ROCSCIENCE

RSPile

Steel Pile for Slope Stabilization in Multi-layer Soil

Verification Manual

November 29, 2022

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1. Steel Pile for Slope Stabilization in Multi-layer Soil

1.1. Introduction

This problem examines a steel pipe pile embedded into multi-layer soil for slope stabilization. The problem will analyze the axial force and shear in the pile when subjected to a uniform soil displacement of 25 mm from the ground to the slip surface intersection as shown in Figure 1-1. The assumed slip surface intersects the pile at 5 degrees to the horizontal which is also taken as the direction of applied soil displacement. The axial force and shear in response to an applied displacement can be taken as the axial and lateral resistance of the pile against sliding. The soil profile along the pile is presented in Figure 1-2. The results from **RSPile** are compared to commercial pile analysis software *TZPile* [1] and *LPile* [2].

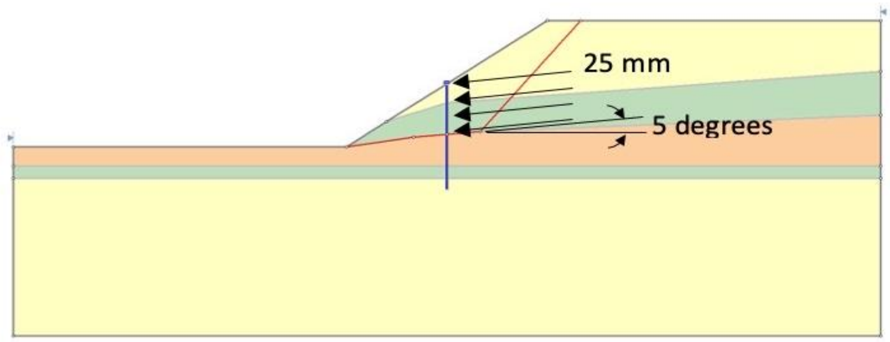

Figure 1.1: **Slide** model of steel pipe pile subjected to a uniform soil displacement of 25 mm

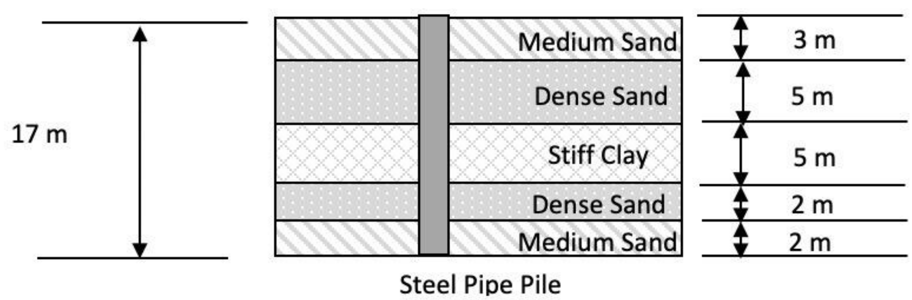

Figure 1.2: Soil profile along a 17 m embedded steel pipe pile

The pile properties are presented in the following Table 1-1.

Table 1.1: Pile Properties

Parameter	Value
Young's modulus (*E*)	200 GPa
Pile Outer Diameter	0.61 m
Pipe Wall Thickness	0.02 m
Embedment Length	17 m

Conventional soil models are different for axially and laterally loaded piles although they may share similar properties. The soil properties for medium sand in the first and fifth layer are presented in Table 1-2.

Table 1.2: Medium Sand Soil Properties

Parameter	Value
General Properties	
Unit Weight	18 kN/m^3
Friction Angle	30 degrees
Axially Loaded Piles	
Soil Type	API Sand
Coefficient of Lateral Earth Pressure	0.8
Bearing Capacity Factor	35
Laterally Loaded Piles	
Soil Type	Sand
Coefficient of soil reaction (k_{py}) (elastic portion of p-y curve)	16300 kN/m^3

The soil properties for dense sand in the second and fourth layer is presented in Table 1-3. The t-z curve is presented in Table 1-4 and Figure 1-3 and the p-y curve is presented in Table 1-5 and Figure 1-4.

