.021
4.040	0.012	0.012	0.004	0.000	0.004	0.012	0.012	0.008	0.008	0.000	0.008	0.008
4.297	0.062	0.097	0.064	0.001	0.063	0.097	0.062	0.135	0.026	0.001	0.026	0.135
4.553	0.004	0.015	0.004	0.000	0.004	0.015	0.004	0.011	0.002	0.000	0.002	0.011
4.810	0.005	0.009	0.003	0.000	0.003	0.009	0.005	0.007	0.002	0.000	0.002	0.007
5.067	0.005	0.006	0.003	0.000	0.003	0.006	0.005	0.006	0.002	0.000	0.002	0.006

RAO – Wire – Type 1 - Sway

Encounter	Sway RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.006	1.160	2.009	2.320	2.009	1.160	0.006	1.160	2.009	2.320	2.009	1.160
0.446	0.011	0.514	0.891	1.029	0.891	0.514	0.011	0.514	0.891	1.029	0.891	0.514
0.703	0.031	0.351	0.606	0.700	0.606	0.351	0.031	0.351	0.606	0.700	0.606	0.351
0.959	0.318	0.521	0.788	0.894	0.788	0.520	0.317	0.523	0.782	0.883	0.782	0.522
1.216	0.162	0.434	0.642	0.720	0.642	0.434	0.162	0.129	0.311	0.378	0.311	0.128
1.473	0.045	0.201	0.373	0.442	0.373	0.200	0.045	0.218	0.347	0.393	0.346	0.218
1.730	0.063	0.119	0.279	0.352	0.279	0.119	0.063	0.174	0.222	0.241	0.222	0.174
1.986	0.079	0.046	0.167	0.227	0.167	0.046	0.079	0.112	0.091	0.090	0.091	0.112
2.243	0.070	0.028	0.049	0.093	0.049	0.028	0.070	0.046	0.039	0.058	0.039	0.046
2.500	0.059	0.046	0.050	0.116	0.050	0.046	0.059	0.058	0.035	0.092	0.035	0.058
2.756	0.064	0.053	0.082	0.120	0.082	0.053	0.064	0.060	0.020	0.106	0.019	0.060
3.013	0.065	0.053	0.067	0.110	0.067	0.053	0.064	0.055	0.007	0.106	0.007	0.055
3.270	0.024	0.021	0.041	0.054	0.041	0.021	0.024	0.027	0.023	0.041	0.023	0.027
3.527	0.008	0.005	0.028	0.035	0.028	0.005	0.008	0.018	0.020	0.010	0.020	0.018
3.783	0.001	0.005	0.018	0.025	0.018	0.005	0.001	0.012	0.019	0.009	0.019	0.012
4.040	0.002	0.007	0.011	0.009	0.011	0.007	0.002	0.004	0.009	0.014	0.009	0.005
4.297	0.029	0.060	0.054	0.167	0.055	0.060	0.028	0.084	0.070	0.120	0.069	0.083
4.553	0.003	0.009	0.003	0.013	0.002	0.009	0.003	0.006	0.005	0.018	0.005	0.006
4.810	0.001	0.005	0.004	0.008	0.004	0.005	0.001	0.004	0.005	0.010	0.005	0.004
5.067	0.001	0.004	0.004	0.006	0.004	0.004	0.001	0.003	0.004	0.007	0.004	0.003

RAO – Wire – Type 1 - Yaw

Encounter	Yaw RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.607	1.401	0.821	0.002	0.818	1.400	1.607	1.401	0.821	0.002	0.818	1.400
0.446	0.684	0.619	0.389	0.001	0.387	0.618	0.684	0.619	0.389	0.001	0.387	0.618
0.703	0.408	0.419	0.316	0.001	0.314	0.417	0.408	0.419	0.316	0.001	0.314	0.417
0.959	0.520	0.611	0.539	0.006	0.548	0.617	0.520	0.617	0.546	0.006	0.553	0.622
1.216	0.061	0.309	0.596	0.009	0.613	0.325	0.046	0.330	0.618	0.008	0.603	0.316
1.473	0.527	0.225	0.923	0.002	0.924	0.225	0.526	0.251	0.948	0.002	0.947	0.250
1.730	1.101	0.131	1.343	0.001	1.341	0.129	1.102	0.190	1.402	0.002	1.403	0.190
1.986	1.671	0.045	1.758	0.000	1.758	0.046	1.671	0.114	1.838	0.001	1.839	0.115
2.243	1.933	0.029	1.933	0.001	1.935	0.030	1.934	0.048	1.985	0.000	1.985	0.048
2.500	1.757	0.054	1.728	0.001	1.730	0.055	1.758	0.068	1.716	0.000	1.716	0.067
2.756	1.425	0.071	1.399	0.002	1.401	0.072	1.425	0.080	1.317	0.001	1.318	0.079
3.013	0.955	0.082	0.964	0.001	0.962	0.083	0.953	0.085	0.935	0.001	0.935	0.085
3.270	0.293	0.031	0.324	0.000	0.324	0.031	0.292	0.040	0.355	0.000	0.354	0.042
3.527	0.042	0.007	0.026	0.000	0.026	0.007	0.042	0.025	0.021	0.000	0.022	0.025
3.783	0.112	0.006	0.107	0.000	0.107	0.006	0.111	0.016	0.106	0.000	0.106	0.016
4.040	0.063	0.009	0.073	0.000	0.073	0.008	0.063	0.005	0.075	0.000	0.075	0.005
4.297	0.986	0.467	0.865	0.009	0.863	0.475	0.991	0.650	1.031	0.007	1.032	0.661
4.553	0.182	0.015	0.184	0.001	0.184	0.015	0.183	0.010	0.180	0.000	0.181	0.011
4.810	0.133	0.008	0.129	0.001	0.128	0.008	0.133	0.007	0.128	0.000	0.128	0.006
5.067	0.038	0.005	0.041	0.000	0.041	0.006	0.038	0.005	0.040	0.000	0.040	0.004

RAO – Fiber – Type 1 - Heave

Encounter	Heave RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.011	1.011	1.010	1.010	1.010	1.011	1.011	1.011	1.010	1.010	1.010	1.011
0.446	1.069	1.068	1.067	1.067	1.067	1.068	1.069	1.068	1.067	1.067	1.067	1.068
0.703	1.249	1.246	1.240	1.237	1.240	1.246	1.249	1.246	1.240	1.237	1.240	1.246
0.959	1.007	1.130	1.358	1.466	1.357	1.129	1.006	1.124	1.350	1.459	1.351	1.125
1.216	6.225	6.341	6.494	6.562	6.493	6.339	6.223	6.272	6.466	6.583	6.467	6.274
1.473	0.517	0.548	0.541	0.531	0.541	0.548	0.517	0.505	0.543	0.577	0.543	0.505
1.730	0.027	0.088	0.033	0.074	0.033	0.088	0.027	0.068	0.036	0.097	0.036	0.068
1.986	0.061	0.071	0.058	0.045	0.058	0.072	0.061	0.050	0.060	0.070	0.060	0.050
2.243	0.031	0.027	0.030	0.032	0.030	0.027	0.031	0.033	0.030	0.026	0.031	0.034
2.500	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020	0.012	0.004	0.012	0.020
2.756	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006	0.002	0.005	0.002	0.006
3.013	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004	0.003	0.006	0.003	0.004
3.270	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008	0.004	0.005	0.004	0.008
3.527	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009	0.005	0.003	0.005	0.009
3.783	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011	0.005	0.002	0.005	0.011
4.040	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002
4.297	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003
4.553	0.002	0.003	0.001	0.003	0.002	0.003	0.001	0.003	0.002	0.003	0.001	0.003
4.810	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004
5.067	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003

RAO – Fiber – Type 1 - Pitch

Encounter	Pitch RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.080	0.307	0.520	0.598	0.519	0.307	0.080	0.307	0.520	0.598	0.519	0.307
0.446	0.589	1.015	1.556	1.768	1.556	1.016	0.589	1.015	1.556	1.768	1.556	1.016
0.703	3.048	3.643	4.668	5.134	4.669	3.644	3.048	3.631	4.651	5.116	4.652	3.632
0.959	47.557	47.325	47.020	47.382	46.952	47.231	47.518	45.719	44.187	44.110	44.136	45.682
1.216	22.351	25.011	27.569	28.636	27.566	25.005	22.345	20.802	20.946	21.476	20.948	20.807
1.473	0.517	1.009	2.607	3.482	2.609	1.011	0.519	0.599	2.577	3.652	2.580	0.601
1.730	1.616	1.093	1.052	1.848	1.054	1.092	1.616	0.752	1.594	2.614	1.596	0.751
1.986	0.783	0.517	0.817	1.235	0.816	0.517	0.784	0.762	0.557	0.817	0.554	0.758
2.243	0.303	0.407	0.361	0.523	0.360	0.407	0.303	0.351	0.275	0.714	0.273	0.350
2.500	0.029	0.309	0.156	0.328	0.156	0.308	0.030	0.216	0.148	0.595	0.147	0.216
2.756	0.136	0.218	0.047	0.188	0.048	0.218	0.136	0.109	0.099	0.445	0.098	0.109
3.013	0.100	0.128	0.111	0.145	0.110	0.129	0.099	0.064	0.083	0.280	0.083	0.064
3.270	0.047	0.036	0.100	0.100	0.100	0.036	0.047	0.041	0.058	0.091	0.059	0.041
3.527	0.032	0.011	0.052	0.082	0.052	0.011	0.032	0.036	0.013	0.031	0.014	0.036
3.783	0.022	0.024	0.029	0.045	0.029	0.024	0.021	0.044	0.027	0.046	0.027	0.044
4.040	0.024	0.016	0.025	0.073	0.024	0.016	0.023	0.031	0.027	0.037	0.028	0.032
4.297	0.045	0.027	0.052	0.093	0.052	0.028	0.045	0.050	0.078	0.046	0.077	0.049
4.553	0.025	0.009	0.006	0.019	0.007	0.009	0.025	0.006	0.026	0.013	0.026	0.006
4.810	0.023	0.014	0.007	0.031	0.007	0.014	0.023	0.006	0.018	0.020	0.018	0.007
5.067	0.023	0.003	0.014	0.010	0.014	0.003	0.023	0.006	0.012	0.011	0.012	0.005

RAO – Fiber – Type 1 - Roll

Encounter	Rolling RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.866	0.752	0.436	0.000	0.436	0.751	0.866	0.752	0.436	0.000	0.436	0.751
0.446	1.871	1.629	0.950	0.000	0.951	1.629	1.871	1.629	0.951	0.000	0.951	1.629
0.703	4.885	4.289	2.543	0.002	2.545	4.290	4.885	4.291	2.544	0.002	2.547	4.292
0.959	57.332	51.862	32.368	0.114	32.160	51.722	57.331	51.983	32.474	0.105	32.280	51.850
1.216	4.077	4.082	2.881	0.023	2.858	4.052	4.038	4.045	2.845	0.023	2.888	4.087
1.473	1.483	2.155	1.799	0.005	1.807	2.160	1.483	1.963	1.663	0.005	1.671	1.968
1.730	1.071	2.122	1.789	0.003	1.795	2.127	1.074	1.493	1.371	0.004	1.375	1.493
1.986	0.871	0.748	0.471	0.003	0.473	0.748	0.872	1.141	0.757	0.001	0.755	1.139
2.243	0.441	0.642	0.252	0.002	0.254	0.642	0.443	0.501	0.230	0.000	0.230	0.500
2.500	0.226	0.518	0.042	0.001	0.041	0.518	0.227	0.312	0.087	0.001	0.087	0.312
2.756	0.092	0.379	0.086	0.001	0.085	0.379	0.092	0.171	0.144	0.001	0.144	0.171
3.013	0.115	0.233	0.065	0.000	0.066	0.232	0.115	0.119	0.112	0.001	0.112	0.118
3.270	0.094	0.072	0.025	0.001	0.027	0.071	0.095	0.079	0.075	0.001	0.075	0.079
3.527	0.034	0.024	0.012	0.001	0.014	0.024	0.035	0.065	0.048	0.000	0.047	0.065
3.783	0.022	0.040	0.022	0.000	0.022	0.041	0.022	0.049	0.029	0.000	0.028	0.049
4.040	0.026	0.031	0.028	0.001	0.028	0.030	0.027	0.061	0.019	0.000	0.019	0.061
4.297	0.079	0.044	0.062	0.001	0.062	0.044	0.079	0.073	0.026	0.000	0.026	0.073
4.553	0.015	0.012	0.030	0.000	0.030	0.012	0.015	0.014	0.015	0.000	0.015	0.013
4.810	0.008	0.019	0.025	0.000	0.025	0.019	0.008	0.022	0.015	0.000	0.015	0.021
5.067	0.008	0.008	0.019	0.000	0.019	0.008	0.008	0.006	0.021	0.000	0.020	0.006

RAO – Fiber – Type 1 - Surge

Encounter	Surge RAO, z_{x0}/z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	2.317	2.007	1.159	0.000	1.159	2.007	2.317	2.007	1.159	0.000	1.159	2.007
0.446	1.027	0.889	0.513	0.000	0.513	0.889	1.027	0.889	0.513	0.000	0.513	0.889
0.703	0.699	0.605	0.349	0.000	0.349	0.605	0.699	0.605	0.349	0.000	0.349	0.605
0.959	1.013	0.881	0.515	0.001	0.514	0.880	1.014	0.889	0.523	0.001	0.522	0.888
1.216	0.546	0.468	0.268	0.000	0.268	0.468	0.546	0.478	0.277	0.000	0.277	0.477
1.473	0.416	0.342	0.189	0.000	0.189	0.342	0.416	0.381	0.227	0.000	0.227	0.381
1.730	0.291	0.208	0.094	0.000	0.095	0.208	0.291	0.304	0.193	0.000	0.193	0.304
1.986	0.151	0.078	0.025	0.000	0.025	0.078	0.151	0.196	0.138	0.000	0.138	0.196
2.243	0.036	0.050	0.061	0.000	0.061	0.050	0.036	0.080	0.063	0.000	0.063	0.080
2.500	0.031	0.080	0.048	0.000	0.048	0.080	0.032	0.101	0.063	0.000	0.063	0.101
2.756	0.054	0.091	0.023	0.000	0.024	0.091	0.054	0.104	0.088	0.000	0.088	0.104
3.013	0.039	0.092	0.034	0.000	0.034	0.092	0.039	0.096	0.078	0.000	0.077	0.095
3.270	0.036	0.036	0.013	0.000	0.013	0.036	0.036	0.047	0.036	0.000	0.036	0.047
3.527	0.028	0.009	0.008	0.000	0.008	0.009	0.028	0.031	0.020	0.000	0.020	0.031
3.783	0.021	0.008	0.011	0.000	0.011	0.008	0.021	0.021	0.010	0.000	0.010	0.021
4.040	0.012	0.012	0.004	0.000	0.004	0.012	0.012	0.008	0.008	0.000	0.008	0.008
4.297	0.062	0.097	0.064	0.001	0.064	0.097	0.062	0.136	0.026	0.001	0.026	0.136
4.553	0.004	0.015	0.004	0.000	0.004	0.015	0.004	0.011	0.002	0.000	0.002	0.011
4.810	0.005	0.009	0.003	0.000	0.003	0.009	0.005	0.007	0.002	0.000	0.002	0.007
5.067	0.005	0.006	0.003	0.000	0.003	0.006	0.005	0.006	0.002	0.000	0.002	0.006

RAO – Fiber – Type 1 - Sway

Encounter	Sway RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.006	1.162	2.012	2.323	2.012	1.162	0.006	1.162	2.012	2.323	2.012	1.162
0.446	0.011	0.515	0.892	1.030	0.892	0.515	0.011	0.515	0.892	1.030	0.892	0.515
0.703	0.031	0.351	0.607	0.701	0.607	0.351	0.031	0.351	0.607	0.700	0.607	0.351
0.959	0.317	0.521	0.789	0.895	0.789	0.520	0.317	0.523	0.784	0.885	0.783	0.522
1.216	0.164	0.437	0.645	0.723	0.645	0.437	0.164	0.125	0.308	0.375	0.308	0.125
1.473	0.045	0.201	0.373	0.443	0.373	0.201	0.045	0.219	0.347	0.393	0.347	0.219
1.730	0.063	0.119	0.279	0.352	0.279	0.119	0.063	0.175	0.222	0.242	0.222	0.174
1.986	0.079	0.046	0.167	0.227	0.167	0.046	0.079	0.112	0.091	0.090	0.091	0.112
2.243	0.070	0.028	0.049	0.093	0.049	0.028	0.071	0.046	0.039	0.058	0.039	0.046
2.500	0.059	0.046	0.050	0.116	0.050	0.046	0.059	0.058	0.035	0.093	0.035	0.058
2.756	0.064	0.053	0.082	0.120	0.082	0.053	0.064	0.060	0.020	0.106	0.020	0.060
3.013	0.065	0.053	0.067	0.110	0.067	0.053	0.065	0.055	0.007	0.107	0.007	0.055
3.270	0.024	0.021	0.041	0.054	0.041	0.021	0.024	0.027	0.023	0.041	0.023	0.027
3.527	0.008	0.005	0.028	0.035	0.028	0.005	0.008	0.018	0.020	0.010	0.020	0.018
3.783	0.001	0.005	0.018	0.025	0.018	0.005	0.001	0.012	0.019	0.009	0.019	0.012
4.040	0.002	0.007	0.011	0.009	0.011	0.007	0.002	0.005	0.009	0.014	0.009	0.005
4.297	0.029	0.060	0.055	0.168	0.055	0.060	0.028	0.084	0.070	0.121	0.070	0.083
4.553	0.003	0.009	0.003	0.013	0.002	0.009	0.003	0.006	0.005	0.018	0.005	0.006
4.810	0.001	0.005	0.004	0.008	0.004	0.005	0.001	0.004	0.005	0.010	0.005	0.004
5.067	0.001	0.004	0.004	0.006	0.004	0.004	0.001	0.003	0.004	0.007	0.004	0.003

