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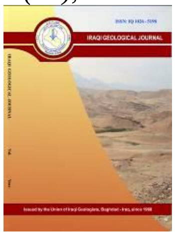

Geotechnical Properties Study of Soil Bank Slopes for Shatt Al-Hilla, Middle of Iraq

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Abstract

The central regions of Babylon Governorate, located on the Shatt Al-Hilla, suffer from problems as the collapse and erosion of its banks, increase in sedimentation in the river, which reduces the river flow efficiency and forms meanders in the river. After the reconnaissance visit to determine the meandering sites. A detailed study of the area was carried out by drilling 6 test boreholes representing three areas (Ancient Babylon, Bata-Bridge, and Al-Khusrweya), two wells on both sides of the meander at a depth of 10m for each borehole to know soil properties, bearing capacity and consolidation, and its effect on the engineering construction. Soil samples have been taken to carry out geotechnical tests. also conducted a study of banks stability for three stations, where the cross-section was monitored by the M9 device and the height of the banks from both sides by the LEVEL device, using the Geo-Studio-2021 program with soil properties and by using Bishop method the safety factor was extracted for the three stations for erosion-prone areas. it was 3.44 in Ancient Babylon, Bata-Bridge was 1.7 and Al-Khusrweya was 1.6 Under natural conditions, the average river flow level reaches it in year respectively are 27.88, 27.74, 27.33 m, above sea level. Where all the stations were safe unless the water level increased or decreased. Also, the research reached a determination of the allowable bearing capacity reaches it before the landslide.

Keywords: Rive meandering; Al-Khusrweya; Triaxial; Boreholes; Geo-studio; Soil

1. Introduction

The research represents a case study of the stability of the banks of the Shatt Al-Hilla, at middle part and determining the effect of the bank's erosion, and the extent of their resistance to landslide by determine type of the soil, and its relationship with the meandering of the river. Shatt Al-Hilla located within the sedimentary plain, and considered one of the most important features of the geomorphology for this region is characterized by its relatively genital slope (at a rate of 1 m per 7 km) , towards the south and southeast, and an oscillating system of water flow (active in spring and summer decreasing in winter) resulting in reduced ability to carry sediment downstream; which makes the lateral activity superior to the vertical, and thus meanders are formed where sediment is transported by the shear stress resulting from the velocity of the water flow at the convex side, The Shatt Al-Hilla is exposed many problems, as the collapse and erosion of its banks, as well as the increase in sedimentation in the river, which reduces the River traffic efficiency; also The erosion of the banks causes damage to agricultural

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areas and agricultural production near the river. Because of the above problems, the aim of this research is to reach a relationship between the slope's stability of banks geotechnical properties of the soil in the meandering sites as well as to determine the safe banks. and deal with some appropriate solutions that limit river erosion. Previous studies close to the research are: Al-Jawthari (2008), studied the stability of the Banks of a part of the Shatt Al-Hilla in al-Talia area in southern Babylon, he made an avalanche hazard map has been prepared, where the research represents a detailed study to describe the stability of river banks and descriptive evaluation of the proportion of shoulder collapse. Al-Zubaidi (2016) study the geotechnical engineering about effective of Shatt Al-Hilla on the neighboring area, as it was found that study area suffers from many engineering problems such as cracks and fractures in the walls and floors of the building. Qader et al., (2020) have also applied a good procedure related to this trend in the north of Iraq. The study determined the effects of fluctuation of the water level leaking from Shatt Al-Hilla on the soil properties and its bearing capacity. Al-Jeafir (2020) studied the bed sediments from Shatt Al-Hilla to Shatt Al-Arab at Basrah, where his study was (Sedimentological, mineralogical and environmental Study of the Euphrates River from Babylon to Basrah, Iraq).

2. Location of Study Area

The location of study area is limited by the longitudes (44º 27´ 11"E) (44º 69´38"E), and latitudes (32 º 72´63" N) (32 º 38´ 33"N), where the study area was divided into three stations it represented to most important meandering for the river (Fig.1) (Jassim and Goff, 2006).

