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Controlled-rocking braced frame bearing on a shallow foundation

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Abstract

Controlled-rocking braced frames are capable of reducing the drawbacks of conventional frames against seismic loading. This paper examines the effects of soil-foundation modeling on the seismic responses of low-rise controlled-rocking braced frames. For this purpose, dynamic analyses are performed on rocking braced frames and similar conventional frames supported on fixed base and flexible foundations. Structural modeling considerations such as nonlinear constitutive modeling of members, post-tensioned cables, and yielding butterfly-shaped fuses are modeled in OpenSees, and shallow foundations founded on the soil are simulated using the beam-on-nonlinear-Winkler-foundation approach. The effects of modeling and ground motion parameters on seismic performance are investigated from various aspects. Findings show significant foundation flexibility effects in rocking braced-frame archetypes.

KEYWORDS: Controlled-rocking braced frame; conventional braced frame; shallow foundation; beam-on-nonlinear-Winkler-foundation.

1. Introduction

The consideration of the interaction of a structure, its foundation and the underlying soils is an important research topic in earthquake engineering. The relative stiffness between a foundation and the soil changes the dynamic properties of a structure, amplifies higher mode effects, and modifies foundation input motions [1]. For various types of conventional structures such as steel moment-resisting frames [2], reinforced concrete shear wall frames [3], and bridges [4], the effects of soil-structure interaction (SSI) are reported to be noticeable.

Recently, aiming to overcome the seismic technical flaws and socio-economic drawbacks of conventional structures, modern low-damage systems such as self-centering braced frames [5-9], rocking base-isolated buildings [10], rocking timber walls [11], rocking concrete walls [12, 13], rocking core-moment frames [14,15], and posttensioned rocking bridge [16] have been developed. However, the effects of the flexibility of the foundation are neglected by the use of rocking frame models founded on a fixed base. For example, in the absence of soil-foundation interaction, a number of studies have investigated the overall behavior of rocking systems equipped with different post-tensioning and energy-dissipating devices [17, 18]. Although, the literature has confirmed their efficiency in reducing major structural damage by preventing soft-story failure, drift concentration, structural plastic deformation, and residual deformation, their cores' uplifting takes place above the fixed base [19, 20]. Therefore, further studied are necessary about rocking systems on flexible foundations and subsoils.

The main objective of this paper is to examine the effects of foundation flexibility on the seismic performance of low-rise controlled-rocking braced frames. In addition, the efficiency