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Ship and Offshore Structure Design in Climate Change Perspective

Springer

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Det Norske Veritas
Høvik
Norway

ISSN 2213-784X ISSN 2213-7858 (electronic)
ISBN 978-3-642-34137-3 ISBN 978-3-642-34138-0 (eBook)
DOI 10.1007/978-3-642-34138-0
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2012956377

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword

Safety at sea is one of the main concerns of shipping and offshore industries in general and Classification Societies in particular. New designs must be assessed and operational decisions/made relative to recognized codes and standards. This will be the responsibility of the relevant authority, the classification society or the user himself, depending on the design and its application.

The importance of including the state-of-the-art knowledge about meteorological and oceanographic (met-ocean) conditions in ship and offshore standards has been in focus in the ship and offshore industry for many years. It has been recognized that there are potential safety, economic, and environmental advantages in utilizing the recent knowledge about met-ocean description in standards' development. To achieve recognition, a met-ocean description must be demonstrated to be robust and of adequate accuracy. Updating codes and standards takes, as most formal processes, some time, and consequently, the updates may lag a little behind the state-of-the-art.

The observed and projected climate changes in the past decades have been followed closely by Det Norske Veritas AS (DNV) and Classification Societies in general. The International Association of Classification Societies (IACS) has met-ocean conditions and variability on the agenda, and DNV is supporting IACS by several activities on adaptation process to climate change. There are still significant uncertainties related to climate change predictions and revisions of rules and standards may seem premature. However, we are concerned with knowing what impact climate changes in met-oceanographic conditions may have on future ship design and operations. Results reported in this monograph are a part of the investigations striving to shed light on the topic.

I endorse the work of the authors and have the pleasure to recommend this monograph for the reader.

Høvik, August 2012

Tor Svensen
DNV President

Preface

Global warming and extreme weather events reported in the past years have attracted a lot of attention in academia, industry, and media. The ongoing debate around the observed climate change has focused on three important questions: will occurrence of extreme weather events increase in the future, which geographical locations will be most affected, and to what degree will climate change have impact on future ship traffic and design of ships and offshore structures?

The present study shortly reviews the findings of the Intergovernmental Panel on Climate Change Fourth Assessment Report, AR4, (IPCC 2007), the IPCC SREX "Summary for Policymakers" report (IPCC 2012) and other relevant publications regarding projections of meteorological and oceanographic conditions in the twenty-first century and beyond with design needs in focus. Emphasis is on wave climate and its potential implications on safe design and operations of ship structures.

The reviewed studies agree that there has been an increase in significant wave height (SWH) from the middle of the twentieth century to the early twenty-first century in the northern hemisphere winter in high latitudes in the north Atlantic and the north Pacific, with a decrease in more southerly latitudes of the northern hemisphere. The increase of the 99-percentile SWH has been observed to be 0.5–1.0 % per year (Young et al. 2011). However, if the record is extended back to late nineteenth century the picture changes, as studies show that storminess and wave heights in late nineteenth/early twentieth century were about the same as near the end of the twentieth century (Gulev and Grigorieva 2004). Thus, it is unclear if the increase observed during the past 4–5 decades is caused by anthropogenic climate change or just manifestation of long-term natural variability.

It is uncertain how future climate change will impact the extreme sea states that will be encountered by ocean going vessels. The reviewed studies show that there will be regional increases in the wind speeds and wave heights, more pronounced for the extremes than for the means. The increases of the 20-year return period of SWH or the highest storms in 20–30 years intervals are generally in the range 0.5–1.0 m in the North and Norwegian Seas, immediately west of the British Isles, off the northwest of Africa, around 30°N from the east coast of the United states to 50°W and in the Pacific between 25 and 40°N and from the west coast of the

United States to 170°W. However, increases up 18 % for the 99th percentile SWH have been reported for the southern North Sea by one paper of Grabemann and Weisse (2008). Thus, the increase may reach more than 10 % above present day extremes in some areas. The projections are influenced by choice of climate model, emission scenario, and downscaling method for waves. The uncertainty of the estimated increases is of the same order as the estimates.

To account for climate change of met-ocean conditions and uncertainty connected to the estimates of future extreme wave heights and other met-ocean parameters a risk-based approach for ship and offshore structure design is proposed. The impact of expected wave climate change on ship design is demonstrated for five differently sized oil tankers, ranging from Product Tanker of length 175 m to VLCC with length 320 m. The presented examples show consequences of climate change for the hull girder failure probability. They demonstrate that in order to maintain the safety level the steel weight of the deck in the midship region should be increased by 5–8 % if the extreme SWH increases by 1 m. However, it should also be noted that weather forecasts are improving, and ships ability to avoid extreme met-ocean conditions by using weather routing systems may imply that the current practice of designing ships to 20-years' North Atlantic extreme conditions may be relaxed in the future.

Recommendations for future research activities allowing the marine industry to adapt to climate change are given.

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Acknowledgments

This work, initiated in 2008, was carried out within the internal DNV Research and Innovation research activities in the DNVR&I Maritime Transport Programme. Our thanks go to the Programme Director Dr. Øyvind Endresen for his encouragement during the writing of this monograph. The application of the risk-based approach using structural reliability analysis builds on research results from the strategic research programmes over a period of two decades, and makes the integration of new information on met-ocean conditions in the Rule development easy and consistent. The continuous support is highly appreciated. We would also like to thank the Norwegian Meteorological Institute for providing the NORA10 hindcast and ERA-Interim data, the anonymous reviewers for valuable comments and several publishers for permissions to reproduce pictures and images. The opinions expressed herein are those of the authors and should not be construed as reflecting the views of the company.

August 2012, Høvik

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