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Evaluation of Some Geotechnical Properties of Chosen Soils From Al-Massab Al-Aam channel Slopes (Middle Sector) of Iraq.

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Abstract

This study is concerned with channel banks slopes in the middle sector of Al-Massab Al-Aam channel in the middle and south of Iraq. The geotechnical properties of soil in the channel banks including physical ,engineering, chemical and mineralogical characters in over (25) station have been studied.

The grain size distribution of the bank soils of channel showed that the clay percentage is higher than those of the silt and sand percentages.

The bank soils are classified according to the **USCS** standards. They are composed of clay with low plasticity (CL) that represents 88% of the soil and ,clay with high plasticity (CH)represents 12% of the soil.

The saturated density values ranges between 1.679 and 1.953 g/cm^3 with average value of 1.790 g/cm^3,while the dry density values ranges between 1.274 and 1.718 g/cm^3 with average value of 1.470 g/cm^3 ; the values of dry and saturated density are within the ideal limits .

Direct shear test shows that the cohesion values (c), range between 5-48 kN/m^2 with average value of 21.68 kN/m^2 , while the internal friction angle (Ø°) of the soil type (CL) ranges between 8.5°-30° with average value of 18.13° . The (Ø°) values of the other soil type (CH) ranges between (20°-30°) with average value of 25° ,therefore the (CH) soil types have higher(Ø°) values than the ideal limits .The result of unconfined compression test ranges between 9.4-73.80 kN/m^2 with average value of 30.6 kN/m^2 of remoulded samples with water percentage of 30%.

The mineralogical test of the banks soil of channel using XRD shows that the mineral contents of the analyzed soil are composed mainly of the minerals Quartz ,calcite, Feldspar (Anorthite), dolomite, and Clay minerals such as (montimorillonite, and Kaolinite) .

The Electrical conductivity of soil is classified depending on (FAO) classification between low to high salinity , and the pH value have low to moderate basicity**.**

The gypsum concentrations range between 0.09 and 12.59% with average value of 2.083% , chlorides concentrations range between 0.017 and 0.166% with average value of 0.079%, sulphates concentrations range between 0.044 and 5.85% with average value of 0.987%,and carbonates concentrations range between 2 and 40%with average value of 20.5% . Some treatment measures are proposed to stabilize the soil of the studied area.

Keywords: soil, geotechnical properties, soil treatment.

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تقييم بعض الخواص الجيوتكنيكية لترب مختارة من منحدرات قناة المصب العام (القاطع الاوسط) من العراق

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الخلاصة

تم في هذا البحث إجراء دراسة لأستقرارية منحدرات الضفاف لقناة المصب العام (القاطع الأوسط)في وسط وجنوب العراق، حيث تم دراسة الصفات الجيوتكنيكية للتربة في منحدرات ضفاف قناة المصب العام (القاطع الأوسط) بواقع (25) محطة والتي شملت الخواص الفيزيائية والهندسية والكيميائية والمعدنية وتأثيرها على أستقراية الضفاف .

أظهرت نتائج التحليل الحبيبي ألحجمي ان نسبة الطين أعلى من نسبتي الرمل والغرين في تربة منحدرات ضفاف القناة ، وحسب نظام التصنيف الموحدة (USCS)وجد انها تتكون من التربة الطينية الواطئة اللدونة (CL) والتي تمثل 88% من تربة محطات منطقة الدراسة ،والتربة الطينية عالية اللدونة (CH) والتي تمثل 12% من تربة محطات منطقة الدراسة ،تراوحت قيم الكثافة المشبعة بين 1.679 – 1.953غم /سم^3 وبمعدل 1.790 غم / سم^3 ،بينما تراوحت قيم الكثافة الجافة بين 1.274 – 1.718 غم /سم^3 وبمعدل 1.470 غم / سم^{33} وكانت القيم ضمن الحدود المثالية .

أظهرت نتائج فحص القص المباشر ان قيم التماسك (c) تراوحت بين (5 – 48) كيلو نيوتن / م^2 وبمعدل (21.68) كيلو نيوتن / م^2 بينما تراوحت قيم زاوية الاحتكاك الداخلية (Φ^0) للتربة الطينية الواطئة اللدنة (CL) بين ($20^0 - 3^0$) وبمعدل(25^0) ^{0} للتربة الطينية عالية اللدونة (CH) وهي اعلى من الحدود المثالية ،وتراوحت قيم فحص الانضغاط غير المحصور بين (9.4 – 73.80) كيلو نيوتن / م^2 وبمعدل 30.6 كيلو نيوتن /م^2.

أظهرت نتائج الفحوصات المعدنية لتربة ضفاف قناة المصب العام (القاطع الأوسط) بأنها تتكون من معادن الكالسايت ،الكوارتز،الفلدسبار، والأطيان من نوع المونتيمورلونايت،والكاؤولينايت.

