Development of models for the dynamic analysis of floating bridges

Summary

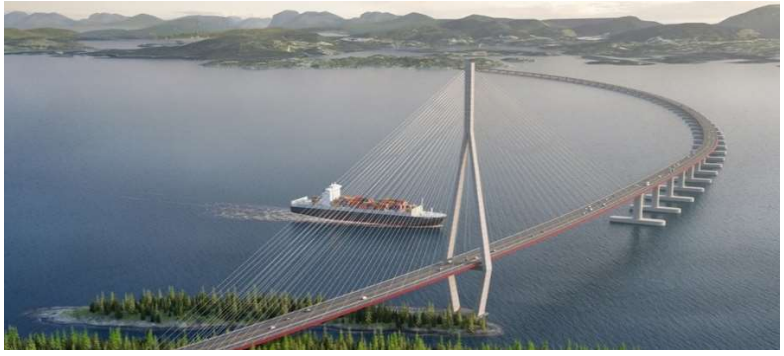
The development of new floating bridge solutions and concepts is motivated by the need to cross wide straits with deeps waters. This is a primary concern on the ongoing project 'Coastal Highway Route E39', owned by the Norwegian Public Roads Administration. Other concept designs are being study worldwide. Despite the existence of other large floating structures already constructed, the experience in design and construction of large floating bridges is still limited.

Extensive research is being carried out at present to extend the existing knowledge about the behaviour of large floating bridges. In addition, there is a need to establish guidelines and recommended practice with respect to: adequate structural modelling, environmental characterisation towards load calculation, analysis of load effects, as well as the assessment of highly relevant non-linear phenomena. The development of guidelines and recommendations should allow the industry to enhance its capabilities to design new floating bridges and also to consider them as an alternative to conventional bottom fixed bridges in locations with poor geotechnical conditions or with seismic activity. The dynamic behaviour of large floating bridges is governed by a set of interacting phenomena. For instance, the wave and wind loads will force the structure to move, and its movement will influence back these loads. Therefore, wave- and wind-induced vibrations can only be determined through a fully coupled analysis, considering the interaction between aero-hydrodynamic loads and the motion of the structure in time.

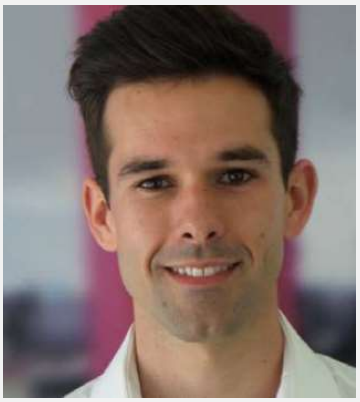
The main goal of this PhD project is the development of fully coupled aero-hydrodynamic and structural models for the dynamic analysis of floating bridges. These will be used in the global analysis of selected case studies and eventually contribute to the development of design guidelines and recommended practice. The work done should allow a comprehensive understanding of the dynamic behaviour of floating bridges to wind and wave-induced vibrations. To this end, a definition and characterisation of environmental loads is required. Waves, current and wind will be modelled in specific software, taking into account the temporal and spatial variations and their dependence on the motion of the structure. A finite element model of the floating structure will describe its response to the incident loading and allow the calculation of motion-induced forces through external algorithms. Finally, the structural response to a seismic attack will be assessed, and the residual strength evaluated. It is expected that some potential for dynamic instability will be noticed during the analysis of the case studies. Moreover, resonance phenomena should be identified. Artificial intelligence algorithms based on neural networks will be used to find trends in patterns in the structural response. This will be useful to reduce computational time when running stochastic analyses, being a valuable input for the designer in preliminary design stages. Ultimately, the work can be used by industry in future projects.

Keywords

Floating bridges, wind loads, wave loads, radiation loads, hidrodynamic-induced loads, fully coupled response, dynamic instability, seismic response.



Concept design of the Bjornafjorden floating bridge, Norway.



PhD student
João Manuel Alves Serra

PhD program
Civil Engineering (IST, University of Lisbon)

Supervisor
Ricardo Vieira (CERIS, IST, University of Lisbon)

Co-supervisor
Jorgen Amdahl (NTNU)

Period
2020-2024

Funding
Ramboll Group A/S, Denmark