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Analysis of Selected Water Absorption Coefficient Measurements

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ABSTRACT: For isotropic materials with a significant fraction of micro-pores, the cumulative water intake per unit of inflow surface area typically yields a linear function of the square root of time elapse. The authors postulate that this dependence has a limited range of validity. The validity of this approximation starts from an initial period that is inversely proportional to the rate of water intake and ends much before the material reaches the capillary moisture content.

Experimental investigation presented here uses a differential presentation of the cumulative water inflow and clearly indicates that material such as calcium silicate or brick belong to a broad class of materials characterized by a constant water absorption coefficient (A-coefficient). Initial period varies from $\frac{1}{2}$ to 4 minutes. On the other hand, materials with a multiple pore-system such as an Aerated Autoclaved Concrete (AAC) may display a systematically varying A-coefficient. Authors propose a test procedure limited to 1-hour duration that can be used to derive a practical and reproducible value of A-coefficient.

KEY WORDS: free water intake, water intake test, cumulative water intake, water absorption coefficient, A-coefficient, imbibition process, capillary water flows, capillary moisture content.

INTRODUCTION

THE PROCESS OF free water intake (imbibition) involves placing a material with its sides sealed in contact with a free water surface. Water enters

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the bottom surface of the specimen, and the weight increase of the specimen is measured during the progression of the free water intake process. For an isotropic material with a significant fraction of micropores, the cumulative water intake per unit of inflow surface area (kg/m^2) is plotted as a function of the square root of time ($t^{1/2}$) yielding the following equation:

$$I = A_0 + A_w\sqrt{t} \tag{1}$$

The model remains valid as long as the following empirical parameters are satisfied:

- the cross-sectional area parallel to the absorbing surface (perpendicular to the direction of liquid inflow) is constant,
- the specimen height is small in comparison to the capillary suction so that the effects of gravity are negligible,
- the immersion depth is small and the water level is maintained at a constant level, typically between 1 and 2 mm above the lower surface of the specimen,
- the possible multidirectional inflow at the lower surface of the specimen created by imperfect sealing at the bottom edges has a negligible effect on the waterflow into the specimen,
- the support system on the lower surface of the specimen has a negligible effect on the waterflow into the specimen,
- a uniform contact between the specimen and the liquid is maintained throughout the test (e.g., no air bubbles are deposited at the specimen surface exposed to water),
- evaporation from the specimen's upper surface is reduced (e.g., by using a plastic cover).

On the other side, to calculate the A-coefficient in the manner consistent with other measurements of moisture profiles, all the requirements for the Boltzmann transformation must be satisfied:

1. the waterfront should not have reached the opposite surface of the specimen,
2. the moisture content at the surface in contact with water is constant (i.e., reaching the capillary moisture content and remaining at this level), and
3. the height of the specimen is only a fraction of its maximum capillary height for the tested material.

Hence during the initial period of free water intake, when the moisture content on the material surface changes from an initial hygroscopic equilibrium to the level of the so-called 'capillary moisture content' (see later discussion) the second requirement is not satisfied. Furthermore, as demonstrated by Descamps (1997), the initial surcharge of water even under a small water head of 2 mm, causes an increase in the air pressure just ahead of the waterfront. While the air pressure peaks and decays rapidly (within few seconds), the rate of decay in the air over-pressure depends on the air permeability and height of the specimen. Therefore, it is necessary to disregard the initial period and start the A-coefficient calculations after an initial time (after satisfying the second requirement for Boltzmann transformation and attaining a similitude in the spatial moisture profiles).

The concept of initial time (t_o) is introduced as the starting point for A-coefficient calculations. This simplifies Equation (1) to Equation (2):

$$A_w = \frac{(M_1 - M_o)}{A\sqrt{t}} \tag{2}$$

where, A_w is the water absorption coefficient, A is the surface area of the cross section of the specimen, M_1 and M_o are mass of the specimen measured at times t_1 and t_o, respectively.

Now, several questions are posed. First, we have introduced in Equation (2) initial time t_1; – what period can one use for the initial time t_1? Is it a matter of days or hours, i.e., one or few days or one or few hours? Second, does this period depend on the material structure? Third, the moisture content at the lower boundary of the specimen is not stable. Water flowing through the lower surface of the specimen brings its moisture content much above the so-called capillary moisture content and closer to the full material saturation. How much would this fact affect the duration of the allowable period t_1?

