Quick and precise Determination of Water Content of Fresh Concrete, directly on Site

Based on state-of-the-art TRIME radar technology it is possible for the first time ever to solve an important task in the construction industry: The quick measurement of water content of fresh concrete, directly on site.

Problems are quickly identified and widely known. Concrete buildings are very long-lived, in best case 80 to 120 years, provided the concrete was exactly and appropriately produced. Nevertheless we know many concrete buildings like bridges or fair-faced concrete façades, which have to be renovated extensively few years after building, or in worst case need to be demolished. A correct water-cement-ratio is the decisive factor for long-lasting concrete. If the wc-ratio in concrete recipes are not met, there are considerable disadvantages for concrete and concrete buildings like: poorer workability of the fresh concrete, greater pores, lower compression strength, lower frost resistance, lower protection for the reinforcing and pre-stressing steel, less bearing load, shrinkage of concrete, cracking, salt efflorescence and spalling.

The easy and fast check of the correct water content can exclude later problems to the building. The previous kiln-drying-method method for controlling the wc-ratio in fresh concrete is limited for use in practice.

The problems with the previous kiln-drying method for controlling the water content:

- The kiln-drying time with half an hour is too long. The concrete is binding during this time and therefore concrete will have poorer quality.
- By use of gas oven kilns, care must be taken that no amounts of solids are blown away in the air during drying, because this could result in a too high moisture value. Sometimes the fresh concrete sample will be stired during drying, sometimes it lies still and accordingly it comes to different results. When not-stiring there is the danger that the water will be bounded chemically inside the cement, due to a too long drying time. Such bounded water cannot escape, even at highest temperatures.
- By drying with microwave ovens the drying time should be noted depending on the electrical power of the microwave oven (e.g. 700Watt to 1000Watt). Furthermore care must be taken that the quantity of the fresh concrete sample (e.g. 2 to 3kg) is not too less or too much. With the same fresh concrete sample, deviations in ranges of +-3 to +-10 liters/m^3 are not unusual when drying with gas ovens or microwave ovens.
- When weighing very hot dried samples, the weighing result could be influenced considerably due to lift forces of vertical hot air streams.

So far, it had not been possible to measure water content of fresh concrete precisely with electronical sensors.

The problems with the previous capacitive and microwave measurement methods:

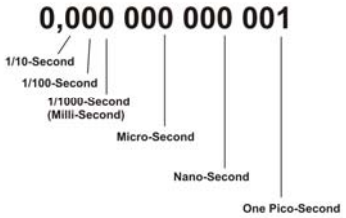
Capacitive and microwave moisture probes have a limited conductivity range when measuring water content, and are therefore not suitable for measurements in fresh concrete. Cement together with water has a very high conductivity, in fresh concrete made with CEM 52.5 the conductivity may amount to up to 45dS/m. With the patented TRIME measurement method in combination with the SONO probes, this conductivity range can be covered.

The new SONO technology offers a new dimension of quality control for fresh concrete, directly on site.

The SONO-WZ Probe as a „Moisture-Tomograph“

The figure shows the SONO-WZ probe. Green shows the radar wave which travels nearly with light speed along the probes surface. Similar to a CT, the fresh concrete is measured disc-shaped and layer by layer. The travel time which is measured with an accuracy of one picosecond (on the 12th decimal place) corresponds to the moisture content.

Time Domain Measurement with the TDR Method



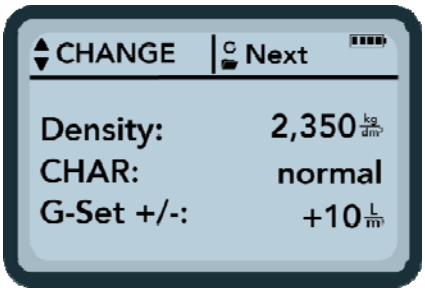
$$c = \frac{c_0}{\sqrt{\varepsilon * \mu}} = \frac{2l}{t} \qquad t = \frac{2l}{c_0}\sqrt{\varepsilon_r}$$

c_0 = Light Speed (3x10 m/sec) ^{8}
μ = 1 (magnetic Permeability)
ε = Dielectric Constant
t = Time Duration
$2l$ = Length of Radar line (back and forth)

And so simply and well-structured is the measuring procedure with SONO-WZ

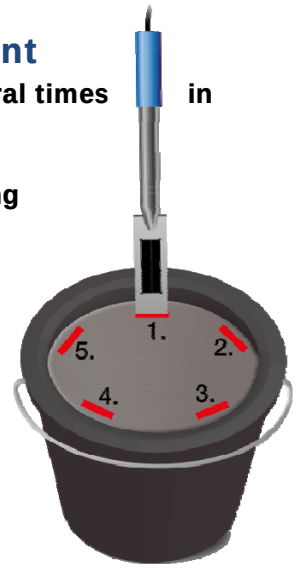
1. The Settings

The parameter CHAR (characteristic of recipe) allows a pre-adjustment to the sieve grading line of the fresh concrete. With G-Set the SONO-WZ can be once adjusted to the used type of rock (core moisture). The determination of water content requires than only the input of the raw density of the fresh concrete.



