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DYNAMIC FLUID-STRUCTURE INTERACTION ANALYSIS OF WATER-PIPE SYSTEMS

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Occasionally, very strict vibrational requirements are specified for sensitive equipment used in high-tech facilities, such as radar towers and synchrotron facilities. Various external and internal vibration sources such as traffic, indoor pumps and human activities can have appreciable effect on the vibration levels in such facilities [1]. In the present study, the synchrotron research facility MAX IV, which is currently under construction in Sweden, is used as a numerical example; see Figure 1. Synchrotron light beams, originated from accelerated electrons, will be used for measurements in various research fields such as material science and medicine. The quality of the measurements at MAX IV is depending on the stability of those synchrotron light beams. Strict vibration requirements are therefore set for the facility.

Figure 1: An architectural sketch of the MAX IV facility as planned, by the architectural bureaus Fojab and Snøhetta.

Several water-pipe systems for cooling purposes will be placed near vibration sensitive parts in the facility. The pipes will transmit vibrations to the facility through their supports. The effects of structural modifications of the water-pipe systems, on the level of vibrations transmitted by the water-pipe system were analysed in order to minimise the transmission to sensitive parts of the facility. A finite element model, involving use of both finite and infinite elements, was employed for analyses in the frequency domain where account was taken of both fluid-structure interaction and soil-structure interaction [2, 3, 4]. The finite element model included the water-pipe system, supports, concrete slab and underlying ground.

As an example of results from initial simulations, the total transmitted force amplitudes versus frequency for different placements of supports for a pipe system are shown in Figure 2. A marked difference in the frequency responses is clearly depicted, which may result in appreciable differences in the magnitude of the transmitted vibrations. As another example of results, in Figure 3, the displacements at an evaluation point on the concrete slab for various involved depths of the ground medium in the finite element model are shown. It can be seen that involvement of 6 m and 12 m of soil, respectively, results in a somewhat similar frequency response. Including a stiffer layer of additional 4 m results in a slightly different response which is, however, similar to the response of the reference model which involves additional 16 m of bedrock. Thus, it was shown that the underlying ground has to be considered in the numerical analyses.

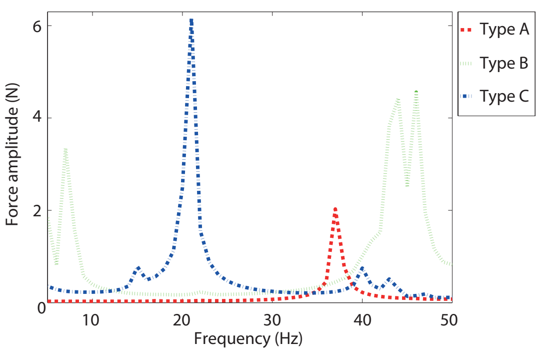

Figure 2: Amplitude of total transmitted force at the supports versus frequency.

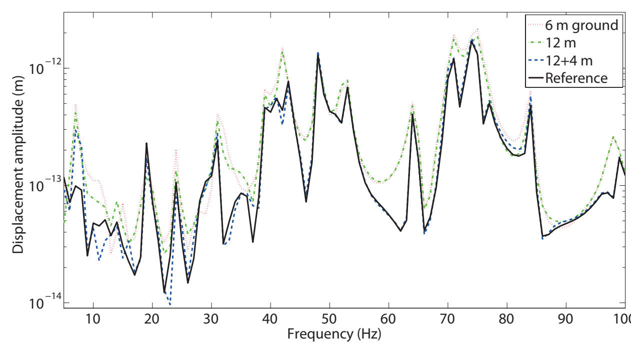

Figure 3: Displacement amplitudes for various involved depth of the ground.

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