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Analysis of Motion and Mooring of Fpso Vessels Due to Different Types of Mooring Material

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Abstract

Mooring is a system of anchoring offshore buildings or floating models in order to survive the threat of the marine environment so that they are held in position. catenary itself is a curve-shaped structure which is usually a cable or chain that hangs freely due to its own weight with both ends held. This paper uses a numerical method based on ANSYS Hydrodynamic Diffraction to analyze the motion of the mooring rope on the FPSO with the type of mooring rope material. So as to see the differences that occur from the type of meterial used, it is necessary to analyze the mooring motion.

Keywords: Mooring, Material, Models

1. Introduction

The introduction in this article provides an overview of Ocean Engineering as a branch of marine engineering and aquatic infrastructure. However, what is missing are details about the journal in which the article was published. The journal Maritime Technology and Society is indexed in several international databases and focuses on topics related to marine technology and aquatic infrastructure. The journal is aimed at academics, researchers, and practitioners in the field of marine engineering and aquatic infrastructure. With an increasing impact factor, it has become one of the leading journals in its field. This information is important for readers to assess the credibility and relevance of the research article in the broader context of the journal.

Ocean Engineering is one of the engineering sciences of marine infrastructure and aquatic environment. Marine engineering was born from the human need to survive by using all the resources on this earth. The presence of marine engineering allows humans to explore the Earth's wealth not only on land but also in the sea. Marine engineering continues to evolve through the development of independent resources. Marine is one of the areas of development of marine engineering. We can talk about offshore resources if they are directly outside the land, they are mechanized or floating.

Examples of offshore infrastructure include oil and gas exploration vessels, marine power plants, floating objects, etc. Floating structures or floating structures are offshore structures that float in the sea. Types of floating structures include semi-submersibles, spars and ships. These three structures are usually designed to move freely in six degrees of freedom (heave, surge, sway, pitch, roll, and yaw). To resist these six motions, floating structures are supported by mooring lines.

The mooring system has the effect of limiting the movement of the floating vessel to keep the vessel in position.

2. Materials and Methods

The research was conducted using the numerical method of ANSYS AQWA

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(Hydrodynamic Diffraction) data processing. The stress range of each mooring line is obtained from the time domain analysis of the catenary mooring system based on the motion response of the FPSO in the 6 degree of freedom direction. The direction of motion is influenced by the wave incidence angle (ÿ), which is the angle of incidence of the wave propagation direction with the speed of the ship's direction. The wave direction angle setting can be seen in the figure below:

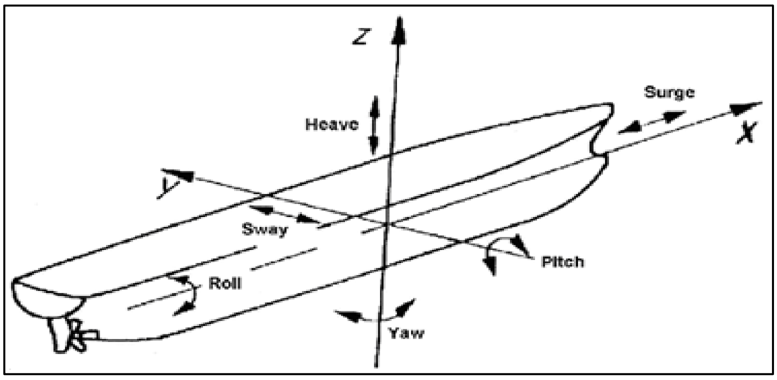


Fig. 1. Floating building movement model

Operation Criteria :

Criteria	Well Production
Mean Heel Angel (deg)	2
Max Pitch Angel (deg)	6
Lateral Acceleration	0.2 * 9.81
Riser Stroke	15
	-10

This analysis uses 4 mooring ropes, 3100 m rope length with different rope variations so as to obtain the stress of each type of mooring rope. The model used is an FPSO with the dimensions below:

Table1. Dimention FPSO

Dimension	FPSO
LOA	= 210
B	= 32.8
H	= 18.2
T	= 11.7

Table 2. Mooring Tipe Chain#1

Mass Unit length	= 438.9 kg/m
Cross Section Area	= 0.018905731 m^2
Stiffness,EA	= 1842397800 N
Maximum Tension	= 19563300 N
Equivalent Diameter	= 0.1588 m

Table 3. Mooring Properties Chain#2

Mass Unit length	= 438.9 kg/m
Cross Section Area	= 0.019805731 m^2
Stiffness,EA	= 18423978000 N
Maximum Tension	= 19563300 N
Equivalent Diameter	= 0.1588 m

