

Collapsibility Of Gypseous Soil In Tikrit city – Salahaddin

Governorate-Iraq: case study

**انهيارية التربة الجبسية في مدينة تكريت – محافظة صلاح الدين – العراق : الدراسة
الحالية**

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Abstract:

This investigation is carried out to study the phenomenon of collapsibility that occurrence in the city of Tikrit in Salahaddin Governorate at located 170 km north of Baghdad . The physical indexes and engineering properties tests were to used determine the natural water content, Atterberg limits, grain size distribution of soils, shear strength and consolidation test .The grain size distribution of soil showed the silt percentage is higher than those of clay and sand. They are composed of silt that represents (52 - 60)% of the soil and ,Clay represents (34 - 45) % of the soil. The liquid limits(L.L) values ranges between (23 – 37)%, While the plastic limit (P. L.) values ranges between (21-31)% and Plasticity index (P.I) values ranges between (6 - 7)% .The moisture content values between (1.9 - 2.2) , are classified low, due to high gypsum percentage, which absorbed most of the amount of water, and incorporated into its molecular structure. Direct shear test shows that the cohesion values (C),range between (40 – 51) kN/m², While the internal friction angle(Ø°) of the soil ranges between (25° - 33°),The consolidation parameters showed that the compression index (Cc)values ranges between (0.040-0.055),swelling index (Cr) values ranges between (0.003-0.015),and Pre- consolidation pressure (Pc) values ranges between (125-275) kN/m². The Collapse potential (C_p*100) values ranges between (1.41 – 1.85) kN/m², as a moderate trouble. The chemical tests of the soil showed that the percentage of Total soluble salts (T.S.S)range between (24.24 - 56.63)% ,While the gypsum content range between%(22.35 - 55.15)% ,which play a role in soil properties fluctuation Therefore, gypsum soils should be studied during investigation phase, to assess the soils ability to prevent failure in future.

Key words: Gypseous Soil, Collapsibility, Pre consolidation pressure, cracks, shear strength.

الخلاصة :

اجريت هذه الدراسة للتحري عن ظاهرة الانهيارية التي حدثت في مدينة تكريت محافظة صلاح الدين ، والتي تقع 170 كم شمال بغداد . تم اجراء الفحوصات الفيزيائية والهندسية ، لاحتساب المحتوى الرطوبي ، وحدود اللدونة ، التوزيع الحجمي للتربة ، مقاومة القص، الانهيارية ، و الانضمام . اظهرت نتائج التدرج الحجمي ان نسبة الغرين للنماذج المفحوصة هي اعلى من نسبة الطين والرمل ، اذ تمثل 52 – 60 % من مكونات التربة ، والطين بنسبة 34 – 45 % . تراوحت قيم حد السيولة 23 – 38 % ، بينما قيم حد اللدونة 21 – 31 % و قيم دليل اللدونة 6 – 7 % . اصنافها طينية غرينية ، غرينية لاعضوية واطئة اللدونة . كانت قيم المحتوى الرطوبي 1.9 – 2.2 % . يصنف على انه واطيء ، وسبب انخفاضه لاحتواء التربة على نسب عالية من الجبس الذي يستحوذ على معظم كمية الماء ويدخلها في تركيبه الجزيئي تظهر نتائج فحص القص المباشر . تراوحت قيم مقاومة التماسك 40 – 51 كيلو نيوتن / م² وقيم زاوية الاحتكاك الداخلي 25° - 33° ، قيم معاملات الانضمام ، دليل الانضغاط 0.040 – 0.055 ، معامل الانتفاخ 0.003 – 0.015 . تراوحت قيم نسب الفجوات 0.42 – 0.62 % ، قيم الضغط الفعال 370.5 - 528 كيلو نيوتن / م² وقيم ضغط الانضمام المسبق 125 – 275 كيلو نيوتن / م² ، تراوحت نسبة الافراط

بالانضمام 1.437 – 4.224 . تراوح معامل الانهيارية 1.41 – 1.85 كيلو نيوتن/م² . تم تصنيف المشكلة انها متوسطة .
اظهرت نتائج التحاليل الكيميائية ، ان قيم مجموع الاملاح الذائبة 24.24 – 56.63% . تراوحت قيم محتوى الجبس 22.35 –
55.15% ، الذي يلعب دورا في تغيير خواص التربة ، لذلك يجب دراسة التربة الجبسية خلال التحريات ، لتقييم قابلية الترب
لمنع الانهيارات مستقبلا .
الكلمات الدالة : التربة الجبسية ، الانهيارية ، ضغط الانضمام المسبق ، تكريت ، مقاومة القص .

