The “Waterfall” presentation

A deeper look

Erez I Amir. Piletest

Background

The waterfall presentation, as required by the latest ASTM standard D6760-16, originates from the very early beginning of the CSL testing when analog oscilloscopes were used as data loggers (Levy, 1970).

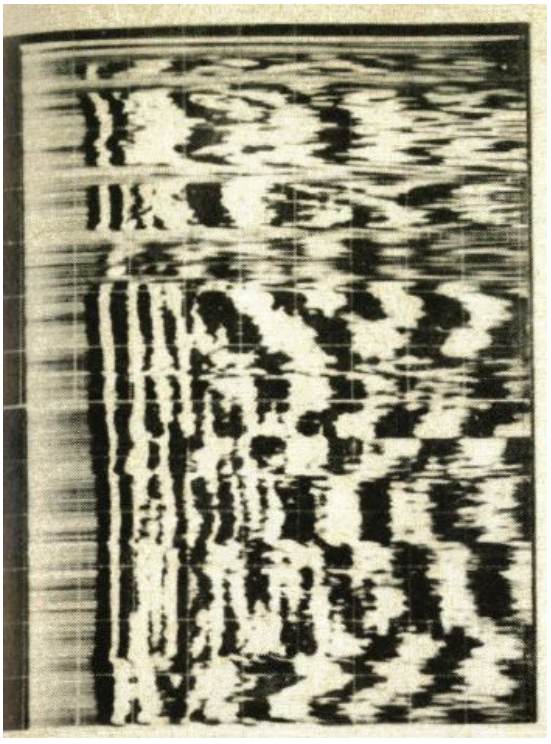


Figure 1 - An early waterfall presentation

In this presentation mode, the voltage of each period along a given pulse is mapped to one pixel, as seen by Figure 2

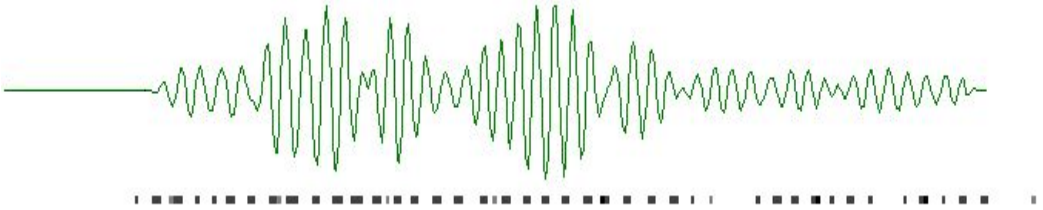


Figure 2 - Raw signal captured by a modern A/D (Analog to Digital code converter) and the corresponding waterfall pixel representation of the digital code

Nowadays, all done by software, the waterfall presentation mode can be seen as a voltage(signal)-to-color, code mapping. Different mapping schemes may be used - such as full color, B&W or grayscale. Mapping can emphasize or, on the other hand, hide flaws in the tested profile of the pile.

Voltage → Color Mapping

In the early days of CSL testing, without high resolution Analog-to-Digital (A/D) convertors, an analog knob was used to set a fixed threshold level of a voltage comparator. The 0/1 value of the comparator were translated to Black/White “colors” on the oscilloscope or an attached printer to create a basic (rudimentary) waterfall plot.

The Voltage-Color mapping can be presented on XY graph as in Figure 3

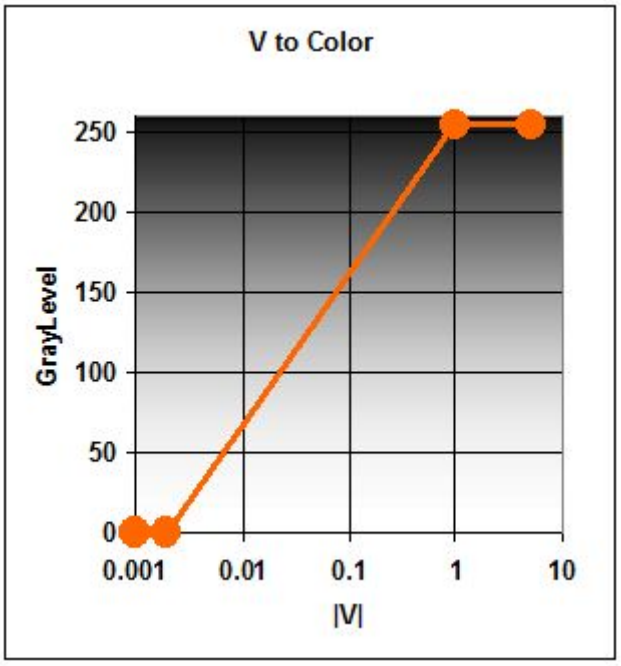


Figure 3 - Typical Voltage-to-Color mapping

The vertical axis is shown here (for simplicity) as gray level with 0 being totally White and 255 being totally Black
Note: For the sake of brevity, mapping to any other full-color palette and different mapping for positive and negative values has been omitted. .