All these questions can only be answered through the analysis of experimental results. This paper reviews the current state-of-the-art methodology in determining the A-coefficient, starting with the examination of the sources of uncertainties in the measured results.

SOURCES OF UNCERTAINTY IN A-COEFFICIENT MEASUREMENTS

Possible sources of uncertainty in A-coefficient measurements are:

1. Deviations from the strictly one-dimensional (1-D) waterflow, and in particular:
   - effect of different geometries i.e., shape, and size of the specimen,

- effect of different sealing materials i.e., wax, epoxies, wet caulking, and low permeability coatings that are used on the sides of the specimen to ensure 1-D air and waterflows
- type and area of the support at the bottom surface of the specimen,
- conditions on the top surface i.e., air pressure ahead of the advancing waterfront (typically the optimum is achieved with a 1-mm airspace above the top surface, created with a sheet of plastic film, perforated to provide air pressure equalization).

2. Method of specimen preparation including:

- effect of differences in the specimen conditioning prior to the test and resulting in variation of the initial moisture content,
- effect of roughness of the bottom surface on the liquid inflow.

3. The procedures applied during the actual testing, in particular:

- manual or automatic measurements of mass increase caused by water inflow,
- method of ensuring the stability of the water level,
- effect of mean temperature applied during the test,
- effect of temperature fluctuations during the test,
- effect of break in the water inflow process for a period required to conduct manual weighing including: removal of the specimen, surface blotting, measurements with a balance, and replacing the specimen in a test tank, versus an automatic balance providing the mass increase without removal from the water tank,
- effect of the manner in which the excess of water is removed from the lower surface of the specimen for example, with different types of dry or prewetted paper towels or fabrics.

Recently, there has been a lot of interest for the reduction of uncertainties in the determination of A-coefficient. This is caused by the difficulties encountered in the direct measurement of liquid capillary conductivity. One prefers an indirect approach in which the measured A-coefficient forms the basis for calculations leading to a more or less optimized value of the liquid conductivity. The most notable example of such a work was the interlaboratory comparison (Roels et al., 2003), that involved three building materials: calcium silicate, clay brick, and aerated autoclaved concrete. Those materials were chosen because of the difference in material homogeneity, mean pore size, pore-size distribution structure, and the complexity of pore systems.

Calcium silicate plate is a capillary-active thermal insulating material utilized in the retrofit applications of masonry buildings. The material possesses high capillary absorption coefficient and capillary moisture content. It is largely composed of synthetic mineral xonotlite, a complex calcium silicate hydrate (Hamilton and Hall, 2003). Calcium silicate plate is a homogenous material with a micropore structure. The total open porosity of the clay brick is much lower. Owing to the nature of the material and its production process, one can expect a higher variability of the material properties compared to calcium silicate plate.

Aerated autoclaved concrete (AAC), also known as cellular concrete, has a complex multiphase structure (Alexanderson, 1979; Kooi, 1971; Prim and Wittmann, 1983; Roels et al., 2002). The pore system in AAC includes large spherical macropores with a diameter up to 1 mm formed as a result of mass expansion due to aeration and micropores within the material matrix (Tada and Nakano, 1983).

These macropores and air voids play a significant role in reducing the quantity of moisture that enters the pore matrix under capillary forces. The AAC was selected for testing because of its complex pore structure. To avoid differences caused by the production process, the same batch of product was used for all samples sent to the participating laboratories.

In presenting the results (Roels et al., 2003) stated:

> 'Ceramic brick and calcium silicate plate show a distinct first and second stage; twice a linear relationship between cumulative inflow and square root of time. For this kind of materials the determination of the capillary absorption coefficient and capillary moisture content appears to be reliable, though it is less reproducible than a vacuum saturation test. To determine the capillary moisture content and capillary absorption coefficient for the AAC appeared to be very difficult, as the cumulative inflow versus square root of time is not linear . . . a distinction between first and second stage of the process becomes somewhat arbitrary.'

Therefore, additional experiments were carried out on ceramic bricks. This time, however, the specimen preparation and test procedures were much better defined and a strict weighing scheme was designed in such a way that an equidistant square root of time interval was obtained. Each of the three laboratories performed at least three additional free uptake experiments. The results showed a very good agreement for calcium silicate (mean values were 1.18, 1.19, and 1.18 $\mathrm{kg/m\,s^{1/2}}$, respectively). In the analyzed case, it was noted that, the method of surface sealing was affecting the results and a good agreement was obtained for specimens with the same type of surface sealing. This observation highlighted the need for an improved definition of the test procedure.

