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GEOTECHNICAL AND RADIOMETRIC STUDIES FOR EL-HAMRAWEIN AREA-EASTERN DESERT- EGYPT

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ABSTRACT

This research involves geotechnical and radiometric studies for El-Hamrawein area- Eastern Desert- Egypt. The studied area is mainly composed of gravely sands enriched soil cover the rock with large thickness. Laboratory tests were performed on representative soil and rock samples to determine their physical, mechanical and chemical characteristics such as: grain size distribution, specific gravity, moisture content, bulk density, shear box, bearing capacity, unconfined compressive strength, chemical analysis, uranium and thorium concentrations of rocks and soils. One hundred and eight samples were collected from 16 boreholes and classified into 24 rock sample and 84 friable sand and gravel, have been taken at a depth from 1 to 15 m. Uniformity coefficient (**C_u**) value ranges from (4.55mm) to (7.91mm) and curvature coefficient (Cc) value ranges from (1.98mm) to (0.70mm). The studied samples in this study are classified as well-graded soil from the point of view of classification engineering geology. Specific gravity values range from 2.47 to 2.70. The geotechnical studies include direct shear test, where effective friction angle (ϕ) range from 36º to 37º and bearing capacity of soil are ranging from (1901 KN/m^2 to 2059 KN/m^2). Radiometric studies including gamma-ray logging and quantitative uranium and thorium analyses were carried out in order to give an idea about the distribution of uranium and thorium in the study area. Uranium ranges from 1.8ppm to 2ppm, thorium range from 3.6ppm to 4.2ppm at different depths from 0 to 5m. These values indicate that the area has safe radiation .

Keywords: Soil, shear box, radiometric, uniformity coefficient.

1. INTRODUCTION

The present research deals with the geotechnical and radiometric studies to get information about the foundation beds and determine the risk zone of the urbanized. The study area is located in the central part of the Eastern Desert along Red Sea Coast at the north western part of the Red Sea. It lies about 20 km north of El Quseir city and at about 60 km south of Safaga. The area is approximately 1000 km^2 and raise from 21 to 27m above sea level. It is bounded by Longitudes 33° 45/ and 34° 22/ E .and Latitudes 26° 00/ and 26° 47/ N **(Fig. 1).**

The main topographic features are Wadi El Nakheil, Gebel Duwi, Gebel El Anz, Wadi El Atshan, Wadi El Sodmein, Wadi Abo Zirayb and others. It is also bounded by the Pre-Cambrian rocks of the Red Sea Hills from the west, and the Red Sea Coast from the east. It is considered as one of the old phosphate on the Egyptian Red Sea Coast. Some sediments have brown color due to phosphate shipment operations. In the last few years, the Red Sea Coast has one of the most important areas, which receives considerable attention by the government as one of the promising sites for development in Egypt. It is characterized by considerable Tourist's potentialities and the existence of important phosphate mines. The area under investigation was affect by serious flash floods that took place occasionally in the region. The most recent flood event that hit the area and the properties on the shore lines was that of 1997 **[1], [2] and [3].**

The exposed rocks of El Hamrawein area are composed of more than 1300 m**.**thick**.**The area is geologically significant because it is can be used as a model for rift blocks development in Phanerozoic sedimentary succession between Pre- Cambrian basement rocks. It is considered a part of rift system; this rift system was formed by the antilock wise rotation of Arabian Plate away from African Plate about a pole of rotation in the central or south – central Mediterranean Sea **[4], [5] and [6]**.

2. GEOLOGIC SETTING

Stratigraphically, the area is dominated by a wide variety of rocks. Pre-Cambrian basement rocks covered by Cretaceous, Tertiary and Quaternary sediments which were deposited in synclinal fold within the basement complex rocks. The stratigraphy and the structures of the Upper Cretaceous – Lower Tertiary sequence in the Quseir –Safaga area was studied by many authors such as **[7], [8], [9], [10], [11], [12], [13 a,b], [14] and [15],** has identified the region as a syncline structure . Also, **[16]** divided the sedimentary rocks of region into two divisions: the pre-rifting Oligocene and later sedimentary group. Hence, the term tectono stratigraphy is introduced to the rock assemblages of such divergent rift basin **[17]**.

The rocks cropping out is divided into two groups based on tectonic and stratigraphic aspects, pre-rift and syn-rift sedimentary groups. The pre-rift sedimentary rocks are exposed all over the central and western parts of the study area. The pre-rift sequence is essentially Late Cretaceous to Early Eocene in age, and overlies non- comfortably the Pre-Cambrian basement and is comparable to that found in the Red Sea. The Pre-Cambrian basement rocks, cropping out along the western margin belong to the Eastern Desert of Egypt. Based on lithology and age, the basement rocks of the Eastern Desert of Egypt have been divided into three domains; North ,Central, and South Eastern Desert.

