Analytical developments to assess the crashworthiness of an offshore wind turbine jacket impacted by a ship

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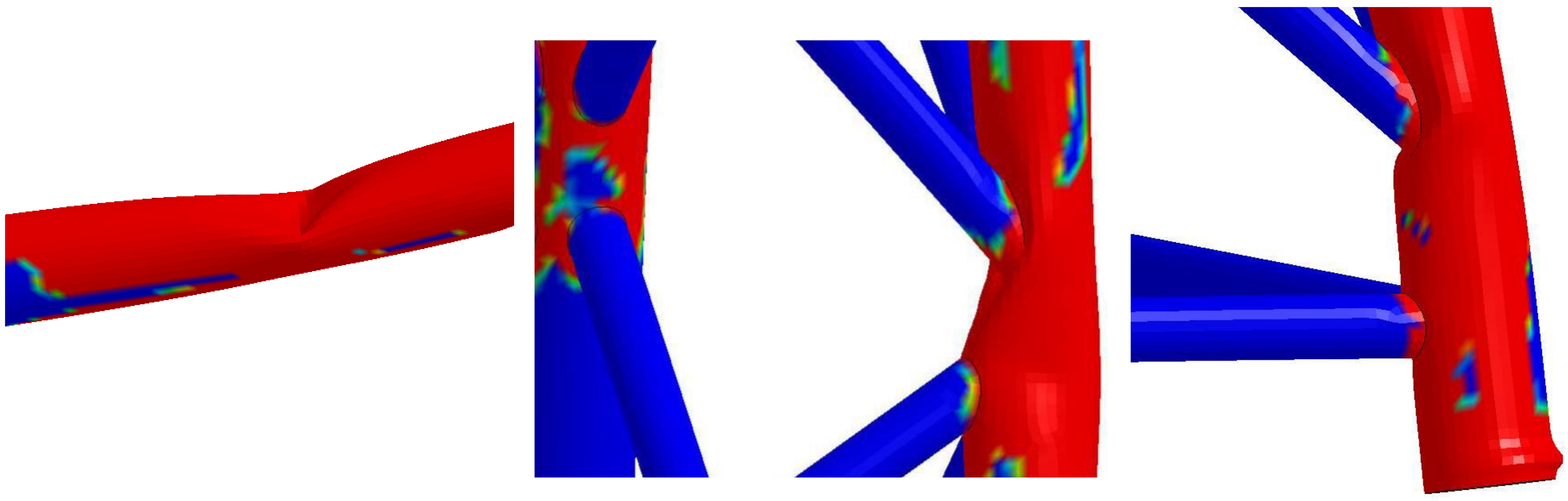
As the number of offshore wind farms is constantly increasing, impacts between ships and wind turbines is becoming a major concern. Nowadays, design offices use finite elements simulations to assess the crashworthiness of offshore supporting structures, which give accurate results but is time demanding. There is therefore a need for a faster method, especially during the pre-design stage. The purpose of this research is to develop analytical formulations, based on the so-called continuous elements method in order to compute the resistance of offshore wind turbine jackets when submitted to an impact.

