GeoStudio Example File
Wick Drain Patterns

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Introduction

Wick drains assist with the dissipation of excess pore-water pressures caused by surficial loading. They may be installed in numerous spatial patterns with varying distances between the drains. Water flows into the drains from all directions as excess pore-water pressures decrease, and this flow is influenced by the interaction with neighbouring drains. Thus, the associated flow regime is three-dimensional. This example illustrates how SEEP/W and SEEP3D can be used to study drain patterns and spacing.

Numerical Simulation

This example considers a five-metre deep soft compressible layer with the initial water table at the ground surface. The project file includes four 3D geometries to model two wick drain patterns, square and triangular, with two different drain spacing, 2 m and 4 m (Figure 1).

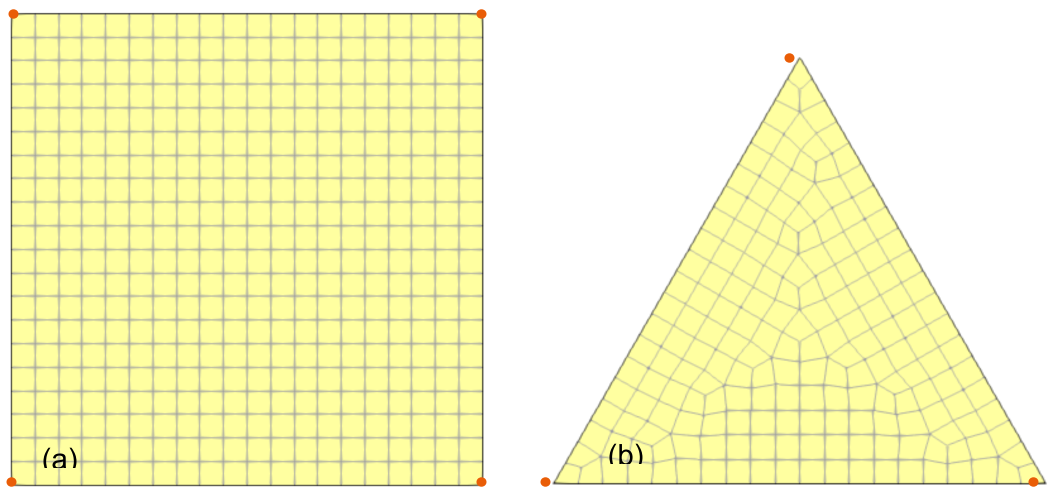

Figure 1: Top view of the square wick drain geometry (a) and triangular wick drain geometry (b) with orange circles representing drain placement.

In this example, excess pore-water pressures arise due to the placement of 2 m of sandy fill above the compressible layer. Given a unit weight of 20 kN/m^3 for the sand and a unit weight of 10 kN/m^3 for water, the surficial loading induces 4 m of excess pressure head on the compressible layer. A 3D body representing the sandy fill is not necessary given the assumption that water flowing into the wick drains easily moves through the overlying sand, such that flow through the soft compressible layer governs. Thus, only one material need be defined for the project file. The soil employs the saturated only material model with a saturated hydraulic conductivity of 1x10^{-8} m/s, saturated volumetric water content of 0.5, and compressibility of 0.001 /kPa.

All four geometries include a steady-state seepage analysis to establish the initial surficial loading (Figure 2). A water pressure head boundary condition of 4 m is applied to the top faces in the steady-state seepage analyses. A transient analysis follows each steady-state seepage analysis to simulate the consolidation (dissipation) phase with the presence of wick drains. Given the assumption that there is no head loss in the drain itself, the pressure in the drain instantaneously becomes hydrostatic at the start of dissipation. A total head boundary condition set equal to the ground surface elevation (5 m) simulates this condition; consequently, the boundary condition is applied to the vertical lines representing the drains. Despite the free draining nature of the fill, the upper surface was assumed to be a no-flow boundary to conservatively force all water into the drains.

