Piling with vibration

Method description

Piling with vibration

The versatile procedure

Why piling with vibration?

Piling with vibration belongs to the most important procedures in civil engineering. It is economical and in most soil types applicable. During the piling operation vibrations are used to drive and/or extract piles.

Depending on the projects steel sheet piles, steel sections, beams, casings and tubes, or in cohesive and displaceable soils, even full displacement piles can be driven. Typical examples are retaining walls, cut-off-walls or foundations are built. These can be used for temporary or for permanent measures. For temporary needs the pile elements can be extracted with the same equipment and reused.

ABI's design and development concentrates on the high frequency vibrators. They work above the natural frequency of the soil so that only minor negative resonances are generated and therefore less disturbance of the surroundings are achieved.

The vibrators as attachment for the telescopic leader masts are manufactured in different types and sizes. Beside the series of fixed vibrators MRZV-S ABI offers two types of vibrators with a resonance-free starting and stopping behaviour. The vibrator MRZV-V features adjustable static moment. The second type is the twice variable vibrator MRZV-VV additionally with variable displacement. As attachment for hydraulic excavators ABI has developed add-on vibrator series HVR.

The advantages

- **Low vibration** – because of the high frequency work range. With MRZV-V and MRZV-VV vibrators additionally the vibration peaks are avoided when crossing the natural frequency of the soil.
- **Economically** - an economical option for foundations and shoring works in particular on inner city sites. For extracting of the pile elements the same equipment is used.
- **Versatile** - piling can be used in most soils. Different pile elements can be driven or extracted. Various clamp assemblies are available as double clamp assemblies for piling of several elements or casing clamp assemblies for piling of tubes.

Typical applications

Piling and extracting of:
- steel sheet piles
- beams
- steel elements/profiles
- casings and tubes
- full displacement piles

Further applications:
- Stone columns
- Soil compaction
- Geo textile columns
- Steel foundation piles
- Vertical-drain

Adjustable vibrator MRZV 18V

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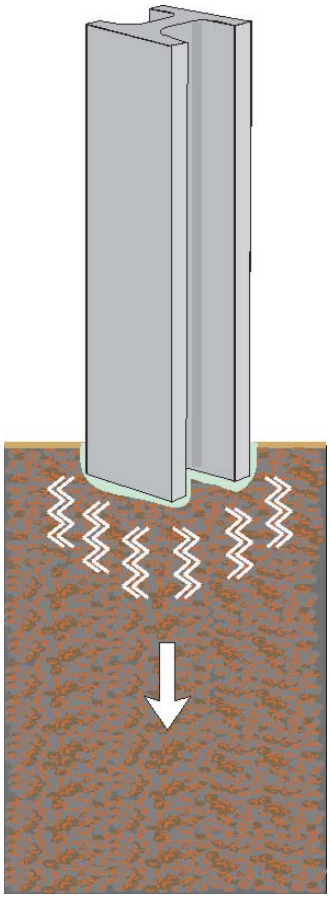
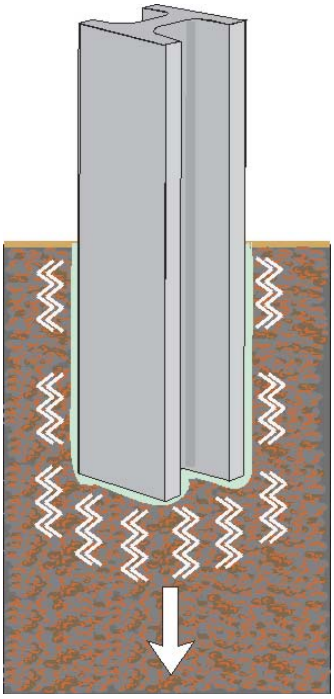
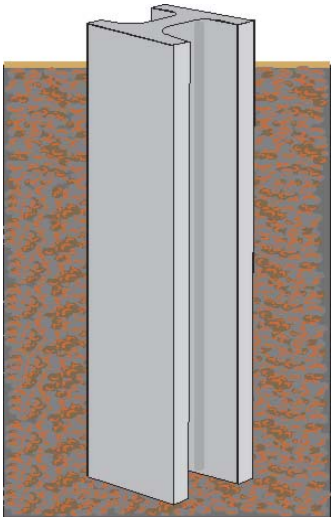
The principle



