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SOME MECHANICAL PROPERTIES OF SANDY GYPSEFEROUS SOILS IN RUMAILA - KHOR AL-ZUBAIR AREA, SOUTHERN IRAQ

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ABSTRACT

Six gypseferous soil samples were collected from Rumaila to Khor Al-Zubair areas, Didibba Desert west of Basrah city, Southern Iraq. These soil are gypseous in nature with an average gypsum content of 15.5% W/w The mineralogical analyses revealed that they are consisting of quartz, gypsum, carbonate, and feldspar. The grain size analysis showed that the sand fraction form more than 80% of soil samples understudy. Several geotechnical properties were determined. The testing program comprises the determination of the effect of the different gypsum contents on the shear strength parameters; cohesion and internal friction angle of the gypseferous soils under consideration. Furthermore, the testing program exhibits the cohesion increases as gypsum contents increases up to 20% then decreases at 30%. The results indicate that the improvement and deterioration of cohesion and shearing strength of soils are a result of the gypsum dual role, firstly bonding the soil particles, causing the and soil enhancement (up to 20% added gypsum), and secondly causing the flocculation of soil particles leading to the deterioration (More than 20% added gypsum) of cohesion and shear strength of the gypseferous soils.

INTRODUCTION

The climatic condition in Dibdibba Desert is characterized by hot climate, irregular rain and falls only during winter, the average annual rain fall is about 133 mm (Al-Marsoumi and Al-Mosaeed, 1999). However, the rainfall in desert region is very low: and occurs with high intensity over short periods, creating flash floods, these floods play a significant role in salt dissolving and redeposition after evaporation Stioho (1985). Based on the global distribution of dry lands suggested by UNEP (1992), Dibdibba Desert located within the semi-arid zone. As a matter of fact the arid zone present a wide range of geomorphic features for instance, sabkha, playa, and Aeolian deposits. Gypseferous soils have a wide distribution in Iraqi territories, the total area of Iraqi gypseferous soils is about 4780 Km^2 or 11% of the total area of Iraq (FAO, 1990), whereas, Al-Barazanji (1973) estimates that gypseous soils cover about 20% of the total area of Iraq. These soils commonly found in arid and semi arid areas where the annual quantity of rainwater is inadequate for leaching. The accumulation of salts in Mesopotamia soils is a normal process (Buringh, 1960). Gypsum is a water soluble salt, its solubility depends on many factors such as velocity of flow water, area exposed to flow water, temperature, and many other factors, moreover, the dissolved salts were redeposit under evaporation condition, thus gypsum contents in soil are changeable through time either increasing by new formation, translation by water or wind or decreasing by dissolution by flow water (Al-Heeti, 1990). As a result the engineering and geotechnical properties of such soils in both cases will change with the time. Gypsum within soils acts as a cementing agent between soil particles. It is important to illustrate that the dissolution of gypsum due to flow of ground water, the surplus of irrigation and industrial water, and rain water brought about the subsurface cavities of various dimensions in gypesous soil causing the catastrophic settlements. Such cases was recorded in Mosul city where the cavities in gypsum beds within Fat'ha Formation (Middle Miocene) caused the catastrophic failure of many existing structures such as houses and Mosul Sailo grain (Thabet *et al*., 1986), the settlement in Karbula water tank area (Kadhem, 2005). Many structures in the neighboring countries were survive of many problems owing to gypsum dissolution such as sport stadium in Saudia Arabia and Dubi Dry Dock (James, 1993). Furthermore, the failure of Francies Dam in Calfornia-USA represents a case- history of catastrophic failure due to gypsum dissolution (Calcano and Alzura, 1967).

The gypseferous sandy soils have wide distribution in the Dibdibba Desert west of Basrah city, few accounts were published on the gypseferous soil in this desert. Consequently it is necessary to study the effect of different gypsum contents on the engineering properties of Rumaila – Khor Al-Zubair gypsiferous sandy soils.

Geologic setting

The study area is a part of Dibdibba Desert, which has low topographic relief with gentle northwest and west ward rise from sea level, except Jabal Sanam (the Hump mountain) about 50km southwest Basrah which is 152 m above sea level. The land surface elevations range from 6 m to 27 m above sea level (Al-Abadi, 2002). There are some depressions such as, Al-Brjisyah, Al-Najmi and Safwan, as well as, some scattered sand dunes. The Dibdibba Desert is an undulating step desert with gravely and sandy surface. No perennial streams reach the plain. The drainage system if any, comprises numerous imperceptible shallow gentle dry westerly wadis, following the regional plain, run in northeasterly and easterly to met Hor-Al-Hammar and Khor Al-Zubair, respectively. The wadies course only carry water during the wet season especially after heavy rain storm (Al-Naqib, 1970). The vegetation cover is spare because of the dominancy of the arid conditions.