Table 4. Mooring Properties Chain#3

Mass Unit length	= 264 kg/m
Cross Section Area	= 0.01 m^2
Stiffness,EA	= 1060000000 N
Maximum Tension	= 10300000 N
Equivalent Diameter	= 0.115 m

Table 5. Mooring Properties Polyester

Mass Unit length	= 120.5 kg/m
Cross Section Area	= 0.057213122 m^2
Stiffness,EA	= 256217600 N
Maximum Tension	= 2135500 N
Equivalent Diameter	= 0.2699 m

Table 6. Mooring Properties Wire segment

Mass Unit length	= 42.77 kg/m
Cross Section Area	= 0.006 m^2
Stiffness,EA	= 764000000 N
Maximum Tension	= 8380000 N
Equivalent Diameter	= 0.09 m

3. Results

In this FPSO modeling is done by Hydrodynamic Diffraction simulation through ANSYS where the model uses a Barge model which is simulated using the dimensions of the FPSO ship.

The following are the simulation results of the Barge model using 3 types of chain material:

1.Operator Amplitude Response Analysis

Response amplitude operator (RAO) is a mathematical function to determine the response by floating buildings based on their amplitude as a result of wave excitation loads in a certain frequency range or period. In other words, RAO is the information of the motion characteristics of marine buildings against waves with operator functions.

Response Amplitude Operator (RAO) is a tool to transfer the wave force into the dynamic response of the structure. The RAO equation can be expressed as:

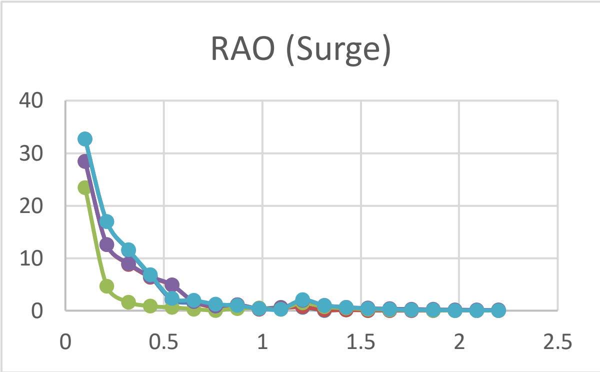
$$RAO(\omega) = \frac{Xp\ (\omega)}{\eta(\omega)}$$

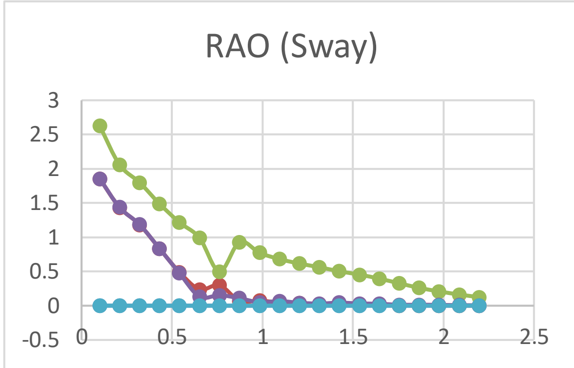
where:

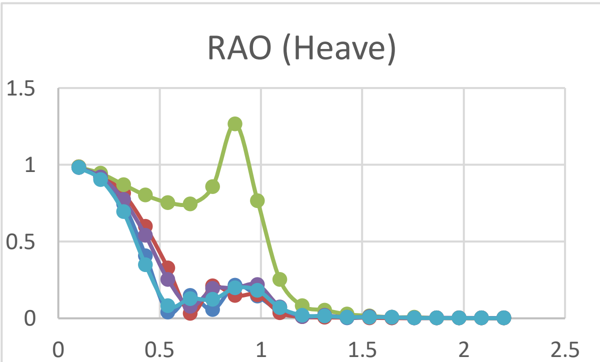
$Xp\ (\omega)$ = Structure amplitude (meter)

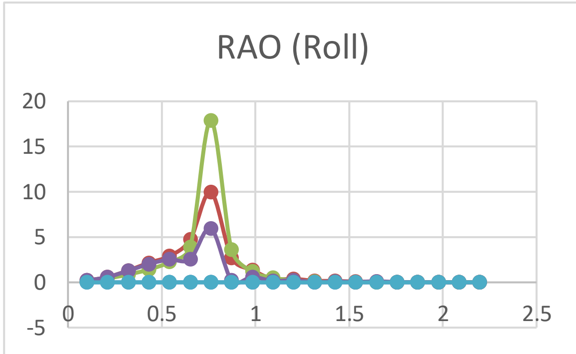
$\eta\ (\omega)$ = Wave amplitude (meter)