RAO – Fiber – Type 1 - Yaw

Encounter	Yaw RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.605	1.400	0.820	0.002	0.817	1.399	1.605	1.400	0.820	0.002	0.817	1.399
0.446	0.683	0.619	0.388	0.001	0.387	0.618	0.683	0.619	0.388	0.001	0.387	0.618
0.703	0.408	0.418	0.316	0.001	0.314	0.417	0.408	0.418	0.316	0.001	0.314	0.417
0.959	0.520	0.611	0.539	0.006	0.548	0.617	0.520	0.617	0.545	0.006	0.553	0.621
1.216	0.062	0.309	0.596	0.009	0.613	0.324	0.047	0.330	0.618	0.008	0.603	0.316
1.473	0.527	0.224	0.923	0.002	0.924	0.225	0.526	0.250	0.948	0.002	0.947	0.250
1.730	1.101	0.131	1.343	0.001	1.341	0.129	1.102	0.190	1.402	0.002	1.403	0.190
1.986	1.671	0.045	1.758	0.000	1.758	0.046	1.671	0.114	1.838	0.001	1.839	0.115
2.243	1.933	0.029	1.933	0.001	1.935	0.030	1.935	0.048	1.985	0.000	1.985	0.048
2.500	1.757	0.054	1.728	0.001	1.730	0.055	1.758	0.068	1.716	0.000	1.716	0.067
2.756	1.425	0.071	1.399	0.002	1.401	0.072	1.425	0.080	1.318	0.001	1.318	0.079
3.013	0.955	0.082	0.964	0.001	0.962	0.083	0.953	0.085	0.935	0.001	0.935	0.085
3.270	0.293	0.031	0.324	0.000	0.324	0.031	0.292	0.040	0.355	0.000	0.354	0.041
3.527	0.042	0.007	0.026	0.000	0.026	0.007	0.042	0.025	0.021	0.000	0.022	0.025
3.783	0.112	0.006	0.107	0.000	0.107	0.006	0.111	0.016	0.106	0.000	0.106	0.016
4.040	0.063	0.009	0.073	0.000	0.073	0.008	0.063	0.005	0.075	0.000	0.075	0.005
4.297	0.988	0.468	0.863	0.009	0.862	0.476	0.992	0.652	1.031	0.007	1.031	0.663
4.553	0.182	0.015	0.184	0.001	0.184	0.015	0.183	0.010	0.180	0.000	0.181	0.011
4.810	0.133	0.008	0.129	0.001	0.128	0.008	0.133	0.007	0.128	0.000	0.128	0.006
5.067	0.038	0.005	0.041	0.000	0.041	0.006	0.038	0.005	0.040	0.000	0.040	0.004

RAO – Chain – Type 2 - Heave

Encounter	Heave RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012
0.446	1.080	1.080	1.079	1.078	1.079	1.080	1.080	1.080	1.079	1.079	1.079	1.080
0.703	1.304	1.300	1.294	1.290	1.294	1.300	1.304	1.301	1.294	1.291	1.294	1.301
0.959	1.570	1.622	1.722	1.772	1.722	1.622	1.570	1.614	1.710	1.759	1.710	1.614
1.216	3.108	3.155	3.208	3.230	3.208	3.155	3.108	3.121	3.198	3.247	3.199	3.122
1.473	0.405	0.427	0.418	0.407	0.418	0.427	0.404	0.392	0.419	0.444	0.419	0.392
1.730	0.040	0.082	0.043	0.052	0.043	0.082	0.040	0.047	0.045	0.088	0.045	0.047
1.986	0.042	0.060	0.040	0.021	0.040	0.060	0.042	0.024	0.042	0.061	0.042	0.024
2.243	0.024	0.029	0.024	0.019	0.024	0.029	0.024	0.019	0.024	0.029	0.024	0.019
2.500	0.012	0.010	0.012	0.012	0.012	0.010	0.012	0.012	0.012	0.010	0.012	0.012
2.756	0.004	0.003	0.004	0.000	0.004	0.003	0.004	0.000	0.004	0.003	0.004	0.001
3.013	0.002	0.006	0.002	0.008	0.002	0.006	0.002	0.008	0.002	0.006	0.002	0.008
3.270	0.001	0.007	0.001	0.009	0.001	0.007	0.001	0.010	0.001	0.007	0.001	0.010
3.527	0.004	0.005	0.004	0.009	0.004	0.005	0.004	0.009	0.004	0.005	0.004	0.009
3.783	0.005	0.001	0.005	0.009	0.005	0.001	0.005	0.009	0.005	0.001	0.005	0.009
4.040	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002
4.297	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.003
4.553	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003
4.810	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004
5.067	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003

RAO – Chain – Type 2 - Pitch

Encounter	Pitch RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.088	0.297	0.499	0.574	0.499	0.297	0.088	0.297	0.499	0.574	0.499	0.297
0.446	0.661	1.025	1.516	1.712	1.516	1.025	0.661	1.025	1.516	1.712	1.516	1.025
0.703	3.759	4.177	4.970	5.355	4.971	4.178	3.759	4.162	4.946	5.328	4.947	4.163
0.959	28.129	27.497	25.957	25.308	25.937	27.475	28.126	26.584	24.253	23.272	24.234	26.566
1.216	9.538	11.119	13.189	14.166	13.191	11.121	9.537	9.533	10.970	11.901	10.973	9.537
1.473	0.347	0.619	1.808	2.515	1.810	0.620	0.346	0.350	1.834	2.687	1.836	0.352
1.730	1.141	0.815	0.739	1.441	0.740	0.811	1.140	0.585	1.196	2.068	1.198	0.581
1.986	0.544	0.321	0.910	1.351	0.907	0.319	0.546	0.732	0.555	0.661	0.552	0.729
2.243	0.285	0.309	0.330	0.611	0.329	0.309	0.284	0.352	0.132	0.564	0.131	0.351
2.500	0.189	0.309	0.163	0.516	0.163	0.309	0.189	0.289	0.085	0.613	0.085	0.289
2.756	0.118	0.286	0.113	0.319	0.114	0.286	0.119	0.160	0.033	0.586	0.033	0.160
3.013	0.064	0.178	0.061	0.184	0.060	0.178	0.063	0.072	0.054	0.383	0.054	0.072
3.270	0.048	0.040	0.113	0.151	0.114	0.040	0.048	0.064	0.080	0.104	0.081	0.064
3.527	0.029	0.025	0.069	0.114	0.070	0.024	0.030	0.048	0.036	0.047	0.037	0.048
3.783	0.012	0.035	0.032	0.056	0.032	0.035	0.013	0.047	0.032	0.069	0.031	0.047
4.040	0.013	0.021	0.023	0.076	0.022	0.021	0.013	0.032	0.027	0.047	0.027	0.033
4.297	0.036	0.024	0.046	0.056	0.045	0.023	0.036	0.032	0.068	0.037	0.067	0.031
4.553	0.023	0.006	0.003	0.013	0.003	0.006	0.023	0.005	0.025	0.011	0.025	0.005
4.810	0.020	0.014	0.008	0.027	0.008	0.014	0.020	0.005	0.017	0.019	0.016	0.006
5.067	0.021	0.003	0.013	0.008	0.013	0.002	0.020	0.005	0.011	0.010	0.011	0.005

RAO – Chain – Type 2 - Roll

Encounter	Rolling RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.858	0.745	0.432	0.000	0.432	0.745	0.858	0.745	0.432	0.000	0.432	0.745
0.446	1.809	1.577	0.922	0.000	0.922	1.577	1.809	1.577	0.922	0.000	0.922	1.577
0.703	4.858	4.278	2.550	0.002	2.552	4.279	4.858	4.280	2.552	0.002	2.554	4.281
0.959	18.927	17.320	10.995	0.025	10.950	17.289	18.926	17.371	11.039	0.023	10.998	17.343
1.216	2.532	2.705	1.999	0.011	2.003	2.705	2.522	2.695	1.989	0.010	2.008	2.712
1.473	0.756	1.492	1.278	0.003	1.284	1.496	0.756	1.343	1.174	0.004	1.180	1.347
1.730	0.730	1.651	1.323	0.002	1.328	1.655	0.732	1.164	0.993	0.004	0.995	1.164
1.986	0.946	0.541	0.111	0.002	0.114	0.540	0.948	1.192	0.716	0.001	0.715	1.190
2.243	0.324	0.497	0.217	0.001	0.219	0.497	0.325	0.553	0.273	0.000	0.272	0.552
2.500	0.086	0.529	0.174	0.001	0.175	0.528	0.087	0.463	0.211	0.000	0.211	0.463
2.756	0.021	0.500	0.065	0.000	0.065	0.500	0.022	0.276	0.170	0.000	0.170	0.276
3.013	0.082	0.321	0.039	0.000	0.041	0.321	0.082	0.145	0.059	0.001	0.060	0.145
3.270	0.116	0.082	0.037	0.001	0.038	0.081	0.116	0.121	0.081	0.000	0.081	0.121
3.527	0.060	0.040	0.009	0.001	0.008	0.041	0.060	0.092	0.055	0.000	0.055	0.092
3.783	0.030	0.060	0.024	0.000	0.024	0.060	0.031	0.059	0.020	0.000	0.020	0.059
4.040	0.029	0.039	0.022	0.001	0.022	0.039	0.030	0.064	0.008	0.000	0.008	0.063
4.297	0.070	0.036	0.051	0.001	0.051	0.035	0.070	0.044	0.020	0.001	0.020	0.043
4.553	0.013	0.008	0.029	0.000	0.029	0.008	0.013	0.010	0.013	0.000	0.013	0.009
4.810	0.008	0.018	0.022	0.000	0.023	0.018	0.008	0.019	0.013	0.000	0.013	0.018
5.067	0.008	0.007	0.017	0.000	0.017	0.007	0.008	0.005	0.019	0.000	0.019	0.005

RAO – Chain – Type 2 - Surge

Encounter	Surge RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	2.247	1.946	1.123	0.000	1.123	1.946	2.247	1.946	1.123	0.000	1.123	1.946
0.446	0.996	0.862	0.498	0.000	0.498	0.862	0.996	0.862	0.498	0.000	0.498	0.862
0.703	0.676	0.585	0.337	0.000	0.337	0.585	0.676	0.585	0.337	0.000	0.337	0.585
0.959	0.741	0.642	0.373	0.000	0.373	0.642	0.741	0.645	0.375	0.000	0.375	0.645
1.216	0.524	0.450	0.258	0.000	0.258	0.450	0.524	0.458	0.266	0.000	0.266	0.458
1.473	0.400	0.331	0.183	0.000	0.183	0.331	0.401	0.366	0.218	0.000	0.218	0.366
1.730	0.279	0.201	0.092	0.000	0.092	0.201	0.279	0.291	0.185	0.000	0.185	0.291
1.986	0.143	0.075	0.022	0.000	0.022	0.075	0.143	0.186	0.131	0.000	0.131	0.186
2.243	0.034	0.050	0.058	0.000	0.058	0.051	0.034	0.077	0.060	0.000	0.060	0.077
2.500	0.029	0.078	0.047	0.000	0.047	0.078	0.029	0.099	0.061	0.000	0.061	0.098
2.756	0.050	0.087	0.024	0.000	0.024	0.087	0.050	0.100	0.084	0.000	0.083	0.099
3.013	0.038	0.085	0.031	0.000	0.031	0.085	0.038	0.089	0.071	0.000	0.071	0.089
3.270	0.034	0.033	0.012	0.000	0.012	0.033	0.034	0.044	0.034	0.000	0.034	0.044
3.527	0.026	0.008	0.007	0.000	0.007	0.008	0.026	0.029	0.019	0.000	0.019	0.029
3.783	0.020	0.007	0.010	0.000	0.010	0.007	0.020	0.020	0.010	0.000	0.010	0.020
4.040	0.011	0.011	0.004	0.000	0.004	0.011	0.011	0.007	0.007	0.000	0.007	0.007
4.297	0.047	0.081	0.054	0.001	0.054	0.080	0.047	0.114	0.025	0.001	0.025	0.114
4.553	0.004	0.014	0.004	0.000	0.004	0.014	0.004	0.010	0.002	0.000	0.002	0.010
4.810	0.005	0.008	0.003	0.000	0.003	0.008	0.005	0.007	0.002	0.000	0.002	0.007
5.067	0.004	0.006	0.002	0.000	0.002	0.006	0.004	0.005	0.002	0.000	0.002	0.005

RAO – Chain – Type 2 - Sway

Encounter	Sway RAO, z_{x0}/z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.008	1.127	1.951	2.253	1.951	1.127	0.008	1.127	1.951	2.253	1.951	1.127
0.446	0.013	0.499	0.865	0.999	0.865	0.499	0.013	0.499	0.865	0.999	0.865	0.499
0.703	0.040	0.340	0.587	0.677	0.587	0.340	0.040	0.340	0.587	0.677	0.587	0.340
0.959	0.197	0.406	0.644	0.735	0.644	0.406	0.197	0.397	0.630	0.719	0.630	0.396
1.216	0.099	0.321	0.512	0.584	0.512	0.321	0.099	0.231	0.409	0.475	0.409	0.231
1.473	0.047	0.193	0.357	0.424	0.357	0.193	0.047	0.211	0.335	0.381	0.335	0.211
1.730	0.062	0.115	0.267	0.337	0.268	0.115	0.062	0.168	0.213	0.233	0.214	0.168
1.986	0.075	0.044	0.159	0.215	0.159	0.044	0.075	0.107	0.086	0.087	0.086	0.107
2.243	0.067	0.029	0.047	0.089	0.047	0.029	0.067	0.044	0.038	0.058	0.038	0.044
2.500	0.058	0.045	0.047	0.114	0.047	0.045	0.058	0.057	0.033	0.090	0.033	0.057
2.756	0.062	0.051	0.077	0.115	0.077	0.051	0.061	0.057	0.018	0.101	0.018	0.057
3.013	0.059	0.049	0.063	0.103	0.063	0.050	0.059	0.052	0.009	0.099	0.009	0.052
3.270	0.023	0.019	0.039	0.051	0.039	0.019	0.023	0.026	0.022	0.038	0.022	0.026
3.527	0.007	0.004	0.026	0.033	0.026	0.004	0.007	0.017	0.019	0.009	0.019	0.017
3.783	0.001	0.004	0.017	0.024	0.017	0.004	0.001	0.012	0.018	0.008	0.018	0.012
4.040	0.002	0.007	0.011	0.009	0.011	0.007	0.002	0.004	0.009	0.013	0.009	0.004
4.297	0.023	0.049	0.044	0.138	0.044	0.049	0.023	0.069	0.056	0.098	0.056	0.068
4.553	0.003	0.008	0.002	0.012	0.002	0.008	0.003	0.006	0.004	0.016	0.004	0.006
4.810	0.000	0.005	0.004	0.008	0.004	0.005	0.001	0.004	0.004	0.010	0.004	0.004
5.067	0.001	0.003	0.004	0.006	0.004	0.003	0.001	0.003	0.004	0.007	0.004	0.003

RAO – Chain – Type 2 - Yaw

Encounter	Yaw RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.608	1.403	0.822	0.000	0.821	1.403	1.608	1.403	0.822	0.000	0.821	1.403
0.446	0.681	0.620	0.392	0.000	0.392	0.619	0.681	0.620	0.392	0.000	0.392	0.619
0.703	0.399	0.417	0.324	0.001	0.322	0.417	0.399	0.417	0.324	0.001	0.322	0.417
0.959	0.323	0.457	0.469	0.004	0.473	0.459	0.323	0.459	0.471	0.004	0.474	0.461
1.216	0.099	0.311	0.639	0.004	0.644	0.316	0.095	0.321	0.648	0.004	0.645	0.317
1.473	0.592	0.223	0.985	0.001	0.985	0.224	0.591	0.247	1.008	0.001	1.007	0.247
1.730	1.182	0.129	1.420	0.001	1.419	0.129	1.182	0.187	1.480	0.002	1.477	0.186
1.986	1.744	0.045	1.827	0.003	1.831	0.046	1.745	0.111	1.906	0.002	1.908	0.112
2.243	1.975	0.031	1.974	0.002	1.977	0.032	1.976	0.048	2.025	0.001	2.025	0.047
2.500	1.764	0.056	1.737	0.001	1.739	0.057	1.765	0.070	1.722	0.000	1.722	0.069
2.756	1.402	0.071	1.377	0.002	1.379	0.073	1.401	0.080	1.294	0.001	1.294	0.080
3.013	0.897	0.079	0.908	0.001	0.908	0.080	0.896	0.082	0.886	0.001	0.885	0.082
3.270	0.290	0.029	0.321	0.001	0.321	0.030	0.289	0.039	0.351	0.000	0.350	0.040
3.527	0.024	0.007	0.019	0.000	0.019	0.006	0.024	0.024	0.023	0.000	0.023	0.025
3.783	0.096	0.006	0.091	0.000	0.091	0.006	0.096	0.017	0.091	0.000	0.091	0.016
4.040	0.059	0.008	0.068	0.000	0.068	0.008	0.058	0.005	0.070	0.000	0.070	0.006
4.297	0.946	0.404	0.943	0.008	0.941	0.411	0.942	0.579	1.058	0.007	1.058	0.576
4.553	0.174	0.014	0.175	0.001	0.175	0.014	0.174	0.009	0.172	0.000	0.172	0.010
4.810	0.126	0.008	0.122	0.001	0.122	0.008	0.125	0.006	0.121	0.000	0.122	0.006
5.067	0.036	0.005	0.039	0.000	0.039	0.005	0.036	0.004	0.038	0.000	0.038	0.004

