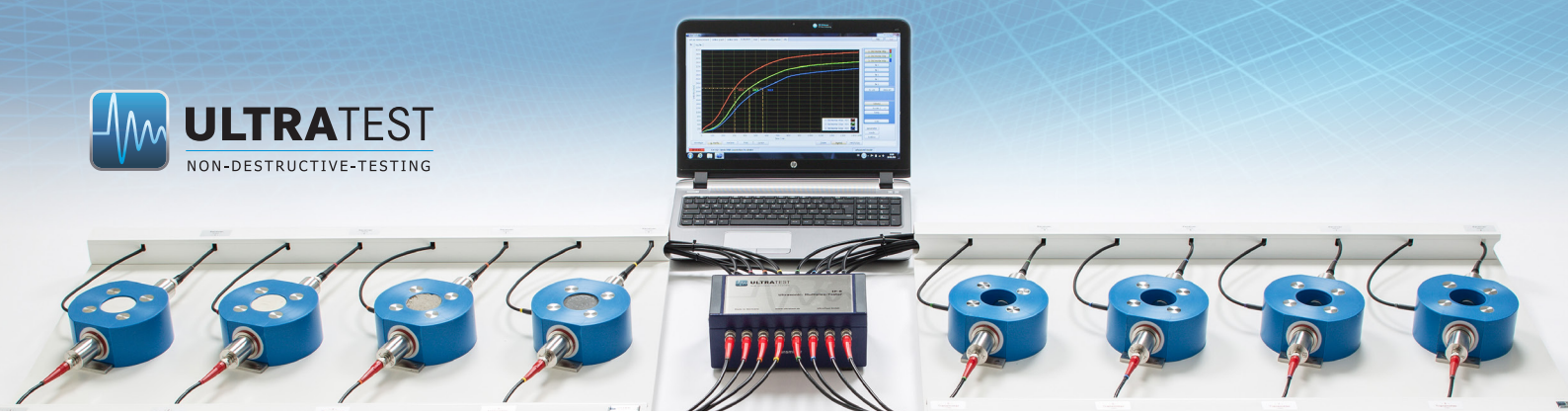
ULTRATEST
NON-DESTRUCTIVE-TESTING



NEW: LOGISTIC FITTING MODULE (LFM)

Sketching of Ultrasonic Transit-Time Curves

Logistic fitting is a newly developed method for extracting more information from your ultrasound measurements. The Logistic Fitting Module for Ultra TestLab fits a logistic sum function to a measured transit-time curve and permits a mathematical derivative with respect to time to be made. Single-term considerations of the sum function provide information about individual processes during the setting of your formulations.

What Does the LFM Do?

It uses a complex mathematical process to fit a differentiable sum function comprised of logistic terms to a measured transit-time curve. The first derivatives (sound particle accelerations) of individual sum terms that this makes possible are time-correlated with individual physical and chemical processes during setting. The characteristics of these processes are calculated by means of curve sketching (analysis). The measured sound velocity curve is subdivided into several sections. A logistic term is precisely adapted to each of these sections.
For each term (process), the LFM determines characteristics such as duration, point of maximum sound particle acceleration and contribution to the velocity development.

Theory

The strength development of a mineral construction material during setting is the result of the crystal growth of hydrated phases. Growth processes can be mathematically described by means of a logistic function. This is already familiar from biology and economics. In a setting mortar, such growth processes for many different hydrate phases take place overlapping in time. The beginning and end of each individual process are manifested as a change in the strength development over time. The strength of a material is linked to its sound velocity via the dynamic elastic modulus. By fitting the sum formula to the ultrasound transit-time curve and analyzing it into individual logistic terms, these terms can be associated with the growth processes in the mortar.

Practice

The known, individual stages of hydration can be illustrated by analyzing a transit-time curve (Fig. 1) of a setting Portland cement. During the initial period, 1st generation ettringite forms (A). Following the dormant period (B), there is an accelerated period, when the main silicate hydration (C + D) takes place. This is followed by the second ettringite formation (E).