Dibdibba Formation forms the only formation which cropping out in the study area. The age of this formation ranges from upper Miocene through Pliocene to Lower Pleistocene (Buday, 1980). Lithologically Dibdibba Formation composed of sand and gravels partially cemented with gypsum laid down in fluviatile and deltaic depositional environment (Van Bellen *et al.,* 1959). Regarding the gypsum contents of the soils under study, It is believed that the isolated restricted coastal basins possibly causing the development of gypsum in Dibdibba Formation. Furthermore, owing to Stipho (1985), gypsum represents the natural product in flat poorly drained area likes Dibdibba Desert. It is originated by evaporation of mixed rain water and the marine water during the pluvial periods 60000 – 10000 years B.C. (Robinson and Al-Ruwaih, 1983).

METHODOLOGY

Six disturbed specimens were selected from six gypseous sandy soils in Rumaila-Khor Al-Zubair area; Rumaila (R-1), Toba (R-2), Barjisyah (R-3), Shuaiba (R-4), Zubair (R-5), and Petrochemical plant (R-6) (Fig, 1). In an attempt to make specimens selection covering as possible the whole area. The specimens were taken by using hand auger at 1-1.5 m depth to get ride of the top shallow layer, which usually contains organic matter such as plant roots. Thereafter, each specimen was cleaned; air dried and kept in nylon bags for further use.

Grain size analysis for soil specimens were done according to the ASTM D422-63 (ASTM, 1983). The wet sieving and hydrometer method was adopted for coarse and fine grained soils, respectively. The results were illustrated in Figure (2). X-ray technique was employed to shed light on the overall mineralogical contents of gypseous soils investigated. The amount of natural gypsum contents were determined chemically following USDA-Agricultural Hand Book No. 60 method. To clarify the effect of different gypsum contents on the engineering properties of investigated soil specimens, many laboratory tests were carried out. Unconfined compression test (Cu) was conducted owing to the ASTM D2166-66 (ASTM, 1983) using compression apparatus WF-No. 10204. This apparatus was also used to conduct the confined or triaxial compression test (C) but with the applying of confining pressure.

