Idealisation and Selection of Appropriate Design Impact Load for Jacket Leg

by

Zul Hazmi bin Mohd Zulkifli

Dissertation submitted in partial fulfilment of

The requirement for the

Bachelor of Engineering (Hons)

(Civil Engineering)

JANUARY 2014

Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Programme
Universiti Teknologi PETRONAS
In partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(CIVIL ENGINEERING)

Approved by,

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(Dr. Zubair Imam Syed)

UNIVERSITI TEKNOLOGI PETRONAS.

TRONOH, PERAK

January 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgement, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

ZUL HAZMI BIN MOHD ZULKIFLI

ABSTRACT

Accidental vessel-platform collision can severely affect the integrity of a fixed platform. Due to lack of comprehensive studies, the currently used design guidelines often results in over conservative or under design of jacket platform legs for vessel impact loads. The number of accidental collision recorded in the recent past between vessel and platform is significantly high. Failure to identify and select proper design load can lead catastrophic accidents. The performance and structural response of variation diameter of jacket leg on vessel collision impact was not well studied in the past. The relationship between specification of vessel mass and indentation of jacket leg due to vessel impact is also required better understanding. In this research, numerical simulation was conducted to investigate different parameter associated with boat impact on jacket leg of a fixed platform. This research is expected to contribute a better understanding of the vessel-platform collision event in terms of various related parameters. This study has the potential to significantly contribute in idealising and selecting design impact load for jacket legs vessel impact in Malaysia oil and gas operation.

Keyword: Vessel-platform collision, Impact, Jacket leg.

ACKNOWLEDGEMENT

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

In the name of Allah, The Beneficent, The Merciful.

First and foremost, the author would like to praise Allah the Almighty for with His blessings and guidance the author is able to successfully complete this project.

The author would like to express deepest gratitude and appreciation to Dr. Zubair Imam Syed, the supervisor of this project for his willingness for the discussion and providing criticisms and suggestion many of which for the sake of this project. His tremendous contributions of ideas and suggestion have made this project a successful to the author.

A million thanks to Dinesh a post graduate student for his suggestion, time, comment, guidance and information towards this project completion.

Finally, the acknowledgement is considered incomplete without thanking all to fellow friends and family who has been giving great support and encouragement to the author to finish this project.

TABLE OF CONTENTS

List of Figures

List of Tables

CHAPTER 1: INTRODUCTION

1.1. Background of Study

An offshore structure is exposed to many types of risk and hazards. One of the major hazards to offshore structures is vessel collision. An analysis of incident records 1975-2001 of the United Kingdom Continental Shelf shows that the mean incident collision frequency is 0.24 per year for collisions (HSE, 2003). Other statistics show by (Wicks et al. 1992) that approximately 0.15 per platform every year encounter collision between the vessels and offshore structure platform. To this end there has no catastrophic failures, but rather severe accidents have taken place.

The concern for vessel collision is reflected in various design codes. The U.K. Department of Energy Guidances Notes specify a vessel displacement of 2500 tonnes and an impact velocity of 0.5 m/s for the design of structure, which gives impact energy of 0.44 MJ with added mass factor 0.4 (DOE,1985). The Det Norske Veritas rules on the other hand, requires that offshore structure design capable of withstanding an impact from supply vessels of 5000 tonne travelling at a speed of 2m/s. An added mass factor of 0.4 is allowed for broad side collision and 0.1 for bow and stern collisions, yielding a kinetic energy of 14MJ for beam impact and 11MJ for bow or stern impact (DNV,TNA 101). According to PETRONAS Technical Specification (PTS) requires the platform normally be design of impact from supply vessels of 1000 to 2500 tonnes displacement with a speed of 0.5 m/s. An added mass factor of 1.4 is allowed for broad side collision and 1.1 for bow and stern collisions (PTS,2010). It can be seen that between these 3 design codes have similar principle of designing structure of boat impact except for slightly changes of mass coefficients in PTS. This is due to the factor of location and weather which reflect the level of risk collision incidents is higher at the North Sea compare to South China Sea.

There a numerous studies had been publish mainly focus on the consequences of a collision depend on characteristics such as the type of vessel, the speed of vessel, the mass of the vessel and location of vessel hits. For the most part of this report deals with aspects of idealisation and selection of appropriate design impact load on jacket leg and also to study the effects of jacket leg parameters under the idealised vessel impact using finite element modelling.

1.2. Problem Statement

1.2.1. Problem Identification

1) Absence of equivalent vessel impact load on jacket legs for Malaysia oil and gas operation.
2) Available guidelines on vessel impact loads only cater the European operation which involves vessel displacement in the range of 2000-5000t.

1.2.2. Significance of Project

1) Provide a reference for platform designs against vessel impact in Malaysia oil and gas operation.
2) Result from this project can be used for design optimisation of boat fenders and riser guards

1.3. Objectives & Scope of Study

1.3.1. Objectives

1) To study the vessel impact loading on jacket legs of fixed platform for Malaysia oil and gas operation.
2) To study the effects of vessel mass specification under the idealised vessel impact on jacket leg using finite element modelling.
3) To study the dynamic response and determine appropriate design impact loads for jacket legs of fixed platform.

1.3.2. Scope of the Study

The project is basically based on simulation work. There are four main elements in this scope of studies which are:

1) Parametric study
2) Numerical Modelling Analysis
3) Data analysis and simulation work.
4) Interpretation and verification of the model

1.4. Relevancy of the Project

The project is focused on the effects of impact loads on design of jacket leg of offshore platform for Malaysia oil and gas operation has not been conducted. PETRONAS Technical Standards rely on international design codes such as code by American Petroleum Institute. This research will provides better understanding of the effect of accidental impacts of jacket legs for future design and strengthening of the existing platform legs. Thus, it can be used as references for designing new platform in future and reduce the risk of vessel collision in Malaysia oil and gas operation.

1.5. The Feasibility of the project within the Scope and Time

1) Software and Subject Feasibility

The software required for the project is ANSYS 14 and the software is available and can be used in Universiti of Technologi PETRONAS. Furthermore, the software allowed to model and calculates the structural behaviour of the jacket leg in proper manner and provides reliable results.

2) Time Feasibility

The project required lab work of time for data analysis and simulation work. Thus, to ensure the project is feasible within time frame, the analysis of the jacket leg member has been limited to one specific tubular member of jacket leg and the preferred idealised vessel impact to meet the objective of this project.

CHAPTER 2: LITERATURE REVIEW

This section summarizes the various aspects of ship-platform collision and also presents the review of the past research in the related areas. This section is divided into four parts to easily give an overview of the project.

2.1. Orientation of Vessel

The orientation of the vessel in a collision is important. It will influence both the added mass and the collision velocity. Most importantly, the difference in stiffness and strength of a vessel's bow, stern or side, can affect the amount of damage caused to platform jacket. The load indentation relationships for typical supply vessels presented in reference (Kenny J.P, 1988) indicate that a ship's stern is its stiffest section, and is therefore the part liable to cause most damage to an installation in a collision.

There are 3 vessel orientation normally considered in collision studies (Kjeoy H. and Amdahl J.,1979):

