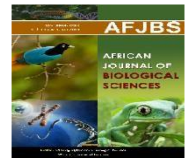
https://doi.org/10.33472/AFJBS.6.4.2024.79-86

African Journal of Biological Sciences



Research Paper **Open Access**

EVALUATING COMPOSITE AND UNCONNECTED PILED RAFTS ENHANCED WITH STONE COLUMNS

Baneen fouad abas abd[1a] , Athraa Mohammed Jawad Alhassani[2b]

1-Department of Civil Engineering / University of Kufa , Najaf , Iraq

2-Department of Civil Engineering / University of Kufa , Najaf , Iraq

a-E-mail: ah12121982@yahoo.com

b- E-mail: athraa_alhassani@yahoo.com

Article History

Volume 6,Issue 4, Feb 2024

Received:17 Feb 2024

Accepted : 01 Mar 2024

doi: 10.33472/AFJBS.6.4.2024.79-86

Abstract

The constructions with a moderate to high height are where this is used the most often. The majority of the time, it is obvious that the base of the construction is supported by stone columns or piles. The combination of a stone column and a pile makes for the most practical foundation for structures with a medium height. This kind of foundation has the advantages of being more affordable and higher in quality. Additionally, this kind of foundation increases the quality of the earth. Raft Foundations improved with stone columns can give a successful answer for structures on delicate soils. In any case, restricted direction is accessible on the distinctions between utilizing composite versus separate foundation frameworks improved with stone section considerations. This study assesses the way of behaving of these two establishment frameworks mathematically utilizing PLAXIS 3D. Parametric investigations are performed to evaluate the effects on bearing limit, differential settlement, and burden sharing for various designs of raft, piles, and stone columns. The outcomes give bits of knowledge on fitting specifying to advance the exhibition of these composite foundation frameworks on feeble soils. Plan suggestions are produced for choosing doable choices relying upon soil conditions and stacking.

Keywords: Composite material, Unconnected plied rafts, construction, and Raft foundation

Baneen fouad abas abd / Afr.J.Bio.Sc. 6(4) (2024) 79-86

Introduction

Over the past few years, it can be seen that the use of the raft foundation has increased a lot and includes significant reasons for so. There are different reasons behind this. The most use of this can be seen in the structures having a “moderate to high” height. In most cases, it can be seen that there are columns made of stones or piles used as the foundation of the structure. The most useful foundation for buildings having a medium height is to use the combination of the stone column & the pile for making the foundation. This form of foundation provides the benefit of being more economical & superior in quality. Also, the ground improves with the use of this form of foundation. For identifying the several aspects of this form of foundation the different data regarding this are needed to be analyzed. In this project, different data regarding the stone columns & piles used in the raft foundation were collected. After this, these data were analyzed in order to find out the behavior of these in the foundation of the structures. The main things that were checked in this regard were the mode of failure of the foundation of the structures and the change in the bearing capacity of the s oil on which the foundation is present. In addition to this, the behavior of this combined form of the foundation was also studied here. In this project, the different characteristics of the columns and piles were determined separately. Moreover, the benefits of these were identified here. Hence, how these two can be effective in making a raft foundation together was analyzed here in this project.

‘Column & pile” foundation, including raft foundation upheld by heaps, are a successful answer for structures on delicate soils. Stone segments can additionally improve the bearing limit and settlement execution of heaped rafts. This study intends to assess and think about the way of behaving of “pile & column” in raft foundation, where the piles are associated with the columns, v both improved with stone section considerations. Mathematical examinations are performed utilizing PLAXIS 3D Establishment to evaluate the effects on bearing limit, differential settlement, and stress dissemination. The outcomes give direction on fitting setups of improved raft foundations for various soil conditions and stacking situations. This will uphold more improved plan of these composite establishment frameworks.

Baneen fouad abas abd / Afr.J.Bio.Sc. 6(4) (2024) 79-86

Project Background

It can be seen that there is a rapid form of urbanization is taking place in different parts of the world. This is the reason that the increased number of use of "high-rise buildings" can be seen all over the world. The main foundation that can be seen used in this form of building is the raft foundation [1]. In the foundations, either the stone columns or the piles are used. The main use of the piles is in soils that are soft in nature and have a low "bearing capacity". In this case, the load is carried by both end bearing & skin friction. So, from here it can be identified that the main use of the piles is in the structures having a great load, and the soil is not well defined [2]. In this case, the main challenge that is faced is the requirement of complex & heavy machinery are required for driving the piles into the soil.

On the other hand, the stone columns are different from the piles. The main constituent of this column is the coarse aggregates having different sizes. These are mainly placed in soils that are well-compacted [3]. The main thing that is achieved by this is to make the performance of the soft soils good. This also reduces the amount of consolidation. It is to be noted that when the stone columns are placed on the ground it changes the soil forming a soil having a low compressibility and a high "shear strength" at the same time. Hence, this can be considered as an option that can result in reducing the cost of projects. The best structure for which it is the most suited is the "industrial structure". The many facts pertaining to this sort of foundation must be studied in order to discover the various components of it. Various information on the stone columns and piles utilized in the foundation of rafts was gathered for this project. The course of these data in the basis of the structures was then determined by analyzing the data.

From the above discussion, it can be understood that the combination of these two types of foundations improves the quality of the foundation. The benefit of using this form of foundation is seen in the form of improving the capacity of carrying loads [15]. Moreover, there is also the benefit of modification of the properties of the soil on which the foundation is resting. In addition to this, another benefit that can be observed in this form of foundation is the reduction of the cost that is incurred in doing different forms of geotechnical work. It is found that the quality of this form of foundation is far better than the other foundations. This is more economical as compared to the pile foundation. Also, this proves to provide more quality than the stone columns [4]. This foundation improves the soil of the foundation and makes the performance of the soil better than other types of foundation. It is to be noted that this foundation is the most suitable for buildings having medium height.

In this project, the previous data regarding this foundation is presented. The previously used raft foundation having the presence of a pile & stone column is collected here for identifying the different aspects of this foundation. Moreover, the behavior of the piles & stone columns was also studied in this project. The main thing that was checked was the behavior of this foundation in the soft clayey soils [14]. In addition to this, the mode of failure of the foundation was also checked in this project. It can be said that the analysis of the behavior of this foundation in the clayey soils is the main thing that is present in this project. For this reason, the data that is most recent in nature was collected here to identify the several aspects of this foundation.

Raft foundations contain “piles & columns”, giving an effective groundwork framework to structures on delicate or frail soils. The pile diminishes differential settlements while the heaps give extra bearing limits and lessen absolute settlement. Further upgrades can be accomplished by joining of stone sections which disperse pore pressures and offer stiffer help. Stone segments can be introduced previously or after raft depending upon site conditions.

Restricted direction is accessible on proper designs and relative way of behaving of these frameworks improved with stone segments. This study will assess execution through mathematical investigations to give experiences on the best use of stone sections for worked on bearing, decreased differential settlement, and more uniform pressure circulation.

Aim & Objectives

The main aim of this project is to find out the behavior of the foundation in which piles and columns are used in the form of a raft foundation. The objectives of this project are as follows.

- To find out why it is beneficial to use a raft foundation.
- To check if a raft foundation is more beneficial than other forms of foundations.
- To find out the factors that govern the design of a raft foundation.
- To check the process of design of a raft foundation.

