POPULAR SCIENTIFIC ABSTRACT

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Vibration and strain monitoring of an offshore structure

Modern structures like high-rise buildings, suspension bridges and offshore windmill turbines are becoming more flexible and their lifetime is typically governed by structural vibrations caused by external forces from for example wind and waves, which lead to metal fatigue. During the design of these structures the lifetime is assessed based on statistical models that are rarely validated. By measuring the vibrations of these structures, a more accurate state of health may be obtained. The work in this PhD project does not directly quantify the state of health of these structures but propose and demonstrate a set of tools that may be useful within this field.

The vibration measurements are useful for extracting information about resonances in the structure, that can be used to validate or update some of the models used during the design phase. The process of extracting this information is, however, very time-consuming as it requires some decision making by an expert operator. Therefore, an automated procedure for extracting vibration parameters was developed in this project. This method nullifies all decision making and at the same time successfully identifies similar vibrations parameters that an expert operator would also have found.

Temperature, wind and waves are known to have some influence on the structural resonances. The proposed method for automated parameter extraction is used in conjunction with several months of vibrations measurements from an offshore structure. The information about the resonances were then paired with temperature, wind velocity and wind direction as well as wave height and wave direction. In this way the relation between these vibration parameters and temperature, wind and waves are identified. Also, the effect of wind and wave directions on the vibration parameters are investigated.

Material strains are proportional to material stresses and are crucial when calculating the fatigue lifetime. Conventional sensors for strain measurements are not suitable for long-term monitoring in harsh environments or installation may not be possible due to inaccessibility. Therefore, strain estimation using the vibration data from the offshore structure are also explored. Results suggest that reasonable accurate strain estimates are obtained. It is also found that some common methods used for strain comparison are poorly correlated with the subsequently calculated fatigue lifetime. It is therefore recommended that the fatigue lifetime is also calculated when assessing the quality of the estimated strains.