Time-Domain Analysis Approaches of Soil-Structure Interaction: A Comparative Study

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Abstract : This paper compares the substructure and direct methods for soil-structure interaction (SSI) analysis in the time domain. In the substructure SSI method, the soil domain is replaced by a set of springs and dashpots, also referred to as the impedance function, derived through the study of the behavior of a massless rigid foundation. The impedance function is inherently frequency dependent, i.e., it varies as a function of the frequency content of the structural response. To use the frequency-dependent impedance function for time-domain SSI analysis, the impedance function is approximated at the fundamental frequency of the structure-soil system. To explore the potential limitations of the substructure modeling process, a two-dimensional reinforced concrete frame structure is modeled using substructure and direct methods in this study. The results show discrepancies between the simulated responses of the substructure and the direct approaches. To isolate the effects of higher modal responses, the same study is repeated using a harmonic input motion, in which a similar discrepancy is still observed between the substructure and direct approaches. It is concluded that the main source of discrepancy between the substructure and direct SSI approaches is likely attributed to the way the impedance functions are calculated, i.e., assuming a massless rigid foundation without considering the presence of the superstructure. Hence, a refined impedance function, considering the presence of the superstructure, shall be developed. This refined impedance function is expected to significantly improve the simulation accuracy of the substructure approach for structural systems whose behavior is dominated by the fundamental mode response.