Literature Review

Empirical Study

According to Konopatski *et al*. 2019 [6], the main approach that is used for stone columns is making holes in the ground that are cylindrical in nature. This is done in order to improve the performance of the soils [13]. The main constituent of these columns is the granular "coarse aggregates". It is to be noted that this form of foundation is not suitable for all types of structures but is only limited to the structures where the load is less. Hence, from here it can be said that this is less suitable for carrying heavy loads. On the other hand, different scenarios can be observed for the piles. The piles are long in dimension [6]. These are slender elements. There are different materials that are used for making piles. These are "concrete", "steel", and polymer. There is a particular mechanism that is can be observed in the process of transfer of loads by piles to the ground. The loads directly come to the piles then it is transferred to the bedrock on which the piles rest [12]. This can be seen in the case of soils where the firm bedrock is available at a shallow depth. Although where this is not available at a shallow depth, the load is mainly transferred by skin friction.

According to Genette & Levett, 2023, for analyzing this form of foundation there can be seen much data regarding this is available. In the history of this foundation, it can be seen that the stone columns were used by the military of France first time [5]. This was used for supporting the structure that was made of iron. This was actually artillery. This column was prepared by the use of crushed "limestones". There were holes that were boring for placing the columns. It is to be noted that the load that each of the columns had to carry was 10 kN. For this the design cross-section decided was a circle [11]. The diameter of the column was 0.2 m. Also, the length of the column was 2 m. In later years, the use of this was seen in compacting "granular soils". It was found that the use of granular columns in the granular soils increased the capacity of carrying the load of the ground. It is known that columns transfer loads by both end bearing & skin friction. In the granular soils, there can be seen the load is mainly carried by skin friction. So, if the column is made of granular material then the friction between the column & the soil becomes more. This results in increasing the capacity of carrying the load. From this, it can be said that the combined form of foundation is more suitable for structures having a medium height [7]. It can be seen that the performance of these piles has improved a lot. The performance of the stone columns & piles can be increased when both of these are used together in the raft foundation.

According to PÁLSSON, 2020, it can be seen that there are different forms so laboratory works that were conducted for checking the usefulness of these foundations. From the results of the experiment, it was found that the main mode of failure of the stone column is bulging. In addition to this, for checking the capacity of the column there was a particular method was used. This concept is called the concept of the unit cell. In this case, the capacity of the column group was determined by taking the summation of the individual columns [8]. Although in actual practice, it can be observed that the capacity of the column group is slightly more than the capacity of the summation of each column [9]. There can be seen the presence of different theoretical models that can describe the capacity of the bearing of the columns. The main inconsistency that can be seen here is that because of not considering the interaction of columns the results of these columns may not match exactly with the actual results.

Methodology

There was a particular method applied to this project. It can be seen that for this project it was required to find out how the raft foundation becomes effective for “medium-rise” building. The process that was applied for this project is to collect data from the different secondary sources regarding the topic of this project [10]. These data were about columns & piles used in the foundation. After this thorough study was done for finding out the important results of this research. Moreover, an analysis of designing one raft foundation was also done here in this project.

This study uses mathematical demonstrating with the limited component programming PLAXIS 3D Establishment to examine and contrast Raft Foundations Models are created addressing different powerless soil profiles comprising of delicate dirts or free sands. Composite and raft foundations are demonstrated, with and without stone section considerations. Stone sections are demonstrated as barrel shaped volume components with higher firmness implanted in the dirt.

The models are stacked up to inability to foster burden settlement bends and recognize a definitive bearing limits. Differential settlement across the pontoon is additionally evaluated in view of removals. The dispersion of stresses in the heaps, pontoon, and soil are assessed to comprehend load sharing components. Parametric examinations are led changing the dividing

Baneen fouad abas abd / Afr.J.Bio.Sc. 6(4) (2024) 79-86

and design of heaps and stone sections to concentrate on their associations and composite way of behaving.

The approved mathematical models give an effective means to assess various plan options not possible with actual testing. The outcomes will be utilized to foster direction on suitable specifying and setups of improved raft foundations for various site conditions and stacking situations. Ideal plans give satisfactory bearing limit while limiting differential settlements.

Results

Table 1 shows the characteristics of different types of soil that can be present under a raft foundation. It is to be noted that there can be different amounts of penetration with the change in the depth depending on the type of soil. Here, the values of this carried out in different forms of soil are shown. Stiffness defines the resistance offered by a soil against the penetration of any object into the soil. There can be seen a variation in the amount of penetration according to the soil type.

Table 1: Different forms of soils under raft foundation

Soil Description	**Depth (m)**	**Soil Data**	**SPT-N**	**Stiffness E (kN/m^2)**
Plastic Clay	0-2.2	γ_{dry} = 11.7 kN/m^3, γ_{sat} = 16.4 kN/m^2 c= 20 kN/m^2 $\phi = 16^0$, v = 0.27	2	1000
Marine Clay	2.2-4.5	γ_{dry} = 14.2 kN/m^3, γ_{sat} = 20.4 kN/m^2 c= 13 kN/m^2 $\phi = 19^0$, v = 0.27	3	1500
"Stiff Marine Clay"	4.5-8.3	γ_{dry} = 12.8 kN/m^3, γ_{sat} = 17.7 kN/m^2 c= 13 kN/m^2 $\phi = 28^0$, v = 0.3	13	6500
"Medium Fine Sand"	8.3-12.4	γ_{dry} = 14.6 kN/m^3, γ_{sat} = 18.5 kN/m^2 c = 3 kN/m^2 $\phi = 28^0$, v = 0.27	20	10000
"Medium Plastic Clay"	12.4-15.5	γ_{dry} = 15.1 kN/m^3, γ_{sat} = 18.8 kN/m^2 c = 20 kN/m^2 $\phi = 21^0$, v = 0.3	21	11000
Clayey sand & gravel	15.5-20	γ_{dry} = 15.6 kN/m^3, γ_{sat} = 19.1 kN/m^2 c = 10 kN/m^2 $\phi = 10^0$, v = 0.27	50	25000

Table 2 presents the description of the changes in the bearing capacity of soil according to the change in the cross-sectional area and depth. It is to be noted that the more the breadth the more the capacity of the foundation to bear loads. This is because of the fact that, with the increase in the breadth the load gets the chance to spread over a wide area.

Table 2: Influence of Dimensions on the capacity of the foundation

Foundation Depth D (m)	Foundation Breadth B (m)	D/B	SPT Value (N)	Depth Factor (F_d)	Allowable Bearing Capacity (kN/m^2)
1.0	8	0.125	6	1.041	161.2
	9	0.111		1.036	159.1
	10	0.100		1.033	157.6
	11	0.090		1.029	156.1
	12	0.083		1.027	155.1
	13	0.076		1.025	154.2
	14	0.071		1.023	153.4
	15	0.066		1.021	152.7
1.2	8	0.150	6	1.049	162.4
	9	0.133		1.043	160.2
	10	0.120		1.039	158.5
	11	0.109		1.035	157.0
	12	0.100		1.033	156.0
	13	0.092		1.030	155.0

Baneen fouad abas abd / Afr.J.Bio.Sc. 6(4) (2024) 79-86

	14	0.085		1.028	154.0
	15	0.0806		1.026	153.5
1.4	8	0.175	6	1.057	163.6
	9	0.155		1.051	161.4
	10	0.140		1.046	159.6
	11	0.127		1.041	157.9
	12	0.116		1.038	156.9
	13	0.107		1.035	155.5
	14	0.100		1.033	154.9
	15	0.093		1.030	154.0
1.6	8	0.200	6	1.066	165.1
	9	0.177		1.058	162.4
	10	0.160		1.052	160.5
	11	0.145		1.047	158.8
	12	0.133		1.043	157.6
	13	0.123		1.040	156.6
	14	0.114		1.037	155.5
	15	0.106		1.034	154.6

Baneen fouad abas abd / Afr.J.Bio.Sc. 6(4) (2024) 79-86

The variation of the capacity of the bearing of the foundation with respect to the change in the breadth is shown here. From Figure 1, it can be understood that with the increase in the breadth by having the depth constant the "bearing capacity" increases.

