Spatial Pore Water Pressure Head

1 Introduction

There are several different ways that pore-water pressures can be defined within SLOPE/W. For the most simple of scenarios, a piezometric line can easily be drawn with hydrostatic conditions assumed both above and below the piezometric line. For more complex pore-water pressure situations, you may want to integrate results from a SEEP/W finite element analysis where the total heads at each node are computed and used by SLOPE/W. Another option is to specify different pore-water pressure heads at discrete points within the SLOPE/W profile using the pressure head spatial function option.

The purpose of this example is to highlight the use of the pressure head spatial function option. Features in this analysis include:

- Analysis method: GLE method (half-sine function)
- Surface entry and exit slip surface option
- Pressure head spatial function option
- A wet tension crack controlled by a tension crack angle

2 Configuration and setup

Figure 1 shows the profile and material property information used to develop this simulation. The embankment is approximately 40 feet high. Table 1 shows the properties of the various material layers.

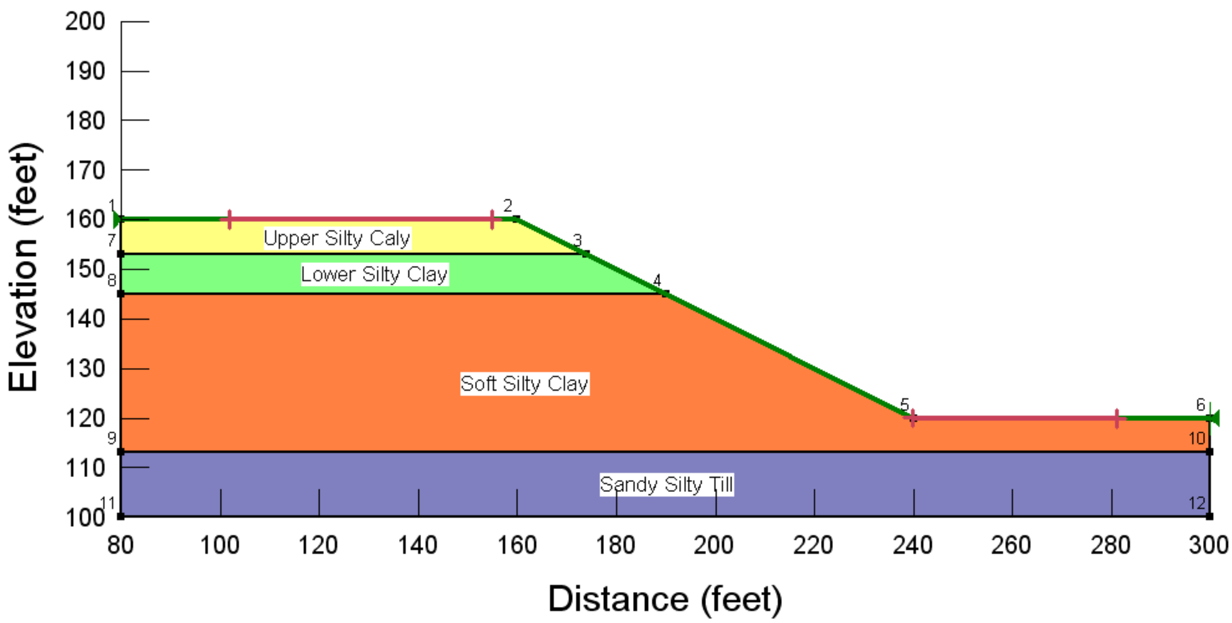

Figure 1 Profile and material property information

Table 1 Material properties

Description	Soil Model	Unit Weight	c’	ϕ’
Upper silty clay	Mohr-Coulomb	115 pcf	700 psf	22 °
Lower silty clay	Mohr-Coulomb	112 pcf	600 psf	21 °
Soft silty clay	Mohr-Coulomb	110 pcf	300 psf	20 °
Sandy clay till	Mohr-Coulomb	123 pcf	600 psf	27 °

For this example, pore-water pressure heads are defined at a number of discrete (x,y) locations as shown in Figure 2. The input pressure head points appear as blue dots when the spatial function is created or edited using the KEYIN menu.