2.1. Structure Setting

El Hamrawein area was affected by different types of structure, of which faulting is the predominant. Folding plays an important role in the deformation, and is generally related to these faults. It can be classified into two large structural blocks; these are the Western and Eastern blocks separated by Queih and Hamrawein Shear Zones. The area is highly

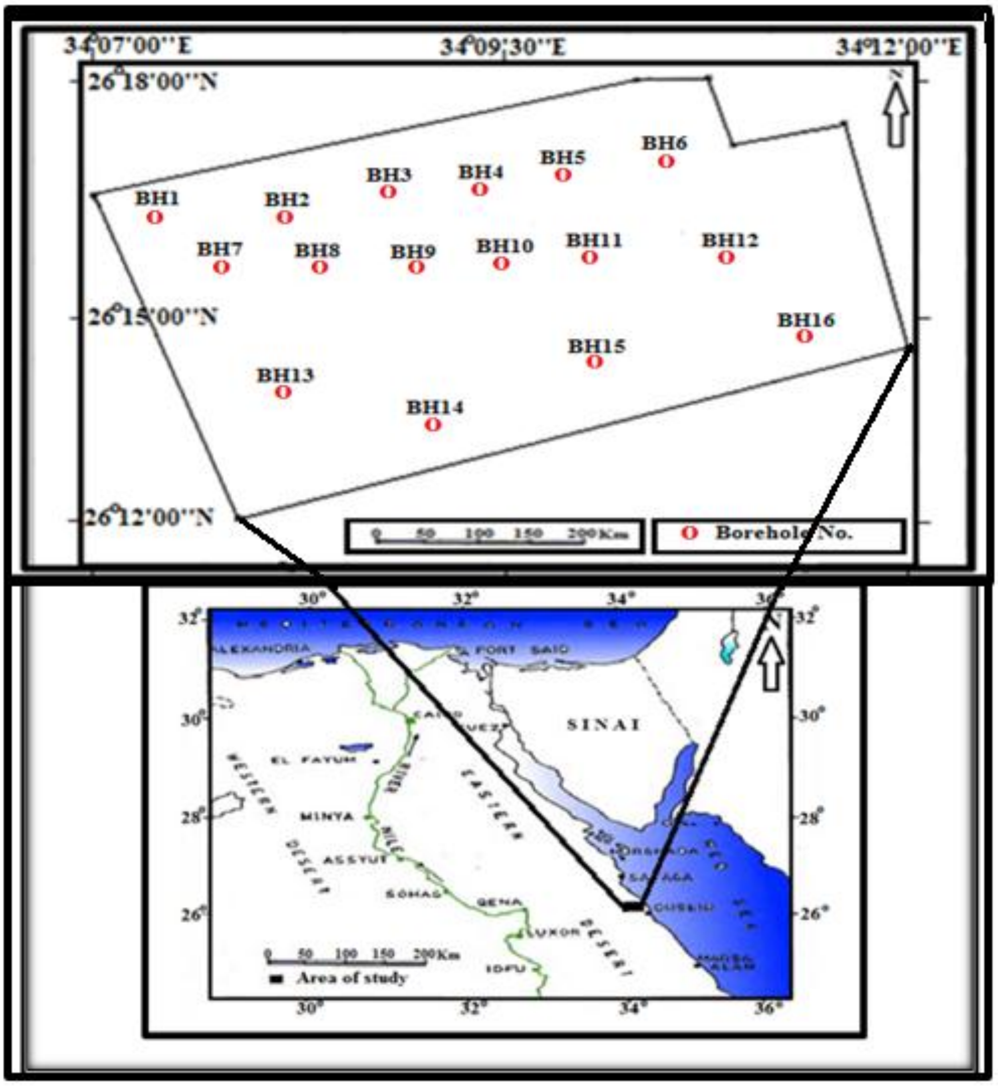

Fig. 1: Location map of the study area with boreholes and measured sections.

complicated affected by the faults, folds, (anticlines and synclines) unconformities and disconformities **[18]**.

The area under study has been affected by major faults of different trends. These trends are NW, NNW, NS and NE normal faults; all the mapped faults have normal movements due to an extensional force. Five of the main faults are extending for long distance and play an essential role in shaping of the structural setting of the area. These are:-

a) El Nakheil Fault (NF)
b) Atshan Fault (ATF)
c) Queih – Abu Shegeily Fault (QAF)
d) Um El Huwytat Faults (UHF)
e) West Gebel Duwi Fault (WGDF)

Folds have an important role in the structural framework of the area. A group of NNW oriented folds is associated with the mapped parts of the Nakheil (NF) Mohammed Rabah (MRF) Um El Huwytat (UHF) and Atshan (ATF) faults. Five of these fault related folds will be studied more detail. These are

a) El Nakheil Syncline (NS)
b) Atshan Syncline (ATS)
c) El Anz Syncline (AS)
d) Um El HUwytat Syncline (UHS)
e) Mohammed Rabah Syncline (MRS).

