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DYNAMIC BEHAVIOR OF TALL ADJACENT BUILDINGS HAVING DIFFERENT FOUNDATION EMBEDMENT DEPTHS

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Structure-soil-structure interaction　Embedded foundation　Dynamic cross interaction
Tall buildings　Fourier amplitude spectra　Rocking motion

1 Introduction

In the works done about structure-soil-structure interaction (SSSI) and dynamic cross interaction (DCI) phenomenon [1-9], the mechanism of the problem could not be cleared adequately and adjacent buildings having different embedded depth of foundations are not analyzed.

Therefore, a wide parametric analytical study is applied considering different kinds of embedment situations and fixed based natural frequencies of two closely spaced elastic adjacent buildings for low, middle and tall buildings and important findings are obtained for tall adjacent identical structures having different foundation embedment depth. Therefore, research results are given for this analysis situation case.

2 Analysis Model

To represent high story building, single degree of freedom (SDOF) system is selected for effective height (H_{eff}) 40m to represent 20 story building. Fixed based natural periods of superstructures (T_{fix}) is taken 2.0 sec, mass of superstructures (m_s) is taken as 10,000 t. Foundations are modeled as 20x20m square mat foundation having embedded depth 0, 2, 4, and 8m. The damping for the superstructures (h_{str}) is taken as 3%. The mass of foundation (m_f) is selected fixed for all cases as 500 ton.

The soil is idealized as homogeneous elastic half-space having 3% material damping (h_s). The mass density of soil (ρ) is considered as 1.7 t/m^3 and shear wave velocity of soil (V_s) is selected as 100 and 200 m/s. Poisson's ratio of soil (ν) is taken as 0.45. Soil is modeled by the thin layers and to represent unbounded soil, the paraxial boundary is applied to the bottom of the models. Moreover, a square rigid foundation placed on this half-space is also divided into the finite elements, as it is seen in Figure 1 where x and y directions are also given (Wen [6]).

To see the effect of DCI for closely built structures, the clearance between foundations is selected as 3m. Layout of adjacent buildings and a main building for adjacent building cases can be seen in Figure 2, where D is clearance between foundations, e_1 is the embedment depth of foundation of the main building, e_2 is the embedment depth of foundation of the adjacent building.

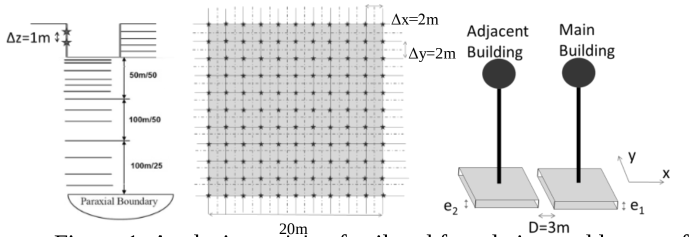

Figure 1: Analysis models of soil and foundation and layout of buildings

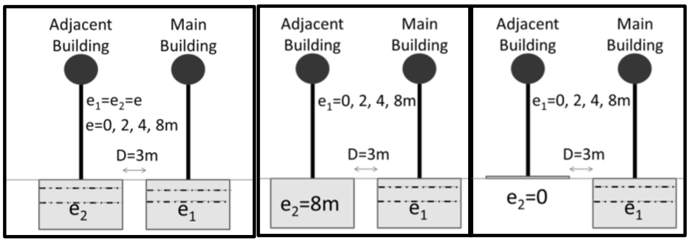

Figure 2: Layout and embedment case for foundations

3 Analysis Method

To judge the effect of DCI, the similar method is applied as Alexander *et al.* [8]. In this method, mean power values, which are the area under the power spectra, for the mass of superstructures are calculated and the ratio for adjacent building cases to single building case shows the effect of DCI, and this ratio is called as mean power ratio (MPR). To obtain general results, a dimensionless Fourier amplitude spectra (FAS) is created as similar to zero damping velocity spectrum based on Japanese design spectrum [10] as it is seen in Figure 3 for the excitation.

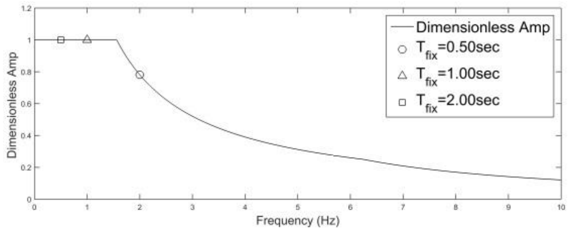

Figure 3: Dimensionless amplitude of excitation

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3 Analysis Results

The MPRs of superstructures being adjacent to identical structure case to the single structure case for *x* and *y* direction and V_s=100 m/s are given in Figure 4 where *x* axis represents the foundation depth of main building. If Figure 4 is examined, it can be said that the maximum MPR is seen for main buildings having deeper embedment depth of foundation than foundation of adjacent building (e_1>e_2) and for shallower embedment depth of main building (e_1<e_2), the minimum MPR is observed. Therefore it is claimed that effect of DCI is detrimental on deeper embedded adjacent buildings and beneficial on shallower embedded adjacent buildings on *x* direction. However diverse effect is observed at Figure 4 for *y* direction.