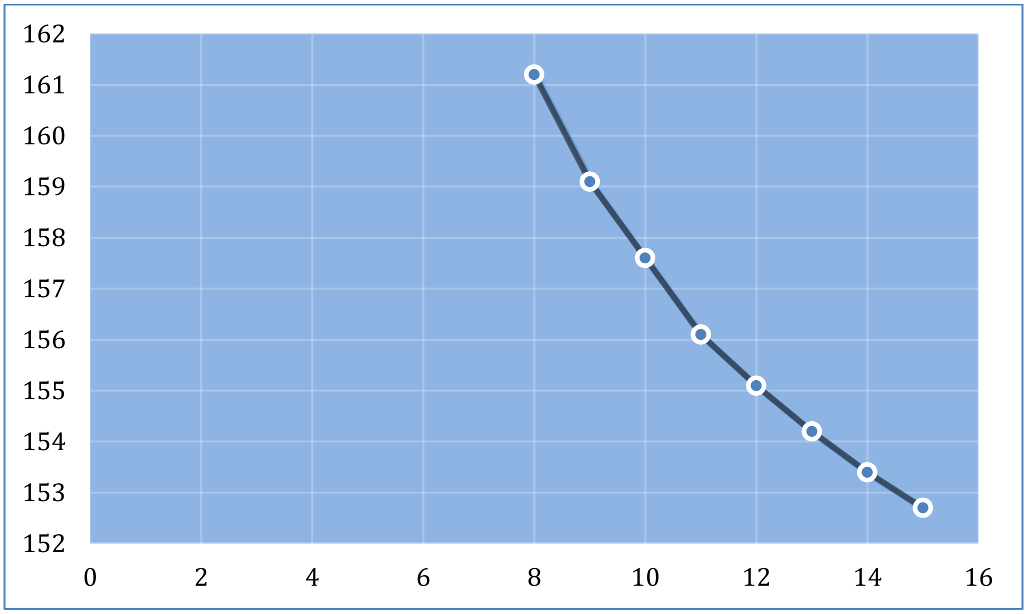


Figure 1: Bearing Capacity variation with change in breadth at 1m depth

The Figure 2 that describes the capacity of the bearing of the foundation with respect to the change in the breadth is shown here. In this case, the depth has increased to 1.2m. At this depth, the different "bearing capacity" was determined with changing breadth.

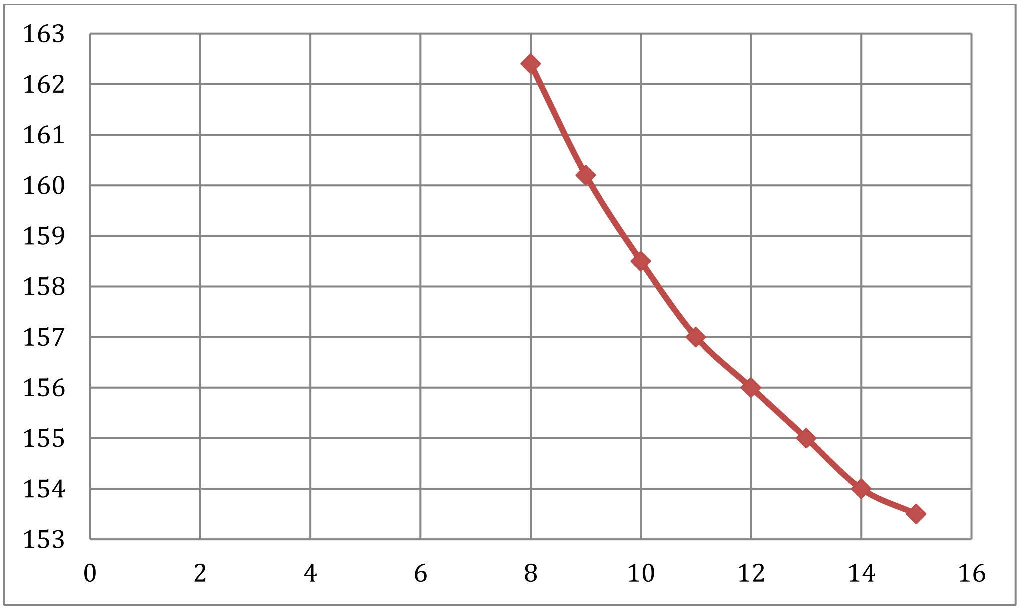


Figure 2: Bearing Capacity variation with change in breadth at 1.2 m depth

Figure 3 presents the variation of the capacity of the bearing of the foundation with respect to the change in the breadth is shown here. The variation in the bearing capacity was determined here at a constant depth of 1.4 m. The characteristics of this change are shown here.