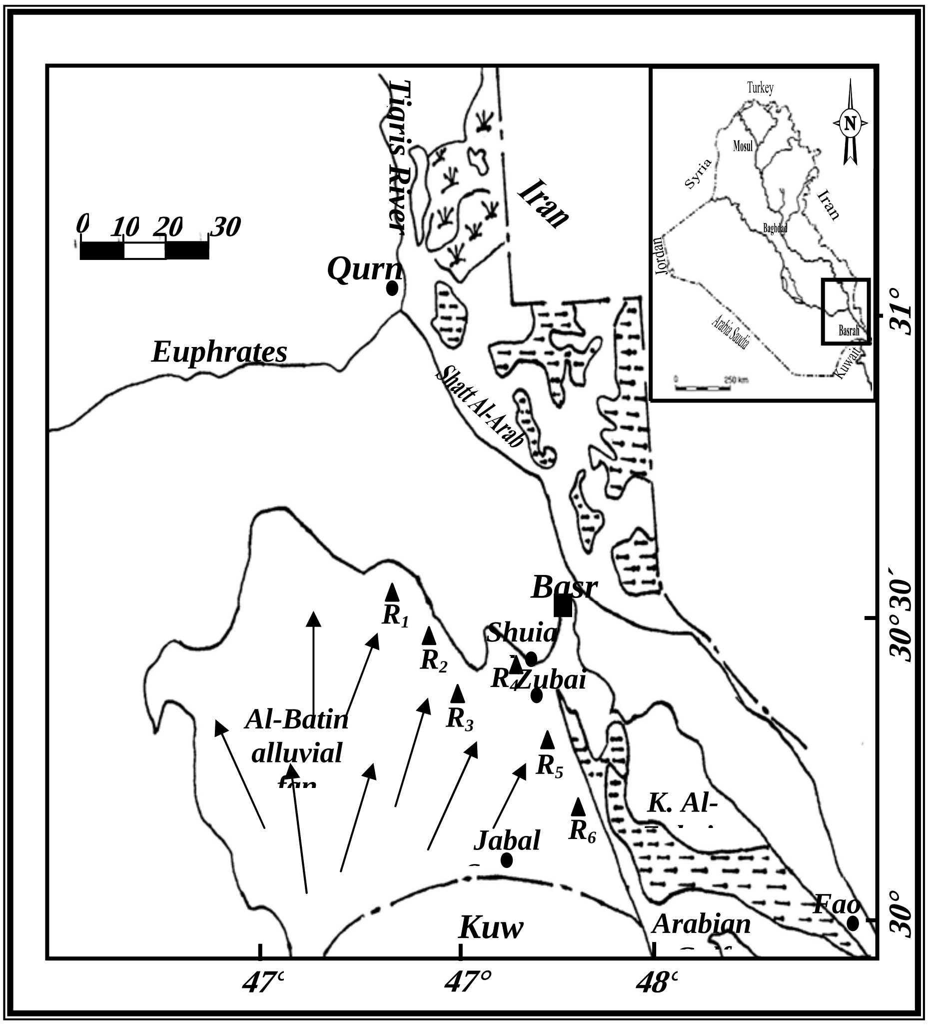

Fig. (1) Location map of Sampling stations

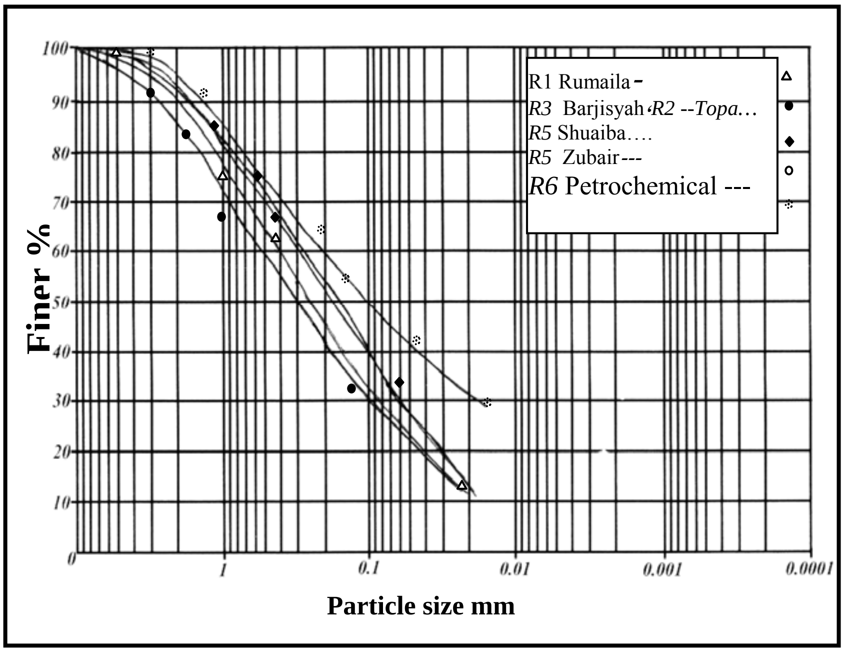

Fig. (2), Grain size distribution of the studied soils.

RESULTS AND DISCUSSION

The grain size analysis results (Fig. 2) showed that the texture of the soils consist of 84.4%, 8.6%, 7% of sand, silt, and clay respectively. Owing to the Unified Soil Classification (USC) system, the texture of the studied soils could be classified as sandy soils of (SM) type. The natural gypsum contents of Rumaila-Khor ranges between 8- 20%, with an average value of 15.5%. the highest and lowest gypsum contents were detected at Rumaila and Al-Berjasia area respectively. Basing on their gypsum contents, the soils understudy could be classified as gypseferous soil because their gypsum constitutes less than 50%. The mineralogical analyses of the studied samples showed that they are mineralogicaly composed of the following minerals owing to their abundance; Quartz, gypsum, carbonate, and feldspar (Fig, 3). The gypsum and carbonate reflect the arid and semi arid conditions, whereas, feldspar reflects the aridity of the paleoclimate since such mineral altered to sericite under humid condition. It is believed that gypsum formed as a result of evaporation of isolated swamps remains after the withdrawal of sea shore.

Numerous tests were conducted on Rumaila - Khor Al-Zubair gypseferous sandy soils show variation in their shear strength (cohesion and friction) at different gypsum contents, before and after gypsum leaching. The soil cohesion were firstly increases with adding gypsum (Fig, 4 and 5), this increase is found to continue to particular gypsum amount(in the present study 20%) after which it starts to reduce with further gypsum adding (Table, 1), this phenomenon could be interpreted as follow; gypsum play a dual role, firstly act as filler for the interparticles space, so increase the overall soil density, and firmly cementing the soil grains, thus increases the soil cohesion, nevertheless, when the added gypsum fills all the empty space within the examined sample, the surplus amount become harmfully when exceeded certain limit (in the present study 20%), the cohesion value decreases again because gypsum act as dispersant material for soil particles i.e. decreases their friction and deteriorate the cohesion value. It is worth to mention that the sandy soils of Al-Berjisia and Al-Toba revealed high value of cohesion (Table, 1), this could be attributed to their relative high clay mineral contents in comparison with the other areas. Taking in consideration the low density of gypsum (2.3 gm/cc), the added gypsum acts as passive role in decreasing the soil density via increase the sample volume, hence decreasing the overall density of the mixture, as well as act as dispersant material for the soil particles (Mahdi, 2004). It is worth to be mentioned that gypsum dissolving leads to the development of cavities between soil particles which in turn leads to the rupture of the samples (Table, 2).

