STUDIES OF POUNDING AND MITIGATION MEASURES ON STEEL ELEVATED BRIDGES BY 3D MODELING

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Introduction

Upon 3D modeling of elevated bridges, pounding effects between bridge girders and pounding countermeasures are studied through computations of a chosen three-span steel bridge.

3D Modeling of Elevated Bridges

An elevated bridge is composed of foundations, piers and superstructures. Superstructures include supports, girders and decks. To conduct a precise analysis, detailed model for each of these components are needed. A 3D pounding model is employed to simulate the pounding effects between girders[1]. Considering steel elevated bridges isolated both in longitudinal and transversal directions, a bi-axial model of rubber bearing is adopted for supports[2]. The fiber model, known as a discretized-section model for nonlinear analysis, is used to model piers in the analysis. A bilinear hysteresis model is employed for fibers of steel. Soil-structure interactions should also be taken into account. A soil-grouped pile model with simplifications has been adopted, which uses a single equivalent beam instead of a group of piles.

Modeling of a Three-span Steel Bridge

A general-purpose dynamic analysis program for bridges has been developed[3]. Written in C++, the program implements 3D models of bridge structures including the proposed pounding model. A typical three-span steel bridge has been selected for analysis. As shown in Fig. 1, fiber model is adopted at the first segment of each pier from foundation. Base-isolation rubber bearings are applied for each pier. For computation of pounding, a simple supported girder in each span is assumed. Restrainers are adopted as a countermeasure for pounding effects.

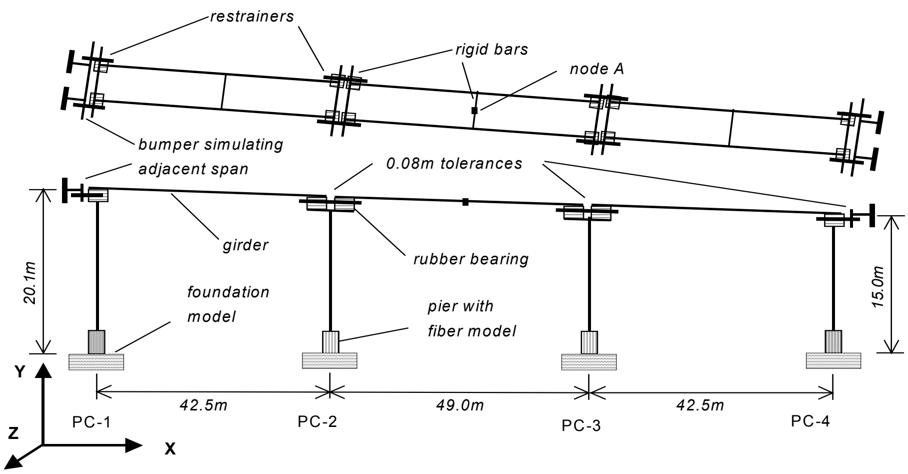

Fig. 1 Bridge girders in arbitrary contact

Computations were conducted in three cases: 1) without pounding, 2) considering pounding and 3) considering pounding and applying restrainers. All parameters and the bridge structure model are the same for these three cases, except that in third case, restrainers were adopted. In the first case of without pounding, no material contacts were assumed, though girders may overlap each other in real. Takatori waves from the 1995 Kobe earthquake in 3D were used. Parameters for time-history analysis: Time interval=0.001 (sec), duration=10 (sec).

