

ABSTRACT

Excessive vibration may cause disruption of sensitive equipments, annoyance, and distress or damage to structures and sub-structures. Vibration isolation is the technique of mitigating ground-borne vibration which is often accomplished by constructing barriers across the path of propagation of surface waves.

This study deals with an extensive numerical investigation on vibration isolation by barriers using a finite element package, PLAXIS 2D. The analyses are carried out in a 2-D context with axisymmetric models. Screening effectiveness of four different barriers; i.e. open trench, in-filled trench, dual open trenches, and dual in-filled trenches are investigated in this study. The trenches are assumed to be rectangular in cross-section with vertical sides. The half-space is assumed to be linear elastic, isotropic, and homogeneous acted upon by a steady-state vertical excitation on its surface. The backfill (as applicable in case of in-filled trenches) is also assumed to be linear elastic.

Barrier efficiency is analyzed in terms of amplitude reduction factor which is the ratio between peak surface displacement amplitudes with and without barrier. The amplitude reduction factors are not uniform over a zone of study. The overall degree of isolation is hence evaluated in terms of average amplitude reduction factor which is the weighted average of all amplitude reduction factors obtained over the zone of interest.

The study adopts a non-dimensional approach. Since vibration isolation is primarily accomplished by screening of Rayleigh waves, barrier geometric features are normalized against the Rayleigh wavelength of vibration in half-space. In case of in-filled trenches, in addition to normalizing the geometric features, effects of backfill material parameters are studied in terms of backfill shear wave velocity ratio which is a dimensionless quantity indicating the ratio between shear wave velocities of backfill and that of parent soil.

Isolation effectiveness of open trench barriers is studied against the variations in barrier geometric features; i.e. barrier depth, width, and its distance from source of excitation. Extensive investigation is made encompassing a wide range of barrier cross-sectional features and locations varied from active to passive cases. Results are depicted in non-dimensional graphical forms relating overall amplitude reduction with barrier cross-sectional parameters and location. These non-dimensional plots would serve as design guidelines in practical applications. Effects of the participating parameters are elaborately discussed and the key parameters are highlighted. Simplified regression models are developed for designing such barriers in active and passive schemes. The models involving the vertical vibration component are found to be in excellent agreement with some published results.

Screening efficiency of in-filled trenches is investigated against the variations in barrier geometric features and variations in in-fill material characteristics with respect to the parent soil. Barrier effectiveness is first investigated against the backfill material properties and found that softer barriers provide better effectiveness than stiffer ones. Softer barriers characterized by lower shear wave velocities than the parent soil (backfill shear wave velocity ratios less than unity) are hence considered in the subsequent investigations. Effects of barrier location from source, its depth, and width are extensively studied. Non-dimensional charts are developed which would provide a sound basis for designing such barriers in practice. The design charts are validated with some documented results and close agreement is obtained. Effects of the parameters participating in wave isolation are discussed and some guidelines are framed regarding their optimal selection.

Vibration isolation by dual open trenches (an isolation scheme comprising of a pair of open trenches) is studied in terms of the effects of relevant geometric features. Effects of barrier locations are first investigated with a specific case. A large number of cases are analyzed to investigate the effects of barrier depths and widths in active and passive cases. Results are presented in the form of non-dimensional design charts. Effects of all these features are discussed and some conclusions are made regarding the selection of these parameters for optimal effectiveness of the barrier.

Investigation on isolation by dual in-filled trench barriers is made against the effects of geometric parameters and characteristics of in-fill material. Softer barriers of backfill shear wave velocity ratios less than unity are considered in the analyses. Barrier effectiveness is first evaluated with respect to its location from source. Non-dimensional design charts are developed relating overall amplitude reduction with barrier cross-sectional features and shear wave velocity ratios of backfill. Effects of barrier depths, widths, and backfill shear wave velocity ratios are extensively discussed and the key parameters governing isolation efficiency are identified. Recommendations are made regarding the optimal selection of these parameters.

In case of dual trench barriers, no specific comparison can be made as such barriers are not addressed in any of the previous literatures. However, advantage of dual trench barriers over isolated trenches is justified with examples.

This study, in general, unfolds several unaddressed issues on trench barrier isolation. The design charts, simplified regression models, crucial observations regarding the effects of various barrier features, and recommendations on their optimal selection would provide valuable inputs in practical application of such barriers.

Keywords: *vibration isolation, open trench, in-filled trench, wave barrier, non-dimensional, Rayleigh wavelength, half-space, finite element method*