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Numerical Modeling Load Displacement Behavior of Screw Piles under Seismic Loading in Soft Soil

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Abstract—Steel screw piles are deep foundations made of a square or circular shaft with one or more screw-bearing plates. This study focused on numerical modeling of pullout behavior of screw piles installed in layered soil and subjected to seismic loading. Six models of screw piles (HPT1, HPT2, HPT3, HPT4, and SPT2) were analyzed numerically using PLAXIS 3D software. All screw piles were subjected to a static uplift load, but the screw piles (HPT1 and HPT3) are subjected to additional seismic loading. The seismic loading represents the range of peak ground acceleration (0.25g and 0.47g) of earthquakes that hit Baghdad city in the last few years. The pullout failure load was assumed corresponding to a displacement of around 5% of the helix diameter obtained from numerical analysis, which gives quite similar values to those recorded experimentally. Individual plate bearing was the failure pattern for a screw pile with a spacing to diameter ratio of (S/D=3), while cylindrical shear failure was the failure pattern for a screw pile with (S/D=2). The numerical simulations revealed that the number of helices has a substantial impact on the axial displacement and failure pullout capacities of the screw pile when subjected to seismic loading. While the number of screw-bearing plates has a very slight effect on the lateral displacement.

Keywords—Seismic loading, screw piles, soft soil, PLAXIS 3D.

1. Introduction

The screw piles are solid or hollow steel shaft with a series of circular helix bearing plates welded at a location below or along the shaft according to specific measurements. These helix-plates give a high resistance to tensile and compressive forces, allowing them to be used in many applications [1, 2, 3, 4]. Sakr [5]investigated the behaviour of single and double helices screw piles implanted in sandy soil during compression, tension, and lateral pressure in a field studies.The findings of the testing revealed the capability of screw piles to sustain heavy structures and can also withstand lateral loads, especially when the shaft is circular. Sakr [6] conducted the first large-scale compression and tension field test for screw piles. Thirteen tests were conducted on two types of sandy soils: dense and very dense. Nine axial compression tests were performed, while the remaining four were tensile tests. According to the findings of this study, the compressive strength of screw piles can reach 2500 kN, while the tensile strength can reach 2000 kN.

Salem and Hussein [7]conducted field and numerical research on the behaviour of screw anchors with (S/D=2.5) under pullout loading in cohesive and cohesionless soils.The results of the two studies showed that the embedment depth, the number of helix bearing plates, and the strength of the soil were the most influential parameters on the uplift capacity of the screw anchors than the other parameters. Rawat and Gupta [8]used numerical modeling to better understand screw piles behavior in well-graded sandy soil when uplift forces are applie. The results showed that increasing the parameters (S/Dh, Dh/Ds, H/Dh, and Dh/Ds) increases the tensile capacity, although the critical spacing between helices (S/Dh) is 3. The results of tests confirmed that cylindrical shear failure occurs at S/D<3 and the individual plate failure at S/D>3. Orang et al. [9] conducted a study on shallow foundations supported by screw piles to minimize the effects of liquefaction that causes an arbitrary ground settlement. The results showed that the screw piles supporting the shallow foundation considered an efficient technique against those effects

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resulting from liquefaction and reduce the settlement of buildings.

Many theoretical and experimental studies investigated the behavior of the screw piles under compression loading, pullout loading in static and dynamic. However, few studies described the behavior of such type of foundation under seismic loading. In this study, the behavior of screw piles in layered soil is modeled numerically using PLAXIS 3D software. The models of screw piles with different numbers of screw plates were inserted in layered soil. The load-displacement of screw pile models under static pullout load and seismic loading is investigated in detail. The failure pullout capacity of the screw pile is assumed to correspond to a settlement of 5% of the helix diameter, which agrees well with the experimental results obtained from previous studies.

2. Utilization of Screw Piles in Construction

The screw piles have a tapered end to guide it in the ground in order not to deviate during insertion. The central section contains screw-bearing plates that are pushed into the soil by rotating with a hydraulic machine and is pushed into desired depth in the ground, which often contain screw-bearing plates to support the main section. Buildings subjected to winds or seismic loading, the foundations of such buildings are susceptible to a moment, with one end subjected to pullout force and the other side subject to a compressive force such as telecommunication towers, electricity towers, and wind turbines, see **Figure 1**[10].

Using of screw pile decreased to a certain extent due to the lack of installation machinery and the proliferation of mechanical and drilling piles[11]. The systems screw foundation is called many names, including (e.g., screw piles, screw piers, screw anchors, etc.), and these names can be classified or applied according to the design of the screw and the function that it will perform. Perko [11] and Nazir et al. [12] highlighted the advantages of screw piles over other types of foundations:

- Resistance to scour and undermining for bridge applications.
- Easy transportation to remote sites, and need for smaller, more accessible equipment.
- Torque measurements can verify failure load.
- Fast installation and can be removed and reinstalled again.
- Installation in battered angles for additional lateral resistance.
- Installation with low noise and minimization of disturbance to sites.
- Elimination of drill spoils.
- Cost-effectiveness.

The disadvantages of the screw pile can be highlighted as follows:

- The lack of soil produced after installation prevents founding materials confirmation.
- Relatively small shaft diameter may affect capacity during overturning moments or lateral loads.
- Hard layers or obstructions may prevent embedment of the screw pile.
- The soil corrosion may limit the life cycle of screw pile (as with all buried steel piles).

