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Study and Evaluation of Geotechnical Properties of Soil Banks Slopes for Al-Masab Al-Aam Channel (Southern Sector) and the Possibility of Improving Them. Iraq

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Abstract

This study is concerned with channel banks slopes in the southern sector for Al-Masab Al-Aam channel south of Iraq. The geotechnical properties of the soil in the banks of the channel including the physical, engineering and chemical properties of (15) stations were studied. The grain size distribution of soil showed that the proportion of sand was higher than that of clay and silt.

Based on the USCS standards of soil of the study area can be classified as clay with low plasticity (CL) that represents 33.3% of the soil and ,clay with high plasticity (CH) represents 20% of the soil and nonplasticity (SM) represents 46%.The dry density values range between (1.51-1.86) g/cm3 , the saturated density values range between (1.61-2.2) g/cm^3, and the water content values range between (25.2-42%), while the specific gravity values range between (2.51-2.74).The internal friction angle (Ø°)from direct shear test ranged between (21.5-37°). The values of unconfined compression test range between (37-126.2) kN/m^2 of remolded samples with 25% water, The values of chloride range between (0.053-0.195%), while the values of sulfate range between (0.053-0.195%), the carbonates concentrations range between (15-50%), the organic materials concentrations range between (0.140-1.125%), The pH value range between (7.5-9). According to these results, the stability of the ramps of the banks of the downstream general channel (Southern District) was evaluated and appropriate solutions were proposed to support their stability and treat the unstable ones.

Key words:

AI- Masab Al-Aam channel, geotechnical properties, chemical test , southern sector..

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1. Introduction

AI- Masab Al-Aam channel project (the third river) is considered one of the important strategic projects that extend from the Ishaqi channel north of Baghdad and ends when it meets the Shatt al-Basra channel (Fig. 1). The main functions of the river are to receive saline water from the irrigated area between the Tigris and Euphrates rivers to reduce the salinity of agricultural soils. On the one hand and to act as a barrier against the expansion of sand dunes towards the irrigated lands [1]. The importance of the river lies in its connection with the sewage channels. The Hammar Marsh to avoid drying it again through the Khamisiya channel [2]. The research aims to study the geotechnical properties of slopes banks soil and evaluate of failures sites from banks channel and their relationship with the hydrological and hydrochemical properties of surface water of AI- Masab Al-Aam channel.

River banks are not completely stable and are in constant change, whether sedimentary or erosion, and river banks are exposed to erosion by removing soil particles from the face of the slopes and moving them away. of the soil from the face of the cliffs and their fall, overturning, or slipping into the waters of the river. Soil collapse often occurs due to the removal of the support or support, which gives resistance to the soil, so the forces of attraction overcome the resistance of the soil, and the moisture content is one of the main factors in this aspect (Al-Khatib, 2002).

(Dapporto *et al*, 2001) distinguished three types in which a block collapses from a river shoulder, leaving alcove-shape failures: porthole collapse in which the block collapses in slap-shape failure in the shoulder from which it collapsed, and slab-shape failure Where the rear slit expands gradually (toppling-shape failure) thin, and collapses in the form of inversion with relative stability of its base until it is overturned and the surface of the back slit is relatively flat.

1-1-Location of the study area

The study area occupies some southern parts of the Mesopotamian plain, and the length of the southern sector (study area) is 166 km, starting from the Thi- Qar Governorate (the city of Nasiriyah) to the Basrah governorate (the city of Zubair) , the study area extend between longitude (46˚ 16′ 30″) -(48˚ 22′ 30″) E and latitude (30˚ 05′ 51″) (31˚ 06′ 09″)N, Figure(1). The climate of the southern region, especially Basra, is characterized by a significant change in temperatures, low rainfall and high humidity represented in the Arabian Gulf [3].

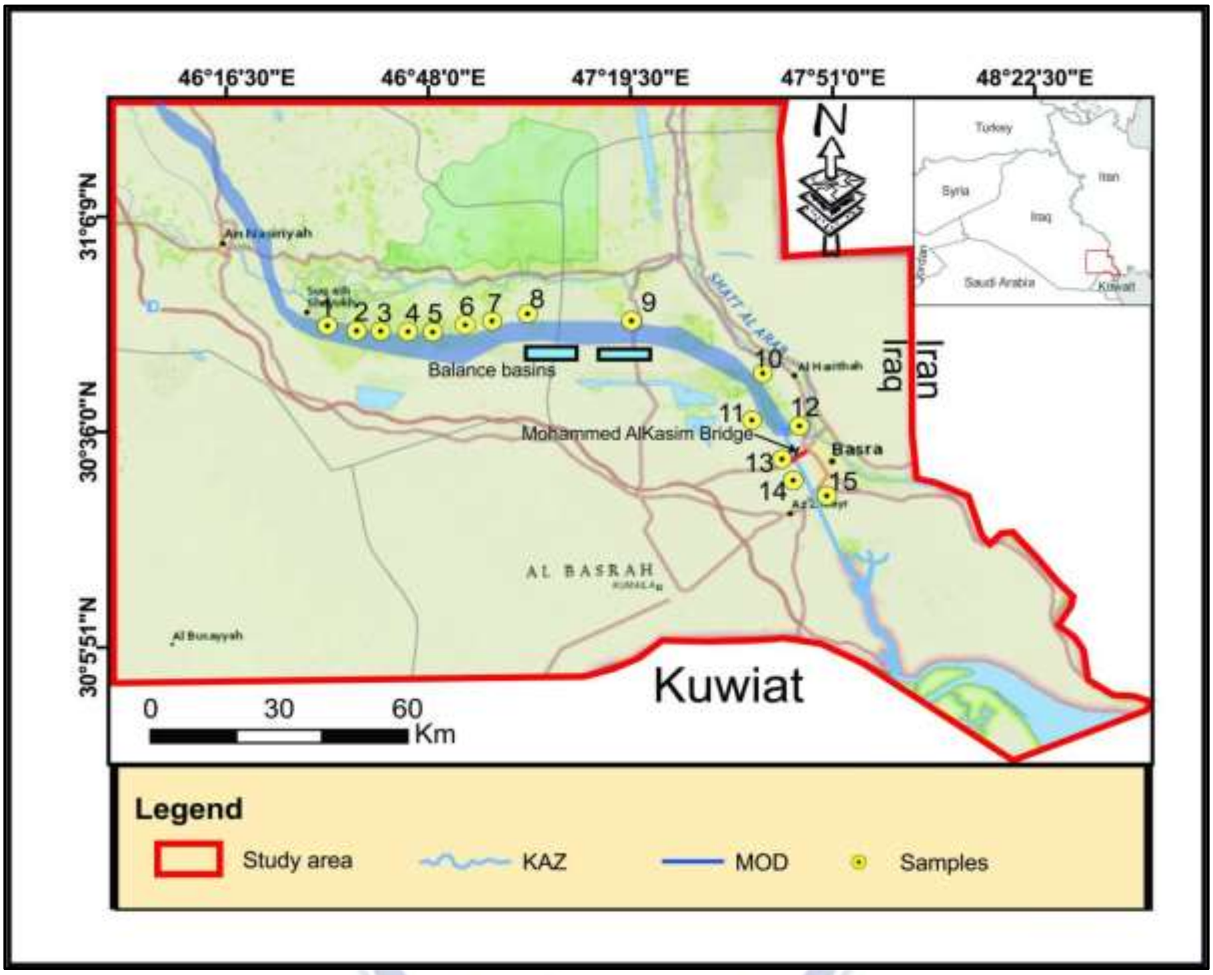

Figure 1- Location map of the study area

1-2Aim of the study area

The study aims to evaluate the geotechnical properties of soil banks slopes and evaluate of failures sites from banks channel and their relationship with the hydrological and hydrochemical properties of surface water of AI- Masab Al-Aam channel and stabilizing of soil banks by treatment methods for protection of .

1-3 Geology of the study area

The study area is located within the Mesopotamian plain in the region of the unstable region in relation to the tectonic divisions of Iraq [4]. where the study area covered sediments from the Quaternary period, especially from the Holocene, and these sediments accumulated in a thick sequence consisting of sediments consisting mainly of sand, silt, and clay, which are depressions that fill sediments[5]. figure(2).

