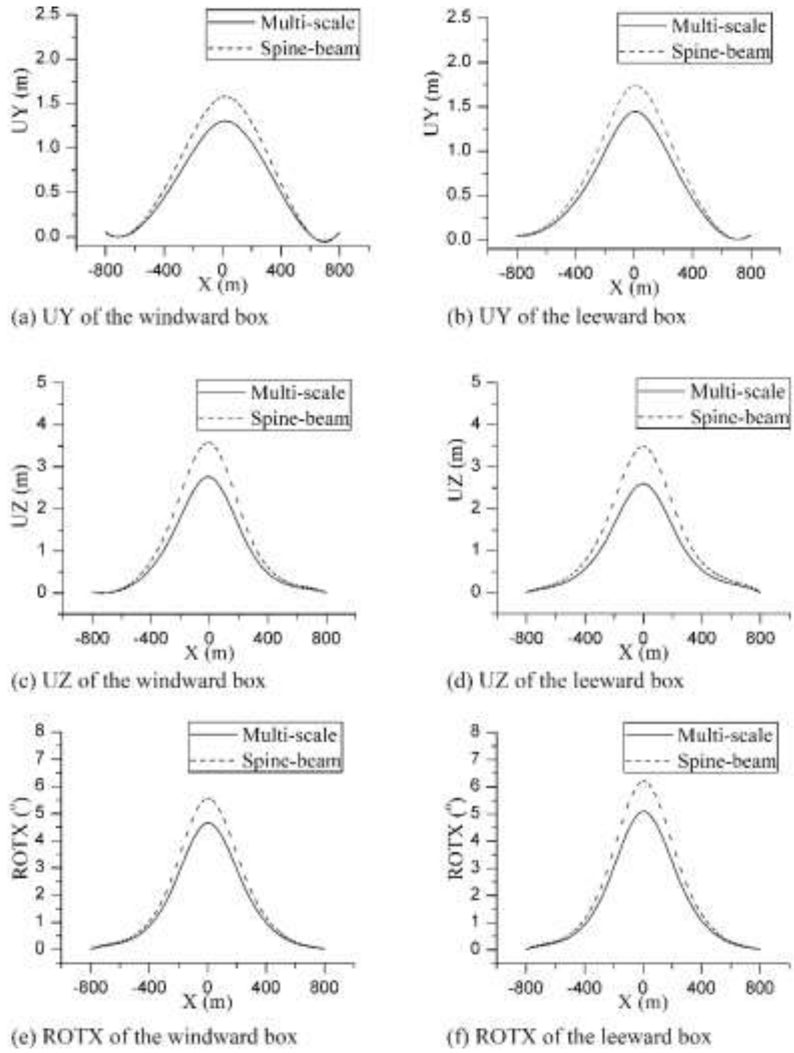
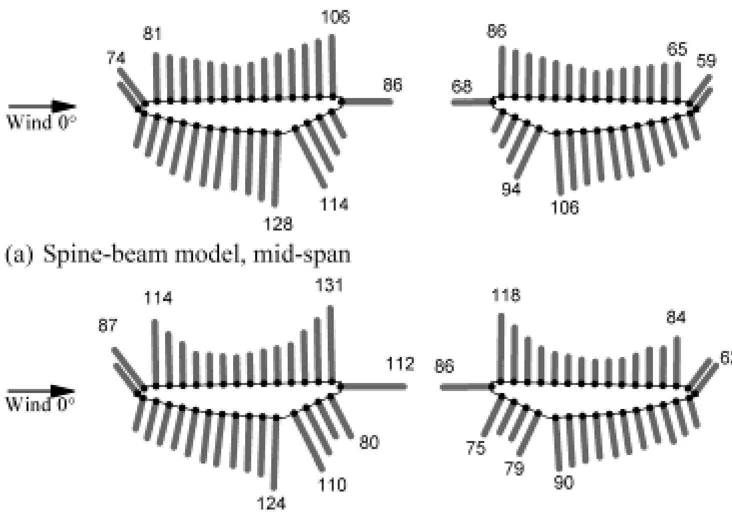


