35 CONFINED SEEPAGE AROUND IMPERMEABLE SHEET PILE

In this example, we consider the confined seepage around a sheet pile wall as shown in Figure 35.1. It is assumed that the sheet pile wall is positioned under an 8 m wide impermeable dam. Rather than modeling the dam, the base of the dam is considered impermeable. Similarly, rather than explicitly modeling the water on the upstream side of the dam, equivalent fixed head boundary conditions are imposed. On the downstream side of the dam, the water table is maintained at ground level. The sheet pile wall is modeled as a Rigid Plate. In OptumG2, such elements may be either permeable or impermeable as indicated in Figure 35.1. In this example, the sheet pile is considered impermeable. The hydraulic model is taken as the Linear model with default settings and $k_x = k_y = 1$ m/day.

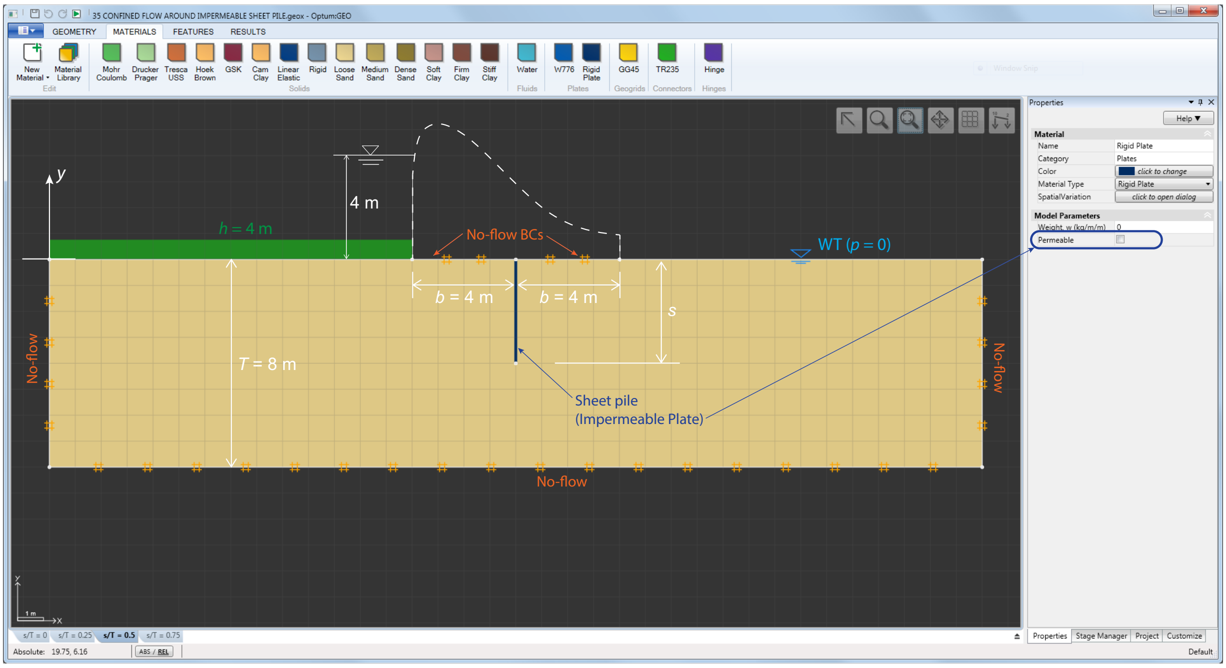


Figure 35.1: Confined seepage around sheet pile.

This problem has been solved analytically by Polubarinova-Kochina (1962) for a range of geometries. The total flux, Q, from one side of the dam to the other can be determined from the charts in Figure 35.2. Comparisons between analytical and computed solutions for selected wall depths, s, are shown in Table 35.1. We see that the numerical and analytical solutions are in very good agreement already for the coarsest meshes comprising 1,000 elements. The pressure head distributions (for 16,000 elements) are shown in Figure 35.3.