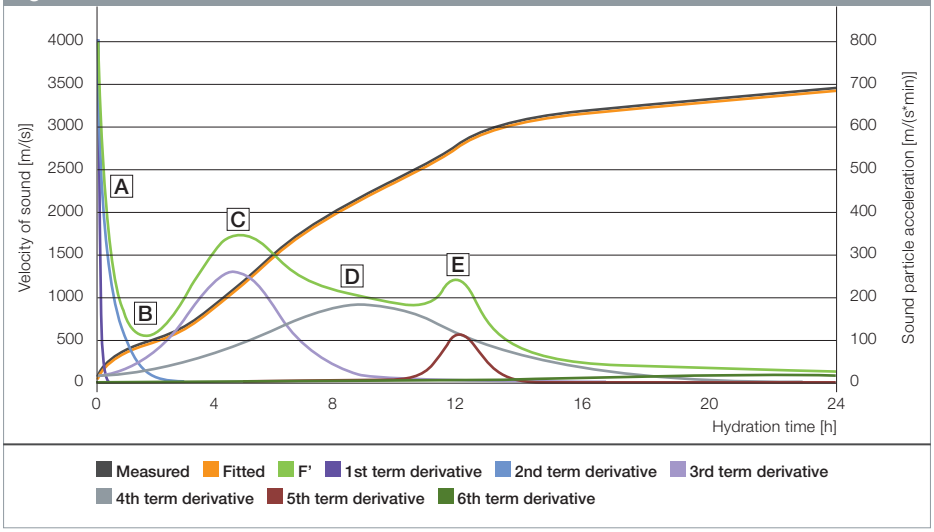
Incoming Quality Control

Individual cement batches (from different production periods) often show different hydration behaviors. As hard criteria for the quality control, specification limits are determined, within which the times of maximum sound particle acceleration are permitted to vary.

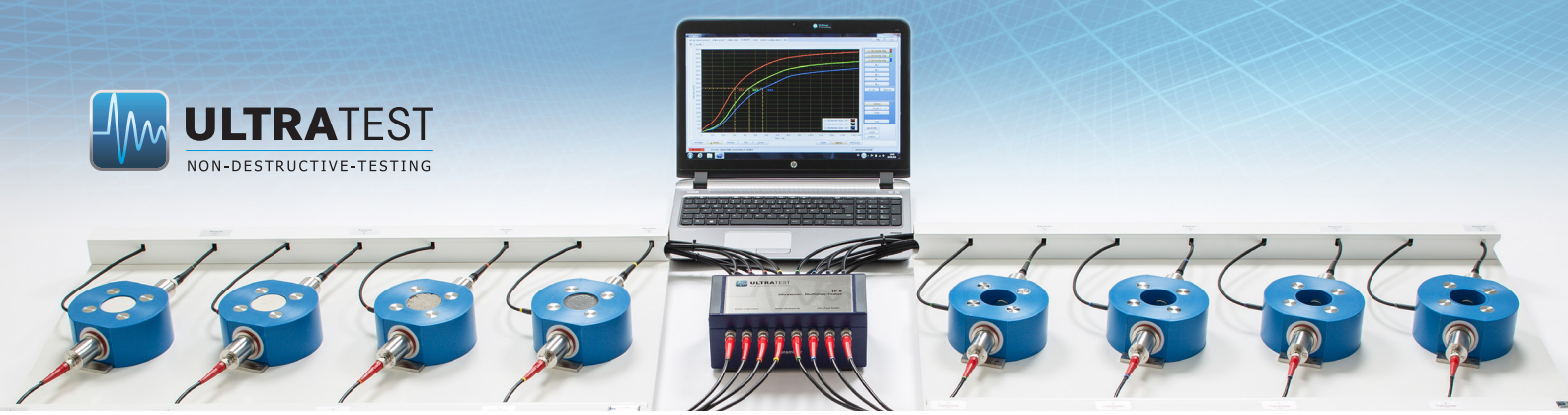
Storage Stability

The setting behavior also gives an indication of the mortar aging. This method is very suitable for recording and evaluating changes.

Figure 1



Setting behavior of a Portland cement: the transit-time curve (black), logistic sum function (orange), global sound particle acceleration (green) and individual term derivatives (colored) can be seen



What Does the Program Show Me?

Without further information, the graphs and calculated key parameters show the profiles over time of individual processes during setting, but not which processes these are. The latter requires complementary analytical methods, e.g. X-ray diffractometry for quantitative phase determination.

