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Discussion of "Thermal conductivity of porous building materials: An exploration of new challenges in fractal modelling solutions"

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Abstract

In November 2023 this journal published "Thermal conductivity of porous building materials: An exploration of new challenges in fractal modelling solutions". That paper gauges four fractal building materials' thermal conductivity models, concluding that fractal-geometry-based approaches appear "a promising method" as they "demonstrate high reliability in reproducing experimental data". This discussion of the paper aims to shine a different light on the potential of fractal thermal conductivity models. It shows that good agreement with experimental data usually originates from calibration of various "physical" factors comprised in these models, with the fitted numbers commonly deviating from physical reality. Moreover, exemplary instances reveal that good agreement with experimental data is obtained despite misinterpretation of measured outcomes or critical defects in model development, or, exceptionally, due to fabrication of validation information. This discussion does hence not share the paper's positive opinion on the prospects of fractal-geometry-based thermal conductivity models, and advises caution instead.

Keywords: Thermal condutivity; Porous materials; Fractal dimension; Fractal geometry; Discussion.

1 Introduction

In November 2023 this journal published the paper "Thermal conductivity of porous building materials: An exploration of new challenges in fractal modelling solutions" [1]. That paper assesses four fractal models for the thermal conductivity of dry and moist porous materials, and concludes that fractal-geometry-based approaches seem "to be a promising method" as they "demonstrate high reliability in reproducing experimental data under various conditions". The paper ultimately asserts that "the future prospects for the use of fractal geometry for the formalisation of predictive models of thermal conductivity in porous materials are definitely promising and require further research and development to overcome current challenges".

This discussion aims to shine a different light on the potential of fractal models for thermal conductivity of porous materials. It is shown below that the good agreement with experimental data often stems from calibration of the various "physical factors" that are typically comprised in these models, with the ensuingly fitted values commonly deviating (highly) from actual physical reality. These factors, being allocated but not employed as physical features, thus reduce to plain fitting factors without physical meaning, which in turn degrades the models from predictive to heuristic. In addition, exemplary instances expose that good agreement with experimental data is achieved despite misinterpretation of measured outcomes, despite critical defects in model development, or, albeit exceptionally, due to fabrication of validation information. This discussion does hence not share [1]'s positive opinions on the prospects of fractal-geometry-based thermal conductivity models, and advises caution instead.

In what follows, an opening discussion introductorily establishes some crucial concepts. Subsequently, the four models tackled in [1] are critically assessed first. These findings are then complemented by assessments of a few other fractal porous media thermal conductivity models. In a closing discussion, a similar verdict is established on another popular application of fractal models, particularly fractal bundle-of-tube models for capillary absorption in porous materials.

2 Opening discussion

2.1 Porous materials' fractural nature

The four fractal thermal conductivity models discussed in [1], in line with many other fractal models in literature, all conjecture that porous media are intrinsically statistically self-similar [2], and that they hence can unreservedly be represented by fractal models. The seminal article on this

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front though formulates particular conditions to be met in order for porous materials to have fractal nature [2]. The statistical self-similarity requires that the particle/pore size distribution follows the fractal power law over a sufficiently large range of magnitudes:

$$\mathrm{N}(L \geq \lambda) = (\lambda_{\max}/\lambda)^{D_f} \quad \text{with } \lambda_{\min} \leq \mathrm{L} \leq \lambda_{\max} \text{ and } \lambda_{\min}/\lambda_{\max} \ll 1 \tag{1}$$

with N [-] number of particles/pore with diameter L [m] larger than cut-off diameter λ [m], λ_{min}, λ_{max} [m] minimum and maximum diameter respectively, and D_f [-] fractal dimension. Particularly, the fractal power law imposes that the particle/pore counts increase exponentially with decreasing particle/pore sizes. It can be shown that this ensuingly forces the incremental particle/pore volumes to shrink exponentially with decreasing particle/pore sizes. For the "sufficiently large range of magnitudes", it is typically required that the ratio of minimum and maximum particle/pore size stays below 0.01. In the literature, the fact that this final condition is usually satisfied for natural porous media is often invoked to presume all porous media having fractal nature. However, that latter condition does not inherently guarantee that the porous media's particle/pore counts/volumes follow the fractal power law by itself. And moreover, for artificial porous media, like sphere packs or particle beds, even that sufficiently small ratio of minimum and maximum particle/pore size often is neither complied with.

