

The role of Uncoupled Eulerian-Lagrangian (UEL) approach in UNDEX investigations for ship-like structures

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ABSTRACT

Understanding the dynamic response of submerged structures under pressure loads is crucial for naval shipbuilding and offshore engineering (de Camargo, 2019). Among these loads, underwater explosions (UNDEX) are particularly critical, directly affecting the safety and performance of submarines, drilling platforms, and cargo vessels. Advancements in numerical methods and semi-analytical models have made simulations the primary tool for addressing underwater challenges. Numerical approaches typically employ coupled or decoupled techniques (Sigrist et al., 2023). Coupled methods, which use input parameters like charge and distance, resolve fluid-structure interaction (FSI) by modelling the interaction between the explosion-induced pressure wave and the ship's dynamic response. Decoupled methods, on the other hand, impose pre-defined shocks as time-domain signals or frequency-domain spectra, simplifying the computational process. Coupled models are highly accurate for UNDEX scenarios, while decoupled models offer efficiency and ease of implementation. Despite their importance, there is a lack of comprehensive studies comparing coupled and decoupled approaches for underwater explosions. This work addresses that gap by evaluating the structural integrity of a submerged ship-like structure under a UNDEX scenario. It employs a Coupled Eulerian-Lagrangian (CEL) method for FSI and a two-step Uncoupled Eulerian-Lagrangian (UEL) approach for the decoupled analysis, excluding seabed or surface reflection effects. The study highlights the key results of both strategies, comparing their advantages, limitations, and applications in marine and naval engineering.

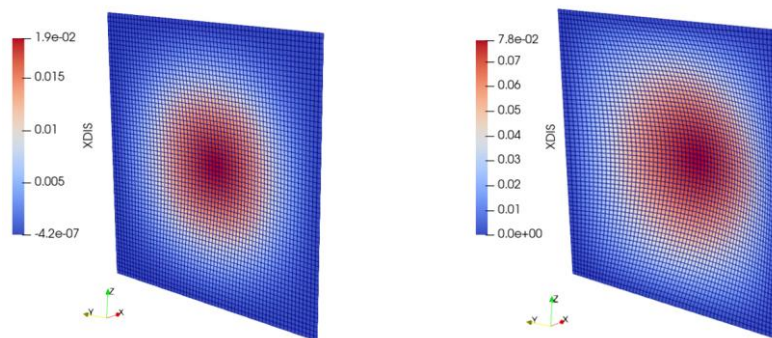


Figure 1: Example of the differences between CEL (left) and UEL (right) approaches (displacement contour in meter) for a simple vertical square plate subjected to 1.5 kg TNT-charge lateral UNDEX (standoff distance equal to 0.5 meter).

References

Vannucchi de Camargo, F. Survey on Experimental and Numerical Approaches to Model Underwater Explosions. *J. Mar. Sci. Eng.* 2019, 7, 15. <https://doi.org/10.3390/jmse7010015>

Sigrist JF, Broc D. A versatile method to calculate the response of equipment mounted on ship hulls subjected to underwater shock waves. *Finite Elements in Analysis and Design* 2023;218. <https://doi.org/10.1016/j.finel.2023.103917>