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Calculation of Seismic Interaction Forces and Interaction-induced Excitation for Coupled Rigorous-Substructure SSI Analysis

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Abstract

In this study, some earthquake records have been inspected for the sake of seismic soil-structure interaction (SSI) analysis in order to assess the interaction forces between the linear elastic far-field and the nonlinear inelastic near-field. The interaction forces may later be used to examine SSI effects using the substructure method to satisfy the infinite boundary condition after modeling the near-field rigorously. These forces, which will later result in the real excitation to the system, act virtually on the near- and far-field interface which serves as the truncation limit chosen to carry out the analysis. To satisfy the mentioned boundary condition, the Scaled Boundary Finite Element Method (SBFEM) is chosen for its accuracy and conciseness. The media is inspected assuming compressible and incompressible cases and outputs are compared revealing that the force time history is much bigger for incompressible and clayey cases admitting the liquefaction possibility to exist for incompressible sand. It is observed that the forces, calculated via convolution integrals, vanish rapidly but not immediately after the motion ceases. The interaction-induced excitation may be up to four times the free-field motion.

Keywords: Soil-structure interaction, earthquake, scaled boundary FEM, interaction forces, compressible and incompressible conditions

1. INTRODUCTION

The importance of soil-structure interaction (SSI) effects has been growing since effects of incident motion frequency versus the natural frequency of the structure have come into consideration and resonance possibilities have been inspected. Yet, as numerical modeling leads to a lot of simplifying hypotheses, no exact evaluation of SSI has been offered so far. Researchers have tried a lot to come up with models able to be solved though. The importance of nonlinearities in seismic SSI came into consideration after some seemingly illogical events happened during such big earthquakes as Mexico City 1985, Loma-Prieta 1989, etc. Some well-known scientists have done great deals on the subject ever since. JP Wolf has written two valuable books named *Dynamic Soil Structure Interaction* (1985) [1] and *Dynamic Soil Structure Interaction in Time Domain* (1989) [2]. The problem with these conventional methods, beside the complicatedness of the procedures discussed, is that all assumptions are based on linear elastic behavior of the media which, in its own terms, has little correspondence with observed and possible behavior of soils. The rather newly developed engineering method Cone Model is not excluded from this. The discussion should be focused on whether soil exhibits linear elastic response at all. The answer to this question has been proven to be yes, although this should be managed carefully. Studies have revealed that where soil is provided with enough confinement and the finite input loading is distributed to a vast soil region, this assumption is well close to reality [2]. Thus, to yield accurate enough results along with efficient computation procedures it is of great importance to figure out which part of the media is close to elastic and which should be treated as inelastic.

The substructuring method, which has long been made use of in SSI problems, has been generalized to suit the needs of elastic-inelastic superposition schemes [3]. Since the application of Infinite Element Method (IEM) and later Boundary Element Method (BEM) got common, the need of such methods in hybrid