JOURNAL OF UNIVERSITY OF BABYLON
For Pure and Applied Sciences (JUBPAS)

ARTICLE
Vol.29; No.3. October-December | 2021

Geotechnical Properties and Slopes Stability for Banks Soils in North Part of Shatt Al-Hilla at Meandering Sites, Babylon Governorate / Central of Iraq

Wael Noori Mrzah[1*], Raid Aziz Mahmod[2]
Aamer Atia Lafta[3]

[1]department of geology ,college of science, Basrah university, waelnoori01@gmail.com Basrah, Iraq,
[2]department of geology ,college of science, Basrah university, raidaziz14@yahoo.com Basrah, Iraq,
[3]department of geology ,college of science, Babylon university, amer-atyah@yahoo.com Babylon, Iraq
Corresponding author Email: waelnoori01@gmail.com

Received: 20/7/2021 **Accepted:** 12/10/2021 **Published:** 1/12/2021

Abstract

Background:
The northern regions of the Babylon Governorate, located on the Hilla River, suffering from problems as the collapse and erosion of its banks, as well as the increase in sedimentation in the river, which reduces the River flow efficiency; due to the effect of the velocity river flow, which works on eroding one side of the river and sedimentation on the other side, forming meanders in the river.

Materials and Methods:
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(Al-Sadda, Al-Mahaweel ,and Sinjar), two wells on both sides of the meander and at a depth of (10 m), for each borehole to observe the effect of the river flow velocity on the stability of slopes and to know the variation in soil properties, its bearing capacity and the consolidation on both sides of the river, and thus its effect on the engineering construction .
Soil samples have been taken to carry out physical tests including: (moisture content test , specific gravity test , Atterberg limits tests , sieve analysis and hydrometer tests) ,also carried out engineering tests including: (permeability test , unconfined & triaxial compressive strength test , direct shear test , consolidation test and bearing capacity) , soil chemical tests have been perform also which are (pH , total soluble salt , sulfate test , chloride test , gypsum test and organic matter test) .
A study was also conducted for the stability of the banks slopes for the three stations, where the cross-section was monitored by the M9 device, as well as 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.

Conclusion:
The highest result of the safety factor was in Sinjar Station (2.5), then the banks of Al-Sadda Station, with a value of (2.3), and the lowest value of Al-Mahaweel Station, which amounted to (1.4). Under natural conditions, the average river flow level reaches it in year is (28.7 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 The soil of the banks reaches it before the landslide.

Key words:
Rive meandering, Al-Sadda Station, Consolidation, Boreholes, Geo-Studio 2021.

Citation:
Wael Noori Mrzah[1*], Raid Aziz Mahmod[2] Aamer Atia Lafta[3]. Geotechnical Properties and Slopes Stability for banks soils in north part of Shatt Al-Hilla at meandering sites, Babylon Governorate/ central of Iraq. Journal of University of Babylon for Pure and applied science (**JUBPAS**). October-December , 2021. Vol.29; No.3: 257-276

Introduction

The research represents a case study of the stability of the banks of the Hilla River and determining the effect of erosion of the banks, and the extent of their resistance to landslide by knowing the type of soil, and its relationship with the meandering of the river.

The Euphrates River divided in to two branches in the north of Babylon Governorate at the following coordinates (44º 27´ 11"E) (32 º 1.272´63´´N), They are AL- Hilla River and AL- Hindeya River.

Hilla river located within the sedimentary plain, and one of the most important features of the geomorphology of 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 Hilla River 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 areas and agricultural production near the river. [1], 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. [2], 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. The study determined the effects of fluctuation of the water level leaking from Shatt Al-Hilla on the soil properties and its bearing capacity. While [3], 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).

Location of study Area

The located of study area 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 ten Stations it represented to most important meandering for the river as show in the figure (1),

The main aims of this study

1. Identifying the relationship between river meandering and slopes stability of the of the river banks, and knowing the cause of the landslide (collapse).
2. Knowing the geotechnical properties of the soils of river banks.

Geology & Tectonic Of Study Area

Geologically, Babylon Governorate (Study area) is located within the Sedimentary basin in the Unstable Shelf according to the tectonic division of Iraq (Buday and Jassim, 1984). The stable Shelf according to the modern classification of Iraq [4], This area is called Mesopotamian zone, that it is located within the geosyncline basin between the Zagros Mountains in the north-east and the Stable Arabian plateau in the south , [5].