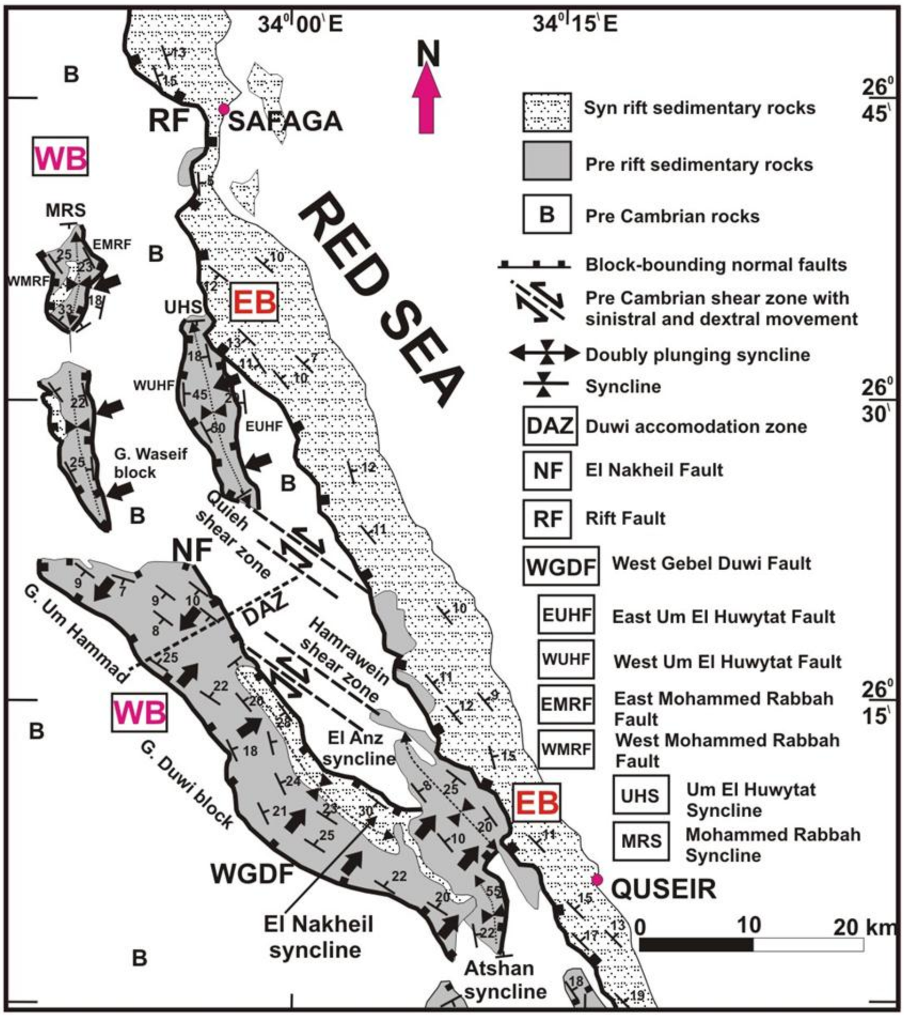

Fig. 2: Map showing principal structural elements and fault blocks of El Hamrawein and surrounding areas, modified after **[19] and [20].** Queih and Hamrawein shear zones after **[20] and [21],** respectively. Short bold arrows show main dip direction of pre-rift sediments. WB: Western block; EB: Eastern block.