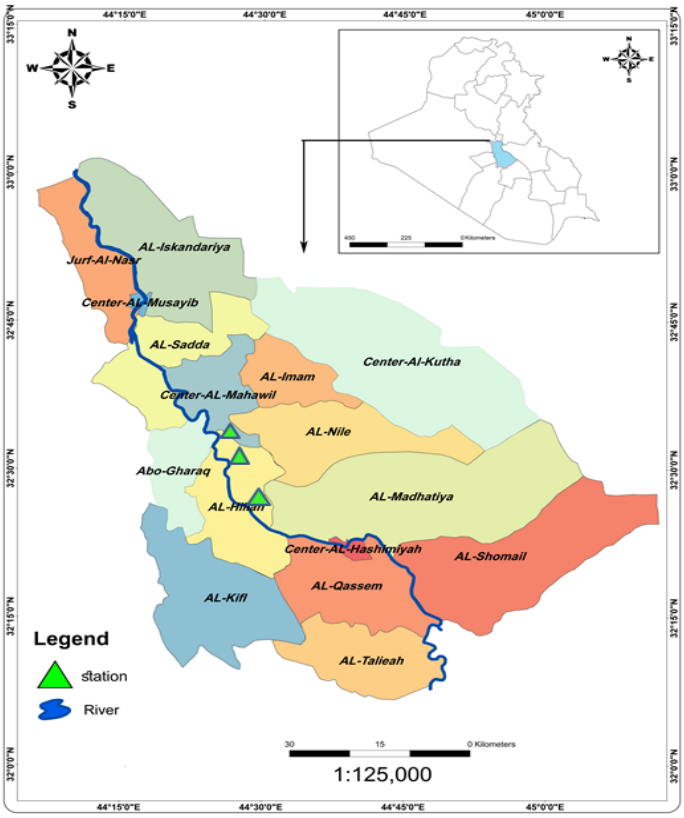

Fig. 1. study area location

3. Geology & Tectonic of Study Area

Geologically, Babylon Governorate is located within sedimentary basin at the Unstable Shelf, Stable Shelf according to the modern classification of Iraq (Jassim and Goff, 2006), This area is called Mesopotamian zone, within the geosyncline basin between the Zagros Mountains in the north-east and the Stable Arabian plate in the south (AL-Hiti, 1989).This area formed from recent deposits from the Quaternary period of the Pleistocene and from Holocene in the study area, while alluvial deposits were formed during the Pleistocene period (Buringh, 1960), and there are deposits that fill the depressions, where it forms because of flooding, generally consist from thin layers formed from fine grains sand or silt with low percentage of clay where the river passes through it (Parsons, 1957).

4. Materials and Methods

4.1. River Meandering

They are curvatures that occur in the channel of the river and according to the stage the river passes through, and it is on a large scale when the river be in the maturity stage, and this phenomenon is giving Indicator for end of the youth stage in the river, where meanders are formed when the velocity of the river flow drops to the point in which river activity moves from vertical (towards the river bed) to lateral erosion (towards the banks), (Crosato, 2008). River meander develop when the river erode in the concave side of the river's flow continuously, and in the opposite side (convex side), sedimentation occurs , and at the same time a backflow of water will erode its direction to the bottom and it is slow working with it a quantity of sediments that have been carved and deposited on the convex side, Also riverine islands are play a large role, especially in the straight parts of river in generating a water current towards the outer side of the meander, which leads to carving in it, There are three forms of the cross-section according to the erosion activity of the river, they are (A) convexity to the left of the flow, (B) there is no torsion due to the vertical activity of erosion, and (C) to the right convexity of the flow (Al-Zamili, 2015). The river meandering from because of vertical activity (deepening) of river flow be less than horizontal activity (widening), there for meander occurs (Crosato, 2008). Classification of rivers meandering: where the river sinuosity index (S), is the ratio of the real length to the ideal length as in equation (1).

$$\boldsymbol{S} = \frac{\boldsymbol{Lt}}{\boldsymbol{LO}} \qquad (1)$$

where:
L_t = Actual distance between start and end point of river along the channel center line (real length) (m)
L_o= Ideal length (river length between the same start and end point) (m).

According to (Brice, 1982), meandering rivers have a sinuosity larger than 1.25; according to (Leopold et al., 1964). and (Rosgen, 1996)., the minimum ratio between the true length and the ideal length of the river sinuosity is (1.5) so that the sinuosity of the river is called meander. From these values, consider that the measurement of river level consists of a series of measurements of opposite bends in which the ratio ranges from 1 to 3.14.

1. If the ratio equal to 1, the course of the river is straight.
2. It is considered (torsional), if the ratio ranges between 1-1.25 according to (Leopold et al., 1964) & (Rosgen, 1996), and According to (Brice, 1982) the ratio is (1-1.5).
3. If it exceeds (1.5), calculated (meander), the semicircle has equal to $\pi / 2 = 1.57$.

According to the above equation, the Shatt Al-Hilla is considered Meandering River, where the flow index of the Shatt Al-Hilla was 1.27 after measuring according to Brice (1982), where the true length of the course (104 km), was measured and divided by the shortest distance between two points specified (The ideal length), which is 82 km

4.2. The Slopes Stability

The slope stability is defined as the ratio between the force resisting collapse to the force causing the collapse and according to the conditions of the slope if it is soil or rocks; If the slope is from the soil, then the collapsed mass of soil slides on the landslide surface, the shear stress applied to the soil (the strength is resistance to collapse) and the safety factor is extracted ;Safety factor (Fs) is important consideration in design, engineering construction on a natural slope. Failure is often catastrophic and results Human and material losses (Law and Lumb, 1978). Classify the slope soils (Sowers,1979) according to the safety factor value (FS) as:

FS < 1.0: unsafety Soil; FS = 1.0 -1.2: Questionable safety Soil

FS = 1.3-1.4 Satisfactory safety Soil; FS ≥ 1.4 stable (safety Soil)

$$Fs = \frac{\textit{The forces resisting movement}}{\text{The forces promoting } \textit{movement}} \qquad (2)$$

4.3 Field Investigations

Six Boreholes were drilled, using specific machine in drill, where carried out depending on standard of American society for testing and materials (A.S.T.M) where consist from number of codes are 1452 and 5783, it uses to sampling. Borehole depth was 10 m, under natural ground surface, three types of samples taken as in plate 1 are, disturbed sample (DS), depend on ASTM (1586), at to determine classification layers of soil. The sample which takes from split spoon of standard penetration (SPT), symbol (S.S.), where it carried out in station, and considered partial-disturbed samples. Undisturbed samples, symbol (U.S.), this sample do according to ASTM (1587), after extraction, covered with a polyethylene sacks or paraffin wax, from bottom and top, then sealed properly at both ends, then transported to laboratory for examining. Test program depends on the type of sample (D. S. U.S., and S.S.) and the nature of its material (Plate 3-2).

