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EVALUATION OF GEOTECHNICAL SUBSOIL PROPERTIES FOR WASIT GOVERNORATE

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Abstract: The first step in performing a subsurface investigation is a thorough review of the project requirements. The necessary information that should be provided by the designer to the geotechnical engineer includes the project location, roadway alignment and profile, structure locations, substructure locations and estimated scour depths (if applicable). The geotechnical engineer should have access to typical sections, plan and profile sheets, and cross sections. This information allows the geotechnical engineer to properly plan and execute the subsurface exploration program [5]. Considerable information on the geological conditions of Wasit governorate can often be obtained from this studying. This studying often shows the relative position of the different geologic strata and provides information on the general characteristics for the sub-soil layers. This information is extremely useful in establishing preliminary boring locations and depths and in predicting problem areas.

Keywords: *Evaluating subsoil, geotechnical properties, Wasit governorate*

تقييم الخصائص الجيوتكنيكية للتربة التحتية في محافظة واسط

الخلاصة: الخطوة الأولى للقيام باعمال تحريات التربة هي استعراض شامل لمتطلبات المشروع. المعلومات الرئيسية الواجب توفيرها من قبل المصمم الى المهندس الجيوتكنيكي تتضمن موقع المشروع، جوانب الطريق المحاذي، موقع المنشأ، مواقع المنشآت المحيطة، وتحديد الاعماق بصورة تخمينية ان امكن ذلك. وايضا يجب ان تتوفر للمهندس الجيوتكنيكي المقاطع النموذجية، والمخططات. هذه المعلومات تمكن المهندس الجيوتكنيكي من التخطيط والتهيئة لبرنامج تحريات التربة[5]. المعلومات الافتراضية لطبيعة التربة في محافظة واسط تتوفر في هذه الدراسة التي تعرض المواضع النسبية الجيولوجية لطبقات التربة وتزود معلومات عن الخصائص العامة لطبقات التربة التحتية. هذه المعلومات مفيدة للغاية في إنشاء مواقع الحفر الأولية والأعماق وفي التنبؤ بمشاكل التربة في تلك المنطقة.

1. Introduction

The design of foundation of structure such as buildings generally requires knowledge of such factors as: (1) The load that will be transmitted by superstructure to the foundation system, (2) The requirements of the local building code, (3) The behavior and stress-related deformability of soils that will support the foundation system, and (4) The geological conditions under constructions. To the foundation

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engineer the last two factors are extremely important because they concerned soil mechanics [8].

This is need to the spatially studied for soil properties in many sites within the study area which explains the high costs and the time required for conducting these studies whereas these studies needed to make testing bore holes, their numbers and depths depend on the importance of the project to be created [7]. The study on soil properties in a given area helps reduce time and cost terms used at the stage of collecting information on the proposed sites to create projects in addition to reducing the number of test bore holes and number of samples taken from every hole but does not pose as a substitute for soil sampling and laboratory tests.

2. Objectives of Research

The main objective of this paper is to present the geotechnical subsoil properties of Wasit governorate to evaluate the field conditions to facilitate the foundation design.

3. Studying Area

This studying summarizes the findings from a soil investigation done by the author, where the drilling was (103) test bore holes in (10m) depth distributed by areas of Wasit governorate that's shown in plate(1) as follows:

1- Al-Kut District (5 sites, 20 bore holes)
2- Al-Suwaira District (6 sites, 25 bore holes)
3- Al-Hai District (5 sites, 20 bore holes)
4- Al-Nou'manyia District (5 sittes, 21 bore holes)
5- Al-Azizyah District (4 sites, 14 bore holes)
6- Badrah District (1 site, 3 bore holes)

Plate (1): Google Earth satellite image of Wasite governorate

4. Experimental Work

The Geotechnical investigation described in this study consists of studying physical, chemical and engineering properties of the soil and chemical tests for ground water. In the present study, a geotechnical assessment of Wasit governorate was carried out in three stages as below:

4.1. Stage One- Site Exploration

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4.1.1. Drilling and sampling

Drilling was done using flight auger. The diameter of drilled boreholes is (15 cm). The disturbed samples (D.S) were collected from the cutting of auger at any depth. The undisturbed samples (U.S) were obtained using Shelby tubes. The split spoon samples (S.S) were obtained from standard split spoon used in standard penetration test which was performed at different intervals depending on the stratification of the soil. The ground water sample was obtained from every bore hole.

4.1.2. Standard Penetration Test (S.P.T.)

In-situ standard penetration test was carried out in order to obtain the penetration resistance of the soil strata (according with ASTM D 1586-99) [3]. The test consisted of driving the standard split spoon sampler with 5 cm diameter in the soil and counting the number of blows required to drive the sampler a distance of 30 cm by dropping a 63 kg hammer falling freely a 76 cm. The number of blows is referred to as N-values and represents the standard penetration resistance.

4.2. Stage Two- Laboratory Works

A series of laboratory tests were performedon selected soil samples as listed below in the "Table (1)".

Table 1. Summary of Laboratory Tests.

Type	Test	Standard Specification
Classification& Physical Properties	Natural water content	ASTM D2216-98 [2]
	Liquid and Plastic Limits	ASTM D 4318 [2]
	Sieve Analysis and Hydrometer	ASTM D 422 [2]
	Specific Gravity	ASTM D 854-00 [2]
	Unit weight	BS 1377:1990 [4]

Compressibility and Swelling characteristics	Consolidation Test	ASTM D 2435-96 [2]
Strength Tests	Triaxial (UU) Test	ASTM D 2850 [2]
Chemical Tests for Soil and Water	TSS, SO3 and organic content	BS 1377:1990 part 3 [4]
	pH, Cl, SO4 and TDS	

5. Results and Discussion of Tests Results

5.1. Standard Pentration Test (S.P.T.)

The results indicates a wide variation between (N) values from Standard penetration tests (SPT) in same depths as shown in "Fig. 1", this variation may be happened because of the situation of some sites, where some of them were swamps and the others were demolishing and reconstruction, therefore, this is maybe a main reasons in variation of (N) values in same depth below natural ground surface.

