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Time dependent backward piping erosion 2D modeling with laminar flow transport equations

Juan Pablo Aguilar-Lopez[1,2], Manuel Wewer[1], Thom Bogaard[1], and Matthijs Kok[2]
[1]Water resources section (Hydrology), Faculty of civil engineering, Delft University of Technology, Delft, (j.p.aguilarlopez@tudelft.nl)
[2]Hydraulic engineering (Hydraulic structures and flood risk), Faculty of civil engineering, Delft University of Technology, Delft, (j.p.aguilarlopez@tudelft.nl)

Backward piping erosion (BEP) is a highly complex erosive process which occurs on granular soils when large head differences are exerted. This process represents a significant threat to dams and levees stability and therefore a large part of the design and reliability assessment of these water retaining structures is devoted to this single process. Several authors have achieved great accuracy in predicting the critical head difference that triggers the process but not so much has been studied regarding the time of occurrence and the duration of the erosive process. In the present study we propose a 2D finite element model for which not only the critical head difference can be predicted but also the development of the erosive process in time. This was achieved by coupling the 2D Darcy partial differential equation with Exner's 1D sediment transport mass conservation equation. Different laminar sediment transport rate empirical models were tested and used as inputs in the coupled model. To test the performance of the proposed model, the IJkdijk real scale experiment for piping erosion was simulated. The results show that the model is capable of predicting not only the critical head and its progression in time but also specific events of the process such as the instants of start of the erosion and the complete seepage length development . An important conclusion of the study is that from several transport empirical formulas tested, the model from Yalin which is widely recognized by the sediment transport community performs the best.