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THREE DIMENSIONAL FINITE ELEMENT PROGRAM TO PREDICT THE BEHAVIOR OF SOILS AND SUBSTRUCTURE COMPONENTS

PROBLEM STATEMENT

The Florida Department of Transportation (FDOT) has many soil-structure systems: piles, drilled shafts, walls, embankments, culverts, etc., whose behavior is both two/three dimensional, as well as changing over time. Present design methods have been limited to either one-dimensional (e.g., embankments), limit state (e.g., walls) or simple model application (e.g., piles/shafts). Moreover, these methods usually do not consider the nonlinear stress-strain behavior of the soil or rock, or the material creep.

Presently, there exist few finite element codes capable of modeling the soil-structure problems identified. Such codes are expensive (>$5,000) and limited in scope (i.e., two-dimensional, not three-dimensional, or consolidation, but no creep, etc.).

Recently, FDOT undertook the development of a two/three dimensional coupled (fluid and soil skeleton) large deformation finite element code (PlasFEM) to model Polk County Parkway (State Job No. 99700-3333-119, Contract No. B-9900). PlasFEM had all the features (nonlinear, two/three dimensional, coupled, etc.) to model soil-structure interaction; however, it had no pre-processor and a very crude post-processor.

OBJECTIVES

The purpose of this research was to develop a finite element package (pre- and post-processor with engine) capable of modeling soil-structure interaction problems. This work involved:

- Developing an automatic mesh generator (quadrilaterals and triangles) from multiple connected regions that the user draws to represent his/her problem.
- Modeling the construction process by placing soil in lifts (i.e., layers), by excavating soil in lifts, or by applying surface loads.
- Modeling the fluid flow by identifying the flow boundaries and natural water table in user's drawing.
- Selecting boundary constraints (pins and rollers), as well as soil models (Cam-Clay, Sandler-DiMaggio, etc.) and material parameters, through mouse and popup windows.
- Displaying Pore Pressures, Displacements, and Stresses as a function of time in multiple threaded windows (i.e., pore pressure and effective stresses may be displayed together) after the user analyzes his/her problem.

FINDINGS AND CONCLUSIONS

A pre-processor (PlasGEN) was developed which requires the user to draw the geometry and identify the flow boundaries, water table, construction sequence, and soil models with properties (see example below: embankment constructed on a soft clay layer).

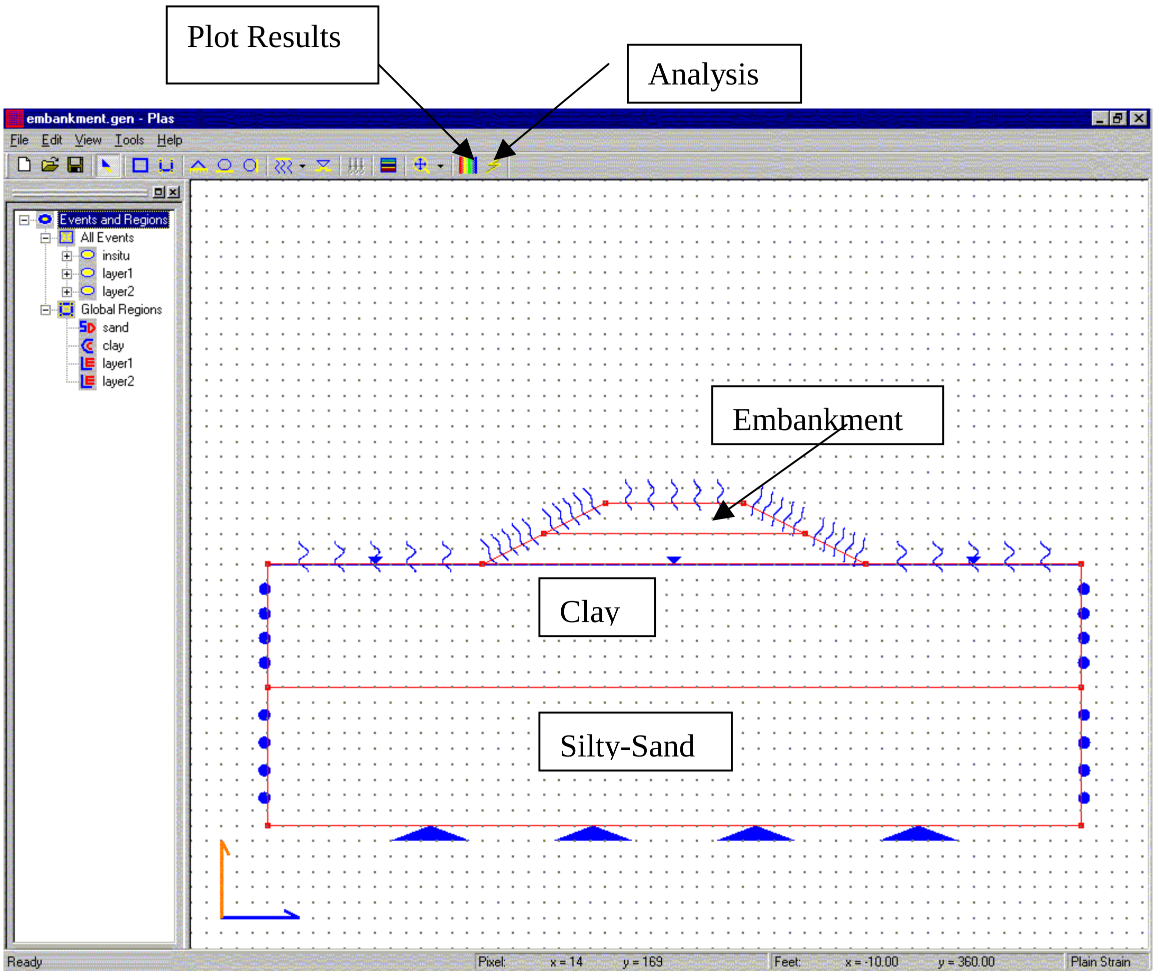

Figure 1. Pre-processor Screen

When the engine icon (Fig. 1--Analysis Icon) is clicked, the developed pre-processor automatically generates the mesh (Figure 2) and writes an ASCI file containing all the input for PlasFEM code which performs the analysis.

