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How the Initial Water Table is Applied in Seepage Models
A transient analysis is a simulation where changes in the profile that occur with time are considered. Before you can conduct a transient seepage analysis, you must know the starting or initial conditions that exist in the soil. In particular, the total head (H) must be defined for every node in the finite element mesh. The total head at each node provides two important pieces of information. It is used to determine the hydraulic conductivity within the surrounding soil elements and also how much water is stored in the soil elements at any time.

A rigorous method to get initial conditions is to have the solver point to output data from a previously solved analysis conducted on the same soil profile. The previous results may be total heads from a seepage model (e.g., VADOSE/W or SEEP/W), pore-water pressures generated during an earthquake (e.g., QUAKE/W), or pore-water pressures generated during soil loading or embankment construction (e.g., SIGMA/W).

A simpler way to get started is to specify the location of an existing water table. This technical paper discusses how to draw an initial water table, how to interpret what you have drawn, and some potential drawbacks of using an initial water table as opposed to using results from another finite element analysis.

How to draw the initial water table
The initial water table is drawn by using the Draw Initial Water Table command and specifying the maximum negative pressure head that will exist above the elevation of the water table. The mouse is then used to draw a water table across the model cross-section as a single line or series of line segments. The line(s) do not have to be horizontal which means you can draw a phreatic line such as a drawdown cone, as an initial condition. The SEEP/W solver will then use the elevation of the drawn water table to compute the total head for all finite element mesh nodes located above and below the water table; where total head is the sum of pressure head and elevation.

Figure 1 and Figure 2 show a water table with a maximum negative pressure head of 2 m drawn across the base of a dam. Distance units of meters have been used in this example, therefore the pressure head also has units of meters (m).

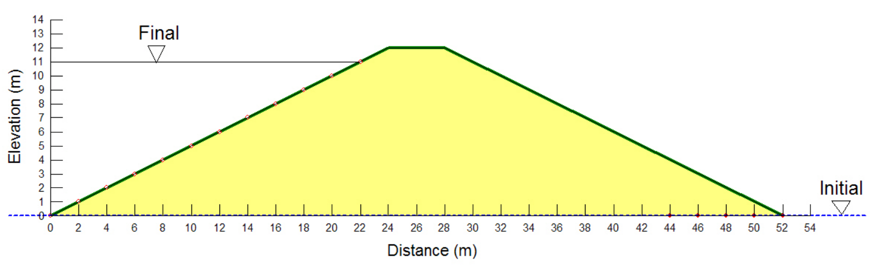

Figure 1 Cross section of dam with initial water table at base elevation

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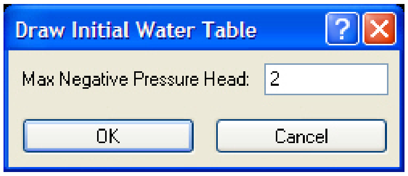

Figure 2 Water table drawn with maximum negative pressure head of 2m

In entering the maximum negative pressure head within the Draw Initial Water Table dialog box, a "negative" sign was not required, since it is implied as the requested input.

How to interpret the water table
In the example above, a maximum negative pressure head of 2 m was applied to the water table. What does this really mean? Consider the image in Figure 3 in which the input water content function for the embankment soil has been rotated 90 degrees so that the pressure axis is vertical instead of horizontal. The right side of the image shows the pressure axis in units of kPa while the left side shows pressure head units of meters. The pressure head units are also an indication of the elevation above the water table.

Superimposed in this image is the position of the water table (on the P=0 kPa axis) and a red line, which shows the resulting pore water pressure profile both above and below the water table. We know that the pressure below the surface of the water increases hydrostatically with depth. It is also true that under true hydrostatic conditions, where there is no flow in or out of the ground surface, pressures will become increasingly negative with height above the water table. However, in reality, there is almost always a surface flux or some kind of net infiltration across the ground surface that controls or limits the negative pressure profile that is allowed to develop above the water table. Therefore, it is often realistic to truncate the maximum negative pressure to a particular value. The red line shows how the negative pressure profile above the water table starts at a value of 0 kPa at the water table, and increases to the specified maximum negative pressure head of 2 m (-20 kPa). For all elevations above this point, the pressure is assumed to be constant at -20 kPa.

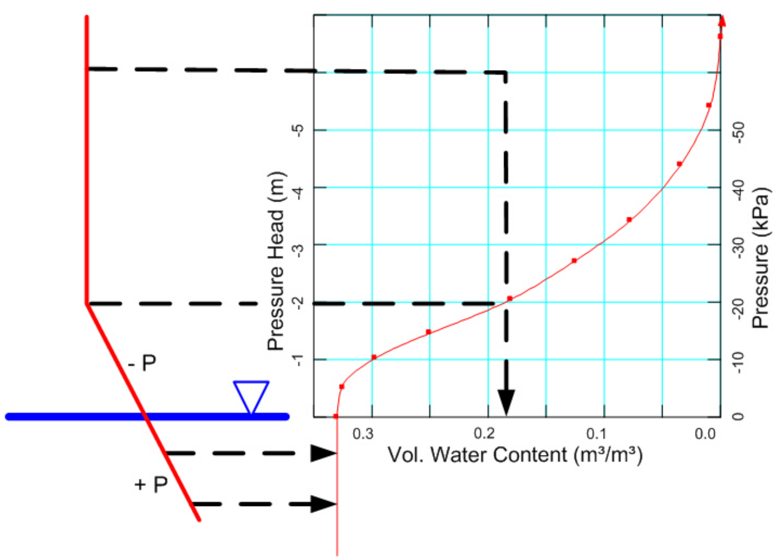

Figure 3 With a "max negative pressure head" of 2 m, water content is constant with elevation above 2 m