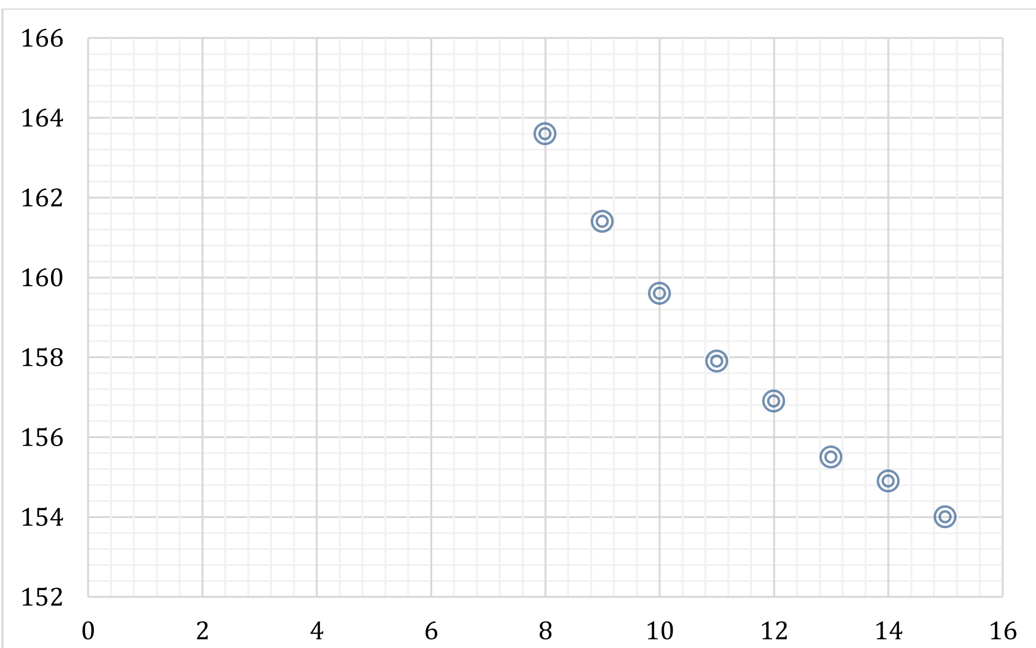


Figure 3: Bearing Capacity variation with change in breadth at 1.4 m depth

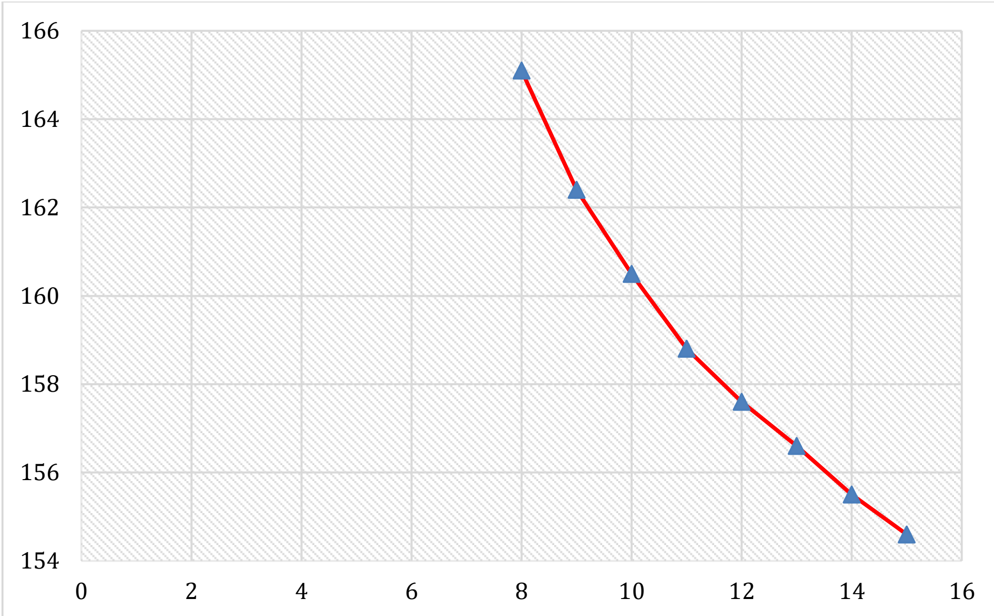


Figure 4: Bearing Capacity variation with change in breadth at 1.6 m depth

The variation of the capacity of the bearing of the foundation with respect to the change in the breadth is shown here. Figure 4 shows the change in the bearing capacity with respect to the breadth at a a constant depth of 1.6 m.

The variation & dependence of the dimension of the foundation & the depth of the foundation in determining the capacity of the bearing of the foundation is described above.

Table 3: Different characteristics of piles

Parameter	**Piles**
Unit Weight, γ (kN/m^3)	25
Young`s Modulus, E (kPa)	35x10^6
Poisson`s ratio, υ	0.2
Side Length, b (m^2)	0.275
Normal Stiffness (kPa)	50000
Shear Stiffness (kPa)	6000
Cohesion, c (kPa)	3.2
Friction Angle, ϕ (^{0})	24.79

Baneen fouad abas abd / Afr.J.Bio.Sc. 6(4) (2024) 79-86

In the Table 3, there are different features are presented that provides the evaluation of a pile. The characteristics of a pile that is considered in the design of the foundation are presented here. These are the parameters on the basis of which the pulse is evaluated. Also, this also presents the different characteristics of the soil in which these piles are present.

Discussion

Design of Raft Foundation

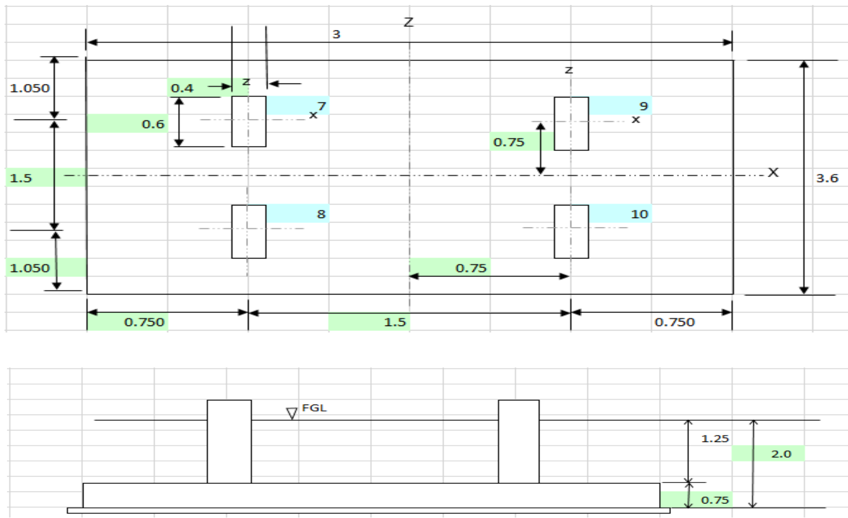


Figure 5: Dimensions of the foundation

The Figure 5 presents the dimensions of the designed foundations. The foundation is designed in MS excel, the length and the dimension of breadth are 3.6m and 3m respectively. The calculations for the foundation are presented below:

Assumed Data,

Soil Unit Weight = 1.8 T/m^3

Water Density = 1 T/m^3

Concrete Unit Weight = 2.5 T/m^3

Concrete Compressive Strength (f_c) = 30 N/mm^2

Steel Yeild Strength (f_y) = 415 N/mm^2

Friction Coefficient (μ) = 0.5

Baneen fouad abas abd / Afr.J.Bio.Sc. 6(4) (2024) 79-86

Net SBC = 8 T/m^2

Gross SBC = 13.6 T/m^2

Foundation Length L_f = 3 m

Foundation Width W_f = 3.6 m

Foundation Thickness T_f = 0.75 m

Foundation Depth D_f = 2 m

Pedestal Length L_p = 0.4 m

Pedestal Width W_p = 0.6 m

Pedestal Height H_p = 1.25 m

Calculation

Foundation Self-weight = 3 x 3.6 x 0.75 x 2.5 = 20.25 T

Foundation Buoyant Self-weight = 3 x 3.6 x 0.75 x 1.5 = 12.15 T

Soil Self-weight = 1.8 x 1.25 x (3 x 3.6 – 0.6 x 0.4 x 4) = 22.14 T

Soil Buoyant Self-weight = 0.8 x 1.25 x (3 x 3.6 – 0.6 x 0.4 x 4) = 9.84 T

Pedestal Self-weight = 2.5 x 0.6 x 0.4 x 1.25 x 4 = 3 T

Pedestal Buoyant Self-weight = 1.5 x 0.6 x 0.4 x 1.25 x 4 = 1.8 T

Weight without considering buoyancy = 20.25 + 22.14 + 3 = 45.39 T

Weight considering buoyancy = 12.15 + 9.84 = 23.79 T

Application of Load Combination

<u>Column 1:</u>

Table 4: Load Combination on column 1

Combination No	Load Combination	Force-X	Force-Y	Force-Z	Moment-X	Moment-Y	Moment-Z
1	10 (SELF+WL+X)	-0.184	0.105	-0.017	-0.04	0	0.42
2	11 (SELF+WL-X)	0.097	2.203	0.033	0.07	0	-0.22
3	12 (SELF+WL+Z)	0.141	-4.62	-0.926	-2.13	0	-0.32
4	13 (SELF+WL-Z)	-0.228	6.925	0.941	2.16	0	0.52
5	14	-0.196	-0.868	-0.141	-0.32	0	0.45
6	15 (SELF+PO+WL+X)	-0.336	-1.916	-0.166	-0.38	0	0.77
7	16 (SELF+PO+WL-X)	-0.056	0.182	-0.116	-0.27	0	0.13
8	17 (SELF+PO+WL+Z)	-0.012	-6.64	-1.074	-2.47	0	0.03
9	18 (SELF+PO+WL-Z)	-0.38	4.904	0.793	1.82	0	0.87

