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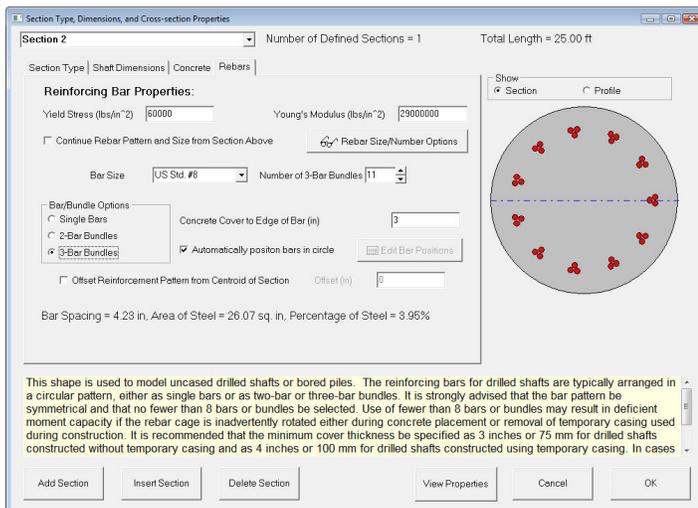
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LPILE v2013 (v7)

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 embedded pile length.



New Input Data for Section Properties of Drilled Shafts (Bored Piles)

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, the user can enter externally generated p - y curves.

Five types of pile-head boundary conditions may be selected, and the structural properties of the pile can vary as a function of depth. *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.

Sample results from push-over analyses

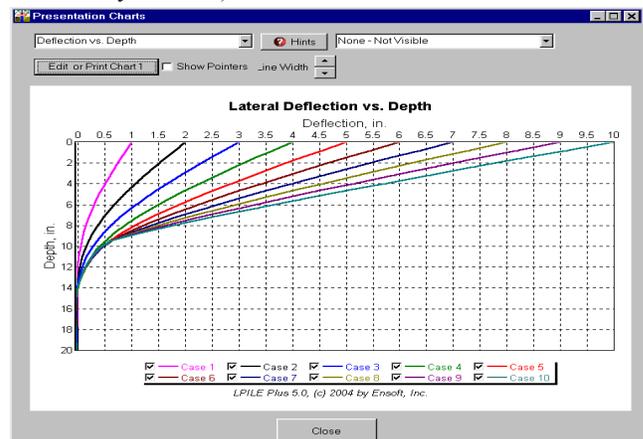
LIST OF FEATURES

Boundary Conditions and Loading

- Five sets of boundary conditions are available to model the pile head: free head, pinned head with sway, fixed head with sway, or elastically-restrained with a rotational spring. Depending on boundary conditions, pile-head loading may consist of a lateral load, a bending moment, a specific lateral displacement, or a specific pile-head rotation. The ability to specify both deflection and rotation at the pile head is an useful feature available in *LPILE*.
- Up to fifty different load cases may be applied at the pile head in a single analytical run. This is a helpful feature for the quick observation of pile behavior for a specified range of external loads.
- 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.
- A set of distributed lateral loading may be applied anywhere along the length of the pile. Loading may be specified as constant or varying linearly with depth.

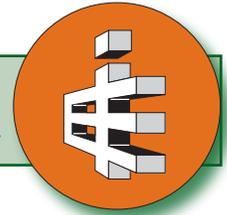
LRFD Analyses

- *LPILE* v2012 introduced the capability of performing analyses for Load and Resistance Factor Design (LRFD).
- Up to fifty load-case combinations may be defined with up to 100 unfactored loads grouped in 13 pre-defined load types.
- Load-case combinations are defined by entering the load factors for each load type and the resistance factors for flexure and shear. Optionally, the user may enter the load case combinations by reading external text files (previously created by the user).



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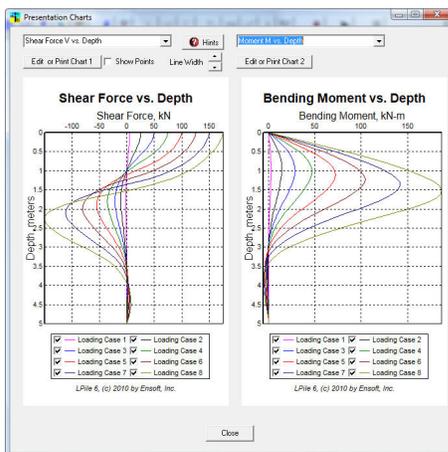


LIST OF FEATURES

- Unfactored loads are defined for: shear, moment, axial thrust, and distributed lateral load.
- Load types for unfactored loads are: dead load, live, earthquake, impact, wind, water, ice, horizontal soil pressure, live roof, rain, snow, temperature plus two user-defined load types.
- Factored loads are computed for each load-case combination by multiplying the appropriate load factor by the sum of loads of the same type. Summary reports of the computed load-case combinations are generated by the program.

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), sand (API), cemented c - ϕ soils (silt), liquefiable sand, strong rock, weak rock, modified stiff clay without free water using initial k , Piedmont Residual Soils, Loess Silt, 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 v2012 allows users to observe inputted curves with dynamic graphs.*
- *LPILE* can adjust p - y curves for soil-layering effects (for example, where there may be layers of sand and clay).
- User-defined multipliers are provided to increase or reduce the soil resistance (p - y) curves at any points along the length of the pile. This feature is used in seismic conditions to reduce the response of liquefied layers or to account for Group Effects.



Custom charts for shear force and moment

- *LPILE* has the capability of analyzing the behavior of piles subjected to the free-field soil movement in the lateral direction.

Structural Features

- Linear interpolation of bending stiffness is possible for piles with varying 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.
- *LPILE* v6 allows the user to define up to 10 sections with nonlinear bending properties. This permits the designer to cut off part of the reinforcing steel from the lower sections of a drilled shaft, as is common construction practice.
- 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).
- A new feature in Version 6 is the power to automatically generate bundled bar arrangement for 2-bar and 3-bar bundles.
- Also new in Version 6 is the ability to offset the reinforcing steel from the centroid. This option was provided to allow analysis of drilled shafts where the reinforcement was placed (or accidentally moved) off-center.

Features for Optimization of Pile Designs

- Several pile lengths can be automatically checked by the *LPILE* program in order to help the user 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 are provided to review the adequacy of the pile's section. In addition, the user may also observe the interaction diagram of the modeled pile section.
- *Automated analyses for push over and pile buckling studies are introduced with LPILE v2013.*

Functional Features

- Internal modification factors are automatically calculated to model pile batter and sloping ground surfaces.
- An user-specified curve may be used to model the additional shear resistance provided by the soil at the base of large-diameter drilled shafts and/or short piles.
- *LPILE* v2013 updates all standard menus and speed buttons and introduces new font type and graphics.
- Soil-layer data structures and input screens are improved to help the user enter data conveniently with default values. Hints and notes were also introduced on input windows to assist the user for data entry.
- A digital Technical Manual is provided with relevant theoretical equations along with digital User's manual.