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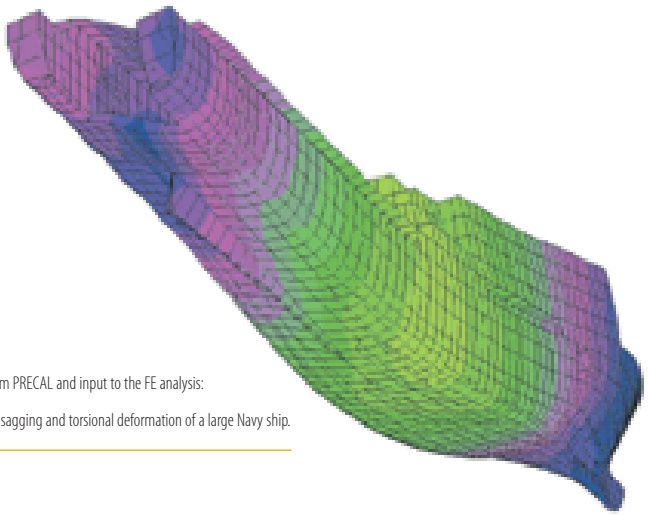
Seakeeping studies thro

Throughout its existence the CRS community has devoted considerable attention to the effects of waves on the ship. Report touches on some of the most significant developments.

Over the past decades the scantlings of ships have seen a gradual reduction, to the extent that the shell plating of present day cruise liners is about half of what it was on passenger ships some 50 years ago. Reduction on this scale needs to be in step with increased knowledge about what minimum scantlings are really needed.

Research on ships in waves only started in earnest in the 1950s and although a good deal of knowledge has been acquired in this field, ships have grown in size and have changed in hull form too. Therefore, loading and strength issues remain as important as ever. Here, a few of the latest CRS developments are outlined.



Output from PRECAL and input to the FE analysis: combined sagging and torsional deformation of a large Navy ship.

Motions and global hull girder loads: PRECAL

Tools employed over the years have seen considerable development. Strip theory has been the mainstay of seakeeping analysis since the early 1970s. Mid-way through the 70s, 3-D linear panel methods were developed but it is only recently that these methods can be used in the early design stage, thanks to the powerful PCs of today. The CRS community has decided to implement such a panel method. The resulting program, PRECAL (Pressure Calculation), is now a tool that is used to calculate the seakeeping behaviour of monohulls, catamarans and trimarans. Next to the rigid body motions, it can also calculate the deformation modes of the ships girder, internal loads, pressures on the hull panels and the added resistance in waves. These pressures are used as input for a structural FE analysis. This program has been validated against model tests for many different ships and is now being used by most CRS members.

Time-domain simulations: PRETTI

The time domain program, PRETTI – currently under development – will increase the capabilities of the linear program PRECAL, by introducing non-linear effects created by the shape of the bow and stern. This plays an important role in large waves and/or at large motions. The program will be used to study roll motions in stern quartering seas, including the effect of the manoeuvring characteristics and control surfaces, like fins. Also special phenomena such as parametric roll can be studied using PRETTI.

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Model tests with a segmented ferry using a flexible backbone. Results were used for the validation of PRETTI.

Transverse loading of the hull girder

The objective of this project was to create a database of experimental results of motions, internal loads, relative motions and local pressures, for a large container ship, in oblique waves. Tests were carried out at two speeds and for five wave directions. Results were compared to predictions made by the linear program, PRECAL. This analysis showed the reliability of PRECAL for predictions in the linear regime.

Impulsive loads: Slamming

The SLAM working group was tasked to develop methods for predicting slamming loads on ships. The group implemented a 2D BEM (boundary element method) and a momentum theory method and compared these predictions to results of model tests. The 2D-BEM program gave good results for drop tests with a ship section. Comparing the results to impacts against a ship's bow showed the weakness of the 2D approach; predictions are only possible in head seas and the results show the right order of magnitude in the best case. It was concluded that additional research is still needed for real case predictions. A proposal is being written to continue the research.

Elastic deformation of the hull girder

Normally, the theory concerning ship motions in waves considers the ship as a rigid body. This project extended the theory by adding the elastic deformations of the ship's hull to the equations of motion. This was incorporated in the frequency domain program, PRECAL and in the time domain program, PRETTI. The impulsive loads on the bow are calculated using the approximate method developed by the SLAM working group. The new software was compared against results of experiments with a model equipped with a flexible backbone. The ultimate goal is to determine the whipping response of a ship on an impulsive load at the bow or stern.

Coupling of hydrodynamic and structural models

The coupling of the hydrodynamic and the structural model has been an objective of the PRECAL development from the start. A special tool was developed to transfer the pressures from the course hydrodynamic mesh, to the much finer structural model. In this way, a small number of selected conditions were chosen to calculate the pressure distribution and the structural loads. The STRUC working group is now working on a special post-processor to efficiently calculate many different load cases for a fatigue analysis of the structure.

The developments outlined in this article illustrate the progress in seakeeping research. Today many questions can be answered and alternative design solutions can be studied, which was unthinkable in the past. Many of the current studies have been instrumental in the design of modern ships. This testifies to the importance of the research carried out by CRS.

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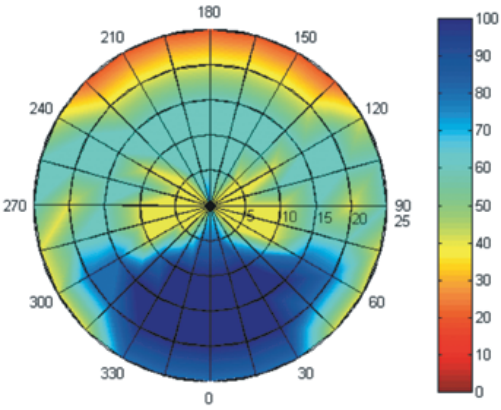

Result of the PRECAL post-processor: operability analysis for helicopter launch and recovery onboard a frigate. The figure shows the relevant motion in colors as a function of heading and ship speed.