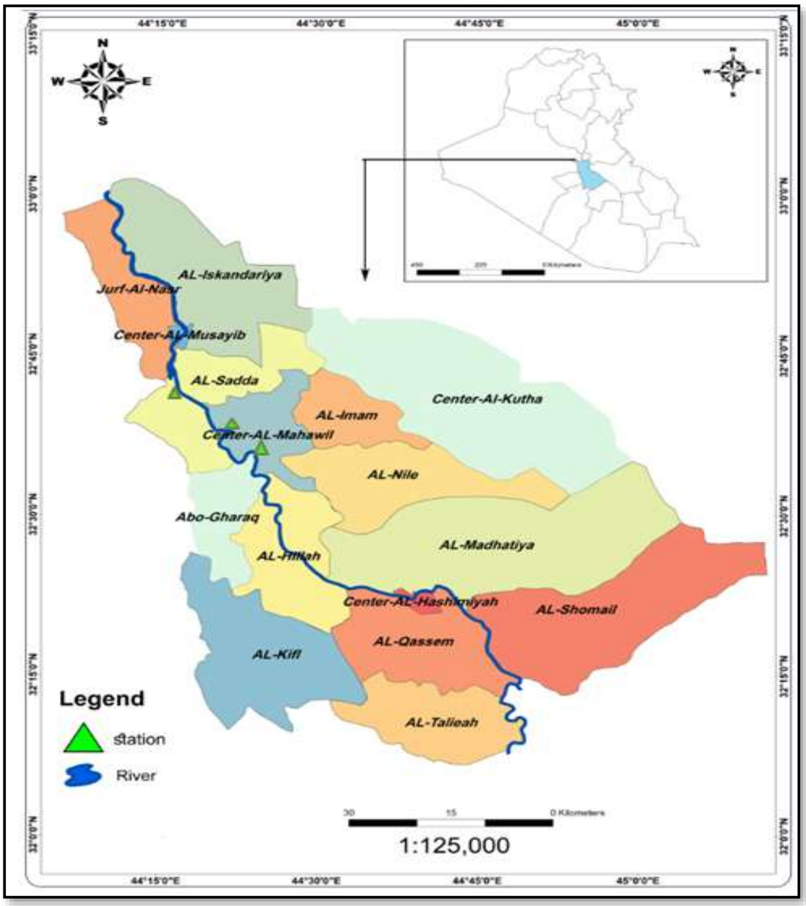


Fig. (1) Study area locations

From the geological point of view, recent deposits from the Quaternary period of the Pleistocene and from Holocene in the study area, and these sediments are characterized by the Flood Plain Deposit of both the Euphrates River and its branches[6] , while alluvial deposits were formed during the Pleistocene period [7] , and there are deposits that fill the depressions, which collect as a result of floods, and generally consist of thin layers of fine sand and silty clay through which the river passes [8] .

As for the tectonics of the region, [9]. described tectonic of the region as by Mesopotamia is a large sedimentary basin (Syncline) which is active tectonically and passes through a subsidence with (Local Minor uplift),This Geosyncline is linked to the mountain-building movement that occurs in the Zagros mountain range, which is still active so far. This basin receives the products of erosion as the downward movement continues. [10]

Materials and Methods

- **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 a 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), [11] .

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 as in figure(2-1) [12]. .

1. Causes of the river torsion

The river meandering from because of vertical activity (deepening) of river flow be less than horizontal activity (widening), there for meander occurs [11].

2. Classification of rivers meandering

That is, the river sinuosity index is the ratio of the real length to the ideal length as in equation (1).

$$S = \frac{Lt}{Lo} \qquad (1)$$ where:

S = river sinuosity index , L_t = the distance between start and end point of the considered river reach computed along the channel center line (real length) (m). L_o=the valley length between the same start and end point (ideal length) (m).

According to[13] , meandering rivers have a sinuosity larger than 1.25; according to[14] and [15] , 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[14] (Leopold et al. 1964) & [15] (Rosgen, 1994), and According to Brice[13] (1984) the ratio is (1-1.5).

3. If it exceeds (1.5), calculated (meander), the semicircle has equal to π / 2 = 1.57.

According to the above equation, the Hilla River is considered Meandering River, where the flow index of the Hilla River was (1.27) after measuring according to[13] Brice, 1984), 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

- **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 (*F*s) is important consideration in design , engineering construction on a natural slope. Failure is often catastrophic and results Human and material losses [16]

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)

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

- **4.3 Field Investigations:**

Six Boreholes have been Drilled in March -2020 by using mechanical machine type (Flight Augers drill) ; the method of drilling was carried out according to the standard of the American society for testing and materials (ASTM D-1452 –D5783) which are used for taking the samples; The depth of boring were (10) m from the natural ground surface (N.G.S), three types of sample were taken ; the first samples were disturbed samples (DS) , according to (ASTM D-1586) at intervals required to determine the classification of the soil layers . All disturbed samples were sent to the laboratory for further examination and testing . The second sample take from standard penetration Test (S.P.T); its symbol is (SS) take from split spoon of standard penetration test carried out in site, were also used as undisturbed samples and the third samples were undisturbed, its symbol is (US), it were obtained according to(ASTM D-1587) after extraction , the Disturbed sample were trimmed off , capped with polyethylene sacks or paraffin wax from top and bottom , and sealed properly at both ends , transported to laboratory for testing .

- **4.4. Laboratory Tests:**

The test program was decided by the soil special .The actual test proposed for a particular sample depends on the type of sample (DS ,US and SS) and the nature of its material .

A full list of tests conducted for this project is:

A. Physical properties test

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

B. Engineering tests:

Consist number of tests as: (Consolidation tests, and swelling test according to (ASTM D-2435-02) ; triaxial compression test (UU) according to (ASTM D- 2850) , Unconfined compression test, according to (ASTM D-2266) , and Direct shear (ASTM D-2850, D-4767)

C. Chemical tests on soil and water

Consist from number of analysis (Total Soluble salts test for soil (T.S.S) , PH test , Chloride content CL-, Gypsum content. , Carbonate Content CaCO3. , Organic matter. And Sulphate content). according to (B.S. 1377-1990)

All the tests were conducted according to the current standards of the American society for testing and materials (ASTM) , and British Standard, mentioned against each test

5- Results & Discussion

5.1 Stations resultes

The river meandering in *Al Sadda Station* toward right side, *Al Mahaweel Station* toward left side, *Sinjar 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 station is (28.7 m), above sea level, as in Figure (2), (3),and (4), The flow velocity recorded highest rate from the right side, (1.5m/sec) for *Al Sadda Station* , (1.38 m/sec) for *Al Mahaweel Station*, and(1.30 m/sec) for (maximum discharge is (235 m^3/sec.) which effect on river bank with the impact angle (meander degree) is (53°), (45°), and (70°), for the three stations respectively .

