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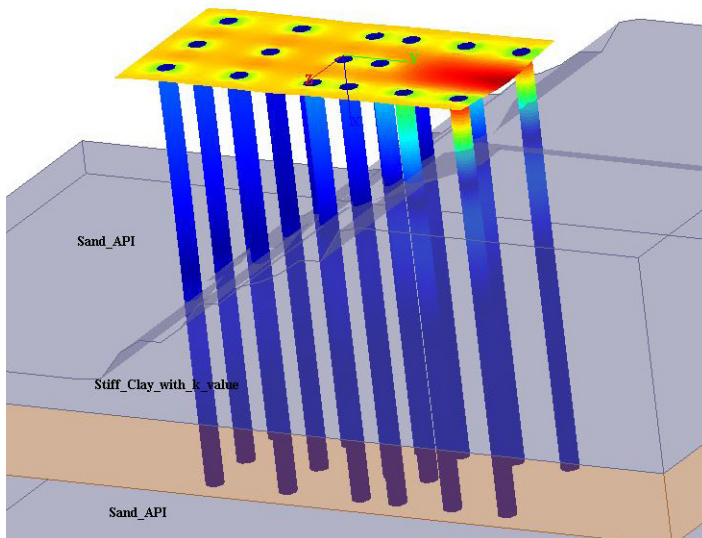


GROUP

A Program for the Analysis of Piles in a Group

GENERAL DESCRIPTION

GROUP has been well accepted as a valuable design tool for analyzing the nonlinear behavior of piles in a group subjected to axial, lateral and torsional loadings. The program computes the distribution of loads (in six degrees of freedom) applied from multiple locations in the pile cap to piles arranged in a group and embedded in a layered subsurface. **User can specify displacements and rotations (in 3D) on a rigid or flexible pile cap, which will resolve the forces that are generated with such movements/rotations.**



Contoured graphics of stresses in flexible pile cap and piles

Piles may be installed vertically or on a batter and their heads may be fixed, pinned, or elastically restrained by the pile cap. The pile cap may settle, translate, and/or rotate and is assumed to act as a rigid body.

The program generates internally the nonlinear response of the soil, in the form of t - z and q - w curves for axial loading, in the form of p - y curves for lateral loading, and in the form of t - r curves for torsional loading. A solution requires iteration to accommodate the nonlinear response of each pile in the group model. Program *GROUP* solves the nonlinear response of each pile under combined loadings and assures compatibility of deformations and equilibrium of forces between the applied external loads and the reactions of each pile head.

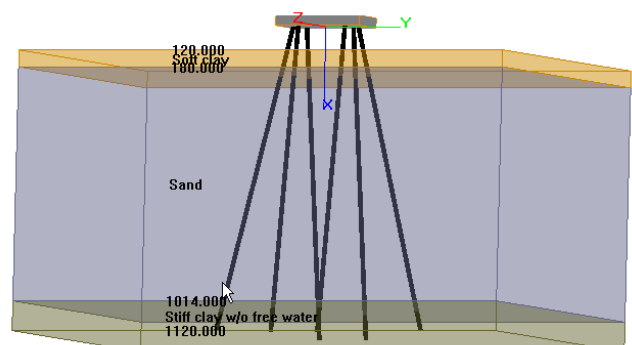
Program GROUP allows the input of groups of straight or batter piles, layered soil profiles, various cross-sections of pile sub-groups, and several loading arrangements

For closely-spaced piles, the pile-soil-pile interaction (group effects) can be taken into account by introducing reduction factors for the p - y curves used for each single pile. As an option, the user may ask the program to automatically generate suggestions of p -multipliers for the internal reduction of the soil resistance in closely-spaced piles. In *GROUP* the user may enter p - y modification factors that can vary along the length of each pile in the model.

The program allows the user to select computations of the required unit side friction at the top and bottom of each soil layer along with a unit tip resistance. The program employs commonly-accepted equations to compute the estimated unit side friction and unit tip resistance based on the soil properties that are specified by the user. Users may also input external nonlinear curves of axial load versus settlement for each pile in the group. Those external curves can be obtained by the user based on load tests or from Ensoft programs *APILE* and/or *SHAFT*.

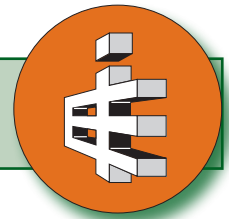
The foundation stiffness can be generated based on equivalent elastic stiffness (thus generating a symmetric stiffness matrix). Users of *GROUP* are also able to select to print out a text file (response file) or export to spreadsheet the equivalent nonlinear springs along the pile, which is useful for performance of complete soil-structure interaction analyses using other structural software.

Other features in *GROUP* are: Multiple load cases representing concentrated loads at the pile cap and/or distributed lateral load at any pile; Concentrated loads at the pile cap may be defined at any position; Load combinations can be specified by the user and are set by load factors applied at the defined load cases; Maximum and minimum envelopes may be computed for both load cases and load combinations; *GROUP* can provide flexibility and stiffness matrices (in 2D or 3D models) for different levels of loading.



