Levee with Toe Drain Tutorial

1. Introduction

In this tutorial, finite element groundwater seepage analysis is used to simulate a levee with a horizontal toe drain. Toe drains are often used to prevent capillary rise on the downstream sloping surface. Slide2 can be used to test the effectiveness of different drain configurations.

The finished tutorial can be found in **File > Recent Folders > Tutorials Folder >** ***Tutorial 15 Levee with Toe Drain.slmd***.

2. Model

Open the file *Tutorial 15 Levee with Toe Drain template.slmd file*. The following changes have been made to the file:

• Groundwater settings have been specified in the Project Settings

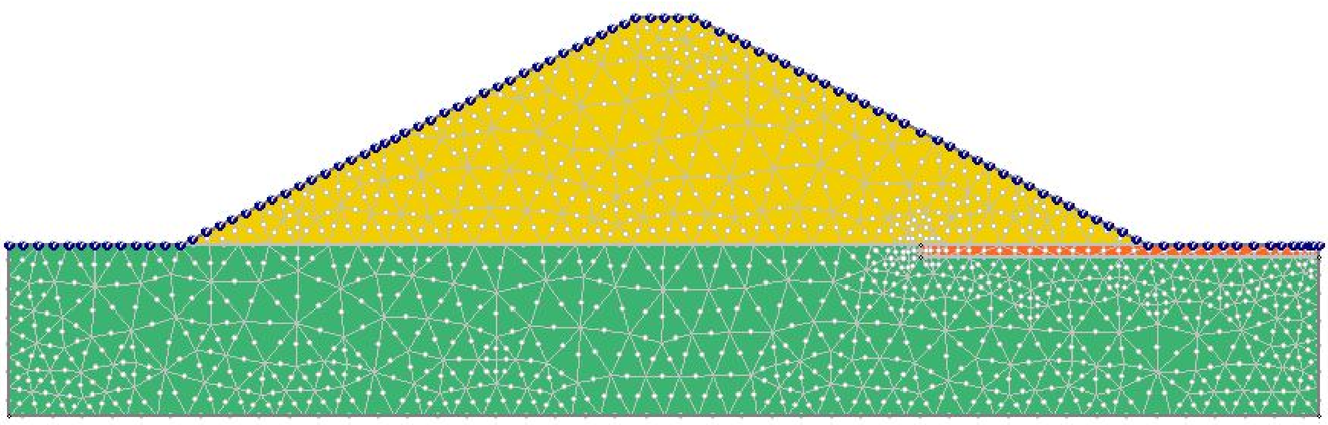
• External and material boundaries have been defined

• Material assignments have been made

• Material hydraulic properties have been defined. Note that we are considering the underlying soil to be impermeable.

• The model has been meshed. Note that we are using 6-noded elements in this tutorial.

The model should look like this.



BOUNDARY CONDITIONS

The model shows the default boundary conditions (no flow on the external boundaries and unknown conditions at the surface). We wish to simulate ponded water to the left of the levee. The ponded water is at a depth of 18 m, therefore we will set the total head for these boundaries to 18 m. To do this, choose **Set Boundary Conditions** from the **Mesh** menu. For BC Type choose Total Head. Enter a Total Head Value of 18.

Now select the two boundary segments that enclose the ponded water:

