



GeoStudio Example File Excess Pore-Water Pressure using Skempton's B-bar

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Introduction

Excess pore-water pressures can develop in saturated or nearly saturated soils of sufficiently low hydraulic conductivity during relatively rapid construction or due to the placement of a load at the ground surface. This occurs because the fluid in the pore space inhibits the volumetric strain necessary to transfer the load to the soil skeleton. The development of excess pore-water pressure can be modeled in SLOPE/W using a variety of approaches including a spatial pressure head function, finite element pore-water pressures from a coupled SIGMA/W analysis, or the use of Skempton's B-Bar. The latter approach is the most straightforward and does not require a finite element analysis. This example demonstrates how to set-up and interpret the results for a SLOPE/W analysis using the B-bar pore-water pressure definition.

Background

The pore-water pressure (u_w) at the base of a slice is calculated as follows:

$$u = u_0 + \Delta u \quad \text{Equation 1}$$

where u_0 is the *in situ* pore-water pressure and Δu is the change in pore-water pressure due to a change in stress. Skempton (1954) published an equation for the change in pore-water pressures arising from changes in total principal stress changes as:

$$\Delta u = B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)] \quad \text{Equation 2}$$

where A and B are pore-pressure coefficients and $\Delta\sigma_1$ and $\Delta\sigma_3$ are changes in the principal stresses.

This equation can be simplified for field applications into the ratio \bar{B} (B-bar):

$$\frac{\Delta u}{\Delta\sigma_1} = \bar{B} \quad \text{Equation 3}$$

Furthermore, it is often assumed that the major principal stress is equal to the vertical total stress (σ_v). The definition for \bar{B} then is:

$$\bar{B} = \frac{\Delta u}{\Delta\sigma_v} \quad \text{Equation 2}$$

It is important to recognize that the Skempton pore-water pressure coefficients are based on total stress changes, not effective stress changes.

Numerical Simulation

Figure 1 presents the geometry and configuration for the analysis. It is assumed that the embankment is placed rapidly and that the initial water table is located at the ground surface. The embankment is a granular material that does not develop excess pore-water pressure during construction. The B-bar for the foundation soil is assumed to be 0.7.

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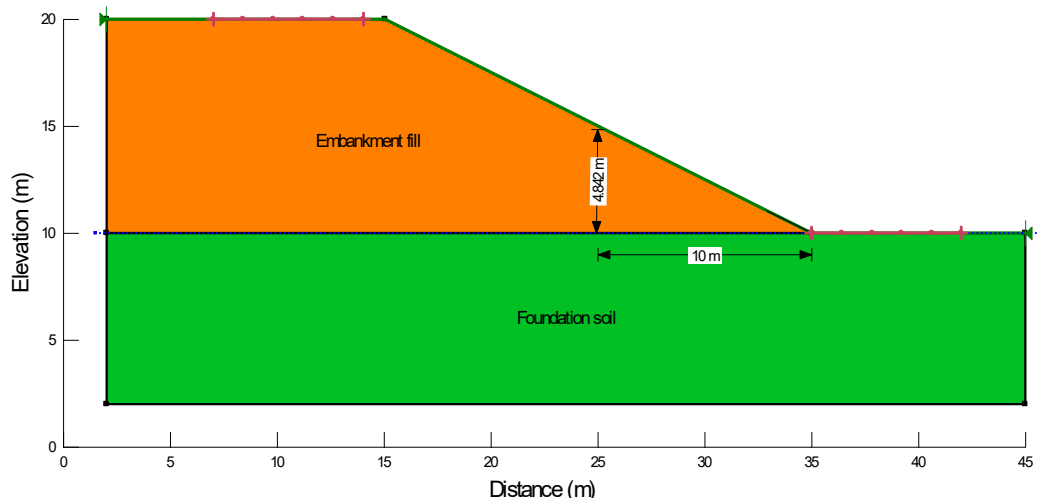


Figure 1. Problem configuration.

The self-weight of the foundation soil will not generate excess pore-water pressures, but the foundation soil has some initial pore-water pressure prior to the fill placement. The objective is to combine the initial pore-water pressure in the foundation with excess pore-water pressures that come from the fill placement, while ignoring any pore-water pressure in the fill. The first step is to identify the source of the pore-water pressures for the analysis via the Define Analyses dialog box (Figure 2).

The dialog box shows the 'Settings' tab with the following options:

- Side Function: Half-Sine
- PWP Conditions from: Piezometric Line with B-bar
- ☐ Apply Phreatic Correction

Figure 2. Defining the pore-water pressure conditions.

The piezometric line was drawn at the top of the foundation soil. Finally, the B-bar conditions are defined under Define | Pore Water Pressure in the Define Piezometric Lines dialog box (Figure 3). The piezometric line applies only to the foundation soil (marked yes) and not the granular fill.

The dialog box shows the 'Properties' tab with the following table:

Name	Color	Piezometric Line
* Embankment fill	Orange	No
Foundation soil	Green	Yes

Below the table, there is a section for '*Weight included in PWP' with a 'Define B-bar...' button and a checked 'Apply Piezometric line to material' checkbox.

Figure 3. Identifying which materials use the piezometric line.

The next step is to define the B-bar properties (Figure 4). The B-bar is set to zero for the embankment material, but the 'Add Weight' toggle is set to yes, implying that the embankment soil will generate excess pore-water pressure in the foundation soil. The foundation B-bar is

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specified as 0.7, but the weight of the foundation soil is not used in the pore-water pressure calculations (toggled to 'No').

