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PREDICTION OF VIBRATION LEVELS FROM NEW BALL MILL AT THORLAKSHÖFN, ICELAND

TECHNICAL NOTE

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1 Introduction and conclusion

This note presents predictions on vibration levels expected to be propagated into surrounding environment by four ball mills for a new cement plant to be built at Thorlakshöfn, Iceland.

It is concluded that the emitted vibration levels from the ball mills is likely to fall below the estimated seismic background noise.

2 Prediction of ground vibration levels

Prediction of ground vibrations emitted from machinery into the surroundings requires knowledge of two components:

- The source strength of the machinery, i.e. the vibration level induced into the sub-soil close to the foundation of the machinery. The source strength

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is defined through the frequency content of the vibrations and a characteristic distance typically equal to the dimension of the area in which the machinery is located.

- The transmission loss representative of the site, i.e. the decrease of the vibration amplitudes as they propagate into the surrounding subsoil. The transmission loss is composed of geometrical spreading and attenuation arising from friction between soil particles.

2.1 Estimated source strength

The source strength of the Thorlakshöfn ball mill is estimated from measurements made at an existing ball mill at Gorazde, Poland.

The shaft rotation rate of the Gorazde ball mill is recorded as 14 rpm corresponding to a frequency of 0.23 Hz. The vibration measurement system at Gorazde is capable of measuring vibration frequencies down to 0.5 Hz thus the basic vibration component at the shaft frequency is lost leaving only the higher harmonics to be measured. Vibration spectra measured at three locations on the shop floor close to the gearbox of the ball mill (P2, P3, P4), Figure 2.1, has been applied for estimation of the source spectrum.

Figure 2.1 Measurement locations at the Gorezde ball mill.

The estimated source spectrum, Figure 2.2, is assumed to be representative of the vibration level everywhere on the shop floor within a radius r_s = 40 m from the centre of the ball mill facility.

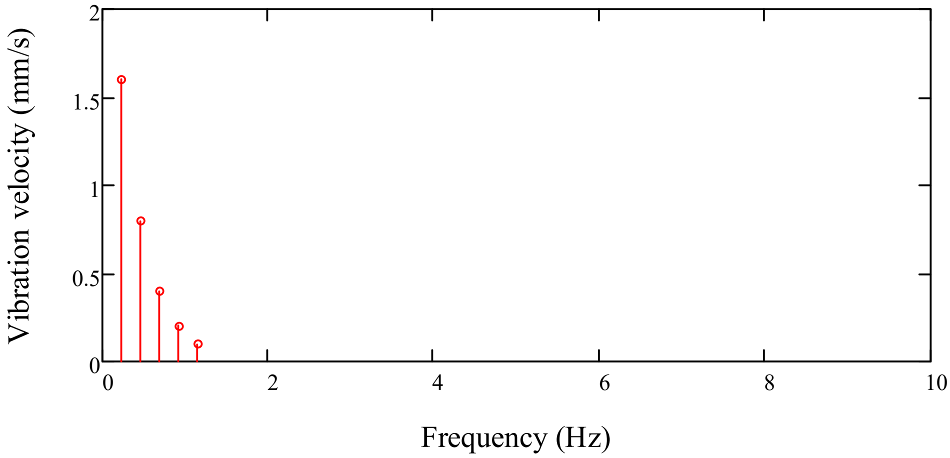

Figure 2.2 Estimated source strength spectrum v_s for Thorlakshöfn ball mill facility.

2.2 Transmission loss

When vibrations spread from machinery into the surrounding subsoil the vibration level will be attenuated due to geometrical spreading and viscous damping. For a stratified subsoil characterized by a fairly homogeneous top layer having a depth h and characteristic speed of sound c sitting on a deeper layer having a different speed of sound, the geometrical part of the attenuation can be approximated by cylindrical spreading whereas the viscous part of the attenuation is well presented by an exponential decay.

