Asociación Argentina
de Mecánica Computacional

Mecánica Computacional Vol XXXIX, págs. 483-483 (resumen)
F.E. Dotti, M. Febbo, S.P. Machado, M. Saravia, M.A. Storti (Eds.)
Bahía Blanca, 1-4 Noviembre 2022

MODELLING OF VORTEX INDUCED VIBRATIONS

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Keywords: Vortex-induced vibrations, wake oscillator models, fluid-structure interaction, beam structures.

Abstract. Vortex-induced vibrations (VIV) need to be accounted for in the design of marine structures such as risers and umbilicals. If a resonance state of the slender structure develops due to its interaction with the surrounding fluid flow, the consequences can be severe resulting in the accelerated fatigue and structural damage. There is a range of VIV models and specific software available in the modern engineering practice. In general, two important aspects need to be balanced in any applied method: accuracy of predicting the development of the resonance state in given conditions, and computational time to get reliable results. The existing software is able to provide either accurate prediction by complex computational fluid dynamics (CFD) estimations of the fluid characteristics around the structure, or a relatively fast result, but with a probability of risk of underestimation. In both cases, when the decision needs to be made about VIV prevention, designers tend to apply high safety factors. That means that there is a limited trust in the existing models, and, hence, there is a room to improve computational approach to VIV problem. Wake oscillator models allow to estimate the fluid force acting on the structure without complex and time consuming CFD analysis of the fluid domain. However, contemporary models contain a number of empirical coefficients which are required to be tuned using experimental data. In this work the fluid–structure interactions are considered by investigating a straight but slender pipe vibrating in a uniform water flow. The pipe is modelled as an Euler–Bernoulli beam with flexural stiffness. The external fluid force applied to the structure is the result of the action of sectional vortex-induced drag and lift forces which are modelled using various nonlinear oscillator equations. The coupled system of nonlinear partial differential equations describing the dynamic behaviour of the system was simplified employing Galerkin–type discretisation to obtain the reduced order model. The resulting ordinary differential equations were solved numerically providing multi-mode approximations of the structure displacement and non-dimensional fluid force coefficients. The wake oscillator model proposed by A. Postnikov et al. (*Int. J. of Mech. Sciences*, 127:176–190,2017) is modified in the current work to deliver an adequate prediction of the system as variation in the applied damping in fluid equation is considered (V. Kurushina et al., *Int. J. of Mech. Sciences*, 142-143:547–560, 2018; V. Kurushina et al., *Int. J. of Eng. Science*, 150:103211, 2020). The priority during calibration is given to predicting peak displacements of a structure. The validation is performed using the published data from different experimental set-ups. This work is aimed to be one of the steps on the way to introduce modern, refined wake oscillator models into wide engineering practice.