Research on buffeting force spatial correlation of box girder based on pressure measurement test of full bridge aeroelastic model

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SUMMARY:
This paper sought to illuminate the turbulence-induced changes in the aerodynamic correlation structure on a stationary/vibrational full-bridge aeroelastic model. The pressure test includes a movable section of 37 pressure measuring points. By simulating three different wind fields, the effects of turbulence integral scale and structural motion on the span and direction correlations of integrated aerodynamic parameters (lift force or torsional moment) and pressures are studied. The correlation coefficient of buffeting lift and buffeting moment under vibration condition is slightly smaller than that under static condition. Turbulence integral scale has a great influence on the correlation coefficient of buffeting force, and buffeting force has obvious three-dimensional effect.

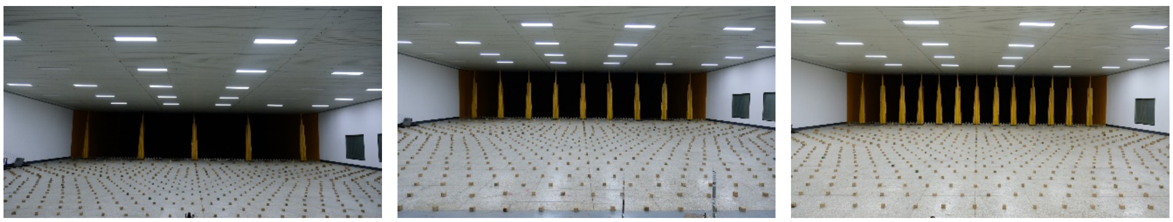
Keywords: correlation structures, full-bridge aeroelastic model, turbulence,

1. INTODUCTION

Generally, the spanwise correlation function and coherence function of buffeting force are used to describe it. In the traditional buffeting calculation theory, the spanwise correlation of buffeting force is reflected in the joint acceptance function, and the strip assumption is adopted to consider that the spanwise correlation of buffeting force is equal to the spanwise correlation of fluctuating wind speed, which greatly simplifies the calculation and analysis of buffeting. However, existing experimental results have found that the spanwise correlation of buffeting force acting on airfoil section or rectangular section in three-dimensional turbulent flow field is much greater than that of fluctuating wind speed. At the same time, it is found that when the turbulence integral scale is close to or smaller than the characteristic size of the structure, the three-dimensional effect is more significant, and the spanwise correlation of buffeting force is stronger. Therefore, in order to accurately calculate the buffeting response of long-span bridges, it is necessary to deeply analyze the span-direction correlation of buffeting forces. At present, the research of spanwise correlation of buffeting force is mostly based on the pressure test of section model, and also on the pressure test of forced vibration section model, but there are few pressure tests of vibration full-bridge aeroelastic model. Compared with the section model pressure test, the aeroelastic model can simulate the vibration mode of the structure. When buffeting occurs, the spanwise correlation function of buffeting force is identified by measuring the pressure at the measuring points arranged on the model surface. The correlation function obtained by this method is closer to the reality. In this paper, the buffeting force correlation of a long-span cable-stayed bridge with box girder section is studied through the pressure test of the aeroelastic model of the whole bridge.

2. EXPERIMENTAL ARRANGEMENTS

Three typical turbulent flow-fields were simulated in the wind tunnel by spires and combination of spires and roughness elements, as presented in Fig. 1a) ,b) and c) respectively. Turbulent wind fields were carried out in the XNJD-3 wind tunnel. Adjusting the distance between the spires can produce different wind fields.



(a) (b) (c)

Figure 1. Arrangements for generation of turbulent flow-fields (a) first turbulent flow-field (b) second turbulent flow-field (c) third turbulent flow-field.

This research is based on the pressure test of the aeroelastic model of the long-span cable-stayed bridge. The wire rope pulls the model to keep it stationary, and releases the wire rope to make the model vibrate, so as to realize the pressure measurement under both static and vibration conditions. The aeroelastic model wind tunnel test photos are shown in Figure 2a), and the 37 pressure measuring points and 6 pressure measuring strips arranged in the midspan are shown in Figure 2b).

(a) (b)

Figure 2. Arrangements for the aeroelastic model (a) aeroelastic model (b) pressure measuring points.

The turbulence characteristic parameters were measured using the TFI Cobra Probe installed at the model's leading-edge position, which is a multi-hole pressure probe able to resolve 3 components of the flow velocity with a frequency response of up to more than 2 kHz as shown in Fig. 3a). Turbulence characteristics of wind tunnel test measured by the TFI Cobra Probe are shown in Table 1 The surface pressure of the segment model is measured by the Scanivalve DSM3400 electronic pressure scanning valve system, which is composed of the DSM3400 main engine and the ZOC33 electronic pressure scanning valve (Fig. 3b)). The model to be tested and the electronic pressure scanning valve are connected with PVC plastic pipes, and the scanning valve is fixed inside the model (Fig. 3c)).

(a) (b) (c)

Figure 3. Measuring equipment (a) Cobra probe for measuring wind velocity (b) DSM 3400 pressure measurement system (c) Connection between Z0C33 electronic pressure scanning valve and model.

Table 1. Turbulence characteristics for the wind tunnel tests.

Number	σ_u / U	σ_w / U	L_u^x (m)	L_w^x (m)
1	0.105	0.081	1.41	0.71
2	0.121	0.101	1.05	0.52
3	0.135	0.122	0.84	0.42

3. RESULTS AND DISCUSSIONS

The power spectrum of midspan displacement (Figure 4) shows that the installation and release of wire rope can achieve the static and vibration states of the model, and the main modal response of the model buffeting is also the first order positive symmetry vertical.

