11 POTATO FIELD MOISTURE CONTENT

This tutorial demonstrates the applicability of PLAXIS to agricultural problems. The potato field tutorial involves a loam layer on top of a sandy base. The water level in the ditches remains unchanged. The precipitation and evaporation may vary on a daily basis due to weather conditions. The calculation aims to predict the variation of the water content in the loam layer in time as a result of time-dependent boundary conditions.

Objectives:
• Defining precipitation

11.1 INPUT

Due to the symmetry of the problem, it is sufficient to simulate a strip with a width of 15.0 m, as indicated in Figure 11.1. The thickness of the loam layer is 2.0 m and the sand layer is 3.0 m deep.

To create the geometry model, follow these steps:

General settings
• Start the Input program and select Start a new project from the Quick select dialog box.
• In the Project tabsheet of the Project properties window, enter an appropriate title.
• In the Model tabsheet keep the default options for Model (Plane strain), and Elements (15-Node).
• Set the model dimensions to $x_{\text{min}} = 0.0\,\text{m}$, $x_{\text{max}} = 15.0\,\text{m}$, $y_{\text{min}} = 0.0\,\text{m}$ and $y_{\text{max}} = 5.0\,\text{m}$.
• Keep the default values for units, constants and the general parameters and press OK to close the Project properties window.
**Definition of soil stratigraphy**

Due to the geometry of the model, the options for snapping should be changed.

- Click the *Snapping options* button in the bottom toolbar.
- In the appearing window set the *Number of snap intervals* to 100 (Figure 11.2).
- Click *OK* to close the *Snapping* window.

![Figure 11.2 Modification of the Number of snap intervals](image)

To define the soil stratigraphy:

- Create two boreholes located at $x = 0.75$ and $x = 2.00$ respectively.
- In the *Modify soil layers* window add two soil layers.
- In the first borehole set $Top = 3.75$ and $Bottom = 3.00$ for the uppermost soil layer. Set $Bottom = 0$ for the lowest soil layer.
- In the second borehole set $Top = 5.00$ and $Bottom = 3.0$ for the uppermost soil layer. Set $Bottom = 0$ for the lowest soil layer.
- For both boreholes the *Head* is located at $y = 4.25$. Figure 11.3 shows the soil stratigraphy defined in the *Modify water levels* window.

![Figure 11.3 Soil stratigraphy in the Modify soil layers window](image)
Create the material data sets according to Table 11.1.

- Assign the material data set to the corresponding clusters in the model.

Table 11.1 Material properties for potato field

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Name</th>
<th>Loam</th>
<th>Sand</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Material model</td>
<td>-</td>
<td>Linear elastic</td>
<td>Linear elastic</td>
</tr>
<tr>
<td>Type of material behaviour</td>
<td>Type</td>
<td>Linear elastic</td>
<td>Linear elastic</td>
<td>Linear elastic</td>
</tr>
<tr>
<td>Soil unit weight above p.l.</td>
<td>$\gamma_{\text{unsat}}$</td>
<td>19</td>
<td>20</td>
<td>kN/m$^3$</td>
</tr>
<tr>
<td>Soil unit weight below p.l.</td>
<td>$\gamma_{\text{sat}}$</td>
<td>19</td>
<td>20</td>
<td>kN/m$^3$</td>
</tr>
<tr>
<td>Parameters</td>
<td>Young's modulus</td>
<td>$E'$</td>
<td>$1.0 \times 10^3$</td>
<td>$1.0 \times 10^4$</td>
</tr>
<tr>
<td></td>
<td>Poisson's ratio</td>
<td>$\nu'$</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Data set</td>
<td>Type</td>
<td>Staring</td>
<td>Staring</td>
</tr>
<tr>
<td>Model</td>
<td>Van Genuchten</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subsoil/Topsoil</td>
<td>Topsoil</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Type</td>
<td>Clayey loam</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Use defaults</td>
<td>From data set</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Horizontal permeability</td>
<td>$k_x$</td>
<td>0.01538</td>
<td>0.1270</td>
<td>m/day</td>
</tr>
<tr>
<td>Vertical permeability</td>
<td>$k_y$</td>
<td>0.01538</td>
<td>0.1270</td>
<td>m/day</td>
</tr>
</tbody>
</table>

11.2 MESH GENERATION

- Proceed to the Mesh mode.
- Multi-select the line segments composing the upper boundary of the model (Figure 11.4).

