ABSTRACT

Floating Production Storage and Offloading (FPSO) is a vessel that are currently in demand all over the world in which it is operated in a deep water region. Fixed platforms such as the bottom-supported steel jackets and concrete platforms are said to be impractical in the economic point of view which pipelines need to be installed along the seabed which is very costly especially in the deep water areas. Most floating production units is a buoyant structure which allows six degree of motion in surge, heave, pitch, yaw, sway, and roll. This floating structure is able to rotate freely in response to harsh environment and the mooring system used is disconnectable from the FPSO so that it can be protected from natural disaster such as Hurricane and Katrina. The need to possess a study on this floating structure on the dynamic responses due to environmental load is essential for excellent operation in the deep water areas. The dimension of FPSO is taken from FPSO Berantai project whereas the environmental data conditions were taken from the Petronas Technical Standards (PTS) for operating condition which consist of wave height, period, wind and current speed. FPSO is modelled as a floating structure with three degrees of motion: surge, heave and pitch motion. Since FPSO is a very large structure, the excitation of wave forces acting on this floating structure is calculated by using the Froude-Krylov Theory. This theory utilizes the incident wave pressure and pressure-area method on large surface to determine the forces. The ship's behavior and motion is studied by using Response Amplitude Operator (RAO) to determine the sea state when there is a ship move along the water. Frequency Domain Analysis was used to conduct hydrodynamic analysis in order to determine the floating platform motion in surge, heave and pitch motion in regular and random wave. The energy distribution on sea is represented using frequency domain analysis and wave motion profile was generated using P-M wave spectrum. In a conclusion, it is vital to determine the motion on each direction to ensure the safety of the FPSO and maintain the operation in the most ideal and stabilize condition.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

As the history of oil and gas industry shows that all the offshore structure (oil platform) were installed on the seabed in the shallow water. The hydrocarbon production were then been transported to the shore either by using tanker or pipeline. According to Strickland J., & Freudenrich C.,(2013) not all oil is accessible on land or in shallow water. Some oil deposits can be explore only deep under the ocean floor. In order to meet the increasing global demand of the oil and gas resources, the oil and gas industry extend its operation to deep water in which the water depth is greater than 300 m. Although it seems to be beyond the bounds of possibility at the beginning of the deep water exploration, but with the modern technology that come into view, the operation in the deep sea seems possible which brought floating structure into place.

Floating production, storage and offloading vessels (FPSO) are very much effective in faraway or deep water area where fixed platform are said to be impractical in economic point of view because the installation of the seabed pipelines are costly to build if a fixed platform was installed. In addition, the advantage of using FPSO is that the need to place those pipelines along the seabed from the processing facility to the mainland can be terminated. The uniqueness of this floating structure is that it can be decommissioned once it is used and can be moved to another location for reuse purpose. This floating structure was able to rotate freely in respond to the harsh environment of the deep ocean and weather conditions if central mooring system is used. FPSO is usually designed for a specific location by considering the dynamic responses of this structure subjected to waves, current and wind which plays a very important role for the conceptual design.

1.2 PROBLEM STATEMENT

Floating, Production, Storage and Offloading system (FPSO) have been successfully installed around the globe for oil and gas production. Drilling exploration in deep water areas basically is done by drill ships, floating vessel and semi-submersible. Oil and gas industry, with its booming demands nowadays lead the industry to explore the resources in deep water region instead of shallow water areas. However, when dealing with the deep ocean environment, every factors such as the weather conditions have to be taken into account in order to ensure the structural design of the oil platform is acceptable and functional. Extreme and extraordinary environmental condition may bring effects to the offshore structure that are going to be design. Dynamic responses such as wave, wind, current in offshore projects are our main consideration. Several researchers have done various studies about the dynamic characteristics of FPSOs in winds, waves, and currents. The dependability and safety of the designed platform are much more dependent on how it reacts when dealing with the extreme wave, wind and current. The most acceptable design is the one that manage to withstand the extreme condition of the ocean with longer period of serviceability and those three parameters need to be forecast precisely as it plays a very vital role in the process of designing the Floating, Production, Storage and Offloading (FPSO) structure. Therefore, a study on dynamic responses due to environmental load is essential for excellent operation in the deep water areas.

1.3 OBJECTIVES

Throughout the process of running this project, there are few objectives that actually have been set at the beginning of the project. These objectives need to be attain at the end of this project. An outcome that the author expected to achieve and to be completed within the Final Year Project 1 (FYP 1) time frame are described as follow:

1. To complete a dynamic analysis of Berantai (East Fortune) FPSO due to a regular and random wave using (P-M Wave Spectrum).
2. To study on the motion responses of this FPSO in surge and heave direction.
3. To find the forces on the ship when it is restrained from motion and subjected to regular waves.

1.4 SCOPE OF STUDY

Due to significant increase of growth and development in this oil and gas industry and with fewer remaining easy-to-access oil fields, we are now witnessing the industry has started to expand its operation to a more extreme and challenging environment which is in the deep water region. The exploration of oil and gas resources in deep water makes the floating structure is the most practical platform to be used. However, since there are few parameters that need to be taken into consideration such as wave, wind and current which may affect the oil platform itself, this study is performed to analyse the dynamic responses towards Floating, Production, Storage and Offloading (FPSO) platform. The Linear Airy Wave Theory was studied to get a rough estimation of the wave behaviour and its effect to the floating structure. Besides, the wave forces are calculated when it is restrained from motion and subjected to regular waves using Froude-Krylov equation. Response Amplitude Operator (RAO) which describe the ship's behaviour and motion is used to identify the sea condition when there is a ship move along the water. Frequency Domain Analysis was used to conduct hydrodynamic analysis in order to determine the floating platform motion in surge, heave and pitch motion in regular and random wave. Last but not least, the wave profile is generated from the P-M wave spectrum in regular and random wave.

CHAPTER 2

2.0 LITERATURE REVIEW

The exploration under the deep water region increases along with the booming demand in the oil and gas industry and is expected to continue its growth in the future. The development in our technology helps the exploration in deeper offshore which seems to be impossible before. Floating platform like FPSO is the most practical and economical platform that the industry used for deep water exploration. Ha, T.P., (2011) mentioned that the use of FPSO in marginal field is the right choice, which the pipelines need not to be lay down on the seabed which actually very costly if being installed.

FPSO are said to be very flexible structure in which it is able to disconnect the turret and mooring line in extreme environmental condition. He also stated that this floating production and storage offloading unit needs a long operational period which makes the analysing and estimating work are very crucial for the dynamic responses of the FPSO due to environmental factors such as wave, wind and current. In general, the floating structure undergoes six degrees of motion which are three translational and three rotational (Chakrabarti, S.K., 1987). Usually for FPSO, wave always dominating other types of induced loads which are grouped by significant height, and associated wave period. Many research and studies has been done related to motion responses of FPSO due to regular and random waves.

Chakrabarti, S.K., (1987) stated that different kind of environment requires different types of wave theories which dependant on the environmental parameters such as water depth, wave height and also wave period. Since there are numerous wave theories that have been developed, there are some theories that apply a sloping seabed but the common theories that been used is the one that assume the waves are in two-dimensional in the XY plane and have a flat bottom of seabed which have a constant water depth.

Holmes, P., (2001) mentioned that random waves that were generated by the winds have different wave height and wave period. According to linear wave theory, that waves with longer periods travel at a higher severity if compared to waves with a shorter period. As a result, the waves with a longer period will tends to travel faster compared to the short period waves. Wave characteristic can be predicted roughly by using this linear wave theory.

Haritos, N., (2007) comes out with a comprehensive range of study on the wave theories, the interaction between structure and fluid to the extreme responses prediction from the spectral modelling approaches. Wave–structure interaction can be subsequently divided into few steps which are: surface elevation, wave kinematics and dynamics, forces on structure and motions on the structure. Wave is one of the environmental load that needs to be taken into consideration because it brings great impact to the motion of the floating offshore structure like FPSO (Chakrabarti, S.K., 1987). As the wave hits the floating offshore platform, it generates some forces which can be calculates based on few conditions:

1. **Morison Equation**: The force composes of drag force and inertia force in which the drag force is very big in value. This usually happens when the offshore structure is large enough compared to the wavelength.
2. **Diffraction Theory:** When the waves smashes the offshore structure, waves tend to scattered from the surface of the platform in the form of reflected waves.
3. **Froude-Krylov Theory**: If neither separation (structure not too small compared to L), or (structure not too large compared to L), then this theory is applicable

The dynamic responses of FPSO in waves is also known as transfer function, as it allows the exciting waves to be transferred into the response of the platform (Chakrabarti, S.K., 1987). Response Amplitude Operator (RAO) is denoted by the ratio of the response amplitude to the wave amplitude, (Kannah R.T., & Natarajan

R., 2006). They also have presented the dynamic responses of the floating platform as follow:

Surge RAO = Surge amplitude / Wave amplitude

Heave RAO = Heave amplitude / Wave amplitude

Pitch RAO = Pitch amplitude / Wave amplitude

Hydrodynamic coefficient such as RAO is obtained by using the linear diffraction theory. By specifying the wave spectrum, this diffraction theory for massive floating platform which is subjected to regular uni-directional wave is expanded to obtain the responses in multi-directional wave.

During the design phases of the platform, RAO helps to identify if there is any modification should be done to ensure the safety aspect is taken into consideration. RAOs of the actual shape of the vessel and response of it is gained through the hydrodynamic analysis, (Clauss, G. F., & Birke, L., 2006). RAO give certain guarantee about the behaviour of a proposed ship design besides it allows the engineer to design the platform which it can hold up a maximum and the worst environmental condition that the sea might offer. Generally, for a linear system of inertial forces with the amplitude of the wave, the response function at a wave frequency can be presented as follow:

$$\text{Response (t)} = (\text{RAO})\eta(t)$$

Strength assessment of the platform needs to consider the wave condition that include all modes of operation, whether normal operating condition or extreme-storm condition (Zhao, C., Bai, Y., & Shin Y., 2001). When the sea state experience extreme and harsh condition on its large body, the motion of FPSO can be large. To overcome this kind of environment, a turret mooring system is usually used in order to allow the FPSO to weathervane to the least loading (Ha, T.P., 2011). Mooring system is a very important to ensure the operation conducted is safe by performing a design and analysis on the system. The function of the mooring lines is to ensure that the floating offshore structure like FPSO be at a fixed location during the operations (Wilson, J.F., 1933).

The wave forces are one of the important parameters that need to be analyse in order to meet certain design aspect for mooring system. Mooring analysis should be carry out so that the mooring system design could be optimized and to avoid uncontrolled lateral motions of vessel. Luo et. al, (2003) mentioned that natural periods of the horizontal motions of the FPSO is affected by the stiffness of the mooring lines whereas the mooring loads did affect the wave frequency. Brinati et. al, (1997) also stated that evaluation of damping forces has become the main problem in moored ship dynamic analysis. Some of the damping forces sources are the hull of the ships, the mooring lines and interaction between the wave and current.

According to Kannah, T.R & Natarajan R. (2006), investigation has been done on the effects of single point mooring system to the motions of the floating offshore structure by varying the wave condition and few system parameter. From the results obtained, by increasing the frequency of the wave, the surge RAO shows the decreasing trend for all operating conditions for both external turret system and fixed structure. On the other hand, the heave RAO shows an increasing trend with an increase in frequency of the wave. However, when the heave RAO is maximum, the response in heave motion shows a decrease in trend with an increase of wave frequency. The pitch RAO also increases for all operating conditions.

Frequency-domain analysis is a dynamic analysis that is carried out to problems of floating platform dynamics and is very useful for long term forecast. Motion responses due to random waves input can be determined using this frequency-domain analysis through spectral formulations (Chakrabarti, S.K., 1987). Furthermore, this analysis is very much simpler to interpret if compared to time-domain analysis.

CHAPTER 3

3.0 METHODOLOGY

3.1 DATA COLLECTION

3.1.1 Floating, Production, Storage, Offloading (FPSO) Dimension

As per stated in the objective earlier, the aim of this project is to complete a dynamic analysis of Berantai (East Fortune) FPSO which is located in Malaysia. The dimensions of this Berantai FPSO were extracted from 2013 Worldwide Survey of Floating, Production, Storage and Offloading (FPSO) Unit.

Table 3.1-1 : Berantai (East Fortune) FPSO Dimension

Specifications	Design Scale
Length overall LOA(m)	207
Length Between Perpendiculars LBP (m)	200
Hull Width (m)	32
Hull Depth (m)	17
Maximum Operating Draft (m)	12
Weight (Tonnes)	55337

Basically the vessel was divided into two main parts; first part is a rectangular shape hull and assumed to be loaded with standard facilities on topside and has the cross sectional area of 5 m x 32 m from the top MSL and the second part is a horizontal half cylinder with the 12 m of draft to the bottom keel of the FPSO.

In this project, the bow part of the ship is assumed to be in semi-elliptical shape of because this shape is most representing the normal shape of the conventional design of FPSO.

The surface area on bottom side of the vessel was used to calculate the vertical wave forces on y-axis component. Figure 3.1-1 shows the design shape of half -cylindrical hull for FPSO.

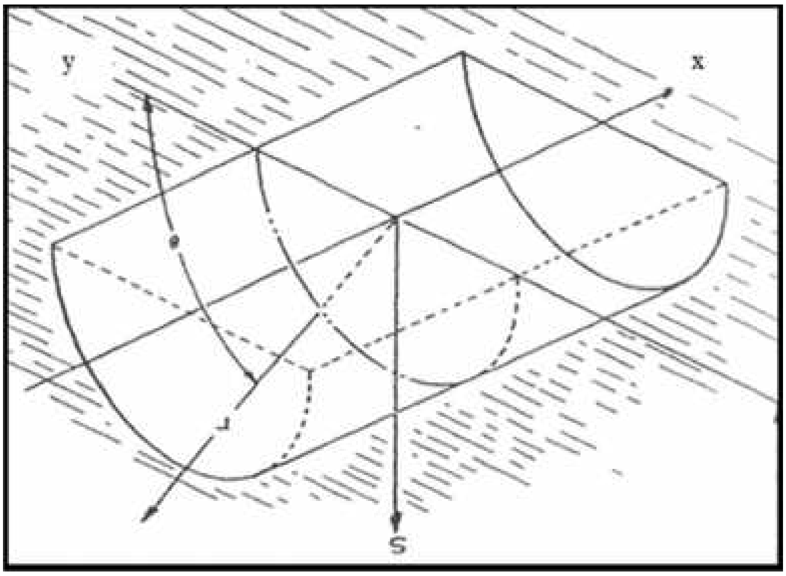

Figure 3.1-1 Half Cylinder Shape at Bottom Side

3.1.2 Environmental Design Conditions

The environmental data is obtained from Petronas Technical Standards (PTS) for both operating and storm condition which consist of wave height, period, wind and current speed. The vessel is said to be in operating conditions when the vessel was able to produce oil and offload it about ninety-five percent of the service life under a one year of non-typhoon storm event (Curt et al., 2006).

Table 3.1-2 Environmental Data at 1 Year Operating Condition

Environmental Condition	Parametric
Maximum Wave Height (Hmax)	8.44 m
Significant Wave Height (Hs)	4.38 m
Significant Peak Wave Period (Tp)	9.74 s
Significant Zero Crossing Period (Tz)	6.91 s
Associated Zero Wave Period (Tass)	8.38 s

3.2 THEORETICAL CALCULATION

3.2.1 Wave Forces

Since FPSO is a big structural and have larger surface area, Froude-Krylov theory is the most applicable method for calculating the wave forces in this project. As mentioned in (Chakrabati, 2001, p.331), Froude-Krylov equation is the diffraction force on the structure at its equilibrium condition and the radiation forces on the structure in its six degree of displacements.