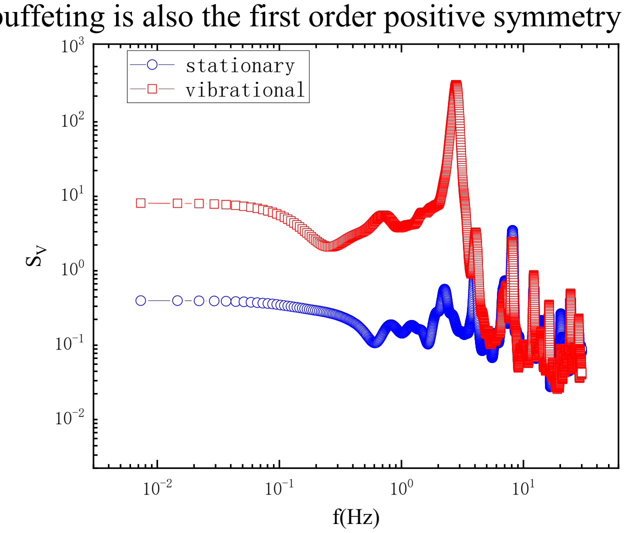


Figure 4. The power spectrum of midspan displacement

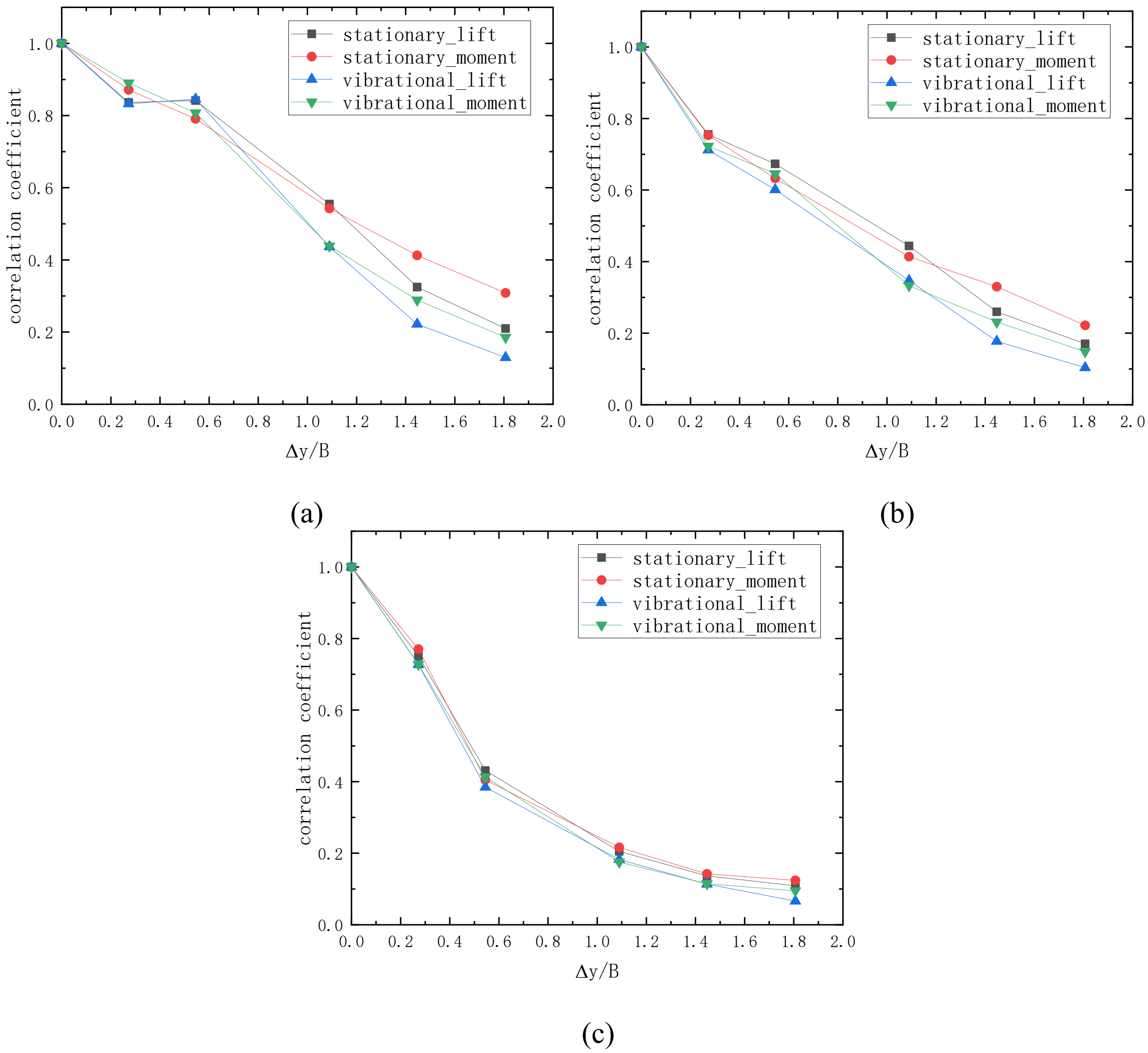


Figure 5. Correlation coefficient of lift force and moment under stationary and vibrational conditions (a) in the first turbulent flow-field (b) in the second turbulent flow-field (c) in the third turbulent flow-field.

4. CONCLUSIONS

The correlation coefficient of buffeting lift and buffeting moment under vibration condition is slightly smaller than that under static condition. Turbulence integral scale has a great influence on the correlation coefficient of buffeting force, and buffeting force has obvious three-dimensional effect.

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