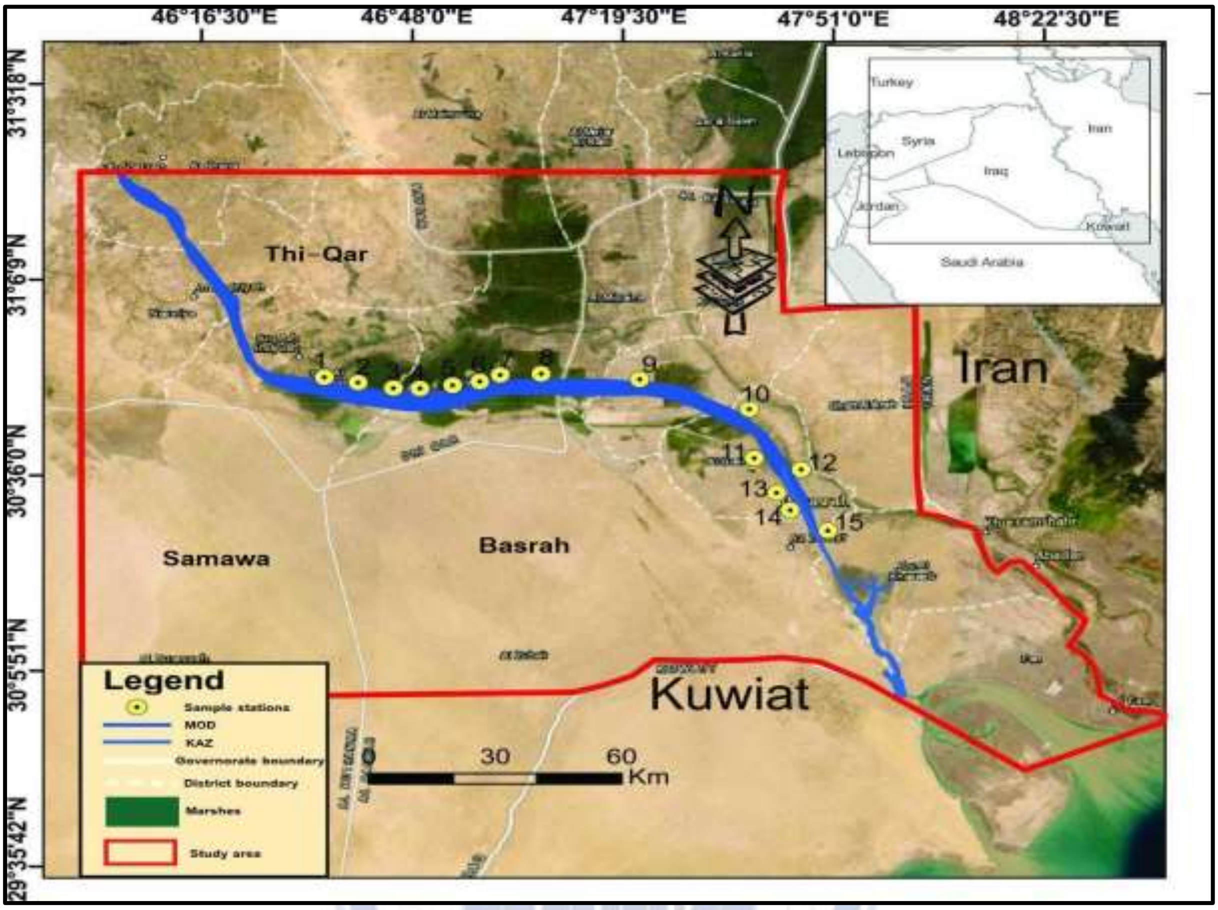

Fig.2. Geological map of the study area

2. Materials and methods

(15)Fifteen soil samples disturbed were taken from the study area, at a depth of (30) cm, and kept in clean plastic bags on which the station numbers were recorded and sent to the laboratory for the purpose of analysis and determining its geotechnical characteristics. The samples were analyzed in the National Center for Research and Construction Laboratories, Babylon Branch, Soil Department, Babylon Branch, where the physical, engineering and chemical properties were measured according to the(ASTM) [6,7,8,9,10] in addition to measuring the concentrations (Cl, SO_3, $CaCO_3$, Organic matter, pH) according to (B.S) [11], after obtaining and comparing the results, three sites (15, 9, 2) were selected from the study area to add stabilizers (sulphates resisting cement, limestone powder, sodium bentonite) according to weight ratio(5, 10,15%) to improve geotechnical properties.

Table 1. Shows the count of samples for each test

geotechnical properties			
Physical properties	Engineering properties		Chemical properties
	Shear strength	Unconfined compressive strength	
15 samples	7 samples	8 samples	15 samples

3. Results and Discussions

3.1 Physical properties of soil

3-1-1 Grain size analysis:

The results grain size analysis table(1) showed that the sand content was higher than that of clay and silt and that the maximum value of sand (97%) for Station No. (3) and the minimum value (4%) for Station No. (14). While the maximum value of clay (65%) for station No. (15) and the minimum value (2%) for station No. (3). The maximum value of silt (45%) in station No. (14) and the minimum (1%) in station No. (3) Table 1. and figures (3,4,5,6) show the grain size distribution curves for stations (1,9) (10,11) (12,13)and (14,15) respectively.

The (USCS) classification standards of soil of the study area showed that the soil samples were of a type of silty clay with low plasticity (CL) by (33.3%) and sandy silt (SM) by (46.6%) and silty clay with high plasticity (CH) by (20%) , The difference in the distribution ratios of particle size analysis is observed due to the change in sedimentary deposits during the recent sedimentary history, which had a direct impact on the soil diversity in the study area.

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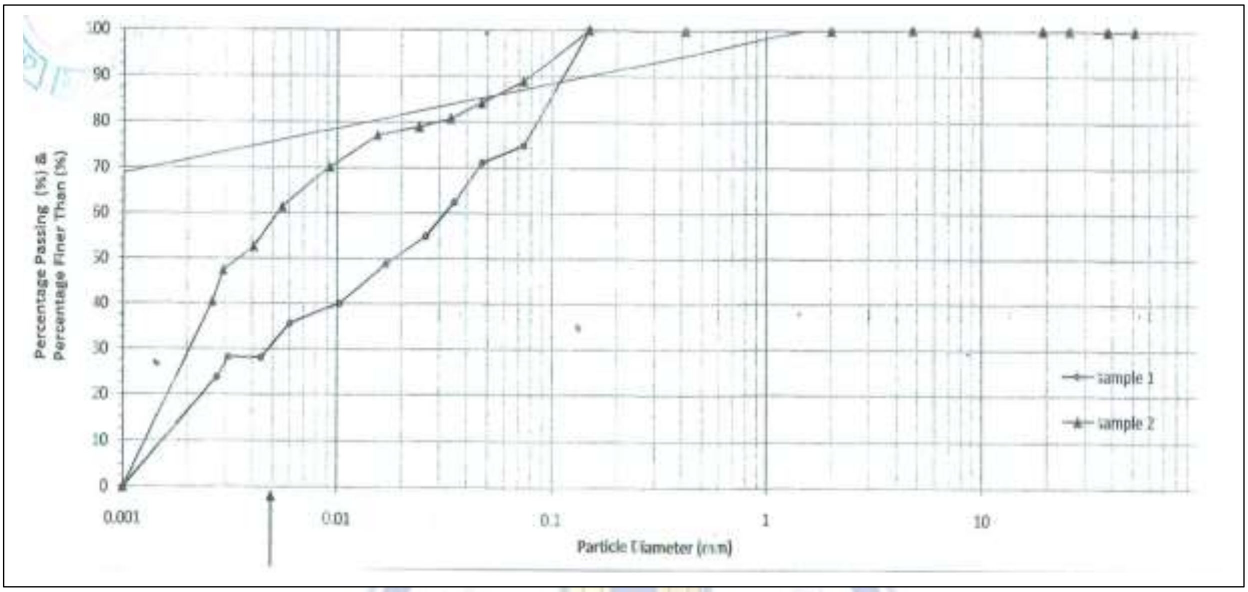
Particle – size distribution	Based on ASTM D422-63 (2007)	Station No. 1-9



Clay	Silt	Sand			Gravel
		Fine	Medium	Coarse	

Fig.3. grain size distribution curves for stations No.1,9.

