RESPONSE TO COMMENTS ON THE CONVECTIVE-DIFFUSION EQUATION IN BUILDING PHYSICS

Z. Svoboda
Faculty of Civil Engineering, Czech Technical University, Thakurova 7, 166 29 Prague 6, Czech Republic

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Interesting comments on paper [1] by Jones [2] discussing in detail two aspects which have not been so extensively or clearly described in [1].

The first comment [2] concerns the general form of the convective-diffusion equation written in [1] as:

\[
\eta \left( \frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial y^2} + \frac{\partial^2 U}{\partial z^2} \right) - \gamma \left( u \frac{\partial U}{\partial x} + v \frac{\partial U}{\partial y} + w \frac{\partial U}{\partial z} \right) + Q = 0
\]

(1)

No units are assigned to quantities U, Q, \eta and \gamma in [1] intentionally because - for example - U could stand not only for concentration but also for temperature. The combined heat transfer equation with temperature instead of U is analysed in detail in [1]. If we would like to take a closer look at some typical examples of the convective-diffusion equation with concentration instead of U, we could use for this purpose the combined radon transfer equation (e.g. [3]) in the form:

\[
D_e \left( \frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial y^2} + \frac{\partial^2 C}{\partial z^2} \right) - \frac{1}{p} \left( u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} + w \frac{\partial C}{\partial z} \right) + G - \lambda \cdot C = 0
\]

(2)

where C is radon concentration in Bqm^-3, D_e is effective radon diffusion coefficient in m^2s^-1, G is radon generation rate in Bqm^-3s^-1, \lambda is radon decay constant in s^-1 and finally p is porosity of the porous material (dimensionless). It is clear that Jones’s comments on units in case of the convective-diffusion equation with unknown concentration are correct with one exception - the quantity:

\[
\gamma = \frac{1}{p}
\]

in equation (2) is really dimensionless and so the studied equation is dimensionally consistent - at least in the case of equation (2).

The quantity \gamma in equation (1) is in [1] generally – and maybe unfortunately slightly vaguely – described as “parameter describing the convective properties of the medium” because \gamma stand-alone is not a convection mass transfer coefficient. The convection mass transfer coefficients in the directions of co-ordinate axes are the quantities \gamma_u, \gamma_v and \gamma_w and these quantities have units m s^-1 as dimensional analysis requires. This fact is really not so clearly shown in [1].

The second comment [2] concerns the thermal conductivity of closed air gap in the model construction analysed in [1]. The paper [1] does not really clearly state how the thermal conductivity of the air gap is treated. The thermal conductivity of the non-ventilated air gap in [1] is taken as effective or equivalent value which involves both conduction and natural convection in air gap. Such treatment of non-ventilated air gaps is practically a standard in the field of common calculations of hygrothermal performance of building components. Standard EN ISO 6946 [4] even defines the design (effective, equivalent) values of thermal conductivity for non-ventilated air gaps which are dependent on the thickness of air gaps and which are recommended for common heat transfer calculations through the building components exposed to heat conduction.

So the natural convection in the air gap is in a simplified way contained in its equivalent or effective thermal conductivity and this is also the way how the paper [1] solves this problem. The sentence on p. 77 of the article [1] therefore does not mean that the author of [1] says that no natural convection occurs in construction with no crack or not exposed to pressure difference. That is of course not true. This sentence was written only to comment the fact that the first temperature profile with its straight lines looks like a typical temperature distribution in the construction exposed exclusively to heat conduction.

The comments [2] are valuable regardless of the fact that not every remark could author of [1] accept without hesitation, as could be seen from the text above. Author of [1] is thankful for such interest and especially for the notice concerning the natural convection through the composite construction. Natural convection through the analysed composite construction is not considered
in [1] - and this is of course a scope for more detailed modelling based on extension of present computer model which assumes only forced convection combined with conduction.

REFERENCES