The natural vegetation on the two banks is *High density*; fro willow, and reeds

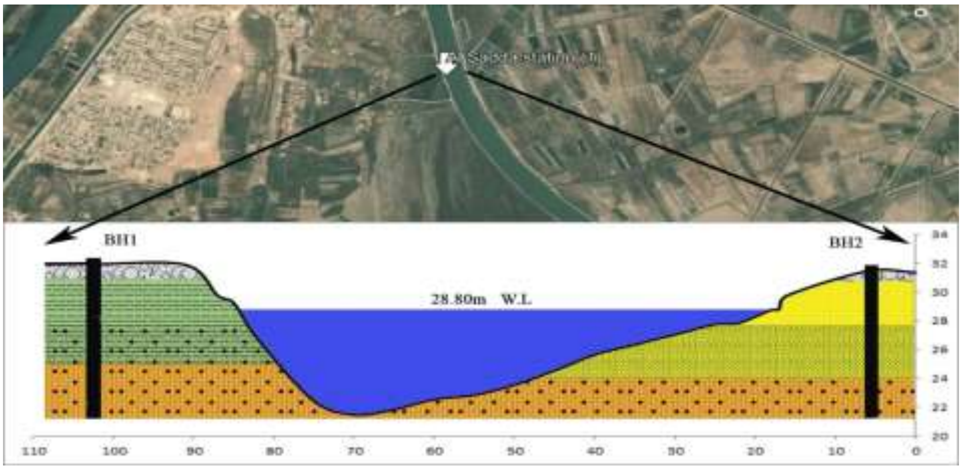


Figure (2) River cross section showing boreholes, and soil layers sequence of Sadda station.

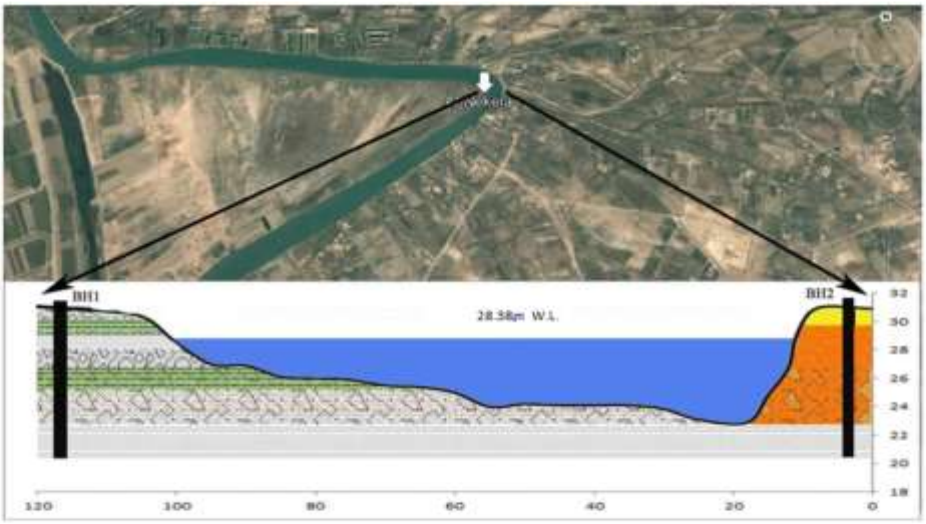


Fig. (3) River cross section showing boreholes, and soil layers sequence Al- Nikhela station.

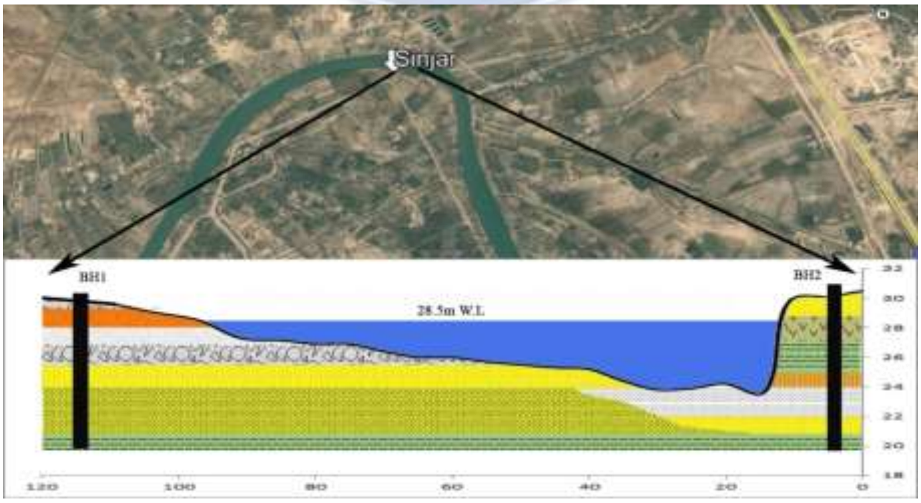
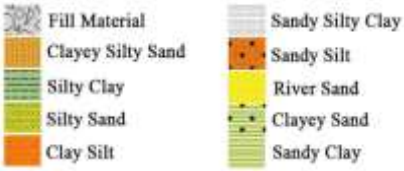


Fig. (4) River cross section ,showing boreholes and, the soil layers sequence Sinjar station.

JOURNAL OF UNIVERSITY OF BABYLON
For Pure and Applied Sciences (JUBPAS)
ARTICLE
Vol.29; No.3. October-December | 2021

The common legend of the three stations is:



A. Physical properties of soil:

The results of basic properties tests explained in Table (1), (2), (3).

5.2. Stations Results Discussion

A. 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/cm3.

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-Ashw, 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.

JOURNAL OF UNIVERSITY OF BABYLON
For Pure and Applied Sciences (JUBPAS)

ARTICLE

Vol.29; No.3. October-December | 2021

Table 1. The results of the Basic properties tests for the soil in Al Sadda station.

