TECHNICAL NOTE

Introducing New Pile Element for Dynamic Response Analysis of Large Pile Groups in SASSI
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MTR & Associates

Pile foundations are often required to support large and heavy structures by transferring the weight of the structure to more competent materials at depth and to minimize foundation settlements.

Dynamic response analysis of pile-supported structures in SASSI is relatively complex and requires proper modeling and knowledge of pile-soil-structure interaction. The inter-pile element in the original SASSI code requires large number of interaction nodes which makes it unattractive for practical applications. In two previous technical notes we examined alternative methods for analyzing dynamic response of pile groups in SASSI using the Spile and beam elements. These studies revealed severe deficiencies in the use of Spile and Beam element for such applications. To address the current inadequacy of SASSI for analysis of large pile groups, a new pile element has been developed and implemented in MTR/SASSI.

To evaluate the numerical accuracy of the new pile element, the dynamic response of a 6x6 pile group in a deep layered soil system analyzed by Kaynia, 2014 was used. The pile group configuration and properties are shown in Figure 1. The piles are 15m long, 0.456m in diameter and spaced 1.2m center-to-center. The piles are connected to a rigid massless pile cap at the ground surface. The soil properties included mass density, shear and compression wave velocities and damping. The shear and compression wave velocities range from 84 and 164 m/s at the ground surface to about 330 and 686 m/s at a depth of 15m below the surface. Water table is below the pile tips. Figure 2 shows the finite element SSI model of the pile group in MTR/SASSI. The piles are subjected to horizontal and vertical loading at the center of pile cap at ground surface. The results in terms of the foundation dynamic stiffness and damping functions calculated using the new pile element together with those provided by Kaynia are shown in Figure 3 for the horizontal and in Figure 4 for the vertical loading, respectively.

As shown in Figures 3 and 4, there is reasonably good agreement between the two results. For the horizontal loading, resonant frequency of the pile group occurs around 34Hz in the MTR/SASSI model and 39Hz in Kaynia's solution. This difference is attributed to the depth of significant stress transfer between soil and piles in the two methods. It appears that in Kaynia's solution, this depth is larger for the pile group resulting in sampling higher soil velocities from deeper depths. The magnitude of the stiffness and damping at the natural frequency of the pile group are somewhat higher in Kaynia's solution than those of MTR/SASSI. In the case of vertical loading, the piles mobilize soil resistance along the entire length of the piles with both methods indicating similar resonant frequency around 30Hz. The magnitude of stiffness and damping at the resonant frequency are only slightly higher in Kaynia's solution.

