8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

EFFECT OF SOIL-STRUCTURE INTERACTION ON THE SEISMIC RESPONSE OF BRIDGES UNDER MULTIPLE HAZARDS

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Keywords: Soil-structure interaction, Seismic response, Carbonation, Corrosion, OpenSees

In seismic assessment of bridges, the soil-structure interaction may have significant effects on the seismic response if the redundancy of the bridge is high and structural members participate in resisting the earthquake load. Besides, bridges are exposed to long term hazards such as scour and environmental degradation. Most current bridge design codes and standards consider extreme hazards independently. Therefore, a multi-hazard assessment is required to more realistically evaluate the design of new bridges as well as the retrofit of existing bridges.

In this paper, the effect of soil-structure interaction on the seismic response of an integral reinforced concrete bridge is investigated. The bridge is subjected to multiple hazards. The earthquake is selected as the extreme event. Concrete carbonation and rebar corrosion are also selected as two main hazards that degrade the life cycle operational performance of reinforced concrete bridges. To model the soil-structure interaction, equivalent force-deformation relationships are derived for abutments and foundation of piers [1]. Besides, chloride induced corrosion of the steel reinforcement is represented by the loss of steel cross section in columns [2]. A three dimensional fiber based distributed plasticity finite element model of the bridge is developed in OpenSees [3]. A pushover analysis is then carried out for the assessment of the bridge seismic response.

To investigate the effect of soil-structure interaction, four different interaction scenarios are applied to a four-span integral reinforced concrete bridge, shown in Figure 1. These scenarios include two soil types representing loose and dense sand, and two foundation types representing flexible and stiff foundations. The seismic response of the bridge is then evaluated and compared at three cases: the bridge in its pristine condition (time zero), after 25 years and after 50 years.

Results of the analysis indicate that the unfavorable effect of the soil-structure interaction on the displacement response of the bridge increases during its lifetime. As can be seen in Figure 2, the lateral displacements of the bridge deck in all soil-structure interaction scenarios are increased as the age of the bridge increases.

This can result in overestimation of the bridge capacity during its lifetime and the bridge may be more vulnerable than predicted. Therefore, the soil-structure interaction should be carefully modeled and included in the seismic assessment of bridges under multiple hazards. This will assist engineers to decide when and under what conditions it is necessary to include this interaction in the seismic evaluation and design of bridges.

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