Experimental study concerning stimulated outflow from porous structures

Josef Pražák, Bartoloměj Biskup
Institute of thermomechanics ASCR, Dolejškova 5, Praha 8, CZ 18200
M. Šír
Institute of hydrodynamics ASCR, Pod Paťankou 30/5, Praha 6, CZ 16612

It is generally supposed that the water flow in massive spates occurring in small catchments areas have two components. The first one is the direct surface outflow of the water from a preceding rain (new water) the second one is caused by the water "pending" in the soil already before the rain (old water) and stimulated by the rain to flow out. The relation between the two components can be rather variable. The stimulated outflow has been studied in a new series of experiments by means of 2D and 3D models. It was found that in laboratory test a situation where the stimulated outflow exceeds the stimulating inflow can be simulated in a easy way. Transformation of this fact to the natural conditions means that situations can occur where a relatively insignificant rain causes a significant spate/flood.

A stabile distribution of fluid in porous structures is determined by relation of gravitational and surface forces between fluid and matrix. For dynamical phenomena (the outflow e.g.),the viscosity of fluid is important as well. The interplay between gravity and surface tension can be well seen in a simple experiment by drying 2D transparent structure in two different positions (1). In vertical case, a sharp border between dry and saturated region moving down arises, in the horizontal one, a fractal structure of water islands spanning all the body occurs (all figures are included in the full text of the paper).

A submitting of the liquid/water into the sample in vertical position drop by drop in one point leads under identical conditions to a forming of identical water trajectories. Characteristic feature for these trajectories are random horizontal deflections (if the radii of pores are randomly distributed). For an isotropic homogeneous distribution follows, that the horizontal deflection of trajectory is approximately proportional to the sqrt of the vertical distance from the surface (2) – a Brownian motion in the x-direction. It can (and in fact must) lead to the fact, that some trajectories join together. The inverse phenomenon occurs to. When a trajectory channel is "overloaded" – by a high velocity of submitting the water or after joint with other stream, the trajectory divides spontaneously into more (practically 2) parts (2). The described mechanisms cause in most cases a "network-like" filling of the structure.

The outflow of the structures saturated in this way was described already in (3) in both 2D and 3D geometries. The dependence of amount of water on time can take various forms depending on mentioned quantities (gravity, density, surface tension, and viscosity). For relative big gravitational forces it is characterized by expressed oscillations in beginning of the process, if the capillary forces are more important the outflow curve has the smooth form corresponding to the Richard's equation commonly used in hydrology. The stimulated outflow in this and similar cases has not been observed.

For the studying of the stimulated outflow other filling than the above described one has been used: in the first step, the structure (4 - model, micromodel) was completely filled with water, in the second step, the water not fixed in the structure was left out and after that the upper surface of the model was submitted to a simulated rain (regularly or randomly distributed drop by drop inflow). For the 2D experiments, 2 micromodels differing in size and pore distribution were used, the 3D micromodel has been developed for this study. In the experiments where the last mentioned manner of filling has been used it has been shown that the unstable pending of water in the structure can relatively frequently cause the stimulated outflow – it means the situation where the outflow is bigger then the inflow. On the other hand the relation of the two quantities can be rather variable. Some quantitative results of the 2D experiments were reported in (5), the 3D experiments have a quantitative character in the moment.

It can be concluded that the stimulated outflow from porous structures can be in a simple way simulated in laboratory condition, but that in the nature the corresponding starting distribution occurs only rarely.

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