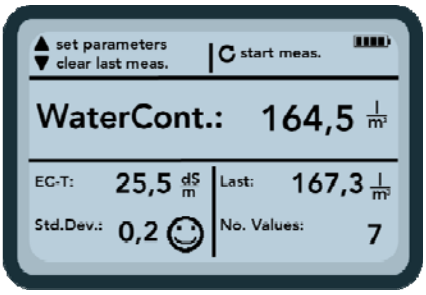
2. The Measurement

Immerse SONO-WZ several times in the fresh concrete and perform single measurements by pressing a start button



3. The Evaluation

The determined effective water content can be clearly seen in liter / m^3 as well as other useful results.

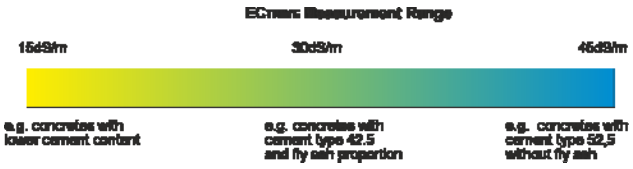


In practice, different types of concrete can be measured with SONO-WZ, concretes with water-cement ratios from 0.32 to >1 and at water contents with >200 liter per m³.

In addition to the determination of the water content, the radar based **E**lectrical **C**onductivity parameter EC_{TRIME} is shown on the LCD of the SONO-DIS. SONO-WZ determines cement type and cement quantity by using and detecting the electrical attenuation of the radar pulse. At that time this raw value EC_{TRIME} can be used for a **preliminary analysis of the cement** and therefore allows higher security when testing a concrete type which has to be controlled continually.

The following graphic shows possible EC_{TRIME} values at different concrete and cement types. As user of SONO-WZ and for later controls and better verifications it is to recommend and helpful, to document EC_{TRIME} with the respective concrete type.

EC_{TRIME} a valuable cement parameter for continuous control of concrete recipes



Following companies and organizations are successfully using the SONO-WZ for a longer time in practical trial:

HOLCIM Switzerland
Mr. Benedikt Schneider
http://holcim.com

BASF Construction Solutions
Mr. Sebastian Dittmar
http://www.dispersions-pigments.basf.com

Dr. Jürgen Krell
Publicly appointed and sworn building expert
http://www.krell-consult.de/

BAS Research
Mr. Wilko van der Meer
www.basbv.com

MBL Certified-Concrete-Laboratory
Mr. David Dreher
http://www.bkgbeton.de/betonlabor.html

In the following an assessment of the MBL Certified-Concrete-Laboratory about the SONO-WZ in practical use:

We use SONO-WZ in our certified concrete laboratory since more than one year for controlling the water content of different concrete types. We verified our whole range of concrete compositions with water contents >200 liter per m³. The reliability of SONO-WZ could be ascertained, independent on water-cement ratios from 0.32 up to >1, and also independent on different cement types and different aggregates.
*After more than 150 performed tests we are so confident about the **SONO-WZ**, that we are able to waive additional tests with the kiln-drying procedure in our factory production control system. Therefore, for us this means a considerably simplified work with significant reduction of time. On the other hand, with little effort we can increase the number of tests for achieving further valuable information.*
Vladimir Naumann, Concrete Technologist
http://www.bkgbeton.de/betonlabor.html

In the following an assessment of the company BAS Research about the SONO-WZ in practical use:

B|A|S Research & Technology is a high-qualified research and knowledge institute in the building sector and a specialist in the concrete and asphalt sector. Our activities are carried out to every layer of the building sector. We are always in search of the newest building materials, applications and production processes. With specializing in concrete and with most modern laboratories, we have tested the ***SONO-WZ*** *in various concrete types. Tests were also made at low and high concrete temperatures. To avoid possible errors with kiln-drying, we have produced all mixtures with dry aggregates. We are impressed about the good accordance of the water/cement-values of our concrete recipes which were measured in comparison with the* ***SONO-WZ.***

Wilko van der Meer, Director
www.basbv.com

Conclusion

There is every growing demand on the quality of concrete. New and innovative technologies can lead to better techniques as well as lower investment and subsequent costs. With the most modern **SONO-WZ** probe for measuring water content in fresh concrete directly on site, a new chapter of moisture measurement was opened for challenging aims.

At this point it should also be noted that there are two weak points in the production-chain in concrete plants:

1. Conventional sand moisture probes respond with significant measuring errors due to following influences: Variations in the grain size distribution, abrasion of the moisture probe´s surface, fluctuating bulk heights and some other disturbance effects.

2. When mixing concrete, the water content of gravel could not be measured by previous moisture probes. Not only sand but also gravel and grit have to be measured with an accuracy of ±0.1%. A moisture value of 2% in gravel means a water content up to 25 liters per m^3, dependent on the recipe. Therefore, to complying with standards it is necessary to measure gravel moisture also for manufacturing ready mixed concrete.

The new and innovative aggregate moisture probe **SONO-VARIO Xtrem** from IMKO cannot be influenced by the above mentioned disturbance effects. For the first time ever it is possible to measure sand and gravel moisture with high precision. Concrete recipes can comply with tolerances of ±2 liter water per m^3, long-term stable without the need of a recalibration for the moisture probe.

Press release January 2016: IMKO GmbH, Phone: +49-7243-59210 info@imko.de

For downloading catalogues of the SONO-Probe series please take a look to the following link:
http://www.imko.de/en/support/catalogues