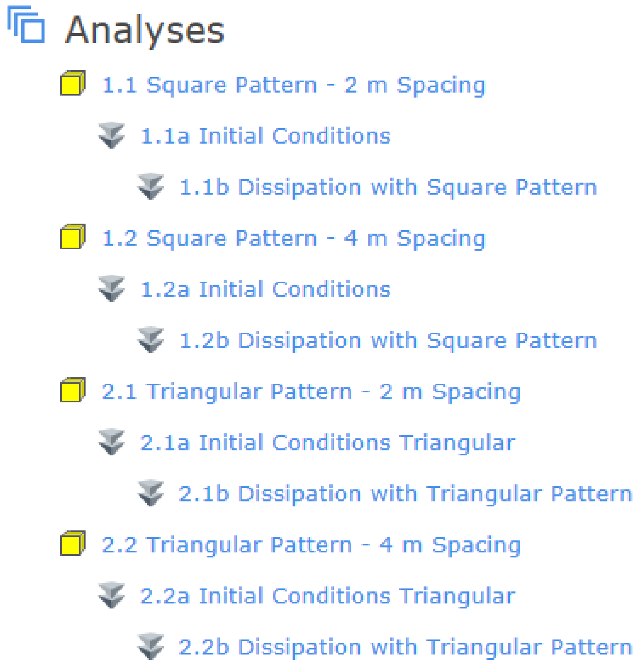

Figure 2: Analysis tree.

Results and Discussion

All initial condition analyses generate the same total head pressure profiles (Figure 3). The pressure head at the surface is 4 m, given the surficial loading, and the pressure head increases linearly with depth, following a hydrostatic pressure profile.

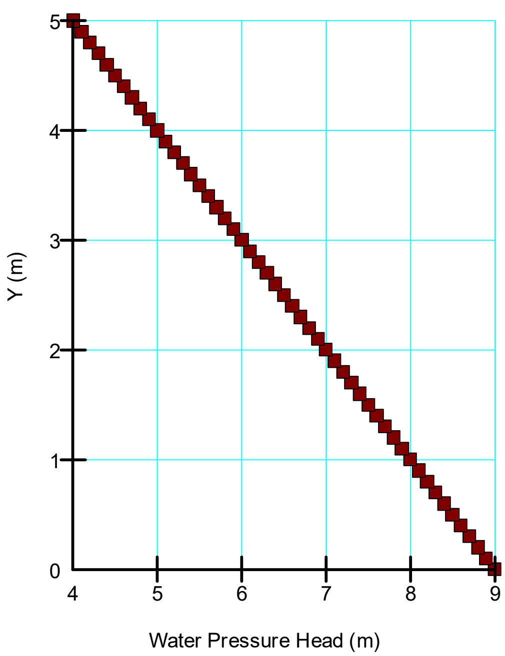

Figure 3: Initial pressure profile with surficial loading (all geometries).

Figure 4 shows the pressure head contours on day 6 for the two square drain pattern analyses. As expected, the larger drain spacing results in less pressure dissipation between the drains.