Plate 3-2. Images for study area represent field investigations stage and sampling

4.4. Laboratory Tests

Laboratory Tests cared out in Construction laboratories, Babylon branch

4.4.1. Physical properties test

Consist number of tests are: analysis of grain size by ASTM (422), and moisture content depend on ASTM (2488), Specific gravity depend on, ASTM (854), Atterberg Limits according to ASTM (4318), and Unit weight (wet and dry) by ASTM (4318).

4.4.2. Engineering tests

Consist number of tests as: (Consolidation and swelling tests, according to ASTM (2435-02); Direct shear by ASTM (2850), (4767). triaxial compression (test-type (UU)), carry out by ASTM (2850), Unconfined compression do depend on ASTM (2266).

C. Chemical analysis of soil

Consist from (Total Soluble salts. (TSS), PH, Carbonate ($CaCO^3$), Chloride (CL^-), Gypsum content, Organic matter. and Sulphate content). according to (B.S. 1377-1990). All the tests depend on standards of American society for testing and materials, (ASTM), and British Standard.

5. Results

5.1 Stations Resultes

The river meandering in Ancient of Babylon Station toward right side, Bata Bridge Station toward left side, and Al-Khusrweya Station toward left side from water flow, which represents the erosion side (maximum velocity of the flow); and at another side is concavity of the river (the sedimentation area), to the left of the flow, the average water level in this stations are 27.88, 27.74,27.33 m above sea level, as in Figs. 2, 3and 4 measured by the M9 device and the height of the banks from both sides by the LEVEL device, using the Geo-Studio-2021 program , The flow velocity recorded highest rate from the right side, (1.25 m/sec) for Ancient of Babylon Station , (1.38 m/sec) for Bata Bridge Station, and 1.0 m/sec for maximum discharge is 195 m3/sec for Al-Khusrweya station, which effect on river bank with the impact angle (meander degree) is 65̊ , 45̊ and 42̊ for the three stations respectively .The natural vegetation on the two banks is middle density; for willow, and reeds.

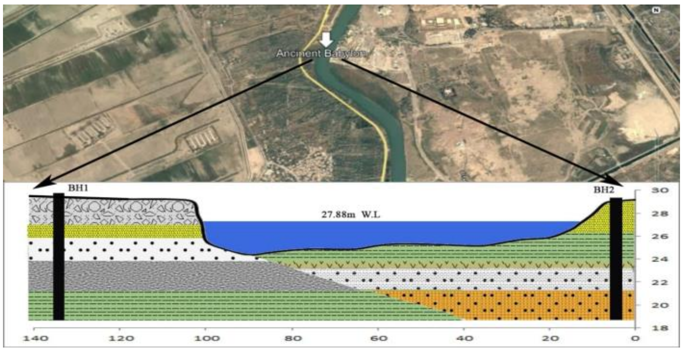

Fig. 2. River cross section showing boreholes & Soil layers of Ancient Babylon station

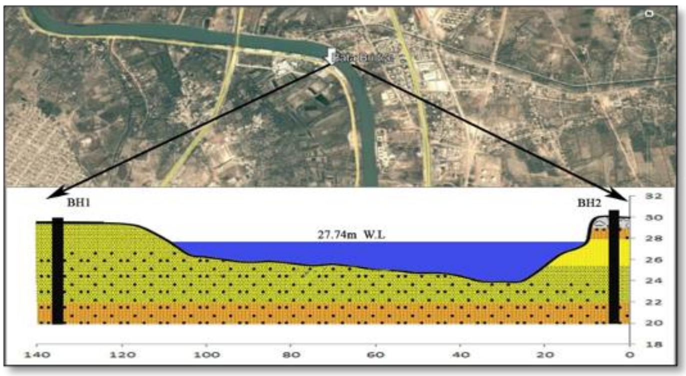

Fig. 3. River cross section showing boreholes, and Soil layers of Bata Bridge station

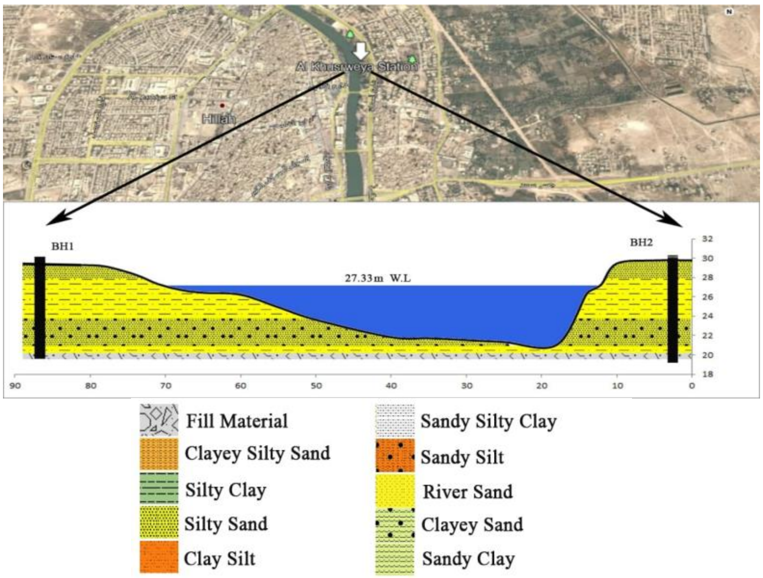

Fig. 4. River cross section showing the boreholes & Soil layers0f Al-Khusrweya station

5.1.1. Physical properties of soil

The results of basic properties tests explained in Tables 1, 2 and 3.

