Presentation of an algorithm to assess the crashworthiness of an offshore wind turbine jacket using analytical formulations

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1. Introduction

In a context of ecological issues, renewable energy systems are developed and enhanced and, amongst them, offshore wind energy. Many wind farm projects will be carried out in the near future and their locations are closer and closer to traffic lanes. For safety, ecologic or economic reasons, it is required to perform a collision risk analysis for each new offshore structure.

Finite elements softwares, widely used actually, provide accurate results but are time-demanding and not suitable for a first design stage. A faster analytical method, based on the plastic limit analysis, is developed by the authors to compute the resistance of an offshore wind turbine jacket when collided by a ship.

This poster presents the methodology used to develop an analytical method to compute the crashworthiness of jackets. Then, some results are given and compared to numerical simulations to validate the model.

2. Analytical developments

Using numerical simulations, the main deformation modes of the collided jacket were identified. Those are:

- Overall motion of the whole structure (Fig. 1)
- Crushing of the impacted cylinder (Fig. 2)
- Punching of legs by compressed braces (Fig. 3)
- Deformation at the base of the structure (Fig. 4)

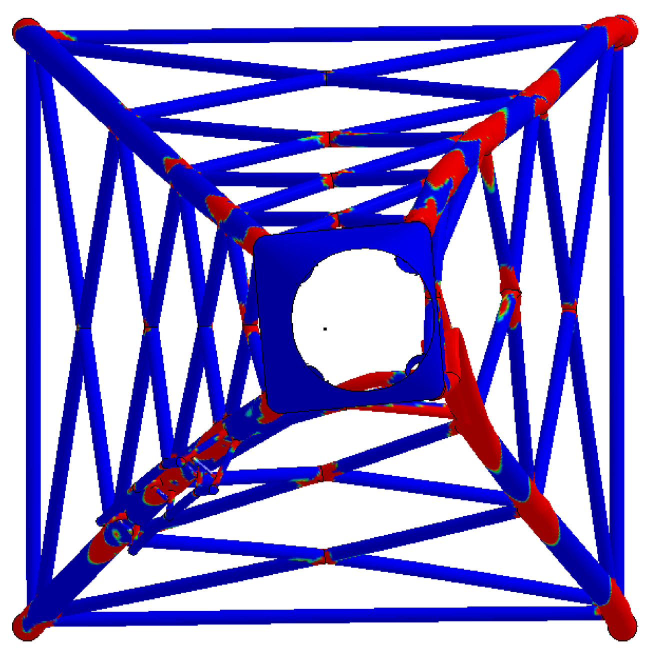


Fig. 1

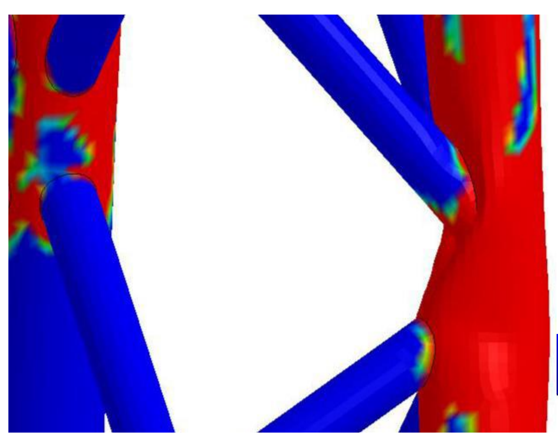


Fig. 3

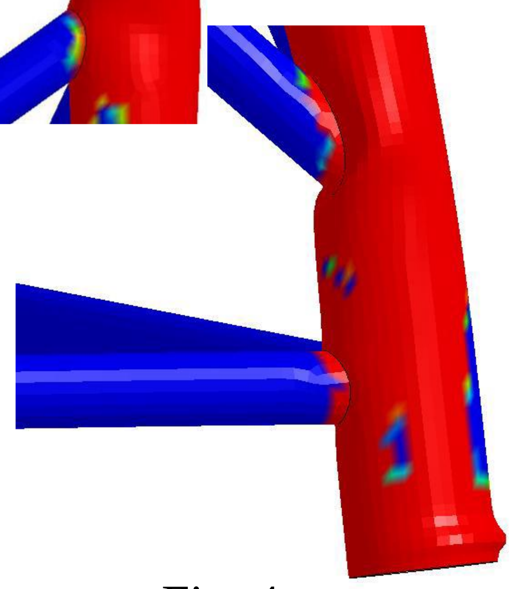


Fig. 4

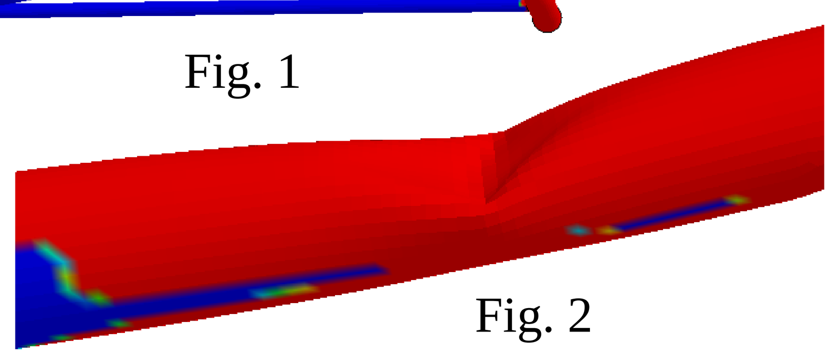


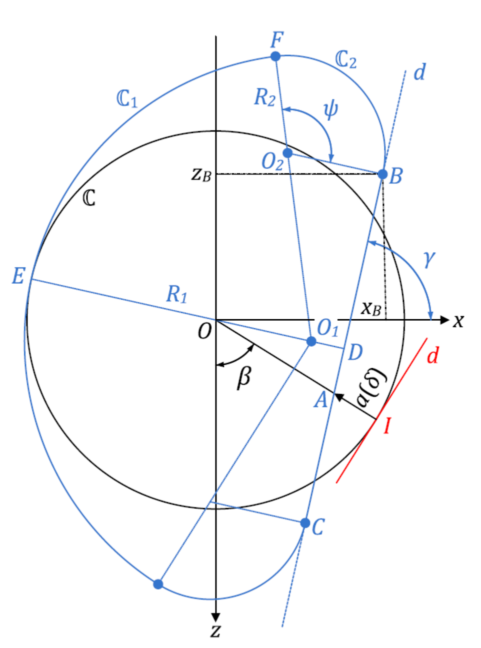
Fig. 2

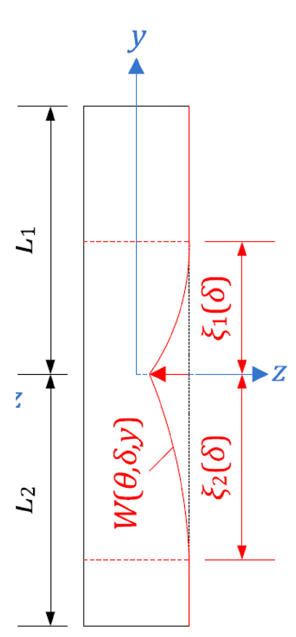
For each of them, analytical formulations were derived using the upper-bound theorem (plastic limit analysis), which states that

$$P \times \dot{\delta} = \dot{E}_{int}$$

where P is the crushing force, $\dot{\delta}$ is the striking ship surge velocity and $\dot{E}_{int}$ is the internal dissipated energy rate.