- Head on collision
- Sideways collision
- Stern collision

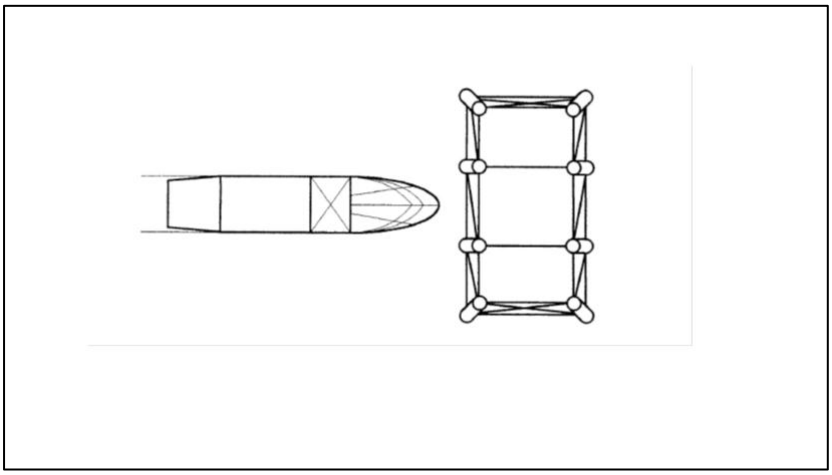


Figure 2.1.1: Head on collision jacket-vessel impact scenario

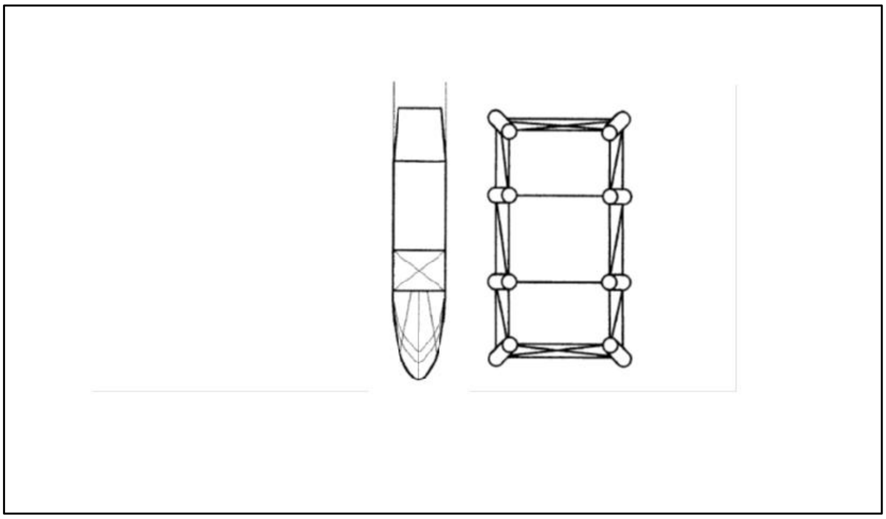


Figure 2.1.2: Sideway collision jacket-vessel impact scenario

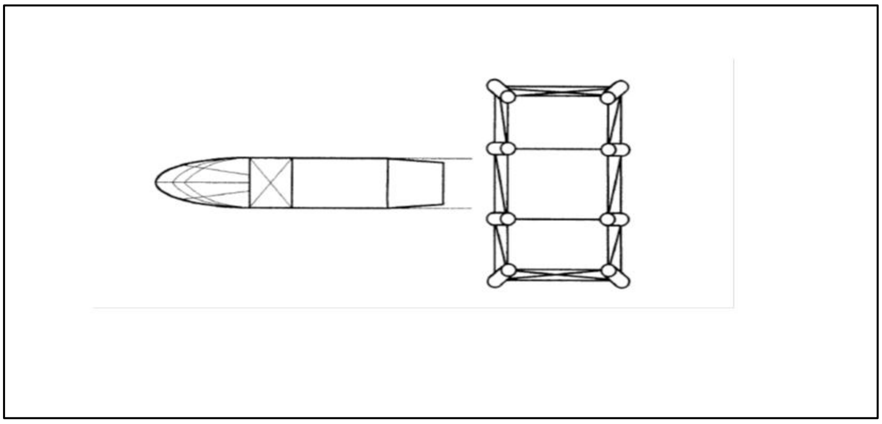


Figure 2.1.3: Stern collision jacket-vessel impact scenario

The most probable collision orientation for passing vessels is head on. The bow of the ship can ram the legs of jacket or the bracings of a steel structure. Statistic according to reference (Kjeoy H. and Amdahl J.,1979) shows that most of the incidents of passing vessel collision in the department of energy accident records were bow collisions. In spite of references finding, NMI LTD (NMI,1985) investigate the severity of collisions of attendant vessels with offshore installations who was commission by Department of Energy discovered the frequency of stern collision occur is much higher than bow and sideway collision reported for fixed platform. Based on this statistic, Modal analysis of finite element modelling can be used for to determine the structure damage cause by vessel head on orientation collision. This is discussed in the following section.

2.2. Members Configuration

Tubular member has been commonly used in most of the platform around the world especially fixed steel jacket platforms. The commonest members of offshore platforms are of circular tubular section with typical geometries in the ranges, $20 < d/t < 60$ and $10 < L/D < 30$. It has proved to have excellent energy absorption capabilities.

When subjected to an impact load a tubular member will usually suffer a combination of both denting and overall bending. The effect of local denting of the tube wall is to cause a reduction in the effective section area and modulus and an eccentricity of the neutral axis over the locally damaged region. Taken overall bending deformations took place at the member, their combined effect can result in rapid deterioration in the load-carrying capacity of the member (API,1986). Calculation and experiences have shown the tubular member able to stop the striking vessel by absorbing the energy of impact acting on the member.

Therefore, the overall of characteristic of tubular members is the appropriate material to use in the offshore industry especially in jacket platform. The next section discuss more in to detail on several method propose in calculating the energy impact to tubular members cause by vessel collision.

2.3. Energy involved in collision

The analysis of collisions at the design stage can become a very complicated and lengthy procedure. Various methods have been considered for estimation of the total strain energy on the platform. Here are 4 main modes of deformation of tubular member studied by Soreide (Soreide T.H.,1981) and Ellinas and Valsgard (Ellinas C.P. and Valsgards S.,1985):

- I. Localised deformation at the point of impact
- II. Overall bending deformation of the beam
- III. Overall elastic deformation of the platform

2.3.1. Localised denting deformation

The energy absorbed in local denting deformation of a tubular member is dependent on the type of impact. A bow collision gives a more concentrated force than a sideways impact and results in a larger amount of energy absorption for a given mass and velocity of the vessel. The theory which used in engineering application involved two analytical methods (Lloyd,1985).

- The Ring Models :Evaluate the energy of plastic deformation.
- The Indentation Models :Evaluate the depth of the dent varies along the length.

In this study four methods have been selected for the dent analysis.

2.3.1.1. Methodology by De Oliviera

This method was developed by De Oliviera (De Oliveira J.,1979) is based on the plastic theory of bending of a wedge shaped mechanism to obtain the energy dissipated in the dent. The characteristic dimensions of the wedge can be varied and therefore the shape of the dent due to an impact can be closely approximated to the shape of the wedge. The total energy dissipation essentially contains two contributions:

- Wedge shaped mechanism
- Flattening of the cylindrical surface to a central rectangular area

These models assume that all the energy is dissipated through bending and that no membrane effects are present. However, this method is simple to use, though somewhat conservative for design purposes.

2.3.1.2. Methodology by Furnes and Amdahl

This method was developed by Furnes and Amdahl (Furness and Amdahl,1980) uses the yield line theory for wedge shaped dents. In this method the characteristic dimensions of the wedge cannot vary. It incorporates the plastic effects from the rotation of the yield lines, flattening of the surface between yield lines and the tension work due to the elongation of the generators. The energy is taken to be the area below the load deformation curve. The theoretical predictions obtained using this methods agrees closely with experimental results for small and medium indentations, although the tubes tested were axially and rotationally restrained.

2.3.1.3. Methodology by Ellinas & Walker and Richards & Andronicou

This method was developed by Ellinas and Walker and Method 4 develop by Richards and Andronicou (Richard D. and Andronicou A.,1985) are both based on empirical function approach. The relationship between the lateral load and the dent depth is obtained from a rigid perfectly plastic deformation curve derived from impact tests on tubes. It is assumed in Method 4 that the tubular cross section in the dent region retains its original circular form, but possesses reduced material properties specifically the tubular member of yield strength and stiffness.

2.3.2. Overall bending deformation of members

The analysis of the energy absorbed by a tubular member in overall bending deformation is carried out by using methods of ideal plasticity. The degree of restraint provide by the end supports can strongly influence the energy absorption capacity of the beam due to membrane tensile forces which develop in members with axially restrained ends. Four methods which complement those considered in the previous section have been chosen, providing varying degrees of axial and rotational restraints.

2.3.2.1. Methodology by De Oliviera

The method by De Oliviera (De Oliveira J.,1981) considers a tubular member with an applied load at any position on the beam. A plastic hinge is assumed to form at the point of application of the load. At large displacements membrane forces are allowed to develop which reduce the moment capacity of the hinge. The joint flexibilities are modelled by idealised axial and rotational springs at the beam ends (UEG,1985).

2.3.2.2. Methodology by Soreide & Amdahl

This method is based on the work of Soreide and Amdahl (Soreide T.H. and Amdahl J.,1982) and consists of a beam model with fixed ends loaded at mid-span. A three hinge mechanism is assumed to form with the full moment capability. At large displacements membrane forces are introduced which reduce with the moment capacity of the hinges. The method assumes that the full plastic capacity of the cross section is retained during deformation. The absorbed energy is obtained by integrating the load displacement expression.

2.3.2.3. Methodology by Ellinas & Walker

This method (Ellinas C. and Walker C.,1983) considers a beam loaded at mid-span with the ends fixed rotationally but free axially. Therefore, no membrane forces are allowed to develop. The reduced stiffness is calculated during the denting phase as the cross section of the tube changes. It is assumed that global bending does not initiate until the load has reached a critical value, depending on the reduced stiffness. At this point, the local denting ceases to increase further and the remainder of the energy is absorbed plastically in the overall bending mode.

2.3.2.4. Methodology by Smith

This method (Smith C.S. et al, 1981) assumes a dent to form at the point of application of the impact load which can be anywhere along the length of the member. The energy absorption prior to the development of a full plastic mechanism comprises elastic bending and local denting. Subsequently, in an axially restrained member, membrane forces may be generated as the member deflects laterally. During this process the local denting action may still proceed and therefore the method allows for interaction between overall bending and local denting. The presence of axial forces is taken into account in the moment thrust collapse criterion and the energy absorption behaviour of the members. In this method the end restraint conditions can be either simply supported or fully fixed.

