Control Of Excessive Bridge Responses Under Design-Unanticipated Earthquakes Through An Innovative Rocking Isolation Bearing System (Ribs)

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In general, bridge structures are designed to resist the maximum considered earthquake (MCE) specified in design specifications. Earthquakes that exceed design expectations consequently cause damage to bridges, which may develop as a catastrophe, such as falling girders and collapse of bridge piers. Given the threat of the occurrence of design-unanticipated earthquakes, e.g., the 2016 Kumamoto earthquake, the development of the bridge with anti-catastrophic or damage-free capability becomes essential. An innovative rocking isolation bearing system (RIBS) was proposed to control the excessive girder response as well as the pier response under design-unanticipated earthquakes. The rocking motion of RIBS is activated to provide seismic isolation effect when the seismic action exceeds a specified value, which is determined by its geometric features. In particular, the seismic energy is dissipated by the collision between the bottom plate of RIBS and the top of the bridge pier. The dynamics of an example bridge featuring such RIBS was characterized as a simplified model. Two coefficient of restitution (COR) models were used to investigate the effects of energy dissipation during the impact: the Housner model and a model derived from the conservation of the angular momentum and the linear momentum in the horizontal direction. A series of nonlinear time-history analyses were performed for the example bridge under varying intensities of the design ground motions corresponding to MCE in Japan. Parametric study indicates that appropriate selection of the design parameters of RIBS can effectively improve the seismic performance of the bridge, namely minimizing the pier displacement at an allowable girder displacement. The maximum pier displacement shows insensitive against varying intensities of ground motions, as a result of the mechanical fuse of RIBS, which limits the maximum reaction force acting on the piers. Furthermore, the rocking bearing is not overturned until the design ground motion is scaled over two times its original intensity, implying its anti-catastrophic or damage-free capability.