

## Comparison of non-destructive moisture measurement methods on cement and calcium sulphate based screed samples

Sabine KRUSCHWITZ<sup>1</sup>, Rüdiger FELDMANN

<sup>1</sup>BAM, Federal Institute for Materials Research and Testing, Unter den Eichen 87, 12205 Berlin, Germany,  
Phone +49 30 8104 4234, Fax: +49 30 8104 1447; e-mail: [sabine.kruschwitz@bam.de](mailto:sabine.kruschwitz@bam.de)

### Abstract

Measuring the moisture content of floor screeds is usually done with minor destructive testing methods like Darr drying or the Calcium Carbide (CM) method. These require small samples, deliver only punctual information and still have proven not to be very reliable. Hence, a study has been made using the standard destructive tests as well as a suite of non-destructive testing methods working out their use for moisture determination. In this study five partners from research institutes and industry worked together and intensively researched different technologies.

The main focus was put on the varying sensitivity of the measuring techniques in different moisture ranges. Especially for low moisture contents (or 'critical' moisture contents when the screed is dry enough to be covered with the final floor finish), several commercial devices including the most commonly used CM-method failed to determine the correct moisture content for cementitious samples. Hence the need for more accurate, if possible non-destructive methods is high, taking also into account that the chemistry (and physical properties) of screeds may vary strongly depending on their origin and purpose.

**Keywords:** moisture, screed, multi-sensor, capacitive methods, electrics, monitoring

## 1. Introduction

In a joint experiment with other research and industry partners the performance of the classical destructive moisture testing methods (Darr and CM, see also [1]) were compared with the results obtained with ndt techniques. In [2] it is shown how poorly the classical sampling and gravimetric or chemical moisture determination may perform – but these problems are at least in Germany well known as also the way of sampling may strongly influence the results. The critical moisture ranges, where the screeds are ready for flooring are 3.5 M% for cement based screeds and 0.5 M% for calcium sulphate based screeds. These are very low moisture contents which for many testing devices are difficult to determine reliably. This paper presents some of the results we obtained focusing on capacitive and electrical methods – the according poster contains more information also on ground penetrating radar and microwave and relative humidity sensors. A comparison of the findings is also discussed in [2].

## 2. Experimental

Three series of experiments were carried out so far. For the first series (MR1) 24 cement (CT) and calcium sulphate (CA) based screed samples were prepared, 12 of them with 35 mm thickness and 12 of 70 mm thickness. The sides and bottom parts were sealed in order to only allow for 1D drying to the top. The samples were stored for several months in a climatic chamber at 50% relative humidity and a temperature of 20°C. In MR1 the samples were measured during drying and hardening on a regular basis until they were about 150 days old. At the end of this series all samples were Darr dried until weight stability. A second series of measurements MR2 was started in order to separate material property changes due to hydration from those due to changing moisture contents. Hence, we re-saturated the samples after Darr drying and repeated the experiment using the 150 days old (to the greatest extent hydrated) samples. For MR3, the third series of measurements, we prepared new CT and CA

samples only of 70 mm thickness and used similar mixtures like in MR1. We compared the most promising methods with a few new sensor types like air humidity sensors and multiring-electrodes. The multiring-electrode (MRE) is a resistivity based sensor for the determination of vertical moisture gradients. It was intended to use it to study moisture transport phenomena within the samples and hence depth sensitivity of the used non-destructive testing methods.

Table 1: Overview of the series of measurements carried out on the screed samples.

Series of measurements	Description
MR1	samples tested during hydration and drying
MR2	samples from MR2 (appr. 160 days old) re-saturated and tested during drying
MR3	samples (different screed mixtures) tested with new sensors types during hydration and drying

### 3. Results

The drying behavior of the samples during the three series of measurements is shown in Fig. 1. The fast changes of the moisture contents always signify the beginning of the oven drying phases towards the particular ends of the tests. The diagrams show clearly that the spreads for the sets of cement based samples is usually much larger than for the calcium sulphate ones indicating that the cement based material is more inhomogeneous.

