SEEQUENT

GeoStudio Example File
Buried Pipe Stresses

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Introduction

This example demonstrates how SIGMA/W can be used to model a structural liner on a circular opening by using a beam applied to the surface of the opening. In addition, the example illustrates how to consider the possibility of slip between the structural liner and the surrounding soil.

Numerical Simulation

Figure 1 shows the soil domain with a 1.5 m diameter circular opening in the centre. There are two analyses in the Analysis Tree (Figure 2). A surface pressure of 100 kPa is applied on the surface. The objective is to determine how this pressure is transmitted to the liner with and without the possibility of slip between the liner and the surrounding soil (Analysis a and Analysis b, respectively). The left and right boundaries in both analyses are fixed in the X-direction so no displacement can occur horizontally. The bottom boundary is fixed both X- and Y-direction.

The opening is created with the Draw Regions command. The circular opening is defined by a Point at the centre and a second Point on the perimeter. The perimeter Point was selected purposely at the invert of the culvert. This is simply for discussion convenience. We will see later, when we look at the culvert bending stresses, that it is nice to refer to the ends of the graph as at the culvert invert.

The only mesh property specified is that, globally, the element size should be approximately 0.2 m. The perimeter of the opening is treated in SIGMA/W as a Line object. This makes it possible to create interface elements along the Line, as shown in Figure 3. Furthermore, a beam can be applied to the Line. In this case, it is a curved Line, but it is nonetheless a Line object in SIGMA/W.

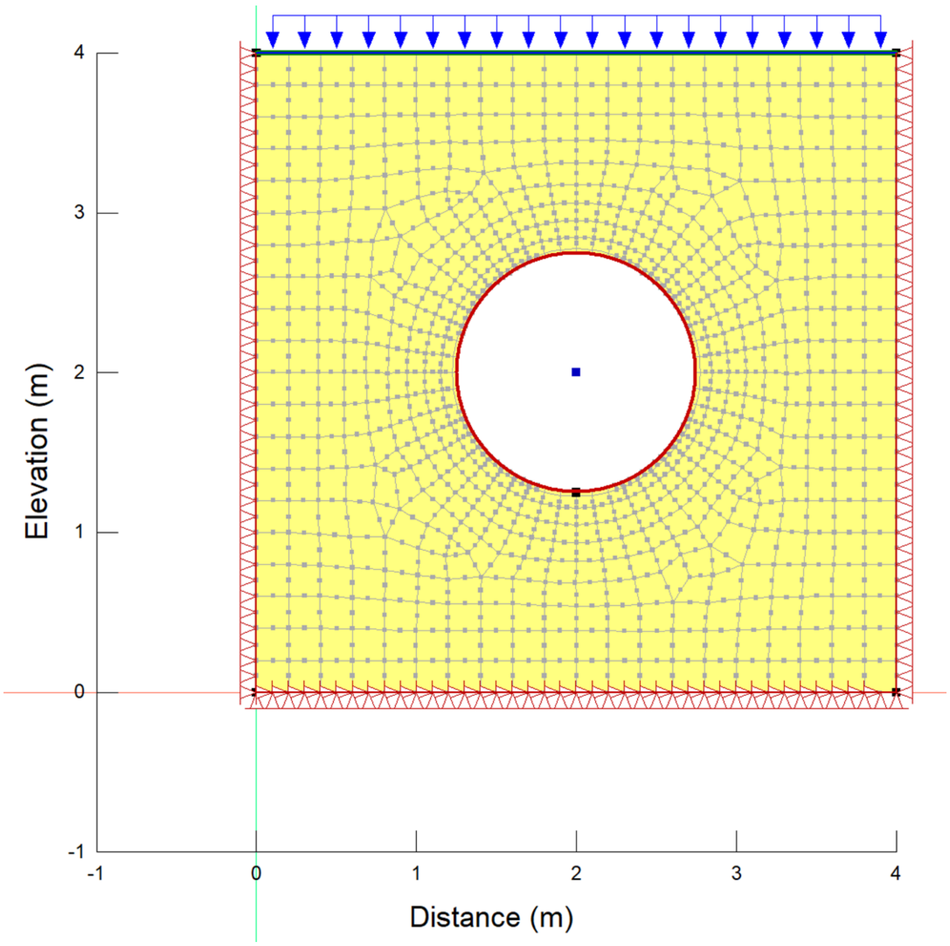

Figure 1. Problem configuration.

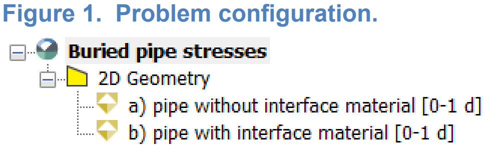

Figure 2. Analysis Tree of the Project.

