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Research into the Positional Erosion around Bridges Abutments in the Garmian Region

Kareem Abdullah Muhammed
College of Computer & Information Technology || Garmian University || Iraq

Abstract: In this research, investigation the impact of the water levels, water velocity on the drift depth of pillars of the bridges in the Garmian region was studied. The water levels and velocity were recorded for periods, different stretches between the months of December of 2018 and March of 2019. The study dealt with the most important postural relationships that can be used to estimate the depth of future drift around the pillars. Description of the site of the studying region within Garmian region includes site measurements of the bridge span, height and pillars. Hydraulic properties of the basins was studied as well as the soil texture depending on clay, silt and sand portions was detected.

The depth of the site erosion did not exceed the critical limit for some pillars because it did not reach the depth of the foundation, while reach the depth of the foundation of the others pillars. The flow around the abutments of the Dardween Bridge is of a critical type, so high drifts are -+expected. The results of the gradient examination of the size of the particles in the Garmian region, shows a high proportions of the Coarse and Fine aggregates "gravel and sand" in the soil which increasing the porosity and the permeability of the soil, thus increasing the possibility of erosion at the bases of the supports for bridges in this area due to high increasing water seepage. A proposal method was obtained by the current study to estimate the erosion around bridges pillars. Using deep piles foundations for the pillar bases instead and rock dam in front of the pile foundations to reduce the impact of the flow was recommended in this study.

Keywords: Soil Texture, Hydraulic properties, Positional Erosion, Bridges Abutments.

بحث في التآكل الموضعي حول دعامات الجسور في منطقة كرميان

كريم عبد الله محمد
كلية الحاسوب وتكنولوجيا المعلومات || جامعة كرميان || العراق

المستخلص: في هذا البحث تم دراسة تأثير منسوب المياه وسرعة المياه على عمق انجراف أعمدة الجسور في منطقة كرميان حيث تم تسجيل مستويات المياه وسرعتها لفترات امتدادات مختلفة بين شهري كانون الأول (ديسمبر) 2018 ومارس (آذار) 2019. وتناولت الدراسة أهم العلاقات الوضعية التي يمكن استخدامها لتقدير عمق الانجراف المستقبلي حول الركائز. تضمن وصف موقع منطقة الدراسة داخل منطقة كرميان قياسات الموقع لطول الجسر والارتفاع والأعمدة وكذلك تمت دراسة الخواص الهيدروليكية للأحواض وكذلك قوام التربة حسب أجزاء الطين والطمى والرمل.

لم يتجاوز عمق تعرية الموقع الحد الحرج لبعض الركائز لأنها لم تصل إلى عمق الاساس بينما وصلت إلى عمق اسس ركائز الاخرى. يعتبر التدفق حول دعامات جسر دردوين من النوع الحرج، لذلك من المتوقع حدوث انجرافات عالية. أظهرت نتائج فحص التدرج لحجم الحبيبات في منطقة كرميان وجود نسب عالية من الركام الخشن والناعم " الحصى والرمل" في التربة مما يزيد من مسامية ونفاذية التربة وبدوره يزيد احتمالية تعرية قواعد دعامات الجسور في هذه المنطقة بسبب ارتفاع تسرب المياه المتزايد. وتم التوصل إلى معادلة

وضعية مقترحة لحساب الانجراف حول قواعد الأسس، التوصية باستخدام أساسات الركائز العميقة لقواعد الأعمدة بدلاً من ذلك والسد الصخري أمام أساسات الركائز لتقليل تأثير التدفق في الدراسة الحالية.

الكلمات المفتاحية: قوام التربة، الخصائص الهيدروليكية، التآكل الموضعي، دعامات الجسور.

Study Methodology.

The researcher relied on two types of approaches, the first of which is the descriptive approach in order to analyze the natural characteristics of the study area, and the second approach is the analytical approach in knowing the impact of the erosion process on the foundations of bridges within the study area.

The problem under study:

Choosing and defining the study problem represents the basic step in scientific research, as it is represented by a set of questions that require answering, and accordingly, the study problem can be formulated into questions as follows:

1. What are the natural characteristics of the study area and their contribution to the formation of its hydrological characteristics?
2. What is the relationship between the influential hydrological characteristics of the basins of the study area and the extent of the impact of water erosion on the surface layer of the soil, and consequently the direct effect on the erosion of the bridge bases within them and the ways to reduce it.
3. What is the relationship between the soil properties of the study area and the extent to which they are affected by erosion processes?

Objectives of the Study:

The study seeks to achieve a number of goals, which are the following:

1. Knowing the effective hydraulic properties directly in the erosion of the bridge bases within the study area
2. Preparing adequate data for the erosion processes of the bridge bases built within the study area
3. Evaluate the appropriateness of the procedures, being taken for reducing the erosion of the foundations of the bridges within the study region.
4. Avoiding cases of collapse as a result of the erosion processes taking place at the bases of the bridges columns within the study area, as happened to the Dardween Wayne Bridge.

Introduction.

Several bridges were damaged in different parts of the Garmian region, where the Qatraka bridge linking Kalar and Darbandikhan collapsed in 2018, and the Dardween bridge that connects Suleimaniyah Governorate and Garmian region in 2019. The heavy rains led to the fall of the iron bridge (Al-Gwer Bridge) and its complete suspension. The bridge began to slowly drift with torrents within the Kurdistan Region in 2019, Several bridges were damaged in different parts of the Garmian region, and failed as a result of a large site erosion around their struts or around their shoulders because the erosion depth was not accurately calculated during the design, where the localized erosion would occur its value is greater as a result of water flowing around a particular obstacle such as bridge supports, shoulders, rocky tongues, etc.

At the front of the supports than at the rear due to the direction and speed of the flow, there are multiple factors that interfere with each other for the occurrence of site erosion and the extent to which it affects the origin in which it occurs (Ahmed, 1998).

These include the depth and intensity of the flow, the properties of the bottom material (sediment), the angle of inclination of the pillars base towards the direction of the flow, in addition the shape of the pillars base. (Stevens M. A., 1991) In site, erosion around bridge abutments has been concluded by researchers through different methods and phases set of equations to estimate the depth of drift around the abutments and shoulders of bridges. In the middle of the last century, many studies were conducted and many positive equations were developed to estimate the drift around bridge trusses have had many formulas using laboratory data and sometimes few field data, and have been studied extensively.

In this study extensive site drift around bridge abutments, and due to the emergence of the condition of the site erosion around the lateral pillar of the Garmian bridges linking Kalar and Darbandikhan city, in a clear way it consists of a hole with a clear depth, so there was a need to study the erosion depth. The amount of future site drift after knowing the site measurements around this pillar and arriving at a suitable suggestion at the site.

Review of Literature:

There are many positional formulas for researchers to estimate the value of the site drift around bridge abutments, but those were taken the site and hydraulic conditions that are appropriate for this study case. (Abdul-Hassan K. H., 2021) (Halah K.J., 2019) Therefore, the drift depth was calculated according to these formulas to compare with field measurements, thus arriving at an appropriate formula for future measurements:

For the measurement of the cross-section of the study area of the river, it was divided into several segments and use the law of small areas to calculate the total area of the segment.

$$A = \sum_{i=1}^{n} (h_i + h_{i+1}) * {}^{x}/_{2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

A = cross-sectional area of the river

hi, hi+1 = Average Height of both sides of the distance x

x= the horizontal distance

Before addressing the positional formulas for calculating the erosion depth and comparing it with those measured in site, many recommended the researchers find out whether or not in site erosion will occur around the struts by finding the value of the runoff intensity which is equal to (v/vc) where (v) is the flow velocity in the river, (vc) is the critical velocity. If the value is greater than (0.5) then this will happen Position drift, the formula for that is (Melville, 1991):

$$\frac{vc}{vc^*} = 5.75\, log(5.53\ \ y/d\,50) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

v_c^* = critical shear velocity of the bottom material.

y = depth of run-off in the river.

$$vc^* = 0.0115 + \left[0.0125[(d\ 50)^{1.4}]\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

1. Ingls-Poona:

The following relationship is applied to the aforementioned researcher when d50 < 0.5 mm and y/b < 4 where b is the width of the abutment. (Melville, 1991)

$$ds/b = 4.025\ ({}^{y}/_{b})^{3/4}\ (Fc)^{0.5} - {}^{y}/_{b}\ \cdots\cdots\cdots (4)$$

$$Fc = \frac{V_c}{\sqrt{g^*\,A/T}}$$

Where:

ds = drift depth.

