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SEISMIC RESPONSE OF DEEP FOUNDATIONS AND PILED STRUCTURES CONSIDERING INCLINED PILES

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Because of their larger horizontal stiffness, battered piles have been broadly used in foundations which are to be subjected to large horizontal loads. Despite this advantage, the use of inclined piles in seismically active regions has been considered detrimental and became highly discouraged in many codes (e.g.[1]) after a series of earthquakes in which deep foundations with raked piles showed a poor performance. Nevertheless, several authors [2, 3] have provided numerical results showing the potential benefits of using inclined piles on the seismic response of both the superstructure and the foundation. The beneficial or detrimental role of foundations including inclined piles remains an open question. This paper focuses on two aspects that need further research. One of them is related to the influence of inclined piles on the kinematic interaction factors of deep foundations. The other is the influence of the rake angle on the seismic response of the superstructure. In this paper, a three-dimensional boundary element (BEM)-finite element (FEM) coupling formulation [4, 5] is used to obtain kinematic interaction factors corresponding to several configurations of deep foundations with inclined piles. The soil region is modeled as a homogeneous viscoelastic isotropic half-space by boundary elements. Piles are modeled by monodimensional finite elements as Euler-Bernoulli beams embedded in the soil. Coupling is performed by imposing equilibrium and compatibility conditions. The system is subjected to harmonic vertically-incident shear waves. Figure 1 illustrates the whole approach. Kinematic interaction factors corresponding to inclined single piles, and square 2 by 2 and 3 by 3 pile groups are presented in ready-to-use dimensionless graphs for different separation ratios. A significant dependence of the foundation kinematic response on the rake angle is shown. A reduction of the horizontal displacements is observed when inclining piles in the direction of the excitation. The response of the superstructure is also addressed in this paper through a procedure based on a substructuring methodology [6] depicted in Figure 2. It is shown that, in general, the rake angle tends to reduce the base shear forces induced at the base of non-slender superstructures, while this trend can

be reversed for slender structures.

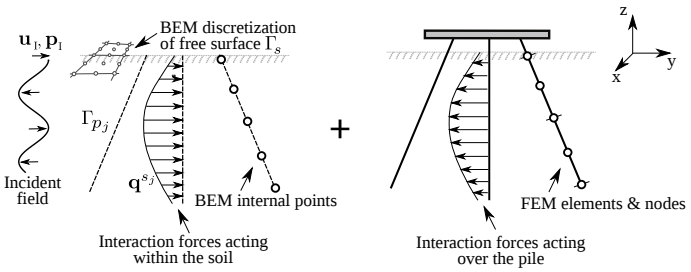

Figure 1: Boundary element-finite element model.

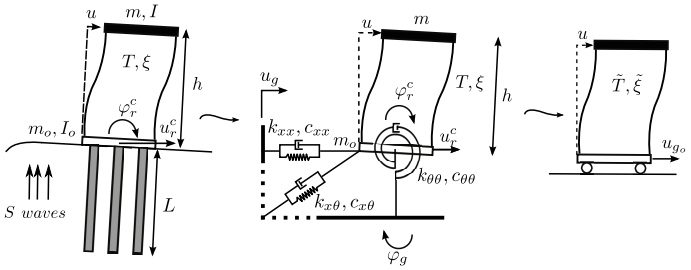

Figure 2: Substructuring model.

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