HWRS 582 – Groundwater modeling

HM1 - Challenge

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Abstract

The report presents the preliminary answers to the challenge, using just the background knowledge about the topic. The goal of this report is to define our baseline to quantify the improvement gotten through the ideas developed in the Tuesday class.

Development

1. Show, based on the flux with depth, that the model is steady-state. Repeat this for a homogeneous and for a heterogeneous column.

Answer: In the steady stage, the change in storage is zero for each grid element in the vertical column. That means the inflow and outflow must the same and constant at each element as presented in Figure 1 and 2.

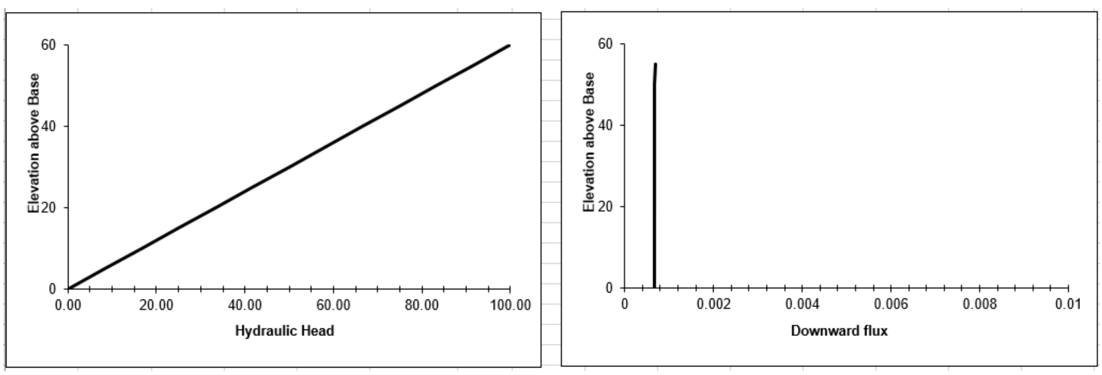

Figure 1 Homogeneous column. K=4e-4

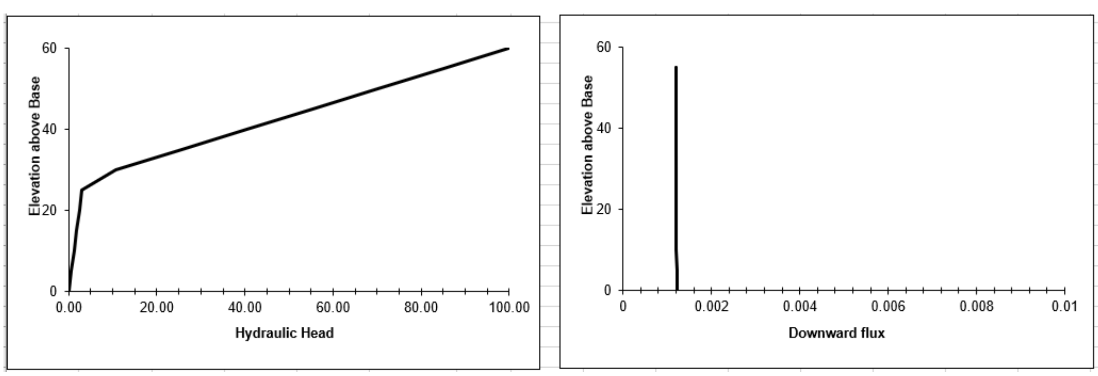

Figure 2 Heterogeneous column. 2 Layers, K1=4e-4 & K2=1e-2

2. Show that the steady-state flux agrees with the direct calculation based on the harmonic mean average K. Write the equation defining the direct calculation of the flux.

Answer: Given that the flux crosses perpendicular to each layer, the lost energy is the sum of the loss of each layer.

$$\Delta H_t = \Delta H_1 + \Delta H_2$$

$$q = K * \frac{\Delta H}{\Delta L}, Applying\ Darcy\ law$$

$$\frac{q * \Delta L_t}{K_{eq}} = \frac{q * \Delta L_1}{K_1} + \frac{q * \Delta L_2}{K_2}, Contant\ and\ equal\ flux\ per\ layer$$

$$\frac{\Delta L_t}{K_{eq}} = \frac{\Delta L_1}{K_1} + \frac{\Delta L_2}{K_2}$$

In the case of figure 2, the flux calculated is q=0.00119 which is consistent with the use of the K_{eq} using the previous equation.

$$\frac{60}{K_{eq}} = \frac{32.5}{0.0004} + \frac{27.5}{0.01}$$

$$K_{eq} = 0.000714$$

$$q = 0.000714 * \frac{100}{60} = 0.00119$$

3. Show the steady-state head profile for a column with approximately equal-thickness layers that have different K values.

Answer: For that, I considered the first layer with K1 between 42.5-60, a second layer with K2 between 22.5-42.5, and K3 between 0-22.5. The head profile is presented in figure 3.

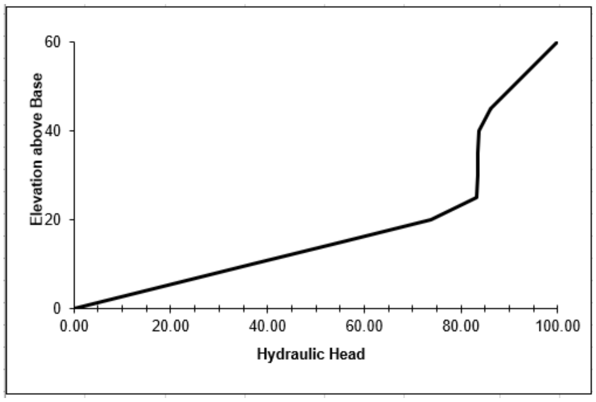

Figure 3 Head profile for a heterogeneous column with 3 Layers, K1=4e-4, K2=1e-2 & K3=1e-4

4. Use the head profile to explain WHY the equivalent hydraulic conductivity, Keq, is closer to the lower of the two K values.

Answer: The K_{eq} (2.22e-4) is closer to K_3 (1.0e-4) because the layer with lower K is where more energy is lost in the process. Figure 3 shows that more than 80 units of energy are lost in this layer, where the total energy is 100 units, therefore K_{eq} must be close to K3.

Discussion

The steady stage is clear enough for me, however, I felt there are still people who do not feel comfortable with that. In my opinion, two main concepts help to understand the water movement. The first one is energy; water always moves from a high energy level to a lower energy level. Probable, some people do not recognize the elevation of water as energy, especially if we assume that velocity energy is neglected, and the elevation level (datum) is kept constant, therefore we always speak about one of the three energy components. The other concept helpful is water laziness. Water always moves in the easy possible way, in other words, water always moves minimizing the total loss of energy. That concept is very useful when we have water movement through different hydraulic conductivities or resistance in surface water.

The explanation of the boundary condition was super clear, and I liked it. It sounds like a mysterious power that allows us to separate our study area of any interaction from the outside universe. Now, from a mathematic context, we are only expressing our knowledge about the system which could be done by defining the energy or the flux. Alternatively, a combination of both is possible.

About the spreadsheet, probably a drawing about the experiment and the equations that are being solved will help to a better understanding.