The Power of Averaging

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Piletest Technical Notes
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Background

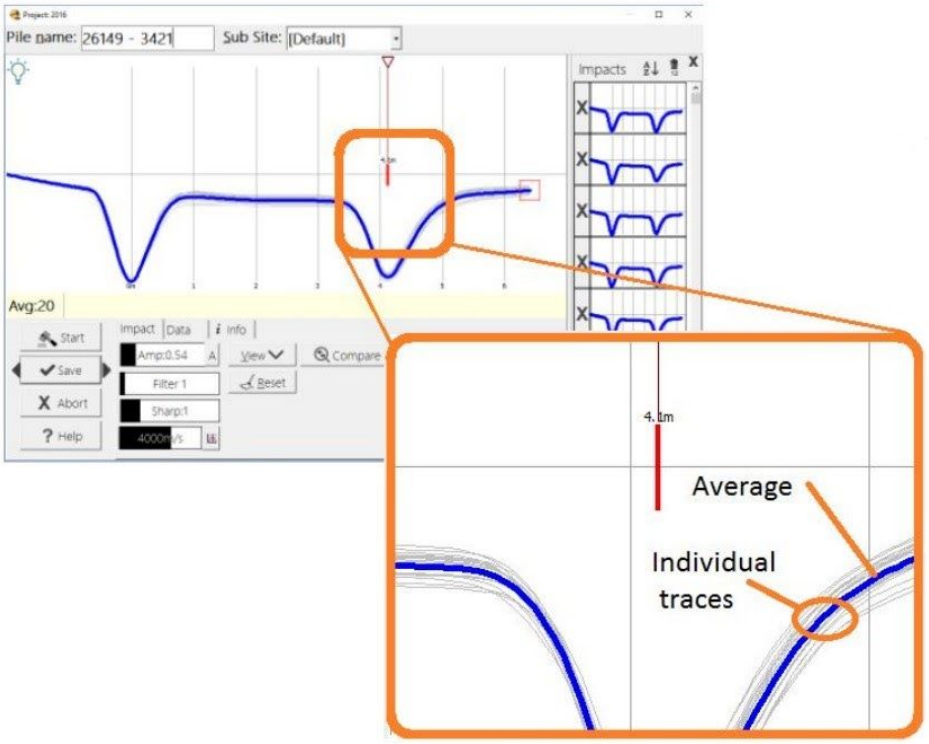
The pulse-echo method (ASTM D5882), is based on tapping the pile head using a small handheld hammer and analyzing the resulting head velocities to find length and anomalies. A single impact trace should theoretically contain all the information needed for the analysis. However, a single impact trace may contain any degree of random noise due to environmental noise, poor pile head preparation, or operator errors. Traditionally, a few additional traces were requested, to demonstrate repeatability - the analysis was, nevertheless, done on a single trace. In contrast, with the PET the operator collects a large number of traces, and the software automatically sorts and averages the impacts while the operator works on the whole set of impact traces as one entity. This approach brings many benefits

Benefits of a large impact set:

- A set of size N reduces the random noise by a factor of, so an average

of 25 impacts has 1/5 (20%) the random noise level of a single impact. This is particularly important in slender piles that produce faint echo and require high amplification which also amplifies the noise. However, Since the signal to noise ratio (SNR) improvement is related to the square root of the number of traces, improvement becomes tedious and marginal as you have to collect four times the amount of traces you already have in order to improve the SNR by a factor of two.

- Averaging impacts from different locations on the pile head can reduce noises generated by 3D head echo effects (Signals bouncing from the sides of the pile before the wave becomes one-dimensional). Those are not "random" noises but they make interpretation more complicated
- The impact set can be sorted, impacts can be hidden and restored and the effect on the average is seen in real-time - which helps to analyze hard-to-test cases
- Seeing the impacts stacked makes the abnormal ones stick out easily



Implementation details

To enable the collection of a large impact set quickly and effectively, PET introduces the following features:

- Automatic collection of traces: once armed, the system will collect all incoming impact traces, as fast as the operator can hit, typically 3-4 impacts per second.
- Low trigger level: The system is set to be triggered on a soft impact which is faster, less tiring to the operator, and produces less parasitic noise.
- Smart Trigger - Incoming impact traces are filtered by smart trigger shape and obviously anomalous triggers (usually due to unintentional sensor movement or missed hammer blow) are rejected.
- Auto Sort - When defined, the impact trace set size is restricted to any wanted number N (typically 10 to 50 see this video), once the N+1' impact trace enters the system, the set is sorted by similarity and the most irregular impact is removed, making the remaining N impact traces set more similar and repeatable.
- The average and impacts are displayed in real-time with no practical delay (typically less than 0.1sec)
- The operator may define a convergence criterion (When enough impacts have been collected) based on impact set uniformness and a minimal number of impacts, typically 10-50 impacts with a 5% change. Once the criterion is met, a message is displayed and the operator can stop collecting impacts.

The above features enable collecting of a large (50) set in typically less than 1 minute - See a short video

More technical notes and papers available here

Conclusions

- PET system and software, make’s it quick and simple to collect and handle a large number of impact traces.
- There is no limit to the number of impact traces collected, but there is little added value above 50 traces.
- PET software treats the whole set of impact traces as one entity. One impact trace might be meaningless, but a consistent set of many impacts is convincing.

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