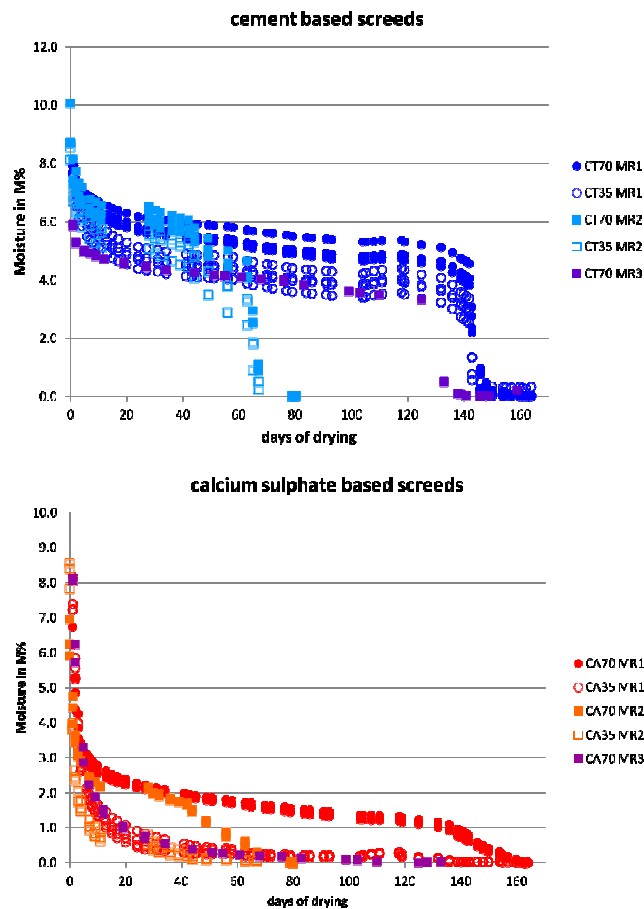


Figure 1. Moisture content of the cement based (CT, top) and calcium sulphate based (CA, bottom) samples during the three series of experiments MR1 - MR3. The thickness of the samples was either 70 mm or 35 mm (comp. legend).

The results we obtained with a Hydromette probe type Compact B from *Gann* [3] are displayed in Fig. 3. The probe uses a ball-capacitor and records changes in the dielectric permittivity of a medium. The sensor seems to be very sensitive in the particular critical moisture ranges (3.5 M% for CT and 0.5 M% for CA) for both the cement based and the calcium sulphate based samples. The thickness of the samples does not influence the results, which suggests that the sensor penetrates the sample adequately. It should be noted though that for very low moisture contents accuracy problems were noted for CT samples and in the very high moisture range for CA samples.

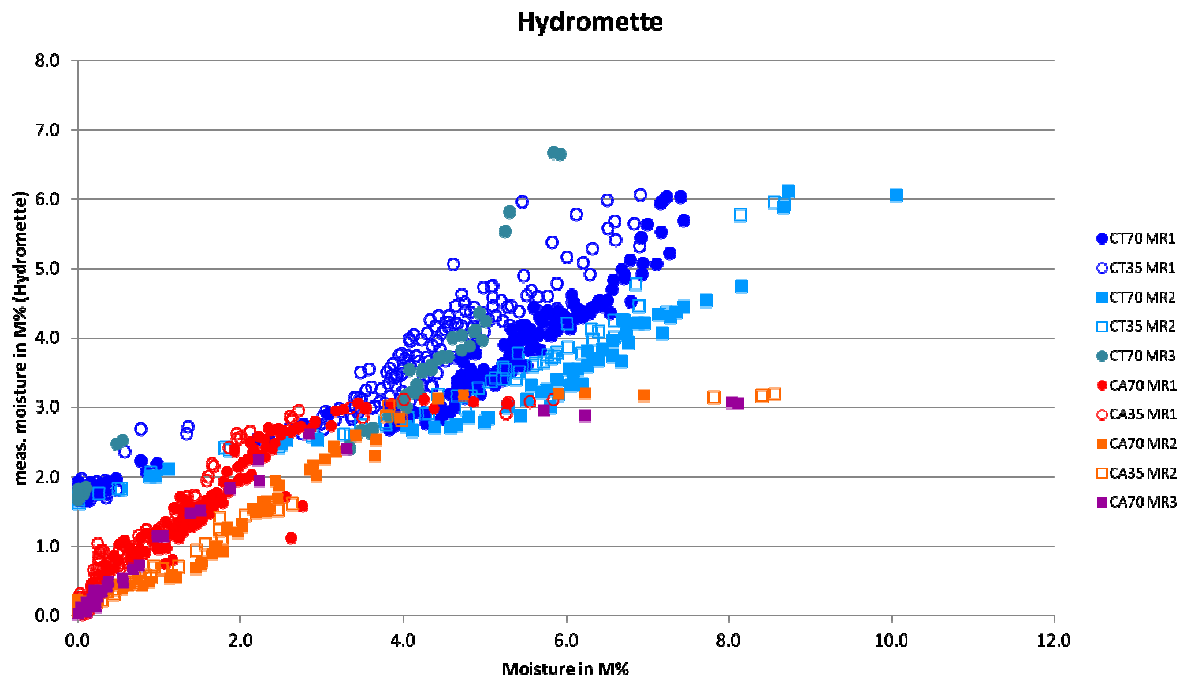


Figure 2: Moisture contents measured with a Hydromette Compact B probe from *Gann* for cement based (CT) and calcium sulphate based (CA) samples during three series of experiments MR1 – MR3.

The results obtained with the galvanically coupled Wennerprobe from *Proceq* [4], which determines the electrical resistivity of a medium, is depicted in Fig. 3. Like for the Hydromette the cement based samples show a larger spreading of the curves. In the critical moisture ranges we observe specific electric resistivities of about 500-2000 kOhms\*cm, which is close to the upper limit of resistivities which can be measured with this device. In electrical measurements only the liquid water content present a medium can be detected and not the gaseous water content (rel. humidity). The multiring-electrode (MRE) is a device which works very similar and determines the electrical resistivity along a height profile. We intend to use the results from MREs for moisture transport studies using simulation tools.