Typically, two values define the mapping:

1) Threshold level below, which values the map to WHITE
2) Maximal level above, which values the map to BLACK

Setting these values to be the same, creates a high-contrast B/W (black-or-white) presentation with no gray scales (equivalent to the historic plots). Otherwise, the middle range of voltage values, are mapped to a gradient of colors.
Different slopes (of the orange curve in image 2) have dramatic effect on the end result, as will be demonstrated next.

Effect of different mapping schemes

Table 1 below shows the effect of different mapping schemes on the **exact same profile** source data. This profile has several areas with somewhat lower energy, and a “soft bottom” with a higher FAT, but with no total signal loss.

- No slope, high-contrast mapping (column 2) hides all low-energy zones
- A steep slope (column 3) shows the low-energy zones
- A more moderate slope (column 4) creates the (wrong) impression that the soft-bottom and all low-energy zones are a total discontinuity

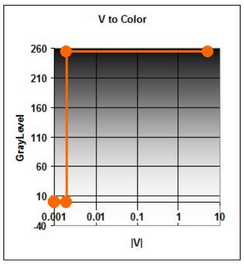
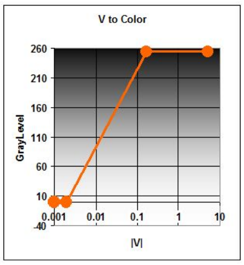
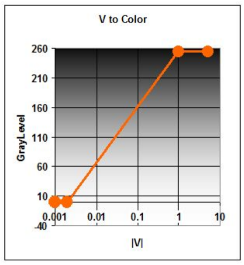
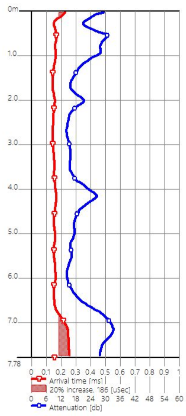
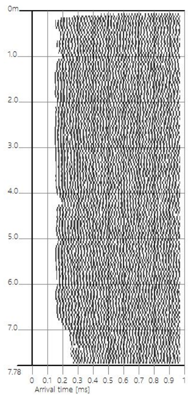
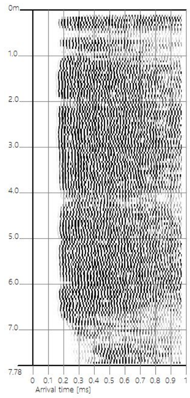
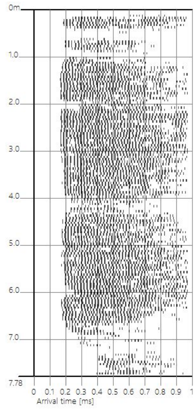
1	2	3	4
FAT (Red) and Attenuation (Blue) curves			
			

Table 1 - Effect of different mapping schemes

CHUM "classic" and "Modern" waterfall presentation modes

CHUM software offers two waterfall mappings (Figure 4):

- A simplistic one called "Classic" is black & white mapping.
- A more advanced mapping called "Modern" which uses a moderate slope mapping to show the signal amplitude

