“NUMERICAL ANALYSIS OF SCREW PILES IN COHESIONLESS SOIL”

A DISSERTATION

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IN

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Submitted by

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I, **Ashish Thakur, 2K20/GTE/05**, student of M.Tech (Geotechnical Engineering), hereby declare that the project dissertation titled **"Numerical analysis of screw pile in cohesionless soil"** is submitted to the Department of Civil Engineering, Delhi Technological University, Delhi, by me in partial fulfillment of requirement for the award of degree of **Master of Technology (Geotechnical Engineering)**. This thesis is original work done by me and not obtained from any source without proper citation. This project work has not previously formed the basis for award of any degree, diploma, fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that project dissertation titled **"Numerical analysis of screw piles in Cohesionless soil"** submitted by **Ashish Thakur, 2K20/GTE/05,** Department of Civil Engineering, Delhi Technological University, Delhi, in partial fulfillment for the award of degree of Master of Technology, is a project work carried out by the student under my supervision. To the best of my knowledge, this work has not been submitted in part or full for any degree or diploma to this university or elsewhere.

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ABSTRACT

Screw piles are hollow steel tubes with one or more helix welded to the shaft, which are inserted into ground by applying torque at head of pile. Use of Screw piles in deep foundation has increased in past few years due to their advantages over other alternatives. Because it takes shorter time to install, it is removable and reusable also, can be installed at any inclination. From performance point of view, it provide greater compressive and uplift capacity than that of traditional driven steel piles with same shaft diameter and length. Due to its many advantages it can be a good option in deep foundation.

In this project, numerical modeling of screw pile is carried out with the help of a 3D finite-element software, Plaxis 3D.Then the results of our numerical modeling are verified by comparing it with the real field test data reported by EIsherbiny and ElNaggar (2013).

Laboratory test has been done to find out the soil properties required for parametric study. And the effect of different parameters like depth, diameter of shaft and helix & helical bade pitch was analysed.

The investigation shows that relative density plays a important role in deciding ultimate axial capacities towards different parameters like depth , diameter of shaft and helix & helical bade pitch. In addition to that, helical blades of screw pile and its embedment ratio (H/ D_h) plays significant role in axial capacity. When considering ultimate axial load capacity, an increase in diameter of helix is significantly more important than an increase in shaft diameter. Increase in the pitch of screw pile has no such significant effect on ultimate axial load- capacity.

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CHAPTER 1 – INTRODUCTION

1.1 General

Piles are structural foundation members that transfer the load from a structure to the soil. Screw piles are steel tubes with one or more helix welded to the shaft, which are inserted into ground by applying torque at head of pile. Similar to driven pile, it is used to stabilize the structures by anchoring the load to the nearby soil.

Screw piles are a type of deep foundation element that can resist compression, tension, and lateral stresses. In the geotechnical sector, screw piles can be used in structures like solar panels, light house, etc. They can support various types of structures with a variety of complex geotechnical characteristics from engineer perspective. From the perspectives of the operator, its quick installation saves time, resulting in significant financial savings. Installation is easy and can be installed at any inclination.

1.2 HISTORY

This method of construction was widely used until RCC piles were adopted. Screw piles were proposed in 1833 by Alexander Mitchell and patented in London. In sandy soils, these piles were satisfactorily installed to support lighthouses. In 1840 , the Maplin Sand lighthouse was built on the Thames Valley in UK. There were 8 screw piles made up of iron in an octagonal pattern in the foundations include center pile. Each screw pile comes with a 4 helical plate mounted on a 5 inch shaft. Screw piles were widely used in England by the 1930s.

Then pile were globalized throughout the world due to increase in British expansion. In the mid 1800's Alexander Mitchell went to the USA to consult on the first helical foundations in the USA. Around 100 lighthouses were built on helical foundations in North America in the next 40 years. However their use declined rapidly because of huge advancement in mechanical pile driving and drilling. Although, its utilization was limited to soft soil because installation of screw pile was done with the help of labour and took many hours .

As of now we can see significant increase in popularity of the screw pile in the recent years because of the introduction of powerful hydraulic rotary heads. Screw piles also have a lot of benefits, including the fact that they are simple to install and require lesser equipment . Second, they provide a quick construction time, which saves time. They can also be used in congested location, such as enclosed spots. They are used to stabilise slopes and can be installed at any inclination. They are also removable and reusable, and can be easily removed if required with almost no damage to the pile. Furthermore, they can be used in any type of environment. In contrast to standard pile systems, there is also less disturbance and construction noise throughout the installation. It is also economical as it reduces disposal cost . plus it can be loaded immediately after installation. It requires less labour as compared to other piles method.

But it has some disadvantages also which includes soil corrosion factors that can affect its life. Secondly hard layers could restrict installation of the screw pile as it is difficult to penetrate very hard soil layer. Also it could damage the helix of pile.

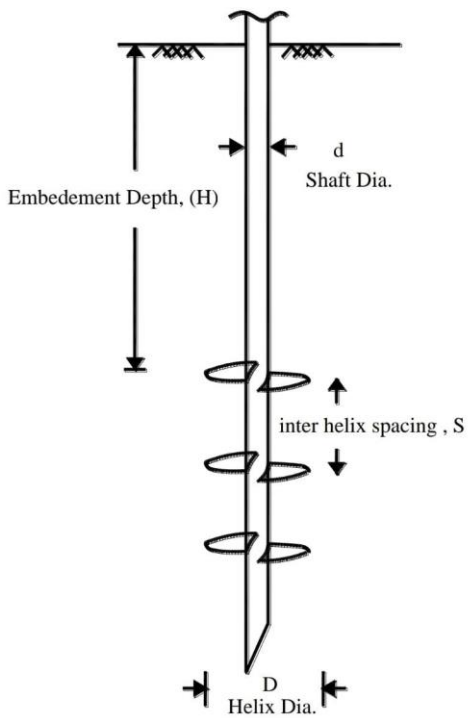

Figure 1: Elements of a Screw Pile

The Screw piles can be used for different purposes such as communication and transmission structures, solar panels, pipe racks, plant and sub-station, retaining walls, etc. Screw pile foundations are widely used in the countries like Canada, America and European countries . Load-bearing capacity of piles depends on many factors, including properties of soil, pile dimensions, material properties, and method of pile installation. According to the ground conditions and intended pile use, helical blades are welded to the shaft of pile. Number of helix, their dimensions, and position on shaft can be determined by a combination of Geotechnical parameters, Environmental corrosion parameter, Structure design load requirement and Minimum design life of the structure.

