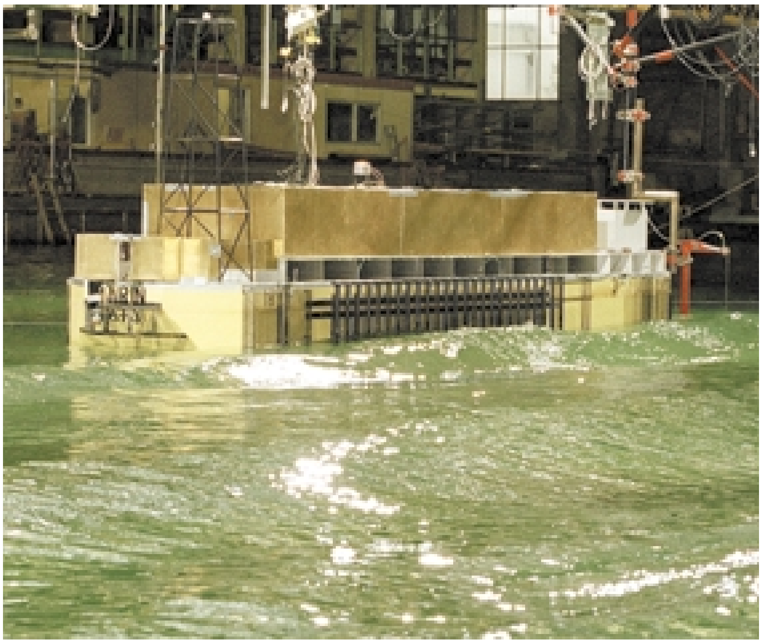
Study results confirmed that simulations combined with model tests gives reliable information on important design aspects such as roll motions.



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Girassol links simulations, model

In 2002 TotalFinaElf (TFE) contracted MARIN to perform motion analyses of the Girassol FPSO. The project proved that a combination of simulations and model tests can provide crucial design information for the future.

Pieter Aalberts
P.J.Aalberts@marin.nl

TotalFinaElf asked MARIN to look at the Girassol motions in relation to the wave and loading conditions. Importantly, these results would also provide valuable input for future projects on TFE's current station off Angola.

The Girassol FPSO, which is currently handling oil production on the TotalFinaElf operated deep-water Block 17 offshore Angola, was built by Hyundai Heavy Industries in Korea and was transported from Ulsan to Angola between March and July 2001. It has a displacement of approximately 400,000 ton and is moored in water 1,400 m deep. The relatively benign environment allows for the unit to be spread-moored using 16 lines.

In preparation for future projects on Bloc 17 (e.g. Dalia), TotalFinaElf decided to monitor the motions of the FPSO during its tow from Korea to Angola. Upon arrival on location offshore Angola, the monitoring campaign then continued throughout the mooring installation, riser connection and system commissioning operators right through to reaching full production. Objectives of the campaign were to evaluate the FPSO Motions Response Amplitude Operators (RAOs) obtained from earlier model tests and calculations with the RAOs derived from full-scale measurements. And as such, provide information which is important for the evaluation of the risers and topsides, both with respect to extreme loads and fatigue.

Full-scale monitoring campaign

Wave frequency motions of the FPSO in six degrees of freedom were measured on the departure of the FPSO from the yard in Korea and these continued onsite offshore Angola. For this purpose a motion measurement system was installed on the topsides of the FPSO near the aft perpendicular.

When the FPSO was on site the waves were measured using a directional wave rider buoy, located six

tests and full-scale monitoring

kilometres from the FPSO's location. The wave rider buoy measurement system allows the computation of the mean wave direction and the standard deviation of the wave direction per wave frequency. In addition, the monitoring campaign measurements included the heading of the ship obtained from the gyro compass and the draft, trim and heel.

From the start of the monitoring campaign in March, 2001, time traces of the wave frequent motions, waves, heading and loading conditions were measured continuously. This provided a wide range of sea states.

Motion analyses

In the overall motion analyses three different steps can be distinguished: (1) analyses of full-scale measurements during transit and on site, (2) hydrodynamical calculations and (3) the comparison between measured full-scale response and the combination of diffraction analysis and model tests.

From the long term statistical analyses of the motion measurements, sea states were selected with a wide range of wave direction, wave height and wave period. For these selected sea states the hydrodynamical calculations took into account non linear roll damping and wave spreading. The selection was also based on different loading conditions. Based on the measured motions and the encountered waves, the motion RAOs for all six degrees of freedom were derived.

It is common practice to derive the motions based on linear diffraction analysis, which are validated and then tuned by model tests. The validation with model tests is necessary because linear diffraction analysis does not take into account non-linear effects. It is, however, important to check the results derived using this combined methodology with the motions of the structure in reality. Scale effects when using the model could for instance affect the accuracy of the results.

Reliable results

A comparison has been made between the measured motion transfer functions and the calculated motion transfer functions based on diffraction theory, taking into account the measured wave spreading. Viscous roll damping has been added in the calculation to obtain the maximum agreement between measured and calculated RAOs.

The results show that wave spreading is a very important factor on how the vessel behaves and should be taken into account when evaluating measured full-scale motion RAOs.
It is shown that the agreement between calculated and measured RAOs is greatly improved by the use of measured wave spreading in the calculation.
The levels of viscous roll damping found in this tuning process can be described as function of loading condition and sea state. The viscous roll damping found in this process is in agreement with the model test results performed earlier on the same FPSO. This confirms that simulations combined with model tests give reliable design information, unaffected by model scale effects.

For more information see: 'Comparison of Full-Scale Measurements with Calculated Motion Characteristics of a West of Africa FPSO', R.R.T. van Dijk, OMAE 2003 conference, paper-37182.

Installation of the Girassol FPSO offshore Angola. Courtesy TFE.