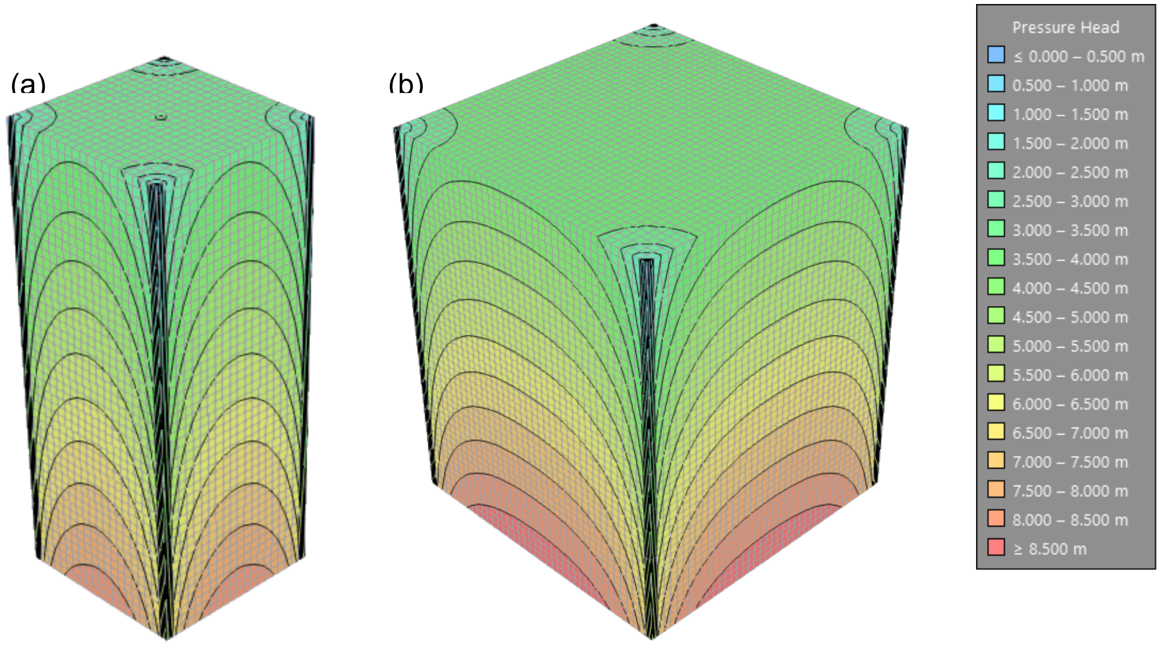

Figure 4: Pressure head contours on day 6 for the square wick drain pattern with (a) 2 m spacing and (b) 4 m spacing.

Dissipation over time plotted along a polyline connecting the base of two wick drains from the square drain patterns are illustrated in Figure 5. At the end of the analysis with 2 m drain spacing, a substantial portion of the excess pore-water pressure generated by the surficial load has dissipated. Over the 30-day analysis, pressure dissipation given 4 m drain spacing is significantly less than the 2 m spacing analysis. The pressure head at the centreline only decreases 0.7 m from the initial loading condition.

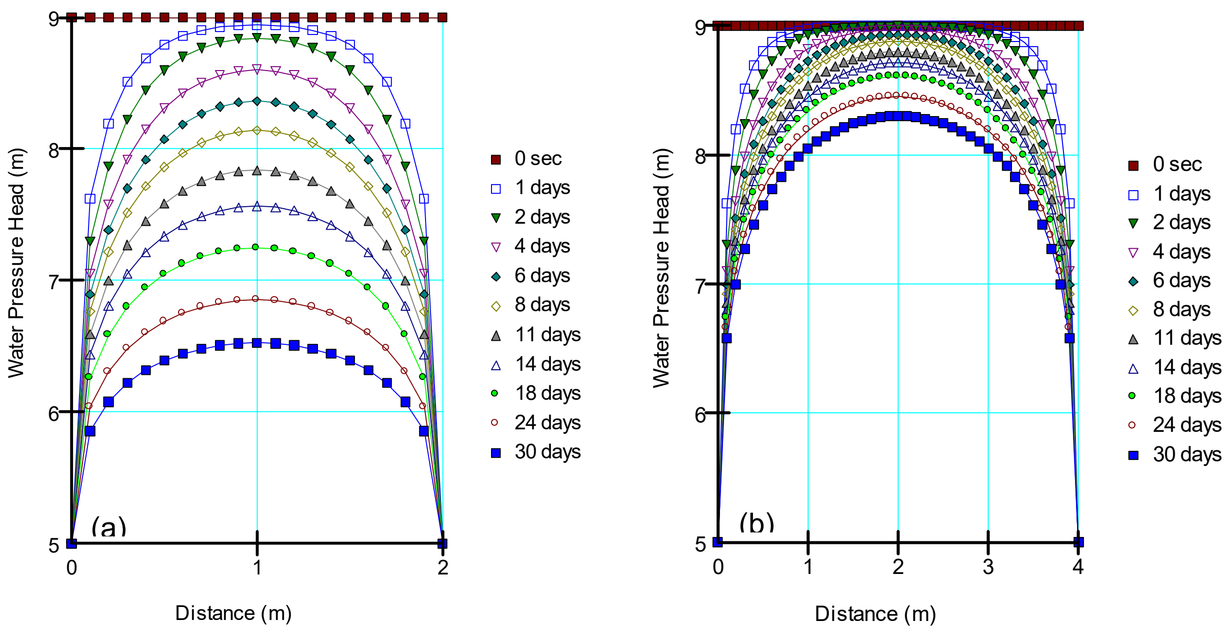

Figure 5: Pressure head distribution at the soil base between the square-pattern wick drains with (a) 2 m spacing and (b) 4 m spacing.

The pressure head contours on day 6 for the triangular drain patterns are shown in Figure 6. The contours along the vertical faces in the 2 m triangular pattern appear to be similar to those in the 2 m square drain pattern analysis (Figure 4). Similarly, the contours along the vertical faces of the 4 m triangular pattern are similar to those for the 4 m square drain pattern analysis.