The transmission loss defined as the ratio of the vibration level spectrum $v_r(f)$ on the soil surface at a given distance r from the centre of the ball mill and the source strength spectrum $v_s(f)$ is modelled by the following expression:

$$\frac{v_r(f)}{v_s(f)} = \left(\frac{r}{r_s}\right)^{\left(1-\exp\left(-\frac{c}{fh}\right)\right)} exp\left(-\left(\frac{2\pi f\eta}{c}\right)|r_s - r|\right) \quad (1)$$

Where f is frequency, h = 15 m, c = 3000 m/s is the depth and the speed of sound in the top layer basalt and η = 0.01 is the estimated damping coefficient for plane sound waves travelling in the top layer basalt.

Other models for the transmission loss are possible including multilayer theoretical models or measurements.

The transmission loss model (1) is applied for propagation of the individual spectral components of the source strength to a given distance r from the ball mill facility. The total vibration level V expected at a distance R from the ball mills is obtained by adding all frequency components on energy basis:

$$V = \sqrt{\sum_f v_r(f)^2} \quad (2)$$

2.3 Predicted vibration levels at distances from the ball mill facility

The predicted vibration levels combining the estimated source spectrum, and the transmission loss (1), (2) is mapped in Figure 2.3.

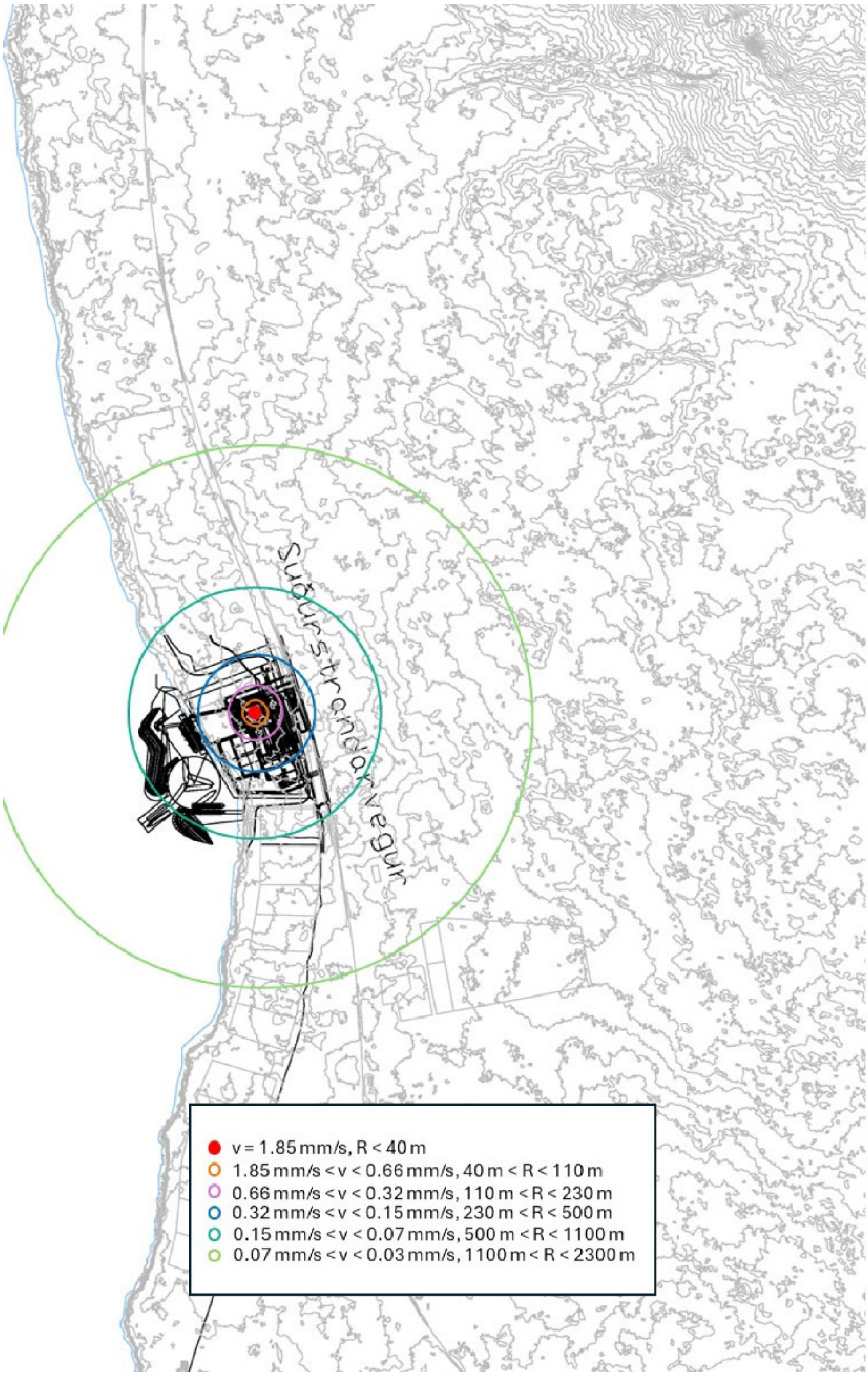

Figure 2.3 Predicted vibration levels at distances R from ball mill facility at Thorlakshöfn.

3 Background vibration levels

The background vibration level in the community is made up from various sources such as road traffic, wave action at the shoreline and seismic activity.

The Icelandic Meteorological Office publishes measurements of earthquakes in Iceland. Locations on the Reykjanes Peninsula and measured Richter magnitudes as function of the time in the day is shown in Figure 3.1.

