Errors in finite element analysis of backward erosion piping

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Abstract
Backward erosion piping (BEP) is a type of internal erosion responsible for the failure of many dams and levees. BEP occurs when small, shallow erosion channels progress upstream through foundation sands beneath the structure. As analysis of BEP involves coupling two different sets of flow equations to describe the groundwater flow and erosion pipe flow, the solution contains a singularity in the gradient field at the juncture of the soil and pipe domains. In addition, the erosion process is highly localized, often occurring over length scales of 1 cm or less. While it is well known that singularities and localized phenomena cause high errors in numerical solutions, there has been no assessment of the magnitude of these errors in BEP numerical models. This study evaluates the magnitude of error in BEP finite element models through comparison of numerical results to measurements from a highly instrumented BEP experiment. The results indicate that discretization errors related to the pipe geometry can cause 50%–300% error in the solution near the pipe tip when the pipe is represented via linear, 1D elements. These errors are significant and must be considered for models that assess pipe progression based on the local solution near the pipe tip. Results also indicate that the pipe width must be modeled as twice the physical pipe width to accurately represent the pipe flow when assuming a rectangular cross sectional shape for the erosion pipe.

Keywords
Backward erosion, Internal erosion, Finite element, Errors

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