FINITE ELEMENT ANALYSIS OF STANDARD CALTRANS 16" CIDH PILE SUBJECTED TO AXIAL LOAD

Ahmed Elgamal and Jinchi Lu
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Introduction

In this study, we conduct a finite element simulation of the standard Caltran 16" CIDH pile using the 3D OpenSeesPL interface. The simulated pile is subjected to axial load.

Axially Loaded Pile

Pile Data

The geometric and elastic material properties of the pile are listed below:

Diameter D = 16"
Pile length l = 35 ft
Moment of Inertia of Pile I = 850 in^4
Young's Modulus of Pile E_c = 4030 ksi

In this initial study, the pile was modeled to remain linear (also in view of the applied load levels).

Soil Domain

Nonlinear soil response is investigated. The Medium relative-density granular soil type (Lu et al. 2006) is selected in the analyses. The material properties of the soil are listed below:

At the reference confinement of 80 kPa (or 11.6 psi), the Shear Modulus of Soil G_s = 10.88 ksi and the Bulk Modulus of Soil B = 29 ksi (i.e., Poisson's ratio ν_s = 0.33), see Lu et al. 2006.

Effective Unit Weight γ' = 110 pcf (given by CalTrans)

For nonlinear analysis, the Friction Angle $\varphi = 33°$ (given by CalTrans) and the peak shear stress occurs at a shear strain γ_{max} = 10% (at the 11.6 psi confinement). The parameter γ_{max} along with the shear modulus define the nonlinear soil stress-strain curve. Other values of γ_{max} should be explored in the future.

Axial Load

An axial load of 243 kips is applied at the pile head (free head connection).

Finite Element Simulation

In view of symmetry, a half-mesh (2,900 8-node brick elements, 19 beam-column elements and 180 rigid beam-column elements in total) is studied as shown in Figure 1. Length of the mesh in the longitudinal direction is 520 ft, with 260 ft transversally (in this half-mesh configuration, resulting in a 520 ft x 520 soil domain in plan view). Layer thickness is 60 ft (the bottom of the soil domain is 25 ft below the pile tip, so as to mimic the analytical half-space solution).

The floating pile is modeled by beam-column elements (Mazzoni et al. 2006), and rigid beam-column elements are used to model the pile size (diameter).

The following boundary conditions are enforced:

i) The bottom of the domain is fixed in the longitudinal (x), transverse (y), and vertical (z) directions.

ii) Left, right and back planes of the mesh are fixed in x and y directions (the lateral directions) and free in z direction.

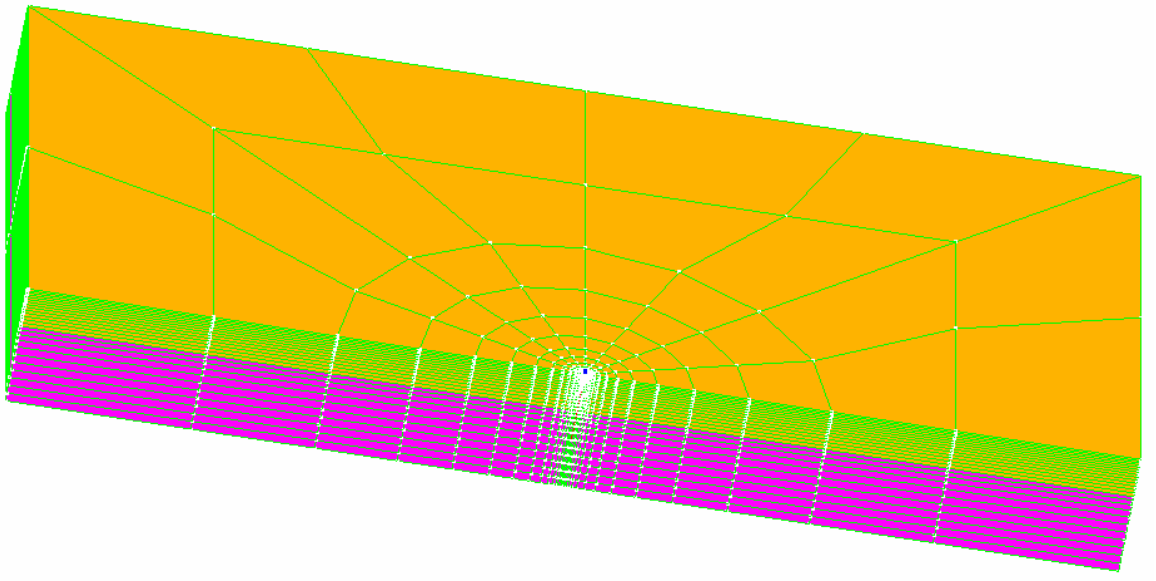
iii) Plane of symmetry is fixed in y direction and free in z and x direction (to model the full-mesh 3D solution).