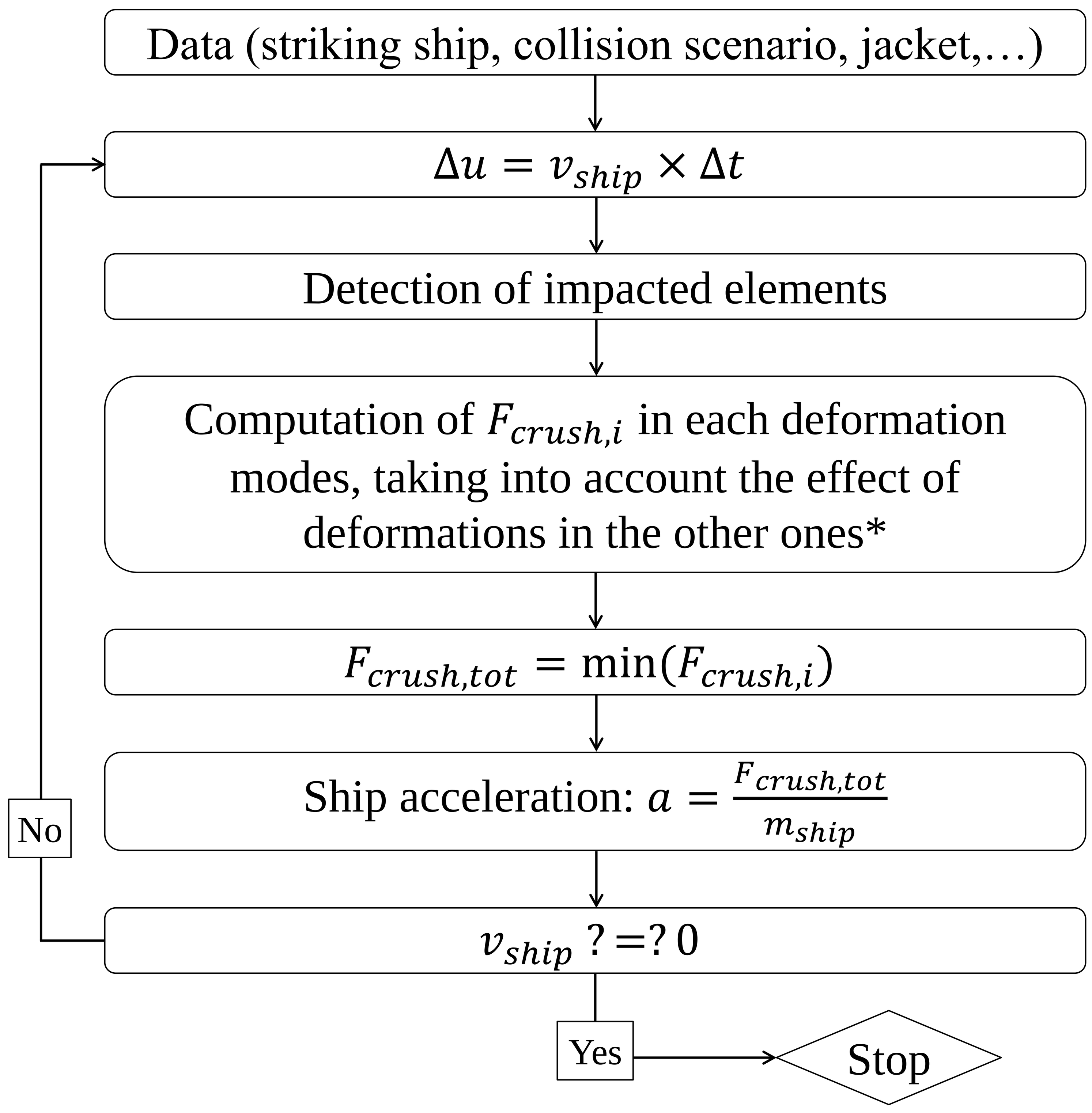
A displacement field, as depicted here for the *impacted cylinder* crushing mode, has to be assumed to apply this method.





