CONFINED FLOW AROUND AN IMPERMEABLE WALL

This document verifies that groundwater flow principles are correctly implemented in PLAXIS. The confined flow around an impermeable wall is studied.

Used version:

- PLAXIS 2D - Version 2018.0
- PLAXIS 3D - Version 2018.0

Geometry: Figure 1 illustrates the model geometry and the considered boundary conditions. A 10 m wide impermeable dam is founded on a soil layer of 10.0 m thickness, with an impermeable bottom. The water level is at 5.0 m at the left side of the dam and at 3.0 m at the right. A 5.0 m tall impermeable wall is placed in the soil, under the mid-line of the dam. In PLAXIS 2D, the wall is modelled by means of an impermeable interface (negative or positive), assigned to a geometry line. Vertical geometry lines are used to define a soil cluster below the dam, from its bottom down to the impermeable layer. Mesh refinement will be used within that cluster to increase results accuracy.

In PLAXIS 3D, the model is extended by 1 m in y-direction (plane strain condition). The wall is modelled with a surface in which an impermeable interface (positive or negative) is assigned. Vertical geometry surfaces are used to define a soil cluster below the dam, from its bottom down to the impermeable layer.

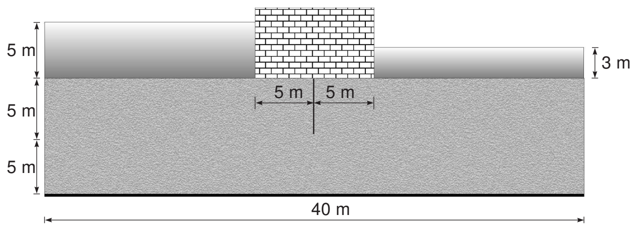

Figure 1 Model geometry and boundary conditions

Materials: The adopted material parameters are:

Soil:	Linear elastic	Drained	E' = 1 kN/m^2	k = 1 m/day
Dam:	Linear elastic	Non-porous	E = 1 kN/m^2	

Meshing: In both PLAXIS 2D and PLAXIS 3D models, the *Fine* option is selected for the *Element distribution*. A *Coarseness factor* equal to 0.2 is assigned to the soil cluster below the dam. The geometry lines (surfaces) representing the wall and the bottom boundary of the dam are refined with a *Coarseness factor* of 0.1. Figure 2 and Figure 3 present the finite element mesh in PLAXIS 2D and PLAXIS 3D respectively.

Calculations: The calculations are performed using the *Groundwater flow only* mode with *Steady state groundwater flow* as *Pore pressure calculation type*. The bottom groundwater flow boundary is set to *Closed* in both PLAXIS 2D and PLAXIS 3D. In addition, both groundwater flow boundaries in the y-direction are set to *Closed* in PLAXIS 3D. The *Tolerated error* is selected equal to 5.0×10^{-6}.

Output: The steady-state groundwater head contours computed by PLAXIS 2D and PLAXIS 3D are presented in Figures 4 and 5 correspondingly. To obtain the results

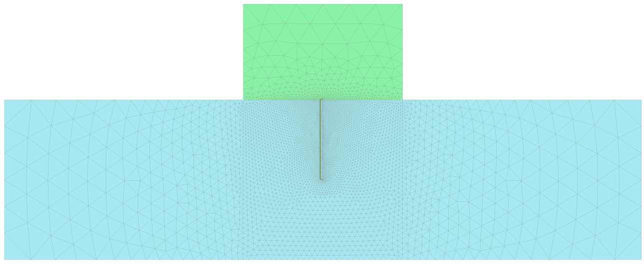

Figure 2 Finite element mesh (PLAXIS 2D)