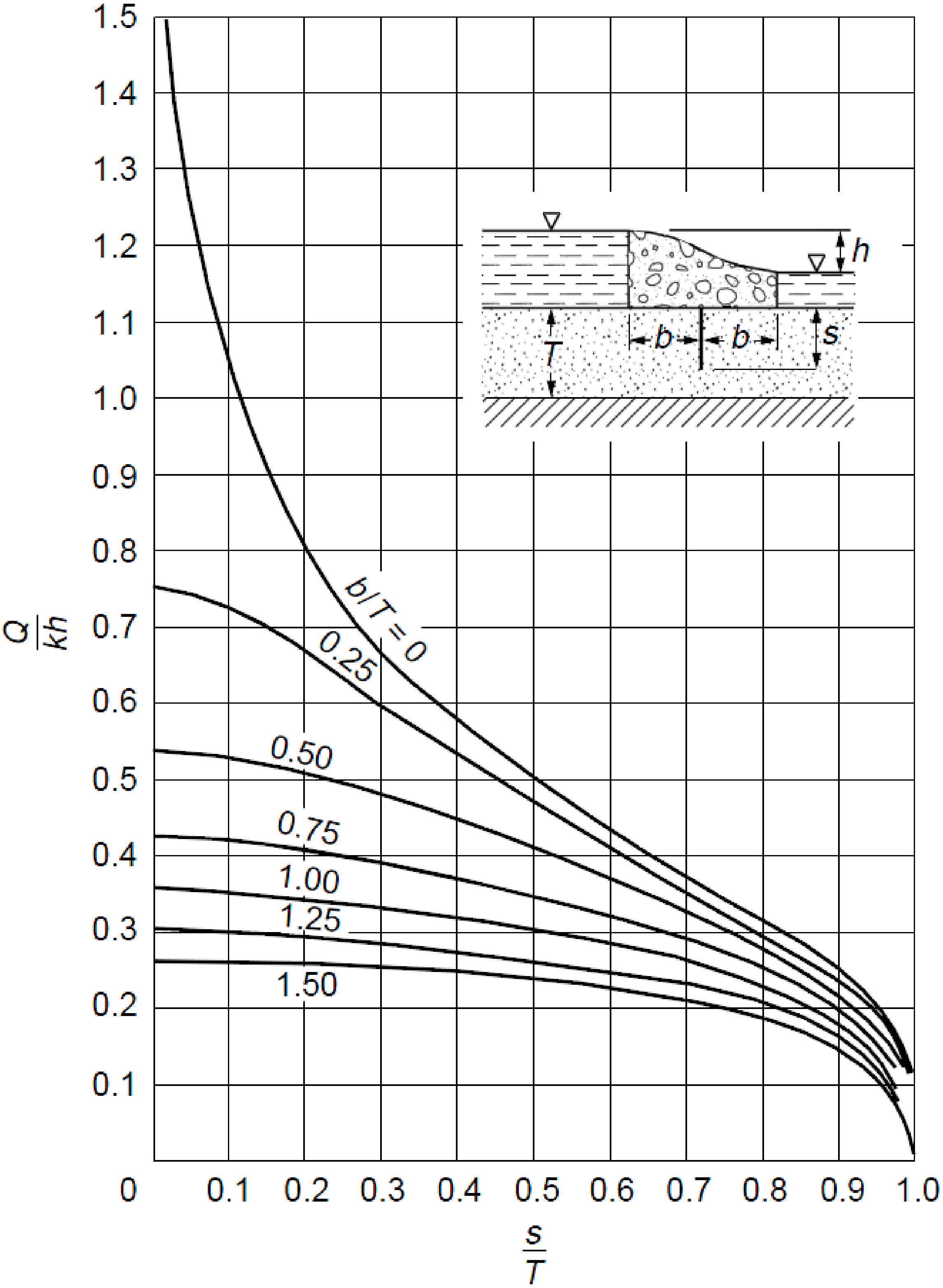


Figure 35.2: Polubarinova-Kochina (1962) solution for confined seepage around sheet pile.

	OptumG2					
s (m)	1,000	2,000	4,000	8,000	16,000	Analytical
0.0	2.19	2.17	2.16	2.15	2.14	2.14
2.0	2.05	2.03	2.01	2.00	1.99	1.98
4.0	1.69	1.67	1.66	1.65	1.64	1.64
6.0	1.27	1.25	1.24	1.23	1.22	1.21

Table 35.1: Comparison between analytical (Polubarinova-Kochina 1962) and computed fluxes Q (m^3/day/m) using 1,000 to 16,000 elements.