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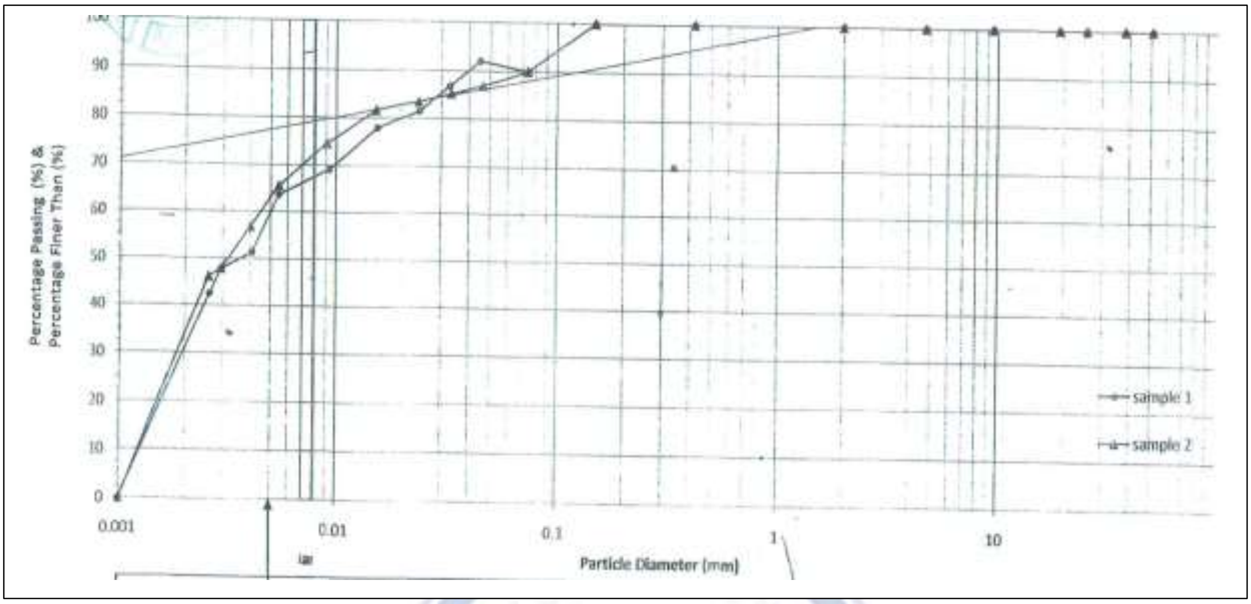
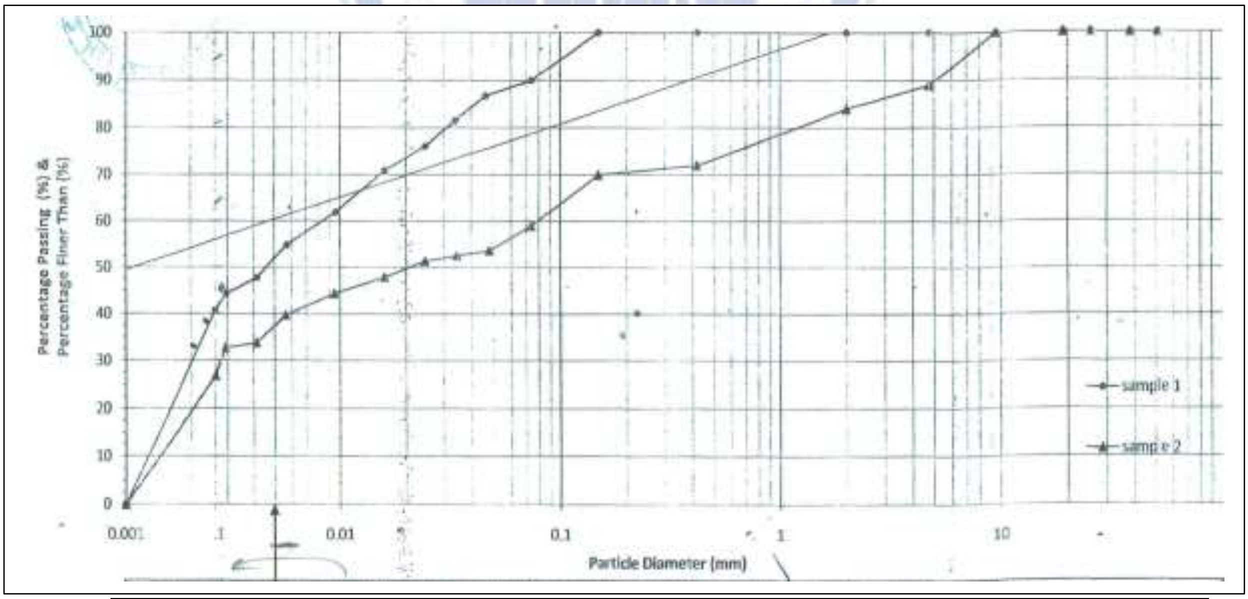
Particle – size distribution	Based on ASTM D422-63 (2007)	Station No. 10-11



Clay	Silt	Sand			Gravel
		Fine	Medium	Coarse	

Fig.4. grain size distribution curves for stations No.10,11.

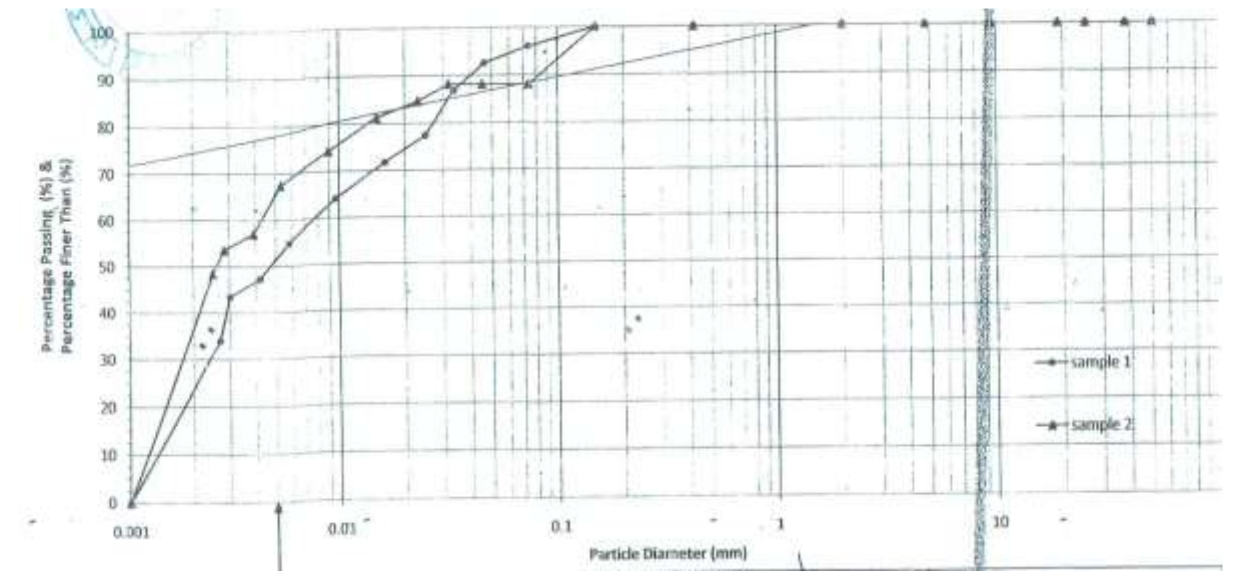
Particle – size distribution	Based on ASTM D422-63 (2007)	Station No. 12-13



Clay	Silt	Sand			Gravel
		Fine	Medium	Coarse	

Fig.5. grain size distribution curves for stations No.12,13.

Particle – size distribution	Based on ASTM D422-63 (2007)	Station No. 14-15



Clay	Silt	Sand			Gravel
		Fine	Medium	Coarse	

Fig.6. grain size distribution curves for stations No.14,15.