Originally from the Froude Krylov theory, the total forces on the structure can be determined by integrating the pressure component whether in horizontal or vertical direction over the submerged portion of the vessel. The expressions for the horizontal and vertical force components in the *x* and *y* directions are as follows:

$$F_x = C_H \iint \rho n_x dS \quad (1)$$

$$F_y = C_H \iint \rho n_y dS \quad (2)$$

Where n_x and n_y = directional normal to horizontal and vertical

dS = an elemental area of submerged surface of the structure

By using the fundamental equation of the force, to suit the conservative dimension of FPSO designed for this project.

Horizontal Force, $Fx = P \times A \times Ch$ (3)

Vertical Force, $Fy = P \times A \times Cv$ (4)

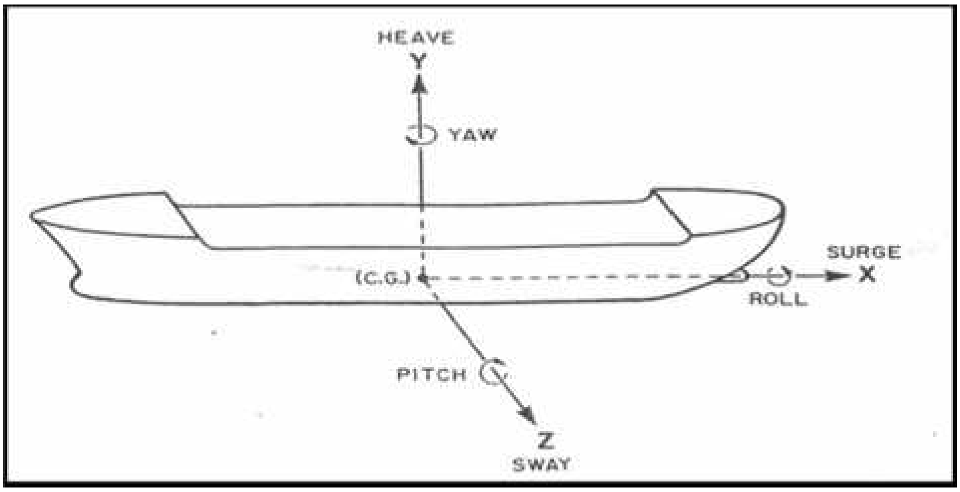

Figure 3.2-1 Six Degrees of Motion of A Floating Tanker (Chakrabati, 2001)

The expression of ρ, represents the dynamic pressure from the Linear Airy Wave Theory or known as sinusoidal wave theory. It was derived based on assumption that the wave height is small compared to the wave length or water depth. The pressure is assumed to act normal to the submerged structure surface at the particular point at particular surface area. Theoretically, ρ is given as;

$$\rho = \rho g \frac{H}{2} \frac{\cosh ks}{\cosh kd} \cos(kx - \omega t) \quad (5)$$

where,

ρ ,density = 1025 kg /m^3 ; g = 9.80665m/s^2

H = Maximum Wave Height (m)

T = Associated wave period

s = *y* + *d*, elevation from seabed;

y, height of the point of evaluation of water particle kinematics;

d, water depth

$\Theta = kx - \omega t$;

k, wave number = 2Π/L (rad/m);

x, point at origin;

ω, natural frequency 2Π/T (rad/s);

t, time instant at which particle kinematics is evaluated.

The main six degree of motion consist of three translational (surge, heave, sway) and three rotational (roll, yaw, pitch) but in this project, the FPSO was modelled as a floating body with three degrees-of –freedom; surge, heave and pitch because waves was assumed to propagate in uni-directional wave.

3.2.2 Motion Responses

Response Amplitude Operator was used as wave amplitude factor to determine the responses at each motion-direction (i.e surge, heave and pitch motion) when subjected to random wave. The RAO equation of motion can be written as;

$$\left| \frac{F_i / [(Hmax)/2]}{[(K - m\omega^2)^2 + (C\omega)^2]^{1/2}} \right| \tag{6}$$

Where,

F_I = Maximum force of Fx or Fy

C = ωn*m*ζ with damping ratio of ζ= 5%

$\omega^2 = K/m$,

ωn = 2 Π/Tn ; Tn is natural period

K = stiffness of the structure

m = actual mass + added mass

3.2.3 P-M Wave Spectrum

The mathematical spectrum model are dependent on few parameters such as significant wave height, wave period, and so on. The most common and practicable wave spectrum is Pierson-Moskowitz (P-M Spectrum). Microsoft Excel was used to compute all the data and graphs in this project (Chakrabarti, S.K., 1987). The P-M spectrum model is defined as:

$$S(f) = \frac{\alpha g^2}{(2\Pi)^4} [f^{-5}\exp[-1.25(f/f_0)^{-4}] \qquad (7)$$

where $\alpha = 0.081$

The relationship between peak frequencies to the significant wave height, Hs is obtained as follows:

$$\omega^2_o = 0.161g/Hs \qquad (8)$$

3.2.4 Simulation of Wave Profile from Spectra

Sometimes it is necessary to calculate the height of the wave at a particular frequency. For particular frequency of f_1, the energy density is $S(f_1)$. The height of the wave is then calculated using the following equation:

$$H(f_1) = 2\sqrt{2(f_1)\Delta f} \tag{9}$$

This relationship was transformed to evaluate the motion spectrum in terms of wave spectrum and RAO. The equation was obtained by multiplied the equation (8) with square of RAO from surge, heave and pitch direction. The equation can be expressed as follows:

$$S_x(f) = \left[\frac{F_i / [(Hmax)/2]}{[(K - m\omega^2)^2 + (C\omega)^2]^{1/2}} \right]^2 s(f) \tag{10}$$

Then, for a given location of x (horizontal coordinate of the desired wave profile) and time, the wave profile can be obtained from given formula below:

$$\eta(x,t) = \sum_{n=1}^{N} \frac{H(n)}{2} \cos[k(n)x - 2\pi f(n)t + \varepsilon(n)] \tag{11}$$

Where,

- Time, t which is incremented varies from t=0 s to t=500 s
- k(n)= 2Π/L(n) ; L(n) correspond to the wave length for the nth frequency *f*(n)
- ⌂*f*, equal width frequency by dividing 2Π with 40 component for randomness
- ξ(n) is a random number, R_N generated in Microsoft excel.

3.3 KEY MILESTONE

No	Deliverables/Activities	Schedule
1	**Extended Proposal** **- Introduction (Week 3)** **- Literature Review (Week 4)** **- Methodology (Week 5)**	**Week 6 (26 June 2014)**
2	**Proposal Defence** **- Presentation slides preparation (Week 8)**	**Week 10**
3	**Submission of Interim Report** **- Finalize the project (Week 11)**	**Week 14**
4	**Submission of Progress Report**	**Week 21**

3.4 GANTT CHART

A work schedule is vital in every work that we are going to perform in order to ensure that the plan can be executed on time. A gantt chart which illustrates the works schedule is used to ease the tracking process of the work to ensure the work flow is tally with the planning. All in all, this project was successfully done within the FYP 1 time frame as the planned schedule. Refer Appendix A for FYP 1 Gantt Chart.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 FPSO Weight

In order to calculate the weight of Berantai FPSO, the principle of the ships need to be understood in which, according to Archimedes Principle, indicates that the upward buoyant force that is exerted on a body immersed in a fluid, whether the body is fully or partially submerged, is equal to the weight of the fluid displaces. The concept that is used to calculate the weight of the FPSO was divided into two parts; half cylindrical shape which represents the body of the FPSO and the semi-elliptical shape at the bow side. The total volume of this Berantai FPSO is calculated to be **80, 193.33 m^3** and the total FPSO weight is **83 M-kg**. The calculation for both parameters are clearly shown in the Appendix section.

4.2 Motion Responses

Floating offshore platforms that are operating at sea need to have the great capability to resist the unpredictable waves. Research and investigation need to be done on the motion characteristic and how it influence the behaviours of the ship itself. The motion responses of the FPSO are determined by using the Response Amplitude Operator (RAO) equation at each motion direction such as surge, heave and pitch with damping ratio of 5%.

4.3 Force and Moment Calculation

The horizontal and vertical forces acting on the submerged body of floating structure FPSO is calculated using the Froude-Krylov equation for surge and heave motion. The forces were obtained by multiplying the dynamic pressure with the cross sectional area of the floating structure and the horizontal and vertical force coefficients, Ch and Cv. The cross sectional area of the FPSO is shown in Appendix C.

To calculate the wave forces acting on the structure in surge motion, the forces from the bow side of the ship (Fx) and the aft side (Fx) of the ship is sum up. In this project, the bow shape of the FPSO Berantai is assumed to be semi-elliptical shape. Due to this assumption, the wave was considered to strike the submerged body of FPSO at an angle of 0°. 15°, 30°, 45°, 60°, 75°, and 90° at the bow side of the ship, refer Figure 4.3.1.

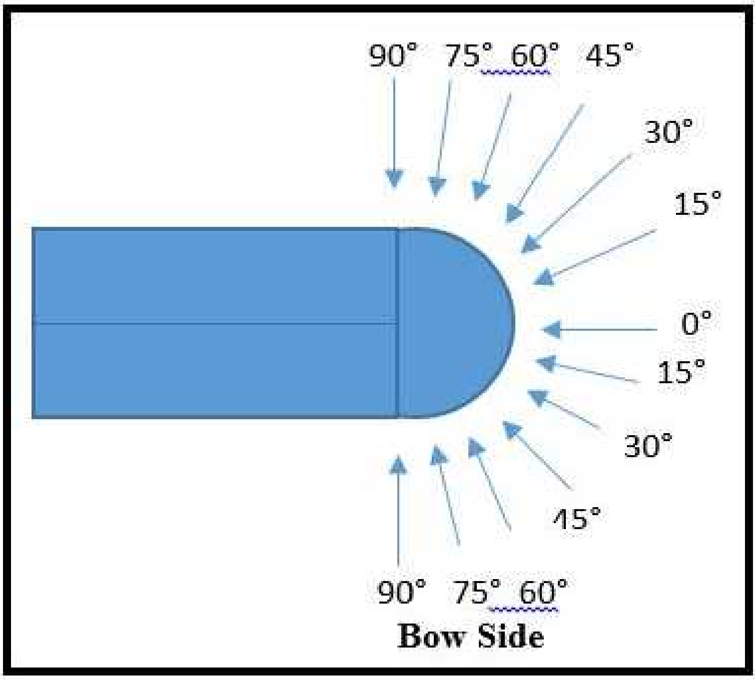

Figure 4.3-1 Direction of the Wave at Bow Side

Since the wave hits the structure in these angular-direction, this will result in forces in x-direction, Fx and in y-direction, Fy. Apart from that, it is a different concept when calculating the forces at the aft side. The aft side of the FPSO is assumed to be flat surface and thus the forces that attacks the FPSO's body are assume to act perpendicular to the surface. Meanwhile, the wave forces that acting at the side of the ship and at the starboard are assumed to cancel each other which it can assumed as negligible.

For the heave motion, the total forces is obtained by summing up the forces acting in y-direction, Fy of the bottom side of the ship and the vertical forces, Fy from the bow side of the ship. The wave forces that acting on the keel of the ship were assumed to hits the body like it did hits the bow side in angular-direction as the design of the hull is half-cylindrical shape, so the calculation of the wave forces is similar with the calculation at the bow side.

4.3.1 Added Mass

In calculating the forces acting on the body of the FPSO, we need to take into consideration the additional effect that comes as a result from the water acting on the structure and to investigate how much the forces that the water need to overcome to the motion of the ship. The depth of the water, frequency and direction of the wave also can give impact to the added mass. (Chung, J.S.,1994). For this project, the added mass for surge and heave are taken to be 6.22 M kg while for heave is simply the weight of the FPSO itself. The reason behind this is that, the volume under the draft will experience additional effect which comes from the fluid that strikes the structure when the ship is in motion. Table 4.3.1-1 below shows the added mass for both surge and heave motion and subsequently the total mass for both motion is calculated.

Motion	**Mass of FPSO (M kg)**	**Added Mass (M kg)**	**Total Mass (M kg)**
Surge	83	6.22	89.22
Heave	83	83	166

Table 4.3-1 Total Mass for Surge and Heave Motion

4.3.2 Water Plane Area

To calculate the forces acting on the floating structure FPSO, it is very important and crucial to know the surface area of the FPSO. The water plane area is actually an area along the hull in which it has the contact with the water. For surge motion, the water plane area is at the aft side and the bow side of the ship. While for heave motion, the surface area that has been considered is at the bottom side of the ship. Since FPSO is a very large floating structure, the forces acting on it is calculated by dividing the area at the bottom side of the FPSO into small strip section as shown in

Figure 4.5 -1 below. Pitch motion does not take water plane area into consideration since what affects the pitch motion is the centre of gravity of the FPSO itself.

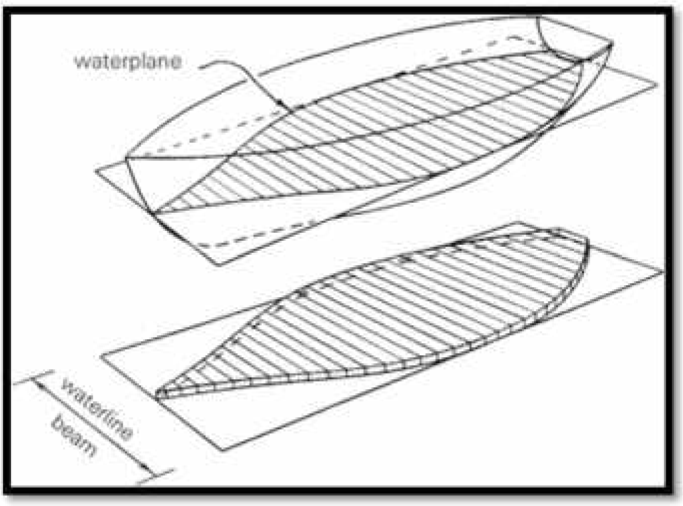

Figure 4.3-2 Water Plane Area

4.3.3 Natural Period

Table 4.3-2 Natural Period for Surge and Heave (Ward et. al)

Motion	Period (sec)
Surge	206.8
Heave	10.7

4.3.4 Stiffness Value at Surge and Heave motion

The stiffness value for surge, heave and pitch motion were not being used in the calculation of the forces, but it is a need to know the stiffness of the mooring line that is attached to the FPSO. The mooring line stiffness is was calculated using the equation $K = m\omega_n^2$. Mooring line is attached to the FPSO and it helps to limit the movement and motion of the FPSO from moving away from the desired location. Basically, the larger the stiffness of the mooring line, the lesser the motion of the ships away from its original location. Table 4.3.4-1 below shows the stiffness value at surge, heave and pitch motion.

Table 4.3-3 Stiffness Value at Surge, Heave, and Pitch Motion

Motion	Stiffness Value
Surge	0.08236 MN/m
Heave	57.237 MN/m

4.4 P-M Wave Spectrum

Various spectra that have been idealized by many scholars and researchers but in this project, the author is using the Pierson-Moskowitz spectrum (P-M) in order to determine the energy wave spectrum. This energy wave spectrum is generated using the P-M spectrum model which the formula is defined as in equation (7) with the significant wave height of 4.38 m. The range of frequencies that were used varies from 0 Hz to 0.4 Hz with 40 components of 0.01 Hz increment. From the wave spectrum graph, the wave energy spectrum is actually drawn from 0.05 Hz to 0.395 Hz and as shown from the graph, the maximum wave energy was at 0.095 Hz frequency with density energy spectrum of 18.02322m^2s. This finding shows the real condition at the sea without disturbance from any other floating offshore structure. The details on the calculation of the P-M spectrum is clearly shown in the Appendix.

