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Andersen, Lars

Published in:
Proceedings of the 15th UK Conference of the Association of Computational Mechanics in Engineering

Publication date:
2007

Document Version
Publisher's PDF, also known as Version of record

The Fifteenth UK Conference of the Association of Computational Mechanics in Engineering

Paper 80

Do Lumped-Parameter Models Provide the Correct Geometrical Damping?

L. Andersen
Department of Civil Engineering, Aalborg University, Denmark

CDROM ISBN
978-1-905088-13-3

Keywords: foundations, soil dynamics, wave propagation, structural vibration.

full paper (pdf) - reference

The dynamic response of engineering structures is highly dependent on the impedance of the foundation. Unfortunately, a numerical model describing both the structure and the subsoil may be computationally inefficient--especially in the case of time-domain analyses. Alternatively, soil-structure interaction may be accounted for by fitting a lumped-parameter model (LPM) [1] to the results of, for example, a finite-element (FE) model of the ground. In contrast to the original FE model, the LPM only introduces a few degrees of freedom in addition to those of the structure, thus leading to a significant reduction in the size of the global system of equations. This is particularly useful in parametric studies and lifetime analyses of structures.

The present paper concerns the calibration of consistent lumped-parameter models for rigid hexagonal footings on a homogeneous or layered half-space with emphasis on the horizontal sliding and rocking. The impedance functions are computed in the frequency domain by means of the domain-transformation method (DTM) [2], and an "exact" solution in the time-domain is achieved by inverse Fourier transformation of the DTM solution.

In the study of the lumped-parameter models, focus is put on two characteristics of the approximate solution: Firstly, the ability of an LPM to reproduce the maximum response of a structure subject to a transient load is examined; secondly, the damping of free vibrations is considered. Here, geometrical dissipation due to wave propagation into the subsoil accounts for the major part of the energy loss in the structure.

Numerical studies show that the maximum response of the structure may be determined correctly by the application of an LPM with few internal degrees of freedom, indicating that the dynamic stiffness of the footing is preserved. However, for a layered half-space an accurate prediction of free vibrations cannot be achieved with low-order models, suggesting that geometrical dissipation is not well-represented. This leads to the conclusion that an LPM with several parameters is necessary to correctly predict the fatigue lifespan of structures subject to repeated transient loads.

References

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Glasgow, United Kingdom, 2-3 April 2007