PII: S0043-1354(00)00385-7

Wat. Res. Vol. 35, No. 5, pp. 1369–1370, 2001

Printed in Great Britain
0043-1354/01/$ - see front matter

PERGAMON
www.elsevier.com/locate/watres

AUTHORS' REPLY

We thank the commentator for his interest and contribution. This has indeed stimulated us to clarify a few important points in our presentation. We would respond in this reply in an orderly sequence as indicated below.

(A) The way to classify the literature works

In the second paragraph of the Comment, the commentator questioned why we classified the previous studies into the following four categories: conventional theory, diffusional modeling, multiphase modeling, and particle dynamics approach. To the commentator's opinion they should be divided into two categories: the former three as continuous models and the latter, the discrete model. We agree with such a classification. However, as discussed in our review paper, the three mentioned continuous models are different by their basic assumptions regarding the interactions between solid and liquid, from which a long debate has been raised for the validity of some commonly adopted assumptions, like the four assumptions listed on p. 2 in the Comment. Also, the commentator addressed that the diffusional modeling is different from the other two continuous models by adopting the Lagrangian formulation. Such an argument may be confusing since the coordinate systems for both conventional theory and multiphase flow modeling could be easily changed from spatial coordinate (Eulerian formulation) into material coordinate (Lagrangian formulation). Equations (10) and (11) in the original paper clearly reveal this point. Therefore, the more detailed classification into four categories of current modeling works, as well as the presence of the Table 2, would greatly help the readers to understand their differences.

(B) Formulation

The commentator also addressed in the paragraph 3 of Comment that Equations (10) and (12) could not be regarded as a complete formulation for the cake filtration. Other conditions like interface conditions are required. This apparently is a misunderstanding on the part of commentator. Our wordings in the review paper are as follows: "Notably, if the (constitutive) relationships K are available then the formulation is completed (for the momentum balance). Physically relevant initial and boundary conditions are required for solutions. (p. 4)", which appears under the sub-title "Momentum Balance" in the review paper. Clearly, equation (10) is derived for the momentum balance to cake body only, while equation (12) represents one of the most widely used constitutive equation that connects the solid pressure and the local cake characteristics. The other conditions at interfaces were definitely necessary and were discussed in the sub-section headed "Initial and boundary conditions" in the review paper (pp. 5, 6).

(C) Discrepancy between Conventional Theory and Multiphase Flow Modeling

The commentator addressed in the paragraph 3 of Comment that equation (3) (or equation (4)) and equation (8) for conventional theory correspond to equations (A2.3) and (A2.7) for multiphase flow modeling, respectively, hence concluding that these two models are actually identical. In paragraphs 5 and 6 the commentator highlighted the difference between these two modeling approaches using momentum balance equations:

$dP_L + dP_S = 0$ [equation (7) in the original review paper, for conventional theory]

and

$\varepsilon_L dP_L + dP_S = 0$ [equation (i) in the Comment, for the multiphase flow modeling] Restated, only if $\varepsilon_L = 1.0$ the results derived from multiphase flow model were consistent with that adopted in conventional theory. This point is mentioned on p. 7 in the review paper (right panel) that we use equation (8) and equation (25) (or equation A2.7) rather than equation (7) in the present work and equation (1) in the Comment. (The commentator also mentioned in the last paragraph that equation (25) does not correspond to equation (A2.7) as stated in the review paper. However, these two equations are apparently identical by simply recalling the fact that P_L in equation (25) is the liquid pressure averaged over the entire cake cross-section and $\langle P_l \rangle^l$, liquid pressure averaged over the void space only, and one has $P_L = \varepsilon_L \langle P_l \rangle^l$.) Such a difficulty might be arising from the fact that the employment of representative elementary volume (REV, on the right panel of p. 18) in the multiphase flow modeling is of finite size and should include sufficient solid and liquid phases. To discuss the limit at very small control volume of REV could face the difficulties like the discrepancy noted above. However, we do agree with the commentator that it is necessary to re-examine the correspondence between C-P cell data and the filter performance.

(D) Formation of initial deposition

In the 7th paragraph of the Comment the commentator spent some space to clarify that the initial deposition concept is used merely for initiating the numerical integration works presented in Stamatakis and Tien (1991), but not to present as a description to the initial deposition. In ST paper, the cake of infinitesimal

thickness is assumed incompressible, from which the pressure distribution is derived based on Darcy's law. In reality these authors had described in some details the characteristics of the initial deposited cake. Moreover, their work indeed stimulated some follow-up studies, like Koenders and Wakeman (1996). To give the credit for such an effort, we hence stated that the ST work is the first work for analyzing the initial stage of filtration. since the co-author of ST paper insists that such a contribution merely serves as the initial condition for numerical simulation, we nonetheless apologize for the misunderstanding and withdraw the statement about the ST paper.

(E) Other comments

In the last paragraph, the commentator kindly pointed out some mistakes made in the review paper. We agree with the commentator that (i) equation (8) should be without the negative sign, and (ii) the tensor should not be used as a divisor. However, the other suggestions made by the commentator might be questionable. For example, once the sign error of equation (8) has been corrected, one could easily derive equation (9) as stated in the review paper (p. 4). Furthermore, as stated in the previous paragraph (C), equations (25) and (A2.7) are really identical. Moreover, as the points (A) and (C) discussed above, all the four modeling approaches could be regarded as different in the sense of basic assumptions to formulation. Table 2 was included in the review paper in response to the request made by one referee during the review process. We agree with this referee that it could be helpful to the readers for better understanding their differences.

D. J. Lee[1,2] and C. H. Wang[1]
[1]*Department of Chemical and Environmental Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore, 119260*
[2]*Department of Chemical Engineering, National Taiwan University, Taipei, Taiwan 10617*