In the first step the pile element is pitched with pitching chain to the vibrator. After lifting up the pile element is clamped with the clamp assembly and positioned. The vibrator is speeded up to the ideal working frequency.



Due to the acceleration the friction in the grain structure is reduced, so that the soil reaches a „pseudo liquid“ condition and the pile element is penetrating into the soil. The deeper the pile element sinks, the higher get the opposing forces.



If the desired depth is reached, the clamp assembly and the pitching chain are removed. Pile extracting is carried out in the same way. When extracting pile elements, which were already in the soil for long period, they are first driven down for loosening and then being extracted.

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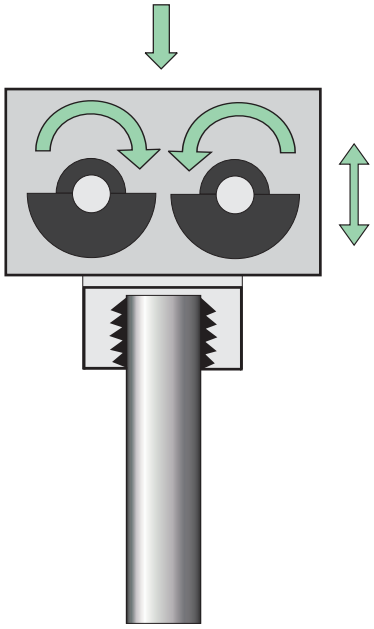


Characteristic data of the vibrators

Input power
– is conditioned by the carrier

Revolutions
- number of revolutions (vibrations) per minute.

Static moment
- the measure for the size of the eccentric weights. The static moment results from the product of the mass of rotating eccentric weights and their distance from the rotation axle.

Centrifugal force
- depends on the static moment and the angular speed of the eccentric weights. It affects strongly the reduction of the skin friction and overriding of the tip resistance.

Amplitude x 2
- entire vertical shift during a revolution of the eccentric weights.

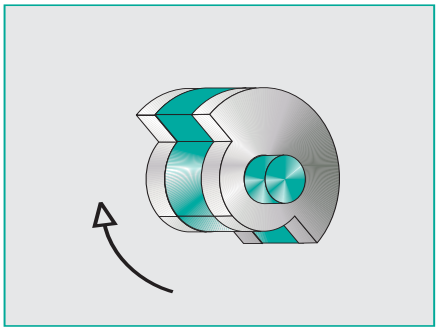
Pre-stressing forces
- only available at leader mast guided vibrators. By vibration alone no crowd forces are fed in. With a hydraulic cylinder or a winch system pre-stressing forces are produced to accelerate the penetration of the pile element. Free suspended vibrators have only the weight of the pile element and their own weight for the penetration available. Leader mast guided pile drivers are supported by the pre-stressing forces of the leader mast.

Work principle

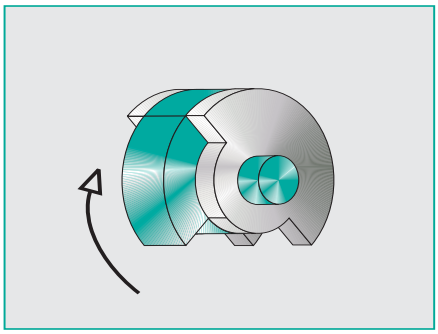
The vibrator produces with in opposite directions rotating eccentric weight segments vertical vibrations, which are transferred to the pile element. The neighbouring soil nearby swings also and achieves a „pseudo liquid“ condition. The friction is reduced, so that the pile element can penetrate more easily into the soil.