1. INTRODUCTION:

The study area is an important part of the dry and semi-arid region , which has many problems, on of which is the spread of large-scale gypsum soil, as in Tikrit Salahaddin governorate, Figure(1),where there are many problems in buildings, walls, floors, cracks occurs as in plate 1 (A,B,C), and the same problems occurred on roads and streets. Plate 2 (A, B). Due to soaking or washing, water leakage (fresh water pipes, sewage, irrigation water, and rain fall), plate 3(A,B). Tikrit is 170 km away from Baghdad, toward the north , located at 110 m. above sea level, at coordinate (43°30'78"- 43°30'81") E (34°30'27"- 34°37'38") N. The Tigris river was bounded the city of Tikrit from the east and south, and is bounded by highway (Baghdad – Mosul -Turkey) from the North and west.



Figure (1) Located map of research area [1]

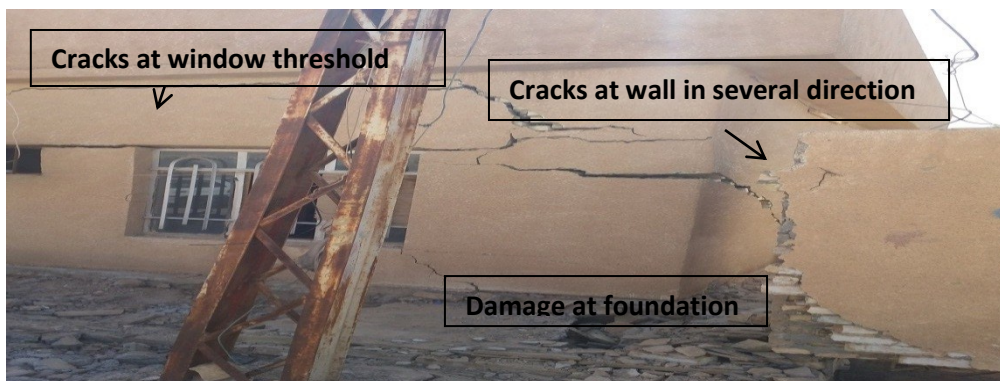


Plate 1 (A) Cracks at walls and window threshold due to Damage found

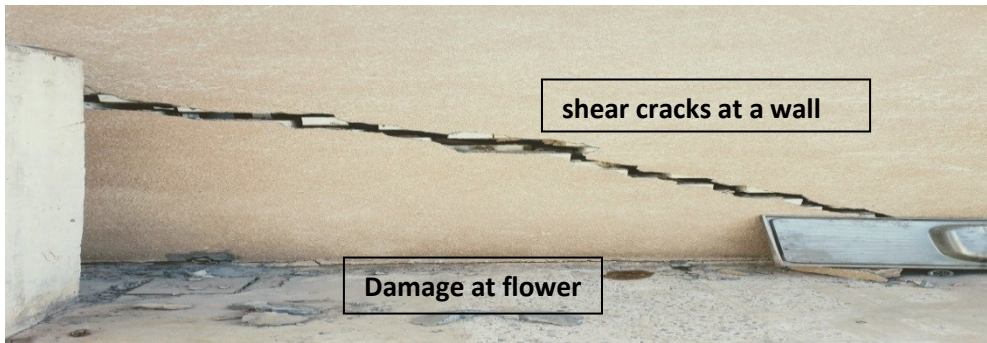


Plate 1 (B) cracks at a wall and ground deformation due to shear stresses

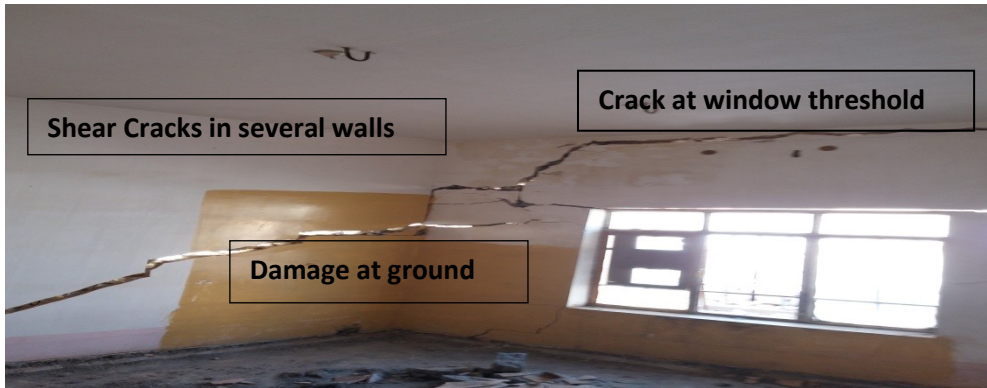


Plate 1(C) Several Cracks at walls , Window threshold and ground damage



Plate 2(A) Several cracks at street near girls education college



Plate 2 (B) Sink hall in Major Street near Passports office



Plate 3 (A) Fresh water pipe broken



Plate 3 (B) sewage pipe broken

1.1.Aim Of the study :