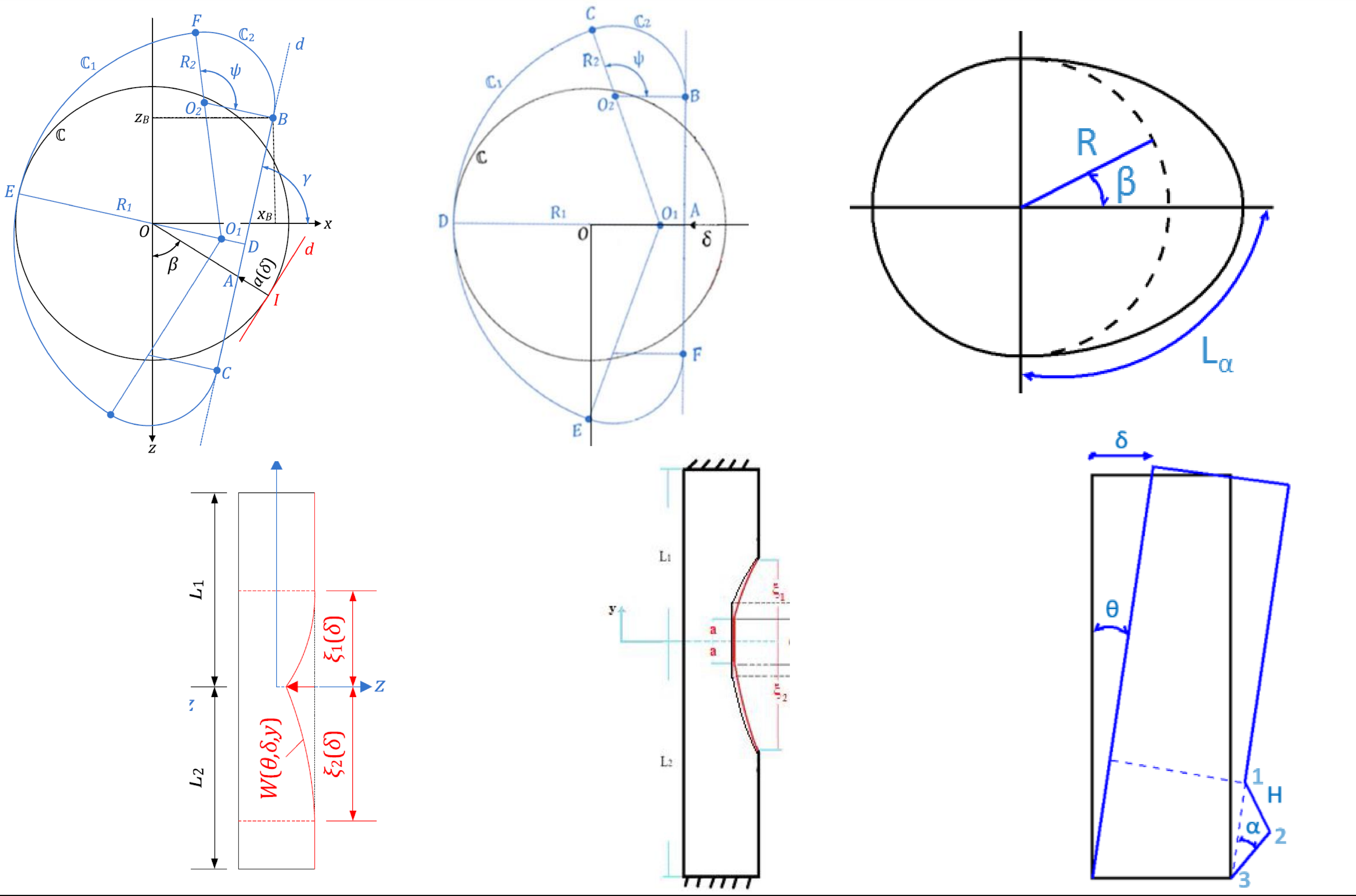
Deformation modes

Finite elements simulations are performed in order to identify the main deformation modes, namely:

- Crushing of impacted elements
- Punching of legs by compressed braces
- Buckling of compressed legs



Analytical developments



The resistance in the three considered deformation modes is computed using the upper-bound theorem that states that:

$$F \cdot \dot{\delta} = \iiint_V \sigma_{ij} \cdot \dot{\epsilon}_{ij} \cdot dV = \dot{E}_{int}$$