RAO – Wire – Type 2 - Heave

Encounter	Heave RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012
0.446	1.080	1.079	1.078	1.078	1.078	1.079	1.080	1.079	1.078	1.078	1.078	1.079
0.703	1.301	1.298	1.291	1.288	1.291	1.298	1.301	1.298	1.292	1.289	1.292	1.298
0.959	1.563	1.615	1.715	1.764	1.715	1.615	1.563	1.607	1.703	1.752	1.703	1.607
1.216	3.166	3.214	3.268	3.291	3.268	3.214	3.166	3.180	3.258	3.308	3.259	3.180
1.473	0.407	0.430	0.421	0.409	0.421	0.430	0.407	0.394	0.422	0.446	0.422	0.394
1.730	0.040	0.082	0.043	0.052	0.043	0.083	0.040	0.047	0.045	0.088	0.045	0.047
1.986	0.043	0.060	0.040	0.021	0.040	0.060	0.042	0.024	0.042	0.061	0.043	0.024
2.243	0.024	0.029	0.024	0.019	0.024	0.029	0.024	0.020	0.024	0.029	0.024	0.020
2.500	0.012	0.010	0.012	0.012	0.012	0.010	0.012	0.012	0.012	0.010	0.012	0.012
2.756	0.004	0.003	0.004	0.000	0.004	0.003	0.004	0.000	0.004	0.003	0.004	0.001
3.013	0.002	0.006	0.002	0.008	0.002	0.006	0.002	0.008	0.002	0.006	0.002	0.008
3.270	0.001	0.007	0.001	0.009	0.001	0.007	0.001	0.010	0.001	0.007	0.001	0.010
3.527	0.004	0.005	0.004	0.009	0.004	0.005	0.004	0.009	0.004	0.005	0.004	0.009
3.783	0.005	0.001	0.005	0.009	0.005	0.001	0.005	0.009	0.005	0.001	0.005	0.009
4.040	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002
4.297	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.003
4.553	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003
4.810	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004
5.067	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003

RAO – Wire – Type 2 - Pitch

Encounter	Pitch RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.088	0.297	0.500	0.575	0.499	0.297	0.088	0.297	0.500	0.575	0.499	0.297
0.446	0.659	1.024	1.516	1.713	1.516	1.024	0.659	1.024	1.516	1.713	1.516	1.024
0.703	3.744	4.166	4.965	5.353	4.966	4.167	3.745	4.152	4.942	5.327	4.943	4.152
0.959	27.976	27.348	25.827	25.192	25.807	27.326	27.973	26.444	24.140	23.178	24.121	26.425
1.216	9.718	11.308	13.379	14.356	13.381	11.309	9.717	9.698	11.121	12.048	11.124	9.701
1.473	0.344	0.623	1.813	2.520	1.815	0.624	0.344	0.354	1.838	2.691	1.840	0.355
1.730	1.140	0.815	0.740	1.442	0.741	0.811	1.140	0.585	1.198	2.068	1.199	0.581
1.986	0.544	0.321	0.909	1.349	0.906	0.319	0.546	0.731	0.555	0.661	0.552	0.728
2.243	0.284	0.309	0.330	0.610	0.329	0.309	0.284	0.351	0.132	0.563	0.130	0.350
2.500	0.188	0.309	0.163	0.516	0.163	0.309	0.188	0.289	0.084	0.612	0.084	0.289
2.756	0.118	0.285	0.113	0.318	0.113	0.285	0.118	0.160	0.033	0.586	0.033	0.160
3.013	0.063	0.177	0.060	0.183	0.060	0.178	0.062	0.072	0.054	0.383	0.054	0.072
3.270	0.048	0.040	0.113	0.150	0.114	0.040	0.048	0.064	0.080	0.104	0.081	0.064
3.527	0.029	0.025	0.069	0.114	0.070	0.024	0.030	0.048	0.036	0.047	0.037	0.048
3.783	0.012	0.035	0.032	0.056	0.032	0.035	0.013	0.047	0.032	0.069	0.031	0.047
4.040	0.013	0.021	0.023	0.076	0.022	0.021	0.013	0.032	0.027	0.047	0.027	0.033
4.297	0.036	0.023	0.046	0.056	0.045	0.023	0.036	0.032	0.068	0.037	0.067	0.031
4.553	0.023	0.006	0.003	0.014	0.003	0.006	0.023	0.005	0.025	0.011	0.025	0.005
4.810	0.020	0.013	0.008	0.027	0.008	0.014	0.020	0.005	0.017	0.019	0.016	0.006
5.067	0.021	0.003	0.013	0.008	0.013	0.002	0.020	0.005	0.011	0.010	0.011	0.005

RAO – Wire – Type 2 - Rolling

Encounter	Rolling RAO, z_{x0}/z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.858	0.745	0.433	0.000	0.433	0.745	0.858	0.745	0.433	0.000	0.433	0.745
0.446	1.811	1.578	0.923	0.000	0.923	1.578	1.811	1.578	0.923	0.000	0.923	1.578
0.703	4.863	4.282	2.552	0.002	2.555	4.284	4.863	4.284	2.554	0.002	2.557	4.286
0.959	18.962	17.350	11.011	0.025	10.966	17.319	18.961	17.400	11.055	0.023	11.015	17.373
1.216	2.538	2.710	2.001	0.011	2.005	2.709	2.528	2.700	1.990	0.011	2.010	2.717
1.473	0.760	1.493	1.279	0.003	1.284	1.498	0.760	1.344	1.174	0.004	1.180	1.348
1.730	0.732	1.651	1.324	0.002	1.328	1.655	0.735	1.165	0.993	0.004	0.995	1.165
1.986	0.945	0.540	0.111	0.002	0.114	0.539	0.947	1.190	0.715	0.001	0.714	1.188
2.243	0.324	0.497	0.216	0.001	0.218	0.497	0.325	0.552	0.272	0.000	0.271	0.551
2.500	0.086	0.528	0.174	0.001	0.174	0.528	0.087	0.463	0.211	0.000	0.211	0.463
2.756	0.021	0.500	0.065	0.000	0.065	0.500	0.022	0.275	0.169	0.000	0.169	0.275
3.013	0.082	0.321	0.039	0.000	0.041	0.320	0.081	0.145	0.059	0.001	0.059	0.145
3.270	0.116	0.082	0.037	0.001	0.038	0.081	0.116	0.121	0.081	0.000	0.080	0.121
3.527	0.060	0.040	0.009	0.001	0.008	0.041	0.060	0.091	0.055	0.000	0.055	0.092
3.783	0.030	0.060	0.024	0.000	0.024	0.060	0.031	0.059	0.020	0.000	0.020	0.059
4.040	0.029	0.039	0.022	0.001	0.022	0.039	0.030	0.064	0.008	0.000	0.008	0.063
4.297	0.070	0.035	0.051	0.001	0.051	0.035	0.070	0.044	0.019	0.001	0.020	0.043
4.553	0.013	0.008	0.029	0.000	0.029	0.008	0.013	0.010	0.013	0.000	0.013	0.009
4.810	0.008	0.018	0.022	0.000	0.023	0.018	0.008	0.019	0.013	0.000	0.013	0.018
5.067	0.008	0.007	0.017	0.000	0.017	0.007	0.008	0.005	0.019	0.000	0.019	0.005

RAO – Wire – Type 2 - Surge

Encounter	Surge RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	2.251	1.949	1.126	0.000	1.125	1.949	2.251	1.949	1.126	0.000	1.125	1.949
0.446	0.998	0.864	0.499	0.000	0.499	0.864	0.998	0.864	0.499	0.000	0.499	0.864
0.703	0.677	0.586	0.338	0.000	0.338	0.586	0.677	0.586	0.338	0.000	0.338	0.586
0.959	0.743	0.644	0.373	0.000	0.373	0.644	0.743	0.646	0.376	0.000	0.376	0.646
1.216	0.525	0.451	0.259	0.000	0.259	0.451	0.525	0.459	0.266	0.000	0.266	0.459
1.473	0.401	0.331	0.184	0.000	0.184	0.331	0.401	0.366	0.218	0.000	0.218	0.366
1.730	0.280	0.201	0.092	0.000	0.092	0.202	0.280	0.292	0.186	0.000	0.185	0.292
1.986	0.144	0.076	0.022	0.000	0.022	0.076	0.144	0.186	0.131	0.000	0.131	0.186
2.243	0.034	0.051	0.058	0.000	0.058	0.051	0.034	0.077	0.060	0.000	0.060	0.077
2.500	0.029	0.078	0.048	0.000	0.048	0.078	0.029	0.099	0.061	0.000	0.061	0.099
2.756	0.050	0.087	0.024	0.000	0.024	0.087	0.050	0.100	0.084	0.000	0.084	0.100
3.013	0.038	0.085	0.031	0.000	0.031	0.086	0.038	0.090	0.072	0.000	0.072	0.090
3.270	0.035	0.033	0.012	0.000	0.012	0.033	0.035	0.044	0.034	0.000	0.034	0.044
3.527	0.026	0.008	0.007	0.000	0.007	0.008	0.026	0.029	0.019	0.000	0.019	0.029
3.783	0.020	0.007	0.010	0.000	0.010	0.007	0.020	0.020	0.010	0.000	0.010	0.020
4.040	0.011	0.011	0.004	0.000	0.004	0.011	0.011	0.008	0.007	0.000	0.007	0.008
4.297	0.047	0.081	0.054	0.001	0.054	0.081	0.047	0.115	0.026	0.001	0.025	0.114
4.553	0.004	0.014	0.004	0.000	0.004	0.014	0.004	0.010	0.002	0.000	0.002	0.010
4.810	0.005	0.008	0.003	0.000	0.003	0.008	0.005	0.007	0.002	0.000	0.002	0.007
5.067	0.004	0.006	0.002	0.000	0.002	0.006	0.004	0.005	0.002	0.000	0.002	0.005

RAO – Wire – Type 2 -Sway

Encounter	Sway RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.008	1.129	1.955	2.257	1.955	1.129	0.008	1.129	1.955	2.257	1.955	1.129
0.446	0.013	0.500	0.867	1.001	0.867	0.500	0.013	0.500	0.867	1.001	0.867	0.500
0.703	0.040	0.341	0.588	0.678	0.588	0.341	0.040	0.341	0.588	0.678	0.588	0.341
0.959	0.196	0.406	0.645	0.736	0.645	0.406	0.196	0.397	0.631	0.720	0.631	0.397
1.216	0.100	0.323	0.514	0.586	0.514	0.323	0.100	0.231	0.408	0.474	0.408	0.231
1.473	0.047	0.194	0.358	0.424	0.358	0.194	0.047	0.211	0.336	0.381	0.336	0.211
1.730	0.063	0.115	0.268	0.338	0.268	0.116	0.062	0.168	0.214	0.234	0.214	0.168
1.986	0.075	0.044	0.159	0.216	0.159	0.044	0.076	0.107	0.086	0.087	0.086	0.107
2.243	0.067	0.029	0.047	0.089	0.047	0.029	0.067	0.044	0.038	0.059	0.038	0.044
2.500	0.058	0.045	0.047	0.114	0.047	0.045	0.059	0.057	0.033	0.090	0.033	0.057
2.756	0.062	0.051	0.077	0.115	0.077	0.051	0.062	0.057	0.018	0.101	0.018	0.057
3.013	0.059	0.050	0.063	0.103	0.063	0.050	0.059	0.052	0.009	0.099	0.009	0.052
3.270	0.023	0.019	0.039	0.051	0.039	0.019	0.023	0.026	0.022	0.038	0.022	0.026
3.527	0.007	0.004	0.026	0.033	0.026	0.004	0.007	0.017	0.019	0.009	0.019	0.017
3.783	0.001	0.004	0.017	0.024	0.017	0.004	0.001	0.012	0.018	0.008	0.018	0.012
4.040	0.002	0.007	0.011	0.009	0.011	0.007	0.002	0.004	0.009	0.013	0.009	0.004
4.297	0.023	0.050	0.044	0.139	0.044	0.049	0.023	0.070	0.057	0.099	0.056	0.069
4.553	0.003	0.008	0.002	0.012	0.002	0.008	0.003	0.006	0.004	0.016	0.004	0.006
4.810	0.000	0.005	0.004	0.008	0.004	0.005	0.001	0.004	0.004	0.010	0.004	0.004
5.067	0.001	0.003	0.004	0.006	0.004	0.003	0.001	0.003	0.004	0.007	0.004	0.003

RAO – Wire – Type 2 - Yaw

Encounter	Yaw RAO, z_{x0}/z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.606	1.401	0.821	0.000	0.820	1.401	1.606	1.401	0.821	0.000	0.821	1.401
0.446	0.680	0.619	0.392	0.000	0.391	0.619	0.680	0.619	0.392	0.000	0.391	0.619
0.703	0.399	0.417	0.323	0.001	0.322	0.416	0.399	0.417	0.323	0.001	0.322	0.416
0.959	0.322	0.456	0.469	0.004	0.472	0.459	0.323	0.459	0.471	0.004	0.474	0.460
1.216	0.099	0.311	0.639	0.004	0.644	0.316	0.095	0.320	0.648	0.004	0.645	0.317
1.473	0.592	0.223	0.985	0.001	0.985	0.224	0.591	0.247	1.008	0.001	1.007	0.247
1.730	1.183	0.129	1.420	0.001	1.418	0.129	1.182	0.187	1.479	0.002	1.477	0.186
1.986	1.745	0.045	1.827	0.003	1.831	0.045	1.746	0.111	1.905	0.002	1.908	0.112
2.243	1.975	0.031	1.974	0.002	1.977	0.032	1.976	0.048	2.025	0.001	2.025	0.047
2.500	1.764	0.056	1.737	0.001	1.739	0.057	1.765	0.070	1.723	0.000	1.722	0.068
2.756	1.402	0.071	1.377	0.002	1.379	0.073	1.401	0.080	1.294	0.001	1.294	0.080
3.013	0.897	0.078	0.908	0.001	0.908	0.080	0.896	0.082	0.886	0.001	0.885	0.082
3.270	0.290	0.029	0.321	0.001	0.321	0.030	0.289	0.039	0.351	0.000	0.350	0.040
3.527	0.024	0.007	0.019	0.000	0.019	0.006	0.024	0.024	0.023	0.000	0.023	0.025
3.783	0.096	0.006	0.091	0.000	0.091	0.006	0.096	0.017	0.091	0.000	0.091	0.016
4.040	0.059	0.008	0.068	0.000	0.068	0.008	0.058	0.005	0.070	0.000	0.070	0.006
4.297	0.947	0.405	0.941	0.009	0.940	0.413	0.943	0.581	1.058	0.007	1.058	0.578
4.553	0.174	0.014	0.175	0.001	0.175	0.014	0.174	0.009	0.172	0.000	0.172	0.010
4.810	0.126	0.008	0.122	0.001	0.122	0.008	0.125	0.006	0.121	0.000	0.122	0.006
5.067	0.036	0.005	0.039	0.000	0.039	0.005	0.036	0.004	0.038	0.000	0.038	0.004

RAO – Fiber – Type 2 - Heave

Encounter	Heave RAO, z_{x0} / z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012
0.446	1.079	1.079	1.078	1.078	1.078	1.079	1.079	1.079	1.078	1.078	1.078	1.079
0.703	1.300	1.297	1.290	1.287	1.290	1.297	1.300	1.297	1.291	1.287	1.291	1.297
0.959	1.559	1.611	1.710	1.760	1.710	1.611	1.559	1.603	1.698	1.747	1.698	1.603
1.216	3.205	3.254	3.309	3.331	3.309	3.254	3.205	3.219	3.299	3.349	3.299	3.220
1.473	0.409	0.431	0.422	0.411	0.422	0.431	0.409	0.396	0.423	0.448	0.423	0.396
1.730	0.040	0.083	0.043	0.052	0.043	0.083	0.040	0.047	0.046	0.089	0.045	0.047
1.986	0.043	0.060	0.040	0.021	0.040	0.060	0.043	0.024	0.043	0.061	0.043	0.024
2.243	0.024	0.029	0.024	0.019	0.024	0.029	0.024	0.020	0.024	0.029	0.024	0.020
2.500	0.012	0.010	0.012	0.012	0.012	0.010	0.012	0.012	0.012	0.010	0.012	0.012
2.756	0.004	0.003	0.004	0.000	0.004	0.003	0.004	0.000	0.004	0.003	0.004	0.001
3.013	0.002	0.006	0.002	0.008	0.002	0.006	0.002	0.008	0.002	0.006	0.002	0.008
3.270	0.001	0.007	0.001	0.009	0.001	0.007	0.001	0.010	0.001	0.007	0.001	0.010
3.527	0.004	0.005	0.004	0.009	0.004	0.005	0.004	0.009	0.004	0.005	0.004	0.009
3.783	0.005	0.001	0.005	0.009	0.005	0.001	0.005	0.009	0.005	0.001	0.005	0.009
4.040	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.002	0.002
4.297	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.003
4.553	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003
4.810	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004	0.001	0.002	0.001	0.004
5.067	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.003