B.H.	Samples Type	Depth of Sampling (m)		Particle size distribution and hydrometer analysis				Physical properties							SP.T. "N" Value	Symbol Unit Class	Description of soil
		From	To	Gravel %	Sand %	Silt%	Clay%	A	L.L%	P.I%	MC. %	G.S	Unite weight g/cm^3 γwet	Unite weight g/cm^3 γDry			
1	D.S	0.0	1.0	4	19	26	51				21	2.65	1.71	1.33			Fill material, brown sandy silty clay
1	S.S	1.0	1.5	0	21	24	55	0.2	31	22	21				13	CL	Stiff brown sandy silty clay with org. mat., iron oxide and gypsum
1	U.S	2.5	3.0	0	22	27	50				32	2.67	1.88	1.48			=
1	S.S	4.0	4.5	0	21	32	47	0.7	42	33		2.7			8	CH	Medium stiff, brown sandy silty clay with iron oxide
1	U.S	6.0	6.5	0	5	23	72	0.4	45	29	33	2.73	1.72	1.36			Medium stiff ,brown silty clay
1	S.S	6.5	7.0	0	21	21	58		38	18					9	CL	Stiff brown sandy silty clay
1	U.S	8.5	9.0	0	10	42	48				31		1.88	1.45			=
1	S.S	9.0	9.5	0	34	46	20	1.1	45	18	34		1.71	1.34	10	CH	Stiff, grey, clayey sandy silt
1	U.S	9.5	10	0	51	32	17					2.73					Loose , grey clayey silty sand
2	D.S	0.0	1.0		44	32	24				21						Fill material, brown silty sand with org. mat.
2	U.S	1.0	1.5	0	19	58	23		43	19		2.68	1.85	1.41		OL	Medium stiff ,brown sandy clayey silt
2	S.S	1.5	2.0								22	2.69			6		=
2	D.S	3.0	3.5	0	35	49	16	1.5	47	24			1.98	1.62			Medium stiff ,brown silty clay with org. mat.
2	U.S	4.5	5.0	0	62	20	18				16	2.67	1.76	1.38		SW	Medium stiff ,brown clayey silty sand
2	S.S	5.0	5.5		24	32	54	0.9	41	24					10	CL	Stiff, brown silty clay with org. material
2	D.S	5.5	6.0	0	8	47	45	0.5	46	23	25		1.92	1.47		CL	Stiff brown clayey silt.
2	S.S	6.5	7.0								27	2.72	1.91	1.52	9		Stiff brown sandy silty clay
2	U.S	8.5	9.0	0	52	31	17	0.5	21	9	26					ML	Stiff brown silty sand
2	S.S	9.0	9.5								27	2.65	1.82	1.44	11		Stiff grey silty sand

Table 2. shows the results of the tests for the soil in Al- Mahaweel station.

B.H.	Samples Type	Depth of Sampling (m)		Particle size distribution and hydrometer analysis				Physical properties							SP.T. "N" Value	Symbol Unit Class	Description of soil
		From	To	Gravel %	Sand %	Silt%	Clay %	A	L.L%	P.I%	MC.%	G.S	Unite weight g/cm³ γ_{wet}	Unite weight g/cm³ γ_{Dry}			
1	D.S.	0.5	1.0	8	52	32	8				14	2.67	1.73	1.30			Fill Material
	U.S	1.5	2.0	0	48	25	27	0.3	34	9		2.69				ML	Medium stiff black clayey silty sand with org. mat.
	S.S	2.0	2.5	0	51	29	20				28		1.84	1.49	7		Loose grey clayey silty sand
	U.S	3.0	3.5	0	54	20	26					2.71				SW	Loose grey silty clayey sand
	S.S	4	4.5								30		1.82	1.46	9		=
	D.S	5.0	5.5	0	53	23	24				29					SW	=
	S.S	6.0	6.5	0	51	24	25				27	2.70			9		=
	DS	6.5	7.5	0	45	23	32	0.5	34	11			1.88	1.51		OL	Stiff black silty clayey sand
	S.S	8.0	9.0	0	43	26	31	0.5	33	10	26	2.69			11		=
	D.S	9.5	10	0	44	36	20						1.79	1.40		ML	Medium stiff black clayey silty sand
2	D.S.	0.5	1.0	4	48	35	13				16						Fill Material
	U.S	1.5	2.0	0	17	21	62	0.3	38	19		2.74	1.92	1.54		CL	Stiff brown sandy Silty Clay
	S.S	2.0	2.5								23				16		Very stiff brown sandy Silty Clay
	U.S	3.0	3.5	0	21	38	41	0.2	36	8		2.73	1.90	1.52		ML-OL	=
	S.S	4	4.5								24				19		=
	D.S	5.0	5.5	0	23	39	38	0.3	38	12		2.71	1.91	1.54		CL	Very stiff brown sandy clayey silt
	S.S	6.0	6.5								26				17		=
	U.S	7.0	7.5	0	41	22	37	0.2	29	6		2.73	1.80	1.36		OL	Very stiff brown silty sandy clay
	S.S	8.0	9.0								27		1.82	1.39	17		=
	D.S	9.5	10	0	43	34	33	0.3	36	11		2.72	1.82	1.44		ML	Very stiff grey clayey silty sand

JOURNAL OF UNIVERSITY OF BABYLON
For Pure and Applied Sciences (JUBPAS)

ARTICLE
Vol.29; No.3. October-December | 2021

Table 3. shows the results of the tests for the soil in Sinjar station.

