



Vibration attenuation performance of decorative roadside boulders

Keywords: Soil-structure interaction, ground vibration, roadside boulders.

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INTRODUCTION:

Roadside boulders are large rocks left decoratively along roads. They may be formed due to natural erosion or be byproducts of explosions of larger rocks during the construction of the road. Other than their decorative function, it is believed that these rocks have a role in attenuating vibrations caused by the road, by dissipating part of the energy impinged into them by the soil.



Figure 1: *Roadside Boulders.*

Vibration attenuation methods are extensively studied. One of the reasons for this is the importance of vibration isolation in structures like particle accelerators. Sophisticated foundation projects and attempts to reduce the severity of the vibration sources are two of the measures taken with this go; another type of solution is the opening of trenches between the sensible structure and the source of vibration. In his work, Krylov (2007) proposed that surface bodies, like roadside boulders and gabion walls, might also have significant roles in attenuating soil vibrations.

A recent study from the Soil-Structure Interaction Laboratory from Unicamp, (Carneiro et al., 2022), showed that, in a certain range of frequencies, gabion walls produce large vibration attenuation, confirming Krylov's hypothesis. In this study, the analysis was made using a model of indirect boundary

elements for the soil and a model of finite elements for the gabion. This model, however, is bidimensional, and it would not be possible to use it to tackle the roadside boulders problem.

In this project, we proposed the use of finite element models for both the soil and the surface bodies, and to solve the issue of FEM models not being able to satisfy Sommerfeld's radiation condition, (Sommerfeld, 1949), the PML (Perfectly Matched Layers) will be used.

The PML is a method proposed by Berenger (1994), that brought a meaningful advance to the idea of absorbing layers and boundary conditions. It consists in surrounding a finite domain with finite layers designed to not reflect incoming waves, so that this domain is capable of satisfying Sommerfeld's radiation condition even while being bounded.

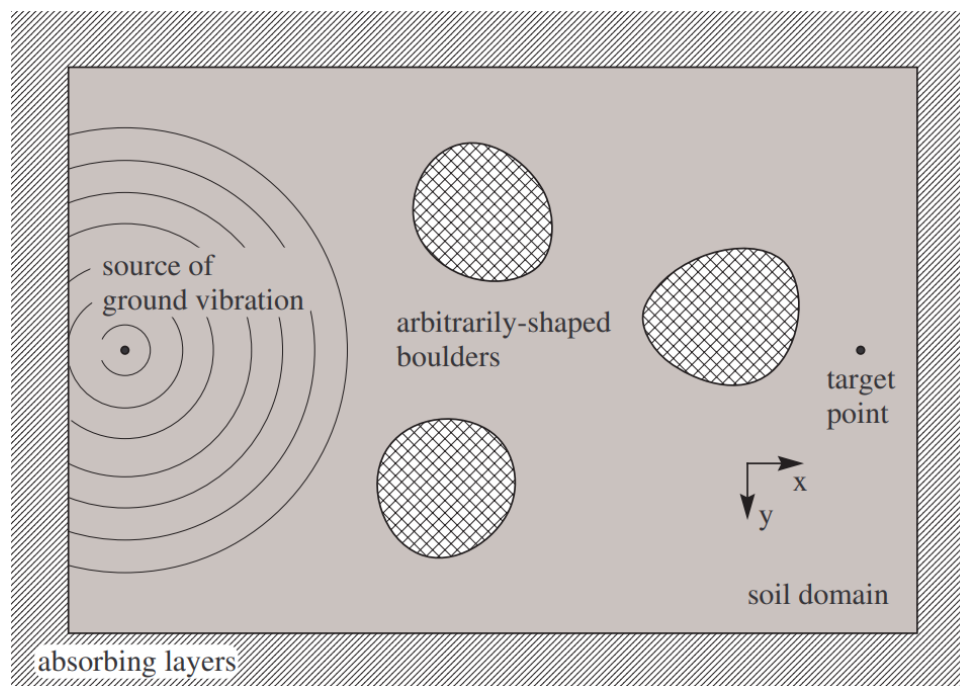


Figure 2: 2-D representation of the roadside boulders problem.

METHODOLOGY:

The modeling of studied problems was made through a FEM commercial software, Ansys, which presents a well-defined method for implementing the PML in structural problems, both for static and harmonic response analysis.

Before directly evaluating the performance of the roadside boulders in attenuating vibrations, a preliminary study was made to test the results obtained by the PML, in which a known problem, previously studied using an IBEM-FEM model, was analyzed using PML. An attempt was made to reproduce part of the results from Barros et al. (2019), which evaluates the frequency response of the displacement of a rigid plate over the soil, subject to a pressure in its surface.