2.3.3. Overall elastic deformation of the platform

The overall deformation characteristics of platforms due to collisions with vessels have been studied by several researchers for example Pettersen and Valsgard [21], Kheoy [22] and Kavlie & Soreide [23]. For impact on brace members the platform responds by transferring the loads into the main legs. Impact directly or indirectly onto the main legs initiates the dynamic response of the structure. This can have a significant contribution to the energy absorption capability of the platform. The strain energy absorbed by the platform can be evaluated from a finite element analysis using the reactions at the ends of the impacted members as applied loads on the structure.

2.4. Impact related studies using Finite Element Modelling

Nonlinear finite element modelling (FEM) is a powerful tool for analysing vessels collision problem and has seen more and more applications in recent years. A series of analytical method was developed and applied shows how finite element method have developed its advance technology in oil and gas industry (Figes Engineering, n.d).

The use of nonlinear finite element model helps to provide the starting point for a more detailed collision analysis between vessels and the jacket legs. The simulation can capture the structural behaviour in a proper manner and provide reliable results.

Here are three main parameters to be used in analysing the impact on jacket leg cause by the vessel collision:

1. Energy Absorption – This is one of the most commonly used parameters used in verification of these types of structural interactions problems. Specifically, it is the energy being absorbed as the indenter is pressed into the double hull test bed.
2. Applied Load – This is often used in more accurate and advanced calculation approaches, and provides a better indication of different failure events and the resulting load and deformation changes throughout the entire loading process.
3. Progressive Damage – This is the overall observed behaviour of the structural interaction.

CHAPTER 3: METHODOLOGY

3.1. Introduction

This chapter presents the methodology that was followed in this research to attain the well-defined objectives for this research. A detail numerical analysis and systematic parametric study was conducted to investigate various aspects associated with jacket leg-vessel impact. The numerical model was developed using ANSYS software to simulate the effect of rigid body impact on a jacket leg. Few parameters were identified as the possible important parameter to provide better understanding of impact phenomena. The parameter selected for the detailed analysis are listed in Table 3.1. The developed numerical model was analysed repeatedly with variation in parameter mentioned to study the sensitivity of various parameters. The results obtained from the parametric study were used to achieve the main objective of this project which is the idealization and selection of appropriate design impact load for jacket leg.

Table 3.1: Parametric Study

No	Parameters
1	The weight of the vessel
2	Location of collision of the vessel impact
3	The velocity of vessel collide with jacket leg
4	The size of the deformation resulted by the vessel collision

3.2. Nonlinear Finite Element Analysis using ANSYS 14

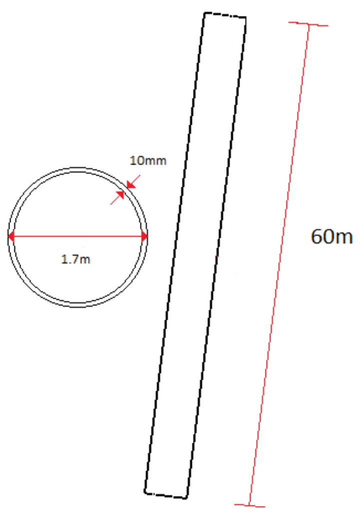
3.2.1. Finite Element Model

<u>Jacket Leg</u>

The Jacket leg segment is modelled using Isotropic hardening material models as described in section 3.2.4, is used in analyses where the column is allowed to deform and dissipate compact energy. The column ends are model considered completely fixed in all translational and rotational degrees of freedoms. Therefore, the surrounding structure is assumed strong enough to resist the loads that arise when the column deforms. In this research study, the dimension of the jacket leg play important role in determine the parameters required. Hence, the simulation design dimension value for jacket leg segment remain constant thorough out the rest of the simulation. The material properties and dimension of jacket leg segment used for this model are based on the properties present in table 3.2.

Table 3.2: Material properties and jacket leg dimension

Density (kg/m3)	7850
Young Modulus (MPa)	2E+05
Poison Ratio	0.3
Bulk Modulus (Pa)	1.6667E+11
Shear Modulus (Pa)	7.9623E+10
Yield Strength (MPa)	516
Tangent Modulus (MPa)	201.06

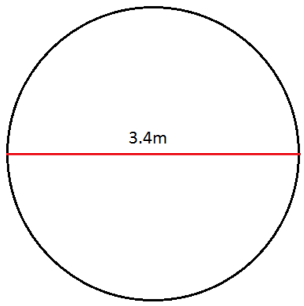


Sphere Shape

Sphere model is simulated as a reference to vessel in this research study. Due to the complexity of simulating the entire vessel, most of the details had been left out or simplified in the modelling process. Simplifications reduced the modelling and meshing time and also the calculation time. The sphere shape model assigns as a rigid material model where the sphere model will not allow to deform or dissipate impact energy during the collision between the jacket leg. The sphere model is using the same material properties which are isotropic hardening except the mass of the sphere changes according to Petronas Technical Standard section 4.11“boat impact” prior to parameter study in this research paper.[5]

Table 3.3: Sphere material properties and dimension

No.	Mass (MT)
Scenario 1	1000
Scenario 2	1500
Scenario 3	2500



3.2.2. Model Verification

It is always important to verify the finite element model before starting an analysis. The most important verification is to verify that there are no duplicate nodes. When parts are created separately as in this case, it is important to verify that the parts are connected. For example: if two plates are supposed to be connected at one edge but are created separately, both plates will have nodes at the common edge. The nodes need to be merged in order to connect the plates. The model was verified and did not have any duplicate nodes.

3.2.3. Idealization boundary condition

The model of leg jacket is 15.0 m long, while the total jacket leg which may exceed 60 m long. The length of the leg segment is determined based on the braced length of the jacket leg of which potentially subjected to vessel impact. Since the leg segment is supported by the braces and the jacket is piled, it is acceptable to assume the leg jacket ends are clamped in all translational and rotational degrees-of-freedom, provided that the load transfer from the leg segment to other members and braces is carried out ideally. Thus, all the analyses have been simulated under the assumption that the jacket leg is fixed at it ends.

However, one should be aware that the fixed-ends assumption does not represent the real boundary conditions as the jacket structure also subjected to other loads (environmental, gravitational, etc.). These loads contribute to the global deformation of the jacket structure and interact with the local deformation of the jacket leg. Thus, the ideal boundary conditions should have the flexibility range in between the clamped and the pinned supported.

3.2.4. Material Model

<u>Power law isotropic material</u>

This material model provides elastoplastic behavior with isotropic hardening. The material is assigned to the model to comply with the type of analysis being concerned. This material model is used in all deformable structures in this research paper.

<u>Rigid Material</u>

The material requires some input parameters such as Young's modulus, Poisson's ratio and density. These parameters are for instance used for determining interface parameters for contact problems and should therefore be realistic values. The user also has the opportunity to specify constraints in all 6 degrees of freedom which can be applied either in the global coordinate system or a user-defined local coordinate system.

3.2.5. Mesh and Element

The mesh method used for the jacket leg model is Sweep method. This method allowed fine element to be modelled at the location of the impact of the vessel while coarse element model the rest of the jacket leg. The jacket leg is built up with four-node quadrilateral elements. The wall thicknesses of the jacket leg chosen in present work is 10 mm and the element size is set 300 mm. The element size of 300 mm is applied for jacket leg model to avoid the element intrusion at the contact interface during the impact.

The mesh method used for the sphere model is Hex Dominant methods. This methodical approach generally gives nice hex elements on the boundary of a sphere shape. Therefore the method is suitable to be applied on the sphere when it collides with the jacket leg to obtain the deformation displacement. The element size of the sphere is more than the jacket leg model which is 500mm.

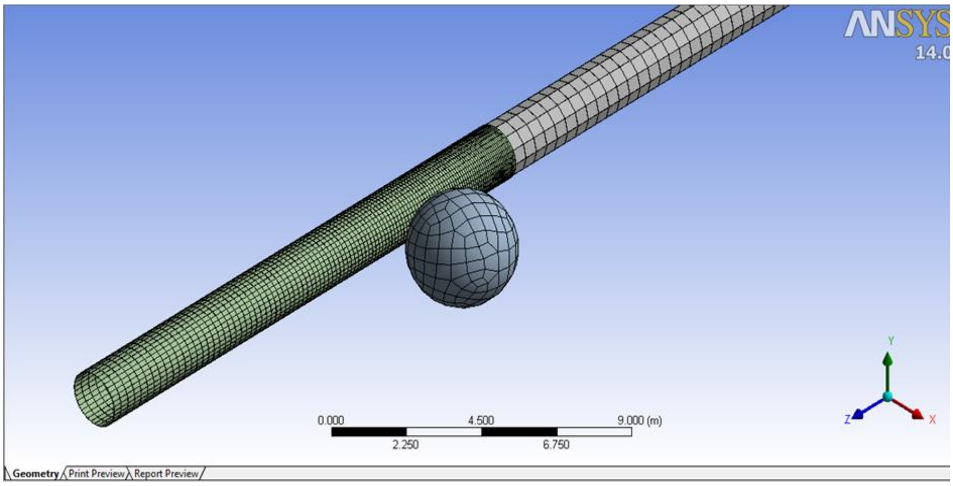


Figure 3.2: Mesh method of both model

3.3. Explicit Dynamic Analysis

3.3.1. Introduction

The dynamic finite element analysis can be solved by either implicit or explicit method. The implicit method is unconditionally stable, and demands significantly long computational time, thus is costly and generally not preferred to be applied. In contrast, the explicit method is preferred since the computational time is relatively shorter. However, the explicit method is conditionally stable. The stability of this method can be assured by setting its time step size to be lower than the critical time step for the model.

