A Comprehensive Study of Franki pile with the other pile models Embedded within cohesionless soils

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Abstract. Frankie pile is classified as a large displacement pile cast in place with a concrete mixture. This paper dealt with the laboratory work to produce a model of the Franki pile similar to the full-scale production process in the field to investigate its behaviour and make a comparison study with the other familiar types of piles models (precast concrete pile, closed-ended steel pipe pile, and bored pile with the same surface and cross-sectional area). The investigation occurred within dry sandy soil with two different relative densities (30 and 60) % will be denoted as (S1) and (S2) respectively. Axial compressive piles load tests were performed for embedded piles models in sandy soils at relative densities of 30% and 60%. Several interpretations have been used to estimate the ultimate capacity of pile models from the results of pile load tests. It was found that the Davisson, De Beer, Fuller and Hoy, and Tangent Methods gives an approximate acceptable result for all typical pile load tests, so average values of theses methods were adopted for comparisons. It was observed that the ultimate bearing load value at a Franki pile was greater than the other types of piles models in both densities. The for precast concrete pile, 2.98 for close ended pipe pile and 5.5 for bored piles for low relative density. While for high relative density the bearing ratio of Franki pile over other pile models were 0.94 for precast concrete pile , 2.26 for pipe pile model and 3.16 for bored pile model.

1. Introduction
Piles are slender foundational elements designed to support structural loads by mobilizing soil resistance along the depths. A pile is installed by either remove or to displace the original soil. Displacement piles densify the soil, resulting in comparatively greater potential for bearing capacity. Such type of displacement piles is Franki pile, the displacement element for cast-in-situ piles is a Plugged casing (Franki) or a drilling tool (Drilled Displacement Piles, e.g., Omega) Piles (Dias, 2017) [1]. Franki pile was first licensed by its inventor Frankignoul in Belgium as a patent in 1908. The installation method of Franki pile has been developed further in Germany in recent years. The way in which the load distribution across a pile base and the output of the pile shaft can be optimized has been considered since the end of the 1970s. Since the mid-1980s in Germany, Franki pile methods for production and its dimensioning have been employed and today considered high-quality method for pile foundations (Ulrich Smoltczyk, 2003) and (FRANKI Grundbau GmbH & Co. KG-2020) [2,3].
Franki piles also are known as pressure-injected footings and extended compacted base piles. Typically, 6 to 18 m long and can hold loads of 534 to 1068 kN [2]. Such piles are best suited for granular soils where the bearing is accomplished by compacting around the base of the pile (Prakash, S., & Sharma, H. D. (1990)) [4].

The standard Franki pile has been produced on the same basic principle for nearly a century. As shown in Figure 1, the pipe is filled with semi dry concrete or gravel and tamped with gentle ramming impacts. The freefall hammer with the typical fall height of 6-7 m is pulled up after the stopper has been created, and let fall on the stopper, at this way the pipe is driven into the ground until it achieves the appropriate depth. Upon reaching the depth of the placement, the advance pipe is kept fixed and the hammer drop height increased to remove the stopper and stamp out the base of the pile. After the construction of the base and a small portion of the shaft, the reinforcement cage is employed, and the pile shaft is stamped out with the application of earth-moist concrete with mild stamping impacts.

Frankie piles, being one of the most used piles in weak soils, and loose sand used to densify the soil and get high bearing capacity. The ultimate bearing capacity of Frankie's pile will also be evaluated compared to other types of piles such as precast concrete pile, bored pile, and closed-end steel pipe pile. Many researchers who have observed the behavior of Franki piles embedded in various soils, (Tamer Elkateb, 2003) [5] addressed the existing Franki pile foundations (base-expanded) for residential unit construction. The size of the Franki pile was 0.4-0.5 m shaft diameter and the base volume ranged from 0.14 m$^3$ to 0.85 m$^3$. The program study passed through three stages: evaluation of the capacity of the Franki pile using the theoretical method, then confirmation of the evaluated capacity from the pile process. József PUSZTAI, 2004 [6] investigated the behavior of the Franki piles in various soil types through experimental testing. The studier's main objective was the relationship between the pile capacity and soil layer variations. All data has been collected by others from experimental tests and then statistical analysis, the data and then the regression method was adopted to assess the Franki pile's bearing capacity as a function of soil layer variations. The analyzed results suggested that the Franki pile can only be used for granular soils and that the failure under the bulb occurs at smaller settlement than for the bored pile. M. Dithinde et al., 2011 [7], shows Franki pile strength capacity and other different types of piles were evaluated throughout the collected database by other researchers from experimental tests. The data was drawn, and statistical analysis of regressions was performed to suggest empirical formula representing the ability of the piles for each type. Results from the proposed models showed that findings from experimental experiments are very different from
that. In addition to what was mentioned previously, many companies specialized in this field. FRANKI Grundbau GmbH & Co.KG [3] has developed various types of Frankie pile as well as methods of implementing them through practical experience and supplying scientific research with the necessary data for static load testing that has been implemented within its construction projects.