UNCERTAINTY IN A-COEFFICIENT MEASUREMENTS WITH CALCIUM SILICATE

Using the same calcium silicate batch, additional tests were performed to examine the relative significance of the different experimental parameters. These parameters included: method of gravimetric data collection (i.e., manual vs. automatic means of measuring the specimen's water mass increase), changing the operator, changing the size of the specimen, different types of side protection, and different initial moisture content. First, the manual and automatic method of determining mass increase in the tested specimen was compared in Figures 1 and 2. Figure 2 shows a derivative of the cumulative inflow in relation to the square root of time, i.e., the stability of A-coefficient value during the progression of the free water intake process.

Even though a fewer data points were used in the manual method of data collection, the results indicate a good agreement between the manual and automatic modes of data collection. It is clear that performing manual measurements may produce results as good as those generated with an automatic experimental setup.

Since the manual method allows for a greater number of specimens to be tested at the same time, it was then utilized in examining the effects of change of the operator and different levels of initial moisture content. The results indicated that when different operators have performed free water intake test following the same standard operating procedure, the results were in agreement with each other.

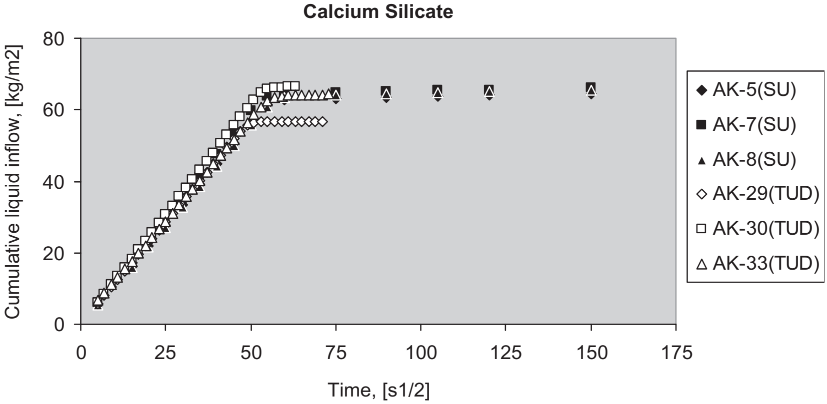

Figure 1. *Cumulative liquid inflow in calcium silicate measured manually (SU) and automatically (TUD).*

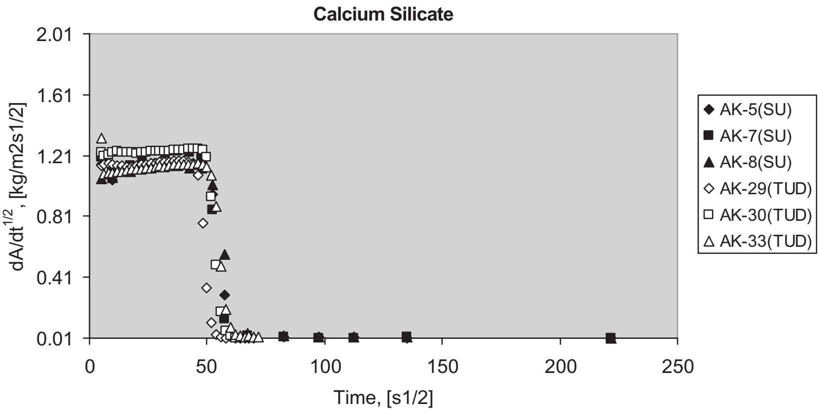

Figure 2. *The derivative of A-coefficient for calcium silicate plotted as a function of the square root of time as from manual (SU) and automatic measurements of mass increase (TUD).*