3.3.2. Velocity

The velocity of the colliding bodies will determine the total energy released during the collision, which will then influence the energy absorbed by the strain energy dissipation. In this work, three constant velocity parameter have been used to analyze the simulation model. The analysis arrangement used for the comparison is based on the vessel impact on three different scenario discuss in section 3.3.4 using the same dimension of jacket leg. The result obtains will be able to determine the mass-displacement range and jacket leg-displacement relationship for the specify velocity.

3.3.3. Time Step

The critical time step is governed by several parameters. To fulfil the conditions for stability the time step needs to be smaller than the time a pressure wave uses to pass through the element. If this was not the case, uncontrolled pressure waves could pass through the model and the results would at best be inaccurate. Another important factor regarding time step size is contact between bodies, as this requires a low time step to be stable.

3.3.4. Location of impact

The collision location is determined from the very first point where the vessel touches or interacts with the struck object (jacket leg). From this point of view, in order to observe the effect of the collision point location, three scenarios have been set with regard to the length (span) of the column.

A) Scenario 1 (Middle Span)

This point will be regarded as the reference impact-point. In this scenario, the sphere model is arranged such that level of reference impact-point has the same level with the middle span of the column as indicated in Figure 3.3. Consequently, at the first contact, the sphere model will hit the column at around its middle span (half-length). In present work, this scenario will be regarded as "middle span impact".

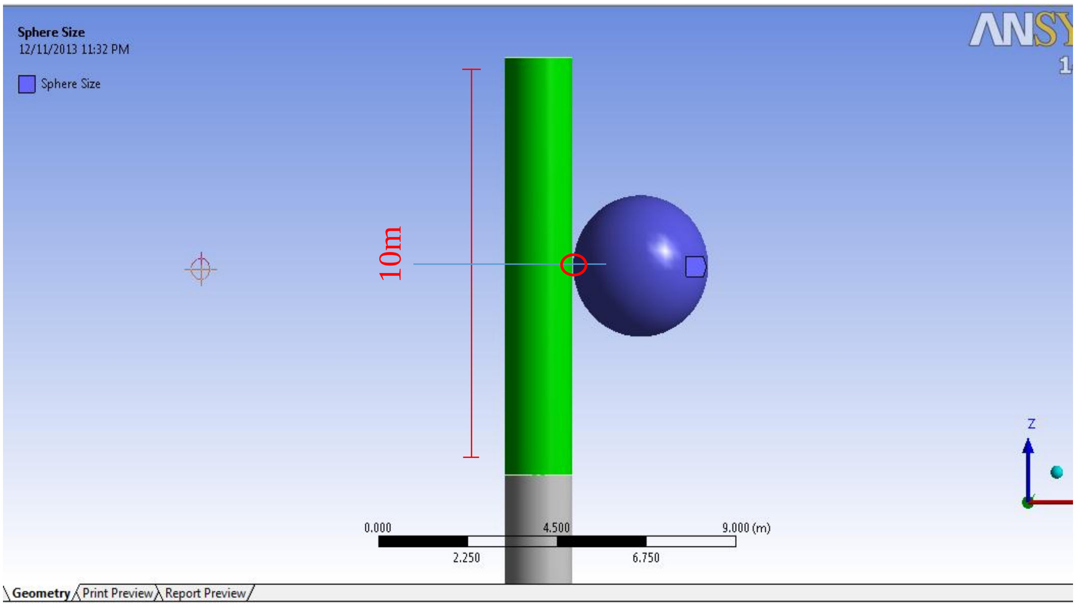


Figure 3.3: Scenario 1 (Middle Span)

B) Scenario 2 (Three Quarter Span)

By this scenario, the sphere model is located such that the half-height of its flat front interface is at the same level with the half-length of the column. The first strike sphere model will then strike the column at about 5 m up from the bottom-end of the column. This arrangement has been used in present work to represent the effect of impact at the quarter span of the column, thus will be further regarded as “three quarter span impact” [26]. This scenario is illustrated in Figure 3.4.

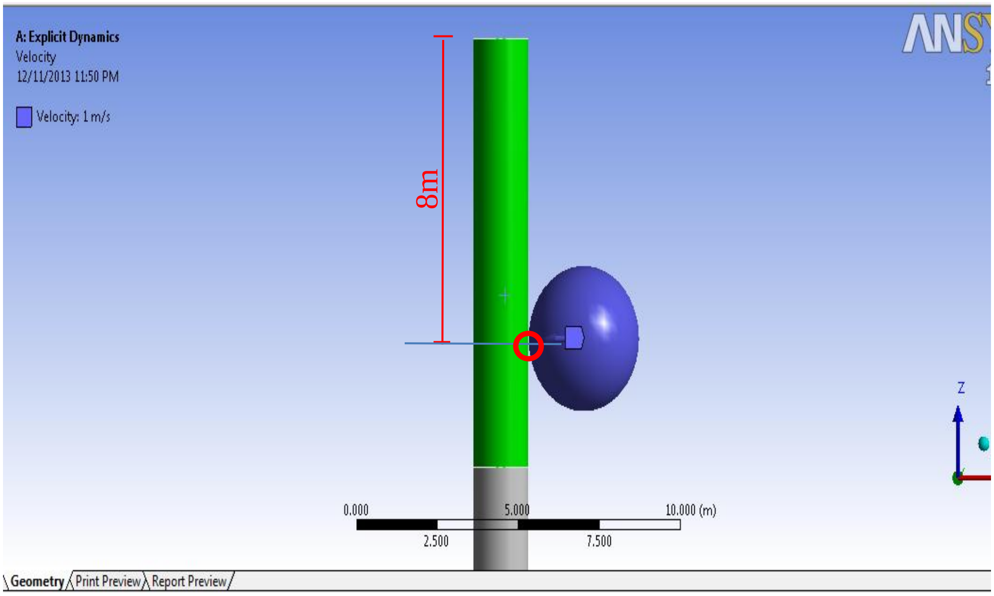


Figure 3.4: Scenario 2 (Three Quarter Span)

C) Scenario 3 (Below Mean Sea Level Impact)

In this scenario, the sphere model is arranged such that level of reference impact-point is quarter span below the mean sea level indicated in Figure 3.5. This arrangement has been set to follow like in real situation of oil and gas operation where the bottom hull of the vessel will hit the jacket leg below the mean sea level. In present work, this scenario will be regarded as “Below Mean Sea Level Impact”.

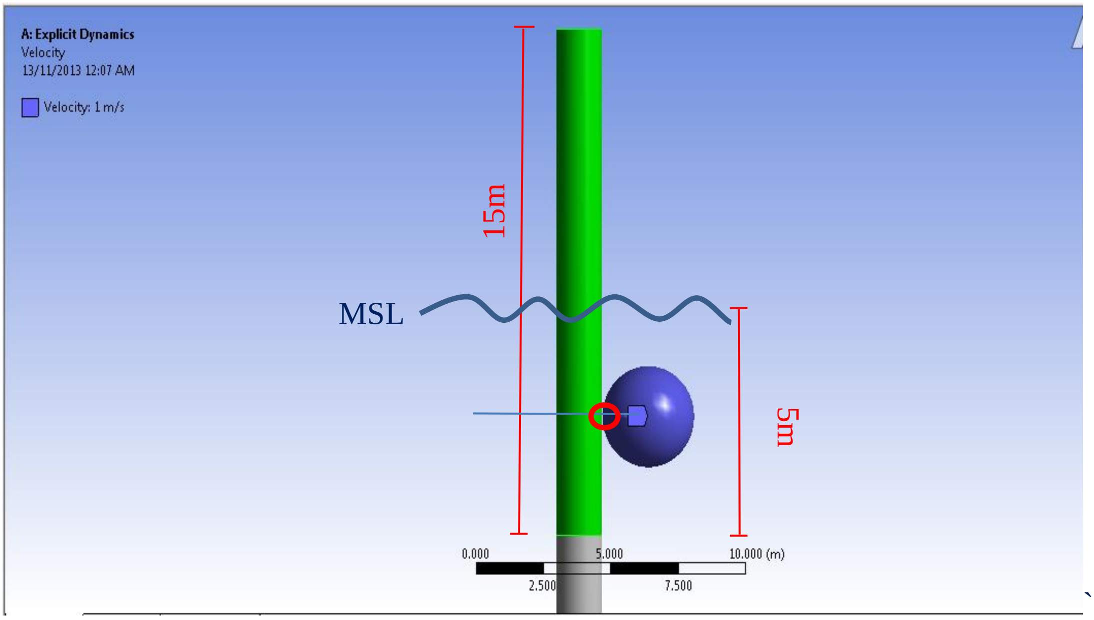


Figure 3.5: Scenario 3 (Below Mean Sea Level Impact)

