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TRANSIENT LOAD EFFECTS - RINGING ON EXISTING STRUCTURES

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Visiting Gullfaks C last week, two of my colleges was met by a Statoil safety officer telling that yesterday they had ringing on the platforms. - The ringing problem have received a large interest among scientist, engineers and the people working offshore; even if the large public interest with daily headlines in the newspapers are non existent at the moment.

The large public interest of ringing started in 1992 when ringing was found in the model testing of Draugen. But transient load effects have been discovered on Norwegian platforms before Draugen. Heidrun is well known, but also loading buoys, build in the mid 1980-ies have the transient responses we to day call ringing.

In this presentation I will review the status on existing structures. Describing Condeep platforms, jackets, jackup, TLP, semisubmersibles, loading buoys and other types of offshore structures. I will summarise the input given to NPD from the different operators. A list of references is given in the end.

CONDEEP

Exited by waves the loading on a large volume structure the short term response should be Rayleigh distributed. The measurements on Frigg TCP2, Statfjord A and Statfjord B demonstrate that the largest responses frequently are higher than predicted by a Rayleigh (Spidsøe and Hilmarsen, 1983). Since the total response are calculated very conservative, these small deviations do not have any effect of the safety of the platforms.

Robberstad and Ohm (1992) demonstrates that Frigg TCP2 have a natural period of 1.7 sec and the dynamic contributions included ringing is insignificant.

Nielsen and Hunstad (1992) has analysed the full scale measurements at Oseberg A. The natural period is 1,6 sec. They demonstrate that resonant response is present, but were are insignificant. They found resonant response in two directions, and the dynamic response orthogonal to the wave direction was the largest.

Langen (1992) has evaluated the measurements on Gullfaks C based on measurements in 5 high sea states. He demonstrate that ringing in present in some sea states, but has a minor effect; less than 5% on the total response. The ringing is most pronounced in moderate storms; which also to be in accordance to the experience from the safety officer on the platform reasonable number for the highest sea states. Gullfaks C has a natural period of about 3 sec.

For fatigue the ringing will only have a minor effect on Gullfaks C. The reason is the low number of cycles. In average the resonant response is a few percents; most probably springing (Langen, 1992).

The Draugen mono tower was installed in the summer season of 1993. The platform had the first natural period of about 5 sec in the design. After the fabrication of the platform had started ringing was found in model testing. The ringing gave a major contribution to the total load. Operational precautions have be necessary to take the ringing. The water level in the shaft will be reduced in heavy storms and an active skirt pressure system have been included.

No storms have occurred during the first winter season, which included ringing events or where ringing events were expected. The full scale measurements indicate a lower natural period than assumed in the design. This should give ringing which is not as severe as found in the design. Recently a leakage in the lower dome have opened the discussion on ringing on Draugen again.

JACKET STRUCTURES

Spidsøe (1992) has reviewed the measurements at Valhall QP, Ekofisk 2/4-H and Frigg DP2. All these measurements have natural periods less than 2 sec. He conclude that ringing might be present, but is insignificant.

Nielsen and Hunstad (1992) have analysed the data from Oseberg B. It has a natural period of 1.7 sec. Resonant response are present, but insignificant.

Egeland (1992) told that the jacket Bullwickle got ringing in the hurricane Andrew after the maximum of the hurricane was over. Bullwickle has a natural period of 4 sec.

BP (1992) reported that no ringing has been observed on Magnus. It has a natural period of 3 sec. There is some response energy at the natural period of the structure (Fugro McClelland, 1991) The distribution functions deviate insignificant from a Rayleigh distribution.

JACKUP

Christensen (1993) has examined ringing on Maersk Guardian for the winter season 1990/1991. It was than at Ekofisk in about 70m water depth. Several occasions were observed with transient response. The magnitude was small and not significant for the ultimate limit state nor fatigue. The natural period for the jackup was 5-6 sec, and the significant wave height was up to 11,7m. Singe waves was up to 22m. In this situation the total dynamic amplification was not more than 1.10.

TLP STRUCTURES

Marthinsen (1992) has reviewed the model results from Snorre again. Ringing is observed, but the level was low.

Martinsen and Muren (1993) have analysed the full scale measurements from Snorre. Ringing is observed, but they are small compared with other responses.

LOADING BUOYS

On the Statfjord C articulated loading buoy strong transient responses was observed in the model testing (Mobil, 1985). It came when waves with high crests hit the columns and caused vibrations in the column in its natural period. The effect increased when current also was added. The testing were performed with a current velocity of 1.25 m/s. The damping in the tests were about 6%.

Langen (1993) has evaluated the ringing on three loading buoys operated by Statoil. At Statfjord C strong transient response was observed at high steep waves. A resonant amplification factor of up to 1.55 was found for regular waves and up to 1.83 on steep, breaking or close to breaking waves. Langen demonstrated that springing is insignificant and that the ringing is dominating. In influence of ringing on fatigue was insignificant. The design was based directly on the model testing, and treated in a conservative manner.

Langen (1993) has also the two identical loading buoys at Gullfaks A and B. The dynamic amplification was 36% for a significant wave height of 16m and a period 16 sec. The maximum value was Rayleigh distributed, but for lower sea states the short term distribution deviated significant from the Rayleigh distribution.

Langen (1993) concluded that the ringing on the loading buoys are higher than expected from a fixed column from the simulations performed by Sintef.

Robberstad and Ohm (1993) have evaluated the ringing on Nord-Øst Frigg. No sign of ringing are found in the model testing time series which have been kept. Full scale measurements have also been performed, but only for a short time period, and no time series where stored. Some odd vibrations have been felt by personnel visiting the platform, but it is difficult to evaluate the information.

OTHER STRUCTURES

Tørum (1992) and Langen (1993) have demonstrated that transient loading was found in the model testing for the Kalstø tunnel. It was for breaking waves on shallow water. The natural period was about 2 sec. No large transient loads are present, but many small giving a distribution close to the gaussian.

CONCLUSION

Model testing and full scale measurements have proved the existence of transient loading on several platforms. The model testing have up to now been necessary to support a good design. An analytical method was developed in the Draugen project. The adequacy of the analytical methods which have been used used are reasonable compared with the model testing, but have not been verified for offshore use. The next years of offshore experience from Draugen and Troll will demonstrate if the model test results and the calculation methods are reasonable.

Despite the joint industry project on ringing no analytical method is as far as I have understood available to handle ringing on structures as Heidrun. To achieve such a method will be important for future platform development into deeper water.

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