For these statistically self-similar porous media, there exists a widely accepted relation between porosity, fractal dimension and ratio of minimum and maximum particle/pore size [2]:

$$\mathrm{D_f} = \mathrm{D_E} - \ln(\varphi)/\ln(\lambda_{\min}/\lambda_{\max}) \tag{2}$$

with D_E [-] Euclidian dimension, and φ [-] porosity. While this relation has originally been derived for Sierpinski carpets exclusively [2], it is presently generally accepted and employed for porous media in the fractal model literature.

2.2 Thermal conductivity analogon

An analytical model for the effective thermal conductivity of composite materials, explicitly considering the materials' particle size distribution, is brought forward in [3]. In the model, the particle size distribution is approximated with a Weibull distribution, with shape factor s [-] and scale factor λ [-]. The model is founded on Maxwell's equation, but applies an equivalent porosity instead of the actual porosity, to account for that impact of the pore size distribution:

$$k_e = \frac{k_f\left(k_s + 2\cdot k_f + 2\cdot \varphi_e \cdot \left(k_s - k_f\right)\right)}{\left(k_s + 2\cdot k_f - \varphi_e \cdot \left(k_s - k_f\right)\right)} \tag{3}$$

with k_e, k_f, k_s [W/mK] the composite's effective conductivity, the fluid conductivity, the solid conductivity, and φ_e the equivalent porosity [-], attained by inflating the actual porosity φ [-] with χ [-]:

$$\varphi_e = \varphi \cdot \chi = \varphi \cdot \Gamma^2(1+3/s)/\Gamma^3(1+2/s) \quad \text{with } \lambda = 1/\Gamma(1+1/s) \tag{4}$$

with Γ [-] the gamma function. The physical parameter s hence fully governs the original particle size distribution and the resulting equivalent porosity. Equation (3) is now applied to measured results from [4], particularly the first four data sets from its Table 1. These data have also been used in [5], which is one of the models discussed in [1], and are hence relevant for this discussion. This yields the results in Table 1, wherein calculated and measured values match perfectly. One could consider this a successful validation of the model, given the perfect fit between measured and modelled results, obtained by accounting for the physical influence of the particle size distribution. The Weibull parameters listed above all translate to distributions with a wide spread of particle size diameters around the average, with relative standard deviations amounting from 30 % up to 45 % of the average.

This success is annulled however by the fact that the particle sizes of [4]'s configurations do not follow such wide Weibull distribution. Instead they are constant, see the unique particle sizes in Table 1. This infers that the "physical factor" s is improperly employed to match measured and modelled results. And this implies that s is theoretically defined as physical factor, but is practically applied as a plain fitting factor without physical meaning. And this indicates that s implicitly compensates for another physical impact which is not explicitly considered in Equation (3).

This in turn degrades the model from predictive to heuristic, as it becomes infeasible to predict the s value for other configurations based on physics. Instead, these other configurations are to be measured, to again fit Equation (3) via s. This is already exemplified with the different values of s necessary for configurations 2 and 4, wherein only the liquid differs, as the solid fraction is composed of the same particles and has (nearly) the same porosity. These two configurations make clear that there is a physical influence of the liquid – e.g. on the local resistance at particle contacts –, which is not comprised in Equation (3), and which it instead incorrectly conceals via a different particle size distribution parameter s.

Table 1. Results from fitting [3]'s calculated values to [4]'s measured values.