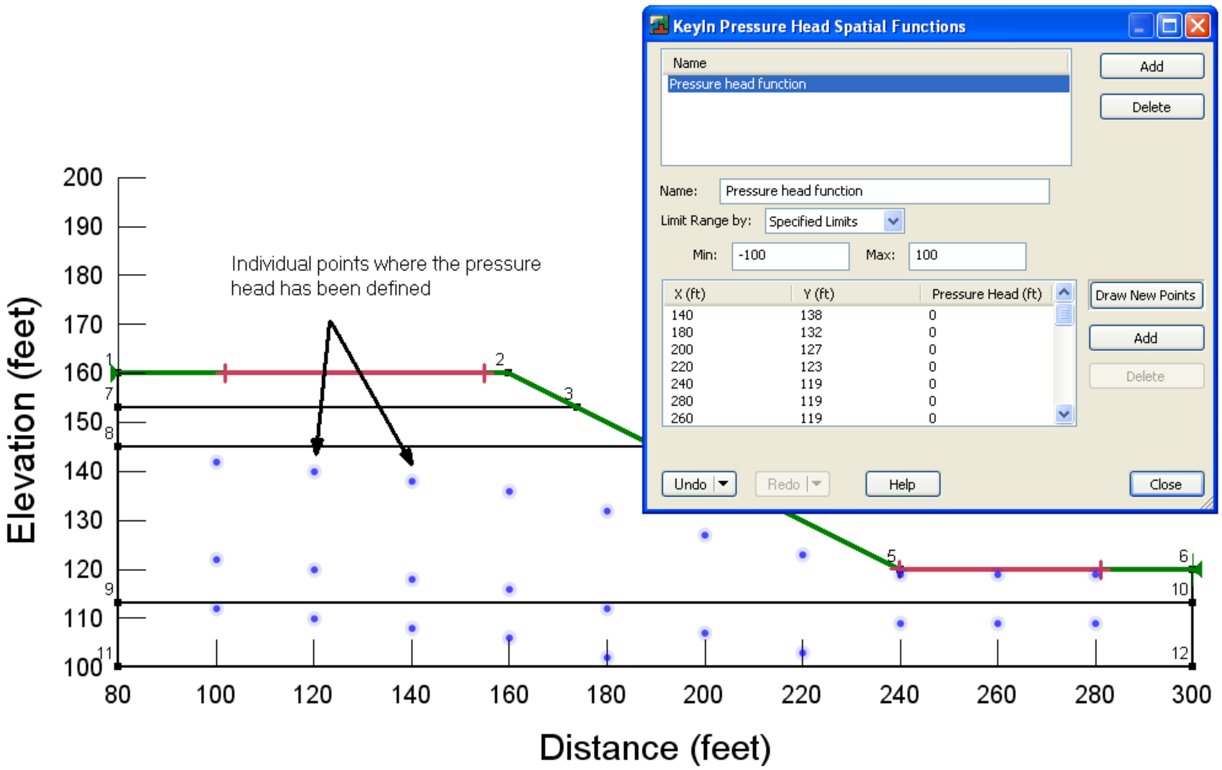

Figure 2 Series of points representing pore-water pressure heads within the profile

A spatial pore-water pressure head function must first be at least partially created and then assigned to an analysis in order to use the contouring feature in DEFINE. The contouring feature provides a visual representation of the resulting pore-water pressure head surface that is developed from the individual data points using a method known as Kriging. Once you can contour the pore-water pressure head surface, you can then fine-tune individual points by adding, deleting or changing points and the contours will automatically be updated as shown in Figure 3 The contours can also be labeled.

