LPILE
Analysis and Design of Deep Foundations Under Lateral Loads

GENERAL DESCRIPTION

LPILE is a special-purpose program for analyzing a single pile (or drilled shaft) under lateral loading using the *p-y* method. *LPILE* solves the differential equation for a beam-column using nonlinear lateral load-transfer (*p-y*) curves. The program computes lateral deflection, bending moment, shear force, and soil response over the length of the pile. Options are provided to compute components of the pile-head stiffness matrix for use in analysis of the super-structure and to compute pile-head deflection of various pile lengths.

*New Input Data for Structural Inserts
of Steel Shapes on Drilled Shafts*

Nonlinear lateral load-transfer from the foundation to the soil is modeled using *p-y* curves generated internally using published recommendations for various types of soils. Special procedures are programmed for computing *p-y* curves for layered soils and for rocks. Alternatively, users can enter any external (user-specified) nonlinear or linear *p-y* curves.

LPILE has analytical features to compute the nonlinear moment-curvature relationships and nominal moment capacity of a pile's section based on specified pile dimensions and nonlinear material properties. Optionally, the user may enter nonlinear moment-curvature relationships to be used in place of the internally generated values. Users can include any AISC section for nonlinear or elastic pile models either as driven piles or as embedded structural inserts on drilled shafts.

*Sample results from push-over analyses*

LIST OF FEATURES

Boundary Conditions and Loading

- Boundary conditions are available to model the pile head as free head, pinned head with sway, fixed head with sway, or elastically-restrained with a rotational spring. Pile-head loading may consist of a lateral load, a bending moment, a specific lateral displacement, or a specific pile-head rotation.

- Up to fifty different load cases may be applied at the pile head in a single analytical run. Models with multiple load cases are analyzed independently & produce results or warnings if one or more load case fails to reach numerical convergence.

- Users can specify any of the applied loads to be used for computations of pile-head deflection vs pile penetration to check critical pile length and produce efficient penetration designs.

- Concentrated Loads (Shear and/or Bending Moment) or distributed lateral loading may be applied anywhere along the length of the pile. Distributed loading may be specified as constant or varying linearly with depth.

- *LPILE* has the capability of performing analyses for Load and Resistance Factor Design (LRFD).

- In LRFD models the program checks factored moment and shear capacities w/ACI-318 based factors.

- Unfactored loads are defined for: shear, moment, axial thrust, and distributed lateral load.

- Allows for analyses of embedded piles with pile head that is below one or more soil layers.
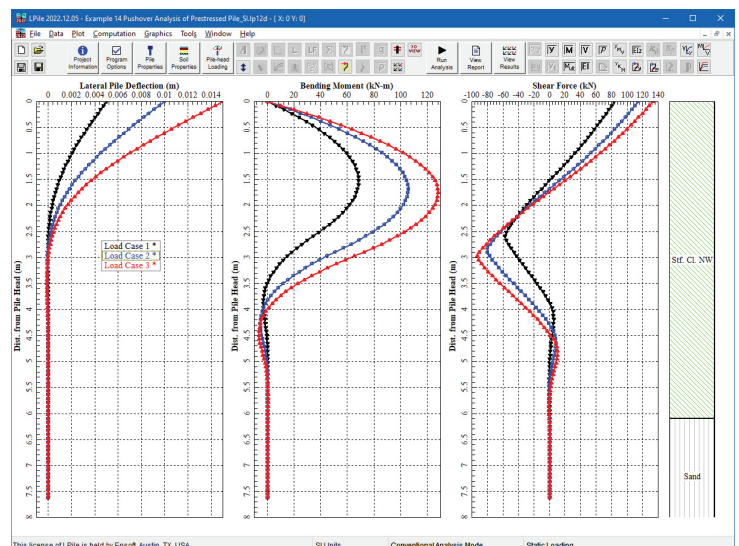
LPILE
Analysis and Design of Deep Foundations Under Lateral Loads
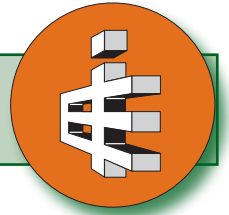
LIST OF FEATURES

Generation of Lateral Load-Transfer (*p-y*) Curves

- Soil-resistance (*p-y*) curves can be internally generated by the program for the following soils: soft clay, stiff clay with or without free water, sand (Reese et al or API), cemented *c*-φ soils (silt), liquefiable sand (Rollins & Hybrid), massive rock, strong rock, weak rock, modified stiff clay without free water using initial *k*, Piedmont Residual Soils, Loess Silt, Small Strain Sand and Elastic Subgrade. The *p-y* curves may be printed at any depth for reviews or reference.