2. Materials, Equipment, and Test Setup

2.1. Manual Dynamic Hammer Device
Design and manufactured of the manual winch, and two hammers of (0.6 and 1.23) kg, the first small one of 22.5 mm diameter and 200mm height used to applied mechanical energy to the dry material and to create the stopper (the compactive effort). The second hammer of 22.5 mm diameter and 400mm height using to remove the stopper and stamp out the base of the pile by increased mechanical energy via increases the weight. Hollow steel opens ended pipe of (38mm dia. and 500mm depth) mm used to simulation the field scale rig that uses to installation Franki piles in laboratory conditions. Manual winch and hammer were set up to apply dynamic force on the dry material to drive the pipe in the ground. The parts of the winch are formed as cable guide, pipe hand, pipe guide, and winch base. The details on each hammer and winch part were outlined below, Figure 2 shows the hammers, hollow steel open end pipe, and Figure 3 shows a winch device.

![Figure 2. Details of hammers and steel pipe](image1)

![Figure 3. Parts for Winch device with a base.](image2)

2.2. Soil Box (Container)
A soil container with outer dimensions of (700 ×700) mm and (800) mm depth was made as one piece to conduct all the tests, the container is made of (6) mm thickness of steel plate to avoid the lateral displacement of the soil as shown by Ternet, (1999); Garnier, (2001 and 2002)[8],[9] and [10]. In the present study, the distance between the piles surface and the container wall is 331 mm (> 9D) to avoid the effect of stress zone around the piles due to the stress that results from this process, as many earlier researchers have stated Meyerhof, (1959); Kishida, (1963); Robinsky and Morrison, (1964) [11,12] and [13], indicating that the extension of the disturbance zone is about 3-8 of pile diameter.

2.3. Steel Load Frame and Axial Loading System
The steel frame involves mainly of four columns and four transverse beams. All parts are made of steel with a square cross-sectional area of (80mm× 80mm) and a wall thickness of 4 mm. The steel frame dimensions are (1170mm length × 570mm width × 1700 mm height). To resist the applied load during the static load test, four beams were added to support the load frame with a square cross-sectional area of (40×40) mm and wall thickness of 4 mm, as shown in Figure 4. Hold the hydraulic jack system as shown in Figure 5, on the frame.
The axial load was applied through a hydraulic jack having a maximum loading capacity of (10 Ton) according to the hydraulic jack catalogue. A rubber tube was used to pump the hydraulic from the manual system to the piston.

![Figure 4. Steel frame of loading.](image1)

![Figure 5. Steel plate with a hydraulic jack.](image2)

### 2.4. Instrumentation

#### 2.4.1. The “S” Type Load Cell (FSRS) model

The “S” Type Load Cell (FSRS) model from the “Forsentek” company was used to measure the applied static load. It is made of stainless steel based on strain gauge technology with trimmed 3.0mV/V output intended for tension/compression force measurement, its capacity of 1 ton with a maximum 0.02% non-linearity of the full-scale Figure 6.

#### 2.4.2. VL53L0X (TOF) Laser Ranging Sensor

This sensor was used to measure the pile settlement during the loading test for models. It is a carrier/breakout board for the laser-range sensor VL53L0X of ST which measures the range to a target object up to a distance of 2 m. The VL53L0X uses infrared pulses time-of-flight measurements for range, enabling it to deliver accurate results independent of the color and surface of the target. Measurements of distances can be read via a digital I²C interface Figure 7.

![Figure 6. “S” type Load cell.](image3)

![Figure 7. TOF sensor.](image4)

#### 2.4.3. Data Logger (Arduino)

It is an electronic development board consisting of an open-source electronic circuit with a computer-controlled microcontroller and is designed to facilitate the use of interactive electronics in interdisciplinary projects Figures 8 and 9.

#### 2.4.4. Dial Gauge

The dial gauge with a sensitivity of 0.01 mm was used to calculate the pile displacement during the pile load test, which was mounted using a magnetic base holder Figure 10.

