Chair of Structural Mechanics
TUM School of Engineering and Design
Technical University of Munich

COME and Civil Eng. students welcome!

Master's Thesis

Modeling of a single layer with a cylindrical or spherical cavity: Implementation & Application

Motivation: Vibrations introduced into the ground by dynamic loads in underground structures, or because of earthquakes are particularly significant in densely populated, modern metropolitan regions. More and more tunnels, supply lines, and underground structures are being built there, which on the one hand, are affected by the incoming vibrations and on the other hand, have an impact on the dynamic deformations of the earth's surface and the adjacent structures. To enable a reliable prediction and assessment of vibrations due to dynamic effects, the complex interaction between soil and structure must be modeled. In contrast, one of the major challenges is the infinite dimension of the soil. One method for describing the elastodynamic behavior of the soil with infinite expansion is the integral transformation method (ITM), as this provides closed solutions for different fundamental systems, and thus, artificial reflections at the edges of the domain can be avoided. By carefully superimposing these fundamental systems, solutions for more complex systems can be derived. For the system of an infinitely extended half-space, an analytical solution can be derived using the ITM. This involves decoupling the *Lamé* differential equation through *Helmholtz*'s theorem, followed by a threefold *Fourier* transformation to convert it into a set of ordinary differential equations. The values of the unknowns are determined by applying boundary conditions at the surface of the half-space. Additionally, for the system of a full-space with a cylindrical or spherical cavity, a fundamental analytical solution can be obtained by evaluating *Lamé*'s differential equation in the respective cylindrical or spherical coordinates.

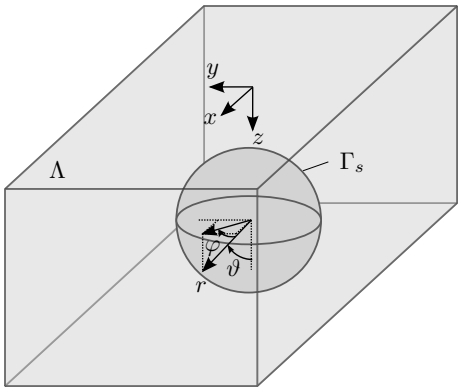

Fig. 1: Schematic sketch of a single layer including a spherical cavity

Tasks: In the scope of this master's thesis, the system of a single layer including a cylindrical or spherical cavity shall be analyzed using the Integral Transformation Method (ITM). Interest shall be directed to the question of how to superpose the fundamental solutions provided to achieve the single-layered system. To this end, the superposition procedure will be implemented into the Chair's MATLAB framework. The implementation needs to be validated by comparing the results to predictions obtained from the classical fundamental systems.

Project Stages

- Familiarization with the topic *Integral Transformation Method.*
- Introduction to the Chair's MATLAB-based code framework.
- Implement a single layer including a cylindrical cavity within the code framework.
- Validation of the implementation based on suitable cases selected from literature studies.
- *Extension to a single layer including a spherical cavity (optional)

Literature

[1] Freisinger *et al.* (2022): A coupled Integral Transform Method - Finite Element Method approach to model the Soil Structure Interaction of finite (3D) and length invariant (2.5D) systems. In *The Journal of Sound and Vibration* Vol. 482, pp. 115443. DOI: 10.1016/j.jsv.2020.115443

[2] Hackenberg (2016): A Coupled Integral Transform Method - Finite Element Method Approach to Model the Soil-Structure-Interaction. PhD thesis. Technical University of Munich.

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