صنفت التوصيلية الكهربائية(EC) للتربة حسب منظمة FAO بأنها ذات ملوحة واطئة الى عالية ،و قيم الأس الهيدروجيني (pH) للتربة ذات قاعدية قليلة الى متوسطة ،وتراوحت تراكيز الجبس بين(0.09 12.59%) وبمعدل (0.987%)، ،وتراوحت تراكيز الكلوريدات بين(0.017 –0.166 %) وبمعدل (0.079%)، ،وتراوحت تراكيزالكبريتات بين(0.044 – 5.85%) وبمعدل (0.987%)،الكاربونات تراوحت بين %(2 – 40%) وبمعدل (20.5%).

واخيرا تم وضع بعض المعالجات المقترحة لتثبيت تربة منطقة الدراسة .

1-Introduction

1-1 Location of the Study Area

The study area occupies some of the central and southern parts of the Mesopotamian plain, along 199km .It is located within Babylon , Al-Qadissiya, Wasit and Thi-Qar Governorates and bounded by Al-Shomaly district (Hilla-Waist road) from east and Al-Nasriya city from west ,the study area extends between longitudes (45° 00' 00" - 46° 30' 00") E and latitudes (31° 00' 00" -32° 30' 00") N as in Figure- 1.

1-2 Aims of this Study

1-To study the physical, mechanical and chemical properties of the soil slopes of banks and mineral constituents of the soil.

2-To suggest remedial measures to protect the channel banks and their stability to ensure optimum investment of the water resources of the river qualitatively and quantitatively.

1-3 Methodology

Stages of research involved:

1-The Data Collection Stage : in which maps and references about the study area have been collected.

2-Field work stage: where the number of sites for slope stability assessment was(25)stations. Soil samples from the bank of river were collected and the laboratory analyses were carried out for those samples.

3- Laboratory work stage in which the physical and chemical tests of the soil samples at sites were carried out.

1-4 - Previous studies

The Previous studies on Al- Masab AL-Aam channel focused on different aspects, including topography ,geomorphology of the region and the economic significance of the river. Most of the previous studies did not pay attention to the nature of the soil slopes of the channel banks .

The following are the most important of these studies :

1. Abdul Ameer, (2012) carried out a geomorphological study of dune fields and their environmental effects at Al-Muthana Governorate-Iraq.(west of the study area).
2. Al-Amar, (2014) studied evaluation of slope stability of main outfull drain banks (Middle sector).
3. Al-Bhadri(1997) dealt with the changes in the quality of Al- Massab AL-Aam channel water and to determine water quality for irrigation purposes and determine the cations and anions and the value of electrical conductivity.
4. Al-Ezerajawi,(2012)carried out an environmental study of Dalmaj marsh area Wasit Governorate (Middle of Iraq).
5. Al-Husseini, (1998)refers to the behavior of the interference of surface water in Al- Massab AL-Aam channel with the groundwater adjacent to it in the area between Mahmudiya and Al-Suwaira .
6. Al-Khatib, (2002) studied Analysis of soil banks failures of Al- Massab AL-Aam channel(North sector).
7. Al-Muttalibi(1992) dealt in his study with topographic features in the alluvial plain and their impact on the path of Al- Massab AL-Aam channel, and the difference in levels between the opposite parts of the valley of the Tigris and the Euphrates rivers.
8. Imran et al.,(1996) Focused in their study on performing analytical study of the distribution of sediments in the northern sector with the analysis of soil and river bottom sediment concentration to calculate its total load , and the application of mathematical methods to calculate the sediment.