The black arrows in the above image show that for a negative pressure head of 2 m the resulting volumetric water content is about 0.18 or 18%. It becomes more clear now that by specifying a maximum negative pressure head of 2 m, the implication is that the water content is fixed in the soil at all points in the model which are 2 m or more higher above the drawn water table. The question to ask yourself is: "Is this what I want to imply?"

Implications of drawing an initial water table
The corresponding hydraulic conductivity function for the embankment soil can be used to determine the flow rate that would be required to maintain a fixed soil water content of 18% above the water table. Figure 4 shows the defined hydraulic conductivity function for the embankment soil. It shows that at a pressure of -20 kPa, the conductivity (or flow rate) required to maintain that pressure would need to be about 6e-8 m/s. Converting time units to days reveals a rate of approximately 0.005 m/day. In time units of years, the resulting flow rate is 1.89 m/year. Is it reasonable to have an average recharge rate of 1.89 meters of water per year? This is something that you would need to decide and if not, then you would have to specify a different maximum negative pressure head value that is more realistic.

A better approach to choosing the appropriate maximum negative pressure head for the water table is to FIRST look at the conductivity function with some knowledge of long term recharge rates in the vicinity of your site, THEN choose the pressure that corresponds with that recharge rate. Remember to convert the chosen pressure from units of "pressure" to "pressure head" by dividing the value by the unit weight of water. In this case, -20 kPa / 10 kN/m3 = 2 m negative pressure head.

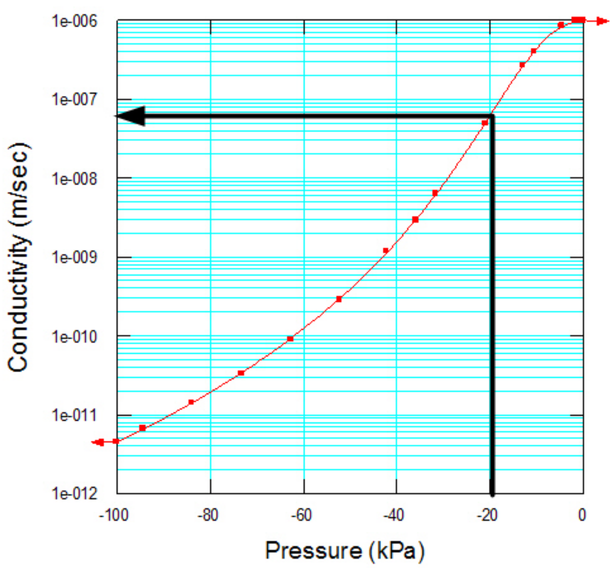

Figure 4 At a pressure of -20 kPa (-2m pressure head) the influx rate is 6e-8 m/sec

If you define an unrealistic maximum negative pressure (i.e., one that is too low), then when the transient model is first started, all the "stored water" (e.g., the 18% by volume held in the soil above the water table) will be suddenly pulled down by gravity and may result in a transient mounding of the water as shown in Figure 5 below.

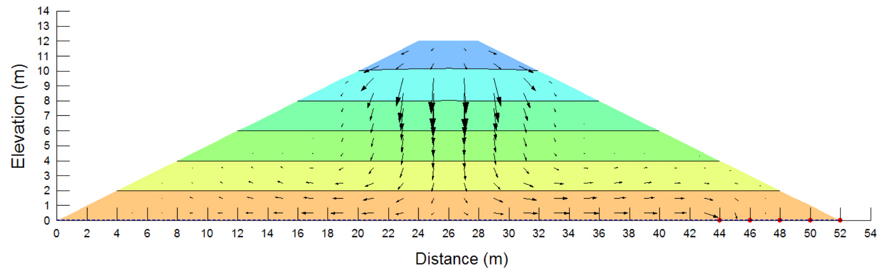

Figure 5 Unintentional drainage of "stored" initial condition water due to gravity

Concluding comments

The Draw Water Table command is a very useful tool for specifying the initial starting condition of a transient seepage analysis. However, care should be used in how it is applied to ensure that the specified starting condition is appropriately describing what exists in the field. Use the soil conductivity and water content functions together to decide upon a realistic maximum negative pressure head above the water table. Do not just blindly use the default value of 1 m. In the absence of any knowledge about site average recharge rates, specify the negative pressure head to be the height of the ground surface above the water table. This will result in a more realistic water content profile which is less likely to cause inaccurate results in the early time steps of the transient analysis.

GeoShanghai - June 6 to 8, 2006

GEO-SLOPE's partner, CnTech, will be representing our software products at the GeoShanghai International Conference, taking place at Shanghai International Convention Center. If you are at the conference, please stop by our booth to say hello and pickup our latest free CD-ROM.

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