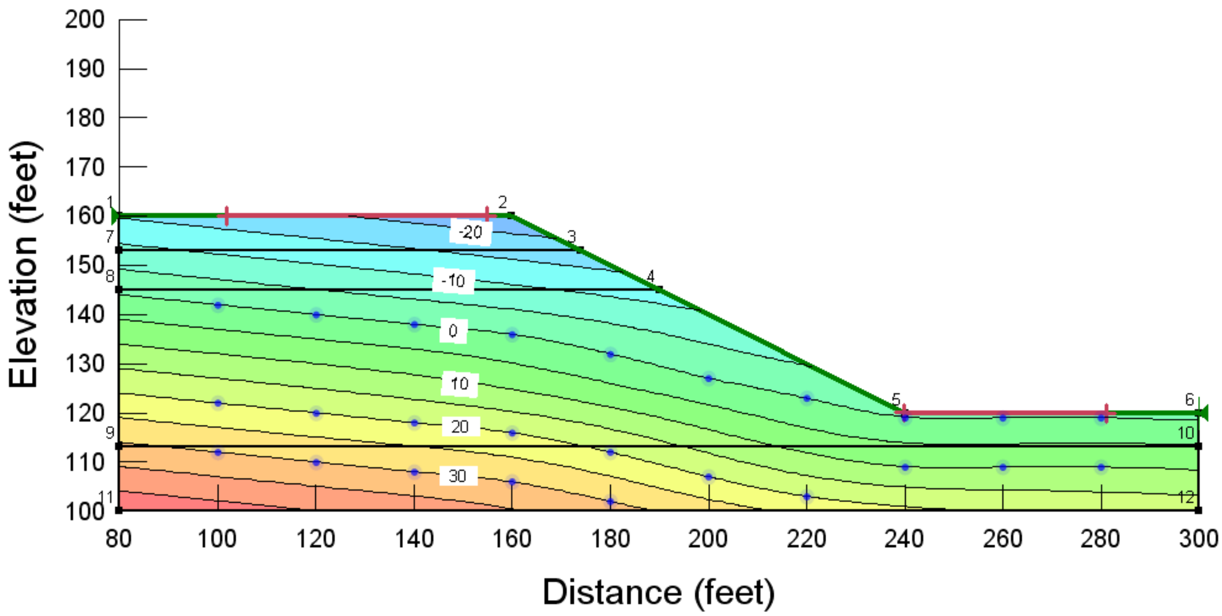

Figure 3 Contoured pore-water pressure heads together with the series of points

There are some other interesting features that have been included in this example, including the entry and exit slip surface option and a tension crack angle. With the slip surface option, both entry and exit zones are identified on the ground surface and all analyzed slip surfaces are controlled by the location of these zones.

When a tension crack angle is defined, the program will project vertically to the surface any slip surface that exceeds this limiting angle. If the angle at the base of the slice does not exceed the tension crack angle, a tension crack will not form. The tension crack angle for this simulation has been set equal to 120 degrees. In addition, if a tension crack forms, it is assumed to be water-filled in this example.

3 Critical factor of safety

A GLE method with a half-sine interslice force function was used in this simulation. The factor of safety of 1.382 and critical slip surface are shown in Figure 4.

