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Reduction of VIV using suppression devices—An empirical approach

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Abstract

Helical strakes are known to reduce and even eliminate the oscillation amplitude of vortex-induced vibrations (VIV). This reduction will increase the fatigue life. The optimum length and position of the helical strakes for a given riser will vary with the current profile.

The purpose of the present paper is to describe how data from VIV experiments with suppressing devices like fairings and strakes can be implemented into a theoretical VIV model. The computer program is based on an empirical model for calculation of VIV. Suppression devices can be accounted for by using user-defined data for hydrodynamic coefficients, i.e. lift and damping coefficients, for the selected segments.

The effect of strakes on fatigue damage due to cross flow VIV is illustrated for a vertical riser exposed to sheared and uniform current. Comparison of measured and calculated fatigue life is performed for a model riser equipped with helical strakes. A systematic study of length of a section with strakes for a set of current profiles is done and the results are also presented.

Keywords: Vortex induced vibrations; Suppression devices; Marine risers

1. Introduction

Vortex induced vibrations are known to contribute significantly to fatigue damage for deepwater risers and free span pipelines. The tools for VIV analysis that are presently used

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by the industry are semi-empirical, meaning that the response models rely only on empirical coefficients.

Empirical models for VIV prediction of slender marine structures have been applied since the early eighties. The models have traditionally been based on data from oscillation tests with short (two-dimensional) cylinder sections, and some assumptions on application of such results for a slender beam with an unlimited number of eigenfrequencies and modes. The simplest model can handle uniform current and uniform cross sections, and is based on the assumption that the response will appear at an eigenfrequency and have the shape of the associated eigenmode, see Larsen and Bech [1]. There is a long evolution from that stage to today's models, and the research effort that has made this improvement possible has been substantial. An overview of recent research on aspects of VIV related to empirical models is presented by Larsen [2].

A strong effort has been seen at several institutions aiming at improving these methods, and new versions of computer programs like SHEAR7, Vandiver [3], VIVA, Triantafyllou [4], and VIVANA, Larsen et al. [5] have been released. Parallel to this work we have also seen progress made on alternative methods based on direct numerical simulations [6].

Strakes are used to reduce vortex-induced vibrations and belong to a larger group of VIV suppression devices. During the years, several experiments have been conducted to measure the effect of these devices. Some attempts have also been done to implement the effect of strakes and other suppression devices in empirical models. So far it seems that the existing methods are premature. Effort must be put into understanding the physics as well as implementation and verification against experimental data.

2. Theoretical background

The purpose of this section is to give a brief introduction to the analysis method applied by VIVANA, and to describe how suppression devices can be accounted for in this model. A more detailed presentation of this theory is given by Larsen [5]. The model is based on a general three-dimensional beam finite-element model that in principle can account for variation of current and cross section properties along the structures. The element theory is described by Fylling et al. [7].

2.1. Basic concepts

The present version of the model is based on some basic concepts:

1. The response takes place at a limited number of discrete frequencies that are all eigenfrequencies, but with an added mass as a function of the local flow conditions. The added mass coefficient is a function of the local flow condition, the oscillation frequency and the cross section geometry.
2. The current profile is unidirectional and always in a plane defined by the slender stretch or perpendicular to this plane.
3. VIV are assumed to have a cross-flow component only, meaning that oscillation in the current direction is not accounted for.
4. A structure in sheared current will normally have one or more excitation zones (energy input) and damping zones (energy dissipation). There will be a balance between energy input and energy dissipation during one cycle at dynamic equilibrium, see Fig. 1.