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EARTHQUAKE INDUCED DAMAGE OF BURIED PIPELINES: A CASE STUDY

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Quite little is known about seismic behaviour of underground lifelines. The damages after an earthquake are hidden, but their proper functioning can be vital for to the support of life and maintenance of property. This paper discusses actual earthquake damages in underground lifelines, i.e. in segmented pipes, in the town Hveragerdi in South Iceland. The damages resulted from an earthquake of magnitude M_w 6.3 in South Iceland the 29th of May 2008.

The town is in the immediate vicinity of the earthquake source with a minimum distance to the causative fault of about 1.0 km (see Figure 1). The town is about 2.0 km^2 in size and its population is about 2300.. Although no collapse of buildings was reported, the buried pipes carrying sewage and rainwater were extensively damaged. The strong ground motion in Hveragerdi during the earthquake was recorded by eleven accelerometers of ICEARRAY (Halldorsson and Sigbjörnsson, 2009)—a small aperture strong-motion array installed before the earthquake. Severe ground accelerations, close to the acceleration of gravity, were recorded at some stations. The vicinity of the town from the source caused in strong forward directivity effects resulting in strong pulses in ground velocity (Rupakhety et al., 2011). The recorded ground velocities were over 100 cm/s at some of the ICEARRAY stations.

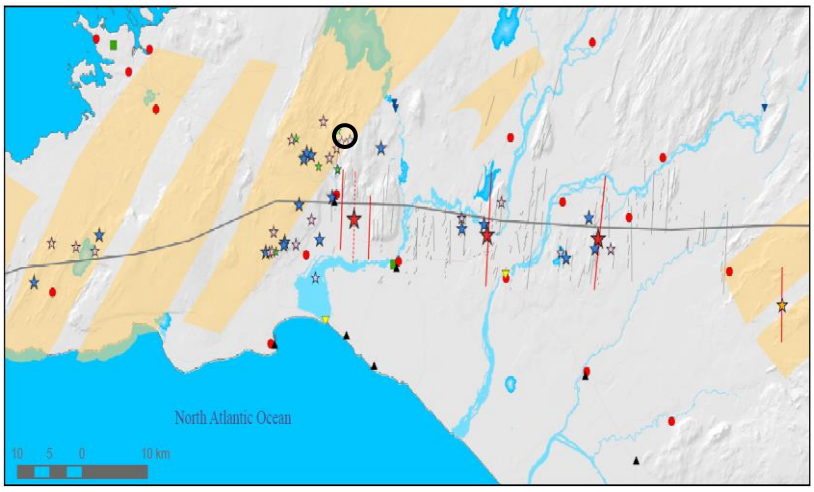

Figure 1. Map of South Iceland showing the study area (big hollow circle with black outline). The filled dots, triangles, and squares are the locations of accelerometric stations of the Icelandic Strong Motion Network. The starts indicate the past epicentres of earthquake above M_w 5. The bigger red stars from left to right indicate the macroseismic epicentres of the 17 June 2000 Earthquake, the 21 June 2000 Earthquake, and the 29 May 2008 Ölfus Earthquake.

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The large ground velocities resulted in significant strains in the ground which proved detrimental to the buried pipelines. The damaged pipelines were studied in detail after the earthquakes. This included video footages collected by camera-equipped robots that surveyed the inside of the pipes. In this study, the collected damage data is organized and systematically classified for easier interpretation. Several factors such as the material of the pipes, the location and type of joints, the year of construction, and the type of damage observed have been compiled. In addition, a geo-referenced database with the location, type, and extent of occurred damage is being created. The layout of the studied pipelines is shown in Figure 2 along with the peak resultant horizontal acceleration (PHA) interpolated from the recordings of ICEARRAY.

Preliminary analysis studying the rate of repair per unit length of the pipe has been completed. The obtained repair rates are variable in the region, ranging from 3 to 60 repairs per km of pipe (see Figure 3).