Subsequently, by clicking on the post-processor icon (Fig. 1--Plot Results), a post-processor displays the results (soil stresses, pore pressures, displacements, etc.), as shown in Figure 3.

A number of different example sets are presented that show the versatility of the software:

- Excavation behind a sheetpile wall.
- Backfilling around a culvert with surface loading.
- Skin and tip resistance of a drilled shaft in a conventional load test.
- Surcharge loading a soft clay layer with soil and pore pressures and bearing failure.

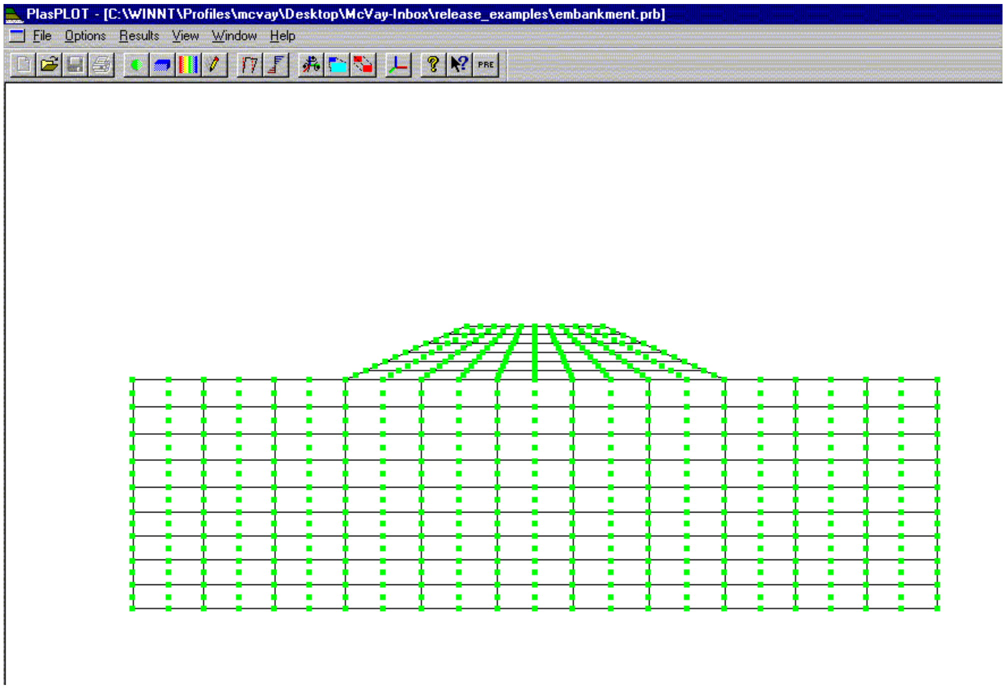

Figure 2. Automatic Mesh Generator.

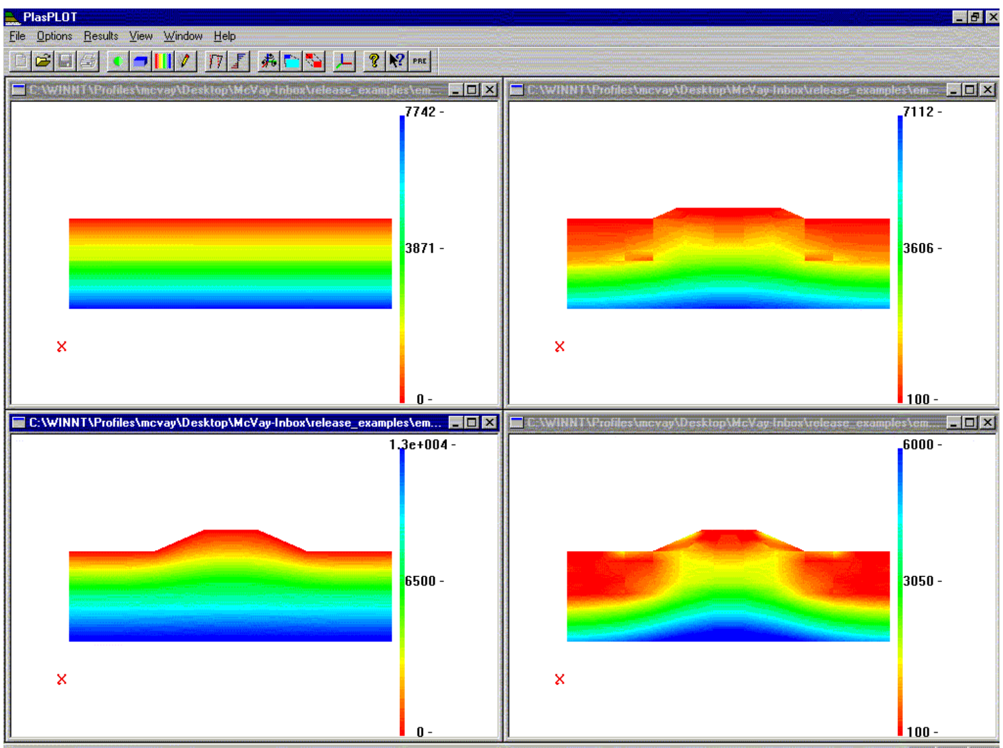

Figure 3. Soil Stresses and Pore Pressures

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