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.

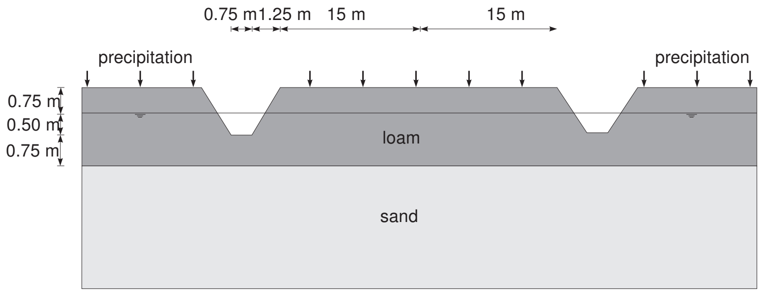

Figure 11.1 Potato field geometry

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_{min} = 0.0 m, x_{max} = 15.0 m, y_{min} = 0.0 m and y_{max} = 5.0 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.

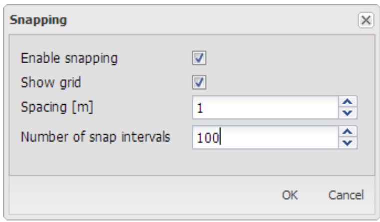

Figure 11.2 Modification of the *Number of snap intervals*

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.

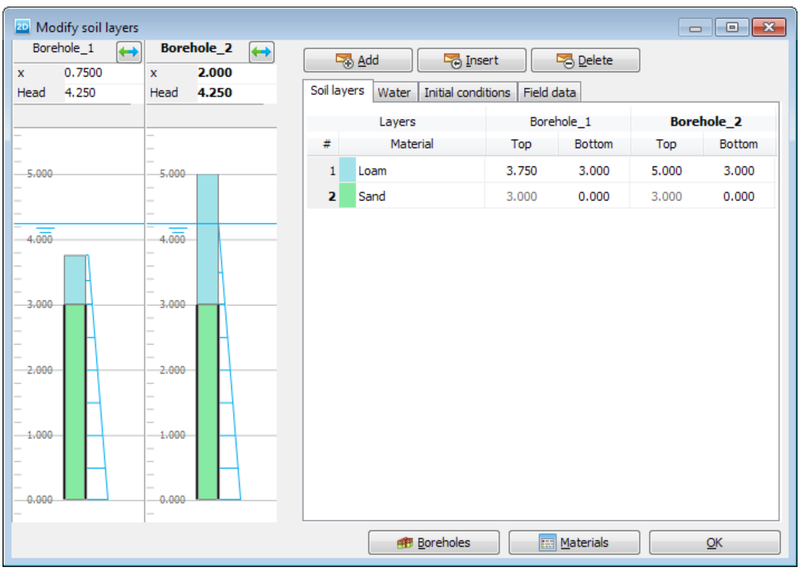

Figure 11.3 Soil stratigraphy in the *Modify soil layers window*

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

Parameter	Name	Loam	Sand	Unit
General				
Material model	-	Linear elastic	Linear elastic	-
Type of material behaviour	*Type*	Drained	Drained	-
Soil unit weight above p.l.	γ_{unsat}	19	20	kN/m^3
Soil unit weight below p.l.	γ_{sat}	19	20	kN/m^3
Parameters				
Young's modulus	*E'*	$1.0 \cdot 10^3$	$1.0 \cdot 10^4$	kN/m^2
Poisson's ratio	ν'	0.3	0.3	-
Groundwater				
Data set	*Type*	Staring	Staring	-
Model	-	Van Genuchten	Van Genuchten	-
Subsoil/Topsoil	-	Topsoil	Subsoil	-
Type	-	Clayey loam (B9)	Loamy sand (O2)	-
Use defaults	-	From data set	From data set	-
Horizontal permeability	k_x	0.01538	0.1270	m/day
Vertical permeability	k_y	0.01538	0.1270	m/day

11.2 MESH GENERATION

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

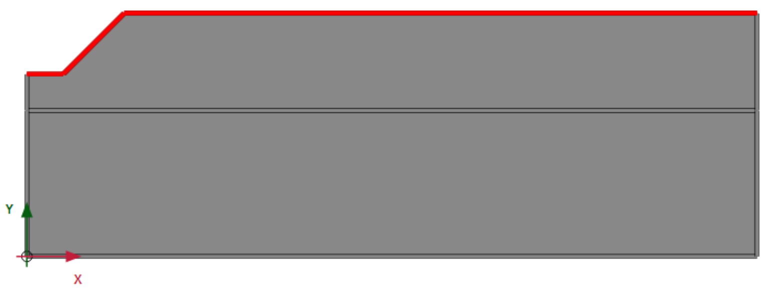

Figure 11.4 The upper boundary of the model

- 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.

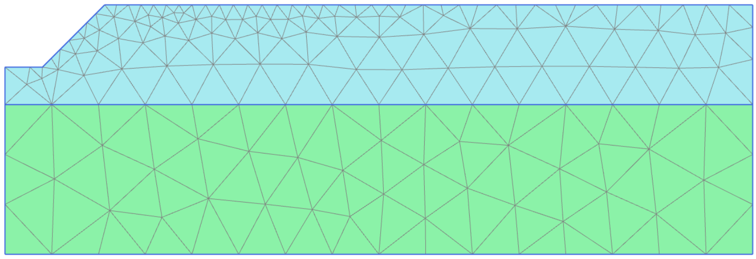

Figure 11.5 Potato field mesh

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_{ref} to 3.0 (Figure 11.6).