Table 1. The results of the basic properties tests for the soil in Ancient of Babylon station

B.H.	Samples Type	Depth of Sampling (m)		Particle size distribution and hydrometer analysis				Physical properties							S.P.T "N" Value	Symbol Unit Class
		From	To	Gravel %	Sand%	Silt%	Clay%	A	L.L%	P.I%	MC.%	G.S	Unite weight g/cm³			
													γwet	γDry		
1	D.S	0.5	1.0	4	18	27	51	0.5	33	21	16	2.65	1.77	1.31		CL
	S.S.	1.0	1.5										1.81	1.39	9	
	U.S	1.5	2.0	0	14	36	50	0.6	47	29	26	2.74	1.92	1.51		CL-CH
	D.S.	2.0	2.5	0	20	38	32				27		1.84	1.43		
	U.S	3.5	4.0	4	27	45	24	0.5	42	11	25	2.72	1.83	1.40		ML-OH
	S.S.	4.0	4.5	0	23	32	45	0.4	38	19	29				16	
	D.S	6.0	6.5	0	69	19	12					2.67	1.78	1.40		SM
	S.S.	6.5	7.0	-	-	-	-				17				15	
	D.S	7.5	8.0	-	32	30	38	0.7	43	27			1.91	1.46		CL
	U.S.	9.0	9.5	3	27	28	32					2.72	1.88	1.45		
2	D.S	0.5	0.5	15	14	35	36	0.4	31	14	22		1.79	1.34		CL
	S.S.	1.0	1.5	2	11	47	40	0.5	39	21		2.73			8	
	U.S	3.0	3.5	1	23	48	28	0.5	41	13		2.66	1.83	1.44		ML-OH
	D.S.	4.0	4.5	1	28	39	32	0.3	31	10	28					
	S.S	5.0	5.5									2.72			5	
	U.S	5.5	6.0	0	14	46	40	0.6	35	24			1.82	1.41		CL
	S.S	7.0	7.5								28	2.74			36	
	D.S.	8.0	8.5	0	26	51	23	0.7	47	16			1.88	1.46		ML-OH
	S.S	9.0	9.5								26	2.71			27	

Table 2. Tests results for the soil in Bata Bridge station.

B.H.	Samples Type	Depth of Sampling (m)		Particle size distribution and hydrometer analysis				Physical properties							SP.T. "N" Value	Symbol Unit Class
		From	To	Gravel %	Sand%	Silt%	Clay%	A	L.L%	P.I%	MC.%	G.S	Unite weight g/cm³			
													γ_{wet}	γ_{Dry}		
1	D.S	0	0.5	2	64	29	5				16					
	D.S.	0.5	1.0	0	69	28	3						1.71	1.33		SM
	S.S	1.5	2.0	0	72	25	3				20	2.65			3	SM
	D.S.	2.5	3.0	0	68	28	4									SM
	S.S	3.5	4.0	0	72	25	3				23	2.67	1.72	1.34	4	SM
	D.S.	4.5	5.0	0	70	28	2									SM
	S.S	6.0	6.5	0	72	26	2				26	2.65	1.75	1.36	15	SM
	D.S.	7.0	7.5	0	73	24	3									SM
	U.S	8.0	8.5	0	69	26	5				26	2.69	1.76	1.38		SM
	S.S.	9.0	9.5	0	60	27	13						1.8	1.41	16	SM
2	D.S	0	0.5								14		1.79	1.38		
	D.S.	1.0	1.5	0	29	24	47	0.6	44	29						CL-CH
	S.S	1.5	2.0	0	32	27	41	0.6	38	23	28	2.70	1.82	1.48	8	CL
	D.S.	2.5	3.0	0	18	34	48	0.4	32	17	29	2.72	1.88	1.49		CL
	S.S	3.5	4.0	0	66	31	3				27	2.65			6	SM
	D.S	4.5	5.0	0	68	30	2						1.75	1.32		SM
	S.S	6.0	6.5	0	71	27	2				28	2.65			15	SM
	D.S.	7.0	7.5	0	73	24	3						1.82	1.41		SM
	S.S	8.0	8.5	0	68	27	5				27	2.65			21	SM
	D.S.	9.0	9.5	0	72	25	3				28	2.66	1.79	1.42		SM