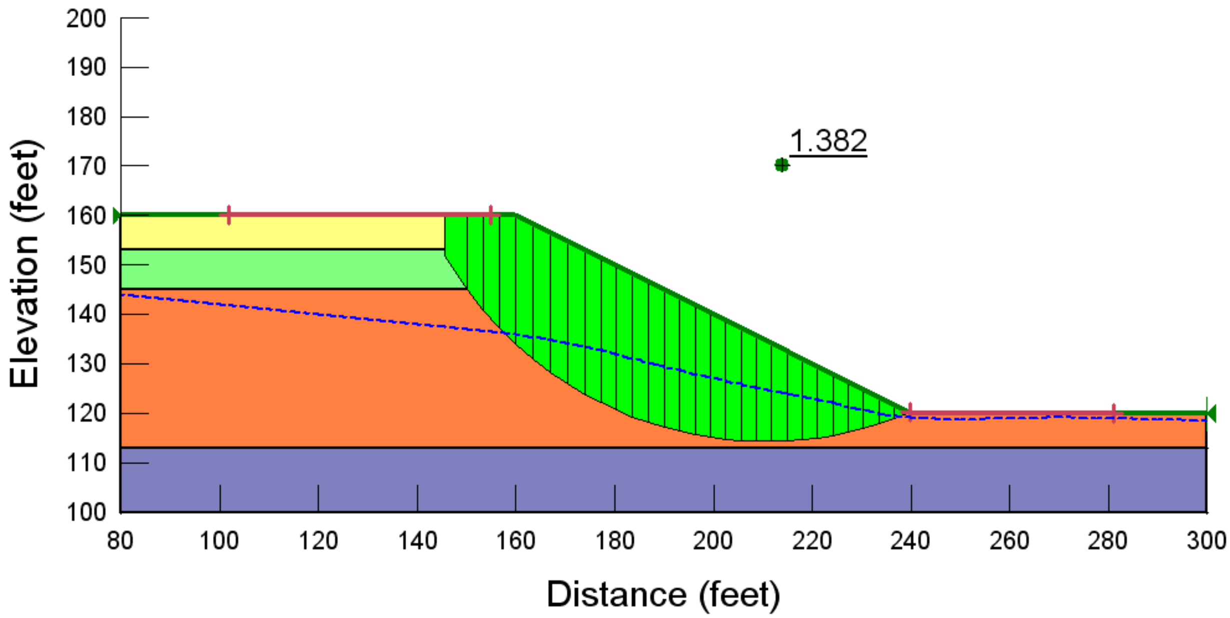

Figure 4 Critical slip surface, factor of safety and resulting P = 0 contour from the pressure head distribution.

Using a mathematical technique known as Kriging, SLOPE/W constructs a smooth surface that passes through all the specified pressure head points. Once the surface has been constructed, the pore-water pressure can be determined at any other x-y coordinate point in the vicinity of the specified data points. For each slice, SLOPE/W knows the x-y coordinates at the slice base mid-point. These x-y coordinates, together with the pore-water pressure surface, are then used to establish the pore-water pressure at the base of each slice. Figure 5 shows the pore-water pressure at the slice base center along the entire critical slip surface.

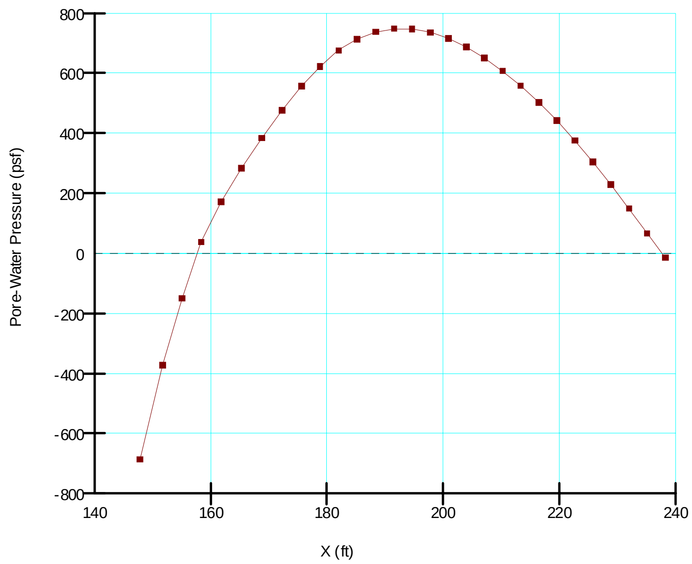

Figure 5 Pore water pressure at slice base center along critical slip surface

The highest pore-water pressure as read from the graph is just under 750 psf, and occurs along the slip surface at about 190 feet. If we were to mark this location on the slip surface profile, it would be where it is indicated with a black dot in Figure 6. The pressure head contours in the vicinity of the black dot indicate that a pressure head of approximately 12 ft exists at this location. Given the unit weight of water is 62.4 pcf, the resulting pressure at this point should be 749 psf, which correlates with the pore-water pressure that is used in the analysis and presented in the graph above. This shows that the contouring feature is working as intended.

