Week #2 - Flow around a sheet pile wall

Use the course notes to understand the solution of this problem by the finite element method.

1 Uniform permeability case

In the script `sheet_pile_wall.m` (located under sessions/week_2/), you will find *most* the solution of the flow around a sheet pile wall for the uniform permeability case (the corresponding mesh part of the exercice last week is scripted at the start of the file). This script is partially written so that you will have to finish coding up the remaining parts by completing the following:

1. Impose the boundary conditions of the problem which are describe below.
2. Solve the resulting system of equations to get the piezometric head at all the nodes.

The boundary conditions of this problem are defined by the following assumptions:

- The sheet pile wall —which is separating the excavation from the ground level (see figure 1)— is impervious (note: we have considered a small thickness of the wall when creating the mesh in order to impose this boundary condition).
- The domain is fully saturated and the phreatic surface is located at the ground level on the left side of the wall and at the excavation bottom on the right side of the wall.
- The remaining boundaries are all considered as natural boundaries conditions (i.e., no flow in the perpendicular direction of the respective boundary).

So far, you have meshed the problem for arbitrary dimensions (see figure 1), now, you are asked to compute the solution (piezometric head + flux at all the nodes) for the following two particular cases:

1. H = 0.2, t = 0.4, s = 0.5, b = 0.5 and D = 1. Permeability coefficient of unity.
2. H = 0.3, t = 0.3, s = 0.5, b = 0.5 and D = 1. Permeability coefficient of unity.

Compare the numerical solution of both cases to the graphical exact solution for the exit gradient given in the figure 2. Use different refinements of the mesh in order to investigate the convergence of the numerical solution. As in the past exercise, use the functions `trisurf` and `quiver` to visualize your numerical results.

2 Impact of layers with different permeabilities

An extension of the previous script, let's consider the case where layers with different permeabilities are present. Create a new script (starting from the previous one) to investigate such layered soil structure. The main modifications are: i) the mesh (using `refine2`, you need to define internal constraints of the mesh - by giving nodes and edges of the internal material boundary in addition to the domain boundaries), ii) using mesh.id to tag different materials and assign different permeability coefficients.

Use this script to see the impact of, for instance, an intermediate layer with higher permeability (see figure 3). Note that this layer will act as a preferential path of flow.

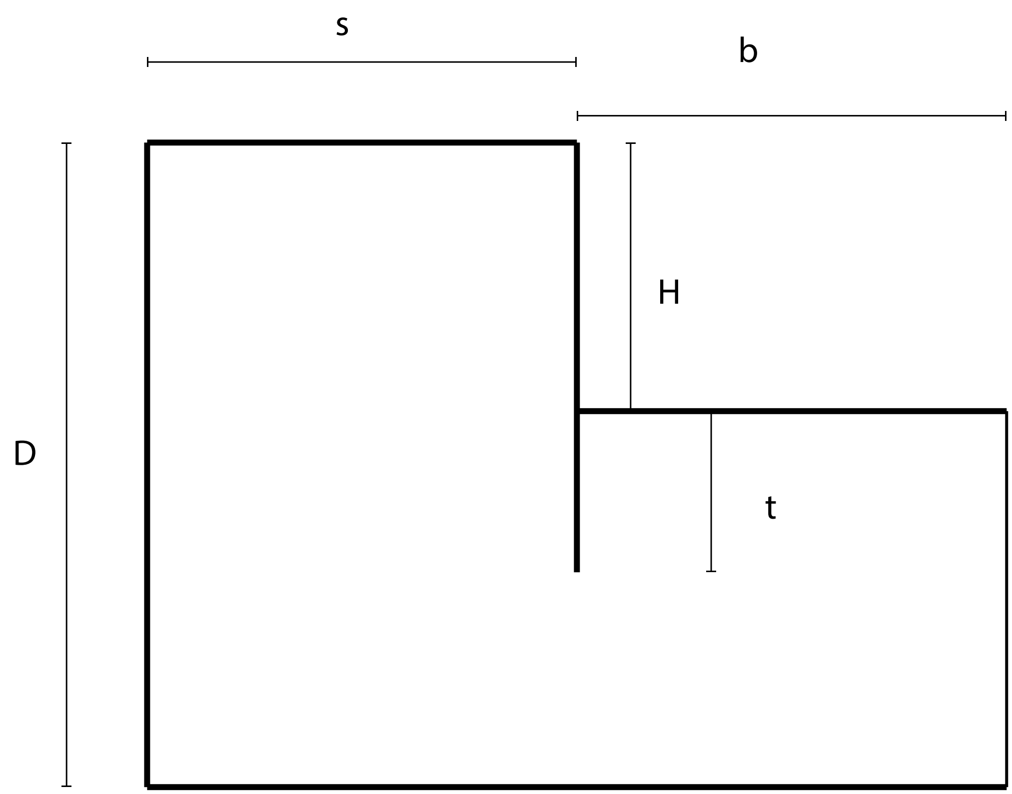

Figure 1: Sketch of a sheet pile wall.