3. General algorithm

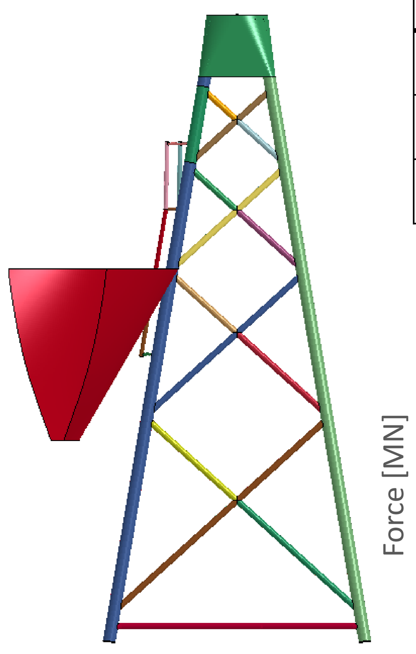
The general algorithm presented here combines the resistance of all the deformation modes described.



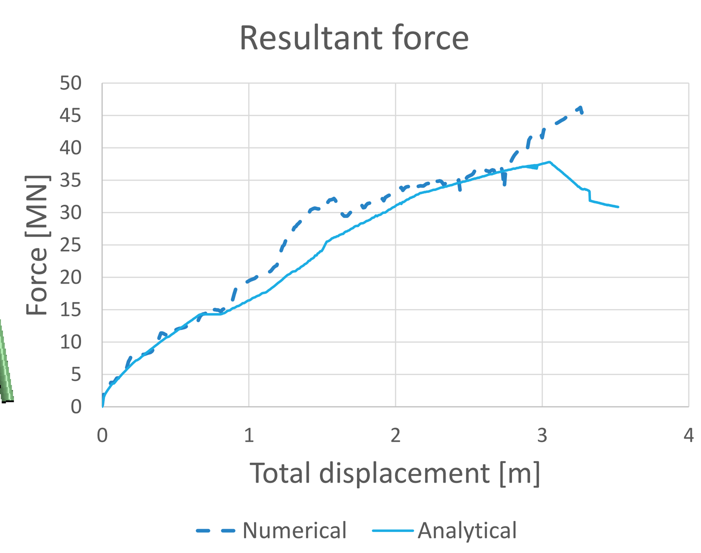
As presented in this algorithm, we consider at each time step that the resistant force is the lowest one among all the deformation modes, and only the deformation occurring in that mode is taken into account.

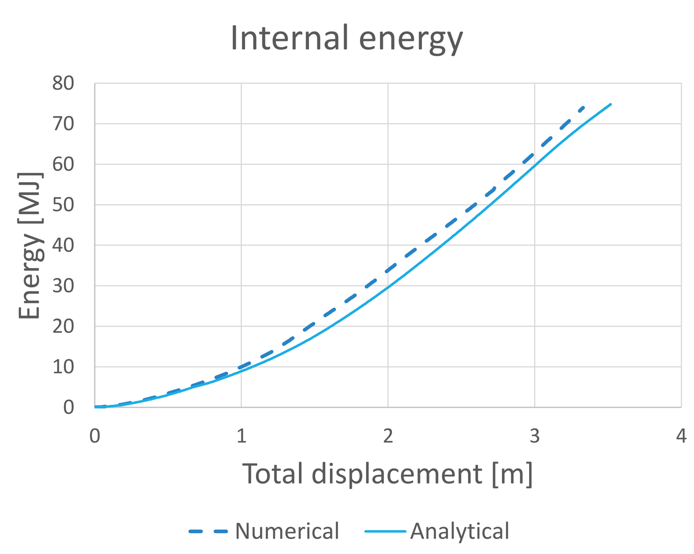
*For example, mechanical properties of the legs punched by braces are reduced and the updated values are considered to compute the stiffness of the leg for the *overall motion* mode.

4. Results & Validation



Jacket		Ship	
Height [m]	56	Weight [T]	6000
Bottom width [m]	25	v_{init} [m/s]	5
Top width [m]	6,4	Trajectory [°]	30





5. Perspectives

The work presented here can be extended to assess the crashworthiness of other offshore structures, such as offshore platforms or floating offshore wind turbines, for instance.

Publication

Le Sourne H, Pire T, Hsieh JR, Rigo P. 2016. New analytical developments to study local and global deformations of an offshore wind turbine jacket impacted by a ship. Proceedings of the ICCGS, Ulsan, Korea.

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