Fc = Freud's critical number

v_c = critical velocity

T = width of the flow section from the top

2. Shen I:

Shen considers that the effect of particle size is negligible if d50 < 5.0 mm and takes the effect of flow velocity into account and the following formula. (Ettemb, 1998)

$${}^{ds}/_{b} = 2F^{0\cdot43}(y/b)^{0\cdot355} \cdots\cdots\cdots (5)$$

Where:

F = Freud's number

3. Shen II:

There is a second form of Shen: (Ettemb, 1998)

$$ds/b = 3 \cdot 4(Fp)^{0 \cdot 67} \cdots \cdots \cdots (6)$$
$$Fp = v/\sqrt{g * b}$$

Where:

Fb: is a Froude number in function of the width of the strut b

4. Tor Sethaugen:

In his relationship, the researcher relied on the intensity of the flow and the depth of the water and neglected the effect of the granular size of the bottom material. (Francis, 2001)

$$ds/b = 1 \cdot 8(v/v_c - 0 \cdot 54) * y/b \cdots \cdots \cdots (7)$$

5. Breusers et. al.

This relation is applied in the case of y/b < 1. (Breusers, 1977)

$$ds/b = \left((2\, v/v_c - 1)(2 \tan h\ {}^{y}/_{b})\right) \cdots \cdots \cdots (8)$$

6. Subhash C. Jain:

The formula that was developed. (Chiew, 1989)

$$ds/b = 1 \cdot 84({}^{y}/_{b})^{0 \cdot 33}(Fc)^{0 \cdot 25} \cdots \cdots \cdots (9)$$

7. Qader:

The researcher analyzed the mechanics of drift around the bridge supports with the following equation (Melville, 1991):

$$ds = 538\ C_o^{1 \cdot 28} \ \cdots \cdots \cdots (10)$$

Where:

$$C_o = v_o r_o$$
$$r_o = 0 \cdot 1 * b$$
$$v_o = 0 \cdot 92\ b^{0 \cdot 5} v^{0 \cdot 83}$$

8. Salih Essa:

In order to find a formula suitable for the location of the study to estimate the local drift around the pillar the formula assumed according to the hydraulic conditions of the site can be set as follows: (Salih, 2008.)

$$ds/b = C(y/b)^a\ (F)^b \cdots \cdots \cdots (11 \cdot a)$$

The field data were divided into two groups, the first group to find a situational formula suitable for the study site.

It was entered into a statistical program and the following formula was arrived at:

$$ds/b = 2 \cdot 07(y/b)^{0 \cdot 34}\ F^{0 \cdot 45} \ \cdots \cdots \cdots (11 \cdot b)$$

From field measurements, the calculated drift depth was tested with the measured drift depth, where it was found that the error rate is very low compared to the man-made formulas that were mentioned, some of which can be used to estimate the depth of the site erosion around the pillars of the Kufa Bridge, especially those that give a small error rate.

Site Description of the Studying Region:

Location:

The study area is geographically located within the undulating region in the northeastern part of Iraq and the southeastern part of the Kurdistan Region. Administratively in the southern part within the borders of Suleimaniyah Governorate, as it is bordered on the north by Darbandikhan Lake, on the east by Khanaqin district and Diyala River, and on the west by Salah al-Din governorate. The south is bordered by Diyala Governorate. It is (150) km from Kirkuk Governorate and (140) km to the south of Suleimaniyah Governorate. Astronomically, it is located between latitudes (35.10 - 34.40) ^{0} North and longitudes (45.10 - 45.40) ^{0} East.

Natural Properties

The region is located in the southeastern part of the Kurdistan Region of Iraq. The region is part of the undulating region, which serves as a transitional region between the mountainous region in the north and northeast and the plain region in the south.

The data indicate that the study area is located between the altitude line (1780) m above sea level in the northern part of the study area and the altitude line of 188 m above sea level in the southern part of it. Depending on the terrain characteristics, the area can be divided into: (Al-Askari, 2018)

1. The region of the low mountains, confined between altitudes of (701—1780) m above sea level.
2. The hills region, confined between altitudes of (499 —701) m above sea level.
3. Plains region, confined between altitudes of (188 — 449) m above sea level.

Slope Properties

The importance of regression can be highlighted by the effect it has on many operations. The gradient properties are one of the main factors affecting the activity of erosion processes and the resulting erosion of the surface layer of the soil, as well as the inverse relationship between the amount of sedimentary water and the degree of slope. The more the slope increases, the less the amount of water deposited inside the cracks, joints and pores in the soil, But if the slope is moderate, the surface water speed decreases, and then it gives way to its deposition.

Accordingly, the study area was classified into five regression classes (Abbas, 2018)

1. Flat land area

This range is characterized by its flat surface and low slope, as its slope ranges between $(0 - 1.9)^0$ and is located to the south of the study area.

2. The range of lands with light ripples

Its gradient is between $(2 - 7.9)^0$.

3. Range of undulating land

Its gradient ranges between $(8 - 15.9)^0$ and appears in the southern and southwestern parts of the study area.

4. Sloping lands range

Its slope is limited between $(16\text{-}29.9)^0$ and appears in the parts that surround the mountain ranges, which is represented by the hills within the region.

5. The range of steep terrain

The slope of this range is more than $(30)^0$ and is represented by the upper parts of the study area.

The Dardween Bridge was established in the last century, within the borders of Darbandikhan district, which is the main road linking Suleimaniyah and Garmian for the purpose of passing vehicles and pedestrians on it, with a length of 135 m as shown in Fig-1-.

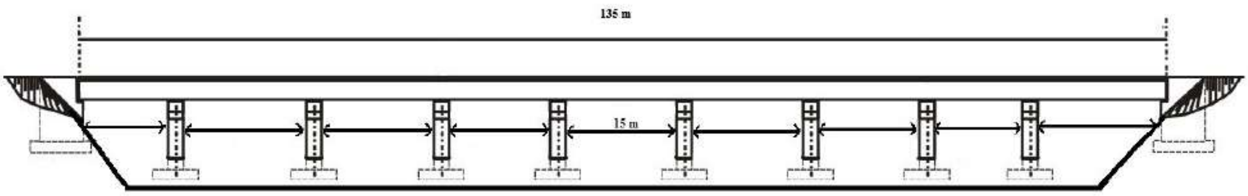

Fig.1 General Description of Bridge Supports and Shoulders

Site Measurements and Equipment:

Test sieves conforming to the Iraqi or British standards and, GSI, Machine weight Sensitive to 0.1% of the model's weight equipment as well as an electric oven at a temperature of 105 ± 5 °C were used in this study.