- Users may optionally input their own lateral load-transfer (*p-y*) curves for specified soil layers. *LPILE* allows users to observe inputted curves with dynamic graphs.

- *LPILE* adjusts *p-y* curves for soil-layering effects (for example, where there may be layers of sand and clay). Users may select to turn off layering computations for all cases or only when soils are of the same type. This feature may be useful for research or to study layering impact on some models.

- User-defined multipliers can be provided to increase or reduce the soil resistance (*p-y*) curves at any point in the pile length. This feature is used in seismic conditions to reduce the response of liquefied layers or to account for Group Effects.

- Internal modification factors are automatically calculated to model influence of pile batter and sloping ground surfaces.

- In short piles or shafts w/large diameters, LPile users can evaluate the impact of any Side Resistance that may be developed along the pile length and Shear/Moment Resistance at the pile base.

- *LPILE* has the capability of analyzing the behavior of piles subjected to the free-field soil movement in the lateral direction.
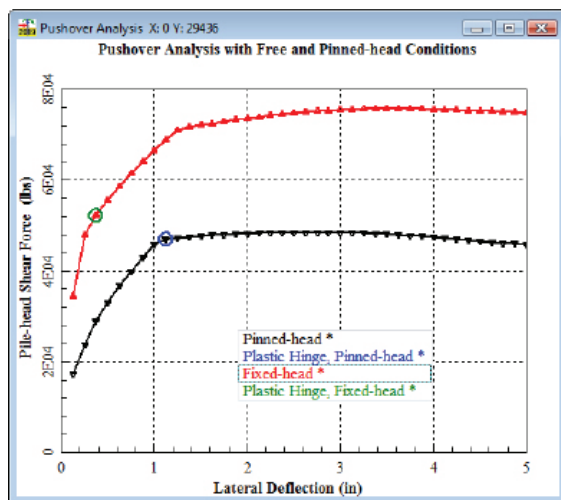
Plastic Hinge Formation on Push-Over Analyses

Structural Features

- Linear interpolation of bending stiffness is made internally for piles with variable cross sections.

- The user may optionally ask the program to generate and take into account nonlinear values of flexural stiffness (EI). These values are generated internally by the program based on: cracked/uncracked concrete behavior, user-specified pile dimensions, and nonlinear material properties.

- The user can define up to 10 sections with nonlinear bending properties. This allows the designer to cut off part of the reinforcing steel from the lower sections of a drilled shaft.

- Structural model of pile sections can include the confinement effect for rectangular and circular shafts for moment-curvature analyses following the Mander, Priestley & Park (1988) model for confined concrete.

- Four values (K_{22}, K_{23}, K_{32}, and K_{33}) of a typical 6x6 matrix for foundation stiffness may be generated by the program for a range of loading. These values can be used to model nonlinear foundation springs in the analysis of the superstructure.

- *LPILE* has the capability to perform push-over analyses and can study the pile behavior after the development of plastic hinges (yielding).

- In section analyses, *LPILE* can automatically build the full interaction diagram for all sections.

- Reinforcing steel can be offset from the centroid. This option is provided to allow analysis of drilled shafts where the reinforcement was placed (or accidentally moved) off-center.

- Longitudinal reinforcement can be selected with user-defined bar area, which is useful to model bars with some degree of degraded conditions.

Features for Optimization of Pile Designs

- Multiple pile lengths can be checked by the *LPILE* program to produce a design with an optimum pile penetration. For this purpose, users can evaluate the curve of pile-head deflections vs pile length.

- Curves of flexural stiffness versus bending moment and/or moment versus curvature plus interaction diagram are provided to review the adequacy of the pile's section.

- Automated analyses for push over and pile buckling studies are available options for LPILE.

Functional Features

- *LPILE* has the ability to perform batch analyses of multiple input-data files.

- Soil-layer data structures and input screens are formatted to help the user enter data conveniently with default values.

- Export any outputted graphics into excel spreadsheets w/ pre-formatted tabs for numerical values & graphs.

- Technical and User's Manuals are provided in PDF format.