The peak of the internal friction angle (Ø) was also determined (Fig, 6 & 7). It was observed that the adding of gypsum to the studied sandy gypseferous soil samples causing the increases of their internal friction angle, this obtained results could related to the increasing in the degree of friction between soil particles owing to dissolving of gypsum cementing material that separate them apart. On the other hand, the angle of internal friction was found to reduce as gypsum content increases because the gypsum act as dispersant material between soil particles therefore, decreases their friction and causing the sliding of these particles (Nashat, 1990). On the contrary, the dissolving of gypsum increases the surface area between soil particles together with the weakling up of their bonds causing the decreases of internal friction angle. This decreasing directly related to the amount of dissolving gypsum.

CONCLUSION

The gypseferous sandy soils of Rumaila-Khor area exhibit a variation in their gypsum contents possibly due to paleogeography of the depositional Basins. They are also showed a wide variation in the measuring of engineering properties especially the shear strength of the remolded samples. The addition of gypsum to the tested samples plays a major role in controlling the cohesion and the internal friction angle, generally there is an improvement in shear strength parameters as gypsum content increase up to 20% of gypsum added, then decreases, the wetting of the gypsum-bearing desert sandy soils leads to the dissolution of gypsum and subsequent reduce in shearing strength, thus the problem of gypsum or salt leaching is most important in designing and constructing the ifra structure buildings on a gypseferous sandy soils under study. It could result in many geotechnical hazards if ignored.

