

## Sand Box Verification

### 1 Introduction

Rulon and Freeze (1985), have studied the development of multiple seepage faces on earth slopes due to a layered soil system. To verify their theory, a physical model was constructed in the laboratory. **Error! Reference source not found.** Figure 2-1 below shows a schematic diagram of the physical model. Water was sprinkled on the upper flat part to simulate rain, and instruments were installed to measure the pore-water pressure distribution and to measure the total seepage outflow. The model developed two seepage exit points on the slope. In addition, Rulon used a finite element analysis to predict the model performance. The observed results compared favorably with the predicted performance.

#### Feature Highlights

- Non-linear unsaturated flow
- Verification with laboratory solution
- Multiple seepage faces
- Unit flux boundary conditions

### 2 Geometry and boundary conditions

The geometry of the actual physical model is shown below as published, and as developed in a SEEP/W analysis. The boundary condition locations are shown on the SEEP/W model as being a fixed total head of 0.3 near the toe, a potential seepage face on the slope, and a flat infiltration surface along the crest.

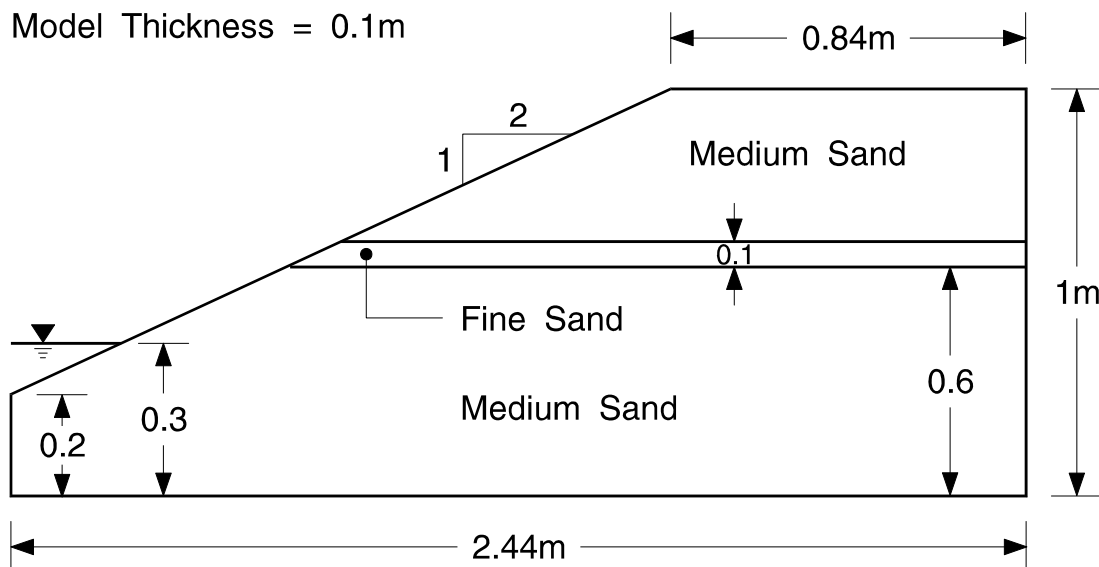
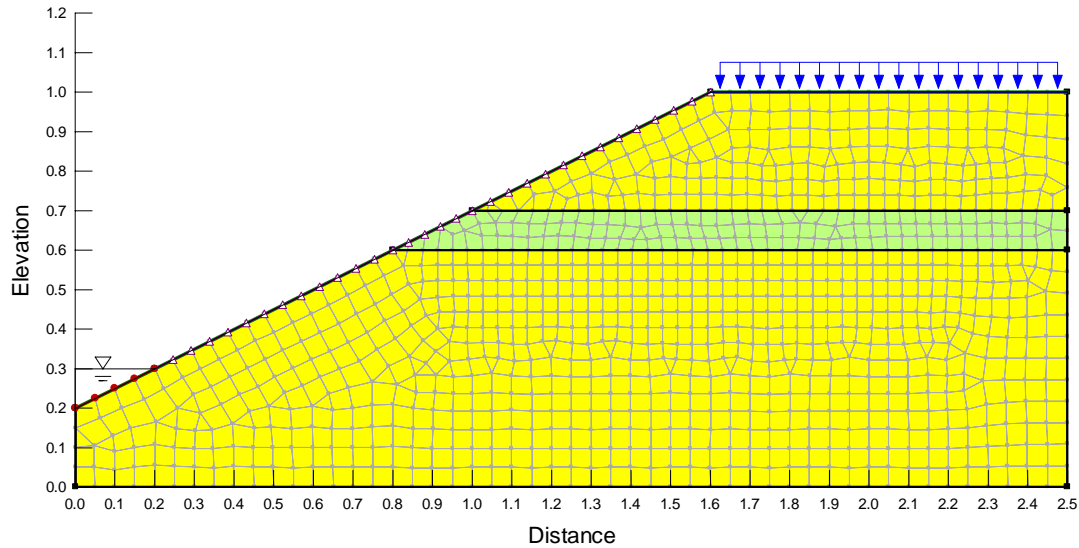


