Application of Tuned Mass Dampers for the Hong Kong-Zhuhai-Macau Bridge for Mitigation of Wind Vibrations

Hongbing XIE
Chief Engineer´s Office
Deputy Manager
Prof. Senior. Engineer
Hong Kong-Zhuhai-Macao Bridge Authority, Zhuhai, P.R. China
xhb@hzmbo.com

Xie Hongbing, born 1967, received his civil engineering degree from Changsha Railway Insititute.

Quanke SU
Prof. Senior Engineer
Hong Kong-Zhuhai-Macao Bridge Authority, Zhuhai, P.R. China
sqk@hzmbo.com

Su Quanke, born 1962, received his civil engineering degree from Xi'an Highway Insitute

Peter HUBER
Mechanical Engineer
MAURER AG
Munich, Germany
huber@maurer-soehne.de

Peter Huber, born 1970, received his mechanical engineering degree from the Technical University Munich.

Summary

The steel deck design of the series of bridges within the Hong Kong-Zhuhai-Macau Bridge results in natural frequencies requiring additional damping measures by Tuned Mass Dampers (TMDs). At the hand of the specified structural data, the authors explain the technical solution for the applied Tuned Mass Dampers (TMD) and highlight their benefits. Such TMD protection systems not only ensure structural safety combined with durability, but also presenting potential commercial relevance, as they may reduce the total construction costs compared to stiffening measures.

Keywords: Bridge, Tuned Mass Dampers, Damping, Durability, Wind Vibrations

1. Introduction

The steel deck design of the Deep Water viaducts and the Jianghai Bridge within the Hong Kong-Zhuhai-Macau Bridge Link results in natural frequencies between 0,33Hz and 0,8Hz. The combination of the exposed location of the bridge over the Pearl River Delta with more or less strong laminar winds and low values for the structural damping will cause severe deck vibrations due to vortex shedding, as found in the relevant wind tunnel model test (Fig. 1).

Therefore additional damping in the bridge sections for stabilization, fatigue reduction to ensure durability and to achieve sustainability was required, which was decided by the designer on utilizing Tuned Mass Dampers [3]. These TMDs shall mitigate vertical vibrations, increase structural damping and must fit into the limited space condition of the steel deck. Within the single spans up to four TMDs with 3.000kg to 6.250kg will be placed at mid span location.

Indeed the chosen TMD system for the low frequencies of 0,33Hz to 0,8Hz in combination with the required approx. +/-300mm displacement amplitudes of the TMD mass is rather challenging, unique, but the solutions adopted is found to be economical and technically sound to the needs of the structure. The applied hydraulic, non-pressurised rotation damping units within the TMDs provide the required exact and efficient linear viscous damping behaviour. The specially coated helical compression springs were tested up to 3 Mio fatigue load cycles. An almost frictionless vertical rail system grants for best possible vertical guidance of the TMD mass to avoid any losses of damping efficiency.

2. Specified characteristics for the TMD protection system

2.1 Various bridge sections to be fitted with TMDs

According to the design engineers there are various bridges to be fitted with additional TMDs listed in table 1 below.

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