Table 5: Load Combination on column 2

Column 2

Combination No	Load Combination	Force-X	Force-Y	Force-Z	Moment-X	Moment-Y	Moment-Z
1	10 (SELF+WL+X)	-0.212	3.032	0.051	0.12	0	0.49
2	11 (SELF+WL-X)	0.058	0.932	0.002	0.01	0	-0.13
3	12 (SELF+WL+Z)	0.378	-3.629	-0.206	-0.47	0	-0.87

Baneen fouad abas abd / Afr.J.Bio.Sc. 6(4) (2024) 79-86

4	13 (SELF+WL-Z)	-0.532	7.595	0.26	0.6	0	1.22
5	14	-0.22	3.492	0.069	0.16	0	0.51
6	15 (SELF+PO+WL+X)	-0.355	4.541	0.093	0.21	0	0.82
7	16 (SELF+PO+WL-X)	-0.084	2.441	0.044	0.1	0	0.19
8	17 (SELF+PO+WL+Z)	0.235	-2.12	-0.165	-0.38	0	-0.54
9	18 (SELF+PO+WL-Z)	-0.675	9.105	0.302	0.69	0	1.55

Table 6: Load Combination on column 3

Column 3

Combination No	**Load Combination**	**Force-X**	**Force-Y**	**Force-Z**	**Moment-X**	**Moment-Y**	**Moment-Z**
1	10 (SELF+WL+X)	-0.184	0.105	0.017	0.04	0	0.42
2	11 (SELF+WL-X)	0.097	2.203	-0.033	-0.08	0	-0.22
3	12 (SELF+WL+Z)	-0.223	6.973	-0.943	-2.17	0	0.51
4	13 (SELF+WL-Z)	0.136	-4.668	0.927	2.13	0	-0.31
5	14	-0.258	0.592	-0.097	-0.22	0	0.59
6	15 (SELF+PO+WL+X)	-0.398	-0.455	-0.072	-0.17	0	0.92
7	16 (SELF+PO+WL-X)	-0.117	1.642	-0.122	-0.28	0	0.27
8	17 (SELF+PO+WL+Z)	-0.438	6.413	-1.032	-2.37	0	1.01

Baneen fouad abas abd / Afr.J.Bio.Sc. 6(4) (2024) 79-86

9	18 (SELF+PO+WL-Z)	-0.078	-5.229	0.838	1.93	0	0.18

Table 7: Load Combination on column 4

<u>Column 4</u>

Combination No	**Load Combination**	**Force-X**	**Force-Y**	**Force-Z**	**Moment -X**	**Moment -Y**	**Moment -Z**
1	10 (SELF+WL+X)	-0.213	3.032	-0.051	-0.12	0	0.49
2	11 (SELF+WL-X)	0.058	0.931	-0.002	0	0	-0.13
3	12 (SELF+WL+Z)	-0.528	7.546	-0.259	-0.6	0	1.21
4	13 (SELF+WL-Z)	0.373	-3.581	0.206	0.47	0	-0.86
5	14	-0.35	4.888	-0.093	-0.21	0	0.81
6	15 (SELF+PO+WL+X)	-0.485	5.937	-0.118	-0.27	0	1.12
7	16 (SELF+PO+WL-X)	-0.215	3.837	-0.069	-0.16	0	0.49
8	17 (SELF+PO+WL+Z)	-0.801	10.452	-0.326	-0.75	0	1.84
9	18 (SELF+PO+WL-Z)	0.1	-0.675	0.139	0.32	0	-0.23

Table 8: C.G Moments

C.G Moment

Load	**F_x**	**F_y**	**F_z**	**M_x**	**M_y**	**M_z**
1	-0.184	0.105	-0.017	-0.079		-0.079
2	0.097	2.203	0.033	-1.653		-1.653
3	0.141	-4.62	-0.926	3.465		3.465

4	-0.228	6.925	0.941	-5.194		-5.194
5	-0.196	0.868	-0.141	0.651		0.651
6	-0.336	-1.916	-0.166	1.437		1.437
7	-0.056	0.182	-0.116	-0.137		-0.137
8	-0.012	-6.64	-1.074	4.98		4.98
9	-0.38	4.904	0.793	-3.678		-3.678
1	-0.212	3.032	0.051	-2.274		2.274
2	0.058	0.932	0.002	-0.699		0.699
3	0.378	-3.629	-0.206	2.722		-2.722
4	-0.532	7.595	0.26	-5.697		5.697
5	-0.22	3.492	0.069	-2.619		2.619
6	-0.355	4.541	0.093	-3.406		3.406
7	-0.084	2.441	0.044	-1.831		1.831
8	0.235	-2.12	-0.165	1.59		-1.59
9	-0.675	9.105	0.302	-6.829		6.829
1	-0.184	0.105	0.017	0.079		-0.079
2	0.097	2.203	-0.033	1.653		-1.653
3	-0.223	6.973	-0.943	5.23		-5.23
4	0.136	-4.668	0.927	-3.501		3.501
5	-0.258	0.592	-0.097	0.444		-0.444
6	-0.398	-0.455	-0.072	-0.342		0.342
7	-0.117	1.642	-0.122	1.232		-1.232
8	-0.438	6.413	-1.032	4.81		-4.81
9	-0.078	-5.229	0.838	-3.922		3.922
1	-0.213	3.032	-0.051	2.274		2.274

2	0.058	0.931	-0.002	0.699		0.699
3	-0.528	7.546	-0.259	5.66		5.66
4	0.373	-3.581	0.206	-2.686		-2.686
5	-0.35	4.888	-0.093	3.666		3.666
6	-0.485	5.937	-0.118	4.453		4.453
7	-0.215	3.837	-0.069	2.878		2.878
8	-0.801	10.452	-0.326	7.839		7.839
9	0.1	-0.675	0.139	-0.507		-0.507

Foundation Reaction

Table 9: Foundation Reaction

Load	**F_x**	**F_y**	**F_z**	**Total**					
				M_{xx1}	**M_{xx2}**	**M_{xx}**	**M_{zz1}**	**M_{zz2}**	**M_{zz}**
1	-0.793	6.274	0	0	0	0	4.39	1.82	6.21
2	0.31	6.269	0	0	-5E-18	-5E-18	-1.908	-0.7	-2.608
3	-0.232	6.27	-2.334	17.077	5.37	22.447	1.173	0.53	1.703
4	-0.251	6.271	2.334	-17.078	-5.36	-22.438	1.318	0.57	1.888
5	-1.024	8.104	-0.262	2.142	0.59	2.732	6.492	2.36	8.852
6	-1.574	8.107	-0.263	2.142	0.61	2.752	9.638	3.63	13.268
7	-0.472	8.102	-0.263	2.142	0.61	2.752	3.34	1.08	4.42