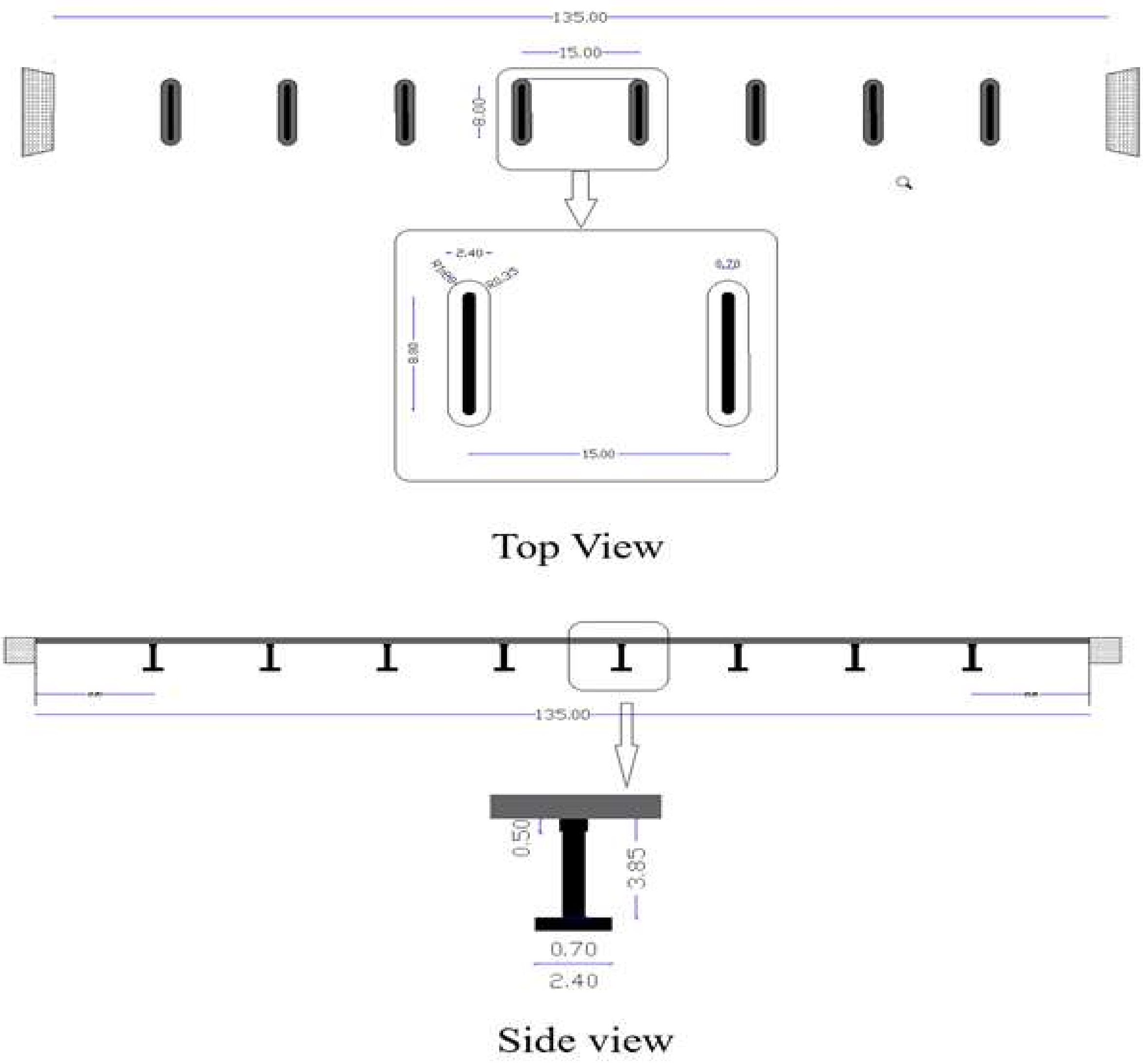

Figure -2- Top and Side Views of the Bridge.

As shown in Images The bridge consists of eight concrete supports with total nine spans and the distance between one pillar and another is 15 meters, the width of one pillar is (8 meters), has a curve shape (not sharp) in the front and rear, and the shoulders of the bridge have been created outside the river section the total height of the bridge is 3.85 m shown in Fig -2- and images (1,2,3,4,5).

Hydrological Characteristics of the Basins of the Studying Region

River Drainage:

The high drains of water are the result of the flow at the front of the bridge. Table -1- Shows the values of the river depths during the specified period.

Table (1) Hydraulic Estimated at the Location of the Dardween Bridge Supports.

Date	Water depth rate (m)	Date	Water depth rate (m)
6 / 12 / 2018	1.58	23 / 3 / 2019	1.68
7 / 12 / 2018	2.66	24 / 3 / 2019	2.31
8 / 12 / 2018	3.85	25 / 3 / 2019	2.86
9 / 12 / 2018	3.25	26 / 3 / 2019	2.05
10 / 12 / 2018	2.24	27 / 3 / 2019	1.02

Torrent Properties

1. Time of Concentration

This variable expresses the time taken for the surface runoff from the maximum point of the basin to its mouth. The less time the focus of the basins, the more dangerous. It was calculated from the equation. (Najah, 2021)

Tc= 75+ (4(S) 0.5+ (1.5L) / (0.8(H) 0.5))

Where:

Tc: Time of Concentration

S: slope of water stream

L: length of the stream / km

H: the difference in height between the average and the minimum height of the water basin (m)

Table (2) Hydraulic and Positional Information of the Studying Region.(Time of Concentration)

Seq.	Zone No.	Stream Slope S	Stream Length L	Height Difference H	Time of Concentration Mints	Time of Concentration hrs.
1	Zone -1-	17.5	46.9	820	257.70	4.295
2	Zone -2-	22.2	18.5	410	172.11	2.868
3	Zone -3-	13.3	19.2	255	211.90	3.531
4	Zone -4-	7.4	28.6	212	311.25	5.187
5	Zone -5-	20.5	27.7	568	199.06	3.317
6	Zone -6-	36.7	20.5	752	146.54	2.442
7	Zone -7-	20.8	27.9	580	198.41	3.306
8	Zone -8-	36.2	17.4	630	142.34	2.372
9	Zone -9-	60.4	13.4	810	117.41	1.956

Seq.	Zone No.	Stream Slope S	Stream Length L	Height Difference H	Time of Concentration Mints	Time of Concentration hrs.
10	Zone -10-	25.5	21.8	555	170.31	2.838
Average		26.05	24.19	559.2	11.885	3.211

The less the concentration time, the greater the severity of the danger, and this is due to the steepness of the stream in these areas.

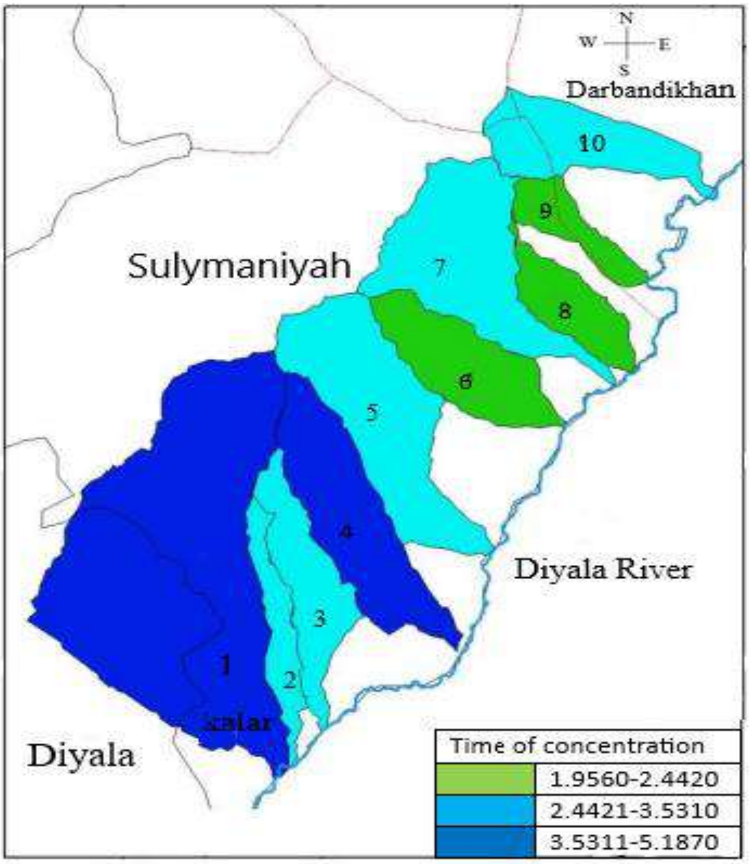

Fig. -3- Time of Concentration Depending of the Studying Region on Table -2-

Velocity of Flow Rate:

It is the volume of water across a river section during a unit time. It is one of the important hydrological parameters of drainage basins because it determines the degree of its ability to erosion of the soil

The general average velocity of the torrential flow of the basins of the region was 7.43 km / h.

