# Lateral Arch Vibrations of a Steel Bowstring Bridge due to Traffic Loads

**Thomas BITTERMANN**
Structural Engineer
B+J Engineering GmbH
Wismar, Germany
***thomas.bittermann@bj-eng.de***

**Kersten LATZ**
Professor
Univ. of Applied Science
Wismar, Germany
***kersten.latz@hs-wismar.de***

**Stefan LÜHR**
Project Manager
Federal Waterway Admin.
Lauenburg, Germany
***stefan.luehr@wsv.bund.de***

Thomas Bittermann, born 1974, received his civil engineering degree from the Univ. of applied science Wismar, Germany

Kersten Latz, born 1961, received his civil engineering degree from the Technical Univ. of Braunschweig, Germany

Stefan Lühr, born 1967, received his civil engineering degree from the Univ. of applied science Hamburg, Germany

## Summary

Steel bowstring bridges or tied-arch bridges are common structures in contemporary bridge building. For architectural reasons and to achieve a preferably slender visual impression, bowstring bridges are often designed without lateral bracing and with free standing arches. Therefore the arches are likely to be exited by the impact of traffic loads which are passing the end crossbeam. Most commonly, the resultant lateral arch vibrations poses fatigue problems related to a decreased service life of the bridge.

Experimental investigations and numerical simulations of the dynamic behavior of a bowstring bridge with free standing arches will be presented in this paper. The experimental results of the measurements using a test vehicle with different velocities are introduced first. Afterwards these results are used to develop and validate a numerical model of the bridge. Based on this model parameter studies are carried out taking into account the fatigue load model given in European Bridge Code and different crossing velocities.

It will be shown that the simplified fatigue check given in European Bridge Code may not be sufficient if applied to bridges that are susceptible to vibrations as the number of stress cycles is much higher.

Using the example of a new-built road bridge, the results of simulations by using tuned mass dampers to reduce the lateral arch vibrations, to avoid fatigue problems and to increase the service life of the bridge are put forward at the end.

**Keywords:** bowstring bridge, lateral vibration, measurements, fatigue, tuned mass damper.

## 1. Introduction

The Elbe-Lübeck Canal, connecting the Baltic Sea with the Elbe River, meets 10 km south of Lübeck on the territory of the municipality Krummesse. The east and west of the canal lying villages are connected by bridge. A first bridge structure was build at the same time the Elbe-Lübeck Canal was constructed in 1900. This steel truss bridge was no longer sufficient for todays needs of road traffic, so that the Federal Waterway Administration decided to build a replacement new bridge.

The new road bridge was completed in Dec 2007. The superstructure is a bowstring arch bridge with an orthotropic deck and has a span of 47 m. To achieve a slender design as possible, the arches were constructed as free standing arches without lateral bracing. The roadway with a width of 4.75 m and the two walkways with a total width of 3 m are entirely between the arches. The stiffening girders and the cross beams are made of open cross sections with low torsional stiffness whereas the arches were constructed with boxed cross section (Fig. 1). To allow for lateral stabilization of the arches, they are hingeless connected to the end crossbeam.

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