ABSTRACT

Capsizement and sinking of a coastal car ferry has occurred in a Korean offshore area and has caused hundreds of human casualties. The rapid turn and improper cargo loading are inferred as the main reasons of the accident. It has motivated to develop a new system of cargo securing with improved safety of Korean coastal ferries. This paper provides a new approach regarding cargo securing safety assessment which is purely based on force equilibrium conditions, because IMO CSS is suitable for the ocean-going vessels. The mathematical formulations are presented for the new approach. This paper also introduces a newly developed safety assessment system based on the new approach. Most outstanding features are that it can utilize acceleration data produced from hydrodynamic motion analyses or assumed maximum extents of ship motion components and that securing safety assessment is simultaneously possible for unlimited number of cargoes with finite number of lashings.

KEY WORDS: car ferry; cargo securing; acceleration; lashing equipment

INTRODUCTION

A sinking accident of a Korean coastal car ferry has occurred in 2014. It has motivated to review importance of ship stability with cargo securing. It is announced that general cargoes and cars loaded inside of the ship did not use lashing equipment as well as extreme heel has been assumed one of the main reasons of rushing cargoes that were not secured.

Unlike Car ferries, it is well defined that lashing force of containers for full container ships in Rules of Class (GL, 2013). Hwang et al. (2004) studied for fixing kinds and size of lashing equipment for containers, Shin & Hwang (2014) performed optimization of container stowage in container ships.

On the other hand, it is not many that lashing for a variety of cars including cars, trucks, buses, etc. Turnbull & Dawson (1997) suggested mathematical models for calculating lashing force for trailers loaded on car ferries. DNV developed cargo securing evaluation system based on IMO (international maritime organization) CSS (code of safe practice for cargo stowage and securing) (IMO, 2011).

The Force acting on a shipped cargo in a sailing ship is classified static force with dynamic force. It is known that rolling caused the most inertial force one of the dynamic inertial force based on ship motion pitching, heaving as well. IMO CSS (2011) suggests a procedure for verifying lashing equipment safety. However, it is not reasonable for car ferries sailing in Korean coastal area since it does accept inertial force based on sailing in ocean going. Coastal car ferries experience less acceleration than ocean going ships.

In this paper, first of all, cargo securing safety assessment will be introduced. Secondly, not only it will be conducted research of assuming external force acting on a cargo loaded in carferry such as based on IMO CSS, simplified formulas, and DLA(direct load approach), but also those will be clearly compared considering assuming a long-term acceleration distribution about Korean coastal environment. Lastly, our lately developed program, which is called ‘LashingSafety’ will be calculating external force and lashing force, and conducting assessment.

CARGO SECURING SAFETY ASSESSMENT

External force and moment must less than lashing force and lashing moment. Therefore, when Eqs. (1), (2) and Eq. (3) are fulfilled, cargo securing safety is also considered as satisfied.

\[ F_x \leq F_{cx} \]  \hspace{1cm} (1)

\[ F_y \leq F_{cy} \]  \hspace{1cm} (2)

\[ M_x \leq M_{cx} \]  \hspace{1cm} (3)

External Force based on force equilibrium conditions

The theoretical rotation accelerations (\( \alpha_x \) and \( \alpha_y \)) about roll and pitch of ships are Eq. (4) and Eq. (5). The maximum angle of roll and pitch (\( \theta_x \) and \( \theta_y \)) is based on kinds of ships and navigation area, however, Eq. (6) and Eq. (7) suggested by IACS (2015) CSR (common structural rules for bulk carriers and oil takers) for estimating depending on 3