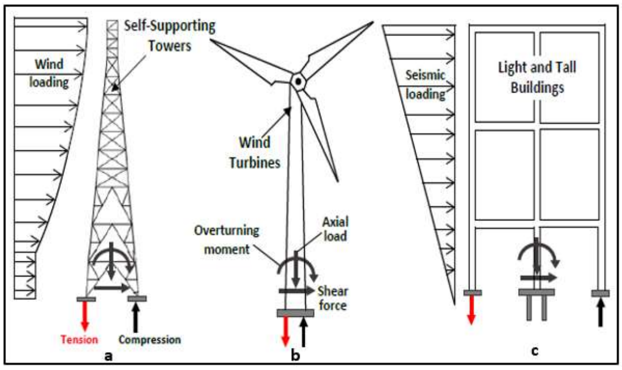

Figure1: Uplift in a (a) A transmission tower that has been subjected to wind loads, (b) A wind turbine is subjected to a load of wind, (c) Seismic loading on a residential structure[10].

3. Seismic Loading

Seismic loading is one of the basic concepts of earthquake engineering that applies seismic vibrations to structures[13]. Catastrophic earthquakes, periodic wind forces, and vehicles traffic forces confirm the need for the safe design of structures to resist those forces. In particular, there is an increasing demand for foundations that give more safety against these forces and at the lowest cost. The screw piles are suitable to sustain such forces and also can be used for supporting an existing building that has experienced some failure or damaged[14].

Iraq is geographically located on the Arabian plate's northeastern boundaries and tectonics in an area with relatively active earthquakes. The seismic history of Iraq shows the presence of annual seismic activity of varying strength. The southern and southwestern regions in Iraq have less seismic activity than the northern and northeastern regions. The statistical results of earthquakes in Iraq show that earthquakes with magnitudes from 4 to 5.4 constitute 90.95%, while earthquakes with magnitudes from 5.5 to 7.4 constitute 6.03% of the total events. These results for the regions of Iraq with the classifications were agreed upon, as shown in **Figure 2**, which represents the Iraqi map of earthquakes from 1960 to 2006[15].

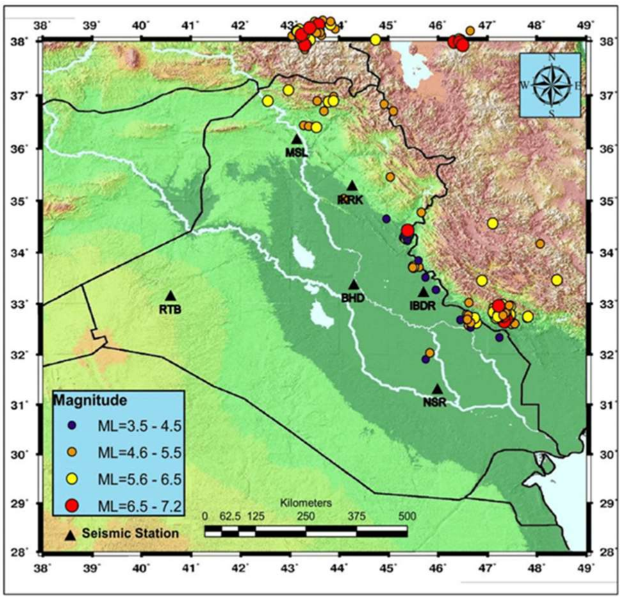

Figure 2: The Iraq seismic sources map updated up to 2006[16].

4. SOFT CLAY SOILS

Soft clay is one of the types of cohesive soils that can be characterized by their water content that is higher than their liquid limits. Soft clays are characterized by high compressibility and low strength, and emerging from sedimentary processes in various environments. The requirements that must emphasized when designing the foundation on clayey soil is that the amount of settlement is within the allowable limits and safe against shear failure. Nevertheless, it is necessary to know the critical depth of foundations resulting from the applied loaded and the consolidation characteristics of the soft clayey soils to estimate the amount of the settlement[17, 18].

The soft soil is a difficult challenge for geotechnical engineering, as it is not only possible to take into account bearing capacity but also the amount of deformation that occurs in the soil and the behavior of the structures that are erected on such soil. Acording to the aforementioned, the undesired properties, so design on them becomes difficult [19, 20]. The soft clays spread in the central and southern regions of Iraq. The percentage of soil texture of silt, fine clay, and silty clay and clay fraction reaches 50-70% [21], where the southern regions have a high groundwater level and a fair to poor soft deposits. Several polarization reports collected from random data for different sites to assess the undrained shear strength, as its value in Maysan and Nasiriyah governorates was less than 40 kPa. While, in Basrah governorate, it was less than 30 kPa. However, what collected data for a low compression index of 0.3, where the southern regions have a high groundwater level and a fair to poor soft deposits[22]. Al-Qayssi [23]presented nearly 41 reports that it conducted for different locations in southern Iraq by (the National Center for Construction and Research laboratories). The results showed that most of the sites have an undrained shear strength less than 50 kPa, and the value of N resulting from the standard penetration test (SPT) is 5.

5. Numerical Modeling of Screw Piles

Numerical modelling is widely used to simulating the behaviours of various types of foundations and subjected to different types of loading. Numerical modeling can be used in several ways such as boundary element method (BEM), the finite element method (FEM), and the discrete element method (DEM). Although there are several types of numerical methods, but using finite element method is considered the formative approach that can be used to solve most geotechnical problems. This study will use PLAXIS 2020 V20 software to model the behavior of screw piles under seismic loading. This software is globally used now to analyses stress-strain, stability, and groundwater flow for technical purposes.

5.1 *Screw Piles and Soil*

Two models of screw piles are analyzed using PLAXIS 3D (V20) in this paper to find the pullout capacity of screw piles in layered soil under seismic loading. The screw piles are inserted into two layers of soft silty clay and sandy silt, the geotechnical properties of two layers of soil are given in **Table 1**. The first screw pile (HPT) has tube shaft and one to three bearing helical plate of 610 mm diameter and a length of 7.2 m. The second screw pile (SPT) has tube shaft and one to two bearing helical plates with a diameter of 406 mm and a length of 3.2 m. **Table 2**and **Figure 3**shows the geometry and mechanical characteristics of screw pile.

