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Numerical Simulations of Pile Using Plaxis

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ABSTRACT

Background: An attempt to study the behavior of sheet pile in this paper. The finite element package PLAXIS 2D, Version 8, is used for this purpose. The excavation is 5m wide and 15m deep, 12m long concrete diaphragm walls of 0.6m thickness are used to retain the surrounding soil. The top 3m consists of Sandy Clay, 3 to 6m consists of clayey fine sand and 6 to 15m consists of weathered rock. Ground water table located at 2m from top. The soil stratum is idealized by 15 noded triangular elements with elastic-plastic Mohr Coulomb model and the sheet pile behavior is assumed to be linear-elastic. Interface elements have been used to model the interface between the sheet pile and the soil models. The deformation, SFD, BMD obtained from analytical method and then compared with the finite element simulation results using PLAXIS 2D, showing reasonable agreement. Sensitivity analyses have been carried out for selecting the appropriate mesh size and its gradation and also appropriate constitutive relationships and also tower foundation in Bangalore, case study is presented.

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INTRODUCTION

When the soil at shallow depth is not capable of supporting a structure, deep foundations are required to transfer the loads to deeper strata. If a firm stratum is so deep that it cannot be reached by open excavation, the deep foundation will be adopted. The most common types of deep foundations are Piles, Piers and Caissons. The mechanism of transfer of the load to the soil is essentially the same in these types of foundations. When piles and raft are both equal in cost, then piles are preferable to rafts as the settlement for piles is considerably less than that of a raft. Economy in pile foundation is achieved by designing the piles of suitable diameters such that the sum of safe capacity of piles under a column should be almost equal to the load coming on the column. In one pile group there should be preferably only one diameter of piles. In a building, diameter of piles may vary under various columns depending on the magnitude of load being carried by the columns.This paper presents the Comparison results between analytical and numerical method and also attempts to study the sheet pile behaviour by using a two-dimensional finite element model.

M.K.Legian and P.K. Hadley (1977): describes procedure for estimating the uncertainties in the computed defections and bending moments in a pile subjected to lateral loads. In this procedure, the uncertainty of soil properties and soil response are first estimated, then finite difference equations, governing the pile behaviour, estimates are made of uncertainty in the computed curves which describes the lateral behaviour of pile.

Case study-i:
The Proposed Tower Foundation At Karnataka Golf Association, Bangalore

The Karnataka Golf Association has decided to erect fencing of 30m height towers along the boundary of golf course to prevent the Golf ball going out of the golf boundary. The wind blowing in this area as maximum velocity of 60 to 70 Km/hr this speed of wind will except heavy lateral force on the towers in terms towers will except a heavy moment on there foundations subjecting part of foundation under uplift force to resist this uplift forces a very heavy open foundation were to be used.

Design for uplift resistance of pile:
Data:
d = 400mm = 40cm

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du = 2.5d = 2.5*40 = 100cm
L1= 4m = 400cm
Ca = 0.5
Where
Ca = Adhesion between soil and shaft
Cb = Cohesion of soil at bulb
Nc = Bearing capacity factor = 6
Taking the soil parameter values from soil investigations report
Qr1 = Лd L1 Ca (1)
Qr1= 250KN
Qr2 = Ca Nc Л(du 2– d2) (2)
Qr2 = 197KN
Qu = Qr1+ Qr2 (3)
Qu = 447KN
Qsafe = 220KN

In the configuration of 4 Piles system, the wind pressure produce tension on two piles and compression on other two piles. Hence the uplift resistance offered by two piles = 440KN which is safe.

Case study-ii:
The proposed commercial building at lalbagh road, bangalore:

There was proposed to construct shopping mall with 2 Basement at Lalbagh road in Bangalore. This site is surrounded by residential apartment of 3 storeyed building on one side and Industrial structure on other side. At the backside of the site deep nalla is flowing. Hence site situation has created necessity to protect the sides of deep excavations. For this purpose Touch Pile of 600mm dia. and depth varying from 12m to 8m was proposed and hence pile were installed. Naveen et al (2010).

Design for sheet pile by using closed form solution:

Depth of Pile = 12.0m
Ø = 35º, γ = 20KN/m3
Ka = tan2 (45- Ø/2)
= tan2 (45- 35 /2)
Ka = 0.27
Kp = 1/ Ka
= 1/0.27 = 3.69
Solving using closed form equations and increasing the
Depth of embedment by 20%, D = 10.19m.
Bending moment and shear force works out to be,
BMD = 146.4 KN m SFD = 64.7 KN

Numerical simulations:

An attempt to study the behaviour of sheet pile in this paper. The finite element package PLAXIS 2D, Version 8, is used for this purpose. The PLAXIS is a finite element package that has been developed specifically for the analysis of deformation and stability in geotechnical engineering projects. The simple graphical input procedures enables a quick generation of complex finite element models, and the enhanced output facilities provide a detailed presentation of computational results. The calculation itself is fully automated and based on robust numerical procedures.