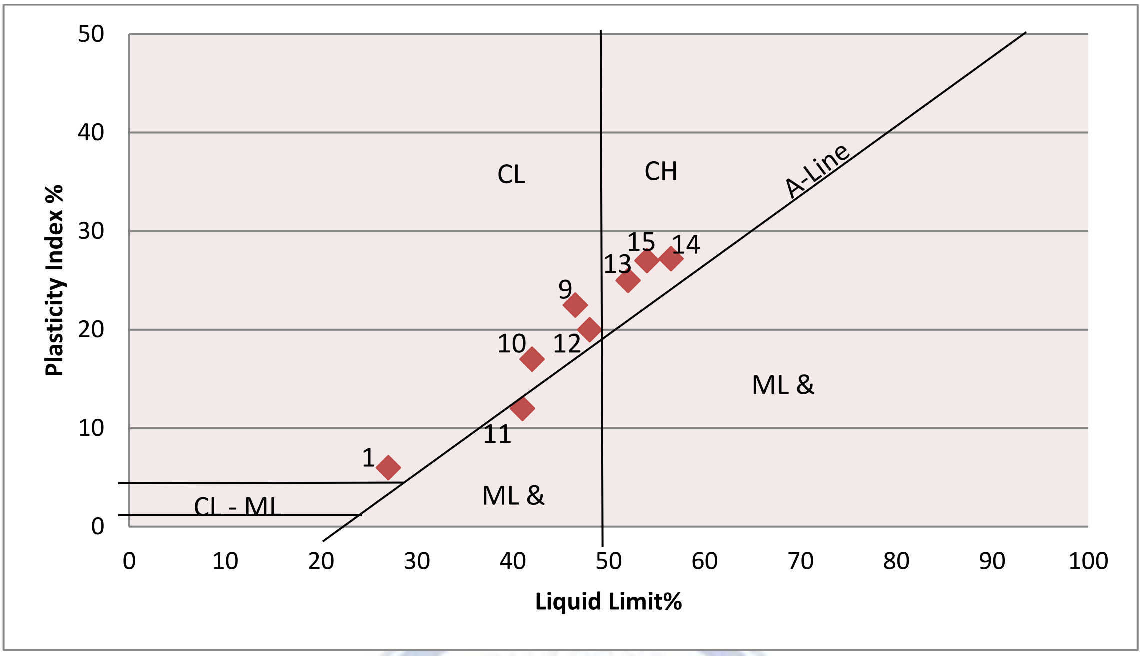
3-1-2 Specific Gravity:

The results of specific gravity showed that the maximum value (2.74) in station No.15 and the minimum value (2.51) in station No.5. Table 1.

3-1-3 Atterberg limits:

In the study area (slope banks soil) the maximum value of liquid limit (L.L) in (56.5%) in station (15) while the minimum value (27%) in station 1.The maximum of plasticity Index (PI) (27.2%) in station 15 and the minimum value (6%)in the station 1. Table 1.

The slope banks soil of study area can be classified according to the plasticity chart (Figure 7), it shows that clayey soil of low plasticity (CL) represented by (33%), and clayey soils of high plasticity (CH) represented by (20%)and the other non-plastic (SM) represented by (46.6%) (Figure 7).



(Fig.7.) Plasticity chart of slope banks soil for study area

Table 1. Shows the results of some physical tests of the bank soils in AL-Massab AL-Aam channel. southern sector

Statior	Depth (cm)	clay%	Silt %	sand%	L.L. %	P.I. %	M.C %	IC %	Sym USC	S.G	Density (g/cm^3)	
											Sat	Dry
1	50	32	43	25	27	6	25.2	22.80	Cl	2.7	1.98	**1.78**
2	50	3	2	95	-	-	-	-	SM	2.63	1.66	**1.57**
3	50	2	1	97	-	-	-	-	SM	2.67	1.61	**1.51**
4	50	4	2	94	-	-	-	-	SM	2.66	1.62	**1.54**
5	50	3	2	95	-	-	-	-	SM	2.51	1.63	**1.57**
6	50	4	3	93	-	-	-	-	SM	2.62	1.62	**1.53**
7	50	12	10	78	-	-	-	-	SM	2.68	1.71	**1.59**
8	50	17	12	71	-	-	-	-	SM	2.67	1.69	**1.56**
9	50	38	21	41	46.5	22.5	42	44.17	Cl	2.72	1.95	**1.73**
10	50	42	26	32	42	17	39.4	39.68	Cl	2.73	1.97	**1.64**
11	50	52	38	10	41	12	28.9	30.59	Cl	2.72	1.95	**1.63**
12	50	49	40	11	48	20	37.8	39.20	Cl	2.73	1.93	**1.55**
13	50	60	30	10	52	25	26.4	26.97	CH	2.7	2.03	**1.71**
14	50	51	45	4	54	27	28.3	32.17	CH	2.73	1.94	**1.61**
15	50	65	23	12	56.5	27.2	31.5	34.90	CH	2.74	2.2	**1.86**
Max.	-	65	45	97	56.5	27.2	42	44.17	-	2.74	2.2	**1.86**
Man.	-	2	1	4	27	6	25.2	22.8	-	2.51	1.61	**1.51**
Mean	-	32.12	20.35	48.35	36.30	14.60	32.67	33.75	-	2.67	1.84	**1.63**

3.2 Chemical analysis of soil

Chemical analysis of the soil samples were carried out for (15) fifteen stations selected from AL-Massab AL-Aam channel, which included measuring the concentrations of the chlorides content (Cl%), sulfates content (SO_3%), carbonates content ($CaCO_3$%), organic matter (Org%) and the value of (pH). The maximum of chloride percentage of soil samples (0.195%) in station No. 14 and the minimum values (0.053%) at station No. 4and 5. (Table 2). The natural inputs of chlorine in the soil come mainly from Rainfull, dust and air pollution in addition to human practices such as irrigation and the use of fertilizers that lead to the precipitation of large of chlorine in the soil [12]. The maximum of sulfate percentage (9.75%), at station No.7 and the minimum value (0.35%) at station No. 9.(Table 2). Sulfates are deposited in the soil due to sewage water and the effects of hot and dry climate in addition to the misuse of fertilizers and agricultural pesticides on agricultural lands on both sides of the river [13]. The maximum value of calcium carbonate**(** CaCO3**)** percentage (50%) in Station No. 5 and the minimum value (15%) at Station No.14, By mean (29%).(Table 2). River sediments constitute a large proportion of calcium carbonate sources resulting from the erosion of limestone and dolomite rocks that are found in most of the formations' sediments through which the Tigris and Euphrates and their tributaries pass [14]. It is worth noting that the percentage of calcium carbonate if it exceeds 30% leads to engineering problems such as increasing porosity and voids and thus reducing the bearing capacity of the soil [15]. The maximum value of organic matter percentage (1.125%) at station No.5 and the minimum value (0.14%) at station No.8.Table 2. Organic carbon represents the amount of organic matter in sediments resulting from processes by plants and microorganisms [16]. The percentage of organic matter in the soil depends on the conditions and climatic factors, so the organic matter decreases when the temperature rises and the dry climate prevails, while the organic matter increases due to the natural processes of oxidation of organic materials by microorganisms and humans activities such as fertilizers and industrial waste.The maximum value of (pH) (9.06) in Station No.6 and the minimum value (7.5) in Station No.1 (Table 2).

Table 2. The chemical properties of soil bank slopes in AL-Massab AL-Aam channel. southern sector

Station	Chloride content(Cl%)	Sulphate (SO_3%)	calcium carbonate ($CaCO_3$%)	Organic(Org%)	PH value
1	0.0880	0.3840	29	0.4220	7.5
2	0.1153	0.5530	49	0.8400	8.33
3	0.0621	1.3030	45	0.5620	8.94
4	0.0532	0.3790	40	0.2814	8.14
5	0.0532	2.2430	50	1.1256	8.85
6	0.0621	6.3950	25	0.7030	9.06
7	0.1330	9.7540	35	0.8440	7.99
8	0.1065	5.5560	31	0.1407	8.41
9	0.0976	0.3530	20	0.7100	8.53
10	0.1240	0.4699	20	0.5630	8.26
11	0.1420	0.5590	20	0.7035	7.91
12	0.1330	0.4050	19	0.4220	8.51
13	0.1100	3.8020	20	0.2810	8.52
14	0.1952	2.8300	15	0.8440	8.99
15	0.1060	0.9510	22	0.7035	7.87
Max.	0.195	9.754	50	1.125	9.060
Man.	0.053	0.353	15	0.140	7.500
Mean	0.108	2.708	29	0.612	8.375

3.3 Engineering properties

3.3.1 The Unconfined Compression Strength (U.C.S):

. The results of remolded sample showed that the maximum value(126.2 kN / m^2)in station No.15 while the minimum value (37 kN / m^2)in Station No.1.(Table 3). The critical value of the strength and durability of a material depends on mineral properties such as texture, degree of compression and water content, which reduce the degree of cohesion between the grains by reducing their internal friction angle [17]. The reason for the difference in the compressive strength values is due to the difference in the mineral composition of the soil, the moisture content and the rate of loading in addition to the relationship of the grains to each other.

