DYNAMIC TESTS OF A BRIDGE WITH THE DECK RETROFITTED WITH EXTERNAL PRE-STRESSING

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ABSTRACT

This paper addresses the evaluation of the structural condition of a bridge based on the experimentally evaluated dynamic characteristics. The presented study was developed in a pre-stressed concrete bridge with more than 30 years of service, which was retrofitted with external pre-stressing of its deck. This structural intervention was performed after studies and inspections that detected the existence of several deficiencies, including cracks in the longitudinal beams of the deck, as well as cracks in the base and footing of some piers. In the paper the dynamic tests are described and the identified dynamic characteristics are compared with the ones computed with a finite element model of the bridge.

KEYWORDS: ambient vibration tests, modal identification, model correlation and updating, damage detection, rehabilitation of bridges.

1 INTRODUCTION

Structural condition evaluation is one of the applications of the experimental identification of the dynamic properties of structures. In this domain, several studies and research projects have been developed to check the potential of considering the dynamic characteristics for structural condition evaluation and damage detection. If the modal identification is performed with the data collected from ambient vibration tests, then this approach can be applied without introducing restrictions to the normal use of the structures. The dynamic tests can, therefore, be considered as a non-destructive testing method that can be applied to evaluate the dynamic parameters that reflect the global structural behavior of constructions.

The study present in this paper was developed in a pre-stressed concrete bridge, with more than 30 years of service, which was retrofitted with external pre-stressing of its deck. This bridge has a length of 300 m between axis of the supports at the abutments, subdivided in eight spans,

two extreme with 30 m and six intermediate with 40 m. Its piers have heights from 27 m up to 64 m and the deck is composed by four longitudinal beams with a top slab and transverse beams at the mid span in the extreme spans, at thirds of the intermediate spans and at the sections over the piers and abutments.

The retrofitting of the bridge was performed after inspections that detected the existence of several structural deficiencies. The bridge deck had excessive deformation, poorly vibrated concrete areas or with deficient connection between the concrete joints, as well as cracks in the longitudinal beams, associated with flexural stresses and caused by the reduced compression induced by the pre-stress prescribed in the design. In the base of some piers, namely in their footings, cracks were also detected as a result of internal expansive reactions in the concrete.

2 MODAL IDENTIFICATION AND FE MODEL CORRELATION

Dynamic tests were performed in the bridge, consisting in the measurement of the roadway traffic induced accelerations in a total of 64 points of the structure.

The identification of the global dynamic characteristics of the structure was carried out using the enhanced frequency domain decomposition method (EFDD). With this method it was possible to, clearly, identify a total of 22 vibration modes (7 transverse, 9 vertical and 6 torsional).

A finite element model was developed to help in the preparation and interpretation of the results of the dynamic tests. In the model, a modulus of elasticity of 34 GPa (C30/37 grade) was considered for the elements that model the deck and piers. The natural frequencies of vibration computed with this model agreed very well with the identified ones.

3 CONCLUSIONS

Dynamic characterization tests were performed in a bridge which was retrofitted with external pre-stressing of its deck, in order to help in the evaluation of its structural condition. The identified dynamic characteristics agreed very well with the ones computed with a finite element model. The frequency identified for the first vertical vibration mode is about 20 % larger than the values obtained in two other bridges, built in the same period and with the same deck cross section and span lengths. This reflects the effect of the added external pre-stress, since the two other bridges hadn’t yet been retrofitted when the dynamic tests were performed.