Table 1: Description and mechanical properties of the soft soil layers[24].

Depth (m)	Description	c_u (kPa)	Ø	γ (kN/m^3)	K_s	Poisson ratio, υ	E (MPa)
0-3.0	Sandy silt	36	0	17	1	0.49	24
3.0-10.25	Silty clay (very soft)	9	0	17	1	0.49	7

Table 2: Dimensions and mechanical properties of screw pile used in the analysis [24].

Piles	Shaft diameter (mm)	Wall thick. (mm)	Length (m)	Helix diameter D_h(mm)	No. oh helices	Spacing between helices (m)	Poisson ratio, v	E (GPa)
HPT1	178	10	7	610	1	-	0.3	200
HPT2	178	10	7	610	2	1.83	0.3	200
HPT3	178	10	7	610	3	1.83	0.3	200
HPT4	178	10	7	610	4	1.83	0.3	200
SPT1	114	10	3.2	406	1	0.81	0.3	200
SPT2	114	10	3.2	406	2	0.81	0.3	200

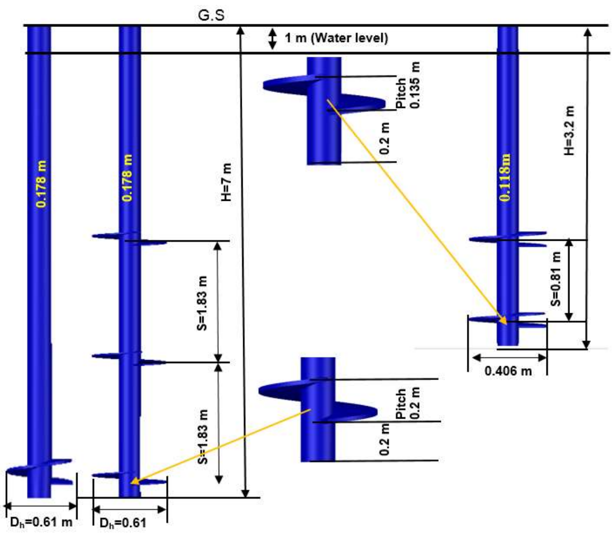

Figure 3: Geometry and dimensions of two screw piles used in the analysis.

The calculation stages are carried out according to several steps to represent the static pullout and seismic loads. In the first stage, an initial geo-stress represents the self-weight of soil was established. The horizontal stress state calculated from the relationship (Ko =1-sin φ'), as shown in **Figure 4a**. The second stage is to place the screw pile inside the soil and define its properties, as shown in **Figure 4b**. The third stage is to create a soil-screw pile interface, which involves creating an interface for each helix within the soil, as shown in **Figure 5**. In the fourth stage, after completing the installation and defining the interface between soil and screw pile, a 50 mm prescribed displacement is applied to determine the pullout capacity of the screw pile for each studied case in this paper. The last stage represents by the application of seismic loading, this load represented by peak ground acceleration of 0.28g and 0.47g. In addition, during the earthquake, screw piles at the heads were subjected to axial seismic loads of 10 and 20 kN intensity. The selected values of peak ground acceleration are corresponding to frequency of 4 and 5 Hz.

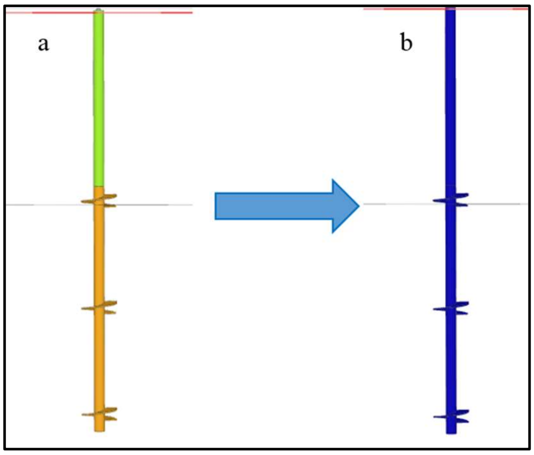

Figure 4: a) Initial geo-stress; b) Definition of the screw pile geometry.

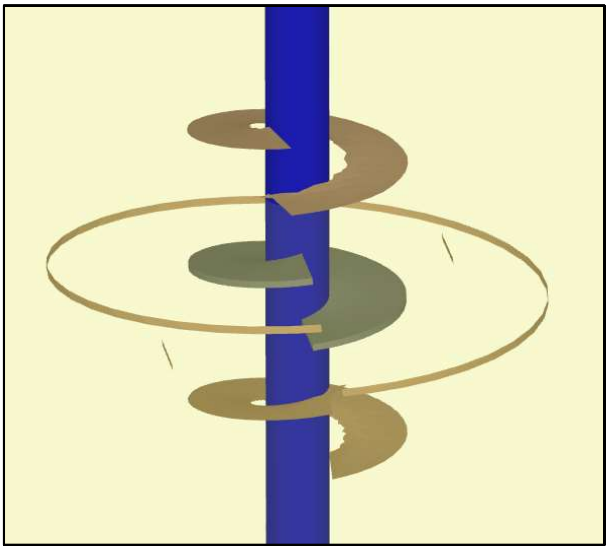

Figure 5: The soil-screw pile interface.