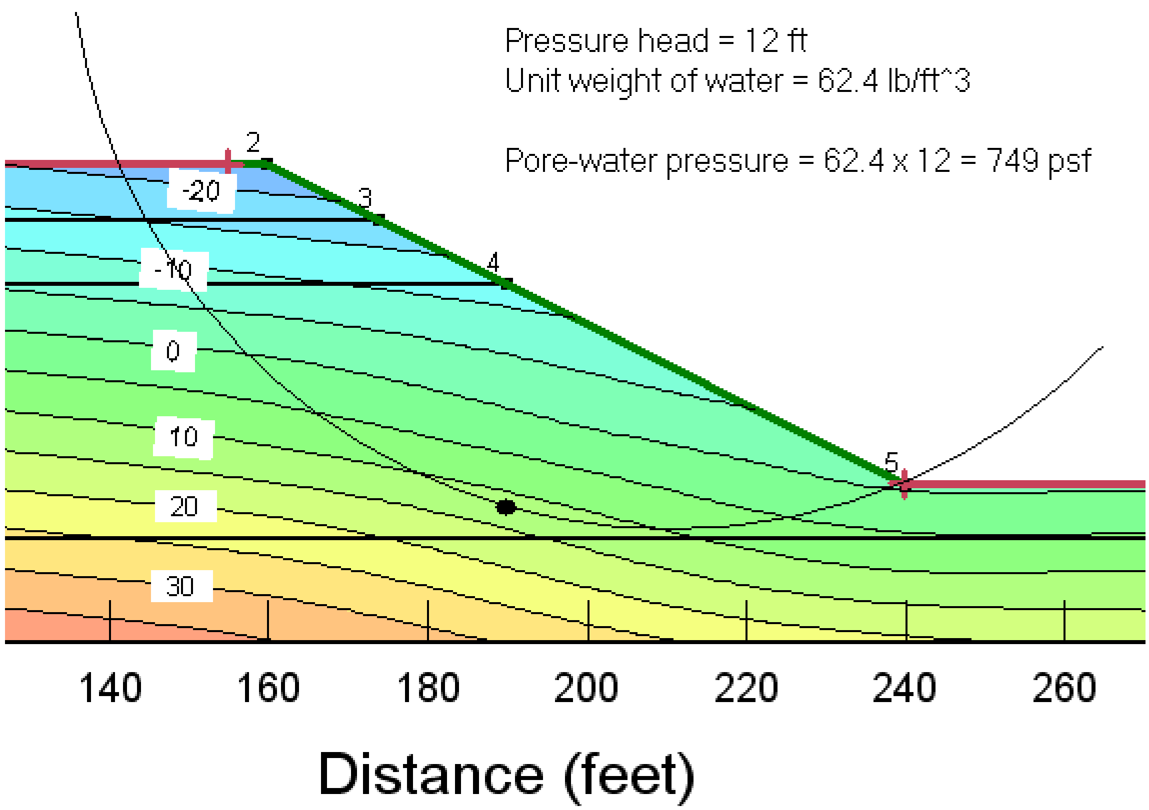

Figure 6 Pore-water pressure head contours used to estimate the value used at the location at a selected point at x = 190 feet