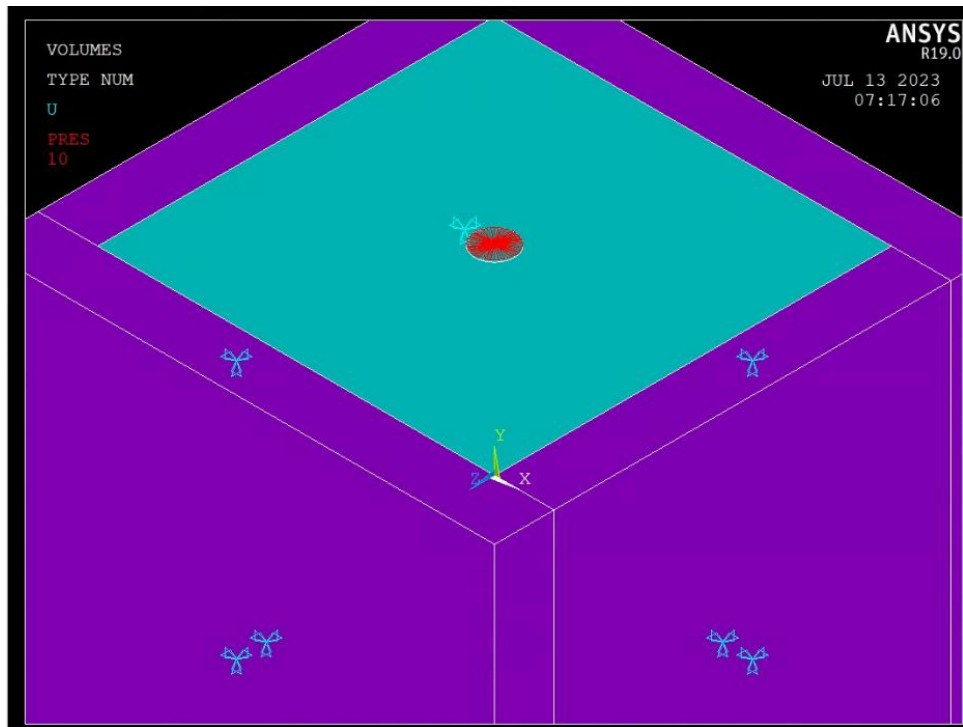
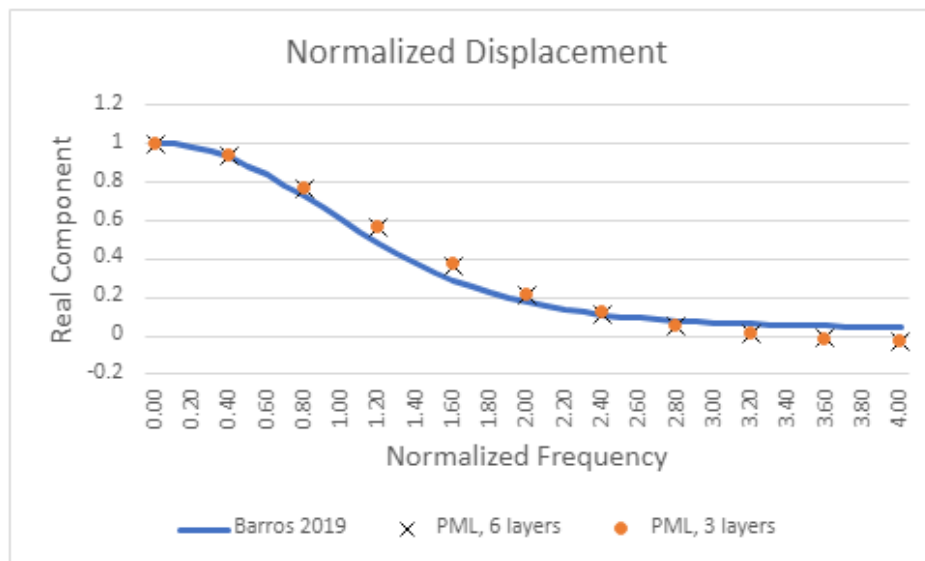


Figure 3: PML model in Ansys. In purple, the absorbing region, in blue, soil's model.

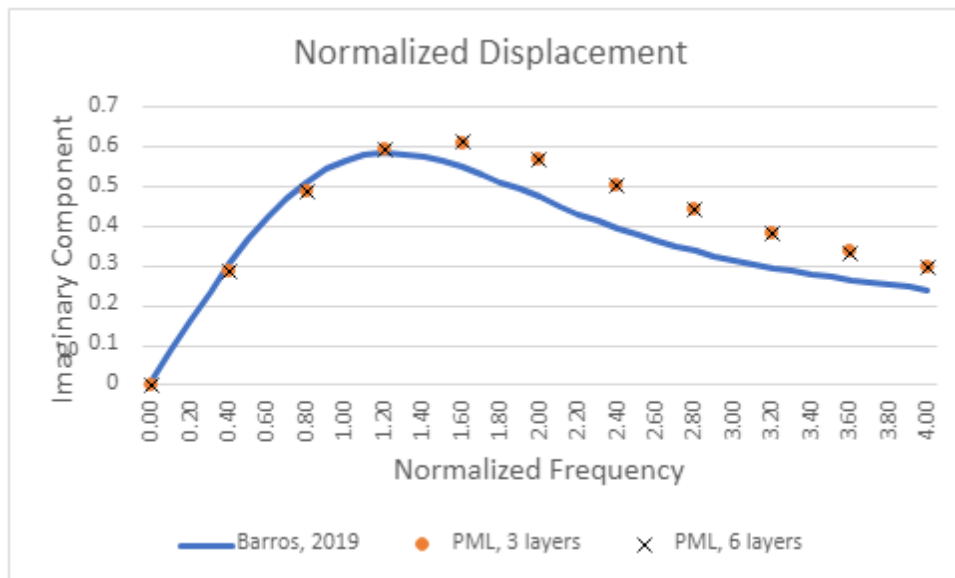
RESULTS:

The PML implementation in Ansys was successful. Graphics 1 and 2 show a comparison between results obtained by Barros et al. (2019), and those obtained using PML, to the plate problem.

In this case, it was also possible to test how the variation of PML parameters affected the model's performance; in the graphics, it is possible to see the influence of the number of absorbing layers in the results.



Graphic 1: Real component of the plate's displacement.



Graphic 2: Imaginary component of the plate's displacement.

The results indicate that PML is capable of satisfactorily modeling soil-structure interaction problems, and that it is suited for studying the roadside boulders problem, as proposed in this article. It is also possible to see that there was not a significant variation in the results due to the change in the number of layers.

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