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Validity of the Lower Zab River Sediments for Road and Asphalt Works - Southwest of Kirkuk/Northern Iraq

Ibrahim Mustafa Hassan, Mohammed Rashid Abood, Lafta Salman Kadhim

Applied Geology Department College of Science, Tikrit University, Tikrit , Iraq

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Corresponding Author:

Name: Ibrahim Mustafa Hassan

E-mail: ibraheem.mustafa100@gmail.com

Tel:

ABSTRACT

In this study, a geotechnical assessment of gravel and sand deposits were conducted on both sides of the Lower Zab River in the southwest of Kirkuk Governorate/Northern Iraq. geologically the sediment related to Quaternary age and tectonically located at the unstable zone. 5 samples were collected from the study area for the purpose of conducting various geotechnical tests on them and their validity for road works to the sub-base layer and the base layer for asphalt works.

The results of the physical tests were shown by grain size analysis of thes aggregates for the samples of the study area, and it was found that they are identical to class (A) According to the American Standard [1], and suitable for use in road works for the sub-base layer. The moisture ratio ranging between (1.95 - 4.26) %. The tests of flatness and elongation showed that the highest percentage of flat-shaped particles was (29%) and longitudinal-shaped particles (19%).

The laboratory tests results showed the durability tests such as - Los Angeles test the highest percentage of weight loss was (20.06%), and thus it is valid according to the Iraqi Standard Specification [2] for use in road works. the highest result of test the aggregate impact value of samples is 7.8%, It conforms to the requirements of specifications that must be provided for road works for a sub base layer. Accordingly it is valid for road works. It was found from Proctor test for (5) samples from the study area that the values of the maximum dry density ranged between (2.14-2.28 gm/cm3), and the values of the optimum moisture content ranged between (3.1-2.41%).

An asphalt typical mixture was designed for the base layer from the aggregate of the first station S1 as represent station consisting of coarse crushed aggregate 12%, medium crushed aggregate 22%, fine crushed aggregate 20%, river sand 40% and the proportion of filler 6%. The results of the asphalt tests for the ideal station S1 showed that the ideal percentage of asphalt from the weight of the mixture in the asphalt mixture is 4.1, which is within the limits of the specification Roads and Bridges [3]. The percentage of asphalt to the weight of the aggregate after adding the ideal percentage of asphalt showed that its value was 4.3%, As for the stability test result (Marshall), it reached 11.4 kN, and the result of the creep test (Marshall) reached 2.9 mm, and the density was 2.362

gm/cm3. The percentage of air voids is 4.2, the voids in the mineral aggregate are 14.3%, and the result of checking the remaining strength factor is 86%. The results of asphalt tests are within the limits of American and Iraqi specifications standards Thus, it is suitable for asphalt work for the base layer, depending on the recommended asphalt mixture.

1- Introduction

Engineering geology is concerned with all aspects of the development of facilities and projects, construction, planning, and construction. It is necessary to choose appropriate materials within specifications required for the success of road construction. According to engineering tests, measurements and their results ensures the success or failure of the work before starting thus project, and increase in economic costs of it.

The study area is located southwest of Kirkuk Governorate, includes the Lower Zab River basin from the village of Lazagah to the proposed Makhul Dam location on the Tigris River, which is the boundary between the governorates of Kirkuk and Salah al-Din The study area is about (68) km away from the center of Kirkuk governorate. With coordination (UTM) between the Easting lines (384000), (354000), and between the Northing (3918000), (3892000) lines. figure (1).

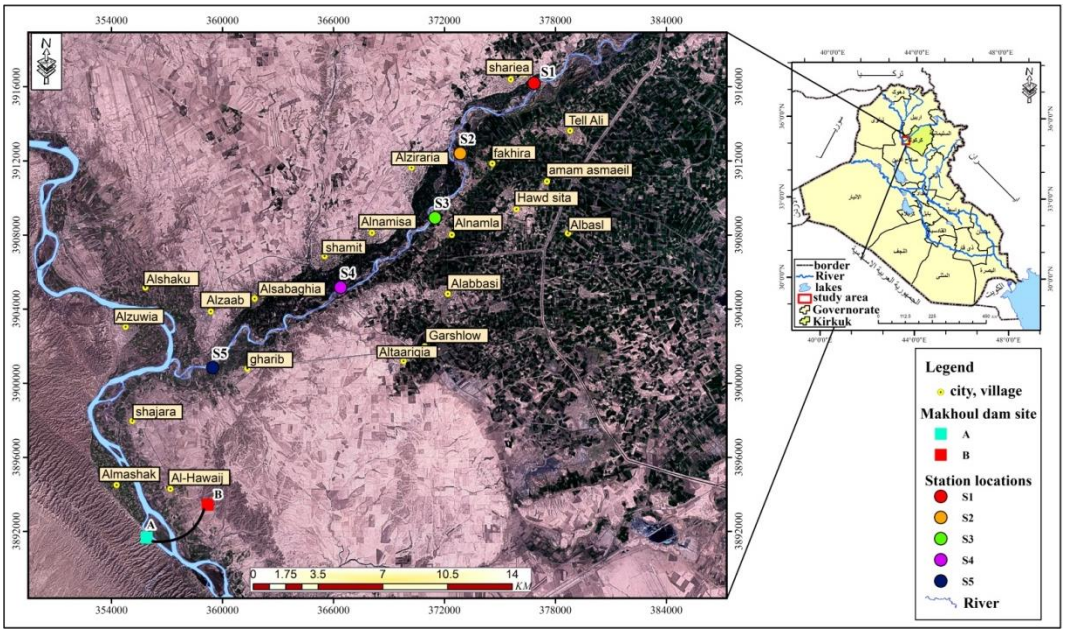

Fig. 1: location map of the study area showing the sample station

There are several previous studies related to the topic of research, including:

