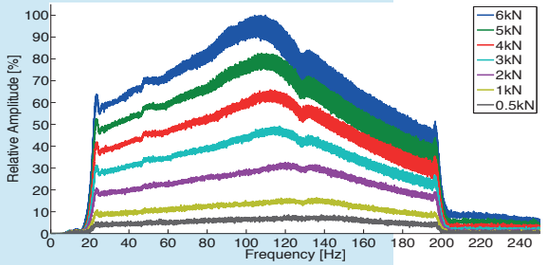
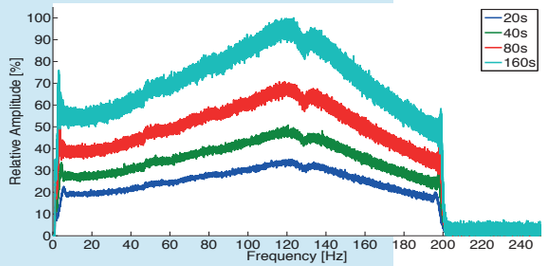
Contact

rik.noorlandt@deltares.nl
T +31(0)6 1307 1553

A seismic vibrator driven by linear synchronous motors



Effect of drive level on the generated spectrum



Effect of signal duration on the generated spectrum

It is necessary to obtain images of the subsurface in a non-destructive way for a wide range of applications such as investigations of aquifer geometry. One of the options is the seismic method, which uses the propagation of mechanical waves, one type being sound waves. The structure of the earth can be inferred by analysing how the earth affects the propagation of these waves. Seismic waves can be generated in different ways. The source can be as simple as a heavy hammer or a weight dropped on the ground, but more advanced sources allow for more control and better quality data.

The seismic vibrator is an advanced seismic source of this kind. It can repeat a dedicated signal with predefined signal properties. A vibrator generates a sweep of several seconds of sinusoidal signals with varying frequencies and relatively low instantaneous power. A hammer produces a very short signal (lasting milliseconds) with much higher instantaneous energy, which is possibly more destructive for its surroundings. However, the vibrators that are generally used suffer from the distortion of the signal in the low-frequency band that contains an important part of the data. To overcome this problem, a new type of vibrator was developed by Deltares and Delft University of Technology as part of a doctorate research project. The paper in Geophysics describing this vibrator received the best paper award in 2016.

The new vibrator is driven by linear synchronous motors (LSM) and it can produce very repeatable signals in the low-frequency band.

Seismic LSM vibrator in the field

LSMs are electric motors that can generate linear forces and they are found in numerous applications. They are used in factories to move objects quickly and precisely, and in the propulsion system of some magnetic-levitation trains and roller coasters. The current design of the LSM vibrator allows the generation of seismic waves with frequencies between 2 and 200 Hz in continuous operation. The source can be used to investigate the subsurface down to a depth of approximately a kilometre with a maximum driving force of 7 kN.

Experiments with the newly developed LSM-driven vibrator showed that using sweeps of different duration leads to the uniform scaling of the spectrum, while using signals with different force levels alters the relative shape of the spectrum. This implies that this type of seismic vibrator can be used for the in-situ measurement of non-linear soil behaviour as well as the standard imaging of the subsurface. The ability to produce undistorted low-frequency signals makes this new source suitable for the analysis of surface waves to extract shear wave velocities down to considerable depths and to investigate the response of buildings to earthquakes. It also opens up possibilities for the automatic processing of the seismic data through full waveform fitting.

Further reading:
R.P.Noorlandt (2016) A seismic vibrator driven by linear synchronous motors http://doi.org/10.4233/uuid:080a025d-f059-42c8-9229-c3dba2dd4400