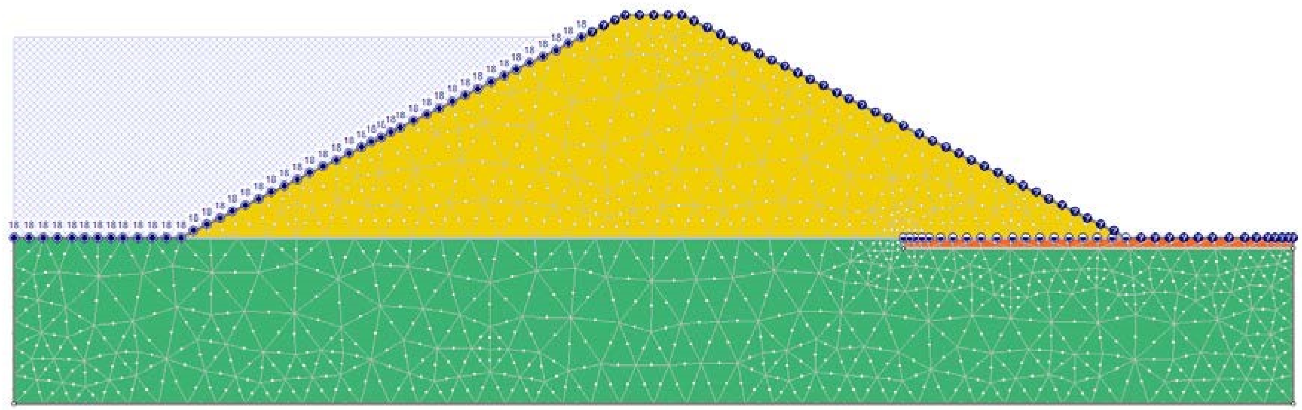
Line 1: from (-15,0) to (0,0)

Line 2: from (0,0) to (36,18)

Click Apply.

We will assume that the drain provides a drained boundary such that the pressure along the top of the drain is 0. Therefore choose Zero Pressure for the BC type.

Click on the top of the drain material (line from 65,0 to 85,0) and click apply. Close the dialog.



TIP: You can also right-click on a boundary to define its boundary conditions.

You have now completed the definition of the model. Save the model.

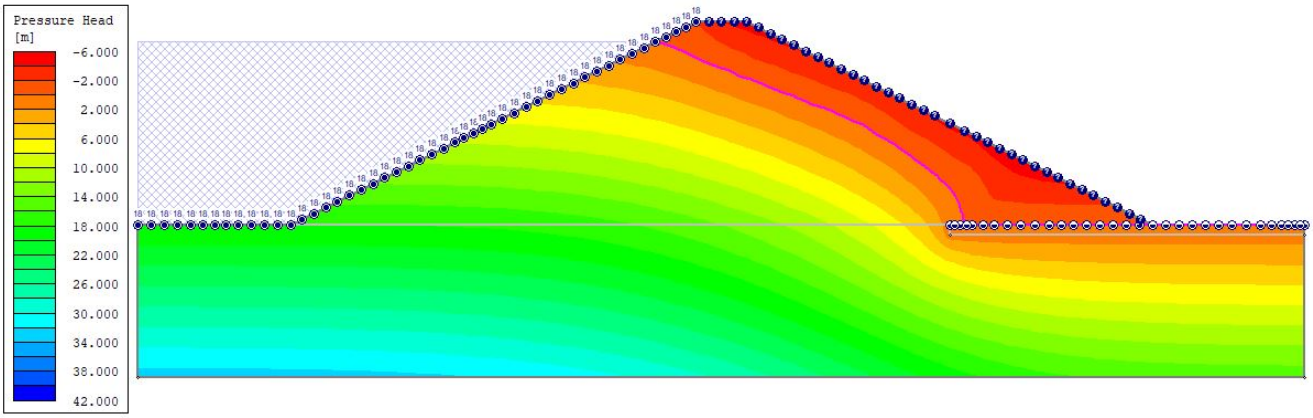
3. Compute

Since we are only interested in the groundwater results, we only need to run the groundwater computation. Select **Compute (groundwater)** from the **Analysis** menu (or click the **Compute groundwater** button in the toolbar). The analysis should take a few seconds to run.

Once the model has finished computing (Compute dialog closes), select the Interpret (groundwater) option in the Analysis menu to view the results.

