Computing Pile Resistance from Applied Soil Displacement for Slope Stability Analysis

1 Pile Resistance for Slope Stability Analysis

For slope stability analysis using limit equilibrium methods, the displacement of moving soil against the pile above the slip surface can be used to compute the lateral and axial resistance against sliding through the principles of superposition. As shown in Figure 1-1, an assumed uniform soil displacement is applied against the pile from the ground to the slip surface. The direction of the applied soil displacement is tangent to the slip surface at the intersection point of the pile and slip surface. The axial and lateral components of the applied displacement are used to compute the axial and lateral resistances separately. The resultant pile resistance force at the slip surface is used to satisfy force equilibrium for the selected limit equilibrium method.

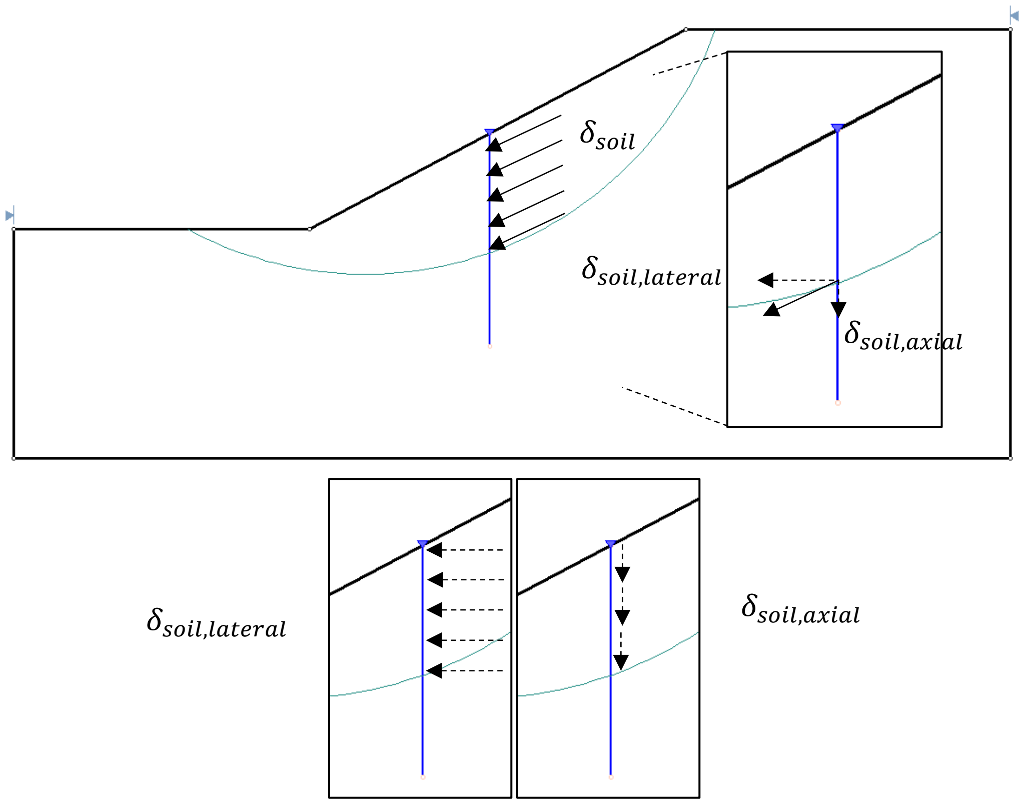

Figure 1-1: Slope Stability Analysis Considering Pile Resistance

The assumed displacement is the maximum allowable soil displacement based on design tolerances. Allowing a larger maximum soil displacement increases the pile resistance against sliding until the pile or soil reaches ultimate capacity. However, mobilizing ultimate resistance, especially for laterally loaded piles, may require as great as 8 inches of soil movement according to a study by Loehr and Brown (2008) [1] which is typically larger than most design tolerances.

2 Axial Resistance for Slope Stability Analysis

The axial resistance against axial displacement is calculated as the pile internal axial force at the location of sliding. In *RSPile*, a uniform axial soil displacement profile can be applied as a boundary condition from the ground to the sliding depth, as shown in Figure 2-1.

