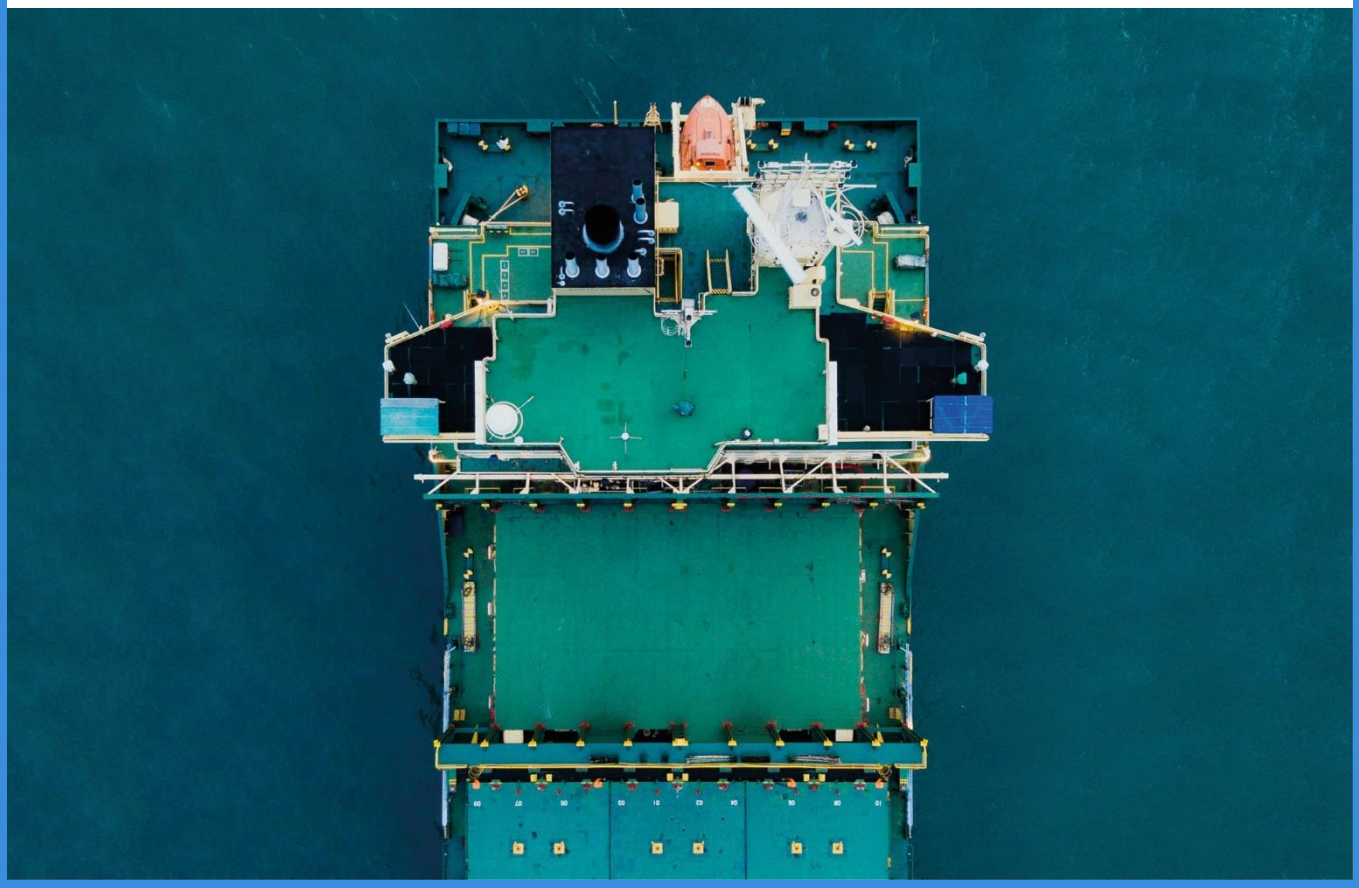
LR Barge Wave Slamming Analysis

UBC MECH 45X – Capstone Design Projects Course

31 August 2020

Lloyd's Register



Summary

LR Barge Wave Slamming Analysis

Proposal date:
31 August 2020

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Martec Limited is a member of the Lloyd's Register Group, doing business as the Applied Technology Group