RAO – Fiber – Type 2 - Pitch

Encounter	Pitch RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.088	0.297	0.500	0.575	0.500	0.297	0.088	0.297	0.500	0.575	0.500	0.297
0.446	0.658	1.024	1.517	1.714	1.517	1.024	0.658	1.024	1.517	1.714	1.517	1.024
0.703	3.735	4.159	4.963	5.352	4.964	4.160	3.735	4.145	4.939	5.326	4.940	4.146
0.959	27.876	27.251	25.743	25.116	25.723	27.229	27.873	26.353	24.068	23.117	24.049	26.335
1.216	9.839	11.434	13.507	14.483	13.509	11.436	9.838	9.809	11.222	12.146	11.225	9.812
1.473	0.342	0.626	1.816	2.522	1.818	0.626	0.342	0.356	1.840	2.694	1.843	0.357
1.730	1.140	0.815	0.741	1.442	0.742	0.811	1.140	0.585	1.198	2.069	1.200	0.581
1.986	0.544	0.320	0.908	1.348	0.905	0.319	0.545	0.730	0.555	0.661	0.551	0.728
2.243	0.284	0.309	0.330	0.610	0.329	0.309	0.284	0.351	0.132	0.563	0.130	0.350
2.500	0.188	0.309	0.163	0.515	0.163	0.308	0.188	0.289	0.084	0.612	0.084	0.289
2.756	0.118	0.285	0.113	0.318	0.113	0.285	0.118	0.160	0.033	0.585	0.033	0.160
3.013	0.063	0.177	0.060	0.183	0.060	0.177	0.062	0.072	0.054	0.382	0.054	0.072
3.270	0.048	0.040	0.113	0.150	0.114	0.040	0.048	0.064	0.080	0.104	0.081	0.063
3.527	0.029	0.025	0.069	0.114	0.069	0.024	0.030	0.048	0.036	0.047	0.037	0.048
3.783	0.012	0.035	0.032	0.056	0.032	0.035	0.013	0.047	0.032	0.069	0.031	0.047
4.040	0.013	0.021	0.023	0.076	0.022	0.021	0.013	0.032	0.027	0.047	0.027	0.033
4.297	0.036	0.023	0.046	0.056	0.045	0.023	0.036	0.033	0.068	0.037	0.067	0.031
4.553	0.023	0.006	0.003	0.014	0.003	0.006	0.023	0.005	0.025	0.011	0.025	0.005
4.810	0.020	0.013	0.008	0.027	0.008	0.013	0.020	0.005	0.016	0.019	0.016	0.006
5.067	0.021	0.003	0.013	0.008	0.013	0.002	0.020	0.005	0.011	0.010	0.011	0.005

RAO – Fiber – Type 2 - Roll

Encounter	Rolling RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.859	0.745	0.433	0.000	0.433	0.745	0.859	0.745	0.433	0.000	0.433	0.745
0.446	1.812	1.579	0.923	0.000	0.923	1.579	1.812	1.579	0.923	0.000	0.923	1.579
0.703	4.866	4.285	2.554	0.002	2.556	4.286	4.867	4.287	2.556	0.002	2.558	4.288
0.959	18.985	17.369	11.022	0.025	10.977	17.339	18.984	17.420	11.066	0.023	11.025	17.392
1.216	2.542	2.713	2.003	0.011	2.007	2.712	2.532	2.702	1.992	0.011	2.011	2.720
1.473	0.762	1.494	1.279	0.003	1.284	1.499	0.762	1.345	1.174	0.004	1.180	1.349
1.730	0.733	1.651	1.324	0.002	1.329	1.656	0.736	1.165	0.993	0.004	0.995	1.165
1.986	0.945	0.540	0.111	0.002	0.114	0.539	0.946	1.190	0.715	0.001	0.714	1.187
2.243	0.324	0.497	0.216	0.001	0.218	0.496	0.325	0.552	0.272	0.000	0.271	0.551
2.500	0.086	0.528	0.173	0.001	0.174	0.528	0.087	0.462	0.211	0.000	0.210	0.462
2.756	0.022	0.500	0.065	0.000	0.065	0.499	0.022	0.275	0.169	0.000	0.169	0.275
3.013	0.082	0.321	0.039	0.000	0.041	0.320	0.081	0.145	0.059	0.001	0.059	0.145
3.270	0.116	0.082	0.037	0.001	0.038	0.081	0.116	0.121	0.081	0.000	0.080	0.121
3.527	0.060	0.040	0.009	0.001	0.008	0.041	0.060	0.091	0.055	0.000	0.055	0.091
3.783	0.030	0.060	0.024	0.000	0.024	0.060	0.030	0.059	0.020	0.000	0.020	0.059
4.040	0.029	0.039	0.022	0.001	0.022	0.039	0.030	0.064	0.008	0.000	0.008	0.063
4.297	0.070	0.035	0.051	0.001	0.051	0.035	0.070	0.044	0.019	0.001	0.020	0.043
4.553	0.013	0.008	0.029	0.000	0.029	0.008	0.013	0.010	0.013	0.000	0.013	0.009
4.810	0.008	0.018	0.022	0.000	0.023	0.018	0.008	0.019	0.013	0.000	0.013	0.018
5.067	0.008	0.007	0.017	0.000	0.017	0.007	0.008	0.005	0.019	0.000	0.019	0.005

RAO – Fiber – Type 2 - Surge

Encounter	Surge RAO, z_{x0}/z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	2.254	1.952	1.127	0.000	1.127	1.952	2.254	1.952	1.127	0.000	1.127	1.952
0.446	0.999	0.865	0.499	0.000	0.499	0.865	0.999	0.865	0.499	0.000	0.499	0.865
0.703	0.678	0.587	0.338	0.000	0.338	0.587	0.678	0.587	0.338	0.000	0.338	0.587
0.959	0.744	0.645	0.374	0.000	0.374	0.645	0.744	0.647	0.376	0.000	0.376	0.647
1.216	0.526	0.451	0.259	0.000	0.259	0.452	0.526	0.459	0.266	0.000	0.266	0.459
1.473	0.402	0.332	0.184	0.000	0.184	0.332	0.402	0.367	0.218	0.000	0.218	0.367
1.730	0.280	0.201	0.092	0.000	0.093	0.202	0.280	0.292	0.186	0.000	0.186	0.292
1.986	0.144	0.076	0.022	0.000	0.022	0.076	0.144	0.187	0.131	0.000	0.131	0.187
2.243	0.034	0.051	0.059	0.000	0.059	0.051	0.034	0.077	0.060	0.000	0.060	0.077
2.500	0.029	0.078	0.048	0.000	0.048	0.078	0.029	0.099	0.061	0.000	0.061	0.099
2.756	0.050	0.087	0.024	0.000	0.024	0.088	0.050	0.100	0.084	0.000	0.084	0.100
3.013	0.038	0.086	0.031	0.000	0.031	0.086	0.038	0.090	0.072	0.000	0.072	0.090
3.270	0.035	0.033	0.012	0.000	0.012	0.033	0.035	0.044	0.035	0.000	0.034	0.044
3.527	0.026	0.008	0.007	0.000	0.007	0.008	0.026	0.029	0.019	0.000	0.019	0.029
3.783	0.020	0.007	0.011	0.000	0.010	0.007	0.020	0.020	0.010	0.000	0.010	0.020
4.040	0.011	0.011	0.004	0.000	0.004	0.011	0.011	0.008	0.007	0.000	0.007	0.008
4.297	0.047	0.082	0.055	0.001	0.054	0.081	0.047	0.115	0.026	0.001	0.025	0.115
4.553	0.004	0.014	0.004	0.000	0.004	0.014	0.004	0.010	0.002	0.000	0.002	0.010
4.810	0.005	0.008	0.003	0.000	0.003	0.008	0.005	0.007	0.002	0.000	0.002	0.007
5.067	0.004	0.006	0.002	0.000	0.002	0.006	0.004	0.005	0.002	0.000	0.002	0.005

RAO – Fiber – Type 2 - Sway

Encounter	Sway RAO, z_{x0}/z_0 (m/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	0.008	1.130	1.957	2.260	1.957	1.130	0.008	1.130	1.957	2.260	1.957	1.130
0.446	0.013	0.501	0.868	1.002	0.868	0.501	0.013	0.501	0.868	1.002	0.868	0.501
0.703	0.040	0.341	0.588	0.679	0.588	0.341	0.040	0.341	0.588	0.679	0.588	0.341
0.959	0.195	0.406	0.646	0.737	0.645	0.406	0.195	0.397	0.632	0.721	0.632	0.397
1.216	0.101	0.324	0.516	0.588	0.516	0.324	0.101	0.230	0.408	0.474	0.408	0.230
1.473	0.047	0.194	0.358	0.425	0.358	0.194	0.047	0.212	0.336	0.382	0.336	0.212
1.730	0.063	0.115	0.268	0.338	0.268	0.116	0.062	0.168	0.214	0.234	0.214	0.168
1.986	0.075	0.044	0.159	0.216	0.159	0.044	0.076	0.108	0.086	0.087	0.086	0.108
2.243	0.067	0.029	0.047	0.089	0.047	0.029	0.067	0.044	0.038	0.059	0.038	0.044
2.500	0.059	0.045	0.047	0.114	0.047	0.045	0.059	0.057	0.034	0.090	0.033	0.057
2.756	0.062	0.051	0.077	0.115	0.077	0.051	0.062	0.057	0.018	0.101	0.018	0.057
3.013	0.059	0.050	0.063	0.104	0.063	0.050	0.059	0.052	0.009	0.099	0.009	0.052
3.270	0.023	0.019	0.039	0.051	0.039	0.019	0.023	0.026	0.022	0.038	0.022	0.026
3.527	0.007	0.004	0.026	0.033	0.026	0.004	0.007	0.017	0.019	0.009	0.019	0.017
3.783	0.001	0.004	0.017	0.024	0.017	0.004	0.001	0.012	0.018	0.008	0.018	0.012
4.040	0.002	0.007	0.011	0.009	0.011	0.007	0.002	0.004	0.009	0.013	0.009	0.004
4.297	0.023	0.050	0.045	0.139	0.044	0.049	0.023	0.070	0.057	0.099	0.056	0.069
4.553	0.003	0.008	0.002	0.012	0.002	0.008	0.003	0.006	0.004	0.016	0.004	0.006
4.810	0.001	0.005	0.004	0.008	0.004	0.005	0.001	0.004	0.004	0.010	0.004	0.004
5.067	0.001	0.003	0.004	0.006	0.004	0.003	0.001	0.003	0.004	0.007	0.004	0.003

RAO – Fiber – Type 2 - Yaw

Encounter	Yaw RAO, z_{x0} / z_0 (deg/m)											
Freq (rad/s)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
0.189	1.605	1.400	0.820	0.000	0.820	1.400	1.605	1.400	0.820	0.000	0.820	1.400
0.446	0.680	0.618	0.391	0.000	0.391	0.618	0.680	0.618	0.391	0.000	0.391	0.618
0.703	0.398	0.417	0.323	0.001	0.322	0.416	0.398	0.417	0.323	0.001	0.322	0.416
0.959	0.322	0.456	0.468	0.004	0.472	0.459	0.323	0.458	0.471	0.003	0.474	0.460
1.216	0.099	0.311	0.639	0.004	0.644	0.316	0.095	0.320	0.648	0.004	0.645	0.317
1.473	0.592	0.223	0.985	0.001	0.985	0.223	0.592	0.247	1.007	0.001	1.007	0.247
1.730	1.183	0.129	1.420	0.001	1.418	0.129	1.182	0.187	1.479	0.002	1.477	0.186
1.986	1.745	0.045	1.827	0.003	1.831	0.045	1.746	0.111	1.905	0.002	1.908	0.112
2.243	1.975	0.031	1.974	0.002	1.977	0.032	1.977	0.048	2.025	0.001	2.025	0.047
2.500	1.764	0.056	1.737	0.001	1.739	0.057	1.765	0.070	1.723	0.000	1.722	0.068
2.756	1.402	0.071	1.377	0.002	1.379	0.073	1.401	0.080	1.294	0.001	1.294	0.079
3.013	0.897	0.078	0.908	0.001	0.908	0.080	0.896	0.082	0.886	0.001	0.885	0.082
3.270	0.290	0.029	0.321	0.001	0.321	0.030	0.289	0.039	0.351	0.000	0.350	0.040
3.527	0.024	0.007	0.019	0.000	0.019	0.006	0.024	0.024	0.023	0.000	0.023	0.025
3.783	0.096	0.006	0.091	0.000	0.091	0.006	0.096	0.017	0.091	0.000	0.091	0.016
4.040	0.059	0.008	0.068	0.000	0.068	0.008	0.058	0.005	0.070	0.000	0.070	0.005
4.297	0.948	0.406	0.940	0.009	0.939	0.414	0.943	0.582	1.058	0.007	1.058	0.580
4.553	0.174	0.014	0.175	0.001	0.175	0.014	0.174	0.009	0.172	0.000	0.172	0.010
4.810	0.126	0.008	0.122	0.001	0.122	0.008	0.125	0.006	0.121	0.000	0.122	0.006
5.067	0.036	0.005	0.039	0.000	0.039	0.005	0.036	0.004	0.038	0.000	0.038	0.004

Attachment 3

SPECTRUM RESPONSE

Spectrum Response – Chain – Type 2 – Heave

0°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (m/m)	RAO^2 (m^2/m^2)	Sr(ω) (m^2/(rad/s))
0.189	0.000	0.000	1.012	1.025	0.000
0.446	0.515	0.591	1.080	1.167	0.689
0.703	0.898	0.101	1.304	1.699	0.172
0.959	0.969	0.023	1.570	2.465	0.057
1.216	0.988	0.007	3.108	9.659	0.069
1.473	0.994	0.003	0.405	0.164	0.000
1.730	0.997	0.001	0.040	0.002	0.000
1.986	0.998	0.001	0.042	0.002	0.000
2.243	0.999	0.000	0.024	0.001	0.000
2.500	0.999	0.000	0.012	0.000	0.000
2.756	1.000	0.000	0.004	0.000	0.000
3.013	1.000	0.000	0.002	0.000	0.000
3.270	1.000	0.000	0.001	0.000	0.000
3.527	1.000	0.000	0.004	0.000	0.000
3.783	1.000	0.000	0.005	0.000	0.000
4.040	1.000	0.000	0.002	0.000	0.000
4.297	1.000	0.000	0.001	0.000	0.000
4.553	1.000	0.000	0.001	0.000	0.000
4.810	1.000	0.000	0.001	0.000	0.000
5.067	1.000	0.000	0.001	0.000	0.000

30°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (m/m)	RAO^2 (m^2/m^2)	Sr(ω) (m^2/(rad/s))
0.189	0.000	0.000	1.012	1.024	0.000
0.446	0.515	0.591	1.080	1.166	0.689
0.703	0.898	0.101	1.300	1.691	0.171
0.959	0.969	0.023	1.622	2.631	0.061
1.216	0.988	0.007	3.155	9.953	0.072
1.473	0.994	0.003	0.427	0.182	0.001
1.730	0.997	0.001	0.082	0.007	0.000
1.986	0.998	0.001	0.060	0.004	0.000
2.243	0.999	0.000	0.029	0.001	0.000
2.500	0.999	0.000	0.010	0.000	0.000
2.756	1.000	0.000	0.003	0.000	0.000
3.013	1.000	0.000	0.006	0.000	0.000
3.270	1.000	0.000	0.007	0.000	0.000
3.527	1.000	0.000	0.005	0.000	0.000
3.783	1.000	0.000	0.001	0.000	0.000
4.040	1.000	0.000	0.001	0.000	0.000
4.297	1.000	0.000	0.002	0.000	0.000
4.553	1.000	0.000	0.003	0.000	0.000
4.810	1.000	0.000	0.002	0.000	0.000
5.067	1.000	0.000	0.001	0.000	0.000

Spectrum Response – Chain – Type 2 – Heave

60°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (m/m)	RAO^2 (m^2/m^2)	Sr(ω) (m^2/(rad/s))
0.189	0.000	0.000	1.012	1.024	0.000
0.446	0.515	0.591	1.079	1.164	0.687
0.703	0.898	0.101	1.294	1.673	0.169
0.959	0.969	0.023	1.722	2.964	0.068
1.216	0.988	0.007	3.208	10.291	0.074
1.473	0.994	0.003	0.418	0.175	0.000
1.730	0.997	0.001	0.043	0.002	0.000
1.986	0.998	0.001	0.040	0.002	0.000
2.243	0.999	0.000	0.024	0.001	0.000
2.500	0.999	0.000	0.012	0.000	0.000
2.756	1.000	0.000	0.004	0.000	0.000
3.013	1.000	0.000	0.002	0.000	0.000
3.270	1.000	0.000	0.001	0.000	0.000
3.527	1.000	0.000	0.004	0.000	0.000
3.783	1.000	0.000	0.005	0.000	0.000
4.040	1.000	0.000	0.002	0.000	0.000
4.297	1.000	0.000	0.001	0.000	0.000
4.553	1.000	0.000	0.001	0.000	0.000
4.810	1.000	0.000	0.001	0.000	0.000
5.067	1.000	0.000	0.001	0.000	0.000

90°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (m/m)	RAO^2 (m^2/m^2)	Sr(ω) (m^2/(rad/s))
0.189	0.000	0.000	1.012	1.024	0.000
0.446	0.515	0.591	1.078	1.163	0.687
0.703	0.898	0.101	1.290	1.665	0.168
0.959	0.969	0.023	1.772	3.139	0.073
1.216	0.988	0.007	3.230	10.433	0.075
1.473	0.994	0.003	0.407	0.165	0.000
1.730	0.997	0.001	0.052	0.003	0.000
1.986	0.998	0.001	0.021	0.000	0.000
2.243	0.999	0.000	0.019	0.000	0.000
2.500	0.999	0.000	0.012	0.000	0.000
2.756	1.000	0.000	0.000	0.000	0.000
3.013	1.000	0.000	0.008	0.000	0.000
3.270	1.000	0.000	0.009	0.000	0.000
3.527	1.000	0.000	0.009	0.000	0.000
3.783	1.000	0.000	0.009	0.000	0.000
4.040	1.000	0.000	0.002	0.000	0.000
4.297	1.000	0.000	0.003	0.000	0.000
4.553	1.000	0.000	0.003	0.000	0.000
4.810	1.000	0.000	0.004	0.000	0.000
5.067	1.000	0.000	0.003	0.000	0.000