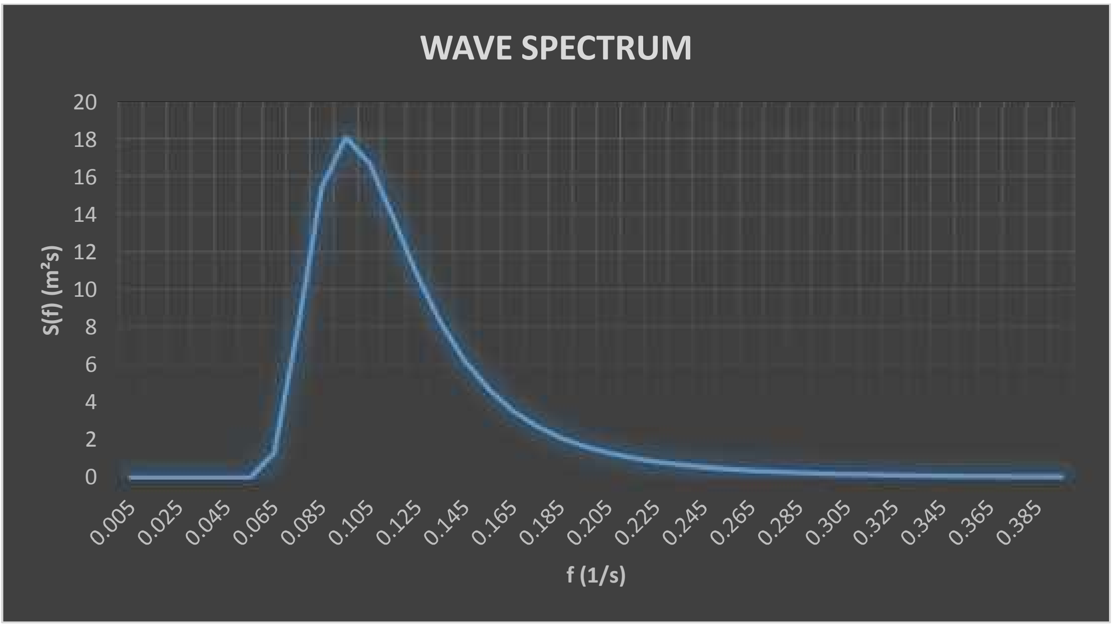

Figure 4.4 -0-1 P-M Wave Spectrum for Hs = 4.38 m

4.5 Time History

Time – history in which the motion-response profile for random wave was also obtained from equation (11) where the time is incremented varies from t = 0 s to t = 500 s at x = 0 m. Based on the calculations done, it can be clearly seen that the maximum wave height is approximately at 2.078 m.

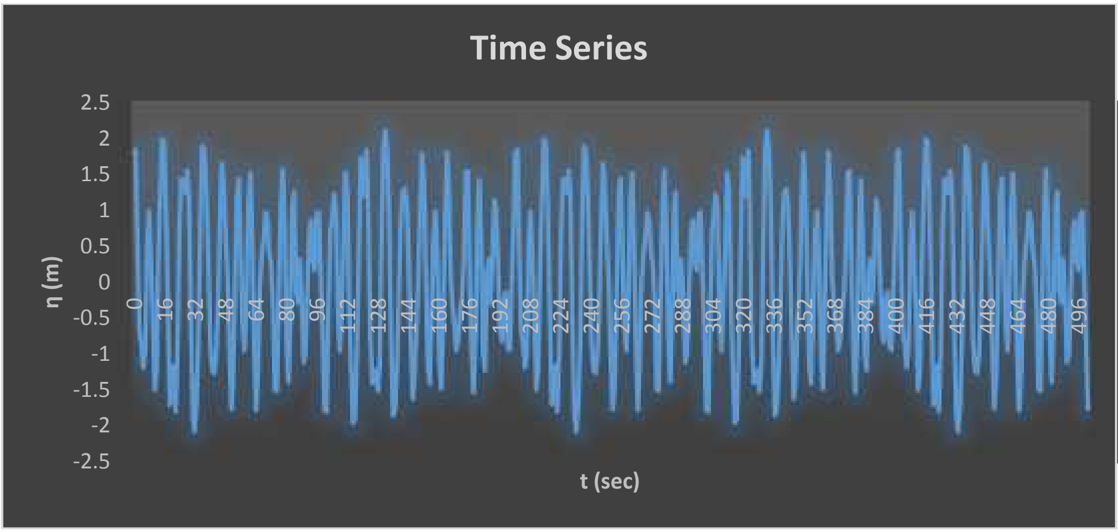

Figure 4.5-1 : Simulated time-series (t = 0 s to t = 500 s)

4.6 MOTION RESPONSES SPECTRUM

By using the equation (6) which has been stated before in the methodology, the motion responses for surge and heave has been determined. Figure 4.6.1 shows the motion responses of the surge in which the highest RAO is 42.4579 m at 0.005 Hz. While for heave motion, at similar frequency as the surge, which is 0.005 Hz records the highest RAO of 1063.15 m, refer Figure 4.6 – 2.

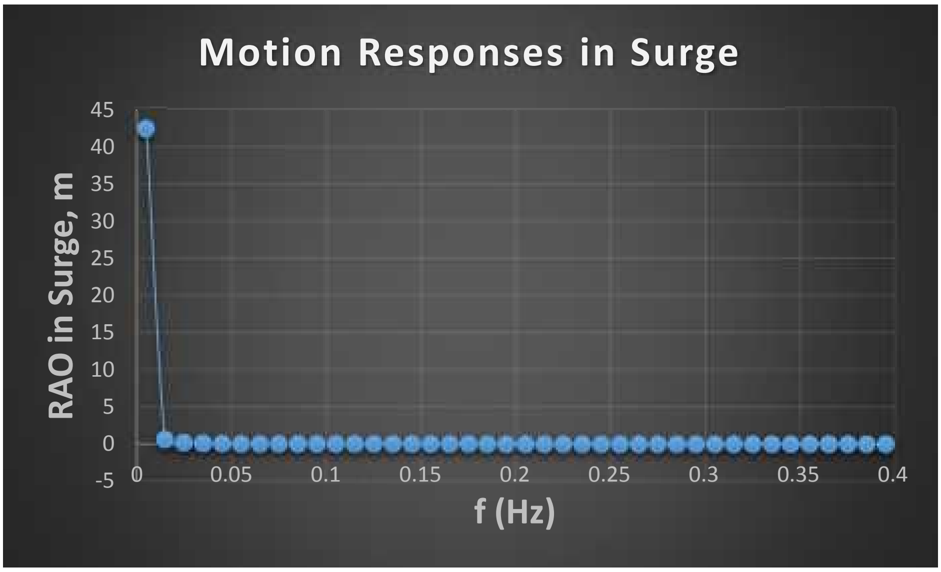

Figure 4.6-1 Motion Responses in Surge

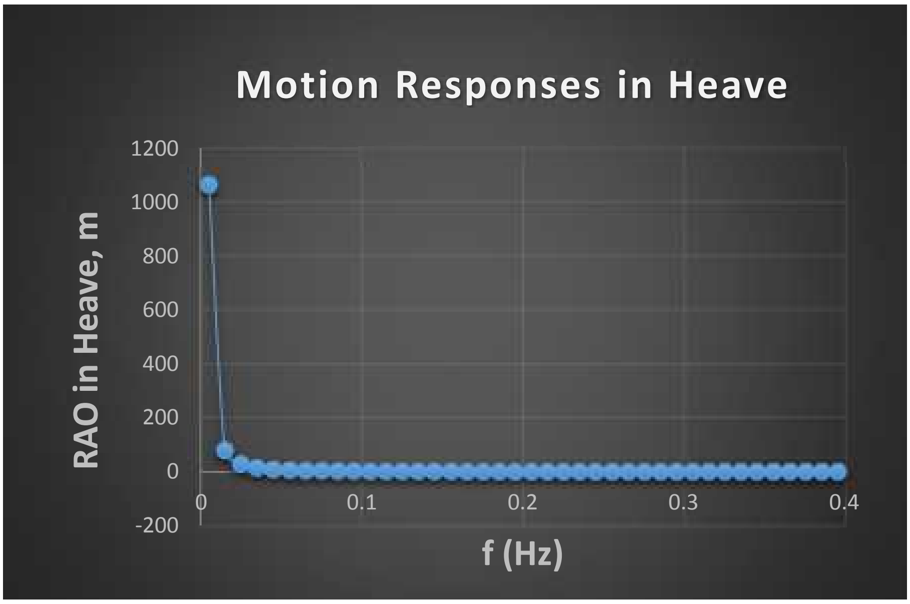

Figure 4.6-2 Motion Responses in Heave

Apart from that, Figure 4.6 -3 shows the surge motion responses spectrum for different frequencies from 0.005 Hz to 0.395 Hz which was obtained by multiplying the response amplitude operator (RAO) with P-M wave spectrum obtained in Section 4.5 to get surge motion responses spectrum, Sx (f). As we can see from the graph, it shows that the highest wave energy density is 502.966 m^2s which is at 0.095 Hz in frequency. Whereas for heave motion, the method used to obtain the heave motion responses spectrum is similar with surge, in which, at frequency of 0.395 Hz shows the highest wave energy density of 68539.50 $m^2 s$, refer Figure 4.6 – 4.

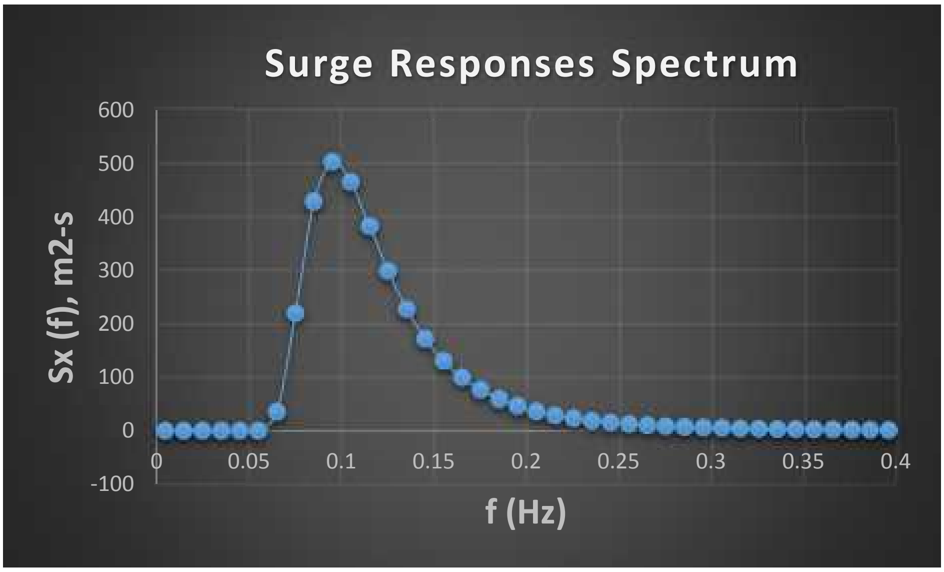

Figure 4.6-3 Surge Responses Spectrum

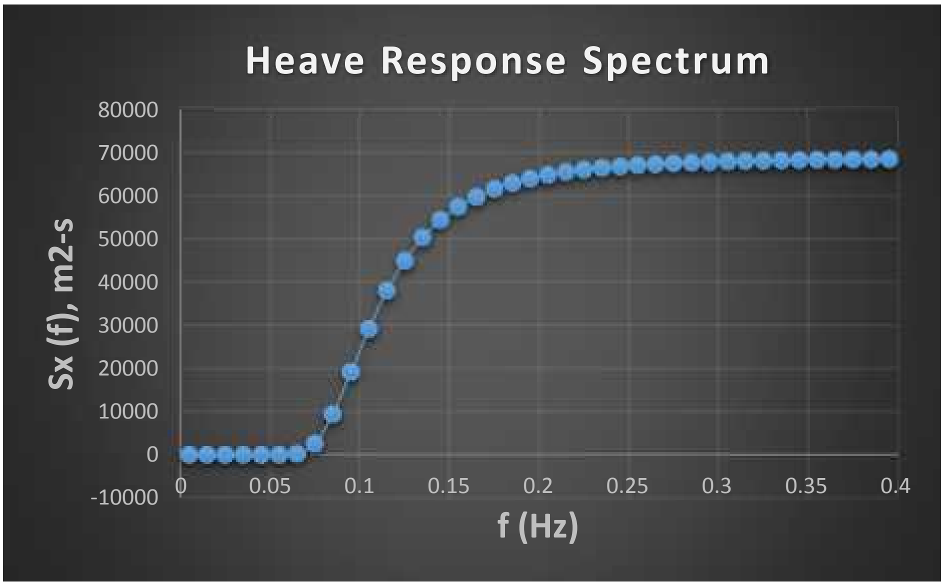

Figure 4.6-4 Heave Response Spectrum

In this study, the motion responses spectrum were determined for surge and heave motion to analyse the response of FPSO towards these two motion. The motion response spectrum were obtained by using equation (10), with damping ratio 5% and P-M wave Spectrum with significant wave height of 4.38. For surge motion, it clearly shows that high energy spectrum was in between 0.055 Hz frequency to 0.245 Hz frequency with the highest wave energy density at frequency of 0.095 Hz. On the other hand, high energy spectrum for heave was observed to be between the ranges of 0.055 Hz frequency to 0.395 Hz frequency with maximum energy density at 0.395 Hz.

Table 4.6 - 1 shows the maximum result of surge and heave motion at location x= 0 m as from the results obtained shows that all maximum value were obtained at that location.

Table 4.6-1 Maximum Result for Motion Response Spectrum at x= 0 m

Maximum Result	**Surge**	**Heave**
Frequency, f_x (Hz)	0.095	0.395
Energy Spectrum, $S_x(f)$	502.966 m^2-sec	68539.501
Motion response, RAO	42.4579	1063.15

4.7 WAVE PROFILE

To obtained the wave profile for surge motion, equation (11) was used to determine the time-series of the wave profile from the spectrums result obtained in section 4.3 at location x= 0 m. this wave profile is obtained within the time t = 0s to t = 500 s in surge motion. A random phase is in range (0,2Π) and random number was assigned to alter the randomness of the time history.

