Vibration-assisted friction modulation: theory and application for a slip joint connection

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Abstract

In the last 5 years, TU Delft investigated the use of a slip joint to connect offshore structures, such as wind turbine towers to their corresponding support structure. The slip joint, also sporadically used for telecommunication towers, is a direct steel-to-steel connection obtained by overlapping two identical conical sections over each other. The connection solely depends on the geometry and contact mechanism between the two steel surfaces, and the load transfer depends on the frictional stress between the surfaces in contact. Hence, the key challenge for such connection is to guarantee a proper fit and sound contact. To either enforce the fit and the sound contact or to loosen it, a vibration-assisted technique was explored at TU Delft.

The goal of this technique is to take advantage of the interaction between friction and an imposed high-frequency vibratory load, to control and facilitate the initiation of sliding between the surfaces in contact. At first, experimental evidences of the developed methodology will be shown, using a 1:10 scaled model of the slip-joint. Subsequently, unique results are showcased, obtained by applying the vibration-assisted technique to decommission a real slip joint assembled offshore, in the North Sea.

To explain the observed experimental data and the success of the applied technique, a slow-fast process is assumed, through a selection of simplified models (e.g. mass-spring systems, mass-rod systems). The slow process refers to the steady sliding state, while the fast process intends to encapsulate the vibratory load and includes its averaged effect on the slow process. Specifically, the slow-fast analysis enables the investigation of the interaction between the imposed high-frequency vibratory load and the friction force, which can facilitate the sliding process by means of an averaged reduction of the friction force. The simplified models and the assumed slow-fast process is solved through the method of direct separation of motion.

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