Calculating Water Infiltration Rates

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The water infiltration rate is dependent upon the type of soil water is flowing through. By understanding Darcy’s Law, we can see that flow (also known as the flux) is proportional to the water potential gradient and the saturated hydraulic conductivity of the soil. The saturated hydraulic conductivity is a constant for each soil. The flux changes with water potential and length of the soil column, but the conductivity remains constant. A soil with a high hydraulic conductivity (like a sandy soil) has a faster rate of water infiltration than a soil with a lower hydraulic conductivity (like a clay soil). This relationship is described by Darcy’s Law:

\[ Q = \frac{V}{A \times t} = K \times \frac{\Delta H}{\Delta X} \]

Where

- \( Q \) = flow rate (flux) in cm/hr
- \( V \) = volume of water (cm³)
- \( A \) = cross-sectional area through which flow is occurring (cm²)
- \( K \) = hydraulic conductivity (cm/hr)
- \( t \) = time to collect V amount of water (hr)

\[ \frac{\Delta H}{\Delta X} = \text{hydraulic gradient (water potential gradient)} (cm/cm) \]

The table below shows the water infiltration rate and hydraulic conductivity for a sandy loam soil.

<table>
<thead>
<tr>
<th>Start time</th>
<th>Ending time</th>
<th>Total volume collected (mL)</th>
<th>Height of soil in column (( \Delta X )) (cm)</th>
<th>Soil + water height (( \Delta H )) (cm)</th>
<th>Inside diameter of column (cm)</th>
<th>Area of soil (cm²)</th>
<th>( Q ) (cm/hr)</th>
<th>( \Delta H/\Delta X ) (cm/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:10</td>
<td>12:40</td>
<td>103</td>
<td>4.5</td>
<td>8.5</td>
<td>5.2</td>
<td>21.24</td>
<td>9.7</td>
<td>1.89</td>
</tr>
</tbody>
</table>

\( \Delta H \)

\( \Delta X \)

\( X2 = 0 \)
TrueGrid acts as a retention basin for water to percolate through. If the underlying layers of TrueGrid go in order of most porous to least porous down, then there will be a higher infiltration rate. For our design, we have gravel (very porous) layered in the TrueGrid followed by the engineering soil, followed by the native silty clay loam soil. Thus the height of the sub-layer (gravel) does not have much of an effect on overall percolation rate. A thicker sub-layer serves as a “reservoir” which can contain the water until it can percolate by the native soil. In addition, these calculations are done assuming that there is no slope to the landscape. If there is an incline, design procedures change and account for the water flowing down an incline. As seen in Figure 2, as rain falls, gravity will try to pull the water downhill. In order to compensate for this, baffles need to be installed to allow water to have time to percolate into the ground using the calculations above.