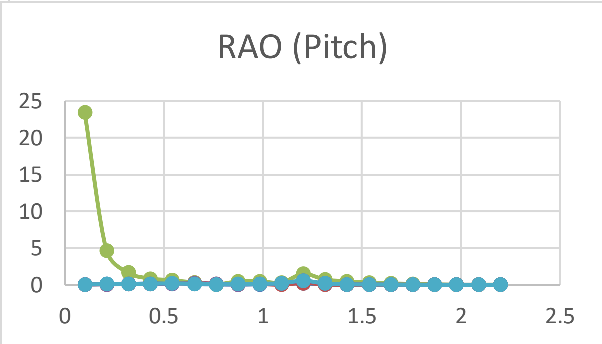
RAO values obtained based on simulation and analysis on the FPSO.

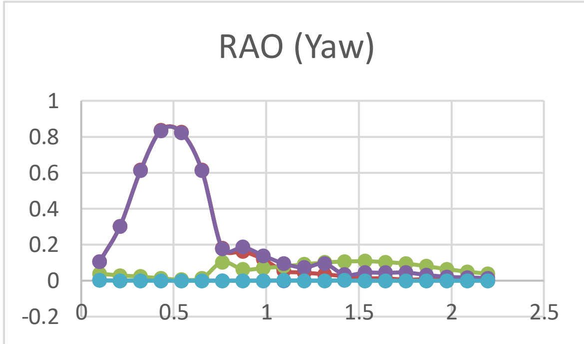












2. Hydrostatic analysis of geometric characteristics

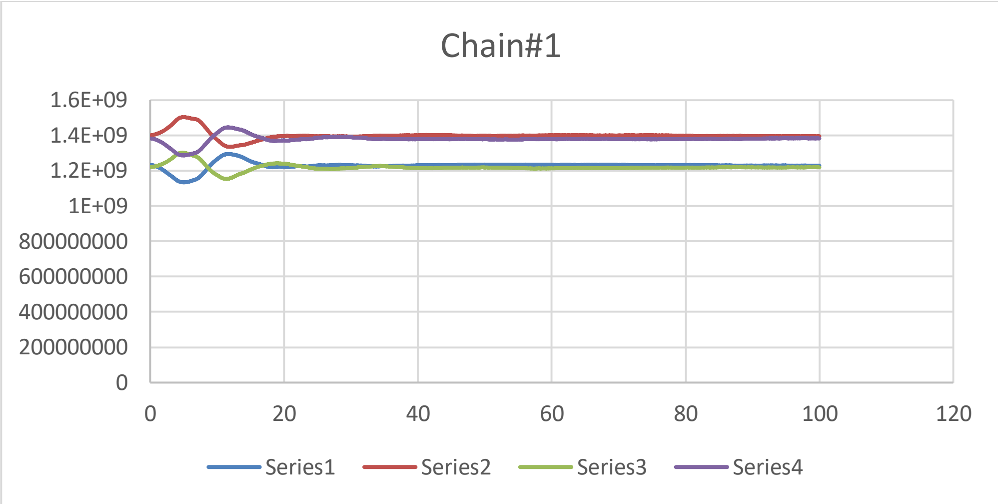
The results of the hydrostatic analysis of the FPSO are obtained from the hydrodynamic diffraction that considers the x,y, and z motions listed below:

