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Modal characteristics of integral bridges including the effect of soil-structure interaction

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Abstract

A numerical study is conducted in this paper to investigate the effect of soil-structure interaction on modal characteristics of an integral bridge. The study includes four different interaction scenarios applied to a four-span integral reinforced concrete bridge. These scenarios are selected such that they capture common boundary conditions of pile foundations supported on sandy soil. A three dimensional fiber-based distributed plasticity finite element analysis is carried out in OpenSees to assess the dynamic response and modal properties of the bridge. Numerical results indicate that modal characteristics of the bridge can be significantly affected in different interaction scenarios. Besides, the effect of higher modes may vary in different soil-structure interaction scenarios. As the stiffness of the foundation and soil increases, the contribution of higher modes in the behavior of the bridge increases. Therefore, the effect of soil-structure interaction should be carefully modeled and included in the seismic assessment of integral bridges in order to achieve realistic and accurate seismic evaluation for engineering applications.

Keywords: Modal characteristics, Higher modes, Soil-structure interaction, Integral bridge.

1. INTRODUCTION

An important issue in the analysis of integral bridges is the modeling of interaction between the soil and the bridge foundation. This interaction may have significant effects on the seismic response and modal characteristics of the bridge and thus should be carefully included in the analysis of the bridge [1]. This is even more important when the superstructure of the integral bridge is monolithically connected to its piers. The soil-structure interaction (SSI) in such bridges plays a key role in the dynamic behavior and modal properties of the bridge.

In recent years, various studies have been conducted in order to account for SSI effects in the seismic evaluation of bridges. Several researchers have incorporated the SSI effect for case study purposes with predefined geometry and site-specific soil properties [2, 3]. Some other studies [4-6] have investigated the effect of different SSI conditions on the seismic response of continuous span bridges. However, many of these studies have considered limited soil types and foundation systems. Besides, few studies have focused on modal properties and its change when different SSI scenarios are taken into account. Therefore, further studies are required to thoroughly investigate the effect of different soil types and foundation systems on modal characteristics of bridges.

The main objective of this paper is to investigate the effect of different SSI scenarios on modal characteristics of integral bridges. To do this, a numerical study is conducted including four different SSI scenarios applied to an integral bridge. The selected scenarios consist of two soil types and two stiffness values for the foundation of the bridge. The input ground motion is applied in the transverse direction of the bridge and is compatible with the return period of approximately 2500 years. A multimode adaptive pushover procedure [7] is conducted to investigate the effect of higher modes on the modal response of the bridge for each SSI scenario. Results of the numerical study is discussed and concluded afterwards.