Crashworthiness of an alternative construction within the scope of A.D.N. regulations using super-elements method

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Abstract

The main objective of this paper is to present the work performed for the evaluation of an alternative construction within the scope of A.D.N. Regulations using the Super-Elements Method. Currently, A.D.N. requires Finite Element Analysis to demonstrate the equivalence between conventional and non-conventional structures. However, this method is often time consuming and expensive, and does not allow for a quick assessment of different alternative designs. Bureau Veritas proposes to use the simplified tool SHARP for the deformation energy computations instead of a Finite Element software. This tool allows to test quickly several structural arrangements and impact locations.

Keywords

A.D.N.; inland navigation; collision; simplified method; super-element.

Introduction

Due to the dense traffic in narrow areas, the inland navigation induces an important risk of ship collisions where human and environmental consequences could be disastrous, especially when carrying hazardous products. For the inland waterways, the rules are governed by a European Agreement concerning the International Carriage of Dangerous Goods (A.D.N.). A.D.N. Regulations have been issued by the United Nations Economic Commission for Europe and contain all the requirements for the design and the construction of inland vessels involved in the transport of dangerous goods. In general, for this type of carrier vessels, innovative solutions for the structural arrangement are not retained by owners and designers due to their approval difficulties. Indeed, in case of a non-conventional structure, the cargo tank failure risk of the alternative design has to be lower than or equivalent to the conventional construction. This approach is clearly detailed in the A.D.N. Regulations and is based on the failure probability of the structure using a Finite Element Analysis (FEA). However, this method is often time consuming and expensive, and does not allow for a quick assessment of different alternative designs.
In this context, Bureau Veritas has been involved in the development of SHARP, a simplified tool based on analytical formulations. It permits to perform several quick ship collision analyses thanks to its solver based on the so-called "super-element" method and a friendly graphical user interface. SHARP is able to compute a large amount of collision scenarios by changing the impact locations, the collision angles or the striking ship speeds. It is also advantageously used to compare different designs by changing the stiffeners arrangements or the plate thicknesses optimizing the structure relative to the collision aspects.
The paper details the A.D.N. Regulations approach for the alternative design of a Type-C tanker and introduces the super-element theory developed in the framework of the SHARP project. The results provided by SHARP with the alternative hull structure are evaluated within the scope of the A.D.N. Regulations and are compared to a conventional design. Finally, the advantages and development of the proposed method are exposed.

A.D.N. Regulations presentation

The European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) was made in Geneva, on May 26, 2000 on the occasion of a Diplomatic Conference held under the joint auspices of the United Nations Economic Commission for Europe (UNECE) and the Central Commission for the Navigation of the Rhine (CCNR). It entered into force the February 29, 2008.
ADN consists of a main legal text (the Agreement itself) and annexed Regulations and aims at:

- ensuring a high level of safety of international carriage of dangerous goods by inland waterways;
- contributing effectively to the protection of the environment by preventing any pollution resulting from accidents or incidents during such carriage; and
- facilitating transport operations and promoting international trade in dangerous goods.