Generally, in Al-Suwaira and Al- Nou'manyia, the result indicate that N values of SPT test are converged between them, where (N) values increase with increasing the depth until (4.5-5 m) after that the variation between N values are found until (8.5-9 m). After (9m) depth (N) values become converging. While in Al-Kut, Al-Hai, Al-Azizyah and Badrah, the result of (N) values of SPT test are converged between them, where (N) values increase with increasing the depth until (4 m) after that the variation between N values are found to the (10m) depth.

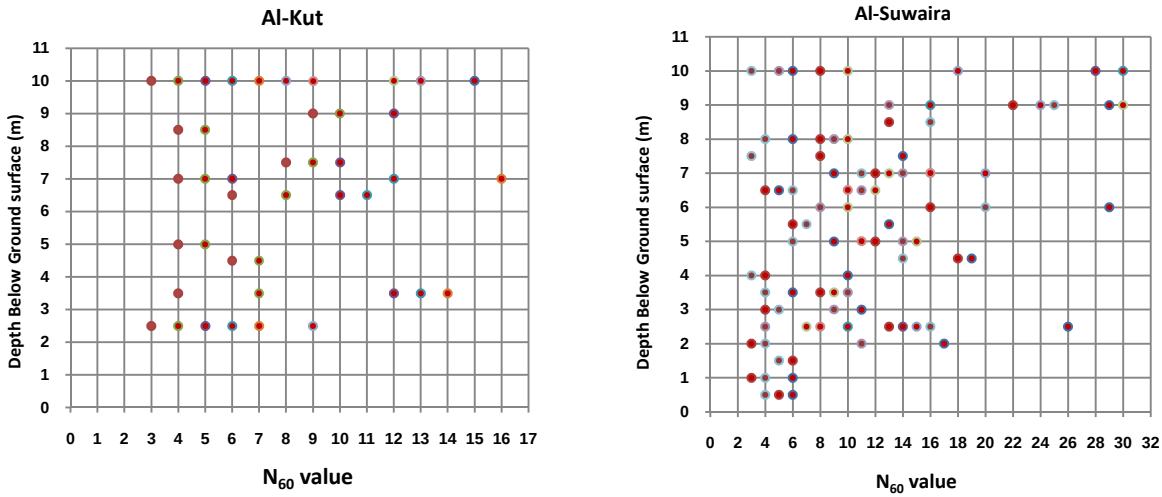

Figure 1. The average values of (N60) in different depths according to the districts