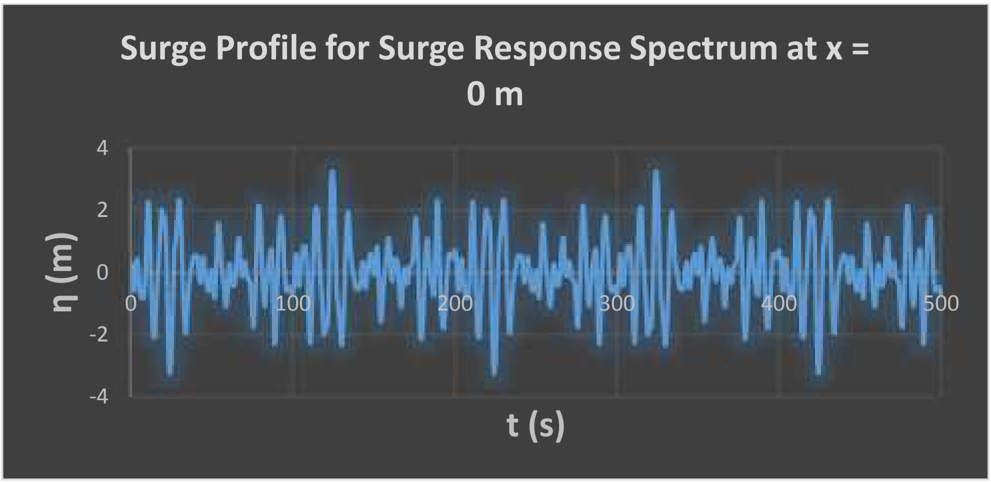

Figure 4.7-1 Surge Profile for Surge Response Spectrum at x = 0 m

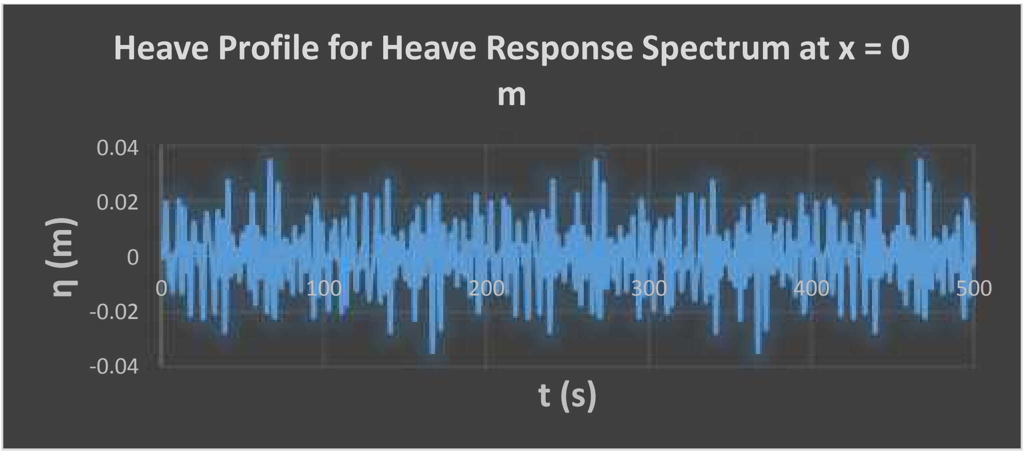

Figure 4.7-2 Heave Profile for Heave Response Spectrum at x = 0 m

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATION

Throughout conducting this project, many literature reviews have been studied on the hydrodynamic analysis of FPSO and its response in surge, heave and pitch motion. All research that has been done is mainly on how this floating structure response to a harsh environment of the sea. Linear Airy Wave theory and Froude-Krylov theory are the main concept that has been studied to conduct this research. The forces acting on the structure is calculated using the Froude–Krylov Theory by using the pressure-area method. As the FPSO's shape is irregular, the calculation of the forces were quite challenging. Furthermore, Berantai FPSO dimension is used and the environmental data condition is obtained from the metocean data from Petronas Technical Standards (PTS) in operating condition. The response of the FPSO in surge, heave and pitch motion were also obtained using the Response Amplitude Operator (RAO).

There are few recommendations that should be considered in order to enhance the study on the hydrodynamic analysis of FPSO. Some of the recommendations are as follow:

1. Conduct more detailed dynamic analysis by considering other parameters such as wind and current condition despite of taking into consideration the wave effects only.
2. Conduct further study on the multi-direction waves acting on the FPSO that represent the real situation in the sea state.

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APPENDIX

A. GANTT CHART

PROJECT ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Selection of Project Title																												
Identify & clarify research element, project objectives.																												
Read research works, journals, papers, articles etc.																												
Identify research methodology to be used.																												
Data collection & Requirement Gathering																												
Submission of Extended Proposal																												
Proposal Defence																												
Submission of Interim Report																												
Theoretical Calculation																												
Submission of Progress Report																												

APPENDIX

B. WEIGHT CALCULATION OF FPSO

i) Volume of ½ cylinder shape = $\Pi r^2 h/2$

$= (\Pi \times 16^2 \times 199)/2$

$= 80022.648\ m^3$

ii) Assume the curvature shape at bow side as ¼ of the oval shape (below the MSL)

Volume of ellipsoid $= 4/3\ \Pi\ xyz$

¼ of ellipsoid, $= 1/3\ \Pi\ xyz$

$= 1/3 \times \Pi \times 16\ m \times 8\ m \times 12\ m$

$= 170.667\ m^3$

The total volume of the FPSO is **80, 193.33 m^3**

The weight of the FPSO is calculated using the density equation. (ρ= 1030 kg/m^3)

Density (ρ) = m/V

m = ρV

= 1030 kg/m^3 x **80, 193.33** m^3

= 82,599,130 kg

= 83 **M-kg**

C. CROSS-SECTIONAL AREA AT BOW SIDE

Depth (m) Below MSL	Breadth (m)	Depth (m)	Cross-Sectional Area (m^2)
0	32	1	32
-1	31.94	1	31.94
-2	31.75	1	31.75
-3	31.43	1	31.43
-4	30.98	1	30.98
-5	30.39	1	30.39
-6	29.66	1	29.66
-7	28.77	1	28.77
-8	27.71	1	27.71
-9	26.46	1	26.46
-10	24.98	1	24.98
-11	23.24	1	23.24
-12	21.17	1	21.17

D. COEFFICIENT VALUE FOR Ch AND Cv

From the book of "Hydrodynamics of Offshore Structure" by Chakrabarti, the inertia force coefficients for basic structures are stated as follow:

	Force Coefficients	
	Horizontal	**Vertical**
Hemisphere	1.5	1.1
Sphere	1.5	1.1
Horizontal halfcylinder	2.0	1.1
Horizontal cylinder	2.0	2.0
Rectangular block	1.5	6.0

E. WAVE FORCE CALCULATION - SURGE AND HEAVE for x=0m, t =0s

Regular Wave-Froude Krylov Force

Parameters needed for Wave Forces Calculation in Surge and Heave.
PI (π) = 3.1416
Sea Water Density (ρ) = 1030 kg/m^3
Gravity Acceleration (g) = 9.807 m/s^2
Water Depth , (d) = 60 m
Distance from the origin (x) = 0 m
Time at x distance (t) = 0 s (varies from t = 0 to t = 8.38 s)

Wave Data

Maximum Wave Height (Hmax) = 8.44 m
Associated Wave Period (Tass) = 8.38 s
C_H = 2.00
C_V = 1.10
Wave Length (L) = 109.56
Wave Frequency (ω) = 0.7498
Wave Number (k) = 0.0573

Calculated Data

cosh kd = 15.5784
H/2 = 4.22

F. CALCULATION of WAVE SPECTRUM at x = -100 m

α	0.0081
g	9.807
Hs(m)	4.38
ωo	0.60
PI	3.1416
fo	0.0955
(α*g^2)/ (2π^4)	0.000499848
⌂f	0.01
x(m)	-100

SURGE

t (s) = 0											
Coordinates			**y (m)**	**s (m)**	**cosh ks**	**cos (kx-ωt)**	**Pressure (P)**	**Cross Sectional Area (m2)**	**Fx (N)**	**Fy (N)**
x	**y**	**z**								
0	0	0	0	60	15.57839	1	42627.07643	32	2728132.89	1500473.1
0	0	-1	-0.5	59.5	15.13932	1	41425.65852	31.94	2646271.07	1455449.1
0	0	-2	-1.5	58.5	14.29812	1	39123.88072	31.75	2484366.43	1366401.5
0	0	-3	-2.5	57.5	13.50387	1	36950.59311	31.43	2322714.28	1277492.9
0	0	-4	-3.5	56.5	12.75398	1	34898.65821	30.98	2162320.86	1189276.5
0	0	-5	-4.5	55.5	12.04597	1	32961.33709	30.39	2003390.07	1101864.5
0	0	-6	-5.5	54.5	11.37752	1	31132.2672	29.66	1846766.09	1015721.3
0	0	-7	-6.5	53.5	10.74644	1	29405.44155	28.77	1691989.11	930594.01
0	0	-8	-7.5	52.5	10.15065	1	27775.1889	27.71	1539300.97	846615.53
0	0	-9	-8.5	51.5	9.588202	1	26236.15521	26.46	1388417.33	763629.53
0	0	-10	-9.5	50.5	9.057239	1	24783.286	24.98	1238172.97	680995.13
0	0	-11	-10.5	49.5	8.556023	1	23411.80977	23.24	1088180.92	598499.5
0	0	-12	-11.5	48.5	8.082906	1	22117.22234	21.17	936443.194	515043.76

t (s) = 1											
Coordinates			**y (m)**	**s (m)**	**cosh ks**	**cos (kx-ωt)**	**Pressure (P)**	**Cross Sectional Area (m2)**	**Fx (N)**	**Fy (N)**
x	**y**	**z**								
0	0	0	0	60	15.57839	0.9999	42622.81372	32	2727860.08	1500323
0	0	-1	-0.5	59.5	15.13932	0.9999	41421.51596	31.94	2646006.44	1455303.5
0	0	-2	-1.5	58.5	14.29812	0.9999	39119.96833	31.75	2484117.99	1366264.9
0	0	-3	-2.5	57.5	13.50387	0.9999	36946.89805	31.43	2322482.01	1277365.1
0	0	-4	-3.5	56.5	12.75398	0.9999	34895.16835	30.98	2162104.63	1189157.5
0	0	-5	-4.5	55.5	12.04597	0.9999	32958.04095	30.39	2003189.73	1101754.4
0	0	-6	-5.5	54.5	11.37752	0.9999	31129.15397	29.66	1846581.41	1015619.8
0	0	-7	-6.5	53.5	10.74644	0.9999	29402.501	28.77	1691819.91	930500.95
0	0	-8	-7.5	52.5	10.15065	0.9999	27772.41138	27.71	1539147.04	846530.87
0	0	-9	-8.5	51.5	9.588202	0.9999	26233.5316	26.46	1388278.49	763553.17
0	0	-10	-9.5	50.5	9.057239	0.9999	24780.80767	24.98	1238049.15	680927.03
0	0	-11	-10.5	49.5	8.556023	0.9999	23409.46859	23.24	1088072.1	598439.66
0	0	-12	-11.5	48.5	8.082906	0.9999	22115.01061	21.17	936349.549	514992.25

t (s) = 2											
Coordinates			**y (m)**	**s (m)**	**cosh ks**	**cos (kx-ωt)**	**Pressure (P)**	**Cross Sectional Area (m2)**	**Fx (N)**	**Fy (N)**
x	**y**	**z**								
0	0	0	0	60	15.57839	0.9996	42610.03	32	2727041.64	1499872.9
0	0	-1	-0.5	59.5	15.13932	0.9996	41409.09	31.94	2645212.56	1454866.9
0	0	-2	-1.5	58.5	14.29812	0.9996	39108.23	31.75	2483372.68	1365855
0	0	-3	-2.5	57.5	13.50387	0.9996	36935.81	31.43	2321785.2	1276981.9
0	0	-4	-3.5	56.5	12.75398	0.9996	34884.70	30.98	2161455.93	1188800.8
0	0	-5	-4.5	55.5	12.04597	0.9996	32948.15	30.39	2002588.71	1101423.8
0	0	-6	-5.5	54.5	11.37752	0.9996	31119.81	29.66	1846027.38	1015315.1
0	0	-7	-6.5	53.5	10.74644	0.9996	29393.68	28.77	1691312.31	930221.77
0	0	-8	-7.5	52.5	10.15065	0.9996	27764.08	27.71	1538685.25	846276.89
0	0	-9	-8.5	51.5	9.588202	0.9996	26225.66	26.46	1387861.97	763324.08
0	0	-10	-9.5	50.5	9.057239	0.9996	24773.37	24.98	1237677.7	680722.73
0	0	-11	-10.5	49.5	8.556023	0.9996	23402.45	23.24	1087745.65	598260.11
0	0	-12	-11.5	48.5	8.082906	0.9996	22108.38	21.17	936068.616	514837.74

t (s) = 3										
Coordinates			**y (m)**	**s (m)**	**cosh ks**	**cos (kx-ωt)**	**Pressure (P)**	**Cross Sectional Area (m2)**	**Fx (N)**	**Fy (N)**
x	**y**	**z**								
0	0	0	0	60	15.57839	0.9992	42592.97	32	2725950.39	1499272.7
0	0	-1	-0.5	59.5	15.13932	0.9992	41392.52	31.94	2644154.05	1454284.7
0	0	-2	-1.5	58.5	14.29812	0.9992	39092.58	31.75	2482378.93	1365308.4
0	0	-3	-2.5	57.5	13.50387	0.9992	36921.03	31.43	2320856.11	1276470.9
0	0	-4	-3.5	56.5	12.75398	0.9992	34870.74	30.98	2160591.01	1188325.1
0	0	-5	-4.5	55.5	12.04597	0.9992	32934.97	30.39	2001787.36	1100983
0	0	-6	-5.5	54.5	11.37752	0.9992	31107.36	29.66	1845288.68	1014908.8
0	0	-7	-6.5	53.5	10.74644	0.9992	29381.92	28.77	1690635.52	929849.53
0	0	-8	-7.5	52.5	10.15065	0.9992	27752.97	27.71	1538069.53	845938.24
0	0	-9	-8.5	51.5	9.588202	0.9992	26215.17	26.46	1387306.6	763018.63
0	0	-10	-9.5	50.5	9.057239	0.9992	24763.46	24.98	1237182.43	680450.34
0	0	-11	-10.5	49.5	8.556023	0.9992	23393.08	23.24	1087310.37	598020.71
0	0	-12	-11.5	48.5	8.082906	0.9992	22099.53	21.17	935694.039	514631.72

t (s) = 4											
Coordinates			**y (m)**	**s (m)**	**cosh ks**	**cos (kx-ωt)**	**Pressure (P)**	**Cross Sectional Area (m2)**	**Fx (N)**	**Fy (N)**
x	**y**	**z**								
0	0	0	0	60	15.57839	0.9986	42567.40	32	2724313.51	1498372.4
0	0	-1	-0.5	59.5	15.13932	0.9986	41367.66	31.94	2642566.29	1453411.5
0	0	-2	-1.5	58.5	14.29812	0.9986	39069.11	31.75	2480888.31	1364488.6
0	0	-3	-2.5	57.5	13.50387	0.9986	36898.86	31.43	2319462.48	1275704.4
0	0	-4	-3.5	56.5	12.75398	0.9986	34849.80	30.98	2159293.61	1187611.5
0	0	-5	-4.5	55.5	12.04597	0.9986	32915.19	30.39	2000585.32	1100321.9
0	0	-6	-5.5	54.5	11.37752	0.9986	31088.68	29.66	1844180.62	1014299.3
0	0	-7	-6.5	53.5	10.74644	0.9986	29364.27	28.77	1689620.32	929291.18
0	0	-8	-7.5	52.5	10.15065	0.9986	27736.30	27.71	1537145.95	845430.27
0	0	-9	-8.5	51.5	9.588202	0.9986	26199.42	26.46	1386473.55	762560.45
0	0	-10	-9.5	50.5	9.057239	0.9986	24748.59	24.98	1236439.53	680041.74
0	0	-11	-10.5	49.5	8.556023	0.9986	23379.03	23.24	1086657.46	597661.61
0	0	-12	-11.5	48.5	8.082906	0.9986	22086.26	21.17	935132.173	514322.7

