The Royal Institution of Naval Architects

Damaged Ships V

International Conference
Damaged Ships V
11th March 2020,
RINA HQ, London, UK

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Tanker Damage Stability: Historical Problems and Current Solutions
K. W. Hutchinson, Safinah Group, UK
A. L. Scott, Maritime and Coastguard Agency, UK

The fundamental issue with tanker damage stability lies with the complexity of dealing with fluid loss from a damaged tank which may be filled to any level and carrying liquids with a wide potential range of specific gravity (SG). When this is allied to an extensive variety of loading patterns with empty, part-filled or full tanks and multi-compartment side or bottom / raking damages, demonstration of compliance can be problematic even though the regulations permit the simplifying assumption that all the fluid in the damaged compartment is instantaneously lost and replaced by seawater up to the outside damaged equilibrium waterline. For some tankers, such as crude oil tankers and liquified petroleum and natural gas carriers (LPGCs / LNGCs), the loading pattern, cargo SG and tank filling levels are often predictable and hence the damage stability can be verified against pre-approved loading conditions in the approved Trim and Stability Book / Stability Information Booklet (SIB). However, as soon as a loading condition deviates 'significantly' from the approved conditions in the SIB, which is quite common for parcel tankers, products carriers, chemical tankers, FSOs and FPSOs, then some of the regulations require a new damage stability verification which must be undertaken and be approved by the authorities for compliance before the ship sails. It is possible to demonstrate compliance by consulting 'simplified stability information' namely 'condition' or 'generic' combined (intact and damaged) critical limiting KGf or GMT curves - however, in order to fully cover the wide range of possible loading scenarios such information is difficult to produce and present in a concise and accessible manner and hence their application is often not 'simple' or quick. The other option is through 'direct' verification of the condition using an onboard Stability Instrument or shore-based loading computer - although in practice, for various reasons, advance approval of all the potential damage scenarios for 'non-standard' loading conditions is seldom sought. Over a decade ago, inspections of tankers established, in many instances, that such verification and approval of damage stability compliance was not being undertaken. It was also revealed that there was a considerable lack of awareness of the complexity of damage stability calculations, with many loading officers believing, for example, that compliance with the intact stability criteria alone was sufficient.
A previous paper read to the RINA by the authors at the 2011 'Design and Operation of Tankers' International Conference held in Athens discussed and illustrated the above issues in detail. It was widely acknowledged by the industry that there was an urgent need to develop guidelines for the verification of damage stability requirements for tankers that regularly sail in conditions of loading significantly different from those in approved documentation, and as a result several international and national guidelines have been developed over the past few years. This paper will summarise the historical problems, and then move on to discuss the recently introduced guidelines and particularly the Marine Guidance Note (MGN) published a few months ago by the United Kingdom's Maritime and Coastguard Agency (MCA), namely MGN 611 (M). This paper will therefore conclude the subject first highlighted by the authors in their paper of nine years ago and also bring under one 'cover' four articles published over the last year or so in RINA's The Naval Architect journal, by discussing these issues from the aspects of the ship designer, regulators and operators, and will also proposes practical and effective solutions.

Strength Assessment Of A Container Ship Damaged By Side-Collision
S. Li, Z.Q. Hu & S.D. Benson, Newcastle University, UK

This paper presents a strength assessment for a damaged container ship suffered from side-collision. Simplified progressive collapse method is employed for the prediction of ultimate strength under vertical bending after a validation using equivalent nonlinear finite element method. A parametric study is conducted to identify the most critical damaged scenario. Residual strength index versus damage extent diagrams are established, which may be useful for a rapid prediction of the residual ultimate strength of container ship under a given collision damaged scenario.

Development of a New Method for Assessment of Safety of Ships in Damaged Conditions with use of the Mathematical Risk Calculation Model
P. Szulczewski, KASI Group, Malaysia

There is a need for developing improved methods of evaluating the safety of cargo ships that would quantify and assess the ship safety more comprehensively than current methods and further allow for a more direct comparison of ship designs safety-wise so that safety could become one of the goals of design process. This newly developed method will not only have to allow for effective determination of ship safety, but also should meet expectations from various industries. This paper presents an alternative approach to safety of ships in damaged conditions, which when further verified and evaluated, could serve as a useful tool for designers and ship operators alike. It was shown that a computationally efficient quasi-dynamic method that addresses the main drawbacks of current regulations can be formulated for evaluating the exact risk levels at any stage of vessel's life.

Past, Present And Future Of Damage Stability Calculations
R. Pérez Fernández, SENER, Spain

Historically, damage stability calculations relied on manual calculations, often tied to a specific system of measurement. Some of these very old equations continue to be used in naval architecture books today. However, the advent of the towing tank allows much more complex analysis. Damage stability calculations are much more complicated than other naval architecture calculations, as for example, intact stability. Software utilizing numerical methods are typically employed because the areas and volumes can quickly become tedious and long to compute using other methods. Stability tests in damage conditions, as in shipyards, technical offices or universities, are performed with software packages that starting from conceptual design information are able to quickly compute the required data. This paper focuses on evaluating old and new methods of damaged stability calculations. From the times of Pierre Bouguer and Fredrik Henrik auf Chapman until the latest developments in shipbuilding CAD tools.

