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Jacket Structure's Responses due to Ship Collision

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ABSTRACT

Jacket structure is affected by fluid load or external load when it operationed. One of external load that affect it is impact load subject to something collision. This examination talked about graded and velocity supply vessel influence to local and global structure damage subject to collision. Jacket structure in this examination is CONOCO BELANAK wellhead plaform, mass of supply vessel is 2500 tonnes, with tidal variation (such as: MSL, HWL, LWL) for scenario sideway and stern/bow impact for each normal and 10% exceedane velocity. Deformation type of landing platform impact load is dent subject to landing platform material unability to proof againts pressure. This examination refers to J.P. Kenny in 1988 with title Protection of Offshore Instalasions agains Impact. This examination uses 2 software are ANSYS LS-DYNA 9.0 version and GT-STRUDL 27.0 version. First of all, modeling geometry and loading in ANSYS LS-DYNA to acquired local deformation. Than modeling jacket structure in GT-STRUDL to acquired global deformation uses dynamic trancient analysis. Outside diameter of landing platform is 0.9144 m with wall thickness is 0.0381 m. Normal velocity in each sideway and stern impact is and 10% exceedance velocity is 0.28 m/s and 0.39 m/s. 10% exceedance velocity in each sideway and stern impact is and 10% exceedance velocity is 0.54 m/s and 0.73 m/s. The resutl of this examination is dent of landing platform for each normal and 10% exceedance is 0.2725 m and 0.2352 m, it must be repaired or changed because of it is 10% larger than spacing frame. Maximum displacement x, y, z direction is 0.2423 m on 0.38 s, 0. 0559 m on 0.39 s, 0.7492 m on 0.41 s. The deformation in landing platform and jacket structure is smaller than examination result indeed.

KEY WORDS: *Landing Platform; Impact; Dent; Eksplicit Method; Dynamic Respondes.*

1.0 INTRODUCTION

Development damage of offshore structure will be occur for along time. One of the large deformation is due to severe ship-platform collision. Such collision are considered to be a dynamic phenomenon that has costly consequences in material, environmental, and human terms. The dynamic collision response of platforms should be analyzed at the design stage. This precaution ensures that the structure has sufficient strength to withstand impact and therefore has a low probability of severe collision damage.

The secondary data is available in Kenny (1988) research report such as accident due to vessel and collision velocity scenario for collision details. There have been 3 reported incident of impact between very large vessels, such as semi-submersible work barges or drilling rigs, and jackets under construction. This type of impact is potensial cause of significant damage. Consequently, the construction period would appear to be a perticularly high risk period (Kenny, 1988).

The supported data such as ship displacement, ship velocity, record accident, and rules that get Kinetics Energy at structure collision than kinetics energy will be distributed to supply vessel and structure.

The paper presents the velocity effect and collision form of supply vessel to structure and the response and strength of the structure in extreme condition based on accident record at barge bumper and jacket leg. 2500 tonnes supply vessel is observed on the mean, low, and high sea water levels. Colision velocity at stern and bow impact for normal condition is 0.28 m/s and 0.39 m/s. Collision velocity at sideway impact for extreme condition is 0.54 m/s dan 0.73 m/s. Collision effect at landing platform and global jacket structure.

2.0 LITERATURE REVIEW

Offshore jacket platforms have been widely used in offshore oil and gas exploitation with complicated ocean environments. Besides the normal operational loads, the platforms are subjected to other loads, such as wind, wave, current and ice loads (Jin, 1996). At the same time, the platforms are also exposed to unexpected incidents inducing sudden loads due to collision of a vessel with the platform, or impact from a heavy object dropping from the top of the platform. These may result in crooking or buckling of some members, thus reducing their load bearing capacity and potentially affecting the safety and the integrity of the whole structure. To effectively repair the damaged members and restore the desired state of the structure requires a good assessment of the condition of the structural system after an accidental event (API RP-2A WSD, 2000).

The impacts between supply vessels and offshore structures were analyzed by Jorgen in 1983 with two particular areas which were energy dissipation in the ship's bow and stern structures and the deformation behavior of tubular bracings. Various mechanisms of energy dissipation in a ship structure subjected to collision loads were identified and described; design curves were proposed for bow and stern impacts with supply vessels. The different modes of energy dissipation were described, for assessing the load carrying capacity in the beam mode of deformation accounting for the detrimental effect of local indentation.

Jorgen.et.al in 1993 studied a numerical simulation of ship collision with a jack-up and a jacket platform focus on the effect of dynamic on the platform response in term of energy dissipation and load effect using Non-liner Finite Element USFOS. In the study, three factors seem to be important: the local strength of the platform and the strength of the ship relative to the overall strength of the platform, the duration of the collision relative to the fundamental period of the governing motion and the strength of the members transmitting forces needed to accelerate the deck. The jack-up behaves elastically for the design ship beam impact. The jack-up has little sensitivity to uncertainty in ship deformation characteristics and impact speed. The jacket response for impact scenario considered can be reasonably well predicted by static approach, because the impact duration is relatively long compared to the fundamental period of the governing motion and contact.

