Long-term Dynamic Monitoring of the historic "San Michele" Iron Bridge (1889)

Carmelo GENTILE
Associate Professor
Politecnico di Milano
Milan, Italy
carmelo.gentile@polimi.it

Antonella SAISI
Assistant Professor
Politecnico di Milano
Milan, Italy
antonella.saisi@polimi.it

Summary

The San Michele bridge is an iron arch bridge that crosses the Adda river about 50 km far from Milan. The bridge, built in 1889, is the most important monument of XIX century iron architecture in Italy and is still used as a combined road and railway bridge. In order to assess the structural condition of the bridge, ambient vibration tests were performed in 2009 and suggested the opportunity of installing a permanent dynamic monitoring system with Structural Health Monitoring purpose. Hence, a continuous monitoring system was designed and it is now active on the bridge since late November 2011. The paper, after a brief summary of the experimental studies developed since 2009, describes the monitoring system and the software developed in LabVIEW for processing the collected data. Subsequently, the tracking of natural frequencies automatically identified until the beginning of September 2012 is presented and the effects of environmental and operational conditions on the dynamic response of the bridge are investigated.

Keywords: Arch bridge; automated modal identification; continuous dynamic monitoring; environmental/operational effects; frequency domain decomposition; iron.

1. Introduction

In the last few years, the concern with the ageing and structural degradation of bridges and civil infrastructures (see e.g. [1]) have contributed to significantly increase the interest on vibration-based Structural Health Monitoring (SHM) and the installation of dynamic monitoring systems, especially on bridges, has become more common [2]. The vibration-based approach to SHM has been favoured also by the technological advances, allowing more economical installation and operation of permanent monitoring systems as well as efficient transmission and processing of the recorded data. Examples of well-known bridges equipped with continuous monitoring systems include Akashi Kaikyo bridge [3] in Japan, Commodore Barry bridge [4] in the United States, Infante D. Enrique bridge [5]-[6] in Portugal, Øresund Bridge [7] in Denmark, Tamar bridge [8] in Southwest England and Tsing Ma bridge [9] in Hong Kong.

Strategies based on continuous vibration monitoring generally involve automated modal identification and the use multivariate statistical tools [6], [8] in order to firstly investigate the relationships between features considered to be sensitive to structural condition, such as natural frequencies, and environmental (e.g. temperature) and operational conditions (e.g. traffic intensity). Once the normal response of a structural system to changes in its environmental and operational conditions has been explored and can be filtered out to normalize response data, any further changes in dynamic characteristics should rely to structural changes, which could be either a slow degradation (e.g. reduction in member stiffness due to corrosion) or some sudden change.

A multi-channel dynamic monitoring system has been recently installed in a centenary iron arch bridge that crosses the Adda river about 50 km far from Milan: the San Michele bridge. The historic infrastructure (Figs. 1-2), better known as Paderno bridge, is an iron arch bridge built between 1887 and 1889 by the Società Nazionale delle Officine di Savigliano (SNOS) in order to complete one of the first Italian railway lines [10]-[11].

The historic bridge, protected by the Italian Ministry of Cultural Heritage since 1980, is a symbol of

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