1.3 FAILURE MODES IN SCREW PILE IN SOIL

i) Cylindrical Shear Method

Mitsch and Clemence (1985) proposed the cylindrical shear method. This method assumes that the topmost and lowermost helices are connected by a cylinder shear failure plane. When appropriate installation depth is provided, the friction generated along the shaft is examined. Because friction generated around screw pile cannot be accurately predicted, many theories neglect it. The effect of installation depth on the screw pile's ultimate uplift capacity is calculated. The uplift capacity is given by the following equation:

$$Q_t = Q_{helix} + Q_{bearing} + Q_{shaft} \qquad (1.1)$$

Where,

Q_{helix} = Shear resistance generated over the cylindrical failure plane;

$Q_{bearing}$ = for top helix bearing capacity; and

Q_{shaft} = friction generated around steel shaft;

ii) Individual Bearing Method

Adams and Klym (1971) introduced Individual Bearing Method .They used this approach for predicting screw pile uplift capacity . According to this method, failure may occur over each individual helices. The overall uplift resistance is the summation of their individual capacity. The equation is as follows:

$$Q_t = Q_{shaft} + Q_{bearing} \qquad (1.2)$$

Where, Q_{shaft} =Adhesion generated along the shaft;

and $Q_{bearing}$ = summation of each individual helix's load carrying capacity

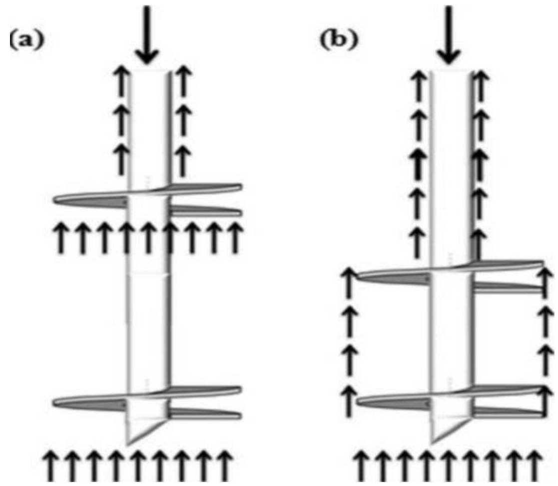

Figure 2. failure mechanisms (a) individual (b) cylindrical

iii) Empirical Method

The empirical method is related with the torque which is measured at pile installation to the ultimate uplift pile capacity. The method was designed empirically which lacks geotechnical explanation . It is, however, statistically examined using a vast dataset. This method has been effectively used in the installation of several screw piles in recent years . This method is simple to use. The equation can be defined as following

$$Q_t = K_t T \qquad (1.3)$$

Where , K_t = Empirical factor, and

T = Avg torque

1.4 FACTOR OF SAFETY USED IN THE DESIGN

As a matter of fact, Empirical factors are used in the design methods to counter the uncertainties, like the issues faced during the determining properties of the subsurface conditions over the site, and variation in the construction and installation procedures. As a result, a common solution is to apply a safety factor to the maximum capacity obtained by pile load testing at site. Therefore, the result obtained is termed as the allowable pile capacity, that is generally used in design. The allowable net ultimate uplift capacity can be expressed as follow:

$$Q_{\text{allow}} = \frac{Q_{\text{ultimate}}}{F_s} \qquad (1.4)$$

Q_{allow} = Allowable net ultimate capacity ,

$Q_{ultimate}$ = ultimate capacity;

and F_s = Factor of safety.

1.5 OBJECTIVES

- To analyse the screw piles in cohesionless soil using Plaxis 3D software.

- To compare load– displacement curve under axial compression with the results of full-scale compressive loading test from the case study .

- To analyse the effect of different parameters like depth , diameter of shaft , diameter of helical blade, embedment ratio and pitch of helical blade.

CHAPTER 2 -LITERATURE REVIEW

2.1 BACKGROUND

The objective of this chapter is to provide background information about screw piles. Screw piles (referred as anchor piles, or helical piles) are traditionally been used to resist tension forces. Screw piles are generally designed and built for the use as anchor. For decades, screw piles have been commonly used in a variety of practical applications. Screw piles are commonly employed to resist significant uplift forces such as utility poles, overhead lines, aircraft docks, and underwater lines. It also contributes significantly to the supporting structure of foundations, underpasses, and earth dams.

Screw piles are used in many different structures because of combined effect of various pile height and screw diameters. Furthermore, the screw pile can be extended easily with bolts or welding , used at higher depth, increasing their functionality

Fig 3 Screw Pile

Mitsch and Clemence (1985) proposed the cylindrical shear method .They verified the observations by modeling the pile in laboratory. When the pile is screwed into the ground, soil around the helices is sheared and displaced laterally. When the pile is screwed into the soil , the sand around the helices is sheared and displaced laterally. This lateral movement introduced lateral tension to the surrounding sand which increase density of soil. Laboratory experiments proved that this increase in lateral stress increase the possibility for a cylinder failure plane to increase. They conducted field tests and proposed equations to determine uplift capacity of screw piles in sandy soil.

- They recommended plain failure surface inclined at an angle approximately Φ / 2 degree to the vertical axis.
- They proposed that a pile will act as a shallow pile if ratio of pile depth to helical diameter (H / D) is lesser than 5.
- When the H / D ratio exceeds 5, then pile will act as a deep pile.

Das (1990) gives a overview of the studies on screw pile uplift capacity estimation. Meyerhof and Adam's formula was explained by Das (1990) in terms of the breakout factor, Fq, and Equation can be stated as follows:

$$Q_t = F_q \gamma A \quad (2.1)$$

According to Das (1990), the uplift capacity of shallow anchors is equal to the summation of the anchor plate's uplift capacity & the anchor's weight, Wa, which may be stated as

$$Q_t = F_q A H + W_a \quad (2.2)$$

The uplift capacity of deep foundations is determined by three factors: the helical plate's uplift capacity, friction around shaft, and the load of pile. The equation is written as:

$$Q = F\gamma AH + K_O P_S(H - H_{cr}) \sigma_o tan\emptyset + W_a \quad (2.3)$$

Where: Ps = Perimeter of shaft;

$H - H_{cr}$ = Effective length of shaft;

σ_o = Average effective stress between Z = 0 to Z = H - H_{cr} = 1/2 γ (H - H_{cr})

and Earth Pressure Coefficient. Das (1990) also introduced factor of safety in screw piles subject to uplift forces. He concluded that a safety factor of 2 to 2.5 should be imposed to the ultimate capacity to evaluate the allowed uplift capacity of a screw pile group under uplift loading.

Ghaly et al. (1991) examined non linear behaviour of screw piles in cohesionless soil and further using them to predict load carry capacity. In addition, a number of experiments on screw piles have been carried out, which helps in finding the failure plain. They also introduced unfavorable ground conditions for screw piles, such as rocks, gravel, and bedrock.

Tomlinson (1994) proposed factor of safety in screw piles for calculating ultimate pile capacity by conducting experiments . He recommends multiplying the ultimate capacity by 2.5, to ensure that settlement of more than 10 mm does not occur under working load. Many factors influence the selection of the optimum safety factor .This factor of safety is based on a significant number of loading experiments using piles with diameters up to around 600 mm set in clays and sands that were taken to failure. Even though the ultimate pile capacity is estimated by the pile load test results, the factor of safety should not be taken less than 2.

2.2 NUMERICAL MODELING

Merifield et al (2006) used a 3D FEA to investigate the impact of screw pile shape on load carry capacity of screw piles. They investigated the impact of the anchor plate shape (square, circular, or rectangular) on the load carrying capacities. They observed that plate with a circular shape give more uplift resistance than the other.

Merifield (2011) used small strain axisymmetric FEA models of the ultimate uplift capacity of circular plates at variable S/D ratios to show that at S/D = 1.58, the mode shifted from cylindrical failure to individual failure. The influence of the pile shaft and the installation method on the ultimate capacity of screw piles was not included in this study. In order to model screw pile systems, it is necessary to simulate the interaction between screw piles and soil.

Stanier et al. (2013) investigated the effect of installation of screw pile.They found the influence of length and helix plate ratio on a transparent synthesized soil. The pile capacity rely on the length, & the failure occurs as a cylinder planar failure. The length of screw pile is influenced by the number, spacing, and thickness using partial factor approach in Finite Element analysis. They found out the relation between torque and and the ultimate capacity.

Livneh and El Naggar (2008) simulates the screw pile to explore the failure method as well as elastic deformation characteristic for screw piles. They analyse the uplifting capacities of screw piles using Plaxis 3D software. . Livneh and El-Naggar (2008), find out that screw piles are installed without any vibrations , that also prevents damage of nearby buildings. They came to the conclusion that the load carrying capacities of the bottom helical plate and the cylinder failure surface following the tapering profile were the major factors in a screw pile's load transfer process in soil surface.