The present study aims to determine of the collapse potential of the region, and the identification of the characteristics of the collapse, and its type according to the worldly standard.

2.Methods and Materials:

2.1Preliminary stage:

The reports, researches and some studies on the studied area were collected In this stage . Other necessary tools, GPS device, hammer, camera, note book, lens. Model extraction tools (Pick, Iron heap ...etc.), and nylon bags.

2.2.Field works stage :

Three subsurface soil samples were collected, which they were non- disruptive, Irregular blocks, and from excavation , below the depth (1.5-2.2) m. Plate 4(A,B), a general description of the search area, was taken. Exchange and repair layers of streets Plate5(A,B), many images were taken , to document the work. Using G.P.S., to measure coordinates in the area (X, Y,Z).



Plate4 (A) Underground sample at street in Tikrit university site



Plate 4(B) underground sample site in street in front of passport office



Plate 5 (A) Exchange layer of street for repair it



Plate 5 (B) Repair of upper layer of street by concentrate

2.3.Laboratory works stage:

According to American Standards for Tests & Materials (A.S.T.M, 2004). were been done.

-Moisture Content(A.S.T.M,D-2216,2004)[2].

-Specific Gravity (A.S.T.M, D-854, 2004)[3].

-Grain size distribution (mechanical& wet analysis) (A.S.T.M, D-422-6, 2004)[4].

-Atterberg Limits(A.S.T.M, D, 4318-00, 2004) [5].

2.3.2.Chemical Analysis:

According to British Standard,(1990),(B.S. 1377) [6], were been done.

Gypsum Content%.

Total solute Salts (T.S.S. %).

pH – Values.

2.3.3.Engineering Tests:

Direct Shear(A.S.T.M, D-3080 -72- 2004)[7]

Consolidation, Collapse (A.S.T.M, D-4546 ,2004)[8].

2.4.Office work stage:

Prepared located Map, Drawing Figures (Phases), arranged tables, gave interpretations for results & complete search.

3.Previous Studies:

Surface and subsurface geological studies including: Sedimentary, Mineralogical, Hydrological, Geophysics, Engineering geology,...etc.).There are no collapse studies of surface & subsurface Soil, in this area.

4.Geological Setting of the Studied Area:

New sediments covering the study area, generally, of deposit valley fill and shallow valley deposits Holocene period . The deposit valley fill were formed due to the erosion ridges and mountain and the deposition of materials in the valleys, consisting of gravel, sand, silt, and clay, whose composition depends on the thickness of source region. While shallow valley deposits which cover the lower part of search area are located on the flow of the basin (flood *plain*) .a leveled land that extends along both sides on the submerged river, and consists of a large amount of silt[9]. Tikrit lies directly on the west bank of Tigris river (river beds), sandy gravel - soft soil, .represented two or three sediment cycle, with thickness 25-35m.[10], plate 6(A,B). Two main types valley covering the area,(Dendritic, Parallel), such as the Wadi Shi Shin , east & south east [11]. While structure and tectonic of study area its located near the low hill zone area , about 40 km from Tikrit(tectonic point of view).Tikrit lies within the unstable shelf and into the Mesopotamian plain [12].The study area is affected by hydrological Tigris

river, was running from the north to the east & south east. All of them are formed with Seasonal valleys of surface water in Tikrit. Ground water, is at a depth 0.4-26.5m. in shallow wells, depth 4.0- 49.5m. in deep wells. The water movement is from high level to low level (west side to the east) .