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UBC MECH 45X – Capstone Design Projects Course

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1. Introduction

Lloyd's Register (LR) prescribes rules to which vessels must be built to in order to ensure seaworthiness. We are exploring having specific rules regarding barges (in addition to various ship types). For competitors with specific barge rules, the difference is primarily the size and extent of the structural members (frames, girders, stiffeners and plates) on the bottom of the vessel. LR's bottom strength requirements are significantly higher, and extend further aft, since we apply Ship Rules for the assessment of wave slamming pressures (even when considering barges). The reason why LR's Ship Rules require that higher wave slamming pressures are accounted for, is because a ship can sustain relatively high speeds in rough weather, whereas a barge being towed by a typical tug cannot. The involuntary speed loss by the tug is typically greater, and so the speed the barge encounters the waves is much lower than a similar sized ship. Even in moderate seas a small tug towing a large barge will lose a great deal of speed, and therefore the barge will tend to contour the waves rather than leap out of waves as some ships would at higher speeds. If we can design rules for lighter barges, our clients will be more inclined to build and class to LR rules as it will increase the carrying capacity of the barge.

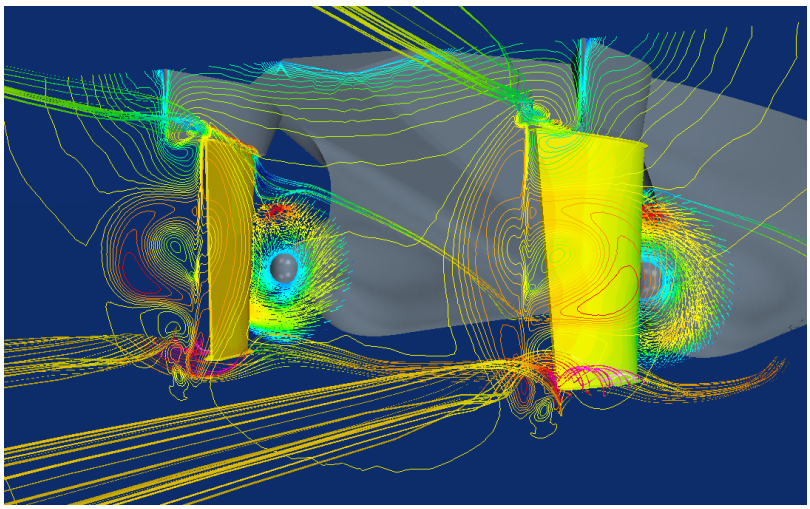

Figure 1: CFD solution of streamlines past vessel rudders

2. Project Description

This project will simulate wave slamming loads on a representative barge and from these, attempt to determine what structural strength is required on the bottom of the vessel. For low speed flow, the hydrodynamic forces on a vessel can be determined via Boundary Element (Panel) methods. LR has its Waveload tool available for this project. Once the motion leaves the linear regime and true wave slamming events are encountered, Computational Fluid Dynamic (CFD) methods are required. LR has a long history of similar analyses utilizing the Star-CCM+ code.