(a) UY of the windward box
(b) UY of the leeward box
(c) UZ of the windward box
(d) UZ of the leeward box
(e) ROTX of the windward box
(f) ROTX of the leeward box

Fig. 11 Maximum total displacements (N-E wind direction, U = 46 m/s)



(a) Spine-beam model, mid-span
(b) Multi-scale model, mid-span

Fig. 12 Maximum total stresses (N-E wind direction) (MPa)

$$Coh_y^{1/2}(\Delta y) = \begin{cases} 1 & \text{when } \Delta y = 0 \\ 0 & \text{when } \Delta y \neq 0 \end{cases} \quad (33)$$

The maximum total stresses in the mid-span of this analysis are shown in Fig. 13.

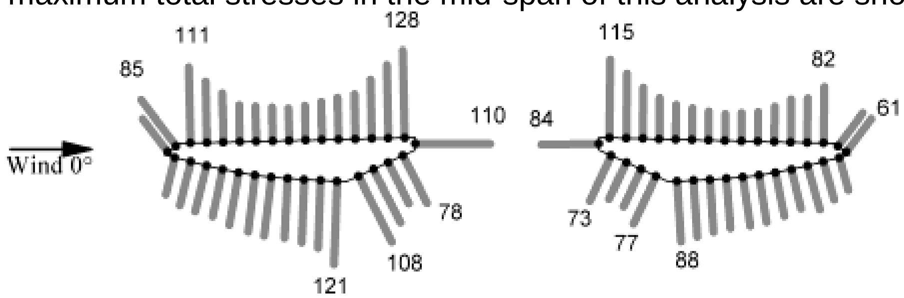


Fig. 13 Maximum total stresses in the mid-span neglecting chord-wise cross-spectra (Mpa)

A comparison between Fig. 13 and Fig. 12b shows that neglecting the chord-wise cross-spectra of the aerodynamic forces only lead to about 2.5% decrease in the calculated stress responses.

5. CONCLUDING REMARKS

This paper proposes a stress-level buffeting analysis framework for a long-span twin-box deck bridge under distributed wind loads. Special features included in this framework are : (1) obtaining the distributed aerodynamic pressure admittance and identifying the frequency-domain characteristics of the aerodynamic pressure of a twin-box deck based on wind tunnel pressure test results; (2) obtaining the distributed aeroelastic parameters from wind-tunnel-measured integrated aeroelastic parameters; (3) establishing a 3D multi-scale FE model for the bridge using the sub-structuring method; (4) updating the multi-scale FE model using the measured modal frequencies and multi-scale influence lines; and (5) how to combine stress-level buffeting analysis with a sub-structuring multi-scale FE model of a long-span bridge for both global and local buffeting responses.

The proposed framework was then applied to the Stonecutters cable-stayed bridge in Hong Kong. The responses computed using the proposed buffeting analysis framework were compared with those computed using the sectional-force-based traditional method on a spine-beam model. The mean wind stress responses of the multi-scale model are significantly larger than those of the spine-beam model on the edges of both boxes. The dynamic stress responses of the multi-scale model are also larger than those of the spine beam model on the edges of both boxes. This difference results partly from the larger aerodynamic and aeroelastic loads on the edges, and partly from the stress concentration induced by the longitudinal-and-cross-girder connections on the inner edge and the cable-deck connections on the outer edge.

This study also investigates the chord-wise correlation of aerodynamic pressures. This is necessary for a complete buffeting analysis framework that takes into account the distributed wind loads. The results show that the chord-wise and diagonal correlation is remarkably weaker than the span-wise correlation and neglecting the chord-wise cross-spectra of the aerodynamic forces only lead to about 2.5% decrease in the calculated stress responses.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the financial support from the Research Grants Council of Hong Kong for the second author (PolyU15221815). Any opinions and concluding remarks presented in this paper are entirely those of the authors.

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