DYNAMIC PROPERTY IDENTIFICATION METHOD FOR LONG-SPAN BRIDGES USING STEADY-STATE EXCITATION

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Extended Abstract

Accurate identification of dynamic characteristics, including natural frequencies and damping ratios, is essential for construction safety control and precise alignment adjustment of long-span bridges. These parameters directly reflect structural stiffness, mass distribution, and wind-resistant performance. However, environmental and vehicle-induced excitations during construction often result in low signal-to-noise ratios, leading to poor accuracy and instability in dynamic parameter identification.

To address this issue, this study proposes a steady-state excitation-based method for identifying dynamic properties of long-span bridges during construction. A purpose-built steady-state exciter is mounted on the main girder to apply stable and controllable harmonic forces, selectively exciting the first symmetric and first antisymmetric vertical bending modes. As shown in Figure 1, the exciter adopts a highly integrated design with a 2-ton effective inertial mass, precisely adjustable amplitude within ±0.5 m, and a continuously tunable excitation frequency ranging from 0.15 Hz to 2.0 Hz. By incorporating a dynamic amplification mechanism, the device efficiently converts low-power input into high-amplitude excitation, significantly enhancing the response energy of target modes and improving signal quality. Combined with signal filtering and modal separation techniques, single-degree-of-freedom steady-state responses are extracted, enabling high-precision identification of natural frequencies and damping ratios.

Finite element analysis of a typical long-span cable-stayed bridge during double-cantilever erection reveals that the first antisymmetric vertical bending mode is dominated by tower deformation (88.92% strain energy), while the first symmetric vertical bending mode is governed by stay cables (93.04% strain energy). Field tests using the developed steady-state exciter verify that the proposed method can accurately capture real-time dynamic parameters. Test results show that the average frequency of the first antisymmetric mode is 0.1802 Hz with a damping ratio of 0.629%, and the first symmetric mode is 0.7468 Hz with a damping ratio of 0.115%. Repeated tests yield frequency errors below 1% and damping ratio errors below 5%.

This method overcomes the limitations of traditional environmental excitation methods and provides a reliable technical solution for construction-stage dynamic monitoring, alignment adjustment, and wind-resistance safety assessment of long-span bridges.

Figure 1 Steady-state exciter.

Keywords*: Long-span bridge; Dynamic properties identification; Steady-state excitation; Field testing.*