Collision Study of Rigid Ships with a Deformable Offshore Wind Turbine Jacket Structure

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CHARGEOL Project

- Project for the foundations of renewable marine energy.

Focus of study:

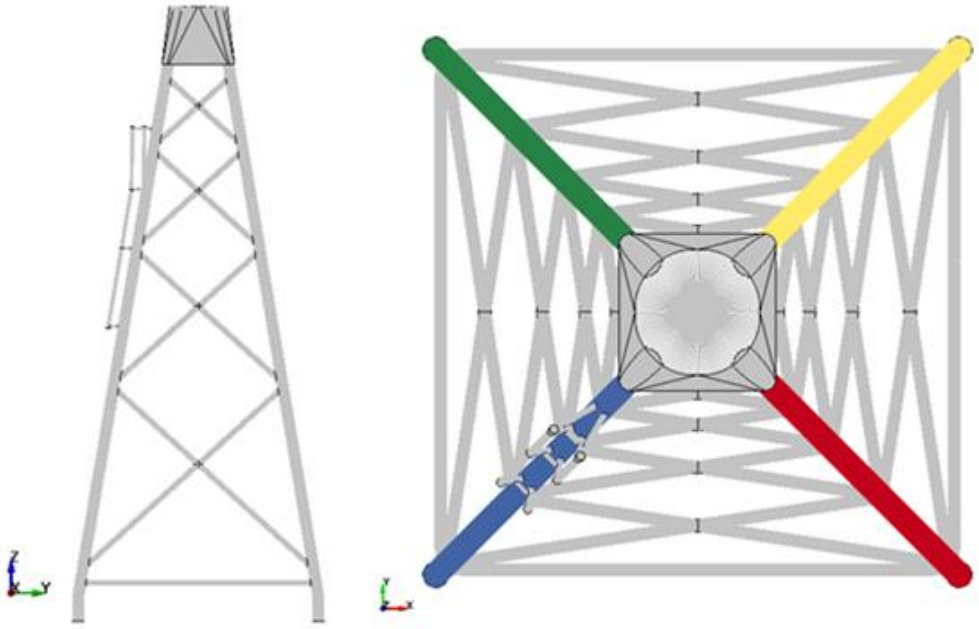
- Risk of Collision.
- Understanding seabed behavior.
- Scouring issues.
- Better understanding of load response of the structures.

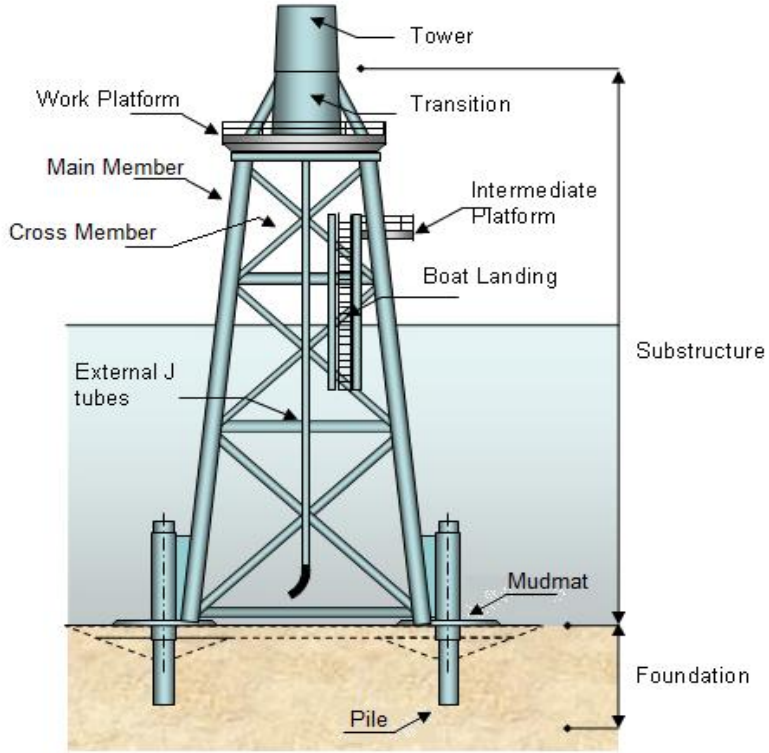
Objectives

- General:
  - Develop Numerical Basis for the Simplified Calculation Tool.
- Specific:
  - Characterizing the sensitivity of the jacket to:
    - Gravity Loads/Tower
    - Ship Type
    - Velocity/Collision Angle/Impact height
  - Determine Resultant Force Distribution
  - Comparison to simplified calculation tool