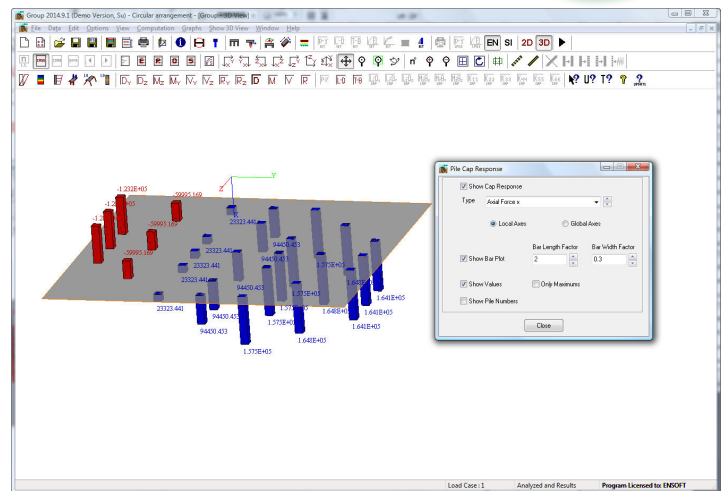
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LIST OF FEATURES

- A pile cross-section dialog is included to allow the user define piles with circular (straight or tapered), rectangular and wide-flange sections. **GROUP uses internal nonlinear flexural stiffness computations for reinforced concrete sections and for complex composite sections with structural steel inserts.**
- A template option is added so the program will generate basic rectangular or circular pile group layouts easily. This is particularly useful for models with large number of piles.
- Batter and vertical piles can be included in the same group analysis. Up to 1000 piles can be modeled in a group and piles can have different EI values in orthogonal directions.
- Parallel-processing and 64-bit programming in GROUP allows for efficient usage of multi-core processors and considerable reductions in computing time on large models.
- Pile-head connections to the rigid or flexible cap may be selected as: pinned, fixed, or elastically restrained. The flexible pile cap is modeled using plate elements and/or beam elements.
- Soil Movement can be specified as part of the loading.
- p - y curves may be inputted by the user or may be automatically generated by the program and printed for review. Non-linear user-defined soils can be mixed with soil layers having response curves that are automatically generated.
- Points of p - y curves (that were internally generated by GROUP) but requested as output/printout can be generated according to user-defined levels of deflections (y values).
- GROUP provides stiffness and/or flexibility matrices for foundations in 2D or 3D models.
- GROUP can plot the force and displacement on the pile cap,



Visualizations of 3D Model in GROUP displaying distribution of axial forces at pile cap

such as the axial force (tension and compression) of each pile on the pile cap, the lateral forces (shear and moment) of each pile on the pile cap, and the displacement of the pile cap in different directions. **All plots can be exported to pre-formatted Excel files.**

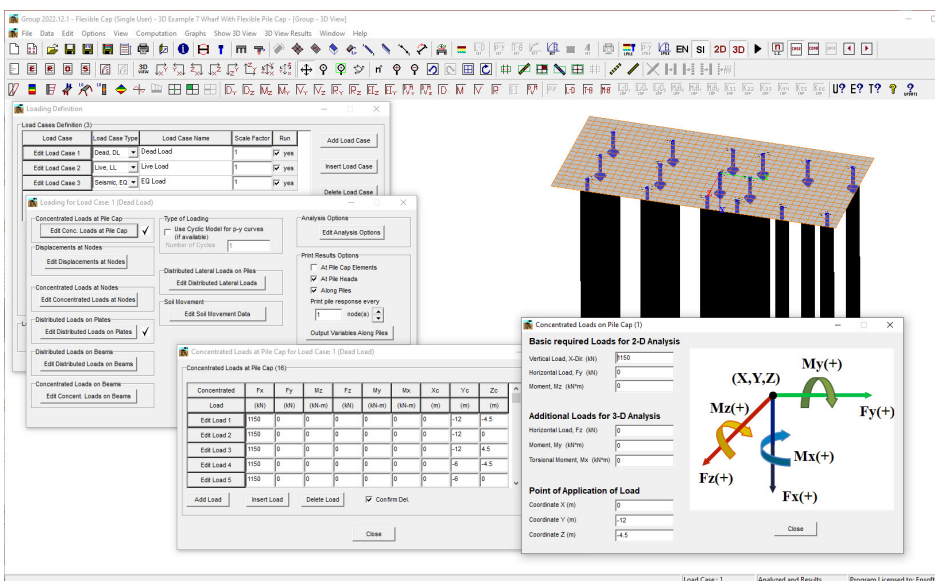
- 3D View graphics has been enhanced extensively to include various new features for inquiring of results and visual presentations for any load case/combination.
- GROUP provides a summary table of output data, which includes maximum and minimum effects for pile heads and over the pile length.
- More efficient algorithms are used to improve significantly the solution accuracy of a problem due to iterations because of the non-linearity of soil parameters.

• GROUP can consider lateral soil resistance against embedded pile caps and option to specify a reduction factor on the axial capacity of each individual pile. The output file includes the passive soil resistance that is computed internally against embedded pile caps.

• User can select the information to be printed, for convenience when the size of the output file becomes very large due to large number of piles and/or number of load cases.

• Models can be made in English or SI Units (w/automated conversion).

• New p - y curves for Liquified Sand Hybrid, Piedmont Residual, Massive Rock, Loess and Modified Soft Clay w/Initial K improving convergence in complex group models.



Sample windows used for data input