5.2 . *Pile–Soil Interface*

In reality, the relationship between the pile shaft and surrounding soil is not rigid and almost it is considered weak, so there is a relative displacement between the pile shaft and its surrounding soil. The magnitude of displacement depends on the strength of the interface of the surrounding soil used and the type of pile material (steel, concrete, wood, etc.) and number of helical plates. Tsuha et al. [25] explained how the number of helical plates is affects the soil deformation, reduced cohesion in clay soils, and a loss of relative density between grains in sandy soils above helical plates, in turn, affects the pullout capacity of screw piles. Despite the pullout capacity of screw piles increases with increasing the helical plate'snumber, the helical plate's number does not affect the sandy soils with low relative density, unlike sands whose relative density is high as shown in **Figure 6.**

The pile-soil interface values in PLAXIS can be set directly using a strength/stiffness reduction factor (Rinter≤1.0). The default value is Rinter=0.7 represents a fully bonded pile-soil interface. In the finite element analysis, an important part that must be specified is the boundary conditions. Where it must take into account the boundary conditions within reliable limits that do not reach the distribution of stresses to obtain reliable results and predict the correct behavior of the screw pile. The boundary conditions were taken from Abbas et al. [26]for the finite element method for piles. The soil body surface distances are of a cube shape of (10D) for each side from the center of the pile diameter and (5D) below the base of the pile as shown in **Figure 7**.

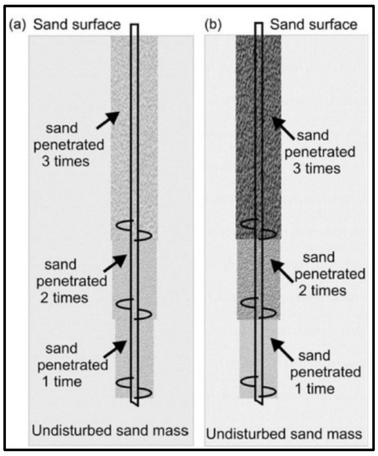

Figure 6: Illustration of the hypothesis for sand disturbance after installation of a three-helix pile: a) loose sand; b) dense sand[25].

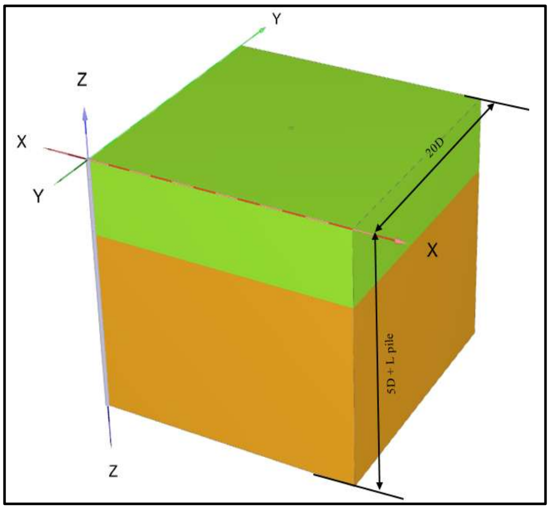

Figure 7: Dimensions of soil mass used in the numerical modeling.

The soil body modeled in a rectangular with exterior dimensions equivalent to (20D) for the surface dimensions (x, y) and (5D+Lpile) for the depth dimension (z) to prevent boundary effects. A mesh containing 10 nodded elements is used in the analysis. This element is the most significant and largest number used by the PLAXIS 3D (V20) software to give accurate results. The screw pile designed in a circular shape with one, two, and three helix-plates high stiffness reduces its deformation through loading. The pile head is at the level of the soil surface. The grid coarseness was select as the medium. The fine experiments of mesh were than those selected, but the results difference is minimal. The soil from mesh generated 19069 elements, 30454 nodes for HPT1, generated 15538 elements, 24789 nodes for SPT2, and generated 20591 elements, 33193 nodes for HPT3 from medium-mesh, as shown in **Figure 8**.

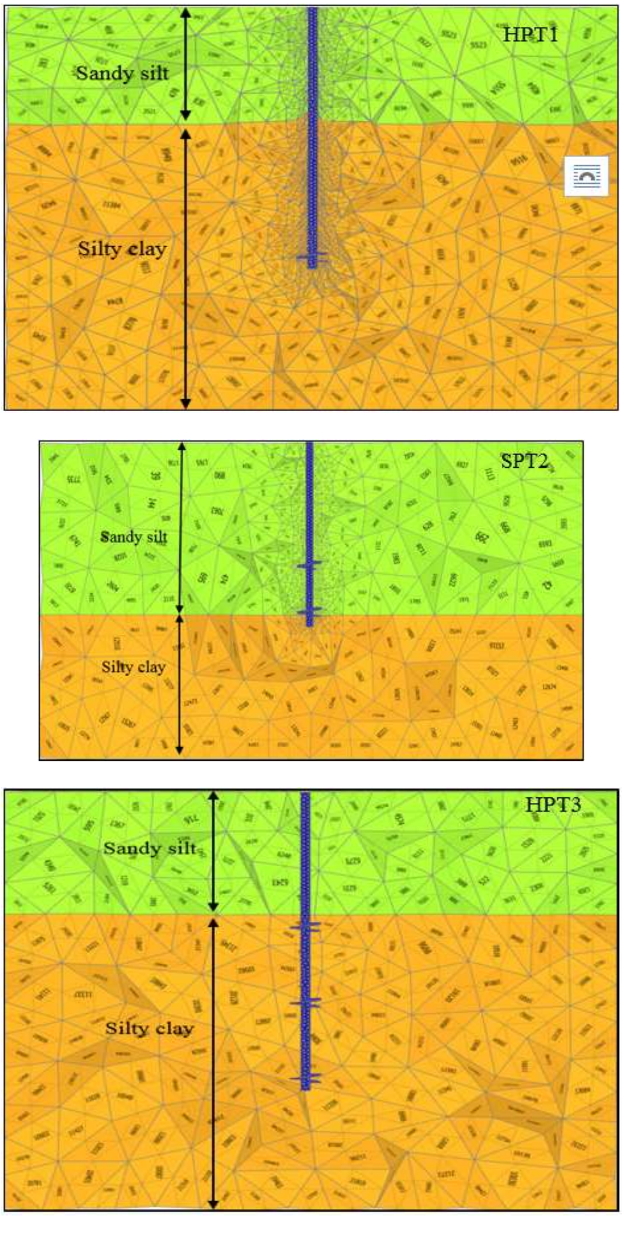

Figure 8: Typical mesh for screw piles HPT1, HPT2, and HPT3 analyzed in this study.