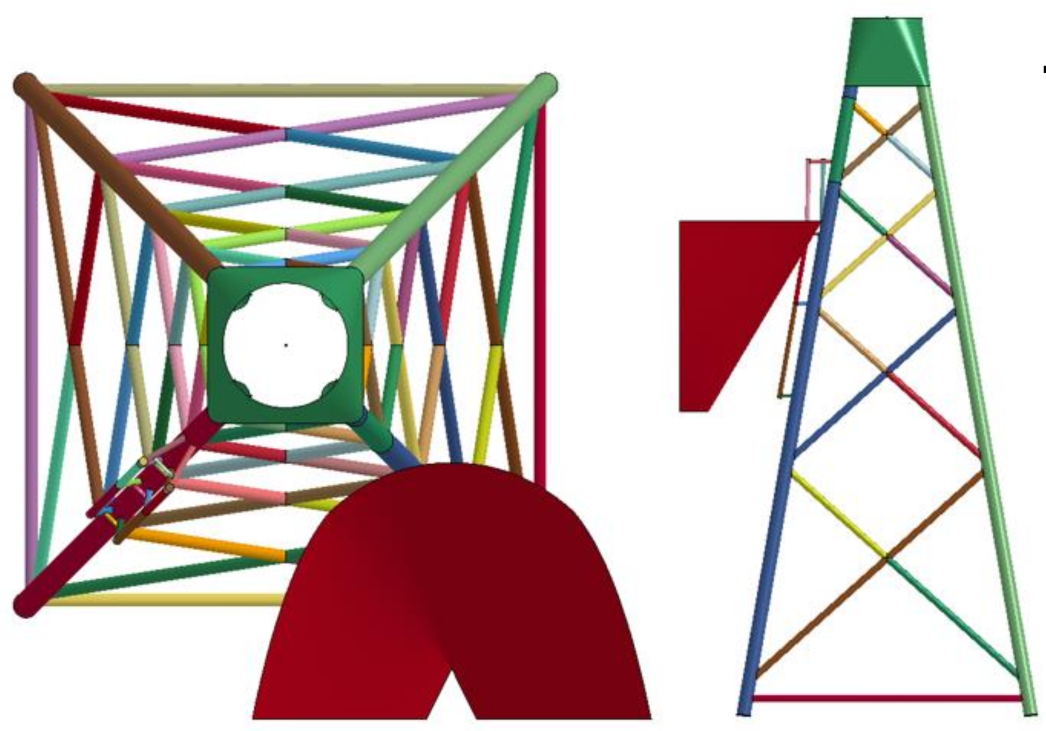
with $\dot{\delta}$ is the striking ship surge velocity,
σ_{ij} is the stress tensor of the structure,
$\dot{\epsilon}_{ij}$ is the strain rate tensor.

Assumptions on the deformation patterns have to be performed to apply this theorem.