3.3.2 Direct shear strength:

The results of direct shear test showed that the maximum value of the internal friction of disturbed sample (Ø°) is (37°) in station No.5 and the minimum value of the angle of friction is (21.5°) in station No. (6). (Table3). Whereas, when the proportion of clay in the soil increases, the internal friction of disturbed sample (Ø°) between the grains will decrease due

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to the increase in soil elasticity which increases the pressure, and the cohesion increases between the electronic bonds that bind the soil particles [18]. The water content also affects the shear strength, as the angle of internal friction of the granules decreases and thus the shear strength decreases [19]. Figures (8,9,10,11,12,13,14) show the relationship between normal stress and shear stress at stations (2,3,4,5,6,7,8), respectively.

Table 3. Showing the some engineering properties of slope banks soil in AL-Massab AL-Aam channel. southern sector

Station	Type of Sample	Type of soil	Unconfined (KN/m^2)	Direct shear strength			
				Normal stress (KN/m2)	Shear stress (KN/m2)	Φ/ Degree	C (kN/m^2)
1	Remoulded	CL	37			-	-
2	Disturbed	SM	-	100	79.13	33.5	0
				200	148.01		
				400	318.69		
3	Disturbed	SM	-	100	64.16	36	0
				200	149.72		
				400	320.83		
4	Disturbed	SM	-	100	62.02	34	0
				200	142.23		
				400	314.41		
5	Disturbed	SM	-	100	72.29	37	0
				200	151.43		
				400	322.97		
6	Disturbed	SM	-	100	42.77	21.5	0
				200	92.4		
				400	167.47		
7	Disturbed	SM	-	100	62.02	29	0
				200	106.94		
				400	239.55		
8	Disturbed	SM	-	100	74.86	34.5	0
				200	128.33		
				400	294.09		
9	Remoulded	CL	89.5			-	-
10	Remoulded	CL	57.8			-	-
11	Remoulded	CL	43.3			-	-
12	Remoulded	CL	58.5			-	-
13	Remoulded	CH	40.6			-	-
14	Remoulded	CH	41.3			-	-
15	Remoulded	CH	126.2			-	-
Max.	-	-	126.2			37	-
Man.	-	-	37			21.5	-
Mean	-	-	65.74			31.5	-

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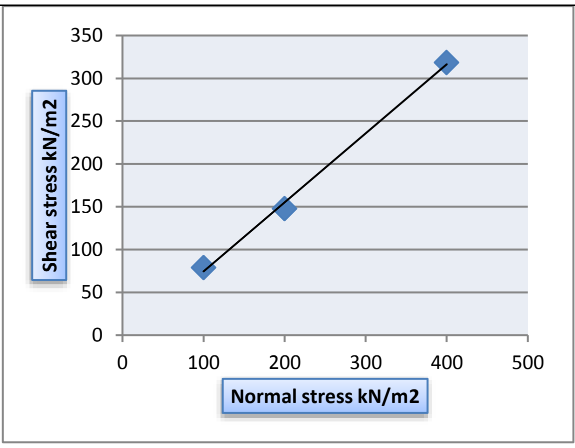

Fig 8. Relationship between Normal stress and shear stress in station (2) of AL-Massab AL-Aam

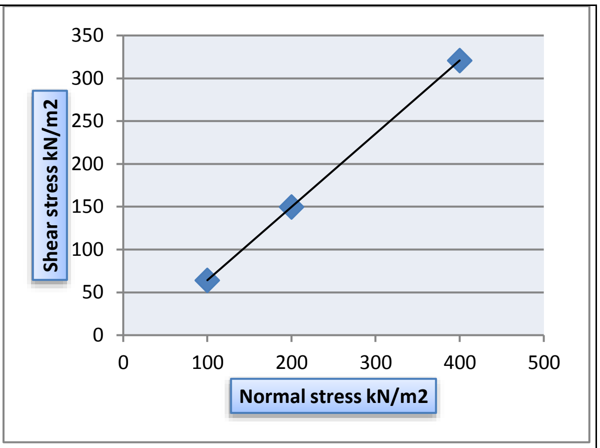

Fig.9. Relationship between Normal stress and shear stress in station (3) of AL-Massab AL-Aam.

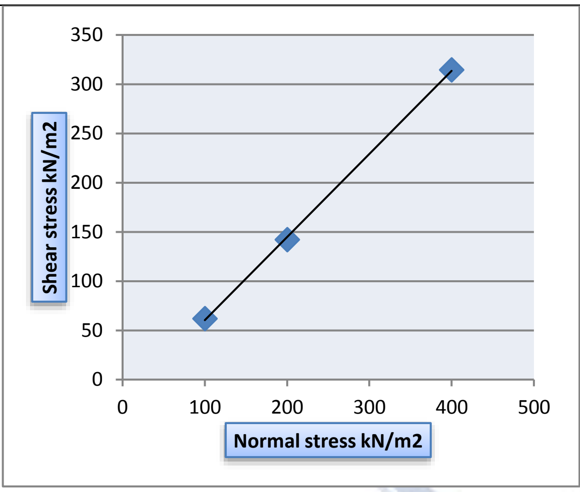

Fig10. Relationship between Normal stress and shear stress in station (4) of AL-Massab AL-Aam River.

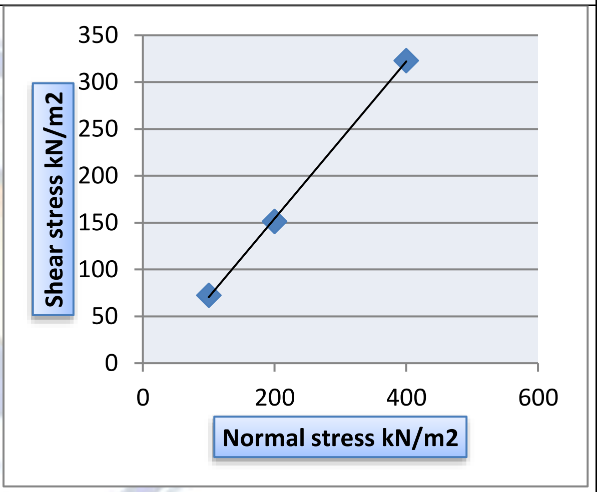

Fig11. Relationship between Normal stress and shear stress in station (5) of AL-Massab AL-Aam River.

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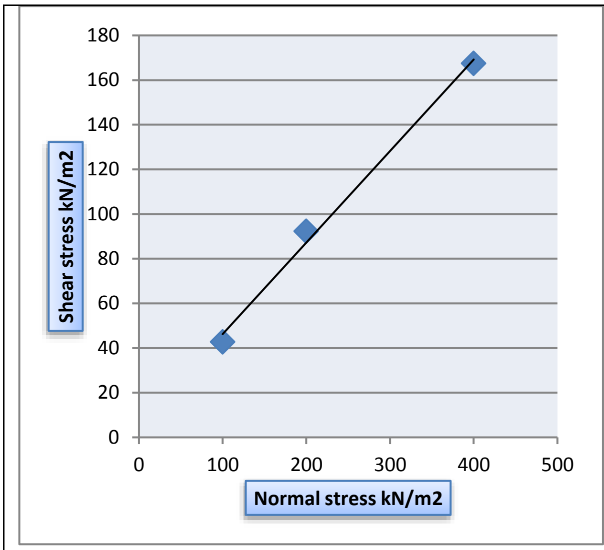

Fig.12. Relationship between Normal stress and shear stress in station (6) of AL-Massab AL-Aam River.

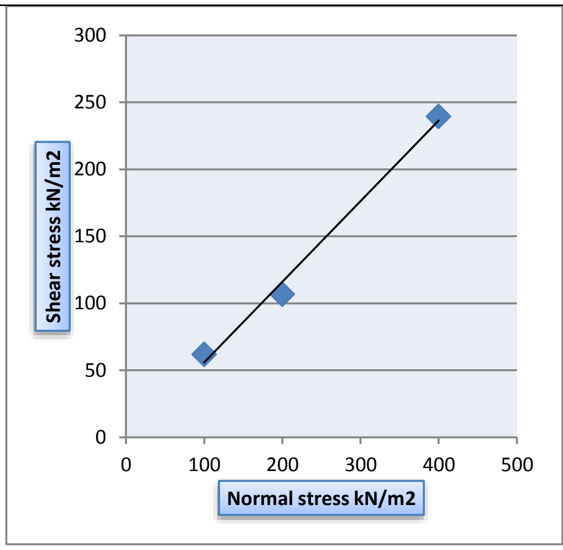

Fig.13. Relationship between Normal stress and shear stress in station (7) of AL-Massab AL-Aam River.