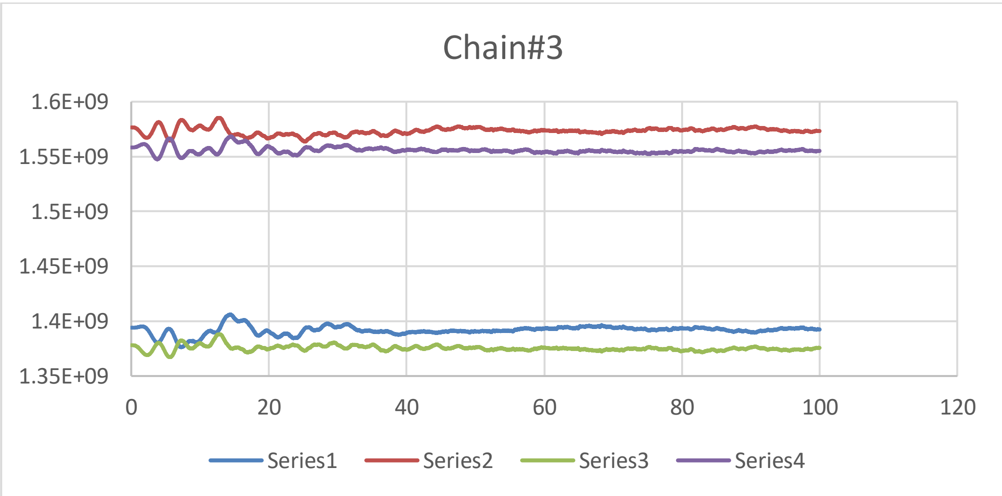
Aqwa Hydrostatic Results

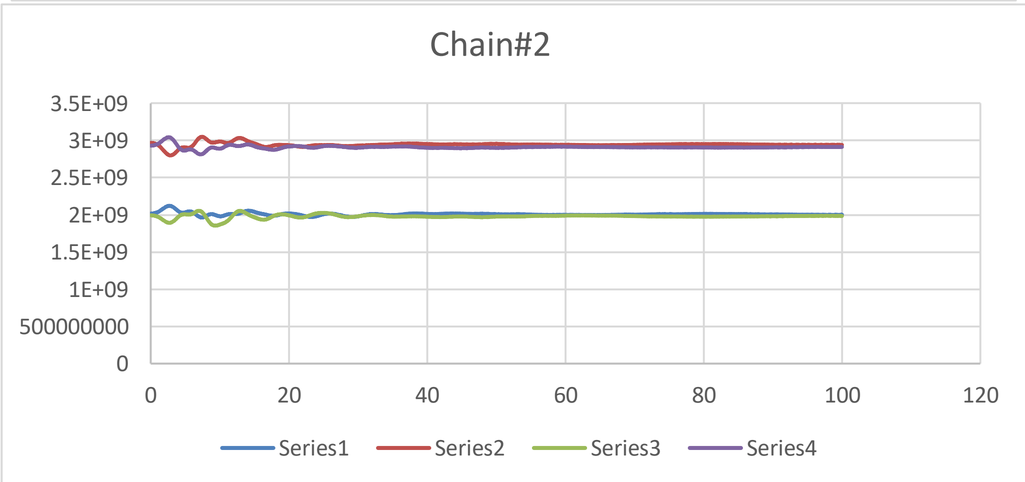
Heave(Z):	65159056 N/m	-29.228874 N/°	6540314. N/°
Roll(RX):	-1674.6912 N.m/m	29168368 N.m/°	80.038445 N.m/°
Pitch(RY):	3.74732e8 N.m/m	80.038445 N.m/°	3.7277e9 N.m/°
Hydrostatic Displacement Properties			
Actual Volumetric Displacement:	69708.477 m³		
Equivalent Volumetric Displacement:	9.7561e-4 m³		
Centre of Buoyancy Position:	X: -3.506588 m	Y: -5.4874e-4 m	Z: -5.6015882 m
Out of Balance Forces/Weight:	FX: -100663.	FY: 0.2923717	FZ: 71451136
Out of Balance Moments/Weight:	MX: -38012.805 m	MY: 2.50712e8 m	MZ: 82.775459 m
Cut Water Plane Properties			
Cut Water Plane Area:	6482.3164 m²		
Centre of Floatation:	X:-5.7510409 m	Y:-2.5702e-5 m	
Principal 2nd Moment of Area:	X: 556739.13 m^4	Y: 21424114 m^4	
Angle Principal Axis makes with X(FRA):	2.2251e-4 °		
Small Angle Stability Parameters			
C.O.G. to C.O.B.(BG):	5.6015882 m		
Metacentric Heights (GMX/GMY):	2.3850894 m	301.73712 m	
COB to Metacentre (BMX/BMY):	7.9866776 m	307.33871 m	
Restoring Moments/Degree Rotations (MX/MY):	509084.13 N.m/°	64404116 N.m/°	