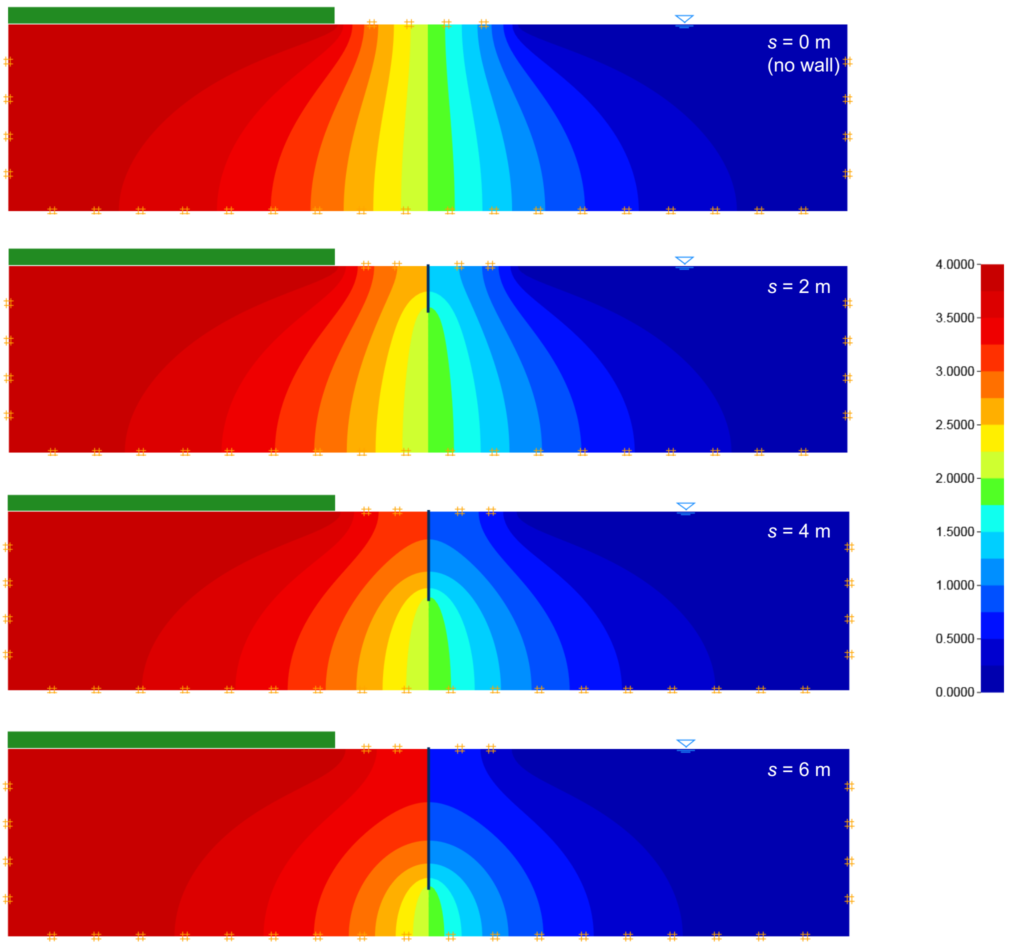
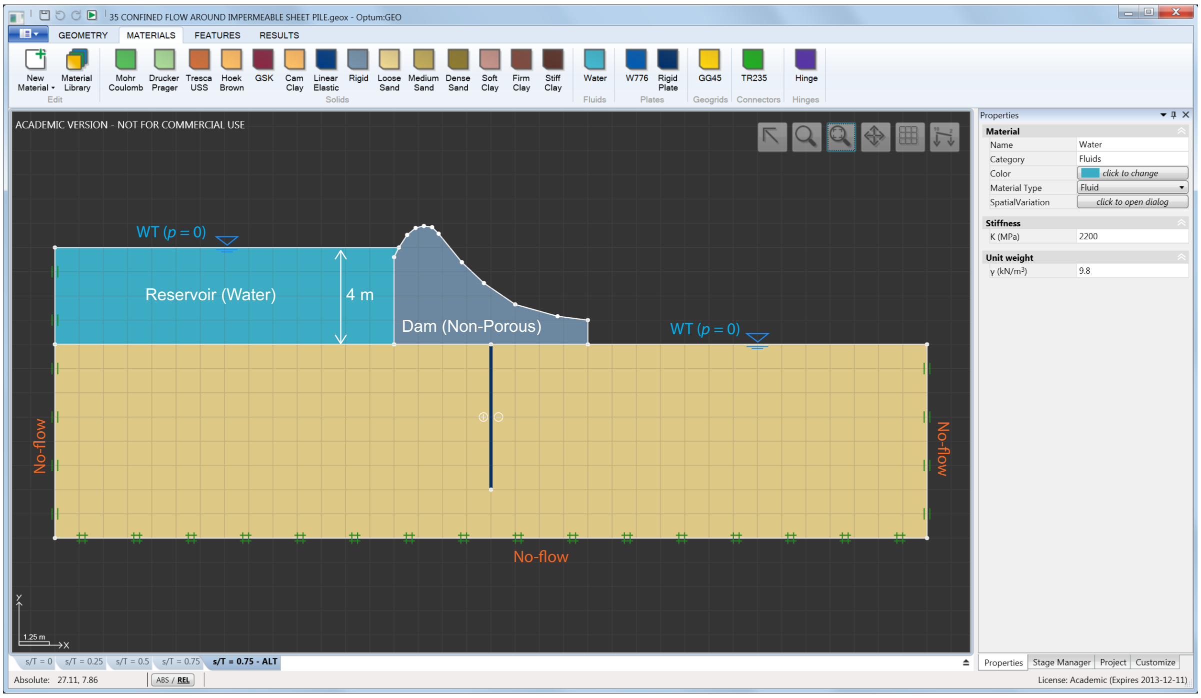


