Nonlinear response of high-rise buildings subjected to rocking motion induced by passage of Rayleigh waves

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Résumé :

Long-period surface waves are known to be the cause of resonant response in large engineering structures such as high-rise buildings. Besides, as Rayliegh waves propagate deforming the ground, the vertical component of such deformations induce rocking motion at the base of the strucutres. The consequence of both phenomena for high-rise buildings can be translated into a significant increase in displacements demands. However, the reponse of buildings to rocking motion has not been extensively studied, because rocking time histories are not available to the analysts on a routine basis.

The present work presents results of a study investigating the effects of Rayleigh waves on the response of soil-structure systems with nonlinear behavior at the level of the superstructure. We start by selecting a number of recorded seismic motions which include surface waves, on sedimentary basins from recent well recorded earthquake events. Then we proceed to extract surface waves from the recordings using the «Normalized Inner Product» a technique that exploits the orthogonality properties of Rayleigh waves to identify them in the time-frequency space. Then rocking time histories are derived from the exracted waves using plane wave assumptions and after estimating their frequency-dependent phase velocities.

To model the superstructure, we adopt a realistic analytical model that has been proposed in the published literature for high-rise buildings, namely, the flexure-shear coupled-beam model. We expand this analytical model to introduce interaction with a flexible underlying soil by implementing time-domain impulse response impedance functions. We also take into account the stiffness reduction of the building due to damage to its lateral load-resisting system by introducing a rigid-elastic rotational spring at its base.

Considering different levels of ductility and post-yield stiffness, we investigate the impact of rocking due to Rayleigh wave passage on maximum and residual interstory drift ratios of several high-rise buildings. Of particular interest is to compare the response of such structures with and without the presence of rotational motions due to surface waves. Our results indicate that rocking due to surface waves should be an important consideration for design and evaluation of tall buildings, as inelastic action elongates their effective natural period and, consequently, they are more prone to be damaged by Rayleigh waves.

Mots clefs : **High-rise buildings, surface waves, rocking, ductiliy demand, interstory drift**

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