The Flow Rate Velocity is calculated by:

$V = L / T_c$

Where:

V = Flow rate velocity (km/hr)

L = Length of the drain pan (km)

T_c = Time of concentration (hrs)

Table (3) Flow Rate Velocity of the Studying Region.

Seq	Zone No.	Zone Length (km)	Time of Concentration (hrs)	Flow Rate Velocity (km/hr)	Flow Rate Velocity (m/s)
1	Zone -1-	42.5	4.295	9.89	2.747
2	Zone -2-	28.3	2.868	9.86	2.738
3	Zone -3-	20.1	3.531	5.69	1.580
4	Zone -4-	28.6	5.187	5.51	1.530
5	Zone -5-	26.2	3.317	7.89	2.191
6	Zone -6-	18.3	2.442	7.50	2.083
7	Zone -7-	25.4	3.306	7.68	2.133
8	Zone -8-	16.2	2.372	6.82	1.894
9	Zone -9-	13.1	1.956	6.69	1.858
10	Zone -10-	19.2	2.838	6.76	1.877
	Average	23.79	3.211	7.43	2.063

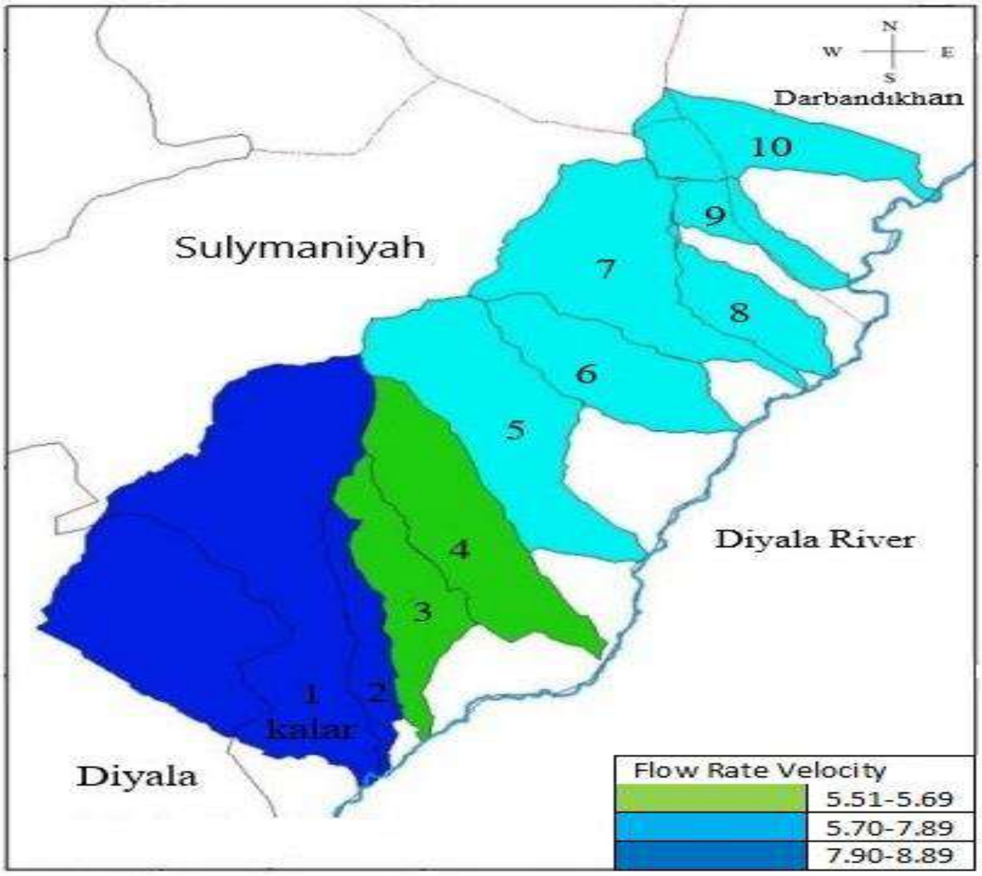

Fig. -4- Flow Rate Velocity of Studying Region Depending on Table -3-

Natural Properties of the Soil of the Studying Region

Soil properties and composition regarded as the factors that determine the degree of soil permeability, which in turn affects water run-off, penetration and filtration. Depending on Buring classification for soil, the soil within the region of study was classified into four types as shown in Fig.-5- that are:

1. Cracked, Rocky Soil

It is located in the far north of Kalar and occupies an area of 101.76 km², with a rate of 6.6% of the total area of the district.

2. Brown Soil of Medium and Shallow Thickness

It is located in the north and center of Kalar and occupies an area of 668.51 km² with a rate of 43.38% of the total area of the district.

3. Lithosol Soil with Sandstone or Gypsum

It is located in the northeast of the region and occupies an area of 70.32 km² and represents 4.56% of the total area of the region.

4. Reddish-Brown Soil of Medium Thickness Covering Gypsum Layers

It is located in the south of the region, occupies an area of 700.41 km², and represents 45.45% of the total area ofthe region.

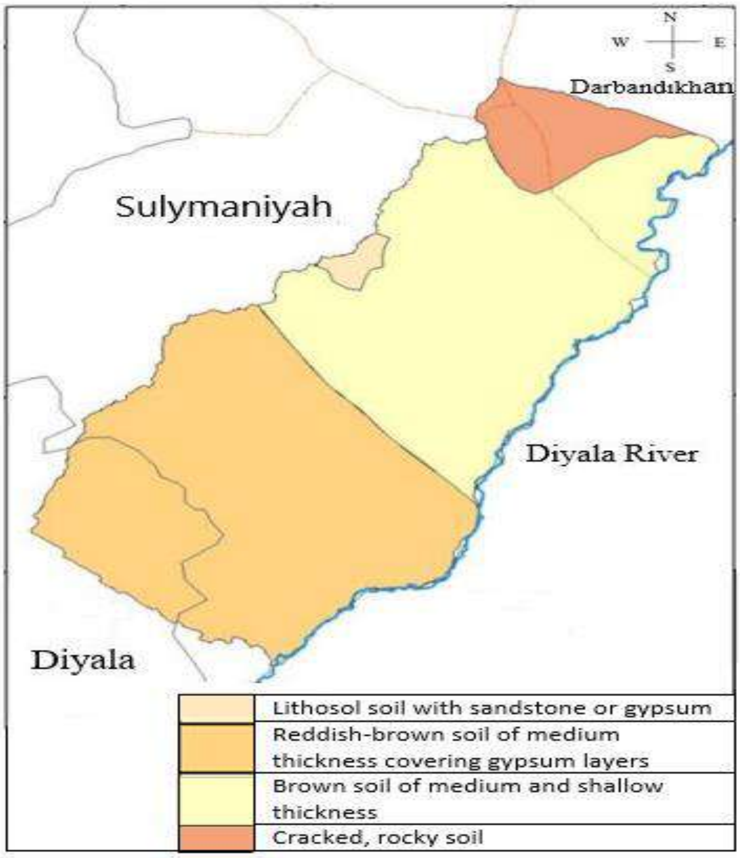

Fig. -5- Soil Types of Studying Region Depending on Buring Classification for Soil

Soil Texture

It reflects the relative distribution of the mineral soil particles, which are represented by sand, silt and clay, and due to the different soils in the proportions of these particles, in addition to their difference in size and shape, they have become a guide used to determine the extent of the roughness and softness of the soil, as well as determine the properties of the soil in terms of ventilation, porosity, water permeability within the soil and its ability to retain water as well as the ease or difficulty of soil erosion.