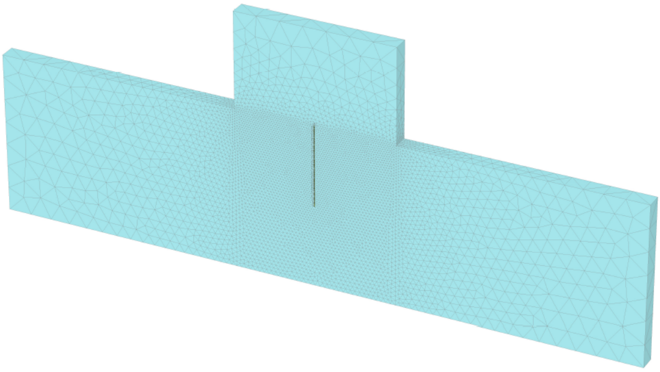

Figure 3 Finite element mesh (PLAXIS 3D)

illustrated in Figure 5, a vertical cross section at the middle of the PLAXIS 3D model in y-direction is used (y = 0.05 m).

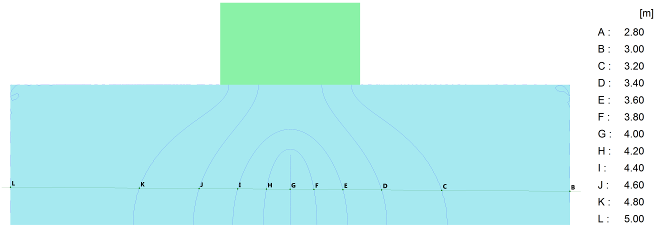

Figure 4 Groundwater head contours (PLAXIS 2D)

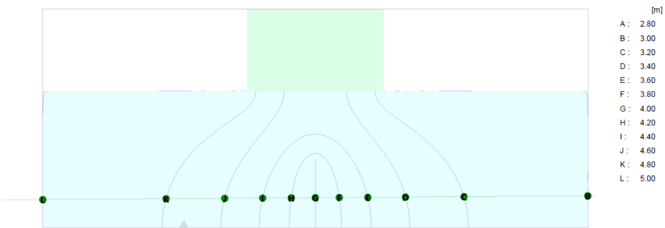

Figure 5 Groundwater head contours (PLAXIS 3D)

Verification: Harr (1962) has given a closed form solution for the confined flow total discharge (q) around an impermeable wall. The influencing parameters are the width of the dam (b), the depth of the soil layer (T), the water level variation (Δh) and the permeability of the soil layer (k). Figure 6 graphically presents his approach.

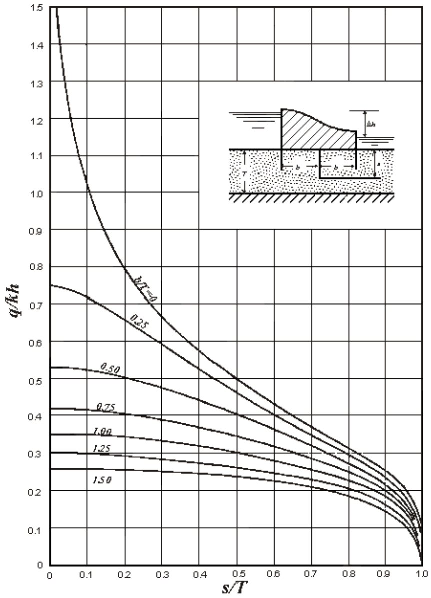

Figure 6 Closed form solution for total discharge (q), Harr (1962)

With respect to the assumed boundary conditions (s/T = 0.5, b/T = 0.5), the analytical solution reads:

$$Q/(k\Delta h) \approx 0.41$$

which gives a total discharge equal to 0.82 m^3/day/m (for kh = 2).

Table 1 presents the comparison between the results obtained from PLAXIS and the closed form solution introduced above. It is concluded that PLAXIS approaches the analytical solution with adequate accuracy.

Table 1 Comparison between total discharge (q) obtained from the closed form solution proposed by Harr (1962) and PLAXIS

Total discharge under the dam (m^3/day/m)			Error (%)	
Harr	PLAXIS 2D	PLAXIS 3D	PLAXIS 2D	PLAXIS 3D
0.8200	0.8180	0.8187	0.24	0.15

REFERENCES

[1] Harr, M.E. (1962). Groundwater and seepage. McGraw-Hill, NY.