B.H	Samples Type	Depth of Sampling (m) From	Depth of Sampling (m) To	Particle size distribution and hydrometer analysis: Gravel %	Sand %	Silt %	Clay %	Physical properties: A	L.L%	P.I%	MC.%	G.S	Unite weight g/cm³ γ_{wet}	Unite weight g/cm³ γ_{Dry}	SP.T. "N" Value	Symbol Unit Class	Description of soil
1	D.S	0	0.5	6	71	12	11				16	2.63	1.81	1.42			Very loose gray clayey silty sand with organic material
	S.S.	1.5	2	0	59	35	6				21				4	SM	Very loose gray clayey silty sand
	D.S	2.5	3	0	63	34	3				20	2.67	1.84	1.42		SM	Loose grayish clayey silty sand
	S.S.	3.5	4	0	65	29	6				23				8		Loose grayish clayey silty sand
	D.S	4.5	5	0	71	25	4					2.69	1.76	1.34		SM	Medium dense grayish clayey silty sand
	S.S.	5.5	6	0	65	27	7				24				16		Medium dense grayish clayey silty sand
	D.S	6.5	7	0	61	34	5					2.69	1.71	1.33		SW	Medium dense grayish clayey silty sand
	S.S.	7.5	8	0	33	28	39	0.3	29	13	28				17	CL	Very stiff brown silty sandy clay
	U.S	8.5	9	0	32	27	41	0.5	34	18		2.73	1.89	1.43		CL	Very stiff brown silty sandy clay
	S.S.	9.5	10	0	25	28	47	0.5	38	25	30		1.90	1.43	18	CL	Very stiff brown sandy silty clay
2	D.S	0	0.5	3	61	31	5				16.7	2.64	1.78	1.31		SM	fill materials
	D.S.	0.5	1	2	64	28	8						1.81	1.32			Very loose gray clayey silty sand
	S.S	1.5	2	2	61	24	13				27.6	2.71	1.83	1.42	6	SM	Loose gray clayey silty sand
	D.S.	2.5	3	0	23	48	29	0.5	44	15						OL	Medium stiff brown sandy clayey silt
	S.S	3.5	4		22	37	41				29.2	2.74	1.93	1.54	9		Stiff brown sandy silty clay
	D.S	4.5	5	0	22	29	49	0.3	27	14						CL	Stiff brown sandy silty clay
	S.S	6	6.5	0	19	37	44	0.5	31	19	28.3	2.72	1.91	1.52	14	CL	Stiff brown sandy silty clay
	D.S.	7	7.5	0	20	46	34	0.6	38	21							Stiff brown sandy clayey silt
	D.S	8	8.5	0	58	31	11				24.5	2.66	1.83	1.42		SM	Medium dense gray clayey silty sand
	S.S.	9	9.5	0	46	31	23	0.3	27	14	31.2	2.73	1.89	1.51	19		Medium dense gray clayey silty sand

B. Engineering properties of soil

Table 5. the results of the Engineering properties of soil in Al- Mahaweel station.

B.H. NO.	Depth (m) From-To	q_u kN/m²	K mm/sec	C kN/m²	∅o	Consolidation				
						e_o	C_c	C_r	P_o kN/m²	P_c kN/m²
1	1.0 -1.5	35		23.8	8	0.69	0.12	0.042	210	184
	4.0 - 4.5	41	$2*10^{-3}$	7.5	31					
	7.5 – 8.0	48	$4*10^{-2}$	6	36					
	9.0 - 9.5	51		11	19					
2	1-1.5	46		27	10					
	3.0-3.5	58	$6*10^{-4}$	31	8	0.73	0.11	0.031	202	180
	7.0-7.5	78		35	6	0.61	0.10	0.027	266	190
	9.0-9.5	78	$4*10^{-3}$	9.3	21					

Table 4. the results of the Engineering properties of soil in Al Sadda station.

B.H NO.	Depth (m) From-To	q_u kN/m²	K mm/sec	C ton/m²	∅o	Consolidation				
						e_o	C_c	C_r	P_o kN/m²	P_c kN/m²
1	1-1.5			7	18					
	3-3.5	42	$5*10^{-5}$	23.7	7	0.668	0.246	0.041	220	190
	6-6.5	51		7	19					
	6.5-7.0	64	$7*10^{-3}$	11	13.4	0.711	0.282	0.042	245	210
2	1-1.5			0	23		-	-	-	-
	3-3.5	38	$7*10^{-3}$	0	27					
	6.5-7	42	$3*10^{-6}$	18	9		-	-	-	-
	8.5-9	54		7	18.5					
	9-9.5			30.7	12		-	-	-	-

Electronic ISSN: 2312-8135 | Print ISSN: 1992-0652
Main Campus, Al-Najaf St., Babil, Al-Hilla, 51002, P.O. Box: 4, Iraq

Table 6. the results of the Engineering properties of soil in Sinjar station.

B.H. NO.	Depth (m) From-To	q_u kN/m^2	K mm/sec	C kN/m^2	∅o	Consolidation				
						e_o	C_c	C_r	P_o (kN/m^2)	P_c (kN/m^2)
1	1.0 -1.5	37	$4*10^{-2}$	4	22					
	4.0 - 4.5	-		2	24					
	7.5 – 8.0	62	$8*10^{-4}$	43.2	5	0.77	0.251	0.049	173	165
	9.0 - 9.5	70		31.6	7	0.84	0.147	0.059	220	185
2	1-1.5	-	$6*10^{-3}$	3	27					
	4.0-4.5	48	$2*10^{-4}$	32.5	7	0.75	0.109	0.026	195	170
	6.5-7.0	67		54	5	0.73	0.113	0.027	202	180

C. Chemical properties

JOURNAL OF UNIVERSITY OF BABYLON
For Pure and Applied Sciences (JUBPAS)

Crossref doi

ARTICLE
Vol.29; No.3. October-December | 2021

Table 7. the results of the Chemical analysis of soil in Al Sadda station.