The physical properties of the soil within the study area vary clearly as shown in the Table-4-, Fig.-6- and Fig.-7-

Table (4) Physical Properties of the Soil Samples within Studying Region

Sample No.	Clay%	Silt%	Sand%
1	34	31	35
2	45	22	33
3	31	49	20
4	30	50	20
5	36	49	15
6	16	47	37
7	36	51	13
8	32	36	32
9	24	38	38
10	18	46	36
11	33	32	35
12	31	40	29
13	19	46	35
14	37	46	17
Average	30.2	41.6	28.2

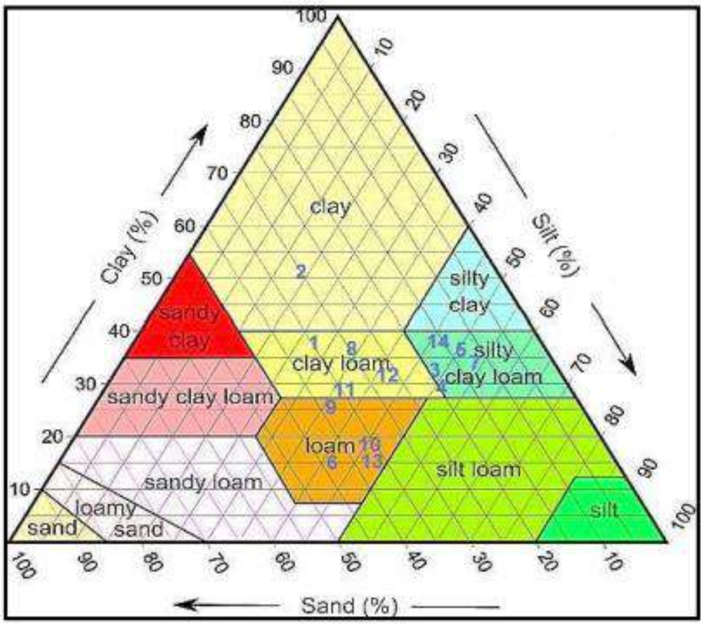

Fig. -6- Soil Texture Triangle for Soil Samples of Studying Region

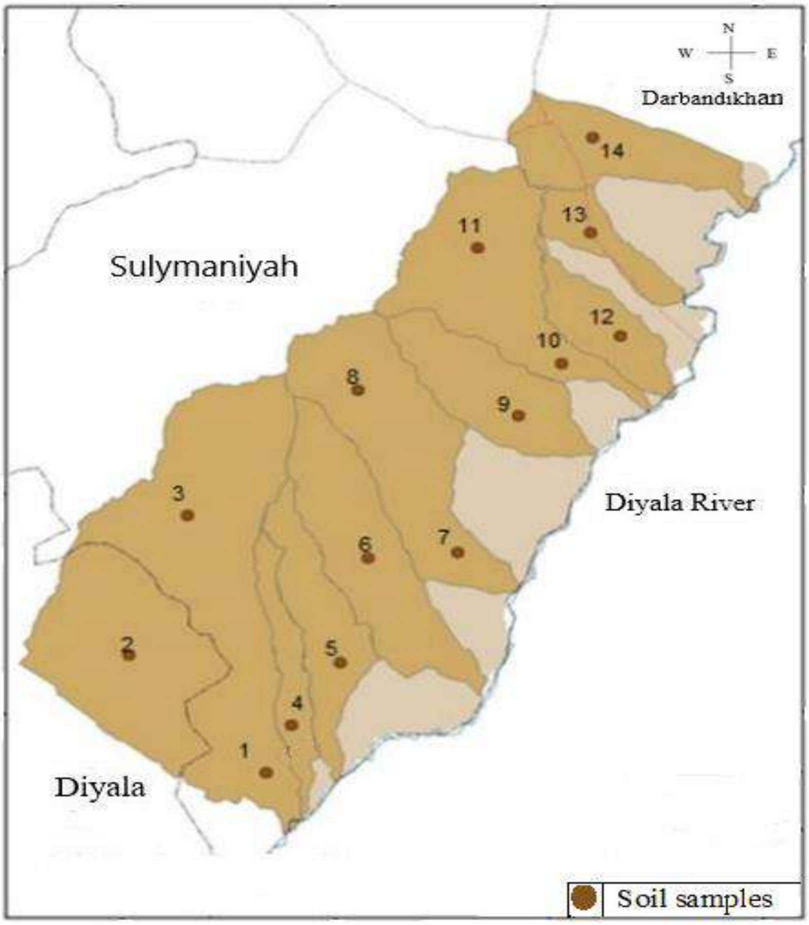

Fig.-7- Soil Samples for Studying Region

The results of the analysis showed the variation in soil texture for the samples taken within the study area, as the average of silt was 41.6, clay 30.2 and 28.2 for sand. The Fig.-8-, Fig.-9- and Fig.-10-.