Damage prediction on corroded ship structures by using peridynamics
S. Oterkus, C. Tien Nguyen, University of Strathclyde, UK

Marine structures can experience damages although they are initially designed with high safety factors. The reasons for these damages are abundant such as collisions, groundings, explosions, corrosion, fatigue or extreme conditions. For addressing the nucleation and growth of damages especially for multiple crack paths, classical continuum mechanics faces conceptual and mathematical challenges since equations of classical continuum mechanics involve spatial derivatives of displacement components. By contrast, peridynamics is a new nonlocal theory which uses integro-differential equations. Therefore, it works well with both continuous and discontinuous models and it is suitable for capturing progressive damages [1-4]. In this study, progressive damages on a corroded ship structure subjected to vertical bending moments are predicted by using peridynamics. For further investigation, the residual strength of the ship with different levels of corrosion is investigated.

SOLAS 2020 Damage Stability and beyond
K. W. Hutchinson, Safinah Group, UK
A. L. Scott, Maritime and Coastguard Agency, UK

Drawing upon the information and arguments put forward in papers read by the authors at the four previous RINA 'Damaged Ship' International Conferences, held in 2011, 2013, 2015 and 2018, and also at RINAs 'Design and Operation of Ferries and RO-PAX Vessels' International Conference of 2016, together with articles recently published in RINAs The Naval Architect magazine, this paper will summarise and critically discuss the historical issues with the damage stability regulations for dry cargo but mainly passenger ships, the current status of these and possible future developments. Hence, this paper will act to conclude the series of five previous papers and two articles addressing this subject, which have been published by the authors at RINA conferences and in RINA journals over the past nine years, at an appropriate juncture given that the amendments to the Safety of Life at Sea (SOLAS) 2009 Chapter II-1 damage stability regulations for both dry cargo and passenger ships enter into force for new ships constructed on or after 1st January 2020.
The degree to which passenger ships designed to comply with the newly amended regulations may be economically compromised in comparison with ships designed to the SOLAS 2009 Regulations is being actively investigated by designers etc., but obviously the effect of changes such as the enhancement of the Required Subdivision Index R for passenger ships carrying up to 1,200 persons is still to be to be fully understood and quantified. For the operators and designers of Roll-On / Roll-Off (RO-RO) passenger ships for service in European Union (EU) waters, the future of the Stockholm Agreement namely EC Directive 2003/25/EC as amended is still uncertain and understandably is of significant concern within this sector of the industry.
Hence, the paper will discuss the final changes to SOLAS 2020 and the Explanatory Notes, the latter of which will be discussed at International Maritime Organization's (IMO) 7th Ship Design and Construction (SDC) Sub-Committee (previously Stability and Load Lines and on Fishing Vessels, SLF) to be held in London in early February 2020 just prior to RINA's Damaged Ship V conference. Depending on progress within the EU, the status and impact of the Stockholm Agreement will also be discussed. In addition, possible changes and enhancements for incorporation in to SOLAS 2024 will be briefly addressed. Finally, bringing all the above together, the impact of these regulations on the practicing ship designer, regulators, and operators will be summarised.

Evaluation of Survivability of a Ship After Damage with Application of a Risk Calculation Method
P. Szulczewski, KASI Group, Malaysia

This paper contains calculations of risk for a selected damage case scenario. The calculations took place with use of a risk model designed for evaluating the safety of ships and were compared with the available and published industry standard (as included in SOLAS 2009) as well. The comparison of results is presented in a shape of a discussion and conclusions are drawn. The currently valid method as included in SOLAS 2009 regulation provides limited information about the actual survivability of a vessel in emergency conditions. It is hence very difficult to compare the current probabilistic model with risk based survivability calculations to evaluate the actual safety provided by an investigated vessel in damaged conditions.

The Digitalization of Navigation: Examining the Accident and Aftermath of US Navy Destroyer John S. McCain
S. C. Mallam, University of South-Eastern Norway, Norway
K. Nordby, The Oslo School of Architecture and Design, Norway
S. O. Johnsen, SINTEF Digital, Norway
Frøy Birte Bjørneseth, Norwegian University of Science and Technology, Norway

The move towards digitalization of maritime operations is prevalent across the domain. A ship's bridge is a complex socio-technical environment where navigational crew are required to manage a plethora of systems through differing types of digital and physical inputs and outputs. The successful interaction between human operators and the technical system is critical for safe and efficient ship operations. The purpose of this paper is to analyze the collision and aftermath of the U.S. Navy Destroyer John S McCain and tanker Alnic MC that occurred in the Singapore Straight in August 2017. A finding from the National Transport Safety Board investigation was that, amongst other causal factors, the design of the digital touch-screen steering and thrust control system increased the likelihood of operator errors, contributing to events leading to the collision. Furthermore, in August 2019, the U.S. Navy announced plans to remove all touchscreen throttle and helm controls with physical controls, such as mechanical joysticks, buttons and levers, across their fleet. We investigate the general trend of digitalization onboard the bridge and explore the relationship between physical and digital systems. This accident provides a relevant case study and input into how the maritime domain moves forward in digitizing the bridge and insight into ongoing research and development of the OpenBridge Design System. In analysing this accident, its findings and the U.S. Navy's decision related to digitalization we map out future development areas of digital applications for future bridge design and navigation.

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