Zheng.et al in 2003, proposed a simplified method for determination of impact duration and transient dynamic response based on sixth degree of freedom (SDOF). Results of calculation using the method were compared with the results from a global jacket-topside non-linear dynamic analysis using program USFOS for validation. The analysis showed the non-linear dynamic analysis was time consuming and the threshold of using the program is still high. The SDOF approach may be a good engineering alternative for further design applications. Further verification works was recommended in order to quantity uncertainties associated with the SDOF approach.

Jin.et.al in 2005 evaluated damage to offshore platform structures due to collision of large barge. The study applied a non-linear dynamical analysis procedure for firstly determining the impact action based on the forensic evidence from the damaged components, and then evaluating the overall damage effects on the platform structure. The impact action of the barge is simulated with a triangle impulse load with different collision contact times. The curves relating the indentation deformations of the damaged member with different collision contact times were simulated using an estimated velocity of the impacting ship. The study found for the particular case, yielding occurred only for the diagonal brace member around its connections to the two legs, while the remaining part of the structure exhibited no inelastic response. Repairing and strengthening appears to be necessary only for the diagonal member which was directly hit during the collision.

3.0 SHIP COLLISION THEORY

3.1 Jacket

Jacket is made of steel substructure construction of pipelines that serve as templates for pilling up from the seabed to rise above sea level. This section is submerged in the water that serves for guidance and anchoring pile lateral forces to the stability of the construction. In addition it also provides a buffer for some equipment such as risers, caissons, boat landing and other.

3.2 Energy Mechanics

Concepts of basic physics, the conservation of mechanical energy of an object which is allowed to fall from a height h under the influence of gravity g, which because of air resistance is ignored, as shown in Fig.1.

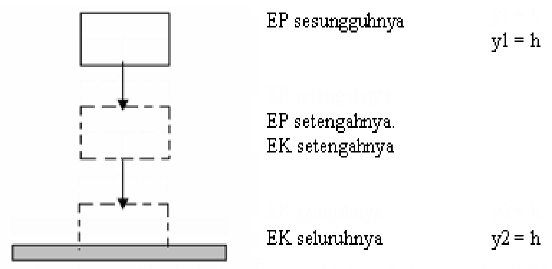

Figure 1: Energy Mechanics (Giancoli, 2001)

The object is initially at rest, only coined the potential energy (T). When dropped, the object T is reduced (because y is reduced). But the kinetic energy (V) increases to compensate, so the number of both remains constant. At each point of the trajectory, the total mechanical energy (E) given by (Giancoli, 2001):

$$E = T + V = mgy + \frac{1}{2}mv^2 \qquad (1)$$

Just before falling to the ground, where y = 0, then all the potential energy is converted into kinetic energy.

$$0 + mgh = \frac{1}{2}mv^2 + 0$$

Thus,

$$T_2 = \frac{1}{2}mv^2 = mgh = V_1 \qquad (2)$$

3.3 Collision Mechanics

According to the direction, the collision can be divided into two, the first collision is central if the center of mass in line with the direction of movement of the object and the second is if the center of mass collision obligue membetuk angle.

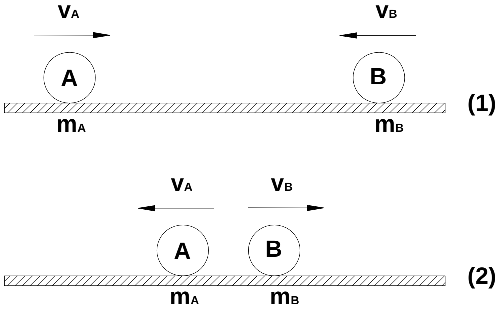

Figure 2: Collision of two objects: (1) Before the collision, (2) After the collision

In the case of the collision mechanism of momentum applies.

$$m_A v_A + m_B v_B = m_A v'_A + m_B v'_B \qquad (3)$$

Of the concept of the collision mechanism, it is found that the coefficient of restitution is formulated according to the following equation:

$$e = \frac{(v_B - v_A)'}{(v_B - v_A)} \text{ dimana } 0 < e < 1 \qquad (4)$$

For the case of perfect collision resilient (elastic) value of e = 1 to equation 2.2 becomes:

$$v_A - v_B = v'_B - v'_A \qquad (5)$$

While for the case of collision does not eject (plastis) the value of e = 0 so that equation 2.3 becomes:

$$v'_B = v'_A = v \qquad (6)$$

That means that after the collision of two objects moving with the speed and the same direction. In fact there are punches that punches eject some of that is the value of e ranges between 0-1.

