Gravity-Head Tests

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Contents

1 Establishment of gravity head in 1D

These tests concern the steadystate pressure distribution obtained either by running a transient model for a long time, or by running a steady-state analysis, both of which should lead to the same result. Without fluxes, the steadystate pressure distribution is just

$$P(x) = P_0 - \rho_0 g x \ , \tag{1.1}$$

if the fluid bulk modulus, B, is large enough compared with P. Here P_0 is the porepressure at $x = 0$. For smaller bulk modulus

$$P(x) = -B \log \left(e^{-P_0/B} + \frac{g\rho_0 x}{B} \right) \ . \tag{1.2}$$

Here it is assumed that the density is given by $\rho = \rho_0 e^{-P/B}$ with constant bulk modulus, g is the magnitude acceleration due to gravity (a vector assumed to be pointing in the negative x direction), and x is position. The tests described below are simple tests and are part of the automatic test suite.

1.1 Single-phase, single-component

Two single-phase simulations with 100 1D elements are run: one with fully-saturated conditions, and the other with unsaturated conditions using the van-Genuchten capillary pressure (this should not, and does not, make any difference to the results). The porepressure is held fixed at one boundary ($x = 0$).

An example verification is shown in Figure 1.1, which also shows results from a 2-phase simulation (see Section 1.2).

1.2 Two-phase, two-component

Two-phase, two-component simulations may also be checked against Eqn (1.2). Four simulations are performed.

One steady-state simulation is performed. Steady-state simulations are more difficult to perform in two-phase situations because of the inherently stronger nonlinearities, but mostly because simulations can easily enter unphysical domains (negative saturation, for instance) without the stabilising presence of the mass time-derivative.

Three transient simulations are performed. In the transient simulations, conservation of mass can be checked, and the tests demonstrate MOOSE conserves mass. Depending on the initial and boundary conditions, the "heavy" phase (with greatest mass) can completely displace the "light" phase, which is forced to move to the top of the simulation. In this case Eqn (1.2) only governs

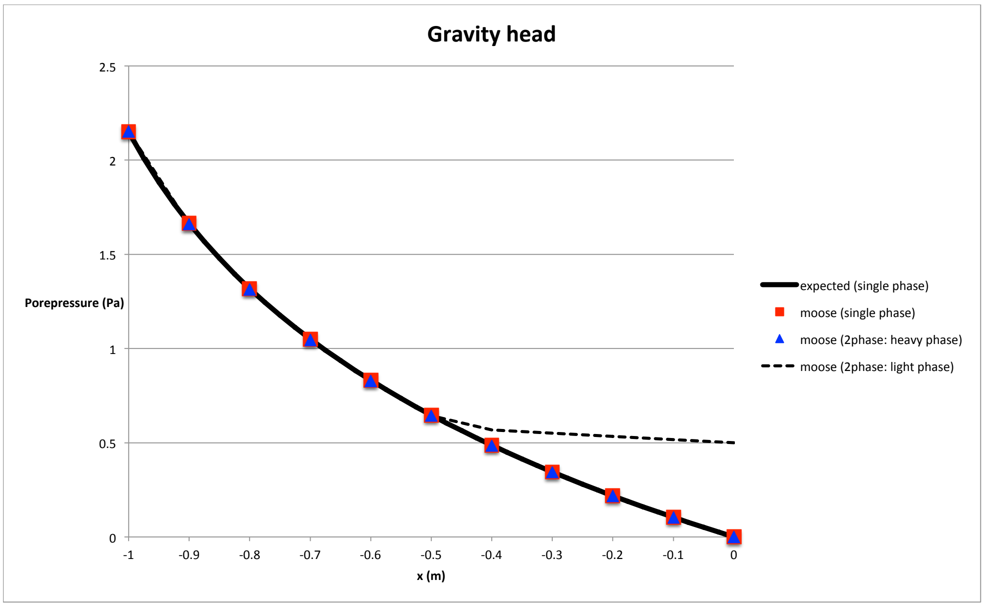

Figure 1.1: Comparison between the MOOSE result (in dots), and the exact analytic expression given by Eqn (1.2). test had 10 elements in the x direction, with $-1 \leq x \leq 0\,$m. The parameters were $B = 1.2\,$Pa, $\rho_0 = 1\,$kg.m^{-3}, and $g = -1\,$m.s^{-2}. For the two-phase simulation, the light phase had $B = 1$ Pa and $\rho_0 = 0.1\,$kg.m^{-2}.

the light phase in the unsaturated zone, since in the saturated zone (where there is zero light phase) the pressure must follow the heavy-phase version of Eqn (1.2). An example is shown in Figure 1.1.