Fatigue Design Assessment of Ship Structures Induced by Ice Loading
- An introduction to the ShipRight FDA ICE Procedure

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ABSTRACT
As part of the ShipRight design and construction procedures, Lloyd's Register has recently developed a Fatigue Design Assessment procedure, ShipRight FDA ICE, to assess fatigue damage of ship structure induced by ice loads for ships navigating in ice covered regions. The paper outlines the ShipRight FDA ICE procedure including the determination of trading routes in ice regions, ice loads and impact frequencies, structural stresses, fatigue performance at low temperatures, fatigue damage and acceptance criteria. The paper provides an overview of the assessment methodology and highlights the key elements with case studies.

KEY WORDS: FDA ICE; fatigue damage; ice classed ships; low temperature; ice loads; Arctic shipping.

INTRODUCTION

Immense reserves of natural resources of energies, oil and gas, are expected to be exploited in the cold regions, e.g. Yamal Peninsula in the Russian Arctic, and as a result there is an increasing demand for oil tankers and LNG carriers to transport the oil and gas.

The harsh environment encountered in cold climates affects the ships safety and operation, and requires a focused review and assessment of the ships capability and structural integrity. One important aspect is the fatigue performance of the hull structure of ships navigating in ice regions, which is a key concern of the industry.

To address this concern, Lloyd's Register (LR) has recently developed a fatigue design assessment procedure for ships navigating in ice, ShipRight FDA ICE (Lloyd's Register 2010). It aims to reduce the risk of fatigue damage and increase the safety of ships operating in cold environments. The fatigue design assessment will increase operators’ and owners’ confidence in operating their ships in these challenging environmental conditions.

The ShipRight FDA ICE procedure has been developed based on:
- Lloyd's Register’s extensive knowledge, expertise and experience on ships operating in ice regions
- Cooperation with world leading specialists in this area
- Measurements conducted on ships navigating in ice regions over the years, and
- Fatigue testing on welded joints of mild and higher tensile steels in cold temperatures.

This paper outlines the principles and features of the ShipRight FDA ICE procedure and highlights some of its key elements with illustrative example applications of the procedure.

SERVICE HISTORY DATA OF ICE CLASSED SHIPS

Fatigue damage of ship structures due the action of wave loads in wave environments has received a great attention in recent years following the fatigue cracking and fracture experienced in oil tankers and bulk carriers in the 1980s’. Lloyd’s Register introduced the ShipRight FDA procedures back in 1994 to provide assessment methods to determine the fatigue performance of structural details. The introduction of the fatigue assessment as part of the classification design appraisal contributed to the reduction in the incidents of fatigue fracture of ship structure.

In contrast, fatigue damage of ship structure due to ice loads has received relatively little attention. To further investigate the fatigue damage history of ice classed ships due to ice loads, LR’s fleet database was analysed. The database records all types of damages and defects found during surveys of LR classed ships. From the database, different type of damages on each ship type or class can be analysed to establish damage patterns.

Four ship types; oil tanker, bulk carrier, container ship and LNG carrier, with different ice class notations, e.g. 1A1, 1A, 1B, 1C and 1D, were investigated. The damage type was limited to incidents of cracks and fractures only, and other types of damage, such as dents and buckling, were excluded. The data used covered surveys carried out in a period of 40 years from January 1970 to December 2009.

Results of the investigation show that out of the total 690 ice classed ships, 57% of them have cracks or fractures at an average age of 13.0