t (s) = 5										
Coordinates			**y (m)**	**s (m)**	**cosh ks**	**cos (kx-ωt)**	**Pressure (P)**	**Cross Sectional Area (m2)**	**Fx (N)**	**Fy (N)**
x	**y**	**z**								
0	0	0	0	60	15.57839	0.9979	42537.56	32	2722403.81	1497322.1
0	0	-1	-0.5	59.5	15.13932	0.9979	41338.66	31.94	2640713.9	1452392.6
0	0	-2	-1.5	58.5	14.29812	0.9979	39041.72	31.75	2479149.26	1363532.1
0	0	-3	-2.5	57.5	13.50387	0.9979	36873.00	31.43	2317836.58	1274810.1
0	0	-4	-3.5	56.5	12.75398	0.9979	34825.37	30.98	2157779.99	1186779
0	0	-5	-4.5	55.5	12.04597	0.9979	32892.12	30.39	1999182.95	1099550.6
0	0	-6	-5.5	54.5	11.37752	0.9979	31066.89	29.66	1842887.88	1013588.3
0	0	-7	-6.5	53.5	10.74644	0.9979	29343.69	28.77	1688435.93	928639.76
0	0	-8	-7.5	52.5	10.15065	0.9979	27716.86	27.71	1536068.44	844837.64
0	0	-9	-8.5	51.5	9.588202	0.9979	26181.06	26.46	1385501.66	762025.91
0	0	-10	-9.5	50.5	9.057239	0.9979	24731.24	24.98	1235572.81	679565.04
0	0	-11	-10.5	49.5	8.556023	0.9979	23362.64	23.24	1085895.74	597242.66
0	0	-12	-11.5	48.5	8.082906	0.9979	22070.78	21.17	934476.663	513962.16

t (s) = 6											
Coordinates			**y (m)**	**s (m)**	**cosh ks**	**cos (kx-ωt)**	**Pressure (P)**	**Cross Sectional Area (m2)**	**Fx (N)**	**Fy (N)**
x	**y**	**z**									
0	0	0	0	60	15.57839	0.9969	42494.93	32	2719675.68	1495821.6
0	0	-1	-0.5	59.5	15.13932	0.9969	41297.24	31.94	2638067.63	1450937.2
0	0	-2	-1.5	58.5	14.29812	0.9969	39002.60	31.75	2476664.89	1362165.7
0	0	-3	-2.5	57.5	13.50387	0.9969	36836.05	31.43	2315513.87	1273532.6
0	0	-4	-3.5	56.5	12.75398	0.9969	34790.47	30.98	2155617.67	1185589.7
0	0	-5	-4.5	55.5	12.04597	0.9969	32859.16	30.39	1997179.56	1098448.8
0	0	-6	-5.5	54.5	11.37752	0.9969	31035.76	29.66	1841041.12	1012572.6
0	0	-7	-6.5	53.5	10.74644	0.9969	29314.28	28.77	1686743.94	927709.17
0	0	-8	-7.5	52.5	10.15065	0.9969	27689.09	27.71	1534529.14	843991.02
0	0	-9	-8.5	51.5	9.588202	0.9969	26154.82	26.46	1384113.24	761262.28
0	0	-10	-9.5	50.5	9.057239	0.9969	24706.46	24.98	1234334.63	678884.05
0	0	-11	-10.5	49.5	8.556023	0.9969	23339.23	23.24	1084807.56	596644.16
0	0	-12	-11.5	48.5	8.082906	0.9969	22048.66	21.17	933540.22	513447.12

t (s) = 7										
Coordinates			**y (m)**	**s (m)**	**cosh ks**	**cos (kx-ωt)**	**Pressure (P)**	**Cross Sectional Area (m2)**	**Fx (N)**	**Fy (N)**
x	**y**	**z**								
0	0	0	0	60	15.57839	0.9958	42448.04	32	2716674.73	1494171.1
0	0	-1	-0.5	59.5	15.13932	0.9958	41251.67	31.94	2635156.73	1449336.2
0	0	-2	-1.5	58.5	14.29812	0.9958	38959.56	31.75	2473932.09	1360662.6
0	0	-3	-2.5	57.5	13.50387	0.9958	36795.40	31.43	2312958.88	1272127.4
0	0	-4	-3.5	56.5	12.75398	0.9958	34752.08	30.98	2153239.12	1184281.5
0	0	-5	-4.5	55.5	12.04597	0.9958	32822.90	30.39	1994975.83	1097236.7
0	0	-6	-5.5	54.5	11.37752	0.9958	31001.51	29.66	1839009.67	1011455.3
0	0	-7	-6.5	53.5	10.74644	0.9958	29281.94	28.77	1684882.75	926685.51
0	0	-8	-7.5	52.5	10.15065	0.9958	27658.53	27.71	1532835.9	843059.75
0	0	-9	-8.5	51.5	9.588202	0.9958	26125.96	26.46	1382585.98	760422.29
0	0	-10	-9.5	50.5	9.057239	0.9958	24679.20	24.98	1232972.64	678134.95
0	0	-11	-10.5	49.5	8.556023	0.9958	23313.48	23.24	1083610.56	595985.81
0	0	-12	-11.5	48.5	8.082906	0.9958	22024.33	21.17	932510.132	512880.57

t (s) = 8.38										
Coordinates			**y (m)**	**s (m)**	**cos (kx-ωt)**	**Pressure (P)**	**Cross Sectional Area (m2)**	**Fx (N)**	**Fy (N)**	
x	**y**	**z**								
0	0	0	0	60	15.57839	0.9940	42371.31	32	2711764.09	1491470.3
0	0	-1	-0.5	59.5	15.13932	0.9940	41177.10	31.94	2630393.44	1446716.4
0	0	-2	-1.5	58.5	14.29812	0.9940	38889.14	31.75	2469460.23	1358203.1
0	0	-3	-2.5	57.5	13.50387	0.9940	36728.89	31.43	2308778	1269827.9
0	0	-4	-3.5	56.5	12.75398	0.9940	34689.27	30.98	2149346.94	1182140.8
0	0	-5	-4.5	55.5	12.04597	0.9940	32763.57	30.39	1991369.73	1095253.4
0	0	-6	-5.5	54.5	11.37752	0.9940	30945.47	29.66	1835685.49	1009627
0	0	-7	-6.5	53.5	10.74644	0.9940	29229.01	28.77	1681837.17	925010.44
0	0	-8	-7.5	52.5	10.15065	0.9940	27608.54	27.71	1530065.16	841535.84
0	0	-9	-8.5	51.5	9.588202	0.9940	26078.74	26.46	1380086.83	759047.76
0	0	-10	-9.5	50.5	9.057239	0.9940	24634.59	24.98	1230743.93	676909.16
0	0	-11	-10.5	49.5	8.556023	0.9940	23271.34	23.24	1081651.83	594908.51
0	0	-12	-11.5	48.5	8.082906	0.9940	21984.52	21.17	930824.535	511953.49

P – M WAVE SPECTRUM DATA

f, Hz	T,s	2πf	L,m	k	(f^-5)	(f/fo)^-4	S(f), m-s2	H(n), m	Rn	ε(n)
0.005	200	0.031	62433.16	0.000101	3.2E+11	133086.3	0	0	0.8416	5.287828
0.015	66.667	0.094	6937.087	0.000906	1.32E+09	1643.041	0	0	0.1841	1.157018
0.025	40	0.157	2497.326	0.002516	1.02E+08	212.9381	1.3E-111	1.02E-56	0.7715	4.847747
0.035	28.571	0.22	1274.108	0.004931	19039686	55.42954	7.72E-27	2.49E-14	0.5124	3.219308
0.045	22.222	0.283	770.7643	0.008152	5419228	20.28446	2.64E-08	4.59E-05	0.8463	5.317231
0.055	18.182	0.346	515.9868	0.012177	1986948	9.089976	0.011544	0.03039	0.9792	6.152471
0.065	15.385	0.408	369.4454	0.017007	861853	4.659723	1.272496	0.319061	0.5996	3.767294
0.075	13.333	0.471	277.4668	0.022645	421399.2	2.628866	7.877786	0.793866	0.7731	4.857566
0.085	11.765	0.534	216.0425	0.029083	225374.8	1.593448	15.37133	1.108921	0.3291	2.067917
0.095	10.526	0.597	172.9347	0.036333	129235.5	1.021219	18.02322	1.200774	0.3040	1.909906
0.105	9.524	0.66	141.5774	0.04438	78352.62	0.684315	16.6494	1.154102	0.2596	1.631135
0.115	8.696	0.723	118.0305	0.053234	49717.67	0.475578	13.71426	1.047445	0.0184	0.115509
0.125	8	0.785	99.89305	0.062899	32768	0.340701	10.69873	0.925148	0.6990	4.392263
0.135	7.407	0.848	85.63277	0.073374	22301.35	0.250425	8.151192	0.807524	0.4382	2.753587
0.145	6.897	0.911	74.24646	0.084626	15601.27	0.188166	6.1638	0.702214	0.5110	3.210603
0.155	6.452	0.974	64.97466	0.096702	11177.42	0.144108	4.666036	0.610969	0.5625	3.534179
0.165	6.061	1.037	57.33817	0.109581	8176.742	0.112222	3.552193	0.533081	0.4431	2.784174
0.175	5.714	1.1	50.96074	0.123295	6092.699	0.088687	2.725852	0.466978	0.8395	5.274639
0.185	5.405	1.162	45.59809	0.137795	4614.678	0.071011	2.110715	0.410922	0.1710	1.074292
0.195	5.128	1.225	41.04416	0.153084	3546.72	0.057527	1.649814	0.363298	0.1106	0.694962
0.205	4.878	1.288	37.13974	0.169177	2762.045	0.047098	1.30167	0.322697	0.7860	4.938386
0.215	4.651	1.351	33.76354	0.186094	2176.746	0.038928	1.036366	0.28794	0.8138	5.113111
0.225	4.444	1.414	30.82502	0.203834	1734.153	0.032455	0.832351	0.258047	0.1278	0.802731
0.235	4.255	1.477	28.25885	0.222345	1395.278	0.027274	0.674051	0.232216	0.9651	6.064217
0.245	4.082	1.539	26.00766	0.24159	1132.843	0.023086	0.550142	0.209789	0.8132	5.109197

0.255	3.922	1.602	24.0088	0.261704	927.4683	0.019672	0.452332	0.190228	0.2551	1.603123
0.265	3.774	1.665	22.231	0.282632	765.1924	0.016867	0.3745	0.17309	0.7951	4.996018
0.275	3.636	1.728	20.63493	0.304493	635.8234	0.014544	0.312089	0.15801	0.1589	0.998251
0.285	3.509	1.791	19.21861	0.326933	531.8335	0.012608	0.261679	0.144687	0.6343	3.985267
0.295	3.39	1.854	17.9372	0.350289	447.5998	0.010983	0.220681	0.13287	0.4252	2.67165
0.305	3.279	1.916	16.78178	0.374406	378.8792	0.009612	0.18712	0.12235	0.6569	4.127269
0.315	3.175	1.979	15.73413	0.399336	322.4388	0.008448	0.159477	0.112952	0.2045	1.285207
0.325	3.077	2.042	14.77782	0.425178	275.793	0.007456	0.136576	0.104528	0.9454	5.939966
0.335	2.985	2.105	13.90734	0.45179	237.0151	0.006604	0.117497	0.096953	0.2709	1.701856
0.345	2.899	2.168	13.11752	0.478993	204.5995	0.005871	0.101521	0.09012	0.3120	1.96034
0.355	2.817	2.231	12.38594	0.507285	177.361	0.005237	0.088075	0.08394	0.0200	0.125704
0.365	2.74	2.293	11.71808	0.536197	154.3603	0.004686	0.076706	0.078336	0.4517	2.838025
0.375	2.667	2.356	11.102	0.565952	134.8477	0.004206	0.06705	0.073239	0.5178	3.253541
0.385	2.597	2.419	10.52687	0.596873	118.2215	0.003786	0.058814	0.068594	0.8838	5.553139
0.395	2.532	2.482	10.00651	0.627911	103.9955	0.003417	0.05176	0.064349	0.1996	1.254206

Total Forces from Aft Side and Bow Side (Wave Angle varies from 0°, 15°, 30°, 45°, 60°, 75°, 90°) at t = 0 s

Angle (Degree)	Aft Side	Bow Side							
		0°				15°			
Depth (m)	Fx (N)	Fy = Fx sin Θ	Fy'= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45	Fy = Fx sin Θ	Fy '= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45
0	2728132.9	0.0	0.0	2728132.9	1433148.2	1774071.6	931958.8	-2072529.6	-1088745.4
-1	2646271.1	0.0	0.0	2646271.1	1390144.4	1720837.9	903994.0	-2010340.1	-1056075.9
-2	2484366.4	0.0	0.0	2484366.4	1305092.3	1615553.3	848685.7	-1887343.1	-991462.9
-3	2322714.3	0.0	0.0	2322714.3	1220172.9	1510432.9	793463.6	-1764538.0	-926950.6
-4	2162320.9	0.0	0.0	2162320.9	1135914.7	1406131.0	738671.5	-1642689.0	-862940.7
-5	2003390.1	0.0	0.0	2003390.1	1052424.9	1302780.2	684379.1	-1521951.2	-799514.4
-6	1846766.1	0.0	0.0	1846766.1	970146.8	1200929.5	630874.7	-1402965.9	-737008.8
-7	1691989.1	0.0	0.0	1691989.1	888839.1	1100279.9	578001.2	-1285383.7	-675240.3
-8	1539301.0	0.0	0.0	1539301.0	808628.6	1000988.7	525841.4	-1169388.3	-614305.4
-9	1388417.3	0.0	0.0	1388417.3	729366.2	902870.9	474297.9	-1054763.9	-554090.7
-10	1238173.0	0.0	0.0	1238173.0	650439.5	805168.8	422972.9	-940625.0	-494131.0
-11	1088180.9	0.0	0.0	1088180.9	571645.4	707630.8	371734.0	-826677.9	-434272.1
-12	936443.2	0.0	0.0	936443.2	491934.2	608957.6	319898.8	-711404.6	-373716.5

Angle (Degree)	Aft Side	Bow Side							
		30°				45°			
Depth (m)	Fx (N)	Fy = Fx sin Θ	Fy'= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45	Fy = Fx sin Θ	Fy '= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45
0	2728132.9	-2695481.6	-1415995.7	420818.5	221065.2	2321377.9	1219470.9	1433148.2	752864.3
-1	2646271.1	-2614599.5	-1373506.6	408191.1	214431.8	2251721.4	1182878.8	1390144.4	730273.4
-2	2484366.4	-2454632.6	-1289472.5	383217.1	201312.4	2113956.1	1110507.6	1305092.3	685593.7
-3	2322714.3	-2294915.2	-1205569.4	358282.0	188213.4	1976405.8	1038249.4	1220172.9	640983.6
-4	2162320.9	-2136441.4	-1122319.6	333541.1	175216.5	1839926.4	966553.8	1135914.7	596721.0
-5	2003390.1	-1979412.7	-1039829.0	309025.8	162338.1	1704691.7	895512.0	1052424.9	552861.9
-6	1846766.1	-1824663.3	-958535.8	284866.3	149646.6	1571419.8	825501.4	970146.8	509639.5
-7	1691989.1	-1671738.7	-878201.1	260991.8	137104.7	1439719.5	756316.3	888839.1	466926.7
-8	1539301.0	-1520878.0	-798950.7	237439.4	124732.1	1309796.6	688065.0	808628.6	424790.4
-9	1388417.3	-1371800.2	-720636.8	214165.4	112505.8	1181409.2	620620.2	729366.2	383152.1
-10	1238173.0	-1223354.0	-642654.8	190990.0	100331.2	1053565.7	553461.3	650439.5	341690.2
-11	1088180.9	-1075157.2	-564803.7	167853.5	88177.1	925937.0	486415.1	571645.4	300297.9
-12	936443.2	-925235.5	-486046.5	144447.7	75881.6	796822.8	418588.5	491934.2	258423.9