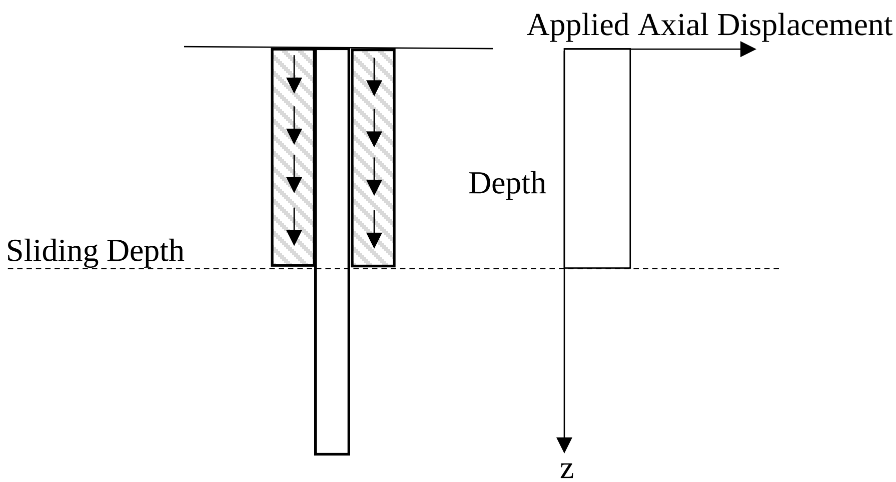

Figure 2-1: Applied Uniform Axial Displacement Profile to calculate Axial Resistance

Alternatively, if a general soil displacement profile is used in *RSPile*, in order to simulate a sliding depth, zero values should be entered below that location.

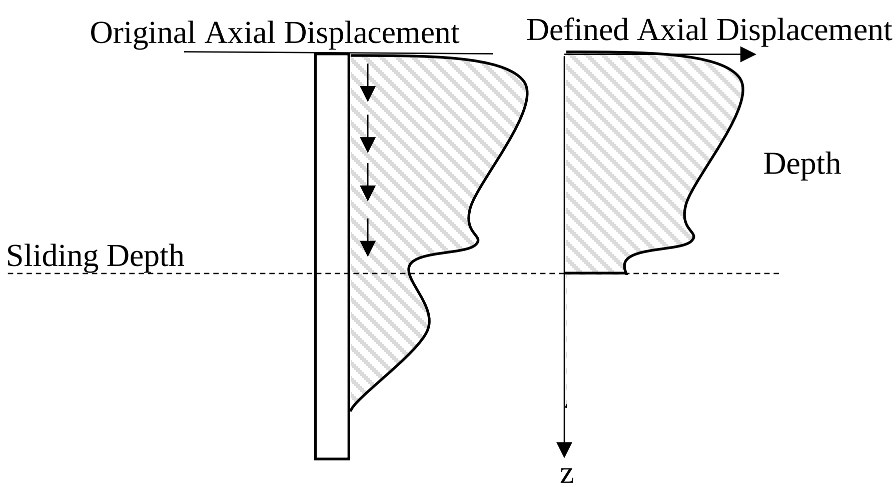

Figure 2-2: Applied General Axial Displacement Profile to calculate Axial Resistance

The internal axial force in the pile at the sliding depth in response to this loading is taken as the pile axial resistance against the applied axial displacement. Note that no axial force is applied to the pile head during this analysis since we are interested only in the resistance against axial displacement. Applying an axial load will increase or decrease the internal forces, but in reality it does not affect the axial resistance.

The process is repeated for a number of sliding depths to obtain an axial resistance to sliding depth relationship where linear interpolation is used to obtain the pile resistance of any intersecting slip surface.

3 Lateral Resistance for Slope Stability Analysis

Similarly, the lateral resistance against lateral displacement is calculated as the pile internal shear force at the location of sliding. In *RSPile*, a uniform lateral soil displacement profile is applied as a boundary condition from the ground to the sliding depth, as shown in Figure 3-1. More information regarding loading by soil movement is provided in the laterally loaded piles theory manual.