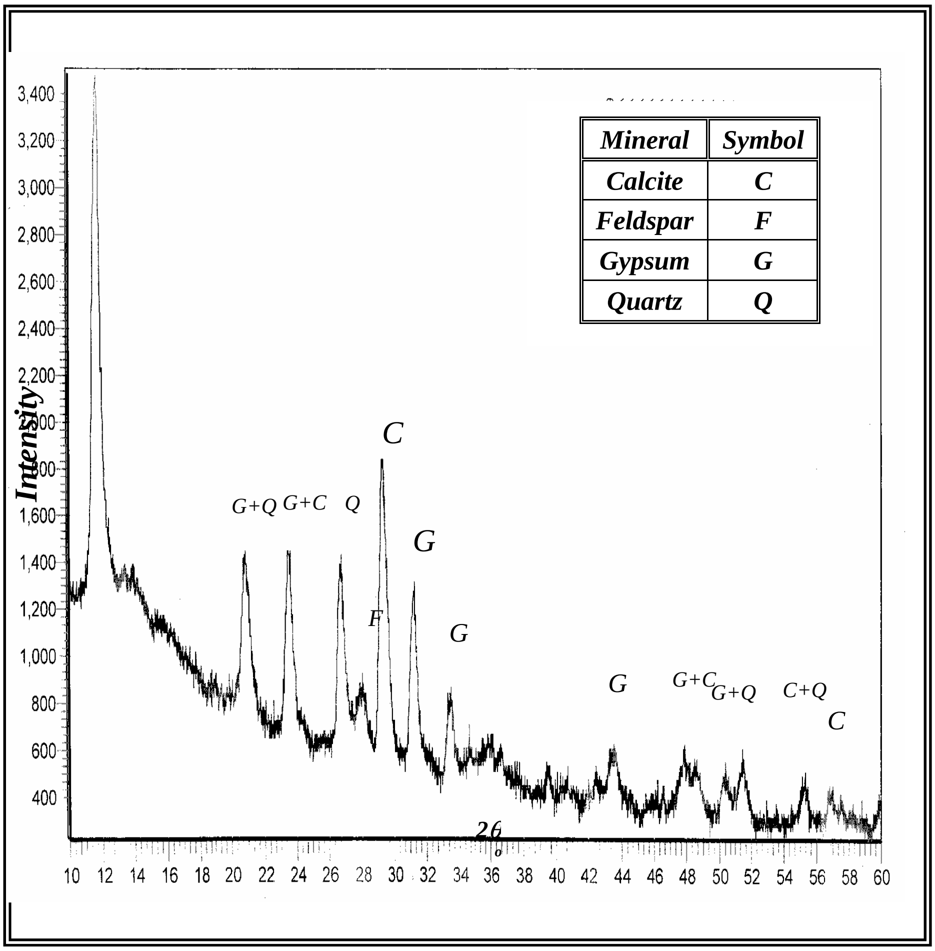

Fig. (3): Minerological copmosition of studied samples

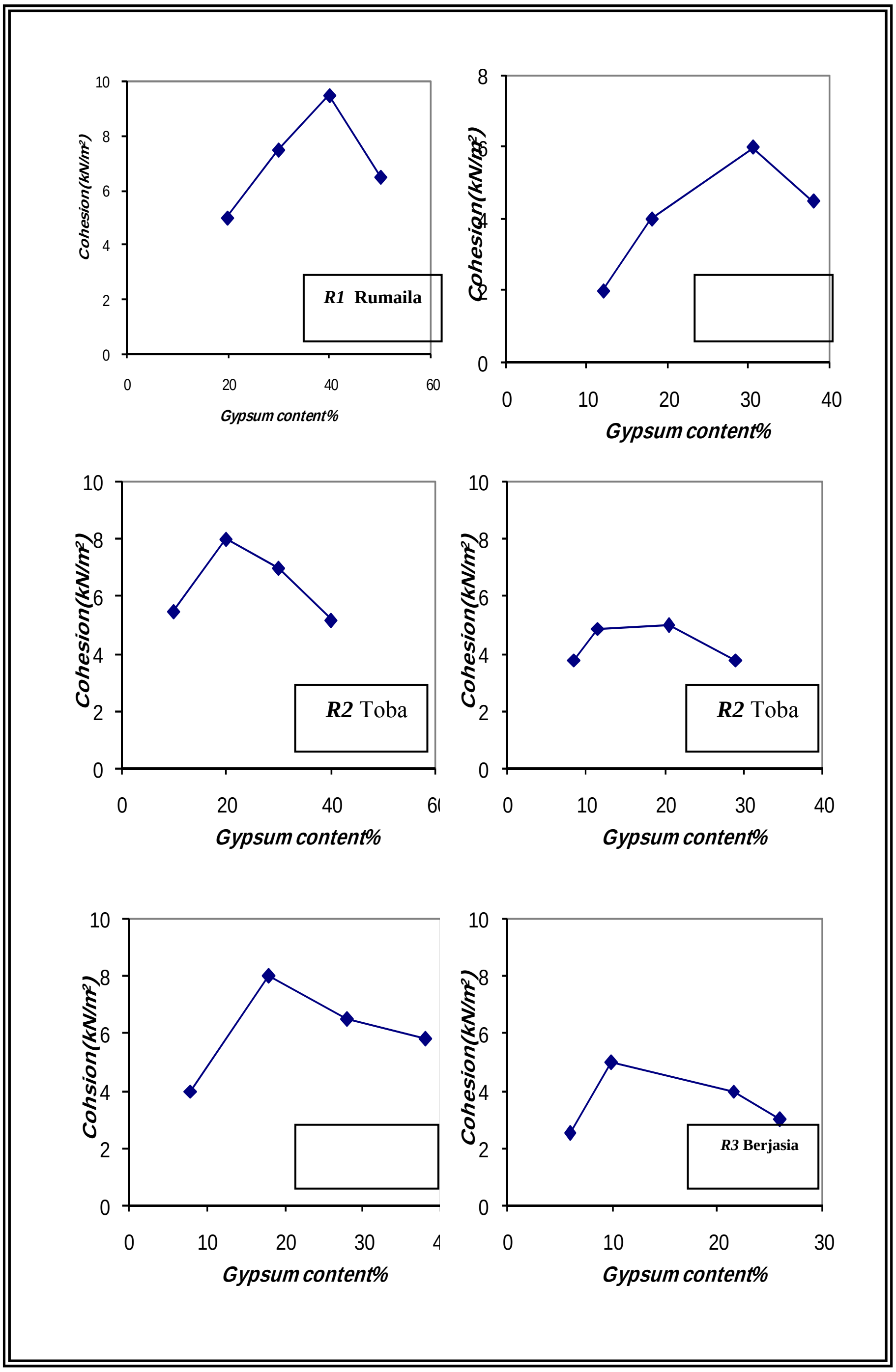

Fig. (4), Relationship between gypsum content and cohesion.