plate 6 (A) Tigris Terraces (Benches River) in Al Mehzam Tikrit

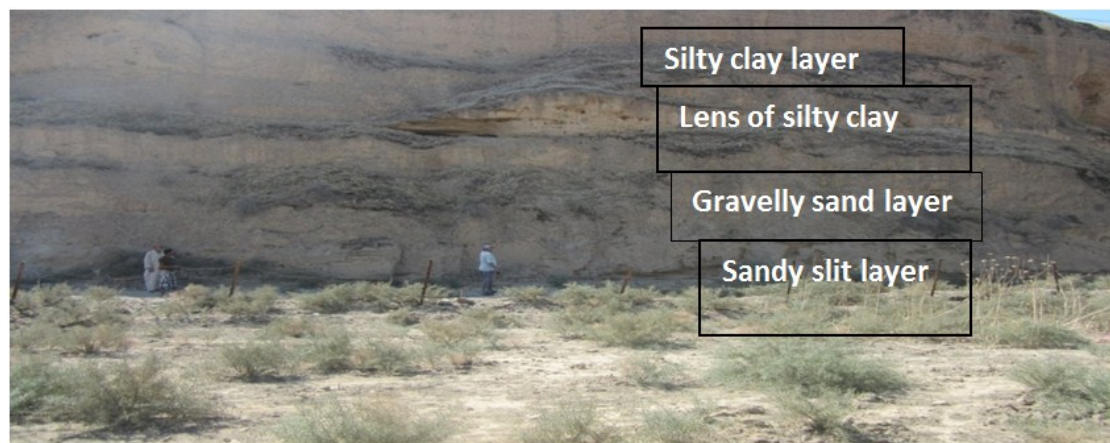


Plate 6 (B) Tigris River Terraces sediments layer

5.Results and discussion:

5.1.Moisture Content (m_c):

Testing the moisture content of soil samples for the study areas according to the specification ASTM D- 2216-2004 [2] Its giving an idea of the soil texture and durability [13], as mentioned [14]. The moisture content values between (1.9 - 2.2) are classified low, due to high gypsum percentage Table (1). This feature may help to create problems for the engineering construction underground.

5.2.Specific Gravity (G_s):

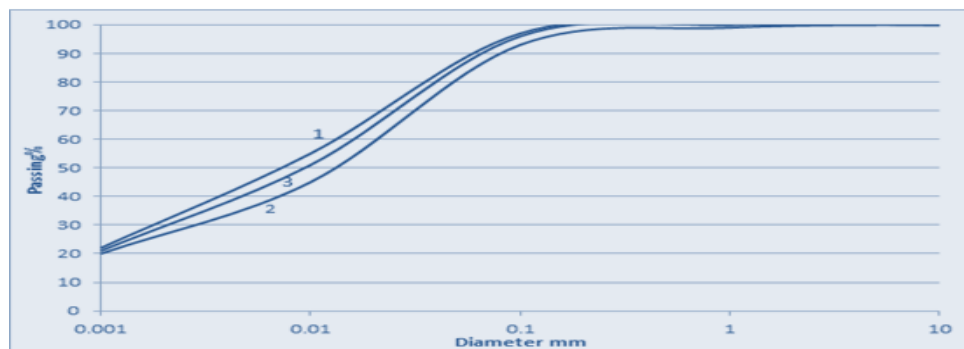
Testing the specific gravity of soil samples for the study areas according to the specification ASTM D- 854-2004 [3]. The specific gravity values between (2.31 - 2.47) Table (1).

5.3. Grain Size Analysis:

This examination of raw soil was conducted by using the method used by the American Society of tests and materials (ASTM-D422-6)- 2004 [4]. The test was conducted by washing approximately 200gm of soil in a sieve No. 200, and drying the remains on the sieve No. 200 and a sieve analysis a number of sieves as softer at the bottom to get the sand and gravel rate and transit sieve 200 taken from 50gm of dry soil, and treated with dispersant Material is material Hex-met-phosphate sodium, being his hydrometer analysis to get the proportion of clay and silt Table (1) show the percentages of soils and the distribution by size distribution curves and these percentages denote the deposition original of the study area. Curve shape (S) indicates a good gradation, of the soil, as contains(Sand, Silt& Clay),figure(2).