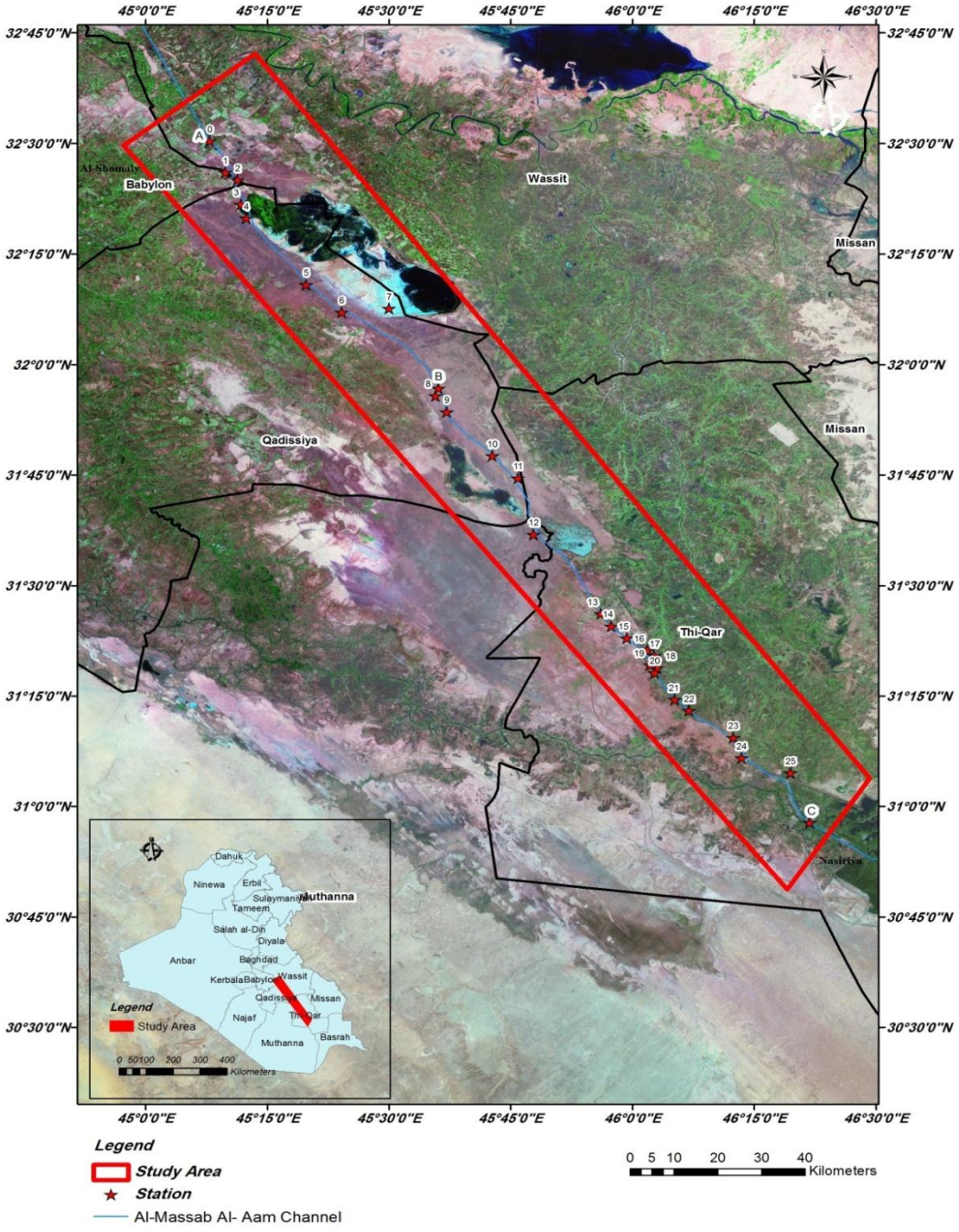

Figure 1- Location map of the study area from satellite image.

1-5- Geology of the study area

The study area is located within the Mesopotamian plain in the area of Unstable Zone relative to the tectonic divisions of Iraq (9,10) within the geosyncline basin, between the Zagros Mountains in the northeast and the Western Stable Arabian Plateau) in south west .

The Mesopotamian plain is a broad syncline formed since the Pliocene period, the delta Plain province is a vast alluvial plain with a slight southeast gradient. It is filled with an accumulation of flood plain, deltaic and lacustrine deposits. human activities for several thousand years led to the construction of many artificial irrigation canals which have behaved as rivers, eroding the original sedimentary cover of the plain.

From geological point of view the study area is covered by Quaternary deposits particularly of Holocene. These deposits were accumulated in thick sequence that consist of clastic deposit composed mainly of sand , silt and clay which represent depression fill deposits, flood plain deposits, and aeolian deposits (11) Figure-2 .

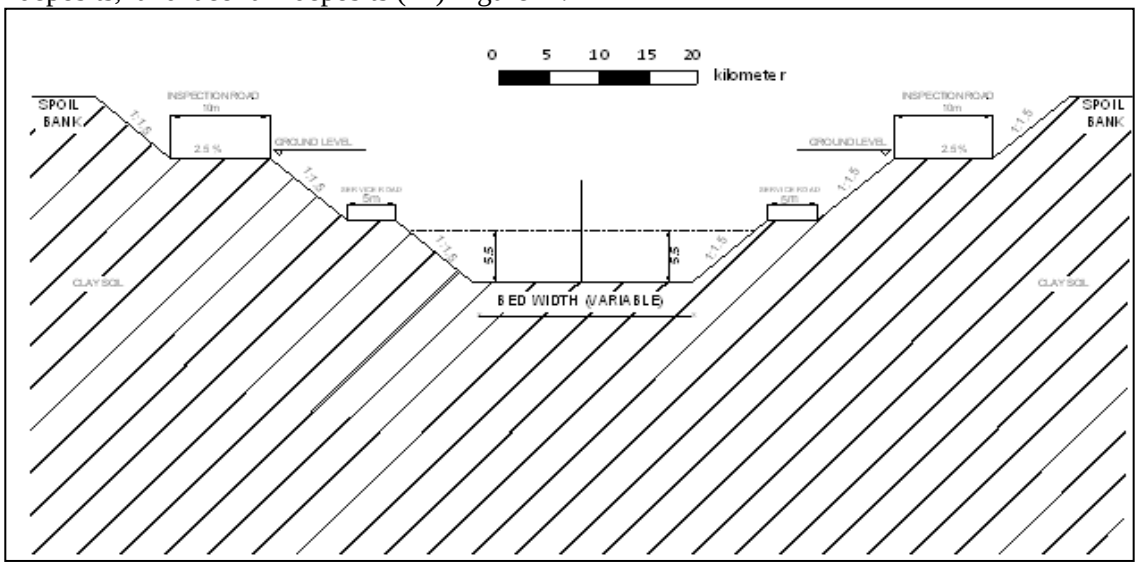

Figure 2- Typical cross section of Al-Massab Al-Aam channel

2-Geotechnical Tests of the Study Area:

2-1 Physical properties of soil:

In the bank soils of Al-Massab Al-Aam Channel the clay percentage is higher than those of the silt and sand percentages. The maximum value of clay percentage(74%) is in station (No.10) and the minimum value(26%) is in station (No.11). The average clay percentage is 54.4% while the maximum value of silt percentageis 52% in station (No.11),the minimum value is 12% in station(No.12) and the average silt percentage is 31.68% ,and the maximum value of sand percentage is 37% in station (No.4),and the minimum value is 2% in stations(No.23 and No.17) and the average silt percentage is 13.92% as shown in Table-1.

