scSTREAM

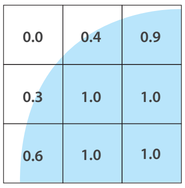
Cradle
MSC Software Company

Analysis of Capillarity and Percolation to Soil

Capillarity and percolation to soil are analyzed with MARS method using scSTREAM

VOF (Volume of Fluid) Method

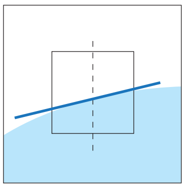
Example: Distribution of F value



Donor-Acceptor method

Stores F value strictly ▶ Interface expressed by rectangles

MARS method



Approximates interface slope by linear function ▶ High reproducibility of interface

VOF method is...

- A free surface flow analysis method that obtains the interface by solving the transport equation of F value ($0 \leqq F \leqq 1$), which is defined as the volume fraction of fluid occupying each element in the computational domain.
- Considers material properties, e.g., density and viscosity, as the 1st fluid (air, for instance) if F value is 0 and as the second fluid (water, for example) if F value is 1.

Case Study of Capillarity

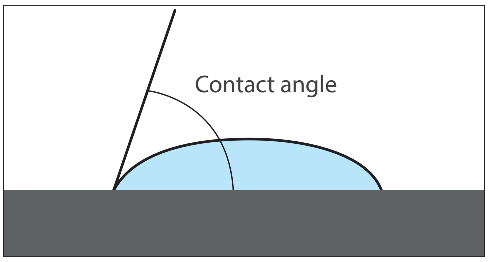


Figure 1: Contact angle

Contact angle is...

The angle between wall and free surface of the fluid (Figure 1). If contact angle is small, wall tends to get wet (hydrophilic), while if it is large, wall tends not to get wet (water-shedding).

Analysis Results

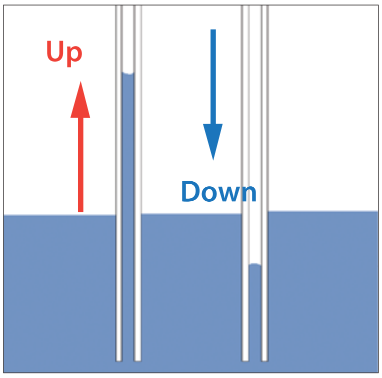


Figure 2: Capillary hydrophilic wall with plates of contact angle 60° (left) and water-shedding wall with plates of contact angle 120° (right)

By capillarity, water rises in between the plates that have hydrophilic surfaces, and falls in between the plates that have water-shedding surfaces. Fluid behavior differs greatly depending on contact angle.

Percolation to Soil

Analysis Model (Soil Cross Section)

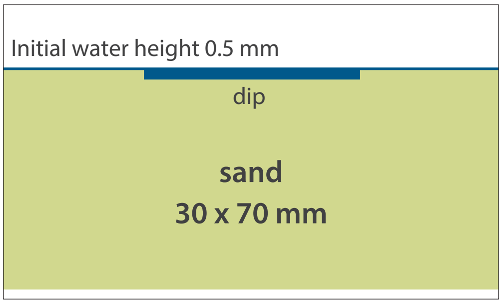


Figure 3: Analysis model

Depth	30 mm
Width	70 mm
Dip	Depth 1 mm
Void fraction	0.15 (sand, resin)
Contact angle	90° (resin)
Darcy coefficient	5×10^{-10} m^2 (Equivalent of permeability when void fraction is 0)
Initial condition	Uniform water height of 0.5 mm (Depth 1.5mm for the dip)

Analysis Results

Figure 4: Water percolation to sand

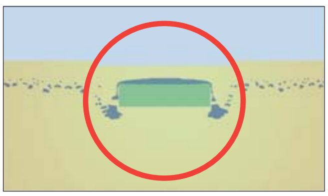


Figure 5: Water percolation to sand (with resin installed)

Notes

Figure 4 is the analysis result after 2 seconds. The apparent percolation velocity is approximately 10 [mm/s] in the middle section. Figure 5 is the analysis result for the case where resin, whose Darcy coefficient is lowered by two digits to improve the water retention of sand, is installed at 5 [mm] deep. Prevention of water percolation by the resin is well simulated.