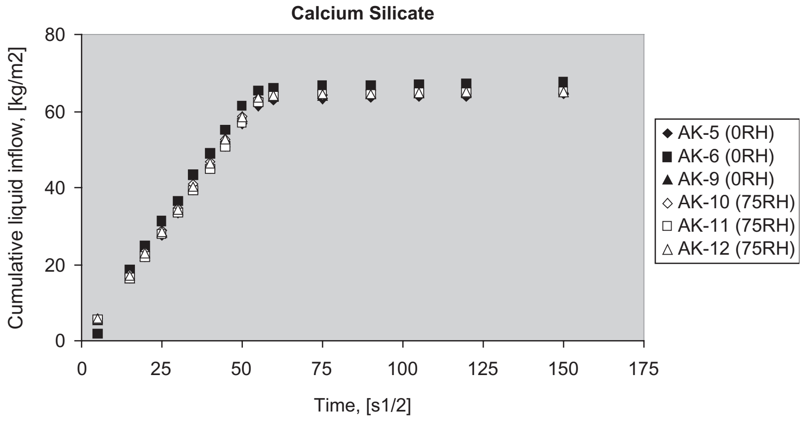

Figure 3. *Cumulative liquid inflow plotted as a function of square root of time as for specimens with initial moisture content at 0 and 75%RH.*

Subsequent experiments involved a change in the initial moisture content. One set involved dry specimens (conditioned for 21 days in an airtight container over anhydrous calcium chloride, which maintained a near 0% relative humidity). The second set was stored in an airtight container over saturated sodium chloride solution, which maintained equilibrium conditions of at near 75%RH. The results are summarized in Figures 3 and 4.

Figure 3 shows a traditional manner of presenting results. Figure 4 shows the same results presented in the manner used at Syracuse University. Figure

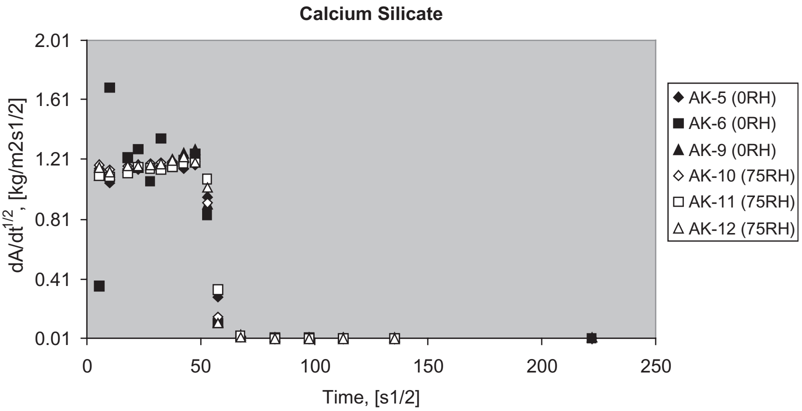

Figure 4. *The derivative of A-coefficient vs square root of time for test series performed with specimen with initial moisture content at 0 and 75%RH.*

4 shows a scatter of data points for the AK-6 specimen even though the plot of cumulative water inflow as a function of the square root of time in Figure 3 shows a good agreement. This indicates that the first two data points obtained on the AK-6 specimen should not be included in the determination of the A-coefficient. The new method of presenting results showed a greater sensitivity and displayed individual variations that were not visible in the cumulative plots used in the traditional manner of presenting water absorption results. Figure 4 also shows that varying initial moisture content within a hygroscopic range had no effect on the measured A-coefficient.

Other Works on the Evaluation of Uncertainty in A-Coefficient Measurements

A large number of student projects at Concordia and Syracuse Universities analyzed uncertainty in A-coefficient measurements, and AAC in particular. Huang (2003) and Liu (2003) conducted two ruggedness studies with similar parameters being evaluated and with the same batch of AAC. Tables 1 and 2 show the parameters evaluated in free water intake tests performed by Huang (2003).

The reference *t*-value for 95% statistical significance and seven degrees of freedom is 1.90. The calculated *t*-values greater than 1.90 (see Tables 1 and 2) were statistically significant. The data indicates that with the exception of the immersion depth, specimen height, and number of readings, other factors showed a significant effect.

The above study supports the conclusion of Roels et al. (2004) who stated:

Table 1. Parameters evaluated in the first series of ruggedness tests and the resulting t-factors for the listed parameters.

Factor	Evaluated Parameters	Setting Low (−)	Setting High (+)	*t*-Factor
A	Side protection	Duct tape	Wax	30.12
B	Immersion depth	1 ± 0.5 mm	3 ± 0.5 mm	1.49
C	Drying the wet surface	Natural	Paper towel	9.90
D	Initial moisture content	70%RH	0%RH	4.09
E	Delayed weighing	5-min delay	Immediate	2.90
F	Roughness of the inflow surf.	Grooved	Smooth	2.35
G	Calculation model	1-P model	2-P model	8.82

Table 2. Parameters evaluated in the second series of ruggedness tests and the resulting t-factors for the listed parameters.