B.H. NO.	Depth from	to	SO_3%	T.S.S. %	Org. %	Gyps. %	$CaCO_3$ %	PH	Cl%
1	1.0	1.5	1.47	3.45	0.81	3.16	20	8.7	0.017
	2.5	3	0.50	0.52	0.135	1.0	27	8.1	0.017
	6.0	6.5	0.07	0.43	0.11	0.15	21	8.3	0.017
	9.0	9.5	0.11	0.81	0.63	0.24	23	8.0	0.017
2	0.5	1.0	0.536	1.62	1.21	1.15	28	9.1	0.035
	1.5	2.0	0.08	0.48	0.69	0.17	25	8.5	0.017
	4.5	5.0	0.09	0.59	0.65	0.19	26	8.3	0.017
	5.0	5.5	0.11	0.76	0.62	0.23	26	8.2	0.016
	6.5	7.0	0.27	0.96	0.48	0.58	39	8.3	0.013
	9.0	9.5	0.36	1.25	0.39	0.80	36	8.2	0.011

Table 8. the results of the Chemical analysis of soil in **Al- Mahaweel** station.

B.H. NO.	Depth from	to	SO_3	T.S.S .%	Org .%	Gyps. %	$CaCO_3$ %	PH	Cl%
1	0.5	1.0	0.34	0.53	1.79	0.73	8	8.1	0.051
	1.0	1.5	0.47	0.82	2.48	1.01	11	8.1	0.049
	2.5	3.0	0.51	1.24	3.72	1.09	11	7.8	0.047
	6.0	6.5	0.60	2.67	4.35	1.29	13	8.0	0.039
	9.0	9.5	0.68	2.61	4.29	1.46	18	8.1	0.031
2	1.0	1.5	1.20	4.14	6.34	2.58	21	8.0	0.028
	4.5	5.0	1.53	4.29	6.72	3.28	5	8.1	0.027
	6.5	7.0	1.76	4.53	7.28	3.78	7	8.2	0.019
	7.5	8.0	1.42	4.11	5.51	3.05	9	8.1	0.018
	9.0	9.5	1.12	3.41	4.89	2.41	12	8.1	0.018

Table 9. the results of the Chemical analysis 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	0.62	3.85	0.019	1.33	6	7.9	0.057
	1.0	1.5	0.53	3.63		1.14	10	8.1	0.053
	2.5	3.0	0.48	3.38	0.011	1.03	18	8.1	0.051
	6.0	6.5	0.33	2.14		0.71	19	8.0	0.047
	9.0	9.5	0.24	1.82	0.009	0.52	21	8.1	0.043
2	1.0	1.5	0.34	0.58	1.82	0.73	8.0	8.1	0.062
	4.5	5.0	0.39	0.65	1.37	0.83	9.0	8.0	0.057
	6.5	7.0	0.41	0.82	1.25	0.88	11.0	8.0	0.051
	7.5	8.0	0.49	0.97	1.14	1.05	17.0	7.8	0.044
	9.0	9.5	0.34	0.58	0.82	0.73	8.0	8.1	0.062

B. 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 It 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 (Al-Sadda, AL-Mahaweel ,and Sinjar) Stations, where the value of permeability (K) for the layers changes between (5*10-5 to 7*10-3) mm/Sec.

As for the highest Bearing Capacity (q all) recorded (q all = 10 Tons/m2, (100 kN/m2) at a depth of 6 m.

As for the right-hand side of the flow (sedimentation area), BH2, the permeability value of the layers (K) ranged between (3.18 x 10-6 to 7.44 x 10¯3) mm/sec., while the highest tolerance was recorded (q all = 7.5 Tons/m2). , (75kN/m2 and was at a depth of 6.5 m.

The results of the uniaxial compressive strength (qu) showed the range of the uniaxial compressive strength of (78-35 kN/m2), 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 (0-35) 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 (5°- 27°), 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 (Cc) Compression index that the range value of the index was (0.10-0.28), 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 (0.26-0.52), 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 (0.61-0.84), 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 (165-320 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 (173-266 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.

The over consolidation ratio (OCR), has the highest value less than (1) where the soil classified according to (Holtz & Kovacs, 1981)

C. Chemical Results Discussion

The Chemical tests for soil and water samples results in Al-Sadda, Al-Mahaweel, and Sinjar) Stations were as follows:

The percentage of (SO_3) ranged between (1.76 to 0.09)%, 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 (4.5-0.4)%.

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 (7.2-0.01)%.

Results Discussion

The highest result of the safety factor was in Sinjar Station (2.5), then the banks of Al-Sadda Station, with a value of (2.3), and the lowest value of Al-Mahaweel Station, which amounted to (1.4). Under natural conditions, the average river flow level reaches it in year is (28.7 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 The soil of the banks reaches it before the landslide ,as figure (5,6,and7).

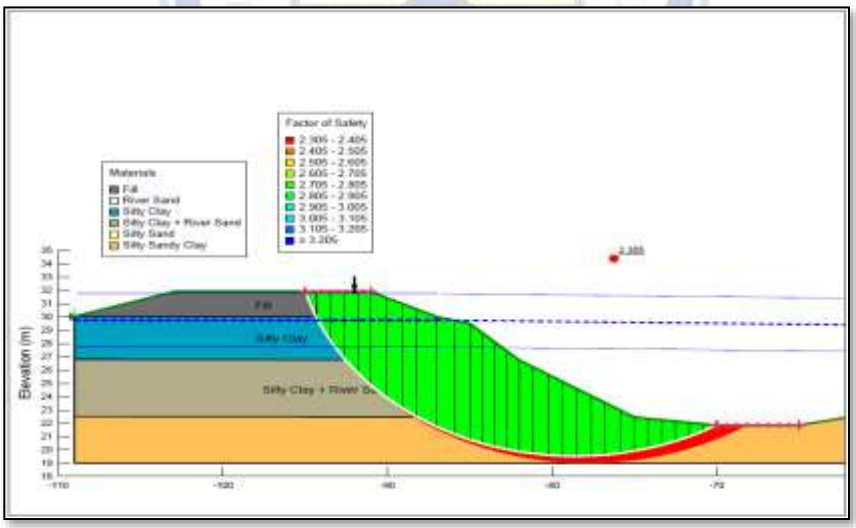


Fig. (5) Safety factor extracting for the left bank of the flow at Sinjar Station, by (GeoStudio 2021).