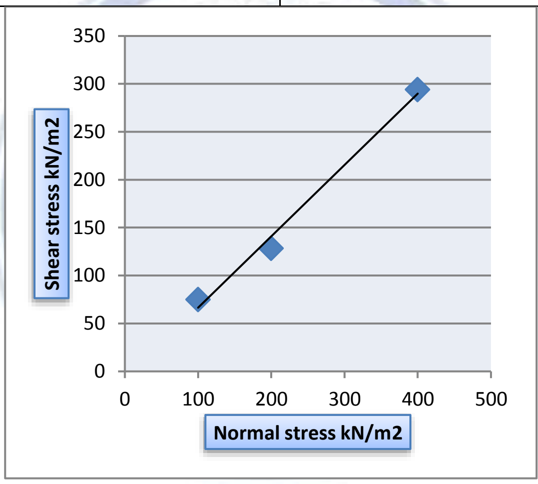

Fig.14. Relationship between Normal stress and shear stress in station (8) of AL-Massab AL-Aam River.

4. Compare the results of the current study with other studies:

The results of the geotechnical properties, including the physical, engineering and chemical properties of the soil sample for the study area, were compared with the results of some studies of the northern and middle sectors of the AL Massab AL Aam channel as shown in Table (4). The comparison showed that there is convergence in most of the results. The physical properties of most of the results were close to the results of [20]. except for the values of Atterberg limits, which were compared with [21].

As for the engineering properties, the results were mixed except for the results of the compressive strength values, and the results were closer to the results [21]. As for the chemical results of soil samples, the results were closer to [20].

Table (4): The compare the results of the current study with other studies

Geotechnical properties		Al-Khatib, 2002	AL-Amar, 2014	The current study
Location study area		The northern sector	The middle sector	The Southern Sector
Physical properties				
Grain size analysis		CL, ML, SM	CL, CH	CL, HC, SM
Atterberg limit	L.L	(27.5-46.9)%	(30.2- 58.2)%	(27-42)%
	P.I	(9.1-13.2)%	(11.3-31.3)%	(6-23)%
Specific gravity		(2.35 -2.69)	(2.63 - 2.70)	(2.61 -2.74)
Density	SAT	(1.61- 2.30)g/cm^3	(1.67-1.95)g/cm^3	(1.61-2.2) g/cm^3
	DRY	(1.50-1.94)g/cm^3	(1.27- 1.71)g/cm^3	(1.51-1.86) g/cm^3
Engineering properties				
Shear Strength		(1.50-47.25)KN/m^2	(5- 48)KN/m^2	(100.88-182.23)KN/m^2
Angle of fraiction (φ)		(15-30)	(8.5-30)	(21.5-37)
Unconfined compressive strength		(24- 96)KN/ m^2	(9.4-73.8)KN/m^2	(37-126.2)KN/m^2
Chemical properties of soil				
Cl		(0.09-2.88)%	(0.017-0.161)%	(0.053-0.19)%
SO_3		(0.13-2.45)%	(0.044-5.85)%	(0.35-9.75)%
$CaCO_3$		(14.58-19.63)%	(2- 40)%	(15- 50)%
Org.		-------------------	---------------	(0. 1-0.84)%
PH		(7.01-7.93)	(7.5- 9.1)	(7.5- 9.06)
EC		(5-10.2)mhos/cm	(3.8- 19.1)mhos/cm	--------------
TDS		(3354.4-10319.5)ppm	--------------	--------------

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5. Materials used to improve the soil properties in the study area

Three sites were selected from the study area with different proportions of clay, silt and sand according to the grain size analysis. The first site station15 is a high-plastic clay(CH) consisting of (65% clay, 23% silt, 12% sand), and the second site station 9 is a mixture of low-plastic clay (CL)consisting of (38% clay, 21% silt, 41% sand). The third site station 2 is a non-plastic sand (SM) consisting of (3% clay, 2% silt, 95% sand), in which the materials (sulphates resisting cement, sodium bentonite and limestone powder) were added according to the weight ratio(5,10,15%).

5.1 **Study the effect of additives on the value of maximum dry density and optimum moisture content:**

The effect of additives on the maximum value of the total dry density and the optimum moisture content for the three sites was studied according to the specified percentages, and the results were included as shown in tables (5,6 and 7).

From table (5,6 and7) that the maximum dry density values(1.89gm/cm^3) with the addition of 5% sulphates resisting cement in station 2 (table.7) ,while the minimum dry density values(1.68gm/cm^3) with the addition of 15% powder limestone in station 9 (table.6) . The maximum of optimum moisture content values(22.3%) with the addition of 15% sodium bentonite in station 15 (table.5) ,while the minimum values (9.3%) with the addition of 5% sulphates resisting cement in station 2 (table.7) . Figures (15, 16, 17, 18, 19, 20) show the relationship of additives with the maximum dry density and the optimum moisture content for the three sites, respectively.

5.2 **A study of the effect of additives on the Atterberg Limits for the soil of the first and second sites**

The effect of additives on the Atterberg limits (liquid limits, plasticity index) for the two sites was studied according to the weight ratio and the results were included as shown in tables (5,6). From table(5,6) that the maximum of (L.L) values(55,9%) with the addition of 15% sodium bentonite in station 15 (table.5) ,while the minimum values (34.2%) with the addition of 10% powder limestone in station 9 (table.6) . The maximum of plasticity index (P.I) values(29.1%) with the addition of 15% sodium bentonite in station 15 (table.5),while the minimum values(14%) with the addition of 10% powder limestone in station 15 (table.5). Figures (21, 22, 23, 24) show the relationship of additives with the liquid limit and the plasticity index for the two sites, respectively.

5.3 **To study the effect of additives on the unconfined compressive strength test (U.C.S) of the soil of the selected sites**

From table(5,6 and 7) that the maximum values of unconfined compressive strength (820KN/m^2) with the addition of 15% sulphates resisting cement in station 2 (table.7) ,while the minimum values(98 KN/m^2 with the addition of 5% sodium bentonite in station 15 (table.5) . Figures (25, 26) show the relationship of additives with the unconfined compressive strength for the three sites, respectively.

5.4 **Study the effect of additives on direct shear strength**

From (table.7) that the maximum values of the internal friction angle (Ø°)from direct shear test (39°) with the addition of 15% sodium bentonite and also in 15 % sulphate resisting cement in station 2 (table.7) ,while the minimum values(32°) with the addition of 5% sulphate resisting cement in station 2 (table.7).

Table 5. The soil characteristics of the first site after adding the additives in station(15).

Addition ratio		Max Dry density gm/cm^3	O.M.C (%)	L.L %	P.L %	P.I %	U.C.S KN/m^2
No. addition	0%	1.86	15.8	56.5	29.3	27.2	126
Sulphates resisting cement	5%	1.82	16.3	42.6	25.3	17.3	148
	10%	1.76	18.7	40	24.5	15.5	336
	15%	1.72	22	41.2	24	17.2	286
$CaCO_3$	5%	1.76	13.6	44.2	23.2	21	110
	10%	1.83	12.2	36.5	22.5	14	298
	15%	1.81	12.9	40.7	21.5	19.2	186
Na-bentonite	5%	1.76	17.2	46.3	24.2	22.1	98
	10%	1.72	20.1	51.2	23	28.2	260
	15%	1.69	22.3	55.9	26.8	29.1	192

Table 6. The soil characteristics of the second site after adding the additives in station(9).

Addition ratio		Max Dry density gm/cm^3	O.M.C (%)	L.L (%)	P.L (%)	P.I (%)	U.C.S (kN/m^2)
No. Addition	0%	1.88	14.8	46.5	24	22.5	89.5
Sulphates resisting cement	5%	1.84	15.2	38.7	23.2	15.5	146
	10%	1.79	15.7	36.5	22.1	14.4	446
	15%	1.74	17.8	37.2	22	15.2	295
$CaCO_3$	5%	1.86	13.1	37.8	21	16.8	132
	10%	1.82	14.2	34.2	16.3	17.9	368
	15%	1.68	14.6	36.1	17.2	18.9	265
Na-Bentonite	5%	1.76	15.3	39.7	23.1	16.6	126
	10%	1.71	17.4	51.3	28.2	23.1	287
	15%	1.69	18.8	55.8	29.6	26.2	244

Table 7. The soil characteristics of the third site after adding the additives in station(2).