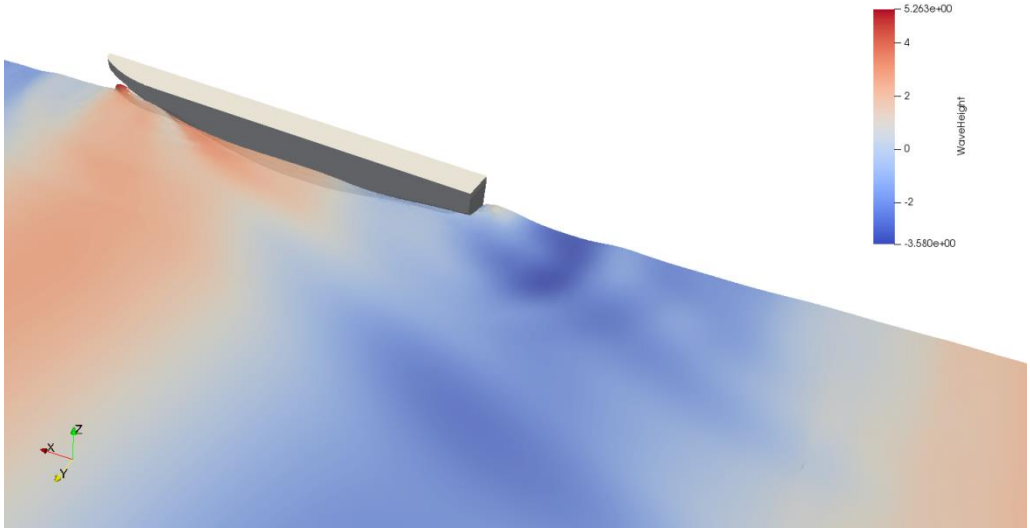

Figure 2: CFD analysis of vessel moving through waves

For this project it is expected that the student(s) will familiarize themselves with the analytical tools required (Waveload, Star-CCM+, and a finite element structural solver). LR staff will help direct the training and provide instruction on use specifically for the scenario in question. The representative barge will then be simulated a variety of wave encounter frequencies (function of vessel speed and wavelength) and wave heights. The boundary element and CFD analyses will be used to calculate bottom wave slamming pressure loads on the barge. The loads will then be examined in a finite element software. The stress and relative displacements that these loads impart will be determined. The design challenge will then be to see what reduction in the size of the structural members is possible, while ensuring the safe operation of the barge.

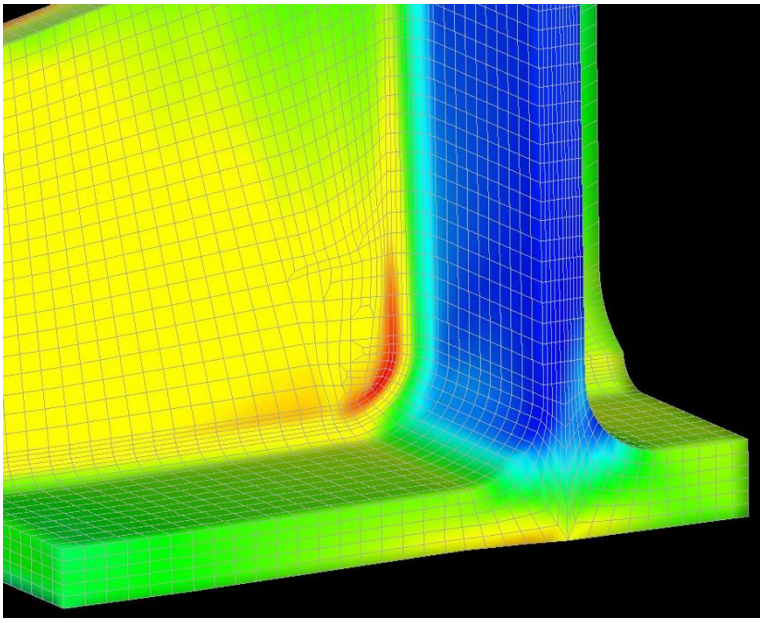

Figure 3: Finite Element (FE) analysis of stress in structural member

A representative barge geometry, applicable sea states, and vessel speeds will be provided. Safety factors on the structural strength will be provided to assist in the final design.

3. Expected Outcomes

A report and final presentation detailing the developed loads and the proposed new barge design are expected. In progress to this goal, timelines will be established for software training on similar scenarios, development of the barge model in each software, production of the hydrodynamic loads, and structural response. The numerical files are also expected as deliverables to allow for further continuation of this project.

4. Resources Available from LR

LR staff will be available to the students throughout the project to provide guidance and assist with any specific inquiries.

5. Project Requirements

First and foremost, the purpose of this project is to establish whether there is merit in developing barge specific rules. This would be demonstration of significant structural reduction for some or all the barge speeds considered. Conversely if structural savings is not possible, a report detailing the analysis that proves this would also be of significant value.

Secondarily, it would be nice to generate the acceptable structural reductions against towing speed/significant wave height.

If the project significantly exceeds expectations, then similar analyses of different barge geometries (draft, width, length) would be beneficial.

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