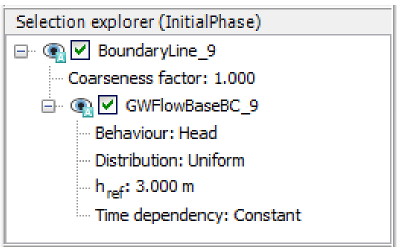

Figure 11.6 Boundary conditions at the bottom of the geometry model

- 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*.

Transient phase

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

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

ID	Time [day]	Δ*Discharge* [m^3/day/m]
1	0	0
2	1	$1 \cdot 10^{-2}$
3	2	$3 \cdot 10^{-2}$
4	3	0
5	4	$-2 \cdot 10^{-2}$
6	5	0
7	6	$1 \cdot 10^{-2}$
8	7	$1 \cdot 10^{-2}$
9	8	0
10	9	$-2 \cdot 10^{-2}$
11	10	$-2 \cdot 10^{-2}$
12	11	$-2 \cdot 10^{-2}$
13	12	$-1 \cdot 10^{-2}$
14	13	$-1 \cdot 10^{-2}$
15	14	0
16	15	0

- 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 (ψ_{min} =

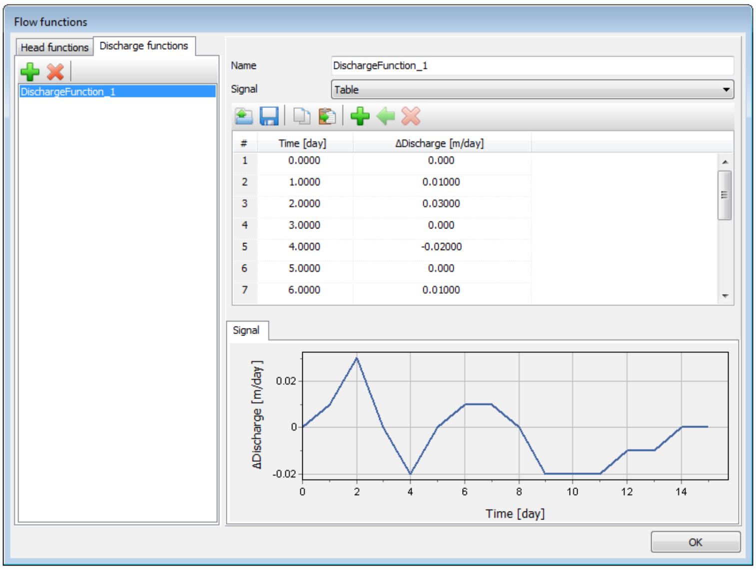

Figure 11.7 The *Flow function* window displaying the precipitation data and plot

-1.0 m and ψ_{max} = 0.1m) are valid.

- For the precipitation select the *Time dependent* option in the corresponding drop-down menu and assign the defined function (Figure 11.8).
- In the *Model explorer* set DischargeFunction1 under *Discharge function*.

Calculate the project.

Save the project after the calculation has finished.

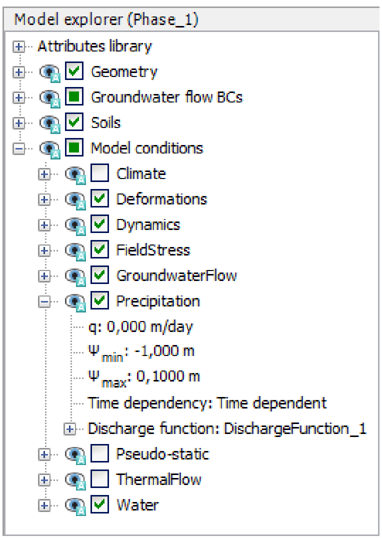

Figure 11.8 *Precipitation* in the *Model explorer*

Hint: Negative values of precipitation indicate evaporation.

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.

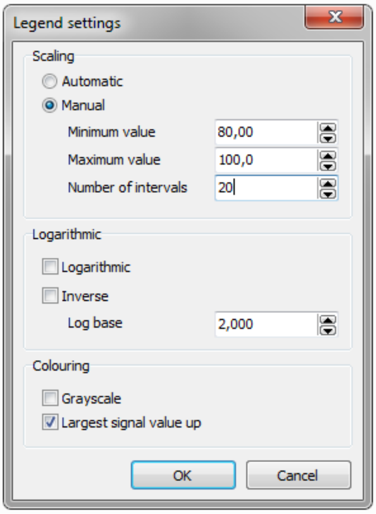

Figure 11.9 Value for settings

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

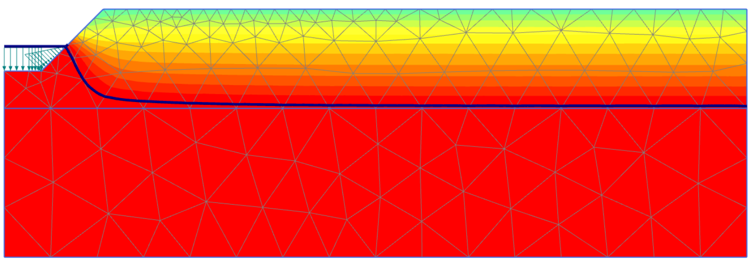

Figure 11.10 Saturation field at day 15

- 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.