

Introducing "Effective Area" calculations in 3D tomography horizontal slices

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Background

True 3D tomography is done by breaking the pile volume into 3D boxes called "Voxels" (image 1) and applying matrix inversion techniques, to calculate the apparent wave speed at each voxel. Once this model is calculated, it can be presented in 3D projection (Image 2) and arbitrary slices in any arbitrary direction and plane, may be drawn (Image 3).

Of particular interest to the structural engineer are the horizontal slices (Image 3). The horizontal slice shows a cross section of the pile, at any desired level, to support the assessment of the effective load bearing capacity of a flawed pile.

To help the engineer's assessment, Piletest introduces to the horizontal slice, the "Effective area" figure. For this figure, the value of 100 percent means "Solid" while 25 percent, for instance, means that the compressive capacity of the pile at this level is reduced to a quarter (25 percent) of the "Solid" value.

See [caveats](#)

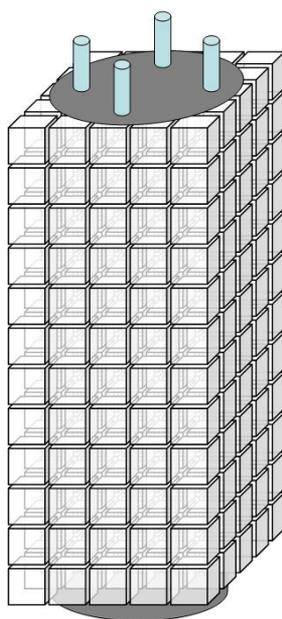


Image 1: Pile volume broken to voxels

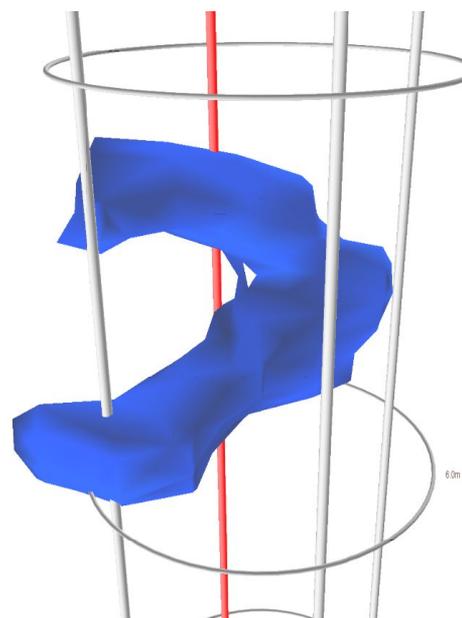


Image 2: 3D visualization of a flaw

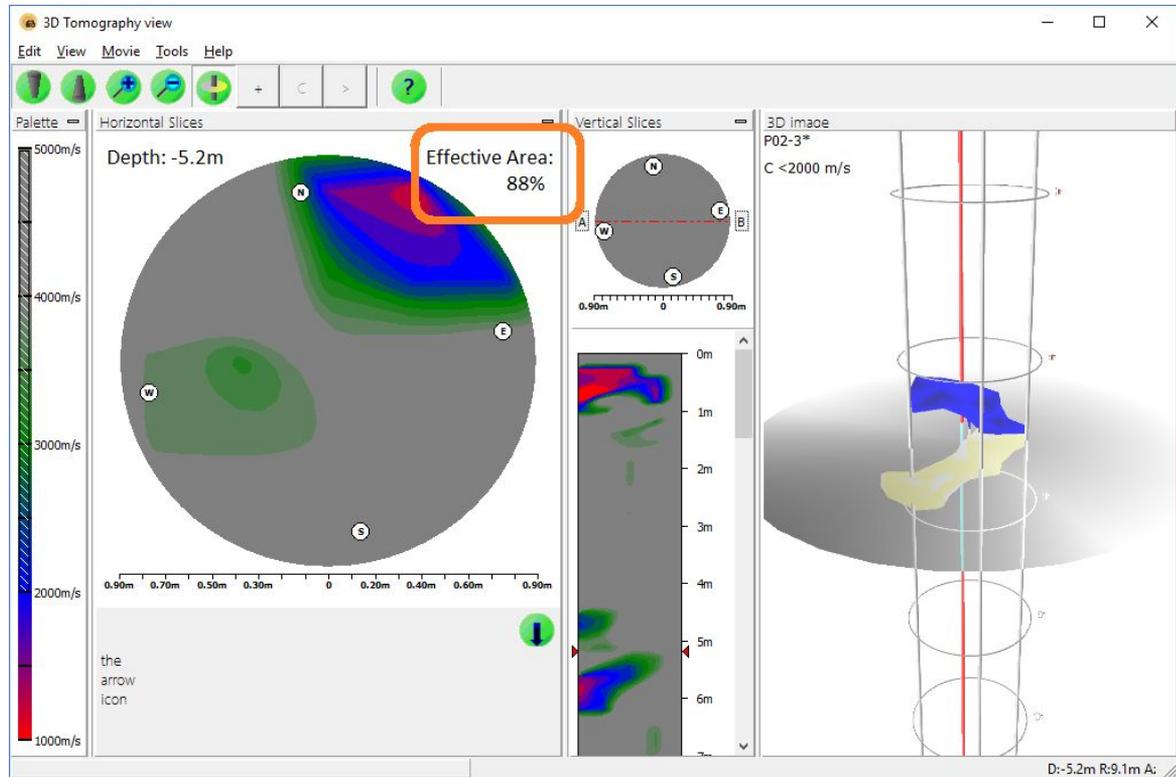


Image 3: A horizontal cross-section showing "Effective Area"

Calculations

The voxels at a specific depth Z are examined and the wave speed C_i at each voxel is compared the "Solid" wave speed C_{ok} of the pile.

The correlation between wave speed and strength is shown by using the following conservative power of 1/6 formula

$$c = k \cdot (f_c)^{\frac{1}{6}} \quad \text{Equation 1}$$

Where C is the wave speed, and f_c is the compressive strength of the concrete.

The effective area of all voxels in a cross section is summed using equation 2:

$$EffectiveArea = 100 \cdot \frac{\sum_{i=1}^n (C_i)^6}{n \cdot (C_{ok})^6} \quad \text{Equation 2}$$