Kurian and Shah (2009) used FEA method to analyze the performance of screw pile. After that they conducted a parametric investigation with various helical geometries. This is the first time screw piles are analysed using FEA method using the Drucker–Prager model with the FEM software, Marc . The effect of distribution of soil on the performance of screw piles is left unresolved in research. Screw plates are typically referred to as annular plate due to the near-impossibility of defining the helical geometry's complication. The systematic parametrical observation of the effect of various factors could help in the understanding of screw pile.

Sakr et al. (2009) estimated axial compressive capacity of screw pile. He also define appropriate failure critera. He carried out a series of experiments in cohesionless soil for understanding the influence of screw pile & found that shift between two types of failure happened around spacing ratio =3 . He observed that screw piles have strong compressive and uplift capacities. He also came to the conclusion that the creep effect was negligible. The paper's limitation is that a relationship of torque & strength can exist, further study is required.

Elsherbiny and El Naggar (2013) studied the axial loading behaviour of screw piles in clay and sandy soil. They proposed a method for modelling screw piles based on finite element. They conducted of 5 compression experiments on a site in northern Alberta, Canada. Then, using the ABAQUS software, a FEA model was developed to validate the field experimental work. They calculated compressive capacity using individual and cylindrical methods. They introduced helix efficiency factor to avoid excessive settlement because calculated capacity is higher than calculated from numerical model. They found that the ultimate load capacity of screw piles is the load equivalent to a 5% displacement of the helical diameter.

Perez et al. (2018) carried out full scale test on screw pile. He investigated influence of anchoring single screw pile on the axial performance in cohesionless soil . As long as the installation factor is taken into account, the screw pile load-displacement plot in dense sand agrees well with test findings, according to finding of this work.

George et al. (2019) studied the benefits of installing screw piles using the displacement approach, while considering the 1-g experimental analysis. They model 2 piles i.e a hollow steel pile and a screw pile. They evaluated the effect of cavity expansion. After that they analysed screw pile using Plaxis 3D software to find the effect of installation method. After that the effects of different parameters were investigated. They proposed reduction factor.

Nowkandeh et al. (2021) investigated compressive capacity for screw pile as wellas pile group. They analyzed the axial compressive strength of screw piles in clay and sandy soil. With the help of ABAQUS software, they investigated influence of soil disturbance throughout the screw pile. They proposed a method to consider the influence of soil disturbance during screw pile installation in a numerical model as the helix of screw piles is more likely to affect the soil near to the pile. They observed that theoretical calculations exceed the ultimate capacity of screw piles in medium and dense sand.

CHAPTER 3 -METHODOLOGY

3.1 INTRODUCTION

The chapter contains the method adopted for this research to achieve the objectives. Here a research paper is taken as a benchmark for the project . In this , data of axial compressive load test on screw pile were taken from research paper by EIsherbiny and ElNaggar (2013) . Numerical modeling is done with the 3D finite element programme Plaxis 3D . The results of our numerical modeling were verified by comparing with the real field test data .Laboratory tests is conducted to determine the soil properties required in parametric study.

3.2 Case Study

The location of our case study is located in northern Alberta, Canada, and is primarily composed of sand. At the site, axial compressive load tests were performed. The piles installed on site have single helical plate . The loading methodologies used throughout the test procedure are in accordance with ASTM 2007 procedure A for axial compressive test. At the time of installation, the groundwater table has not been noticed . Soil profile of our case study is given below.

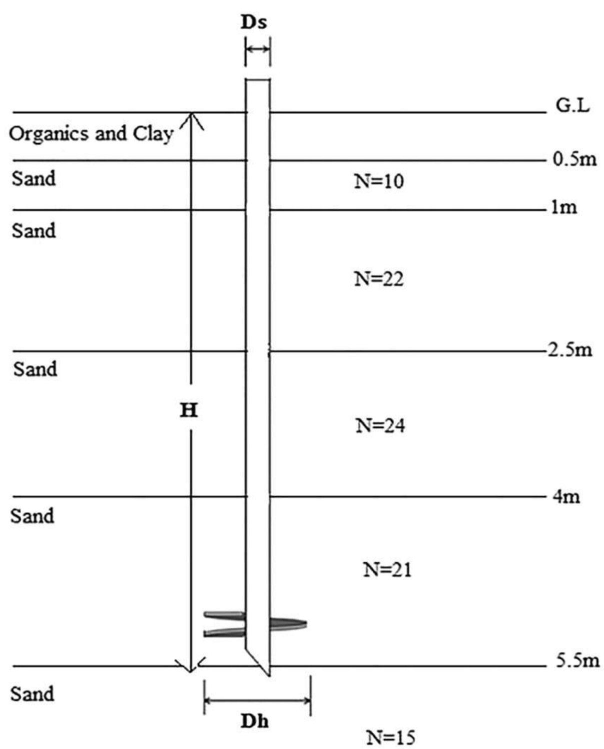

Figure 4. Soil profile as per case study

Pile dimensions

- The piles used in case study were made from a single shaft and helix plate is welded on it. They were installed with the help of a wheeled excavators with a torque motor attached which monitors the torque obtained during installation. At the test site, the screw piles featured cylinder shafts with one helix attached to each shaft.

  The following are the dimensions of the screw piles that were considered:
- Length of screw pile =5.5 m
- Diameter of shaft of screw pile =273 mm
- Diameter of helical plate =610 mm.
- wall thickness of the screw piles is 9 mm.
- The soil properties and material properties used in numerical modeling are same as that of properties given by EIsherbiny and El Naggar (2013) (Modulus of elasticity = 200GPa and μ = 0.3)

3.3 Laboratory test

Laboratory test has been done to find out the soil properties required for parametric study.

1) **Water content** could be measured in a laboratory with the help of the oven dry method as per IS 2720 part 2. In the laboratory, this procedure is quite precise in estimating the moisture content of the soil. The empty container is weighed (W1) in which the moist sample of the soil is placed.Then weight the container again (W2). After that the container is placed in temperature controlled oven for drying for sufficient duration. For inorganic soil, temperature is controlled out in the range of 105°C to 110°C and drying is done for 24 hours in order to ensure that the complete removal of the moisture from the sample and weight of the container with dry sample of soil is again noted (W3).

$$w = \frac{W_2 - W_1}{W_3 - W_1} \qquad (3.1)$$

2) **Specific Gravity** - It can be determined by using pycnometer method as per IS 2720 part 3. Procedure-

- Weight of empty pycnometer is taken (W1).
- Then an oven-dried specimen of soil is put inside pycnometer, then the weight of pycnometer is again noted (W2).
- The pycnometer is poured to half its height with water and then it is stirred with a glass rod. Then more water is added to it and stirred again. screw cap is fitted and filled the Pycnometer flush with the hole in the conical cap and then weighted (W3 in g)
- Pycnometer is totally emptied and then again it is filled with water after being properly cleaned and then weighted again (W4).

$$G = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)} \qquad (3.2)$$

Figure 5: Pycnometer

3) **The Direct Shear Test**– DST is used for determining shearing strength of soil as per IS 2720 Part 13. Shear strength is the resistance offered by soil against shear deformation. Commonly, this is oldest shear test, still in use , quite simple to perform. Moreover, it can be carried out on remoulded or undisturbed samples. Shear strength is calculated using the Mohr-Coulomb's criteria. Shear strength can be expressed by the given equation:

$$\tau = c + \sigma_n \tan(\emptyset) \qquad (3.3)$$

Where, c = cohesion

σ_n = normal effective stress

$(\emptyset)$ =internal friction angle

Direct shear tests can be used to evaluate the cohesiveness and internal friction angle of soil, that is helpful in several designing like foundations and slope stability. The unconsolidated-undrained, consolidated-undrained, and consolidated-drained drainage conditions can all be used for this test. Normally , CD test is performed in Sandy soils for direct shear.

