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 2015.02
- PLAXIS 3D - Anniversary edition (AE.01)

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 5.0 m at the left side of the dam and 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 modeled by means of an impermeable interface (negative or positive) assigned to a geometry line.

In PLAXIS 3D, the model is extended by 1 m in y-direction (plane strain conditions). The wall is modeled with a surface in which an impermeable interface (positive or negative) is assigned.

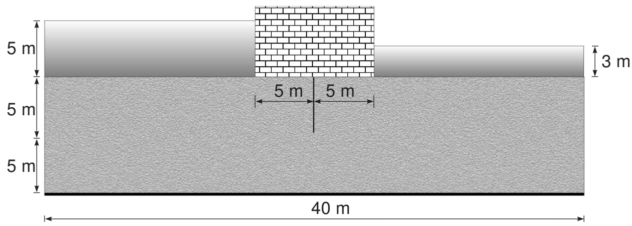

Figure 1 Model geometry and boundary conditions

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 applied to a soil cluster below the dam, from its bottom down to the impermeable layer. The geometry line representing the wall is refined with a *Coarseness factor* which equals 0.075. 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 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 Figure 4 and Figure 5 correspondingly. To obtain the results illustrated in Figure 5, a vertical cross section in the middle of the PLAXIS 3D model in y-direction is used (y = 0.05 m).

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

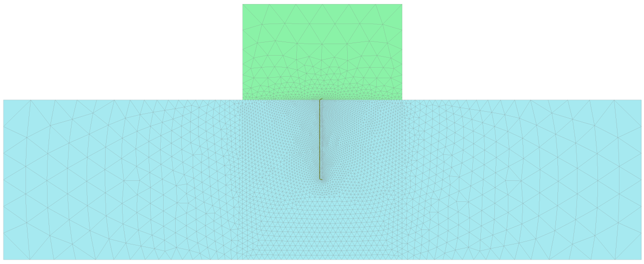

Figure 2 Finite element mesh (PLAXIS 2D)

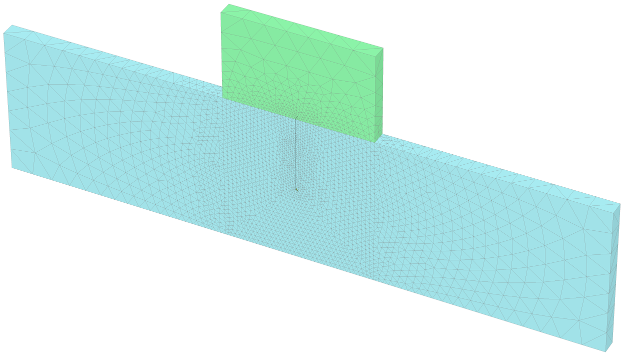

Figure 3 Finite element mesh (PLAXIS 3D)

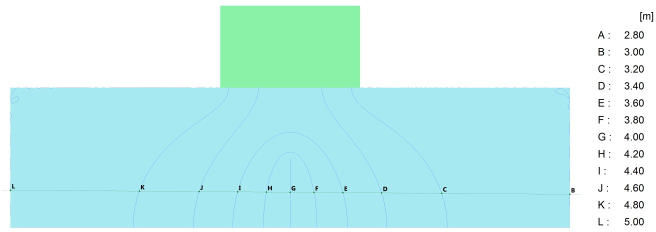

Figure 4 Groundwater head contours (PLAXIS 2D)

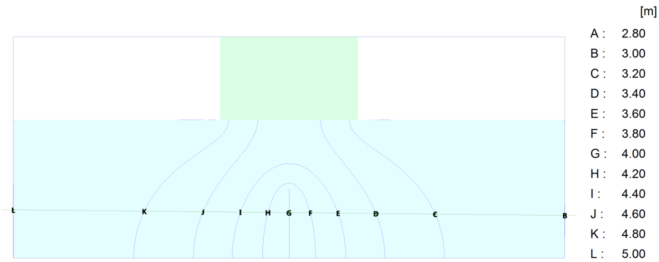

Figure 5 Groundwater head contours (PLAXIS 3D)

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.

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

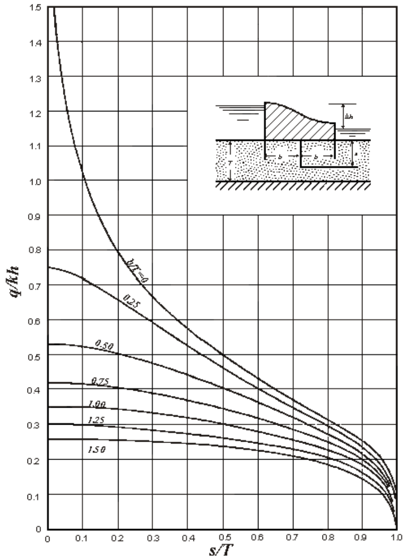

Figure 6 Closed form solution for total discharge (q), Harr (1962)

solution is:

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

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	0.8179	- 0.24 %	- 0.25 %

REFERENCES

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