To show this phenomenon, transfer function amplitudes (TFAs) of superstructures being adjacent to identical structure case to single structure case for e_1=4m and e_2=0m are given for *x* direction in Figure 5, and for *y* direction in Figure 6 for V_s=100 m/s. As it is on these figures, MPR of main building is clearly higher than the adjacent building for *x* direction, and for *y* direction diverse situation is observed.

Finally, the MPRs of superstructures being adjacent to identical structure case to the single structure case for *x* and *y* direction and V_s=200 m/s are given in Figure 7, and if Figure 4 and 7 are compared, same tendency of the MPRs is seen, although MPRs become closer to 1 for V_s=200 m/s than V_s=100 m/s.

4 Conclusions

Consequently, it is asserted that, there is a power transfer from shallowly embedded tall buildings to the deeply embedded tall building for *x* direction, and diverse power transfer occurs for y direction. It can be claimed that mean power of adjacent structures, of which natural frequency does not change under the DCI effect as it is seen in Figure 5(a) and Figure 6(b), increase and that mean power of adjacent structures, of which natural frequency changes under the DCI effect as it is seen in Figure 5(b) and Figure 6(a), decrease. Due to the different mechanism of the DCI effect on *x* and *y* direction, the direction of power transfer between buildings is changed and this effect becomes decreasing by increasing values of shear wave velocity of soil. Finally, it should be asserted that this study is conducted for restricted parameters of *D*, m_f, h_s and V_s, so further research is suggested for other values of these parameters.

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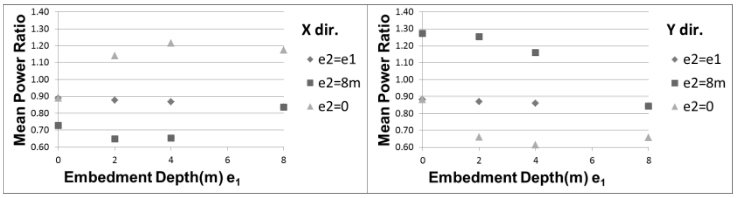
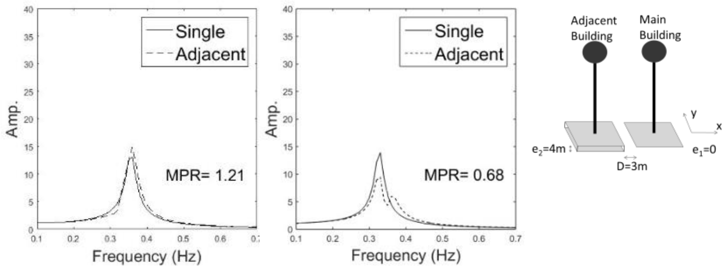
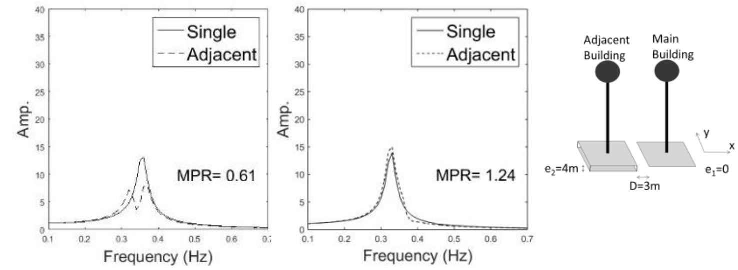


Figure 4: MPRs of superstructures on x and y direction for Vs=100m/s



(a) Main Building (b) Adjacent Building

Figure 5: TFAs and MPR of superstructures on x direction for Vs=100m/s



(a) Main Building (b) Adjacent Building

Figure 6: TFAs and MPR of superstructures on y direction for Vs=100m/s

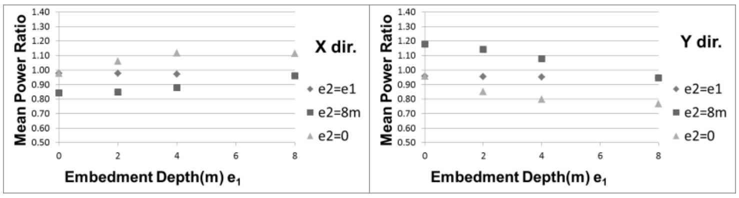


Figure 7: MPRs of superstructures on x and y direction for Vs=200m/s

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