Figure 6 – Direct Shear Test machine

PROCEDURE

1. Soil specimen is collected which is either undisturbed or remolded. In case of Sand, rammer and sampler are just not needed.
2. The sampler's internal measurements are 60 x 60 mm. The box is approximately 50 millimeters thick, whereas the sample is 25 millimeters thick.

Figure 7: Apparatus used in DST

3. The 2 parts of the shear box are then locked together using locking pins, and the base plate is placed in the bottom.
4. Porous stone is placed above the plate, followed by a grid plate. For undrained situations, plain grid plates are utilised, while for drained ones, perforated plates are employed. Then box is weighed and recorded.
5. The soil specimen is then placed on top of the plate. The sample is put in to the shear box. It must be placed layerwise and each layer is tampered, in case of sandy soil.
6. With the soil sample, the weight of the shear box is recorded. Upper plate is put above the sample. Following that, the box is inserted into a container and attached to the frame. Further, the proving ring is positioned so that it touches the top portion of box.
7. In addition, shear and vertical deformation are measured using 2 dial gauges. After that, the shear box's locking pins are released.
8. Normal stress is then applied. Shear stress is also applied at a constant strain rate. The results of dial gauges are recorded.
9. If the proving ring reaches its maximum value and then begins to decline, the specimen is considered fail. Record the value which is the failure stress. Repeat the above steps for normal stresses of 0.5, 1 , 1.50 kg/cm^2.

4) **Unit weight-** In sand replacement method, a small cylindrical pit is excavated and weight of the soil excavated from the pit is measured. By measuring the weight of sand required to fill the pit and knowing its density, the volume of the pit is calculated. Knowing the weight of soil excavated from the pit and the volume of the pit, the unit weight of the soil is calculated as per IS 2720 part 28 .

$$\text{Bulk unit weight} = \gamma = \frac{W}{V} = \frac{W_S + W_W}{V} \tag{3.4}$$

$$\text{Dry unit weight} = \frac{G\gamma_W}{1+e} \tag{3.5}$$

CHAPTER 4- NUMERICAL MODELLING

4-1-Present numerical model

In this project, the 3D finite element programme Plaxis 3D has been used to simulate and analyse the screw pile . The soil was modelled using a typical Mohr–Coulomb elastoplastic material and 10-node tetrahedral element.

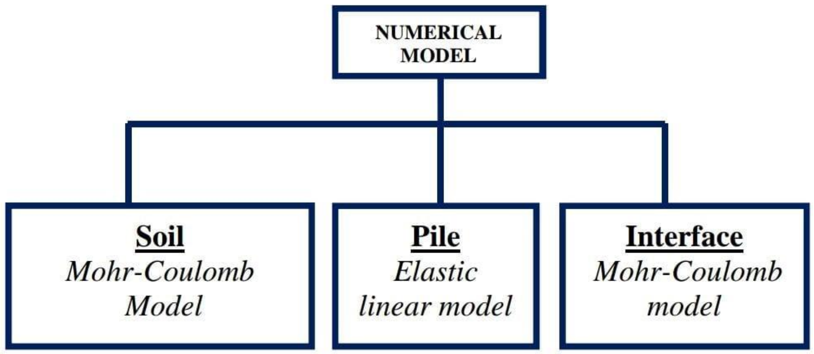

Figure 8 Numerical model

Plate elements using elastic linear model are used to analyse piles. Furthermore, set the numerical model's boundary at a range greater than 10 times the helical blade diameter of screw pile. Also boundary should be 5 times the helical plate diameter below the pile at bottom , to assure that there is no variation in deformation in the bottom during the load application . At the bottom of profile , the boundary layer was fixed.

Table 1. Soil parameters used in the analysis reported by EIsherbiny and ElNaggar (2013)

Parameter	Value
Unit weight γ (kN/m3)	20
Young's modulus E (MPa)	80
Angle of internal friction (φ)	30^o
Friction factor (R_{int})	0.4
Poissons ratio (ν)	0.3

Introduction to PLAXIS 3D

It is a software application used in rock mechanics to perform three-dimensional stability and deformation analysis. PLAXIS is used all over the world for calculating settlements in tunnel construction, tank, aquifers , etc. In addition to that, it is used for estimating the consolidation time

.Furthermore, It is used for settlement study and estimation of load carrying capacity for tanks as well as other .

Engineering firms and universities depend on PLAXIS 3D's designing features like extruding, intersecting, combining, and arraying features in construction projects in the civil & geotechnical engineering sector. It is used to investigate the impacts of vibrations in the ground, such as earthquakes or traffic loads. For both unsaturated and saturated soil types, the programme analyse complicated hydrological condition using time-dependent fluctuations of water levels. It offers a wide range of capabilities. For example, precisely calibrate material models, also it saves time. Import CAD files to make modelling easier. Enhance the accuracy by using a constitutive model library.

4.2 Steps taken:

1)Create a new project- First of all we have click start a new program option. Then project properties window will open as shown in figure. Set boundaries. Set the numerical model's limits at a range greater than 10 times the helical blade diameter of screw pile.

Then we have to select element i.e 10 node and other values as well and then click ok.

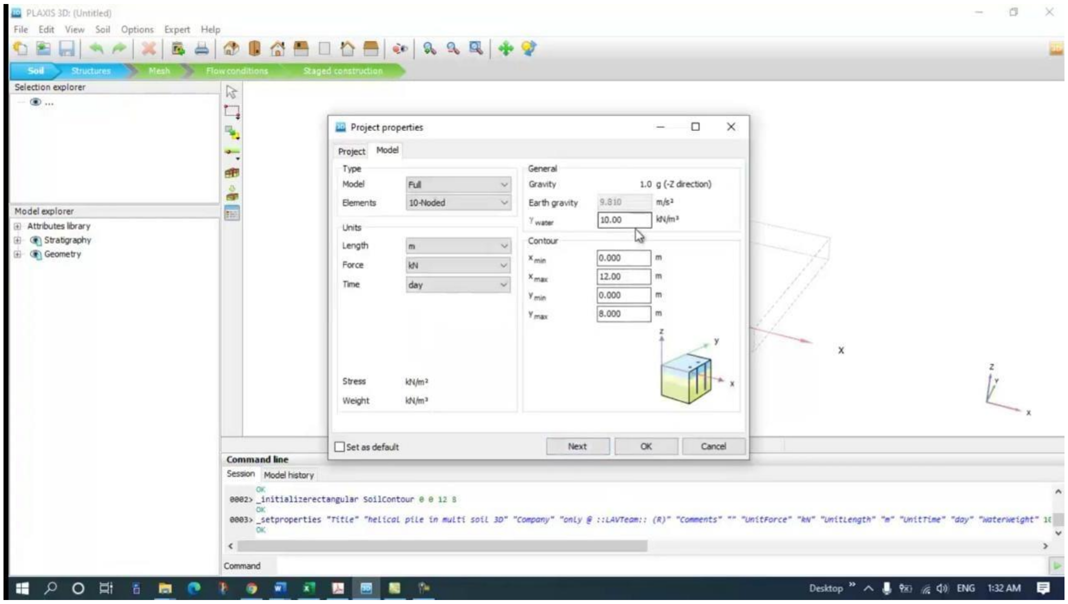

Figure 9 project properties

2) Assign material

After that we will add soil layers as per the soil profile. Then select material option and select material model as Mohr- Coulomb and drainage type as drained. We have to set material properties such as value of modulus of elasticity, angle of friction angle. Then click ok