Besides the use of capacitive and electric commercially available probes we involved ground penetrating radar (GPR) and microwave sensors. The signal parameters we find promising will be discussed further and pros and cons highlighted. Another technique with good prospects for fast and reliable practical use to monitor relative moisture changes and determine equilibrium states seem to be embedded relative humidity sensors. Our experience has shown that this type of sensor is capable to measure very low moisture contents. All this findings are intended to be combined and develop comprehensive moisture transport models for different screed types.

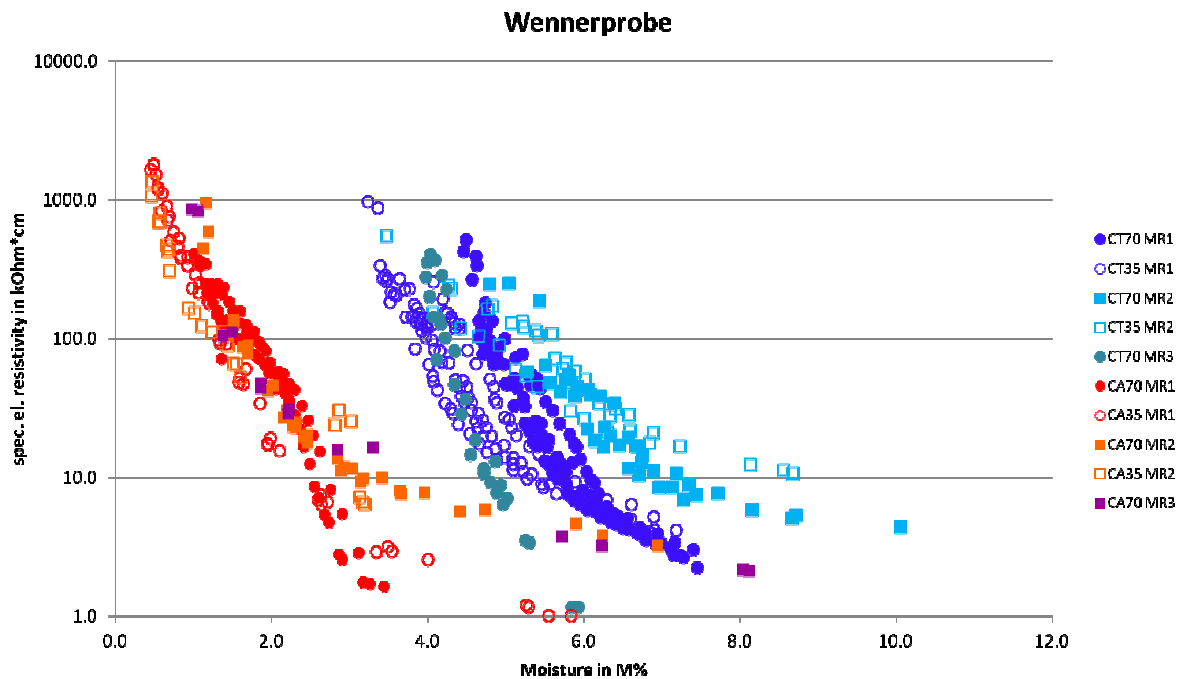


Figure 3: Specific electric resistivities measured with a Wennerprobe form *Proceq* for cement based (CT) and calcium sulphate (CA) based samples during three series of experiments MR1-MR3.

## 4. Conclusions and Outlook

In our study we compared different ndt methods like capacitive and electric handheld devices, but also microwave and GPR for screed moisture determination. We worked with cement and calcium sulphate based samples and addressed signal parameter and according the sensitivity ranges where we find them to be correlated well to changing moisture. The classical destructive tests Darr and CM proofed to perform well for calcium sulphate screeds, but failed completely for the cement based screeds. In our study the cement based screeds generally showed much greater scattering of parameters than calcium sulphate based screeds probably due to inhomogeneities (variations of porosity, pore sizes, amount of aggregates etc.). Future work will involve a more comprehensive feasibility study also using relative humidity sensors and working towards a multi-sensor data fusion analysis.

## References

1. BEB-Merkblatt: CM-Messung (2007), edition Jan. 2007, Bundesverband Estrich und Belag e. V., Troisdorf.
2. Kruschwitz, S. 2015, NDT-CE 2015, Proceedings, Berlin, Germany
3. Gann website as of August 31<sup>st</sup>, 2015:  
[http://www.gann.de/Portals/0/Attachments/Catalogue\\_11.2014\\_V3.13\\_EN\\_s.pdf](http://www.gann.de/Portals/0/Attachments/Catalogue_11.2014_V3.13_EN_s.pdf)
4. Proceq website as of 31<sup>st</sup>, 2015, sales flyer of,  
[http://www.proceq.com/fileadmin/documents/proceq/products/Concrete/Resipod/English/resipod\\_SF\\_E\\_2013.06.19\\_low.pdf](http://www.proceq.com/fileadmin/documents/proceq/products/Concrete/Resipod/English/resipod_SF_E_2013.06.19_low.pdf)