5.3 *Seismic Loading and Failure Criteria*

Several forces affect the behavior of deep foundations such as forces result from the wind effects on the superstructures that one side under compression and other side under tension, or traffic or earthquakes inside the soil. The seismic range can be distinguished from 0-10 Hz, while the marine environmental load is from 0-1 Hz. While, the normal range for the machines is 5-200 Hz[27]. Farman and Saeed [28] introduced the spectral acceleration of three cities in Iraq (Erbil, Basra, and Baghdad) in 2018. The recorded peak gravity acceleration (PGA) in the three cities were (0.71, 0.35, 0.33, 0.17, 0.47, and 0.25g). In this study, the values of PGA for Baghdad city were taken (0.47g and 0.28g) as shown in **Figure 9.** The displacement amplitude (D) is assumed 5% of the pile shaft diameter. **Equation 1**can be used to calculate the frequency value from the magnitude (PGA) and the displacement amplitude. Accordingly, the calculated frequency is 4 and 5 Hz.

$$F = \sqrt{\frac{G\,A}{2\,\pi^2\,D}} \quad (1)$$

Where:
D is displacement (mm), F is frequency (Hz), A is peak ground acceleration (g), and G is constant (9.806 m/s²).

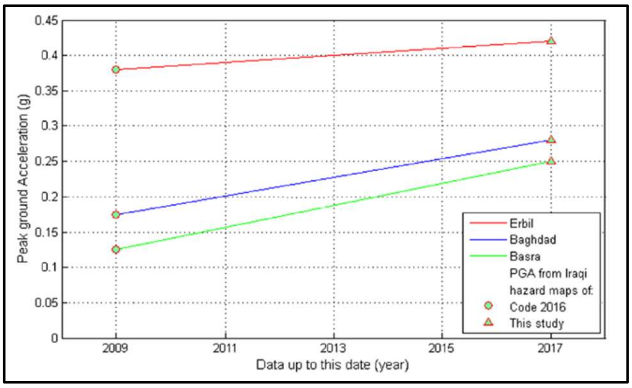

Figure 9: PGA values from the seismic design code of Iraq for version (2016) with that from study of [28].

There are several methods can be used to evaluate the failure capacity of screw piles under compression or tension loads such as Brinch-Hansen criterion, Davisson criterion[29], Federal Highway Administration FHWA (5% of the helix bearing plate diameter), L1–L2 method, ISSMFE (10% of the helix diameter). The ISSMFE deals with finding the load at a displacement value of the helix plate diameter [30, 31, 5,32]. In this study, 5% of the helix bearing plate diameter will be considered to determine the failure point that gives more reliable values in comparison with the results of experimental work. To introduce an accepted failure criterion, it should take into consideration: length of pile, diameter of pile shaft, diameter of helix, number of helical plates, spacing between helical plates, and the geotechnical properties of soil.

6. RESULTS AND DISCUSSION

The results from the analyses of axially loaded screw piles using the finite element software PLAXIS 3D are presented in this paper. The analysis is conducted for screw piles under static and seismic loading. The numerical analysis was conducted on two models: the first model was screw piles (HPT1, HPT2, HPT3, and HPT4) with dimensions of (12×12×10.25) m in the axes (X, Y, and Z) respectively, while the other type of screw pile (SPT2) was (9×9×5.5) m. A theoretical model is developed to predict the axial pullout load of screw piles in the soft soil.

6.1 *Static Pullout Loading*

PLAXIS software used to analyze six types of screw piles inserted in layered soil under static axial pullout load. The load was applied in increments of equal magnitudes and the displacement corresponding to each load increment is recorded before applying new load increment. In this study, the application of load on the head of screw pile continued to a displacement of 50 mm, which considered corresponding to the maximum load carried by the screw pile in layered soil. Six types of screw piles are analyzed with one, two, three, and four helices plates and inserted in one layer and two layers of soft soil .

The main results of numerical modeling includes comparison between the load-settlement curve of screw pile with multi helices (from 1 to 4 helices) has the spacing ratio (S/D=3) inserted in two layers of soft soils. The failure criterion adopted in this study assumes that the ultimate pullout capacity of screw pile corresponding to a displacement of 5% of the helix diameter. Increasing the number of helices in a screw pile is the most effective way to increase its capacity more than its other determinants. The axial pullout capacity of the screw pile increased by 58% with increasing the number of helices from one to four, 118 kN for HPT1 to 186 kN for an HPT4. The screw piles (HPT2 and HPT3) have failure pullout capacities of 132 and 147 kN, respectively. In other words, as compared to a reference screw pile (HPT1), the screw piles HPT2, HPT3, and HPT4 have their failure pullout capacity increased by 12, 23, and 58%, respectively.In screw piles (HPT2, HPT3, and HPT4), the net increase for each additional helix is 12, 11, and 27%, respectively, as shown in **Figure 10a** .