Electronic ISSN: 2312-8135 | Print ISSN: 1992-0652
Main Campus, Al-Najaf St., Babil, Al-Hilla, 51002, P.O. Box: 4, Iraq

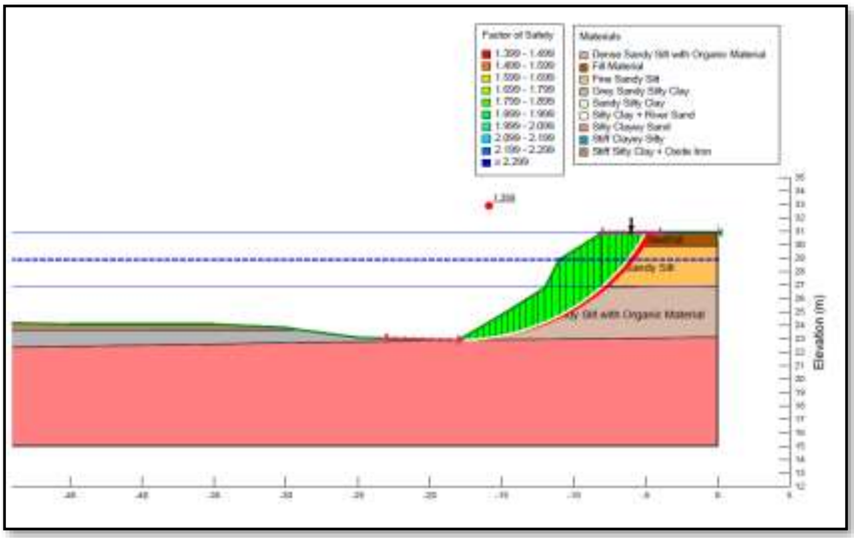


Fig. (6) Safety factor extracting for left bank of flow at Al-Mahaweel Station, by (GeoStudio 2021).

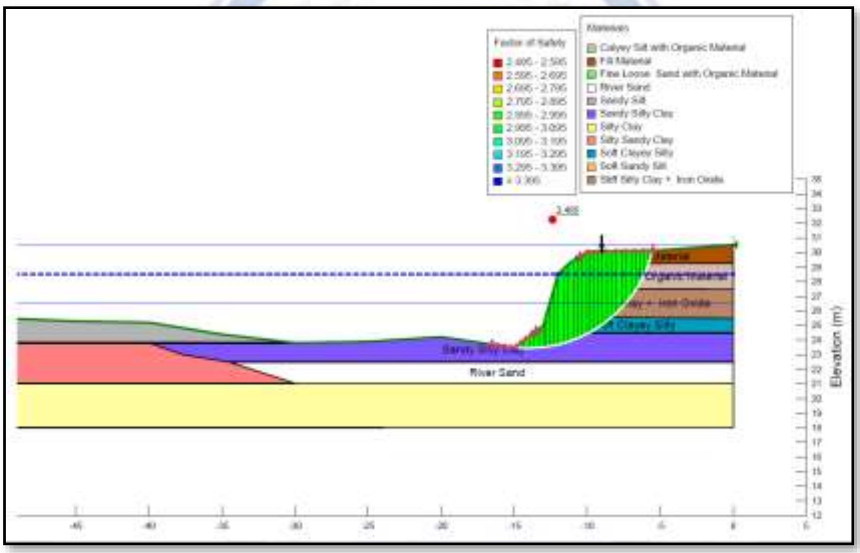


Fig. (7) Safety factor extracting for the left bank of the flow at Sinjar Station, by (GeoStudio 2021).

Conclusions

1- The geotechnical results in all study stations showed that the convex side (erosion), is consisting from 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)

1- Hilla River affected by the energy of the flow velocity and according to type of banks soils ,there for the meander is forming.

2- the rise and fall of the river water level affects the safety of the slopes, as in both cases the safety factor decreases, but when it decreases (dry season), its effect is often greater.

3. the bearing capacity of the banks on both sides of the river is low for all study stations, reaching at its best to 7 t/m^2.

Recommendations

1. Develop a comprehensive study along Hilla River about the effect of the river flow on the slopes stability of the banks.
2.Slope grading (flattening) the steep bank slopes of by reducing their slope angle ,This will increase slope stability.
3. Not to be construct buildings on or near that require high bearing capacity .

Acknowledgment

First, I deeply thank our God for all benefits , with his a continuity care of me.

I would like to gratefully my supervisors , Assist. Prof. Dr. Raad Aziz M. ; and prof. Dr. Aamer Atia Al-Khalidi .

I extend my thanks and appreciation to the Deanship of the College of Science, represented by Prof. Dr. Mowaffaq Fadhel Al-Shahwan, and a head of Geology Department Prof. Dr. Abbas Hamid Al-Baydhani and Staff of Geology Department , College of Science , Basra University, Whose made all their scientific and knowledge efforts and provided support to graduate students. The duty of the scientific secretariat also calls me to extend my a deep thanks to prof. Dr. Bader Akash Al Badran , Dr. Imad Al-Ainchi ,and prof. Dr. Hamed Al-Jubouri for assistance which provided me in collecting data and information on the practical side of the study.