Table1 Some Physical Properties Results

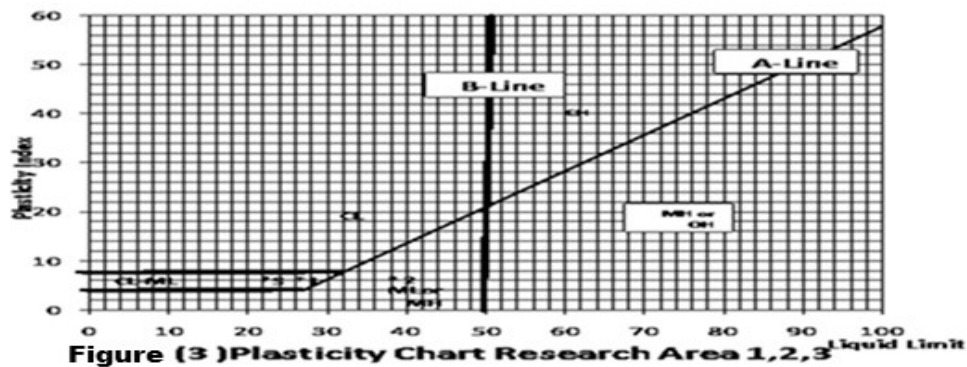
| S. No. | 1 | 2 | 3 |
|-----------|--------|-------|---------|
| L.L. | 29% | 38% | 27% |
| P.L. | 23% | 31% | 21% |
| P.I. | 6% | 7% | 6% |
| Soil Sym. | CL- ML | ML | CL – ML |
| Gs | 2.40 | 2.47 | 2.31 |
| mc | 2.20% | 1.90% | 2.00% |
| e | 0.64 | 0.42 | 0.62 |
| Clay% | 45% | 34% | 40% |
| Silt% | 52% | 60% | 54% |
| Sand% | 3% | 6% | 6% |
| Depth m | 2.2 | 1.5 | 2.0 |
| Wt. gm. | 100 | 100 | 100 |



Figure(2) Grain size analysis samples 1,2,3

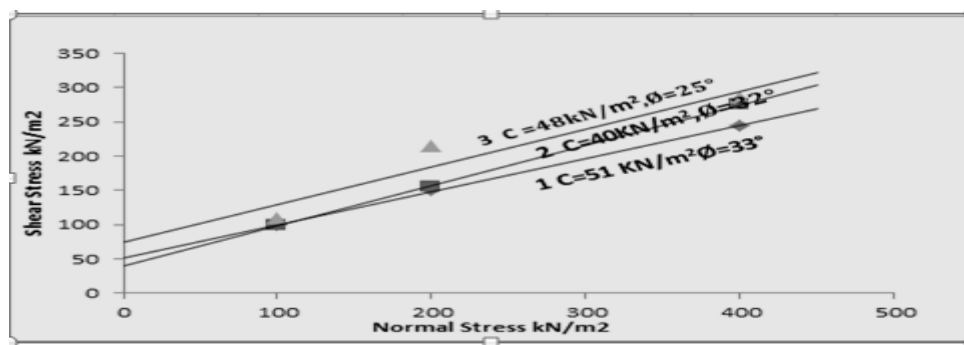
5.4. Atterberg Limits:

Atterberg Limits are the Liquid limit (LL) which represents the nature content which turns soil from the case of plasticity to the liquidity situation by using A Gasagrande apparatus [15] Three samples were taken within the studied area to identify each sample Liquid limit (LL), plastic limit (PL), and also plasticity index (PI) mathematically calculated by the following relationship. $(P.I = L.L - P.L)$. Where these limits were carried out according to standard ASTM D- 4318-84. The liquid limits (L.L) values ranges between (23 – 37)%, While the plastic limit (P. L.) values ranges between (21-31)% and Plasticity index (P.I) values ranges between (6 - 7)% table (1). According to the plasticity chart [5], the soils of study area are classified into (ML, CL-ML) as, in figure(3).



5.5. Shear strength:

Testing the shear strength of soil samples for the study areas according to the specification ASTM D- D-3080-72 -2004. [7]. Direct shear test shows that the cohesion values (C), range between (40 – 51) kN/m², While the internal friction angle (ϕ°) of the soil ranges between (25°- 33°) table(3) figure(4).



5.6.Collapsibility:

It is one of the problems, of the famous sub surface soil, which occurs in gypsum soils according to Soil wetting, washing with water during sedimentations, and then disassembling the grains, as a result of solubility of gypsum& salts in the water product from broken pipes, plate 5(A,B), surface problems results, such as building collapse, cracks of walls, and ceiling, door and window sills, foundation subsidence and sink holes, cracks, at roads. Therefore, gypsum soils should be studied during investigation phase, to assess the soils ability to prevent failure. Testing the shear strength of soil samples for the study areas according to the specification ASTM D-3080-72 -2004. [7]. The Collapse potential ($C_p \cdot 100$) values ranges between (1.41 – 1.85) kN/m^2 , as a moderate trouble table(2) figures (5.6).