High frequency vibrators work at frequencies, which are higher than the natural frequencies of the soil. Vibrators with fixed static moment develop vibration peaks crossing the natural frequency of the soil, which can represent a damage risk for adjacent buildings. The development of vibrators with adjustable static moment led to the reduction of damaging resonances to nearby structures.

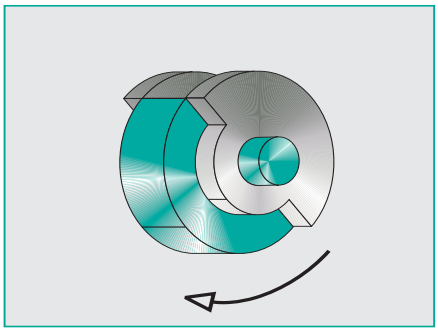
By the ABI vibrators MRZV-V and MRZV-VV the static moment can be set between 0 and 100 % turning the eccentric weight segments on each shaft. For a vibration-free starting and stopping the eccentric weight segments are set in position in which the static moment amounts to 0. After the vibrator reaches its working frequency, the eccentric weights are slewed towards each other to increase the static moment in 10 % increments.



Eccentric weights position with maximum static moment



Adjustable eccentric weights for a static moment between 0 and 100 %



Eccentric weights position with minimum static moment = 0 during starting and stopping

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The maximum static moment is reached, when the outside segments and the middle segment of the eccentric weights are in the same position (see illustrations page 4).

Due to the adjustability of the static moment an optimum adjustment to the existing soil conditions and requirements of the construction site is possible.

The condition of the soil is determining for piling success and progress. Characteristics such as compactness, consistency and water content must be examined in advance. Due to the soil examinations a decision of the use of piling aids can be made. Driveability of the soils can be improved by ground release drilling, compressed air or water injections and soil exchange.

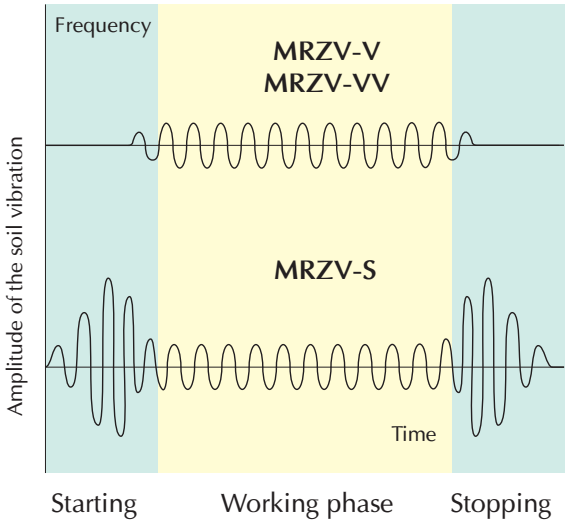
Soil facts like grain size and composition are described in three categories: cohesive, non-cohesive and organic soils.

Organic soil is not suitable as building ground. It has a high portion of organic components, which result from the decomposition of plants and animals.