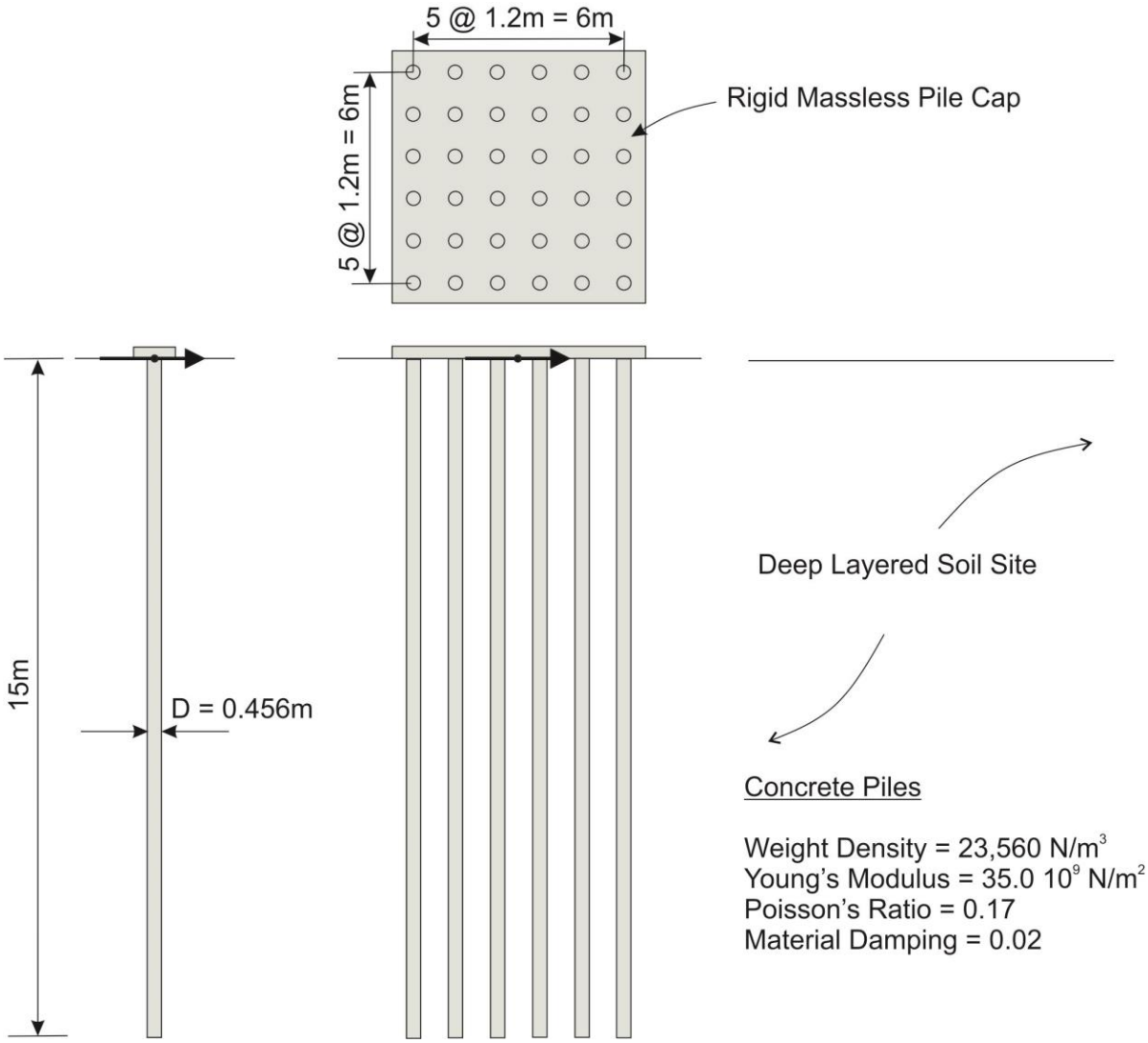


Figure 1 - Pile Group Configuration and Properties

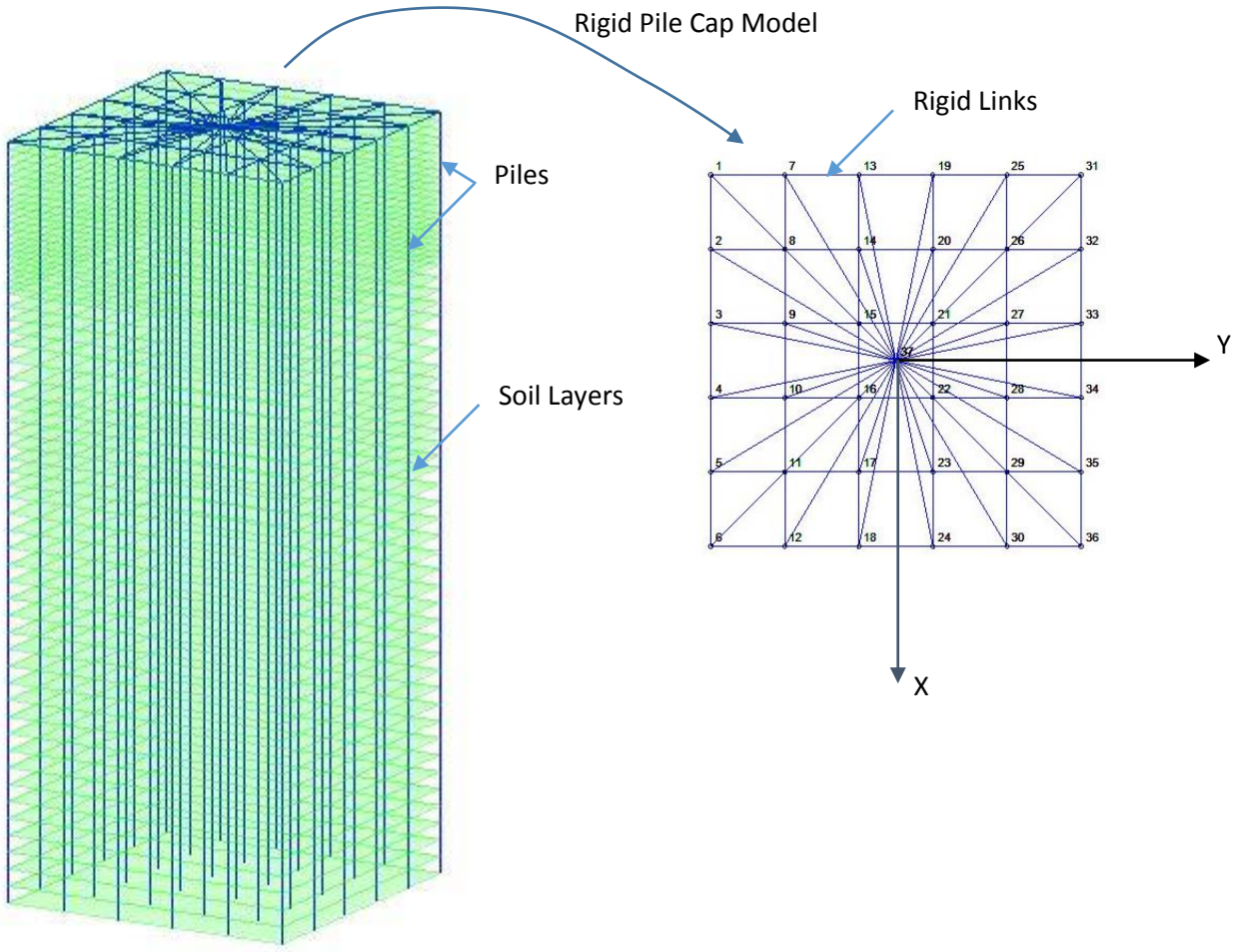


