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How a Vibratory Pile Driver/Extractor Works

Vibratory Drivers and Extractors

The mechanics of the vibratory driver and extractor

Vibration is created in the gear case by rotating eccentric weights powered by hydraulic motors. Only vertical vibration is created in the gear case as the paired eccentrics that are connected with gears to maintain synchronization and cancel horizontal vibration.
The vibration created in the gear case is transmitted into the pile being driven (or extracted) by means of a hydraulic clamp attached to the bottom of the gear case. The complete vibratory hammer / extractor is held by a crane. To prevent the vibration created in the gear case from affecting the crane line, a vibration suppresser is attached to the top of the gear case. The suppresser contains rubber elastomers that dampen the vibration reaching the crane by 90% or more.

Technical parameters of a vibrator

Engine power (HP, kW)
Engine power is one of two key factors in vibrator performance. If power is too low, the vibrator will not be able to overcome the skin friction between pile and soil.
Eccentric moment (in-lbs, kg-m)
Eccentric moment is the other key factor in vibrator performance. The eccentric moment must create enough amplitude to exceed the elastic range of the soil. More eccentric moment increases amplitude; more pile weight decreases amplitude.
Eccentric moment = total eccentric weight x eccentric distance.
Amplitude (in, mm)
Vertical travel of pile per vibration.
Amplitude = eccentric moment x 2 / vibrating weight
Frequency (vpm)
Vibrations Per Minute and speed of rotating eccentrics
Suspended weight (lb, kg)
Total weight of vibrator = gear case, suppressor, clamp, typically 1/2 the weight of the hydraulic hoses and any additional bias weight or other special additions
Non-vibrating weight (lb, kg)
Weight of the non-vibrating parts of the vibrator(suppressor + typically 1/2 weight of elastomers), including any added extra(bias) weight. Understand weight must be handled by crane.
Vibrating weight (lb, kg)
Suspended weight - non-vibrating weight + clamp weight + pile weight + weight of any soil sticking on pile
Line pull for extraction (tons, kN)
Amount of pull suppresser can handle before engaging safety stops. More is better, but understand the crane must be able to apply pull at radius.
Clamping force (tons, kN)
Hydraulic pile clamping force provided by clamp(s).
Centrifugal force, dynamic force (tons, Nm)
Force generated by rotating eccentrics. Understand the limited value when considering vibratory hammers.As small increases in speed cause large increases in centrifugal force, but little increase in productive capability.
Centrifugal force (US tons) = Eccentric moment (in-lb) x 0.0142 x frequency/1,000,000
Centrifugal force (kN) = Eccentric moment (kgm) x 1.12 x frequency/1,000,000

Standard, high frequency & lower frequency vibrators

The ICE design approach...
Over 20 years of experience on thousands of pile driving and extracting jobs has confirmed that a combination of high eccentric moment and 1600 vpm will provide the most productive, reliable, and durable vibratory hammer, day in and day out, job after job. Based on this experience, the ICE approach to vibrator design is very simple - with available engine power, we turn as much eccentric moment as possible at 1600 vibrations per minute. For unusual jobs requiring light-weight hammers or minimum vibration in nearby buildings, ICE produces high frequency (2300 vpm) vibrators. For situations where initial cost is of particular concern, lower frequency (1200 vpm) units are available with lower cost power units.

Vibrators and the soil

In granular soils (sands), the vertical vibration in the pile disturbs or "liquefies" the soil next to the pile causing the soil particles to lose their frictional grip on the pile. The pile moves downward under its own weight, plus the weight of the vibrator. An amplitude of at least 0.25"(6mm) is usually considered the minimum to cause enough soil disturbance to achieve pile movement. Adding additional non-vibrating weight (bias weight) will usually aid driving in granular soil. Vibrators are usually very effective on non-displacement piles such as sheet piling, H-beams, and open-end pile or caissons. Vibrators are less effective for displacement piles such as concrete, timber, and closed-end pipe where the soil particles must move much further to allow the pile tip to move downward.
In cohesive soils (clays), the vibration must shear the soil-to-pile adhesion to allow the pile to move downward. Amplitude of at least 0.25"(6 mm) is usually considered the minimum to cause enough relative movement to shear the soil away from the pile. With less amplitude, the soil will simply move with the pile. The soil under the pile tip must also be pushed out from under the pile. This occurs more easily with non-displacement pile than with displacement piles. Adding additional non-vibrating weight (bias weight) aids driving in cohesive soils.
For extracting piles, a vibrator is effective since the resistant soil during driving under the pile tip does not have to be moved
For soil compaction of granular soils, a vibrator works well as the soil disturbance caused by vibration causes the soil particles to move into a denser configuration.

Vibrators and bearing capacity

Although there are several research projects underway, there is presently no way to correlate the driving performance of a vibratory pile driver with the bearing capacity of the pile being driven. ICE is participating in this research and will advise if positive results are available. In the interim, due to the effectiveness of the driving with a vibrator, it is often practical to drive piles to near the desired elevation and then use an impact hammer for final driving.

"Due to improvements to ICE manufactured products and the EPA mandated Tier III emission regulations, unit specifications are subject to change without notice. Please contact ICE engineering department to confirm possible changes."