3.4. Flow chart of vessel impact against jacket leg

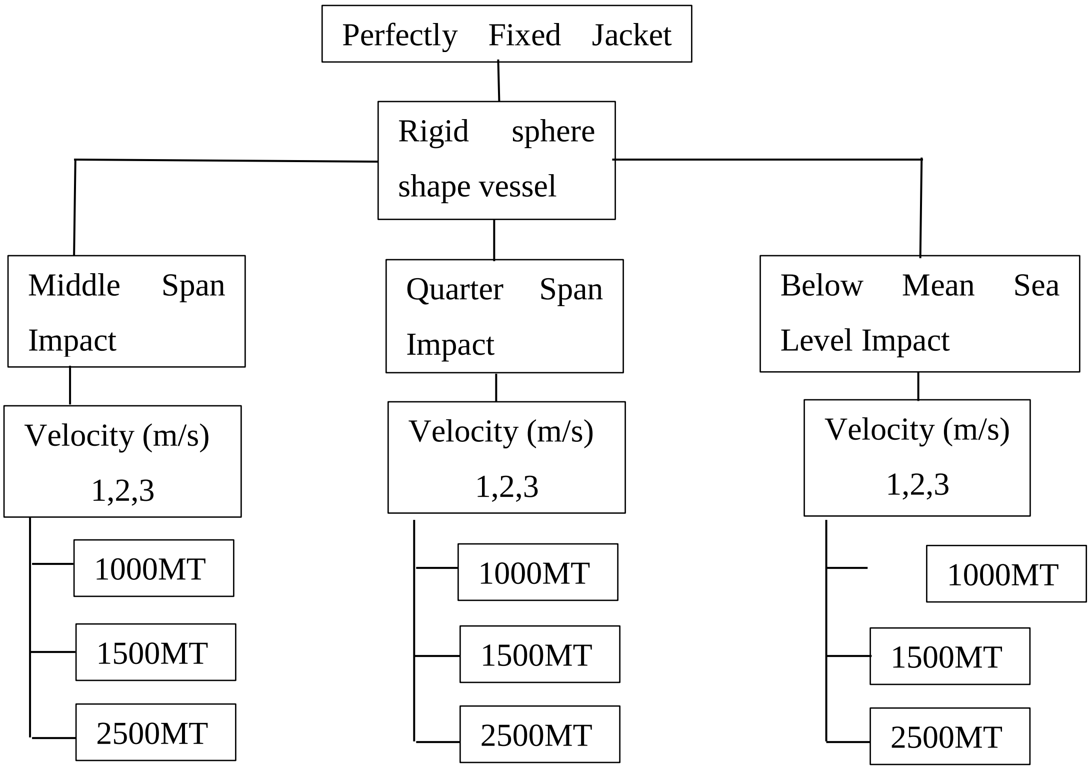


Figure 3.6 : Flow chart of simulation

CHAPTER 4: RESULT AND DISCUSSION

4.1. Parameter Study

A parameter study of the jacket leg member subjected to vessel impact collisions was performed. The parameters mainly focus were the mass of vessel and vessel velocity impact. Thus, the discussion will mainly be focused on rate of deformation of the jacket leg. The jacket leg and vessel dimension are constant according to table 4.1:

Table 4.1: Parameter study table

MIDDLE SPAN					
Velocity (m/s)	Jacket Leg		Sphere		Max Deformation Depth (m)
	Diameter (m)	Length (m)	Diameter (m)	Weight (MT)	
1	1.7	60	3.4	1000	0.71129
2	1.7	60	3.4	1500	1.3837
3	1.7	60	3.4	2500	1.7065

THREE QUARTER SPAN					
Velocity (m/s)	Jacket Leg		Sphere		Max Deformation Depth (m)
	Diameter (m)	Length (m)	Diameter (m)	Weight (MT)	
1	1.7	60	3.4	1000	0.51056
2	1.7	60	3.4	1500	1.1181
3	1.7	60	3.4	2500	1.663

BELOW MEAN SEA LEVEL SPAN					
Velocity (m/s)	Jacket Leg		Sphere		Max Deformation Depth (m)
	Diameter (m)	Length (m)	Diameter (m)	Weight (MT)	
1	1.7	60	3.4	1000	0.49878
2	1.7	60	3.4	1500	0.99633
3	1.7	60	3.4	2500	1.4973

The collision scenario on middle impact was defined as the situation in which vessel strikes most significant impact on jacket leg compare to other scenarios. The jacket leg undergo a large deformation and a considerable amount of energy would be dissipated in the vessel itself.

4.2. Mass-Deformation (Middle Span)

The following figures show the deformed contour of the jacket leg at final state due to middle span impact of jacket leg with various vessel mass under idealised impact load analyses.

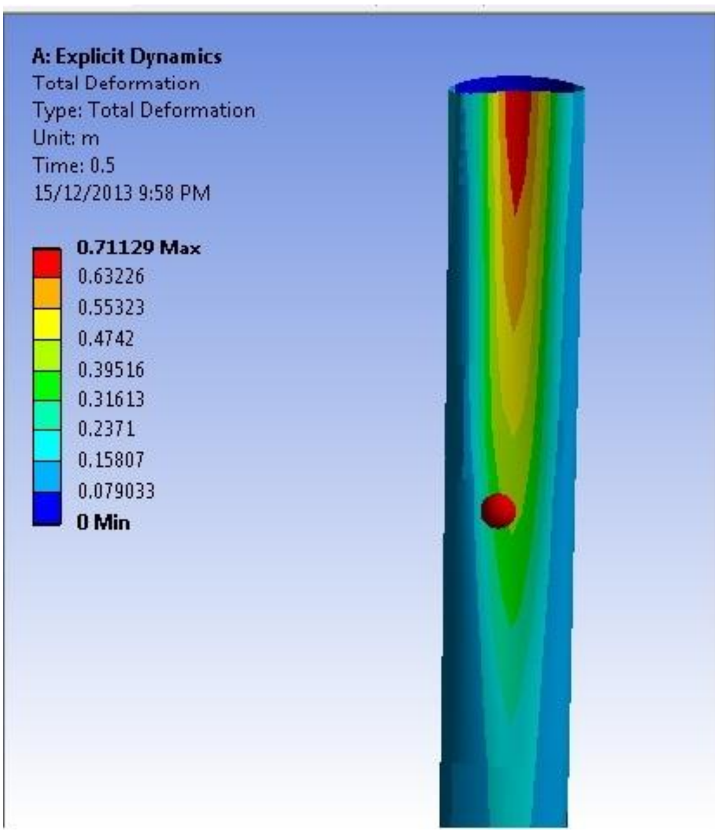


Figure 4.2.1: Displacement contour on the jacket leg at 1000MT (Middle Impact)

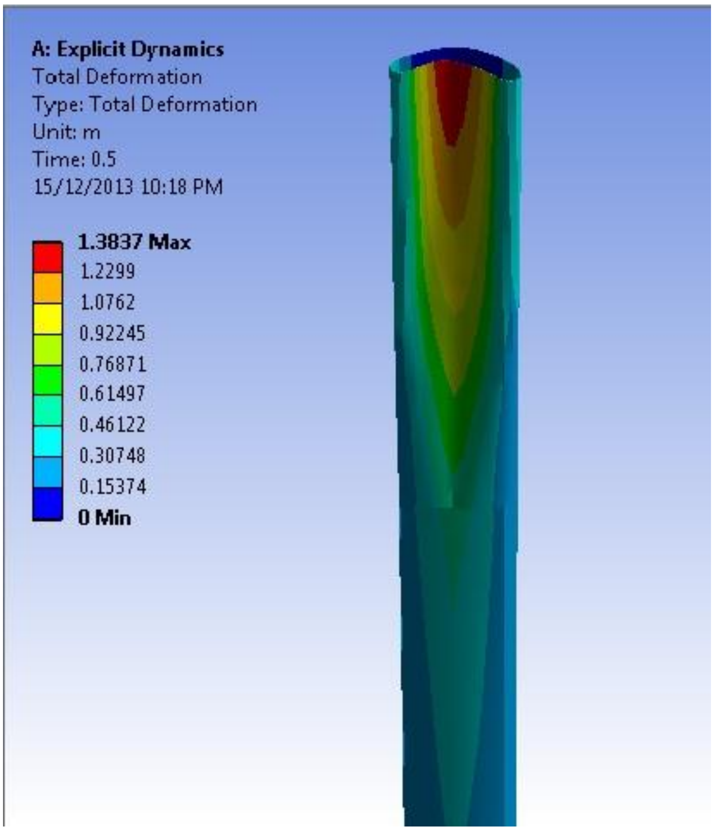


Figure 4.2.2: Displacement contour on the jacket leg at 1500MT (Middle Impact)