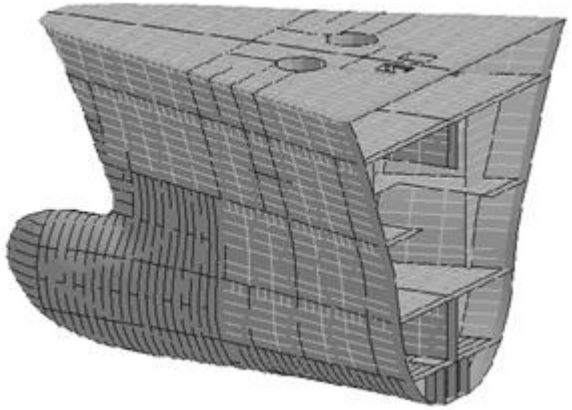
Offshore Wind Turbine Jacket

- Latticed Steel Structure.
- Developed from Oil and Gas Industry.
- Used in renewable wind industry up to depths of 45 m.
- Lower production costs than monopile structures.
- Weakness in welded nodes.





Ship Models



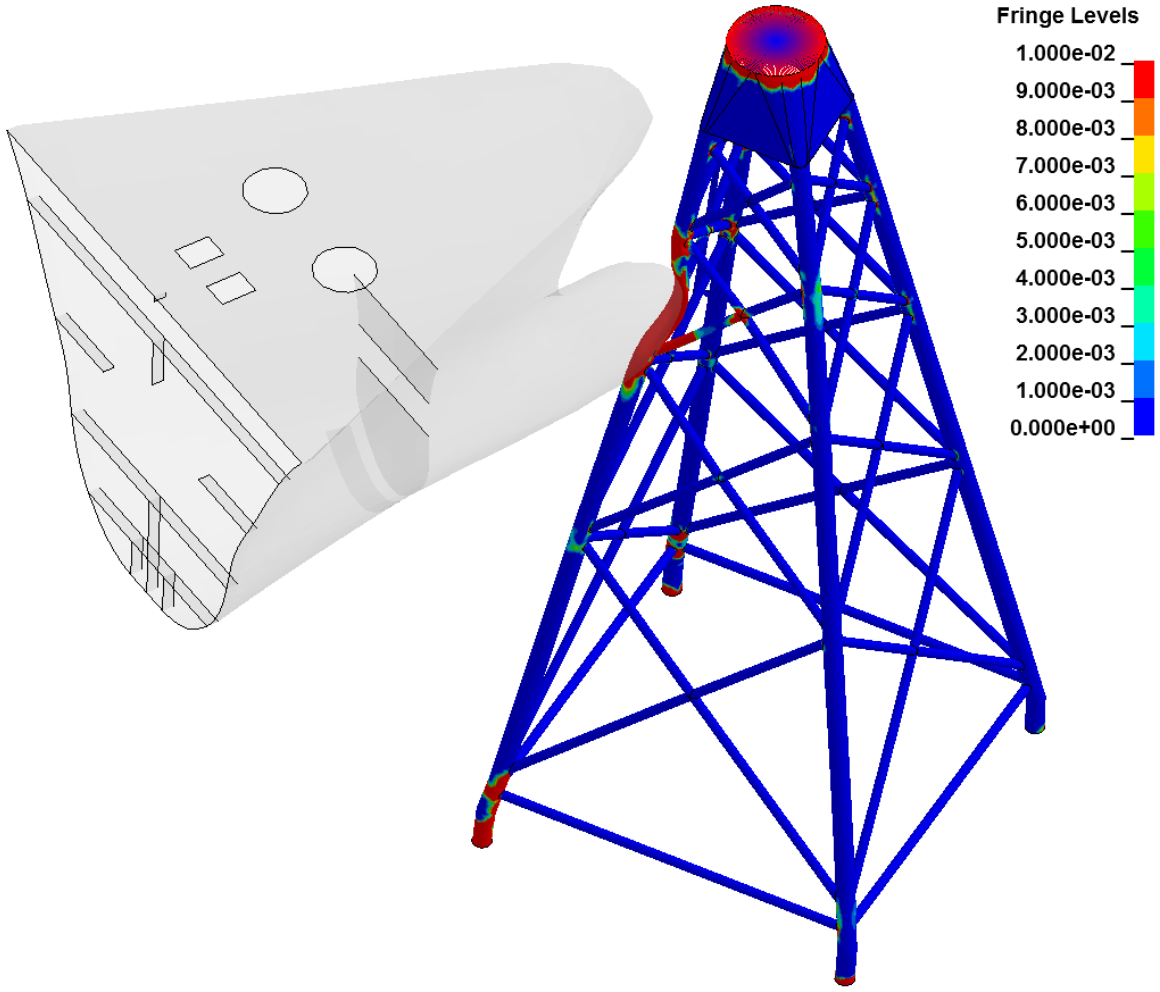
Displacement: 132797 tons
Added Mass: 6639 tons