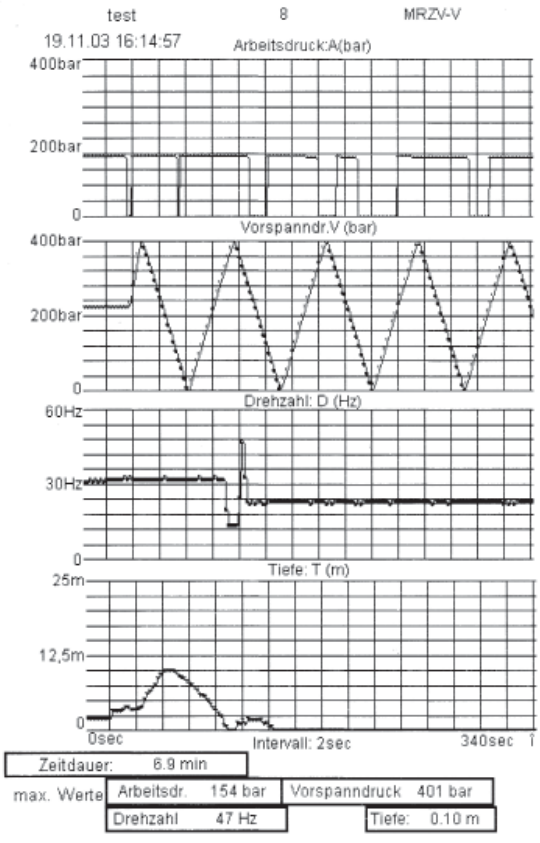
Non-cohesive soils (grain size range > 0.06 mm) consist of differently large grains do not exhibit plasticity or cohesion. The non-cohesive soils attain strength from the friction between the soil grains. During the pile driving in non-cohesive soils the compactness and particle shape determines the success. The granular structure changes due to the movement caused by the vibration. The grains have to have enough voids to be able „to make room“ for the pile element.

Cohesive soils (grain size range < 0.06 mm) have a small plate-like structure and contain always water. The stored void water acts like a lubrication coat at the pile element. Under the influence of the vibration the water withdraws between the pile element and soil, softens the soil and „lubricates“ the surface of pile element.

Due to the multiplicity on soil characteristics which can affect the success of piling process, no general statement about driveability of soils can be made. According to experience non-cohesive soils with low compactness are very well suitable for piling. Cohesive soils are rather limited in driveability based on their firmness or water content.



Effect of the adjusting mechanism on the soil vibrations



Each ABI MOBILRAM-System can be equipped with data recording, so that important parameters of the pile driving application such as working pressure, pre-stressing pressure, number of revolutions, depth and time are stored.

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Site examples

Extension of the Theodor-Stern-Kais embankment in Frankfurt/Main (Germany)

In Frankfurt's district Sachsenhausen the river Main embankment between Friedens bridge and Main-Neckar bridge was extended. Before the actual work in July 2002 began the piling procedure with vibrator was tested. The TM 12/15 with MRZV 925V was operated from a pontoon. The test pile driving took place next to the university clinic to determine whether the noise and, above all, the vibrations do not affect the devices in the operating rooms. Based on the successful tests the actual work could start in August 2002. Approx. 600 tons of steel sheet piles were driven.

Britzer connection channel in Berlin (Germany)

For the development of the water way between the river Spree and the Oder-Havel channel in Berlin's district Neukölln approx. 1700 tons of 15 meters long z-shaped steel sheet piles were installed with the telescopic leader mast TM 14/17 V and vibrator MRZV 1200V.

The work took place in summer 2003 from a pontoon. The wall is a combination of Z-shaped sheet piles and H-beams. Two connected sheet piles were driven between two H-beams, which were also provided with interlocks. The installed wall serves as a stabilization for the river bank.

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Lowering of the railroad line in Los Angeles (USA)

During the lowering of the railroad line two ABI MOBILRAM-Systems were used. At the beginning of the work casings with a diameter of 1220 mm and a wall thickness of 12,5 mm were vibrated into the soil along the whole distance. The area for the clamp assemblies was additionally strengthened. Approx. 17000 piling cycles were required to accomplish the entire distance. The casings were brought to the required depth, bored, filled with reinforced concrete and afterwards the casings were extracted for reuse.

Soil exchange measures in nature protection area of Guadeloupe, California (USA)

The company Condon and Johnson accomplished in year 2000 soil exchange measures in the protected area at the California coast. The sandy soils were contaminated by leaking refinery pipe lines.

The contaminated places were engird with Z-shaped pairs of steel sheet piles interlocked. The sands were excavated, washed and refilled again. Because of the rare kinds of birds the work could be carried out only on certain times beyond their nesting time.

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