In the study area (soil bank slopes) the maximum value of LL percentage is 58.2% in station (No.10),the minimum value(30.2%) in station(No.11) and the average LL percentage is 42.3% ,(as in Table No. 1). Three soils have LL greater than 50 (stations 9,10 and 23) while soils in the other 22 stations have LL less than 50. Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay (11,14,15). The bank soils in Al-Massab Al-Aam Channel are classified depending on Unified Soil Classification System(USCS) as Low plasticity if LL<50 or High plasticity if LL>50 ,all the stations along the Al-Massab Al-Aam Channel as following:

A-low plasticity including the following stations:

(1,2,3,4,5,6,7,8,11,12,13,14,15,16,17,18,19,20,21,22,24 and 25) (CL).

B- High plasticity including the following stations: (9,10 and 23)(CH) Figure - 3 :

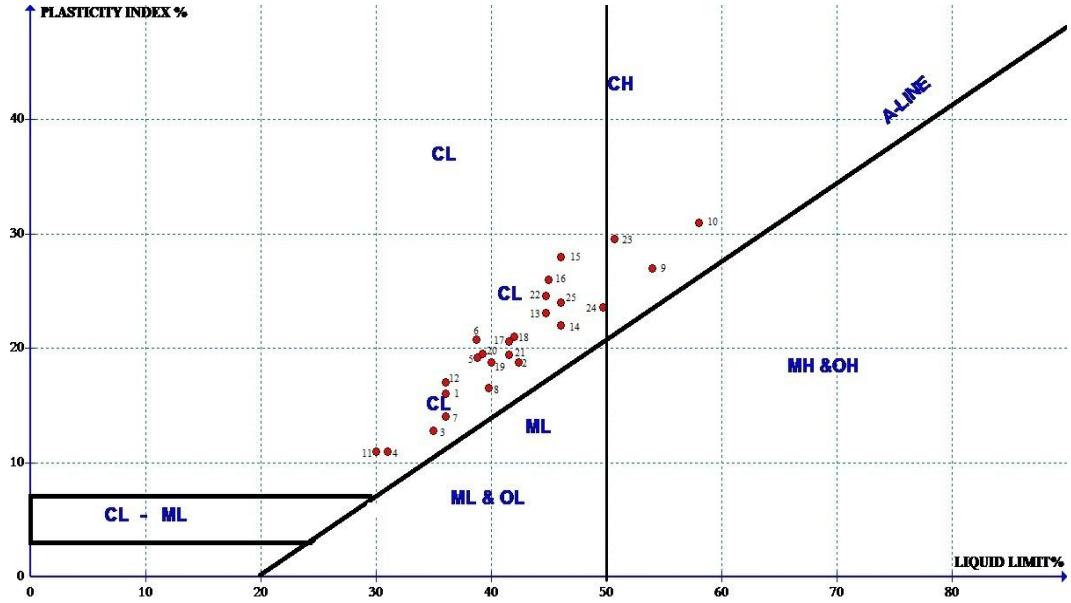

Figure 3 - (USCS) plasticity chart and the soil classification along Al-Massab Al-Aam Channel.

The moisture content for soil of bank slopes in Al-Massab Al-Aam Channel Table-1 ranging from the maximum value of 31.8% in station No.19 ,the minimum value is 13.6% in station(No.11) and the average is 23.06%.

When the moisture content increases for the clayey soil it causes swelling in it, and effect on the soil of the bank slopes then causing soil failure (12,13,14). The values of saturated density for soil of the bank slopes in AL-Massab AL-Aam Channel Table-1 ranges from the maximum value of 1.953 g/cm^3 in station(No.12) ,to the minimum value is 1.679 g/cm^3 in station (No.19) and the average is 1.790 g/cm^3 .While the values of dry density range from the maximum value of 1.718 g/cm^3 in station (No.11) , to the minimum value is 1.274 g/cm^3 in station (No.19) and the average of 1.470 g/cm^3.

Table1- Results of some physical tests of the bank soils in Al-Massab Al-Aam Channel (middle sector).