![Figure 8. Data Logger.](image5)

![Figure 9. Arduino.](image6)
2.5. Properties of the Soil Used
The soil used to conduct the model’s analysis is clean, dry, uniform (Kerbela) sand. Standard tests were performed on the sand having various densities; loose of Dr. 30% and medium of Dr. 60%. The grain size distribution of sand is shown in Figure 11. Physical properties of the sand are described in Tables 1 and 2. Direct shear apparatus used to find the angle of internal friction ($\phi$) for the two sand densities. In order to get the pre determined densities, soil container is divided into equal layers of 50 mm height, each layer is adjusted and compacted manually to specify volume, the procedure is repeated till the target height of the soil has been achieved.

Figure 8. Arduino - UNO-R3 Board. Figure 9. Data logger parts details in the plastic. Figure 10. Dial gauge micrometer.

Figure 11. grain size analysis of soil used.
Table 1. Physical Properties of the sand used

| Characteristics Index | Value    | Standard of the test               |
|-----------------------|----------|------------------------------------|
| Grain size analysis   |          |                                    |
| Effective size, D10 (mm) | 0.16     | ASTM D 422 – 2001                 |
| D30 (mm)              | 0.23     | ASTM D 422 – 2001                 |
| Mean size, D50 (mm)   | 0.32     | ASTM D 422 – 2001                 |
| D60(mm)               | 0.40     | ASTM D 422 – 2001                 |
| Coefficient of uniformity, Cu | 2.50 | ASTM D 422 – 2001 |
| Coefficient of curvature, Cc | 0.83 | ASTM D 422 – 2001 |
| Classification (USCS) | SP       | ASTM D 422 – 2001                 |
| Specific gravity, Gs  | 2.67     | ASTM D 854 – 2005                 |

| Dry unit weight       |          |                                    |
| Maximum, γ_d (max.) kN/m³ | 17.75   | ASTM D4253-2000                   |
| Minimum, γ_d (min.) kN/m³ | 15.97   | ASTM D4254-2000                   |

| Void ratio            |          |                                    |
| Maximum void ratio, e_max | 0.64 |                  |
| Minimum void ratio, e_min | 0.48 |                  |

Table 2. Properties Sandy soil used for modelling research.

| Relative density, Dr% | 30% | 60% |
|-----------------------|-----|-----|
| Dry unit weight (γ_d), kN/m³ | 16.46 | 16.99 |
| The angle of internal friction (φ) | 32 | 34 |

2.6. Piles Modelling

In the present study, three types of pile models are required to be prepared in addition to the Frankie pile model with the same surface area. Details of each type's preparation and production are given below.

1. **Steel Pipe Closed-Ended Pile** dimensions are 36 mm in diameter and 600 mm in total length with a wall thickness of 3 mm Figure 12a.

2. **Precast Concrete Pile** dimensions are 28.25x28.25 mm square section and 600 mm in total length with Figure 12b.

3. **Bored Pile** dimensions are 36 mm in diameter and 600 mm in total length Figure 12c.

4. **Franki Pile** dimensions are 36 mm in diameter and 600 mm in total length Figure 12d.

For the soil used in this study, the ratio between pile diameter and D10 of soil is (D / D10= 225) and this is within requirement of (Vipulanandan et al., 1989) [14]. They specified that the ratio between pile diameters to D10 of the test soil should be at a value of 50 or more to eliminate the internal scale impact between the test soil and the penetrating object.
2.7. **Preparation of Soil Bed**

Franki pile was installation in cohesionless soil (sandy soil) with a relative density of (30% and 60%). From the volume information, the weight of each layer is found via the applicable law of dry unit weight. The container is divided into layers by a height of 50 mm for each layer and an area of (700 x 700) mm, the total number of layers are 16 layers and the weight of the sandy soil for each layer was (41.12 and 42.43) kg for relative densities 30% and 60% respectively. Each layer is deposit with a flat plane and leveled with a sharp tool, and then using a manual tamping tool until the target density is achieved, the last layer is reached and the surface is leveled and prepared to the next stage as shown in Figure 13.

![Figure 12. Pile models](image1)

![Figure 13. Soil preparation for Franki pile model.](image2)

2.7.1. **Setup the Manual Dynamic Hammer Device to Driving Franki Tube**

After the sandy soil preparation process is completed, as explained in paragraph 2.7, the manual dynamic hammer device is set up on the container and slides it horizontally after marking on soil the location of the Franki tube to drive it inside the soil, and then tide it by the bolts on the sides' walls of
the container. The steel hollow tube is installed at the center of the container vertically by the tube guide. The hammer is attached to the strand steel rope and is free-moving inside the tube, taking into account the non-friction with its sides. The height of the free fall on the steel ruler is determined and an indicator is attached to the steel rope.