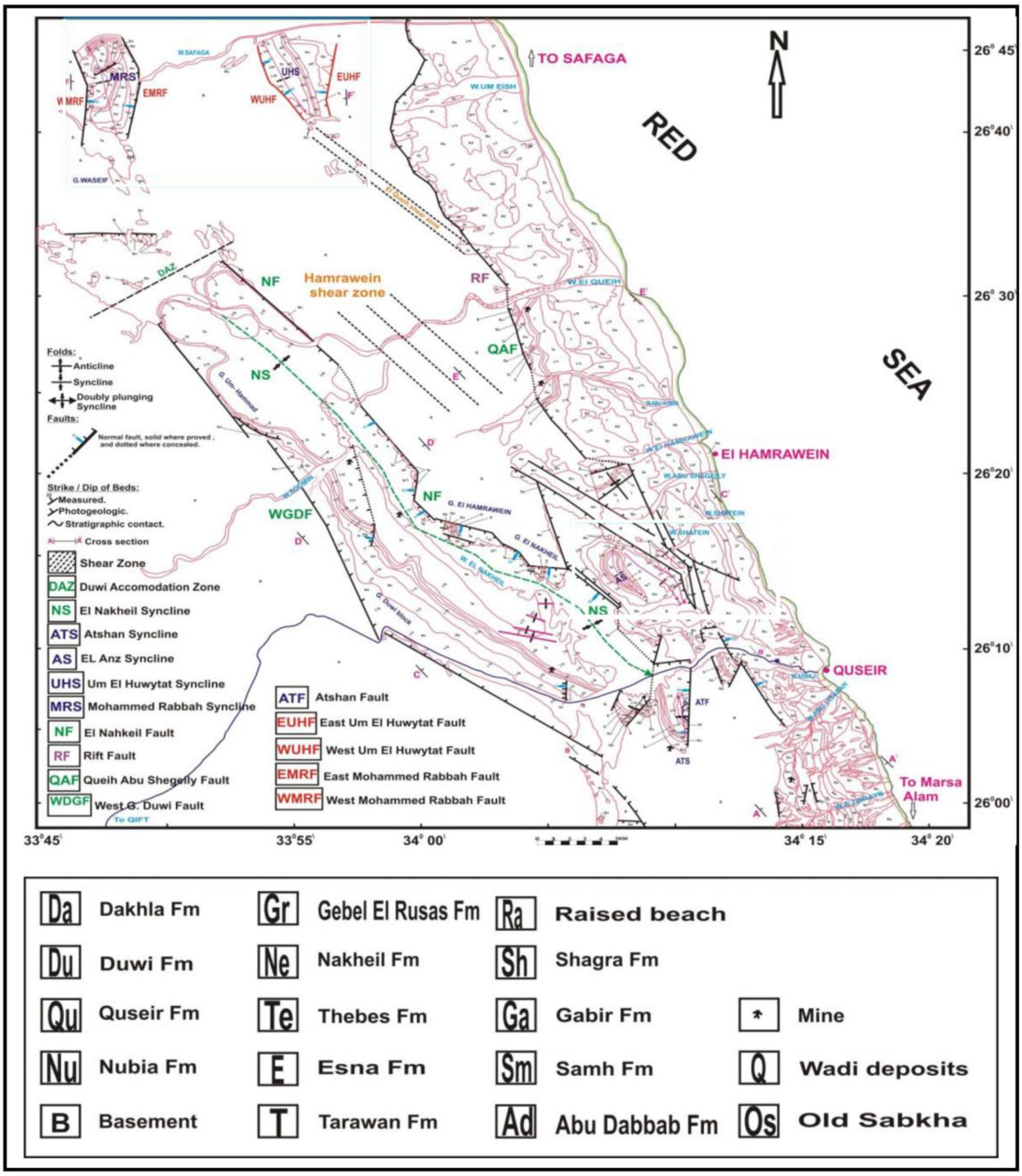

Fig. 3: Geological map of El Hamrawein surrounding areas, NW Red Sea, Eastern Desert, Egypt. **(after [22]).**

3. Physical and Engineering Properties of Soil

In the present research the laboratory tests on the soil samples are grain size distribution, specific gravity, direct shear test , insoluble residual, unconfined compressive strength and chemical analysis.

3.1. Grain Size Distribution

Grain size analysis used for different purposes, such as textural, description, testing and the behavior of sediment during transportation, deposition and to interpret the depositional environments under which these sediments were deposited and evaluation of soil for engineering uses.

From the particle size distribution curve, the values of D10, D25, D30, D50, D60, D75 and D90 were obtained and the mathematical values were calculated according to the formulas of **[23].** The most common procedure based on numerical values is known as Allen Hazen's method. On the basis of a great number of tests with filter sands, **[23]** found that the permeability of these sands in a loose state depends on two quantities that called the effective size and the uniformity coefficient.

The effective size is the diameter Dl0 that corresponds to P = 10% on the grain-size diagram. In other words, 10% of the particles are finer and 90% coarser than the effective size. The uniformity coefficient Cu is equal to D60 / D10. Wherein is the grain size corresponding to P = 60%. A third characteristic of the grain-size distribution, useful in the classification of soils are the coefficient of curvature Cc. defined as D230/Dl0 D60.The results are shown in table (2) these parameters are discussed as follows:

Grain size analysis of the studied samples is shown in table (1). The effective diameter values range from (0.54mm) to (1.18mm) whiles the values of uniformity coefficient range from (4.55mm) to (7.91mm) and the values of curvature coefficient range from (0.70mm) to (1.98mm).These values indicate that the soil is well-graded soil.

3.2. Specific Gravity

The specific gravity (Gs) is the ratio of the weight of the soil solids to the weight of water of equal volume.Table (2) gives the calculated values of specific gravity of the El Hamrawein area. its value range from 2.47 to 2.70

3.3. Unit Weight of Studied Soils

The unit weight or bulk density is the ratio of mass of moist soil to the volume of the soil sample, and is indication to porosity and saturation of soil mass; also it is very important in soil shear strength, settlement and soil pressure as in retained wall designing, The soil unit weight, of course, depends on the packing, compaction, and humidity condition of the soil. (Table 2) shows the results of the dry unit weight of the studied samples. Its values range from 1.81 KN/m^3 to 1.99 KN/m^3.