4. Interpret

After you select the Interpret option, the Interpret program starts and reads the results of the analysis. A screen is displayed showing the pressure head results. Display the material boundaries by selecting **View > Display Options** and checking the box for **Material Boundaries** in the **General** tab. Click **Done**. Your plot should look like this:

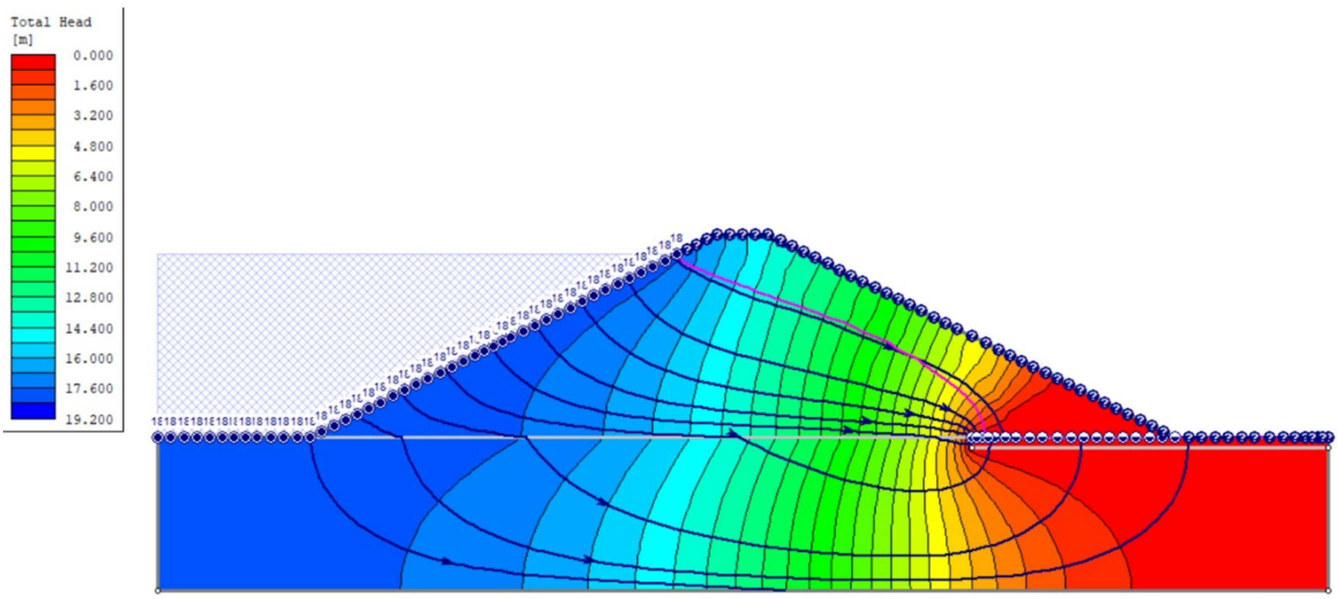


Pressure head in the model

The purpose of the toe drain was to prevent the phreatic surface from intersecting the right (downstream) side of the levee. The phreatic surface is shown as a pink line on the plot and it is clear that it does not intersect the boundary, meaning that the drain performed as desired.

We can easily construct a flow net to examine the results in more detail. Change the quantity being plotted from Pressure Head to Total Head using the drop-down menu on the toolbar. Now right-click on the model and select Contour Options. Under Mode select Filled (with lines) and then select Done. You will now see the equipotential lines of the flownet.