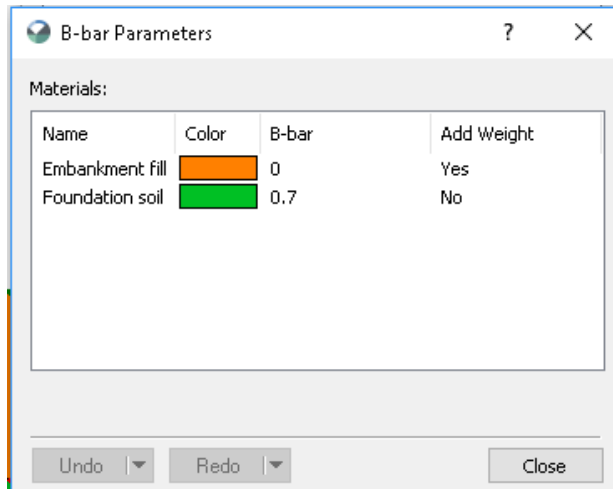


Figure 4. Specifying B-bar and the Add Weight toggle.

Results and Discussion

Figure 5 presents the critical slip surface and factor of safety.

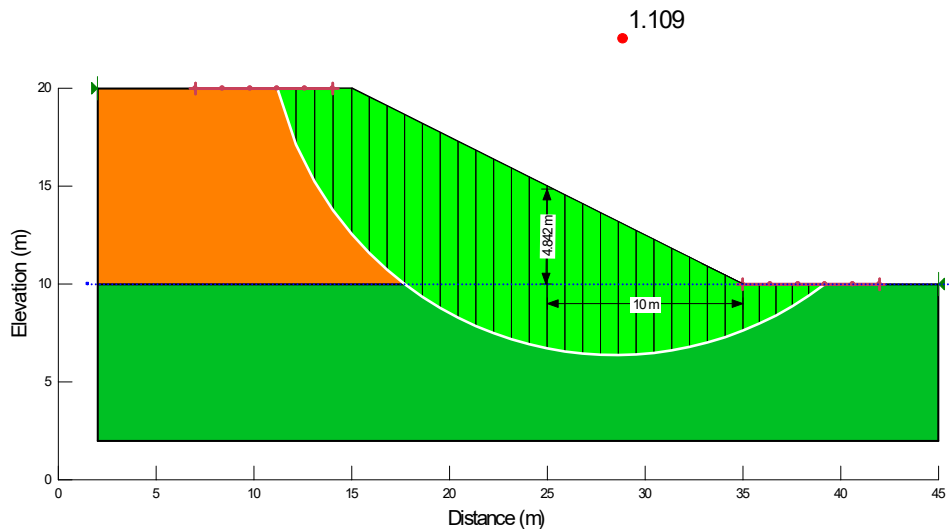


Figure 5. Result with excess pore-water pressures.

Figure 6 presents location of the slice used for verification via hand calculations. From View Slice Information, the total height of the slice is 8.4198 m and the pore-water pressure at the slice base is 97.195 kPa. The portion of the slice height in the foundation is around 3.20 m and the portion in the fill is 5.22 m. The initial pore-water pressure in the foundation is:

$$9.81 \text{ kN/m}^3 \times 3.20 \text{ m} = 31.39 \text{ kPa}$$

The excess pore-water pressure from the weight of the fill is:

$$18 \text{ kN/m}^3 \times 5.22 \text{ m} \times 0.7 = 65.77 \text{ kPa}$$

The total pore-water pressure is $31.39 + 65.77 = 97.17 \text{ kPa}$, which matches the SLOPE/W computed value (any minor difference is in rounding of the heights).

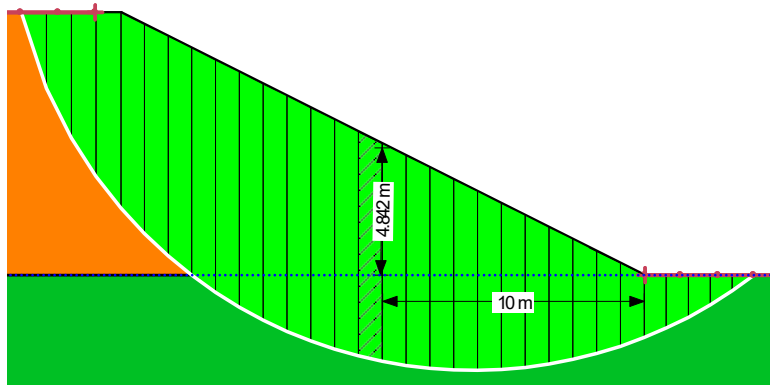


Figure 6. Slice for detailed verification check.

Summary and Conclusions

This example and discussion shows that construction induced pore-water pressures can be simulated in SLOPE/W. It is good practice to verify the results by checking slice information or creating graphs of pore-water pressure verses slice number. While SLOPE/W can be used to simulate construction induced pore-water pressures, SLOPE/W alone can only provide part of the answer. Invariably these types of projects require some staged construction which means halting the construction temporarily to allow some of the excess pore-water pressure to dissipate before carrying on with the fill placement. This type of a staged construction can be examined with a SIGMA/W analysis. Examples are included with SIGMA/W illustrating how this can be done.

References

Skempton, A.W. (1954). The pore-pressure coefficients A and B, *Géotechnique* 4 (4). p 143-147.