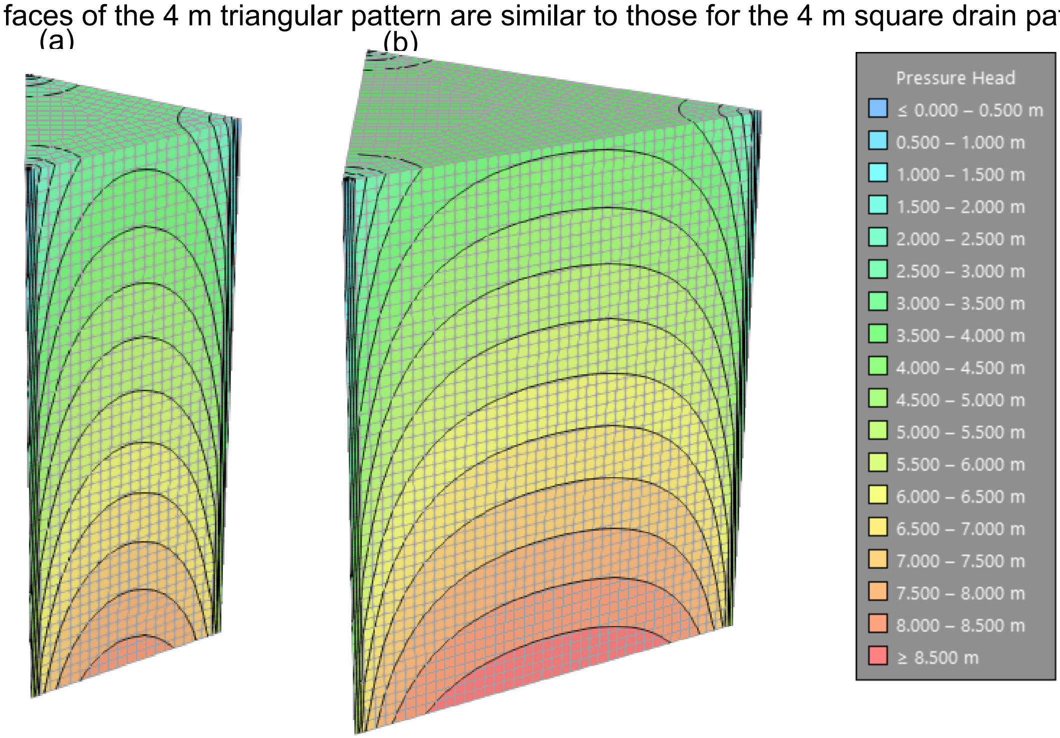

Figure 6: Pressure head contours on day 6 for the triangular wick drain pattern with (a) 2 m spacing and (b) 4 m spacing.

Dissipation over time associated with a polyline connecting the base of the wick drains from the triangular drain patterns are illustrated in Figure 7. As with the square drain pattern analyses, the larger triangular drain spacing results in less pressure dissipation between the drains.