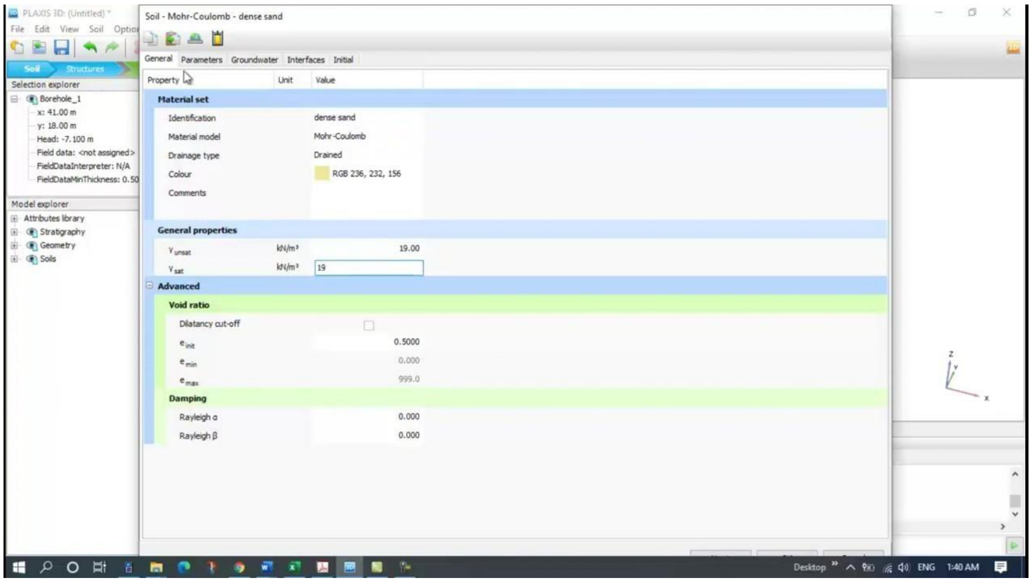

Figure 10 material property

3) Model the pile – To model the helix of pile , we use NURBS curve to create helix of pile and select the dimensions as per requirement. After that repeat the same step for modeling the inner curve of screw pile. Now select both the curve and right click and select option loft polycurve.

After that draw a cylinder i.e. shaft of pile and select dimensions. For multi helix we use array option.

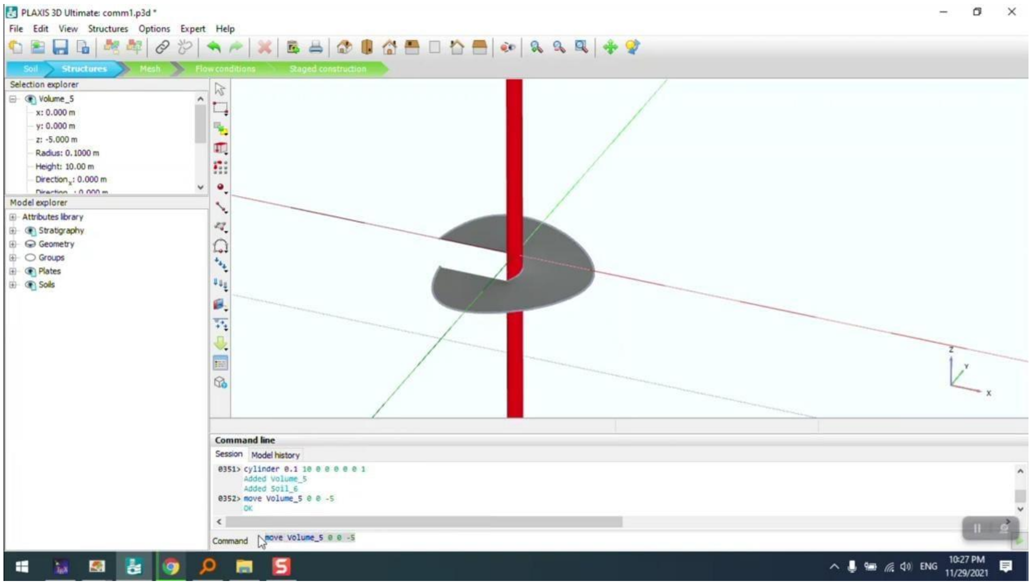

Figure 11 simulation of screw pile

4) Mesh generation

Click on mesh option and start genearting mesh. In the output portion we can see the element contour as shown in figure.

In circumstances where the software was unable to properly generate mesh for the curved region of the helical blade, mesh discretisation was refined.

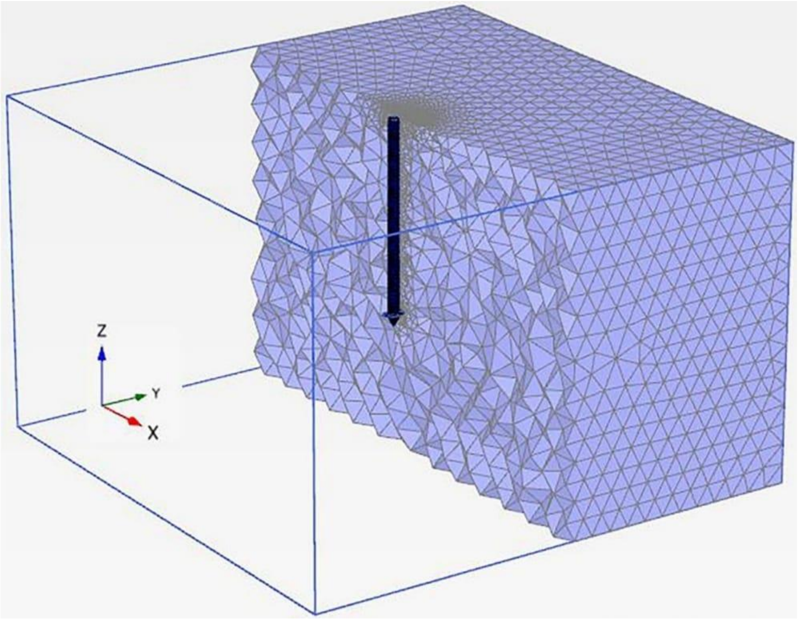

Figure 12 Mesh generation

5) Calculation stages-

After that we have to click on phase option. There are 4 stages in numerical analysis.

- The very first phase contains an initial effective stress for soil load, resulting in K_0 ground consolidation, where K_0 is $1 - \sin\varphi$. The initial conditions taken in to account are as follows:

  a) the initial conditions of groundwater,

  b) the initial geometry configuration and

  c) the initial effective state.

- the next phase is the simulation of the effect of pile installation is. A plastic computation is require to simulate the pile settlement in the analysis. Following that, pile material replaced the material of pile cluster, and interfaces between soil and pile are activated.

- The third phase involves deactivating the soil inside the cavity and activating the plate elements for pile installation.

- In the last phase, axial load was applied to pile head. After that pile load test was started. At the pile head, a unit distributed load is applied. Consequently this load is increased till the automatic load-increment test. But, after the initial stress generation the process of pile installation is simulated directly. Finally , the load is manually incremented.