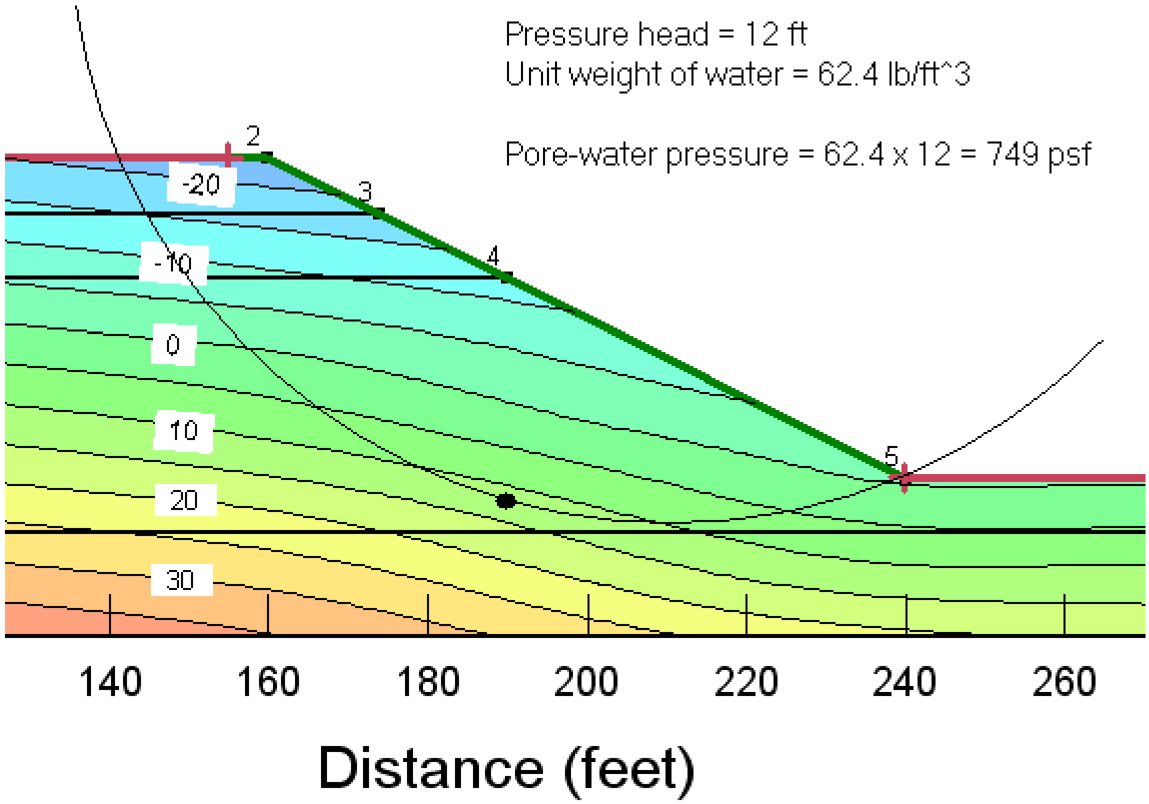

Figure 6 also shows the development of a tension crack on the top of the embankment where the slip surface is projected vertically upward. Viewing the slice force information of the first slice (Figure 7) shows the presence of a horizontal hydrostatic force of 2056.7 lbs acting on the left side of the slice. This force is a result of the assumption that the tension is 100% wet. Since the developed tension crack is about 8.119 feet deep, you may verify that the horizontal hydrostatic force is computed correctly in SLOPE/W as (8.119 x 8.119 x 62.4)/2.

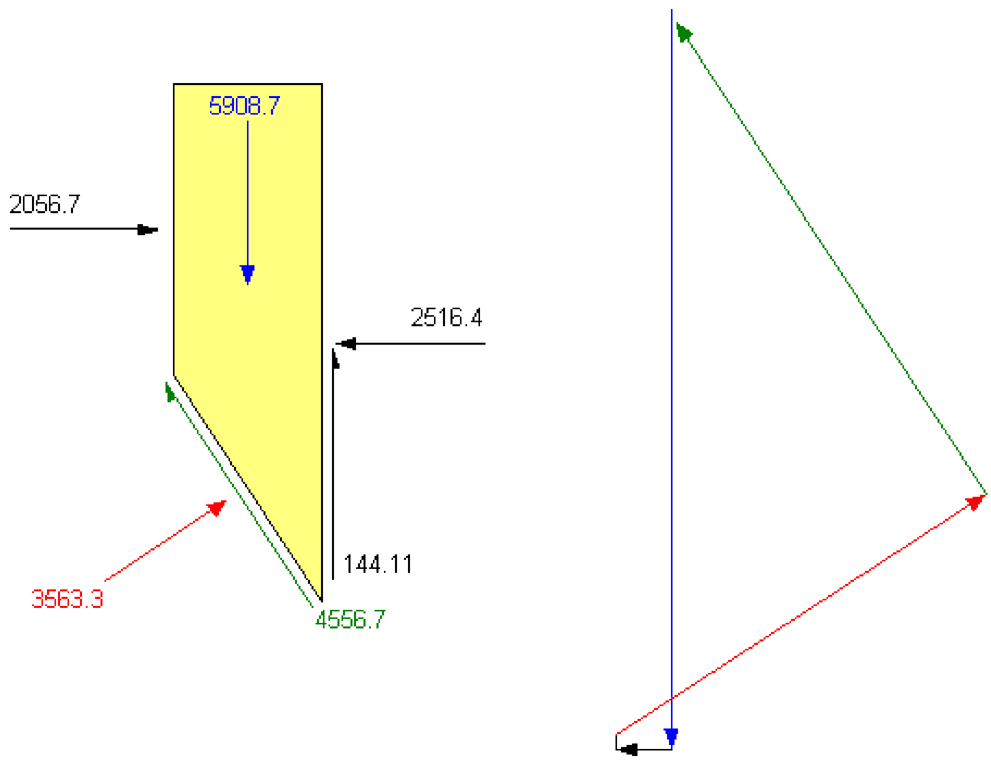

Figure 7 Force polygon of the first slice showing horizontal hydrostatic force from the wet tension crack

