Pseudo Interval or True Interval SCPT?

There are two types of sensor configurations for Seismic Cone Penetration Testing (SCPT) interval velocity determination: 1) *Pseudo-interval* where a single seismic sensor package is advanced to various depths and the relative arrival time between depths is determined using separate seismic events, and 2) *True-interva*l, which involves the simultaneous monitoring of two sensor packages offset vertically in the seismic adapter during each seismic event, and the difference in arrival time is used to derive the wave velocity in the depth interval between the two sensor packages. A frequently asked question is which configuration is preferred and in this technical note we want to address this query.

In case of the *true-interval* configuration the cone is obviously longer as it must accommodate the two sensor packages that are offset vertically, and this additional length makes the cone harder to handle. This configuration also increases the number of data channels to accommodate the extra downhole sensor, which in turn causes the data cable to be thicker and thus the system harder to employ.

These operational aspects are seemingly offset by a simpler analysis. Since the two sensor packages are used in parallel, the trigger reliability is at first sight no longer an issue, as the analysis is based on the difference in arrival time rather than the duration for the seismic wave to arrive at the sensor package once the system has been triggered.

However, without a highly accurate and low noise trigger the data collected at a particular cone penetration cannot be stacked (to improve the signal-to-noise ratio) and moreover the data acquired during tests at different cone penetrations cannot be compared. The means that if the data at a particular depth cannot be used (e.g., due to a low signal-to-noise ratio) no continuous velocity profile as a function of depth can be established (while with an accurate trigger this could be done, albeit with a greater depth interval where a particular trace cannot be used). The possibility that no continuous velocity profile can be derived is obviously a serious concern depending on the use of the derived date (e.g., the determination of the shear modulus along the entire length of a planned foundation).

It should also be noted that in case raypath refraction had to be taken into account (which for near- surface testing is essential) a true-interval cone requires that any subsequent test is conducted with the top sensor at the same depth as that of the bottom sensor depth in the preceding test, unless a highly accurate trigger is used.

For these reasons it is strongly recommended that for all SCPT a highly accurate and low noise trigger is applied, but with such a trigger in place the operational disadvantages of *true-interval* configuration make the *pseudo-interval* configuration automatically the preferred option.

The only remaining question is then whether a highly accurate and low-noise trigger is practical. In SCPT there are two types of trigger mechanisms: 1) *Contact* triggers whereby the system is triggered when contact is made between source and receiver (e.g., when the source hammer strikes the plate), and 2) *Sensor* triggers when the signal of a transducer (e.g. an accelerometer or

geophone) is used to trigger the system. *Contact* triggers are not only very simple (similar to an electrical switch, which is triggered when the hammer makes contact with the source plate), but also clearly the preferred solution. Given the very low noise environment and very fast rise time of the trigger channel when contact is made this trigger ensures a very accurate reference trigger time. Figure 1 illustrates a typical contact type trigger and shows that there is a very low noise environment and very fast rise time of the trigger channel when contact is made. This results in a very accurate reference trigger time (in this case the accuracy is equal to the user specified sampling rate of 150 kHz, which equates to a 0.00667 ms time resolution).

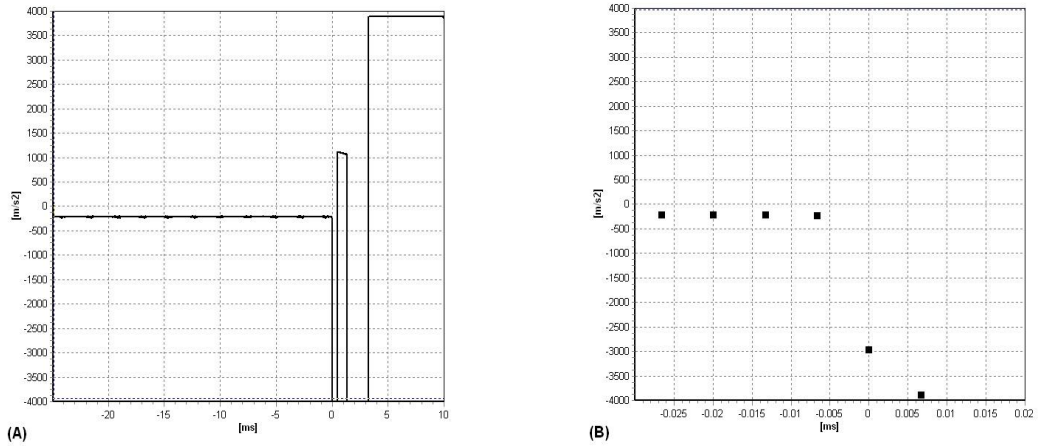

Figure 1. (A) Illustration of a typical *Contact* type trigger (e.g., when the source hammer strikes the truck pads (this is similar to an electric switch)). (B) Graph in (A) zoomed-in between -0.03 ms and 0.02 ms illustrating a sampling rate of 150 kHz (0.0067 ms time resolution). As is shown in (B), the *Contact* trigger resolution is one sample or 0.0067 ms.

From this it is clear that a highly accurate and low-noise trigger is practical, and therefore the *pseudo-interval* configuration is the preferred sensor configurations for Seismic Cone Penetration Testing (SCPT) interval velocity determination.

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