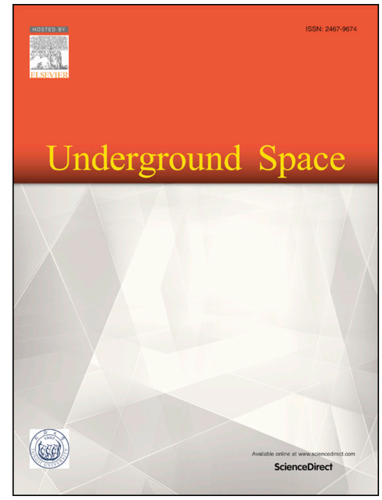

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Effect of frequency and flexibility ratio on the seismic response of deep tunnels

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Abstract

Two-dimensional dynamic numerical analyses have been conducted, using FLAC 7.0, to evaluate the seismic response of underground structures located far from the seismic source, placed in either linear-elastic or nonlinear elastoplastic ground. The interaction between the ground and deep circular tunnels with a tied interface is considered. For the simulations, it is assumed that the liner remains in its elastic regime, and plane strain conditions apply to any cross section perpendicular to the tunnel axis. An elastoplastic constitutive model is implemented in FLAC to simulate the nonlinear ground. The effect of input frequency and relative stiffness between the liner and the ground, on the seismic response of tunnels, is evaluated. The response is studied in terms of distortions normalized with respect to those of the free field, and load demand (axial forces and bending moments) in the liner. In all cases, i.e. for linear-elastic and nonlinear ground models, the results show negligible effect of the input frequency on the distortions of the cross section, for input frequencies smaller than 5 Hz; that is for ratios between the wave length and the tunnel opening (λ/D) larger than ten for linear-elastic and nine for nonlinear ground. Larger normalized distortions are obtained for the nonlinear than for the linear-elastic ground, for the same relative stiffness, with differences increasing as the tunnel becomes more flexible, or when the amplitude of the dynamic input shear stress increases. It has been found that normalized distortions for the nonlinear ground do not follow a unique relationship, as it happens for the linear-elastic ground, but increase as the