Displacement: 5000 tons
Added Mass: 250 tons

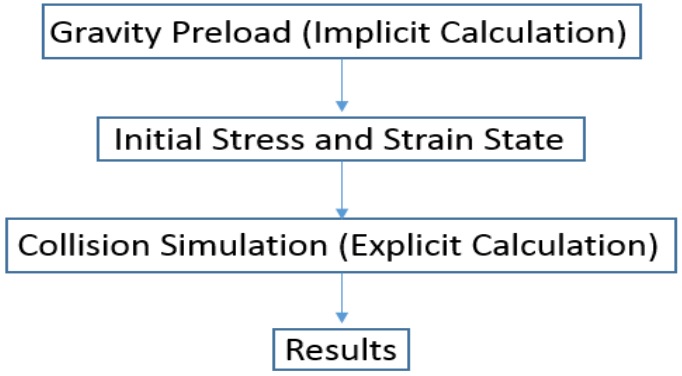
SIMULATIONS CARRIED OUT

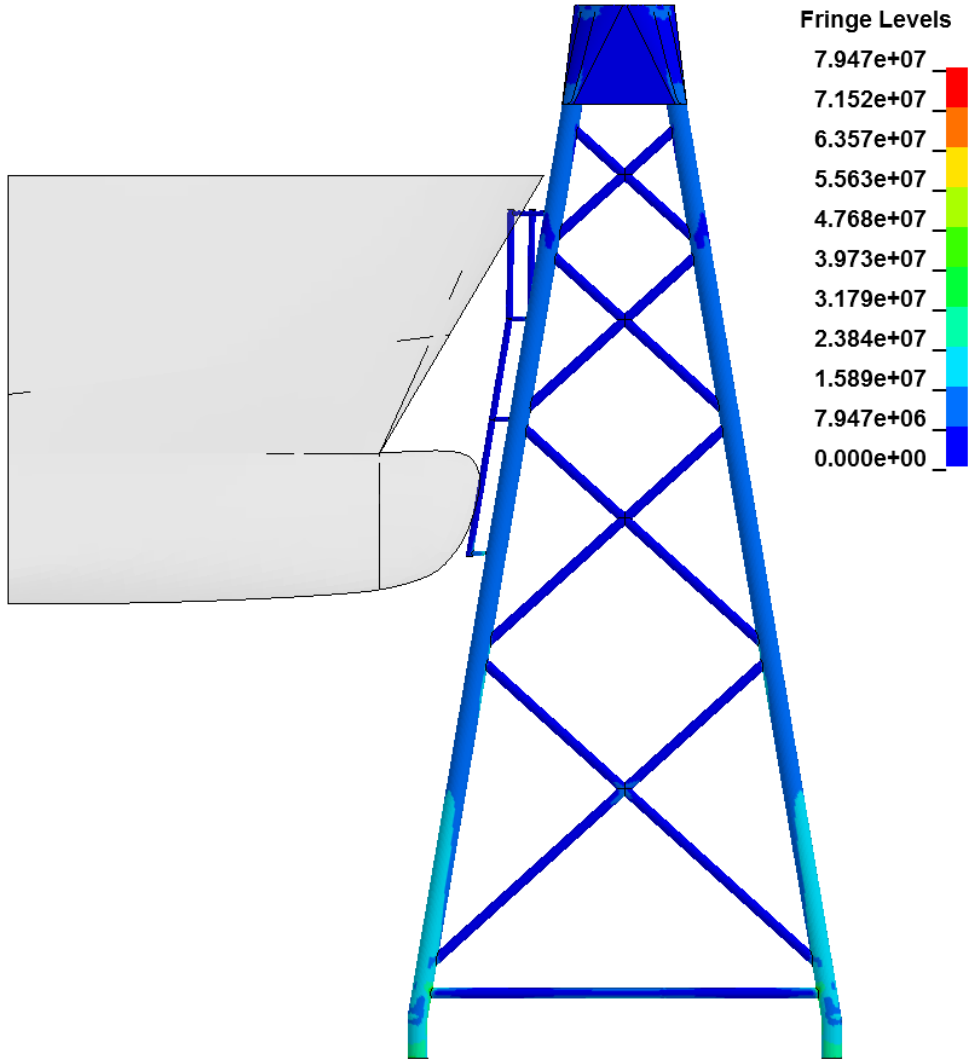
Crude Oil Carrier Simulations

- 6 simulations.
- Sensitivity of the structure to variation in impact location (leg-brace joint), speed and angle.



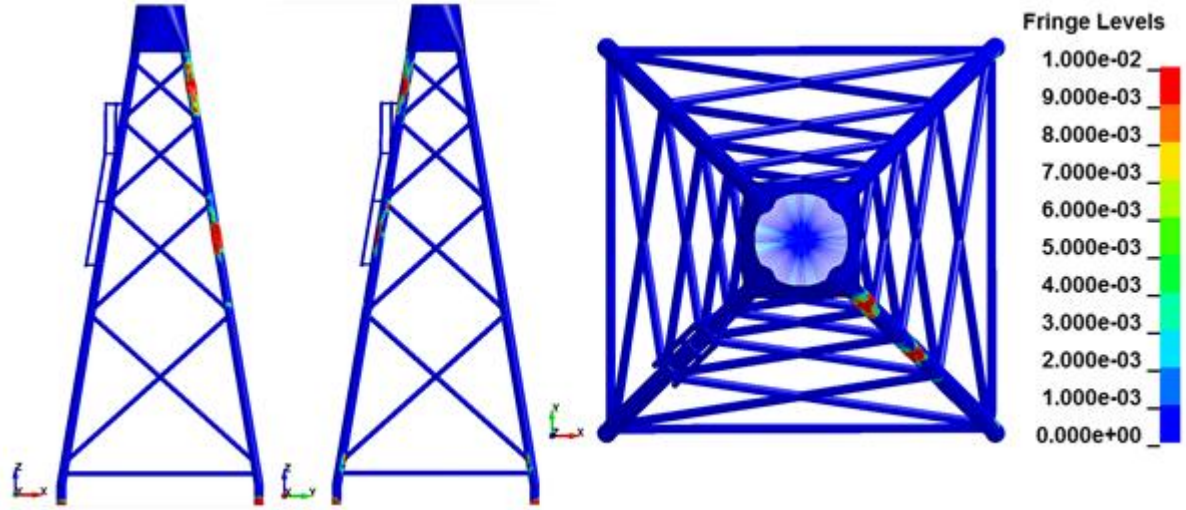
- Sensitivity to Gravity Loads
  - 2 m/s and 6 m/s simulations performed.
- Determination of Critical Scenario (Leg-Brace Joint).
- Sensitivity to OWT Tower
  - Leg Collision 6 m/s with tower
- Study of Resultant Force Transmission
  - Leg Collision, single impact location 6 m/s
- Comparison with Simplified Calculation Tool
  - Leg Collision, single impact location 2 m/s