Addition ratio		Max Dry density gm/cm3	O.M.C. %	Sat density	Dry density	Un confined compressive strength (kN/m2)	Direct shear	
							C.(kN/m^2)	Φ
No addition	0%	1.92	9.1	1.66	1.57	0	0	33.5
Sulphates resisting cement	5%	1.89	9.3	1.73	1.62	175	0	32
	10%	1.87	9.6	1.89	1.72	435	0	38
	15%	1.76	9.8	1.96	1.86	820	0	39
CaCo3	5%	1.85	9.6	1.71	1.65	150	0	33
	10%	1.74	9.7	1.89	1.79	190	0	35
	15%	1.72	9.9	1.92	1.81	230	0	38
Na bentonite	5%	1.83	9.5	1.74	1.66	148	0	34
	10%	1.78	9.7	1.84	1.77	160	0	37
	15%	1.69	10.1	1.98	1.93	185	0	39

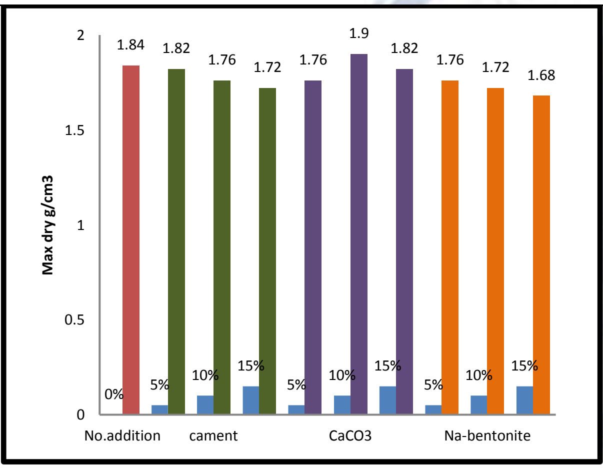

Fig.15. The relationship of additives with the Max dry density.

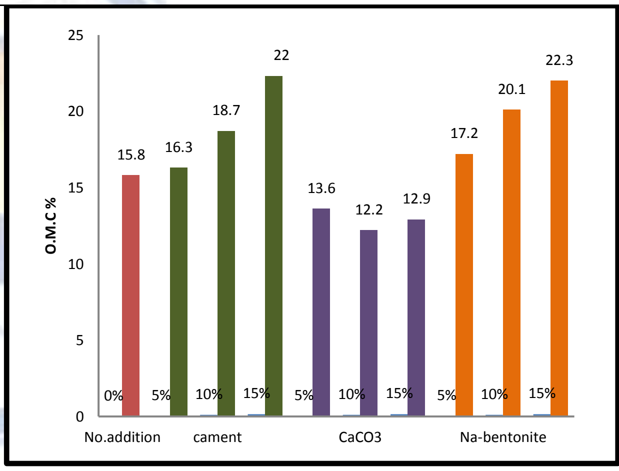

Fig.16. The relationship of additives with O.M.C%.

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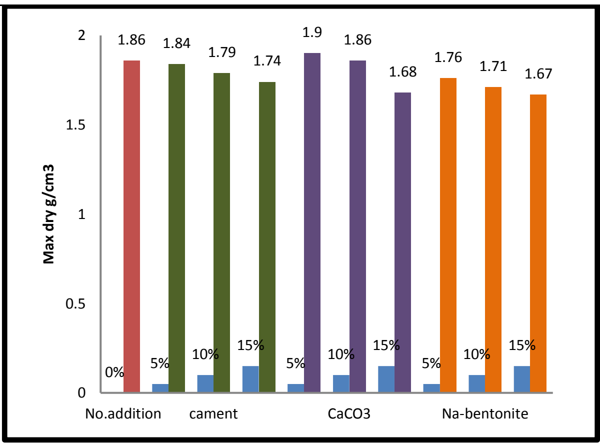

Fig.17. The relationship of additives with the Max dry density.

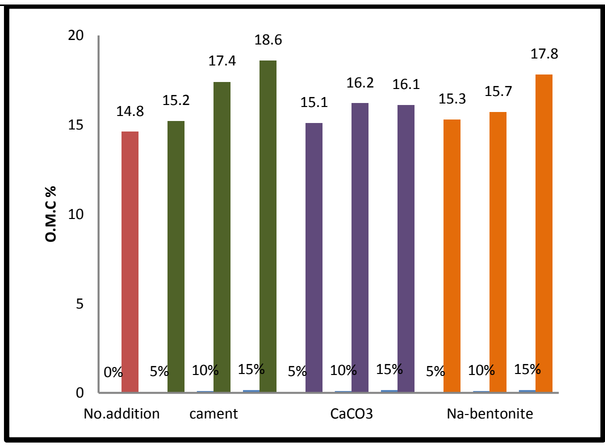

Fig.18. The relationship of additives with O.M.C%.

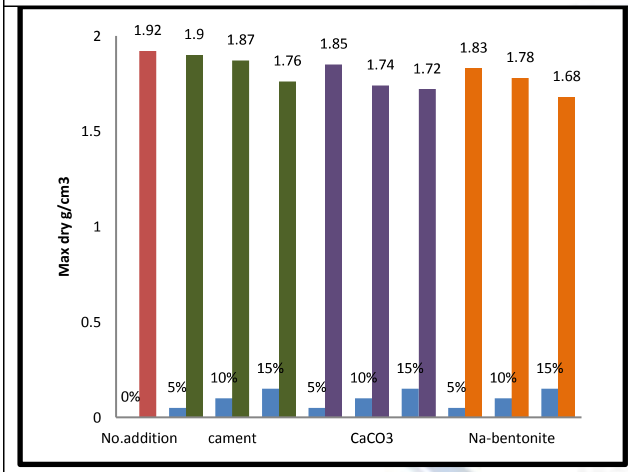

Fig.19. The relationship of additives with the Max dry density.

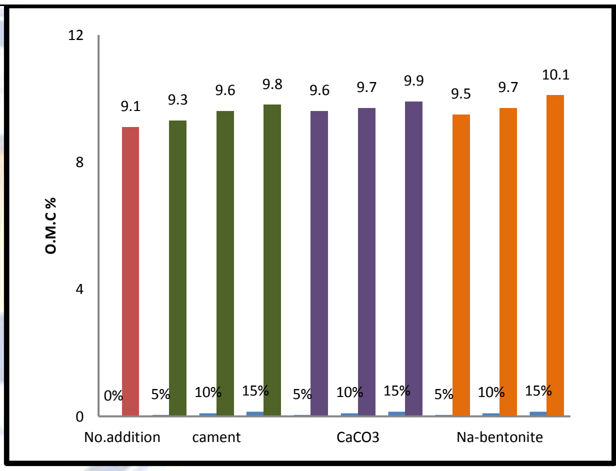

Fig.20. The relationship of additives with O.M.C%.

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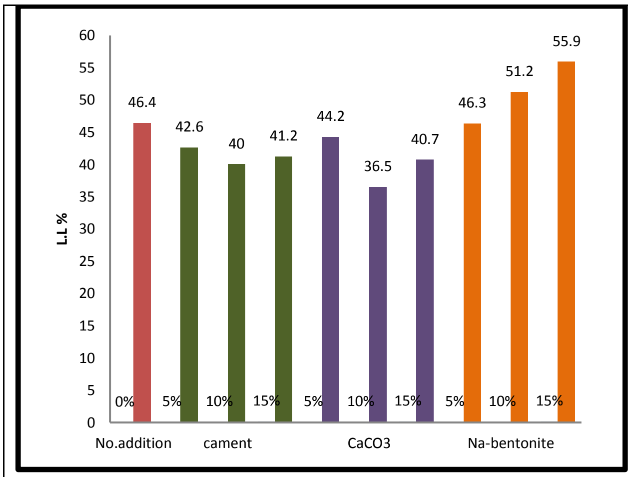

Fig.21. The relationship of additives with L.L%.

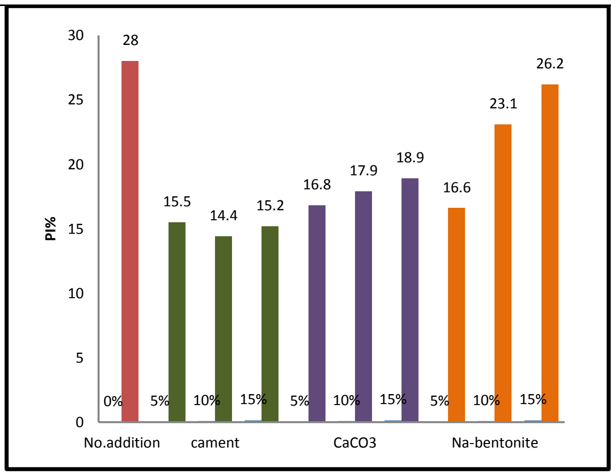

Fig.22. The relationship of additives with P.I%.