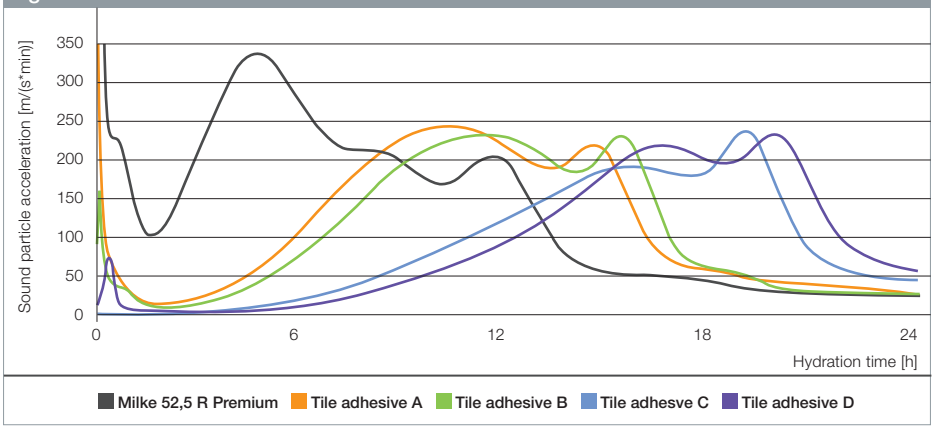
Additive Screening

The comparison of the measurements (Fig. 2) from different formulations demonstrates the influence of the formulation (e.g. due to different additives) on the individual hydration processes. Here, the change of the point of maximum sound particle acceleration, as a key parameter, is determined by logistic fitting.

What Is the Advantage of LFM?

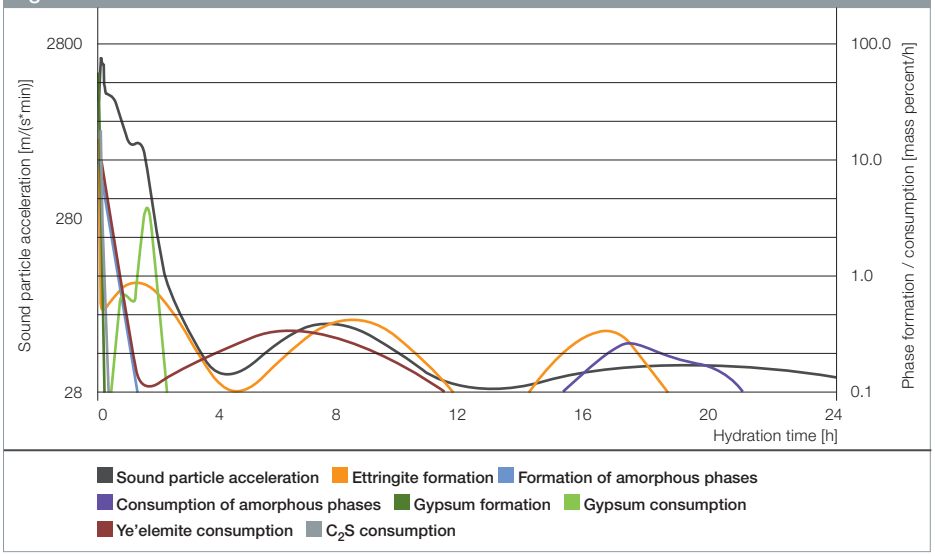
Ultrasound measurements are cost-effective, robust and easy to use, compared to other methods. Once the individual processes in a basic formulation have been determined by more expensive and elaborate complementary methods (Fig. 3), further changes due to additives, aging or quality fluctuations can easily be determined using ultrasound measurements.

Figure 2



Use of different cellulose ethers in tile adhesives (colored) compared to a basic mortar mix without additives (black). The respective sound particle accelerations are shown.

Figure 3



Correlation of global sound particle acceleration (black) with the phase development (colored) of a sulfo-aluminate cement

Cooperation Partners

UltraTest, Achim, Germany
- Hardware and software development
- Marketing and sales

Wacker Chemie AG, Burghausen, Germany
- Method development
- Software development
- Marketing and customer training
- Synchrotron measurements

d:AI:mond, Saarbrücken, Germany
- Software development

HeidelbergCement, Ennigerloh, Germany
- Synchrotron measurements

Paul Scherrer Institut, Villigen, Switzerland
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