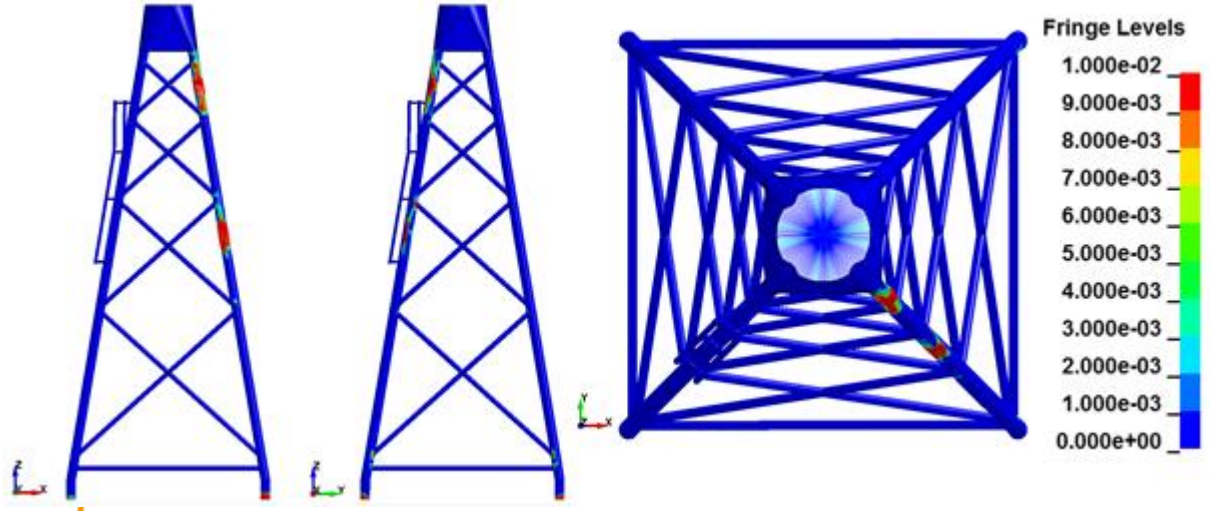


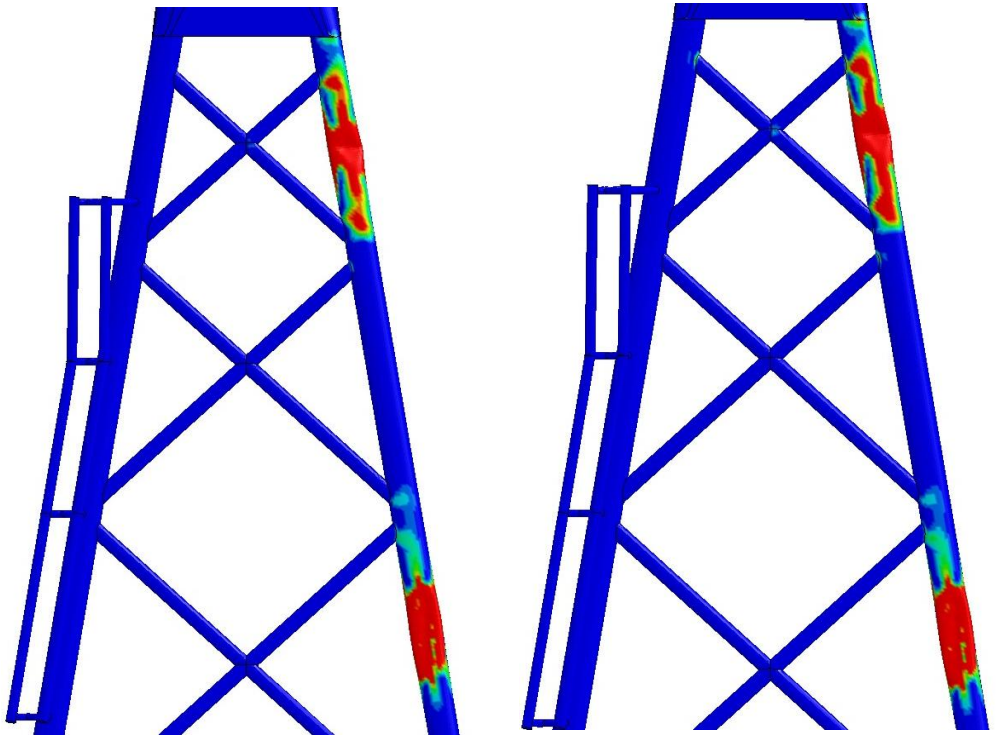
Sensitivity to Gravity Loads

2 m/s Without Gravity Loads



2 m/s With Gravity Loads