Figure 2 – MTR/SASSI Pile Group Finite Element SSI Model

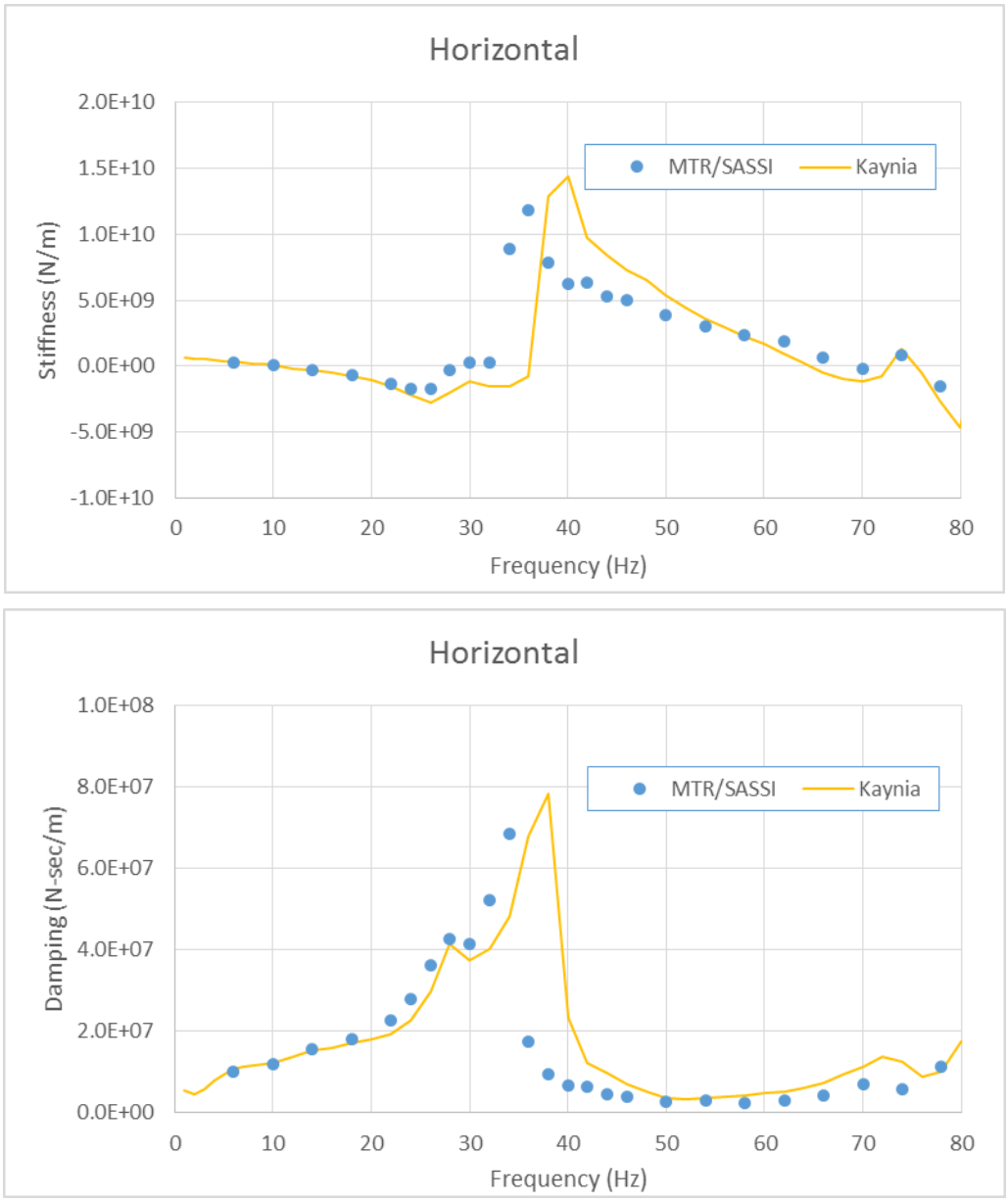
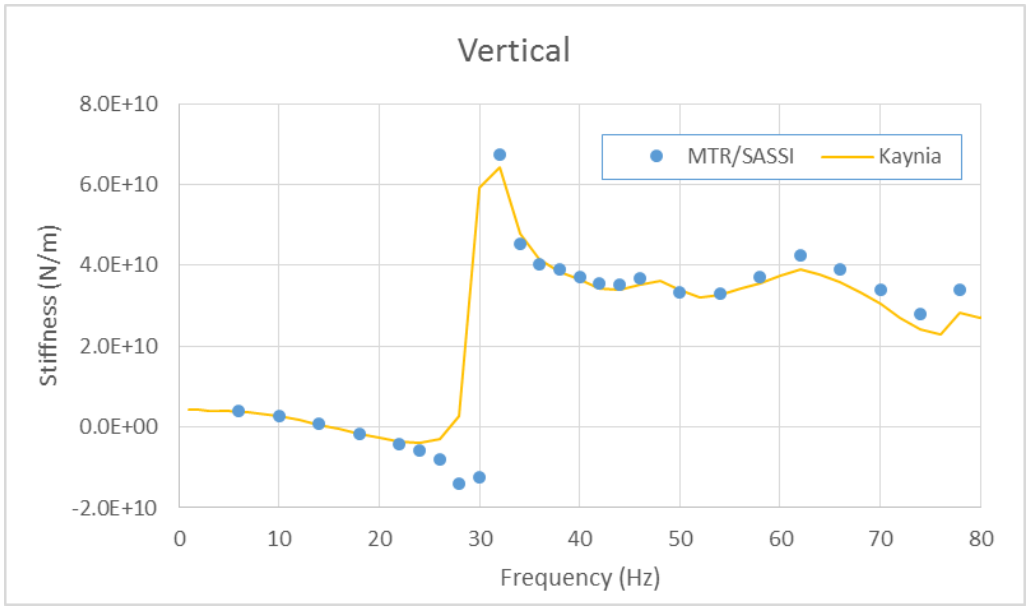


