Seismic evaluation of Garcia Cadena Bridge (Colombia)

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Summary

In this paper a seismic evaluation of Garcia Cadena Bridge is presented. The procedure includes field ambient vibration testing, finite element (FE) modelling, selection of earthquake ground motion, time history analysis, and safety evaluation of the bridge. Ambient vibration tests were carried out to determine the dynamic characteristics of the bridge. A three dimensional FE model was calibrated based on the ambient vibration test results.

Keywords: Bridge; seismic evaluation; field ambient vibration testing; finite element model; damage seismic; dynamic characteristics.

1. Introduction

Currently, some Colombian cities face the implementation of new massive transport systems and as a consequence roads and bridges will be subjected to new load conditions. In turn, taking into consideration that many of these bridges were designed and built more than 20 years ago and that they have not undergone an appropriate maintenance, the deterioration process is considerable. For all the above-mentioned, the necessity to evaluate the integrity of the bridges and to estimate the structural behavior is a priority. One of the bridges that will be subjected to a new massive transport system is the García Cadena Bridge. This bridge was built more than 30 years ago and it has not received a permanent maintenance program. Then, the current state of its materials, the effects of fatigue, the new seismic requirements and the natural deterioration process of its structure can not be ignored. For this reason the government and the community are concerned about the possible current and future behavior of this bridge.

2. Bridge description

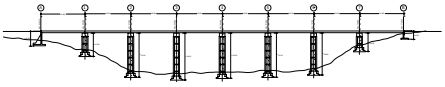

Fig. 1: Elevation of the García Cadena Bridge.

The Garcia Cadena Bridge is the most important bridge in Bucaramanga (Colombia). It was built in 1970 and enlarged and reinforced in 1995. It consists of eight spans with a length of 261 m. The superstructure consists of twelve prestressed concrete girders simply supported on seven reinforced concrete piers and two abutments (*Fig. 1*).

3. Ambient vibration testing and modal identification

Ambient vibration testing was performed to estimate the dynamic parameters of the Garcia Cadena Bridge (stiffness and damping). The instruments system to measure the ambient vibration consists of the following components: a Strong Motion Recording System (Altus K2), two Seismometers SS-1, two Triaxial Accelerometers model FBA-ST (one incorporated into The K2). The *peak picking method* (PP) was used to choose the *modals frequencies*. A total of 4 modes for the deck of the Garcia Cadena Bridge were identified from the ambient vibration data within the frequency range of 3.5 – 25 Hz. They correspond to the modes of the bridge deck which are pure vertical bending modes. Thus the fundamental mode is to a natural frequency of 3,5 Hz.

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The ranges of the damping values were also estimated from these ambient vibration testing. The obtained range was 0.10-0.18 approximately. These values correspond to the first vertical bending mode.

4. Structural modelling and Structural identification technique

The experimental program of field test was supplemented by the development of a three-dimensional finite element model (FE). The model was formulated using the following assumptions:1. The bridge was modelled by eight spans, 2. The girders were modelled by two-node beam elements. These were considered as pinned at their ends. These girders are simply supported on the piers; no restraint to rotation was introduced to the model at both ends of the stringers.3. The piers were modelled as frames with two hollow columns. 4. The abutments were simply excluded from the analysis.

The modulus of elasticity of the deck bridge (E) was un unknown parameter within the FE model. Douglas and Reid [1] [2] was used to determine E. Then, it was defined that E converged to 35110 N/mm^2.

5. Seismic damage evaluation

The Garcia Cadena Bridge is located on a region that is influenced by two seismogenic faults: the Santa Marta – Bucaramanga and the Frontal fault. The accelerograms used for the Seismic Microzonation of Bucaramanga [3] were the reference for this study. They represent in a simply way the acceleration records which are congruent with the ones associated with by the two faults. The local site response was evaluated through empirical methods using these rock accelerograms. The dynamic behaviour of the soil was obtained using a one-dimensional numerical simulation [4]. The damage to the Garcia Cadena Bridge was evaluated using the damage index proposed by [5]. The results show that the damage indexes values are from 0.1 to 0.2, therefore, it is likely that this bridge might suffer slightly damages.

6. Conclusions

To seismically evaluate the Garcia Cadena Bridge located in Colombia, an ambient vibration based seismic evaluation procedure is presented. The field ambient vibration testing was conducted on the bridge. A modal parameter identification method was implemented to accurately extract the dynamic characteristics. A three-dimensional finite element model of the bridge was developed and calibrated in terms of the frequencies obtained from field ambient vibration tests. Seismic evaluation and structural damage was carried out using rock accelerograms congruent to the Santa Marta – Bucaramanga and the Frontal faults. The structural damage was evaluated using IDARC. In conclusion, the Garcia Cadena Bridge is likely to suffer slight damages under the action of earthquakes coming from the two faults mentioned above.

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