Table 2 Collapse Classification [16]

| $C_p \cdot 100$ | Problem Sever |
|-----------------|--------------------|
| 0 – 1 | No Problem |
| 1 – 5 | Moderate trouble |
| 5 – 10 | Trouble |
| 10 – 20 | Sever trouble |
| Greater than 20 | Very Sever trouble |

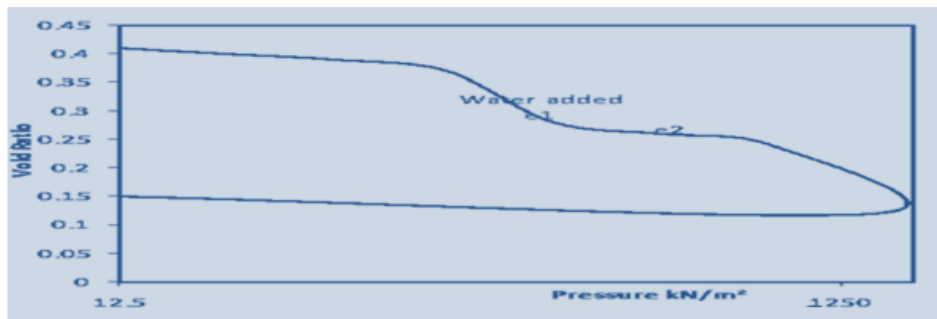


Figure (6) Collapsibility curve sample 2

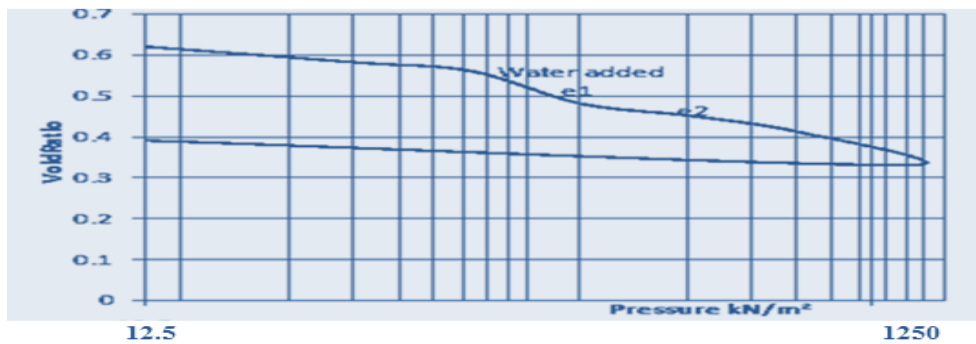


Figure (7) Collapsibility curve sample 3

5.7.Consolidation test:

Testing the consolidation of soil samples for the study areas according to the specification ASTM D-4564-2004. [8]. The consolidation parameters showed that the compression index (C_c) values ranges between (0.040-0.055), swelling index (C_r) values ranges between (0.003-0.015), and Pre- consolidation pressure (P_c) values ranges between (125-275) kN/m^2 table(3). For Consolidation curve as in Figures (8,9,10).Table(3).Show, that the soils of study area have (OCR) values is greater than(1),therefore it is over consolidated soil.