Table3. Results of the tests for the soil in Al-Khusrweya station

B.H.	Samples Type	Depth of Sampling (m)		Particle size distribution and hydrometer analysis				Physical properties							S.P.T "N" Value	Symbol Unit Class
		From	To	Gravel %	Sand%	Silt%	Clay%	A	L.L%	P.I%	MC.%	G.S	Unite weight g/cm³			
													γ_{wet}	γ_{Dry}		
1	D.S	0.5	1.0	8	64	26	2				16					
	S.S	1.0	1.5	0	72	24	4					2.70	1.76	1.31	5	SM
	D.S	1.5	2.5	0	13	43	44	0.2	26	7	24					CL-ML
	U.S	2.5	3.0									2.74	1.73	1.30		
	S.S	3.0	3.5	0	61	25	14				22				6	SM
	D.S	4.5	5.0	0	51	35	14					2.70	1.84	1.43		
	S.S	6.0	6.5		46	34	20	0.4	29	7	24				6	
	D.S	7.5	8.0	0	65	12	23					2.68				SM
	S.S	9.5	10.0	0	11	23	71	0.3	45	21	23	2.76	1.93	1.54	23	CL
2	D.S	0.0	0.5	11	26	36	27				14	2.67	1.73	1.32		
	U.S	0.5	1.0	0	8	53	39	0.3	34	10						ML-OL
	S.S	1.0	1.5	9	26	43	22				26	2.71	1.86	1.48	13	
	U.S	2.0	2.5	0	15	38	47	0.2	26	8	24		1.88	1.52		CL-ML
	S.S	2.5	3.0	0	56	32	12				22	2.68			8	
	D.S	4.5	5.0	0	11	58	31	0.4	38	11	27	2.71	1.89	1.53		ML-OL
	S.S	5.5	6.0	0	39	36	25								9	
	D.S	6.5	7.0	2	77	11	10				23	2.71	1.79	1.40		SM
	S.S	7.5	8.0	0	68	13	19								10	SM
	D.S	9.0	9.5		51	36	13				24	2.70	1.78	1.38		SM

5.1.2. Engineering properties of soil

The results are explained in Tables 4, 5 and 6.

Table 4. Results of the engineering properties of soil in Ancient of Babylon station

B.H. NO.	Depth (m) From-To	q_u kN/m^2	K mm/sec	C kN/m^2	Øo	Consolidation				
						e_o	C_c	C_r	P_o kN/m^2	P_c kN/m^2
1	1.0 -1.5	39	$5*10^{-4}$	28.5	8	0.71	0.44	0.073	190	165
	4.0 - 4.5	41		27.4	9	0.66	0.43	0.068	195	170
	7.5 – 8.0	62	$2*10^{-5}$	29.2	7	0.58	0.43	0.067	208	185
	9.0 - 9.5	60		10.3	21					
2	1-1.5	38	$3*10^{-4}$	27.3	10	0.84	0.147	0.062	220	185
	4.0-4.5	44		16.7	17					
	6.5-7.0	56		18.5	12	0.80	0.145	0.065	202	180
	9.0-9.5	60	$4*10^{-2}$	9	28					

Table 5. Results of the engineering properties of soil in Bata Bridge station

B.H. NO.	Depth (m) From-To	q_u kN/m^2	k mm/sec	C kN/m^2	Øo	Consolidation				
						e_o	C_c	C_r	P_o (kN/m^2)	P_c (kN/m^2)
1	1.5-2.0	31	$4*10^{-2}$	0	24					
	4.5-5.0	42		0	25					
	7.5-8.0	51	$8*10^{-2}$	0	28					
2	1.5-2.0	37		17	18					
	2.5-3.0	54	$5*10^{-4}$	34	8	0.95	0.26	0.038	541	901
	6.0-6.5	56		0	23					
	7.5-8	61	$4*10^{-3}$	8	19					

Table 6. The results of the Engineering properties of soil in Khusrweya station

B.H. NO.	Depth (m) From-To	q_u kN/m^2	K mm/sec	C kN/m^2	Øo	Consolidation				
						e_o	C_c	C_r	P_o kN/m^2	P_c kN/m^2
1	0.5-1.0	31	$4*10^{-3}$	7	19					
	1.5-2.0	44		28.3	6	0.67	0.194	0.045	165	200
	4.5-5.0	51	$1*10^{-4}$	21	8	0.75	0.264	0.043	155	190
	7.5-8.0	53		4	33					
2	1-1.5	37	$4*10^{-2}$	21	9					
	2.0-2.5	48		26	7	0.90	0.239	0.039	156	195
	4.0-4.5	69	$6*10^{-5}$	47.7	3	0.74	0.253	0.044	195	220
	7.5-8	65		12	16					

5.1.3. Chemical properties

The results are explained in Tables 7, 8 and 9.

Table 7. The chemical analysis results of soil in Ancient of Babylon station

B.H. NO.	Depth From – To		SO_3	T.S.S.%	Organ. %	Gypsum %	Ca CO_3 %	PH	Cl %
1	0.5	1.0	1.08	4.09	0.53	2.32	15	7.8	0.072
	1.0	1.5	0.33	1.66	0.42	0.72	13		0.053
	2.5	3.0	0.27	1.31	0.14	0.60	22	8.1	0.051
	6.0	6.5	0.11	1.12	0.11	0.22	29		0.038
	9.0	9.5	0.09	1.09	0.10	0.19	32	8.1	0.024
2	1.0	1.5	1.28	3.1	0.19	2.76	15	8.0	0.058
	4.5	5.0	0.96	2.89	0.11	2.07	32		0.052
	7.5	8.0	0.55	2.16	0.07	1.18	38		0.039
	9.0	9.5	0.18	0.97	0.05	0.38	40	8.1	0.035