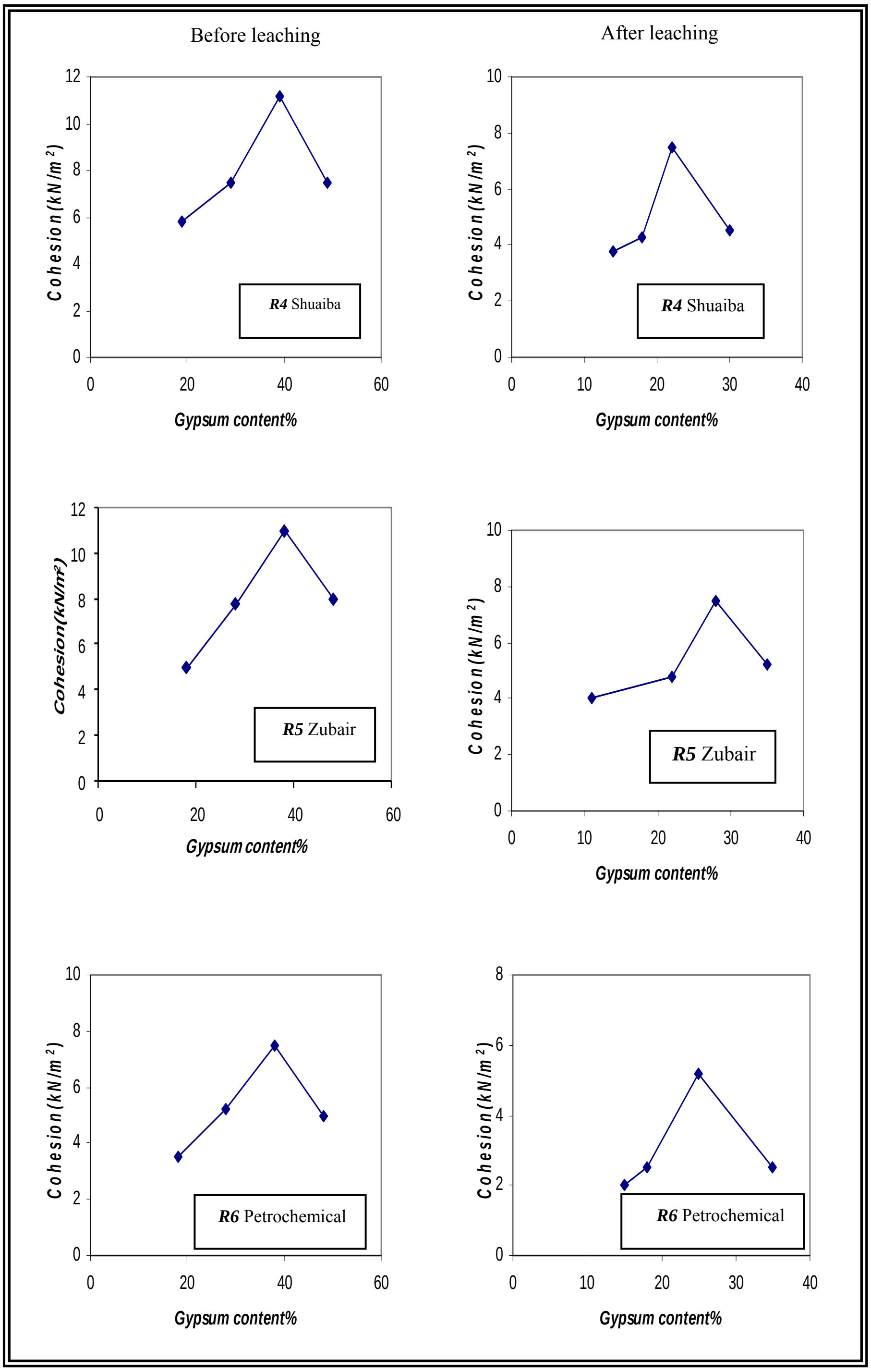

Fig. (5), Relationship between gypsum content and cohesion

Table (1): The effect of gypsum contents on the Rumaila – Khor sandy soils properties before and after gypsum leaching.

Samp. No.	Gypsum%		C kN/m^2	Ø°	Gypsum leaching		C kN/m^2
	Nat.	Add.			Dissolved %	Remains %	
R1	20	0	5	28	12	8	2
		10	7.5	31.5	18	12	4
		20	9.5	29	30.5	9.5	6
		30	6.5	26	38	12	4.5
R2	10	0	5.5	29.5	8.5	2	3.8
		10	8	30	11.5	8.5	4.9
		20	7	28	20.5	9.5	5
		30	5.2	25	29	11	3.8
R3	8	0	4	31	6	4	2.5
		10	8	32	10	8	5
		20	6.5	29.5	21.5	7.5	4
		30	5.8	27.5	26	8	3
R4	19	0	5.8	29	14	5	3.8
		10	7.5	31	18	11	4.3
		20	11.2	27.5	22	17	7.5
		30	7.5	24	30	19	4.5
R5	18	0	5	28	11	3	4
		10	7.5	30	11.5	16.5	4.8
		20	11	26.5	22	16	7.5
		30	8	23	35	13	5.2
R6	18	0	3.5	34	15	2	2
		10	5.2	35	18	10	2.5
		20	7.5	33	25	13	5.2
		30	5.3	30	35	13	2.5

Table (2): The shear strength before and after gypsum leaching.

Sample No.	Gypsum %		% Shear strength Before leaching		% of Shear strength after leaching	
	Natural	Added	C kN/m^2	Ø	C kN/m^2	Ø
R1	20	0	0	0	0	0
		10	2.5	3.5	2	5
		20	4.5	1	4	2
		30	1.5	-2	-2.5	-1
R2	10	0	0	0	0	0
		10	2.5	0.5	1.1	0.5
		20	1.5	-1.5	1.2	1
		30	-0.3	-4.5	0	-4.5
R3	8	0	0	0	0	0
		10	4	1	1.5	2.5
		20	2.5	-1.5	1.3	0.5
		30	-1.8	-3.5	0.9	
R4	19	0	0	0	0	0
		10	1.7	2	0.5	3
		20	5.4	-1.5	3.7	0
		30	1.7	-5	2	-4
R5	18	0	0	0	0	0
		10	2.5	2	2.2	3
		20	6	-1.5	2.5	-2.5
		30	3	-5	0	-2.5
R6	18	0	0	0	0	0
		10	1.7	1	0.5	1.5
		20	4	-1	3.2	-0.5
		30	1.5	-4	0.5	-2

