Ship Collision Impact Analysis of Pile-Supported Structure for Protection System

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Summary

Ship collision analyses for the hard impact on rigid wall and the soft impact on protective structure were carried out to evaluate the ship collision force on substructure and the energy dissipation of pile-supported structure during ship collision. The ship with bulbous bow and the pile-supported structure were modeled in a finite element analysis package. As results, the deformations, displacements and stresses of protection system were obtained and the kinetic energy of colliding ship were analyzed into the absorbed parts such as plastic deformations of protective structure and vessel, friction between structure and vessel, rebounding of vessel, etc. The collision energy of vessel was almost translated to the plastic deformation energy of the pile-supported structure and the considerable energy was also translated to that of vessel.

Keywords:ship collision, protection system, energy dissipation, nonlinear analysis

1. Introduction

Vessel collisions are extreme events with a very low probability of occurrence, therefore the limit state considered is usually structural survival. Depending on the importance of the bridge, various degrees of damage are allowed provided that the structure maintains its integrity, hazards to traffic are minimized, and repairs can be made in a relatively short period of time. When the design is based on more frequent but less severe collisions, structural damage and traffic interruptions are not allowed.

Piers exposed to vessel collision can be protected by special structures designed to absorb the impact loads (forces or energies), or redirect the aberrant vessel away from the pier. Because of the large forces and energies involved in a vessel collision, protection structures are usually designed for plastic deformation under impact (i.e., they are essentially destroyed during the head-on design collision and must be replaced). General types of physical protection systems include fender systems, pile-supported systems, dolphin protection systems, island protection systems, and floating protection systems.

The main function of these protective structures is the dissipation of the kinetic (impact) energy of the vessel, and this dissipation is performed by several mechanisms, such as the plastic deformation and the friction between vessel and the protective structures. Therefore, the energy dissipation capacity and the damage level of protected structures are different as the type of protective structures.

The internal mechanics involved in ship collision and grounding accidents is complex, and involves deep collapse, large plastic deformation, fracture and friction. A broad spectrum of methods has been developed for the analysis of internal mechanics as a result of recent extensive research[1]. Generally, these methods can be grouped into four categories: 1) simple formulae, 2) simplified analytical methods, 3) simplified finite element methods, and 4) non-linear FEM simulations.

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