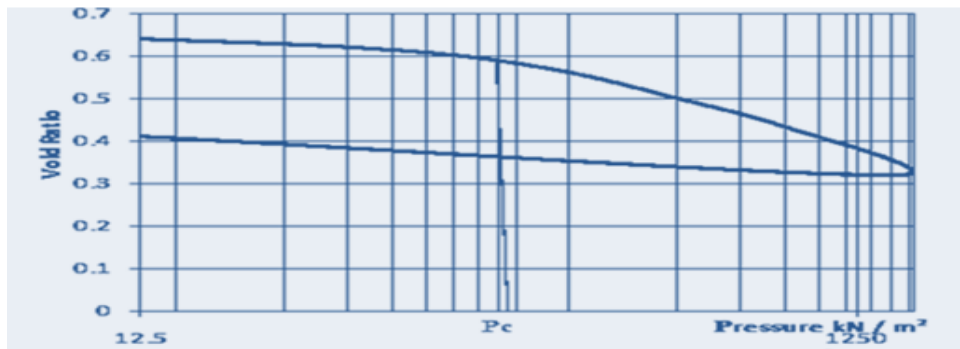


Figure (8) consolidation curve sample 1

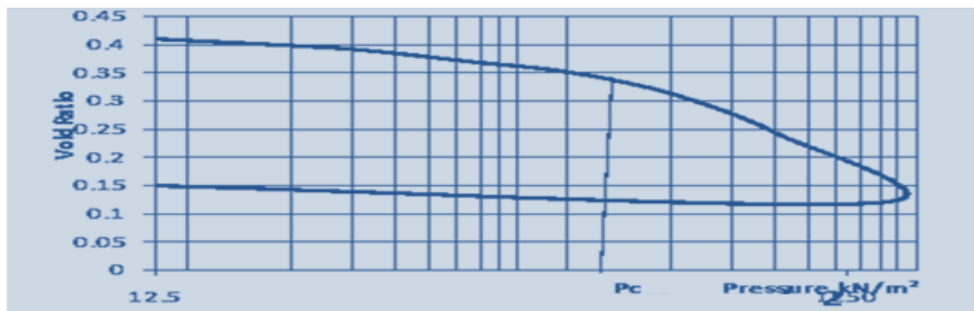


Figure (9) Consolidation curve sample 2

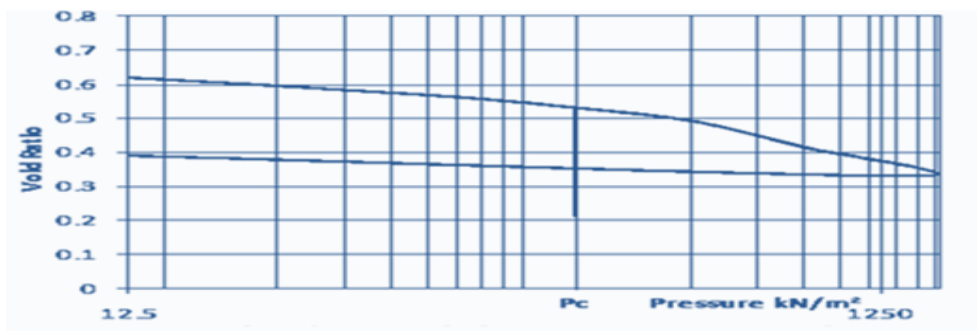


Figure (10) Consolidation curve sample 3

Table 3 Some Engineering & Chemical

| Sample No. | 1 | 2 | 3 |
|----------------------------|--------------|--------------|--------------|
| Cohesion kN/m ² | 51 | 40 | 45 |
| Ø° | 33° | 32° | 25° |
| Pc kN/m ² | 125 | 275 | 200 |
| OCR | 2.82 | 8.48 | 4.83 |
| Cp*100 kN/m ² | 1.82 | 1.41 | 1.85 |
| Collapse problem | Mod. Trouble | Mod. Trouble | Mod. Trouble |
| Comp . coif . Cc | 0.055 | 0.040 | 0.044 |
| Swelling index | 0.015 | 0.004 | 0.003 |
| Gypsum content | 41.1 | 22.3 | 53.15 |
| T.D.S% | 45.46 | 24.24 | 56.63 |
| PH. value | 6.6 | 6.51 | 6.55 |

5.8. Chemical Tests:

These tests have been applied on the three samples of soil study area .After carrying out these tests a table was constructed to show the results of the tests (Table 3)

5.8.1. Gypsum Content:

The presence of gypsum reduces the optimum dry density and increase the proportion of moisture content, and reduces the resistance of the soil and the possibility of swelling soils gypsum and then work to change in the composition of the soil or pushing establishment and bases in the case of. Since gypsum soluble in water, leading to affected soils gypsum when exposed to changes in the proportions of water content because of the fluctuation of the groundwater level or leakage of water, which leads to melt part of the gypsum content in it and enlarge the gaps existing in the soil mass and this leads to a settlement in soil below the level load inflicted[17].The most secondary Gypsum (CaSO₄.2H₂O) found in north and middle of Iraq. The Gypsum values of study area , tables(3) ranges from the maximum value is (53.15%) , to the minimum value is (22.3%)₂

5.8.2. Total solute Salts (T.S.S.):

Salts dissolved in water according to soil weight[18], the degree of solubility of salt varies, depending on their nature of the salts. The solubility is easier to dissolve chloride, carbonates and sulfates are affected by melting temperature, pH value, and soluble (CO₂), evaporation and moisture. High solubility in water has an effect on velocity, as it interferes with the rehydration process, if water is added to cement or if it present with cement or with water, but if they are present in the surrounding that affect the concrete hardness, some cement compounds dissolve in them, resulting in reduce density, reducing the resistance of the concrete to external stresses[19], based on values [20]. T.S.S. is high if it reaches more than (0.5%), high rates are considered negative effect on the concrete, for samples. The study area has exceeded the value of the salts to all samples (0.5%)₂

5.8.3.pH-value:

The pH values of study area , tables(3) ranges from the maximum value is (6.6), to the minimum value is(6.51),therefore it is have acidity in soil of study area

6.Conclusions:

After studying the determination of collapsibility of selected soils in Tikrit city, the following conclusions are obtained:

-Physical and Mechanical properties, indicate to a different types from normal values, due to the presence of gypsum in the soils.

