SUSTAINABLE AND RESILIENT SEISMIC DESIGN OF CALIFORNIA HIGH SPEED RAIL COMPLEX BRIDGES CROSSING ACTIVE FAULTS

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ABSTRACT

The California High Speed Rail (CHSR) project is one of the largest and most challenging infrastructure projects in the U.S.A. The initial 520 mile of the rail corridor will connect San Francisco, through Silicon Valley and Central Valley to Los Angeles in less than 3 hours. Due to mountainous terrain along substantial portions of the alignment, rail infrastructure includes long span viaducts with tall columns. Geologic conditions along the alignment are expected to be extremely variable including large number of fault crossings with high slip rates and potential of large fault rupture displacements. Bridges that cross hazardous faults or are located at a very close proximity to an active fault are subject to transient vibratory ground motion and static fault offset displacement. The vibratory ground motion, which is nucleated from the fault rupture, can cause large dynamic deformation demands due to near fault effects, such as rupture directivity and fling effects. Faults with larger displacements due to permanent tectonic fault offsets can cause severe damage with potential of collapse for the bridges crossing the faults. This can be a threat to public life safety, and/or cause interruption of service, and consequently loss of revenue as well as economic losses to the state. According to the CHSR design criteria, seismic design of all CHSR bridges shall be based on Operating Base Earthquake (OBE) ground motions with a 50 years return period and Maximum Considered Earthquake (MCE) ground motions with a 950 years return period. Three levels of seismic performance criteria govern the designs. Operability Performance Level (OPL) is based upon essentially elastic response, no derailment of trains, and nearly immediate resumption of the train service. The OPL shall be evaluated with respect to the OBE. Repairable Performance Level (RPL) is based upon limited, repairable damage, with safe immediate evacuation of occupants, and timely return to the train service. No Collapse Performance Level (NCL) is based upon no collapse of the structure, and safe immediate evacuation of occupants for life safety. The RPL and NCL shall be evaluated with respect to the MCE. Sustainable and resilient bridges can be designed using modern Isolation Bearings (IB) with wide bent caps, wide abutment seats, and innovative capacity protected foundation design during an MCE vibratory ground motions and fault displacement events. However; IB increases displacement and irregularities of the rail supported on the bridge deck which can cause derailment of the operating train during an OBE event.

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Therefor; particular attention must be paid to the design of IB such that they will not be activated during an OBE event. The purpose of this paper is to present the development of a high-fidelity three-dimensional finite element model for the seismic design and analysis guidelines related to seismic performance objectives and mitigation measures for the California High Speed Rail (CHSR) complex bridges crossing hazardous faults.