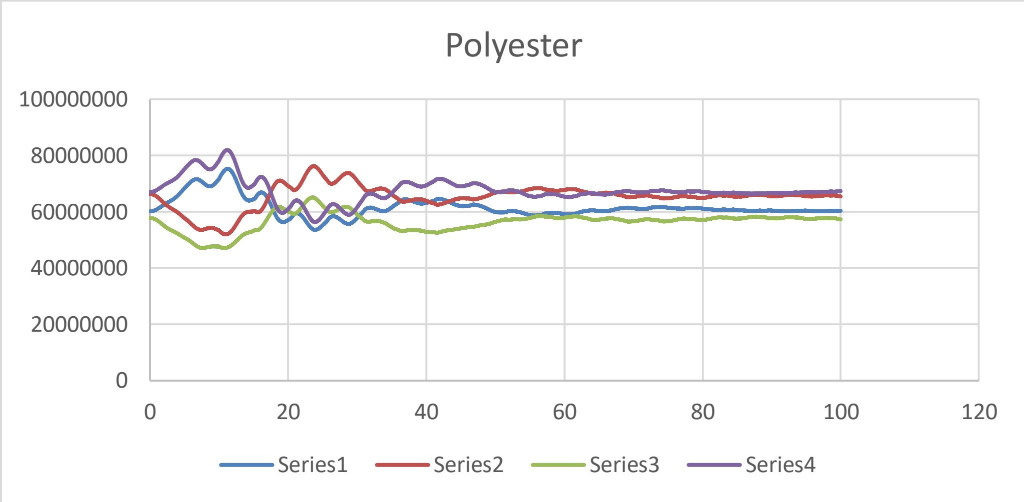
3. Cable Force Stress

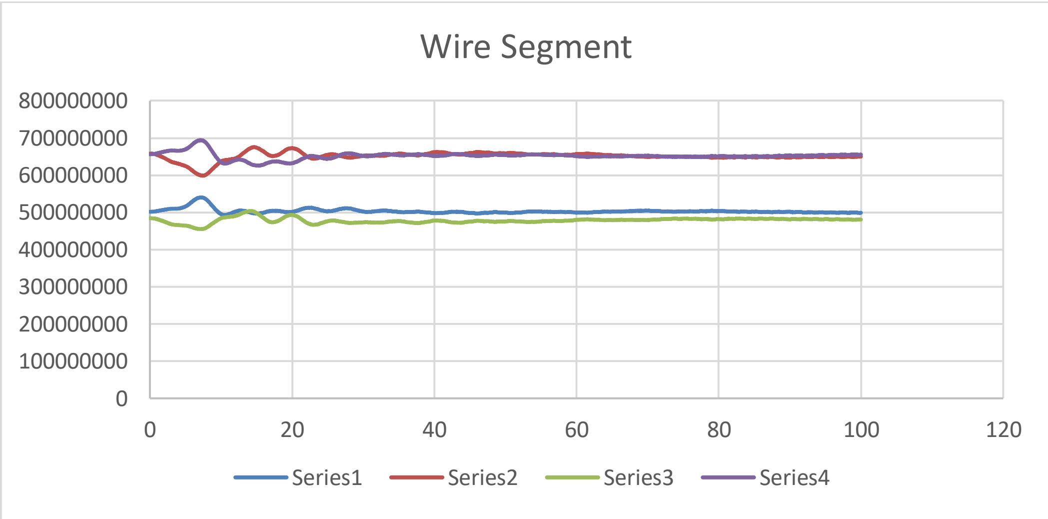
The voltage generated from 3 types of Catenary is obtained from the results of ANSYS processing (hydrodynamic time response) then the value is divided by the Equivalent cross sectional area of each type of catenary so as to produce different voltages, with a time span of 100 seconds.