Without Gravity

Gravity Loads

icam

EMship Advanced Design

Université de Liège

ECN Centrale Nantes

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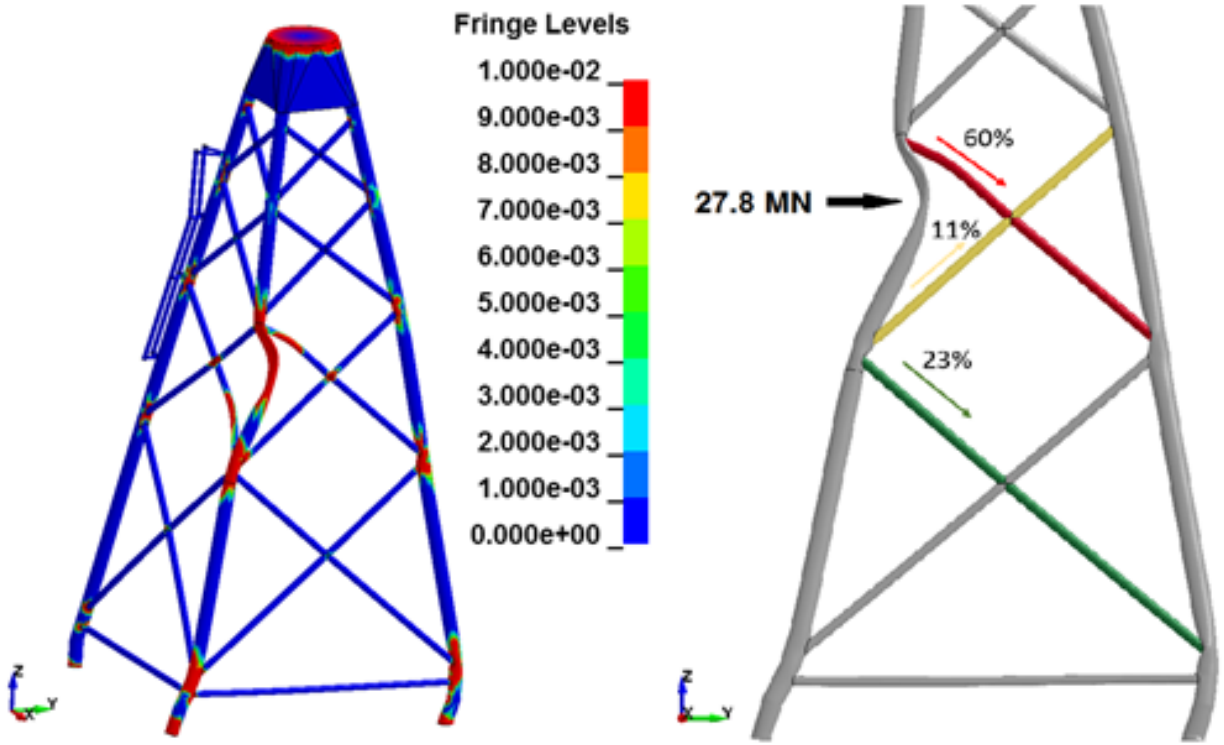
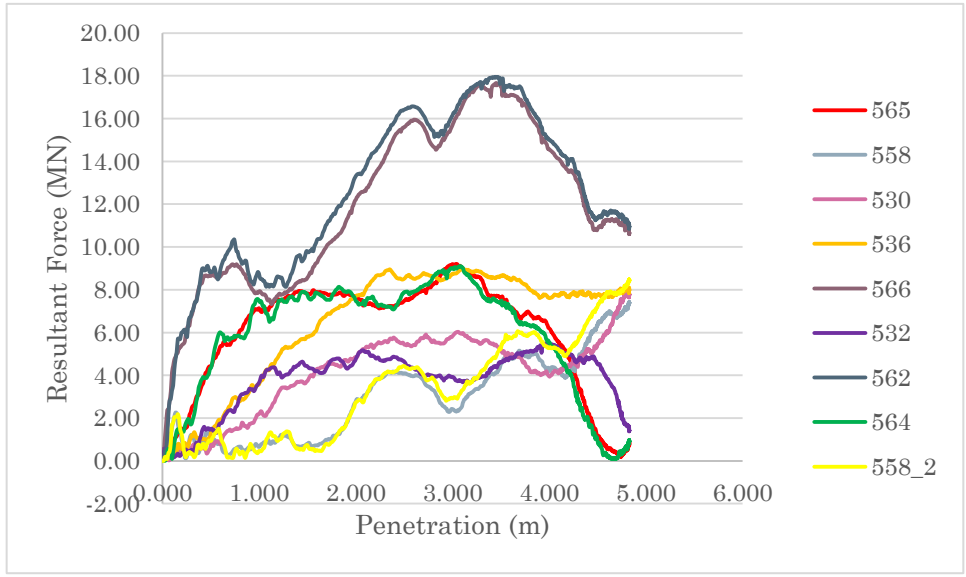
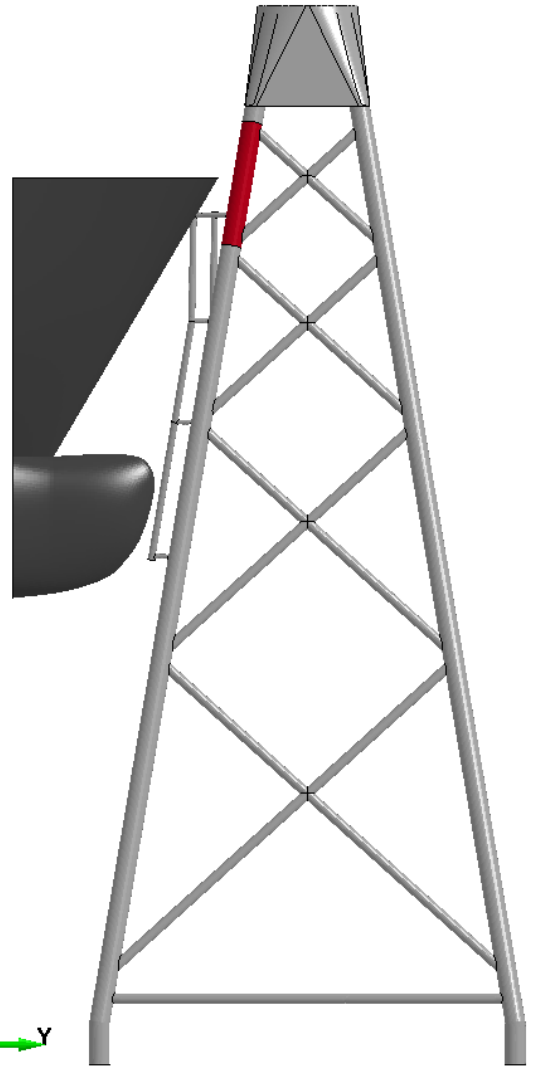
Resultant Force Transmission