Factor	Evaluated Parameters	Settings Low (−)	Settings High (+)	*t*-Factor
H	Material thickness	20 ± 0.5 mm	50 ± 0.5 mm	0.22
I	Initial time of weighing	Excluding zero	Including zero	8.02
J	Water level stability	Periodic check	Constant level	3.60
K	Period of testing	24 h	2 h	8.71
L	Evaporation – top surface	Restricted	Unrestricted	3.49
M	Number of readings	5 points	3 points	1.45
N	Surface area	$100 \times 100\,\text{mm}^2$	$50 \times 50\,\text{mm}^2$	3.15

> ‘for AAC no linear behaviour of cumulative inflow as a function of square root of time was found. All test data of cellular concrete showed noticeable curvature and force fitting to subsets of data, as performed by the different laboratories, resulted in a poor agreement of the absorption coefficient values.’

Some findings in these student projects may be questionable because the height and the surface area were varied in the same ruggedness test. As the Plackett–Burman ruggedness test can only determine the main effects for noninteracting variables, the introduction of a known interaction may obscure the obtained ratings. Yet, Huang (2003) showed that calculating the absorption coefficient from a cumulative liquid inflow taken at different time periods led to significant differences. He also showed that a two-parameter model, which assumes a systematic variation of A-coefficient was found to describe the process much better than that of a constant A-coefficient.

Liu (2003) repeated some of the ruggedness parameters on specimens with the same thickness (Table 3).

Table 3. Parameters evaluated in ruggedness tests performed by Liu (2003).

Factor	Evaluated Parameters	Settings		t-Factor
		Low (−)	High (+)	
A	Surface area	$90 \times 90\,mm^2$	$50 \times 50\,mm^2$	10.95
B	Immersion depth	2 ± 0.5 mm	15 ± 0.5 mm	1.07
C	Drying the wet surface	Paper towel	Natural (1 min)	3.45
D	Initial moisture content	0%RH	75%RH(1)	1.67
E	Evaporation – top surf.	Restricted	Unrestricted	1.18
F	Length of test	1 h	4 h	3.62

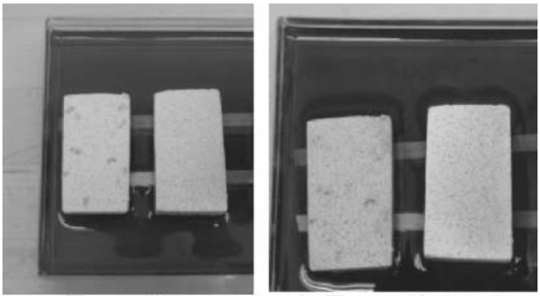
a. Time = 10s b. Time = 3h:15 min

Figure 5. *Digital images of AAC specimens' top surfaces taken at 10 s and 3 h after the start of the test.*

As this study restricts the duration of the process to 4 h (i.e., to a short time) one may observe that the relative significance of conditions on the top surface and that of the initial moisture content is low. These factors are not found significant under the conditions analyzed in the test.

Pazera (2004) restricted the period of testing AAC to a few hours and examined the significance of varying the thickness of the AAC specimen. First, a pilot test was performed with a dissolved food coloring and AAC specimens having two arbitrarily selected heights (7 and 25 mm) to determine the period until water can be observed on the upper surface of the specimen. Figure 5 shows the digital images of the top surface of the specimen taken during the test.

Figure 5 indicates that the waterfront appears on the upper surface of the 7-mm specimen 10 s after the test was started. For a specimen of height 25 mm the waterfront does not appear on the upper surface even after 3 h. Since for any diffusion-based process (Bomberg, 1990) one expects the Fourier number to be constant and time should be proportional to the second power of thickness i.e., $10 \times (25/7)^2 = 127$ s i.e., less than 3 min.

