Postprint: Feng C, Janssen H. 2017. The influence of temperature on the capillary absorption coefficient - a confrontation of two recent papers in Building and Environment, *Building and Environment*, 116: 257-258.
doi: http://dx.doi.org/10.1016/j.buildenv.2016.11.049

The influence of temperature on the capillary absorption coefficient

- a confrontation of two recent papers in Building and Environment

Chi Feng[1,2*], Hans Janssen[1]

1. KU Leuven, Department of Civil Engineering, Building Physics Section, 3001 Leuven, Belgium
2. China Academy of Building Research, 100013 Beijing, P.R. China

In April 2016 this journal published our paper "*Hygric properties of porous building materials (II): Analysis of temperature influence*" [1], wherein we – among other things – discussed the dependence of the capillary absorption coefficient on temperature, based on water uptake tests on calcium silicate, ceramic brick and aerated concrete at 11, 22 and 38 °C. Our results agreed with the broadly accepted Lucas-Washburn equation, which asserts that the temperature influence on capillary absorption is governed by the surface tension and the viscosity of water. In September 2016 however, this journal also published the paper "*Effect of temperature on water capillary rise coefficient of building materials*" [2], wherein water uptake tests on 10 different bricks, stones and mortars at 15, 20, 25 and 30 °C were analysed. Based on these results, it was professed that the temperature influence on capillary absorption cannot be solely attributed to surface tension and viscosity, but that the microstructure of the porous material plays a role in this temperature influence as well.

This letter to the editor aims at resolving that conflict. However, given that the journal has strict limitations on the extent of such contribution, we need to be succinct, and we can hence not include all elements of our confrontation here. We have therefore made an extended and detailed comment available via an online repository [3].

Critical review of paper [2]

Paper [2]'s primarily relevant results are found in its Tables 5 and 6. Its Table 5 confronts measured and Lucas-Washburn-predicted capillary absorption coefficients A_w ($kg/m^2s^{0.5}$) at 30 °C, while its Table 6 opposes measured and Lucas-Washburn-predicted ratios of sorptivity S ($m/s^{0.5}$) at 20 °C and 30 °C. In both cases deviations between measured and predicted results are observed, leading to a claim that the material's microstructure also partakes in the temperature influence on capillary absorption.

There are however numerous inconsistencies in the values reported in [2]. First and foremost, dividing each respective A_w by S should give the density of water, which ranges from 996 kg/m³ to 998 kg/m³ between 20 °C and 30 °C. Our divisions however lead to values from 964 kg/m³ to 1191 kg/m³, hence deviating far more than what can be attributed to the limited number of available decimals. Implicitly assuming the A_w's as [2]'s original measurement results, it therefore appears that the reported S values are outright unreliable, invalidating all claims based on these.

The A_w values are regrettably neither free from doubt, as becomes clear from a comparison of [2]'s Figures 1-4 and Tables 2 and 5. For example, mca30/70's $A_{w,20°C}$ in [2]'s Table 2 is 0.160 $kg/m^2s^{0.5}$, while its Figure 3 yields something closer to 0.145 $kg/m^2s^{0.5}$. Additionally, our approximate reinterpretation of [2]'s Figure 1 for BRM results in $A_{w,20°C}$ and $A_{w,30°C}$ values of 0.229 $kg/m^2s^{0.5}$ and 0.247 $kg/m^2s^{0.5}$, while its Tables 2 and 5 give 0.206 $kg/m^2s^{0.5}$ and 0.228 $kg/m^2s^{0.5}$. The observed discrepancies are often similar in magnitude to the examined temperature influence on capillary absorption. Our Table A collects the potential inconsistencies in [2]'s results, with highlights for the largest deviations.

Finally, a calculation mistake is present in [2]'s Table 4: the C-coefficient for mca25/75 is reported to be 0.009, while our processing yields 0.013. This mistake resulted in an incorrect prediction of the $A_{w30°C}$ value for mca25/75 in [2]'s Table 5: this should be 0.118 $kg/m^2s^{0.5}$ rather than 0.089 $kg/m^2s^{0.5}$, now agreeing nicely with the experimental 0.116 $kg/m^2s^{0.5}$.

It must therefore be concluded that [2]'s measurements and interpretations on the whole cannot be considered very dependable.