Table 1.3: Dense Sand Soil Properties

Parameter	Value
General Properties	
Unit Weight	20 kN/m^3
Axially Loaded Piles	
Soil Type	User Defined
Ultimate Unit Skin Friction	150 kPa
Ultimate End Bearing Resistance	0 kN
Laterally Loaded Piles	
Soil Type	User-Defined

Table 1.4: Load-transfer (t-z) curve for skin friction

Soil displacement (m)	Unit Skin Friction (τ) / Ultimate Unit Skin Friction (τ_{ult})
0	0
0.000287	0.4
0.000476	0.6
0.000561	0.675
0.000695	0.76
0.000854	0.83
0.0011	0.9
0.0014	0.935
0.00174	0.965
0.00195	0.972
0.00305	1
∞	1

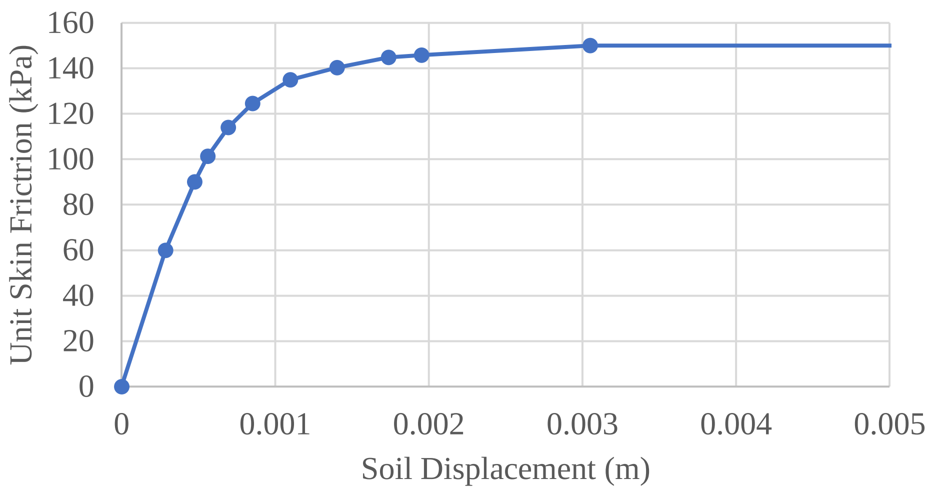

Figure 1.3: Load transfer (t-z) curve for skin friction

Table 1.5: Load-transfer (p-y) curve for lateral soil reaction

Soil displacement (m)	Lateral Soil Reaction (kN/m)
0	0
0.001	300
0.02	1800
∞	1800

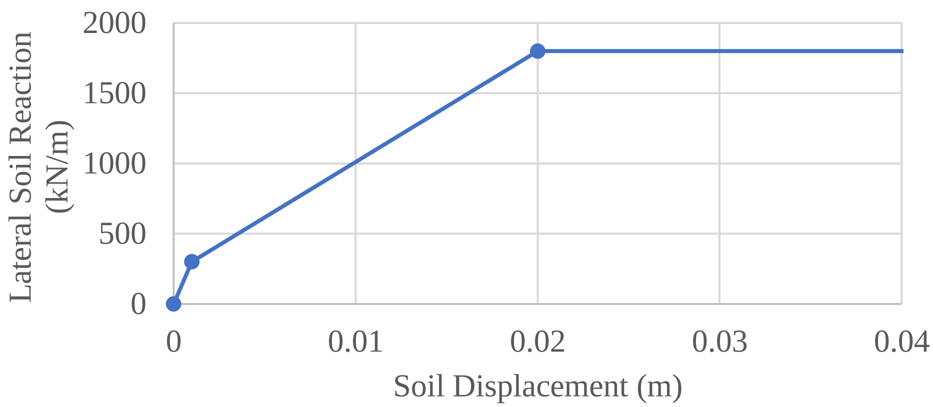

Figure 1.4: Load transfer (p-y) curve for lateral soil reaction

The soil properties for stiff clay in the third layer are presented in Table 1-6.

