Dynamic Analysis of Connected Jackets

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Introduction

An increasing number of jacket platforms, both in the North Sea and other parts of the world are approaching or has passed their original design life. The oil and gas industry is constantly developing techniques to ensure safe use of these assets. New technology and increasingly accurate sensors, has opened up for new methods of doing structural monitoring of jackets. According to the latest revision of NORSOK N-005, accelerometers may be used for monitoring of changes in response of jacket platforms. In order to do this, it is essential to understand how interaction between connected jackets may influence the acceleration measurements. This understanding needs to be established before measurements of such systems can be assessed.

Objective and Scope

The objective of the thesis is to assess how/if the behavior of jackets connected with bridges are affected by the neighboring jacket. The analysis are done in USFOS, where the responses are solved in the time domain. The model consists of two equal jackets, connected by a bridge modelled as a linear spring, see Figure 1. The analysis is limited to waves from only one direction. The key responses that are compared for several configurations are horizontal displacement in the deck of the first jacket, as well as the force in a brace below the sea surface. The responses from the different configurations are compared with respect to fatigue, extreme response and mean square response. To study the additional eigenfrequency introduced by the bridge, together with the super harmonic force components from Morison's equation, the displacement response has been plotted in the frequency domain by doing many analysis with different wave frequencies, keeping the phase angle constant by changing the distance between the jackets. Initially, this was done for a simplified model consisting of two cylindrical cantilevered beams.

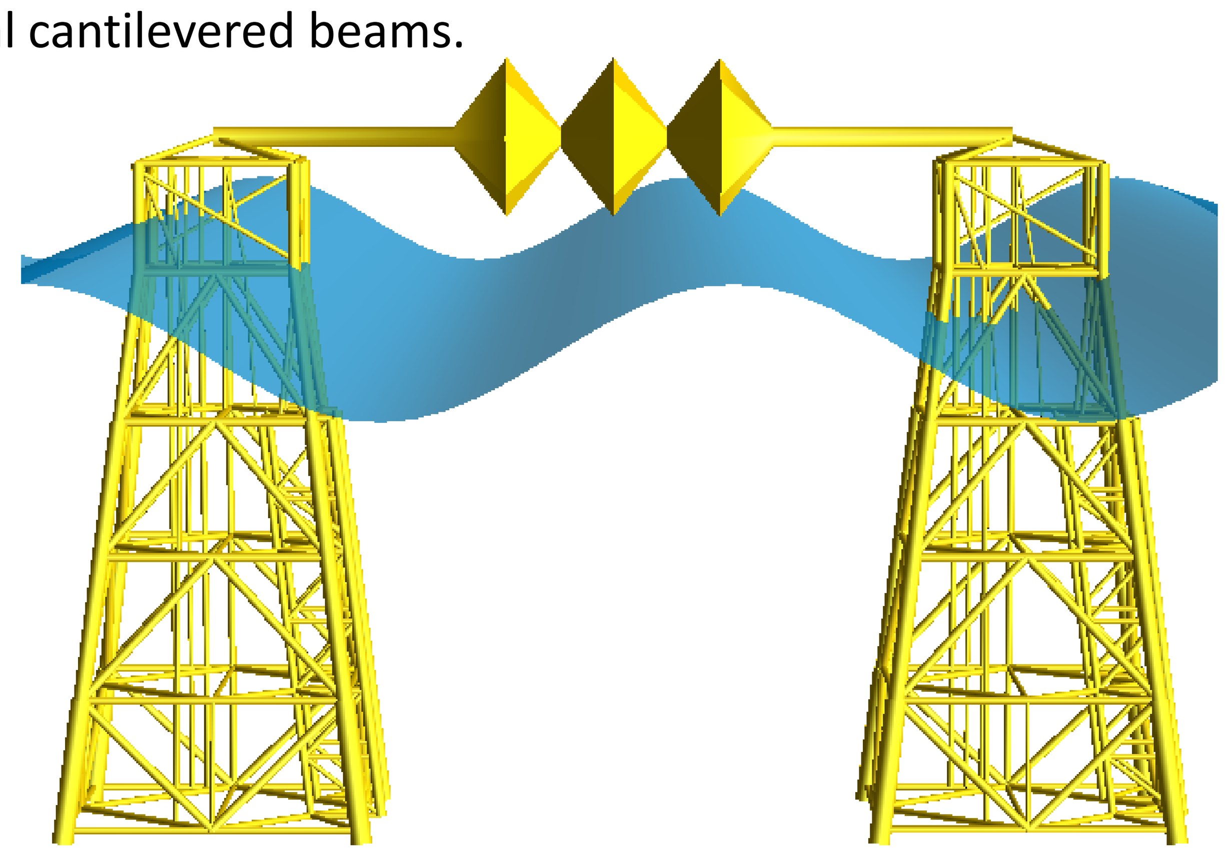

Figure 1: USFOS model with two equal jackets connected by a bridge modelled as a linear spring .