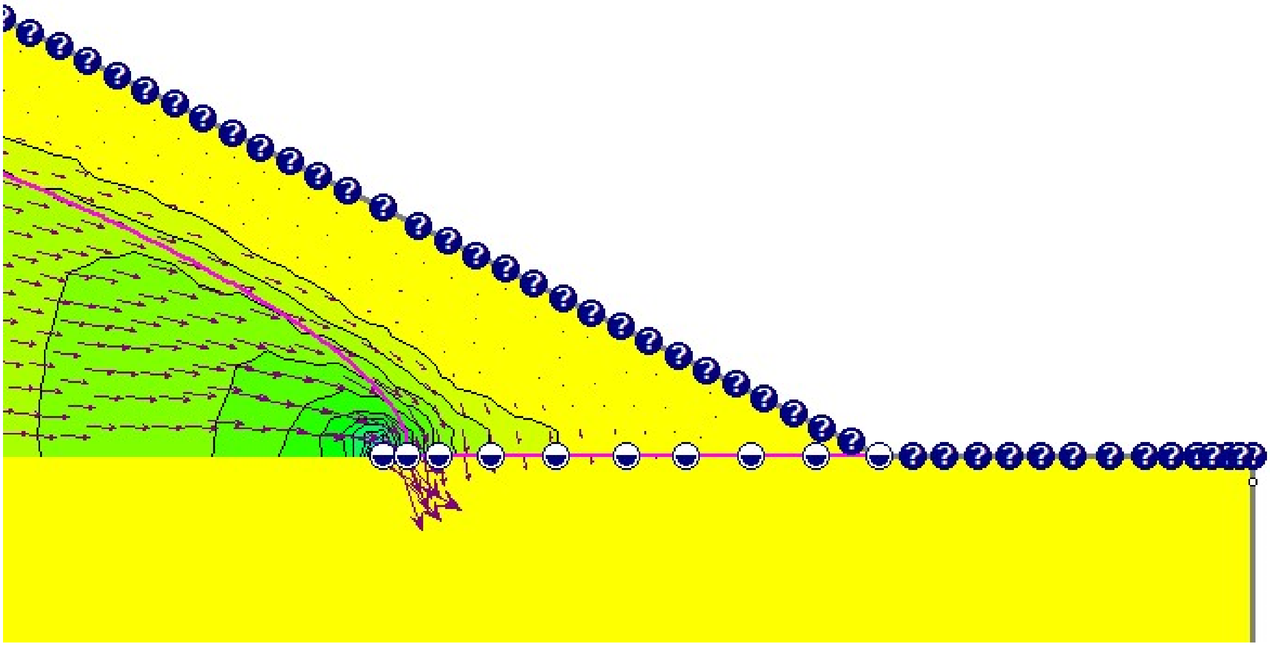
To plot the flow lines, go to the Groundwater menu and from the Lines sub-menu select Add Multiple Flow Lines. Select the top left corner of the levee as the first point (40,20). Now select the bottom left corner of the levee (0,0). Hit enter to finish. You will see the Flow Line Options dialog. Here you can choose how many flow lines you wish to plot. Under Start Flow-Lines select the first option and leave the default value (10 locations, evenly spaced along the polyline). Click OK to close the dialog. You will now see 10 flow lines plotted as shown.



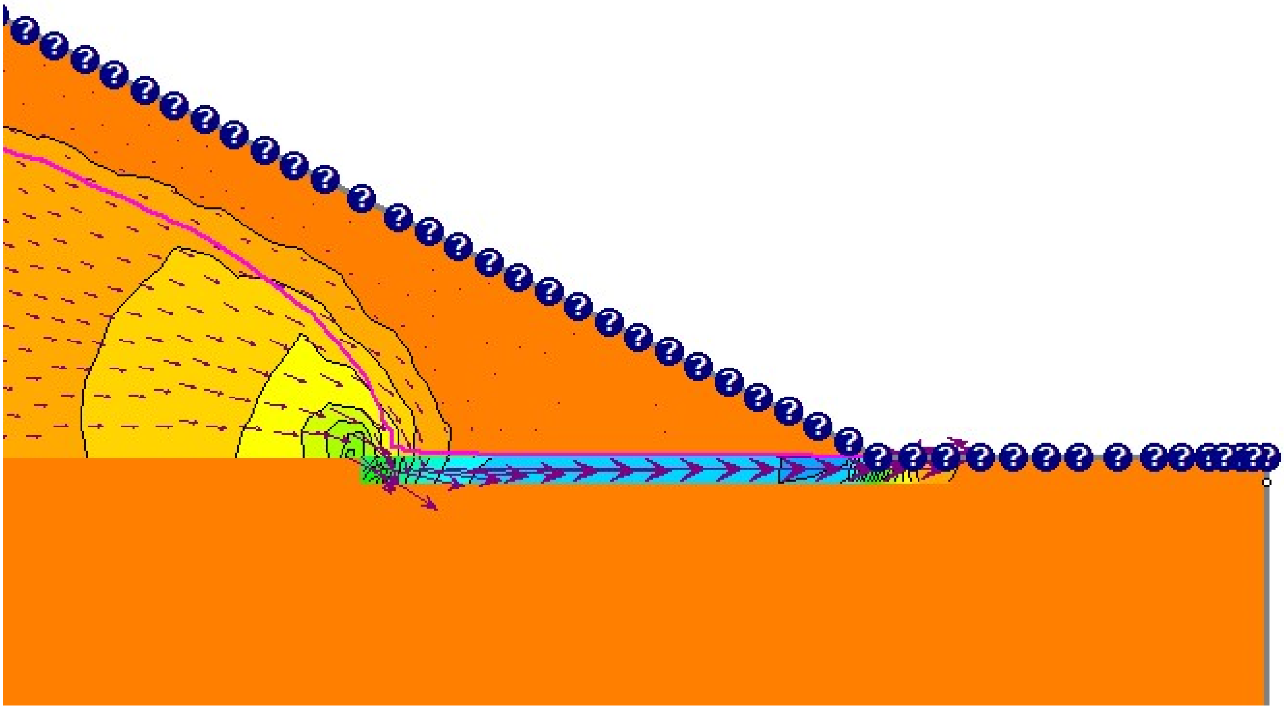
This concludes the Levee with Toe Drain tutorial.