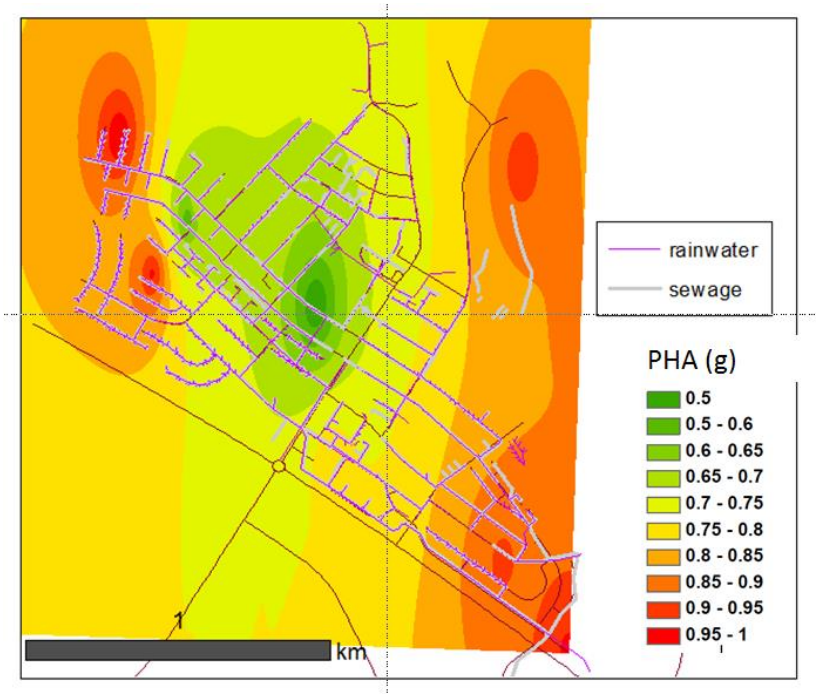

Figure 2. Layout of the underground pipeline in the town of Hveragerdi. The filled colours indicate the peak resultant horizontal acceleration.

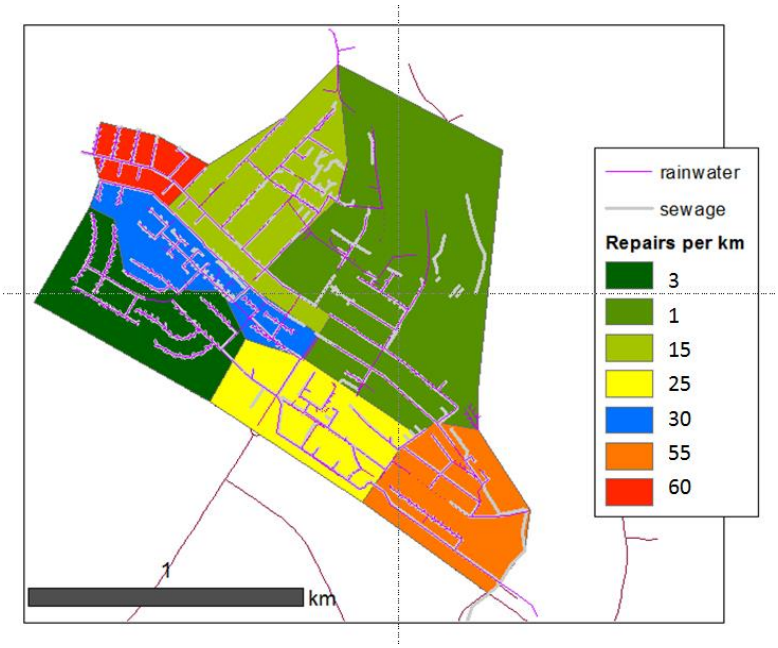

Figure 3. Repair rates of buried pipelines in different sections of the town.

It is also observed that the repair rate is strongly correlated to the peak ground velocity, but not correlated to the peak ground acceleration. The response of buried structures is not controlled by the inertial actions induced by earthquake ground motion. The inertial action in such structures is actually negligible. On the other hand, the ground velocity, being directly related to the ground strain, is more responsible for damaging buried pipelines. The results of this study confirm this. It is planned to study in more detail the type of damage, and their relation to the ground motion parameters, the local soil conditions, and the parameters of the pipes, such as, diameter, material, and age. Such results will be included in the full paper.

REFERENCES

Halldorsson B, Sigbjörnsson R (2009) The Mw 6.3 Ölfus earthquake at 15:45 UTC on 29 May 2008 in South Iceland: ICEARRAY strong-motion recordings. Soil Dynamics and Earthquake Engineering, 29(6):1073—1083

More to follow in the full paper