Effects of Wind Induced Vibrations on the Humber Bridge

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Introduction

In this project the effects of wind induced vibrations on the Humber bridge were investigated. A computational fluid dynamics model of air flow was simulated over a section of the deck. Additionally the structural characteristics of the bridge were modelled.

Structural

The bridge was modelled computationally and analytically, the results from these were in the form of mode shapes and natural frequencies. From these the structural response of the bridge was ascertained.

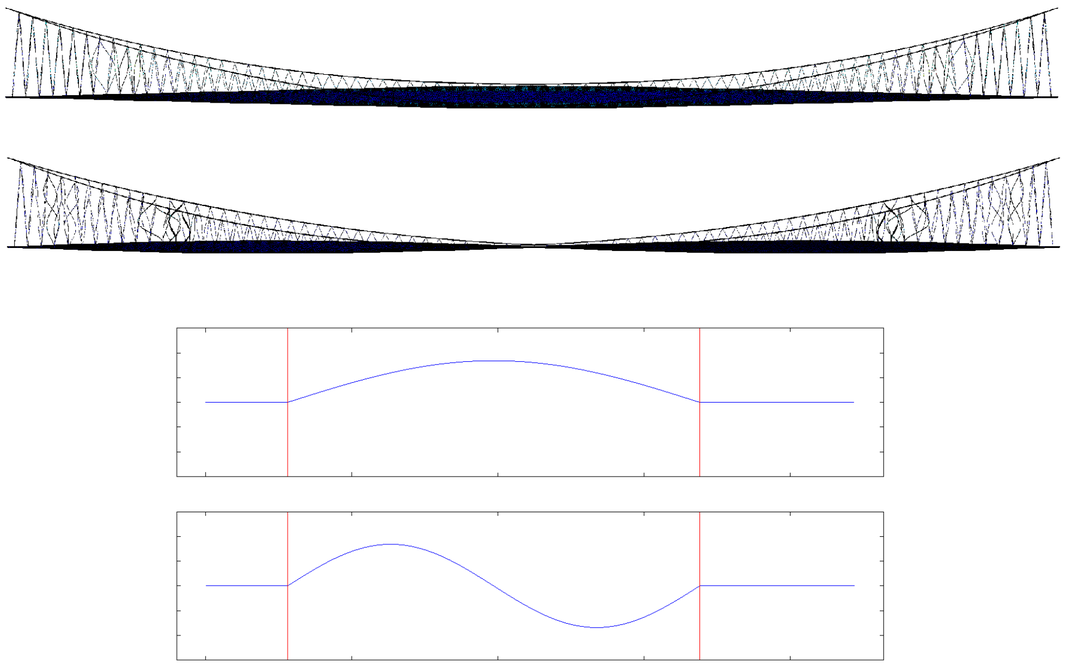

Figure 1 – A comparison of torsional modes using different methods

The results obtained from the different structural analysis methods were compared to an experimental study of the Humber Bridge [1]. The results were then used to calculate the critical wind speed that would resonate the structure at its natural frequency.

Fluids

A simulation of 12 minutes of 1m/s airflow over a section of the Humber Bridge deck was carried out. Large eddy simulation was used to accurately model the time dependent turbulent structures.