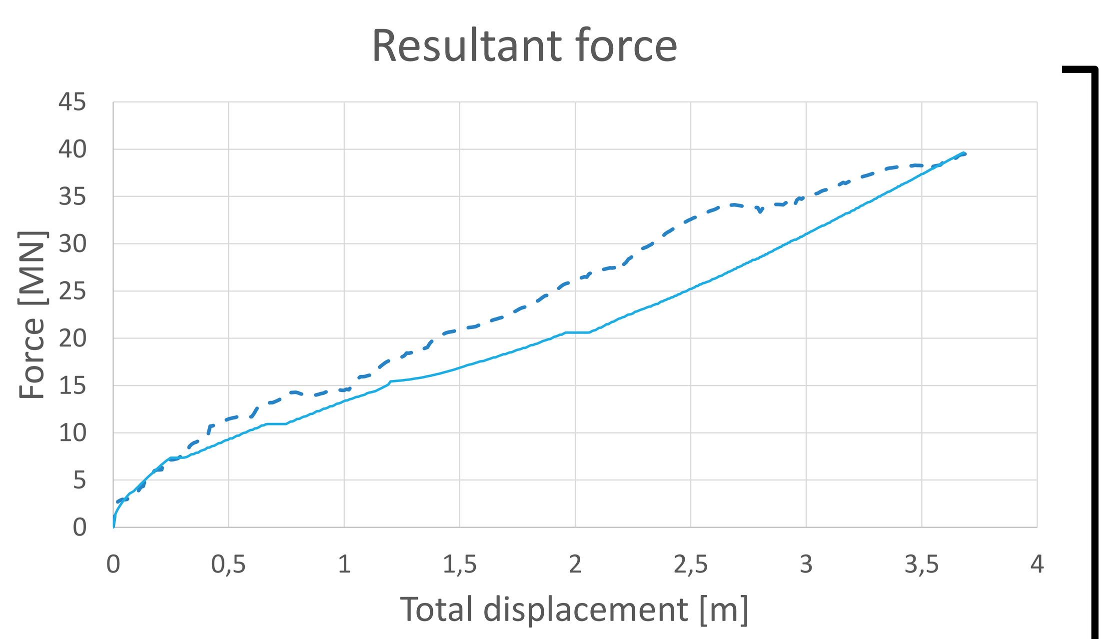
Application

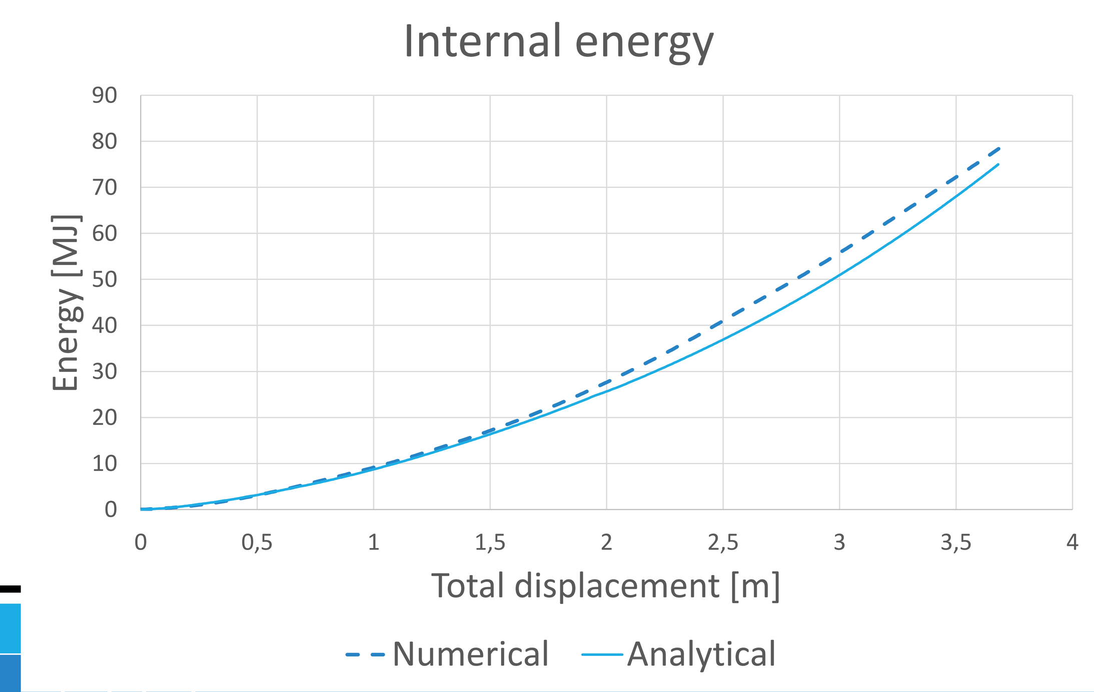
At each time step, the resistant force is computed for each deformation mode. The total crushing force is then considered as the lowest one.

The methodology described above is applied in the case of an OSV colliding a OWT jacket.



Jacket		Rigid non-bulbous OSV	
Height [m]	56		
Bottom width [m]	20	Weight [T]	6000
Top width [m]	8	v_{init} [m/s]	5





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