Table 8. The chemical analysis results of soil in Bata Bridge station

B.H. NO.	Depth From- To		SO_3	T.S.S. %	Org. %	Gyps. %	Ca CO_3 %	PH	Cl %
1	0.5	1.0	0.62	2.54	0.1	0.91	7	8.0	0.047
	1.0	1.5	0.49	2.48	0.09	0.81	11		0.042
	2.5	3.0	0.48	2.61	0.07	0.59	12	8.1	0.038
	6.0	6.5	0.45	2.17	0.05	0.61	15		0.036
	9.0	9.5	0.35	2.95	-	0.61	17		0.028
2	0.5	1.0	0.73	4.55	0.05	0.32	6	8.1	0.051
	1.0	1.5	0.65	3.49	0.04	2.23	8		0.046
	4.5	5.0	0.62	3.25	0.04	1.84	11	8.2	0.042
	6.5	7.0	0.58	2.51	0.03	1.81	14		0.037
	9.0	9.5	0.33	1.82	-	6.7	19		0.019

Table 9. The chemical analysis results of soil in Sinjar station

B.H. NO	Depth From- To		SO_3	T.S.S. %	Org.%	Gypsum %	$CaCO_3$ %	PH	Cl%
1	0.5	1.0	0.19	2.0	0.06	2.15	28	8.0	0.025
	2.5	3.0	0.21	1.0	0.03	6.4	34	8.4	0.018
	7.0	7.5	0.03	0.4	-	0.64	23	8.3	0.02
	9.0	9.5	0.02	0.2	-	0.43	26		0.18
2	0.5	1.0	0.51	9.7	0.79	1.1	8	8.2	0.053
	1.0	1.5	0.86	7.7	0.73	1.84	10		0.057
	4.5	5.0	0.71	6.7	0.61	1.52	11	8.4	0.052
	7.5	8.0	0.49	5.8	0.51	1.0	16	8.5	0.045
	9.0	9.5	0.33	5.1	0.48	0.6	18		0.043

6. Discussion

6.1. Physical Results Discussion

The moisture content and the saturation rate of the soil are affected by two factors are sub-surface water level, which changes with the fluctuation of the water levels of the river adjacent to the bank; The second influencing factor is the type of soil, either composed of coarse sediments such as sand with high permeability and low porosity, in which water retention is low, or vice versa in fine grains soils such as clay and silt; Where it recorded the range moisture content(W%) was between (14-34) %, and the main moisture source is through capillary property. As for the specific gravity (Gs), which is affected by the type of sediments and the extent of their compactness and convergence when forming the soil, as is the case in examining the weight of the dry and wet unit volume, where the highest specific weight was recorded values between (2.63-2.74) As for dry Unit weight was between (1.30-1.61), while wet Unit weight was between (1.70-1.98) g/cm^3. Another important characteristic that depends on the moisture content and soil type is the atterberg limits. The range percentage of the liquid limit is (21-47) %, because of the moisture content of soil is low, and fine grain size of soil. While the range of the Plasticity Index is (6-33) %, and therefore it is classified according to (Al-Ashu, 1991) as low plasticity soil. - highly plastic soil while the range of the clay percentage was 3-72 %, While the range of silt percentage was 12-58 %, sand percentage was 5-71 %, and low percentage of gravel in the three stations.

6.2. Engineering Results Discussion

Discussing engineering properties of soils consist Discussion (permeability, uniaxial compressive strength, direct shear test, unconsolidated undrained (UU), and consolidation test) as below:

Permeability depends on the size and shape of the soil granules, where the increase of sorting and the grain size, leads to increase of the permeability, as for the bearing capacity of the soil, it is depending on the type of soil as its percentage ranged in (Ancient of Babylon, Bata Bridge, and Al-Khusrweya) Stations, where the value of permeability (K) for the layer's changes from $2*10^{-5}$ to $2*10^{-2}$ mm/Sec. and the range Bearing Capacity (q_{all}) recorded 3-9 Tons/m^2. The results of the uniaxial compressive strength (q_u) showed the range of the uniaxial compressive strength of (7-3) ton/m^2, cause of rise in values because the soil It consists of a high percentage of clay, characterized by its high resistance to loads because of its high cohesion, and the minimum value because the layer is made of sand with little cohesive strength. The results of the cohesion force (C) and the internal friction angle have the range value of the cohesion force of 0-48 ton/m^2 cause of rise in values, because the soil contains a high percentage of clay, which has a high cohesion force that resists the shear force, while the minimum value of the cohesion strength because the soil contains a law percentage of clay. And the range value of the angle of internal friction is 7°- 28 because the soil contains a high percentage of sand, which has a high angle of friction, and the lowest value of the angle of internal friction because the soil contains a low percentage of sand. Consolidation and the results were Compression index that the range value of the index was (0.14-0.44), because the soil has a high percentage of clay, which is characterized by its ability to compress, and the lowest value of the Compressive Index, because the soil has a low percentage of clay, which is characterized by being highly compressible. ((Cr) Swelling index The range value was 0.038-0.079 this may be due to the soil containing some clay minerals that have the ability to swell, also Primary void ratio (eo) the highest ratio was 0.58-0.95 because the soil contains a high percentage of clay as it is characterized by containing connected voids, because of its high porosity, and the lowest initial void ratio because the soil contains a relatively small proportion of clay, as clay is characterized by containing gaps, because its porosity is high . The range value of Pre- consolidation pressure (P_c), was (165-220 kN / m^2), this means that the soil contains a high percentage of clay or has been affected by previous loads that caused the consolidation, and the lowest value of Pre- consolidation pressure (P_c) , because the soil contains a low percentage of clay or the soil may not have been previous loads that caused its consolidation; And the initial consolidation pressure (P_o),it is Primary consolidation pressure , the range value of (P_o) was (154-220 kN/m^2), due to the increase in the density of the soil layers above the sample, due to the increase in depth effect of lithostatic pressure above the sample , and the lowest value of (P_o) due to the low density of the soil layers above the sample.