Spectrum Response – Chain – Type 2 – Heave

120°					
ω (rad/s)	exp	$S_J(\omega)$ $(m^2/(rad/s))$	RAO (m/m)	RAO^2 (m^2/m^2)	Sr(ω) $(m^2/(rad/s))$
0.189	0.000	0.000	1.012	1.024	0.000
0.446	0.515	0.591	1.079	1.164	0.687
0.703	0.898	0.101	1.294	1.673	0.169
0.959	0.969	0.023	1.722	2.965	0.069
1.216	0.988	0.007	3.208	10.292	0.074
1.473	0.994	0.003	0.418	0.175	0.000
1.730	0.997	0.001	0.043	0.002	0.000
1.986	0.998	0.001	0.040	0.002	0.000
2.243	0.999	0.000	0.024	0.001	0.000
2.500	0.999	0.000	0.012	0.000	0.000
2.756	1.000	0.000	0.004	0.000	0.000
3.013	1.000	0.000	0.002	0.000	0.000
3.270	1.000	0.000	0.001	0.000	0.000
3.527	1.000	0.000	0.004	0.000	0.000
3.783	1.000	0.000	0.005	0.000	0.000
4.040	1.000	0.000	0.002	0.000	0.000
4.297	1.000	0.000	0.001	0.000	0.000
4.553	1.000	0.000	0.001	0.000	0.000
4.810	1.000	0.000	0.001	0.000	0.000
5.067	1.000	0.000	0.001	0.000	0.000

150°					
ω (rad/s)	exp	$S_J(\omega)$ $(m^2/(rad/s))$	RAO (m/m)	RAO^2 (m^2/m^2)	Sr(ω) $(m^2/(rad/s))$
0.189	0.000	0.000	1.012	1.024	0.000
0.446	0.515	0.591	1.080	1.166	0.689
0.703	0.898	0.101	1.300	1.691	0.171
0.959	0.969	0.023	1.622	2.631	0.061
1.216	0.988	0.007	3.155	9.954	0.072
1.473	0.994	0.003	0.427	0.182	0.001
1.730	0.997	0.001	0.082	0.007	0.000
1.986	0.998	0.001	0.060	0.004	0.000
2.243	0.999	0.000	0.029	0.001	0.000
2.500	0.999	0.000	0.010	0.000	0.000
2.756	1.000	0.000	0.003	0.000	0.000
3.013	1.000	0.000	0.006	0.000	0.000
3.270	1.000	0.000	0.007	0.000	0.000
3.527	1.000	0.000	0.005	0.000	0.000
3.783	1.000	0.000	0.001	0.000	0.000
4.040	1.000	0.000	0.001	0.000	0.000
4.297	1.000	0.000	0.002	0.000	0.000
4.553	1.000	0.000	0.003	0.000	0.000
4.810	1.000	0.000	0.002	0.000	0.000
5.067	1.000	0.000	0.001	0.000	0.000

Spectrum Response – Chain – Type 2 – Heave

180^o					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (m/m)	RAO^2 (m^2/m^2)	$Sr(\omega)$ (m^2/(rad/s))
0.189	0.000	0.000	1.012	1.025	0.000
0.446	0.515	0.591	1.080	1.167	0.689
0.703	0.898	0.101	1.304	1.699	0.172
0.959	0.969	0.023	1.570	2.465	0.057
1.216	0.988	0.007	3.108	9.658	0.069
1.473	0.994	0.003	0.404	0.164	0.000
1.730	0.997	0.001	0.040	0.002	0.000
1.986	0.998	0.001	0.042	0.002	0.000
2.243	0.999	0.000	0.024	0.001	0.000
2.500	0.999	0.000	0.012	0.000	0.000
2.756	1.000	0.000	0.004	0.000	0.000
3.013	1.000	0.000	0.002	0.000	0.000
3.270	1.000	0.000	0.001	0.000	0.000
3.527	1.000	0.000	0.004	0.000	0.000
3.783	1.000	0.000	0.005	0.000	0.000
4.040	1.000	0.000	0.002	0.000	0.000
4.297	1.000	0.000	0.001	0.000	0.000
4.553	1.000	0.000	0.001	0.000	0.000
4.810	1.000	0.000	0.001	0.000	0.000
5.067	1.000	0.000	0.001	0.000	0.000

Spectrum Response – Chain – Type 2 – Pitch

0°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.088	0.008	0.000
0.446	0.515	0.591	0.661	0.437	0.258
0.703	0.898	0.101	3.759	14.130	1.429
0.959	0.969	0.023	28.129	791.235	18.283
1.216	0.988	0.007	9.538	90.970	0.654
1.473	0.994	0.003	0.347	0.120	0.000
1.730	0.997	0.001	1.141	1.301	0.002
1.986	0.998	0.001	0.544	0.296	0.000
2.243	0.999	0.000	0.285	0.081	0.000
2.500	0.999	0.000	0.189	0.036	0.000
2.756	1.000	0.000	0.118	0.014	0.000
3.013	1.000	0.000	0.064	0.004	0.000
3.270	1.000	0.000	0.048	0.002	0.000
3.527	1.000	0.000	0.029	0.001	0.000
3.783	1.000	0.000	0.012	0.000	0.000
4.040	1.000	0.000	0.013	0.000	0.000
4.297	1.000	0.000	0.036	0.001	0.000
4.553	1.000	0.000	0.023	0.001	0.000
4.810	1.000	0.000	0.020	0.000	0.000
5.067	1.000	0.000	0.021	0.000	0.000

30°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.297	0.088	0.000
0.446	0.515	0.591	1.025	1.050	0.620
0.703	0.898	0.101	4.177	17.444	1.764
0.959	0.969	0.023	27.497	756.090	17.471
1.216	0.988	0.007	11.119	123.638	0.888
1.473	0.994	0.003	0.619	0.383	0.001
1.730	0.997	0.001	0.815	0.664	0.001
1.986	0.998	0.001	0.321	0.103	0.000
2.243	0.999	0.000	0.309	0.096	0.000
2.500	0.999	0.000	0.309	0.096	0.000
2.756	1.000	0.000	0.286	0.082	0.000
3.013	1.000	0.000	0.178	0.032	0.000
3.270	1.000	0.000	0.040	0.002	0.000
3.527	1.000	0.000	0.025	0.001	0.000
3.783	1.000	0.000	0.035	0.001	0.000
4.040	1.000	0.000	0.021	0.000	0.000
4.297	1.000	0.000	0.024	0.001	0.000
4.553	1.000	0.000	0.006	0.000	0.000
4.810	1.000	0.000	0.014	0.000	0.000
5.067	1.000	0.000	0.003	0.000	0.000

Spectrum Response – Chain – Type 2 – Pitch

60°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.499	0.249	0.000
0.446	0.515	0.591	1.516	2.297	1.357
0.703	0.898	0.101	4.970	24.698	2.498
0.959	0.969	0.023	25.957	673.758	15.568
1.216	0.988	0.007	13.189	173.948	1.250
1.473	0.994	0.003	1.808	3.270	0.009
1.730	0.997	0.001	0.739	0.546	0.001
1.986	0.998	0.001	0.910	0.828	0.001
2.243	0.999	0.000	0.330	0.109	0.000
2.500	0.999	0.000	0.163	0.027	0.000
2.756	1.000	0.000	0.113	0.013	0.000
3.013	1.000	0.000	0.061	0.004	0.000
3.270	1.000	0.000	0.113	0.013	0.000
3.527	1.000	0.000	0.069	0.005	0.000
3.783	1.000	0.000	0.032	0.001	0.000
4.040	1.000	0.000	0.023	0.001	0.000
4.297	1.000	0.000	0.046	0.002	0.000
4.553	1.000	0.000	0.003	0.000	0.000
4.810	1.000	0.000	0.008	0.000	0.000
5.067	1.000	0.000	0.013	0.000	0.000

90°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.574	0.330	0.000
0.446	0.515	0.591	1.712	2.932	1.731
0.703	0.898	0.101	5.355	28.674	2.900
0.959	0.969	0.023	25.308	640.508	14.800
1.216	0.988	0.007	14.166	200.672	1.442
1.473	0.994	0.003	2.515	6.326	0.018
1.730	0.997	0.001	1.441	2.076	0.003
1.986	0.998	0.001	1.351	1.824	0.001
2.243	0.999	0.000	0.611	0.373	0.000
2.500	0.999	0.000	0.516	0.267	0.000
2.756	1.000	0.000	0.319	0.101	0.000
3.013	1.000	0.000	0.184	0.034	0.000
3.270	1.000	0.000	0.151	0.023	0.000
3.527	1.000	0.000	0.114	0.013	0.000
3.783	1.000	0.000	0.056	0.003	0.000
4.040	1.000	0.000	0.076	0.006	0.000
4.297	1.000	0.000	0.056	0.003	0.000
4.553	1.000	0.000	0.013	0.000	0.000
4.810	1.000	0.000	0.027	0.001	0.000
5.067	1.000	0.000	0.008	0.000	0.000

Spectrum Response – Chain – Type 2 – Pitch

120°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.499	0.249	0.000
0.446	0.515	0.591	1.516	2.297	1.357
0.703	0.898	0.101	4.971	24.707	2.499
0.959	0.969	0.023	25.937	672.731	15.544
1.216	0.988	0.007	13.191	174.003	1.250
1.473	0.994	0.003	1.810	3.277	0.009
1.730	0.997	0.001	0.740	0.547	0.001
1.986	0.998	0.001	0.907	0.823	0.001
2.243	0.999	0.000	0.329	0.108	0.000
2.500	0.999	0.000	0.163	0.027	0.000
2.756	1.000	0.000	0.114	0.013	0.000
3.013	1.000	0.000	0.060	0.004	0.000
3.270	1.000	0.000	0.114	0.013	0.000
3.527	1.000	0.000	0.070	0.005	0.000
3.783	1.000	0.000	0.032	0.001	0.000
4.040	1.000	0.000	0.022	0.000	0.000
4.297	1.000	0.000	0.045	0.002	0.000
4.553	1.000	0.000	0.003	0.000	0.000
4.810	1.000	0.000	0.008	0.000	0.000
5.067	1.000	0.000	0.013	0.000	0.000

150°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.297	0.088	0.000
0.446	0.515	0.591	1.025	1.050	0.620
0.703	0.898	0.101	4.178	17.453	1.765
0.959	0.969	0.023	27.475	754.886	17.443
1.216	0.988	0.007	11.121	123.670	0.889
1.473	0.994	0.003	0.620	0.384	0.001
1.730	0.997	0.001	0.811	0.658	0.001
1.986	0.998	0.001	0.319	0.102	0.000
2.243	0.999	0.000	0.309	0.095	0.000
2.500	0.999	0.000	0.309	0.095	0.000
2.756	1.000	0.000	0.286	0.082	0.000
3.013	1.000	0.000	0.178	0.032	0.000
3.270	1.000	0.000	0.040	0.002	0.000
3.527	1.000	0.000	0.024	0.001	0.000
3.783	1.000	0.000	0.035	0.001	0.000
4.040	1.000	0.000	0.021	0.000	0.000
4.297	1.000	0.000	0.023	0.001	0.000
4.553	1.000	0.000	0.006	0.000	0.000
4.810	1.000	0.000	0.014	0.000	0.000
5.067	1.000	0.000	0.002	0.000	0.000

Spectrum Response – Chain – Type 2 – Pitch

180°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.088	0.008	0.000
0.446	0.515	0.591	0.661	0.437	0.258
0.703	0.898	0.101	3.759	14.131	1.429
0.959	0.969	0.023	28.126	791.077	18.279
1.216	0.988	0.007	9.537	90.947	0.653
1.473	0.994	0.003	0.346	0.120	0.000
1.730	0.997	0.001	1.140	1.301	0.002
1.986	0.998	0.001	0.546	0.298	0.000
2.243	0.999	0.000	0.284	0.081	0.000
2.500	0.999	0.000	0.189	0.036	0.000
2.756	1.000	0.000	0.119	0.014	0.000
3.013	1.000	0.000	0.063	0.004	0.000
3.270	1.000	0.000	0.048	0.002	0.000
3.527	1.000	0.000	0.030	0.001	0.000
3.783	1.000	0.000	0.013	0.000	0.000
4.040	1.000	0.000	0.013	0.000	0.000
4.297	1.000	0.000	0.036	0.001	0.000
4.553	1.000	0.000	0.023	0.001	0.000
4.810	1.000	0.000	0.020	0.000	0.000
5.067	1.000	0.000	0.020	0.000	0.000

Spectrum Response – Chain – Type 2 – Roll

0°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.858	0.737	0.000
0.446	0.515	0.591	1.809	3.273	1.933
0.703	0.898	0.101	4.858	23.601	2.387
0.959	0.969	0.023	18.927	358.241	8.278
1.216	0.988	0.007	2.532	6.410	0.046
1.473	0.994	0.003	0.756	0.572	0.002
1.730	0.997	0.001	0.730	0.532	0.001
1.986	0.998	0.001	0.946	0.896	0.001
2.243	0.999	0.000	0.324	0.105	0.000
2.500	0.999	0.000	0.086	0.007	0.000
2.756	1.000	0.000	0.021	0.000	0.000
3.013	1.000	0.000	0.082	0.007	0.000
3.270	1.000	0.000	0.116	0.014	0.000
3.527	1.000	0.000	0.060	0.004	0.000
3.783	1.000	0.000	0.030	0.001	0.000
4.040	1.000	0.000	0.029	0.001	0.000
4.297	1.000	0.000	0.070	0.005	0.000
4.553	1.000	0.000	0.013	0.000	0.000
4.810	1.000	0.000	0.008	0.000	0.000
5.067	1.000	0.000	0.008	0.000	0.000

30°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.745	0.555	0.000
0.446	0.515	0.591	1.577	2.486	1.468
0.703	0.898	0.101	4.278	18.298	1.851
0.959	0.969	0.023	17.320	299.991	6.932
1.216	0.988	0.007	2.705	7.318	0.053
1.473	0.994	0.003	1.492	2.226	0.006
1.730	0.997	0.001	1.651	2.724	0.003
1.986	0.998	0.001	0.541	0.292	0.000
2.243	0.999	0.000	0.497	0.247	0.000
2.500	0.999	0.000	0.529	0.279	0.000
2.756	1.000	0.000	0.500	0.250	0.000
3.013	1.000	0.000	0.321	0.103	0.000
3.270	1.000	0.000	0.082	0.007	0.000
3.527	1.000	0.000	0.040	0.002	0.000
3.783	1.000	0.000	0.060	0.004	0.000
4.040	1.000	0.000	0.039	0.002	0.000
4.297	1.000	0.000	0.036	0.001	0.000
4.553	1.000	0.000	0.008	0.000	0.000
4.810	1.000	0.000	0.018	0.000	0.000
5.067	1.000	0.000	0.007	0.000	0.000

Spectrum Response – Chain – Type 2 – Roll

60°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.432	0.187	0.000
0.446	0.515	0.591	0.922	0.850	0.502
0.703	0.898	0.101	2.550	6.502	0.658
0.959	0.969	0.023	10.995	120.881	2.793
1.216	0.988	0.007	1.999	3.997	0.029
1.473	0.994	0.003	1.278	1.633	0.005
1.730	0.997	0.001	1.323	1.752	0.002
1.986	0.998	0.001	0.111	0.012	0.000
2.243	0.999	0.000	0.217	0.047	0.000
2.500	0.999	0.000	0.174	0.030	0.000
2.756	1.000	0.000	0.065	0.004	0.000
3.013	1.000	0.000	0.039	0.002	0.000
3.270	1.000	0.000	0.037	0.001	0.000
3.527	1.000	0.000	0.009	0.000	0.000
3.783	1.000	0.000	0.024	0.001	0.000
4.040	1.000	0.000	0.022	0.000	0.000
4.297	1.000	0.000	0.051	0.003	0.000
4.553	1.000	0.000	0.029	0.001	0.000
4.810	1.000	0.000	0.022	0.001	0.000
5.067	1.000	0.000	0.017	0.000	0.000

90°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.000	0.000	0.000
0.446	0.515	0.591	0.000	0.000	0.000
0.703	0.898	0.101	0.002	0.000	0.000
0.959	0.969	0.023	0.025	0.001	0.000
1.216	0.988	0.007	0.011	0.000	0.000
1.473	0.994	0.003	0.003	0.000	0.000
1.730	0.997	0.001	0.002	0.000	0.000
1.986	0.998	0.001	0.002	0.000	0.000
2.243	0.999	0.000	0.001	0.000	0.000
2.500	0.999	0.000	0.001	0.000	0.000
2.756	1.000	0.000	0.000	0.000	0.000
3.013	1.000	0.000	0.000	0.000	0.000
3.270	1.000	0.000	0.001	0.000	0.000
3.527	1.000	0.000	0.001	0.000	0.000
3.783	1.000	0.000	0.000	0.000	0.000
4.040	1.000	0.000	0.001	0.000	0.000
4.297	1.000	0.000	0.001	0.000	0.000
4.553	1.000	0.000	0.000	0.000	0.000
4.810	1.000	0.000	0.000	0.000	0.000
5.067	1.000	0.000	0.000	0.000	0.000

Spectrum Response – Chain – Type 2 – Roll

120°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	$Sr(\omega)$ (deg^2/(rad/s))
0.189	0.000	0.000	0.432	0.187	0.000
0.446	0.515	0.591	0.922	0.850	0.502
0.703	0.898	0.101	2.552	6.514	0.659
0.959	0.969	0.023	10.950	119.896	2.770
1.216	0.988	0.007	2.003	4.013	0.029
1.473	0.994	0.003	1.284	1.647	0.005
1.730	0.997	0.001	1.328	1.764	0.002
1.986	0.998	0.001	0.114	0.013	0.000
2.243	0.999	0.000	0.219	0.048	0.000
2.500	0.999	0.000	0.175	0.030	0.000
2.756	1.000	0.000	0.065	0.004	0.000
3.013	1.000	0.000	0.041	0.002	0.000
3.270	1.000	0.000	0.038	0.001	0.000
3.527	1.000	0.000	0.008	0.000	0.000
3.783	1.000	0.000	0.024	0.001	0.000
4.040	1.000	0.000	0.022	0.000	0.000
4.297	1.000	0.000	0.051	0.003	0.000
4.553	1.000	0.000	0.029	0.001	0.000
4.810	1.000	0.000	0.023	0.001	0.000
5.067	1.000	0.000	0.017	0.000	0.000

