Long-Term Monitoring of Sesia High Speed Railway Bridge

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Long-term monitoring has been recognized to be one of the most reliable approach to real-time control of bridge behavior, assuring structural safety and optimizing repairing and maintenance operations. Many different typologies of monitoring systems aimed at the evaluation of structural health condition, identification of possible damages in real time or analysis of strain/stress spectra on structural members have been installed on roadway/railway short to long span bridges. Type, number and configuration of sensors, position of acquisition units, quantity of data collected and eventually processed in real time depends on the kind of structural response monitored. Besides the realization of new high-speed (HS) railways across Europe, as well as in many other countries, has required the development of monitoring systems for many bridges and viaducts, among which there are classical concrete solutions and new steel-concrete composite typologies characterized by light and cheap structures.

Structural monitoring of railway bridges has been widely adopted in the last years in many countries on small, medium and long-span structures. The main functions of structural monitoring systems are the real-time assessment of structural reliability and safety, the control of serviceability conditions, the determination of actual load/stress spectra on main structural elements due to traffic loads. This structural health control approach allows to monitor continuously the structural performance of the bridge, in order to issue early warnings on potentially catastrophic structural damages, and also to plan in advance maintenance and repair operations with consequently economic benefits [1].

A monitoring system is generally composed of a set of sensors connected to one or more data acquisition systems (depending on bridge dimensions, number and type of sensors, etc.) and involves many different scientific applications, including sensing, data acquisition/management/elaboration techniques, electric and electronic engineering, informatic science, etc. Many new type of sensors are nowadays available together with classic solutions, including fiber optic sensors, GPS, laser transducers, MEMS and total stations. Sensors can also be embedded into structural elements, for example into a concrete slab (strain sensors) or into a bridge cable (fiber optic sensors).

The reliability and effectiveness of a monitoring system is the result of a proper design process, calibrated on the specific structure object of the analysis. This process can be divided into two steps: i) experimental dynamic analysis of the structure, realized to obtain an extended and reliable knowledge of structural behaviour; ii) design of the monitoring system, by a proper evaluation of environmental conditions, durability and costs of devices, quality of recorded data, etc. The data acquisition system collects, stores and transmits the signals from sensors to a central control unit, where it is possible to elaborate the data manually or automatically, obtaining specific on-time informations or warnings on the structural behaviour of the structure [1].

Among many different techniques, the vibration measurement approach is one of the most widely adopted technique for the dynamic evaluation of civil structures. This method is based on the inverse evaluation of structure dynamical modal properties generally by the elaboration of structural acceleration data. In this way it is possible to evaluate the structure modal parameters, composed by frequencies, shape and damping ratio for each mode of vibration [2]. Modal parameters can then be
adopted as reference for a monitoring system, as structural damages or deteriorations significantly change their values. It is also possible to develop numerical procedures for the real-time identification of damage entity and position along the structure, by a proper informatics implementation into the central control unit [3]. Monitored modal parameters can also be adopted into numerical updated FE models, in order to obtain a reliable real-time evaluation of forces/stresses in structural elements and, consequently, of global/local safety of the bridge. Strain measurements have been also widely adopted in the monitoring of civil structures for the real-time control of strain/stress load spectra in structural elements, in order to evaluate resistance safety and fatigue life behaviour of local details [4]. Strain sensors embedded into structural concrete structural elements were adopted to evaluate directly loads, frequencies and velocity of vehicles on railway bridges [5].

In the last few years, the construction of new high speed (HS) railway lines across Europe was accomplished. The high value of design speed and the strict parameters for vertical and transverse acceleration imposed by tracks to vehicles required the realization of lines characterized by lower values of vertical gradient and curvature radius than classical railway lines. Many bridge and viaduct solutions were realized in these new lines by the adoption of classical concrete solutions together with new steel-concrete typologies [6]. Maintenance and serviceability of bridges and viaducts constitute a crucial aspect in the management of high speed railway lines, due to the economic losses connected with unplanned interruption of traffic. Monitoring systems were installed on most bridges and viaducts, to control continuously the structural health conditions and the serviceability performance of structures.

In this paper, a long-term dynamical monitoring of the Sesia viaduct, a medium span double box composite bridge of the new Italian HS network, is exposed and analyzed. Modal properties, e.g. frequencies and mode shapes, are observed in order to determine the real-time structural behavior and the effects of dynamic interaction between train and bridge deck. A suitable procedure, based on the correlation between video and dynamic data, is applied to determine typology, length and velocity of train vehicles passing on bridge, to obtain a reliable evaluation of real traffic spectra of HS bridge superstructures.

References