6.3. Chemical Results Discussion

The results of chemical analysis are very important in the evaluation of soil, as the proportion of sulfate, gypsum and organic matter affects in soil cohesion and weak composition, as it is inversely proportional to the bearing capacity of the soil. The chemical analysis for soil samples results in Al-Sadda, Al-Mahaweel, and Sinjar) stations, where it conducted in the Babylon Construction Laboratory were as follows: The percentage of SO_3 ranged between (0.02 to 1.28) %, within the normal range of its concentration in soil. The same applies to the total salts in soil and water, which were within the normal range, as they ranged in the two pits from 0.2-4.55 %. As for the organic matter content of the soil in the Al-Sadda station, it was little, reduced to relatively high percentages in the upper layers, and this percentage begins to decrease with depth, since the density of organic matter is low in relation to the components of soil, Also, its source is the surface, where a value ranged 0.79 -0.01 %.

6.4. Slopes Stability Results Discussion.

The highest result of the safety factor was in in Ancient-Babylon, Bata-Bridge was 1.7 and Al-Khusrweya was 1.6. Under natural conditions, the average river flow level reaches it in year respectively are 27.88, 27.74 and 27.33 m, above sea level. Where all the stations were (safe), unless the water level increased or decreased. Also, the research reached a determination of the allowable bearing capacity reaches it before the landslide. Also, the research reached a determination of the allowable bearing capacity. The soil of the banks reaches it before the landslide (Figs. 5,6, and7).

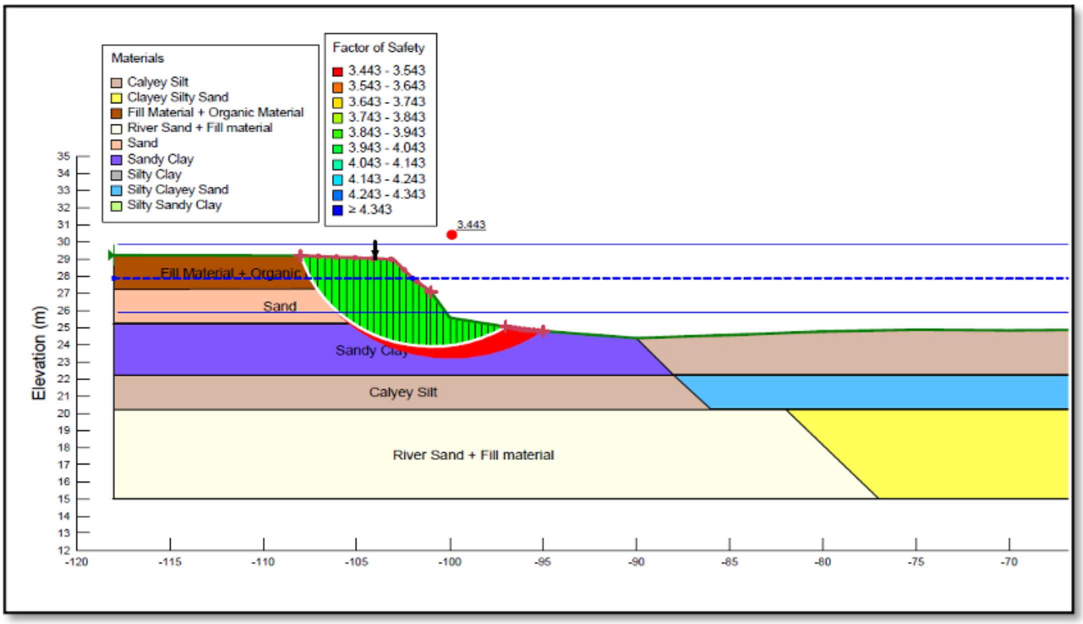

Fig.5. Safety factor extracting for the right bank of flow at Ancient of Babylon Station, (GeoStudio 2021

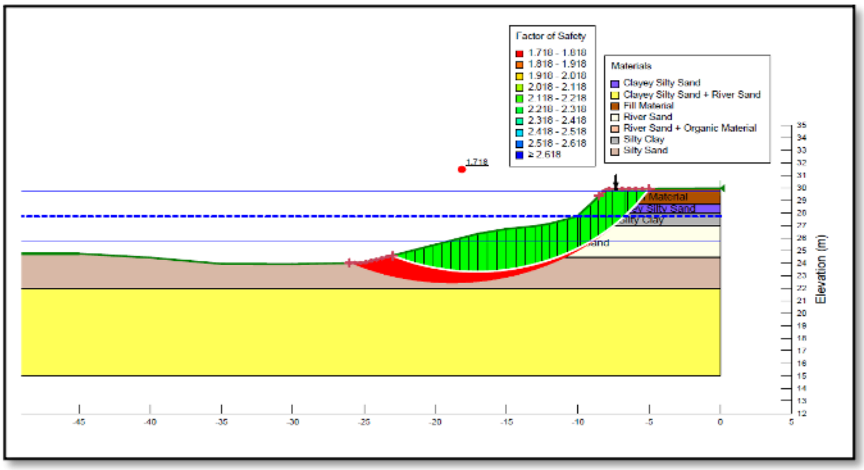

Fig.6. Safety factor extracting for the left bank of flow at Bata Bridge Station (GeoStudio 2021)

