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

Andres Barrera
La Spezia, Italy
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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
Resultant Force Transmission

Fringe Levels

27.8 MN

Resultant Force (MN)

Penetration (m)

565

558

530

536

566

532

562

564

558_2
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.