Results and Conclusions

Response as Function of Frequency for Simplified Model

The highest peak in Figure 2 at wave frequency ω = 2.2 [rad/s] corresponds to the eigenfrequency in sway for a single jacket. Due to the presense of the bridge, the system gets an additonal eigenfrequency at ω = 2.2 [rad/s]. It is observed that these two eigenfrequencies are multiples of the other lower peaks. This is explained by the super-harmonic force components from Morison's equation with frequencies at multiples of the wave frequency.

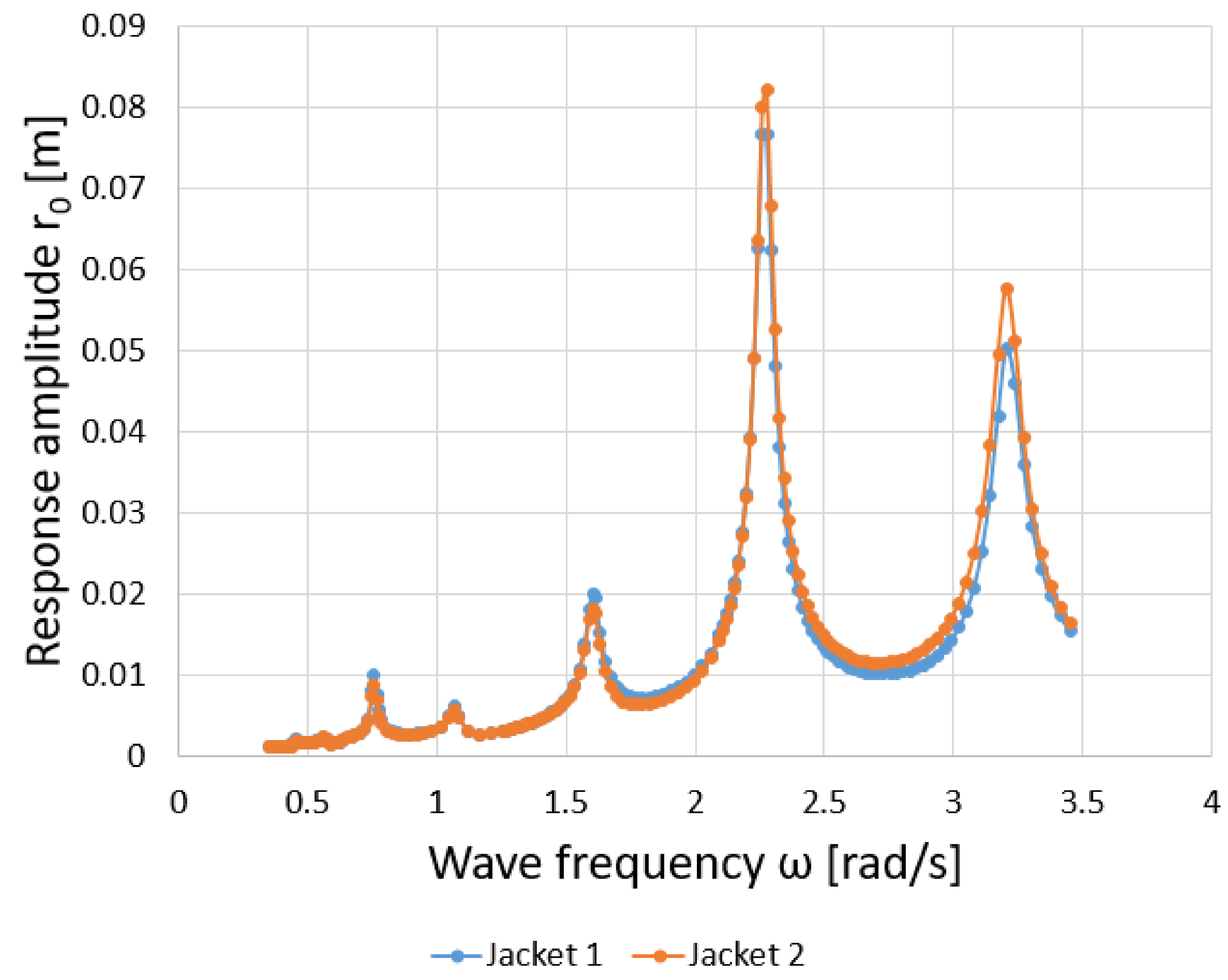

Figure 2: Response amplitude of displacement in deck as function of wave frequency, for a model with two connected jackets.