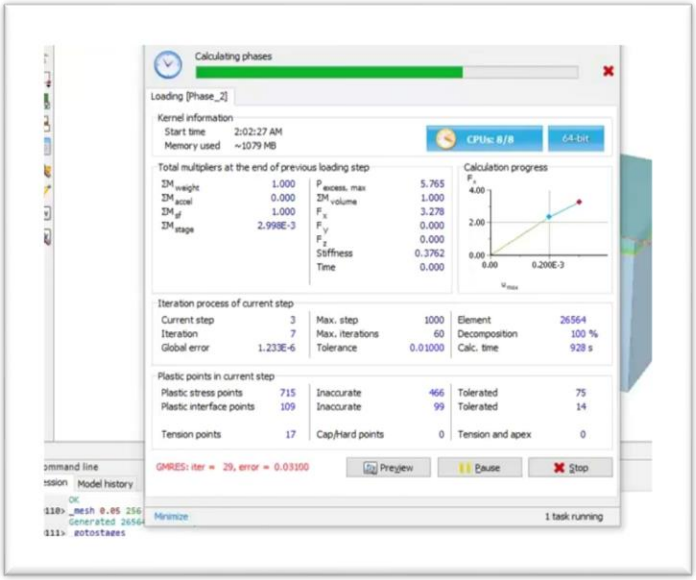

Figure 13- Calculating phases

- After apply phases, we can view output result, it takes some time to generate results.

CHAPTER 5 – RESULTS

5.1 Laboratory Results- Laboratory tests has been performed for obtaining the basic engineering and index properties. Results of the test are discusssed in this section.

Table 2: Soil Results

Parameters	**Results**
Water Content	8.9%
Specific Gravity	2.66
Internal friction angle (φ)°	32°
Unit weight kN/m^3	19

Table 3 Reading of Direct shear test

Normal Stress ((kg/cm^2)	**Shear stress (Kg/cm^2)**
0.50	3218
1.00	6373
1.50	9478

Results of Direct shear test

Angle of Internal Friction (˚)	32.0466
Cohession (kg/cm^2)	0.0020

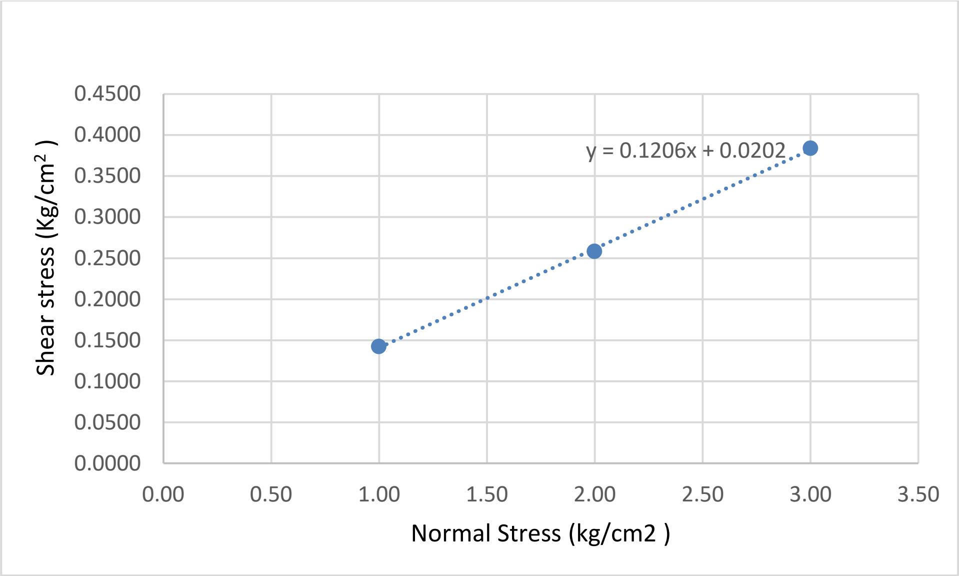

Figure -14 Normal stress vs Shear stress

5.2 NUMERICAL MODELLING TEST RESULT-

The numerical modelling results are shown below. This was done in order to figure out how a screw pile transfers load in a cohesionless soil. The acquired results were compared to the case study's field test and numerical modelling.

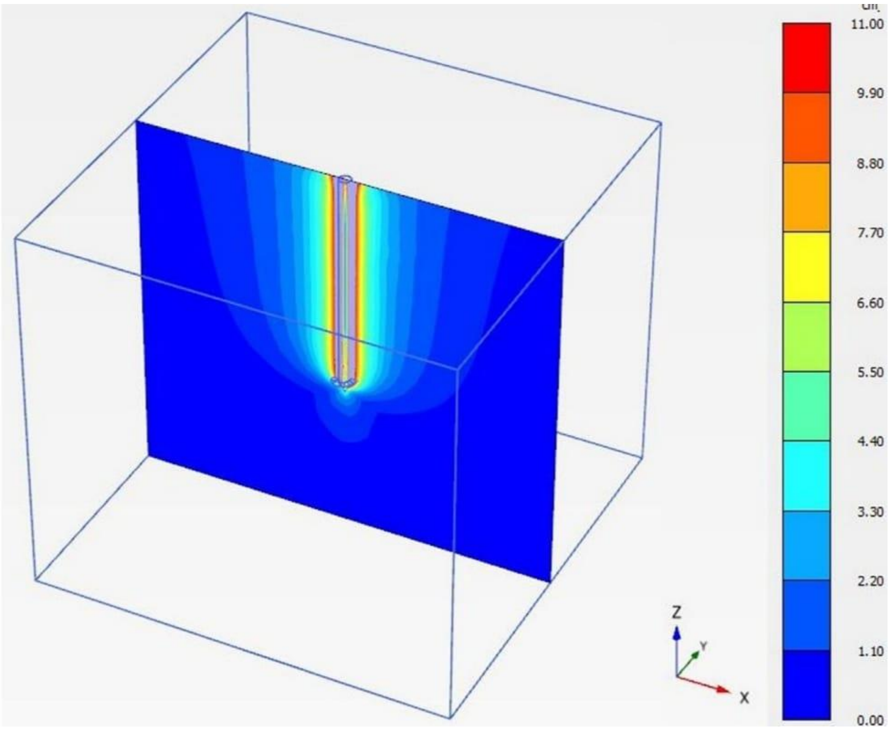

Figure 15 Output of a numerical model for a single pile subjected to axial load

Comparison of the load–displacement behavior

Here we have plotted 3 cases i.e field results and numerical simulation done by Elsherbiny & El naggar and the present numerical modelling by plaxis 3D software. Now as we can observe that our results are quite near to the results of field test. There is a little variation in load–displacement curve obtained from field data because of doubtfullness of available data in literature and variation in soil property at field conditions, and it is well within the allowable range of potential error.

Results obtained from the present numerical modelling differ from the results from the numerical study by Elsherbiny & El naggar could be due to variations in the interface model & finite-element mesh chosen.