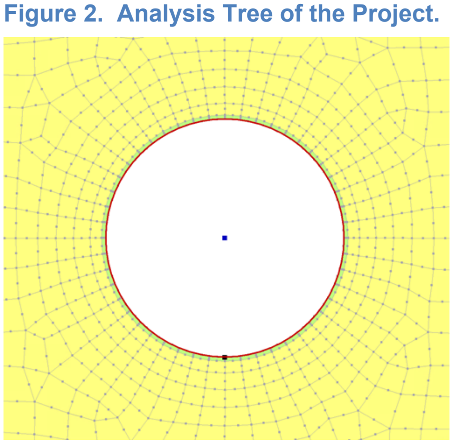

Figure 3. Interface elements and beam around the opening.

Both the soil and the potential slip have been defined using the Mohr-Coulomb material model. The soil has been defined with an Effective Elastic Modulus of 10,000 kPa, unit weight of 20 kN/m^3 and Effective Friction Angle of 30°. The slip material has been applied to the interface elements in the second analysis, with an Effective Elastic Modulus of 10,000 kPa, unit weight of 20 kN/m^3 and Effective Friction Angle of 10°.

The structural beam applied to the perimeter of the circular opening in both analyses has been defined with an E-Modulus of 2x10^6 kPa, cross-sectional area of 0.1 m^2 and Moment of Inertia of 8.33 x 10^{-5} m^4.

Results and Discussion

The compression of the soil, together with the culvert, for Analysis 1 (without the slip) is shown in Figure 4. Notice the slight oval shape of the culvert, which is consistent with what one would expect.

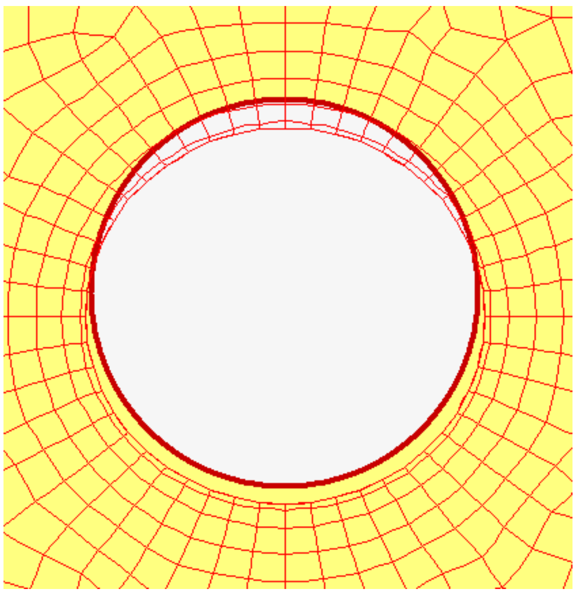

Figure 4. Compression and displacement with no slip (5X exaggeration).

Figure 5 shows the axial pipe forces and the bending moments. The ends of the graph are at the culvert invert (bottom of the culvert). The axial forces are the highest at mid-height or at the widest level, and the lowest at the top. The highest bending moments occur more or less equally at the quarter-points starting at the invert.

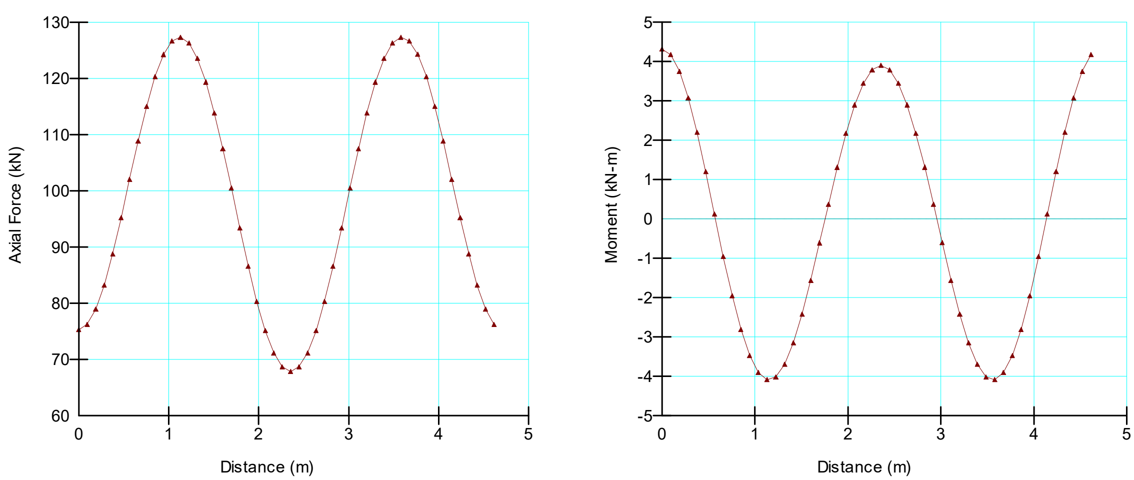

Figure 5. Pipe axial forces and bending moments (Analysis 1).