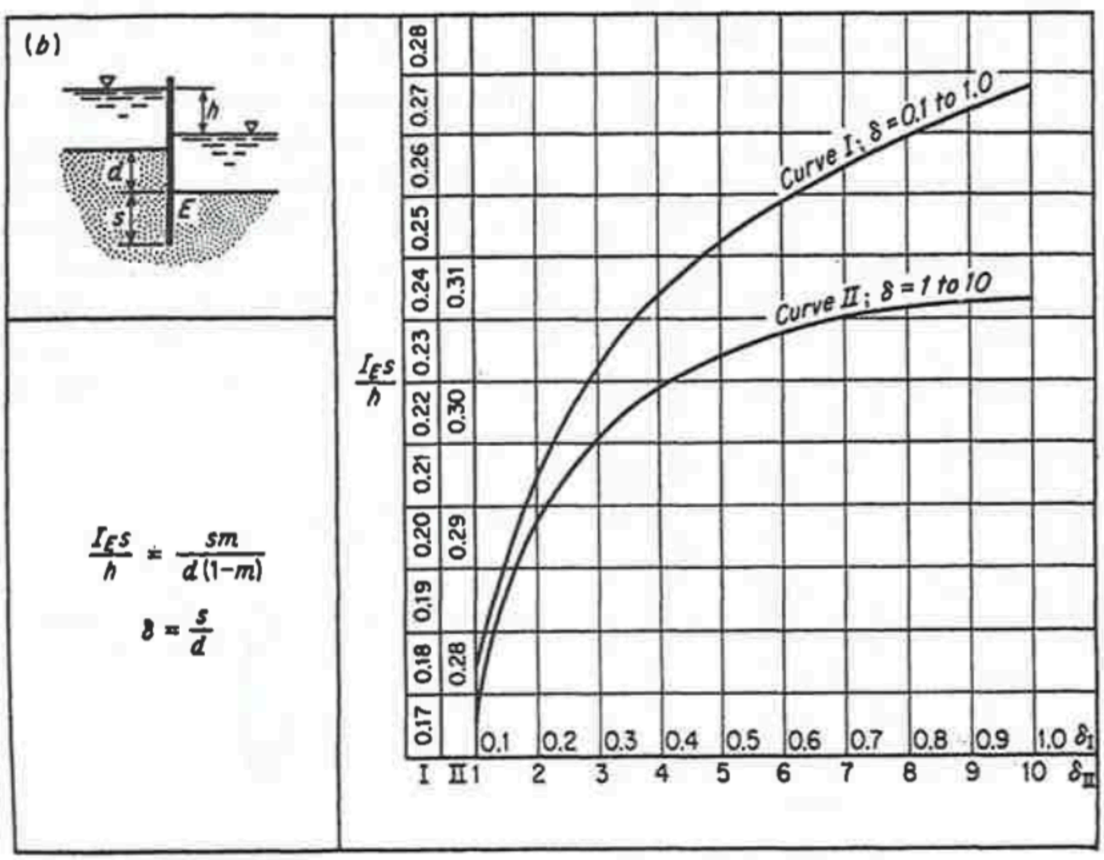

Fig. 5-9. (*After Khosla, Bose, and Taylor* [69].)

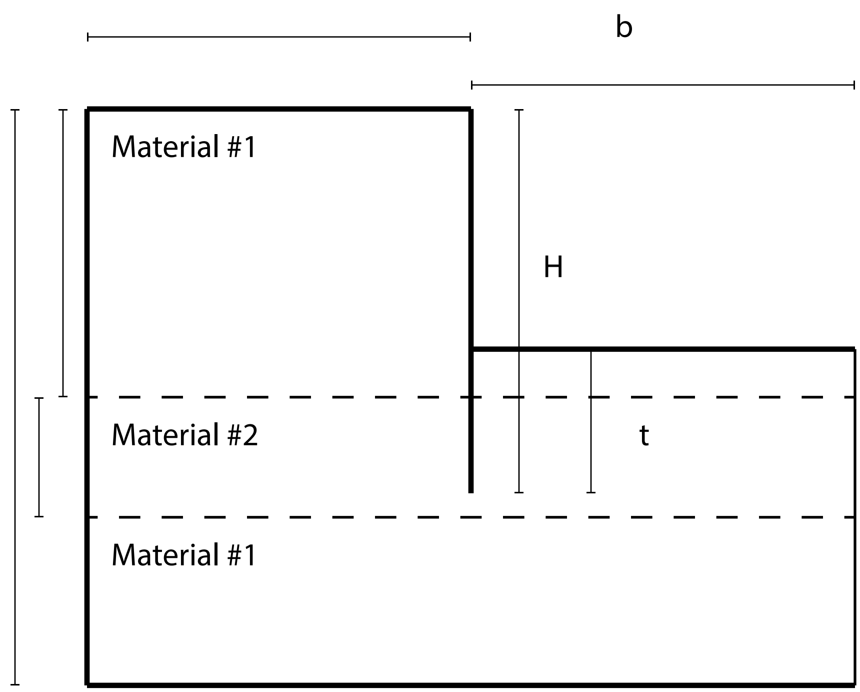

Figure 3: Sketch of a sheet pile wall with three layers.