

OBJECTIVE AND SCOPE

The objective is to investigate the damages caused by supply vessel impacts on a jacket platform. Both structural integrity and damage to critical elements such as risers and conductors shall be analyzed.

In this thesis, potential collision scenarios shall be identified and local NLFEA shall be carried out with the structural OSV-models from DNVGL-RPC208. The force-deformation behaviour of the ship shall be used as input into global analyses in USFOS. The jacket behavior in LS-DYNA and USFOS shall be compared. Furthermore, a residual strength check of the damaged jacket shall be carried out in USFOS with a 100-year wave.

INTRODUCTION

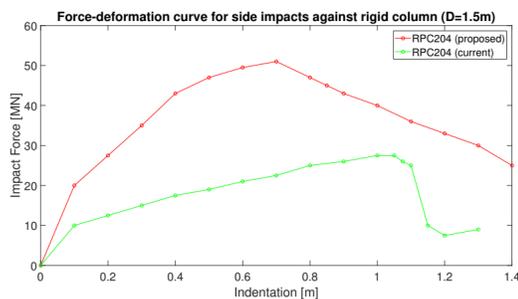
Larger ships and modern ship design have increased the need for an update of the requirements regarding ship collisions for offshore structures. From a structural point of view it is desirable to study the energy dissipation between the platform and the striking ship and NLFEA-tools like LS-DYNA has made this study possible. In 2016 a JIP developed standard bow-, side - and stern models of OSVs for collision analyses [2]. In this thesis a jacket platform will be analyzed in both LS-DYNA and USFOS according to new collision requirements and with the new standard ship models.

THEORY

The kinetic energy E_k of a striking ship is

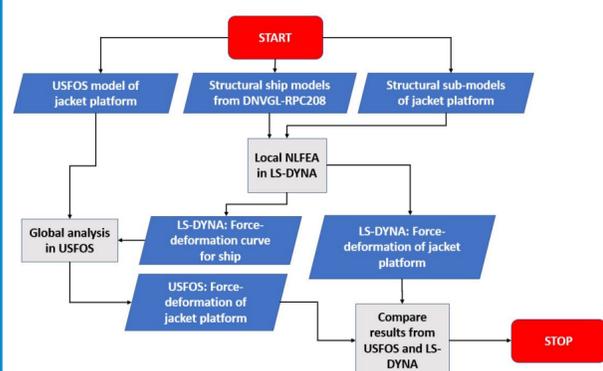
$$E_k = \frac{1}{2} (m_s + a_s) v_s^2$$

where m_s is the displacement, v_s is the speed and a_s is the added mass ($0.4m_s$ for side impact and $0.1m_s$ for stern - and bow impacts) [3]. A jacket platform is a fixed structure, which means that almost the entire kinetic energy of the striking ship is converted into deformation energy during the collision [4]. Both the striking ship and the struck jacket will contribute to the energy dissipation, even though the softest structure will undergo the largest deformations. The figure below compare the current - and proposed force-deformation curves for side-impacts against a rigid cylinders with diameter $D=1.5m$.



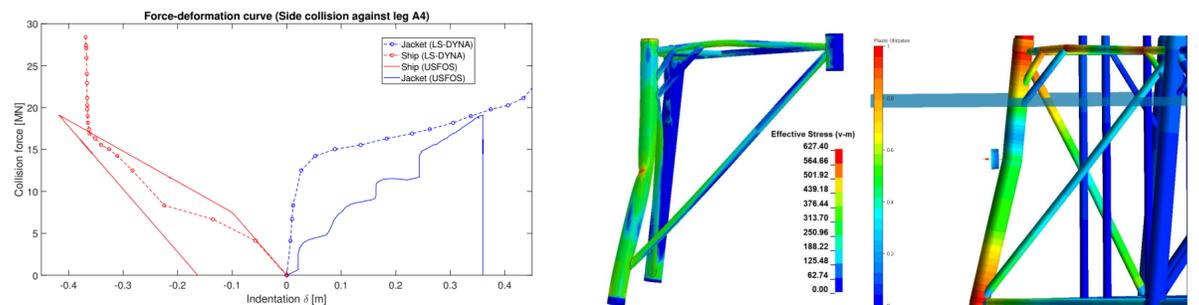
The area under each curve represents the deformation energy and it can be seen that modern geometry and larger vessel size have a major impact on the energy requirements regarding ship collisions.