Angle (Degree)	Aft Side	Bow Side							
		60°				75°			
Depth (m)	Fx (N)	Fy = Fx sin Θ	Fy'= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45	Fy = Fx sin Θ	Fy '= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45
0	2728132.9	-831563.9	-436838.8	-2598309.2	-1364948.9	-1057919.8	-555748.6	2514660.0	1321006.2
-1	2646271.1	-806611.5	-423730.8	-2520342.9	-1323991.6	-1026175.3	-539072.5	2439203.7	1281367.3
-2	2484366.4	-757261.3	-397806.0	-2366142.8	-1242986.9	-963391.7	-506090.8	2289967.9	1202970.5
-3	2322714.3	-707988.0	-371921.7	-2212183.2	-1162108.5	-900705.9	-473160.6	2140964.8	1124695.9
-4	2162320.9	-659098.4	-346238.9	-2059422.5	-1081859.9	-838508.3	-440486.9	1993122.0	1047030.8
-5	2003390.1	-610654.6	-320790.3	-1908054.7	-1002343.1	-776877.9	-408111.0	1846627.3	970073.9
-6	1846766.1	-562913.9	-295711.1	-1758884.0	-923980.4	-716142.0	-376205.1	1702259.0	894234.1
-7	1691989.1	-515736.3	-270927.6	-1611472.4	-846541.9	-656122.3	-344675.5	1559593.1	819288.6
-8	1539301.0	-469195.3	-246478.6	-1466050.2	-770148.4	-596912.6	-313571.3	1418852.6	745354.5
-9	1388417.3	-423204.3	-222318.6	-1322346.7	-694657.8	-538402.7	-282834.8	1279775.4	672294.2
-10	1238173.0	-377408.3	-198260.9	-1179252.0	-619487.0	-480140.7	-252228.5	1141287.5	599543.4
-11	1088180.9	-331689.1	-174243.6	-1036397.6	-544442.5	-421976.6	-221673.6	1003032.1	526914.8
-12	936443.2	-285437.8	-149946.8	-891880.7	-468524.5	-363135.5	-190763.0	863167.7	453441.0

Angle (Degree)	Aft Side	Bow Side				Total Forces		Total Forces (MN)
		90º						
Depth (m)	Fx (N)	Fy = Fx sin Ө	Fy'= Fy cos 45	Fx = Fx cos Ө	Fx' = Fx cos 45	∑Fx (N)	∑Fy (N)	
0	2728132.9	2438941.7	1281229.7	-1222404.4	-642155.9	1835750.0	3410341.1	3873035.5
-1	2646271.1	2365757.5	1242784.4	-1185724.2	-622887.0	1780665.5	3308008.5	3756819.1
-2	2484366.4	2221015.3	1166748.2	-1113179.0	-584777.4	1671720.5	3105617.4	3526968.7
-3	2322714.3	2076498.8	1090830.5	-1040747.0	-546727.3	1562945.4	2903541.8	3297476.8
-4	2162320.9	1933107.6	1015503.9	-968878.9	-508973.4	1455017.3	2703039.7	3069771.8
-5	2003390.1	1791024.0	940864.3	-897666.2	-471563.8	1348073.4	2504366.1	2844143.3
-6	1846766.1	1651002.7	867308.0	-827487.2	-434697.2	1242681.7	2308576.0	2621789.7
-7	1691989.1	1512632.6	794619.2	-758135.7	-398265.3	1138532.9	2115094.9	2402058.2
-8	1539301.0	1376129.9	722911.3	-689720.2	-362325.2	1035789.6	1924224.9	2185292.1
-9	1388417.3	1241240.5	652050.9	-622113.2	-326809.7	934260.6	1735610.7	1971087.9
-10	1238173.0	1106922.5	581490.7	-554792.6	-291444.8	833161.8	1547795.6	1757791.2
-11	1088180.9	972830.1	511049.0	-487585.2	-256139.2	732232.7	1360295.9	1544852.7
-12	936443.2	837177.1	439787.5	-419595.5	-220422.7	630129.0	1170614.0	1329435.9

Total Forces from Aft Side and Bow Side (Wave Angle varies from 0°, 15°, 30°, 45°, 60°, 75°, 90°) at t = 8.38 s

Angle (Degree)	Aft Side	Bow Side							
		0°				15°			
Depth (m)	Fx (N)	Fy = Fx sin Θ	Fy'= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45	Fy = Fx sin Θ	Fy '= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45
0	2711764.09	0.0	0.0	2711764.1	1424549.3	1763427.2	926367.1	-2060094.4	-1082212.9
-1	2630393.44	0.0	0.0	2630393.4	1381803.5	1710512.9	898570.0	-1998278.1	-1049739.4
-2	2469460.23	0.0	0.0	2469460.2	1297261.8	1605860.0	843593.5	-1876019.1	-985514.1
-3	2308778	0.0	0.0	2308778.0	1212851.8	1501370.3	788702.8	-1753950.7	-921388.9
-4	2149346.94	0.0	0.0	2149346.9	1129099.2	1397694.2	734239.5	-1632832.9	-857763.0
-5	1991369.73	0.0	0.0	1991369.7	1046110.3	1294963.5	680272.8	-1512819.5	-794717.4
-6	1835685.49	0.0	0.0	1835685.5	964326.0	1193724.0	627089.4	-1394548.1	-732586.8
-7	1681837.17	0.0	0.0	1681837.2	883506.0	1093678.3	574533.2	-1277671.4	-671188.9
-8	1530065.16	0.0	0.0	1530065.2	803776.9	994982.8	522686.3	-1162372.0	-610619.6
-9	1380086.83	0.0	0.0	1380086.8	724990.0	897453.7	471452.2	-1048435.3	-550766.1
-10	1230743.93	0.0	0.0	1230743.9	646536.8	800337.8	420435.1	-934981.3	-491166.2
-11	1081651.83	0.0	0.0	1081651.8	568215.5	703385.0	369503.6	-821717.8	-431666.4
-12	930824.535	0.0	0.0	930824.5	488982.6	605303.9	317979.4	-707136.1	-371474.2

Angle (Degree)	Aft Side	Bow Side							
		30º				45º			
Depth (m)	Fx (N)	Fy = Fx sin Θ	Fy'= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45	Fy = Fx sin Θ	Fy '= Fy cos 45	Fx = Fx cos Θ	Fx' = Fx cos 45
0	2711764.09	-2679308.7	-1407499.8	418293.5	219738.8	2307449.6	1212154.0	1424549.3	748347.1
-1	2630393.44	-2598911.9	-1365265.6	405742.0	213145.2	2238211.0	1175781.5	1381803.5	725891.8
-2	2469460.23	-2439904.8	-1281735.6	380917.8	200104.5	2101272.4	1103844.6	1297261.8	681480.1
-3	2308778	-2281145.7	-1198336.0	356132.4	187084.2	1964547.3	1032019.9	1212851.8	637137.7
-4	2149346.94	-2123622.7	-1115585.7	331539.9	174165.2	1828886.9	960754.5	1129099.2	593140.6
-5	1991369.73	-1967536.3	-1033590.1	307171.7	161364.0	1694463.5	890138.9	1046110.3	549544.7
-6	1835685.49	-1813715.3	-952784.5	283157.1	148748.7	1561991.3	820548.4	964326.0	506581.6
-7	1681837.17	-1661708.3	-872931.9	259425.8	136282.1	1431081.2	751778.4	883506.0	464125.2
-8	1530065.16	-1511752.8	-794157.0	236014.8	123983.7	1301937.8	683936.6	803776.9	422241.7
-9	1380086.83	-1363569.4	-716313.0	212880.4	111830.8	1174320.7	616896.5	724990.0	380853.2
-10	1230743.93	-1216013.9	-638798.9	189844.0	99729.2	1047244.3	550140.5	646536.8	339640.0
-11	1081651.83	-1068706.2	-561414.9	166846.4	87648.1	920381.4	483496.6	568215.5	298496.1
-12	930824.535	-919684.1	-483130.3	143581.0	75426.3	792041.9	416077.0	488982.6	256873.3

Angle (Degree)	Aft Side	Bow Side							
		60º				75º			
Depth (m)	Fx (N)	Fy = Fx sin Ɵ	Fy'= Fy cos 45	Fx = Fx cos Ɵ	Fx' = Fx cos 45	Fy = Fx sin Ɵ	Fy '= Fy cos 45	Fx = Fx cos Ɵ	Fx' = Fx cos 45
0	2711764.09	-826574.5	-434217.8	-2582719.3	-1356759.3	-1051572.3	-552414.1	2499572.0	1313080.1
-1	2630393.44	-801771.9	-421188.4	-2505220.9	-1316047.6	-1020018.3	-535838.0	2424568.5	1273679.1
-2	2469460.23	-752717.7	-395419.2	-2351946.0	-1235528.9	-957611.3	-503054.3	2276228.1	1195752.7
-3	2308778	-703740.1	-369690.1	-2198910.1	-1155135.8	-895301.7	-470321.7	2128119.1	1117947.7
-4	2149346.94	-655143.8	-344161.4	-2047065.9	-1075368.7	-833477.3	-437843.9	1981163.3	1040748.6
-5	1991369.73	-606990.6	-318865.5	-1896606.4	-996329.0	-772216.6	-405662.4	1835547.6	964253.5
-6	1835685.49	-559536.4	-293936.8	-1748330.7	-918436.6	-711845.1	-373947.9	1692045.4	888868.7
-7	1681837.17	-512641.8	-269302.0	-1601803.6	-841462.6	-652185.6	-342607.4	1550235.5	814372.8
-8	1530065.16	-466380.1	-244999.7	-1457253.9	-765527.5	-593331.2	-311689.9	1410339.5	740882.4
-9	1380086.83	-420665.1	-220984.6	-1314412.6	-690489.8	-535172.3	-281137.8	1272096.8	668260.4
-10	1230743.93	-375143.8	-197071.3	-1172176.5	-615770.1	-477259.9	-250715.1	1134439.8	595946.2
-11	1081651.83	-329699.0	-173198.1	-1030179.2	-541175.8	-419444.7	-220343.5	997014.0	523753.4
-12	930824.535	-283725.2	-149047.1	-886529.4	-465713.4	-360956.7	-189618.5	857988.7	450720.3

Angle (Degree)	Aft Side	Bow Side				Total Forces		Total Forces (N)
		90º						
Depth (m)	Fx (N)	Fy = Fx sin Ө	Fy'= Fy cos 45	Fx = Fx cos Ө	Fx' = Fx cos 45	∑Fx (N)	∑Fy (N)	
0	2711764.09	2424308.1	1273542.3	-1215069.9	-638303.0	1824735.5	2955661.3	3473556.3
-1	2630393.44	2351563.0	1235327.7	-1178609.9	-619149.7	1769981.5	2866972.1	3369326.9
-2	2469460.23	2207689.2	1159747.7	-1106500.0	-581268.8	1661690.2	2691564.5	3163184.1
-3	2308778	2064039.8	1084285.5	-1034502.5	-543446.9	1553567.7	2516430.4	2957362.8
-4	2149346.94	1921509.0	1009410.9	-963065.7	-505919.6	1446287.2	2342660.1	2753144.2
-5	1991369.73	1780277.9	935219.1	-892280.2	-468734.4	1339984.9	2170474.3	2550787.8
-6	1835685.49	1641096.7	862104.2	-822522.2	-432089.0	1235225.6	2000787.8	2351368.6
-7	1681837.17	1503556.8	789851.5	-753586.9	-395875.7	1131701.7	1833102.3	2154301.0
-8	1530065.16	1367873.2	718573.8	-685581.8	-360151.2	1029574.9	1667679.8	1959893.0
-9	1380086.83	1233793.0	648138.6	-618380.5	-324848.9	928655.0	1504212.4	1767782.5
-10	1230743.93	1100281.0	578001.8	-551463.9	-289696.1	828162.8	1341437.5	1576486.1
-11	1081651.83	966993.1	507982.8	-484659.6	-254602.4	727839.3	1178936.0	1385510.8
-12	930824.535	832154.0	437148.8	-417077.9	-219100.2	626348.2	1014543.3	1192312.9

Based on the results obtained, the maximum forces for the surge motion is at t = 0 s which is Force = 34180522.91 N.

t (s)	Max Forces (N)
0	34180522.91
1	30836973.16
2	30827721.15
3	16373422.62
4	30796881.09
5	30775293.0
6	30744452.99
7	30710528.93
8.38	30655016.83
MAX	34180522.91

HEAVE

t (s) 0

Coordinates			y	s (m)	cosh ks	cos (kx-ωt)	Pressure (P)	Area (m^2)	Fx (kN)	Fy (kN)
x	y	z								
-100	0	-12	-12	48	7.856396242	0.850855281	18291.19655	32	1170636.579	643850.1186
-99	0	-12	-12	48	7.856396242	0.819369905	17614.34208	32	1127317.893	620024.8413
-98	0	-12	-12	48	7.856396242	0.785195036	16879.67044	32	1080298.908	594164.3996
-97	0	-12	-12	48	7.856396242	0.748442849	16089.59311	32	1029733.959	566353.6775
-96	0	-12	-12	48	7.856396242	0.70923398	15246.70343	32	975789.0195	536683.9607
-95	0	-12	-12	48	7.856396242	0.667697127	14353.7681	32	918641.1581	505252.637
-94	0	-12	-12	48	7.856396242	0.62396863	13413.71807	32	858477.9566	472162.8761
-93	0	-12	-12	48	7.856396242	0.578192024	12429.63897	32	795496.8941	437523.2918
-92	0	-12	-12	48	7.856396242	0.530517565	11404.76092	32	729904.6991	401447.5845
-91	0	-12	-12	48	7.856396242	0.48110174	10342.44798	32	661916.671	364054.169
-90	0	-12	-12	48	7.856396242	0.43010675	9246.187079	32	591755.973	325465.7852
-89	0	-12	-12	48	7.856396242	0.377699981	8119.576564	32	519652.9001	285809.0951
-88	0	-12	-12	48	7.856396242	0.324053453	6966.314419	32	445844.1228	245214.2675
-87	0	-12	-12	48	7.856396242	0.269343255	5790.186101	32	370571.9104	203814.5507
-86	0	-12	-12	48	7.856396242	0.213748967	4595.052123	32	294083.3359	161745.8347
-85	0	-12	-12	48	7.856396242	0.157453071	3384.835384	32	216629.4646	119146.2055
-84	0	-12	-12	48	7.856396242	0.100640352	2163.508289	32	138464.5305	76155.49179
-83	0	-12	-12	48	7.856396242	0.043497292	935.0797129	32	59845.10163	32914.80589
-82	0	-12	-12	48	7.856396242	-0.013788543	-296.4181615	32	-18970.76234	-10433.91928
-81	0	-12	-12	48	7.856396242	-0.071029119	-1526.943075	32	-97724.35682	-53748.39625
-80	0	-12	-12	48	7.856396242	-0.128036549	-2752.455964	32	-176157.1817	-96886.44993
-79	0	-12	-12	48	7.856396242	-0.184623714	-3968.934214	32	-254011.7897	-139706.4843
-78	0	-12	-12	48	7.856396242	-0.24060487	-5172.384866	32	-331032.6314	-182067.9473
-77	0	-12	-12	48	7.856396242	-0.295796268	-6358.857726	32	-406966.8944	-223831.7919
-76	0	-12	-12	48	7.856396242	-0.350016746	-7524.458323	32	-481565.3326	-264860.933