- pH values less than, 7.0 due to acid root, because of the presence of gypsum soils become weak when wet, and are stiff and consolidated soil when they are dry. When the gypsum dissolves and salts solids dissolved in the water, the leaching occur in the soil, and the granules disintegrate, then the soil structure breaks down, and the soil was collapsed, therefor the foundations were subsidence, and the walls of the buildings were cracked too.

- Types of soil of study area, are inorganic gypsum fine soils, types (CL-ML, ML)

-The moisture content of study area, is a few, due to the high gypsum content, which take most of the amount of water, to survive as gypsum mineral, does not change to anhydrite.

- The shear strength increases with the decrease of the natural water content of the soil.

The swelling index values showed, that the low swelling soil due to the absence of swell minerals, in samples. –The values of compression coefficient, ranging between(0.040- 0.055) depend on the size of the grains. -The soils of study area have (OCR) values is greater than(1),therefore it is over consolidated soil.

References:

[1][Http://www.Wikipedia.com.2007](http://www.Wikipedia.com.2007)

[2]ASTM, D-2216-98, 2004, Standard Test Method for Laboratory Determination Of Water (Moisture) Content Of Soil.

[3]ASTM, D-854-02, 2004, Standard Test Method for Specific Gravity Of Soil By Water Pycnometer .

[4]ASTM, D-422-63, 2004, Standard Test Method for grain –Size Analysis Of Soil.

[5]ASTM, D-4318-00, 2004, Standard Test Method For Plasticity Limits Of Soil.

[6]B.S.1377-3, 1990 Methods Of Testing Soil For Civil Engineering Purposes British Standards Institution, London.

[7]ASTM, D-3080-03, 2004, Standard Test Method for Direct Shear

[8]A.S.T.M, D-4546, 2004, Consolidation, Collapse Test. (Pc, Cp), Collapse Problem., unpublished data.(1990-2011).

[9]Al-Nagash, Adnan, and Al-Sahaf, Mehdi, geomorphological, Baghdad University,1989

[10]Kadhim, L.S, Ajeel, Mohamad,W. and Warid Aied,H. Sediment logical and Mineralogical studies of Quaternary sediments in Tikrit area, First Scientific 1st.Congress ,College of Science ,University of Tikrit .7p. 2009.

[11]Al-Joboory, Nawfal Hasan Ali ,Hydrogeological Condition of Baiji-Tikrit Sub basin, M.Sc. thesis, Tikrit University, College of science 132p.2012

[12]Jassim Saad Z.& Goff Jeremy C., Geology Of Iraq ,Published By Dolin Prague MoravianMuseum,Brno,P341,2006

[13]Al-hadad, Khaled Ahmed Abdullah, the effect of leaching on some properties of Gypsum soils Samarra-Iraq region unpublished PhD thesis, University of Baghdad College of Science 256 p.2005

- [14]AL- Adli, A keel Shaker, The assessment of the geotechnical soil the city of Baghdad and processed, Ph.D. thesis (unpublished), University of Baghdad CollegeofSciences145p.1998.
- [15] Lambe, T,W. Soil testing for Engineering, John Wiley and Sons, New york,1951
- [16]Jenning, J.E .and Knight, K. A guide to construction or with material exhibiting additional settlement due to Collapse of Grain structure Proc.6th regional Conf. for Africa on Soil.. Mechanics& Foundation Engineering ,pp99-105.1975.
- [17]Al-Zubaidi, Jaafar Ali .Engineering geological study of selected areas of the framework of Najaf in central Iraq, Unpublished MSc thesis, Baghdad University - the Faculty of Science 129p.1998.
- [18]Shekel, Naz naz, Fred, Abdul Abad, Thomas, Nawal. The National Center forLaboratories construction the development of the adequacy of the performance program booklet Chemistry (3) 101 p. 1999.
- [19]Skarly, J. and Older, i. the effect of chlorides upon the hydration of Portland cement and upon Some clinker minerals, Magazine of concrete research, Vol19No.61,pp.203210.1967.
- [20]Baver, L.D. Soil Physics, 4th. Ed John Wiley & sons Inc., New York498p1972