Effect of Parallel Strip Water Sources Spacing On Lateral Infiltration Flux

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OVERVIEW

• Introduction

• Previous research review
  • Vertical vs. vertical and lateral infiltration

• Formulation of the problem for numerical solution

• Edge effect in parallel water sources
  • Steady state flow
  • Transient flow (not shown)

• Conclusions
INFILTRATION WITH PARTIAL SURFACE COVERAGE OF WATER

- **Sheet flow**
  - Usual assumption

- **Concentrated flow**
  - 1D-vertical infiltration
  - A lot better assumption

- **Concentrated flow**
  - Vertical and lateral infiltration
  - Even better
VERTICAL AND LATERAL FLOW

\[ i_{2D} = i_{1D} + i_{\text{Edge}} \]

- \( i_{1D} \) is the term for vertical flow
- \( i_{\text{Edge}} = \gamma i_{\text{Horiz}} \); term for capillary-driven lateral flow

\[ i_{\text{Horiz}} = \frac{S}{x_0} (\theta_H - \theta_n) t \]

- \( \gamma \) is a function of strip spacing, soil texture and time
- The challenge is to determine \( \gamma \)
- We should be able to do this with numerical simulation of the Richards equation

From: Warrick and Lazarovitch (2007), infiltration from a strip source
Numerical modeling

Simulations of two-dimensional infiltration based on numerical solution of the Richards within the porous media module of COMSOL_MP.

Governing equation:
\[
\frac{\partial}{\partial t} (\varepsilon_p \rho) + \nabla \cdot (\rho u) = Q_m \\
 u = -\frac{k}{\mu} (\nabla p + \rho g \nabla D)
\]

subject to:
\[
p(x, y, t = 0) = p_0
\]

Initial condition
\[
\frac{\partial}{\partial n} (p + \rho g D) = 0
\]

\[
\frac{\partial p}{\partial n} = 0
\]

\[p = 0\]
VERTICAL AND LATERAL INFILTRATION

At Steady State

Water free to flow in all directions
MULTIPLE STRIP EDGE EFFECT

At Steady State

Water flow confined due to neighboring strip sources (reduces $\gamma$)
MULTIPLE STRIP EDGE EFFECT

At Steady State

![Graph showing Multiple Strip Edge Effect vs. Spacing](image-url)

- **Multiple Strip Edge Effect/Single Strip Edge Effect vs. Spacing**
- **Finer porous media**
- **Spacing of the strips (m)**

**Data Points**:
- Loamy Sand
- Sandy Clay Loam
- Silty Loam

**Legend**:
- Coarse gravel
MULTIPLE STRIP EDGE EFFECT

Transient flow

Water sources
MULTIPLE STRIP EDGE EFFECT

Transient flow

Multiple Strip Edge Effect/Single Strip Edge Effect vs. Spacing (t=200s and Steady State)

Spacing of the strips (m)

- Loamy Sand Steady State
- Loamy Sand t=200s
- Loamy sand t=0s
CONCLUSIONS

- The calculation of infiltration from parallel strip water sources depends on:
  - Width of the strip
  - Texture of the porous media
  - Initial moisture content
  - Strip spacing
  - Time (not shown)

- The calculation of infiltration from parallel strip sources can be approximated by using a 1-D approximation with a shape factor ($\gamma$) to account for the enhancement of infiltration introduced by the actual 2-D flow. The value of $\gamma$ can be quantified with numerical solutions to the Richards equation.