5. Modelling Comments

If you display the flow vectors for this model and view the discharge velocity contours (see figure below), you will observe that there is apparently no flow taking place within the drain material. This is because the zero pressure boundary condition along the top of the drain, acts as a “sink”, and this is what stimulates the drainage condition.

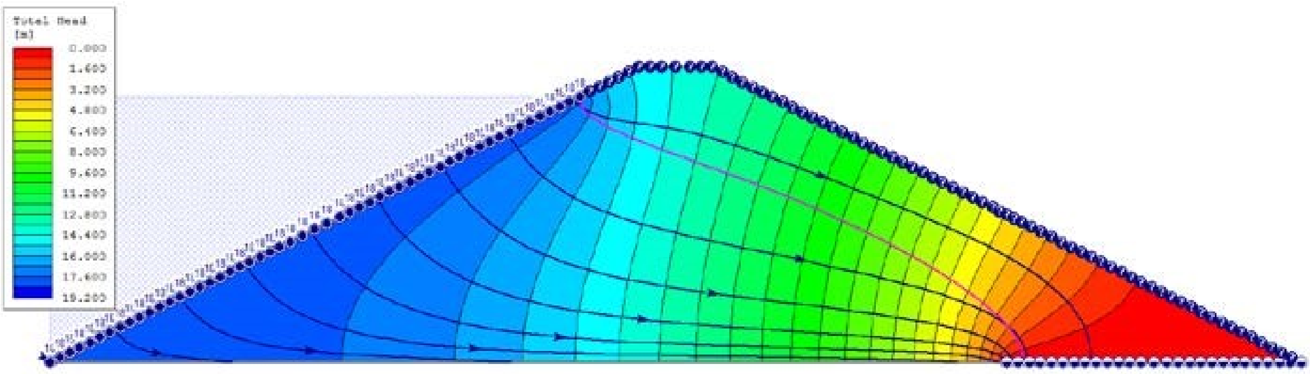


However, if you remove the zero pressure boundary condition at the top of the drain, and re-run the analysis, you will then see actual flow through the drain material, as shown in the figure below. This is due to the difference in permeability of the drain and levee materials.



For this particular model, the analysis results (pressure head, total head, location of water table) are very similar, with or without the boundary condition. However, this will not always be the case, and in general, it is recommended that the zero pressure boundary condition is used to enforce the drainage condition at the desired location.

Another modelling alternative is to exclude the base and drain material altogether, and just model the levee material with boundary conditions, as shown in the next figure.