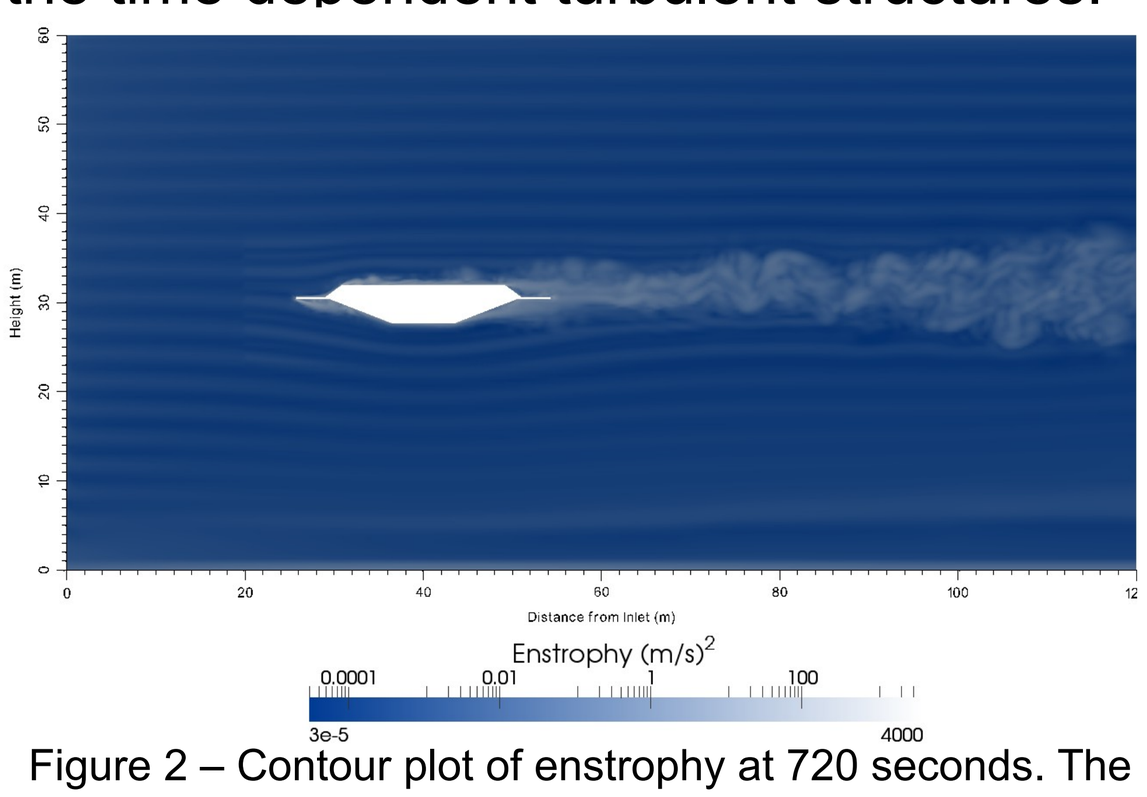

Figure 2 – Contour plot of enstrophy at 720 seconds. The image shows turbulent structures in the wake.

During the simulation the lift forces on the bridge were recorded. A fast Fourier transform was carried out to determine the forcing frequencies for this specific flow. These frequencies were compared to the results of the structural analysis. For the wind velocity used here the forcing frequency did not coincide with any of the natural frequencies.

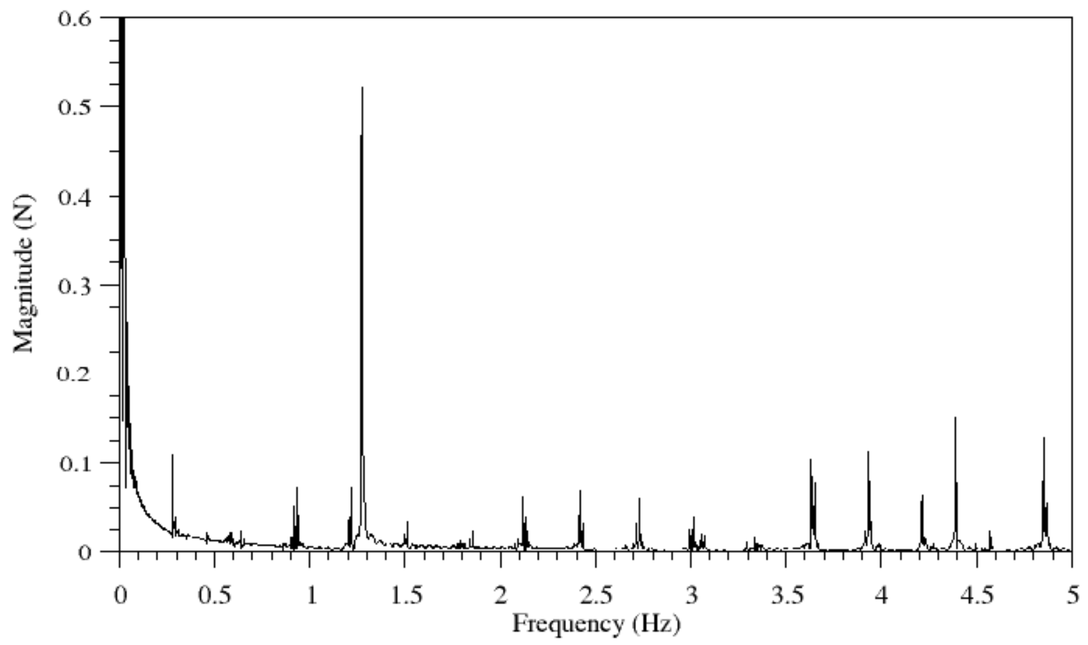

Figure 3 – A Fourier transform of the lift forces on the bridge from the fluid simulation.

[1] Brownjohn, J. M. W., Dumanoglu, A. A., Severn, R. T., & Taylor, C. A. (1987). Ambient vibration measurements of the Humber Suspension Bridge and comparison with calculated characteristics. In *ICE Proceedings* (Vol. 83, No. 3, pp. 561-600)

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