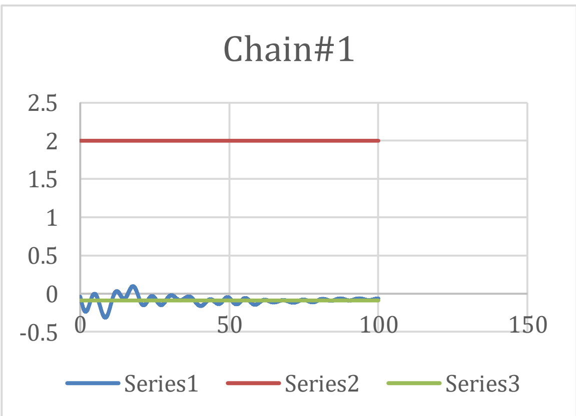


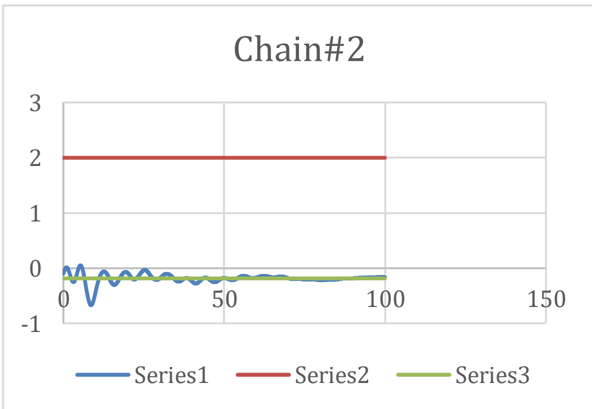


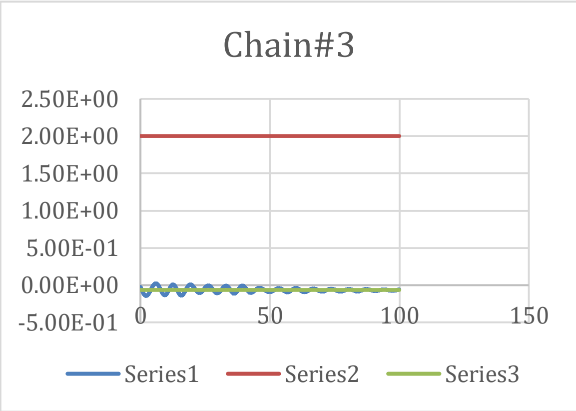


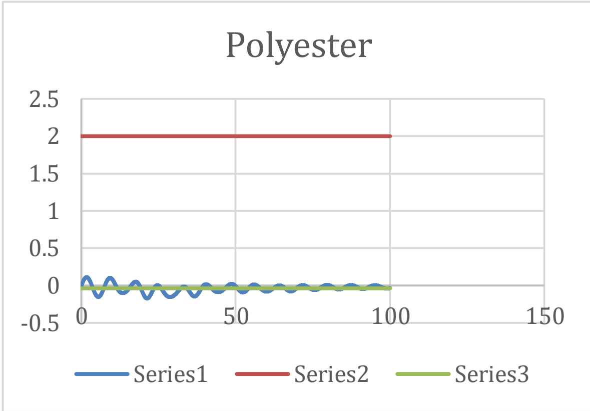
4. Mean Heel Angel

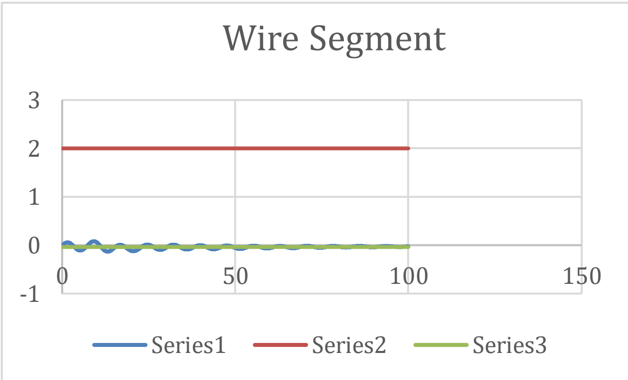
By using 3 types of materials we can see that the Roll Motion (RX) does not exceed the The operating criterion is 2 degrees.