St. No.	Particles size distribution &Hydrometer analysis			Index Properties				US CS system	S.G	Unit Weight g/cm^3	
	Clay %	Silt%	Sand %	LL%	PI%	M.C%	IC%			Sat	Dry
1	27	48	25	36.1	16.3	19.6	1.01	CL	2.66	1.702	1.422
2	42	41	17	42.4	18.8	16.8	1.36	CL	2.66	1.782	1.525
3	71	14	15	35.2	12.8	18.5	1.30	CL	2.67	1.697	1.432
4	44	19	**37**	31.7	11.4	23.6	0.71	CL	**2.63**	1.89	1.584
5	60	25	15	38.8	19.2	17.7	1.09	CL	2.69	1.729	1.469
6	43	23	34	38.7	20.4	19.2	0.95	CL	2.64	1.800	1.551
7	42	41	17	36.3	14.4	19.5	1.16	CL	2.66	1.819	1.565
8	58	20	22	39.8	16.5	19.9	1.20	CL	**2.70**	1.802	1.502
9	71	21	8	54.8	27.6	19.9	1.26	CH	2.67	1.745	1.454
10	**74**	22	4	**58.2**	**31.3**	21.2	1.18	CH	2.68	1.844	1.521
11	**26**	**52**	22	**30.2**	**11.3**	**13.6**	**1.46**	CL	2.67	1.952	**1.718**

12	58	**12**	30	36.8	17.1	15.6	1.23	CL	2.67	**1.953**	1.688
13	55	39	6	44.7	23.1	22.7	0.95	CL	2.66	1.836	1.496
14	54	39	7	46.4	22.4	24.7	0.96	CL	2.64	1.738	1.394
15	58	30	12	46.6	28.8	28.8	0.61	CL	2.65	1.749	1.357
16	44	40	16	45	26.5	29.5	0.58	CL	2.68	1.790	1.381
17	58	40	2	41.6	20.6	22.6	0.92	CL	2.65	1.805	1.471
18	52	34	14	42.6	21.3	22.9	0.92	CL	2.66	1.811	1.473
19	66	26	8	40	18.8	**31.8**	**0.43**	CL	2.68	**1.679**	**1.274**
20	58	36	6	39.2	19.5	20.8	0.94	CL	2.65	1.914	1.584
21	54	35	11	41.5	19.4	28.4	0.67	CL	2.66	1.737	1.353
22	60	32	8	44.7	24.6	30.2	0.58	CL	2.65	1.734	1.331
23	63	35	**2**	50.7	29.6	28.8	0.73	CH	2.67	1.757	1.363
24	51	42	7	49.7	23.6	30.9	0.79	CL	2.67	1.709	1.305
25	71	26	3	45.9	24.8	29.4	0.66	CL	2.64	1.785	1.370
Av	**54.4**	**31.68**	**13.92**	**42.3**	**20.8**	**23.06**	**0.94**		**2.66**	**1.790**	**1.470**

2-2 Engineering properties of soil

2-2-1 Shear strength of the soil

The shear strength for the undisturbed samples relatively decreased because of remolding process. This phenomenon is called sensitivity which is the ratio between the shear of the undisturbed soil to shear of disturbed soil (15,16).

The high values of Ø° when they are greater than 30°,and the low values of Ø° due to the presence of clay minerals such as: (illite), (mica and chlorite minerals because they cause sliding and decreasing the strength during the shear process.

The direct shear results of soil in the bank slopes in Al-Massab Al-Aam Channel are shown in Table-2.Most of the soil type (CL) fall below the ideal limits values of the internal friction angle Ø° and ranges from the maximum value is 30° in station (No.23) to the minimum value is 8.5° in (station No.1) and the average is18.13°. The other soil type (CH) over the ideal limits values of the internal friction angle Ø°and ranges from the maximum value is 30° in station (No.23) to the minimum value is 20° in station (No.9) and the average is 25 °.Thus most of the soils are of the type(CH) having high values of Ø°. The average of all Ø° values along the Al-Massab Al Aam (middle sector) is 18.733°.

The direct shear values of soil in the bank slopes in Al-Massab Al-Aam Channel Table-2 for cohesion c, ranges from the maximum value is 48 kN/m^2 in station(No.2) to the minimum value is 5 kN/m^2 in stations (No.12 and 21) and the average of 21.86° kN/m^2. Some stations have high value of (c) because of the high amount of the clay and silt .A reverse relationship between cohesion and grain size was found.

According to(17) Standard were the ideal value of the internal friction angle Ø equal to 28° for soil type CL, 32° for soil type ML, 25° for soil type MH, and 30° for soil type CH.

2-2-2 Unconfined Compression of the Soil (U.c)

The unconfined compression test one from easily and faster test can determine the shear strength for soil ,the soils testing in this method are unconfined side compressive, thus this method available just for cohesive soils(silt and clay) (18).

The unconfined compression test for in Al-Massab Al-Aam Channel(study area) Table-2 are remolded with 30% water content and ranges from a maximum value of 73.80 kN/m^2 in station (No.10), to a minimum value is 9.4 kN/m^2 in station (No.17) and average 30.6 kN/m^2.

Table 2- Compression and shear strength values and soil type for some stations in Al-Massab Al-Aam Channel.