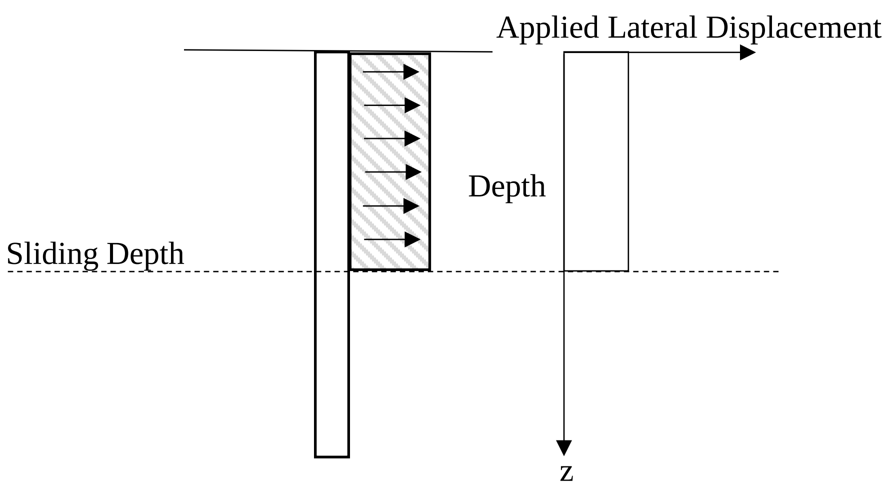

Figure 3-1: Applied Uniform Lateral Displacement Profile to calculate Lateral Resistance

Alternatively, if a general soil displacement profile is used in *RSPile*, in order to simulate a sliding depth, zero values should be entered below that location.

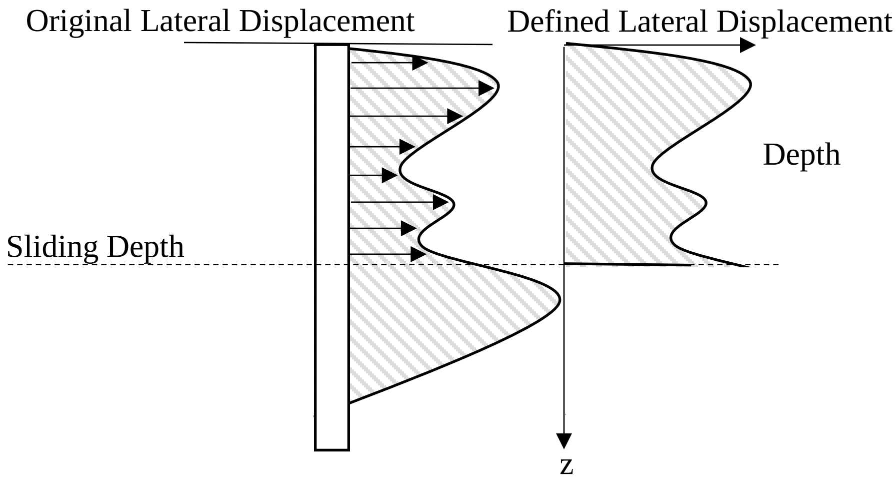

Figure 3-2: Applied General Lateral Displacement Profile to calculate Lateral Resistance

The internal shear force in the pile at the sliding depth in response to this loading is taken as the pile lateral resistance against the applied lateral displacement. For this analysis, pile head loading conditions can be applied to resist the lateral soil forces. Note that the sign convention for the pile head loading remains the same when working with *Slide*, regardless if the *Slide* analysis is left to right or right to left.

The process is repeated for a number of sliding depths to obtain a lateral resistance to depth relationship where linear interpolation is used to obtain the pile resistance of any intersecting slip surface.

In the case of ultimate analysis, substantial soil movement is usually required in order to mobilize transverse resistance in the pile. Rather than always running the analysis until failure of the pile (which can result in unrealistic pile deflections up to 2 meters), it is assumed 0.3 meters of soil movement is considered failure if transverse resistance in the pile has not been mobilized to that point.

4 References

1. Loehr, E.J. and Brown, D.A. (2008). "A Method for Predicting Mobilization Resistance for Micropiles Used in Slope Stabilization Applications", A Report Prepared for the Joint ADSC/DFI Micropile Committee.