150°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	$Sr(\omega)$ (deg^2/(rad/s))
0.189	0.000	0.000	0.745	0.555	0.000
0.446	0.515	0.591	1.577	2.486	1.468
0.703	0.898	0.101	4.279	18.312	1.852
0.959	0.969	0.023	17.289	298.919	6.907
1.216	0.988	0.007	2.705	7.317	0.053
1.473	0.994	0.003	1.496	2.239	0.006
1.730	0.997	0.001	1.655	2.739	0.003
1.986	0.998	0.001	0.540	0.291	0.000
2.243	0.999	0.000	0.497	0.247	0.000
2.500	0.999	0.000	0.528	0.279	0.000
2.756	1.000	0.000	0.500	0.250	0.000
3.013	1.000	0.000	0.321	0.103	0.000
3.270	1.000	0.000	0.081	0.007	0.000
3.527	1.000	0.000	0.041	0.002	0.000
3.783	1.000	0.000	0.060	0.004	0.000
4.040	1.000	0.000	0.039	0.001	0.000
4.297	1.000	0.000	0.035	0.001	0.000
4.553	1.000	0.000	0.008	0.000	0.000
4.810	1.000	0.000	0.018	0.000	0.000
5.067	1.000	0.000	0.007	0.000	0.000

Spectrum Response – Chain – Type 2 – Roll

180°					
ω (rad/s)	**exp**	**$S_J(\omega)$ (m^2/(rad/s))**	**RAO (deg/m)**	**RAO^2 (deg^2/m^2)**	**Sr(ω) (deg^2/(rad/s))**
0.189	0.000	0.000	0.858	0.737	0.000
0.446	0.515	0.591	1.809	3.273	1.933
0.703	0.898	0.101	4.858	23.602	2.387
0.959	0.969	0.023	18.926	358.187	8.276
1.216	0.988	0.007	2.522	6.360	0.046
1.473	0.994	0.003	0.756	0.572	0.002
1.730	0.997	0.001	0.732	0.537	0.001
1.986	0.998	0.001	0.948	0.898	0.001
2.243	0.999	0.000	0.325	0.106	0.000
2.500	0.999	0.000	0.087	0.008	0.000
2.756	1.000	0.000	0.022	0.000	0.000
3.013	1.000	0.000	0.082	0.007	0.000
3.270	1.000	0.000	0.116	0.014	0.000
3.527	1.000	0.000	0.060	0.004	0.000
3.783	1.000	0.000	0.031	0.001	0.000
4.040	1.000	0.000	0.030	0.001	0.000
4.297	1.000	0.000	0.070	0.005	0.000
4.553	1.000	0.000	0.013	0.000	0.000
4.810	1.000	0.000	0.008	0.000	0.000
5.067	1.000	0.000	0.008	0.000	0.000

Spectrum Response – Chain – Type 2 – Surge

0°

ω (rad/s)	exp	$S_J(\omega)$ $(m^2/(rad/s))$	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) $(deg^2/(rad/s))$
0.189	0.000	0.000	2.247	5.048	0.000
0.446	0.515	0.591	0.996	0.992	0.586
0.703	0.898	0.101	0.676	0.457	0.046
0.959	0.969	0.023	0.741	0.549	0.013
1.216	0.988	0.007	0.524	0.275	0.002
1.473	0.994	0.003	0.400	0.160	0.000
1.730	0.997	0.001	0.279	0.078	0.000
1.986	0.998	0.001	0.143	0.021	0.000
2.243	0.999	0.000	0.034	0.001	0.000
2.500	0.999	0.000	0.029	0.001	0.000
2.756	1.000	0.000	0.050	0.003	0.000
3.013	1.000	0.000	0.038	0.001	0.000
3.270	1.000	0.000	0.034	0.001	0.000
3.527	1.000	0.000	0.026	0.001	0.000
3.783	1.000	0.000	0.020	0.000	0.000
4.040	1.000	0.000	0.011	0.000	0.000
4.297	1.000	0.000	0.047	0.002	0.000
4.553	1.000	0.000	0.004	0.000	0.000
4.810	1.000	0.000	0.005	0.000	0.000
5.067	1.000	0.000	0.004	0.000	0.000

30°

ω (rad/s)	exp	$S_J(\omega)$ $(m^2/(rad/s))$	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) $(deg^2/(rad/s))$
0.189	0.000	0.000	1.946	3.786	0.000
0.446	0.515	0.591	0.862	0.744	0.439
0.703	0.898	0.101	0.585	0.342	0.035
0.959	0.969	0.023	0.642	0.413	0.010
1.216	0.988	0.007	0.450	0.203	0.001
1.473	0.994	0.003	0.331	0.109	0.000
1.730	0.997	0.001	0.201	0.040	0.000
1.986	0.998	0.001	0.075	0.006	0.000
2.243	0.999	0.000	0.050	0.003	0.000
2.500	0.999	0.000	0.078	0.006	0.000
2.756	1.000	0.000	0.087	0.008	0.000
3.013	1.000	0.000	0.085	0.007	0.000
3.270	1.000	0.000	0.033	0.001	0.000
3.527	1.000	0.000	0.008	0.000	0.000
3.783	1.000	0.000	0.007	0.000	0.000
4.040	1.000	0.000	0.011	0.000	0.000
4.297	1.000	0.000	0.081	0.007	0.000
4.553	1.000	0.000	0.014	0.000	0.000
4.810	1.000	0.000	0.008	0.000	0.000
5.067	1.000	0.000	0.006	0.000	0.000

Spectrum Response – Chain – Type 2 – Surge

60°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.123	1.262	0.000
0.446	0.515	0.591	0.498	0.248	0.146
0.703	0.898	0.101	0.337	0.114	0.012
0.959	0.969	0.023	0.373	0.139	0.003
1.216	0.988	0.007	0.258	0.067	0.000
1.473	0.994	0.003	0.183	0.034	0.000
1.730	0.997	0.001	0.092	0.008	0.000
1.986	0.998	0.001	0.022	0.000	0.000
2.243	0.999	0.000	0.058	0.003	0.000
2.500	0.999	0.000	0.047	0.002	0.000
2.756	1.000	0.000	0.024	0.001	0.000
3.013	1.000	0.000	0.031	0.001	0.000
3.270	1.000	0.000	0.012	0.000	0.000
3.527	1.000	0.000	0.007	0.000	0.000
3.783	1.000	0.000	0.010	0.000	0.000
4.040	1.000	0.000	0.004	0.000	0.000
4.297	1.000	0.000	0.054	0.003	0.000
4.553	1.000	0.000	0.004	0.000	0.000
4.810	1.000	0.000	0.003	0.000	0.000
5.067	1.000	0.000	0.002	0.000	0.000

90°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.000	0.000	0.000
0.446	0.515	0.591	0.000	0.000	0.000
0.703	0.898	0.101	0.000	0.000	0.000
0.959	0.969	0.023	0.000	0.000	0.000
1.216	0.988	0.007	0.000	0.000	0.000
1.473	0.994	0.003	0.000	0.000	0.000
1.730	0.997	0.001	0.000	0.000	0.000
1.986	0.998	0.001	0.000	0.000	0.000
2.243	0.999	0.000	0.000	0.000	0.000
2.500	0.999	0.000	0.000	0.000	0.000
2.756	1.000	0.000	0.000	0.000	0.000
3.013	1.000	0.000	0.000	0.000	0.000
3.270	1.000	0.000	0.000	0.000	0.000
3.527	1.000	0.000	0.000	0.000	0.000
3.783	1.000	0.000	0.000	0.000	0.000
4.040	1.000	0.000	0.000	0.000	0.000
4.297	1.000	0.000	0.001	0.000	0.000
4.553	1.000	0.000	0.000	0.000	0.000
4.810	1.000	0.000	0.000	0.000	0.000
5.067	1.000	0.000	0.000	0.000	0.000

Spectrum Response – Chain – Type 2 – Surge

120°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.123	1.262	0.000
0.446	0.515	0.591	0.498	0.248	0.146
0.703	0.898	0.101	0.337	0.114	0.012
0.959	0.969	0.023	0.373	0.139	0.003
1.216	0.988	0.007	0.258	0.067	0.000
1.473	0.994	0.003	0.183	0.034	0.000
1.730	0.997	0.001	0.092	0.009	0.000
1.986	0.998	0.001	0.022	0.000	0.000
2.243	0.999	0.000	0.058	0.003	0.000
2.500	0.999	0.000	0.047	0.002	0.000
2.756	1.000	0.000	0.024	0.001	0.000
3.013	1.000	0.000	0.031	0.001	0.000
3.270	1.000	0.000	0.012	0.000	0.000
3.527	1.000	0.000	0.007	0.000	0.000
3.783	1.000	0.000	0.010	0.000	0.000
4.040	1.000	0.000	0.004	0.000	0.000
4.297	1.000	0.000	0.054	0.003	0.000
4.553	1.000	0.000	0.004	0.000	0.000
4.810	1.000	0.000	0.003	0.000	0.000
5.067	1.000	0.000	0.002	0.000	0.000

150°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.946	3.786	0.000
0.446	0.515	0.591	0.862	0.744	0.439
0.703	0.898	0.101	0.585	0.342	0.035
0.959	0.969	0.023	0.642	0.413	0.010
1.216	0.988	0.007	0.450	0.203	0.001
1.473	0.994	0.003	0.331	0.109	0.000
1.730	0.997	0.001	0.201	0.040	0.000
1.986	0.998	0.001	0.075	0.006	0.000
2.243	0.999	0.000	0.051	0.003	0.000
2.500	0.999	0.000	0.078	0.006	0.000
2.756	1.000	0.000	0.087	0.008	0.000
3.013	1.000	0.000	0.085	0.007	0.000
3.270	1.000	0.000	0.033	0.001	0.000
3.527	1.000	0.000	0.008	0.000	0.000
3.783	1.000	0.000	0.007	0.000	0.000
4.040	1.000	0.000	0.011	0.000	0.000
4.297	1.000	0.000	0.080	0.006	0.000
4.553	1.000	0.000	0.014	0.000	0.000
4.810	1.000	0.000	0.008	0.000	0.000
5.067	1.000	0.000	0.006	0.000	0.000

Spectrum Response – Chain – Type 2 – Surge

180°

ω (rad/s)	exp	$S_J(\omega)$ $(m^2/(rad/s))$	RAO (deg/m)	RAO^2 (deg^2/m^2)	$Sr(\omega)$ $(deg^2/(rad/s))$
0.189	0.000	0.000	2.247	5.048	0.000
0.446	0.515	0.591	0.996	0.992	0.586
0.703	0.898	0.101	0.676	0.457	0.046
0.959	0.969	0.023	0.741	0.549	0.013
1.216	0.988	0.007	0.524	0.275	0.002
1.473	0.994	0.003	0.401	0.160	0.000
1.730	0.997	0.001	0.279	0.078	0.000
1.986	0.998	0.001	0.143	0.021	0.000
2.243	0.999	0.000	0.034	0.001	0.000
2.500	0.999	0.000	0.029	0.001	0.000
2.756	1.000	0.000	0.050	0.003	0.000
3.013	1.000	0.000	0.038	0.001	0.000
3.270	1.000	0.000	0.034	0.001	0.000
3.527	1.000	0.000	0.026	0.001	0.000
3.783	1.000	0.000	0.020	0.000	0.000
4.040	1.000	0.000	0.011	0.000	0.000
4.297	1.000	0.000	0.047	0.002	0.000
4.553	1.000	0.000	0.004	0.000	0.000
4.810	1.000	0.000	0.005	0.000	0.000
5.067	1.000	0.000	0.004	0.000	0.000

Spectrum Response – Chain – Type 2 – Sway

0^o					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.008	0.000	0.000
0.446	0.515	0.591	0.013	0.000	0.000
0.703	0.898	0.101	0.040	0.002	0.000
0.959	0.969	0.023	0.197	0.039	0.001
1.216	0.988	0.007	0.099	0.010	0.000
1.473	0.994	0.003	0.047	0.002	0.000
1.730	0.997	0.001	0.062	0.004	0.000
1.986	0.998	0.001	0.075	0.006	0.000
2.243	0.999	0.000	0.067	0.005	0.000
2.500	0.999	0.000	0.058	0.003	0.000
2.756	1.000	0.000	0.062	0.004	0.000
3.013	1.000	0.000	0.059	0.004	0.000
3.270	1.000	0.000	0.023	0.001	0.000
3.527	1.000	0.000	0.007	0.000	0.000
3.783	1.000	0.000	0.001	0.000	0.000
4.040	1.000	0.000	0.002	0.000	0.000
4.297	1.000	0.000	0.023	0.001	0.000
4.553	1.000	0.000	0.003	0.000	0.000
4.810	1.000	0.000	0.000	0.000	0.000
5.067	1.000	0.000	0.001	0.000	0.000

30^o					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.127	1.269	0.000
0.446	0.515	0.591	0.499	0.249	0.147
0.703	0.898	0.101	0.340	0.116	0.012
0.959	0.969	0.023	0.406	0.165	0.004
1.216	0.988	0.007	0.321	0.103	0.001
1.473	0.994	0.003	0.193	0.037	0.000
1.730	0.997	0.001	0.115	0.013	0.000
1.986	0.998	0.001	0.044	0.002	0.000
2.243	0.999	0.000	0.029	0.001	0.000
2.500	0.999	0.000	0.045	0.002	0.000
2.756	1.000	0.000	0.051	0.003	0.000
3.013	1.000	0.000	0.049	0.002	0.000
3.270	1.000	0.000	0.019	0.000	0.000
3.527	1.000	0.000	0.004	0.000	0.000
3.783	1.000	0.000	0.004	0.000	0.000
4.040	1.000	0.000	0.007	0.000	0.000
4.297	1.000	0.000	0.049	0.002	0.000
4.553	1.000	0.000	0.008	0.000	0.000
4.810	1.000	0.000	0.005	0.000	0.000
5.067	1.000	0.000	0.003	0.000	0.000

Spectrum Response – Chain – Type 2 – Sway

60°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.951	3.807	0.000
0.446	0.515	0.591	0.865	0.748	0.442
0.703	0.898	0.101	0.587	0.344	0.035
0.959	0.969	0.023	0.644	0.415	0.010
1.216	0.988	0.007	0.512	0.262	0.002
1.473	0.994	0.003	0.357	0.128	0.000
1.730	0.997	0.001	0.267	0.072	0.000
1.986	0.998	0.001	0.159	0.025	0.000
2.243	0.999	0.000	0.047	0.002	0.000
2.500	0.999	0.000	0.047	0.002	0.000
2.756	1.000	0.000	0.077	0.006	0.000
3.013	1.000	0.000	0.063	0.004	0.000
3.270	1.000	0.000	0.039	0.002	0.000
3.527	1.000	0.000	0.026	0.001	0.000
3.783	1.000	0.000	0.017	0.000	0.000
4.040	1.000	0.000	0.011	0.000	0.000
4.297	1.000	0.000	0.044	0.002	0.000
4.553	1.000	0.000	0.002	0.000	0.000
4.810	1.000	0.000	0.004	0.000	0.000
5.067	1.000	0.000	0.004	0.000	0.000

90°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	2.253	5.076	0.000
0.446	0.515	0.591	0.999	0.998	0.589
0.703	0.898	0.101	0.677	0.459	0.046
0.959	0.969	0.023	0.735	0.540	0.012
1.216	0.988	0.007	0.584	0.340	0.002
1.473	0.994	0.003	0.424	0.179	0.000
1.730	0.997	0.001	0.337	0.114	0.000
1.986	0.998	0.001	0.215	0.046	0.000
2.243	0.999	0.000	0.089	0.008	0.000
2.500	0.999	0.000	0.114	0.013	0.000
2.756	1.000	0.000	0.115	0.013	0.000
3.013	1.000	0.000	0.103	0.011	0.000
3.270	1.000	0.000	0.051	0.003	0.000
3.527	1.000	0.000	0.033	0.001	0.000
3.783	1.000	0.000	0.024	0.001	0.000
4.040	1.000	0.000	0.009	0.000	0.000
4.297	1.000	0.000	0.138	0.019	0.000
4.553	1.000	0.000	0.012	0.000	0.000
4.810	1.000	0.000	0.008	0.000	0.000
5.067	1.000	0.000	0.006	0.000	0.000

Spectrum Response – Chain – Type 2 – Sway

120°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.951	3.807	0.000
0.446	0.515	0.591	0.865	0.748	0.442
0.703	0.898	0.101	0.587	0.344	0.035
0.959	0.969	0.023	0.644	0.414	0.010
1.216	0.988	0.007	0.512	0.262	0.002
1.473	0.994	0.003	0.357	0.128	0.000
1.730	0.997	0.001	0.268	0.072	0.000
1.986	0.998	0.001	0.159	0.025	0.000
2.243	0.999	0.000	0.047	0.002	0.000
2.500	0.999	0.000	0.047	0.002	0.000
2.756	1.000	0.000	0.077	0.006	0.000
3.013	1.000	0.000	0.063	0.004	0.000
3.270	1.000	0.000	0.039	0.002	0.000
3.527	1.000	0.000	0.026	0.001	0.000
3.783	1.000	0.000	0.017	0.000	0.000
4.040	1.000	0.000	0.011	0.000	0.000
4.297	1.000	0.000	0.044	0.002	0.000
4.553	1.000	0.000	0.002	0.000	0.000
4.810	1.000	0.000	0.004	0.000	0.000
5.067	1.000	0.000	0.004	0.000	0.000

