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Pushover Analysis of a Typical Bridge Built in Central Zone of Mexico

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Abstract : Bridges are one of the most seismically vulnerable structures on highway transportation systems. The general process for assessing the seismic vulnerability of a bridge involves the evaluation of its overall capacity and demand. One of the most common procedures to obtain this capacity is by means of pushover analysis of the structure. Typically, the bridge capacity is assessed using non-linear static methods or non-linear dynamic analyses. The non-linear dynamic approaches use step by step numerical solutions for assessing the capacity with the consuming computer time inconvenience. In this study, a nonlinear static analysis ('pushover analysis') was performed to predict the collapse mechanism of a typical bridge built in the central zone of Mexico (Celaya, Guanajuato). The bridge superstructure consists of three simple supported spans with a total length of 76 m: 22 m of the length of extreme spans and 32 m of length of the central span. The deck width is of 14 m and the concrete slab depth is of 18 cm. The bridge is built by means of frames of five piers with hollow box-shaped sections. The dimensions of these piers are 7.05 m height and 1.20 m diameter. The numerical model was created using a commercial software considering linear and non-linear elements. In all cases, the piers were represented by frame type elements with geometrical properties obtained from the structural project and construction drawings of the bridge. The deck was modeled with a mesh of rectangular thin shell (plate bending and stretching) finite elements. The moment-curvature analysis was performed for the sections of the piers of the bridge considering in each pier the effect of confined concrete and its reinforcing steel. In this way, plastic hinges were defined on the base of the piers to carry out the pushover analysis. In addition, time history analyses were performed using 19 accelerograms of real earthquakes that have been registered in Guanajuato. In this way, the displacements produced by the bridge were determined. Finally, pushover analysis was applied through the control of displacements in the piers to obtain the overall capacity of the bridge before the failure occurs. It was concluded that the lateral deformation of the piers due to a critical earthquake occurred in this zone is almost imperceptible due to the geometry and reinforcement demanded by the current design standards and compared to its displacement capacity, they were excessive. According to the analysis, it was found that the frames built with five piers increase the rigidity in the transverse direction of the bridge. Hence it is proposed to reduce these frames of five piers to three piers, maintaining the same geometrical characteristics and the same reinforcement in each pier. Also, the mechanical properties of materials (concrete and reinforcing steel) were maintained. Once a pushover analysis was performed considering this configuration, it was concluded that the bridge would continue having a "correct" seismic behavior, at least for the 19 accelerograms considered in this study. In this way, costs in material, construction, time and labor would be reduced in this study case.

Keywords : collapse mechanism, moment-curvature analysis, overall capacity, push-over analysis
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