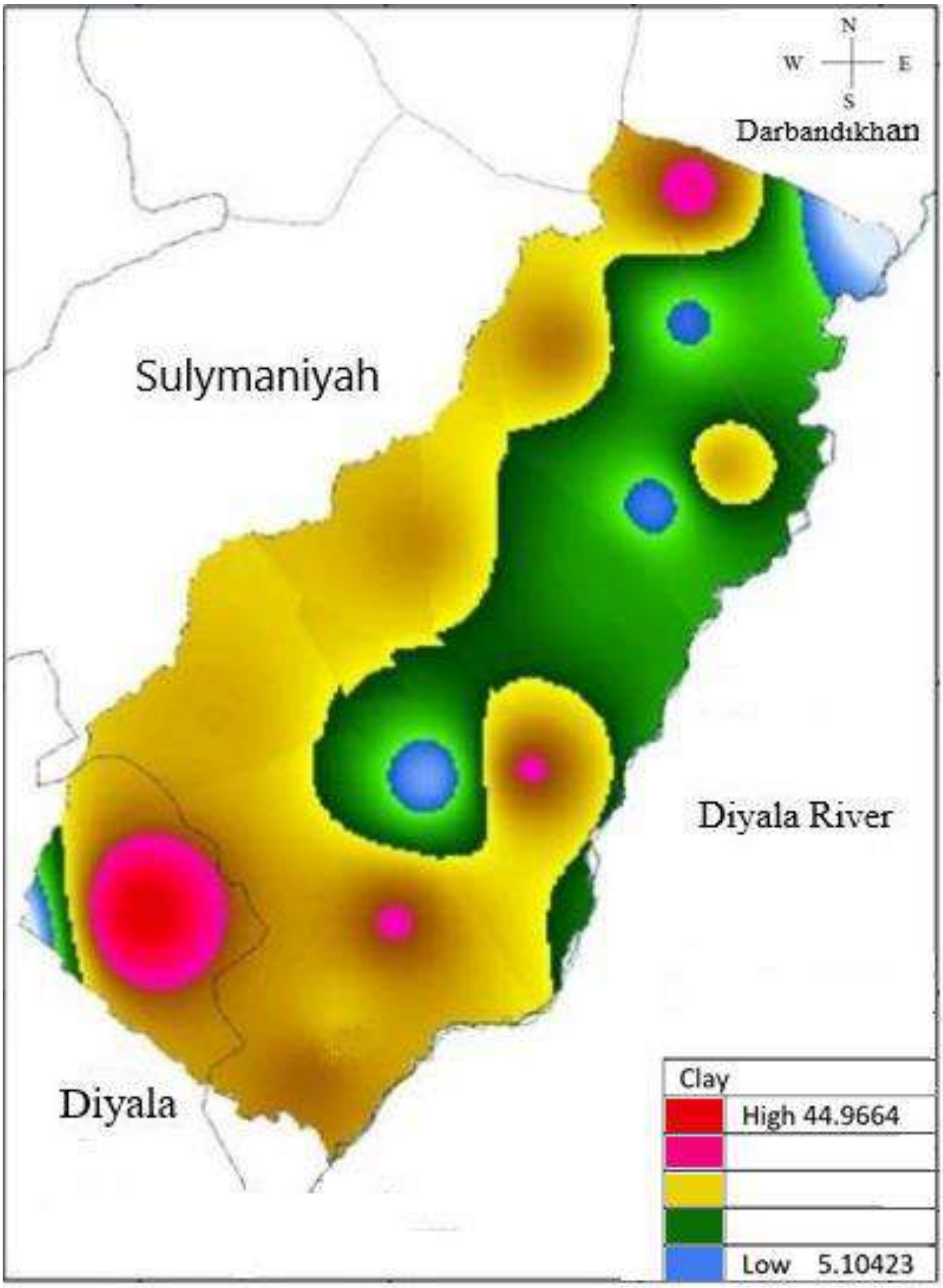

Fig. -8- Clay Proportion within Studying Basins

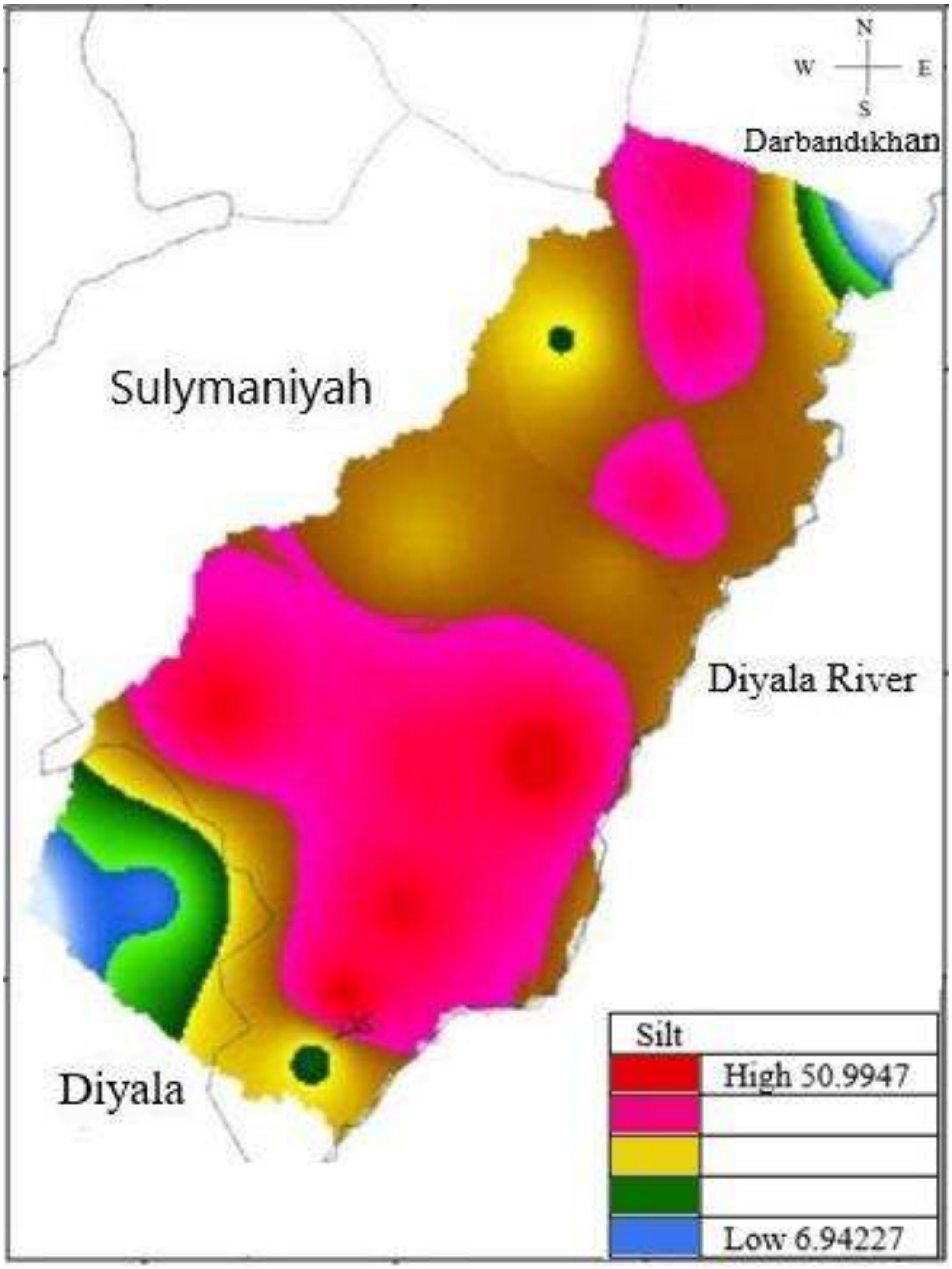

Fig. -9- Silt Proportion within Studying Basins

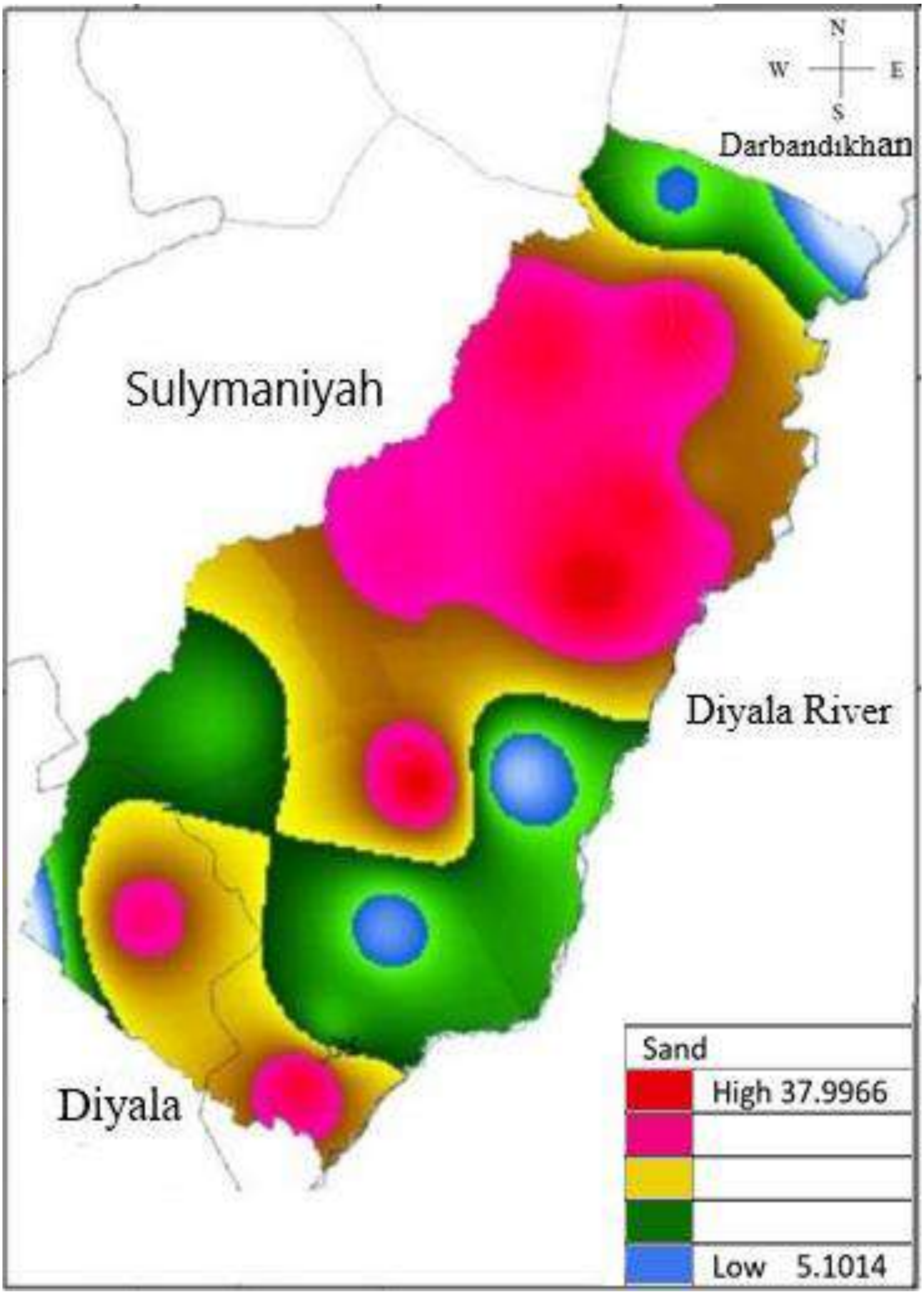

Fig. -10- Sand Proportion within Studying Basins

Based on the data in Table-1- the average water depth is greater than that in Table -5- and according to the data of the studying region as shown in Table-3-, The average water velocity in the valleys within the studying region, including the Dardween Bridge during torrential rains, (see image-6-) is very high. Table-3- shows that the average flow rate velocity is 2.063 m/s, while the corresponding average water velocity of the flow of the Tigris River in Kufa based on table-5- was 0.68 m/s. It noticed that there is a large discrepancy between the velocities of water flow in the rivers in this region with the velocity of the water in the Tigris River in the Kufa region. The nature of the terrain in the Garmian region has a clear effect on increasing the rate of water flow in the rivers.

Table (5) Hydraulic and Positional Information Measured at the Location of the Kufa Bridge Supports

Date	Average Water Depth (m)	Average Water velocity (m/s)	Average Water Drainage (m^3/s)	Average Drift Depth (m)
2/3/2006	1.6	0.71	114.31	1.88
9/3/2006	1.68	0.67	107.20	1.85
16/3/2006	1.58	0.72	116.64	1.92
23/3/2006	1.62	0.70	112.32	1.87
2/4/2006	1.65	0.68	109.21	1.85
10/4/2006	1.6	0.71	115.04	1.94
18/4/2006	1.63	0.70	114.10	1.90
25/4/2006	1.72	0.64	103.68	1.36
5/5/2006	1.7	0.66	106.92	1.89
12/5/2006	1.63	0.67	108.54	1.92
19/5/2006	1.76	0.64	106.24	1.88
27/5/2006	1.72	0.66	109.56	1.90
Average	1.66	0.68	110.31	1.85

The quality of the bottom material plays an important role in the erosion depth. Its quality must be known during estimation of the erosion depth, and this is what was shown by some equations that took into account the bottom material. Through the results of the gradient examination of the size of the particles in the Garmian region and the site view of the north and northeast of the studying region including the Dardween Bridge, shows a high proportion of the coarse aggregate "gravel" in the soil See image-7, which increasing the porosity and the permeability of the soil, thus increasing the possibility of erosion at the bases of the supports for bridges in this area due to high increasing water seepage. Settlement for the foundations of some pillars has been noticed due to erosion at the bases of the supports for some pillars of the Dardween Bridge. (See images-8-,-9-)

Consider three samples from the river bed at the front of the Kufa bridge abutments, conducting a gradient test for the grain size of the river bed. As for the type of bottom material, it was 40% clay, 40% silt, 20% sand for the first model and 42% clay, 32% silt, 26% sand for the second model and 41% for clay, 39% for silt, 20% sand for the third model. Through the soil classification triangle, it appears that the bottom material is a type of clay silt sand. See Table-6-.