Where C_i is the wave velocity of voxel i . C_{ok} is the wave speed of a solid part of the pile and n is the number of voxels in a slice

We have considered this calculation method against an alternative one, where an arbitrary threshold wave speed is selected by the user and the software counts the number of voxels with a higher wave speed.

We found that this method has several advantages:

Chosen method	Alternative method
Correlates speed with strength	Velocity threshold
Based on widely acceptable engineering principle	Based on arbitrary value
Automatic: No pre-selection of threshold value is needed.	Pre-selection is mandatory
Small changes in wave velocity generate small changes to the effective area - effective area is a smooth function of wave speed	Acceptable noise/scatter might move a voxel across the threshold value and have a dramatic go/no-go effect on the result - effective area is a step-function

Caveats

3D tomography is great tool for organizing information in a simple visual form. This simplicity leads to the belief that "what you see is what you get" - which is not always accurate.

3DT has limitations, resulting from many factors, among which are limited wavelength, refractions and diffractions, obstructions, limited viewing angles, unknown curved wave path, noise - all those create shadows, ghosts, and echoes - and a conceptual gap between the presented image and reality.

The calculated effective area, relates to pure compressive loading, as distinct from bending moments loading. Moreover, it provides no clue to re-bar durability which depends on concrete cover.

To sum up: Decision makers should use 3DT and "Effective Area" in particular, only as a decision supporting tools, and not as a "go/no-go" tools.

Summary

3DT helps to visually and easily discover areas of potential flaw. "Effective Area" is an added decision making tool, helping the engineers to quantify and assess flawed areas in a pile based on solid engineering concepts.