Error Estimation of Infinite Element in Geotechnical Problems

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Abstract

In most seismic and geotechnical problems, for analysis of a region, at least one direction of the region extends to infinite. In usual methods of static analysis, for modeling infinite effects, domain over interest point needs to be considered big enough and the displacements to be fixed at boundary (Dirichlet boundary). In conventional methods of dynamic analysis, damping ratio may be supposed higher than material damping to avoid effects of receiving reflected wave from artificial boundary. Also, increasing dimensions of the region to be confident of those waves can't touch the boundary and propagate inside again. In such cases increasing in degrees of freedom is not economical and the accuracy of the results is not guaranteed. An efficient method in showing effects of far field on near field is implementation of Infinite Element. For this reason it is necessary to have sufficient knowledge of the method's accuracy and the mechanism of importing errors in the results. The most important issue in using Infinite elements is the type of their decay functions. Therefore, in this research, Infinite Elements with different decay function are implemented in some singular geotechnical problems and accordingly calibrations of their parameters to reduce their induced errors are revealed.

Keywords: Infinite element, Infinite domain, Numerical error, Decay function

1. INTRODUCTION

Indubitable, decoupling structure from soil-foundation is one of the most important assumptions for analyzing structures. Studies of scientists such as Wolf [1] show that there is an amount of uncertainty when superstructure has been analyzed separately from its base. For an accurate analysis it is required to model the actual structure within the entire region around it that may also be under stress. For this purpose, numerical simulation of near field and far field are needed. In most traditional methods of Discrete Element Method or Finite Element Method, two numerical techniques for approximating governing differential equation, is used for simulating near field and for simulating the far field Dirichlet boundary condition is adopted. In static analyses to achieve suitable answers, it is necessary to impose Dirichlet boundary far enough from the interested area. On the other hand in dynamic analyses, when near field dimensions are not big enough, waves could propagate to the boundaries and scatter back to the under-study area in the analysis duration, so the accuracy of results may not be guaranteed.

There are a number of disadvantages in the case of modeling the entire domain with a numerical method. First of all, these methods need much time to be modeled and even after they are modeled; it takes a lot of computational process and storage to be analyzed.

Different artificial boundary conditions are offered to solve these problems. Simple dampers were proposed with Lysmer and Kuhlmeyer [2] as Absorbing Boundary which working in both time and frequency domains. More accurate results can be taken with Boundary Element Method which calculate integrals of governing differential equations on boundary [3]. Mathematical complexities of BEM hamper its usability in some occasions. Using of coupled Finite Element Method with Infinite Element Method instead of FEM-BEM is an alternative in such a case.

Infinite Element was first proposed by Anderson and Ungless [4] as Infinite Finite Element. They used a prismatic triangle that extends to infinite from one direction. Reciprocal function like 1/x for extending finite domain to infinite ones was adopted. During the period of time they had to solve the stiffness matrix with analytical integration instead of numerical ones due to not mapping the element. After that, Zienkiewicz and Bettess [5] used a similar method for modeling surface wave on water and they used their similar experiences [6] in BEM as parallel. After that, the methodology of IEM improved in two different approaches -Co-ordinate Ascent and Displacement Descent- which now are named as Mapped Element and Decayed Infinite Element. Beer and Meek [7] had developed Anderson and Ungless' method by mapping an