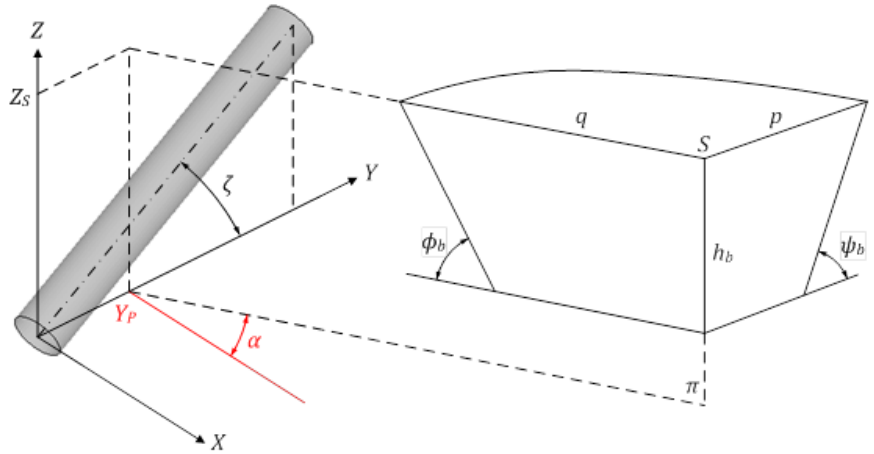


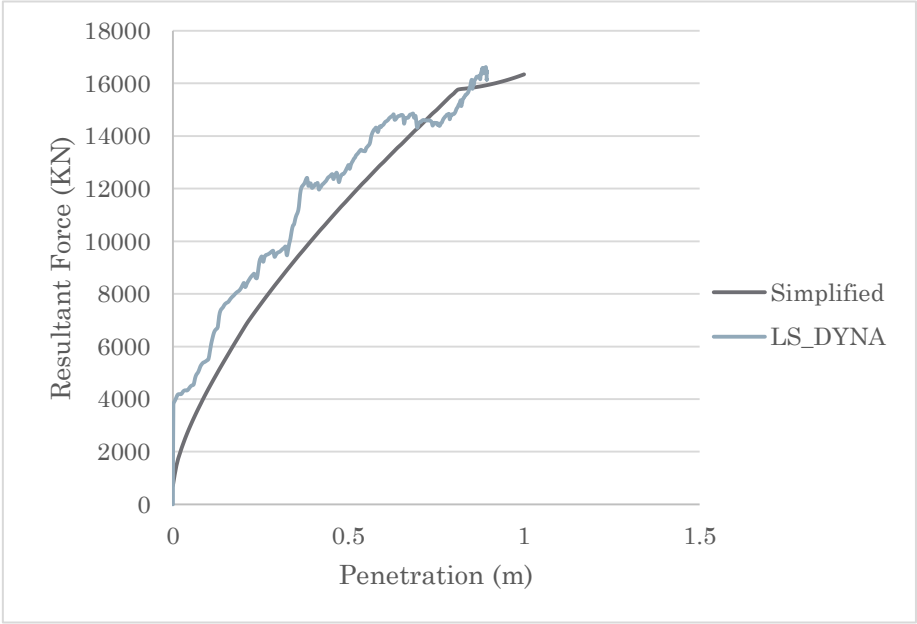


Simplified Tool Comparison

- 2 m/s leg section single impact point







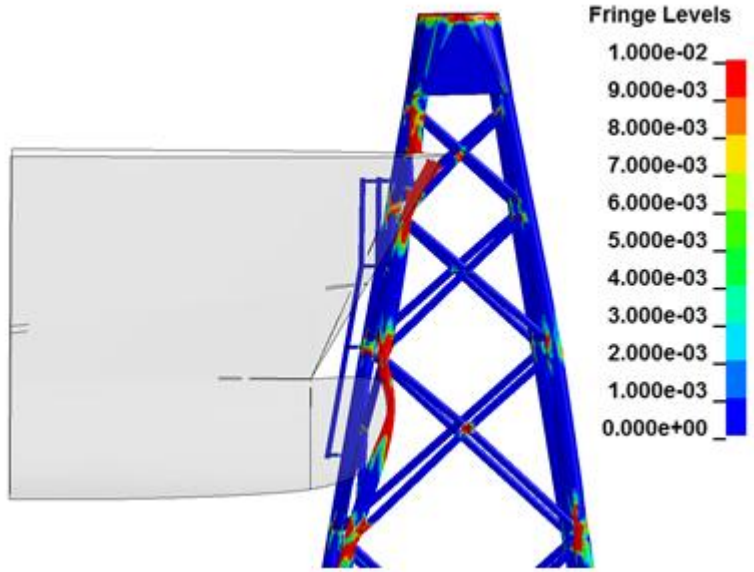
Conclusions I

- High Energy (Tanker):
  - High energy collisions at brace joint are sensitive to variation in collision angle.
  - Leg impact is more detrimental to jacket in high energy scenarios.

Conclusions II

- OSV Simulations
  - Leg impact more detrimental to jacket.
  - High sensitivity to collision angle; initial rupture of leg at 2 m/s.

  - Gravity loads did not affect shock response of structure at 2 and 6 m/s.
  - Coupling between the tower, platform and transition piece cannot be simplified.
  - Legs are more sensitive to local deformation than braces are to bending or buckling failure.
  - Up to penetration of 0,58 m, simplified tool in accordance with simulation, error for internal energy and crushing force below 20%.



Further Work

- Better definition of connectivity between the OWT tower, the platform, transition piece and jacket.
- Additional OSV simulations varying collision height and impact location.
- Additional comparisons to simplified tool with different velocities, impacting ship section geometries (leg and stem).
- Simulations that account for soil/structure interaction.
- Detailed study of buckling of braces for analytical tool.