Figure 35.3: Pressure head distributions (m).

35.1 Alternative modeling

Instead of modeling the problem by imposing relevant fixed head and no-flow boundary conditions to account for the reservoir and the dam, both may be modeled using the Water material from the Fluids category and a solid with Drainage = Non-Porous from the Solids category. This alternative problem setup is shown in Figure 35.4. The reservoir may here be defined as usual, by defining the geometry and assigning the relevant material, or it may be defined using the Water Table tool available in the Features ribbon. Whichever approach is used it is important to note that the top of the water domain must be defined as a zero pressure line (indicated by a blue triangle). The geometry of the dam is defined in the usual way and the Rigid material assigned. The default drainage condition for this material is Impermeable and placing the dam on top of the soil domain as shown will thus have the same effect as imposing a no-flow boundary condition as was done originally.

Using this alternative modeling strategy, all domains including the reservoir and the dam are discretized by finite elements as shown below.



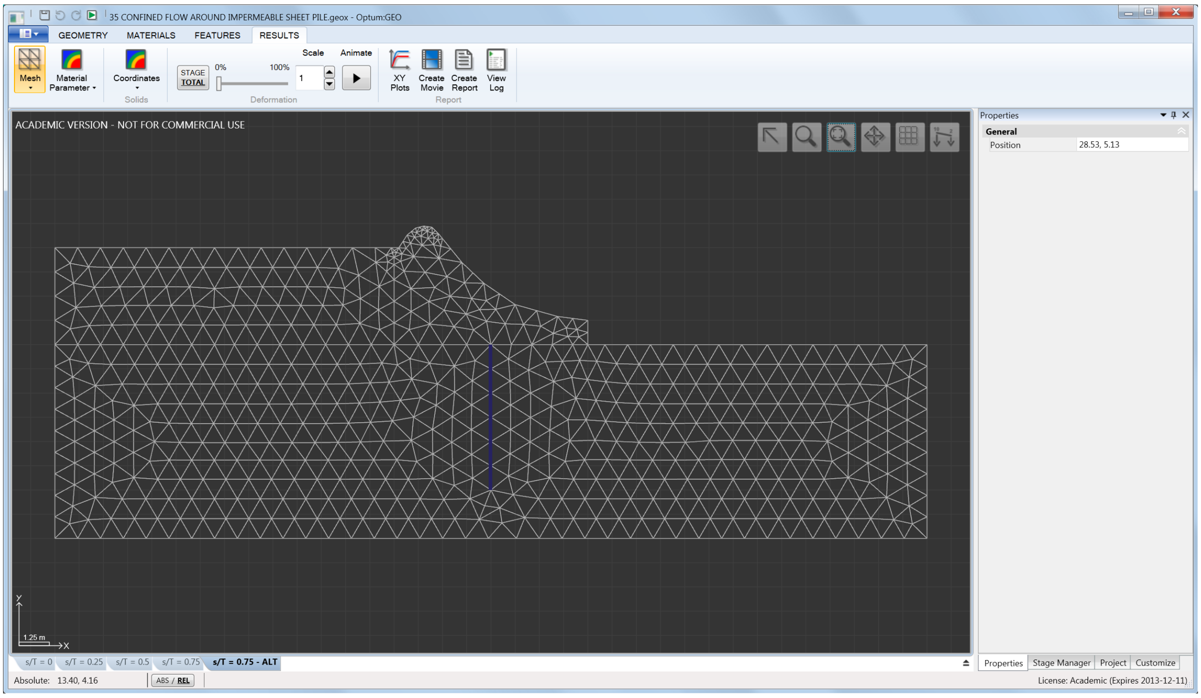


Figure 35.4: Confined seepage around sheet pile: alternative modeling and resulting mesh.