3,4 Beam Centered Impact Problem

Before studying the impact on the pipeline due to trawling gear, conducted the discussion centered on the beam impact problem (affected beam impact in the middle). It is assumed that the beam with a simple pedestal has a length L, which is exposed to impact loading in the middle by a rigid object with a moving mass mA constant initial velocity of vA.

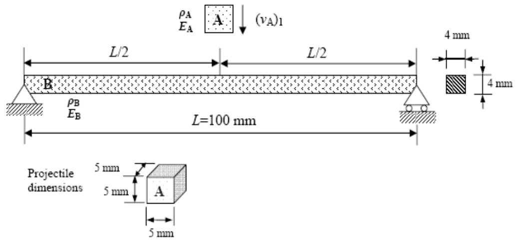

Figure 3: Beam impact problem

Because the impact occurred at one point, the problem can be solved by concentrating the whole mass of the beam at one point in the center of the beam, as shown in Fig.4.

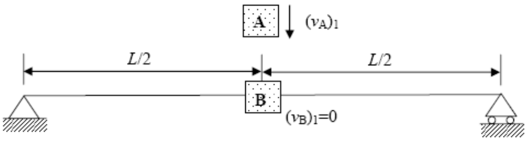

Figure 4: Simplification impact beam problem

Problem solution is divided into two stages. The first is the impact between two masses each have the early speed. At this level of impact force that occurs at the beam exactly equal to the force generated by the beam to an object against his fist. While the second stage is when the two move toward each other the mass and the same speed, for example at plastis perfect punches. Or in other words that the coefficient of restitution of the problem is e = 0. The determination of the restitution coefficient value has been paid to the concept of punching mechanism.

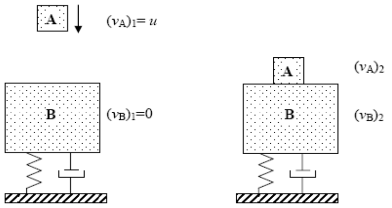

Figure 5: Plastic deformation after the collision

If the object is dropped from a height h, the speed of the object can be calculated with the energy conservation law, namely:

$$T_0 + V_0 = T_1 + V_1 \quad \rightarrow$$

$$0 + m_A gh = \frac{m_A v_A^{\ 2}}{2} + 0$$

So,

$$m_A gh = \frac{m_A v_A{}^2}{2} \qquad \rightarrow (v_A)_1 = \sqrt{2gh} \tag{7}$$

Then use the principle of impulse and momentum. Obtained by integrating the equation of motion with respect to time. Motion equation can be written using Newton's laws II:

$$\sum F = m \cdot a = m \cdot \frac{dv}{dt} \tag{8}$$

Multiplying dt on both sides and integrate anatra limit v = v 1 at t = t1 and v = v2 at t = t2.

$$\sum \int_{t1}^{t2} Fdt = \int_{v1}^{v2} mdv = mv_2 - mv_1 \tag{9}$$

Particle initial momentum plus the total number of impulses that occur from t1 to t2 is equal to the particle momentum end. The principle of linear impulse and momentum in vector form is written with the following general equation:

$$\sum m_j \overrightarrow{vo}_j + \sum \int_{t1}^{t2} Fdt = \sum m_j \overrightarrow{vf}_j \tag{10}$$

Where $\overrightarrow{v_0}$ is the beginning of the velocity vector for mass j, $\overrightarrow{vf}$ is the end of the velocity vector for mass j after the impact and $\vec{F}$ the force vector transmitted during impact. Impulse is a vector quantity equal to the extent of area under the force-time curve in Fig.6.

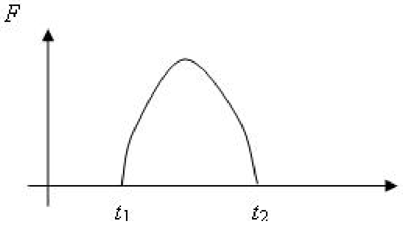

Figure 6: Impulse to force in function of time

In general, impact force varies with time. However, the impact is very short and the style is considered constant, as shown in Figure 2.8. For reasons of time-average force F_{ave} formulated:

$$F_{ave} = \frac{1}{\Delta t} \int_{t1}^{t2} \vec{F} dt \tag{11}$$

Where Δt = t2 - t1. So, the impulse equation:

$$I = \vec{F} \cdot \Delta t \tag{12}$$

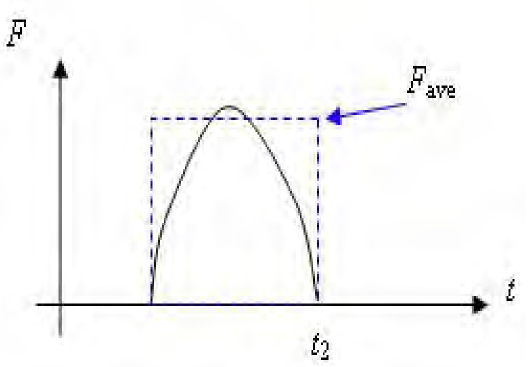

Figure 7: Average Impact Force

For this problem, the theory of impulse and momentum is divided into two parts, described in Fig.8:

