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Estimation of aerodynamic instability of building structures

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Abstract

The interaction of flexible structures with the wind flow and the possibility of the occurrence of so-called aerodynamics instability is an actual problem. The sad experience of different years has shown that the phenomenon of aerodynamics instability is characteristic for various types of structures, such as bridge structures, asymmetric and high structures. This experience gave impetus to the study and development of methods for predicting and preventing all possible resonant and unstable oscillations.
To verify methods for estimating of the aerodynamic instability, following test problem was chosen - the interaction of the cross section of the bridge on the Tacoma River (Tacoma Narrows Bridge) with the air flow. This task was solved by a team of scientists from China and presented at the international conference (The Seventh International Colloquium on Bluff Body Aerodynamics and Applications (BBAA7) Shanghai, China; September 2-6, 2012) [1].

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Keywords: aerodynamics, aeroelastic problems, Fluid Structure Interaction (FSI), aerodynamics instability, bridge aerodynamics, civil wind engineering, numerical simulation, computational fluid dynamics

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1. Verification problem

To verify the method of studying aerodynamics stability, the problem of the interaction of the cross section of the bridge on the Tacoma River (Tacoma Narrows Bridge) with the air flow was chosen. The geometrical parameters of the cross section are shown in Fig.

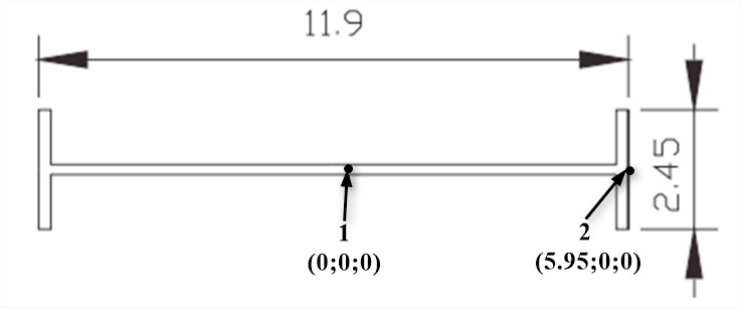

Fig. 1. Geometrical parameters of the cross section of the Tacoma Narrows Bridge

To solve the problem, the following stages was selected:

1. Selection of the parameters of the computational model, using test calculations for various grid sizes;
2. Investigation of the flow around a section of a bridge as a rigid body, at various angles of wind attack at a wind speed of 10 m/s to determine the criteria and critical velocities of aerodynamics instability;
3. Investigations of the mutual influence of the aerodynamics flow and flexible elastic structure by direct coupled aeroelastics computation at different wind speeds, to determine the condition for the onset of aerodynamics instability;
4. Comparison of the results of engineering approach and direct coupled numerical solution.

1.1. Galloping

According to the Glowrt-Den-Hartog criterion (necessary condition), the angles at which galloping can occur are determined.

Below there are results of transient calculations performed using the software ANSYS CFX. Using the ANSYS CFX, the values of the aerodynamic coefficients of the drag force C_D and the lift force C_L at different angles of attack were determined.

$$H = \frac{dC_L}{d\alpha} + C_D < 0 \tag{1}$$

Further, according to the formula (1), the Glowrt-Den-Hartog criterion H was calculated. In Table 1 angles for which the Glowrt -Den-Hartog criterion is satisfied are shown. For these angles galloping is possible.