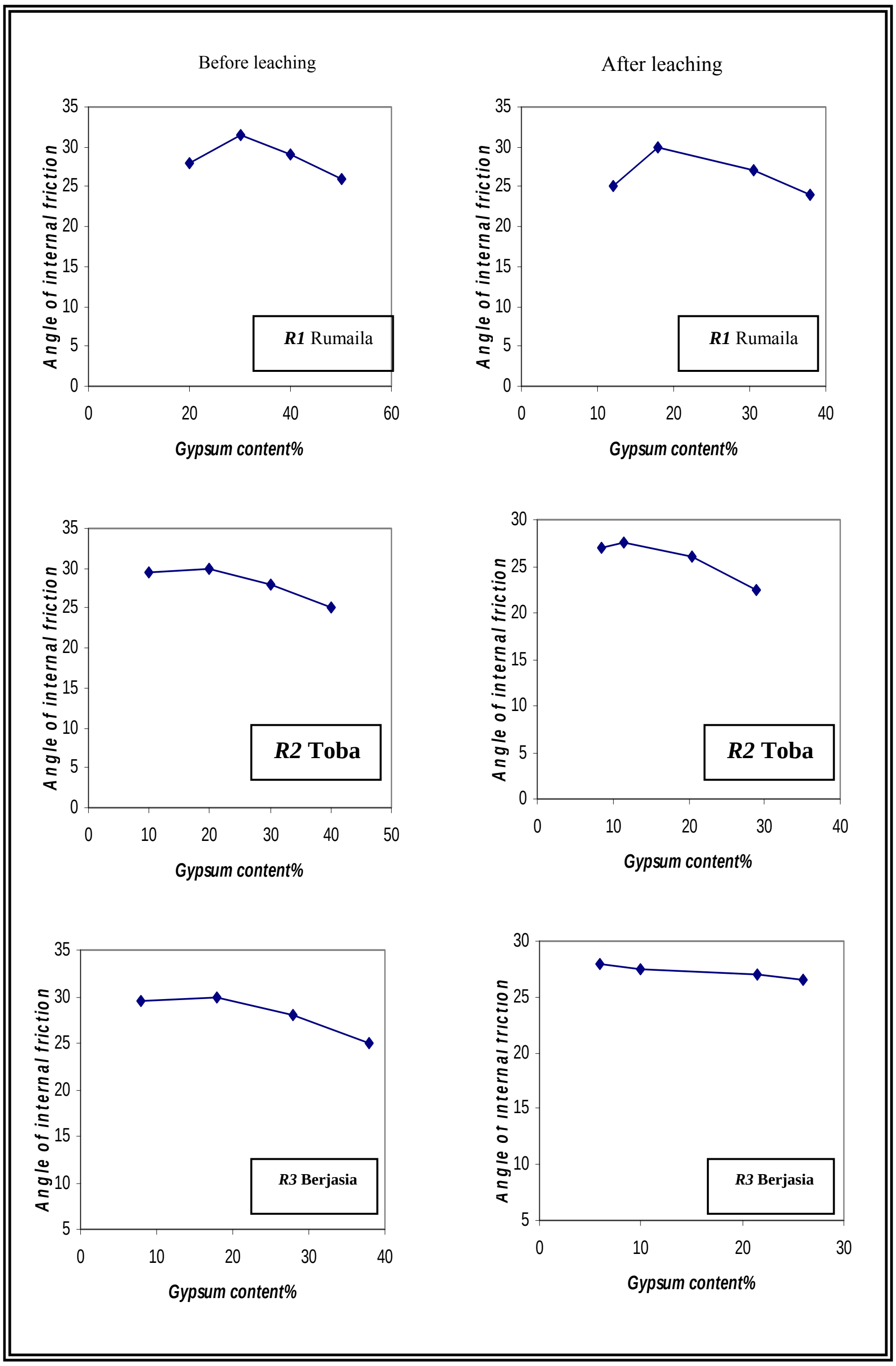

Fig. (6): Relationship between gypsum content and angle of internal friction

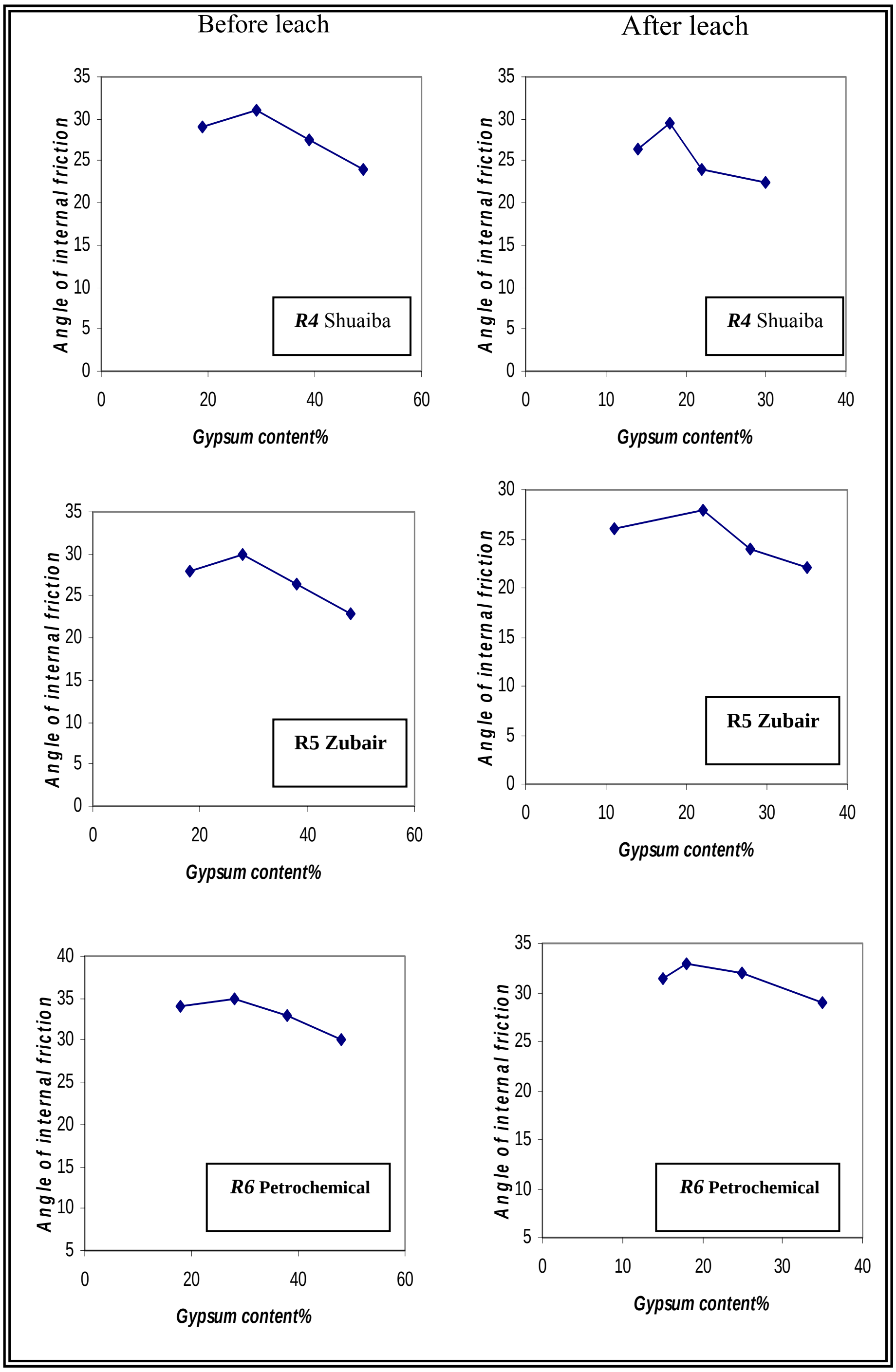

Fig. (7): Relationship between gypsum content and angle of internal friction.

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بعض الخصائص الميكانيكية للترب الرملية الجبسية في منطقة الرميلة- خور الزبير، جنوبي العراق

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المستخلص

ستة نماذج تربة جمعت من منطقة الرميلة إلى منطقة خور الزبير غرب مدينة البصرة جنوب العراق لغرض تقييم الخواص الهندسية لهذه الترب. تمتاز هذه الترب بوجود مادة الجبس كمادة رابطة للحبيبات الرمل وبمعدل 15.5% وزنا. وقد أكدت الفحوصات بالأشعة السينية أنها تتألف معدنيا من الكوارتز والجبس والكاربونيت والفلدسبار. التحليل الحبيبي ألحجمي أشار إلى أن الرمل يشكل نسبة 80% من الترب الجبسية قيد الدراسة. عدة خصائص جيوتكنيكية تم تعينها. برنامج الفحص شمل تحديد تأثير محتويات الجبس المختلفة على جهد القص والتماسك وزاوية الاحتكاك الداخلي لنماذج التربة قيد الدراسة. بينت النتائج أن التماسك يزداد مع زيادة نسبة الجبس المضاف لحد 20% ثم يقل عندما تبلغ نسبة الجبس المضاف 30%. أشارت النتائج إلى أن تحسين ثم تدهور التماسك وجهد القص للترب الجبسية قيد الدراسة يعود للدور المزدوج للجبس والذي يعمل أولا على ربط دقائق التربة فتتحسن مواصفاتها (لغاية 20% جبس مضاف) ويعمل ثانيا على تشتيت دقائق التربة فيدهور مواصفاتها (الكثر من 20% جبس مضاف).