-75	0	-12	-12	48	7.856396242	-0.403088332	-8665.3607	32	-554583.0848	-305020. 6966
-74	0	-12	-12	48	7.856396242	-0.454836824	-9777.819968	32	-625780.4779	-344179.2629
-73	0	-12	-12	48	7.856396242	-0.505092364	-10858.1846	32	-694923.8144	-382208.0979
-72	0	-12	-12	48	7.856396242	-0.553689992	-11902.90842	32	-761786.1387	-418982.3763
-71	0	-12	-12	48	7.856396242	-0.600470194	-12908.56223	32	-826147.9824	-454381.3903
-70	0	-12	-12	48	7.856396242	-0.645279416	-13871.84508	32	-887798.0848	-488288.9467
-69	0	-12	-12	48	7.856396242	-0.687970579	-14789.5951	32	-946534.0861	-520593.7474
-68	0	-12	-12	48	7.856396242	-0.728403553	-15658.79987	32	-1002163.192	-551189.7554
-67	0	-12	-12	48	7.856396242	-0.766445621	-16476.60633	32	-1054502.805	-579976.5428
-66	0	-12	-12	48	7.856396242	-0.801971914	-17240.33011	32	-1103381.127	-606859.6199
-65	0	-12	-12	48	7.856396242	-0.834865822	-17947.46438	32	-1148637.72	-631750.746
-64	0	-12	-12	48	7.856396242	-0.865019372	-18595.68803	32	-1190124.034	-654568.2187
-63	0	-12	-12	48	7.856396242	-0.89233359	-19182.87335	32	-1227703.895	-675237.142
-62	0	-12	-12	48	7.856396242	-0.91671882	-19707.09297	32	-1261253.95	-693689.6725
-61	0	-12	-12	48	7.856396242	-0.938095019	-20166.62619	32	-1290664.076	-709865.2418
-60	0	-12	-12	48	7.856396242	-0.956392023	-20559.96464	32	-1315837.737	-723710.7552
-59	0	-12	-12	48	7.856396242	-0.971549774	-20885.81723	32	-1336692.302	-735180.7663
-58	0	-12	-12	48	7.856396242	-0.983518518	-21143.11438	32	-1353159.32	-744237.6262
-57	0	-12	-12	48	7.856396242	-0.992258968	-21331.01155	32	-1365184.739	-750851.6067
-56	0	-12	-12	48	7.856396242	-0.997742436	-21448.89199	32	-1372729.087	-755000.998
-55	0	-12	-12	48	7.856396242	-0.999950923	-21496.36876	32	-1375767.6	-756672.1802
-54	0	-12	-12	48	7.856396242	-0.998877178	-21473.28602	32	-1374290.305	-755859.6679
-53	0	-12	-12	48	7.856396242	-0.994524728	-21379.71955	32	-1368302.051	-752566.1281
-52	0	-12	-12	48	7.856396242	-0.986907858	-21215.97646	32	-1357822.493	-746802.3714
-51	0	-12	-12	48	7.856396242	-0.976051569	-20982.59422	32	-1342886.03	-738587.3167
-50	0	-12	-12	48	7.856396242	-0.961991497	-20680.3389	32	-1323541.689	-727947.9291
-49	0	-12	-12	48	7.856396242	-0.944773792	-20310.20259	32	-1299852.966	-714919.1312
-48	0	-12	-12	48	7.856396242	-0.924454969	-19873.40025	32	-1271897.616	-699543.6887
-47	0	-12	-12	48	7.856396242	-0.901101723	-19371.36562	32	-1239767.399	-681872.0697
-46	0	-12	-12	48	7.856396242	-0.874790708	-18805.74658	32	-1203567.781	-661962.2795

-45	0	-12	-12	48	7.856396242	-0.845608287	-18178.39971	32	-1163417.581	-639879.6697
-44	0	-12	-12	48	7.856396242	-0.813650248	-17491.38421	32	-1119448.589	-615696.7241
-43	0	-12	-12	48	7.856396242	-0.779021491	-16746.95513	32	-1071805.129	-589492.8207
-42	0	-12	-12	48	7.856396242	-0.74183568	-15947.55599	32	-1020643.584	-561353.9709
-41	0	-12	-12	48	7.856396242	-0.702214873	-15095.81072	32	-966131.8864	-531372.5375
-40	0	-12	-12	48	7.856396242	-0.660289122	-14194.51509	32	-908448.9659	-499646.9312
-39	0	-12	-12	48	7.856396242	-0.616196044	-13246.6275	32	-847784.16	-466281.288
-38	0	-12	-12	48	7.856396242	-0.570080369	-12255.25929	32	-784336.5943	-431385.1269
-37	0	-12	-12	48	7.856396242	-0.522093467	-11223.66451	32	-718314.5287	-395072.9908
-36	0	-12	-12	48	7.856396242	-0.472392849	-10155.22927	32	-649934.6733	-357464.0703
-35	0	-12	-12	48	7.856396242	-0.421141653	-9053.460591	32	-579421.4778	-318681.8128
-34	0	-12	-12	48	7.856396242	-0.368508105	-7921.974906	32	-507006.394	-278853.5167
-33	0	-12	-12	48	7.856396242	-0.314664969	-6764.486196	32	-432927.1165	-238109.9141
-32	0	-12	-12	48	7.856396242	-0.25978898	-5584.793792	32	-357426.8027	-196584.7415
-31	0	-12	-12	48	7.856396242	-0.204060261	-4386.769907	32	-280753.274	-154414.3007
-30	0	-12	-12	48	7.856396242	-0.147661736	-3174.346924	32	-203158.2031	-111737.0117
-29	0	-12	-12	48	7.856396242	-0.090778528	-1951.504491	32	-124896.2875	-68692.9581
-28	0	-12	-12	48	7.856396242	-0.033597349	-722.2564565	32	-46224.41321	-25423.42727
-27	0	-12	-12	48	7.856396242	0.023694109	509.3623071	32	32599.18766	17929.55321
-26	0	-12	-12	48	7.856396242	0.080907794	1739.309144	32	111315.7852	61223.68187
-25	0	-12	-12	48	7.856396242	0.137855908	2963.546887	32	189667.0008	104316.8504
-24	0	-12	-12	48	7.856396242	0.194351525	4178.057108	32	267395.6549	147067.6102
-23	0	-12	-12	48	7.856396242	0.250209205	5378.853309	32	344246.6118	189335.6365
-22	0	-12	-12	48	7.856396242	0.305245599	6561.994006	32	419967.6164	230982.189
-21	0	-12	-12	48	7.856396242	0.359280058	7723.595668	32	494310.1227	271870.5675
-20	0	-12	-12	48	7.856396242	0.412135219	8859.845463	32	567030.1096	311866.5603
-19	0	-12	-12	48	7.856396242	0.463637591	9967.013774	32	637888.8815	350838.8848
-18	0	-12	-12	48	7.856396242	0.513618122	11041.46644	32	706653.8523	388659.6187
-17	0	-12	-12	48	7.856396242	0.561912758	12079.67669	32	773099.3082	425204.6195
-16	0	-12	-12	48	7.856396242	0.608362976	13078.23671	32	837007.1493	460353.9321

-15	0	-12	-12	48	7.856396242	0.652816308	14033.86883	32	898167.605	493992.1828
-14	0	-12	-12	48	7.856396242	0.695126841	14943.43629	32	956379.9228	526008.9576
-13	0	-12	-12	48	7.856396242	0.735155696	15803.95355	32	1011453.027	556299.1649
-12	0	-12	-12	48	7.856396242	0.772771482	16612.59603	32	1063206.146	584763.3804
-11	0	-12	-12	48	7.856396242	0.807850729	17366.70947	32	1111469.406	611308.1734
-10	0	-12	-12	48	7.856396242	0.840278293	18063.81857	32	1156084.388	635846.4135
-9	0	-12	-12	48	7.856396242	0.869947735	18701.63513	32	1196904.648	658297.5566
-8	0	-12	-12	48	7.856396242	0.896761667	19278.0656	32	1233796.198	678587.9092
-7	0	-12	-12	48	7.856396242	0.920632077	19791.21791	32	1266637.946	696650.8704
-6	0	-12	-12	48	7.856396242	0.941480611	20239.40769	32	1295322.092	712427.1505
-5	0	-12	-12	48	7.856396242	0.959238837	20621.1638	32	1319754.483	725864.9657
-4	0	-12	-12	48	7.856396242	0.973848465	20935.23317	32	1339854.923	736920.2076
-3	0	-12	-12	48	7.856396242	0.985261542	21180.58491	32	1355557.434	745556.5887
-2	0	-12	-12	48	7.856396242	0.993440604	21356.41367	32	1366810.475	751745.7611
-1	0	-12	-12	48	7.856396242	0.998358804	21462.14231	32	1373577.108	755467.4093
0	0	-12	-12	48	7.856396242	1	21497.42379	32	1375835.123	756709.3175
1	0	-12	-12	48	7.856396242	0.998358804	21462.14231	32	1373577.108	755467.4093
2	0	-12	-12	48	7.856396242	0.993440604	21356.41367	32	1366810.475	751745.7611
3	0	-12	-12	48	7.856396242	0.985261542	21180.58491	32	1355557.434	745556.5887
4	0	-12	-12	48	7.856396242	0.973848465	20935.23317	32	1339854.923	736920.2076
5	0	-12	-12	48	7.856396242	0.959238837	20621.1638	32	1319754.483	725864.9657
6	0	-12	-12	48	7.856396242	0.941480611	20239.40769	32	1295322.092	712427.1505
7	0	-12	-12	48	7.856396242	0.920632077	19791.21791	32	1266637.946	696650.8704
8	0	-12	-12	48	7.856396242	0.896761667	19278.0656	32	1233796.198	678587.9092
9	0	-12	-12	48	7.856396242	0.869947735	18701.63513	32	1196904.648	658297.5566
10	0	-12	-12	48	7.856396242	0.840278293	18063.81857	32	1156084.388	635846.4135
11	0	-12	-12	48	7.856396242	0.807850729	17366.70947	32	1111469.406	611308.1734
12	0	-12	-12	48	7.856396242	0.772771482	16612.59603	32	1063206.146	584763.3804
13	0	-12	-12	48	7.856396242	0.735155696	15803.95355	32	1011453.027	556299.1649
14	0	-12	-12	48	7.856396242	0.695126841	14943.43629	32	956379.9228	526008.9576

15	0	-12	-12	48	7.856396242	0.652816308	14033.86883	32	898167.605	493992.1828
16	0	-12	-12	48	7.856396242	0.608362976	13078.23671	32	837007.1493	460353.9321
17	0	-12	-12	48	7.856396242	0.561912758	12079.67669	32	773099.3082	425204.6195
18	0	-12	-12	48	7.856396242	0.513618122	11041.46644	32	706653.8523	388659.6187
19	0	-12	-12	48	7.856396242	0.463637591	9967.013774	32	637888.8815	350838.8848
20	0	-12	-12	48	7.856396242	0.412135219	8859.845463	32	567030.1096	311866.5603
21	0	-12	-12	48	7.856396242	0.359280058	7723.595668	32	494310.1227	271870.5675
22	0	-12	-12	48	7.856396242	0.305245599	6561.994006	32	419967.6164	230982.189
23	0	-12	-12	48	7.856396242	0.250209205	5378.853309	32	344246.6118	189335.6365
24	0	-12	-12	48	7.856396242	0.194351525	4178.057108	32	267395.6549	147067.6102
25	0	-12	-12	48	7.856396242	0.137855908	2963.546887	32	189667.0008	104316.8504
26	0	-12	-12	48	7.856396242	0.080907794	1739.309144	32	111315.7852	61223.68187
27	0	-12	-12	48	7.856396242	0.023694109	509.3623071	32	32599.18766	17929.55321
28	0	-12	-12	48	7.856396242	-0.033597349	-722.2564565	32	-46224.41321	-25423.42727
29	0	-12	-12	48	7.856396242	-0.090778528	-1951.504491	32	-124896.2875	-68692.9581
30	0	-12	-12	48	7.856396242	-0.147661736	-3174.346924	32	-203158.2031	-111737.0117
31	0	-12	-12	48	7.856396242	-0.204060261	-4386.769907	32	-280753.274	-154414.3007
32	0	-12	-12	48	7.856396242	-0.25978898	-5584.793792	32	-357426.8027	-196584.7415
33	0	-12	-12	48	7.856396242	-0.314664969	-6764.486196	32	-432927.1165	-238109.9141
34	0	-12	-12	48	7.856396242	-0.368508105	-7921.974906	32	-507006.394	-278853.5167
35	0	-12	-12	48	7.856396242	-0.421141653	-9053.460591	32	-579421.4778	-318681.8128
36	0	-12	-12	48	7.856396242	-0.472392849	-10155.22927	32	-649934.6733	-357464.0703
37	0	-12	-12	48	7.856396242	-0.522093467	-11223.66451	32	-718314.5287	-395072.9908
38	0	-12	-12	48	7.856396242	-0.570080369	-12255.25929	32	-784336.5943	-431385.1269
39	0	-12	-12	48	7.856396242	-0.616196044	-13246.6275	32	-847784.16	-466281.288
40	0	-12	-12	48	7.856396242	-0.660289122	-14194.51509	32	-908448.9659	-499646.9312
41	0	-12	-12	48	7.856396242	-0.702214873	-15095.81072	32	-966131.8864	-531372.5375
42	0	-12	-12	48	7.856396242	-0.74183568	-15947.55599	32	-1020643.584	-561353.9709
43	0	-12	-12	48	7.856396242	-0.779021491	-16746.95513	32	-1071805.129	-589492.8207
44	0	-12	-12	48	7.856396242	-0.813650248	-17491.38421	32	-1119448.589	-615696.7241

45	0	-12	-12	48	7.856396242	-0.845608287	-18178.39971	32	-1163417.581	-639879.6697
46	0	-12	-12	48	7.856396242	-0.874790708	-18805.74658	32	-1203567.781	-661962.2795
47	0	-12	-12	48	7.856396242	-0.901101723	-19371.36562	32	-1239767.399	-681872.0697
48	0	-12	-12	48	7.856396242	-0.924454969	-19873.40025	32	-1271897.616	-699543.6887
49	0	-12	-12	48	7.856396242	-0.944773792	-20310.20259	32	-1299852.966	-714919.1312
50	0	-12	-12	48	7.856396242	-0.961991497	-20680.3389	32	-1323541.689	-727947.9291
51	0	-12	-12	48	7.856396242	-0.976051569	-20982.59422	32	-1342886.03	-738587.3167
52	0	-12	-12	48	7.856396242	-0.986907858	-21215.97646	32	-1357822.493	-746802.3714
53	0	-12	-12	48	7.856396242	-0.994524728	-21379.71955	32	-1368302.051	-752566.1281
54	0	-12	-12	48	7.856396242	-0.998877178	-21473.28602	32	-1374290.305	-755859.6679
55	0	-12	-12	48	7.856396242	-0.999950923	-21496.36876	32	-1375767.6	-756672.1802
56	0	-12	-12	48	7.856396242	-0.997742436	-21448.89199	32	-1372729.087	-755000.998
57	0	-12	-12	48	7.856396242	-0.992258968	-21331.01155	32	-1365184.739	-750851.6067
58	0	-12	-12	48	7.856396242	-0.983518518	-21143.11438	32	-1353159.32	-744237.6262
59	0	-12	-12	48	7.856396242	-0.971549774	-20885.81723	32	-1336692.302	-735180.7663
60	0	-12	-12	48	7.856396242	-0.956392023	-20559.96464	32	-1315837.737	-723710.7552
61	0	-12	-12	48	7.856396242	-0.938095019	-20166.62619	32	-1290664.076	-709865.2418
62	0	-12	-12	48	7.856396242	-0.91671882	-19707.09297	32	-1261253.95	-693689.6725
63	0	-12	-12	48	7.856396242	-0.89233359	-19182.87335	32	-1227703.895	-675237.142
64	0	-12	-12	48	7.856396242	-0.865019372	-18595.68803	32	-1190124.034	-654568.2187
65	0	-12	-12	48	7.856396242	-0.834865822	-17947.46438	32	-1148637.72	-631750.746
66	0	-12	-12	48	7.856396242	-0.801971914	-17240.33011	32	-1103381.127	-606859.6199
67	0	-12	-12	48	7.856396242	-0.766445621	-16476.60633	32	-1054502.805	-579976.5428
68	0	-12	-12	48	7.856396242	-0.728403553	-15658.79987	32	-1002163.192	-551189.7554
69	0	-12	-12	48	7.856396242	-0.687970579	-14789.5951	32	-946534.0861	-520593.7474
70	0	-12	-12	48	7.856396242	-0.645279416	-13871.84508	32	-887798.0848	-488288.9467
71	0	-12	-12	48	7.856396242	-0.600470194	-12908.56223	32	-826147.9824	-454381.3903
72	0	-12	-12	48	7.856396242	-0.553689992	-11902.90842	32	-761786.1387	-418982.3763
73	0	-12	-12	48	7.856396242	-0.505092364	-10858.1846	32	-694923.8144	-382208.0979
74	0	-12	-12	48	7.856396242	-0.454836824	-9777.819968	32	-625780.4779	-344179.2629

