TURBULENCE EFFECTS ON VORTEX-INDUCED OSCILLATIONS OF HEXAGONAL BOX GIRDER

六角形箱桁断面の渦励振への乱流不安定化効果に関する研究

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INTRODUCTION

Modern bridge box girders are designed not to be susceptible to any instabilities caused by wind. Nevertheless, since civil engineering structures differ from aircraft, some changes in their shapes cause "bluffness" and hence sources of aerodynamic excitations. Often met are vortex-induced oscillations (VIO), amplitude restricted vibrations which usually can not destruct bridge but are unallowable. These VIO are the classic Karman type (KV), and also oscillations initiated by the body motion enhancement of the shear layer (MIO) [1], [2]. For buff bodies with slenderness B/D=2.8-6 both VIO often exist. Majority of bridge girders possess similar slenderness and depend upon their shape, sometimes show VIO. The study is focused on a hexagonal box, Fig. 1 which have shown destabilization by a low intensity grid turbulence.

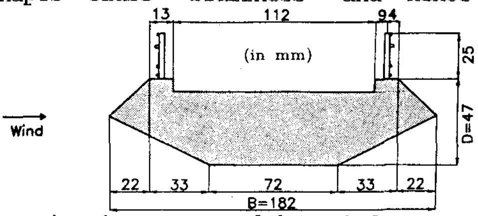

Fig. 1 Hexagonal box girder.

EXPERIMENTAL STUDY AND RESULTS

First series of tests include response measurements by free vibration. As shown in Fig. 2, the heaving was amplified 2.5 times by turbulence, in comparison with smooth flow. The measurement of the aerodynamic damping in amplitudes 0-3 mm, have shown a destabilizing force in turbulence. To distinguish both VIO, a splitter plate was installed and observed amplitude amplification was almost equal to that in turbulence. Next results were obtained measuring the power spectral density (PSD) of the fluctuating in the wake velocity. The force vibration assessment was employed, varying amplitudes 0-10 mm. In smooth flow and small heaving amplitudes (0-4 mm) two peaks

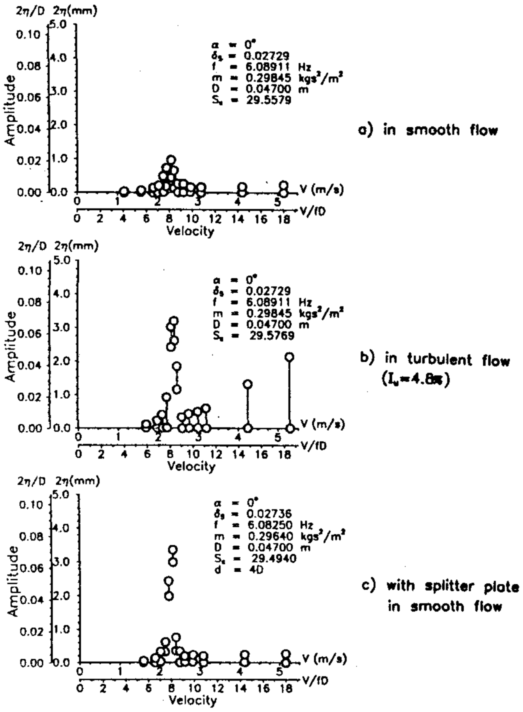

Fig. 2 V-A heaving diagram.

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were observed. Comparing with the steady run, the broad band peak (Fig. 3-a) was assigned to KV while the sharp peak in the PSD correspond to MIO. In amplitudes higher than 4-5 mm, only the second peak was noticed, for the body motion "locks-in" both VIO. In turbulent flow the KV peak disappeared and only one peak corresponding to the motion frequency remained. Similar PSD was measured with a splitter plate.

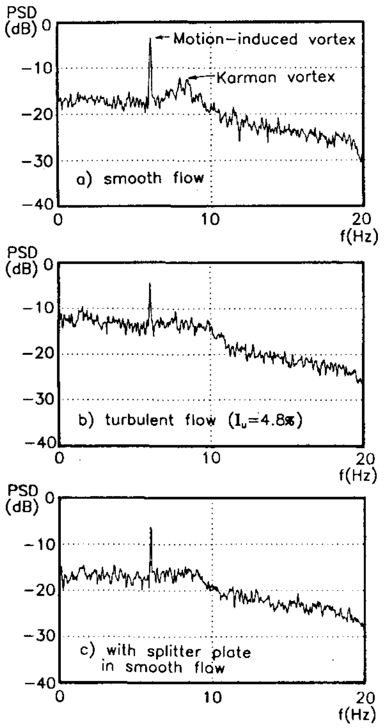

Fig. 3 PSD of velocity fluctuations in wake at V=2.3 m/s (forced vibration at red. amplitude $2\eta/D$=0.021).

CONCLUSIONS

Concerning the effects of turbulence, some authors state that it can stabilize the response of unstable in smooth flow structures, e.g.[3]. Several controversial examples are given in [4]. Presented study have shown that the hexagonal box girder with handrails possess complicated aerodynamics properties. The results have suggest that:

1) interference between the two VIO occurred at small amplitudes;

2) it is the imposed grid turbulence together with the girder shape that could suppress the Karman VIO and amplify the motion-induced VIO.

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

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