By using a funnel, a dry concrete mixture is placed inside the steel tube and the height of this mixture marked on the strand steel rope, after that hold the tube on the soil surface by hooks, and ramming the dry concrete mixture by the smaller hammer to form stopper concrete. After making the stopper, the steel tube is driving into the target depth, and then it is kept in position by hooks. Replacing the hammer with another that has more energy (larger mass) to penetrate the stopper and expel it radially outside the steel tube.

A concrete mixture is mixed with a different ratio of water/cement 0.25-0.35 by volume and preparation of the steel-reinforced mesh to casting the Frankie pile. At the end of the casting process, the pile is left for 7 days to hardening, and then tested as shown in Figure 14.

![Figure 14. Franki pile production steps.](image)

2.7.2. Installation of Pile Models (Precast Concrete, Closed Ended Steel Pipe, and Bored).

After the completion of the process of laying the last layers of the soil completely (as explained in paragraph 2.7), the precast concrete pile and closed ended steel pipe pile models were prepared and the small load cell was connected at the toe to compressing it inside the soil to the required depth, as shown in Figure 15. The process was carried out by slowly and gradually loading on the pile head to avoid soil failure by using a hydraulic jack. The distance between the pile end and the base of the container is 216 mm (i.e. 6 D).

![Figure 15. Installation details for precast concrete and closed ended steel pipe pile models.](image)
For the bored pile, the small load cell is attached to the tip of the pile. Bored pile is included after pouring the soil layers at a height of 216 mm, using a PVC tubes to maintain the verticality of the pile while pouring the remaining soil layers, as illustrated in Figure 16.

![Figure 16. Installation details for bored pile models.](image)

2.7.3. Loading Procedure for pile Models

After 24 hours of completing the preparation of pile models, the soil container is fixed under the steel frame. Figure 17 shows the installation of instrumentations and tools for pile models. Then the load is applied by hydraulic jack slowly and gradually until the required load is reached and maintained for five minutes, the readings are recorded. Then continue to load with the new increment and repeat the process until the failure is reached according to the specifications out the quick test method of ASTM D 1143 / D 1143 M – 07 [15]. This process is repeated for all types of pile models.

![Figure 17. The loading system description.](image)

3. Presentation and Discussion of The Results

The ultimate failure load for a pile is defined as the load when the pile plunges or the settlements occur rapidly under sustained load. A variety of criteria are used to estimate the bearing capacity of the piles from pile load examination, including the criteria used (Tomlinson, 2015) [16]:

- The load where the settlement continues to rise without any further load increases.
- The load which causes a gross settlement of 10% of the minimum pile width.
- The load under which the gross settlement rises is disproportionate to the rise in load.
- The load under which net settlement rises disproportionately to the rise in the load.
- The load which produces a 6 mm plastic yield or net settlement.
- The load shown by the intersection of tangent lines plotted through the initial flatter part of the gross settlement curve and the steeper portion of the same curve.
- The value at which the net settlement slope is equal to 0.25 mm per 10 KN of the test load.
In this study, failure load was determined according to (ASTM D1143M-07, 2013) [15], that is defined the failure load as "the load occurs when the settlement exceeding 15% of the pile diameter or pile width". This criterion was adopted in determining the failure loads for all the piles models carried out in this study. This is the most logical criterion, and its values are close to the measured values.

A static axial loading test is the most accurate way to estimate the ultimate load capacity of piles under vertical loads. Such inquiries are performed using predetermined loads on the pile by testing pile settings against these loads. The pile settlement will take place on the service load and the ultimate load from the data obtained as a result of these experiments. A number of graphical methods developed by (Hansen, 1963), (Mazurkiewicz, 1972), (Chin-Kondner, 1970), (Decourt, 1999), (Corps of Engineers, 1991), (Fuller and Hoy, 1970), (Butler and Hoy, 1977) and (De Beer and Wallays, 1989) [17-24] have been proposed to locate the capacity of the pile bearings.