Keyword: Bridge, 3D nonlinear analysis, Pounding, Pounding mitigation, Restrainer
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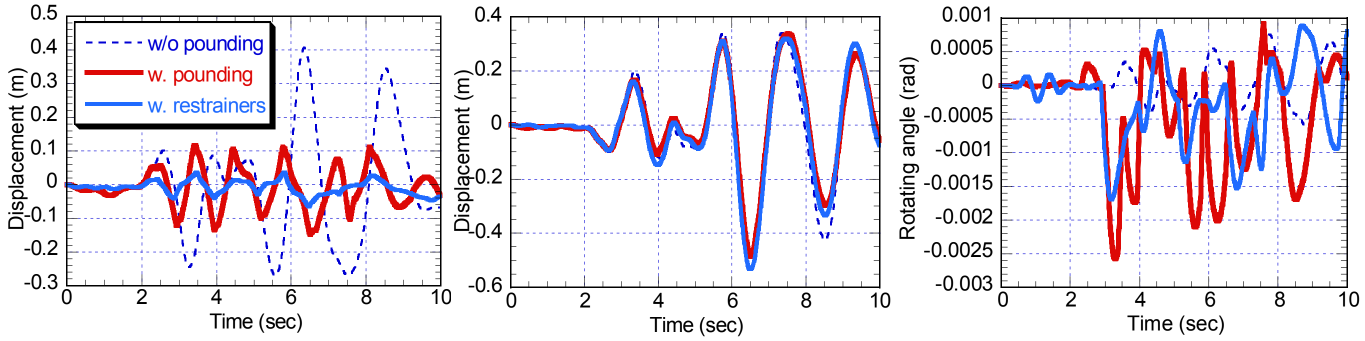
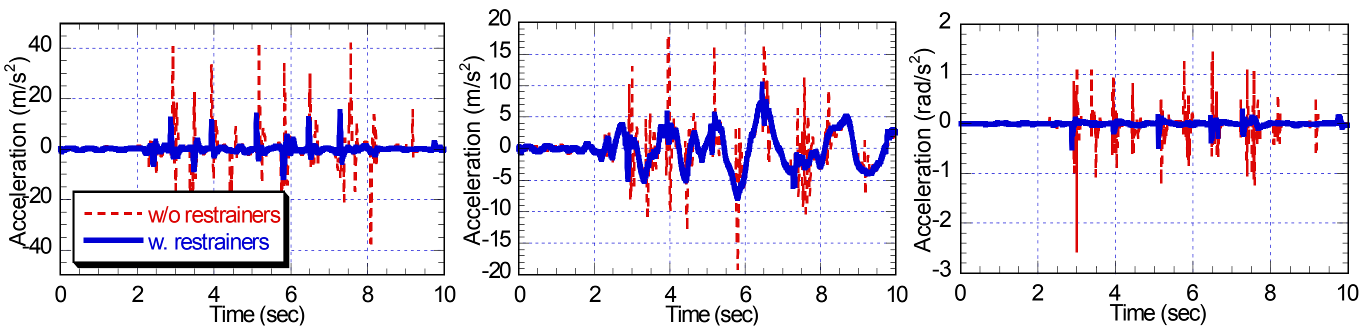
Results and Analyses

One node, node A, was picked from the center of girders of the mid span. Displacements for all the cases and accelerations for case2 and case3 were selected to output in longitudinal, transversal and rotating directions. Rotating direction is in a plane parallel to the ground. Results of computations are given in Fig. 2 and Fig. 3, which show comparisons of displacements and results of accelerations at node A. Responses of pounding at the middle span and side span show same trends. Longitudinal displacements are reduced according to poundings, while displacements at transversal do not have much change, as there is no face-to-face pounding assumed in this direction. A remarkable increase of rotating angle of the girder can be seen as a result of pounding. Results of accelerations show that the structure experiences strong reaction forces during pounding. Comparisons of displacement results for case2 and case3 show that the application of restrainers can reduce the pounding effecting dramatically, not only in the longitudinal direction, but also in the rotational direction. As a view of acceleration results, which refer to the forces induced by pounding, restrainers can also work effectively to reduce pounding forces.



(a) Longitudinal **(b) Transversal** **(c) Rotating**

Fig. 2 Displacement comparisons of the mid span at node A



(a) Longitudinal **(b) Transversal** **(c) Rotating**

Fig. 3 Accelerations at mid span at node A for the pounding case

Conclusion

Upon 3D modeling, computations of a three-span steel bridge considering arbitrary poundings between girders and a countermeasure with restrainers have been conducted as a case study. Results show: 1) poundings between girders may induce a remarkable increase of rotating angle to each girder; 2) restrainers can reduce pounding effects both in longitudinal and rotational directions.

Reference

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