75	0	-12	-12	48	7.856396242	-0.403088332	-8665.3607	32	-554583.0848	-305020.6966
76	0	-12	-12	48	7.856396242	-0.350016746	-7524.458323	32	-481565.3326	-264860.933
77	0	-12	-12	48	7.856396242	-0.295796268	-6358.857726	32	-406966.8944	-223831.7919
78	0	-12	-12	48	7.856396242	-0.24060487	-5172.384866	32	-331032.6314	-182067.9473
79	0	-12	-12	48	7.856396242	-0.184623714	-3968.934214	32	-254011.7897	-139706.4843
80	0	-12	-12	48	7.856396242	-0.128036549	-2752.455964	32	-176157.1817	-96886.44993
81	0	-12	-12	48	7.856396242	-0.071029119	-1526.943075	32	-97724.35682	-53748.39625
82	0	-12	-12	48	7.856396242	-0.013788543	-296.4181615	32	-18970.76234	-10433.91928
83	0	-12	-12	48	7.856396242	0.043497292	935.0797129	32	59845.10163	32914.80589
84	0	-12	-12	48	7.856396242	0.100640352	2163.508289	32	138464.5305	76155.49179
85	0	-12	-12	48	7.856396242	0.157453071	3384.835384	32	216629.4646	119146.2055
86	0	-12	-12	48	7.856396242	0.213748967	4595.052123	32	294083.3359	161745.8347
87	0	-12	-12	48	7.856396242	0.269343255	5790.186101	32	370571.9104	203814.5507
88	0	-12	-12	48	7.856396242	0.324053453	6966.314419	32	445844.1228	245214.2675
89	0	-12	-12	48	7.856396242	0.377699981	8119.576564	32	519652.9001	285809.0951
90	0	-12	-12	48	7.856396242	0.43010675	9246.187079	32	591755.973	325465.7852
91	0	-12	-12	48	7.856396242	0.48110174	10342.44798	32	661916.671	364054.169
92	0	-12	-12	48	7.856396242	0.530517565	11404.76092	32	729904.6991	401447.5845
93	0	-12	-12	48	7.856396242	0.578192024	12429.63897	32	795496.8941	437523.2918
94	0	-12	-12	48	7.856396242	0.62396863	13413.71807	32	858477.9566	472162.8761
95	0	-12	-12	48	7.856396242	0.667697127	14353.7681	32	918641.1581	505252.637
96	0	-12	-12	48	7.856396242	0.70923398	15246.70343	32	975789.0195	536683.9607
97	0	-12	-12	48	7.856396242	0.748442849	16089.59311	32	1029733.959	566353.6775
98	0	-12	-12	48	7.856396242	0.785195036	16879.67044	32	1080298.908	594164.3996
99	0	-12	-12	48	7.856396242	0.819369905	17614.34208	32	1127317.893	620024.8413
100	0	-12	-12	48	7.856396242	0.850855281	18291.19655	32	1170636.579	643850.1186

Coordinate			Bottom Side								Total Forces (MN)
Time (s)	x	Depth (m)	Fy (N)	Fy cos 0°	Fy cos 15°	Fy cos 30°	Fy cos 45°	Fy cos 60°	Fy cos 75°	Fy cos 90°	
0	-100	-12	643850.12	643850.12	-489125.15	99314.81	338228.62	-613211.21	593469.66	-288492.25	284034.6
0	-99	-12	620024.84	620024.84	-471025.38	95639.73	325712.68	-590519.71	571508.68	-277816.77	273524.1
0	-98	-12	594164.4	594164.4	-451379.51	91650.72	312127.62	-565889.89	547671.79	-266229.39	262115.7
0	-97	-12	566353.68	566353.68	-430252.04	87360.88	297518.04	-539402.59	522037.22	-253768.14	249847
0	-96	-12	536683.96	536683.96	-407712.32	82784.28	281931.89	-511144.77	494689.12	-240473.92	236758.2
0	-95	-12	505252.64	505252.64	-383834.32	77935.95	265420.32	-481209.17	465717.26	-226390.38	222892.3
0	-94	-12	472162.88	472162.88	-358696.43	72831.81	248037.54	-449694.05	435216.73	-211563.73	208294.7
0	-93	-12	437523.29	437523.29	-332381.16	67488.6	229840.61	-416702.86	403287.65	-196042.64	193013.5
0	-92	-12	401447.58	401447.58	-304974.88	61923.87	210889.24	-382343.89	370034.82	-179878.07	177098.7
0	-91	-12	364054.17	364054.17	-276567.55	56155.88	191245.66	-346729.92	335567.39	-163123.07	160602.6
0	-90	-12	325465.79	325465.79	-247252.42	50203.57	170974.33	-309977.84	299998.5	-145832.63	143579.3
0	-89	-12	285809.1	285809.1	-217125.71	44086.47	150141.8	-272208.29	263444.9	-128063.51	126084.7
0	-88	-12	245214.27	245214.27	-186286.32	37824.66	128816.45	-233545.25	226026.56	-109874.04	108176.3
0	-87	-12	203814.55	203814.55	-154835.45	31438.69	107068.27	-194115.62	187866.32	-91323.923	89912.83
0	-86	-12	161745.83	161745.83	-122876.36	24949.53	84968.644	-154048.83	149089.43	-72474.041	71354.21
0	-85	-12	119146.21	119146.21	-90513.932	18378.47	62590.122	-113476.39	109823.17	-53386.271	52561.37
0	-84	-12	76155.492	76155.492	-57854.407	11747.1	40006.154	-72531.479	70196.421	-34123.267	33596.01
0	-83	-12	32914.806	32914.806	-25004.98	5077.157	17290.871	-31348.488	30339.264	-14748.256	14520.37
0	-82	-12	-10433.92	-10433.919	7926.5224	-1609.447	-5481.167	9937.40016	-9617.478	4675.16394	-4602.93
0	-81	-12	-53748.4	-53748.396	40832.007	-8290.768	-28235.21	51190.6703	-49542.65	24083.2383	-23711.1
0	-80	-12	-96886.45	-96886.45	73603.465	-14944.88	-50896.58	92275.9125	-89305.21	43412.262	-42741.5
0	-79	-12	-139706.5	-139706.48	106133.33	-21549.93	-73390.89	133058.269	-128774.6	62598.7896	-61631.5
0	-78	-12	-182067.9	-182067.95	138314.82	-28084.24	-95644.3	173403.876	-167821.4	81579.8435	-80319.3

0	-77	-12	-223831.8	-223831.79	170042.31	-34526.38	-117583.8	213180.304	-206317.2	100293.12	-98743.4
0	-76	-12	-264860.9	-264860.93	201211.65	-40855.18	-139137.3	252256.991	-244135.9	118677.196	-116843
0	-75	-12	-305020.7	-305020.7	231720.54	-47049.88	-160234.1	290505.671	-281153.2	136671.727	-134560
0	-74	-12	-344179.3	-344179.26	261468.83	-53090.15	-180804.9	327800.798	-317247.7	154217.647	-151835
0	-73	-12	-382208.1	-382208.1	290358.87	-58956.15	-200782.3	364019.954	-352300.8	171257.365	-168611
0	-72	-12	-418982.4	-418982.38	318295.85	-64628.64	-220100.7	399044.254	-386197.5	187734.948	-184834
0	-71	-12	-454381.4	-454381.39	345188.05	-70088.99	-238696.5	432758.734	-418826.6	203596.313	-200450
0	-70	-12	-488288.9	-488288.95	370947.21	-75319.28	-256508.9	465052.731	-450081	218789.394	-215409
0	-69	-12	-520593.7	-520593.75	395488.78	-80302.34	-273479.3	495820.243	-479857.9	233264.323	-229660
0	-68	-12	-551189.8	-551189.76	418732.19	-85021.82	-289552.1	524960.278	-508059.9	246973.587	-243157
0	-67	-12	-579976.5	-579976.54	440601.17	-89462.22	-304674.4	552377.188	-534594.1	259872.187	-255857
0	-66	-12	-606859.6	-606859.62	461023.92	-93608.98	-318796.7	577980.979	-559373.6	271917.784	-267716
0	-65	-12	-631750.7	-631750.75	479933.41	-97448.47	-331872.6	601687.611	-582317.1	283070.841	-278697
0	-64	-12	-654568.2	-654568.22	497267.56	-100968.1	-343859.1	623419.268	-603349.1	293294.749	-288763
0	-63	-12	-675237.1	-675237.14	512969.5	-104156.3	-354716.9	643104.619	-622400.7	302555.948	-297881
0	-62	-12	-693689.7	-693689.67	526987.66	-107002.6	-364410.4	660679.048	-639409.3	310824.04	-306021
0	-61	-12	-709865.2	-709865.24	539276.04	-109497.7	-372907.8	676084.871	-654319.2	318071.886	-313157
0	-60	-12	-723710.8	-723710.76	549794.31	-111633.4	-380181.2	689271.517	-667081.3	324275.695	-319265
0	-59	-12	-735180.8	-735180.77	558507.94	-113402.7	-386206.6	700195.705	-677653.8	329415.104	-324325
0	-58	-12	-744237.6	-744237.63	565388.33	-114799.7	-390964.4	708821.576	-686002	333473.244	-328321
0	-57	-12	-750851.6	-750851.61	570412.89	-115819.9	-394438.9	715120.817	-692098.4	336436.795	-331238
0	-56	-12	-755001	-755001	573565.13	-116460	-396618.6	719072.751	-695923.1	338296.027	-333069
0	-55	-12	-756672.2	-756672.18	574834.71	-116717.8	-397496.5	720664.406	-697463.5	339044.84	-333806
0	-54	-12	-755859.7	-755859.67	574217.45	-116592.4	-397069.7	719890.559	-696714.6	338680.775	-333448
0	-53	-12	-752566.1	-752566.13	571715.39	-116084.4	-395339.5	716753.749	-693678.8	337205.026	-331995
0	-52	-12	-746802.4	-746802.37	567336.73	-115195.3	-392311.7	711264.272	-688366	334622.439	-329452
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0	-29	-12	-68692.96	-68692.958	52185.21	-10595.99	-36085.92	65424.065	-63317.82	30779.5021	-30303.9
0	-28	-12	-25423.43	-25423.427	19313.87	-3921.601	-13355.49	24213.6021	-23434.08	11391.567	-11215.5
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0	-26	-12	61223.682	61223.682	-46510.891	9443.842	32162.146	-58310.229	56433.007	-27432.717	27008.84
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0	-23	-12	189335.64	189335.64	-143835.99	29205.3	99462.173	-180325.72	174520.36	-84836.303	83525.45
0	-22	-12	230982.19	230982.19	-175474.38	35629.34	121340.02	-219990.44	212908.13	-103497.02	101897.8
0	-21	-12	271870.57	271870.57	-206536.78	41936.43	142819.59	-258933.06	250597.04	-121818.03	119935.8
0	-20	-12	311866.56	311866.56	-236921.26	48105.87	163830.36	-297025.76	287463.4	-139739.18	137580
0	-19	-12	350838.88	350838.88	-266528.06	54117.41	184303.38	-334143.51	323386.19	-157201.65	154772.6
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0	77	-12	-223831.8	-223831.79	170042.31	-34526.38	-117583.8	213180.304	-206317.2	100293.12	-98743.4
0	78	-12	-182067.9	-182067.95	138314.82	-28084.24	-95644.3	173403.876	-167821.4	81579.8435	-80319.3
0	79	-12	-139706.5	-139706.48	106133.33	-21549.93	-73390.89	133058.269	-128774.6	62598.7896	-61631.5
0	80	-12	-96886.45	-96886.45	73603.465	-14944.88	-50896.58	92275.9125	-89305.21	43412.262	-42741.5
0	81	-12	-53748.4	-53748.396	40832.007	-8290.768	-28235.21	51190.6703	-49542.65	24083.2383	-23711.1
0	82	-12	-10433.92	-10433.919	7926.5224	-1609.447	-5481.167	9937.40016	-9617.478	4675.16394	-4602.93
0	83	-12	32914.806	32914.806	-25004.98	5077.157	17290.871	-31348.488	30339.264	-14748.256	14520.37
0	84	-12	76155.492	76155.492	-57854.407	11747.1	40006.154	-72531.479	70196.421	-34123.267	33596.01
0	85	-12	119146.21	119146.21	-90513.932	18378.47	62590.122	-113476.39	109823.17	-53386.271	52561.37
0	86	-12	161745.83	161745.83	-122876.36	24949.53	84968.644	-154048.83	149089.43	-72474.041	71354.21
0	87	-12	203814.55	203814.55	-154835.45	31438.69	107068.27	-194115.62	187866.32	-91323.923	89912.83
0	88	-12	245214.27	245214.27	-186286.32	37824.66	128816.45	-233545.25	226026.56	-109874.04	108176.3
0	89	-12	285809.1	285809.1	-217125.71	44086.47	150141.8	-272208.29	263444.9	-128063.51	126084.7
0	90	-12	325465.79	325465.79	-247252.42	50203.57	170974.33	-309977.84	299998.5	-145832.63	143579.3
0	91	-12	364054.17	364054.17	-276567.55	56155.88	191245.66	-346729.92	335567.39	-163123.07	160602.6
0	92	-12	401447.58	401447.58	-304974.88	61923.87	210889.24	-382343.89	370034.82	-179878.07	177098.7
0	93	-12	437523.29	437523.29	-332381.16	67488.6	229840.61	-416702.86	403287.65	-196042.64	193013.5
0	94	-12	472162.88	472162.88	-358696.43	72831.81	248037.54	-449694.05	435216.73	-211563.73	208294.7
0	95	-12	505252.64	505252.64	-383834.32	77935.95	265420.32	-481209.17	465717.26	-226390.38	222892.3
0	96	-12	536683.96	536683.96	-407712.32	82784.28	281931.89	-511144.77	494689.12	-240473.92	236758.2
0	97	-12	566353.68	566353.68	-430252.04	87360.88	297518.04	-539402.59	522037.22	-253768.14	249847
0	98	-12	594164.4	594164.4	-451379.51	91650.72	312127.62	-565889.89	547671.79	-266229.39	262115.7
0	99	-12	620024.84	620024.84	-471025.38	95639.73	325712.68	-590519.71	571508.68	-277816.77	273524.1
0	100	-12	643850.12	643850.12	-489125.15	99314.81	338228.62	-613211.21	593469.66	-288492.25	284034.6