St. No.	Type of sample	Type of soil	unconfined compression test(kN/m^2)	Shear strength parameters	
				C (kN/m^2)	Ø°
1	Disturbed (Remoulded)	CL	28.0	15	**8.5**
2	Disturbed (Remoulded)	CL	24.2	**48**	18
3	Disturbed (Remoulded)	CL	23.5	40	11.5
4	Disturbed (Remoulded)	CL	31.6	-	-
5	Disturbed (Remoulded)	CL	30.9	-	-
6	Disturbed (Remoulded)	CL	22.8	40	20
7	Disturbed (Remoulded)	CL	29.6	-	-
8	Disturbed (Remoulded)	CL	28.9	25	24.5
9	Disturbed (Remoulded)	CH	42.4	10	20
10	Disturbed (Remoulded)	CH	**73.8**	-	-
11	Disturbed (Remoulded)	CL	44.4	-	-
12	Disturbed (Remoulded)	CL	67.5	**5**	26
13	Disturbed (Remoulded)	CL	23.5	-	-
14	Disturbed (Remoulded)	CL	28.2	20	10
15	Disturbed (Remoulded)	CL	22.2	-	-
16	Disturbed (Remoulded)	CL	10.7	-	-
17	Disturbed (Remoulded)	CL	**09.4**	10	19
18	Disturbed (Remoulded)	CL	14.8	20	10
19	Disturbed (Remoulded)	CL	12.6	10	13
20	Disturbed (Remoulded)	CL	20.8	-	-
21	Disturbed (Remoulded)	CL	29.2	**5**	26
22	Disturbed (Remoulded)	CL	13.4	**45**	12
23	Disturbed (Remoulded)	CH	33.6	10	**30**
24	Disturbed (Remoulded)	CL	16.1	-	-
25	Disturbed (Remoulded)	CL	28.2	25	24
Av.			**30.608**	**21.86**	**18.13**

2-3 Chemical properties of soil

Electrical conductivity(EC) is the ability of 1cm of water to conduct electrical current, at temperature of 25 measured by micromohs/cm (µhs/cm) or (Mhs/cm).It depends on the concentration of soluble salts and the temperature of the water (19,20,21). The EC values of soil bank slopes in Al-Massab Al-Aam Channel, Table-3 ranges from the maximum value is 19.1 Mhos/cm in station (No.11) , to the minimum value is 3.8 Mhos/cm in station(No.3) and the average is 9.26 Mhos/cm .The salinity type for all the station depend on (22) ranges from low to high salinity ,because it is close to water surface of the channel . 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.

Most of the secondary gypsum ($CaSO_4.2H_2O$) is found in middle and south of Iraq. The gypsum values of Al-Massab Al-Aam Channel (study area) , Tables-3 ranges from a maximum value of 12.59% in station (No.2) , to a minimum value of 0.090% in stations (No.6), and the average is 2.083%.

The chlorides have very large destruction ability on the soil when its values exceed(0.5%)(23). The natural origins of chloride in inland waters are attributable to leaching of salts from the underlying rock strata (mostly sedimentary rocks) from which springs arise or over which the river flows.**.**The chloride values of Al-Massab Al-Aam Channel (study area) , Table-3 ranges from a maximum value of 0.161% in station (No.10) , to a minimum value of 0.017% in stations(No.7,13, 14), and the average is 0.079% .

The sulphates values of Al-Massab Al-Aam Channel (study area) , Table-3 range from a maximum value of 5.85% in station (No.2) , to a minimum value of 0.044% in station (No.6) and the average is 0.987% ,from the values above observed high concentration of sulphates ,thus when use the cement for soil stabilization must be from type cement resistance to sulphates .

The source of calcium carbonate ($CaCO_3$) in the soil of the study area, which origin at from river depositions, resulting from the erosion of limestone rocks and dolomite which are found in several layers of formations that passes by Tigris and Euphrates rivers and their tributaries, as the deposits of the Tigris river sand containing a high proportion of calcium carbonate (24 **).** It is worth mentioning that the proportion 30% or more of ($CaCO_3$) with the seriousness and these lead to dangerous in engineering problems like cavities (settlement layers) and falling differential buildings or weaken the soil. (21).

The carbonate ($CaCO_3$) values of Al-Massab Al-Aam Channel (study area) , Table-3 ranges from the maximum value of 40% in station (No.20) to the minimum value of 2% in stations(No.10, and 11) and the average of20.5%.

The pH values of Al-Massab Al-Aam Channel (study area) , Table-3 ranges from the maximum value 9.1 in station(No.11) to the minimum value 7.5 in stations (No.14), and average of 8.1,therefore it has low basicity in soil.

Table 3- The chemical properties of soil bank slopes in Al-Massab Al-Aam Channel.