![Figure 11.4 The upper boundary of the model](image)

- In the Selection explorer set the Coarseness factor parameter to 0.5.
- Create the mesh. Use the default option for the Element distribution parameter (Medium).
- View the mesh. The resulting mesh is displayed in (Figure 11.5).
- Click on the Close tab to close the Output program.
11.3 CALCULATIONS

The calculation process consists of two phases. In the initial phase, the groundwater flow in steady state is calculated. In Phase 1, the transient groundwater flow is calculated.

**Initial phase**

- Proceed to the *Staged construction* mode. In this project only groundwater flow analysis will be performed.
- In the *Phases* window select the *Flow only* option as the *Calculation type* in the *General* subtree.
- The default values of the remaining parameters are valid for this phase. Click *OK* to close the *Phases* window.
- Right-click the bottom boundary of the model and select the *Activate* option in the appearing menu.
- In the *Selection explorer* select the *Head* option in the *Behaviour* drop-down menu and set $h_{\text{ref}}$ to 3.0 (Figure 11.6).

![](image)

**Transient phase**

In the transient phase the time-dependent variation of precipitation is defined.

- In the *Model explorer* expand the *Model conditions* subtree.
- Expand the *GroundwaterFlow* subtree. Set *BoundaryXMin* and *BoundaryXMax* to *Closed*.
- Expand the *Water* subtree. The borehole water level is assigned to *GlobalWaterLevel*. 
Hint: Note that the conditions explicitly assigned to groundwater flow boundaries are taken into account. In this tutorial the specified Head will be considered for the bottom boundary of the model, NOT the Closed condition specified in the GroundwaterFlow subtree under the Model conditions.

Add a new calculation phase.

- In General subtree of the Phases window select the Transient groundwater flow as Pore pressure calculation type.
- Set the Time interval to 15 days.
- In the Numerical control parameters subtree set the Max number of steps stored to 250. The default values of the remaining parameters will be used.
- Click OK to close the Phases window.

To define the precipitation data a discharge function should be defined.

- In the Model explorer expand the Attributes library subtree.
- Right-click on Flow functions and select the Edit option in the appearing menu. The Flow functions window pops up.
- In the Discharge functions tabsheet add a new function.
- Specify a name for the function and select the Table option in the Signal drop-down menu.
- Click the Add row button to introduce a new row in the table. Complete the data using the values given in the Table 11.2.

Table 11.2 Precipitation data

<table>
<thead>
<tr>
<th>ID</th>
<th>Time [day]</th>
<th>∆Discharge [m$^3$/day/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1·10$^{-2}$</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>3·10$^{-2}$</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>-2·10$^{-2}$</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>1·10$^{-2}$</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>1·10$^{-2}$</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>9</td>
<td>-2·10$^{-2}$</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>-2·10$^{-2}$</td>
</tr>
<tr>
<td>12</td>
<td>11</td>
<td>-2·10$^{-2}$</td>
</tr>
<tr>
<td>13</td>
<td>12</td>
<td>-1·10$^{-2}$</td>
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<tr>
<td>14</td>
<td>13</td>
<td>-1·10$^{-2}$</td>
</tr>
<tr>
<td>15</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>15</td>
<td>0</td>
</tr>
</tbody>
</table>

- Figure 11.7 shows the defined function for precipitation. Close the windows by clicking OK.
- In the Model explorer expand the Precipitation subtree under Model conditions and activate it. The default values for discharge ($q$) and condition parameters ($\psi_{min} = \)
-1.0 m and \( \psi_{\text{max}} = 0.1 \text{m} \) are valid.

• For the precipitation select the Time dependent option in the corresponding drop-down menu and assign the defined function (Figure 11.8).

Calculate the project.

Save the project after the calculation has finished.
11.4 RESULTS

The calculation was focused on the time-dependent saturation of the potato field. To view the results:

- From the Stresses menu select Groundwater flow → Saturation.
- Double click the legend. The Legend settings window pops up. Define the settings as shown in Figure 11.9.

![Legend settings window](image)

Figure 11.9 Value for settings

- Figure 11.10 shows the spatial distribution of the saturation for the last time step.

![Saturation field at day 15](image)

Figure 11.10 Saturation field at day 15

- Create an animation of the transient phase for a better visualisation of the results.
- It is also interesting to create a vertical cross section at x = 4 m and draw cross section curves for pore pressure and saturation.