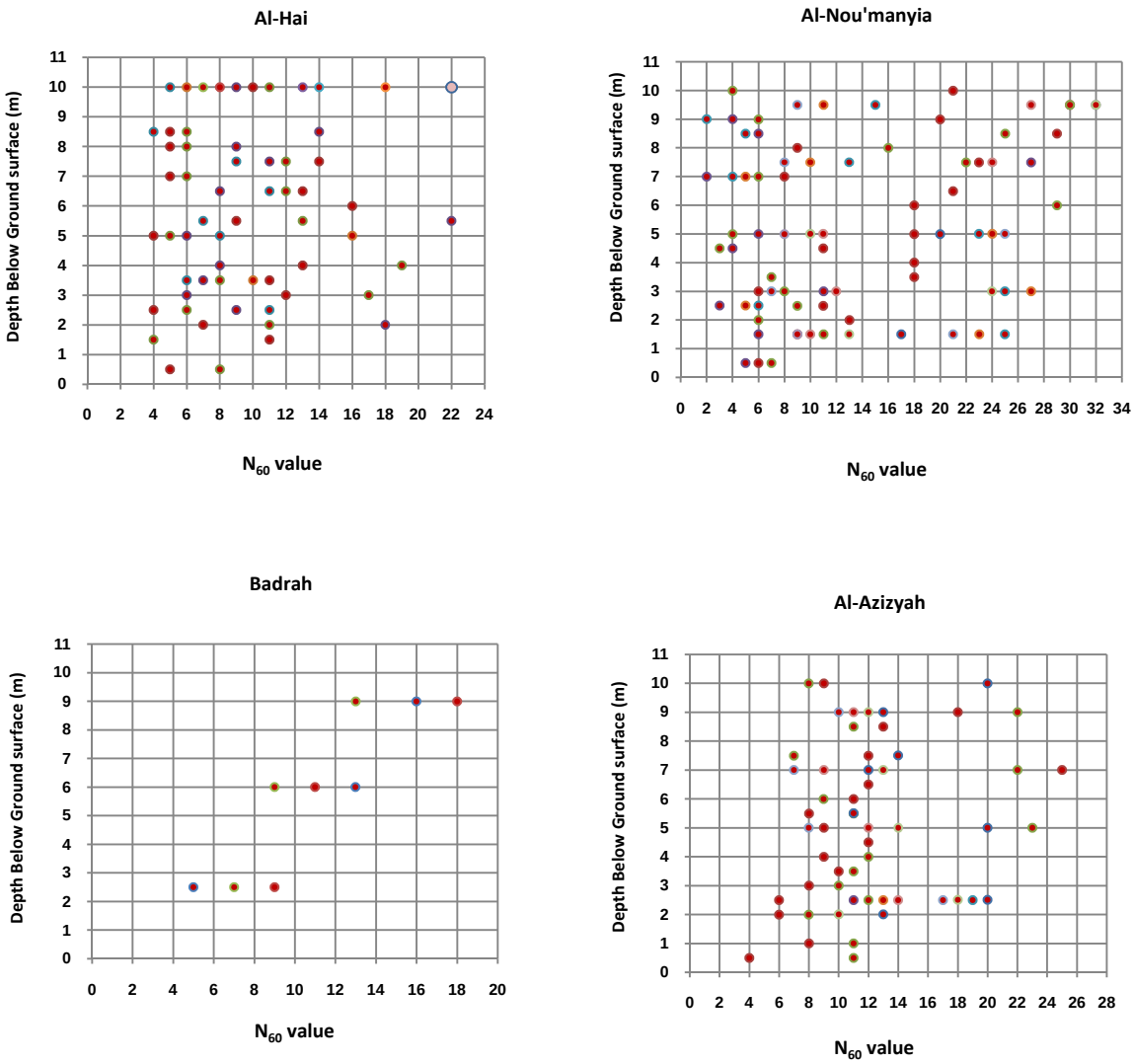

Figure 1. Continuous

5.2. Subsurface Stratification (Graine Size Analysis)

According to the test results obtained from the (103) boreholes and by adopting Unified Soil Classification System (USCS), the soil is generally of fine aggregate in studying area, similar behavior was observed by Al-Sakarchi and Al-Kohza'y [7]. The soil profile analysis content was presented in "Fig. 2" and described as follows:

In Al- Kut, Al-Hai, and Al-Nou'manyia district, cohesive layer started from N.G.L to the end of boring at depth of (10m) this layer consists of brown sandy clay to silty clay with sand to silt with sand, cohesion less black silty clayey sand appeared at a depth of (8-10 m) at one location in Al- Kut consist of (3) bore holes. In Al-Suwaira District, cohesive soil was brown clayey silt with sand to silt with sand. In Al-Azizyah and Bdrah District, cohesive layer started from N.G.L to the end of boring at depth of (10m) this layer consists of brown silty clay sometimes with sand.