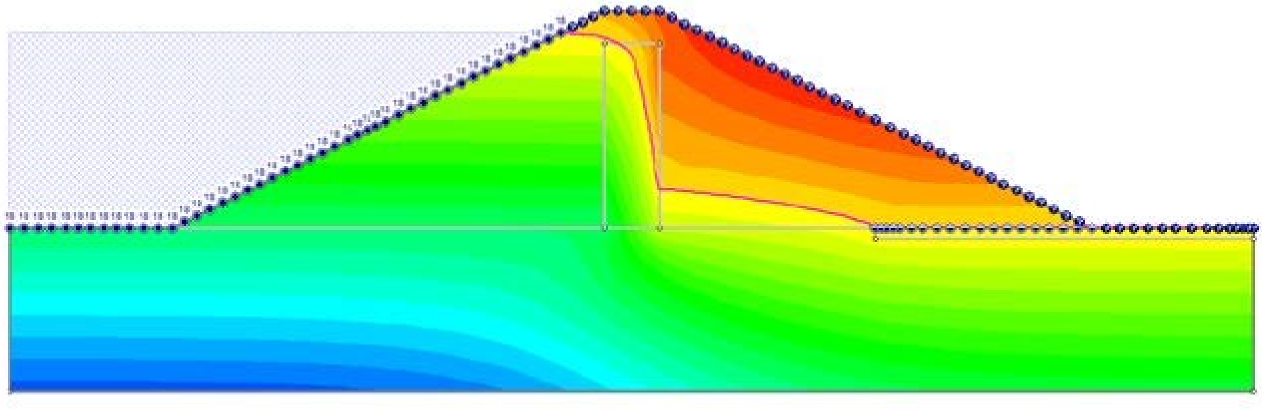


If you are only interested in groundwater results, and the base material is assumed to be impermeable, then it is sufficient to only model the levee as shown in the above figure.

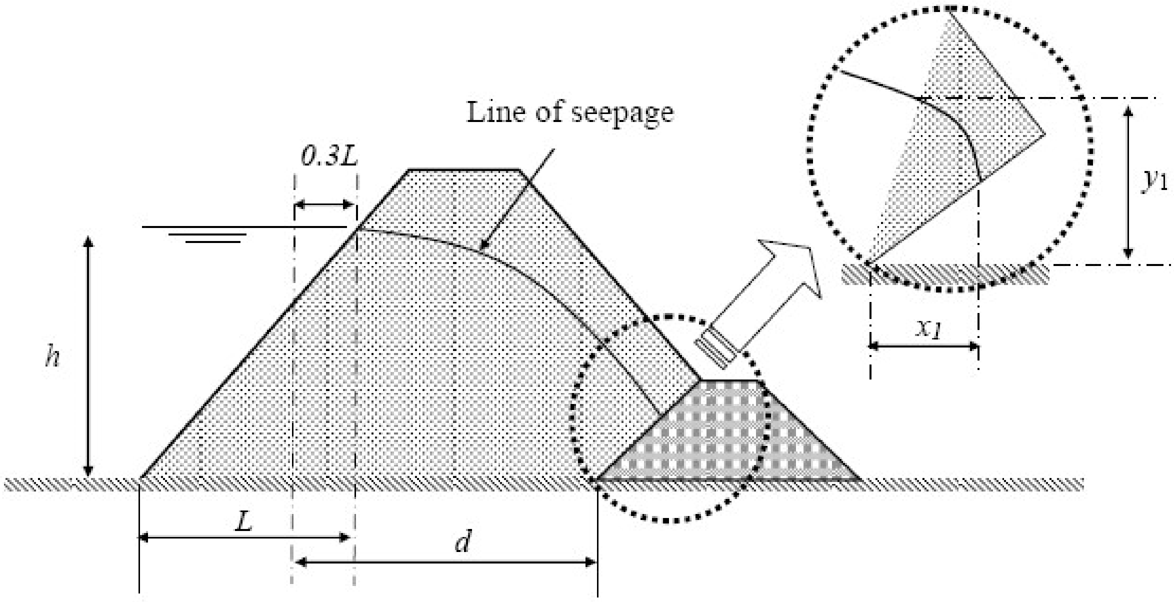
However, if you are also carrying out a slope stability analysis, then you might require the base material in order to ensure a complete slope stability analysis of the entire model (i.e. to account for slip surfaces which pass through the base material).

6. Additional Exercises

We can simulate a levee with a low permeability core by specifying material boundaries to define the core and setting up a new material with a lower permeability (say 1e-11 m/s). An example is shown below:



Another possibility is to construct a levee with a non-horizontal toe drain as shown.



This type of model is described in **Groundwater Verification Problem #4**.