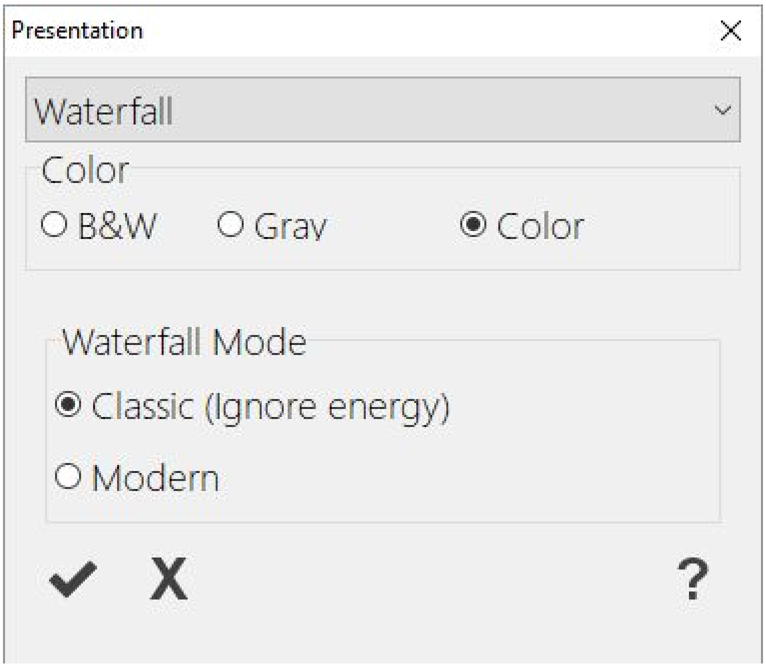


Figure 4 - CHUM waterfall options

The "Modern" presentation contains more information and is therefore the recommended one, while the "Classic" presentation is mainly kept for backwards compatibility.

Figure 5 shows the effect of the CHUM waterfall options on a profile. In this case the received pulse starts with low energy - which maps to a light color in the "Modern" presentation, but shows no effect in the "Classic" one

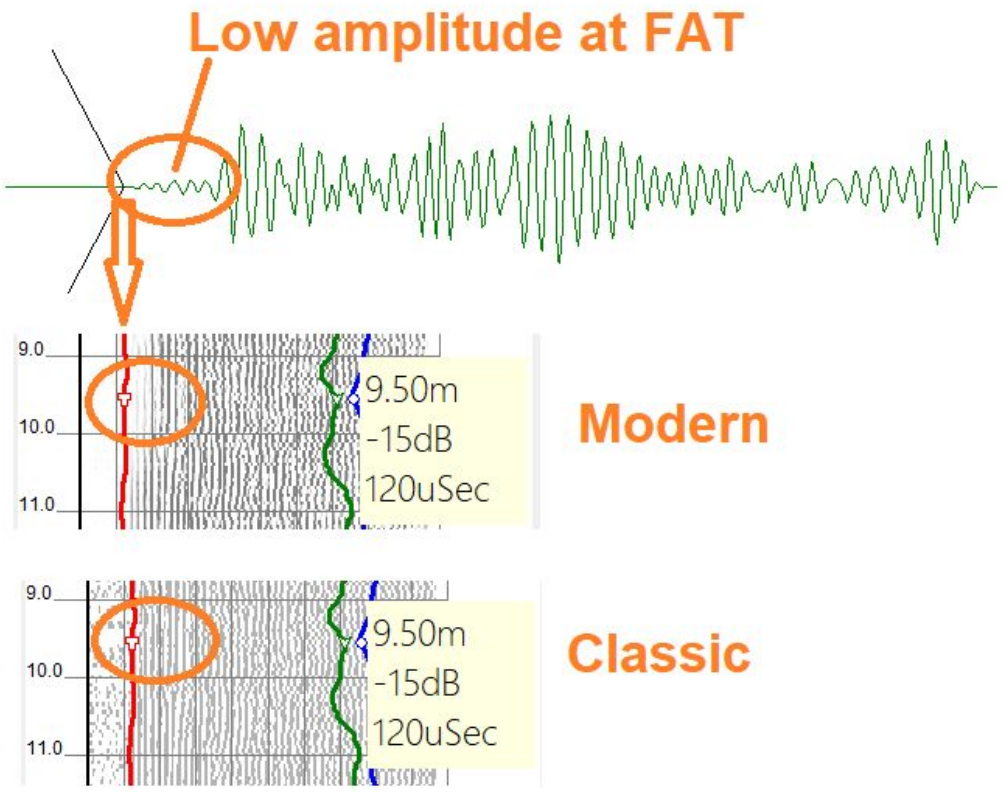


Figure 5 - Effect of waterfall presentation

Conclusions

1. The waterfall presentation is not a golden standard
2. Different mapping schemes can hide or accentuate flaws
3. Over-trusting the waterfall presentation can lead to wrong conclusions
4. Piletest recommends using the waterfall presentation as a supplementary presentation, never to be used without the energy and FAT plots (Table 1).

References:

1. Amir, J.M. (1999).: Caveat Emptor or a Buyer's Guide to Integrity Testing, Proc DFI Annual Conf, Dearborn p. 221

2. Fleming, W.G.K., Weltman, A.J., Randolph, M.F. and Elson, W.K.(1985): Piling Engineering, Surrey University Press, London, p. 287

3. Levy, J.F. (1970): Sonic pulse method of testing cast-in-situ concrete piles, Ground Engineering Vol. 3, pp. 17-19