RS Pile
version 1.0

RS Pile is a general pile analysis software for analyzing driven pile installation, axially loaded piles and laterally loaded piles. It is capable of computing the axial capacity for driven piles as well as the pile internal forces and displacements under various loads and soil displacements.
1 Introduction

*RSPile* is a general pile analysis software for analyzing driven pile installation, axially loaded piles and laterally loaded piles. It is capable of computing the axial capacity for driven piles as well as the pile internal forces and displacements under various loads and soil displacements.

Driven piles are analyzed using methods similar to the software Driven by the Federal Highway Administration. The program can model complex axially loaded or laterally loaded pile models using the load transfer curve method or better known as the p-y method for laterally loaded piles and the t-z method for axially loaded piles. The soil load transfer curves capture the non-linear soil-pile behavior by relating the soil reaction forces to the soil displacement at each depth. Various recommended load transfer curves are available in *RSPile* and are presented in the *RSPile* theory manual. For axially loaded piles, the load transfer curves are known as t-z curves for soil skin friction and q-z curves for soil end bearing resistance. For laterally loaded piles, the load transfer curves are known as p-y curves for soil lateral resistance.

Additionally, *RSPile* can compute pile resistance functions for slope stability analysis using limit equilibrium methods. *RSPile* files can be easily imported into *Slide 7.0* to provide a more thorough slope stability analysis.

2 General Pile Analysis Features

2.1 Pile Internal Forces and Displacements

*RSPile* is able to analyze lateral displacement, moment and shear for laterally loaded piles and axial displacement and force for axially loaded piles.
2.2 Axial Capacity for Driven Piles

The restrike, driving and ultimate capacity for driven piles can be analyzed in the specialized driven mode to consider the effects of pile installation.

2.3 Pile Types

A variety of pile types are available in the program including cylindrical, rectangular, pipe and standardized typical sections (ex. H Piles). Currently, the pile models are elastic-perfectly plastic for non-tapered piles and elastic for tapered piles. However, more complex non-linear models, such as for reinforced concrete piles will be implemented in the future.

For analyzing the axial capacity of driven piles, specialized pile types are available including pipe piles, timber piles, concrete square piles, H piles and monotube piles.
2.4  Soil Types

2.4.1  Driven Piles

Various soil models are available to analyze the axial capacity of driven piles including sand, general clay material, soft clay, clays overlaying sands or sandy gravels and user defined material. Many more models will be implemented in the future.

2.4.2  Axially Loaded Piles

Various soil models are available to produce the t-z and q-z curves including those recommended by the American Petroleum Institute (API) as well as elastic or user defined curves. Many more soil models to compute the ultimate shear and end bearing resistances as well as to define the t-z curve shape will be implemented in the future.

2.4.3  Laterally Loaded Piles

Various soil models are available to produce the p-y curves including elastic, soft clay soil, submerged stiff clay, dry stiff clay, sand, weak rock and user defined. Many more soil models will be implemented in the future.

2.5  Pile Loading Conditions

The user may consider a wide range of pile head loading conditions including axial load, shear, moment, slope, rotational stiffness and deflection in addition to pile toe loading conditions, such as shear or end bearing resistance. The user may also apply axial and lateral soil displacements to analyze slope stability problems or consider the effects of soil settlement.
2.6 Other Considerations

The user may also define the groundwater table depth and pile orientation.

3 Advanced Features: Piles for Slope Stabilization

3.1 Concept

For slope stability analysis using limit equilibrium methods, the soil displacement moving along a slip surface against the pile can be used to compute the axial and lateral resistance against sliding through the principles of superposition. 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 of the pile. 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 intersection is used to satisfy force equilibrium for the selected limit equilibrium method.
Slope Stability Analysis Considering Pile Resistance

The pile internal axial force at the sliding depth in response to the applied axial soil displacement is the axial resistance against sliding for that particular slip surface. Similarly, the internal shear force at the sliding depth in response to the applied lateral soil displacement is the lateral resistance for that particular slip surface.

The figure above illustrates a typical axial force and shear diagram along the pile depth for an applied displacement from the ground to the sliding depth of 10 m. The axial force and shear at a sliding depth of 10 m are the axial and lateral resistances respectively for one tested sliding configuration.

3.2 Automated Computation to obtain the Pile Resistance Function

The pile resistance is dependent on the depth and angle of the slip surface since this will affect the pile response from the applied displacement. As such, the pile resistance must be computed at a number of points along the pile varying the depth and angle of applied displacement at each point. RSPile automates this process by allowing the user to specify the number of sliding depths examined in the analysis and producing the corresponding pile resistance functions. Linear interpolation is used to obtain resistance values of intermediate sliding depths.
The slip surface intersection can be controlled by the sliding depth parameter shown on the left in the figure below. You can also analyze a number of sliding depths along the pile to produce the axial or lateral resistance function as shown on the right in the figure below.

The user may specify the maximum allowable soil displacement moving along any slip surface based on design tolerances to obtain the pile resistances. Alternatively, an ultimate pile resistance can be obtained by increasing the assumed soil displacement independently in the axial and lateral directions until the maximum resistances are reached.

The figure above presents a typical resistance function computed from the maximum allowable soil displacement shown in blue circles and the ultimate resistance function shown in orange squares.
3.3 Importing *RSPile* files into *Slide 7.0*

The pile resistance functions produced in *RSPile* can be imported into *Slide 7.0* through the easy-to-use utility feature in the support properties dialog. One *RSPile* model file can be used to define the soil and pile properties for multiple piles of various embedment lengths and soil layer configurations in *Slide 7.0*. For each intersecting slip surface to a pile, *Slide 7.0* will use linear interpolation to determine the appropriate resultant pile resistance to compute the factor of safety.

As shown in the figure below, the pile resistance functions are shown in the hatched fill on each pile. The functions were computed using only one *RSPile* model file and are the resultant forces of the axial and lateral resistance functions at each sliding depth.