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Original Research Article

Validation of numerical models of concrete box bridges based on load test results

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ABSTRACT

A Results of experimental load tests are used for the validation of numerical models applied in analyses of the concrete box bridges by means of the Finite Element Method. Six different models were used in the analyses: two created of 1-dimensional finite elements in a 2- and 3-dimensional space and four hybrid models composed of 1- and 2-dimensional elements in a 3-dimensional space. Validation of the theoretical models was based on the case of a cable-stayed bridge structure (max. span length 256 m) and a continuous multi-span beam structure (max. span length 60 m). Details of the numerical models, results of static and dynamic analyses as well as the procedure and effects of static and dynamic load tests are presented, compared and discussed.

1. Introduction

Results of load tests of bridges offer very important and effective data for the validation of structural analysis procedures. A comparison of experimental and theoretical values helps with selection of the most effective methodology of structure modelling and analysis. For analysis of concrete box-girder bridge structures, the Finite Element Method (FEM) is usually used. Taking into account conception presented in [1] and developed in [2] classification of the FEM models of bridge structures can be based on two parameters:

– type of finite elements used for construction of a model – with possible application of one- (e^1), two- (e^2) or three-dimensional elements (e^3);
– dimensions of the space needed for model creation – from one-dimensional space (s^1) to real three-dimensional space (s^3).

Possible combinations of the above parameters form six basic classes of the FEM models applied in the structural analysis.

The most popular numerical models of bridges are created of one-dimensional finite elements in a two-dimensional space (e^1,s^2) or three-dimensional space (e^1,s^3). In case of concrete box structures, hybrid models composed of one- and two-dimensional elements in a three-dimensional space ($e^1 + e^2$,s^3) are also successfully used in numerical analyses as presented in [3,4].

A comparison of experimental and theoretical results achieved by means of various models was performed for six box-girder structures of the Rędziński Bridge over the Odra River located along the Wrocław Motorway Bypass. Structural details of this largest concrete cable-stayed bridge in Poland as

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well as erection procedure are described in [5,6]. The bridge is 1742 m long and consists of 610 m long southern flyovers, a 612 m long cable-stayed main bridge with separate decks suspended to one 122 m high pylon and 520 m long northern flyovers as shown in Figs. 1 and 2.

In this paper results of numerical analyses and outcomes of the experimental tests are compared for two representative structures: the long-span cable-stayed main bridge and the continuous 11-span beam structure of the southern flyover.

Load tests of the structures were executed according to recommendations [7] and consisted of two types of experiments [8,9]:

- static load tests performed by means of heavy lorries with controlled parameters (axle loads, geometry, etc.) with measured displacements of the main structure components,
- tests under dynamic loads – produced by heavy lorries crossing the structure – focused on the determination of the natural frequencies and the corresponding mode shapes of bridge vibration based on analysis of structure dynamic displacements and vibration accelerations, using the methodology presented in [10–12].

During the tests and analysis of their results the following conditions, underlined e.g. in [13,14], were taken into account:

- the main parameters of the static and dynamic loads are known and can be controlled;
- the vibrating mass of the bridge is influenced by the moving mass of the vehicles;
- tests have to be performed without any other static or dynamic loads of the bridge.

