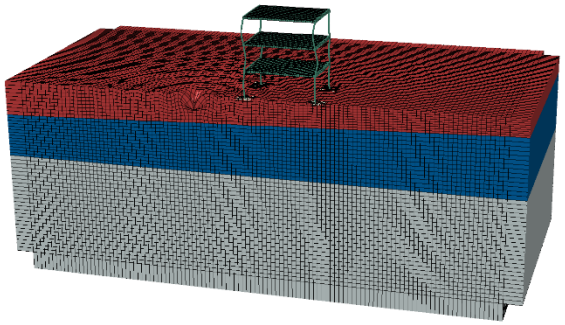
Popular science summary of a master's dissertation in structural mechanics, LTH, Lunds university.

Modelling Ground Vibrations for Fast Analyses

Master's thesis author: Argeta Jupolli

The need for fast and accurate methods to analyse the effects of traffic-induced vibrations on a structure is increasing. This is partly due to continued urbanization causing structures to be built in closer proximity to roads, as well as an increased sustainability awareness leading to more environmentally friendly materials being used in constructions, such as timber which is often considered to be sensitive to traffic-induced vibrations. Analysis of vibrations on, for example, an underground basement can without effective methods take days or even weeks to process, whereas it was found in this project that the same analyses using efficient models can be achieved in mere hours instead.

This project aims to develop a program that produces efficient models for the analysis of traffic-induced vibrations on a structure. Aside from the creation of the models, the program will also be able to send the models for analyses and present the results in a user-friendly manner.



A structure placed on ground consisting of 3 layers, the middle layer being inclined.

The main objectives that were investigated in the study were the following:

- How can accurate ground modelling be achieved?
- Which parameters are relevant for fast and accurate analyses?
- How much time can be saved using efficient models?

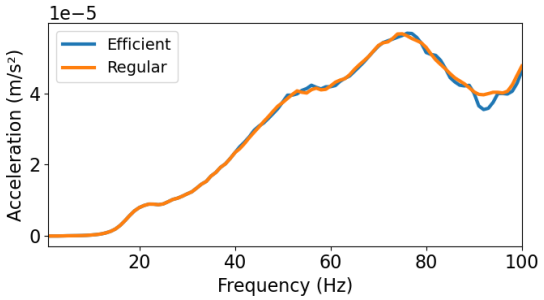
Analyses The program was developed using the programming language Python. The models were created in a manner that was compatible with the finite element software Abaqus, where the analyses were conducted. To create efficient as well as accurate models, the size and spatial discretization of the models were tailored based on the ground wavelengths for specific frequencies.

The models were tested with different values to the parameters affecting dimensions to determine which values would produce accurate enough results while also being fast to analyse.

The results were extracted from Abaqus and presented in diagrams using the program. To achieve user-friendliness, a user interface was developed for managing the program.

Results The most striking conclusion from the study turned out to be that without the use of efficient models, it is not a matter of how much faster the analyses can be performed, but if they can be performed at all. This is due to the models requiring a significant amount of RAM memory when analysed. Even the use of a supercomputer with 512 GB RAM memory proved to be insufficient in some cases.

The accuracy of the results had to be somewhat compromised for frequencies above 80 Hz to achieve reasonable analyses times, or in some cases, to be able to analyse at all. The results were however deemed acceptable, swaying around the results achieved using regular models, i.e. models that were not created to be as efficient as possible, see Figure below.



Accelerations when using efficient vs regular models.

A comparison between analyses times using efficient models compared to less efficient models showed that the 75-100 Hz range could be analysed in 4.5 hours instead of 4 days.

Master's dissertation completed in 2025: ***Modelling Ground Vibrations in Abaqus using Python*** *- Report TVSM-5278. Supervisor Linus Andersson.*