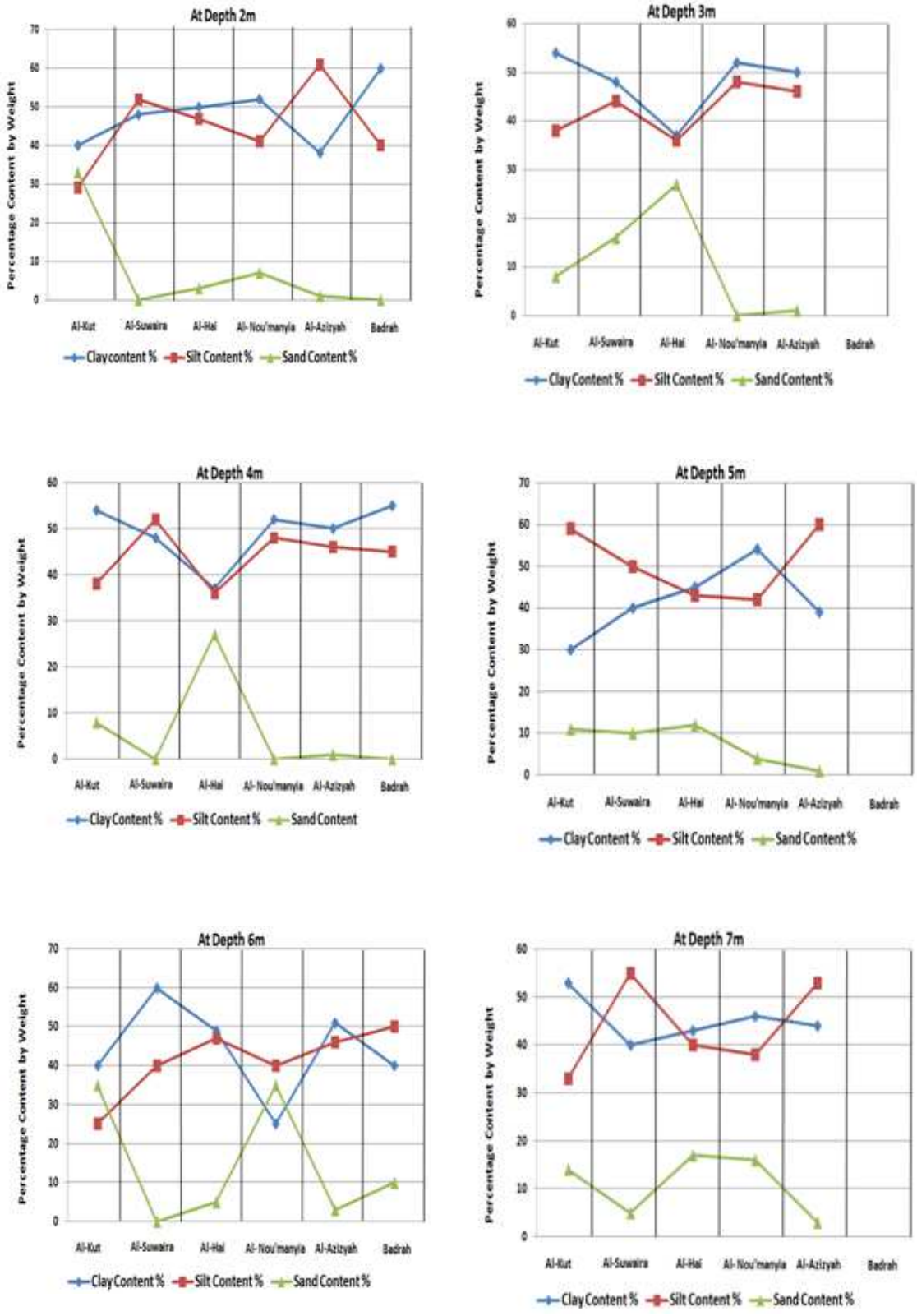

Figure 2. The average values of (Clay, Silt, Sand) Percentage Content

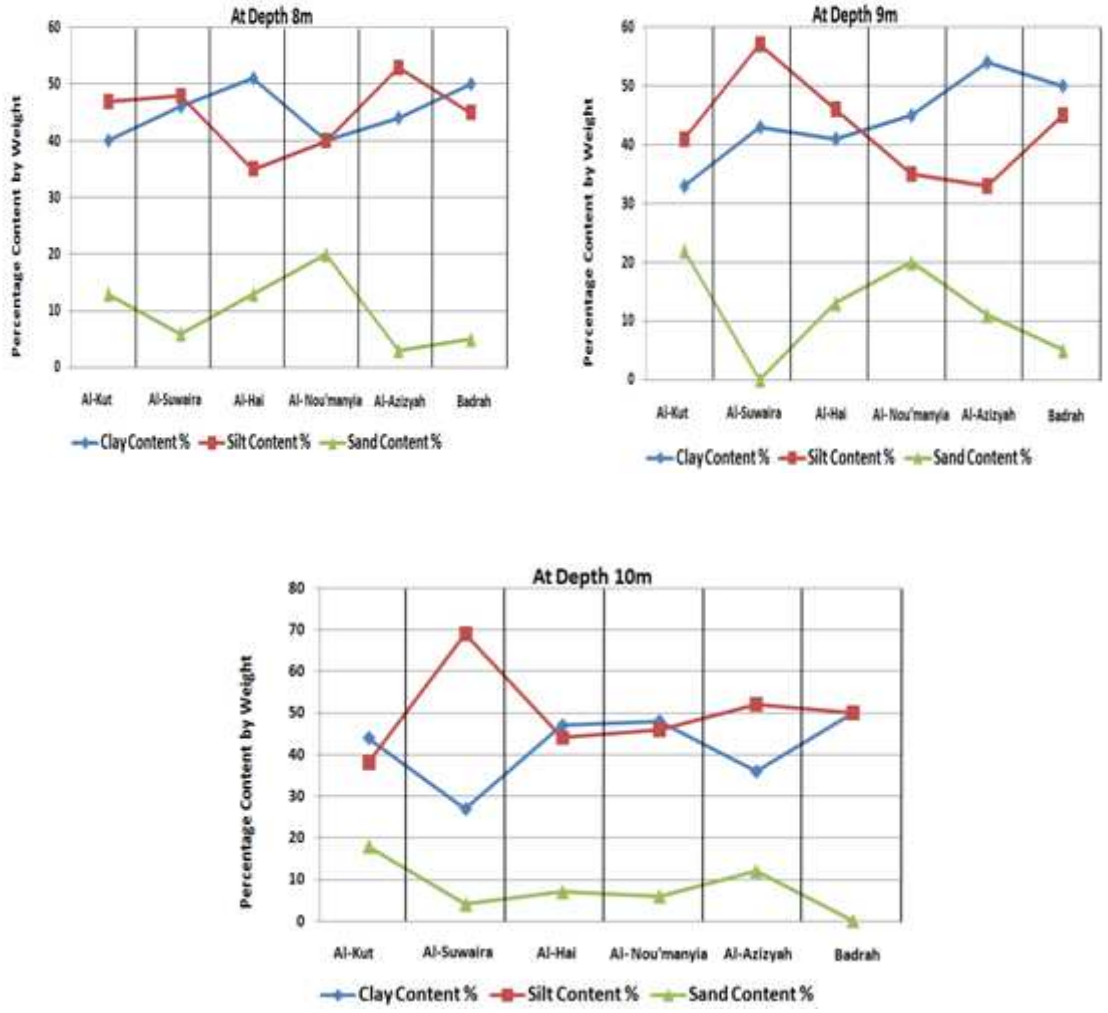

Figure 2. Continuous

5.3.Atterberg Limits

Atterberg limits tests were conducted on soil fractions passing sieve (No. 40) according to ASTM D 4318 [2]. The results of the tests are evidence that L.L values ranged in Al-Kut from (31 to 47) %, Al-Suwaira from (35 to 57)%, Al-Hai from (32 to 41)%, Al- Nou'manyia from (38 to 56)%, Al-Azizyah from (33 to 63) %, and Badrah from (28 to 40)% . While P.L values ranged in Al-Kut from (21 to 27)%, Al-Suwaira from (24 to 32)%, Al-Hai from (23 to 26)%, Al- Nou'manyia from (23 to 29) %, Al-Azizyah from (23 to 30) %, and Badrah from (15 to 27) %. The PI values ranged in Al-Kut from (14 to 23) %, Al-Suwaira from (10 to 19)%, Al-Hai from (10 to 22)%, Al-Nou'manyia from (13 to 28)%, Al-Azizyah from (10 to 36)%, and Bdrah from (6 to 12)%. The results could be shown in "Fig. 3". Generally, the results indicate that the liquid limit values increasing with depth in Wasit governorate and ranging from medium to high as well as, the plasticity of soil between medium to high which classified as (CL-CH) to (ML-MH) in the plasticity chart.