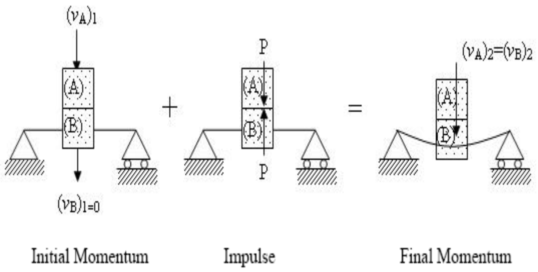

Figure 8: Visualization of the theory of impulse and momentum

Visualization diagram above shows the direction and magnitude of the initial and final particle momentum. Particle initial momentum plus the total number of impulses from t1 to t2 is the final momentum.

$$\sum m_j (v_j)_1 + \sum \int_0^t \vec{F} dt = \sum m_j (v_j)_2 \tag{13}$$

Where

$$m_A (v_A)_1 + 0 + 0 = (m_A + m_B) \cdot (v_A)_2 \tag{14}$$

A final velocity of the object beam is concentrated on the mass of B will be the same after the impact because the coefficient of restitution is zero is assumed for this problem. Final velocity can be calculated by:

$$(v_A)_2 = \frac{m_A}{(m_A + m_B)} \cdot (V_A)_1 \tag{15}$$

As a result of the concentration of mass at the midpoint of the beam, the model is similar to a damped vibration system with one degree of freedom (one degree of freedom damped vibrating system) as shown in Figure 2.9.

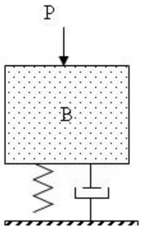

Figure 9: Damped vibration system with one degree of freedom

The principle of impulse and momentum for the above system is formulated as follows:

$$\int_0^{t_0} F(t)dt - \int_0^{t_0} kudt - \int_0^{t_0} cudt = (m_A + m_B)\cdot(v_A)_2 \quad (16)$$

Where t0 is the duration of impact. Because the impact is infinitsimal, it was found that the limit t0 close to zero as in the equation below. Function F (t) is assumed as the impulse - an average constant force acting during the time of impact as shown in figure 2.8. Containing integral damping and stiffness, for infinitesimal time, tends to zero. 2:17 So the equation becomes:

$$F_{ave}\cdot t_0 - 0 - 0 = (m_A + m_B)\cdot(v_A)_2$$

$$F_{ave} = \frac{(m_A + m_B)\cdot(v_A)_2}{t_0} \quad (17)$$

Substituting the final speed of the system (vA) 2 from equation 2:18, 2:16 into the equation yields:

$$F_{ave} = \frac{m_A(v_A)_2}{t_0} \quad (18)$$

Above equation has two unknowns, the average force and the time of impact. The impact can be sought from the LS-DYNA ANSYS software, so that force can be calculated using eq.18.

3.5 Impact Energy

Impact is a collision or a collision between two objects that occur within a very short time interval, during which the two bodies pressing each other with a relatively large force. In accordance with the above basic physics concepts, then the amount of energy which resulted in impact between the supply vessel and the platform is proportional to the change in kinetic energy from the supply vessel (Kenny, 1988).

The highest value of accidents due to collision energy will be absorbed by the installation, with a probability of occurrence for each platform 10-3 every year, which is 4 MJ. This value depends on the size of the vessel as described in formula (Kenny, 1988):

$$\text{Energy absorbed} = 0.5 + m^2(4.2\text{x}10^{-7} - 5.6\text{x}^{10\text{-}11}m)\ \text{MJ} \quad (19)$$

With: m = *displacement* of the impacting vessel (tonnes)

The usefulness of the vessel displacement relationship and the absorbed energy can account for operational differences between areas in the North Sea. Since the serious events that occur because of errors in judgment, the size of the vessel is the most important parameter. Weather conditions did not become important due to the hard collision and are usually not included in the count on the installation of energy absorbed as a result of impact events.