Figure 10b shows the influence of soil cohesion (cu = 9, 15, 25, and 36 kPa) on the pullout capacity of HPT3 with S/D=3 and inserted in one layer of soil. The anticipated failure pullout load increases consistently when soil cohesion is increased. The estimated vertical failure load increased substantially from a soil cohesiveness of (9 kPa) to (36 kPa), resulting in a larger increase in the screw pile pullout capacity. The tensile load was increased by roughly 255% of the original value (9 kPa).

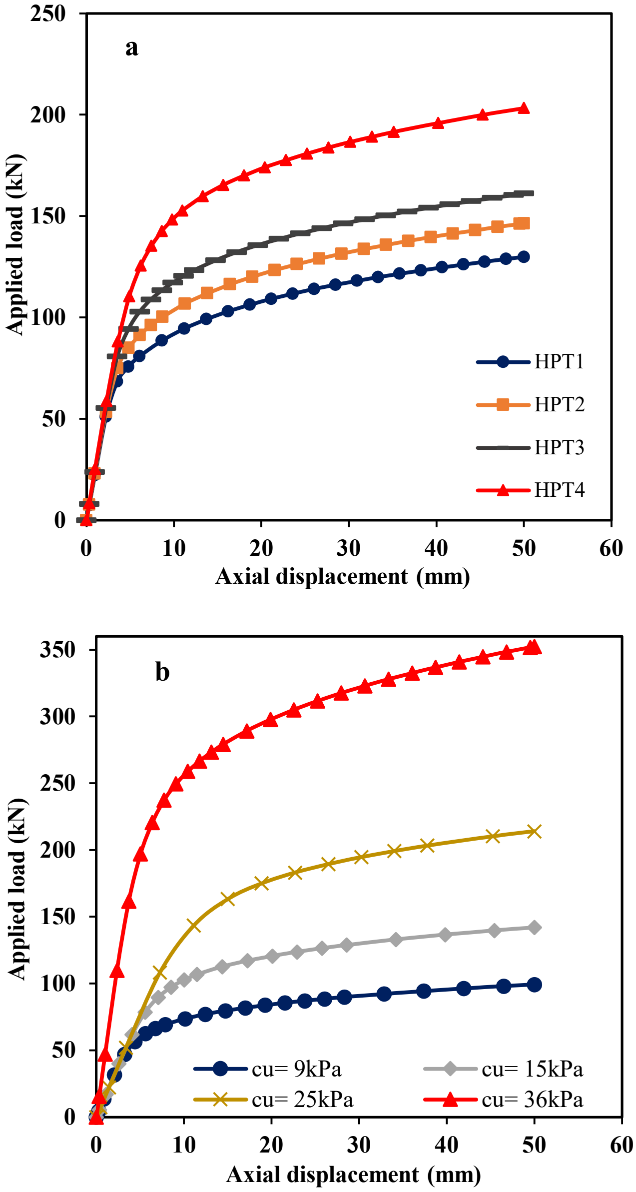

Figure 10: Variation of pullout load versus axial displacement of screw piles: a) screw piles inserted into two layers of soils, b) HPT3 inserted in one layer of soil having different cohesion

The failure pullout capacity of screw pile increased by 44, 48, and 66% for screw piles inserted in soil has cohesion of 15, 25, and 36 kPa, respectively, in comparison with that inserted in soil of cohesion 9 kPa as shown in **Figure 11.** According to the earlier findings, increasing soil cohesion from 15 to 36 kPa by 1.4 times increases the failure pullout capacity by 145%. Salem and Hussein, [33] performed a field investigation on the screw pile for four sites with varying soil cohesion (cu), the failure pullout load of the screw pile increases by 130% when the soil cohesion was increased by 1.38 times. The displacement in the two figures above results from applying the external load with the weight of the screw pile. **Figure 12** shows the displacement resulting from the screw pile'sweight only after the stage of its installation. The prior results show that as the number of helices increases, the bearing loads increase. Even so, when the number of helices is considerable, the surrounding soil is destroyed because the deformation in the soil causes a loss in soil attributes (such as diminishing the cu of cohesive soils and reducing the relative density of non-cohesive soils), particularly when uplift loading occurs. As a result, in cohesive soil, helices the essential number of helices is 3[30, 31,34].

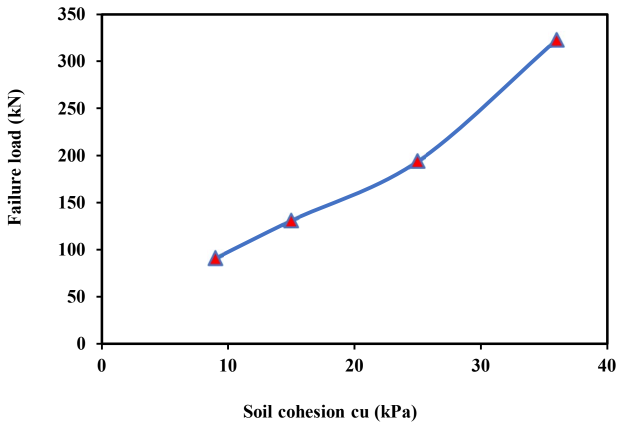

Figure 11: Relationship between failure pullout load of screw pile HPT and soil cohesion.

