FPSO Bow Damage in steep waves

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The Schiehallion FPSO is a ship shaped floating platform, moored with catenary anchors via an internal bow turret, in 395m water to the West of the Shetland Isles.

In December 1998 it suffered bow damage and water ingress caused by a relatively small but steep wave. Watertight subdivision meant that there was no risk to the integrity of the vessel but the question arose as to the required design pressures and loads.

BP and consultant WS Atkins, to decided to instrument the Schiehallion bow, to conduct a series of model tests at Glasgow University and to join the FLOW JIP, organised by MARIN, to try and answer this question.

This presentation describes the bow monitoring system, the Glasgow University tests and some of the interpretation of the existing results for checking the bow strengthening..

The full scale bow monitoring system includes a wave rider buoy, 26 strain gauges and 16 pressure transducers.

The model tests were at 1/80 scale and were on a bow model fixed at a given draft and trim in the wave tank. The bow model was composed of three horizontal sections so that integrated forces (or more precisely responses) could be measured for large parts of the bow. The bow model also contained an array of pressure transducers that approximately corresponded to the system on the FPSO.

Of great importance is the type of wave generated for the tests. As steep wave events are relatively rare it was decided to generate steep wave groups rather than long random sea sequences.

NewWave ideas were used to focus waves to be high or steep at the models bow. This is straightforward for the highest waves and with the model at 10 or 15m from the wavemaker linear random wave theory was found to work quite well, with the measured extreme events corresponding reasonably well with the theoretical predictions. The highest waves however did not produce large impact forces, even when the sea state on which they were based was quite steep and producing waves which broke before reaching the model. This was because the waves were not breaking at the model.

Steep fronted waves were generated by focussing the wave fronts rather than the wave crests. Steep fronted waves broke at the model and produced large impact pressures and forces. However, whereas there is a unique NewWave solution for the highest wave there is not a unique solution for the steepest fronted wave. This is because the theoretically steepest fronted wave has negligible height and for practical purposes a steep high wave is required.

Steep high waves were therefore generated by incorporating:
1) a steepness transform with a high frequency cut-off
2) a linear combination of height and steepness
into the NewWave methodology.

In the tests so far the high frequency cut-off has been found to be an important parameter but the waves producing the largest loads and pressures have otherwise been found to be those calculated to have maximum steepness. These waves are breaking as they pass the model and differ significantly from the underlying linear random wave theory.

The waves used in the tests have, according to the theory, return periods of 100, 1000 and 10000 years. However comparison with limited published data, which is mainly from wave rider buoys (which underestimate steep wave steepnesses), suggests the steepnesses in the wave tank are greater than the target return periods. The reasons will be investigated in later research but may be caused for instance by the lack of any wave directionality, the water depth in the tests being too shallow (185m rather than 395m), the tests being conducted too close to the wavemaker (4.5 to 7 water depths) or the greater likelihood of the waves breaking in advance in real sea conditions where there is much more randomness than in the NewWave.

The water depth effect is being investigated by scaling the waves, the distance from the wavemaker and the effect of the NewWave being part of a random sea is being investigated in the Glasgow tank. Directionality effects will be included in the FLOW JIP and investigated in a basin at MARIN.