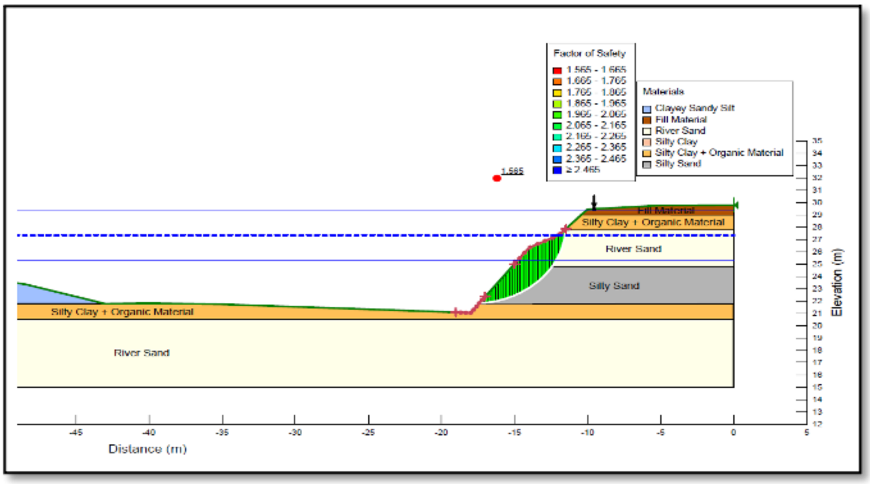

Fig. 7. Safety factor extracting for the left bank of flow at Al-Khusrweya Station (GeoStudio 2021)

7. Conclusions

The geotechnical results in all study stations showed that the convex side (erosion) is consisting of layers of clay, silt and sand, often be regular, while the concave side (sedimentation) mostly consists of river sand low (density, specific gravity and, cohesion). Shatt Al-Hilla is affected by the energy of the flow velocity and discharge according to the type of banks soils, there for the meander is forming. The rise and fall of the river water level affect the safety of the slopes, as in both cases the safety factor decreases, but when it decreases (dry season), its effect is often greater. Bearing capacity on both sides of river banks is low for all study stations, reaching at its best to 7 t/m^2.

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Referencs

Al-Ashu, M. O., 1991. Principles of Soil Mechanics, Dar Al-Kutub for Printing and Publishing, University of Mosul, 574 pp.

Al-Hiti, M. Y H., 1989. Baquba study the internal structure of a career, unpublished MSc Thesis, College of Education, Ibn Rushd, Baghdad University.

Al-Jawthari, J. H, 2008. The stability of the shoulders of a part of the Hilla River in Babil Governorate and its engineering effects. Basra Journal of Science, 26 (1), 37-47.

Al-Jeafir, M.L., 2014. Sedimentological, Mineralogical and Environmental Study of the Euphrates River from Babylon to Basrah, Iraq, Thesis, Department of Geology, College of Science, University of Basrah, Iraq.

Al-Zamili, A., 2015. The geomorphologic phenomenon of Hilla and Al-Hindya Rivers, Journal of the College of Basic Education for Educational and Human Sciences, 20.

Al-Zubaidi, M. M., 2016. Study of the effect of subsurface water on the geotechnical properties of selected parts of the soil of Hilla City, Babil Governorate, Central Iraq, College of Science, University of Babylon.

ASTM, American Society for Testing and Materials, 1985. Classification of Soils for Engineering Purposes: Annual Book of ASTM Standards, D 2487-83, to 04.08, 395–408.

Brice, J. 1982. Stream channel stability assessment. Report no. FHWA/RD, Federal Highway administration, Offices of Research and Development.

British Standard, 1377 ,1990. Method of Testing Soils for Civil Engineering purposes, B. S. L. London, 238 pp.

Buringh, P., 1960. Soil and soil conditions of Iraq, ministry of agriculture, Baghdad, 22 pp.

Crosato, A., 2008. Analysis and Modelling of River Meandering, Ph. D. Thesis, Delft University of technology, United States

Jassim, S. Z. and Goff, J. C., 2006. Geology of Iraq, Dolin, Prague and Moravian museum, Brno, Czech Republic, 314pp.

Leopold, L. B. Wolman, M. C. and Miller, J. P., 1964. Fluvial process. In: Geomorphology.Ed. W.H. freeman. Sanfrancisco.

Parsons, R.M., 1957. Groundwater resources of Iraq (Mesopotamia plain), Development board ministry of development government of Iraq, 11, 5-21.

Rosgen, D., 1996. Applied River Morphology. Wildland Hydrology Books. Pagosa Springs, Colorado.

Law, K. T. and Lumb, P., 1978. A limit equilibrium analysis of progressive failure in the stability of slopes. Canadian Geotechnical, 15, 113-122.

Sowers, G., 1979. Introductory of soil mechanics and foundations: Geotechnical engineering. Maemillian Pup. Co. Inc. New York.

Qader, R.M., Arab, S.H. and Hamahsaeed, M.A., 2020. Engineering geological assessment of the rock slope stability along the proposed lerabire road in the Mergasur city, kurdistan, Iraq. The Iraqi Geological Journal,.65-82.