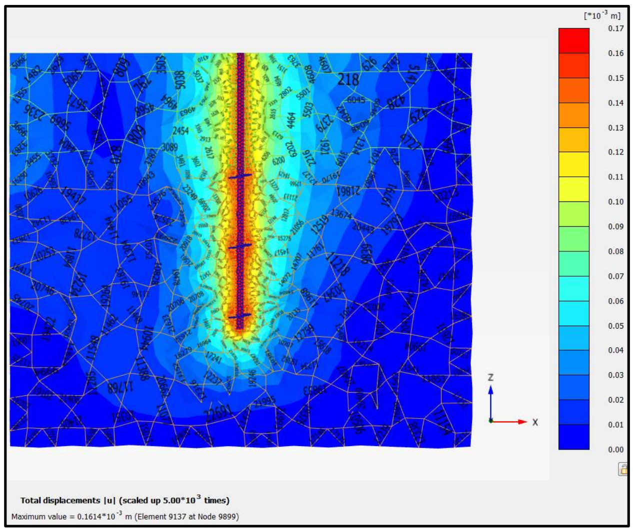

Figure 12: The displacement resulting from the self-weight of the screw pile.

Figure 13 shows the load-settlement relations of another type of screw pile (SPT2), which is 3.2 m in length and contains two helical plates, while the HPT1 has the same length but one helix, and it's inserted in two layers of soft soil. The failure pullout loads are 67 and 83 kN for the screw piles SPT1 and SPT2 respectively inserted into two layers of soil. The failure pullout load capacity was reduced by 24% when the number of helical plates was reduced from two to one. A third helix cannot be placed on the screw pile SPT2 if loads are applied because it will become near to ground level, producing shallow failure because of its length of 3 m. Perko (2009) recommends a sufficient embedment depth so that the bearing helical plate is not placed too close to the soil surface, producing shallow failure.

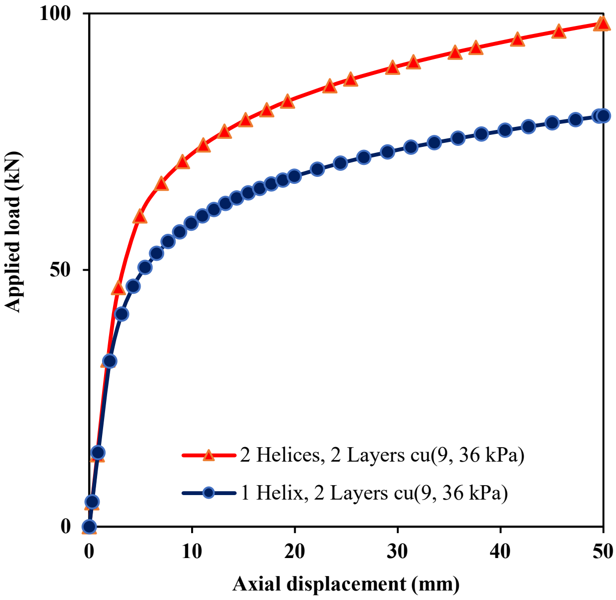

Figure 13: Variation of pullout load and axial displacement of screw piles (SPT1 and SPT2 inserted in two layers of soil).

6.2 *Seismic Loading*

The seismic loading was applied to the screw pile HPT3 inserted into two layers of soil. Two cases were studied: in the first case, the seismic load (PGA) of intensity 0.47g was applied horizontally on the pile head and the pile was subjected to axial pullout load. In the second case, the seismic load (PGA) of intensity 0.47g was applied horizontally on the pile head without axial pullout load. **Figure 14** shows the amount of axial displacement resulting from seismic loading applied at the head of pile (soil surface) and subjected to axial pullout load of intensity 162 kN. Mostly, the seismic loading reduces the axial displacement except at the beginning of loading after 0.08s. The oscillation of displacement with time almost constant and range between 49 and 50 mm.

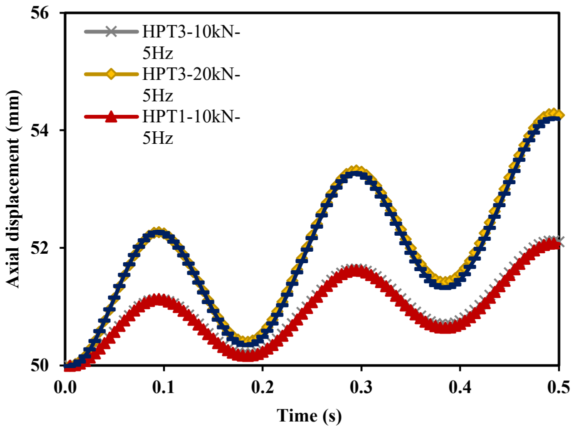

Figure 14: Axial displacement result of seismic loading (0.47g) and axial pullout loading (162 kN).

The variation of axial settlement with time of screw pile HPT3 subjected to seismic load intensities of 10 and 20 kN and frequency of 4 Hz and 5 Hz are shown in **Figure 15**. The results revealed that the displacement results under frequency 4 Hz is greater than that resulting from the application of frequency 5 Hz. In addition, the gap between the two curves increase with increasing time of loading. The results well agreed with **Equation1**, where the frequency is inversely proportional to the displacement, so increasing the frequency reduces the settlement. Also, it’s important to note increasing the intensity of loading increase the resulted axial displacement.

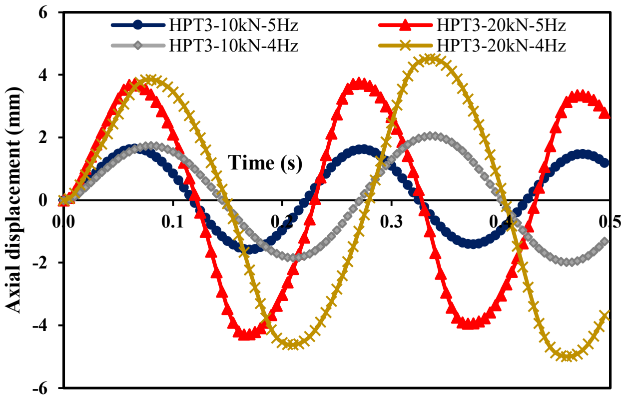

Figure 15: Variation of displacement with time of screw pile HPT3 subjected to seismic loading of intensities (10 and 20 kN) and frequency of 4 Hz and 5 Hz.