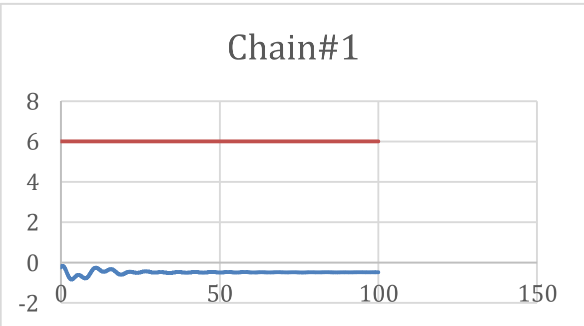


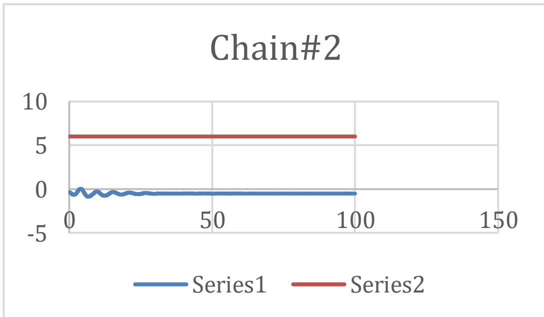


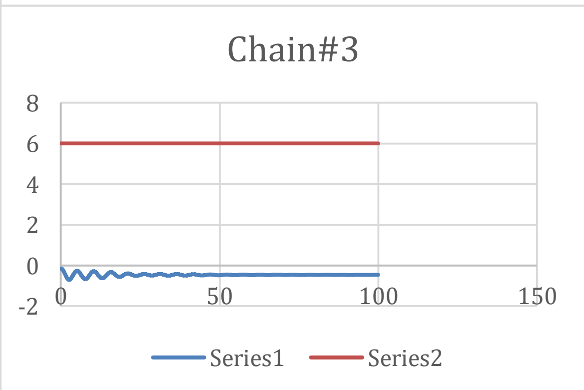


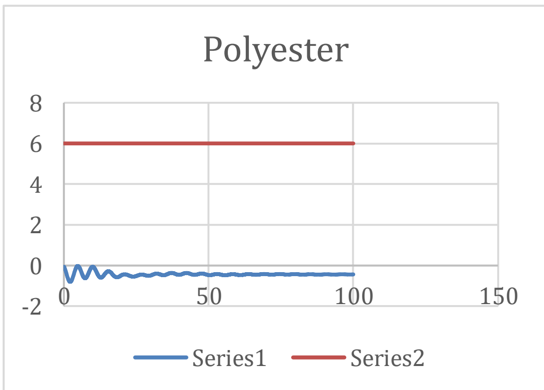
5. Max Pitch Angel

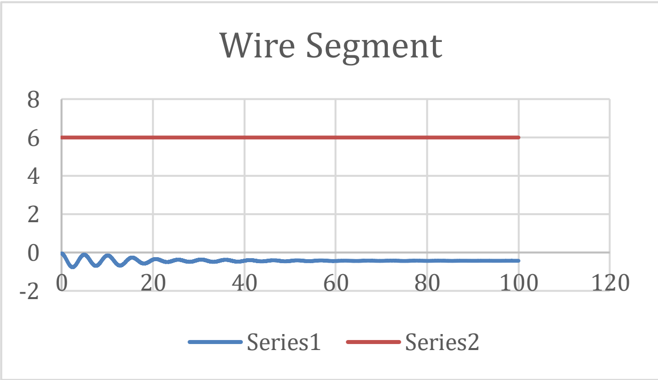
By using 3 types of materials we can see that the Pitch Motion (RY) does not exceed the operating criteria of 6 degrees.