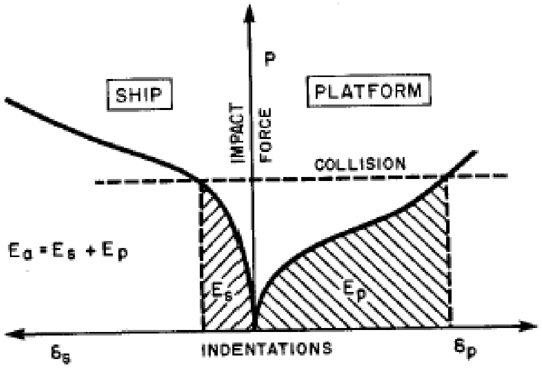

Figure.10 Tipical Energi Absorption (Kenny,1988)

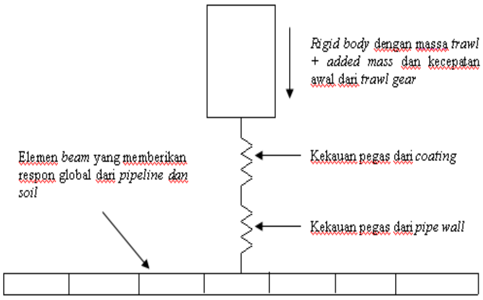

Figure.11 Schema simulation model

3.6 Accidental Impact Loading

Based on HSE, Load 2001, in cases where the stiffness of the impacted part of the Installation is very large in comparison to that of the impacting part of the vessel, as for example in collisions involving concrete Installations or fully grouted elements, the impact energy absorbed locally by the Installation may be very low and it is important to examine damage caused by the impact force.

In such cases, the impact force, F, may be taken as:

$$F = P_o \text{ or } V\sqrt{c\,a\,m} \quad (20)$$

Where
Po = the minimum crushing (or punching shear as appropriate) of the impacting part of the vessel and the impacted part of the installation (MN)
c = stiffness of the impacting part of the vessel (MN/m)
V = impact speed (m/s)
m = vessel displacement (kg)
a = vessel added mass coefficient
= 1.4 for sideway collision
= 1.1 for stern/bow collision

4.0 SHIP COLLISION SIMULATION

The steps to simulate the effect of the ship collision on jacket structure is shown in the Fig.12.

4.1 Landing Platform Modeling

Modelling geometry landing platform and pipe based on the scenario collision velocity data at Table.1.

Table.1 Scenario Velocity Collision (Kenny, 1988)

Impact Scenario	MSL		LWL		HWL	
	Normal Velocity (m/s)	Extreem Velocity (m/s)	Normal Velocity (m/s)	Extreem Velocity (m/s)	Normal Velocity (m/s)	Extreem Velocity (m/s)
Sideway Impact	0.28	0.54	0.28	0.54	0.28	0.54
Stern/Bow Impact	0.39	0.73	0.39	0.73	0.39	0.73

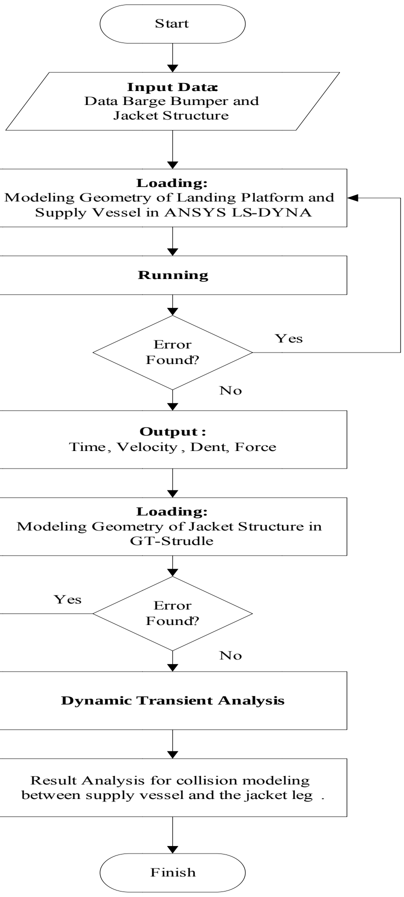

Figure 12: Flowchart of Research

Based on the data above then continue to modelling geometry in ANSYS LS-DYNA 9.0 version. Meshing model landing platform and vessel below:

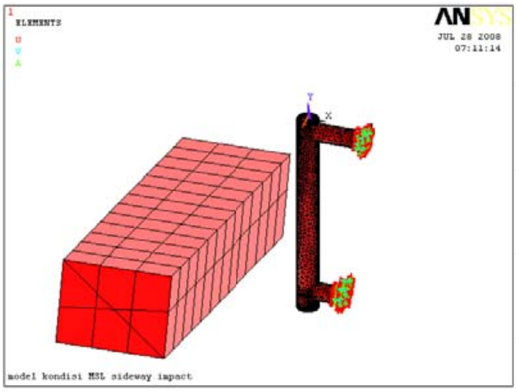

Figure 13: Meshing model landing platform and supply vessel.

