

Homogeneous dam with toe drain

1 Introduction

The objective of this illustration is to look at steady state flow through a homogeneous dam and to compare results with a published solution. In particular, the objectives of this illustration are to:

- Illustrate that a very coarse drain material can be omitted from the geometry
- Show how flux sections can track flows
- Show that flow can cross a phreatic surface and pass in the unsaturated zone

2 Feature highlights

GeoStudio feature highlights include:

- Head boundary conditions
- Flux sections
- Flow lines
- Unsaturated flow above a phreatic line
- Toe drain and seepage faces

3 Geometry and boundary conditions

The problem geometry and boundary conditions are illustrated below, in Figure 1. The dam is a simple homogeneous material with a full reservoir on the upstream side and a toe drain on the downstream side. Notice that the toe drain material has been left out of the mesh. It is well known that this material is very coarse relative to the dam material and as such it will have a much higher conductivity. Because of this, we know that there will be little to no head loss in this material, so there is no reason to include it in the mesh. Leaving it in the mesh would only add to numerical convergence difficulty, as this type of material has a highly non-linear conductivity function.

The upstream boundary nodes are designated as head boundaries with total head equal to the water level in the reservoir (40 feet). The nodes along the contact between the dam and the drain are designated as potential seepage review nodes, since the seepage exit point is unknown. With this review boundary applied, the solver will determine the appropriate nodes that have flow or no-flow. Default boundary conditions (no-flow) are assumed for all other boundaries.

The mesh includes two flux sections. One section passes through the entire dam and the other section is near the downstream face of the dam. The second short flux section is included to estimate how much of the total seepage flows through the unsaturated zone.

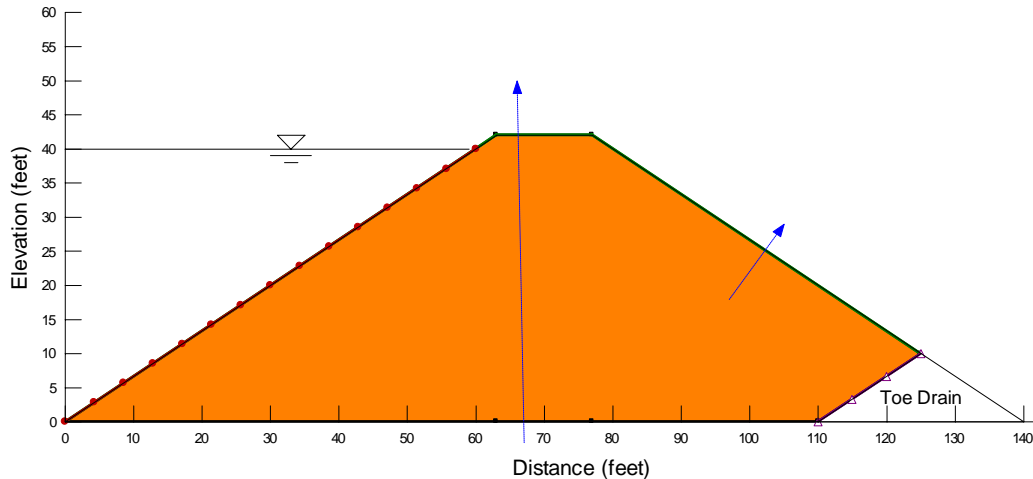


Figure 1 Seepage problem definition

4 Material properties

The material is a homogeneous material with the Saturated/Unsaturated soil model applied as shown in Figure 2. The hydraulic conductivity is 5×10^{-4} ft³/sec. Because the analysis is steady state, it is not necessary to specify a water content function. If you want to view water content in the output, then you need to specify a function for water content in the input. The conductivity function for this material is shown in Figure 3 below. For the case where the dam will have a zone of unsaturated flow, it is very important that a function be defined for the conductivity and that it not be a horizontal line. We know that as the soil dries, the ability for water to move through it is reduced. If a horizontal function was specified, this is implying that water can move equally through both the saturated and unsaturated zone.

Material Model:	Saturated / Unsaturated	
Hydraulic Properties		
Hyd. Conductivity Fn:	Embankment	...
Conductivity Ratio:	1	Direction: 0
Vol. Water Content Fn:	(none)	...
<input type="checkbox"/> Activation PWP:	0	

