Effect of Modelling Simplifications on Nonlinear Seismic Analysis of Integral Bridges Including Dynamic Soil-Structure Interaction

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Summary

In this study, the effect of modelling assumptions and simplifications on the seismic analyses results of integral bridges (IBs) is investigated. For this purpose, five structural models of IBs are built in decreasing levels of complexity starting from a nonlinear structural model including the true behaviour of the foundation and backfill soil and gradually simplifying the model to a level where the effect of backfill and foundation soil is totally excluded. Nonlinear time history analyses of the modelled IBs are then conducted using a set of ground motions with various intensities representing small, medium and large intensity earthquakes. The analyses results are then used to assess the effect of modelling complexity level on the seismic behaviour of IBs. The nonlinear soil-bridge interaction is found to have considerable effects on the seismic behaviour of IBs under medium and large intensity earthquakes.

Keywords: Integral bridge, seismic, dynamic modelling, soil-bridge interaction.

1. Introduction

Many bridge engineers prefer to use a simplified modelling approach in the analyses of the bridges under seismic loads due to the complexity involved in modelling of nonlinear soil-bridge interaction effects. Generally, the foundation system without the bridge is analyzed to determine the force-displacement relationships of the degrees of freedom of the nodes at the interface between the bridge and the soil. Then, boundary springs are attached to the interface nodes between the bridge and the soil to simulate soil-structure interaction effects. In some cases, the soil response is totally excluded from the model. Ideally, earthquake response of bridges should be evaluated with a single direct analysis that models the whole system consisting of the superstructure, foundation and the soil mass. Accordingly, in this study, the effect of modelling assumptions and simplifications on the seismic analyses results is investigated. For this purpose, five structural models of integral bridges (IBs) are built in decreasing levels of complexity starting from a nonlinear structural model including the true behaviour of the foundation and backfill soil and gradually simplifying the model to a level where the effect of backfill and foundation soil is totally excluded. In the most complicated nonlinear structural model (Model 1), the foundation soil is modelled in two parts (i) as a shear column with dashpots to simulate free field motion and (ii) dynamic p-y curves and dashpots connected between the piles and the shear column to simulate local soil-pile interaction effects and radiation damping. Moreover, the nonlinear dynamic interaction between the backfill and abutment is modelled using nonlinear springs and dashpots. The nonlinear model is simplified gradually where four additional models are built. First, the shear column is excluded from the structural model (Model 2). Then, the dashpots which are used to simulate radiation damping are excluded from the structural model (Model 3). Next, the soil-pile interaction is modelled using linear springs (Model 4). Finally, the piles are modelled without springs using an equivalent pile

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