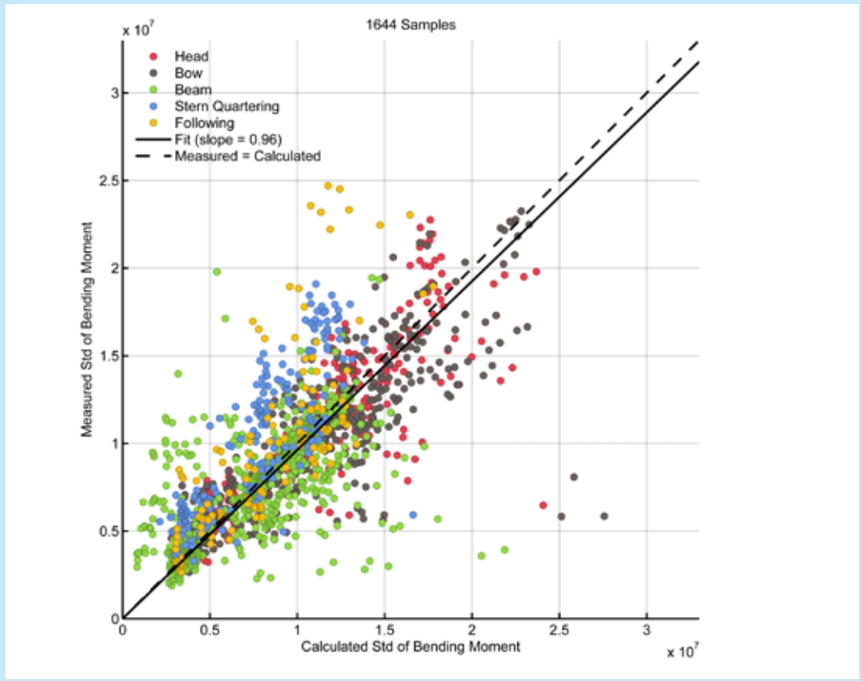
Ensuring design meets operating reality



Monitoring – Does your ship perform as expected? Is the operating environment as anticipated? Should the next vessel be the same? MARIN helps provide some of the answers.

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Discrepancies between design assumptions and operational reality can be costly. Overdesign or overestimates of the operating conditions raise newbuilding costs, while design flaws or underestimates reduce efficiency, safety and raise the probability of early damage and the consequent downtime. Confidence in design standards is therefore essential.

One of the core services of MARIN is to understand and improve ship design and operating principles by carrying out measurement campaigns on board ships at sea. When it comes to the structure of the ship, it is often the fatigue lifetime that is of interest. In the design stage the hull's structural capacity is compared and matched to the loading profile. A multitude of disciplines are involved in the process, each with its own uncertainties. The ratio between capacity and loading is typically increased with a safety margin. It is clear that the safety margin is a compromise between cost and reliability that depends on the accuracy of the design parameters.

With respect to fatigue, unexpected cracks can develop if loading during the operation is larger than anticipated or when capacity is overestimated in the design. On the other hand, a design may be overly conservative and unnecessarily expensive when the capacity ends up being much larger than the loading, or when service loads are less than expected. Operational handling of the vessel adds a large variation on the loads that act on a ship in a given sea state. It is the role of the crew to keep the vessel safe.

The effect of crew actions on actual loads in comparison to design values however is an area that certainly needs more exploration. A sharp design with well-considered safety margins therefore relies on a thorough understanding of both the loading environment, structural capacity and the way the vessel is handled.

MARIN performs long-term measurement campaigns on board ships to gain insight into understanding and improving ship design and operating principles. Typically, the ship is instrumented with sensors measuring waves, motions and accelerations, as well as global and local strains. Crew feedback from logs is used to assess the "human factor". Projects can be conducted for one customer or executed as Joint Industry Projects, such as the Valid JIP and TULCS projects. The benefit of a joint approach is the synergy from multidiscipline expertise by the partners. Last but not least, participants can share the costs required to install equipment, sustain measurements, carry out data analysis, run comparisons and reports over many years.

Valid JIP In the Valid project, dedicated full-scale trials were carried out for a period of two years on a 118 m long US Coast Guard Cutter. Results were correlated with extensive model tests using a segmented model and with numerical simulations. The focus was on global and local stresses. Measured global deformations were extrapolated to local details using results from a Finite Element method and compared with measured hot spot stresses. In this way stress contours over the full structure could be obtained from a limited number of sensors and compared against local measurements and design calculations. A typical result from the monitoring campaign is shown below. The figure shows a comparison of the vertical bending moments derived from measurements and calculated on the vertical and horizontal axis, respectively. The monitoring campaign furthermore showed the ship is operated in less severe wave conditions than was assumed during design. Based on the results from the monitoring campaign, the design approach was verified and uncertainties in this approach were made explicit. This aided maintenance survey planning of the ship and design optimisation for future vessels.

TULCS The TULCS project, initiated by Bureau Veritas, focused on container shipping. Successive generations of vessels have increased their load carrying capacity from 5,000 to 9,000 and 11,000 to 18,000 TEUs. Clearly such steps put stress on design rules and new physical phenomena may become important. The research objective in the project was the modelling and validation of the hydro-elastic response and design tools. MARIN coordinated long-term structural monitoring on board a 9,200 TEU CMA CGM container ship and used the obtained data to better understand the relevant loading mechanisms and uncertainties in the hydro-structural coupling methods used for the design of these ships.

MARIN will continue long-term monitoring projects with an extra focus on the human factor concerning the design uncertainty and to improve feedback to vessel crews for improved awareness of actual loads when it comes to capacity levels.