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Computational and Experimental Wind Engineering for Long-span Bridges: Vortex-induced vibrations

Abstract

Vortex-induced vibrations (VIV) are a key aerodynamic phenomenon. When periodic vortex shedding synchronizes with a structure's natural frequency, a lock-in condition may occur, causing large oscillations. VIV can lead to serviceability issues, fatigue, or even damage. The poster presents both static and dynamic CFD analyses, illustrated through a case study, which is shown on Fig. 1.

Fig. 1. – Alconétar Bridge, Spain (220m arch span, 2006)

Static CFD analysis

The investigation of the VIV phenomenon was carried out through a case study of the Alconétar Bridge, where VIV was observed during construction. Using VXflow, we analyzed vortex shedding in the original geometry and explored possible modifications and their effects on the flow.

As a first step, the original rectangular cross-section of the arch was modeled in VXflow and subsequently modified by adding bracing as well as arc- and rectangular-shaped deflectors. Using static CFD analysis, Strouhal (*St*) numbers and critical wind velocities were determined. Fig. 2 shows the vortex patterns from VXflow for one of the investigated cross-sections. As an outcome of the static simulations, Strouhal numbers and critical wind velocities were calculated based on Fig. 3 and Eq. 1. respectively.

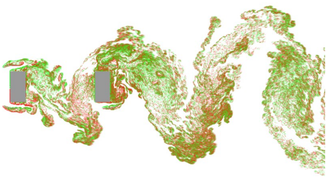

Fig. 2. – Vortex shedding from static CFD analysis

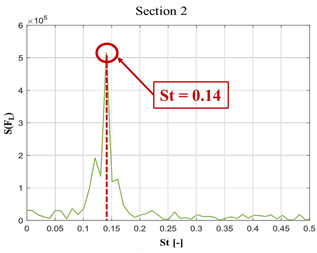

Fig. 3. – Strouhal number evaluation

$$Eq.\ 1. \qquad v_{crit,n} = \frac{D \cdot f_n}{St}$$

Dynamic CFD analysis

After the static analysis, dynamic simulations were performed within an extended range of the critical wind velocity (±6 m/s around the value obtained from the static analysis), allowing for vertical displacements. The main outcomes of the dynamic CFD were the presented diagram on Fig. 4, which shows the vertical displacements' RMS values of the cross-sections as a function of wind velocity.

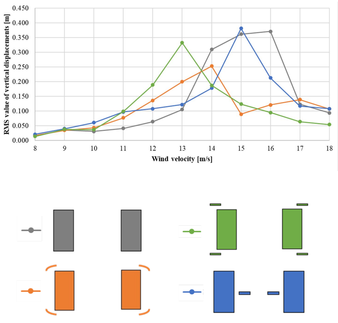

Fig. 4. – Diagram of RMS values of vertical displacements versus wind speed

Conclusions

This study investigated vortex-induced vibrations (VIV) on the Alconétar Bridge during construction. Using VXflow, both static and dynamic CFD analyses were performed on the original and modified arch cross-sections. Results showed that arc-shaped deflectors were the most effective solution, while the influence of damping was smaller than that of a properly selected cross-section.

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