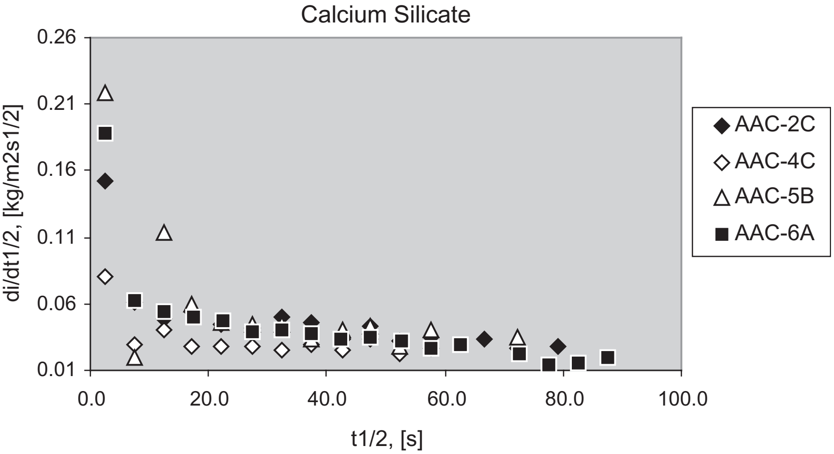

Figure 6. *The derivative of A-coefficient plotted as a square root of time for specimens with different thickness (2C – 16 mm, 4C – 19 mm, 5B – 25 mm, and 6A – 13 mm).*

If the specimen thickness exceeds the capillary rise, the waterfront does not reach the top surface, and the mass increase is a combination of water ingress due to the capillary forces and redistribution within the material.

As the limit of capillary rise was found to be less than 25 mm, a series of water intake tests was performed with the same cross-sectional area (approximately 40 mm by 40 mm) but with a different thickness of the specimen. Figure 6 shows the derivative of A-coefficient for specimens with different thickness, namely: 6A – 13 mm; 2C – 16 mm, 4C – 19 mm, and 5B – 25 mm.

The data shows a good agreement for the derivative of A-coefficient using specimens with different thickness and confirms the findings of Huang (2003) that the critical thing in testing AAC was to limit the specimen thickness and duration of the test. In addition, it is clear that with the exclusion of initial data points, a period of time exists during which the derivative of A-coefficient is relatively stable. With reduced specimen thickness, the waterfront reaches the top surface of the specimen much faster, allowing the tests to be completed before it becomes dominated by another mechanism of moisture flow.

ANALYSIS OF SELECTED A-COEFFICIENT MEASUREMENTS

The duration of free water intake depends on the specimen's height. Because of a simplification used in its definition, the water absorption coefficient should be measured during the initial stage of water inflow into a dry specimen. While earlier discussion indicated that it is necessary to disregard the initial period and start the A-coefficient calculations following some initial time, this time has not been postulated as it may depend on the material structure. On the other hand, the analysis of AAC indicated that if the same test method is postulated for different materials it must be restricted to the initial stages of water intake process.

Currently some material standards require a 24-h period of immersion process (e.g., DIN 52617). Prescribing such a long test period to all materials has many significant implications:

1. Moisture content at the bottom surface of the specimen increases much above the capillary moisture content because the flowing water eliminates air entrapped in the material. When the test is carried over a long period, the transition layer at the water ingress face (where the moisture content exceeds the capillary moisture content) becomes thicker and may introduce significant deviations from the theoretical solution.
2. For a number of porous materials, the first stage of the process in which capillary forces comprise the driving force for water inflow and water vapor diffusion is negligible, is restricted to a short period. This appears to be the case with AAC. For those materials the measured apparent property is not necessarily a valid material characteristic as it becomes dependent on several parameters highlighted in the students' projects (Huang, 2003; Liu, 2003).

We shall therefore review the results of selected measurements to gain some idea about the initial and final time that can be recommended for the determination of A-coefficient.

Initial and Final Time for Clay Brick and Calcium Silicate A-Coefficient Determination

Table 4 lists the initial and final values for the time interval utilized in calculating the A-coefficient for clay brick.

For clay bricks, excluding the initial two data points from the measured results i.e., starting from $15\,s^{1/2}$ (225 s) provides A-coefficient that is constant enough to postulate that this time can be considered as the starting point for A-coefficient determination. For calcium silicate, the corresponding value is much smaller and the second reading obtained $7\,s^{1/2}$ (49 s) into the test appears sufficient.

One may visualize these values on Figures 7 and 8 that show a derivative of A-coefficient for the ceramic brick and calcium silicate, respectively. The specimens selected represent the minimum and median values of A-coefficients from 10 measured replicas.

Table 4. Initial and final times as measured on clay brick and calcium silicate.

