ABSTRACT

Study of the effect of soil-stiffening interventions on the dynamic response of structures

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Soil-structure interaction is known to affect significantly the dynamic behavior of structures. There is a view that this is in favor of the structure's antiseismicity, but this has been proved to be a simplifying and even a mistaken generalization. The dynamic properties of the soil-structure system are modified when the soil is improved, specifically when its stiffness is increased. Therefore this thesis investigates the way soil-stiffening affects the eigenfrequency and in general the response of the structure and of the soil.

This investigation was carried out through a parametric analysis of a model of the improved soil-structure system. The system was simulated with a proper finite element model, which was analyzed in the frequency domain with a numerical code that had been calibrated previously using theoretical formulas and other codes. In specific the ability to simulate soil response was examined and the precision by which the effective frequency of the superstructure can be determined was checked also. The parameters of the analysis are those that according to the bibliography, affect the dynamic behavior of the improved soil-structure system, that is to say the mass and the eigenfrequency of the superstructure, the depth of the intervention in the ground, the shear modulus of the initial and the reinforced soil and their ratio. In addition the span of the values for the shear modulus of the reinforced soil was chosen in accordance to the references.

Before examining the coupled soil-structure system the influence of the depth of the intervention and of the shear modulus of the reinforced soil on soil's response was investigated. The results of the analyses showed that increase of the depth of the intervention and of the shear modulus of the reinforced soil results in decrease of the amplification of the ground's motion at its higher eigenmodes and increase of the corresponding eigenfrequencies.

Having seen that, this thesis looks into the influence of the intervention's characteristics and of the structure's mass and eigenfrequency (for fixed base conditions) on superstructure's and foundation's amplification of movement and on the system's effective eigenfrequency. According to the results increase of the depth of the intervention and of the shear modulus of the reinforced soil does not affect significantly the effective frequency of the system, however it augments the maximum response of the superstructure. Furthermore it was noticed that for higher values of the normalized superstructure's mass, its maximum response and effective eigenfrequency are significantly reduced.

Finally this thesis deals with the variation of the maximum response of the superstructure due to soil stiffening and the difference between the value of the

effective period the way it is determined through the numerical analyses and as computed using analytical formulas. The numerical results show that the maximum response of the superstructure increases significantly due to soil-stiffening in the case of a stiff structure with a low value of mormalized mass on a soft / loose soil. As far as the effective eigenfrequency of the system is concerned, it was noticed that if it is calculated with analytical formulas using the shear modulus of the reinforced foundation soil (as it is done in common practice), then it diverges from the value resulting from the numerical analyses. This divergence may be up to 100% in the case of stiff structures of large normalized mass on soft / loose soil.