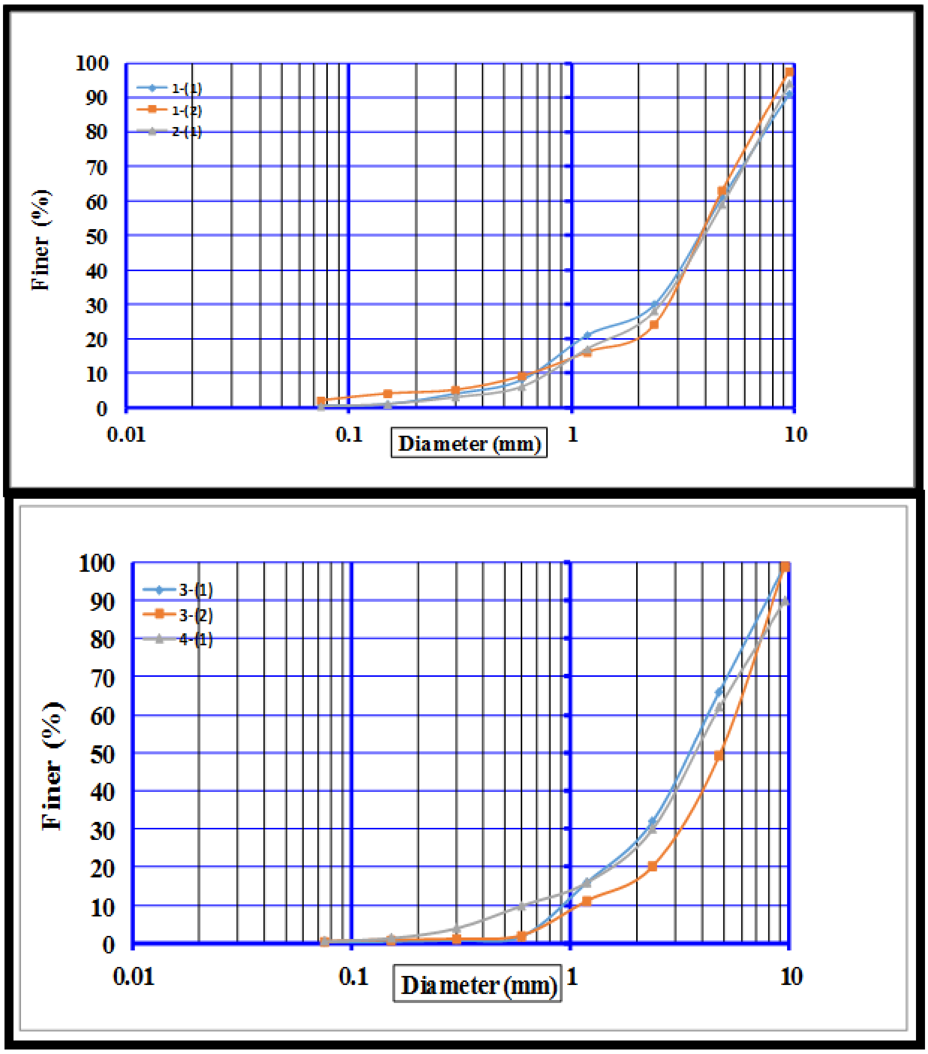

Fig. 4: Grain size distribution curve of the studied samples.

3.4. Natural Water Content

The moisture content is defined as the ratio of the weight of water (Ww) present in a given soil mass to the dry weight of solid soil particles (W_d). It determined by oven – drying method or by pyconometer method. The oven – drying method is the most accurate method of determining the water content and is therefore used in the laboratory according to **[24].** (Table 2) shows the results of the water content of studied samples. Its values range from 5.1 to 7.3%.

3.5. Degree of Aggressive for Soil (Chemical Analysis)

The chemical analysis is mainly used to determine the degree of aggressive of soils and that through determination of sulphates and chlorides salts content. The water extraction

Table (1): Results of grain size analysis of the studied samples.

Sample No.	Weight % of fracture								Mathematical Values					
	9.5-4.75	4.75-2.36	2.36-1.18	1.18-0.6	0.6-0.3	0.3-0.15	0.15-0.75	>0.075	D10	D30	D50	D60	C_U	C_C
1-1	9	30	31	9	13	4	3	1	0.67	2.4	3.9	4.9	7.31	0.78
1-2	2.4	36.6	39	8	7	4	1	2	0.61	2.9	3.9	4.53	7.42	1.11
2-1	6	35	31	11	11	3	2	1	0.8	2.36	4	4.9	6.12	0.90
3-1	11	23	34	16	14	1	0.6	0.4	0.9	2.3	3.5	4.1	4.55	1.16
3-2	11	40	29	9	9	1	0.6	0.4	1.18	3.1	4.75	5.7	4.83	1.98
4-1	10	28	32	14	6	6	2.6	1.4	0.6	2.36	3.81	4.75	7.91	0.70
4-2	10	39	29	12	7	2	0.6	0.4	1.18	3	4.75	5.7	4.83	1.86
5-1	29	15	24	18	9	3.6	0.8	0.6	0.9	2.3	4	5.56	6.17	0.85
6-1	36	11	29	11	9	2.4	1	0.6	0.91	2.9	4.6	5.33	5.85	1.43
7-1	6.6	22.4	45.4	6.4	10.6	5.8	1.8	1	0.65	2.67	3.6	4	6.15	1.15
7-2	7.4	23	45.8	4.2	12.6	3.8	2.4	0.8	0.73	2.68	3.7	4	5.47	1.31
8-1	8	23.6	43	5.4	14.2	3	2.2	0.6	0.75	2.73	3.61	4.2	5.6	1.33
8-2	7.8	21	48.4	5.2	8	4.2	2.6	0.8	0.68	2.81	3.8	4.1	6.02	1.31
9-1	9	21.6	47.4	5.4	9	3	2.2	2.4	0.71	2.82	3.62	4	5.71	1.37
10-1	12.6	19.2	50.6	4	4.4	5.8	1.2	2.2	0.6	2.94	3.81	4.33	7.21	1.19
11-1	12	22	35	14	6	8	1.8	1.2	0.54	2.45	3.55	4.2	7.77	0.77

Table (2): Shows the results of the natural water content, dry unit weight and specific gravity at the study area.

Sample No.	Natural Water Content %	Dry Unit Weight (KN/m^3)	Specific gravity (G/CC)
1-1	5.1	1.90	2.68
1-2	5.3	1.92	2.60
2-1	5.6	1.95	2.47
3-1	5.4	1.99	2.57
3-2	6.4	1.87	2.56
4-1	5.5	1.81	2.49
4-2	7.2	1,91	2.54
5-1	6.1	1.95	2.51
6-1	7	1.80	2.50
7-1	5.2	1.88	2.60
7-2	7.3	1.97	2.70
8-1	5.8	1.84	2.61
8-2	6.5	1.93	2.69
9-1	6.4	1.95	2.59
10-1	6.7	1.86	2.55
11-1	6.2	1.94	2.53

method can be used for the sulphate, chloride, and pH values. From table (3) the studied samples at El-Hamrawein area according to sulphate (So_3^{--}) and chloride (Cl^-) contents classified as non-aggressive soil. The pH values also indicated that all of the studied samples are non-aggressive soil. The chemical analysis values indicate the soil is non aggressive, where it's in the limit allowed according to Egyptian code [25]. So, this type of soil is suitable for construction.