The axial load is applied at the pile head (ground level) in z (vertical) direction.

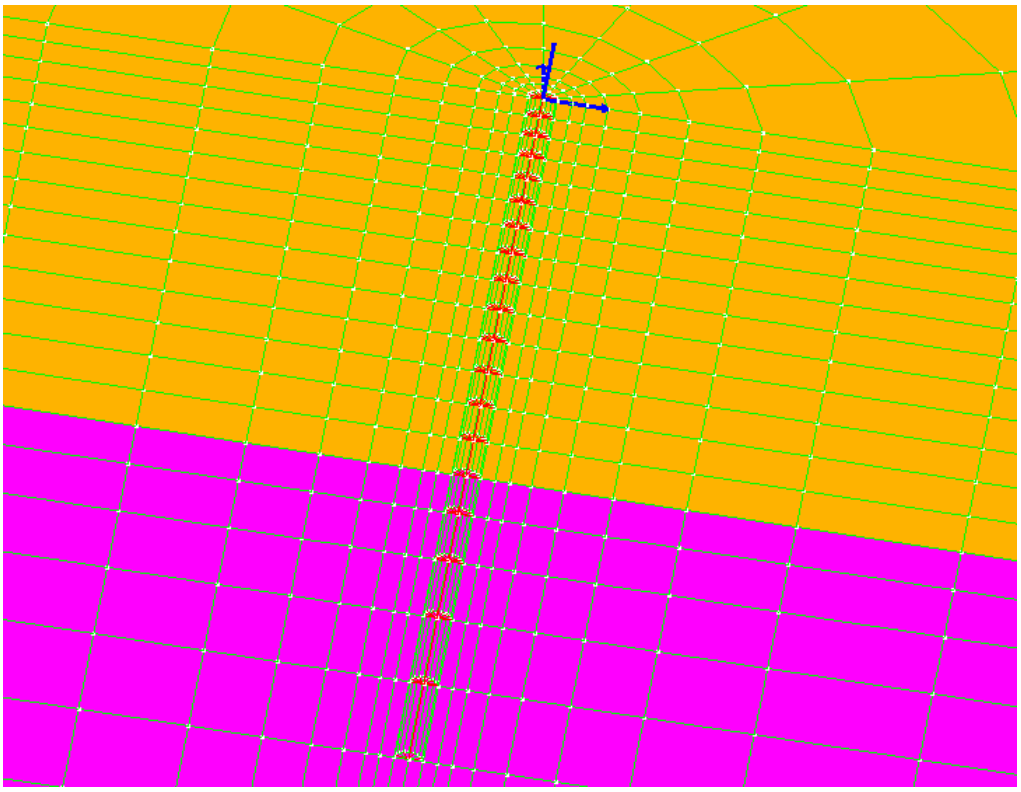
The above simulations were performed using OpenSeesPL (Lu et al. 2006).

Simulation Results

The pile vertical displacement and axial force profiles at the axial load of 243 kips are shown in Figure 2. The final deformed mesh is shown in Figure 3. Figure 4 displays the stress ratio contour fill.



(a) Isometric view



(b) Pile head close-up

Figure 1: Finite element mesh employed in this study.