Table (6) Physical Properties of the Soil Samples at the Location of the Kufa Bridge Supports

Model No.	Clay%	Silt%	Sand%
1	40	40	20
2	42	32	26
3	41	39	20
Average	41	37	22

A clear various in clay, silt and sand proportions in studying basins with that at Kufa bridge was noticed. Based on Table-6-, the average proportion of clay, silt and sand at the location of Kufa bridge supports are (41, 37, 22) respectively, while the corresponding values within studying basins are (30.2, 41.6, 28.2) as shown in Table-4-. Fig.-11- show the proportion of clay, silt, and sand within the studying area respectively.

Fig-11- (Clay – Silt –Sand) % within the Studying Basins

For the purpose of finding the appropriate formula for the study site to estimate the positional drift around the beams of Dardween Bridge and based on the practically measured results as shown in table 7, the following formula was adopted.

$$ds = \frac{v}{\sqrt{g * b}} * \ y^{a} \ldots \ldots \ldots 12$$

Where:

ds = drift depth.

v: water flow velocity.

y: depth of run-off in the river.

g: gravitational acceleration

b: width of the abutment.

Depending on the data recorded in the field and through statistical analysis to find the appropriate formula for the study site, the following formula was estimated:

$$ds = \frac{v}{\sqrt{g * b}} * \ y^{0.5} \ldots \ldots \ldots 13$$

Table (7) Hydraulic and Average Drift Depth Measured at the Dardween Bridge Supports

Average Drift Depth (m)	Average Water velocity (m/s)	Average Water Depth (m)
0.45	1.82	1.58
0.61	1.87	2.66
0.58	1.86	2.24
0.48	1.83	1.68
0.39	1.81	1.31
0.63	1.89	2.86
0.62	1.85	2.05
0.38	1.76	1.02

Results.

Table (8) shows the drift depth calculated at the Dardween Bridge by the current study.

Drift Depth Measured (m)	Average Water Velocity (m/s)	Average Water Depth (m)	Drift Depth Calculated (m)
0.45	1.82	1.58	0.46
0.61	1.87	2.66	0.62
0.58	1.86	2.24	0.56
0.48	1.83	1.68	0.48

Drift Depth Measured (m)	Average Water Velocity (m/s)	Average Water Depth (m)	Drift Depth Calculated (m)
0.39	1.81	1.31	0.42
0.63	1.89	2.86	0.65
0.62	1.85	2.05	0.54
0.38	1.76	1.02	0.36

Table-8- Drift Depth Calculated at the Dardween Bridge Supports by the Current Study

From the above results, the calculated drift depth not exceeded the total depth of the base of bottom foundation for each pillars (0.7m) for the hydraulic condition above. On the other hand and due to the gradient of the basin where Dardween Bridge located, the Average Water Depth at the two lateral pillars was too height and according the current proposal method me the following results obtained:

Table (9) Drift Depth Calculated at the lateral Dardween Bridge Supports

Drift Depth Measured (m)	Average Water Velocity (m/s)	Average Water Depth (m)	Drift Depth Calculated (m)
0.78	1.89	3.85	0.77
0.72	1.89	3.25	0.70

The results shows that the drift depth exceeded the total depth of the base of foundations for the two lateral pillars (0.7m), especially at the front of these foundations, this was leads to failure of these lateral pillars as shown in the images attached (8 and 9). Fig.-12- shows the accuracy of the current proposal method.