The excavation is 5m wide and 15m deep, 12m long concrete diaphragm walls of 0.6m thickness are used to retain the surrounding soil. The top 3m consists of Sandy Clay, 3 to 6m consists of clayey fine sand and 6 to 15m consists of weathered rock. Ground water table located at 2m from top.

Model and parameters of two-dimensional finite element analysis:

Sheet pile in soil has been modelled as an axi-symmetric problem. In PLAXIS 2D, 15 noded triangular element has been chosen which results in a two-dimensional finite element model with two translational degrees of freedom per node. The 15-noded triangle provides a fourth order interpolation for displacements and the numerical integration involves twelve Gauss points. The pile is made up of reinforced cement concrete and the behaviour is assumed to be linear-elastic. The Soil behaviour as described by Mohr-Coulomb and Hardening Soil models is selected for preliminary analyses. After conducting multiple trials and sensitivity analyses, we conclude that the Mohr-Coulomb model is the most suitable model for all the layers of soil. Naveen et al (2011).

The Mohr-Coulomb model can be considered as a first order approximation of real soil behaviour. This elastic-perfectly plastic model requires 5 basic input parameters, namely Young's Modulus, E, Poisson's ratio, ν, cohesion, c, friction angle, Ǿ and dilantacy angle, Ψ. This is a basic, well-known soil model. Boundary conditions: The bottom boundary is rigid, i.e., both horizontal (u) and vertical displacement (v) are zero. Standard fixities are used at the left and right boundaries of the model. This side boundaries act likes rollers such that u=0 but v≠0.Interface element: The soil-structure interaction is modelled using an elastic-plastic model to describe the behaviour of interfaces. For the interface to remain elastic, the shear stress, $|\tau| < \sigma n \tan\Phi i + ci$, where Φi and ci are the friction angle and cohesion (adhesion) of the interface respectively and σn, the effective normal stress. The interface element properties are linked to the strength properties of the soil layers. The main interface parameter is the strength reduction factor Rinter. A strength reduction factor of 1 is used. Rober et al (2001), Tomlinson & Wood (2008). The material properties used are shown in Table 1.

Table 1: The Material Properties of Pile for Laterally Loaded Pile.

No.	Identification	EA [kN/m]	EI [kNm²/m]	w [kN/m/m]
1	PILE	1.211E7	2.72E5	12.46

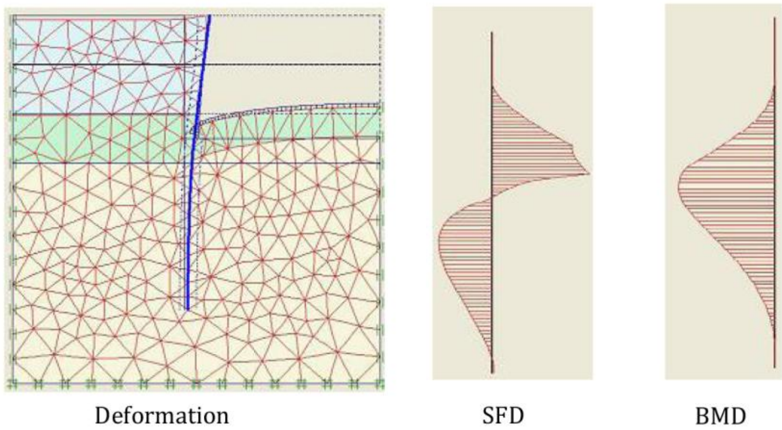

Fig. 1: Shows the Deformation, SFD, BMD of sheet pile.

Table 2: Comparison between analytical and numerical method.

Sl.No	Particulars	Analytical Method	Numerical Method
1.	Deformation	19.18mm	12.75mm
2.	BMD	146.4KNm/m	78.92KNm/m
3.	SFD	64.7 KN/m	43.04 KN/m

Results obtained from PLAXIS are compared with closed form solution Table 2. There is reasonable comparison of results. Result from closed form solution seems to be more conservative compared to numerical method. These may be due to some of the following reasons: In analytical method (closed form) ,it is assumed that whole excavation is done in one stage and soil parameters are normally assumed uniform but in the numerical method the layered system is been analyzed by discretizing the soil media and interface's element are been used to transfer the stress oblique forces to pile system based on the stiffness factor. Further the stage wise excavation can be taken up for analysis. This aspect resembles the actual procedure being carried out in the field. At every stage of excavation displacement, moment, and shear force can be calculated.

Conclusion:

Based on the results obtained using analytical method with Numerical method, the following broad conclusions are drawn.

From above study it can be concluded that the Numerical analysis of sheet piles by using software like Plaxis are more economical and accurate.

In this computer age use of software like Plaxis give better and faster results and approach of analysis represents actual soil conditions.

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