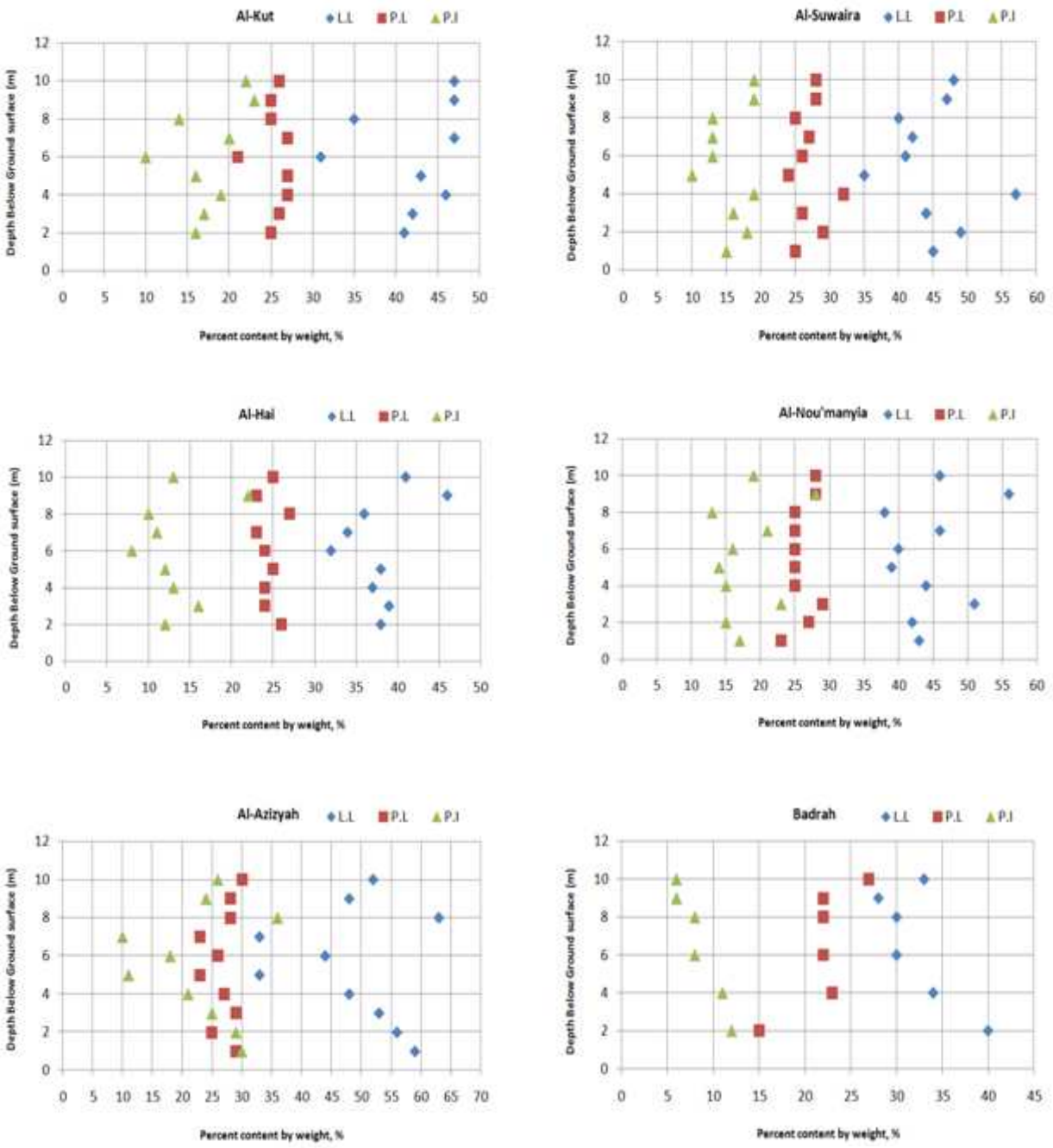

Figure 3. Atterberge average values in different depths according to the districts

5.4. Specific Gravity (Gs)

The specific gravity of soil solids is subscribed to identify the quantity for soil grains in geotechnical applications. As the result shown in "Fig. 4", the GS values ranging from (2.74) to (2.75) in all districts, and the variation in values is very low because of the convergence of soil properties in Wasit governorate.

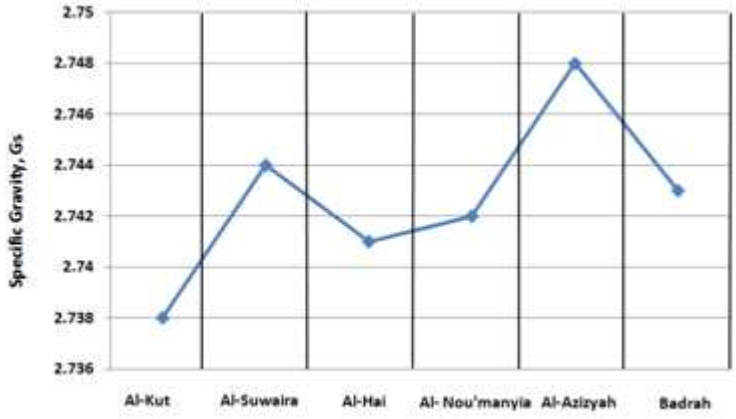

Figure 4. Specific Gravity average values

5.5. Moisture Content and Total Unit Weight of Soil

The moisture was conducted at different depths for (split spoon and undisturbed) soil samples. The average values of moisture content (w_n, %) tested samples were found to be ranging from (23 to 28) % as shown in "Fig. 5(a)". The results generally indicate that the value of moisture content is closer to the plastic limit than to the liquid limit and that maybe refer to the cohesive layer is over consolidated, similar behavior was observed by Al-Jabban in Hilla city[1].

Examining the tests results presented in "Fig. 5(b)", it can be seen that the value of total unit weight (γt, kN/m3) in soil sample tested ranged from (20 to 21) kN/m3. The little variation between values of total unit weight may be back to the convergence of granulation texture and moisture content of the soil in studying area.