8	-1.016	8.105	-2.597	19.219	5.97	25.189	6.419	2.34	8.759
9	-1.033	8.105	2.072	-14.936	-4.76	-19.696	6.566	2.37	8.936

Stability Check (Overturning &Sliding)

Table 10: Stability Check

Load	Sliding Force			Restoring Force				F.O.S	Remark
	F_x	F_z	Resultant	External Load	Foundation Pedestal	Total Load	0.5 x (External Load + Foundation Pedestal)		
1	-0.793	0	0.79	6.274	23.79	30.064	15.04	19.04	Safe
2	0.31	0	0.31	6.269	23.79	30.059	15.03	48.48	Safe
3	-0.232	-2.334	2.35	6.27	23.79	30.06	15.03	6.4	Safe
4	-0.251	2.334	2.35	6.271	23.79	30.061	15.04	6.4	Safe
5	-1.024	-0.262	1.06	8.104	23.79	31.894	15.95	15.05	Safe
6	-1.574	-0.263	1.6	8.107	23.79	31.897	15.95	9.97	Safe
7	-0.472	-0.263	0.54	8.102	23.79	31.892	15.95	29.54	Safe
8	-1.016	-2.597	2.79	8.105	23.79	31.895	15.95	5.72	Safe
9	-1.033	2.072	2.32	8.105	23.79	31.895	15.95	6.88	Safe

P_{max} = 8.46 T/sqm

P_{min} = -2.56 T/sqm

Bearing pressure check

With Buoyancy

Table 11: Bearing pressure check 1

Load	**$F_{y\ (Load)}$**	**Soil + Fd + Pd**	**F_y**	**M_{xx}**	**Mzz**	**F_y/A (1)**	**M_{xx}/Z_{zz} (2)**	**M_{zz}/Z_{zz} (3)**	**1+2-3**	**1-2+3**	**02-01-2003**

1	6.274	23.79	30.064	0	6.21	2.78	0	1.15	1.63	3.93	3.93	1.63
2	6.269	23.79	30.059	-5E-18	-2.608	2.78	0	0.48	2.3	3.26	3.26	2.3
3	6.27	23.79	30.06	22.447	1.703	2.78	3.46	0.32	5.92	6.56	-0.36	-1
4	6.271	23.79	30.061	-22.438	1.888	2.78	3.46	0.35	5.89	6.59	-0.33	-1.03
5	8.104	23.79	31.894	2.732	8.852	2.95	0.42	1.64	1.73	5.01	4.17	0.89
6	8.107	23.79	31.897	2.752	13.268	2.95	0.42	2.46	0.91	5.83	4.99	0.07
7	8.102	23.79	31.892	2.752	4.42	2.95	0.42	0.82	2.55	4.19	3.35	1.71
8	8.105	23.79	31.895	25.189	8.759	2.95	3.89	1.62	5.22	8.46	0.68	-2.56
9	8.105	23.79	31.895	-19.696	8.936	2.95	3.04	1.65	4.34	7.64	1.56	-1.74

P_{max} = 8.46 T/sqm

P_{min} = -2.56 T/sqm

Without Buoyancy

Table 12: Bearing pressure check 2

Load	$F_{y\,(Load)}$	Soil + Fd + Pd		F_y	M_{xx}	Mzz	F_y/A (1)	M_{xx}/Z_{zz} (2)	M_{zz}/Z_{zz} (3)	1+2-3	1-2+3	02-01-2003
1	6.274	45.39	51.664	0	6.21	4.78	0	1.15	3.63	5.93	5.93	3.63
2	6.269	45.39	51.659	-5E-18	-2.608	4.78	0	0.48	4.3	5.26	5.26	4.3
3	6.27	45.39	51.66	22.447	1.703	4.78	3.46	0.32	7.92	8.56	1.64	1
4	6.271	45.39	51.661	-22.438	1.888	4.78	3.46	0.35	7.89	8.59	1.67	0.97
5	8.104	45.39	53.494	2.732	8.852	4.95	0.42	1.64	3.73	7.01	6.17	2.89
6	8.107	45.39	53.497	2.752	13.268	4.95	0.42	2.46	2.91	7.83	6.99	2.07
7	8.102	45.39	53.492	2.752	4.42	4.95	0.42	0.82	4.55	6.19	5.35	3.71
8	8.105	45.39	53.495	25.189	8.759	4.95	3.89	1.62	7.22	10.46	2.68	-0.56
9	8.105	45.39	53.495	-19.696	8.936	4.95	3.04	1.65	6.34	9.64	3.56	0.26

P_{max} = 10.46 T/sqm

P_{min} = 0.56 T/sqm

Conclusion

In this project, the several aspects of the raft foundation was highlighted. It can be seen that together the Piles & columns make the raft foundation better than other foundations. For this reason, there can be seen many benefits of using this form of foundation. Here, the different characteristics of "stone columns" and "piles" when used separately are elaborated. Moreover, the dependence of the capacity of the foundation on the soil type is also discussed here. From the obtained data how raft foundations can be designed is also elaborated here.

Recommendations

There are different things that are recommended for obtaining better results regarding the project. The first thing that can be adopted that there are different forms of columns are there. These columns should also be tried to check the results in terms of suitability of use and bearing capacity. In addition to this, there are different forms of new technologies are coming each day. These technologies should also be implemented for obtaining far better results from this project.

References

1. ALLEN, B. W. 2019. DARKNESS AND LIGHT. In *Tiber: Eternal River of Rome* (pp. 117–151). University Press of New England.
2. Author links open overlay panelAdamu Beyene Negesa, case, H. the floating and AbstractScoria gravel is widely used as stabilizer material in road construction and concrete works. However (2023) *Comparative analysis on effectiveness of crushed aggregate and scoria gravel as columnar reinforcement material under Raft Foundation*, *Results in Engineering*.
3. Author links open overlay panelIrfan Jamil a, a and AbstractContribution of the raft to lateral loads in a piled raft foundation system can be influenced by various factors

including vertical contact pressure (2022) *Factors affecting the lateral contribution of a raft in a piled raft system*, *Ain Shams Engineering Journal*.