Figure 3 - Horizontal Impedance of 6x6 Floating Pile Group in Deep Layered Soil



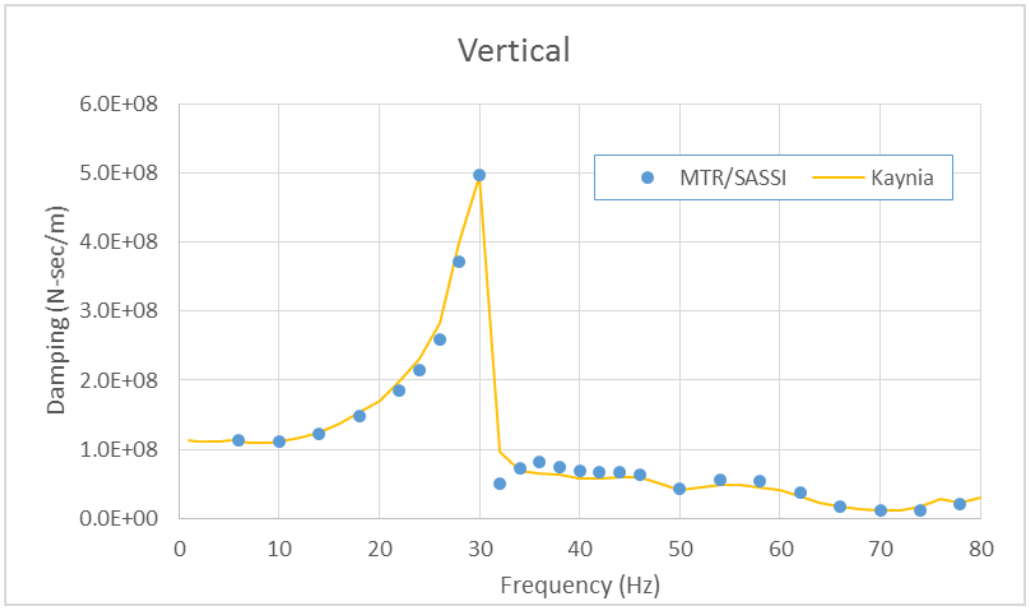


Figure 4 - Vertical Impedance of 6x6 Floating Pile Group in Deep Layered Soil