Specimen Code	Initial Time, $s^{1/2}$ (min)	Final Time, $s^{1/2}$ (min)
HS-B26 – minimum A	15 (3.8)	45 (34)
HS-B27 – median A	10 (1.7)	55 (50)
HS-B33 – median A	15 (3.8)	50 (42)
HS-B32 – maximum A	15 (3.8)	60 (60)
HS-Ak30 – minimum A	5 (0.5)	47 (37)
HS-Ak29 – median A	5 (0.5)	42 (30)
HS-Ak28 – median A	5 (0.5)	50 (42)
HS-A33 – maximum A	5 (0.5)	48 (38)

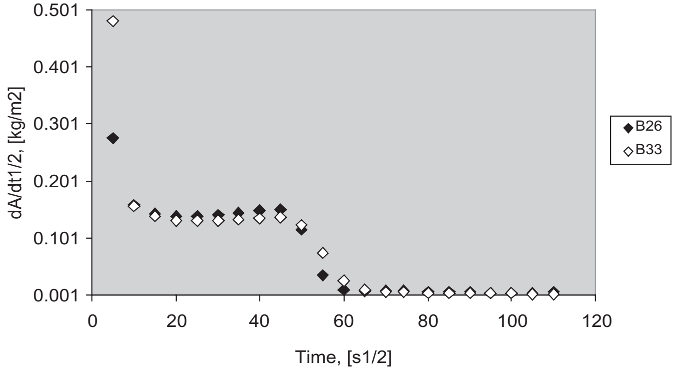

Figure 7. *A-coefficients calculated for ceramic brick specimens: B-26 (minimum A-coefficient), and B-33 (median A-coefficient). Specimens B-26 and B-33 had densities of 1943 and 1957 kg/m^3, respectively.*

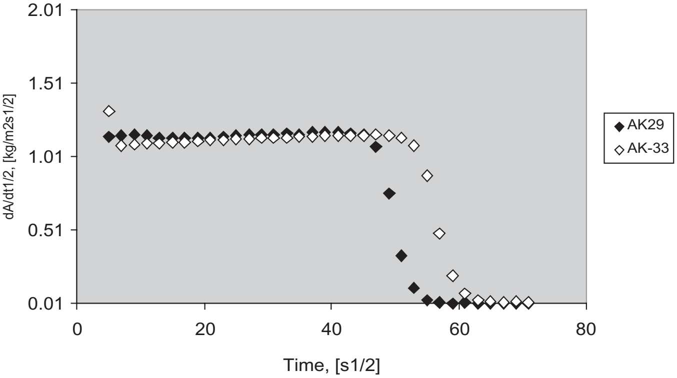

Figure 8. *A-coefficients calculated for calcium silicate specimens: AK-29 (minimum A-coefficient), and AK-33 (median A-coefficient). Specimens AK-29 and AK-33 had densities of 319 and 288 kg/m^3, respectively.*

Table 5. Clay brick–comparison of A-coefficients.

Specimen	A_w (kg/m^2 s$^{\frac{1}{2}}$)	A_o (kg/m^2 s$^{\frac{1}{2}}$)
HS – B 26	0.1559	0.1749
HS – B 27	0.1348	0.1576
HS – B 28	0.1337	0.1561
HS – B 29	0.1638	0.1791
HS – B 30	0.1342	0.1662
HS – B 31	0.1535	0.1972
HS – B 32	0.1588	0.2072
HS – B 33	0.1650	0.2159
HS – B 34	0.1415	0.1762
Mean	**0.1490**	**0.1786**

A-coefficient for Clay Brick and Calcium Silicate Determined During the Recommended Test Period

The A-coefficient for clay brick and calcium silicate was now determined as the mean of the values measured between time t_o and t_1, determined between 3 and 45 min for both clay brick and calcium silicate.

Table 5 presents the absorption coefficients calculated with and without the initial period. The latter calculation includes also the limitation of the test period as determined from the differential plots of A-coefficient.

Table 5 also indicates a significant difference in the calculated A-coefficient when different time intervals are considered. Therefore, it is necessary to improve the current test procedure. A proposal based on the experience of the authors is presented.

