MARIN

Challenging wind and waves

Linking hydrodynamic research to the maritime industry

Vortex-Induced Motions of Offshore Structures

VIM JIP

Background

Floating Offshore structures, such as production semi-submersibles, TLPs and spars, can exhibit significant in-line and transverse motions under current conditions. Such motions are generally called Vortex-Induced Motions (VIM) and could have a strong impact on the fatigue life of mooring and riser systems.

The VIM phenomenon is characterised by complex interactions between the floater and the flow around the floater. At the moment model test programmes are the preferred method to predict the VIM behaviour of the vessel. However, this is only feasible when the final design of the floater is known. Thus, tools and benchmark data are needed to assess the anticipated VIM behaviour at an early design stage to be able to reduce the VIM response of the floater.

The primary objective of the VIM JIP is to increase the physical insight into the VIM phenomenon such that the design of a floater can be improved during the design phase. To address the objective, the JIP plans to focus on model testing methodologies, CFD studies and full-scale monitoring.

Objectives

The main objectives of the VIM Joint Industry Project are as follows:

- Increase insight into the physics/phenomenon behind VIM in order to improve concept design
- Develop an early stage VIM prediction/quantification method
- Provide design guidance or "Best Practice" for VIM model testing and VIM CFD studies
- Evaluation of differences between model tests and CFD on one hand and field observations on the other hand

In order to achieve these objectives, the VIM JIP will combine dedicated VIM model tests, CFD calculations, field observations and existing data available from literature. Items that will be given specific consideration include:

- The effect of geometric design parameters and appendages on vortex-induced motions
- Characteristics of the flow field during VIM
- Differences in (environmental) conditions between model tests, CFD results and field observations with respect to VIM behaviour
- Influence of scale effects on vortex-induced motions

Previous work

In the last 15 years MARIN has tested 9 spars, 4 semi-submersibles and 4 TLPs to obtain the VIM behaviour of the floater. For multi-column floaters much less is known with respect to VIM behaviour compared to spars, which is especially due to the many possible geometric design variations. The VIM response of multi-column structures depends on a synchronisation between the vortices on the different columns as visible in the figure below.

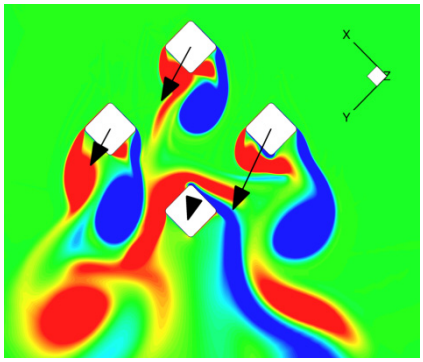

Figure 1: Flow structure around four columns at a certain instant in time. Flow is from top to bottom. Colours indicate vorticity and arrows denote the forces on the column

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Sway motions with A/D values up to 0.6 have been reported and are typically found for current directions at 45 degrees to the column. When discussing VIM motions most often the floater sway response is considered, but it is important to realize that other modes can also be excited. Especially, the possible yaw motions (even up to 9 degrees) of the floater have received attention in recent years due to its importance for risers hanging from riser balconies located on the pontoons.

Scope of work

The main objective of the VIM JIP is to develop an approach that allows engineers to predict full-scale VIM behaviour at an early design stage of the structure. To that end, the complete project is divided into the following work packages:

WP1. Systematic model tests

Model tests are carried out on a large number of basic configurations to obtain a generic A/D curve for everybody's use. The goals are:

1. to increase the insight in the physics/phenomenon behind VIM in order to improve the concept design
2. to obtain a reference data base which can be used for early stage VIM predictions

Together with the JIP participants a final model test scope will be determined. Emphasis will be given to the analysis of the damping in the system, since the ratio of damping versus (added) mass is important for the VIM motions.

WP2. CFD calculations

At present the application of CFD for the prediction of VIM is still in its early stages. However, results from the recent 'Current Affairs' JIP show that CFD tools are already capable of predicting unsteady current loads on offshore structures. In the VIM JIP the applicability, accuracy and limitations of VIM predictions by CFD will be investigated by comparing model test results with model-scale CFD calculations. Additionally, a thorough verification study for full-scale will be carried out to help quantify scale effects.

WP3. Analysis and design methodology

The objective is to define a systematic approach to predict and optimise VIM behaviour of floaters during the design process. This unified step-by-step approach will be formulated to serve as a "best practice" description in order to quantify possible VIM behaviour at an early design stage.

WP4. Proto type data evaluation

To better understand the possible differences between 'clean' model tests in a low-turbulence, uniform-flow tow test and field observations of VIM occurrences, emphasis will be given to the analysis of existing metocean data and field measurements of a floater. The goals of this work package are twofold: 1) Investigate the accuracy of metocean data in relation with possible VIM events; 2) Investigate the actual environmental conditions during an VIM event in the field.

Project deliverables

The deliverables of this JIP can be used to assess the VIM behaviour at an early design stage in order to improve the design of the floater. The most important deliverables of this project will be:

- Model test reports containing the measurement results, analysed data, time records in ASCII format and discussion of the results
- CFD calculation report containing description of applied calculation grids, set-up, analysed data, and discussion of results
- "Best practice for VIM design" reference document including a data base for VIM behaviour depending on hull parameters, floater characteristics, recommended methodology for VIM prediction and analysis based on model tests, data base and CFD calculations

Organisation

The VIM JIP will be conducted as a 3-year Joint Industry Project in close co-operation with oil companies, offshore design companies, operators and offshore contractors. MARIN will act as JIP manager and sign participation agreements with all members. All participating companies will be represented in the JIP Steering Group with meetings every 6 months. Presentations, reports and other relevant info will be posted on the confidential project website.

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