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Aerodynamics challenges and solutions for structures of unique architecture

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Abstract

The paper examines aerodynamic characteristics of close and parallel automobile and rail bridge arches. Aeroelastic stability of the bridge arches is investigated in a specialized wind-tunnel. It is found that the automobile bridge span is subject to vortex-induced oscillations. These oscillations are reduced by arrangement of a fairing on the bridge-span stiffening girder. Possibility of a buffet-type aerodynamic instability is examined in detail.

Keywords: aerodynamics of bridges, aeroelastic vibrations, vortex excitation, reducing vibrations.

Introduction

Aerodynamic stability under effect of wind is a very important aspect of wide-span bridge design. It is well known that bridges with the spans over 100 meters long might have high-amplitude aeroelastic vibrations that could even bring them to a collapse. An example of these unacceptably strong vibrations is vortex resonance of the Volgograd Bridge, and the Tacoma Narrows Bridge of 1940 is an example of a collapse.

The main reasons for aeroelastic vibrations of bridges and their elements in wind are as follows:

- wind gusts;
- periodical aerodynamic force due to periodical shedding of Karman vortices;
- negative aerodynamic damping resulting in self-oscillations;
- aerodynamic bending-twisting coupling;
- periodical changes in the parameters of the system.

Aeroelastic vibrations are characterized by two main parameters: critical speed of vibration inception and maximum vibration amplitude.

Today, practically all wide-span bridges undergo aerodynamic tests serving to find and eliminate negative aerodynamic effects, so the accidents of bridge failures due to winds do not repeat. Aerodynamic studies of unique bridges are performed in special wind tunnels. Unlike those intended for aircraft testing, these wind tunnels have closed test section and can simulate a very important ground layer of the atmosphere.

Object and purposes of aerodynamic studies

The test objects were the arch of a railroad bridge and the arch of a highway bridge installed in parallel at a short distance from each other. Both bridges had the length of 230 m, their arches being ~45 m tall, see Fig. 1.

The purpose of aerodynamic tests was to check aerodynamic stability of the structure. Bridges of this configuration are potentially likely to have

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