The influence of soil type on internal erosion

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Abstract:
Soil erosion is a natural process. It becomes a problem when human activity causes it to occur much faster than under natural conditions.
Soil erosion by water, wind and tillage affects both agriculture and the natural environment. Soil loss, and its associated impacts, is one of the most important of today’s environmental problems.
Soil erosion is a naturally occurring process that affects all landforms. In agriculture, soil erosion refers to the wearing away of a field’s topsoil by the natural physical forces of water and wind or through forces associated with farming activities such as tillage.
This problem can be a slow process that continues relatively unnoticed or can occur at an alarming rate, causing serious loss of topsoil. Soil compaction, low organic matter, loss of soil structure, poor internal drainage, and soil acidity problems are other serious soil degradation conditions that can accelerate the soil erosion process.
Soil quality, structure, stability and texture can be affected by the loss of soil. The breakdown of aggregates and the removal of smaller particles or entire layers of soil or organic matter can weaken the structure and even change the texture. Textural changes can in turn affect the water-holding capacity of the soil, making it more susceptible to extreme conditions.
Many dam ruptures events have occurred throughout the world, some of them were reported by Foster and al. \cite{1}. Then main cause was piping phenomenon that occurred in the foundation soil or in the dam structure. Serviceability of hydraulic infrastructures needs considering vulnerability of soil to internal erosion under the action of a seepage flow, \cite{2,3}. Understanding the underlying mechanisms and quantifying the effects of pertinent variables that affect this phenomenon is of great importance in order to prevent such catastrophes.
In this work, the water erosion is modeled in the fluid/soil interface during the hole erosion test (HET). The Hole Erosion Test is commonly used to quantify the rate of piping erosion\cite{4,5}. The aim of this work is to predict the erosion of soil in the fluid/soil interface by using the three-dimensional Fluent package. This modeling makes it possible describing the effect of the flow on erosion in the interface fluid/soil by using the $k-\varepsilon$ turbulence model equations, and predicts a non uniform erosion along the hole length unlike the usual one dimensional models. In particular, the flow velocity is found to increase noticeably the erosion rate.
Effects on the wall-shear stress resulting from varying flow velocity and applied hydraulic gradient are analyzed. Various parametric studies were performed and had shown that the three-dimensional
modeling introduced in the present study showed that the erosion rate is not uniform along the pipe wall as observed experimentally after performing the standard hole erosion test. [6]

The aim of this study is to describe the biphasic turbulent flow at the origin of erosion taking place inside the porous soil sample by considering the influence of variation of the concentration of clay contained in the flowing fluid. A Computational Fluid Dynamics (CFD) approach is used to investigate the shear stress that develops at the water/soil interface and which represents the main mechanical action that causes surface erosion.

**Key Words:** Soil erosion, Piping, Hole Erosion Test, Computational fluid dynamics, Turbulence.

When the shear stress is calculated by means of Fluent, the classical linear erosion law is used to estimate erosion rate. This law gives erosion rate, considered to be the amount of mass departure due to erosion per unit time and by unit surface area, by $\varepsilon = c_\varepsilon (\tau - \tau_c)$ where $c_\varepsilon$ and $\tau_c$ are constants depending on the considered soil material. For a cylindrical hole, the rate $\varepsilon$ can be related to time variation of local radius by $\varepsilon = \rho_d dR / dt$ where $\rho_d$ is the dry density of soil and $R$ is hole radius. The erosion law yields that $\varepsilon$ is proportional to the amount of shear exceeding the critical shear $\tau_c$ for which erosion begins.

![Figure 1](image-url)  
Figure 1. Wall-shear stress obtained for P=3726 Pa as function of clay concentration

Figure 1 gives the obtained wall-shear stress for inlet pressure $P = 3726 \text{ Pa}$ and for two clay concentration.

The results show that flow velocity, soil type (clay concentration) has a significant effect on shear stress and that this last is not uniform along the hole length. Erosion which is proportional to shear stress is also not uniform. This enables to understand why the erosion pattern is not uniform as observed by examining soil samples after HET testing for which the inlet side is usually more eroded than the outlet side.

**Références**