Figure 2 Homogeneous soil model

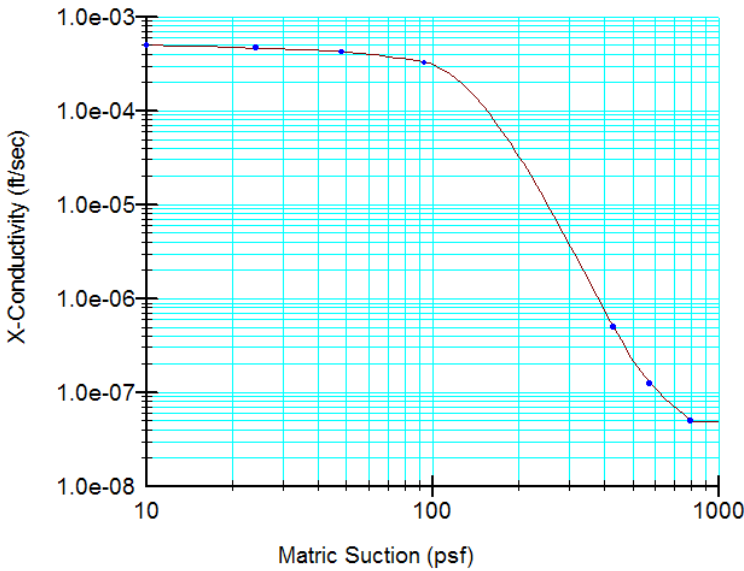


Figure 3 Hydraulic conductivity function for dam

5 Results and discussion

The SEEP/W flow net is given below along with the published solution of Lambe and Whitman (1969). The total SEEP/W seepage flux is computed to be $6.68 \times 10^{-3} \text{ ft}^3/\text{sec}/\text{ft}$. This is higher than $5.9 \times 10^{-3} \text{ ft}^3/\text{sec}/\text{ft}$, the value obtained from the flow net. The difference is largely because SEEP/W allows for the unsaturated flow. It is not possible to completely separate the saturated and unsaturated flow; however, the short flux section near the downstream face can provide an estimate of the unsaturated flow. This flux is approximately $0.728 \times 10^{-3} \text{ ft}^3/\text{sec}/\text{ft}$. Subtracting this value from the total Section 1 flux results in an estimated saturated flow of $6.05 \times 10^{-3} \text{ ft}^3/\text{sec}/\text{ft}$, which is within 3 percent of the flow net value of $5.9 \times 10^{-3} \text{ ft}^3/\text{sec}/\text{ft}$. Evidence of the unsaturated flow can be seen in the flow line that starts at the point where the upstream water intersects the dam face. As the flow moves towards the exit point, the flow path rises above the water table line.

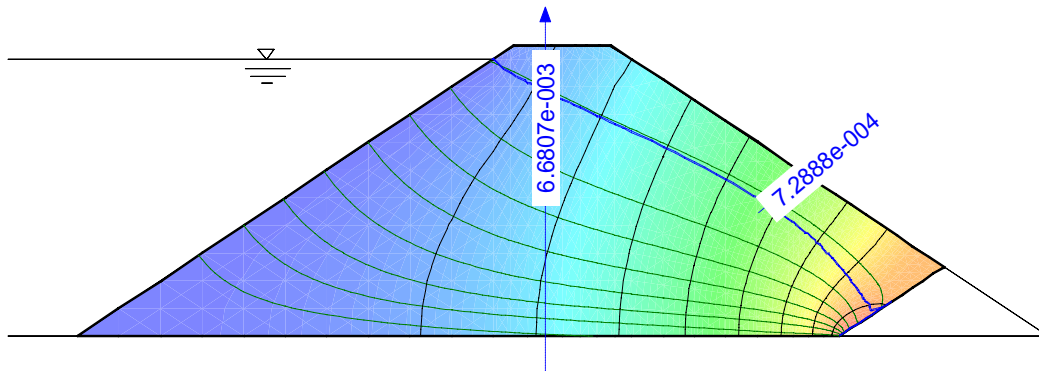
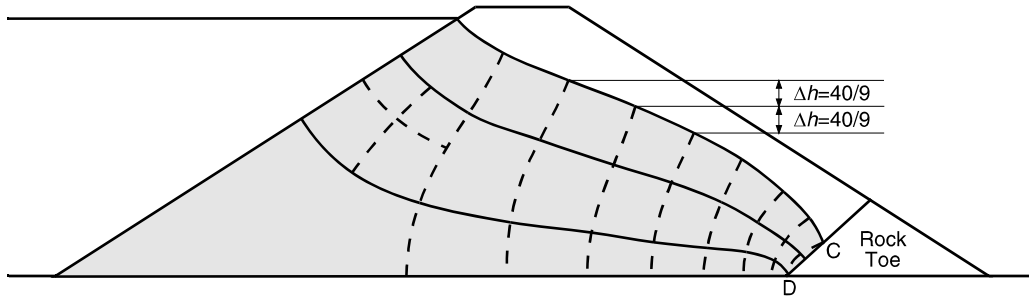
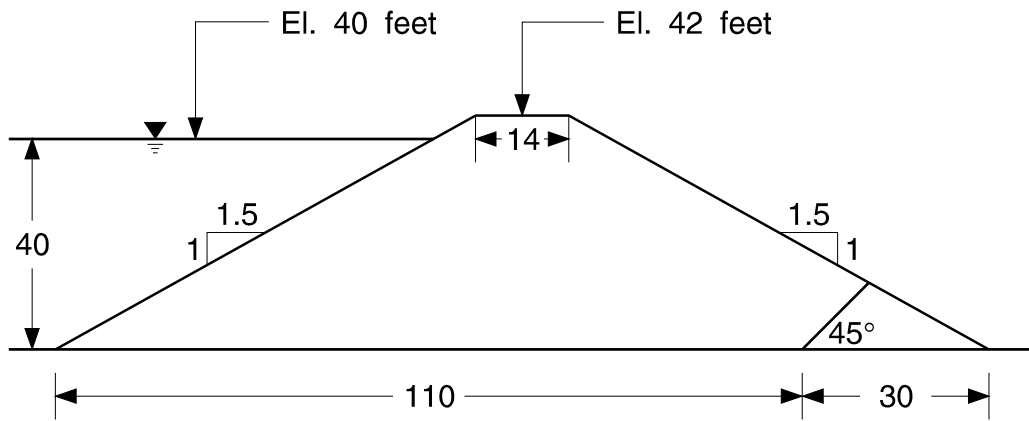


Figure 4 GeoStudio solution



(a) Flow Net Solution



(b) Problem Dimensions

Figure 5 Published solution