Table 1.6: Stiff Clay Soil Properties

Parameter	Value
General Properties	
Unit Weight	17 kN/m^3
Undrained Shear Strength	80 kPa
Axially Loaded Piles	
Soil Type	API Clay
Remolded Shear Strength	60 kPa
Laterally Loaded Piles	
Soil Type	Dry Stiff Clay
Strain Factor (E50)	0.007

1.2. Introduction

To compute the pile resistance, the axial and lateral components are computed separately. For a slip surface intersection at 5 degrees above the horizontal, the axial and lateral components of the applied displacement are 2.18 mm and 24.91 mm respectively, as shown in Figure 1-5. The resultant force of the axial and lateral resistance is the pile resistance.

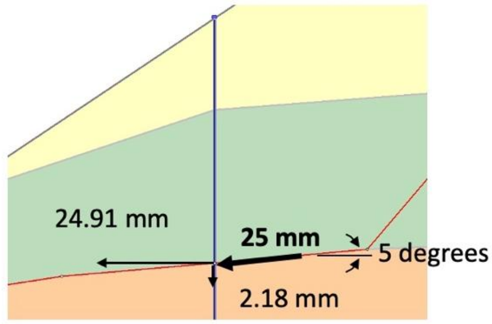

Figure 1.5: Components of the applied displacement to compute axial and lateral resistance

1.3. Results

Figure 1-6 shows the load distribution throughout the pile subjected to an applied displacement of 25 mm at 5 degrees to the horizontal. The results from **RSPile** compare well with *TZPile* [1] and *LPile* [2].

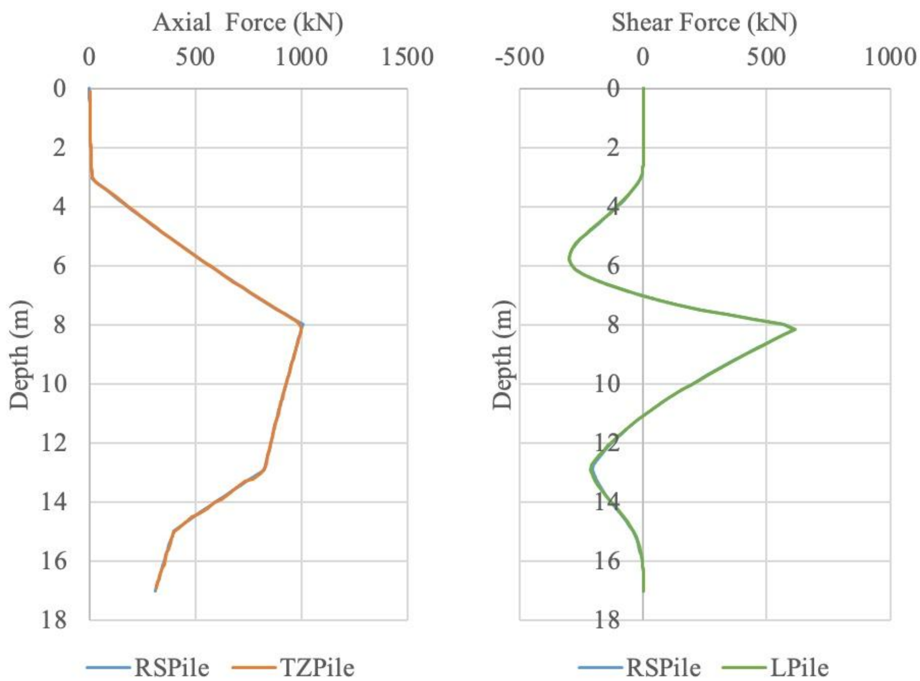

Figure 1.6: Pile load distribution for a sliding depth of 8 m

The axial and lateral resistance at a sliding depth of 8 m are 1003 kN and 582 kN respectively. The resultant pile resistance is 1160 kN.

1.4. References

1. Ensoft, Inc. TZPile. Computer software. Vers. 2014.3.2. Ensoft, Inc., 21 Jan. 2015.
2. Ensoft, Inc. LPile. Computer software. Vers. 2013-7.007. Ensoft, Inc., 24 Oct. 2013.

1.5. Data Files

The input data file *Verification 001 (Steel Pile for Slope Stabilization in Multi-layer Soil).rspil*e can be found in the installation folder.