#	$fluid$	$solid$	φ	d^*	k_f	k_s	$k_{e,mea}{}^*$	s	λ	χ	φ_e	$k_{e,mod}{}^*$
1	water	glass	0.396	0.003	0.62	1.1	0.84	3.40	1.11	1.29	0.510	0.84
2	water	glass	0.425	0.025	0.62	1.1	0.84	3.90	1.10	1.22	0.520	0.84
3	glycol	glass	0.349	0.006	0.26	1.1	0.56	2.42	1.13	1.53	0.535	0.56
4	glycol	glass	0.427	0.025	0.26	1.1	0.60	2.95	1.12	1.37	0.585	0.60

*: d [m] particle size, $k_{e,mea}$, $k_{e,mod}$ [W/mK] measured and modelled effective thermal conductivity

3 Fractal thermal conductivity models

3.1 Ma et al., 2003

"A self‐similarity model for effective thermal conductivity of porous media'' [5] develops and evaluates a fractal thermal conductivity model for two-phase porous media, see [5] and [1]'s Section 5.1 for further details. [5]'s comparison to experimental data is two-fold, see [5]'s Figures 6 and 7, the latter of which is repeated in [1]'s Figure 6b, which is hence targeted in this assessment. For that comparison, [5] adopts 5 data points from [4]'s Table 1 and 10 data points from [6]'s Table 3, and compares these to model predictions at porosity 44 %.

It should initially be noted that [4,6]'s measured porosities range from 34.9 % to 42.7 % [4] and from 39 % to 41 % [6], rendering [5]'s choice for 44 % odd. It should however also be noted that [6]'s Table 3 does not gather measured findings, but instead presents model calculations based on [6]'s own thermal conductivity model, being calculated at 44 % porosity. Instead, [6]'s actual measurements are reported in [6]'s Table 2 and Figure 4, and the latter exposes deviations between measured and calculated data. This already jeopardises, albeit slightly, the good agreement between calculated and "measured" data in [5].

Additionally though, and already more critical, [5] clearly asserts that certain factors in its model have been calibrated for optimal fit with the measured results, stating that "A_{nt}/A = 0.55 and t^+ = 0.001 are chosen as they are the best fit for the experimental data". At no point does [5] provide evidence that these values are in sync with the actual physical features of the porous media involved, and these factors are hence to be considered as plain fitting factors, without a concrete physical meaning, see also Section 2.2.

Most crucially however, [5] strongly defends the use of "1.89" as fractal dimension for the porous materials involved, equalling the fractal dimension of the Sierpinski carpet [2], on which [5]'s model is based. Equation 2 (with D_E 2 and φ 0.44) then results in 0.0006 as the ratio between the smallest and largest particles/pores, suggesting that the largest particle/pore is over 1700 times larger than its smallest counterpart. Such size ratio is however impossible for the glass, acrylic and metal spheres used as particles in [4,6] as they are all characterised with a unique diameter [4,6]. Such size ratio is equally impossible for the pores in between these spheres as [7, among others] establishes that the largest pores in sphere packs commonly are not more than 4 times larger than the smallest pores. The fractal dimension is therefore likewise to be considered as a plain fitting factor, without a concrete physical meaning, see also Section 2.2. On this matter, it must finally be remarked that [2] distinctly stipulates "that $\lambda_{min} \ll \lambda_{max}$ must be satisfied for fractal analysis of a porous medium, otherwise the porous medium is a non-fractal medium", and therefore warns that "caution must be taken for fractal analysis of porous media".

3.2 Jin et al., 2016

"Experimental determination and fractal modeling of the effective thermal conductivity of autoclaved aerated concrete: effects of moisture content" [8] develops and evaluates a fractal thermal conductivity model for two- and three-phase porous media, see [8] and [1]'s Section 5.2 for further details. [8]'s comparison to experimental data is two-fold, see [8]'s Figures 10 for dry materials and [8]'s Figures 11-12 for moist materials, of which the first two are (partially) repeated in [1]'s Figure 8b and 9, which are hence targeted in this assessment. For that comparison [8] applies data points from own measurements on three different types of aerated concrete, at both dry and moist conditions.

