Multiscale approach for the analysis of composite connections and stiffeners in marine shell structures

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ABSTRACT

Marine structures made with composite materials, such as ship hulls or decks, contain discontinuities in the form of stiffeners and connections that affect the global stiffness and strength of the structure. The large dimensions and the morphology of these structures makes necessary to solve them with shell finite elements, which kinematics neither allows a detailed characterization of the existing discontinuities in the composite, nor an accurate evaluation of their contribution to the global performance of the structure. In addition, connections and stiffeners usually suffer from stress concentrations that can result in fatigue failures, being necessary the correct evaluation of their stress fields due to the global loads applied to the structure in order to evaluate this failure case.

This work proposes the use of a multiscale approach to account for the effect composite discontinuities in the global shell structural performance. With the proposed approach, the shell stiffness matrix ABD is obtained from a substructure, analysed with a solid finite element model, that contains a detailed representation of the existing shell connection or stiffener. Therefore, the global structure can be analysed with shell finite elements that have the same exact performance as the solid model, reducing enormously the computational cost of the analysis, and without losing accuracy in the solution obtained. Moreover, the procedure allows analysing afterwards the solid 3D model of the discontinuity with the real loads defined by the global structure, in order to find possible stress concentration patterns that can lead to a fatigue structural failure.

The work conducted and presented in here has been developed in the framework of the EU Horizon funded project Fibre4Yards [1] which, among other objectives, promotes a modular construction of composite ships. With this aim, the project has developed a connection for a sandwich material manufactured with curved moulds. This connection has been analysed with the proposed formulation and the results obtained have been compared with an actual 3D solid model of the connection, and with experimental results obtained from the project. The agreement between all results validates the model developed for the connection, as well as the multiscale approach proposed.

It is expected that analysis such as the one presented in this work will help to design more secure composite structures, reducing their weight, and improving their environmental footprint.

REFERENCES

[1] FIBRE4YARDS Project (European Union's Horizon 2020 research and innovation programme under grant agreement No 101006860). URL: https://www.fibre4yards.eu/ (visited on 02/02/2023).