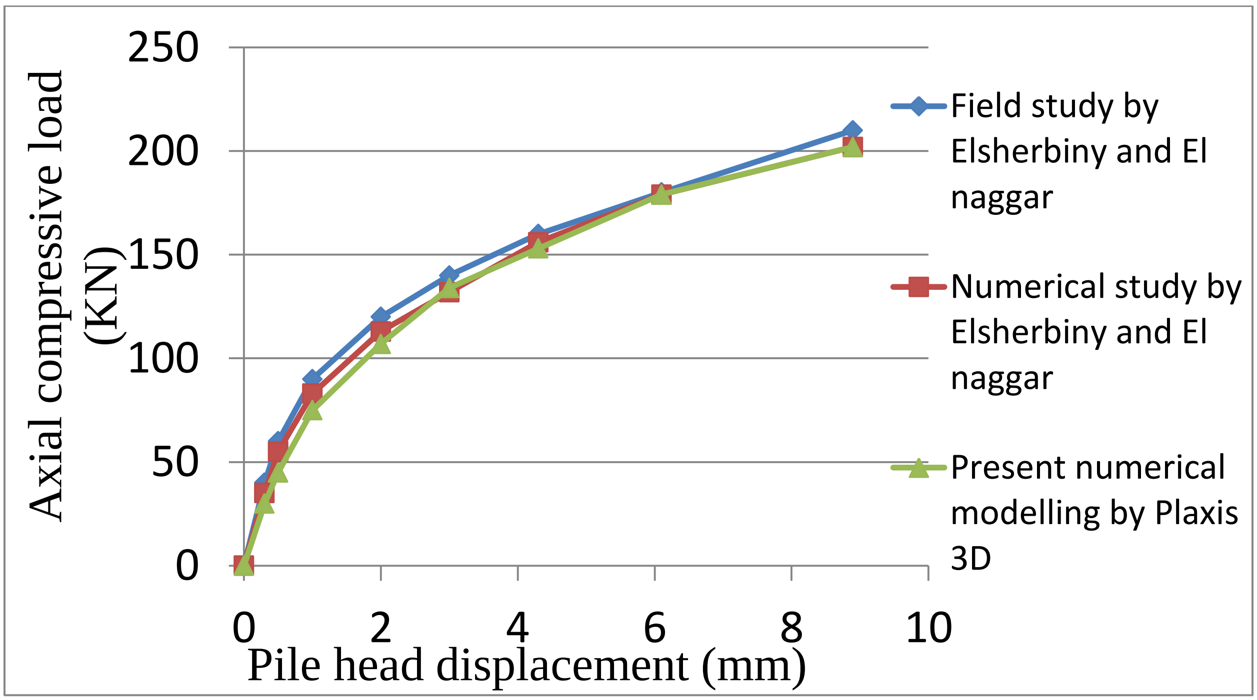

Figure 16 The load–displacement curve of screw pile

After the numerical modelling , a parametric study conducted. 3 distinct shaft diameters i.e 27.3 cm, 24.6cm & 21.9 cm, four distinct installation depths i.e 2.5m, 5.5m, 8.5m, and 10.5m) and 2 distinct helix plate diameter i.e. 50.8, and 61 cm) are all taken into account here. The dimension range was chosen based on the fact that the difference between successive parameters is equal and significant to notice the parametric variation's influence. The base dimension is the same as the one used in our numerical study . The helical plate pitch was kept constant i.e 20 cm. In this soil of 3 relative densities i.e 30%, 40% and 50% were taken for consideration.

5.3 THE PARAMETRIC STUDY

1) The influence of installation depth (H)

With increasing relative density, load-carrying capacity increase. Change in compressive load with installation depth of screw pile with D_h equal to 61 cm for 3 relative densities of sand is depicted in Figure 14

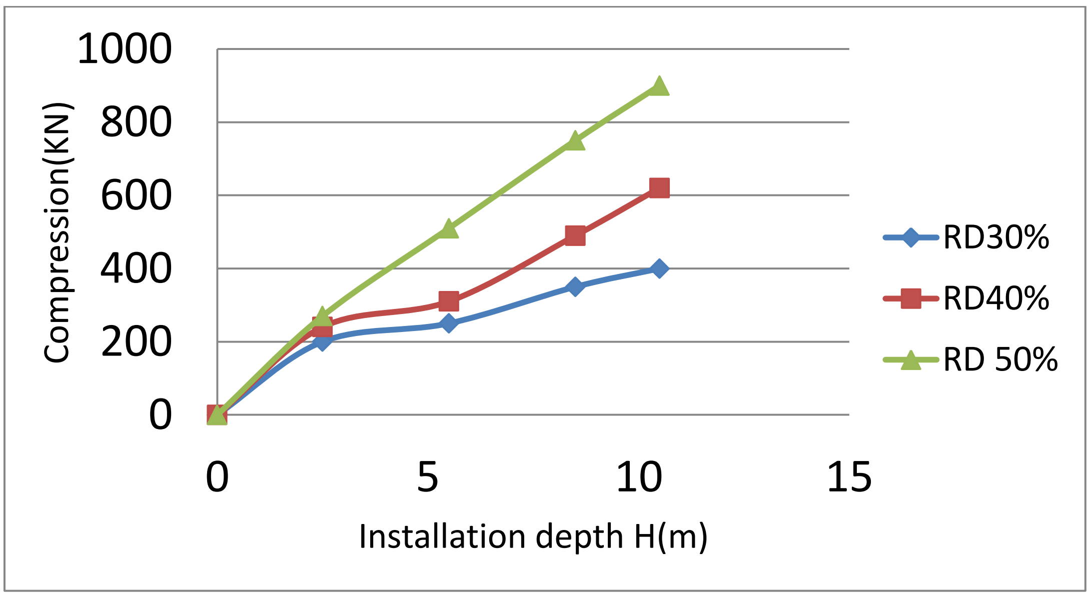

Figure 17 plot of compression vs depth for various relative density

2) Influence of of Embedment Ratio (H/D_h).

Figure 15 depicts the rise in compressive load of a screw pile vs a traditional pile against the embedment ratio (H/Dh). As the embedment ratio increases, ultimate axial capacity reduces. Here helix diameter is taken as 61 cm .

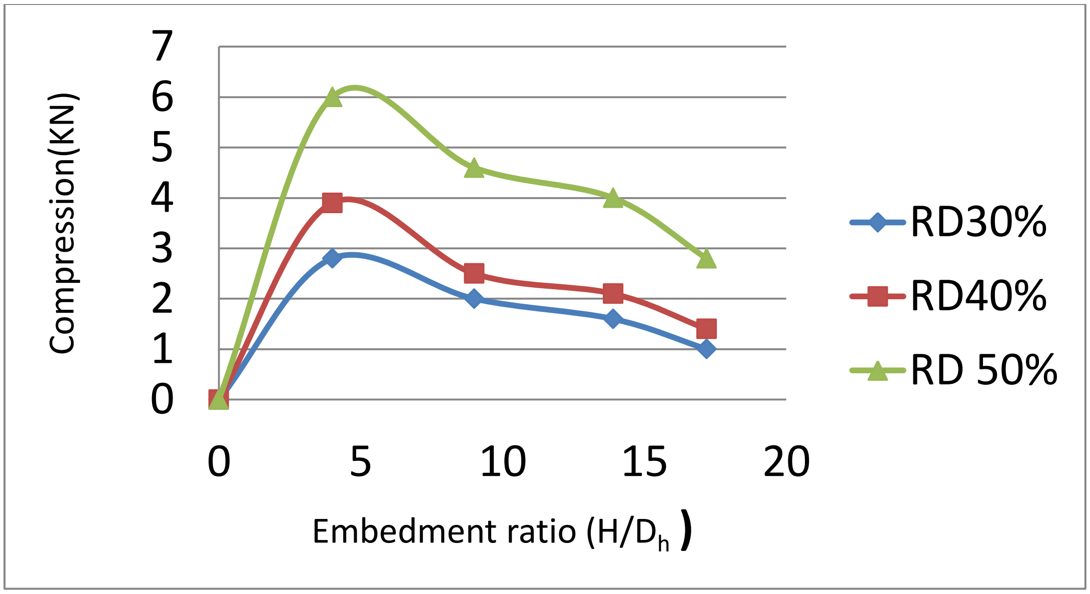

Figure 18 plot of compressive load vs embedment ratio

3) Influence of the helical blade diameter (Dh)

The load carrying capacity of piles with helical blades is significantly more than that of piles without blades. Increase in diameter of helix increases the load carrying capacity . For instance, a screw pile with a diameter of helix equal to 50.8 cm ultimate load-carrying capacity increased by 166 percent and when comparing to a 27.3 cm shaft diameter pile. And for diameter of 61 cm ultimate load-carrying capacity by increased by 275 percent **.**