The performance of HPT3 with a three-helix plate, and HPT1 with a single helix plate of 610 mm diameter and a shaft of 178 mm diameter under seismic loading of intensity 10 and 20 kN and frequency 5 Hz were compared screw pile of single helix plate (HPT1). As shown in **Figure 16**, the results of the numerical analysis revealed that there is an influence of the extracted displacement due to the effect of the number of screw bearing plates during seismic axial loading. According to El-Sawy[14] the number of screw bearing plates in the lateral seismic loading has no effect on the lateral displacement, contrary to its effect on the axial displacement.

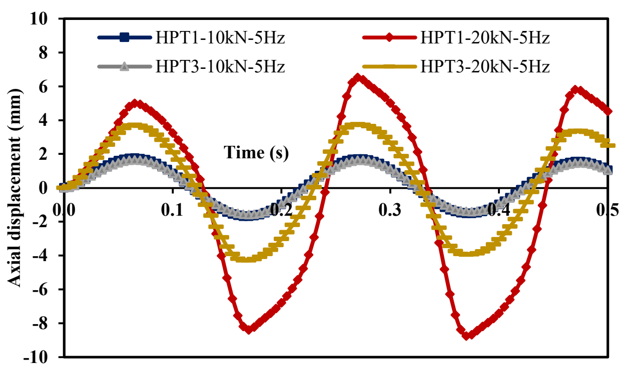

Figure 16: Effect number of helix-plate on axial displacement during seismic axial loading frequency of 5 Hz.

7. CONCLUSIONS

Three-dimensional numerical simulations were carried out for six types of screw pile using PLAXIS 3D software, and results were compared to results from the large-scale model with both static pullout load and seismic loading. Axial static loading was applied on three types of screw piles, and subsequently, two of them was subjected to seismic loading of intensities 10 and 20 kN and two frequencies 4 and 5 Hz. These values of frequency corresponding to spectral acceleration of 0.25g and 0.47g for Baghdad city. The following conclusions can be derived from the study's findings :

- The axial pullout capacity of the screw pile increased by 58% when raising the number of helices from one to four, 118 kN for HPT1 to 186 kN for an HPT4.
- The spacing ratio between the helices to the diameter of the helix (S/D) controls the failure mode of screw piles, where (S/D=2) leads to cylindrical shear failure, while (S/D=3) causes individual bearing failure.
- The pullout capacity of screw piles increases by roughly 255% with increases the undrained shear strength of soil.
- The results revealed that the axial displacement resulted from the seismic load of frequency 4 Hz is greater than that resulting from the application of the same load but with higher frequency of 5 Hz.
- The axial displacement resulted from seismic loading of frequency 4 and 5 Hz is very small in comparison with that resulted from static axial load, so the helical bearing plate is an efficient solution for the reduction of the axial displacement of pile under axial seismic loading.

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Nomenclature

A	Area
D	Helix Diameter
d	Shaft Pile Diameter
L	Length

Greek symbols

τ	Transmissivity
α	Absorptivity

Abbreviations

HPT1	Helical pile with one helix under tension load
HPT2	Helical pile with two helices under tension load
HPT3	Helical pile with three helices under tension load
HPT4	Helical pile with four helices under tension load
SPt1	Screw pile with one helix under tension load
SPC2	Screw pile with two helices under tension load

النمذجة العددية لسلوك الرفع للركائز الحلزونية تحت التحميل الزلزالي في التربة الرخوة

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الخلاصة – الركائزالحلزونية الفولاذية عبارة عن اسس عميقة مصنوعة من عمود ذات مقطع مربع أو دائري به لوح أو أكثر من الألواح الحلزونية. ركزت هذه الدراسة على النمذجة العددية لسلوك الرفع للركائز الحلزونية المثبتة في طبقات التربة الضعيفة المعرضة للحمل الزلزاليوالمعرضة للتحميل الزلزالي. تم تحليل ستة نماذج من الركائز الحلزونية (HPT1 ,HPT2, HPT3, HPT4, SPT1 و SPT2) عدديًا باستخدام برنامج PLAXIS 3D. تم تعريض جميع الركائز الحلزونية لحمل رفع ثابت، كما تم تعريض الركائز الحلزونية (HPT1 وHPT3) لتحميل زلزالي إضافي. مثل نطاق الحمل الزلزالي كمدى (0.25g و0.47g) من الحمل الزلزالي التي تعرضت لها مدينة بغداد في السنوات القليلة الماضية. تم افتراض أن حمل فشل الرفع يتوافق مع إزاحة حوالي 5 ٪ من قطر الحلزونة الذي تم الحصول عليه من التحليل العددي، والذي يعطي قيمًا مماثلة تمامًا لتلك المسجلة تجريبياً. عند (S / D = 3) يحدث مقاومة فردية للالواح الحلزونية الحاملة، بينما كان فشلال قص الأسطوانيه ونمط فشل ركيزة حلزونية مع (S / D = 2). أظهرت النتائج التي تم الحصول عليها من النمذجة العددية وجود تأثير معنوي لعدد الصفائح الحلزونية على الإزاحة المحورية وسعة سحب الفشل للركيزة الحلزونية تحت تأثير التحميل الزلزالي. في حين تبين أن عدد لوحات التحميل الحلزونية له تأثير طفيف جدًا على الإزاحة الجانبية.

الكلمات الرئيسية –التحميل الزلزالي، الركائزالحلزونية، التربة الرخوة، PLAXIS 3D.