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Experimental Improving the performance of absorbing layers with increasing damping in the numerical modeling of surface waves propagation using finite element method

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Abstract

Finite Element codes (FE) are increasingly used to simulate the propagation of elastic waves and dispersion, especially in surface-wave techniques. The common problem when using such methods is unwanted reflections from the boundaries of the model, which is still a challenging issue. In this paper, the effect of different parameters is evaluated to improve the performance of Absorbing Layers using Increasing Damping (ALID) in order to reduce the reflected waves from the boundaries and increase the resolution of the results. In this regard, after identifying the appropriate specifications of ALID layers in Abaqus software, the effect of thickness and number of ALID layers in different soils media with shear wave velocities of 200, 800 and 2000 m/s are investigated on the amplitude damping of incident waves at the boundaries. The results show that applying ALID with the gradual increasing damping significantly prevents the reflection of the waves into the media in comparison with the constant and double increasing damping. Furthermore, the hard soil requires more ALID layers and soft soil including high damping needs lower ALID layers. also increasing the number of ALID layers are more effective than increasing their thickness.

Keywords: *Reflected waves, ALID, Absorbing Layers using Increasing Damping, Absorbing boundary, Finite Element.*

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Extended Abstract:

1. Summery

In this paper, the effect of different parameters is evaluated to improve the performance of Absorbing Layers using Increasing Damping (ALID) in order to reduce the reflected waves from the boundaries and increase the resolution of the results. In this regard, after identifying the appropriate specifications of ALID layers in Abaqus software, the effect of thickness and number of ALID layers in different soils media with shear wave velocities of 200, 800 and 2000 m/s are investigated on the amplitude damping of incident waves at the boundaries. The results show that applying ALID with the gradual increasing damping significantly prevents the reflection of the waves into the media in comparison with the constant and double increasing damping. Furthermore, the hard soil requires more ALID layers and soft soil including high damping needs lower ALID layers. Also increasing the number of ALID layers are more effective than increasing their thickness.

2. Introduction

Finite Element codes (FE) are increasingly used to simulate the propagation of elastic waves and dispersion, especially in surface-wave techniques (Luo and Rose, 2007; Yuan et al., 2015, Jahromi and Karkhaneh, 2019). The common problem when using such methods is unwanted reflections from the boundaries of the model, which is still a challenging issue. FEM simulation of a transient impact on the traction-free surface causes noticeable reflected energy from the infinite element boundary. Infinite element technique is not suitable for modeling complex wave propagation in the surface-wave testing of 2D/3D media. On the other hand, Perfectly Matched Layer (PML) and Absorbing Layers using Increasing Damping (ALID) significantly reduce the geometric and computational size of the numerical model (Rajagopal et al., 2012; Farzanian et al., 2016). Characteristics, number, and thickness of ALID layers are the effective parameters on the impedance of the components at the absorbing boundaries. In this regard, ALID is preferred in this study as it is easier to implement in the FEM package (Abaqus software) by using Rayleigh damping (Pettit et al. 2014, Lin and Ashlock, 2016; Jokar et al., 2019). The suitable ALID is used in these modeling with the same properties to the medium and different materials damping to attenuate the waves.

2. Materials and methods

In this paper, absorbing layers with increasing damping (ALID) are used based on the Rayleigh damping in Abaqus software. In this regard, the coefficients of Rayleigh damping are determined using modal analysis according to the soil properties. The damping coefficients are applied to the model boundaries in three different type as constant, doubling increasing and gradual increasing damping. Then, the most suitable arrangement of ALID type is presented with the characteristics of gradual damping to prevent the reflection of the waves into the soil media. Also, the effect of the number and thickness of ALID layers are evaluated with gradual increasing damping in different soil media with shear wave velocities of 200, 800 and 2000 m/s. In addition, the effect of soil stiffness on the characterization, thickness, and number of adsorbing boundary layers are investigated.

3. Conclusion

The results show that applying ALID with the gradual increasing damping significantly prevents the reflection of the waves into the media in comparison with the constant and double increasing damping. Furthermore, the hard soil (VS=2000 m/s) requires more ALID layers and soft soil (VS=200 m/s) including high damping needs lower ALID layers. Also, increasing the number of ALID layers are more effective than increasing their thickness. For instanece, it could be more effective to use 20 layers with a thichkness of 1 m instead of using 5 layers whith a thickness of 4 m for each layer.

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