Initially, it should be noted that [8] clearly asserts that certain factors in its model have been calibrated for optimal fit with the measured results, stating that "adjusting the dimensionless width, each of the C values could lead to excellent prediction in comparison to the measured thermal conductivity". [1] states that the optimal fit for dry conditions, see [1]'s Figure 8b, is attained with L 13, C 3 and τ between 0.0076 and 0.01. For moist conditions, on the other hand, the optimal fit is obtained with L 13, C 2 and τ 0.003, see [1]'s Figure 9. However, [8]'s Figure 12 corroborates that for low moisture contents, L 13, C 1 and τ 0 give the optimal fit. At no point does [8] provide evidence that these values are in line with the actual physical features of the porous media involved. Moreover, these three factors all define structural features of the porous material, and should thus not vary from application to application, see also Section 2.2. This infers that these factors are resultantly to be considered as plain fitting factors, without a concrete physical meaning.

In addition, the specific Sierpinski carpet configurations considered in [8], with L 13 and C 1, 2 or 3, yield fractal dimensions of 1.998, 1.987, 1.963 respectively, which for an 80 % porosity translate to size ratios between smallest and largest particles/pores of respectively $1.3 \cdot 10^{-42}$, $2.7 \cdot 10^{-8}$, $2.5 \cdot 10^{-3}$, see Equation (2). None of these are in line with the pore sizes presented in [8]'s Figure 2. That figure moreover shows that the incremental pore volumes do not decrease exponentially with decreasing pore size, contrary to the fractal power law. The fractal dimension is therefore similarly to be considered as a plain fitting factor, without a concrete physical meaning.

3.3 Miao et al., 2016

"Analysis of axial thermal conductivity of dual‐porosity fractal porous media with random fractures'' [9] develops and evaluates a fractal thermal conductivity model for fractured two-phase porous media, see [9] and [1]'s Section 5.3 for more details. [9]'s comparison to measured data is based on a single data set comprising merely two data points, see [9]'s Figure 2, which is repeated in [1]'s Figure 11b, and which is hence targeted in this assessment. For that comparison, [9] applies data from [10], related to a specific granite that is extensively documented in [11,12]. [9] reports the following properties having been applied for its model calculations: solid conductivity 2.95 W/mK, air conductivity 0.026 W/mK, maximum pore size 1 mm, maximum fracture length 20 mm. The latter is complemented by a 0.01 ratio of fracture aperture over fracture length, giving rise to a maximum fracture aperture of 0.2 mm.

Actual physical data in [11,12] do though contradict both the maximum pore size and maximum fracture aperture adopted in [9]. In [11], it is verified that close to 95 % of the apertures are "major" and "minor" fractures, which have average apertures of 2.4 mm and 0.5 mm respectively, far above [8]'s assumed maximum of 0.2 mm. In [12], pore volume distributions for several granite variants span from 0.001 to 10 µm, remaining strongly below [9]'s assumed maximum of 1 mm. Furthermore, [9] equally presumes the ratios of minimum over maximum pore size and fracture length to be 0.001, neither of which is supported by information in [10-12]. Finally, [9] states that [10] reports effective thermal conductivities ranging from 2.3 W/mK to 3.9 W/mK, whereas [10] in fact documents local values going up to 4.4 W/mK. These numbers relate to porous samples, which hence undervalue the pure solid conductivity still. That implies that [9]'s adoption of 2.95 W/mK as solid conductivity is equally questionable.

These reflections establish that the good agreement between calculated and measured results, observable in [9]'s Figure 2, stem from calibrating many of the model factors to values that deviate strongly from their actual physical counterparts. As reasoned previously thus, see Sections 2.2, 3.1 and 3.2, these physical factors hence constitute plain fitting factors, without a concrete physical meaning.