Figure 2-1 Laboratory model geometry

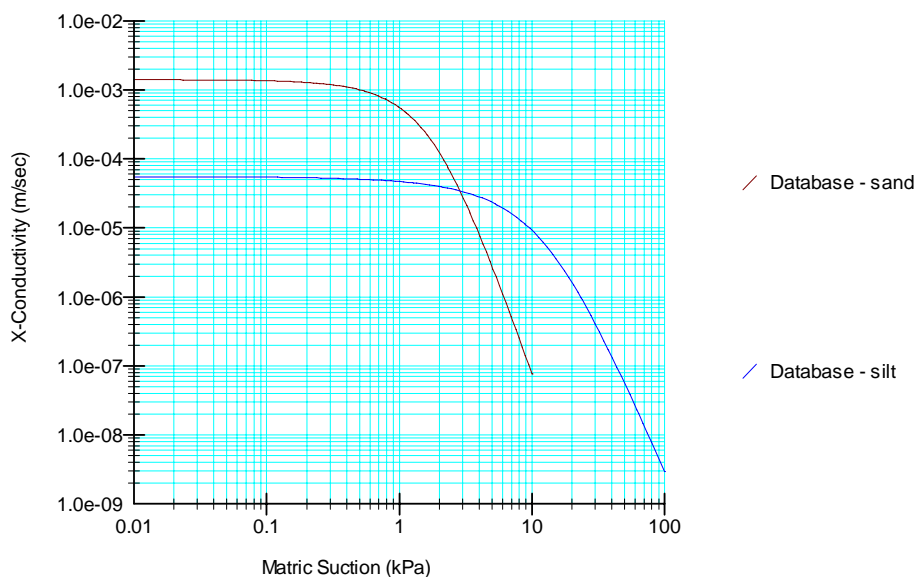


**Figure 2-2 SEEP/W model domain and boundary conditions**

Results of the physical model testing revealed that a simulated rainfall rate of 1.26 cm/min ( $2.1 \times 10^{-4}$  m/sec) produced a steady state water table as shown in below with an observed seepage flow of 996 cm<sup>3</sup>/min. ( $1.66 \times 10^{-5}$  m<sup>3</sup>/sec). These parameters were reproduced in the SEEP/W model.

### 3 Material properties

Rulon used laboratory tests to establish the hydraulic conductivity function for a medium sand. The function was then moved vertically to match a desired saturated hydraulic conductivity. Laboratory tests were conducted to measure the saturated hydraulic conductivity for the medium and fine sands used in the physical model. The best-fit values were found to be  $1.4 \times 10^{-3}$  m/sec for the medium sand and  $5.5 \times 10^{-5}$  m/sec for the fine sand. The function shapes below are for a silt and sand and the Ksat values have been adjusted to match laboratory determined values.



#### 4 Discussion of results

A steady state SEEP/W analysis of the Rulon and Freeze model leads to essentially the same results as observed in the laboratory and predicted by the Rulon and Freeze finite element analysis. Rulon's published results comparing their observed and computed steady state conditions are shown below.

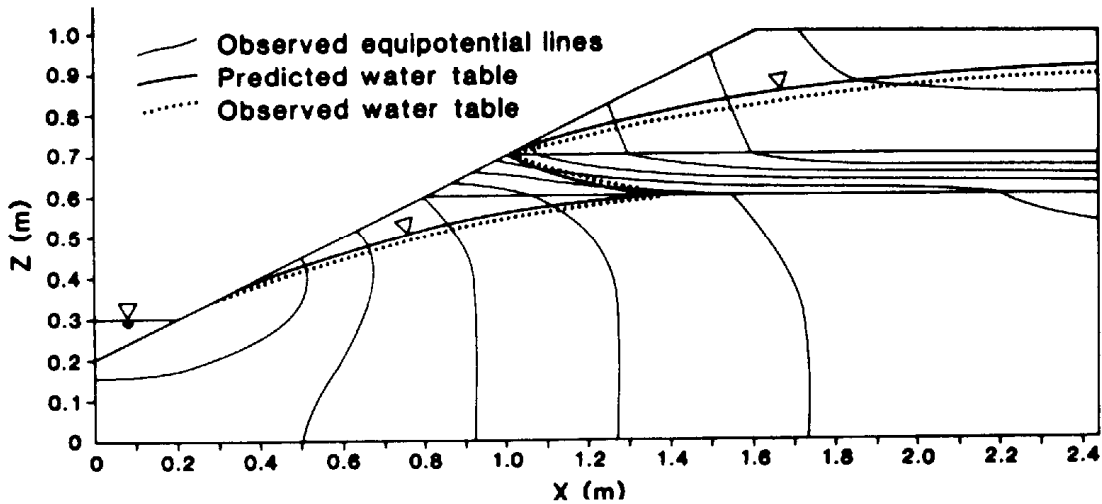


Figure 4-1 Observed perched water table

The results of the SEEP/W seepage modeling are presented in the following image. It is interesting to observe that two different seepage faces develop on the slope, and that both are represented accurately in the model. The locations of the seepage faces are not input as a boundary condition; the model determines this as part of the solution. Finally, it is clear that the seepage model can replicate the laboratory results.

