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Periodic Surface Walls for Ground Vibration Attenuation

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Introduction

Ground vibrations caused by construction, traffic, earthquakes, and other external sources can compromise structural integrity and disturb the operation of sensitive equipment, such as particle accelerators. These facilities demand efficient vibration mitigation strategies to ensure stability and precision. Among the proposed solutions, surface walls (Carneiro et al., 2022) and periodic walls stand out for their ability to reflect and absorb vibrational energy, increasing structural resilience to dynamic disturbances In this work, the interaction between a novel model of periodic walls and the soil is analyzed using a coupled formulation based on the Indirect Boundary Element Method (IBEM) and the Finite Element Method (FEM), the IBEM–FEM coupling scheme. FEM is used to model the walls and IBEM is employed to modeled the soil. To represent a substantial range of phenomena relevant to geotechnical and seismic engineering practice, the proposed models account for ground vibration induced by Rayleigh waves.

Methodology

Figure 1 shows a typical gabion wall structure, commonly used as a surface barrier to attenuate ground vibrations. Building on this concept, the present study investigates the interaction between a novel periodic wall model (Fig. 2) and the soil through a coupled formulation that combines the Indirect Boundary Element Method (IBEM) and the Finite Element Method (FEM). In this coupling scheme, FEM is employed to model the wall, while IBEM represents the soil behavior. To simulate realistic geotechnical and seismic conditions, the model incorporates Rayleigh wave-induced ground vibrations, which are predominant in surface wave propagation.

Fig. 1: Typical Gabion Wall Structure.

Consider n identical linear-elastic walls of width L, height H, and spacing a, characterized by E, ν, η, and ρ. These walls are placed on a homogeneous, isotropic, viscoelastic half-space, defined by ρ_s, G_s, ν_s, and η_s. The analysis assumes plane strain and perfect bonding at the soil–structure interface. Ground vibrations are induced by Rayleigh waves.

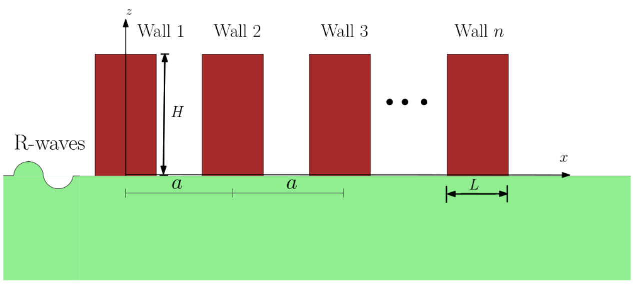

Fig. 2: Periodic structures under Rayleigh wave excitations.

The walls are modeled using quadrilateral FEM elements, while the soil is represented via IBEM as a transversely isotropic half-space. Coupling is enforced through interface equilibrium and displacement continuity, and the system is analyzed under seismic excitation.

Results and discussion

The walls are discretized using quadrilateral FEM elements, with stiffness and mass matrices obtained through standard procedures. The soil is modeled as a transversely isotropic half-space using IBEM, which relates displacements to fictitious tractions through influence matrices. Soil–structure coupling is enforced via equilibrium and displacement continuity at the interface. The system is subjected to seismic excitation by Rayleigh waves acting on multiple walls.

A numerical analysis is conducted for the case of n gabion walls ($E = 367$ MPa) of $H = 2\,m$ and two diferent widths are considered: $L = 1\,m$ and $L = 2\,m$. The insertion point of these walls is is separed by $a = 5\,m$. Tab.1 shows the material parameters of the walls and the soil. The results are expressed in terms of the insertion loss, defined as:

$$IL = 20\log_{10}\left|\frac{u_b}{u_b}\right|,$$

which represents the ratio of ground motion before (u_b) and after (u_a) the installation of the wall. This metric is evaluated for both horizontal and vertical displacements at the measurement point located at $x = 30\,m$.

Table 1: Material properties of walls and soil.

Medium	$\rho(\text{kg/m}^3)$	η	ν
Wall	1700	0.02	0.2
Soil	1945	0.025	0.485

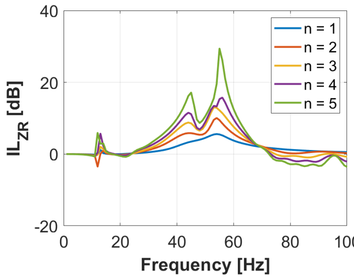

Fig. 3: Vertical insertion loss for $L = 1\,m$ walls.

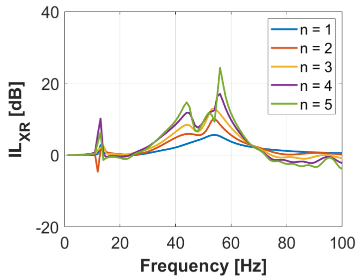

Fig. 4: Horizontal insertion loss for $L = 1\,m$ walls.

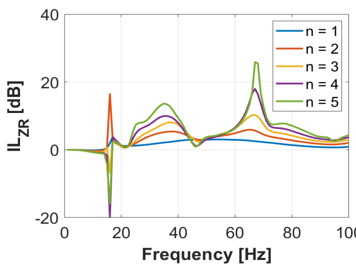

Fig. 5: Vertical insertion loss for $L = 2\,m$ walls.

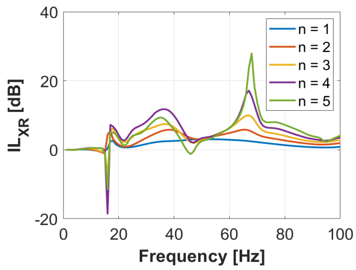

Fig. 6: Horizontal insertion loss for $L = 2\,m$ walls.

Conclusion

The results confirm that periodic surface walls can effectively attenuate ground vibrations, especially when excited by Rayleigh waves. The use of a coupled IBEM–FEM formulation enabled precise modeling of the soil–structure interaction. It was observed that increasing the number of walls intensifies insertion loss peaks, improving vibration attenuation in both vertical and horizontal directions. Moreover, changes in wall width directly influence the frequency range of attenuation, allowing for targeted vibration control. These findings highlight the potential of periodic structures as a passive mitigation strategy in geotechnical and seismic engineering.

Acknowledgements

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References

ANDERSEN, Lars V.; PEPLOW, Andrew; BUCINSKAS, Paulius. Efficiency of nearly periodic structures for mitigation of ground vibration. In: **COMPDYN 2017—Proceedings of the 6th International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering**. 2017.

CARNEIRO, David; BARROS, Pérsio LA; LABAKI, Josué. Ground vibration attenuation performance of surface walls. **Computers and Geotechnics**, v. 149, p. 104715, 2022.