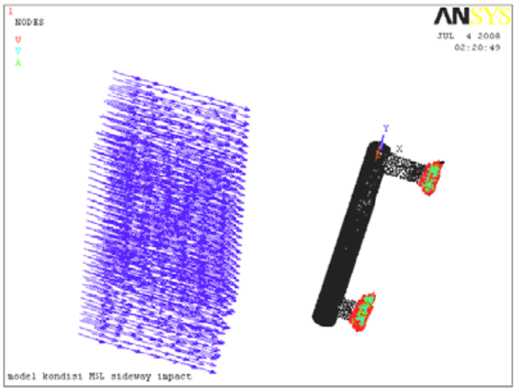

Figure 14: Specify Load when collision

4.2 Platform Structure Modeling

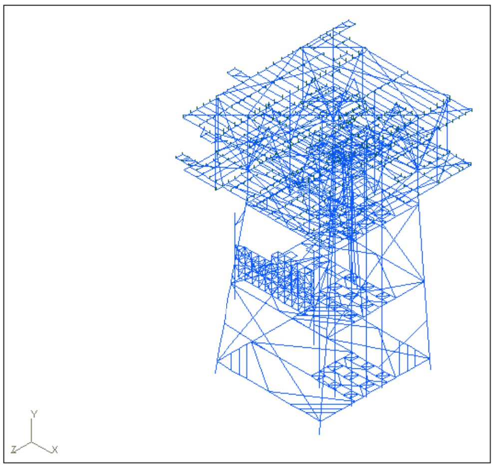

Figure 15: Model Line of Platform Structure.

5.0 RESULT AND DISCUSSION

5.1 The Landing Platform damage by Supply Vessel Collision

Based on modeling results obtained from ANSYS software dent depth for each model are:

General provisions of the jacket structure elements such as diagonal braces, horizontal braces, columns, and if the member had a large dent over 10% of outside diameter, then the elements must be repaired or replaced. Dent that occurred depth lies in the impact site, as shown in Figure 16 and Figure 17 and the dent is formed on the landing platform in Figure 18.

Table 2: Output of the dent depth ANSYS, voltage akipat Impact sideway collision conditions.

Scenario			Denting depth(m)	Extreem condition	Action
MSL	NORMAL	SIDEWAY	0.2027	Yes	Change
		STERN/BOW	0.2246	Yes	Change
	EXTREEM	SIDEWAY	0.2352	Yes	Change
		STERN/BOW	0.2725	Yes	Change
LWL	NORMAL	SIDEWAY	0.2027	Yes	Change
		STERN/BOW	0.2246	Yes	Change
	EXTREEM	SIDEWAY	0.2352	Yes	Change
		STERN/BOW	0.2027	Yes	Change
HWL	NORMAL	SIDEWAY	0.2725	Yes	Change
		STERN/BOW	0.2246	Yes	Change
	EXTREEM	SIDEWAY	0.2352	Yes	Change
		STERN/BOW	0.2725	Yes	Change

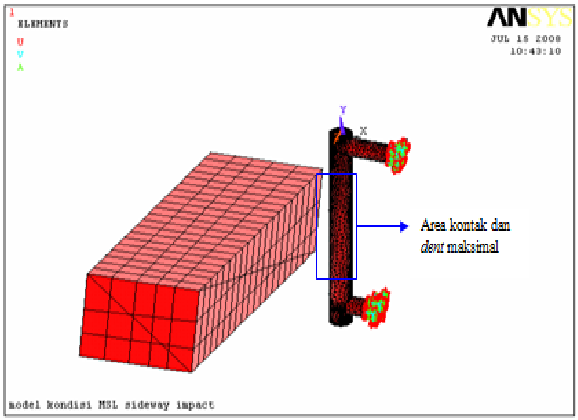

Figure 16: Location and contact area for maximum dent Impact sideway condition.

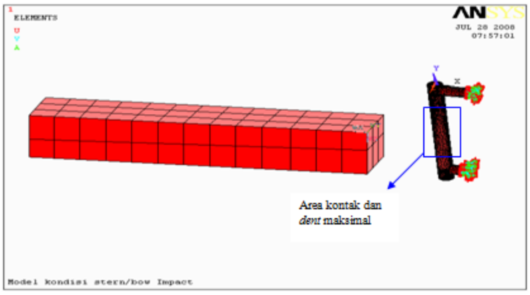

Figure 17: Location and contact area for maximum dent conditions Stern / Bow Impact.

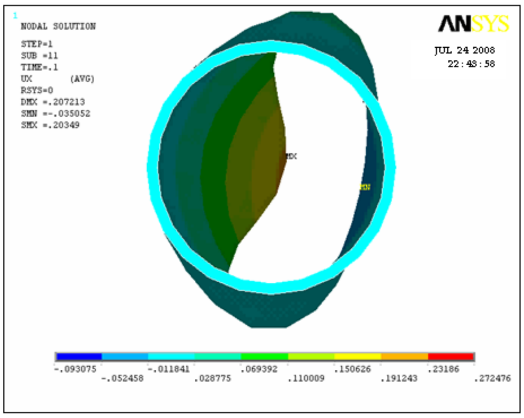

Figure 18: The maximum dent location (plan view x, y).

