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Laminar shallow viscoplastic fluid flowing through an array of vertical obstacles

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A new Bingham-Darcy shallow depth approximation flow model is proposed in this paper. This model is suitable for a shallow viscoplastic fluid flowing on a general topography and crossing an array of vertical obstacles. An analogous porous medium is first introduced to reduce the array of obstacles. The reduction model is based on a continuum model similar to the Brinkman equations, where the usual Darcy model is extended for viscoplastic Bingham fluids. A specific asymptotic analysis of this Bingham-Darcy porous medium for the case of shallow depth flows allows us to produce a new reduced model. The resulting solution is a highly nonlinear parabolic equation in terms of the flow height only, and is efficiently solved by a Newton method, without any regularization. However, our numerical predictions compares well, both qualitatively and quantitatively with both experimental measurements and full tridimensional simulations. Finally, a new experiment for a viscoplastic flow over an inclined plane through a network of obstacles is proposed and numerical simulations are provided for future comparison with experiments.

Auteur principal: BERNABEU, Noé (LJK)

Co-auteur: SARAMITO

Orateur: BERNABEU, Noé (LJK)

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