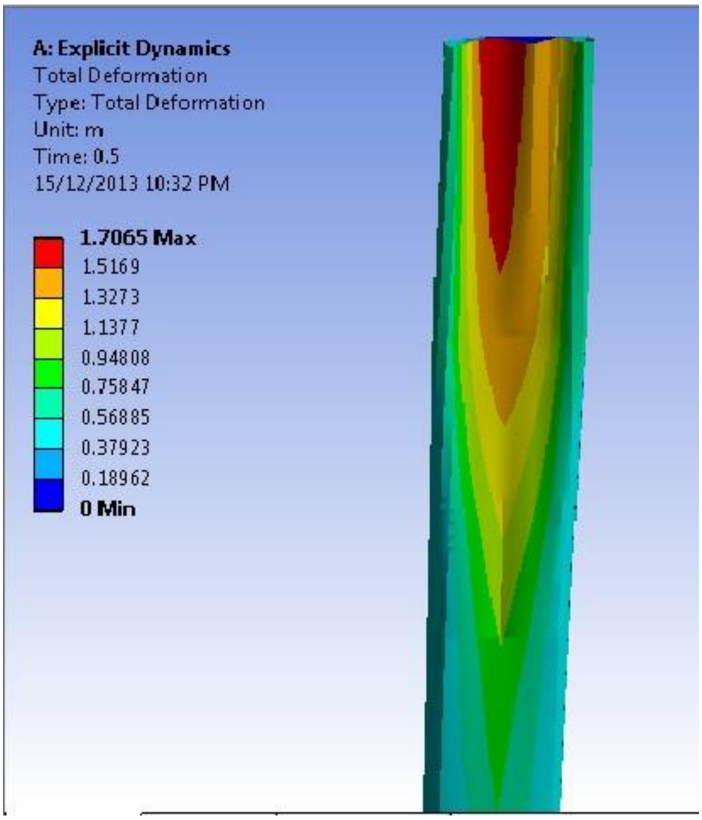


Figure 4.2.3: Displacement contour on the jacket leg at 2500MT (Middle Impact)

The figure show an obvious transformation of jacket leg deformation related to the increment of vessel mass. This is in accordance to what was expected prior to performing the analyses.

The mass-deformation relationship for three type of mass are presented in Figure 4.2.4

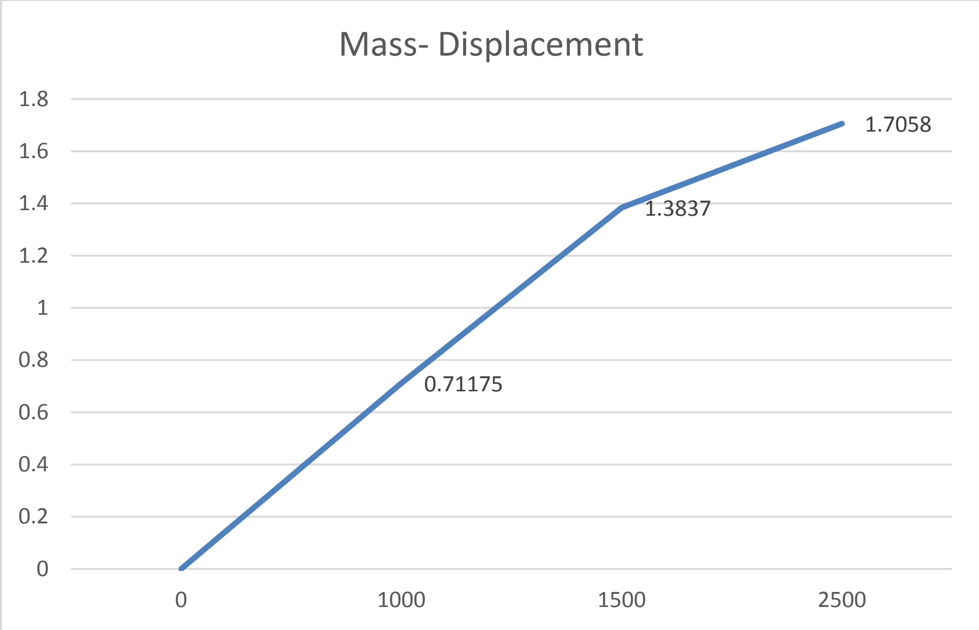


Figure 4.2.4: Mass-Deformation – Middle Impact

From Figure 4.2.4, some observations can be pointed out:

It can be seen that the jacket leg reach its maximum deformation at highest mass of the vessel. The force generate by the highest mass cause the jacket leg to deform more than its diameter which indicate the jacket leg induces large energy absorption.

4.3. Mass-Deformation - (Three Quarter Span)

The following figures show the deformed contour of the jacket leg at final state due to quarter span impact of jacket leg with various vessel mass under idealised impact load analyses.

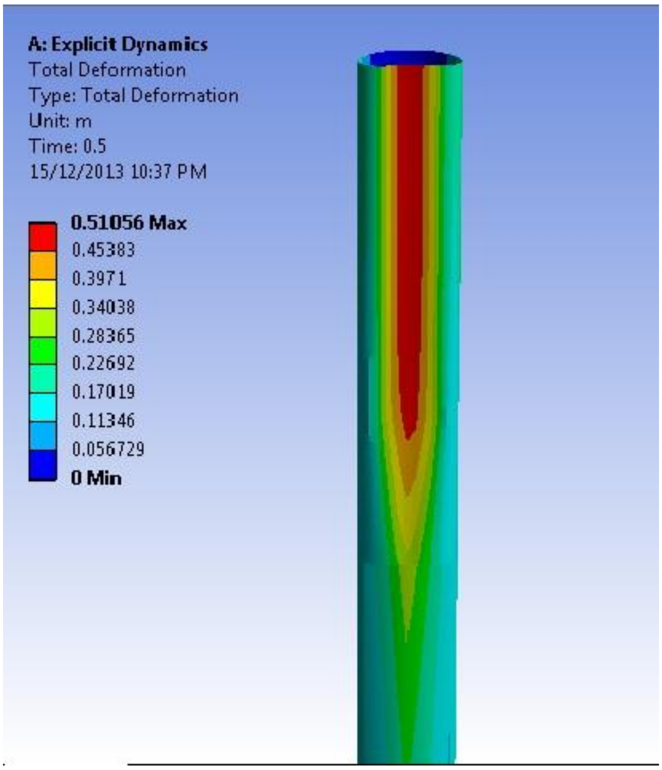


Figure 4.3.1: Displacement contour on the jacket leg at 1000MT (Three Quarter Impact)

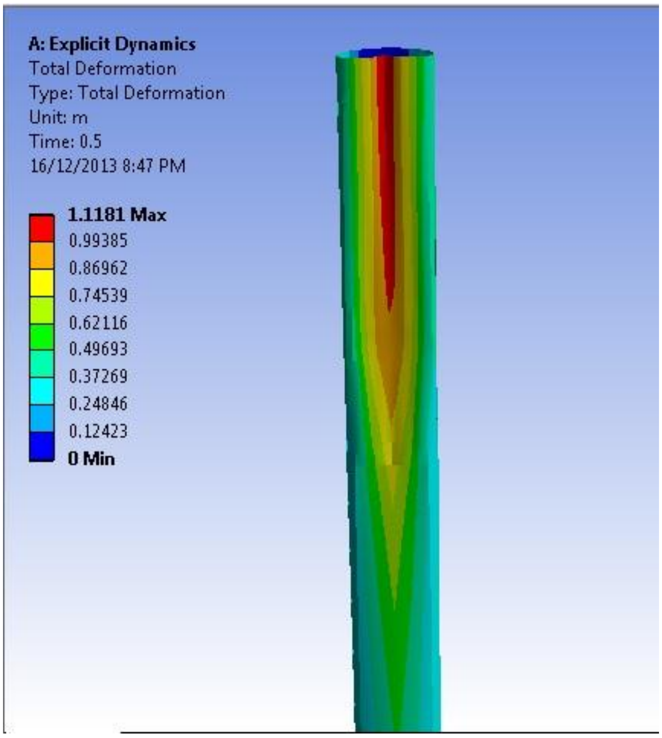


Figure 4.3.2: Displacement contour on the jacket leg at 1500MT (Three Quarter Impact)

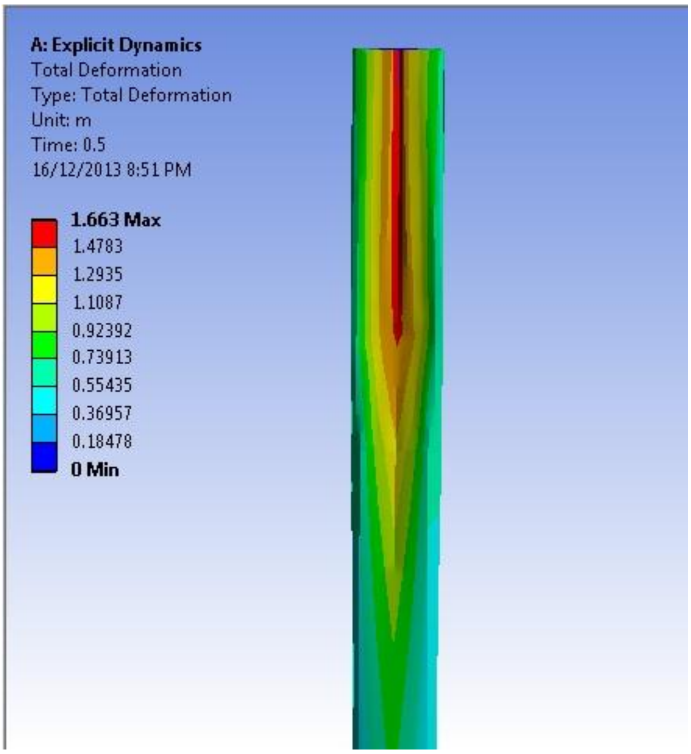


Figure 4.3.3: Displacement contour on the jacket leg at 2500MT (Three Quarter Impact)

At the three quarter of vessel impact, it can be seen that the contact area of deformation is larger but the rate of deformation is less significant compare point of middle span impact

Figure 4.3.4 presents the mass-deformation relationships for the different vessel mass with constant jacket leg dimension.