5.2 Response on Jacket Structure.

Based on the output of the GT-STRUDLE Software version 27.0, which occurred in the structure's response in this study on condition that can be considered to represent the HWL response structures. Jacket response that occurs in the load due to collision can be seen on the GT-STRUDL output version 27.0 as follows:

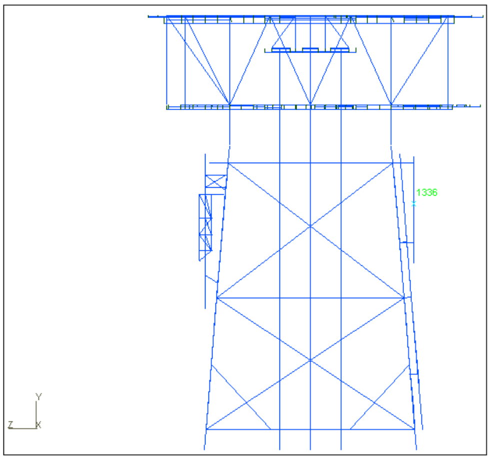

Figure 19: The location of the joint 1336 for HWL conditions (YZ plane).

Based on the output of dynamic analysis with the help of GT-STRUDLE Software version 27.0, which occurred in the structure's response in this study on the Impact sideway HWL conditions at speeds that exceeded 10% can be considered to represent the response of structures. Responses that occur in the Jacket due to impact load response can be seen in the following chart:

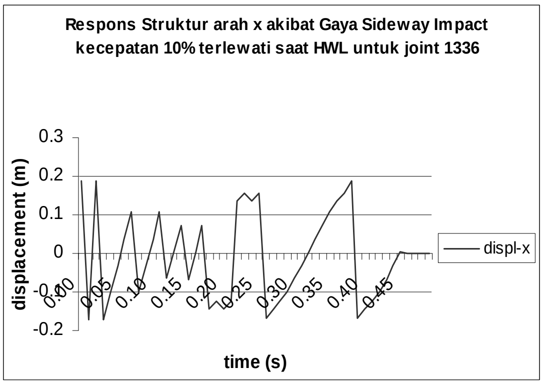

Figure 20: Response of the structure of the x-direction due to sideway style Impact conditions exceeded 10% at HWL.

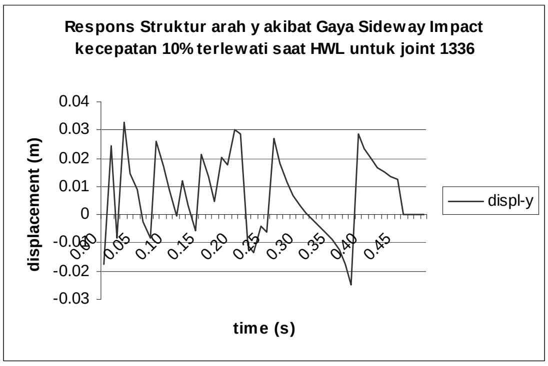

Figure 21: Response of the structure of the y-direction due to sideway style Impact conditions exceeded 10% at HWL.

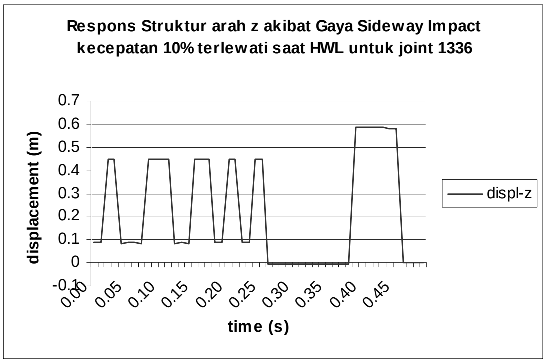

Figure 22: Response of the structure of the z-direction due to the style of the Stern / Bow Impact normal conditions when HWL.

Based on the API RP 2A WSD, the allowable value of unity check is less than 1:33 to extreme conditions and check the value of this research unty still meet the limit of API RP 2A-WSD, the structure is still safe. The following table shows the magnitude of unity check jacket structure:

Table 3: *Unity Check* untuk kondisi *Sideway Impact* HWL kecepatan 10% terlewati

CHORD	BRACE	JOINT	UNITY CHECK	REMARKS
JL-10	E15-1	635	0.4365	OK
JL-10	E15-2	635	0.5724	OK
JL-10	E15-3	635	0.4367	OK
JL-10	1767	635	0.2580	OK
JL-10	E15-3	635	0.2783	OK
JL-11	1767	635	0.4920	OK
JL-12	E50-2	809	0.1198	OK
JL-12	1472	809	0.7567	OK
JL-12	E50-104	809	0.6277	OK
JL-12	E50-2	809	0.2857	OK
JL-12	1472	809	0.3048	OK
JL-12	E50-104	809	0.2847	OK
JL-13	E50-2	809	0.8359	OK
JL-13	1472	809	0.7567	OK
JL-13	E50-2	809	0.2857	OK
JL-13	1472	809	0.3048	OK
JL-15	1741	1042	0.4089	OK
JL-16	E17-2	728	0.8350	OK
JL-16	E17-9	728	0.4900	OK
JL-16	1478	728	0.5327	OK
JL-16	1766	728	0.8108	OK
1136	1473	1336	1.2160	OK

Table 4: Unity Check for conditions Stern / Bow Impact HWL speed exceeded 10%.

