Trigger vs. Smart Trigger

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Piletest Technical Notes
Apr - 2020

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, while 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 is based on several unique PET features, one of them is Smart Trigger

About Smart trigger

With a plain trigger function, the trigger happens when the impact reaches a threshold level. This approach would have been enough in an optimal situation. However, in field situations, many sources of noise may generate false triggering and reject useless information.

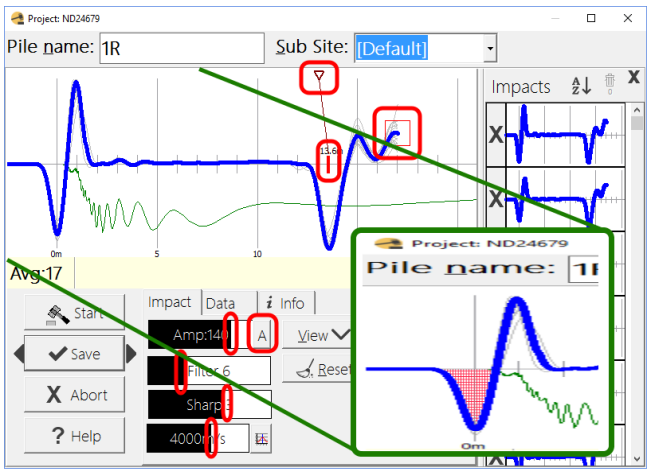


Figure 1

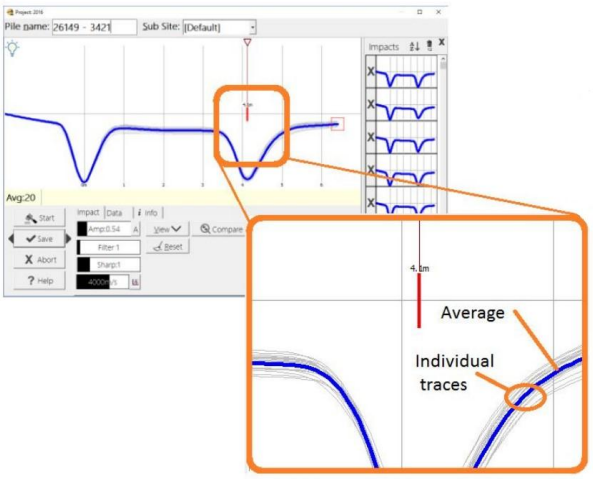
The Smart Trigger examines the *shape* of the impact between the two X-axis crossing (the red grid area in figure 1) A shape analyzed as "normal" triggers the system. "Normal" was measured ad-hoc from a large set of impacts manually selected by the users.

Smart Trigger rejects more than 80% of the false triggers while accepting more than 80% of the good ones. (i.e If 20 impacts of which half are noise are examined, the result set will be 8 good impacts and 2 noisy ones)

An additional advantage of the Smart Trigger is seen when lowering the trigger level and allowing lower-amplitude impacts to be collected. Without the assistance of the Smart Trigger that would inject many noisy traces when the operator is just moving the sensor around. The advantages are: First: Lower-amplitude impacts are cleaner and improve SNR. Second: It is much easier on the field technician's arm, especially when working on a large site testing hundreds of piles a day.

Trigger Trainer - In our latest PET software update, we have introduced a Train function which improves the automation. The Train function helps in training the Smart Trigger on good impacts. It is done by inputting 20 good impacts for reference.

For unusual cases, Piletest recommends disabling the smart trigger and sorting the impacts manually later by human intuition and human intelligence, which is usually based on years of experience. For this case, we have included an AutoSort function which compares and sorts the whole impact set and rejects the unusual ones. AutoSort does not examine the trigger shape but only the uniformity of the impacts set. (see screenshot figure 2)



Benefits of a large impact set:

Number of Impacts - A set of size N reduces the random noise by a factor of $\sqrt{N}$, so an average of 25 impacts has 1/5 (20%) the random noise level of a single impact. This is particularly important in slender (long and narrow) piles that produce faint echoes and require high amplification which increases the noise as it also amplifies it. 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. This is because you have to collect four times the amount of traces you already have in order to improve the SNR by a factor of two..

Impact Location - 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 on the longitude axis of the pile). Those are not "random" noises and yet they make interpretation more complicated.

Trial and Error - The system allows for impact set to be sorted, impacts to be hidden and restored and the effect on the average is seen in real-time - which helps to analyze hard-to-test cases

Comparison - Seeing the impacts stacked makes the abnormal ones stick out easily

Summary

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

- **Smart Trigger** - Incoming impact traces are filtered by smart trigger shape and obvious anomalous triggers (usually due to unintentional sensor movement or missed hammer blow) are rejected.
- **Low trigger level**: The system is set to be triggered on a lower-amplitude impact which is faster, less tiring to the operator, and produces less parasitic noise.
- **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.
- **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.
- **Real-time feedback** - The average and impacts are displayed in real-time with no practical delay (typically less than 0.1sec)
- **The operator experience** - The operator may define when enough impacts have been collected (a convergence criterion), based on impact set uniformness and a minimal number of impacts, typically 10-50 impacts with a 5% difference. Once the convergence criterion is met, a message is displayed and the operator can stop collecting impacts.

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

Conclusions

The PET system makes pile integrity testing easy and increases field efficiency by

- Making 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 (however there is little added value above 50 traces)
- Treating the whole set of impact traces as one entity. One impact trace might be meaningless, but a consistent set of many impacts is convincing.

Send me more information and quotation