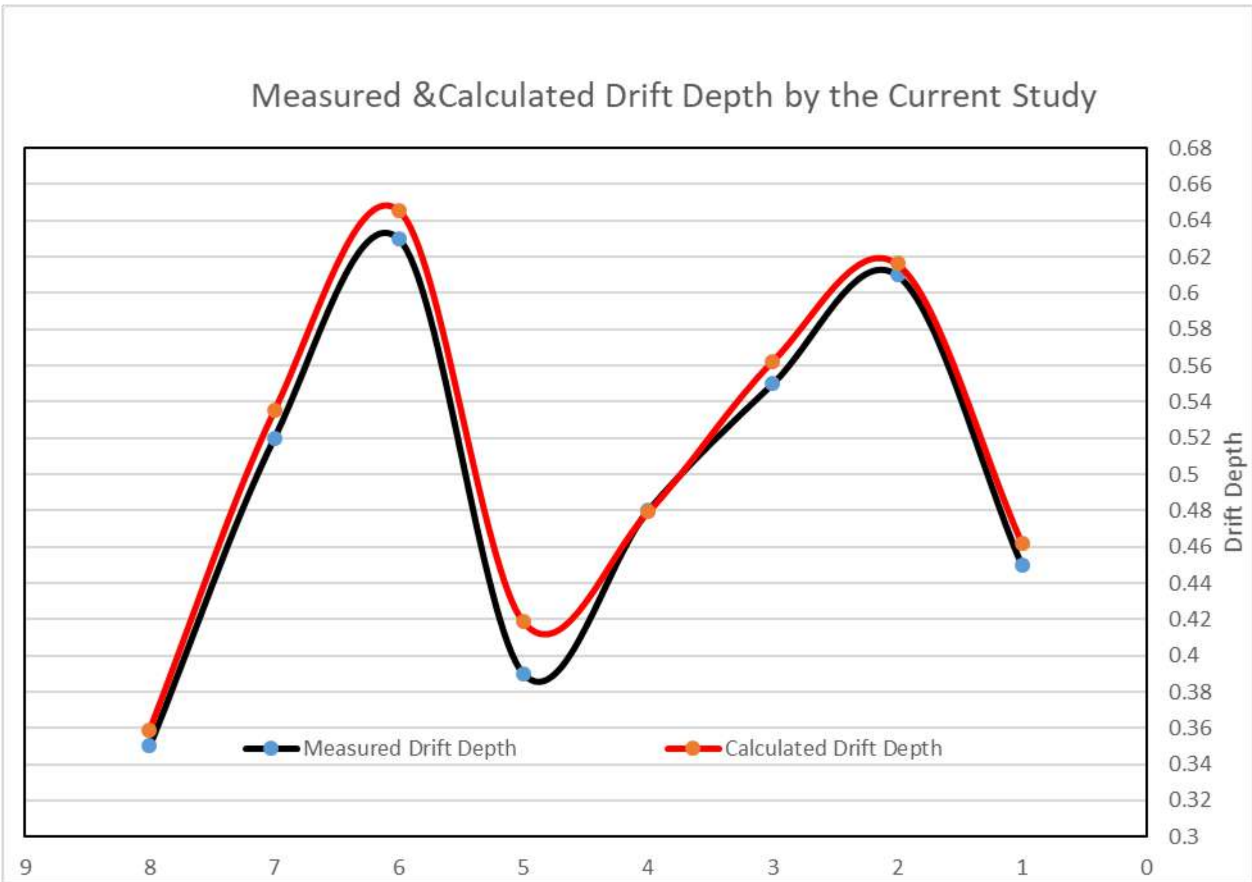

Fig-12- Comparison between the Measured Drift Depth and the Calculated Drift Depth by the Current Study

The drift values calculated around the beams of the Dardween Bridge were compared with the field-measured values; it was found that the error rate was low as compared to the others as shown in the table-8- below.

Error ratio = (Measured drift depth – Calculated drift depth) / Measured drift depth

Table (10) Average Error Drift Depth Calculated at the Dardween Bridge Supports

Method	Drift Depth Measured (m)	Drift Depth Calculated (m)	Average Error %
Ingls-Poona	0.45	3.3	-6
	0.61	3.7	-5
	0.58	3.6	-5
	0.48	3.3	-6
	0.39	3.1	-7
	0.63	3.8	-5
	0.52	3.5	-6
	0.38	2.8	-6
Average			-6
Shen I	0.45	6.2	-13

Method	Drift Depth Measured (m)	Drift Depth Calculated (m)	Average Error %
	0.61	7.4	-11
	0.58	7.0	-11
	0.48	6.3	-12
	0.39	5.8	-14
	0.63	7.6	-11
	0.52	6.8	-12
	0.38	5.3	-13
Average			-12
Shen II	0.45	4.6	-9
	0.61	4.7	-7
	0.58	4.7	-7
	0.48	4.7	-9
	0.39	4.6	-11
	0.63	4.8	-7
	0.52	4.7	-8
	0.38	4.5	-11
Average			-9
Subhash C. Jain	0.45	3.3	-6
	0.61	3.7	-5
	0.58	3.5	-5
	0.48	3.3	-6
	0.39	3.1	-7
	0.63	3.7	-5
	0.52	3.5	-6
	0.38	3.0	-7
Average			-6
Salih	0.45	7.9	-17
	0.61	7.5	-11
	0.58	7.7	-12
	0.48	7.9	-15
	0.39	8.1	-20
	0.63	7.5	-11
	0.52	7.7	-14
	0.38	8.2	-21
Average			-15
The current Study	0.45	0.46	-0.03
	0.61	0.62	-0.01
	0.58	0.56	0.03
	0.48	0.48	0.00

Method	Drift Depth Measured (m)	Drift Depth Calculated (m)	Average Error %
	0.39	0.42	-0.07
	0.63	0.65	-0.02
	0.52	0.54	-0.03
	0.38	0.36	0.05
Average			-0.01

From the previous table, the current proposal method shows an accurate estimated results. Its involved the water depth impact on the drift depth and this is due to the natural gradient of the study region. The rise in the depth of the water with the high speed leads to an increase in the momentum of the water and thus increase its effect.

Based on the previous studies:

- Bridge piers' shape has a main role and effects on local Drift depth of pillars.
- Maximum Drift depth of pillars observed at rectangular shape while minimum depth of drift depth occurred at lenticular shape.
- A rectangular shape with a round head the minimum drift depth occurs.

Conclusions.

Through this study and for avoiding drifts of the pillar of the Dardween Bridge, and the other Bridge within the study region, we can conclude the following:

1. The depth of the site erosion did not exceed the critical limit for some pillars because it did not reach the depth of the foundation, while reach the depth of the foundation of the others pillars. As it was noticed from the site measurement.
2. The flow around the abutments of the Dardween Bridge is of a critical type, so it is high drifts are expected. see image-6-.
3. 3-Flow intensity and depth have a main impact on the drift depth.
4. Through the results of the gradient examination of the size of the particles in the Garmian region and the site view of the north and northeast of the studying region including the Dardween Bridge, shows a high proportion of the gravel in soil which increasing the porosity and the permeability of the soil, thus increasing the possibility of erosion at the bases of the supports for bridges in this area due to high increasing water seepage.
5. The quality of the bottom material plays an important role in the erosion depth. Its quality must be known during estimation of the erosion depth and this is what was shown by some equations that took into account the bottom material.
6. It has been noticed that the depth of the site erosion could be minimized by adopting the lenticular piers.
7. The scour depth increases with increasing flow intensity, flow depth and pier width.

Recommendations:

1. In the event of rising water levels of the Dardween bridge for a long period, a procedure must be taken measurements needed for this and an estimate the erosion depth around the pillars of the Dardween Bridge.
2. Use deep piles foundations for the pillar bases instead.
3. The use of a rock dam in front of the pile foundations to reduce the impact of the flow.
4. Bridge piers' shape has a main role and effects on local scour.
5. The current proposal method can be applied for drift depth calculation of the bridges pillars within the study region, as it showed accurate estimated results.

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Appendix:

Image -1

Image -2-


Image -3-


Image-4


Image -5-


Image -6-


Image -7-


Image -8-

Image -9-