By allowing for some slip between the culvert and the soil (Analysis b), the culvert itself experiences less downward movement (Figure 6). The amount of the movement is not that significant, but it does demonstrate that the soil-structure interaction is influenced by the slip.

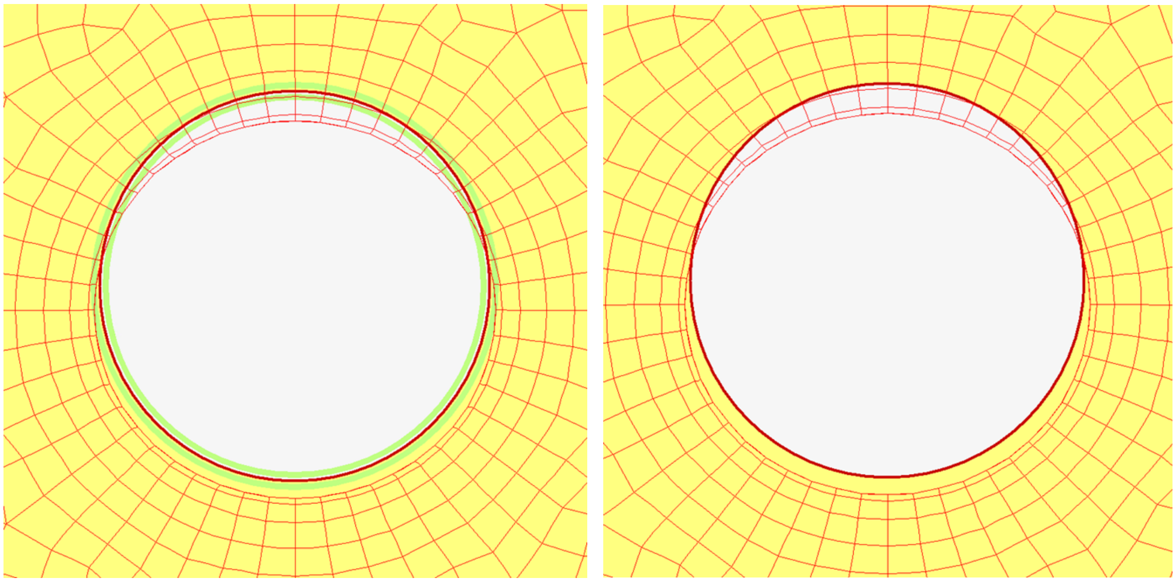

Figure 6. Displacement with (left) and without (right) slip (5X exaggeration).

The axial forces in the culvert or pipe are lower with the slip than without the slip (Figure 7). The lower curve with the square symbols is for the case with the slip. The bending moments are not all that different, as indicated by the graph on the right in Figure 7.

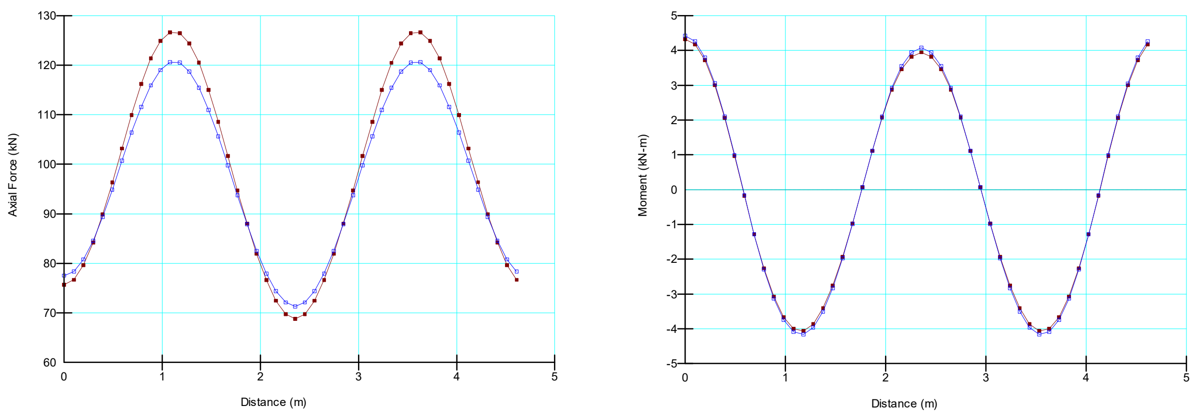

Figure 7. Comparison of axial forces and bending moments

Summary and Conclusions

This example illustrates how simple it is to create an opening in the mesh, and how easy it is to consider the soil-structure interaction for a case like a buried culvert or tunnel lining.