150°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.127	1.269	0.000
0.446	0.515	0.591	0.499	0.249	0.147
0.703	0.898	0.101	0.340	0.116	0.012
0.959	0.969	0.023	0.406	0.165	0.004
1.216	0.988	0.007	0.321	0.103	0.001
1.473	0.994	0.003	0.193	0.037	0.000
1.730	0.997	0.001	0.115	0.013	0.000
1.986	0.998	0.001	0.044	0.002	0.000
2.243	0.999	0.000	0.029	0.001	0.000
2.500	0.999	0.000	0.045	0.002	0.000
2.756	1.000	0.000	0.051	0.003	0.000
3.013	1.000	0.000	0.050	0.002	0.000
3.270	1.000	0.000	0.019	0.000	0.000
3.527	1.000	0.000	0.004	0.000	0.000
3.783	1.000	0.000	0.004	0.000	0.000
4.040	1.000	0.000	0.007	0.000	0.000
4.297	1.000	0.000	0.049	0.002	0.000
4.553	1.000	0.000	0.008	0.000	0.000
4.810	1.000	0.000	0.005	0.000	0.000
5.067	1.000	0.000	0.003	0.000	0.000

Spectrum Response – Chain – Type 2 – Sway

180^o					
ω (rad/s)	**exp**	**$S_J(\omega)$ (m^2/(rad/s))**	**RAO (deg/m)**	**RAO^2 (deg^2/m^2)**	**$Sr(\omega)$ (deg^2/(rad/s))**
0.189	0.000	0.000	0.008	0.000	0.000
0.446	0.515	0.591	0.013	0.000	0.000
0.703	0.898	0.101	0.040	0.002	0.000
0.959	0.969	0.023	0.197	0.039	0.001
1.216	0.988	0.007	0.099	0.010	0.000
1.473	0.994	0.003	0.047	0.002	0.000
1.730	0.997	0.001	0.062	0.004	0.000
1.986	0.998	0.001	0.075	0.006	0.000
2.243	0.999	0.000	0.067	0.005	0.000
2.500	0.999	0.000	0.058	0.003	0.000
2.756	1.000	0.000	0.061	0.004	0.000
3.013	1.000	0.000	0.059	0.003	0.000
3.270	1.000	0.000	0.023	0.001	0.000
3.527	1.000	0.000	0.007	0.000	0.000
3.783	1.000	0.000	0.001	0.000	0.000
4.040	1.000	0.000	0.002	0.000	0.000
4.297	1.000	0.000	0.023	0.001	0.000
4.553	1.000	0.000	0.003	0.000	0.000
4.810	1.000	0.000	0.001	0.000	0.000
5.067	1.000	0.000	0.001	0.000	0.000

Spectrum Response – Chain – Type 2 – Yaw

0°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.608	2.585	0.000
0.446	0.515	0.591	0.681	0.464	0.274
0.703	0.898	0.101	0.399	0.159	0.016
0.959	0.969	0.023	0.323	0.104	0.002
1.216	0.988	0.007	0.099	0.010	0.000
1.473	0.994	0.003	0.592	0.350	0.001
1.730	0.997	0.001	1.182	1.398	0.002
1.986	0.998	0.001	1.744	3.043	0.002
2.243	0.999	0.000	1.975	3.901	0.001
2.500	0.999	0.000	1.764	3.113	0.001
2.756	1.000	0.000	1.402	1.965	0.000
3.013	1.000	0.000	0.897	0.805	0.000
3.270	1.000	0.000	0.290	0.084	0.000
3.527	1.000	0.000	0.024	0.001	0.000
3.783	1.000	0.000	0.096	0.009	0.000
4.040	1.000	0.000	0.059	0.003	0.000
4.297	1.000	0.000	0.946	0.896	0.000
4.553	1.000	0.000	0.174	0.030	0.000
4.810	1.000	0.000	0.126	0.016	0.000
5.067	1.000	0.000	0.036	0.001	0.000

30°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.403	1.968	0.000
0.446	0.515	0.591	0.620	0.384	0.227
0.703	0.898	0.101	0.417	0.174	0.018
0.959	0.969	0.023	0.457	0.209	0.005
1.216	0.988	0.007	0.311	0.097	0.001
1.473	0.994	0.003	0.223	0.050	0.000
1.730	0.997	0.001	0.129	0.017	0.000
1.986	0.998	0.001	0.045	0.002	0.000
2.243	0.999	0.000	0.031	0.001	0.000
2.500	0.999	0.000	0.056	0.003	0.000
2.756	1.000	0.000	0.071	0.005	0.000
3.013	1.000	0.000	0.079	0.006	0.000
3.270	1.000	0.000	0.029	0.001	0.000
3.527	1.000	0.000	0.007	0.000	0.000
3.783	1.000	0.000	0.006	0.000	0.000
4.040	1.000	0.000	0.008	0.000	0.000
4.297	1.000	0.000	0.404	0.163	0.000
4.553	1.000	0.000	0.014	0.000	0.000
4.810	1.000	0.000	0.008	0.000	0.000
5.067	1.000	0.000	0.005	0.000	0.000

Spectrum Response – Chain – Type 2 – Yaw

60°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.822	0.675	0.000
0.446	0.515	0.591	0.392	0.154	0.091
0.703	0.898	0.101	0.324	0.105	0.011
0.959	0.969	0.023	0.469	0.220	0.005
1.216	0.988	0.007	0.639	0.408	0.003
1.473	0.994	0.003	0.985	0.970	0.003
1.730	0.997	0.001	1.420	2.017	0.003
1.986	0.998	0.001	1.827	3.338	0.002
2.243	0.999	0.000	1.974	3.897	0.001
2.500	0.999	0.000	1.737	3.016	0.001
2.756	1.000	0.000	1.377	1.897	0.000
3.013	1.000	0.000	0.908	0.824	0.000
3.270	1.000	0.000	0.321	0.103	0.000
3.527	1.000	0.000	0.019	0.000	0.000
3.783	1.000	0.000	0.091	0.008	0.000
4.040	1.000	0.000	0.068	0.005	0.000
4.297	1.000	0.000	0.943	0.889	0.000
4.553	1.000	0.000	0.175	0.031	0.000
4.810	1.000	0.000	0.122	0.015	0.000
5.067	1.000	0.000	0.039	0.002	0.000

90°

ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.000	0.000	0.000
0.446	0.515	0.591	0.000	0.000	0.000
0.703	0.898	0.101	0.001	0.000	0.000
0.959	0.969	0.023	0.004	0.000	0.000
1.216	0.988	0.007	0.004	0.000	0.000
1.473	0.994	0.003	0.001	0.000	0.000
1.730	0.997	0.001	0.001	0.000	0.000
1.986	0.998	0.001	0.003	0.000	0.000
2.243	0.999	0.000	0.002	0.000	0.000
2.500	0.999	0.000	0.001	0.000	0.000
2.756	1.000	0.000	0.002	0.000	0.000
3.013	1.000	0.000	0.001	0.000	0.000
3.270	1.000	0.000	0.001	0.000	0.000
3.527	1.000	0.000	0.000	0.000	0.000
3.783	1.000	0.000	0.000	0.000	0.000
4.040	1.000	0.000	0.000	0.000	0.000
4.297	1.000	0.000	0.008	0.000	0.000
4.553	1.000	0.000	0.001	0.000	0.000
4.810	1.000	0.000	0.001	0.000	0.000
5.067	1.000	0.000	0.000	0.000	0.000

Spectrum Response – Chain – Type 2 – Yaw

120°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	0.821	0.675	0.000
0.446	0.515	0.591	0.392	0.153	0.091
0.703	0.898	0.101	0.322	0.104	0.011
0.959	0.969	0.023	0.473	0.223	0.005
1.216	0.988	0.007	0.644	0.415	0.003
1.473	0.994	0.003	0.985	0.970	0.003
1.730	0.997	0.001	1.419	2.012	0.003
1.986	0.998	0.001	1.831	3.353	0.002
2.243	0.999	0.000	1.977	3.910	0.001
2.500	0.999	0.000	1.739	3.024	0.001
2.756	1.000	0.000	1.379	1.901	0.000
3.013	1.000	0.000	0.908	0.825	0.000
3.270	1.000	0.000	0.321	0.103	0.000
3.527	1.000	0.000	0.019	0.000	0.000
3.783	1.000	0.000	0.091	0.008	0.000
4.040	1.000	0.000	0.068	0.005	0.000
4.297	1.000	0.000	0.941	0.886	0.000
4.553	1.000	0.000	0.175	0.031	0.000
4.810	1.000	0.000	0.122	0.015	0.000
5.067	1.000	0.000	0.039	0.002	0.000

150°					
ω (rad/s)	exp	$S_J(\omega)$ (m^2/(rad/s))	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) (deg^2/(rad/s))
0.189	0.000	0.000	1.403	1.967	0.000
0.446	0.515	0.591	0.619	0.384	0.227
0.703	0.898	0.101	0.417	0.174	0.018
0.959	0.969	0.023	0.459	0.211	0.005
1.216	0.988	0.007	0.316	0.100	0.001
1.473	0.994	0.003	0.224	0.050	0.000
1.730	0.997	0.001	0.129	0.017	0.000
1.986	0.998	0.001	0.046	0.002	0.000
2.243	0.999	0.000	0.032	0.001	0.000
2.500	0.999	0.000	0.057	0.003	0.000
2.756	1.000	0.000	0.073	0.005	0.000
3.013	1.000	0.000	0.080	0.006	0.000
3.270	1.000	0.000	0.030	0.001	0.000
3.527	1.000	0.000	0.006	0.000	0.000
3.783	1.000	0.000	0.006	0.000	0.000
4.040	1.000	0.000	0.008	0.000	0.000
4.297	1.000	0.000	0.411	0.169	0.000
4.553	1.000	0.000	0.014	0.000	0.000
4.810	1.000	0.000	0.008	0.000	0.000
5.067	1.000	0.000	0.005	0.000	0.000

Spectrum Response – Chain – Type 2 – Yaw

180°					
ω (rad/s)	exp	$S_J(\omega)$ ($m^2/(rad/s)$)	RAO (deg/m)	RAO^2 (deg^2/m^2)	Sr(ω) ($deg^2/(rad/s)$)
0.189	0.000	0.000	1.608	2.585	0.000
0.446	0.515	0.591	0.681	0.464	0.274
0.703	0.898	0.101	0.399	0.159	0.016
0.959	0.969	0.023	0.323	0.104	0.002
1.216	0.988	0.007	0.095	0.009	0.000
1.473	0.994	0.003	0.591	0.349	0.001
1.730	0.997	0.001	1.182	1.396	0.002
1.986	0.998	0.001	1.745	3.047	0.002
2.243	0.999	0.000	1.976	3.906	0.001
2.500	0.999	0.000	1.765	3.115	0.001
2.756	1.000	0.000	1.401	1.963	0.000
3.013	1.000	0.000	0.896	0.803	0.000
3.270	1.000	0.000	0.289	0.084	0.000
3.527	1.000	0.000	0.024	0.001	0.000
3.783	1.000	0.000	0.096	0.009	0.000
4.040	1.000	0.000	0.058	0.003	0.000
4.297	1.000	0.000	0.942	0.886	0.000
4.553	1.000	0.000	0.174	0.030	0.000
4.810	1.000	0.000	0.125	0.016	0.000
5.067	1.000	0.000	0.036	0.001	0.000

Attachment 4

AQWA HYDROSTATIC RESULTS

AQWA Hydrostatic Result - Chain – Type 1

AQWA Hydrostatic Results

Structure	PLTAL					
Hydrostatic Stiffness						
Centre of Gravity Position:	X:	0. m	Y:	0. m	Z:	-7.e-2 m
		Z		RX		RY
Heave(Z):		293466.5 N/m		-1920.9996 N/°		-1.5998094 N/°
Roll(RX):		-110065.17 N.m/m		38337.988 N.m/°		4.027698 N.m/°
Pitch(RZ):		-91.662331 N.m/m		4.027698 N.m/°		37613.184 N.m/°
Hydrostatic Displacement Properties						
Actual Volumetric Displacement:		91.796967 m³				
Equivalent Volumetric Displacement:		168.66551 m³				
Centre of Buoyancy Position:	X:	3.8076e-4 m	Y:	-0.3756678 m	Z:	-1.4470171 m
Out of Balance Forces/Weight:	FX:	1.9528e-8	FY:	-1.6064e-8	FZ:	-0.4557452
Out of Balance Moments/Weight:	MX:	-0.2044594 m	MY:	-2.078e-4 m	MZ:	-1.056e-7 m
Cut Water Plane Properties						
Cut Water Plane Area:		29.195372 m²				
Centre of Floatation:	X:	3.1234e-4 m	Y:	-0.3750519 m		
Principal 2nd Moment of Area:	X:	340.79199 m^4	Y:	340.83817 m^4		
Angle Principal Axis makes with X (FRA):		3502.2991 °				
Small Angle Stability Parameters						
C.O.G. to C.O.B.(BG):		1.377017 m				
Metacentric Heights (GMX/GMY):		2.3354368 m		2.3359396 m		
COB to Metacentre (BMX/BMY):		3.7124538 m		3.7129567 m		
Restoring Moments/Degree Rotations (MX/MY):		656.44104 N.m/°		656.58234 N.m/°		

AQWA Hydrostatic Result - Wire – Type 1

AQWA Hydrostatic Results

Structure		PLTAL				
Hydrostatic Stiffness						
Centre of Gravity Position:	X:	0. m	Y:	0. m	Z:	-7.e-2 m

	Z	RX	RY
Heave(Z):	293466.5 N/m	-1920.9996 N/°	-1.5998094 N/°
Roll(RX):	-110065.17 N.m/m	38337.988 N.m/°	4.027698 N.m/°
Pitch(RZ):	-91.662331 N.m/m	4.027698 N.m/°	37613.184 N.m/°

Hydrostatic Displacement Properties						
Actual Volumetric Displacement:		91.796967 m³				
Equivalent Volumetric Displacement:		168.12573 m³				
Centre of Buoyancy Position:	X:	3.8076e-4 m	Y:	-0.3756678 m	Z:	-1.4470171 m
Out of Balance Forces/Weight:	FX:	1.9591e-8	FY:	-1.6116e-8	FZ:	-0.4539978
Out of Balance Moments/Weight:	MX:	-0.2051158 m	MY:	-2.0847e-4 m	MZ:	-1.0594e-7 m
Cut Water Plane Properties						
Cut Water Plane Area:		29.195372 m²				
Centre of Floatation:	X:	3.1234e-4 m	Y:	-0.3750519 m		
Principal 2nd Moment of Area:	X:	340.79199 m^4	Y:	340.83817 m^4		
Angle Principal Axis makes with X (FRA):		3502.2991 °				
Small Angle Stability Parameters						
C.O.G. to C.O.B.(BG):		1.377017 m				
Metacentric Heights (GMX/GMY):		2.3354368 m		2.3359396 m		
COB to Metacentre (BMX/BMY):		3.7124538 m		3.7129567 m		
Restoring Moments/Degree Rotations (MX/MY):		656.44104 N.m/°		656.58234 N.m/°		

AQWA Hydrostatic Result - Fiber – Type 1

AQWA Hydrostatic Results

Structure	PLTAL (Fiber)					
Hydrostatic Stiffness						
Centre of Gravity Position:	X:	0. m	Y:	0. m	Z:	-7.e-2 m

	Z	RX	RY
Heave(Z):	293466.5 N/m	-1921. N/°	-1.5997885 N/°
Roll(RX):	-110065.2 N.m/m	38337.988 N.m/°	4.0276141 N.m/°
Pitch(RZ):	-91.661133 N.m/m	4.0276141 N.m/°	37613.191 N.m/°

Hydrostatic Displacement Properties						
Actual Volumetric Displacement:		91.796967 m³				
Equivalent Volumetric Displacement:		167.77295 m³				
Centre of Buoyancy Position:	X:	3.8059e-4 m	Y:	-0.3756678 m	Z:	-1.4470171 m
Out of Balance Forces/Weight:	FX:	1.9053e-8	FY:	-1.1517e-8	FZ:	-0.4528497
Out of Balance Moments/Weight:	MX:	-0.2055472 m	MY:	-2.0884e-4 m	MZ:	-1.0646e-7 m

Cut Water Plane Properties				
Cut Water Plane Area:		29.195372 m²		
Centre of Floatation:	X:	3.1234e-4 m	Y:	-0.375052 m
Principal 2nd Moment of Area:	X:	340.79196 m^4	Y:	340.83813 m^4
Angle Principal Axis makes with X (FRA):		3501.3982 °		

Small Angle Stability Parameters		
C.O.G. to C.O.B.(BG):	1.377017 m	
Metacentric Heights (GMX/GMY):	2.3354363 m	2.3359394 m
COB to Metacentre (BMX/BMY):	3.7124534 m	3.7129564 m
Restoring Moments/Degree Rotations (MX/MY):	656.44098 N.m/°	656.58228 N.m/°

AQWA Hydrostatic Result - Chain – Type 2

AQWA Hydrostatic Results

Structure	PLTAL (Chain)		
Hydrostatic Stiffness			
Centre of Gravity Position:	X: 0. m	Y: 0. m	Z: -7.e-2 m
	Z	RX	RY
Heave(Z):	293459.53 N/m	-1920.7898 N/°	-1.3228786 N/°
Roll(RX):	-110053.15 N.m/m	37296.395 N.m/°	3.5707347 N.m/°
Pitch(RZ):	-75.795364 N.m/m	3.5707347 N.m/°	36571.238 N.m/°

Hydrostatic Displacement Properties			
Actual Volumetric Displacement:	94.468277 m³		
Equivalent Volumetric Displacement:	181.53839 m³		
Centre of Buoyancy Position:	X: 3.1761e-4 m	Y: -0.3757095 m	Z: -1.4709059 m
Out of Balance Forces/Weight:	FX: -3.8151e-8	FY: -2.1327e-8	FZ: -0.4796232
Out of Balance Moments/Weight:	MX: -0.1955104 m	MY: -1.6501e-4 m	MZ: 2.0357e-7 m
Cut Water Plane Properties			
Cut Water Plane Area:	29.194675 m²		
Centre of Floatation:	X: 2.5828e-4 m	Y: -0.3750199 m	
Principal 2nd Moment of Area:	X: 340.79028 m^4	Y: 340.83478 m^4	
Angle Principal Axis makes with X (FRA):	3670.1665 °		
Small Angle Stability Parameters			
C.O.G. to C.O.B.(BG):	1.4009058 m		
Metacentric Heights (GMX/GMY):	2.2065516 m	2.2070224 m	
COB to Metacentre (BMX/BMY):	3.6074574 m	3.6079283 m	
Restoring Moments/Degree Rotations (MX/MY):	638.26251 N.m/°	638.39868 N.m/°	

