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Volgograd-Bridge: Efficiency of passive and adaptive Tuned Mass Dampers

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Abstract

In Volgograd the inauguration of the new road bridge across the river Volga took place in October 2009. In May 2010 the bridge was temporarily closed for traffic because of excessive wind-induced vertical vibrations of appr. ± 400 mm amplitude. The owner decided to retrofit the bridge with an adaptive tuned mass damper system.

The paper shows a more precise approach to determine effective structural damping based on harmonic analyses using a FE model of the bridge. It is used to determine effective structural damping for the structure without and with passive and adaptive TMDs. While it is shown that passive TMDs are not able to fulfil serviceability requirements, the adaptive TMD system is proven to provide sufficiently damping to prevent excessive vibrations.

Keywords: Volgograd Bridge, vortex shedding, tuned mass dampers, adaptive TMD, efficiency

1 Introduction

In Volgograd the inauguration of the new road bridge across the river Volga took place in October 2009 (see Figure 1). In May 2010 the bridge was temporarily closed for traffic because of excessive wind-induced vertical vibrations of appr. ±400 mm amplitude [1]. Smooth cross wind with speed between 9.5 m/s to 15 m/s lead to vortex shedding on the leeward side of the bridge deck. The vortex shedding frequency coincided with a vertical natural frequency of the bridge and hence the bridge deck exhibited vertical oscillations severe enough to temporarily shut down the bridge for traffic. After an extensive inspection the bridge was reopened again for road traffic.
Due to limited reserve of the load bearing capacity each span could only be loaded with 21 ton of additional mass. This restriction allows only very low mass ratios for tuned mass damper (TMD) application. Conventional passive TMDs with such a low mass ratio are very susceptible, if dynamic bridge and TMD properties differ slightly from the design values, and hence not sufficiently robust to provide sufficient effective structural damping.

In autumn 2010 the owner decided to retrofit the bridge with an adaptive tuned mass damper system (A-TMD) to reduce efficiently resonant vibrations of the first three vertical modes. Frequency and Damping of each adaptive TMD are adjusted to the actual frequency of vibration in real-time by controlled magnetorheological (MR) dampers according to DEN HARTOG criteria [5,7].

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