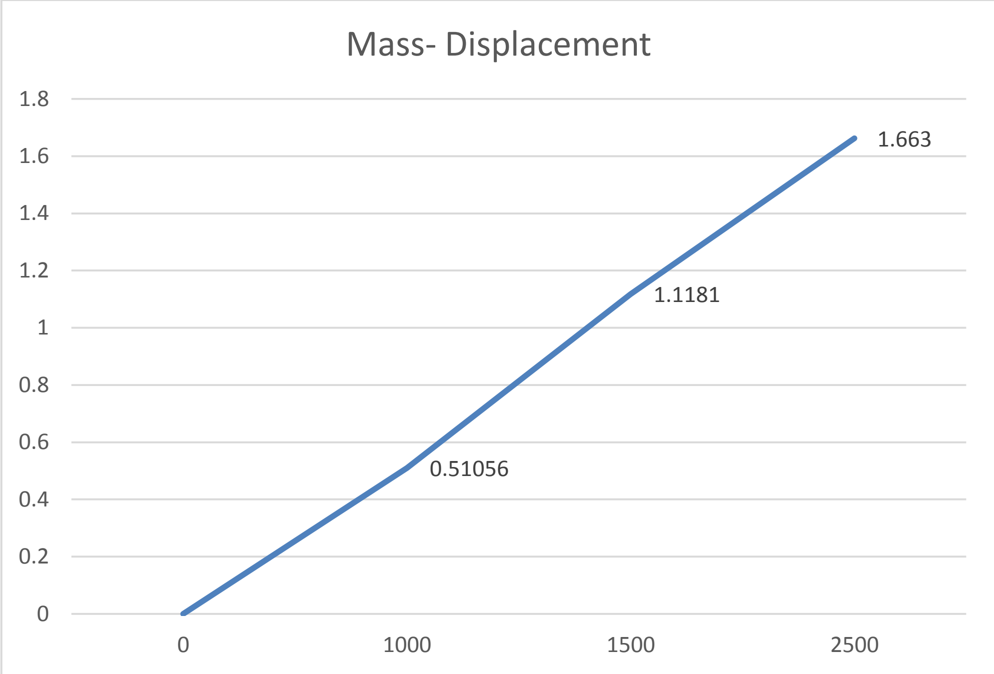


Figure 4.3.4: Mass-Deformation – Three Quarter Impact

From Figure 4.3.4, some observations can be pointed out:

The jacket leg developed resistance higher than middle span impact scenario. A local displacement is generated on the column. Thus, the contact area extended further up giving more resistance to the column. The energy is dissipated by the vessel and resulting damages on the jacket leg.

4.4. Mass-Deformation - (Below Mean Sea Level Span)

The following figures show the deformed contour of the jacket leg at final state due to below mean seal level span impact with various vessel mass under idealised impact load analyses.

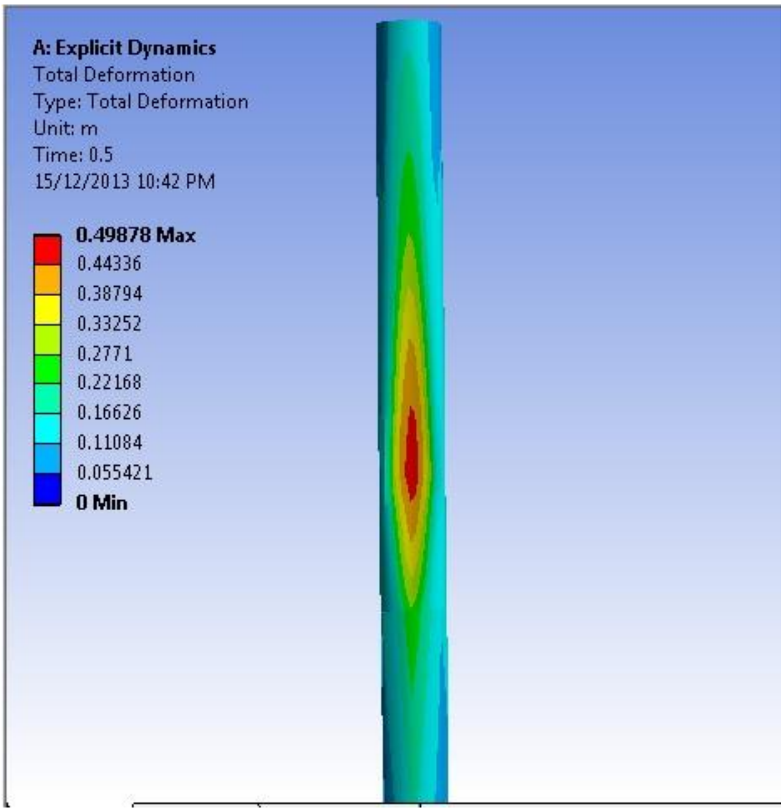


Figure 4.4.1: Displacement contour on the jacket leg at 1000MT (Below Mean Sea Level Impact)

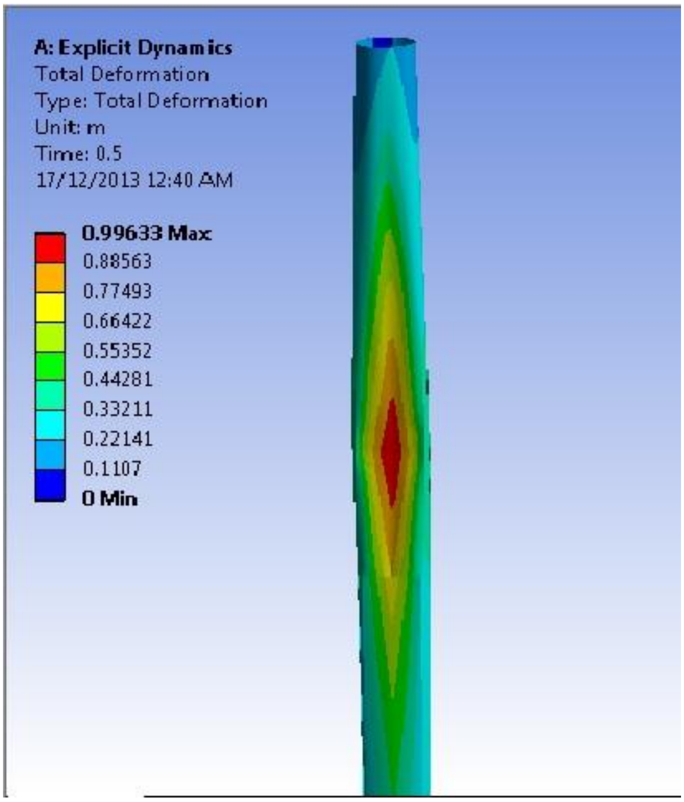


Figure 4.4.2: Displacement contour on the jacket leg at 1500MT (Below Mean Sea Level Impact)

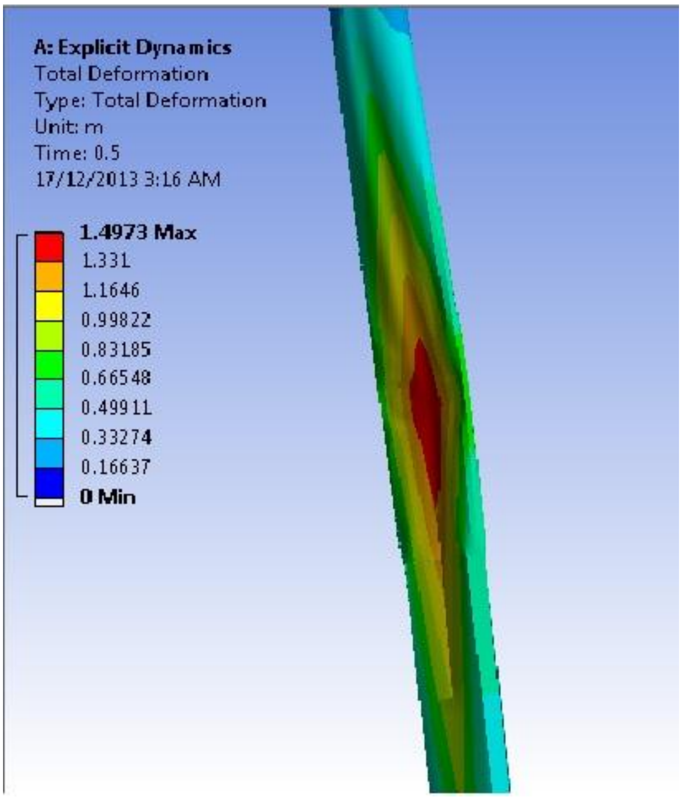


Figure 4.4.3: Displacement contour on the jacket leg at 2500MT (Below Mean Sea Level Impact)

Figure 4.4.4 presents the mass-deformation relationships for the different vessel mass with constant jacket leg dimension.