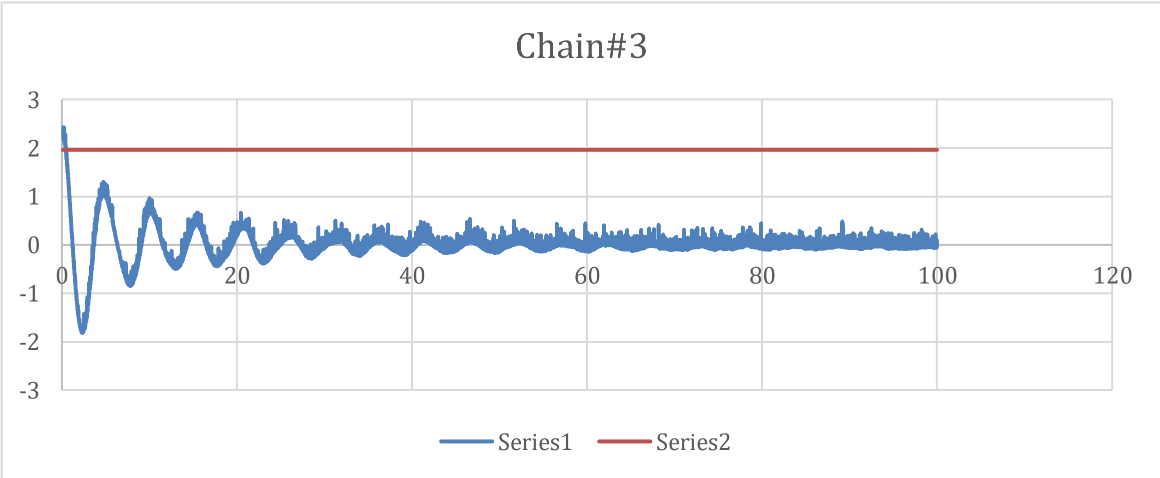


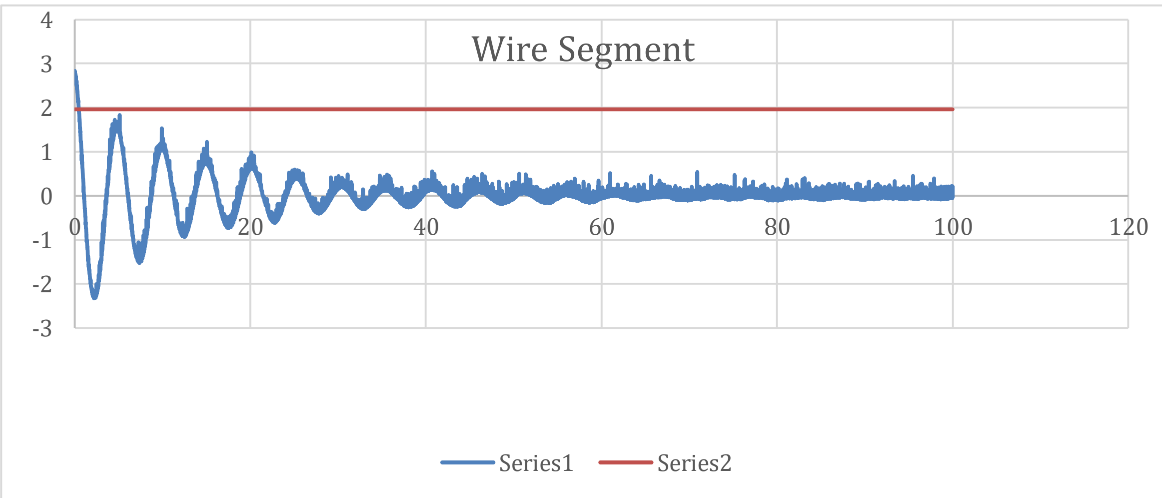


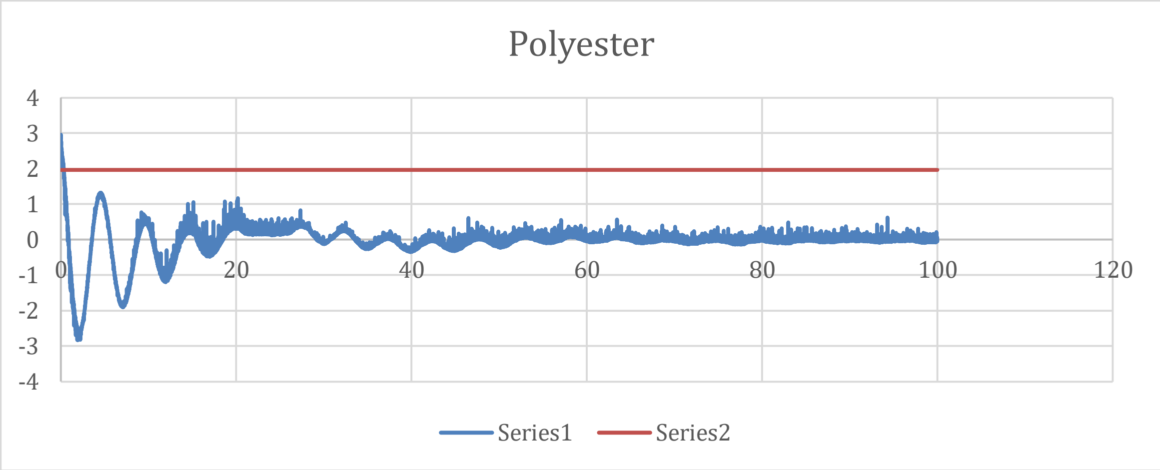


6. Lateral Acceleration

The results of the 3 types of catenary show that the wave speed coming from the X direction (Surge) Crashing towards the bow of the FPSO experienced a wave surge at the beginning so that it exceeded the operational limit of 2 m.







4. Conclusions

Based on the results of the Catenary System Type Analysis using ANSYS (Hydrodynamic Diffraction) it can be concluded that the type of Catenary material produces different motions because it is influenced by the stiffness of the type of meterial. In the Mooring System itself we can see that the 3 types of meterial used meet the operational limits that must be met. In 6 degrees of freedom, namely Surge (X), Sway (Y), Heave (Z), Roll (RX), Picth (RY), and Yaw (RZ) produce varying frequencies. The mooring line model and mooring system have been simulated properly, the statics of the mooring line model are in accordance with the value of the moring line options imputed into ANSYS. Using a cable length of 3100 m produces adjustments to the ship's dimensin so as to produce optimal damping.

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