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A CONTACT INTERFACE MODEL FOR NONLINEAR CYCLIC MOMENT-ROTATION BEHAVIOR OF SHALLOW FOUNDATIONS

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ABSTRACT

It has been recognized that the ductility demands on super structure might be reduced by allowing rocking behavior and mobilization of the ultimate capacity of shallow foundation, particularly for shear wall structures. However, the absence of practical reliable foundation modeling techniques and the uncertainty in soil properties have hindered the use of nonlinear soil-foundation-structure interaction as a designed mechanism for improving performance of a soil-foundation-building system. This paper presents a new "contact interface model" that has been developed to provide nonlinear constitutive relations between cyclic loads and displacements of the footing-soil system during combined loading. The rigid footing and the soil beneath the footing in the zone of influence, considered as a macro-element, were modeled by keeping track of the geometry of the soil surface beneath the footing along with the kinematics of the footing-soil system. The coupling between forces is incorporated in the model through tracking the geometry of the contact interface, interaction diagrams, and the critical contact length ratio; the ratio of the minimum length of the footing required to support the vertical and horizontal loads. Several contact interface model simulations were carried out and the model predictions are compared with centrifuge experimental results that have a wide range of initial static vertical factor of safety. It is shown that the footing-soil contact interface model captures the essential features of the cyclic load-deformation behavior that were observed in the centrifuge experiments. The contact interface model predictions for moment capacity, rotational stiffness, energy dissipation, and permanent deformations compare reasonably well with the centrifuge experimental results.

Keywords: Shallow foundation, rocking, macro-element model, soil-foundation interaction

INTRODUCTION

Soil-foundation interaction associated with heavily loaded shear wall structures during large seismic events may produce highly nonlinear load-displacement behavior. Geotechnical components of the foundation are known to have a significant effect on the building response to seismic shaking (Taylor et al., 1981, Faccioli et al., 2001, and Gajan et al., 2005). The nonlinearity of the soil may provide energy dissipation and serve as a fuse mechanism, potentially reducing shaking demands exerted on the structural components of the building, particularly for shear wall structures. Performance based earthquake engineering design methods emphasize the importance of incorporating the nonlinear soil-foundation-structure interaction in design. In order for structural and geotechnical engineers to make use of the advantages of nonlinear soil-foundation-structure interaction and to use optimum energy dissipation mechanisms in structural elements and foundation soil, reliable structural and foundation constitutive models are necessary. Since the rocking of shallow foundation and soil yielding may

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