3.4 Shen et al., 2020

"A generalized thermal conductivity model for unsaturated porous media with fractal geometry" [13] develops and evaluates a fractal thermal conductivity model for three-phase porous media, see [13] and [1]'s Section 5.4 for more details. The model is compared to three data sets in [13], see [13]'s Figures 3-5, the second of which is repeated in [1]'s Figure 15, which is thus targeted in this assessment. For that comparison, [13] adopts measured thermal conductivities of three moist aerated concretes as reported in [14].

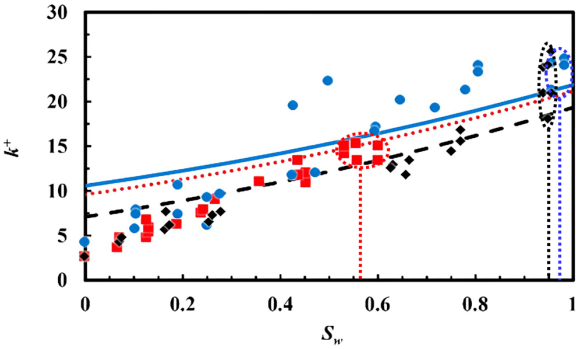

Figure 1. Reproduction of [1]'s Figure 15, with additional highlighting of three characteristic data point clusters. Therein k^+ is normalised thermal conductivity [-] (effective conductivity over fluid conductivity) and S_w [-] is saturation degree (moisture volume over pore volume).

[1]'s Figure 15 is replicated in Figure 1 here, however enriched by highlighting three characteristic clusters of data points. These are the final clusters for each of the three materials involved, and are therefore easily identifiable in the original presentation in [14]'s Figure 5. Comparison of [14]'s Figure 5 with [13]'s Figure 4 however reveals incompatibilities in their moisture contents. It should in this respect be noted that these are gravimetric moisture contents in [14]'s Figure 5 – mass of moisture per unit mass of dry material – versus volumetric saturation degrees in [13]'s Figure 4 – volume of moisture per unit volume of pore space.

To contrast these, [14]'s gravimetric moisture contents are first multiplied with the material density to obtain volumetric moisture contents, which are then divided by the material porosity to attain volumetric saturation degrees. These calculations are clarified in Table 2, in which the last two lines respectively report [14]'s and [13]'s volumetric saturation degrees. These two lines reveal that there is a clear deviation between the moisture contents in [14]'s Figure 5 versus [13]'s Figure 4, thus nullifying the agreement between measured and calculated results.

Table 2. Confrontation of saturation degrees in [14]'s Figure 5 and [13]'s Figure 4.

Material	*P1.8 /ε 0.87*	*P2 / ε 0.82*	*P4 / ε 0.80*
Gravimetric moisture content in [14] [kg/kg]	2.38	1.05	1.21
Material density in [14] [kg/m³]	304	363	500
Volumetric moisture content in [14] [m³/m³]	0.724	0.381	0.605
Material porosity in [14] [m³/m³]	0.874	0.819	0.802
Volumetric saturation degree in [14] [m³/m³]	0.83	0.47	0.75
Volumetric saturation degree in [13] [m³/m³]	0.95	0.56	0.97

It could in this regard be countered that [13] provides two more evaluations of its model, particularly in [13]'s Figures 3 and 5. It can be verified however (not included here) that [13]'s Figure 3 equally suffers from an incorrect translation from gravimetric moisture contents to volumetric saturation degrees. It can as well be established the model results in [13]'s Figure 5 cannot stem from the model. [13] clearly states that the parallel model forms the upper limit for its model predictions. With the values for [13]'s Figure 5 (porosity 39 %, solid conductivity 2.01 W/mK, water conductivity 0.60 W/mK, air conductivity 0.023 W/mK), that parallel model results in an effective thermal conductivity of 1.46 W/mK for fully saturated conditions. With the air conductivity as reference, that translates to 63.5 as normalised conductivity. Strangely, the model prediction, being near to 97, exceeds that upper limit. That conflict implies that the model results presented in [13]'s Figure 5 cannot actually originate from [13]'s model, hence nullifying the good agreement with the measured findings.