St. No.	EC (Mhos/cm)	Salinity type	Gyp.%	Cl%	SO_3%	$Caco_3$%	pH
1	18	High salinity	0.530	0.110	0.240	20	7.8
2	8.1	Medium salinity	**12.590**	0.142	**5.85**	20	7.6
3	**3.8**	Very Low salinity	3.490	0.035	1.627	18	8.2
4	3.9	Very Low salinity	3.390	0.035	1.581	22	8.1
5	11	Medium salinity	3.750	0.142	1.747	5	7.9
6	7.4	Low salinity	**0.090**	0.106	**0.044**	23	7.7
7	18.9	High salinity	0.110	**0.017**	0.051	22	8.4
8	8.7	Medium salinity	3.250	0.160	1.514	13	8.6
9	7.8	Low salinity	1.590	0.124	0.740	8	8.0
10	16.8	High salinity	1.440	**0.161**	0.670	**2**	7.9
11	**19.1**	High salinity	1.670	0.124	0.776	**2**	**9.1**
12	6.3	Low salinity	2.040	0.053	0.950	5	8.4
13	5.4	Low salinity	0.680	**0.017**	0.320	27	8.5

14	4.8	Low salinity	0.410	**0.017**	0.190	27	**7.5**
15	5.8	Low salinity	6.700	0.088	3.120	27	8.1
16	7.8	Low salinity	0.538	0.088	0.250	23	7.9
17	5.6	Low salinity	1.470	0.035	0.680	30	7.7
18	9.4	Medium salinity	0.450	0.035	0.210	29	7.9
19	7.3	Low salinity	0.280	0.106	0.130	30	8.0
20	8.6	Medium salinity	0.490	0.035	0.230	**40**	8.2
21	9.9	Medium salinity	6.300	0.088	2.930	20	8.1
22	8.7	Medium salinity	0.450	0.035	0.212	32	8.1
23	10.3	Medium salinity	0.120	0.035	0.060	23	7.9
24	8.8	Medium salinity	0.766	0.120	0.350	22	8.3
25	9.2	Medium salinity	0.490	0.053	0.205	23	8.5
	9.26	**Medium salinity**	**2.083**	**0.079**	**0.987**	**20.5**	**8.1**

3-Soil slopes stabilization

There are many different methods which can treat the problem of soil slope failures including the following treatments (25,26):

1- Treatment by cement
2- Treatment by lime
3- Treatment by fly-Ash
4- Compaction method
5- Retaining wall method
6-Treatment by riprap
7-Treatment by vegetation

The soil cement mixture can be used for casing the drainage and irrigation channels in Al-Massab Al-Aam channel where most drainage in which the flow of water causes erosion and bank slopes failures therefore must be stabilized especially at stations(7 and,23). Lime stabilizations technology can be using in some station of Al-Massab Al-Aam channel especially stations (9, 10 and 23) because those stations compose of clay with high plasticity (CH). Fly-Ash stabilizations method can be using in some station of Al-Massab Al-Aam channel especially stations (1,2,5,6,8,9,10 ,12,13,14,15,16,17,18,19,20,21,22,,24 and 25) where they had medium swelling in order to decrease the swell pressure .The swell pressure can be attributed to the reduced water absorption tendency of stabilized clay. Compaction method can be used in service roads and berms that's parallels to bank slopes of Al-Massab Al-Aam channel especially which are effected by tension cracks and gullies same like stations(2,4,5,7,8,11,and 12).The retaining walls stabilizations technology can be using in all station of Al-Massab Al-Aam channel(middle sectors) but it is high cost economically. The riprap methods generally used for casing the bank slopes which has high erosion such as the meanderings rivers and the locations of meeting the Al-Massab Al-Aam channel (middle sector) with its branches, therefore this method can be use in some stations especially stations(4,5,7,8,10,24 and 25).

The treatment by vegetation such as(shrubs, grasses ,trees and vegetation structure) is one from best methods which can be used in all stations of Al-Massab Al-Aam channel(middle sector) because it is the least expensive of river bank protection measures.

4- Mineralogical study of Soil

The results of X-Ray diffraction of samples were analyzed showed the mineral content of the Al-Massab Al-Aam Channel(middle sector) , to be composed mainly of the minerals quartz (Q), calcite (C), Anorthite (A) ,Dolomite (D) kaolinite (K), and Montmorillonite(M) Figure-4.