CRITICAL ELEMENTS FOR INCORPORATION INTO A PROCEDURE FOR A-COEFFICIENT DETERMINATION

While an approach based on long-term absorption measurement is currently used in practice in many countries (e.g., Germany, Canada) this approach is not appropriate for material characterization. A more precise method of determining material characteristics, a method that can also provide the information for input to a HAM model is needed. As presented here the procedure may allow either option of data collection (i.e., automatic or manual) to be utilized. Yet, the required degree of precision can be ascertained in each case.

One of the requirements for the A-coefficient test is to ascertain the stability of the free water surface. Two approaches are suitable

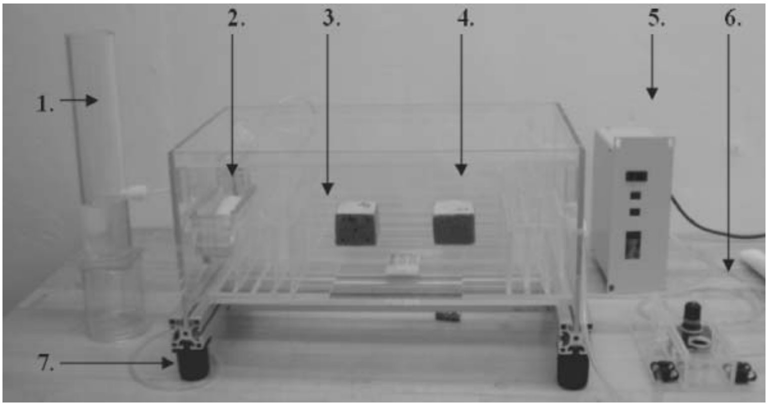

Figure 9. *An inflow and outflow in the tank used for A-coefficient measurement at the SU.*

- using a large tank with an enclosure to limit the evaporation from the free water surface or
- using a tank overflow with a constant water circulation (Figure 9).

As this test provides information on two material characteristics, namely the A-coefficient and the capillary moisture content (the latter will be discussed elsewhere). The stability of the water level should be quantified as less 1 mm per 24 h.

The tank should be provided with a rigid specimen support system, for example, with thin noncorroding plates, machined and set in the tank as leveled within a tolerance of 0.1 mm. An operational overflow system should be designed so that the maximum water level during testing does not exceed 2 mm above the specimen support level.

If an automatic balance is used, two devices should be included in the system. One device would serve as a specimen holder, which would allow the specimen to be leveled to achieve conformance with the above prescribed requirements. The other device accommodates vertical movement of the water tank and provides 1.5 ± 0.5 mm immersion into the water tank at time zero.

Independent from the specifications on the allowed variation in the mean immersion depth, each testing apparatus must be verified to prove the repeatability in the stability of the water level. The difference in the mean value of water immersion depth when three tests are performed in the same laboratory by two different operators should not exceed 0.5 mm.

Two types of test specimens can be used:

- large, either square or round with the side or diameter of 100 ± 10 mm, or
- small, either square or round with the side or diameter of 50 ± 5 mm.

Unless otherwise specified, a test requires an average from a minimum of three large specimens or five small specimens. Specimens should be finished to a smooth finish using grinding wheels or sandpaper.

Two initial conditions are recommended. Procedure (a) requires the specimen to be oven dried (i.e., dried to a constant weight), while procedure (b) accepts conditioning at $32 \pm 2\%$RH (e.g., by using $MgCl_2$) to the equilibrium moisture content. The specimen weight and dimensions should be determined prior to the application of the side protection. The specimen weight should also be determined following the application of both the side protection and the polyethylene covering. Acceptable materials for use as side protection include a paraffin/wax mixture, quick setting epoxies, or other liquid applied coatings (note that self-adhesive tapes are not allowed).

If the overhead balance is used, the space in which the free water intake test is conducted must be enclosed. The relative humidity of the air in the enclosed space above the specimen should not fall below an average of 75%. If the manual method is selected, a plastic film protection of the upper surface of the specimen with a thin air space above the specimen should be incorporated as part of the testing regime. A single pinhole should be introduced into the covering, allowing the air pressure between the specimen's top surface and the covering to equalize. Typically, this space should not exceed 1mm in thickness.

The determination of the A-coefficient from the experimental data requires calculation of the ratio between the difference in mass and the difference in the square root of time between subsequent weightings. The test procedure should require establishment of the following times: t_o and t_1 – the initial and final times for the A-coefficient calculations, and t_2 – time when the increase of mass is stabilized to a small, constant value for the determination of the capillary moisture content.

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