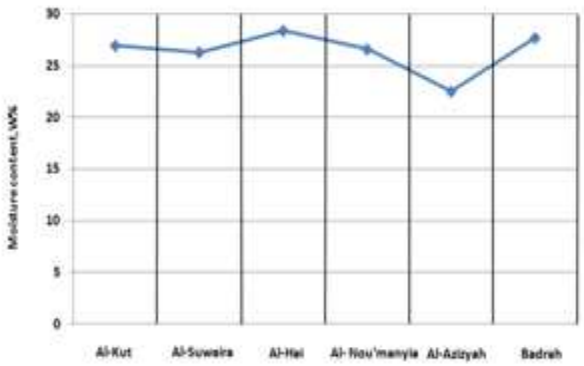

Figure 5(a): The average values of moisture content

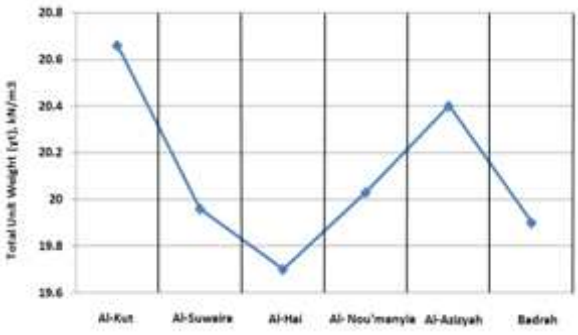

Figure 5(b): The average values of total unit weight

5.6. Soil Compressibility and Swelling Characteristics

According to ASTM D 2435-96a [2], a series of consolidation tests were carried out on Shelby specimens at different depth to determine their compressibility characteristics.

An examination of average results reveals that; the values of void ratio (e_0) ranging from (0.631 to 0.751), while overburden pressure (Po) and pre-consolidation pressure (Pc) were ranged from (46.67 to 51.58) and (97 to 108), respectively. In addition, compression and recompression indices (Cc and Cr) were ranged from (0.146 to 0.191) and (0.020 to 0.029), respectively, the results were shown in "Fig. 6". Generally, the results indicates that average values of compression index Cc are increasing with increasing depth, similar behavior was observed by Al-Shakarchi and Al-Kohza'y [7], and that's mean the soil layers in Wasit governorate are low compressibility.

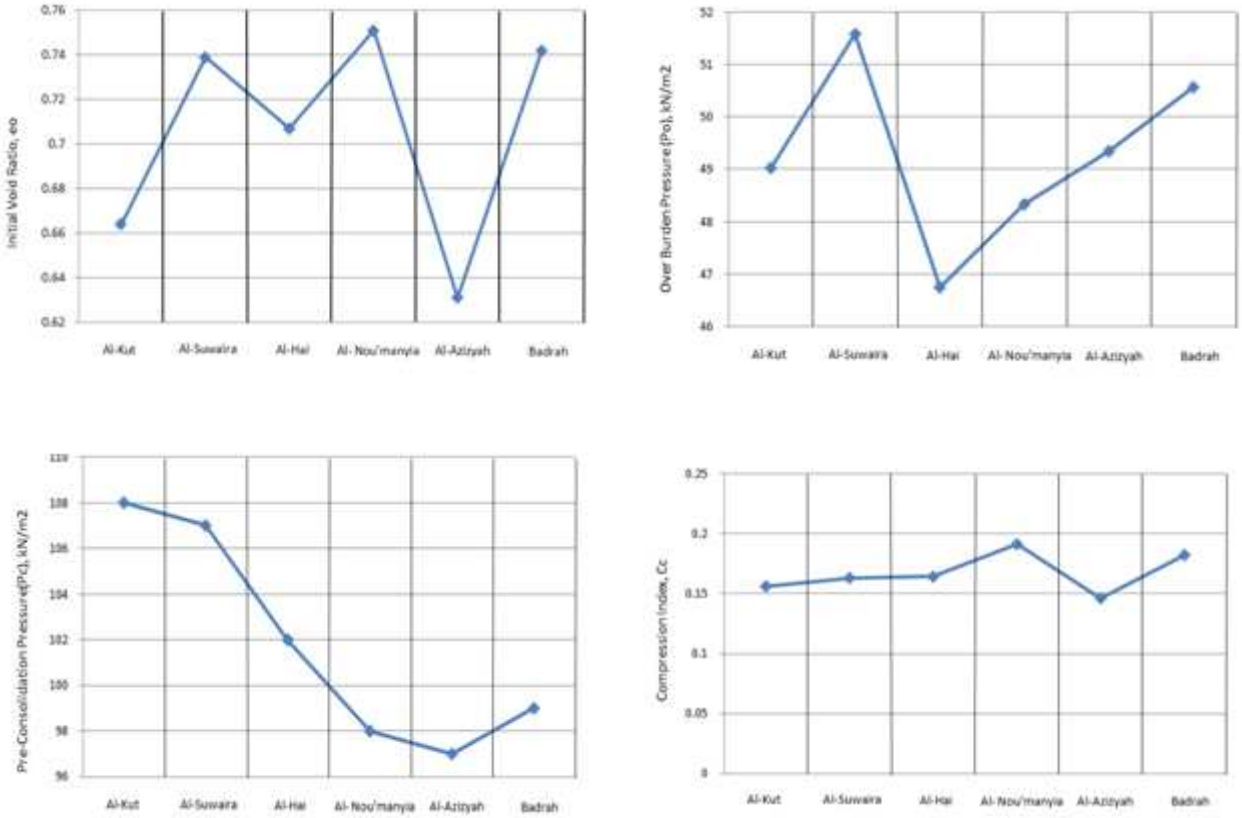

Figure 6. The average values of compressibility test parameters

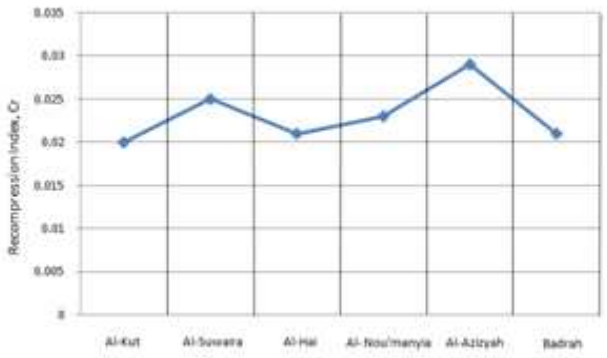

Figure 6. Continuous

5.7.Shear Strength Parameters

Unconsolidated undrained Triaxial test (UU-test) has been carried out on different undisturbed soil samples at different depths of boreholes. The average values of cohesion (c) and angle of internal friction (ϕ) of tested samples were found to be ranging from (24 to 38.7) kPa and (5.5 to 6.48) degree at (2m) depth respectively, also from (16.29 to 35) kPa and (2.41 to 8.02) degree at (5m) depth as shown in "Fig. 7". The consistency and shear strength of clay can also be correlated to the SPT value (Terzaghi et al. 1996[6]) as shown in "Table 2", so the soil could be classified as following:

Medium stiff in Al-Kut district, medium to stiff in Al- Suwaira, Al-Hai, Al-Nou'manyia, and Badrah district, while the soil was classified as stiff in Al-Azizyah district.