Conflict of interests.

There are non-conflicts of interest.

References.

[1] 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 V. 26 (1), pp: 37-47.

[2] 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 - Babylon Governorate - Central Iraq, University of Babylon - College of Science.

[3] Al-Jeafir, M.L., (2020). Sedimentology, Mineralogical and Environmental Study of the Euphrates River from
Babylon to Basrah, Iraq. Ministry of Higher Education and Scientific Research, University of Basrah, College of Science Department of Geology, Iraq.

[4] Jassim, S. Z. and Goff, J. C., (2006).GEOLOGY OF IRAQ. Dolin, Prague and Moravian Museum, Brno, Czech Republic.P314.

[5] AL-Hiti, M. Y H., (1989). (Baquba) study the internal structure of a career, unpublished MSc Thesis (unpublished), College of Education, Ibn Rushd, Baghdad University(In Arabic).

[6] Sissakian , U.K., (editor) ,(2000), Geological map of Iraq, Central company of geological survey and mineralization, GEOSURF.

[7] Buringh, P., (1960) ,"Soil and soil conditions of Iraq", ministry of agriculture , Baghdad, p.322.

[8] Parsons, R.M., (1957). Groundwater resources of Iraq (Mesopotamia plain), Vol.11, Development Board ministry of development government of Iraq, P.5-21.

[9] Lees , G.M. and N.Falcon , (1952), "The geographical history of the Mesopotamian plains" , geographical journal , v.118 , p24-38.

[10] Abdullah, Michael Perrotta, (1982), Sedimentary, petrographic, geochemical and hydrochemical modern sediments, of Al- Hammar Marsh in southern Iraq. Unpublished Master's Thesis, College of Science, University of Baghdad, p. 182.

[11] Crosato, A.,(2008). Analysis and Modelling of River Meandering", PhD. Thesis, Delft University of Technology, United States.

[12] Zamili, A., (2015). The Geomorphologic Phenomenon of Hilla And Al-Hindya Rivers, Journal of The College of Basic Education for Educational and Human Sciences, No. 20, University Of Babylon.

[13] BRICE, J. (1982). Stream channel stability assessment. Report no. FHWA/RD, Federal Highway Administration, Offices of Research and Development.

[14] Leopold, L. B. Wolman, M. C. and Miller, J. P., (1964). Fluvial process. In : Geomorphology .Ed.W.H. Freeman. Sanfrancisco.

[15] Rosgen, D. (1996). Applied river morphology. Wildland hydrology books. Pagosa Springs, Colorado.

[16] Law, K. T. and Lumb, P., (1978). A limit equilibrium analysis of progressive failure in the stability of slopes. Can. Geotech. J. 15 pp: 113- 122.

الخلاصة

مقدمة:

تعاني ضفاف نهر الحلة في المناطق الواقعة في الجزء الشمالي من محافظة بابل من مشاكل هندسية نتيجة لتأثير جريان نهر الحلة الذي يعمل على تأكل (تعرية) من جانب والترسيب على الجانب الاخر وبالتالي يتشكل الالتواء النهرية.

بعد الزيارة الاستطلاعية لمنطقة الدراسة تم تحديد مواقع الالتواء ، حيث اجريت دراسة تفصيلية للمنطقة عن طريق حفر 6 ابار اختبارية تمثل ثلاثة مناطق (السدة، المحاويل، وسنجار) بواقع بئرين على جانبي التعرج وبعمق 10م لكل بئر ، لتحديد خواص التربة وقدرتها على التحمل واتماسك ومقاومة اجهادات القص الناتجة من طاقة تدفق النهر .

طرق العمل:

تم جمع عينات التربة لأجراء الاختبارات الفيزيائية التالية (اختبار المحتوى الرطوبي، الوزن النوعي ، حدود اتربيرك، التحليل المنخلي، والكثافة). كما تم اجراء الفحوصات الهندسية والتي شملت (اختبار النفاذية، مقاومة الانضغاط الاحادي المحور والثلاثي المحور، فحص القص المباشر، اختبار الانضمام وقابلية التحمل). كما تم اجراء مجموعة من الاختبارات الكيميائية وهي (PH، الاملاح الذائبة الكلية ، نسبة الكبريتات ، فحص الكلوريد، نسبة الجبس، ونسبة المواد العضوية).

كما اجريت دراسة لثبات منحدرات البنوك للمحطات الثلاث ، حيث تم رصد المقطع العرضي بواسطة جهاز M9 ، وكذلك ارتفاع الضفاف من الجانبين بواسطة جهاز (LEVEL) ، وتم الربط بينهما بواسطة جهاز Geo-Studio 2021 بعد التعرف على خصائص التربة وباستخدام (Bishop method)

الاستنتاجات:

تم التعرف على عامل الامان للمحطات الثلاثة للمناطق المعرضة للتعرية فكانت اعلى نتيجة لعامل الامان في محطة سنجار (2.5) ومن ثم ضفاف السدة بقيمة (2.3) واقل قيمة محطة المحاويل والبالغة (1.4). في الظروف الطبيعية ومتوسط منسوب جريان يصله بالسنة (28.7 م) فوق سطح البحر .

حيث كانت جميع المحطات امنة مالم يزداد او ينخفض منسوب المياه كذلك توصل البحث تحديد القابلية القصوى للأحمال التي تتحملها الضفة قبل الانهيار .

الكلمات الدالة: التوائية النهر، محطة السدة، الانضمام ، ابار اختبارية ، برنامج جيو ستوديو 2021.