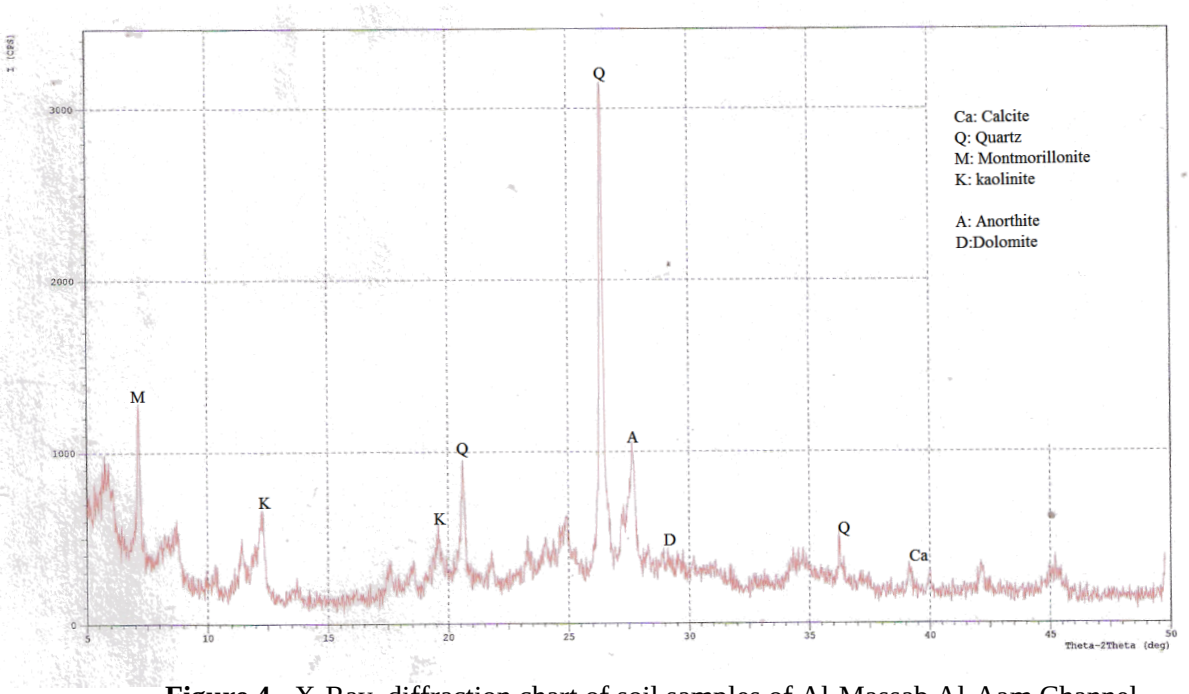

Figure 4 - X-Ray diffraction chart of soil samples of Al-Massab Al-Aam Channel.

5- Conclusions

1. Grain size distribution of the bank soils of Al-Massab Al-Aam Channel shows the clay percentage to be higher than those of the silt and sand percentages; the clay percentage ranges between 26% and74% with average of 54.4% ; the silt percentage range between12%and52% with average of 31.68% ; the sand percentage range between 2%and 37% with average of 13.92% ;the grain size distribution curves show the increase of clay and silt contents along Al-Massab Al-Aam Channel stations .
2. The bank soils are classified depending on the Unified Soil Classification System(USCS).They are composed of Clay of low plasticity (CL) that represents 88% of the study stations. Soil and clay with high plasticity (CH)represents12% of the study stations soil.
3. The saturated density values range between 1.679 g/cm^3 and 1.953 g/cm^3 with average of 1.790 g/cm^3 , while the dry density values range between 1.274 g/cm^3 and 1.718 g/cm^3 ,with average of 1.470 g/cm^3 ,the values of dry and saturated density lie within the ideal limits
4. The direct shear values for soil cohesion(c), range between 5 kN/m^2 and 48 kN/m^2 , with average of 21.68 kN/m^2 ,the high values of (c)in some stations are due to the high amount of the clay and silt, while the internal friction angle (Ø°) of the soil type (CL) range between 8.5° and 26°, with average of 17.11° . Therefore, most of the soil type (CL) fall below the ideal limits values of the internal friction angle (Ø°).The other (Ø°) values of the soil type (CH) range between 20° and30° with average of 25°.Therefore, the (CH) soil types have higher (Ø°)values than the ideal limits values of the internal friction angle (Ø°),the high values of (Ø°) are greater than 30°,and the low values of (Ø°)are due to the presence of clay minerals such as: Illite , mica and chlorite ,because they cause sliding and decrease of strength during the shear process.
5. The unconfined compressive strength values range between 9.4 kN/m^2 and 73.80 kN/m^2 with average of 30.6 kN/m^2 of remoulded samples with water percentage of 30% .
6. Electrical conductivity(EC)of soil concentrations range between 3.8 mhos/cm and 19.1 mhos/cm with average of(9.26) mhos/cm, depend on (FAO classification ,1989) they are classified low to high salinity ,because it is close to water surface of the channel. The pH values ranges between 7.5 and 9.1 with average of(8.1); therefore they have low to moderate basicity**.**
7. The gypsum concentrations ranges between 0.09% and12.59% with average of (2.083%). Chlorides concentrations ranges between 0.017% and 0.161% with average of(0.079%).
8. Sulphates concentrations ranges between 0.044% and 5.85% ,with average of(0.987%).It appears from the values above that the sulphate concentration is high ,thus when cement is used for soil

stabilization must be from the type resistant to sulphates . Carbonates concentrations ranges between 2% and 40% ,with average of (20.5%) .

9. The treatment by vegetation such as(shrubs, grasses ,trees and vegetation structure) is one from best methods which can be used in all stations of Al-Massab Al-Aam channel(middle sector) because it is the least expensive of river bank protection measures **.**

6- Recommendation

After studying all field observations and geotechnical properties of Al-Massab Al-Aam channel soil(middle sector),the following points are recommended :

1. Using some types of plants that have resistance to the high concentration of salts along Al-Massab Al-Aam channel (middle sector) in order to stabilize and protect the soil of bank slopes from failures.

2. Flattening the steep bank slopes by reducing their slope angle or by grading the slope into steps.This will increase slope stability.

3. Using field compaction for the upper layers of the bank slopes in order to increase the soil strength.

4. Using riprap in the banks slopes that are more liable to failures or erosions in order to protect them from such hazards in the future.

5. Conducting similar study for the southern sector of AL-Massab AL-Aam Channel to determine the soil failures and treating them.

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