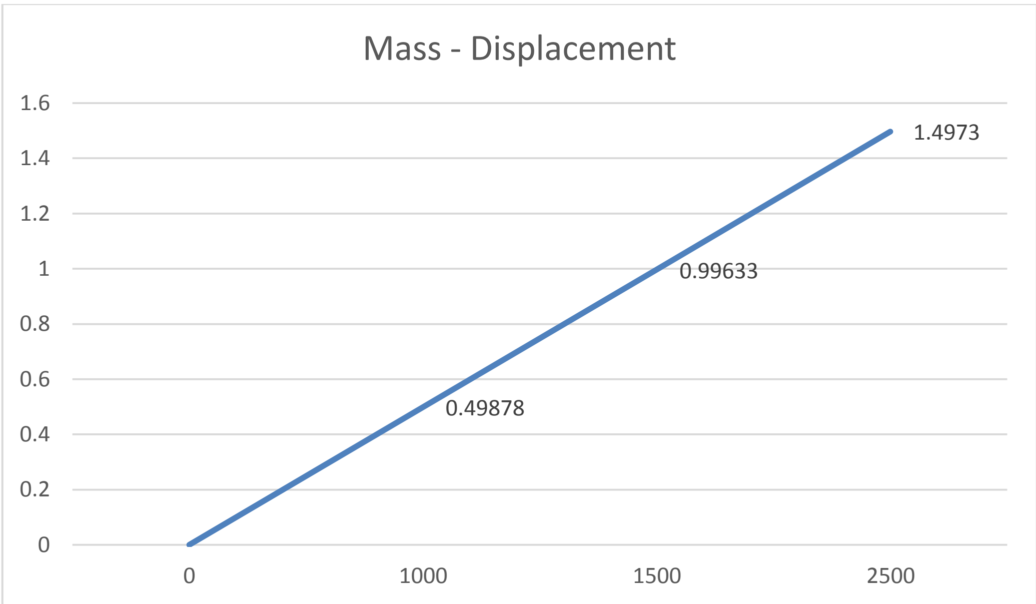


Figure 4.4.4: Mass-Deformation – Below Mean Sea Level Impact

From Figure 4.4.4, some observations can be pointed out:

In this scenario, the simulation clearly shows that the jacket leg endure less deformation compare to other scenario. When the collision occurred close to joint connections, which were points of high local strength, there was a considerable reduction in the collision force, the location of impact point play important role whereby the jacket leg deformed appreciably if the location of impact is farther from the joint.

As for conclusion based on observation made from all the scenarios, according to Amdhal (Soreide T.H. and Amdahl J.,1982), the response of a beam subjected to lateral load consists of two stages. The initial stage of structural member response is governed by bending effects caused by local denting. In the second stage, the tube behaves in manner of a beam and undergoes deflection, which may increase its load-bearing capacity due to the development of membrane tensile forces. Thus, the local deformation will expectedly encourage global deformation to occur and as the impact develops, the column reaches its plastic buckling capacity and starts to deform globally. Local denting around the impact point depends on the collision scenario—impact velocity, shape of colliding vessel, and so forth.

4.5. Idealize design impact load on jacket leg

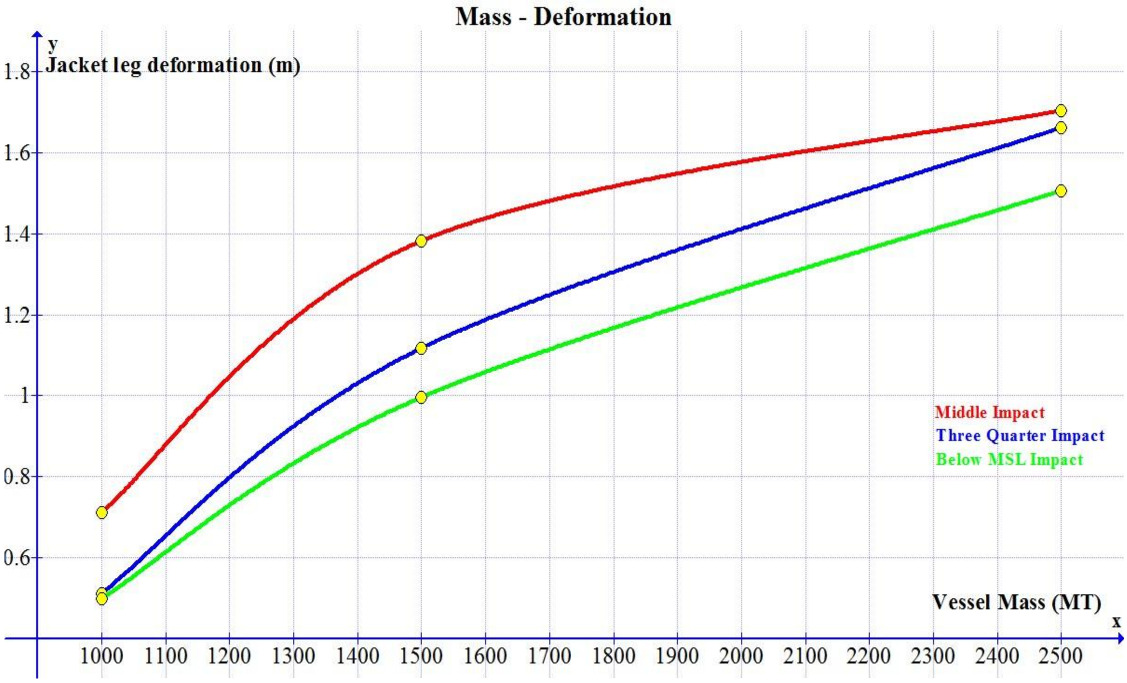


Figure 4.5.1: Mass-Deformation comparison of all the scenario

For low to medium vessel weight the total deformation of the jacket leg is governed by the local indentation. The maximum deformation was observed more than the diameter of the jacket leg member.

Formation of plastic hinge was not observed for low and medium range of vessels. The local deformation will not result into development of plastic hinge formation dissipation. The probability of progressive collapse is low for the case of low weight vessels even though the impact velocity is significantly high.

For high range of vessel impacts, the maximum deformation researched to a level to produce the deformation of the entire section causing a formation of plastic hinge. The vessel weight of 2500t clearly indicate a possibility of failure of the jacket leg which might lead to the progressive collapse of the platform.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The purpose of this project was to achieve a better understanding of why a collision between the effect of accidental impacts of jacket legs for future design and strengthening of the existing platform legs and to identify the sensitive parameter factor that leads to increase number of accidental collision recorded. This was achieved by creating a simulation collision model of between jacket leg and vessel using ANSYS software to analyze the ideal selection design of impact load for jacket leg.

Based on 3 results of different scenario, it can be observed that the existing jacket leg will not undergo significant damage from a collision of a ship with weight of 1500MT but an impact by a vessel with 2500MT can cause a formation of plastic hinge and may instigate a failure of the platform. As the vessel ship weight can be higher than 2500t in some cases, the existing PTS guidelines needs to re-evaluate. The concluded results of the study establishes the deformation-vessel weight curves can provide the designers a references to find the damage consequence of an impact from a vessel with a given weight in predicting future catastrophic event.

Through this research, better understanding of structural dynamic response was achieved and the project has the potential to significantly contribute in providing reference guidelines for platform designs against vessel impact in Malaysia oil and gas operation. Further study on the results obtain from this research can be used as a basis for boat fenders and riser guards design against vessel impact.

5.2. Recommendation for further study

Here are some recommendations that can be done if this any future studies are to be done for this project:

1. Improvement on current method of simulation software (ANSYS 14) to provide more accurate and precise results for example LS-DYNA.
2. Global analyses of the damaged platform should be performed in order to ensure that the platform has the necessary residual strength.
3. A more comprehensive study on impact by other part of the ship, e.g. ship bow, stern end, etc.
4. Consider imperfections, welding, and the fracture criteria of the steel material model, both on the ship and on the jacket-leg
5. Include assessment on the hydrodynamic effect (inertia effect) and the friction effect at the impact interface
6. Evaluation of how sensitive the jacket leg response is with respect to other boundary conditions related to real operation scenario in Malaysia oil and gas

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APPENDICES

Gantt Chart and Key Milestone