3.6- Direct Shear Test

A direct shear test is a laboratory test used by geotechnical engineers to measure the shear strength properties of soil material. The direct shear test values are shown in table (4). For each test, the shear stress and normal stress at failure are plotted for each of the three tests to determine the slope (effective friction angle, ϕ) and intercept (effective cohesion, c) from the best linear fit of the data. These parameters ϕ and c are very important to calculate the soil bearing capacity.

3.7- Bearing Capacity

Terzaghi **[26]** used an approximate method to determine the ultimate bearing capacity, qu. depending on cohesion; C, surcharge; q and unit weight of soil; γ and give general equation as the following:

$$qu = qc + qq + q\gamma = c\,Nc + q\,Nq + 1/2\,\gamma\,BN\gamma \quad \ldots (1)$$

Equation (1) is referred to as bearing capacity equation. The terms Nc, Nq, and N γ are called the bearing capacity factors. The values of these factors are given as constants according to value of ϕ. The main equation for calculation of square footing bearing capacity states as in equation (2).

$$qu = 1.3\,c\,Nc + q\,Nq + 0.4\,\gamma'\,BN\gamma \quad \ldots (2)$$

When the factor of safety, Fs, of about 3 or more is applied to the ultimate soil-bearing capacity arrive at the value of the allowable bearing capacity. An Fs of 3 or more is not considered too conservative.

$$qall = qu / Fs \quad \ldots (3)$$

The results of ultimate bearing capacity of square footing are given in table (5). It was found that, The ultimate bearing capacity increases sharply for a cohesionless soil (c = 0) because of cohesionless soil angle of internal friction (ϕ) is more equal to 30° due to which N_C, Nq and Nγ increase which cause a sharp increase in ultimate bearing capacity. So, this type of soils have good load bearing capacities.

Table (3): Results of chemical analysis of the studied samples.

Sample No.	TDS (%)	Total Chlorides Cl ppm	Total Sulphates SO_3 (%)	pH Value	Degree of Aggressive
1-1	0.742	0.0089	0.098	7.8	Non Aggressive
1-2	0.852	0.0094	0.055	8.1	Non Aggressive
2-1	0.460	0.0092	0.045	7.6	Non Aggressive
3-1	0.453	0.0098	0.058	7.8	Non Aggressive
3-2	0.562	0.0099	0.051	7.9	Non Aggressive
4-1	0.671	0.0098	0.061	8.8	Non Aggressive
4-2	0.371	0.0092	0.063	7.5	Non Aggressive
5-1	0.677	0.0078	0.056	7.3	Non Aggressive
6-1	0.585	0.0093	0.047	8.4	Non Aggressive
7-1	0.474	0.0096	0.053	7.4	Non Aggressive
7-2	0.876	0.0081	0.061	8.2	Non Aggressive
8-1	0.733	0.0079	0.058	8.4	Non Aggressive
8-2	0.683	0.0085	0.042	7.4	Non Aggressive
9-1	0.543	0.0093	0.057	7.7	Non Aggressive
10-1	0.821	0.0080	0.061	7.5	Non Aggressive
11-1	0.672	0.0082	0.049	7.2	Non Aggressive