4. CRIFASI, R. R. 2023. WESTERN WATER A TO Z. In *Western Water A to Z: The History, Nature, and Culture of a Vanishing Resource* (pp. 23–310). University Press of Colorado.
5. Kumar, D., & Sani Mohammed, D. (2023). Detection of Human Protein Structures by Select Deep Learning Models and Dynamic Systems. Tamjeed Journal of Healthcare Engineering and Science Technology, 1(1), 35–42. https://doi.org/10.59785/tjhest.v1i1.4
6. Konopatski, A. K., Konopatskii, A. K., Bland, R. L., & Kuzmin, Y. V. 2019. The Great Explorer of the Past (Academician A. P. Okladnikov: Pages of Biography). In *Aleksei P. Okladnikov: The Great Explorer of the Past. Volume I: A biography of a Soviet archaeologist (1900s - 1950s)* (pp. 1–282). Archaeopress.
7. Li, W. 2022. Elegance and Vulgarity. In *The Promise and Peril of Things: Literature and Material Culture in Late Imperial China* (pp. 81–157). Columbia University Press.
8. PÁLSSON, G., Yates, A., & Downs-Rose, K. 2020. THE BATTLE FOR HEIMAEY. In *Down to Earth: A Memoir* (pp. 117–202). Punctum Books.
9. WEISS, P., Scott, J., & Schutte, J. 2020. I. In *The Aesthetics of Resistance, Volume II: A Novel*, *Volume 2* (pp. 1–148). Duke University Press.
10. Kammer, A., Piraquive, A., Gómez, C., Mora, A., Velásquez, A., Gómez, J. and Mateus-Zabala, D., 2020. Structural styles of the Eastern Cordillera of Colombia. *The geology of Colombia*, *3*, pp.143-183.
11. Butler, A.R., 2019. *Quantifying Energy, Water, and Nutrient Inputs to Vertical Farming Systems*. Villanova University.
12. Chakraborty, S.K. and Chakraborty, S.K., 2021. Methodologies for the assessment of river ecosystem in Southern West Bengal, India. *Riverine Ecology Volume 2: Biodiversity Conservation, Conflicts and Resolution*, pp.747-855.
13. Foster, S. and Jones, S., 2020. *My life as a replica: St John's Cross, Iona*. Windgather Press
14. Bicknell, J., Judkins, J. and Korsmeyer, C. eds., 2019. *Philosophical perspectives on ruins, monuments, and memorials*. Routledge.

15. Tofaif, S., Vandyk, T.M., Le Heron, D.P. and Melvin, J., 2019. Glaciers, flows, and fans: Origins of a Neoproterozoic diamictite in the Saratoga Hills, Death Valley, California. *Sedimentary Geology*, *385*, pp.79-95.
16. Karupusamy, S., Mustafa, M. A., Jos, B. M., Dahiya, P., Bhardwaj, R., Kanani, P., & Kumar, A. (2023). Torque control-based induction motor speed control using Anticipating Power Impulse Technique. The International Journal of Advanced Manufacturing Technology, 1-9.
17. Govindarajan, S., Mustafa, M. A., Kiyosov, S., Duong, N. D., Raju, M. N., & Gola, K. K. (2023). An optimization based feature extraction and machine learning techniques for named entity identification. Optik, 272, 170348.
18. Sudha, I., Mustafa, M. A., Suguna, R., Karupusamy, S., Ammisetty, V., Shavkatovich, S. N., ... & Kanani, P. (2023). Pulse jamming attack detection using swarm intelligence in wireless sensor networks. Optik, 272, 170251.
19. Mustafa, M. A., Kadham, S. M., Abbass, N. K., Karupusamy, S., Jasim, H. Y., Alreda, B. A., ... & Ahmed, M. T. (2023). A novel fuzzy M-transform technique for sustainable ground water level prediction. Applied Geomatics, 1-7.
20. Ali, S. H., Armeet, H. S., Mustafa, M. A., & Ahmed, M. T. (2022, November). Complete blood count for COVID-19 patients based on age and gender. In AIP Conference Proceedings (Vol. 2394, No. 1, p. 020044). AIP Publishing LLC.
21. Kadham, S. M., Mustafa, M. A., Abbass, N. K., & Karupusamy, S. (2022). IoT and artificial intelligence–based fuzzy-integral N-transform for sustainable groundwater management. Applied Geomatics, 1-8.
22. Abdulazeez, M. I., Hamdi, A. Q., Mohammed, H. Y., & Ahmed, M. (2020). Dental trauma of permanent incisor teeth in children/Kirkuk city. studies, 22, 23.
23. Badi, S., Hamed, A., Abualama, M., Mustafa, M., Abdulraheem, M., & Yousef, B. (2021). Knowledge, attitude, and practice of sudanese pharmacists toward COVID-19 in Khartoum State, Sudan: An online-based cross-sectional study. Libyan International Medical University Journal, 6(01), 19-26.
24. Abdulqader, A. T., Al-Sammarie, A. M. Y., & Mustafa, M. A. (2022, May). A comparative environmental study of aqueous extracts of ginger and grapes to protect hepatocytes in Albino rabbits and a comparison of extracts in preserving Awassi lamb

meat from oxidation. In IOP Conference Series: Earth and Environmental Science (Vol. 1029, No. 1, p. 012001). IOP Publishing.

25. Mustafa, H. A., Asaad, M. M. K., Obayes, A. K., & Mustafa, M. A. (2022). Isolation and Identification of Some Types of Pathogenic Bacteria from the Prepuce (Foreskin) of Circumcised Children in Samarra City/Iraq. HIV Nursing, 22(2), 2776-2780.
26. Ali, S. H., Armeet, H. S., Mustafa, M. A., & Ahmed, M. T. (2022, November). Complete blood count for COVID-19 patients based on age and gender. In AIP Conference Proceedings (Vol. 2394, No. 1, p. 020044). AIP Publishing LLC.
27. Mustafa, M. A., Jabbar, D. A., Mohammed, H. Q., Luaibi, S. I., & Al-Ghrebawi, R. H. (2020). Effect of Percutaneous Coronary Intervention (PCI) upon Lung Functions among Patients with Ischemic Heart Disease at Al-Najaf Cardiac Center: Correlation Study. Indian Journal of Forensic Medicine & Toxicology, 14(3), 1569-1575.
28. Hasan, R. H., & Mustafa, M. A. Pharmacological effect of Panax ginseng against oxidative stress that induced by shigella in rats. European Journal of Molecular & Clinical Medicine, 7(10), 2020.
29. Mustafa, M. A., Al-Khafajy, Z. A. A. T., ALAbedi, N. F. H., Fatlawi, D. A. H., & Azooz, H. M. Risk Factors for Pre-Cholecystectomy Patients' at AL-Sadder Medical City.
30. Mustafa, M. A., Al, A. H., & Hamad, S. A. Association between vitamin D3 deficiency and iron status in children between six months to five years.
31. AL-Sammarie, A. M. Y., & Mustafa, M. A. Effect of anemia on pregnant women during the first week in Samarra city.
32. Nassief, T. A., Awwad, A. M., Nassief, T. A., & Mustafa, M. A. Determining the Oxidative State in Children with Enterobiasis Infection.
33. Al-Rasheed, A. A., Mustafa, M. A., & Ahmed, M. T. Complete blood count and some cytokines levels for COVID-19 in diabetic patients. Age (n.= 95), 59, 20-317.
34. Al-Rubaye, D., Mustafa, H. A., & Mustafa, M. A. Molecular Study of Enterococcus Faecalis Isolated from the Inflamed Roots of Teeth in Samarra City.
35. Mustafa, H. A., Al-Lateef, R. K., & Mustafa, M. A. Inhibiting the growth of two types of bacteria using honeybee extract (Apis mellifera or: Hymenoptera) of Samarra city-Iraq.
36. Aetrugh, S., Aboshkiwa, M., Husien, W., Erhuma, M., Corrente, M., Grandolfo, E., ... & Mustafa, M. (2017). Antimicrobial resistance profile and molecular characterization of

methicillin-resistant staphylococcus isolates in Tripoli Central Hospital, Libya. Libyan International Medical University Journal, 2(01), 74-83.