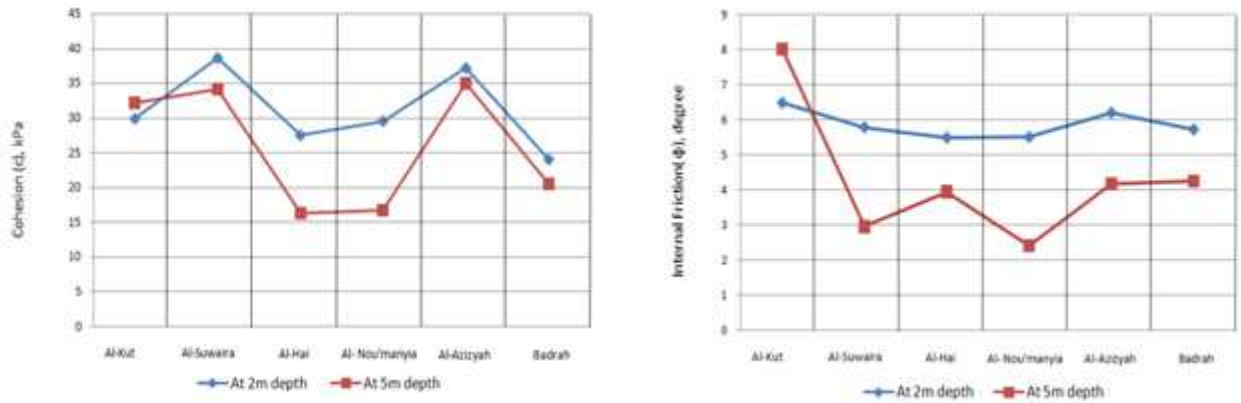

Figure 7. The average values of shear strength parameters

Table 2. Relationship between SPT N-value and consistency after Terzaghi et al. (1996)

Soil Consistency	SPT N	Shear Strength (kpa)
Very Soft	<4	<12
Soft	2-4	12-25
Medium	4-8	25-50
Stiff	8-15	50-100
Very Stiff	15-30	100-200
Hard	>30	>200

5.8. Chemical Tests Results

Both soil and groundwater samples were analyzed for sulphate content. Soil samples were taken from the boreholes at varying depths where tested for organic matters and total soluble salts content. Total dissolved solids (TDS) and power of hydrogen(pH) were also analyzed for water.

5.8.1. Soil Chemical properties

Examining the tests results, it can be seen that the value of sulphate (SO_3) in soil sample tested ranged from (0.579 to 1.161) % while the organic matters were varying from (2.5 to 4.82) %. It can be seen that the total soluble salts (TSS) ranged from (2.7 to 8.0) %. The results could be shown in "Fig. 8".

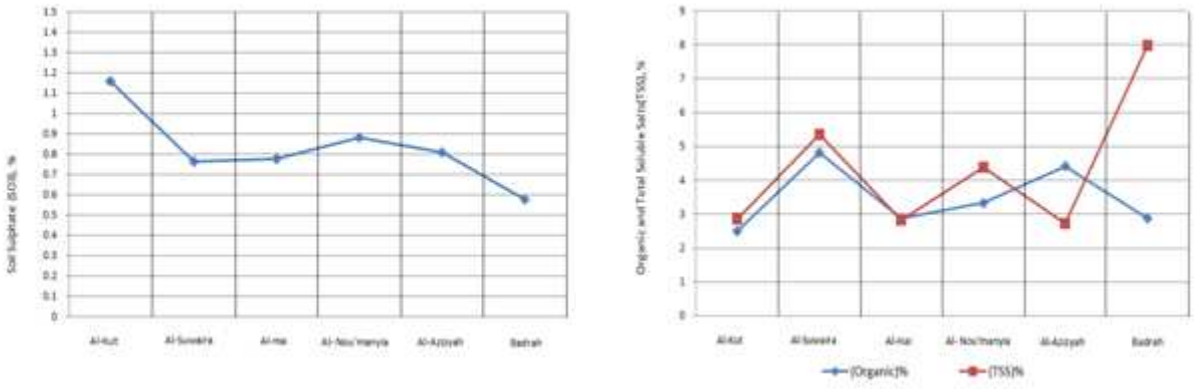

Figure 8. The average values of soil chemical tests

5.8.2. Underground Water Table

The underground water table was encountered in all of the boreholes during drilling and was recorded from the existing ground level after (24) hrs of the drilling termination. The results indicate average value of water table was ranging between (1.2-

2.0) m below natural ground surface in different location in Wasit governorate. The average values of underground water table could be shown in "Fig. 9".