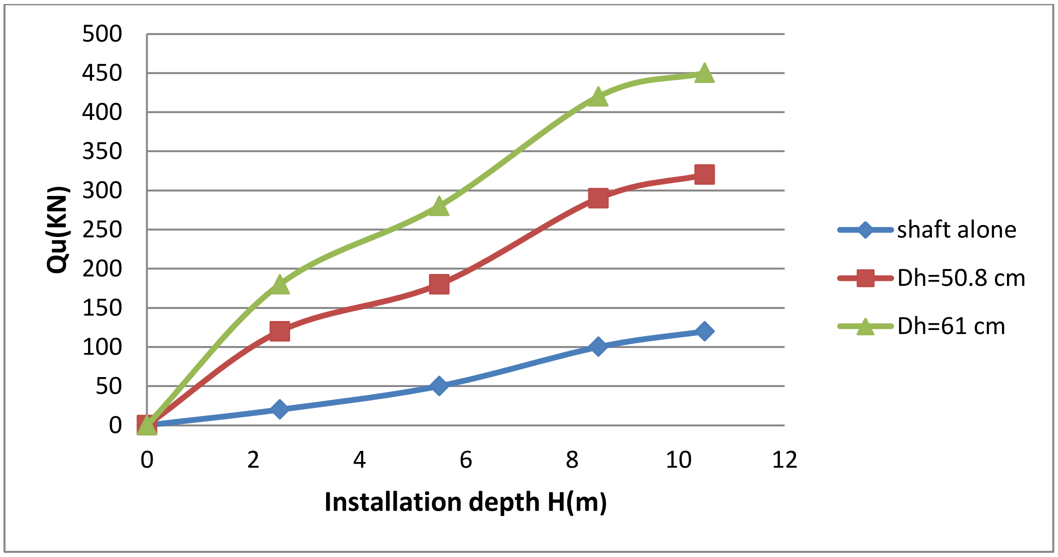

Figure 19 plot of compressive load vs depth for various blade diameters

4The influence of shaft diameter (D_s)

Figure depicts the load carrying capacity of 3 distinct shaft diameters varies with depth. Change in shaft diameter has no significant effect on final capacity. As a result, an increase in helix diameter is significantly more important for load carrying capacity.

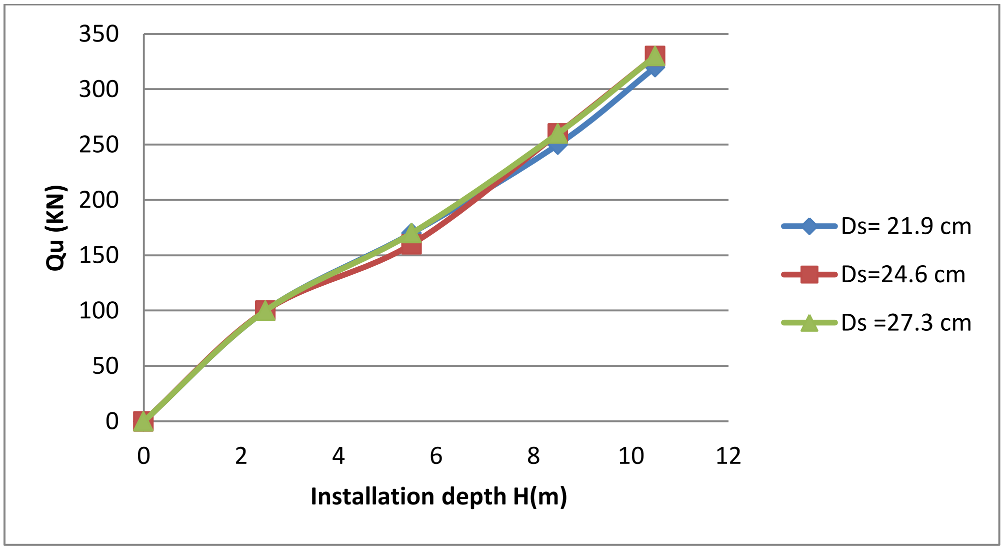

Figure 20 compressive load vs depth for various shaft diameter

5) The influence of helical blade pitch

The pitch of the blades of screw pile was altered from 15 to 30 cm, to evaluate the influence of pitch on load-carrying capacity . Figure 21 indicates that increasing the pitch of screw pile has no significant effect on load-carrying capacity.

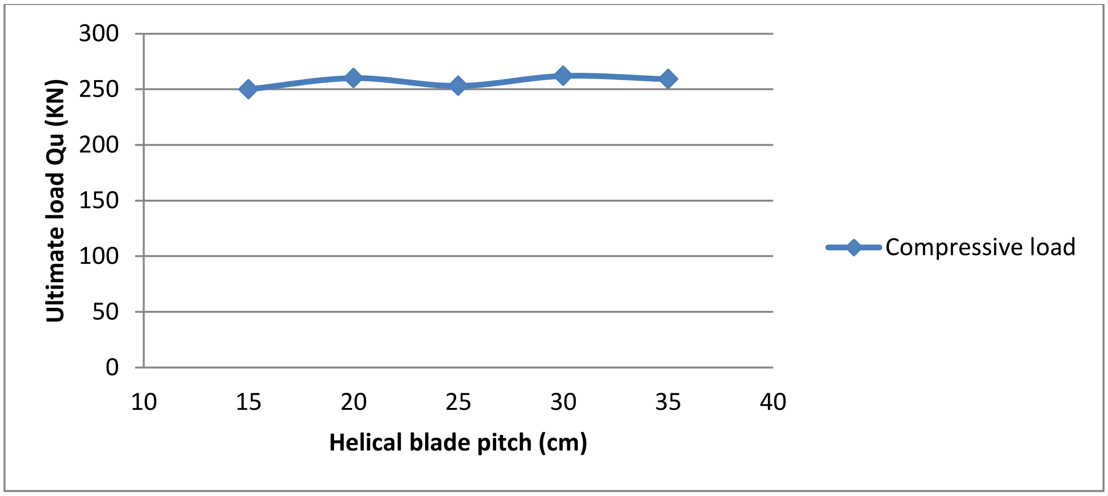

Figure 21 Influence of pitch on screw pile (cm) with load

CHAPTER 6 - CONCLUSIONS

From this project we can conclude that :-

- In this project, numerical modeling of screw pile is carried out with the help of a 3D finite-element software, Plaxis 3D.Then the results of our numerical modeling are verified by comparing it with the real field test data reported by EIsherbiny and ElNaggar (2013).

- Load displacement behaviour under compressive load is compared and our results are quite near to the results of field test. There is a little variation in load–displacement curve and it is well within the allowed range of probable error. The variations in results could be due to doubtfullness of available data in literature and variation in soil property at field conditions

- Results obtained from the present numerical modelling differ from the results from the numerical study by Elsherbiny & El naggar could be different finite-element mesh.

- Furthermore , we analysed effect of different parameters like depth, diameter of the shaft and helix , relative density of soil (RD),and helical blade pitch.

- Screw piles carry a larger ultimate load than traditional piles. Using a blade in a pile improves the ultimate axial load by 275 % in compression as compared to traditional pile.

- Relative density plays a crucial role according in ultimate compressive capacities with various geometrical parameters in cohesionless soil .

- Increase in diameter of helix increases the ultimate axial load capacity .While considering ultimate axial load capacity, an increase in diameter of helix is significantly more important than an increase in shaft diameter.

- Ultimate axial capacity reduces with increase in embedment ratio (H/Dh).

- Increase in the pitch of screw pile has no such significant effect on ultimate axial load- capacity.

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