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Seismic displacement demand of bridge's wall piers controlled by foundation rocking

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Abstract

Applying the effect of soil-structure-interaction on displacement demand of essential structures, like bridges in design or assessment procedures required enormous nonlinear dynamic time history analysis considering rocking and uplifting phenomena in foundations. In conventional bridges with strong wall pier, nonlinear mechanism are controlled by the foundation behavior and geotechnical capacity and in consequence nonlinear sources mainly concentrated in the level of soil and foundation. It is necessary to implement foundation nonlinear behavior in order to utilize linear analysis to determine seismic demand in these types of bridge. Displacement amplification factors mentioned in current codes are not able to consider foundation flexibility, rocking or uplifting phenomena. In this paper in addition to presenting the coefficient derived from solving SDOF system with the potential of rocking-uplifting, a case study bridge is investigated to compare proposed equation with the exact solution and determine their accuracy.

Keywords: Soil-Structure-Interactions, Wall Pier, Displacement Demand, Rocking Motion.

1. INTRODUCTION

Calculating bridges maximum displacement is a crucial parameter in evaluation and assessment. The source of displacement could be due to the pier deformation or foundation rotation and even the foundation uplifting, which based on the design each of these mechanisms are probable to occur. Evaluating the effect of foundation on structural deformation, required knowing the inertial soil-foundation systems on superstructures. SSI (Soil-Structure-Interaction) divided into two types of inertial and kinematic interactions. Kinematic interactions are regarding the difference between the stiffness of soil and the foundation which caused free-field motion to differ with the foundation motion. This problem mainly has the most influence on the embedment foundations and are more sensitive in embedment reservoir. Inertial interaction is relating to the ratio of foundation and structural stiffness, which influence on dynamic characteristics of the soil-structure system [1]. Previous research on rocking motion of rigid block indicated the reduction of seismic demand and this system was introduced as a seismic isolation system [2]. Regardless of authorizing the rocking occurrence in some evaluation and rehabilitation codes [3], in most of them, it has been prevented, which leads to uneconomical foundation rehabilitation and design, and also, increase seismic demand to the pier, so the conservative design and rehabilitation would be inevitable. Uplifting motion will be more probable due to the strong ground motion in large foundation for increasing vertical factor of safety [4]. Rocking motion benefit prevented residual displacement and deck deformation. Many experimental research on the influence of shallow foundation on seismic response of SDOF structures has been conducted [5-6]. Also, numerical and analytical research in order to introduce an appropriate model for capturing sway and rocking phenomena have been done [7-8]. Simultaneous effects of nonlinear behavior in both soil and structures on seismic response of bridge pier has been investigated. Optimum foundation length estimated for bridges rehabilitation versus the conventional methods.