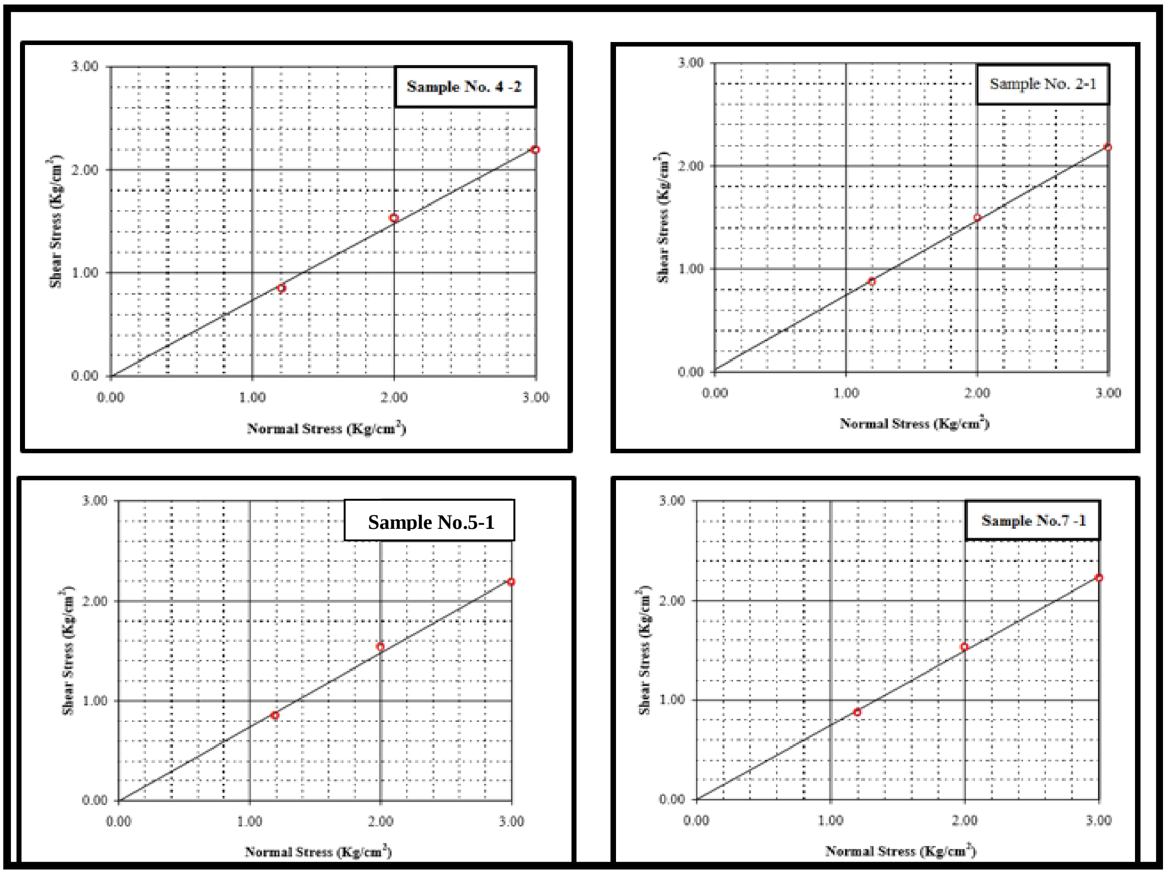

Fig. 5: Shear stress versus normal stress of the studied samples.

Table (4): Shear box data of the studied samples.

Sample No.	Normal Stress (Kg/cm^2)	Shear Stress (Kg/cm^2)	Friction Angle (ϕ)	Cohesion C (Kg)
2-1	1.20	0.85	36	0.00
	2.00	1.45		
	3.00	2.18		
4-2	1.20	0.83	37	0.00
	2.00	1.47		
	3.00	2.02		
5-1	1.20	0.81	36	0.00
	2.00	1.45		
	3.00	2.02		
7-1	1.20	0.84	37	0.00
	2.00	1.48		
	3.00	2.02		

Table (5): The ultimate soil bearing capacity of the studied samples.

Sample No.	Friction Angle(ϕ)	Cohesion (C) (Kg)	Nc	Nq	Nγ	Qu (KN/m^2)
2-1	36	0.00	68.2	68.2	48.3	1901
4-2	37	0.00	57.8	52.7	58.9	2059
5-1	36	0.00	68.2	68.2	48.3	1901
7-1	37	0.00	57.8	52.7	58.9	2059

4. Physical and Engineering Properties of Rocks:

4.1. Insoluble Residue

The insoluble residue is a chemical method to calculate the calcareous content of soil which indicates to degree of solubility of soil by ground water's chemical solution as carbonic acid or rain action. The contents of carbonate are determined by using 10% dilute hot hydrochloric acid. The insoluble residue (I.R) was thoroughly washed with distilled water, dried and weighted. The contents of carbonate and clastics (sand, silt and clay) were determined. The values of insoluble residue of the studied samples are shown in table 6.

Table (6): The insoluble residual results to the studied samples

Sample No.	Carbonate %	Non Carbonate	
		Sand %	Silt & Clay %
1-3	52	32	16
2-2	72	20	8
3-3	100	_	_
4-3	85	8	7
7-3	64	20	16
8-3	82	10	8
9-2	88	4	8
10-2	100	_	_
11-3	100	_	_
12-3	70	21	9
14-3	95	4	1
15-2	97	2	1

4.2- Unconfined Compressive Strength

Unconfined (or uniaxial) compressive strength, is normally determined by statically loading a cylinder, cube, square, of soil to failure, the load being applied across the upper and lower faces of the sample. The results obtained are in part a function of the length breadth ratio of the sample and of the rate of loading. The simplicity of the test is somewhat deceptive **[27]** Samples should be undisturbed. The results of this test are shown in table (7). The majority of the studied samples are medium hard and high strength according to Egyptian code. The rocky soil is a good soil for direct foundation.

Table (7): Compressive strength results to the studied samples.

Sample No.	Density Kg/cm^3	Compressive Strength kg/cm^2	Rock type
1-3	2.41	214	Medium hard
2-2	3.15	30.5	Weak
3-3	2.55	323	Medium hard
4-3	2.39	280	Medium hard
7-3	2.66	364	Medium hard
8-3	2.61	355	Medium hard
9-2	2.77	83.3	Medium weak
10-2	2.35	274	Medium hard
11-3	2.57	340	Medium hard
12-3	2.65	360	Medium hard
14-3	2.11	201	Medium hard
15-2	2.95	29.7	Weak

5. Radiometric Measurements

Exposures can also vary as a result of human activities and practices. In particular, the building materials of houses and the design of ventilation systems strongly control levels of radiation. The averages of radiation doses are usually different depending on the source and type of radiation (Table 9). The average global exposure doesn't specify to any one alone since there is a wide distribution of exposures from each source. The effective doses share in various ways at each location; depend essentially on the specific concentration of radionuclides in the environment and in the body, the latitude and altitude of the location.

