

## Simple Assessment of Post-Grounding Loads and Strength of Ships

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### ABSTRACT

The aim of the present study is to determine the sectional forces induced by ship grounding and also to assess the residual strength of grounded ship hulls. An analytical approach is used to estimate the grounding-induced sectional forces of ships. The extent and location of structural damage due to grounding is defined based on the ABS SafeHull guide. The residual strength of damaged hulls is calculated by using a simple analytical formula. The method is applied to the residual-strength assessment of a double-hull tanker of 38,400 dwt damaged due to grounding.

### INTRODUCTION

Following the *Exxon Valdez* grounding in 1989, all oil tankers must have double hulls by 2015 in order to mitigate the possibility of oil spills after grounding and collision accidents. Although the double-hull concept is not a complete solution, it is one effective way to prevent oil spills in groundings and collisions of oil tankers.

As long as the inner platings are intact, oil spills will not occur immediately after the accidents even though the outer shell platings have been torn. In this case, it is necessary for the designer to know the mechanics of groundings and collisions to insure the rational design and safety evaluation of double-bottom and double-side structures.

On the other hand, there is still a possibility of oil spills or sinkage even if the inner shell platings remain intact immediately after an accident. This can be caused by a hull collapse due to a decrease of the residual ultimate hull strength and/or an increase of the accident-induced sectional forces. This will result in a much more severe oil spill and marine hazard.

In fact, history shows many examples of hull-girder breakage in accident situations, for instance the *Braer* or *Aegean Sea* accidents. The oil tanker *Braer* of 89,730 dwt stranded on a rock at Orkney Islands January 5, 1993. The hull was eventually broken into two parts, spilling out 85,000 metric tonnes of crude oil and 1,600 metric tonnes of fuel oil. The bulk oil carrier *Aegean Sea* ran aground off La Coruna in Spain December 3, 1993. The vessel broke its back, exploded and caught fire, spilling out 71,000 metric tonnes of cargo oil. Though the literature on this topic is relatively rare, recently there has been a lot of research on bottom/side damage due to groundings and collisions (Otsubo et al., 1994).

Classification societies (ABS 1995, DnV 1995) require that damaged hulls retain a minimum hull-girder residual strength

which prevents, or at least substantially reduces the risk of losing the ship due to a post-accident collapse or disintegration of the hull structure during tow or rescue operations. Design hull-girder loads in accident condition are suggested empirically, but the calculation method of residual strength is not provided. For residual strength assessment of ships in accident condition, we are still confronted with a great number of questions due to accident-induced sectional forces, residual strength, etc.

In this study, the grounding-induced sectional forces of ship hulls are determined analytically. The residual strength of damaged hulls is calculated by using a simple analytical formula. Therefore, the possibility of hull-girder breakage of ships in grounding can be assessed by comparing the applied hull-girder loads and the residual strength of the damaged hulls. The method is applied in the assessment of the residual strength of a double-hull tanker in grounding.

### GROUNDING-INDUCED SECTIONAL FORCES

An analytical theory for estimating grounding-induced sectional forces (Pedersen, 1994; Paik and Pedersen, 1995) is described below.

Fig. 1 shows a stranding event of a ship on rock. It is assumed that the hydrostatic forces and moments vary linearly in the heaving and pitching motions of the ship. Also the ship hull is considered as a rigid body.

The vertical component of the grounding-induced force can be calculated as a function of the vertical displacement  $z$  at distance  $l$

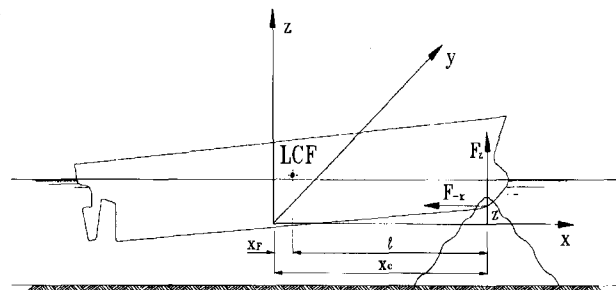


Fig. 1 Forces acting on stranded ship

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