When conducting a GLE method, you can also generate the Factor of Safety versus Lambda plot shown in Figure 8. Looking at this graph helps identify why a particular solution appears to be sensitive to force or moment equilibrium. For this particular example, the Factor of Safety with respect to moment curve is almost horizontal, which explains why the Bishop result is almost the same as the GLE result.

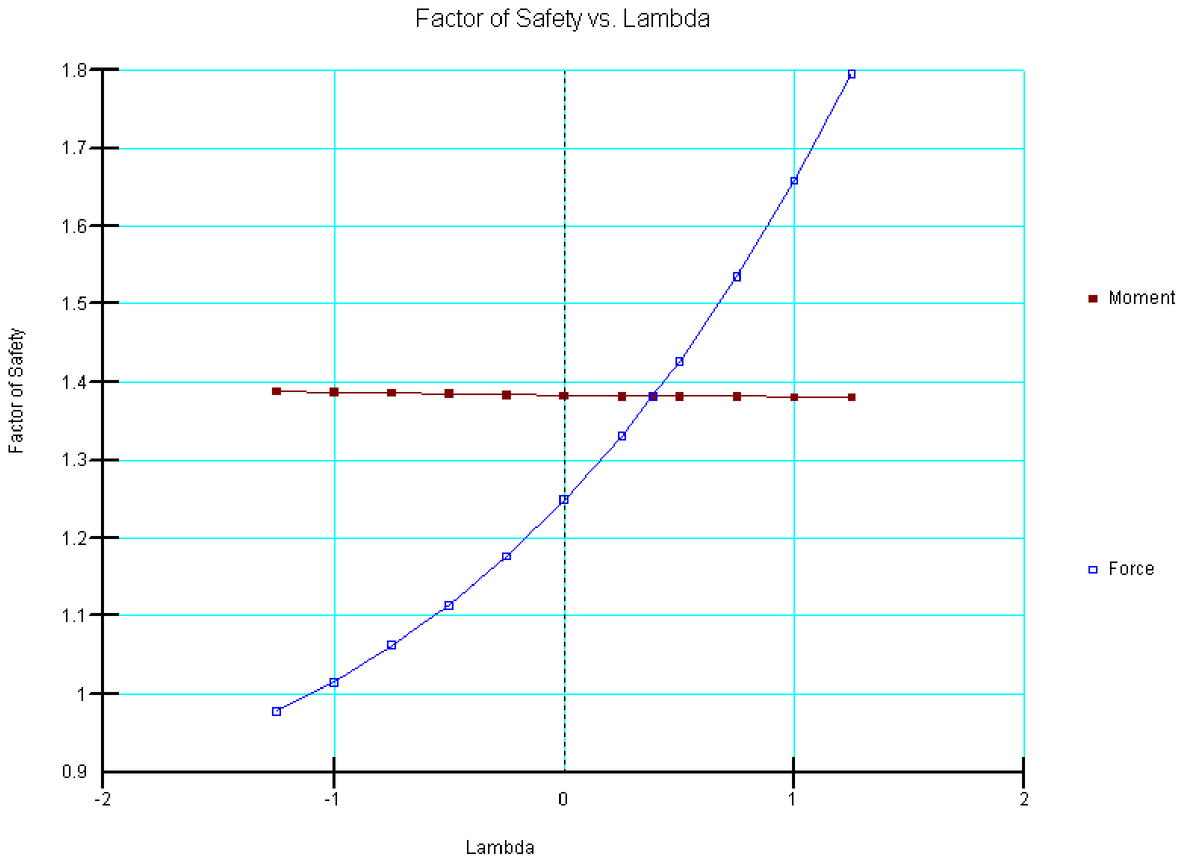

Figure 8 Factor of safety versus lambda