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Quantifying ship impact loads on fenders: Experimental approach

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ABSTRACT: Docking large vessels is a delicate operation as the kinetic energy associated with the large mass of the vessel can result in high impact forces that can damage the vessel, fenders or even the quay. Berthing loads are usually quantified using design formulae based on kinetic energy and a single point of impact. Some correction factors are then used to consider the hydrodynamic mass, the ship's angle with the quay, the softness of berthing and the berth configuration. In this study, a scaled model experimental set-up was used to determine the impact forces of a ship on the fender system, including all fenders touched by the ship, during various docking maneuvers. The pattern and magnitude of the impact forces are different for each fender and are highly dependent on the approach trajectory and mass of the ship. A comparison was made of the measured values of the impacts and the design forces calculated using widely used regulations. Our findings showed some discrepancy between maximum computed forces using kinetic energy method and measured forces, suggesting it may underestimate the maximum impact force in some scenarios.

1 INTRODUCTION

1.1 *Quay and fender design*

Fenders are protective structures mounted on the sides of quays to effectively absorb collision energy and prevent damage to vessels and structures. They are typically made of a resilient material, such as rubber, plastic, or foam. Rubber fenders are the most common type and are usually made from natural or synthetic rubber. Foam fenders are made from a cellular foam material often used in high impact applications.

When properly designed and installed, fenders can significantly reduce the risk of hull damage, which can be costly and time-consuming to repair, and personal injury of crew and passengers.

It is important to correctly design berthing structures and select appropriate ship fenders. For this purpose, the impact forces of ships on the fenders during docking procedures must be well quantified.

Regulation, recommendations issued by PIANC (2002), OCIMF (1992) and other norms such as British Standard (BS 2014) or ROM2.0-11. (2012) provide a set of recommendations for the design of fendering and mooring systems for commercial vessels berthing at quays, dolphins, pontoons, and other structures. The methodology in such norms is similar.

To determine the impact energy, i.e. the maximum energy that the fendering system must absorb in the event of a collision, usually involves the following steps:

(1) Determine the maximum impact speed.
(2) Calculate the kinetic energy of the ship.
(3) Establish a desired coefficient of restitution, CR.
(4) Calculate the impact energy.
(5) Select the appropriate fendering system.

The maximum impact speed is the maximum speed at which the ship could collide with the fendering system. This can be determined from the ship's displacement and easiness of the maneuver (ranked form a, easy berthing with good conditions to e, difficult berthing with bad conditions).

Kinetic energy is the energy of motion of the ship. It can be calculated using the following equation:

$$E_c = 1/2Mv^2C_MC_EC_SC_C \quad (1)$$

where:
M is the mass of the vessel (in tonnes),
v is the maximum impact velocity or berthing velocity (in m/s),

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