37. Elsir, M. A., Almoshraf, I. A., Mustafa, M. A., Hussein, A. R. M. E., & Elkhidir, I. M. (2018). Evaluation of immune response to hepatitis B vaccine in laboratory workers, Khartoum, Sudan. Clin Infect Dis, 2(106), 2.
38. Sadiq, I. M., Nooruldeen, S. A., Hasan, Z. A., & Mustafa, M. (2018). Normal Spleen Size in Adults in Kirkuk Population Using Ultrasound Scan. Journal of Kirkuk Medical College, 6(1), 34.
39. Shakir, O. M., Abdulla, K. K., Mustafa, A. A., & Mustafa, M. A. (2019). Investigation of the presence of parasites that contaminate some fruits and vegetables in the Samarra City in Iraq. Plant Arch, 19, 1184-1190.
40. Abdulazeez, M., Hussein, A. A., Hamdi, A. Q., & Mustafa, M. A. (2020). Estimate the Complications That Resulting from Delayed Management of Dental Trauma in Tikrit City. Journal of Cardiovascular Disease Research, 11(2), 80-82.
41. Hasan, T. A. H., Erzaiq, Z. S., Khalaf, T. M., & Mustafa, M. A. (2020). Effect of Equisetum Arvense Phenolic Extract in Treatment of Entamoeba Histolytica Infection. Systematic Reviews in Pharmacy, 11(11), 618-620.
42. Nijris, O. N., Khaleel, Z. I., Hamady, S. Y., & Mustafa, M. A. (2020). The effectiveness of Aqueous Extract of Grape Seeds Vitis vinifera as an antibiotic for some microorganisms and its Protective Role Histology for Liver, Kidney in Mice. Indian Journal of Forensic Medicine & Toxicology, 14(2), 1838-1845.
43. Mustafa, M. A., Jabbar, D. A., Mohammed, H. Q., Luaibi, S. I., & Al-Ghrebawi, R. H. (2020). Effect of Percutaneous Coronary Intervention (PCI) upon Lung Functions among Patients with Ischemic Heart Disease at Al-Najaf Cardiac Center: Correlation Study. Indian Journal of Forensic Medicine & Toxicology, 14(3), 1569-1575.
44. Abdulazeez, M. I., Hamdi, A. Q., Mohammed, H. Y., & Ahmed, M. (2020). Dental trauma of permanent incisor teeth in children/Kirkuk city. studies, 22, 23.
45. Badi, S., Hamed, A., Abualama, M., Mustafa, M., Abdulraheem, M., & Yousef, B. (2021). Knowledge, attitude, and practice of sudanese pharmacists toward COVID-19 in Khartoum State, Sudan: An online-based cross-sectional study. Libyan International Medical University Journal, 6(01), 19-26.

46.
47. Mahdi, E. M., & Mustafa, M. A. (2022). Effect of different concentrations of extract of Urtica dioica and Cladosporium cladosporiodes on Tribolium castaneum or: Coleoptera after 24-48 hours of exposure in Samarra City/Iraq. HIV Nursing, 22(2), 3207-3210.

48. Yaseen, R. A. A., Ibrahim, M. A., & Mustafa, M. A. (2022). The effect of Schanginia aegyptica and Urtica dioica powder on the growth of Trigonella foenum seedlings in laboratory sterilized soil. HIV Nursing, 22(2), 243-247.
49. Ali, O. S., & Mustafa, M. A. (2022). Complete Blood Count in Children with Acute Diarrhea in Samarra City, Iraq. HIV Nursing, 22(2), 1198-1202.
50. Mahdi, E. M., & Mustafa, M. A. (2022). Effect of different concentrations of extract of Urtica dioica and Cladosporium cladosporiodes on Tribolium castaneum or: Coleoptera after 24-48 hours of exposure in Samarra City/Iraq. HIV Nursing, 22(2), 3207-3210.

51. Ali, A. H., Ahmed, H. S., Jawad, A. S., & Mustafa, M. A. (2021). Endorphin: function and mechanism of action. Sci Arch, 2, 9-13.
52. Asaad, N. K., Razooqi, Q. A., & Mustafa, M. A. (2021). Toxicity of Cadmium Chloride on White Rats Liver and the Protective Role of Brassica Nigra Seed Extract. Indian Journal of Forensic Medicine & Toxicology, 15(2), 4203-4211.
53. Ibrahim, M. A., Mustafa, M. A., & Saleh, M. N. (2021). The Effectiveness of Zeolite in Treating Some Physical and Chemical Properties of Wastewater Discharged from General Sharqat Hospital. Indian Journal of Forensic Medicine & Toxicology, 15(2), 1714-1720.
54. Abdula, R., Fatah, S., Salih, G., Mustafa, M., & Ali, M. (2021). Source rock evaluation of the Chia Gara Formation in the Bekhme-1 well, Harir District, Kurdistan Region, Iraq. JJEES, 106.
55. Ali, A. H., Ahmed, H. S., Jawad, A. S., & Mustafa, M. A. (2021). Endorphin: function and mechanism of action. Sci Arch, 2, 9-13.
56. Asaad, N. K., Razooqi, Q. A., & Mustafa, M. A. (2021). Toxicity of Cadmium Chloride on White Rats Liver and the Protective Role of Brassica Nigra Seed Extract. Indian Journal of Forensic Medicine & Toxicology, 15(2), 4203-4211.

57. Mustafa, M. A., AL-Samarraie, M. Q., & Ahmed, M. T. (2020). Molecular techniques of viral diagnosis. Science Archives, 1(3), 89-92.
58. Ibrahim, M. A. (2020). Effectiveness of zeolite in treating some physical and chemical properties of wastewater discharged from Salah al deen hospital. Journal of Education and Scientific Studies, 7(16).
59. Mustafa, M. A., Al-Tameemi, H. M., & Hakim, M. (2020). Nurses' roles towards patient undergoing cardiac catheterization at Al-Najaf Governorate: Patient Perspective. American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS), 64(1), 200-209.
60. MUSTAFA, M. A. A. K., & HASSAN, D. H. S. (2020). Effectiveness of Nursing Intervention on Early Complications for Patients undergoing Coronary Catheterization. International Journal of Pharmaceutical Research, 12(2).
61. Fadhil, K. B., Majeed, M. A. A., & Mustafa, M. A. (2019). Electronic study of fresh enzyme complexes of antifungal drugs-P450 and Aspergillus kojic acid biosynthesis. W: w saccharose flavus: fructose as a substratum. Annals of Tropical Medicine and Health, 22, 65-72.
62. Matthews, C., Kneale, D., & Mustafa, M. (2018). Effects of Continuous Grazing on Natural Pastures in the Alazarza Region of the Blue Nile State of Sudan. CCAMLR Science, NA-NA.
63. Alhamdany, W. A., Mustafa, M. A., & Mohammed, M. J. (2017). The Study of Physiological Effect of some Common Male Sexual Activators on Prostate Specific Antigen (PSA) and some Hormones and Lipid Components in The Male Rabbets. Tikrit Journal for Agricultural Sciences, 17(2).
64. Mustafa, M. A., Rahman, M. A. A., & Almahdawi, Z. M. M. (2023). Male Infertility Treatment Unveiled: Exploring New Horizons with Q-Well 10-Results from a Pioneering Medical Study.