Sensitivity Study of the Bridge Stiffness

Figure 3 shows that a single jacket has higher q-probability response, and that a higher bridge stiffness gives lower q-probability response. The logic behind this is that one single jacket must absorb all the energy by itself, while two connected jackets can work together since they have maximum response at different time. On the other hand, Figure 2 showed that a bridge introduces a second eigenfrequency with additional peaks due to super harmonic forces. This gives a much larger range of critical frequencies. However, an equivalent dynamic amplification factor was found for the beam force to be EDAF = 1.01, meaning that the dynamics are neglectable for the long term extreme response. In terms of fatigue damage, it was found that the system is more affected by dynamics, but still the single jacket gave the largest fatigue damage during 3 hours.

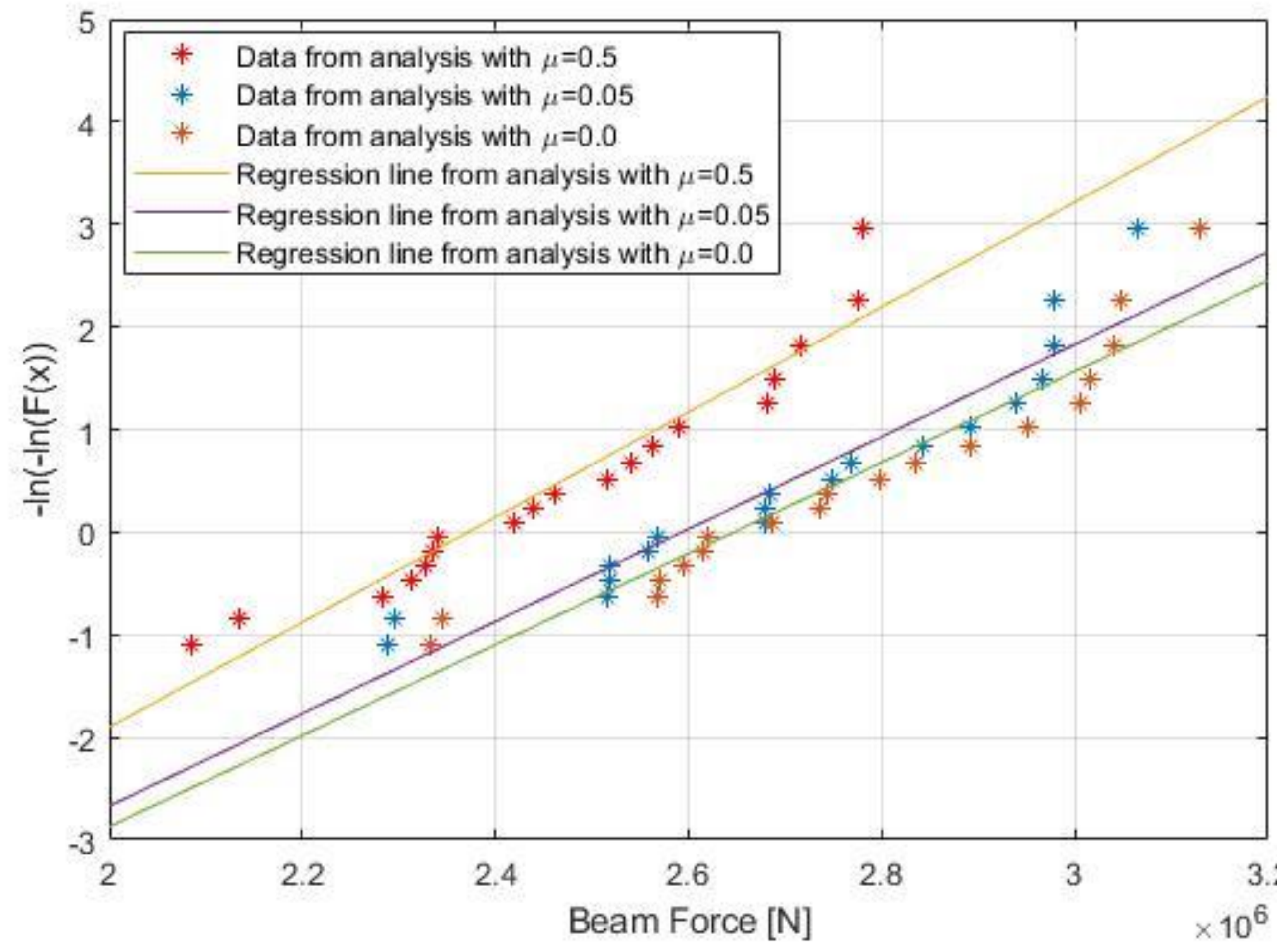

Figure 3: Extreme values of beam force in 20 time series of 3 hours plotted in a Gumbel paper, together with their fitted regression lines. The results are given for three values of relative stiffness μ, which is defined as the ratio between the bridge stiffness and jacket stiffness in sway.

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