AQWA Hydrostatic Result - Wire – Type 2

	AQWA Hydrostatic Results					
Structure	PLTAL (Wire)					
Hydrostatic Stiffness						
Centre of Gravity Position:	X:	0. m	Y:	0. m	Z:	-7.e-2 m
		Z		RX		RY
Heave(Z):		293459.53 N/m		-1920.7898 N/°		-1.3228786 N/°
Roll(RX):		-110053.15 N.m/m		37296.395 N.m/°		3.5707347 N.m/°
Pitch(RZ):		-75.795364 N.m/m		3.5707347 N.m/°		36571.238 N.m/°
Hydrostatic Displacement Properties						
Actual Volumetric Displacement:		94.468277 m³				
Equivalent Volumetric Displacement:		180.9986 m³				
Centre of Buoyancy Position:	X:	3.1761e-4 m	Y:	-0.3757095 m	Z:	-1.4709059 m
Out of Balance Forces/Weight:	FX:	-3.8265e-8	FY:	-2.1391e-8	FZ:	-0.4780713
Out of Balance Moments/Weight:	MX:	-0.1960934 m	MY:	-1.655e-4 m	MZ:	2.0417e-7 m
Cut Water Plane Properties						
Cut Water Plane Area:		29.194675 m²				
Centre of Floatation:	X:	2.5828e-4 m	Y:	-0.3750199 m		
Principal 2nd Moment of Area:	X:	340.79028 m^4	Y:	340.83478 m^4		
Angle Principal Axis makes with X (FRA):		3670.1665 °				
Small Angle Stability Parameters						
C.O.G. to C.O.B.(BG):		1.4009058 m				
Metacentric Heights (GMX/GMY):		2.2065516 m		2.2070224 m		
COB to Metacentre (BMX/BMY):		3.6074574 m		3.6079283 m		
Restoring Moments/Degree Rotations (MX/MY):		638.26251 N.m/°		638.39868 N.m/°		

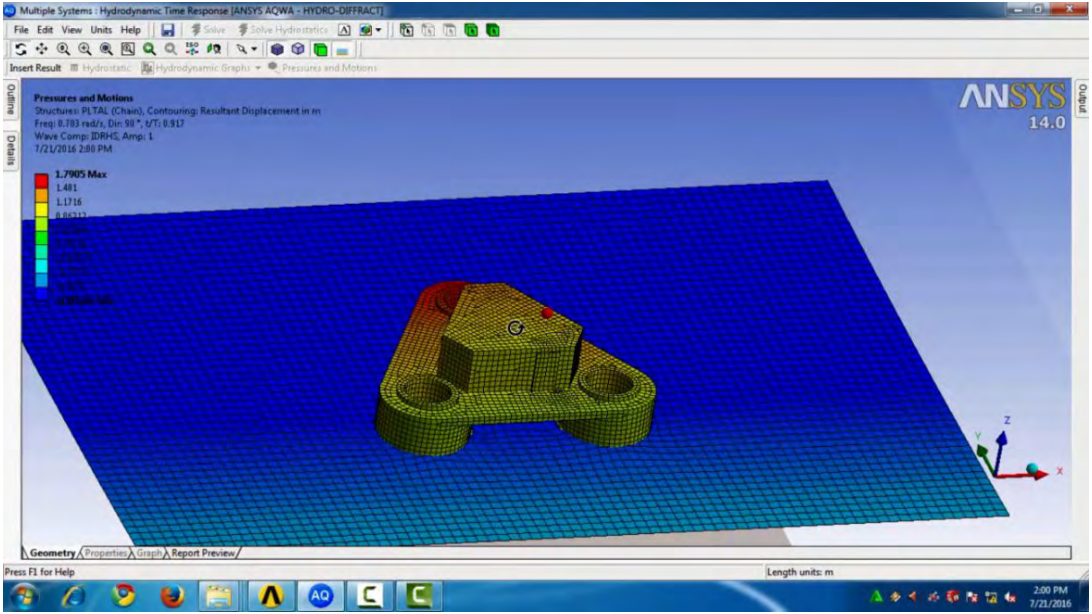
AQWA Hydrostatic Result - Fiber – Type 2

	AQWA Hydrostatic Results					
Structure	PLTAL (Fiber)					
Hydrostatic Stiffness						
Centre of Gravity Position:	X:	0. m	Y:	0. m	Z:	-7.e-2 m
		Z		RX		RY
Heave(Z):		293459.53 N/m		-1920.7898 N/°		-1.3228786 N/°
Roll(RX):		-110053.15 N.m/m		37296.395 N.m/°		3.5707347 N.m/°
Pitch(RZ):		-75.795364 N.m/m		3.5707347 N.m/°		36571.238 N.m/°
Hydrostatic Displacement Properties						
Actual Volumetric Displacement:		94.468277 m³				
Equivalent Volumetric Displacement:		180.64583 m³				
Centre of Buoyancy Position:	X:	3.1761e-4 m	Y:	-0.3757095 m	Z:	-1.4709059 m
Out of Balance Forces/Weight:	FX:	-3.834e-8	FY:	-2.1433e-8	FZ:	-0.4770521
Out of Balance Moments/Weight:	MX:	-0.1964764 m	MY:	-1.6583e-4 m	MZ:	2.0457e-7 m
Cut Water Plane Properties						
Cut Water Plane Area:		29.194675 m²				
Centre of Floatation:	X:	2.5828e-4 m	Y:	-0.3750199 m		
Principal 2nd Moment of Area:	X:	340.79028 m^4	Y:	340.83478 m^4		
Angle Principal Axis makes with X (FRA):		3670.1665 °				
Small Angle Stability Parameters						
C.O.G. to C.O.B.(BG):		1.4009058 m				
Metacentric Heights (GMX/GMY):		2.2065516 m		2.2070224 m		
COB to Metacentre (BMX/BMY):		3.6074574 m		3.6079283 m		
Restoring Moments/Degree Rotations (MX/MY):		638.26251 N.m/°		638.39868 N.m/°		

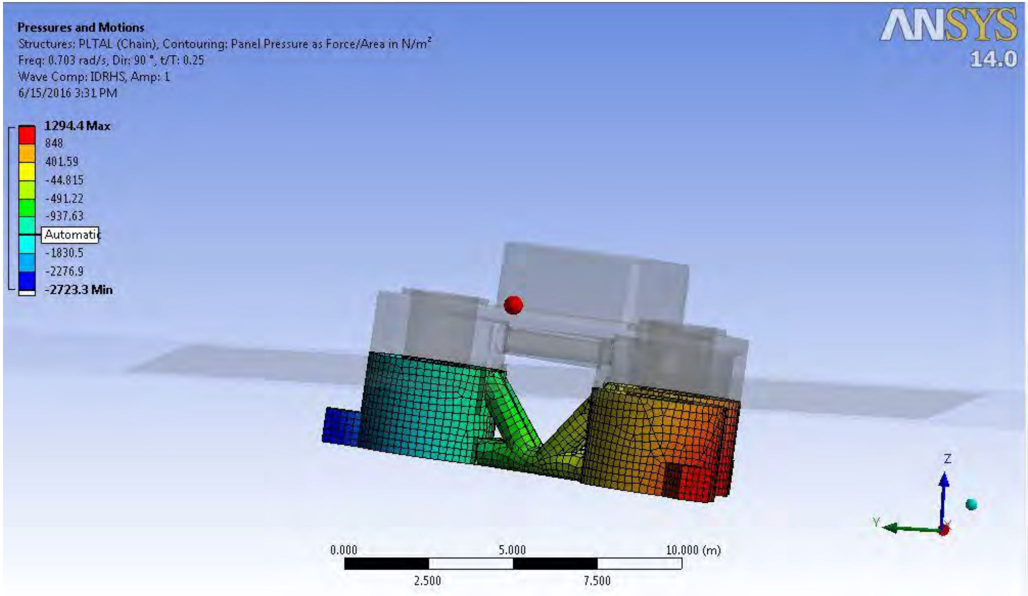
Attachment 5

SOFTWARE SCREENSHOT

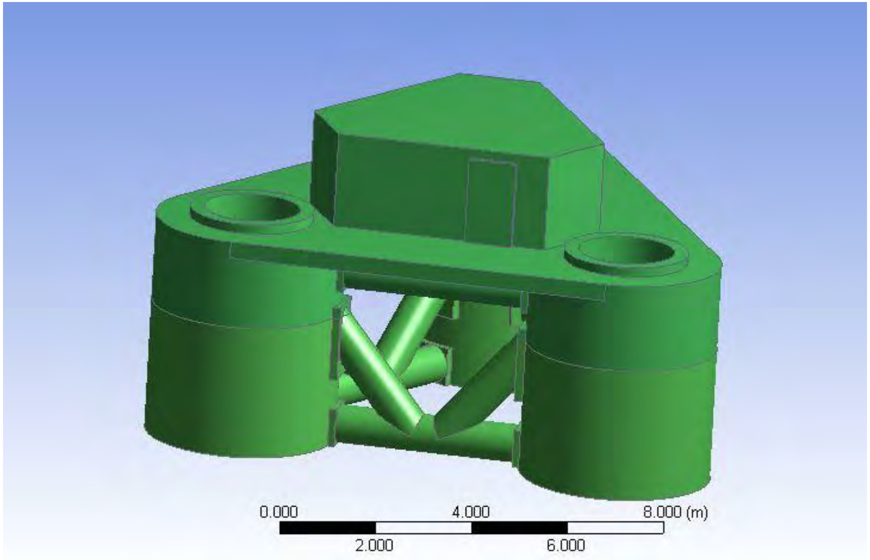
Final Result using Ansys AQWA



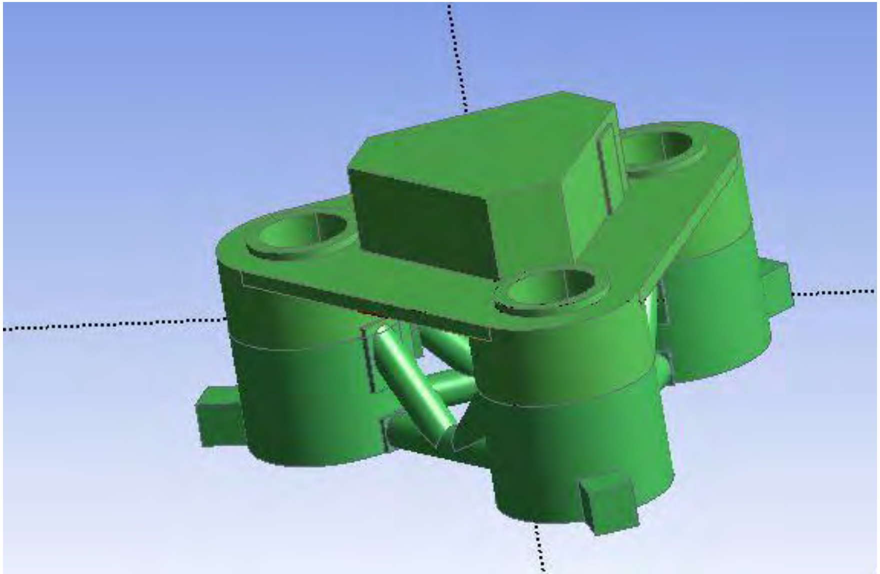
Pressure Above tendon



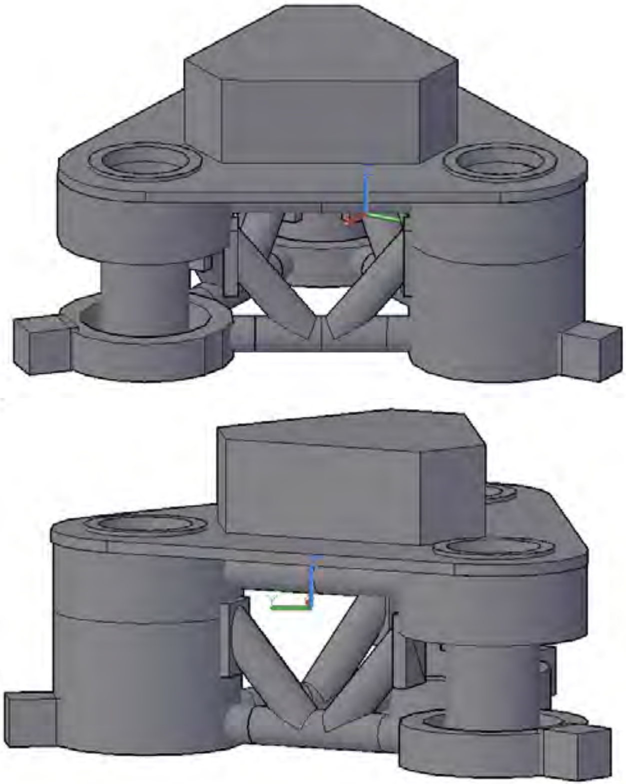
Floating Platform Type 1



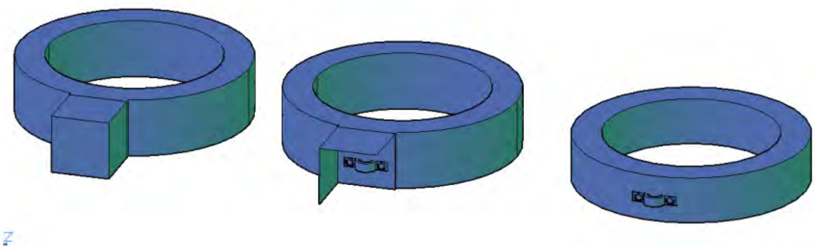
Floating Platform Type 2



Construction inside PLTA - Type 2



Connection Box Detail



Chapter 5
Conclusion

5.1 Conclusion

1. Floating platform receive current force about 0.84 kN, current force about 2.47 kN, and wave force about 2.1 kN. So the total Environment force received by floating platform is 5.41 kN

2. The best mooring line type is Chain because have RAO graph smaller than fiber RAO and wire RAO

3. Diameter chain is 42 mm, Axial stifenness about 178164 kN, maximum tension about 920.9 kN, dan anchor weigh about 926.84 Ton

4. The best mooring line position is in the bottom peak of tendon (type 2) because have smoothly RAO graph and low range RAO than mooring line that placed between tendon

5. Based on simulation results known that Floating platform have maximum resultant displacement about 1.176, maximum pressure at bottom of tendon surface about 1294.4 N/m^2 , COB at X axis about 3.17e-4 m , COB at Y axis about -0.375 m, COB at Z axis about -1.47 m,

6. Maximum RAO heave movement about 3.247m/m When sea wave Direction comes from 300^o, Maximum RAO pitch movement about 28.126^0/m When sea wave direction comes from 0^o, Maximum RAO Roll movement about 18.926^0/m When sea wave direction comes from 0^o, Maximum RAO Surge movement about 2.247m/m When sea wave direction comes from 0^o or 180^o, Maximum RAO Sway movement about 2.253 m/m When sea wave comes from direction 90^o or 270^o, and Maximum RAO yaw

movement about 2.025^0/m When sea wave comes from direction 240^0 or 300^o

5.2 Suggestion

Calculation will be more accurate if tide force, but tide force can’t be calculated and predicted. To calculate and predicted tide force need a experimentation at location during a year.

References

Book:

1) Srinivasan, Chandrasekaran. 2015. *Dynamic Analysis And Design Of Offshore Structures*
2) J.M.J. Journée , W.W. Massie. 2001.*Offshore Hydromechanics First edition.* Delft University of Technology
3) Anchor Manual 2015 - the guide to anchoring – from global maritime
4) Use Of Drag Embedment Anchor For Floating Wind Turbines. Vryhof Anchors BV
5) Budi, Eko Jatmiko.2012. *Prilaku operabilitas bangunan laut di atas gelombang acak. Surabaya: ITS press*
6) Indiyono.2010. Hidrodinamika Dasar Bangunan Laut. Surabaya: ITS Press
7) Soegiono. 2004. Teknologi Produksi dan Perawatan Bangunan Laut. Surabaya: ITS Press.
8) American Petroleum Institute Recommended Practice 2 SK
9) DNV-OS-E301
10) DNV-OS-E302
11) DNV-OS-E303
12) DNV-OS-E304
13) DNV-OS-C101

14) DNV-RP-C205
15) Ansys 2014 Manual Book

Website :

1. *http://www.globalsecurity.org/military/systems/ship/platform-tension-leg.html*
2. *http://www.houston-offshore.com/solutions/tension-leg-platform/*
3. *http://www.floatingwindfarm.weebly.com*
4. *http://Wikipedia.com*
5. *http://www.wikiwaves.org*
6. *http://sciencedirect.com*

Journal:

(1) Chang Gill kim. *Ocean and polar research. Volume 23. 2001. Busan; South Korea*

Author Biography

The author was born in Yogyakarta, May 17, 1994. The author is the second child of four brothers. The author had education at SDN 1 Cipanas, SMPN 1 Cipanas, SMAN 1 Cianjur, and the last is received in Double degree program of marine engineering German-Indonesian at Institute Technology Of 10 Nopember, Surabaya. During lecturing process in institute, the author active in Cianjur student associations in Surabaya and is a member of the MMD (manufacture marine design) laboratory. The author is very interested in Ship construction and system process using the software engineering, then attended many seminar and training held marine software company like as bentley. To improve experience in marine industry, author doing on job training in shipyard as 2 times. Author have abilities to using Autocad 2D and 3D, Maxsurf, Skech up, Ansys Aqwa, and Autocad 3D Plant.