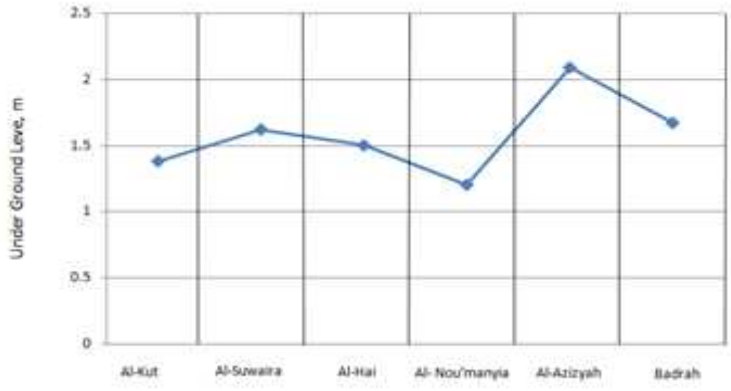

Figure 9. The average values of underground water table

Regarding to chemical test results in "Fig. 10" for underground water, it can be seen that the range of sulphate (SO4) in water between (1916 - 6043) mg/l, while the range of chloride content (Cl^-) is (11442 to 2886) mg/l. On the other hand it also noted that the pH value was (6.88 to 7.68) and TDS values were ranging from (4263 to 37467) mg/l. For all the tested samples, it can be seen that the soil contain appreciable amounts of chemicals and organics, as well as the groundwater were noticed to contain high sulphate and chloride contents. According to the requirement for concrete exposed to sulphate containing solutions, it is recommended to use sulphate-resisting cement.

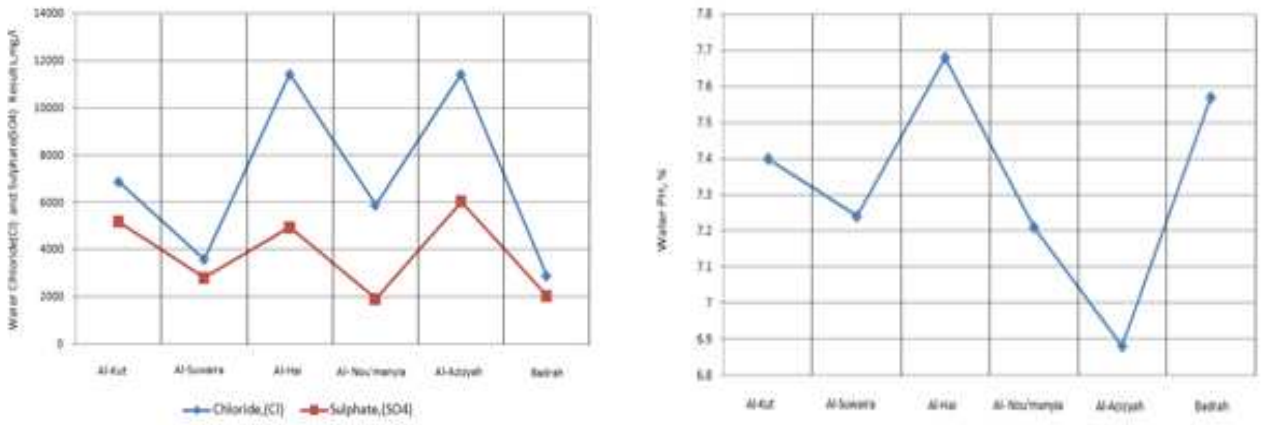

Figure 10. The average values of water chemical tests

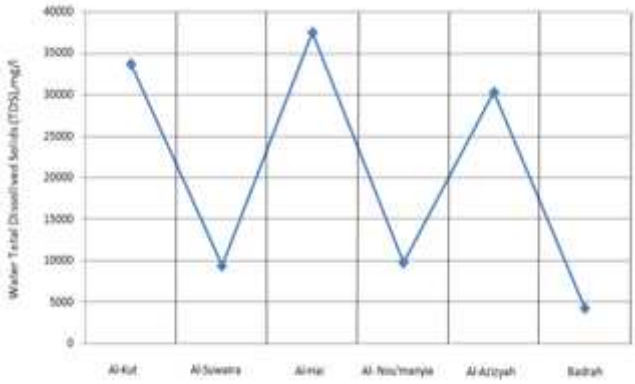

Figure 10. Continues

6. Conclusions

A program of field and laboratory tests was carried out on samples of soil taken from different locations in wasit governorate. Based on the results obtained, the following conclusions are made:

1- Based on results of Standard penetration tests (S.P.T), it can be seen wide variation between (N) values in same depths, this variation may be happened because of the situation of some sites, where some of them were swamps and the others were demolishing and reconstruction, therefore, this is maybe a main reasons in variation of (N) values in same depth below natural ground surface.

2- According to the results of classification tests, the soil is generally of fine aggregate in studying area, the subsoil conditions consist of cohesive layers started from N.G.L to the end of boring at depth of (10.0) m. These layers consists of brown (silty clay to clayey silt to silt) sometimes with sand

3- The results of Atterberg limits test indicate that the liquid limit values increasing with depth in Wasit governorate and ranging from medium to high as well as, the plasticity of soil between medium to high which classified as (CL-CH) to (ML-MH) in the plasticity chart.

4- The GS values ranging from (2.74) to (2.75) in studying area.

5- The average values of moisture content (w_n, %) tested samples were found to be ranging from (23 to 28) %, also the total unit weight (γt, kN/m3) ranged from (20 to 21) kN/m3. The little variation between values of total unit weight may be back to the convergence of granulation texture and moisture content of the soil in studying area.

6- The average values of compression index were ranged from (0.146 to 0.191) and are increasing with increasing depth. The results indicate the soil layers in Wasit governorate are low compressibility.

7- Regarding to UU-test, and SPT-values results, it is obvious that the shear strength of the soil is consistent with medium to stiff.

8- From chemical tests, it can be seen that the soil contain appreciable amounts of chemicals and organics, as well as the groundwater were noticed to contain high sulphate and chloride contents.
9- The underground water table was encountered at the average depth of (1.2 to 2.0) m below the natural ground level.
10- For the time being the data available are not enough to drive equations, this may be than later.

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