935. A sensor instrumentation method for dynamic monitoring of railway bridges

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Abstract. One of the most effective ways for investigating dynamic behaviour of mechanical and civil structures under service conditions is dynamic load testing. The outcomes of dynamic tests are vibration characteristics, and in particular modal parameters such as vibration mode shapes, frequencies, damping ratios. Dynamic diagnosis technique has been already used for many years in mechanical engineering. During the last decades a number of investigations have been performed introducing new dynamic monitoring techniques of civil infrastructures including bridges. Field experimental testing of new steel-concrete composite railway bridge was carried out to determine natural and forced vibration frequencies, corresponding mode shapes and damping ratios. The attention was focused on short-term dynamic monitoring of new innovative structure with the aim to investigate the implementation of sensor technique on real structures, to calibrate a FE model of the bridge that can be used for further simulations and as a result to give feedback to the design of similar structures. Field tests and numerical simulations were conducted using excitations induced by dropping a weight and by ambient traffic excitation loadings. Results of these investigations are presented in this paper.

Keywords: railway steel-concrete composite bridge, dynamic testing, dropping a weight, ambient traffic, modal characteristics, FE analysis.

1. Introduction

Dynamic testing of bridges is relatively recent condition monitoring technique and has been evolved during past few decades from the methods used in mechanical systems [1]. Dynamic monitoring of mechanical and civil structures have a common system demands, but structural system and loading conditions may differ significantly from each other. Especially civil structures have relatively low dynamic response frequencies compared to mechanical systems. Bridge as a system consists of a number of components including bridge super and substructures and their foundations, bearings, ballast, and rails having different stiffness and damping characteristics. The dynamic effects on any railway bridge due to moving traffic depend on the speed of the train, variations in axle loads and spacing, track irregularities. Environmental conditions, such as temperature, humidity, wind, solar radiation that vary with time can affect identification of modal characteristics. Consequently, variation of structural properties and dynamic excitations results in the effects of noise and uncertainties in the structural responses. FE modelling together with in-situ testing of a bridge is an effective tool for its reliable dynamic analysis.

During the last few decades numerous investigations have been performed and dynamic tests and monitoring systems of bridges more and more are employed in order to validate design conceptions, to evaluate condition state and overall performance of structures [1–4]. Variation of vibration modal parameters has received considerable attention in assessment of behaviour of bridges under high–speed trains [5–8] and in vibration based damage detection analysis [9–11].

In recent years, there has been also an increasing interest in the instrumentation systems for dynamic health monitoring of railway bridges. Currently, there are different monitoring techniques that can be used for structural evaluation of bridges [12–14]. In addition to traditional