

Read me

Authors: Christoph Strangfeld (a), Carsten Prinz (a), Felix Hase (a), Sabine Kruschwitz (a,b),

Affiliations: (a) Bundesanstalt für Materialforschung und -prüfung, Unter den Eichen 87, 12205 Berlin, Germany; (b) Technische Universität Berlin, Gustav-Meyer-Allee 25, 13355 Berlin, Germany

Contact email: christoph.strangfeld@bam.de, sabine.kruschwitz@bam.de

Objective

Data of embedded humidity sensors, sample weights, and measured pore volume distribution for eight screed types

Data

All examined screed samples are listed in the overview (pdf-file). Eight different screed types are investigated, including four cement-based and four calcium-sulphate-based screeds. Each screed type consists of three test samples. The first two samples of each screed type are equipped with embedded sensors, the third one was investigated destructively. The weight of the screed samples over time is documented. The corresponding data of the embedded humidity and temperature sensors are given. Furthermore, the data of the pore volume distribution of each screed type based on gas sorption and MIP is documented.

Type of data: Humidity data, porosity, pore volume distribution, sample weight

Data format: txt, csv, rpt, pdf

Experimental Design, Materials and Methods

Each sample label starts with a D and is followed by a distinct sample number. This sample number is the reference for all measurement data. The sample weight during screed hardening, hydration, water evaporation and oven drying is given in txt-files in the folder "sample weight". A high precision balance with a maximum load of 72 kg and an accuracy of 0.1 g is used. The file name represents the date of measurement. During some measurement days, not all samples are measured. The third sample of each screed type, e.g. D-03, is investigated destructively. Thus, significant sample weight deviations occur due to extraction of sample material. From these samples, material for porosity measurements is extracted as well. Two methods are used to investigate the pore volume distribution. The mercury intrusion porosimetry (MIP) applies test pressures between 0.01 MPa and 400 MPa [5]. The conversion from pressure to a certain pore diameter includes the Washburn equation [8]. The measurement procedure is the exact reproduction of the international standard [5]. The calculated pore diameter starts at approximately 100 μm and the sensitivity is recorded up to a minimum pore diameter of approximately 4 nm. The measurement data are given in a csv-format in the folder "MIP mercury intrusion porosimetry". In the csv-file, the relevant data are listed in a table called "experimental data". Column E as "pore size" and column F as "specific pore volume" (cumulated) are used for the prediction of the pore saturation [7]. The other used method is gas adsorption [2][6] based on the physisorption of nitrogen gas at 77 K in a pressure ranges of 4.5 mbar to 1 bar. The conversion from pressure to a certain pore diameter is based on the BJH theory [1]. The BJH theory includes the layer thickness of the adsorbed nitrogen according to

Halsey [3] and the Kelvin equation for calculating the pore radius. The measurement procedure is the exact reproduction of the international standard [6]. The measured pore radii range between 0.8 nm and 100 nm. The measurement data of interest are listed in the rpt-data files in the folder “BET gas adsorption”. In the rpt-file, the table of interest has the title “BJH Adsorption Pore Distribution Report”. The second and third column titled “average diameter” and “incremental pore volume” are relevant for moisture calculations [7]. Although MIP is more appropriate for larger pore and gas adsorption for micropores, both methods overlap each other in the mesopore range of approximately 2 nm to 100 nm. Thus, a sensible combination of the two porosimetry results has to be found for further analysis regarding the moisture calculations [7].

The humidity and temperature data are saved in the folder “embedded sensors”. Only non-destructively tested samples are equipped with embedded sensors. The temperature sensors are MCP9700A three-pin thermistors and the humidity sensors are HIH-5031 sensors [4]. All sensors are in surface mounted device design. The thin samples contain 5 sensors, the thick samples 10 sensors. For each sample, one txt-file with all sensor data exists. The first column shows the date, the second the daytime. Then, the temperature data and the corresponding standard deviation of each sensor are listed. The humidity data are given in percent. The first column with humidity data represents the topmost sensor in the sample. Every humidity value stands for a mean value of 160 single measurements recorded with 16 Hz over 10 s. The standard deviation of these measurements is given in the data file as well. The last columns represent measurements of the electrical resistivity and electrical capacity based on the measurement of embedded multi-ring electrodes. If the measured temperature increases to 40 °C or 105 °C, the samples are placed in the drying oven to get the final dry mass.

Acknowledgements

The authors are grateful to Sarah Nagel for taking several measurements of the screeds over months.

References

- [1] E. P. Barrett, L. G. Joyner, P. P. Halenda, “The determination of pore volume and area distributions in porous substances. I. Computations from nitrogen isotherms”, *Journal of the American Chemical Society* 73 (1) 373–380 1951, doi:10.1021/ja01145a126.
- [2] DIN, „66134 : 1998-02: Bestimmung der Porengrößenverteilung und der spezifischen Oberfläche mesoporöser Feststoffe durch Stickstoffsorption“, German Standard, 1998
- [3] G. Halsey, „Physical adsorption on non-uniform surfaces“, *The Journal of Chemical Physics* 16 (10) 931-937, 1948, doi:10.1063/1.1746689
- [4] F. Hase, „Design und Aufbau verschiedener Messsysteme zur Ermittlung des Feuchtigkeitsprofils von Estrich“, Bachelor thesis, Hochschule für Technik und Wirtschaft Berlin, 2016
- [5] ISO, „15901-1:2016(E): Evaluation of pore size distribution and porosity of solid materials by mercury porosimetry and gas adsorption - Part1: Mercury porosimetry“, International Standard, 2010
- [6] ISO, „ISO 15901-2:2006(E): Pore size distribution and porosity of solid materials by mercury porosimetry and gas adsorption - Part 2: Analysis of mesopores and macropores by gas adsorption“, International Standard, 2006
- [7] C. Strangfeld and S. Kruschwitz, „Monitoring of the absolute water content in porous materials based on embedded humidity sensors“, *Construction and Building Materials*, in press
- [8] E. W. Washburn, „The dynamics of capillary flow“, *Physical review* 17 (3) 273-283, 1921, doi: 10.1103/PhysRev.17.273