These reflections establish that all three of [13]'s comparisons of calculated and measured data are flawed, with resultantly the same conclusion for [1]'s Figure 15. Regrettably though, this discussion cannot offer explanations for the detected defects.

3.5 Other models

3.5.1 Qin et al., 2019

"A fractal model of effective thermal conductivity for porous media with various liquid saturation" [15] develops and evaluates a fractal thermal conductivity model for three-phase porous media. The model is compared to multiple data sets in [15], see [15]'s Figures 4-7. That same model is compared to lattice Boltzmann simulations and Maxwell equation calculations in [16]. Regrettably, [17] reveals that many of [16]'s model results exceed the parallel model, which is generally accepted as the upper limit for the thermal conductivity of porous media. Furthermore, it can be verified that [15,16]'s model may lead to negative conductivities, which should be physically and mathematically impossible. Evaluating [15]'s Equation 19 or [16]'s Equation 1 with solid conductivity 0.2 W/mK, fluid conductivity 1 W/mK, porosity 40 % and particle size ratio 0.001 (the latter two combine to fractal dimension 2.89, see [15]'s Equation 12), yields an effective thermal conductivity of -3.92 W/mK.

Both flaws can be traced back to a plain mathematical error in the model development [17], particularly in [15]'s Equation 15, quantifying the total volume of the solid spheres comprised in the fractal particle assembly. This expression is incorrect, as it applies the third power of the average sphere diameter, whereas it should be using the average of the third power of the sphere diameters, see [17] for more details. Exploratory calculations in [17] establish that [15,16] resultantly strongly underestimate the solid particles' volume, with at least a factor 4, but often going up to and over a factor 10. This error ensuingly nullifies all good agreement between calculated and measured results reported in [15], as [15]'s Figures 4-7 all make use of the flawed model. It can be reasoned (not included here) that [15] has compensated for the error by applying unrealistically small ratios of smallest and largest particle size. While the sources for [15]'s measured data primarily concern sphere packs, see also Sections 2.2 and 3.1, with particle and pore size ratios close to 1 hence, the applied size ratios in [15] are all (far) smaller than that. This implies that this physical factor hence constitutes a plain fitting factor, without a concrete physical meaning. On this matter, it must finally be remarked that [2] distinctly stipulates "that $\lambda_{min} \ll \lambda_{max}$ must be satisfied for fractal analysis of a porous medium, otherwise the porous medium is a non-fractal medium", and hence warns that "caution must be taken for fractal analysis of porous media".

3.5.2 Qin et al., 2023

"A novel fractal model for effective thermal conductivity in granular porous media" [18] develops and evaluates the fractal thermal conductivity model for two-phase porous media. The model is compared to multiple data sets in [18], see [18]'s Figures 3-5, and this assessment exemplarily targets [18]'s Figure 3b. For that comparison, [18] adopts measured data from [19], particularly glass beads, lead shot and quartz sand. For these materials, [19] explicitly states that "the 36% porosity sand was a pack of 20/30 mesh (0.84-0.59 mm) Ottawa sand", "the glass beads (Micro-beads 405) are approximately 40/50 mesh (0.42-0.297 mm). The mean particle diameter of the lead shot was 1.23 mm." These numbers infer that the particle size ratios are all close to 1 thus, whereas [18] employs 0.0025 as this ratio in its model calculations. As before hence, see Sections 3.1, 3.2 and 3.5.1, the fractal dimension is applied as a plain fitting factor, without a concrete physical meaning. Similar reasonings apply to the other relevant figures in [18].

It should moreover be noted that [18] misportrays the result at solid conducitivity/fluid conductivity 1 in [18]'s Figure 3b. Calculations with [18]'s Equation 27 yields 1.21 as the resulting effective conductivity/fluid conductivity, whereas [18]'s Figure 3b clearly puts that value at 1.00. Furthermore, the resulting 1.21 is an unphysical result, as solid conductivity/fluid conductivity equalling 1 implies the same conductivity for solid and fluid. That should lead to the effective conductivity also being equal to that equal solid and fluid conductivity, or effective conductivity/fluid conductivity equalling 1. The observed deviation hence infers a flaw in the model development in [18], which is not further addressed here.