METHOD



RESULTS

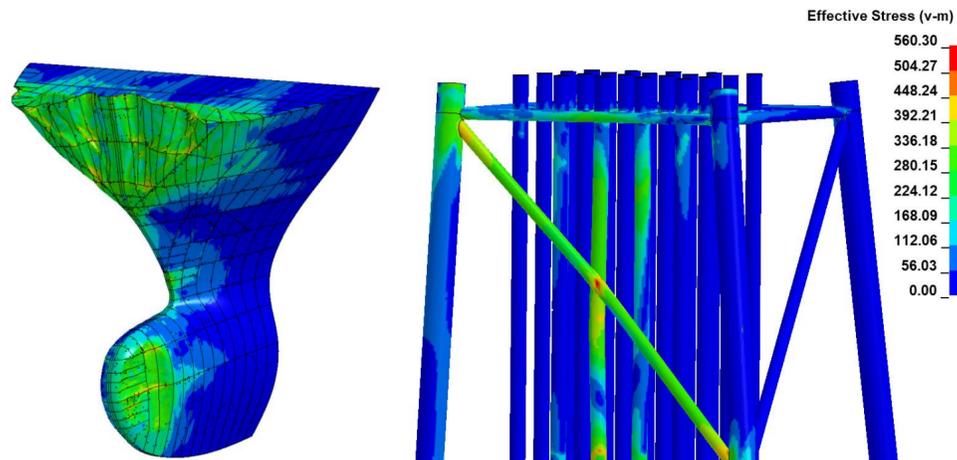
SIDE COLLISION AGAINST JACKET LEG: A side collision with a ship of 7500 tonnes in 2m/s corresponds to a collision energy of 21MJ. The jacket leg has a diameter of 1.46m. A comparison between the force-deformation curves obtained with USFOS and LS-DYNA are shown in the Figure below to the left. The dotted lines are from LS-DYNA and the red solid line is the force-deformation curve for the ship used as input in USFOS. The high slope at the end of the red-dotted line is caused by membrane forces in the side model. The force-deformation curve of the jacket obtained with USFOS was lower than the curve obtained with LS-DYNA. However, in a jacket platform forces is transferred from a struck member to adjacent members and deformations might occur in other braces. For further work it would have been desirable to perform NLFEA on a larger sub-model of the jacket. The energy dissipation in ship and jacket platform was 15.38MJ and 5.48MJ, respectively. A comparison of the jacket response obtained with LS-DYNA and USFOS can be seen in the figure below to the right. A residual strength check showed that the jacket platform was able to resist a 100-year wave (Stokes 5th order wave with T_p 14 sec. and H_S 25m) in damaged condition. Both dynamic - and static analyses were performed in USFOS and it was concluded that the dynamic effects were small.



BOW COLLISION AGAINST CONDUCTORS: A bow collision with a ship of 7500 tonnes in 3m/s corresponds to a collision energy of 37MJ. The objective was to investigate potential damage to the conductors. The conductors have a diameter and thickness of 660mm and 48mm, respectively and according to the compactness criteria

$$f_y t^2 \sqrt{D/t} \geq \frac{8}{3} \left(\frac{M_p}{l} \right) c_1$$

where f_y is the yield strength, M_p is the plastic moment capacity, l is the length and c_1 is a factor which depends on the boundary conditions, denting can be disregarded [5]. The bow hit the conductors with the forecastle above - and the bulb under a diagonal in front of the conductor area. Most of the collision energy (30MJ) was dissipated as deformation energy in the forecastle (see figure below). The remaining energy ($\sim 7MJ$) was mainly dissipated by the diagonal in front of the conductor area while the conductors only suffered minor global damages. In damaged condition the jacket survived the residual strength check.



CONCLUSION

Regarding the structural jacket sub-models some inaccuracies must be mentioned: Joint cans - and braces was not modelled due to difficulties and complex geometry. It was also difficult to model the riser clamps with appropriate boundary conditions. Despite these inaccuracies, reasonable force-deformation behavior of the ship was obtained from LS-DYNA and there were many similarities with the jacket response simulated in LS-DYNA and USFOS. Furthermore, a comparison between static - and dynamic analyses in USFOS showed that dynamic effects are small and static analyses are suitable, with respect to computational time. Global analyses in USFOS showed that the structural integrity of the jacket was maintained even though local NLFEA in LS-DYNA showed that the ship was able to perform damages to critical elements during the impact.

ACKNOWLEDGEMENTS

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ABBREVIATIONS

- JIP - joint industry project
- NLFEA - nonlinear finite element analysis
- OSV - offshore supply vessel
- T_p - peak period
- H_S - significant wave height

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- [5] Storheim, Martin. Structural response in ship-platform and ship-ice collisions (2015) Doctoral thesis, NTNU