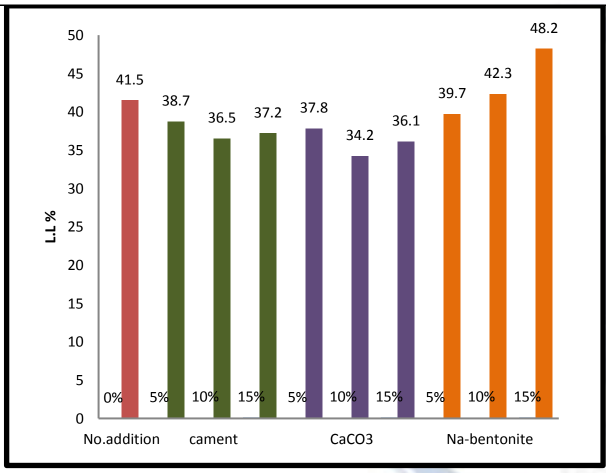

Fig.23. The relationship of additives with L.L%.

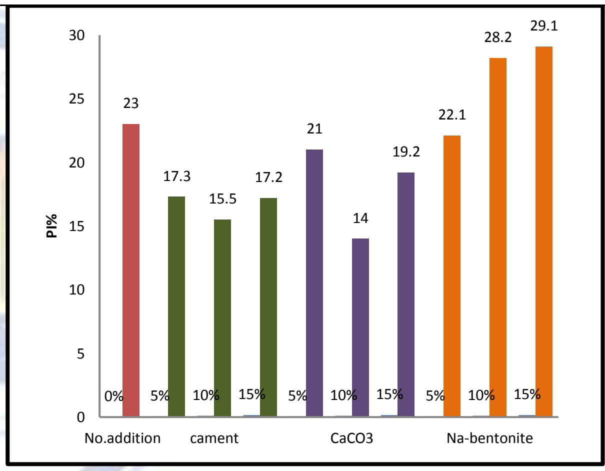

Fig.24. The relationship of additives with P.I%.

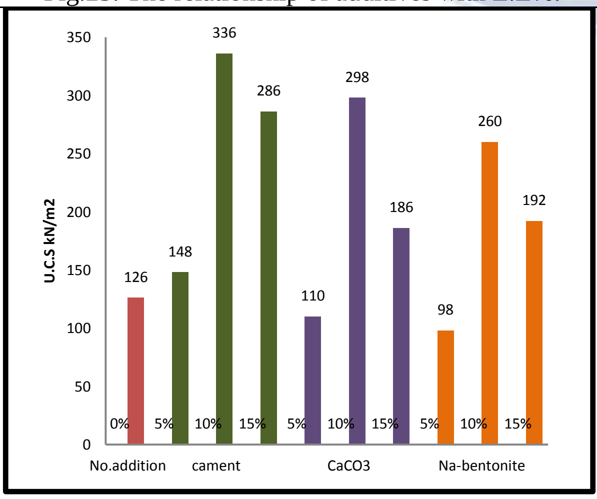

Fig.25. The relationship of additives with U.C.S

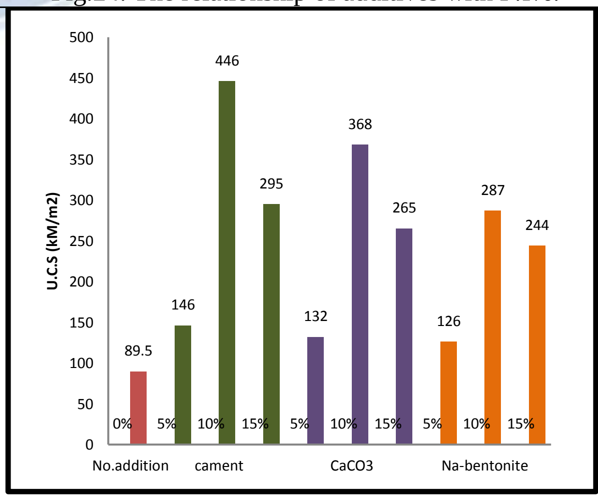

Fig.26. The relationship of additives with U.C.S.

6. Conclusions

After studying the geotechnical properties and recording the observations of the soil of the Al-Massab Al-Aam channel (southern sector), the following points were concluded:

1-There are many types of soil failure in the slopes of the Al-Massab Al-Aam channel southern sector, including the fall of the soil mass resulting from the weight of the mass that represents the main type of soil failure, and constitutes 70% of the soil failure in the study area, while the overturning represents a lower percentage, as it constitutes 20% From the failure of the soil in the study area, and other types (sliding and roll) constitute very little (10%) of the soil failure in the study area.

2- The soil bank slopes of study area can be classified according to the plasticity chart it shows that clayey soil of low plasticity (CL) represented by (33%), and clayey soils of high plasticity (CH) represented by (20%)and the other non-plastic (SM) represented by (46.6%) .

3- The results of direct shear test showed that the maximum value of the internal friction angle(Ø°) is (37°) in station No. (5) and the minimum value of the angle of friction is (21.5°) in station No. (6). Whereas, when the proportion of clay in the soil increases, the internal friction angle (Ø°) between the grains will decrease due to the increase in soil elasticity which increases the pressure.

4- The maximum dry density values(1.89gm/cm^3) with the addition of 5% sulphates resisting cement in station(2),while the minimum dry density values(1.68gm/cm^3) with the addition of 15% powder limestone in station (9). The maximum of optimum moisture content values(22.3%) with the addition of 15% sodium bentonite in station (15),while the minimum values(9.3%) with the addition of 5% sulphates resisting cement in station(2).

5- The maximum values of the internal friction angle (Ø°)from direct shear test (39°) with the addition of 15% sodium bentonite in station (2),while the minimum values(32°) with the addition of 5% sulphate resisting cement in station(2).

6- From the results, it is clear that the addition of materials used to improve the properties of the soil of the banks of the banks of the general estuary is: First site: It is recommended to use both cement and limestone powder, The second site: it is recommended to use all additives and the best resistant cement, Third site: It is recommended using resistant cement.

Conflict of interests.

There are non-conflicts of interest.

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الخلاصة

تضمنت هذه الدراسة منحدرات الضفاف في القطاع الجنوبي لقناة المصب العام جنوب العراق. تمت دراسة الخواص الجيوتقنية للتربة على ضفاف القناة متضمنة الخواص الفيزيائية والهندسية والكيميائية بواقع (15) محطة. أظهر توزيع حجم الحبيبات للتربة أن نسبة الرمل كانت أعلى من نسبة الطين والطمي.

وفقا للتصنيف الموحد(USCS) للتربة في منطقة الدراسة يمكن أن تصنف الى طين ذو اللدونة المنخفضة (CL) والذي يمثل 33.3٪ من التربة ، والطين ذو اللدونة العالية (CH) يمثل 20٪ من التربة وغير اللدنة (SM) تمثل 46٪ ، وتتراوح قيم الكثافة الجافة بين (1.51-1.86) غم/سم^3 ، وتتراوح قيم الكثافة المشبعة بين (1.61-2.2) غم/سم^3 ، وتتراوح قيم المحتوى المائي بين (25.2-42٪). بينما تتراوح قيم الوزن النوعي بين (2.51-2.74) ، وتراوحت زاوية الاحتكاك الداخلي (Ø°) من اختبار القص المباشر بين (21.5-37°). وتتراوح قيم اختبار الانضغاط غير المحصور بين (37-126.2) كيلو نيوتن / م^2 للعينات المعاد تشكيلها بنسبة 25٪ ماء ، تتراوح قيم الكلورايد بين (0.053-0.195%), بينما تراوحت قيم الكبريتات بين (0.35 - 9.75٪) ، بينما تتراوح تركيزات الكربونات بين (15- 50٪) تتراوح تراكيز المواد العضوية بين (0.140 - 1.125٪). تتراوح قيمة الأس الهيدروجيني بين (7.5-9). وبناء على هذه النتائج تم تقييم استقرار منحدرات ضفاف المجرى العام للمصب (المنطقة الجنوبية) واقتراح الحلول المناسبة لدعم استقرارها ومعالجة غير المستقرة.

الكلمات الدالة: قناة المصب العام، الخصائص الجيوتقنية، التحاليل الكيميائية.