Table A Paper [2]'s $A_{w,20°C}$ and $A_{w,30°C}$ values (from [2]'s Tables 2 and 5 and Figures 1-4)

material	*20 °C*			*30 °C*		
	Table 2 & 5	*Figure 2-4*	*Figure 1*	*Table 2 & 5*	*Figure 2-4*	*Figure 1*
BRI	0.252	0.254	0.267	0.263	0.263	0.277
BRM	0.206	0.201	0.229	0.228	0.228	*0.247* **
SRH	0.123	0.115	- *	0.172	0.172	- *
SRY	0.083	0.083	0.091	0.101	0.102	0.100
mca20/80	0.176	0.175	0.195	0.191	0.191	0.240
mca25/75	0.106	0.106	- *	0.116	0.117	- *
mca30/70	0.160	0.147	*0.161* **	0.170	0.170	*0.172* **
mcb20/80	0.106	0.107	*0.133* **	0.117	0.117	*0.149* **
mcb25/75	0.071	0.071	- *	0.081	0.080	- *
mcb30/70	0.065	0.066	- *	0.073	0.070	- *

* *values not quantified due to deviations from the expected $t^{0.5}$ behaviour*
** *values are less reliable estimations*

Further study of papers [1,2]

Given the concerns formulated above, we have reached out to the authors of [2], requesting access to their raw data, to which they have responded not to be willing to do so. In what follows we hence cannot but work with these less reliable published results.

Combining the Lucas-Washburn equation and the temperature variations of water's surface tension γ (N/m) and viscosity μ (Pa·s) allowed establishing [1]'s linear relationship (for temperatures between 0 °C and 50 °C) between the capillary absorption coefficient and the temperature:

$$A_w(T) = k\cdot\sqrt{\gamma/\mu}\Big|_T = k\cdot[0.095\cdot(T-273.15)+6.566] \quad (1)$$

which can be rewritten to:

$$A_w(T)/k = \sqrt{\gamma/\mu}\Big|_T \quad (2)$$

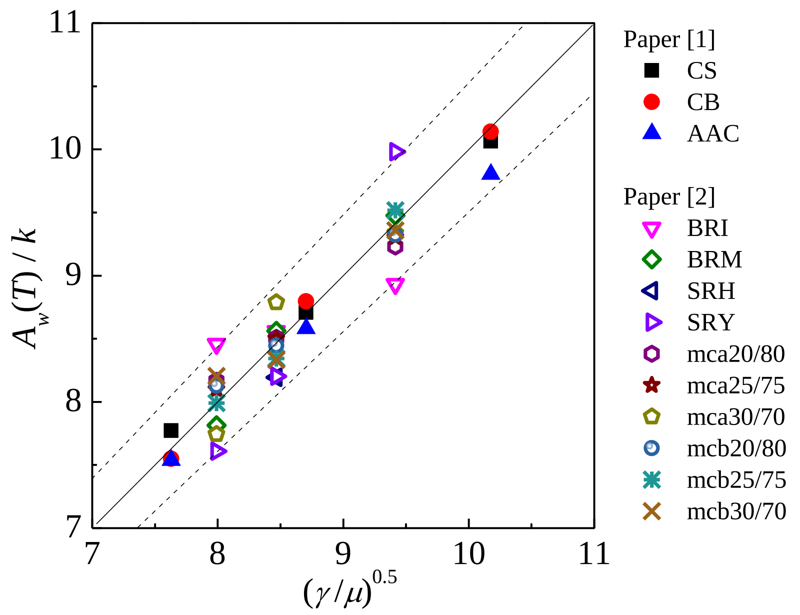

Figure A The $A_w(T)/k$ versus $(\gamma/\mu)^{0.5}$ plots

This equation predicts that, when plotting $A_w(T)/k$ against $(\gamma/\mu)^{0.5}$, data points close to the diagonal line should be obtained. Our Figure A presents the results of both [1] and [2] in this manner, with dashed lines indicating 5% deviations. It is evident that Eq.(2) holds nicely for [1]'s results, demonstrating the validity of Eq. (1) again. Figure 1 similarly shows that most of [2]'s results also stay near the diagonal line, with deviations typically below 5%. Given the formerly demonstrated reservations on the dependability of [2]'s results, such minor deviations cannot be invoked to dispute the validity of Eq. (1), contrary to the conclusions suggested in [2].

Conclusion

The analysis above clearly suggests that the discrepancy between the outcomes of [1] and [2] most probably stems from unreliable measurements and undependable interpretations in [2]. The original conclusions of [1] are confirmed and strengthened: the temperature influence on capillary absorption can generally be assigned to the surface tension and viscosity of water, predictable via a universal linear equation applicable to many building materials (within the temperature range 0-50 °C). Because of the journal's policies we cannot provide more details here, see the extended and detailed comment in the online repository [3].

References

[1] Feng C, Janssen H. Hygric properties of porous building materials (II): Analysis of temperature influence. Building and Environment. 2016;99:107-18.

[2] Karagiannis N, Karoglou M, Bakolas A, Moropoulou A. Effect of temperature on water capillary rise coefficient of building materials. Building and Environment. 2016;106:402-8.

[3]https://www.researchgate.net/publication/312147868_The_influence_of_temperature_on_the_capillary_absorption_coefficient_-_a_comment_on_a_recent_paper_by_N_Karagiannis_et_al