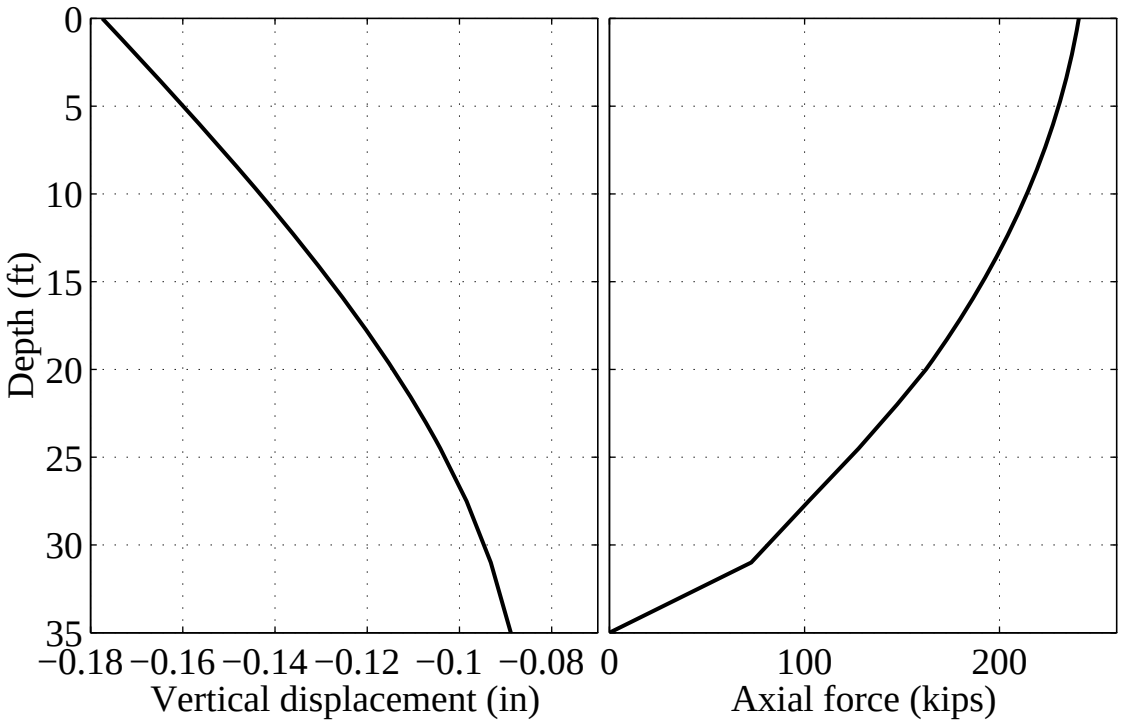


Figure 2: Pile profile response at the axial load of 243 kips.

