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MECHANISM OF TURBULENCE DESTABILIZATION ON VORTEX-INDUCED OSCILLATIONS OF HEXAGONAL BOX GIRDER

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INTRODUCTION

Vortex-Induced Oscillations (VIO) are more or less unavoidable wind induced problem of light civil engineering structures. In the previous studies on the box hexagonal bridge girder with handrails (HBG), shown in Fig. 1, was disclosed a significant amplification of VIO response by a grid generated turbulence [1]. The aroused question have been to explain the genesis of that phenomenon. In [2,3] are reported "Motion Induced vortex induced Oscillations" (MIO). These oscillations due to the shear layer enhancements by the bluff body motions. In some instances, the MIO exhibit a complex interference with the classical Karman type VIO (KV). That is the present case, where perhaps owing to the shape features, shown in smooth flow VIO are magnified by turbulence.

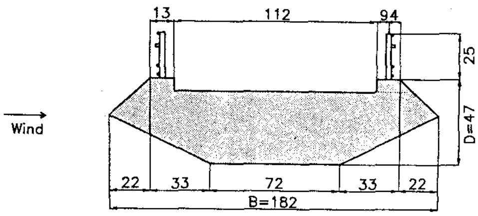

Fig. 1 Hexagonal box girder.

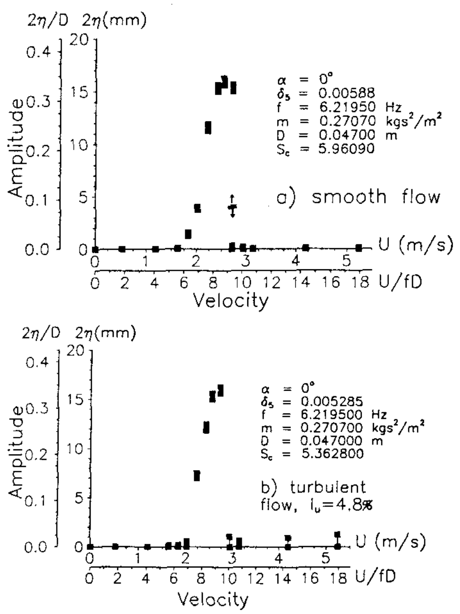

Fig. 2 V-A for small damping.

EXPERIMENTS AND RESULTS

Surprisingly, (Fig. 2) this amplification does not appear in the case when low damping is presented. If additional damping is imposed, the astonishing amplification appears (Fig. 4). A measurement of the aerodynamic damping force in small amplitudes, 0-3 mm, have shown higher values than in smooth flow. Given in Fig. 3 non-dimensional damping force (herein as the aerodynamic derivative H_1^*) v.s. amplitude, shows the effect of damping on VIO. In reduced amplitudes larger than 0.2, H_1^* is approximately the same, both in smooth and turbulent flows and the change of the damping does not affect the response. Probably the motion controls the vibration and in the power spectral density (PSD) of the fluctuating velocity in the wake, KV can not be distinguished. The PSD test have been done by the forced vibration method. In smooth flow and small amplitudes two peaks are visible (Fig. 5). Comparing with the steady state test, the broad band peak could be assigned to KV while the sharp peak corresponds to MIO. In turbulent flow, the KV peak disappears and only one peak, matching to the

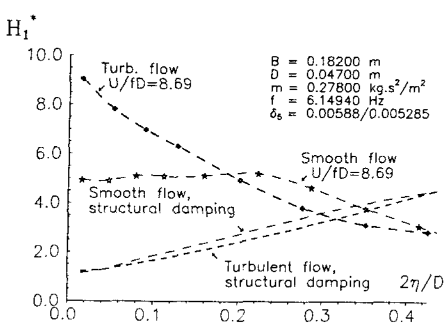

Fig. 3 H_1^* at the maximum VIO response amplitude.

forced vibration frequency, remains. The conventional experiment to suppress KV installing a splitter plate in the wake, shows also an alternation of the response and a similar power spectra.

CONCLUSIONS

Despite some authors [4] claim stabilizing effects in the response of otherwise unstable in smooth flow bluff bodies, resent studies have shown controversial results [5]. Present investigation shows that the hexagonal box girder with handrails possess complicated aerodynamic properties. The response of highly damped HGB model is amplified because: 1) interference between the two types of VIO occurs only at small amplitudes (in large amplitudes, the MIO "lock-in" both VIO; and 2) it is the imposed grid turbulence together with the HGB shape that suppresses the Karman VIO and amplify the motion-induced VIO.

Since grid turbulence differ from real and an experimental model from a prototype bridge, presented results should be interpreted with cautions.

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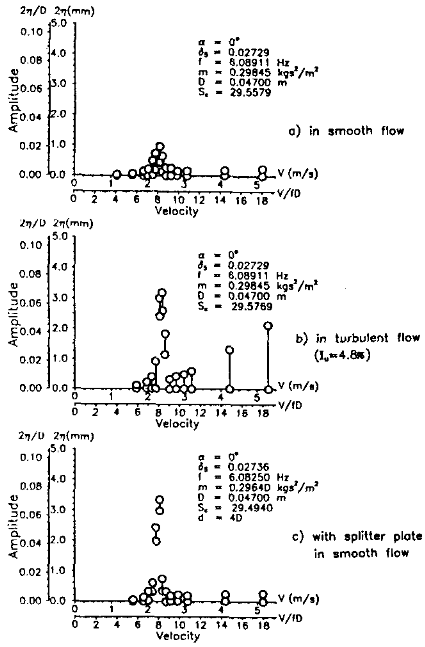

Fig. 4 V-A heaving diagram.

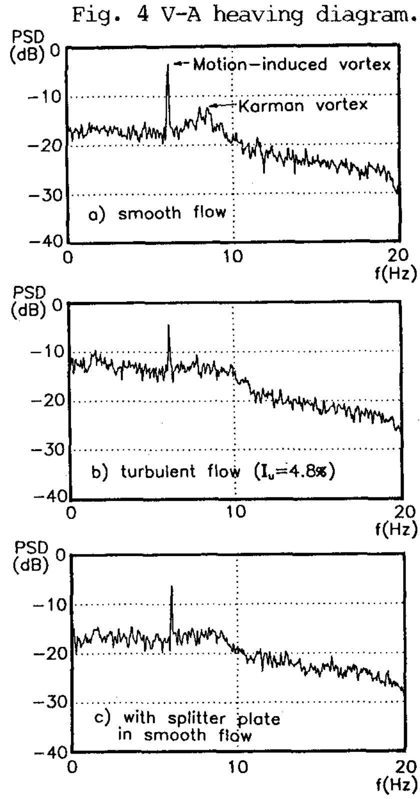

Fig. 5 PSD of velocity fluctuations in wake at V=2.3 m/s (forced vibration at re. amplitude $2\eta/D=0.021$).