35.2 Mesh adaptivity

As with all other analysis types, it is for Seepage analysis possible to adapt the mesh in a series of adaptivity iterations. In this case, the relevant Adaptivity Control variable is Flow. This ensures that the mesh is adapted on the basis of a combination of the ‘flow energy’, $\frac{1}{2}\mathbf{q}^{\mathsf{T}}\mathbf{K}\mathbf{q}$, and a measure ensuring a reasonable concentration of elements around free surfaces (not relevant in the present problem).

The results of the analyses using 1,000 elements and 3 adaptivity iterations are shown in Figure 35.5. As seen, the critical regions are the edges of the dam and the bottom of the sheet pile. Also, note that the results in terms of the total flow are of an accuracy similar to or better than those obtained with 16,000 elements without adaptivity.

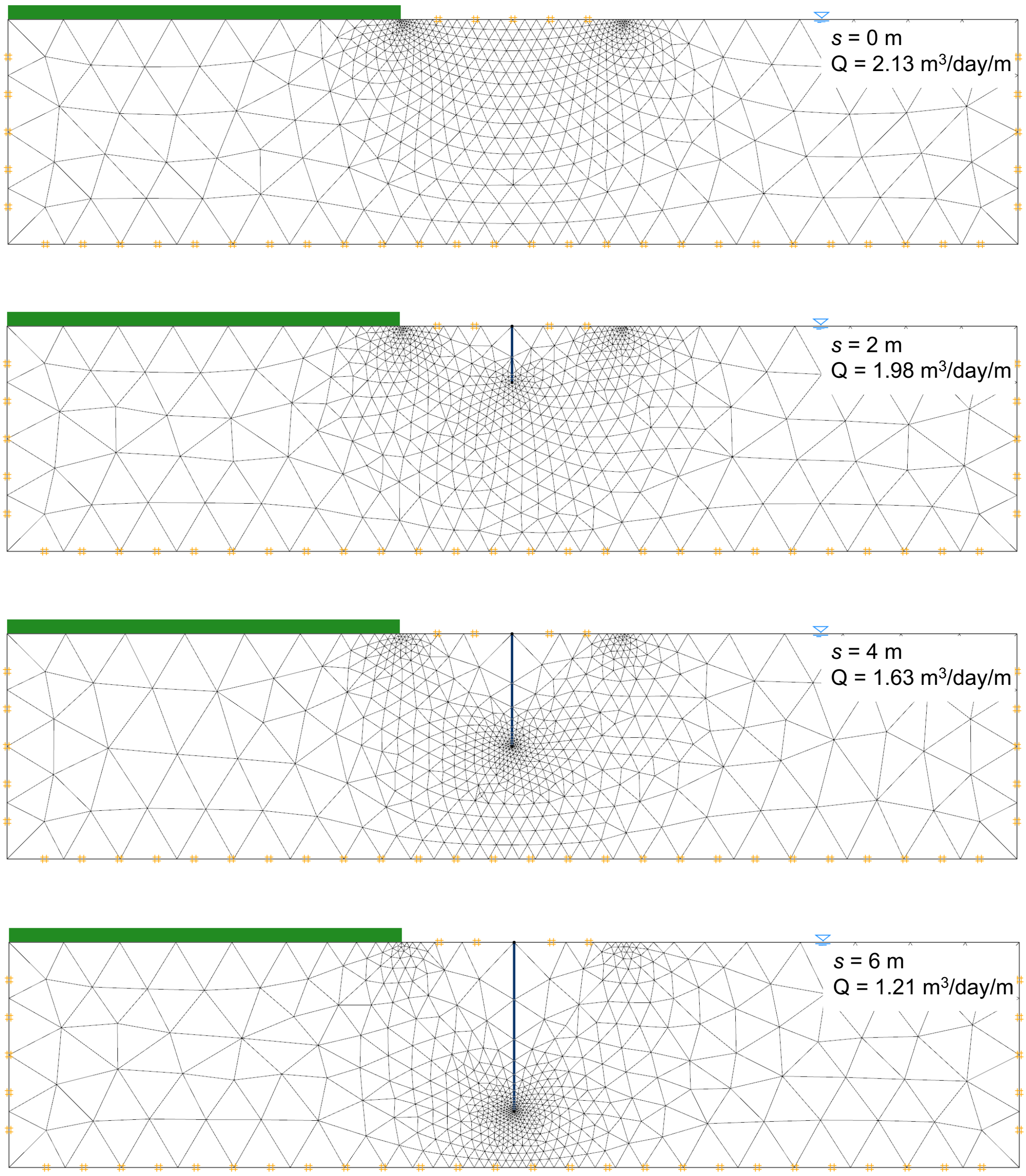


Figure 35.5: Adapted meshes (1,000 elements) and resulting fluxes.