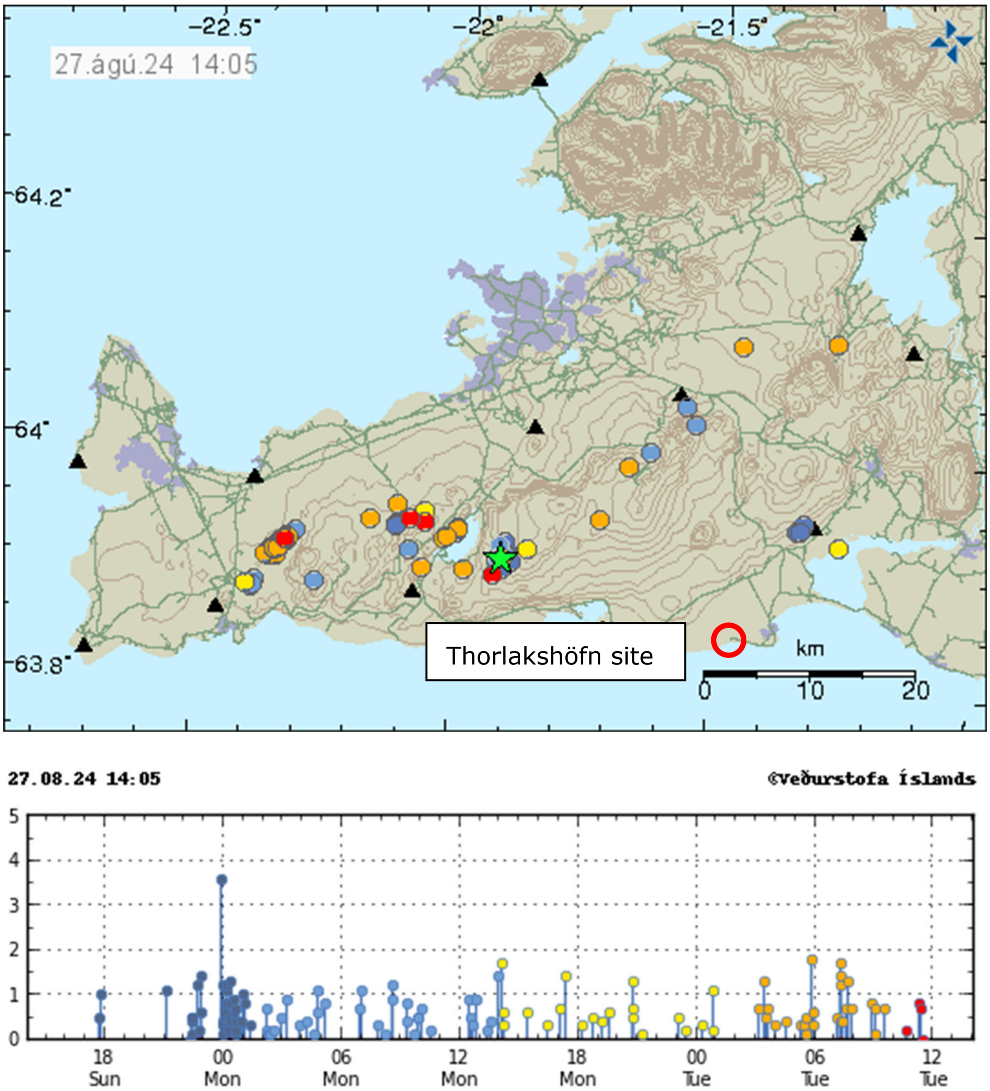

Figure 3.1 Earthquake locations on the Reykjanes Peninsula and measured Richter magnitudes for a two-day period 25.08.2024 – 27.08.2024.

For the particular time period shown in Figure 3.1 the number of measured earthquakes totals about 50/day. This activity will contribute to the background vibration level at the Thorlakshöfn site.

3.1 Estimation of background vibration level from seismic activity

The Richter magnitude and the distance from the epicentre to a given site defines the vibration amplitude of the soil particles as shown in Figure 3.2.

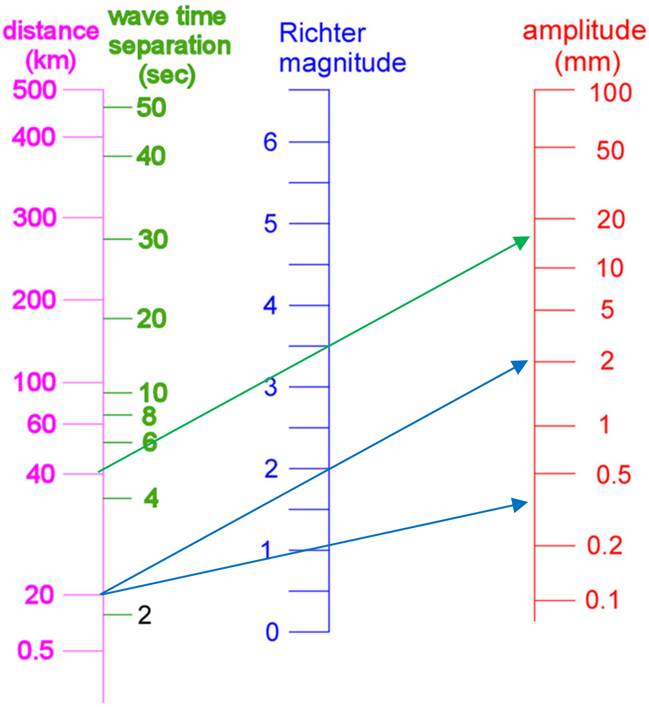

Figure 3.2 *Richter chart showing the relationship between distance, Richter magnitude and vibration amplitude.*

As an example of applying the Richter chart, consider earthquakes of magnitude 1-2 occurring 20 km from the Thorlakshöfn site. Connecting the 20 km mark on the distance scale (purple) with the No. 1, No. 2 marks on the Richter magnitude scale (blue) and extrapolating to the amplitude scale (red) yields a peak-to-peak ground amplitude of approximately 0.3 mm – 2 mm (blue arrows).

Assuming that earthquake spectra display a constant velocity level in the frequency range 0.2 Hz to 1 Hz typical for the ball mill, we can estimate the corresponding vibration velocity level to be approximately 0.2 – 1.1 mm/s. Ground vibration levels of this magnitude must be expected to occur 50 times a day or on average twice an hour.

For a Richter magnitude 3.5 earthquake occurring approximately 40 km from the Thorlakshöfn site (★), the resulting ground peak-to-peak movement is estimated to be 15 mm (green arrow), corresponding to a vibration velocity level of approximately 8.5 mm/s.

Vibration levels from rotating machinery are continuous, unlike the transient vibration levels from earthquakes. However, the above analysis indicates that vibration levels at and beyond 230 m away from the ball mills fall below the seismic background level.