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Analysis of vibrations in high-tech facility

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MAX-lab is a national laboratory operated jointly by the Swedish Research Council and Lund University. Nowadays, the Max project consist of three facilities (three storage rings): Max I, Max II, Max III and one electron pre-accelerator called Max Injector. A new storage ring is needed to improve material science, such as nanotechnology. MAX-IV will be 100 times more efficient than already existing synchrotron radiation facilities, e.g. it is planned to be the next generation Swedish synchrotron radiation facility. MAX IV will basically consist of a main source that will be a 3-GeV ring with state-of-the-art low emittance for the production of soft and hard x-rays as well as an expansion into the free electron laser field. The second source will be the Linac injector that will provide short pulses to a short pulse facility. The Linac will be built as an underground tunnel next to the main ring, Reference [1]. For more information about the project see the homepage, Reference [3].

The floor of the MAX IV building will mainly be constituted of a concrete structure that is built on soil consisting of mostly boulder clay. The inner and the outer radius of the structure are approximately 70 m respectively 110 m. The synchrotron light ring has a radius of approximately 80 m, see Figure 1.

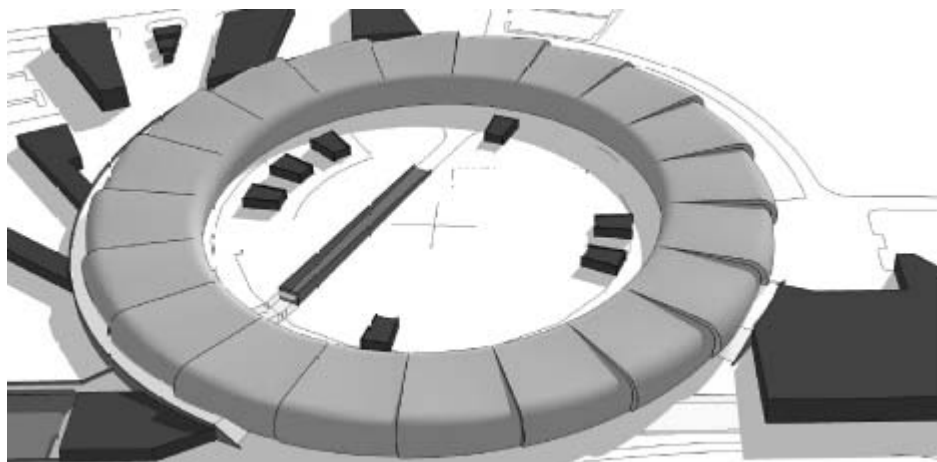


Figure 1: 3D drawing of the MAX IV ring.

The beam in the synchrotron ring is controlled by a large number of magnets that are distributed along the ring. Vibrations at the magnets will give rise to a ten-fold increase of the vibration levels of the beam line. Since the quality of the measurement results from the MAX IV ring is dependent on the precision of the synchrotron light, a very strict requirement regarding the vibration levels of the magnets are defined. The strict requirement is especially put in the vertical direction where the mean vibration level must be less than 26 nm during one second in the frequency span of 5-100 Hz. Vibrations with frequencies lower than 5 Hz may be adjusted by an active calibration system. In the interval between 0-5 Hz vibration levels up to 260 nm are therefore allowed. Frequencies higher than 100 Hz may be neglected and probably have very low amplitudes since they are easily dampened out in the structure. See Reference [2].

The structure is exposed to both to harmonic and transient excitations. The harmonic

excitation is typically working machines and transient excitations are typically traffic from the nearby roads and other human activities in the building such as walking, closing doors and dropping objects.

The main objective is to study vibrations at the foundation to the synchrotron light subjected to different excitations. The aim is to establish realistic finite element models that predict vibrations in the foundation with high accuracy. The ultimate goal is to prove the fulfilment of the needed requirements. If technical conditions are not fulfilled for the proposed structure, solutions to achieve them could be pointed out as well. The vibrations are analysed by the finite element method in both transient as well as steady state solutions. The model contains the concrete floor structure, the concrete structure of the beam containment and the soil to a depth of about 10m extending to the nearby roads.

Since the models become very large, the technique of modal reduction is employed. Firstly, steady-state analyses are performed to determine vibrations of the magnet foundations from excitations at various locations. Secondly, transient analyses are performed by using modal truncated models of walking loads. Excitations from traffic on the nearby roads are analysed as both steady-state as well as transient.

Figure 2 shows primary results of a simplified model of MAX IV ring, the soil is not displayed.

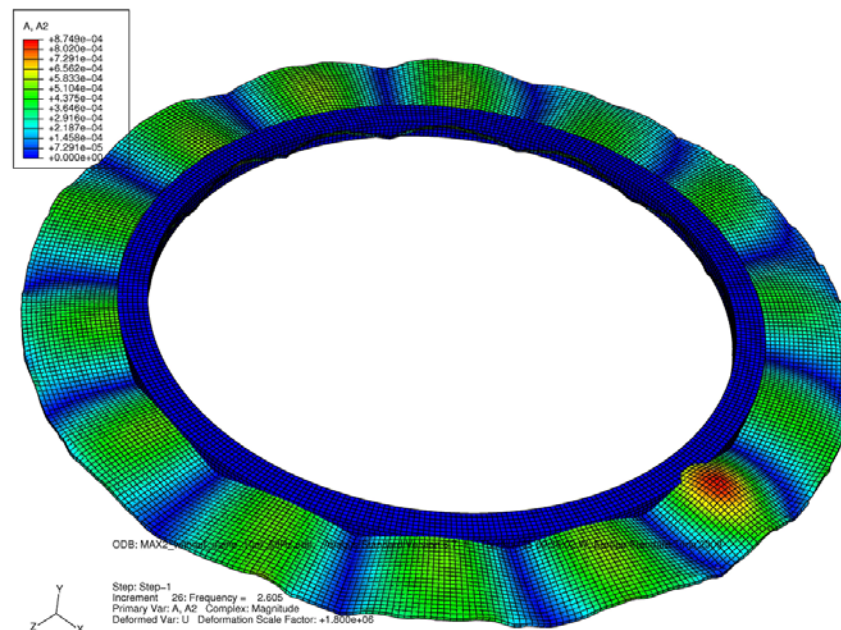


Figure 2: Accelerations at steady-state excitation.

References

- [1] *MAX IV – Framtidens synkrotron inom Brunnsjöområdet i Lund, Förutsättningar 2009-07-08*, Lunds Universitet, SWECO AB, 2009.
- [2] *MAXlab – Lunds Universitet, Maxlab IV, SYSTEMBESKRIVNING BYGG – GEODYNAMIK 2009-03-17*, J. Brown, R Furuhovde, SWECO AB, 2009.
- [3] <http://www.maxlab.lu.se/maxlab/max4/index.html>