CHORD	BRACE	JOINT	UNITY CHECK	REMARKS
JL-10	E15-1	635	0.4515	OK
JL-10	E15-2	635	0.5874	OK
JL-10	E15-3	635	0.4517	OK
JL-10	1767	635	0.2730	OK
JL-10	E15-3	635	0.2933	OK
JL-11	1767	635	0.5070	OK
JL-12	E50-2	809	0.1348	OK
JL-12	1472	809	0.7717	OK
JL-12	E50-104	809	0.6427	OK
JL-12	E50-2	809	0.3007	OK
JL-12	1472	809	0.3198	OK
JL-12	E50-104	809	0.2997	OK
JL-13	E50-2	809	0.8509	OK
JL-13	1472	809	0.7717	OK
JL-13	E50-2	809	0.3007	OK
JL-13	1472	809	0.3198	OK
JL-15	1741	1042	0.4239	OK
JL-16	E17-2	728	0.8500	OK
JL-16	E17-9	728	0.5050	OK
JL-16	1478	728	0.5477	OK
JL-16	1766	728	0.8258	OK
1136	1473	1336	1.1341	OK

5.3 Validation results of the ANSYS Modeling

Calculation of the dent and the Impact force is highly dependent on the configuration parameters and the data type of the supply vessel and the mechanical material landing platform (a pipe). Mechanical properties of the material landing platform in Table 5 as follows:

Table 5: Mechanical properties of the material landing platform.

DESCRIPTION	**Values**	**UNIT**
PIPE NOMINAL O.D.	36	inch
PIPE NOMINAL O.D.	914.4	mm
WALL THICKNESS	38.1	mm
STEEL PIPE D/t RATIO	24	-
STEEL YIELD STRESS	448	Mpa
YOUNG MODULUS	207	GPa

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Table 6: Model validation results of the ANSYS LS-DYNA

Scenario			Force (N)	Force (N)	
			HSE 2000	ANSYS	Error (%)
MSL	NORMAL	*SIDEWAY*	317275000	131248250	0.5863
		STERN/BOW	36786750	44021600	0.1967
	10% EXEEDED	*SIDEWAY*	843750000	172872000	0.7951
		STERN/BOW	1082944954	44021600	0.9594
LWL	NORMAL	*SIDEWAY*	317275000	131248250	0.5863
		STERN/BOW	36786750	44021600	0.1967
	10% EXEEDED	*SIDEWAY*	1082944954	172872000	0.8404
		STERN/BOW	317275000	279346200	0.1195
HWL	NORMAL	*SIDEWAY*	317275000	131248250	0.5863
		STERN/BOW	36786750	44021600	0.1967
	10% EXEEDED	*SIDEWAY*	1082944954	172872000	0.8404
		STERN/BOW	317275000	4733333	0.9851

6.0 CONCLUSION

After analyzing the local structure and global structure of the jacket can be concluded that:Bentuk *dent* yang terjadi adalah *ellips* untuk 2 kondisi, yaitu:

1. Speed Sideway normal punches have a minimum depth of 0.2027 m, while the collision Stern / Bow has a minimum depth of 0.2246 m.
2. Speed of 10% exceeded the minimum depth Sideway punches 0.2352 m, while the collision Stern / Bow has a minimum depth of 0.2725 m.Respons struktur akibat beban benturan yaitu:
3. Maximum Displacement occurs in the direction of x is 0.2423 meters at the 0:38 second.
4. Maximum Displacement occurs in the y direction is 0.0559 meters at the 0:39 second.
5. Maximum Displacement occurs in the direction of z is 0.7492 meters in 0:41 seconds
6. Check that produced the Great Unity of more than 1 but still within the limits of tolerance for extreme conditions that is equal to 1:33.

Predictions are used in this study in a safe condition as:

1. In the local analysis of the structure, the energy is absorbed entirely by the landing platform
2. In the global analysis of the structure, the energy is absorbed entirely by the global structure of the Jacket.

Thus, the deformation that occurs in the structure of the landing platform and Jacket is actually smaller than the results of the study

7.0 RECOMMENDATION

1. Further research needs to be held simultaneously with the modeling to account for the attenuation received by the local

structure of the components of the landing platform and the overall structure of the Jacket.

2. Further research needs to be held simultaneously with the modeling that can calculate the percentage of energy absorbed Jacket structures and supply vessel.

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