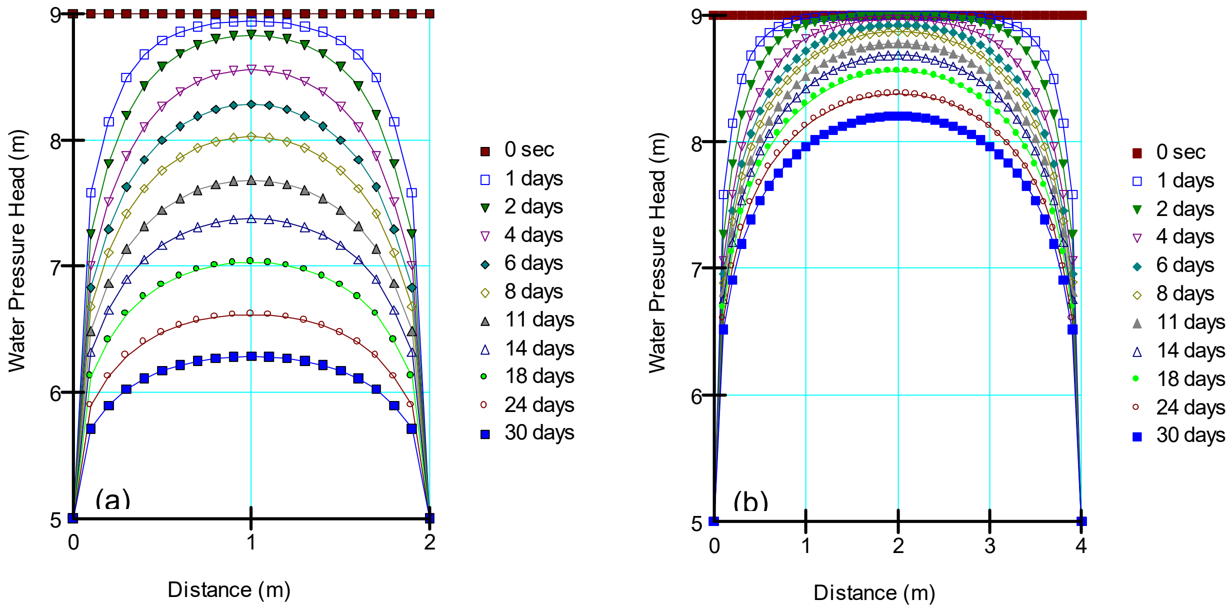

Figure 7: Pressure head distribution at the soil base between the triangular-pattern wick drains with (a) 2 m spacing and (b) 4 m spacing.

A plot of total head over time at a point in the centre of each drain pattern illustrates the efficacy of each scenario to dissipate excess pore water pressures resulting from the surficial loading (Figure 8). The triangular pattern with 2 m spacing provides the greatest pore water pressure reduction.

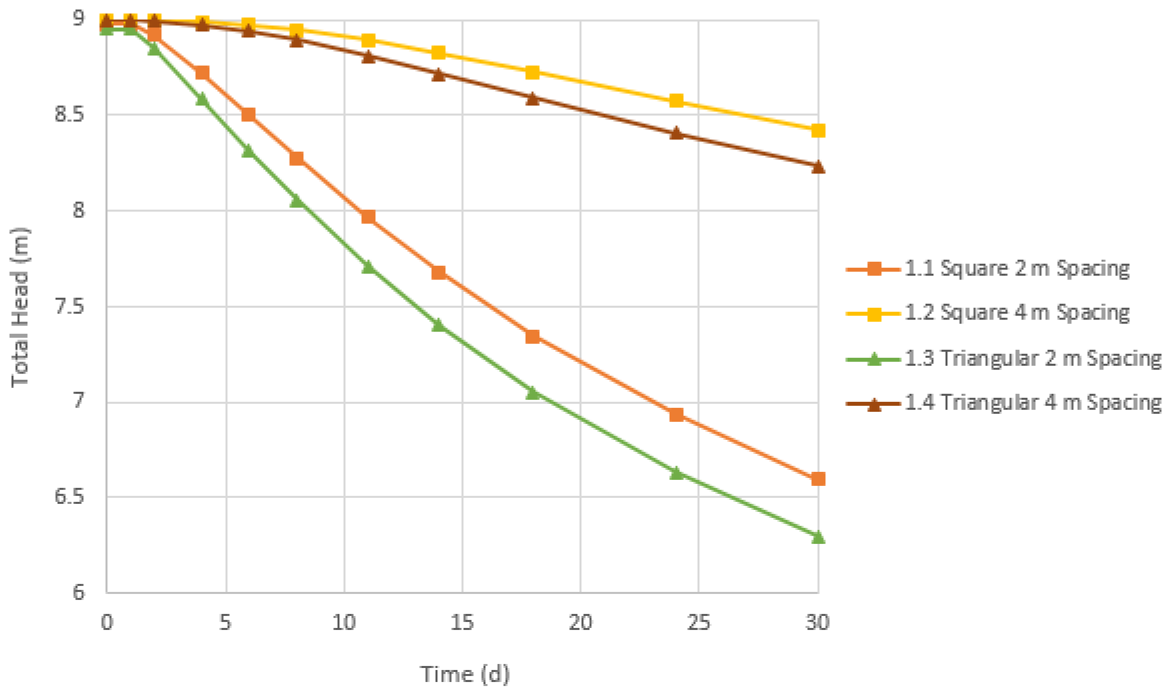

Figure 8: Total head over time in the centre of the drain pattern, bottom of the domain.

Issues associated with soil smearing around the drain during installation may also be investigated. To do so, a small cylindrical region around each wick drain can be added to represent the disturbed soil zone. This region would have a different hydraulic conductivity based on the degree of disturbance.

Summary and Conclusions

These analyses show that SEEP3D can be used to study the layout configuration of wick drains in three-dimensional space. Additional geometries may be added to the project file to test more configurations with varying spacing between the drains.