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Arch Bridge Crossing the Brno-Vienna Expressway

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Summary

A composite arch bridge formed by a steel tube in-filled with concrete that supports a cast-in-place concrete deck of a trough cross section is described in terms of the architectural and structural solutions, static function and process of construction. Results of the static and dynamic tests are compared with the results of the static and dynamic analysis.

1. Architectural and Structural Solution

A new 67.50 m span steel-tube arch bridge carries local road traffic across the new Brno-Vienna Expressway in the Czech Republic. In evaluating the angle of skew of the crossing, it was determined that using only one arch as the load-bearing member would be the most aesthetically and structurally preferable solution. The arch is formed in a circle with a radius of 74.75 m by a single steel tube with a diameter of 900 mm and a thickness of 30 mm in-filled with concrete. Internally, the steel tube is stiffened by diaphragms at a distance of 2 m. The arch is fixed in concrete foundations on each side of the expressway - see Fig. 1. The arch supports a slender trough-shaped cast-in-place concrete deck using edge girders in the shape of New Jersey barriers which serve as stiffening girders as well as safety barriers. The deck is post-tensioned by cables situated at the edge girders and in the deck slab.

The deck is connected to the arch by steel struts situated perpendicular to the axis of the arch at a distance of 6 m. These steel struts, which are connected to the stiffening diaphragms of the steel arch tube, are of a small box-cross section and are also filled with concrete. To guarantee the stability of the arch not only in the vertical direction but also in the transverse direction, these struts are triangular in shape; the width of the triangle is always constant, but the length is variable. In the middle of the bridge, the arch is fix-connected directly with the deck. The first and last side spans, which are relatively long, are supported by inclined cast-in-place concrete struts that are pin connected with the deck and with the concrete foundation of the arch. These concrete struts are arranged directly under the edge girders to transfer the loading directly from the edge girders to the foundations, and thus assure the stability of the structure in the transverse direction.

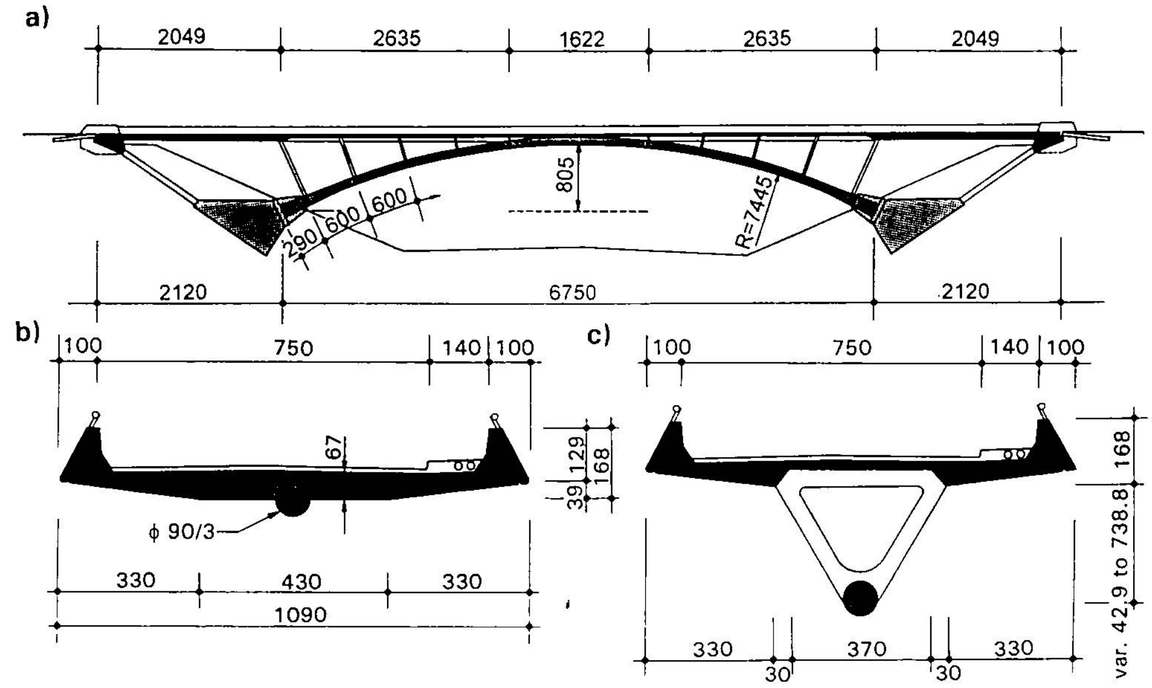

Fig.1 Structural solution: a) elevation, b) cross section at midspan, c) typical section

2. Process of Construction

The steel arch was erected from steel segments with a length of about 12 m. After the erection of the arch, the triangular shaped steel struts were erected. The structure was temporarily supported by hydraulic jacks. Concrete was pumped from the bottom to the top of the arch. To guarantee that there would be no air voids at the top, 3 openings were provided at the top of the arch. After filling the steel tube with concrete, the deck was cast as one unit on traditional scaffolding and post-tensioned. After the deck was post-tensioned, the hydraulic jacks were used to press the arch against the foundation in order to reduce the short-term deformation of the foundation. This operation was repeated after one week.

3. Static and Dynamic Analysis

According to the nature of the problem the structure was analyzed as a 2D, 3D frame, and the 3D structure being assembled of the shell and solid elements. Detailed time-dependent analysis was done by our proprietary program TDA using CEB-FIP functions. The design assumptions and quality of the workmanship were checked by static and dynamic loading tests. The bridge was loaded by eight trucks situated in two positions that created maximum bending and torsion in both the arch and the deck. The structure was also tested dynamically. At first the agreement of excited natural frequencies with theoretical values was checked, then the logarithmic decrement of damping and the impact coefficient was determined. The test confirmed our assumptions and good behavior of the structure. The structure was designed by SHP Brno with the collaboration of Fercon Brno and the Technical University of Brno (Dr.Zak, Dr.Navratil and Ing.Hradil). The structure was developed under support of GA 261635.