The occupational exposure of any worker shall be so controlled that the following limits be not exceeded. An effective dose of 20 mSv per year averaged over five consecutive years. An effective dose of 50 mSv in any single year. An equivalent dose to the lens eye of 150 mSv in a year, and an equivalent dose to the extremities (hand and feet) or the skin of 500 mSv in a year (Table 9). **[28]and [29a]** Radioprotection**,[30 a,b].** For non-workers (i.e. individuals doesn’t related to radiation by any mean) the annual limit is 1 mSv/y.

Table (8): Occupational dose limits [27 and 28a].

Type of limit	Occupational limit
Effective dose	20 mSv per year, averaged over defined period of 5 years
Annual equivalent dose in: Lens of the eye	20 mSv
Skin	500 mSv
Hands and feet	500 mSv

Table (9): Averages of annual effective radiation dose from natural sources [30a,b].

Source	Average Annual Effective Dose (mSv)	Typical Range (mSv)
1) External exposure: Cosmic rays Terrestrial gamma rays	0.4 0.5	0.3-1.0 a 0.3-0.6 b
2)Internal exposure: Inhalation (mainly radon) Ingestion	1.2 0.3	0.2-10 c 0.2-0.8 d
Total	2.4	1-10

a: Range from sea level to high ground elevation.
b: Depending on radionuclide composition of soil and building materials.
c: Depending on indoor accumulation of radon gas.
d: Depending on radionuclide composition of foods and drinking water.

Table (10): Radioactivity of the studied samples at 2.0 depth.

Sample No.	eU (ppm)	eTh (ppm)	eRa (ppm)	K %
1-1	ULD	3	2	1.74
5-1	2	3	4	1.44
8-1	ULD	1	1	1.41
12-1	4	7	2	1.48
2-1	ULD	3	3	1.55
6-1	1	3	1	1.65
7-1	2	5	7	1.56
7-2	1	4	5	1.55
8-2	2	5	7	1.48
9-1	DLU	3	2	1.50
14-2	DLU	2	1	1.46
16-1	DLU	3	2	1.61
average	2	4.2	3	1.53

Table (11): Radioactivity of the studied samples at -5.0 m depth.

Sample No.	eU (ppm)	eTh (ppm)	eRa (ppm)	K%
3-2	2	3	2	1.44
4-1	3	3	2	1.52
10-1	2	3	1	1.55
13-1	2	5	2	1.44
11-2	1	3	2	1.63
4-2	1	6	1	1.66
15-1	2	5	4	1.76
12-2	1	2	5	1.69
14-2	2	4	5	1.51
11-1	2	2	4	1.66
average	1.8	3.6	2.9	1.50

CONCLUSION

This study deals with the geotechnical and radiometric studies of the foundation beds of El Hamrawein area- Eastern Desert- Egypt. The geotechnical studies included the physical and engineering properties of soil and rock samples as well as their effects on the construction stability. According to the Unified Soil Classification System (USCS) and chemical analysis of coarse grained soil the studied samples are well graded soil and non aggressive. This type of soils have good load bearing capacities, good drainage qualities and the study area is suitable for direct foundation above them, because they have a high foundation strength. On the other hand, from radiometric measurements the study area is safe radiation for human activities.

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الملخص العربي :

يتضمن هذا البحث الدراسات الجيوتقنيه والاشعاعيه لمنطقه الحمراوين مصر حيث تتكون تربه منطقه الدراسه بشكل اساسى من الرمال والحصى المغطاه باالصخور ذات السمك الكبير حيث اجريت بعض الاختبارات المعمليه على العينات الممثله لمنطقه الدراسه وذلك لتحديد الخواص الفيزيائيه والميكانيكيه والكيميائيه مثل توزيعات التدرج الحبيبى ،الوزن النوعى،محتوى الرطوبه،الكثافه الجافه،اختبار القص،اختبار قدره التحميل،اختبار الانضغاط والتحليل الكيميائى لمعرفه تركيز بعض العناصر المشعه مثل اليورانيوم والثوريوم للتربه والصخر .حيث يوجد ١٠٨ عينه رسوبيه جمعت من ١٦ جسه وتصنف الى ٨٤ عينه من الرمال والحصى المفتت و٢٤ عينه صخريه والتى اخذت على اعماق من ١ الى ١٥ متر. حيث تتراوح قيم معامل الانتظام بين (4.55-7.91) بينما تتراوح قيم معامل التدرج بين (0.70-1.98)وتدل هذه النتائج على ان التربه ذات تدرج ضعيف وذلك من خلال وجهه النظر الهندسيه. بينما قيم الوزن النوعى تتراوح بين -2.45) 2.70 مم(وتشمل الدراسات الجيوتقنيه ايضا اختبار القص المباشر حيث تاثير زاويه الاحتكاك يتراوح بين (36^0-37^0) والسعه التحميليه تتراوح بين -1901) 2059 كيلونيوتن/متر٢ . من ناحيه اخرى تشتمل الدراسات الاشعاعيه علي تسجيلات اشعه جاما والتحليل الكمى لليورانيوم والثوريوم والتى تم تنفيذها لاعطاء فكره عن توزيعات اليورانيوم والثوريوم فى منطقه الدراسه حيث تتراوح قيم اليورانيوم بين (1.8-2) جزء فى المليون بينما قيم الثوريوم تتراوح بين (3.6-4.2) جزء فى المليون على اعماق مختلفة من صفر الى خمسه متر.وهذا يدل على ان المنطقة امنه اشعاعيا.