It was attempted to determine the ultimate bearing capacity of the piles installation in different soil conditions using the load-settlement data. In mostly, methods of Brinch Hansen, Mazurkiewicz, Chin Kondner, and Decourt predict the pile capacity greater than maximum test load and the other ones predict smaller than it, (Prakash and Sharma, 1990 and Olgun et al., 2017) [4, 25]. Therefore, the ultimate capacities of the piles were determined by using the tangent graphical method (defines the failure as the load at the intersection of the initial straight portion of the curve and final straight portion of the curve).

3.1. Influence of Sand Density

Figures 18 to 21 shows the behavior of (load – settlement curve) for bored pile model, precast concrete pile model, closed ended steel pipe pile model and Franki pile model respectively, with different relative densities. It is noted that the ultimate bearing capacity value increases with increasing of relative densities due increase in shear strength parameters. The increase in soil dry density reduces the soil void ratio and strengthens the soil (Khallawi, 2015) [26]. When pile was loaded with two relative densities, large increment in bearing capacity was observed and trend of behavior is similar to that of local shear failure.

Coefficient of earth pressure k for translating vertical pressure to lateral pressure is one of the most critical parameters that can influence the skin friction capacity of the piles in cohesionless soils. Many studies have shown that the value of k ranges from 0.5 to 1.5 depending on a variety of factors, including the pile construction method used, pile surface roughness, soil type etc. (Das, 2010) [27].

![Figure 18. Load-settlement curve for bored pile in dry sandy soil.](image1)

![Figure 19. Load-settlement curve for precast concrete pile in dry sandy soil.](image2)
3.2. A comparison of Ultimate Bearing Capacity of the Piles Models

Figures 22 and 23 show load settlement curves for all pile models used (bored, precast concrete, closed-ended steel pipe, and Franki piles). The results show that the ultimate bearing capacity of the Frankie pile is the highest and there is a big difference from the nearest pile, where the differences between the remaining types of piles are small. The primary reason for the increase in bearing capacity of Franki pile model is the increase in the size of the bulb base of the pile, which leads to an increase in end bearing capacity of the toe, as well as the roughness surface of Frankie pile (Das, 2010) [27].

The bearing capacities for different piles are calculated using the previous interpretation methods for load settlement curves obtained from experimental work and compared with results obtained from theoretical approaches. To calculate the ultimate load capacity of the Frankie pile model, the traditional mathematical equations method was used and considered as a driven pile. Tables 3 and 4 shows the ultimate bearing capacity values predicted from load settlement curves for different pile models by different methods for 30 and 60 % relative densities. The results show that Franki pile have greater ultimate bearing capacity than that other pile models. Also, the method used as theoretical approach ultimate bearing capacity of Franki pile is greater than the other pile models. The same results obtained for pile in relative density of 60% but with higher values.
### Table 3. Comparison of the measured and estimated pile capacity (Dr = 30%).

| Interpretation methods | Franki Precast concrete | Closed-ended Steel pipe | Bored |
|------------------------|--------------------------|--------------------------|-------|
| Davisson (N)           | 2320                     | 812                      | 620   | 370   |
| Chin (N)               | 5000                     | 1429                     | 1000  | 625   |
| De Beer (N)            | 2250                     | 850                      | 450   | 300   |
| Hansen 90% (N)         | 3622                     | 1222                     | 900   | 536   |
| Hansen 80% (N)         | 5270                     | 1550                     | 1162  | 552   |
| Fuller and Hoy (N)     | 2680                     | 955                      | 694   | 420   |
| Tangent (N)            | 2100                     | 790                      | 580   | 350   |
| Vander Veen (N)        | 9000                     | 1000                     | 2000  | 1400  |
| Decourt (N)            | 3520                     | 1230                     | 900   | 490   |

Ultimate Bearing capacity from theoretical approaches

| Qb (N) | 1578 | 513  | 569  | 144   |
| Qs (N) | 89   | 96   | 43   | 105   |
| Qu (N) | **1667** | **609** | **612** | **249** |

### Table 4. Comparison of the measured and estimated pile capacity (Dr = 60%).

| Interpretation methods | Franki Precast concrete | Closed-ended Steel pipe | Bored |
|------------------------|--------------------------|--------------------------|-------|
| Davisson (N)           | 3760                     | 1800                     | 1100  | 870   |
| Chin (N)               | 10000                    | 3333                     | 2000  | 1667  |
| De Beer (N)            | 3100                     | 2100                     | 1200  | 950   |
| Hansen 90% (N)         | 6044                     | 2833                     | 1680  | 1367  |
| Hansen 80% (N)         | 8452                     | 3371                     | 1917  | 1443  |
| Fuller and Hoy (N)     | 4560                     | 2160                     | 1290  | 1024  |
| Tangent (N)            | 3800                     | 1800                     | 1070  | 810   |
| Vander Veen (N)        | 10000                    | 6000                     | 3500  | 900   |
| Decourt (N)            | 7600                     | 2850                     | 1630  | 1340  |