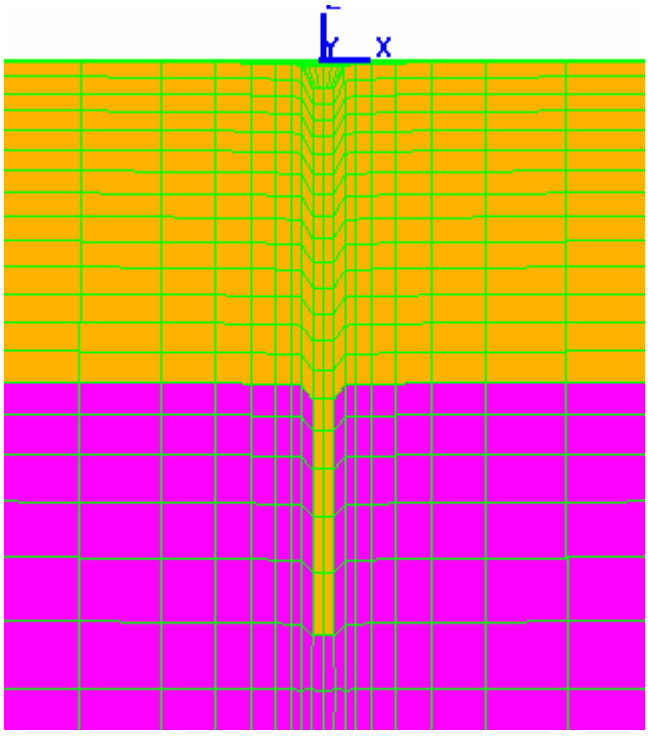
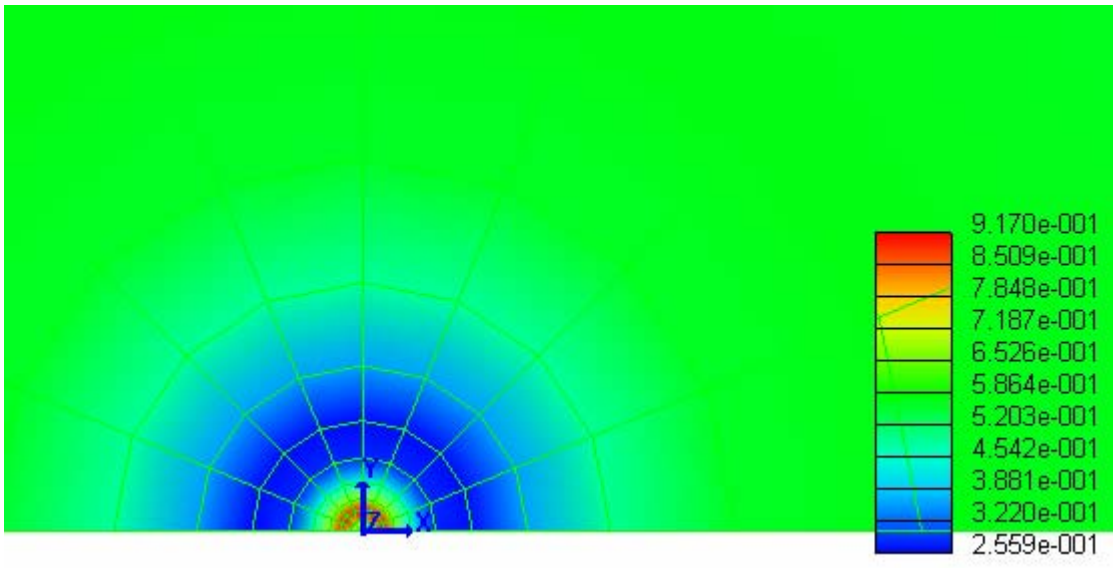
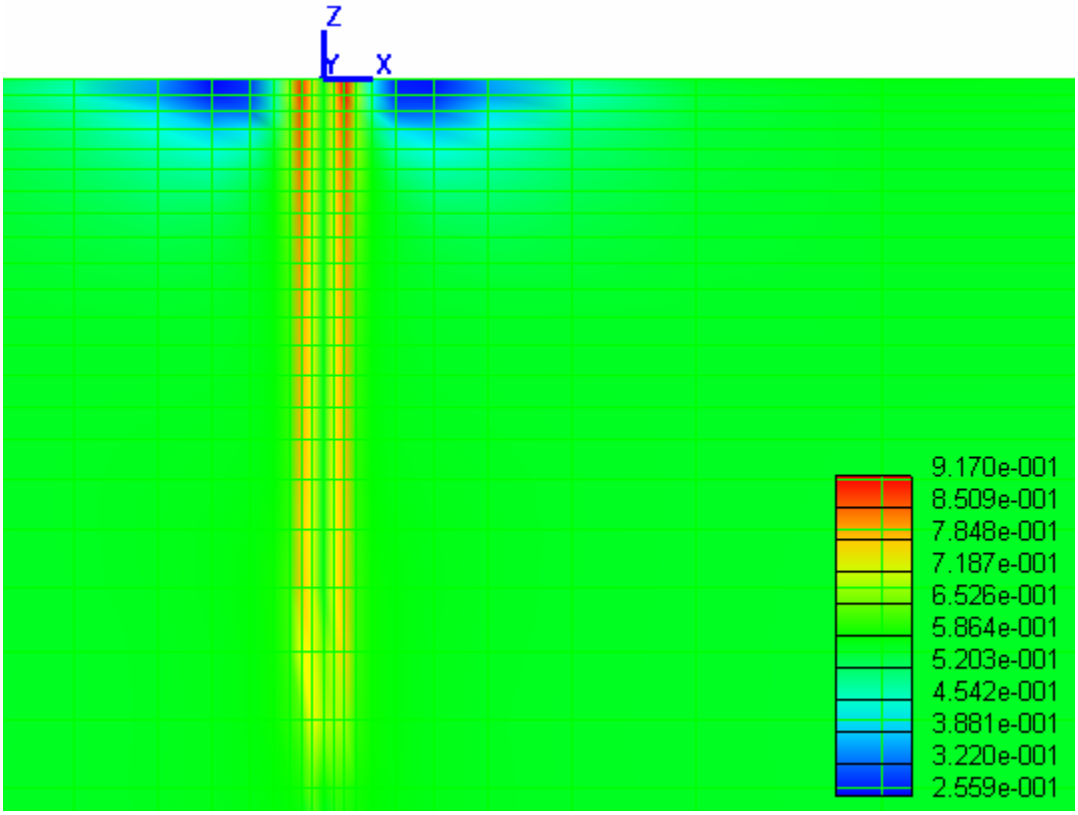


Figure 3: Close-up of final deformed mesh (factor of 120).



a) plan view



b) Side view

Figure 4: Stress ratio contour fill for the nonlinear analysis (red color shows yielded soil elements).