3.5.3 Wu et al., 2020

"A new fractal model on fluid flow/heat/mass transport in complex porous structures" [20] develops and evaluates a fractal thermal conductivity model for three-phase porous media, see [20] for more details. The model is compared to a single data set in [20], see [20]'s Figure 11. It can be clearly noted in this figure that the experimental data depict a negligible influence of moisture content on the effective thermal conductivity, in line with the predictions by [20]'s thermal conductivity model, but contrary to various literature results on this theme. Regrettably, it has been verified that these experimental data were fabricated, in order to realise a good agreement with the modelled data [21]. The same verdict additionally applies to the permeability data presented in [20]'s Figure 9.

4 Closing discussion

Fractal-geometry-based analytical models for the thermal conductivity of dry and moist porous materials are in recent years becoming more and more popular, see the many recent papers on this topic referenced above. A recent publication in this journal [1] assesses a selection of these models, and deems them "to be a promising method" since they "demonstrate high reliability in reproducing experimental data under various conditions".

This discussion of [1] shines a different light on the success of these fractal thermal conductivity models. It is shown above that, in some instances, the good agreement between calculated and measured results is obtained despite mathematical errors in the calculated data or misinterpretation of the experimental data, or exceptionally, via fabrication of measured data. These grave flaws do though not relate to the prevalent segment of fractal thermal

conductivity models, wherein flawed calculated or measured findings do not play a role. For these instances however, it has been strongly established that the many "physical" factors that are typically present in such models (fractal dimension, particle size ratio, solid conductivity,…) are commonly calibrated to attain a good agreement between measured and calculated data. Such calibration would not be frowned upon if the ensuingly fitted numbers would align with the tangible physical reality, which is however generally not the case. It has been extensively demonstrated above that these "physical" factors are in reality often used as plain fitting factors, without concrete physical meaning. This observation reduces [1]'s conclusion that fractal thermal conductivity models "demonstrate high reliability in reproducing experimental data under various conditions" to the conclusion that the fractal models often simply have enough heuristic buttons to adjust the calculated results to the measured data. It should be noted however that this characteristic is almost never acknowledged in the source publications, and neither in [1], therefore yielding an overly positive impression.

As a final complement to this discussion, it should be mentioned that fractal approaches are also gathering momentum for another application related to building materials, particularly for the modelling of capillary absorption via the bundle-of-tubes approach. Discussions of some selected models on that front can be found in [22-25]. All of these formulate serious concerns on the reliability of the fractal bundle-of-tubes models for capillary absorption involved.

5 Conclusion

In November 2023 this journal published the paper "Thermal conductivity of porous building materials: An exploration of new challenges in fractal modelling solutions" [1]. That paper assesses four fractal models for the thermal conductivity of dry and moist porous materials, and concludes that fractal-geometry-based approaches seem "to be a promising method" as they "demonstrate high reliability in reproducing experimental data under various conditions". The paper ultimately asserts that "the future prospects for the use of fractal geometry for the formalisation of predictive models of thermal conductivity in porous materials are definitely promising and require further research and development to overcome current challenges". The discussion above has extensively demonstrated that the good agreement with experimental data often stems from calibration of the various "physical factors" that are typically comprised in these models, with the ensuingly fitted values commonly deviating (highly) from actual physical reality. These factors, being allocated but not employed as physical features, thus reduce to plain fitting factors without physical meaning, which in turn degrades these models from predictive to calibratable. This discussion does hence not share [1]'s positive opinions on the prospects of fractal-geometry-based thermal conductivity models, and advises strong caution instead.

Conflicts of interest

The author declares that he has no conflict of interest.

Authorship statement (CRediT)

H. Janssen: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – Original draft, Writing – Review and editing, Visualization, Supervision, Project administration, Funding acquisition.

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