Ultimate Bearing capacity from theoretical approaches

| Qb (N) | 2021 | 655  | 728  | 216.8 |
| Qs (N) | 146  | 157.6| 65.7 | 115   |
| Qu (N) | **2167** | **812.6** | **793.7** | **331.8** |
Figures 24 and 25 show histograms for ultimate bearing capacity by different methods compared with theoretical approaches. Table 5 shows the percent value of increasing the ultimate bearing capacity with an increase in relative density from (30-60) % for all types of piles models. The methods adopted in the analysis of test results for this study to determine the ultimate load capacity of piles is based on the taking the average for four methods that show realistic results which are Davisson, De Beer, Fuller and Hoy and the intersection of two straight tangent lines method (the initial pseudo-elastic portion of the load-deflection curve and a final pseudo-plastic portion) for interpretation, these methods are adopted by many researchers. Bearing ratio was determined for Franki pile over the other pile models. The results show that for low relative density bearing ratio of Franki pile higher than that for high relative density for all other models. Franki pile shows higher bearing ratio over bored piles for the two relative densities and lower bearing ratio over precast concrete piles.

![Figure 24. Ultimate loads using different methods in sandy soil (Dr = 30%).](image1)

![Figure 25. Ultimate loads using different methods in sandy soil (Dr = 60%).](image2)

| Table 5. The percent of increments in ultimate bearing capacity ratio of Franki pile over the other pile models at the two different densities. |
|---------------------------------------------------------------|
| **Relative Density % (Dr) = 30%**                                |
| **Pile**  |  **Qu (N)** |  **Increments in bearing ratio of Franki pile** |
|------------|-------------|-----------------------------------------------|
| Franki     | 2338        | ------                                      |
| Precast concrete | 852        | 1.74                                          |
| Closed-ended Steel pipe | 586         | 2.98                                          |
| Bored      | 360         | 5.50                                          |
|---------------------------------------------------------------|
| **Relative Density % (Dr) = 60%**                                |
| **Pile**  |  **Qu (N)** |  **Increments in bearing ratio of Franki pile** |
|------------|-------------|-----------------------------------------------|
| Franki     | 3805        | ------                                      |
| Precast concrete | 1965        | 0.94                                          |
| Closed-ended Steel pipe | 1165         | 2.26                                          |
| Bored      | 914         | 3.16                                          |
Since the results representing bored pile, precast concrete pile, closed-ended steel pipe, lower than Franki pile, which means that the Franki pile works efficiently and more effective in weak granular soils. These results are compatible with the results of (Pusztaï, 2004) and et.al [6] who found that the Franki pile system is have greater capacity in granular soil than the other soils types capacities. In this study, pile load tests result for all pile models were greater than theoretical result, which is in agreement with the findings of (Tamer Elkateb, 2003) [5] who found that when using pile load tests resulted an increase of the predicted pile capacity of about 60%.

4. Conclusions

Based on the experimental results of the experimental work, the following conclusions may be obtained:

1. The load-carrying capacity of piles increases when the density of sand increases. The sand density has more effect on the carrying capacity at the toe of pile comparison with shaft capacity.
2. The method of implementation piles, the material of piles, the properties of the soil, and the roughness of the pile surface have clear effect on increasing the bearing capacity.
3. The bearing ratio of Franki pile tested in low relative density (Dr. =30 %) was; 1.7 of precast concrete piles, 2.98 of close ended steel pipe pile and 5.5 of bored pile models.
4. The bearing ratio of Franki pile tested in medium relative density (Dr. =60 %) was; 0.94 of precast concrete piles, 2.26 of close ended steel pipe pile and 3.16 of bored pile models.
5. The ultimate pile capacity resulting from experimental tests is compared with that of theoretical values and shows marginal values.
6. The results indicate that using the theoretical method in determining ultimate bearing capacity gives results close to the experimental results as Davisson, De Beer, Fuller and Hoy and the intersection of two straight tangent lines methods in sandy soil tests, while there is overestimated results when using the other approaches.
7. Frankie pile shows a higher ultimate load capacity than other types of piles in sandy soils for the two relative densities, due to the large cross-sectional area of its base in addition to the roughness of its surface and it is more effective with loose sandy soils.

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