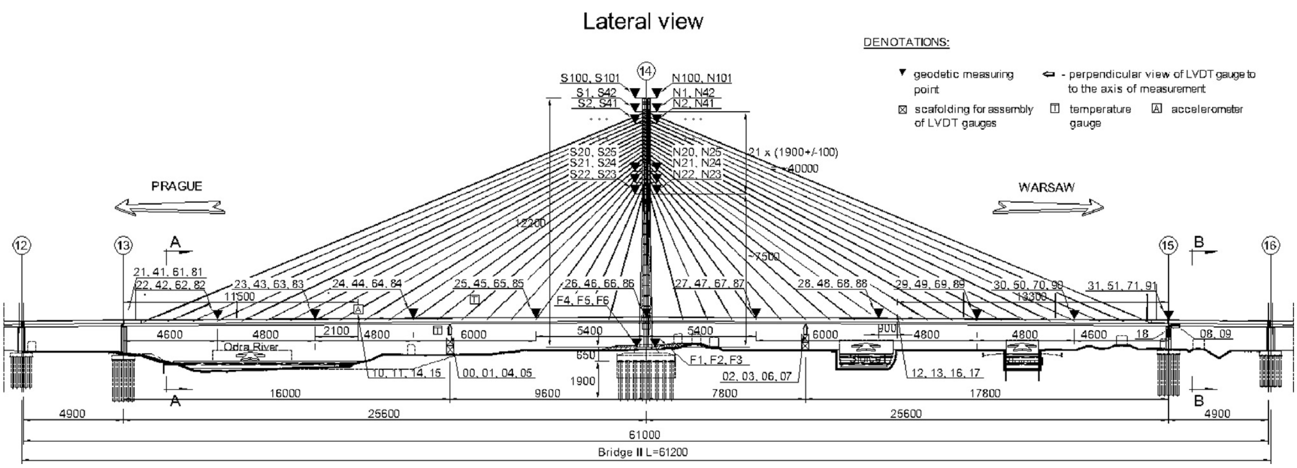

Fig. 1 – Lateral view of the main Rędziński Bridge – measuring points and dimensions.

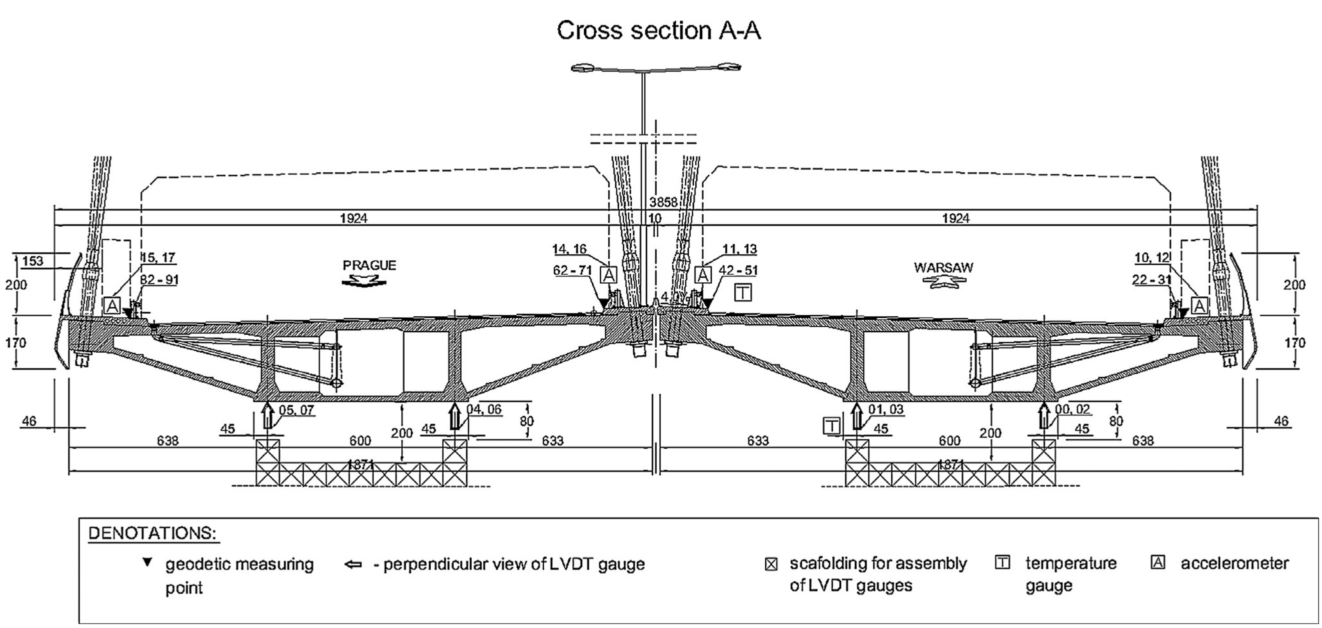

Fig. 2 – Basic dimensions of the bridge cross section and location of measuring points.