[4] studied the geotechnical evaluation and the environmental impacts of the mixed gravel quarries in the Qara Salem / Kirkuk region - Iraq, and it showed that the results of the gradation of fine and coarse aggregates for all samples of the study area matched the requirements of gravel and sand for road works, for the sub-base of the two classes ((A, B, According to the General Specifications for Roads and Bridges and their amendments (SORP/R6), for the year 1999-2003. The inadequacy of coarse aggregates for concrete works and the suitability of fine aggregates according to the specification (IQS. 45/1984).

[5] studied the geotechnical evaluation of the aggregates in the regions of (Chiman) and (Shurau), where the chiman region is represented by (Quaternary-age sediments), and Shurau region by (Bai Hassan), northeast of Kirkuk city for its use in road and concrete works, and showed that the results of the gradation of fine and coarse aggregates for all The samples in the study area conform to the requirements of gravel and sand for road works for the sub-base of the two classes (A, B), according to the general specifications for roads and bridges and their amendments (SORP/R6) for the year 1999-2003, as well as their suitability for concrete works.

[6] studied the qualitative assessment of gravel deposits / Kirkuk governorate from some quarries in the Daquq and Lilan regions. To determine their suitability for road and concrete workS, The evaluation results of the quarrying sediments of the study areas showed their conformity to the class (A) according to (AASHTO, T27-2001), as for the grain size analysis for concrete purposes, the results of the grain size analysis of the coarse aggregate showed their conformity to the class (63 mm) according to the classification (AASHTO, T27-2001). And it was found from the results of the laboratory tests that the samples of the study area are valid for road works for the sub-base layer, and it was found from the tests

required for concrete works that they are valid for concrete works.

[7] studied the geotechnical characteristics of selected areas of Kirkuk Governorate. To show their suitability for road and concrete works, The results of the grain size analysis showed that the sediments conform to class (B) according to the specification for roads and bridges and its amendments for the year 1999-2003, and are valid for road works based on the rest of the tests, or with regard to the gradation of fine and coarse aggregates, it was found that they do not conform to the Iraqi specification (IQS. 45/1989), for concrete works, and the rest of the tests indicated its validity for concrete works

From the geological and Stratifical point: the exposed rock and deposits are;

Fatha Formation (Middle Miocene)

The thickness of Fatha Formation is (268) meters in typical section Fatha area [8]. This formation is revealed on the southwestern side of the proposed Makhul dam reservoir within the Makhul fold flank and on the northeastern side of the Khanukah fold, as shown in the geological map in Figure (2). Fatha Formation consist of cyclic layers of limestone, evaporates and mud rocks and rich sulfur.

Injana Formation (Upper Miocene)

The typical section of the formation is located in the Injana are within south Hamrin fold near the Baghdad-Kirkuk road [9]. The outcrops of this formation expose in the study area on the right bank of the Zab River in the Sabbaghiyah regions and west and southwest of the Zab district. It outcrop on the left bank of the Tigris River, east of the proposed Makhul dam. This formation expose on the northeastern reservoir side of the proposed Makhul dam within the Khanukah fold and the western and southwestern sides of the Makhul dam's reservoir site.

Mukdadiyha Formation (Pliocene)

The Mukdadiyha formation is of great importance in the Middle East due to the large thickness of these sediments, as their late age and wide distribution led to their spread on the surface to a large extent, especially in central and northern Iraq [6]. This formation unfolds in the form of a strip along the right bank of the Lower Zab River, from the villages of Shari'a, Zarariah, and Al-Namisa to the village of Shamit. The distance of this formation from Zab River varies from 1 km to 2.6 km in some areas.

Quaternary Deposits

It consists of eroded sediments from the oldest formations. The age of these sediments dates back to the Pleistocene and Holocene periods. Their layers are flat, have a slight slope, and contain more than 70% of gravel and carbonate sand [9]. These deposits are located in the study area on the Lower Zab River and the Tigris River. These sediments extend over large areas. The Quaternary sediments in the study area are represented by deposits (floodplains, river terraces, slopes sediments, surface runoff, sediments of multiple origins) As in the map Figure (2), these sediments consist of loose or semi-cohesive materials such as gravel, sand, clay and silt in an overlapping or successive manner and varying proportions from one region to another and mostly of river terraces of lesser Zab .

Tectonics - Structure and Geomorphology of the Study Area

The study area is tectonically located within the Hamrin - Makhul Structure belonging to the (Unstable shelf), within the Low Folded Zone, according to the tectonic divisions of Iraq [10]. structurally study area contains Makhul fold parallel to the western bank of the Tigris River, and this fold is located southwest of the study area, The topography of the study area differs from one place to another. The topographical heights in the study area ranges between (115 meters above sea level) in the Lower Zab River and the Tigris River and (482 meters above sea level) on the southwestern side of the Makhul fold.

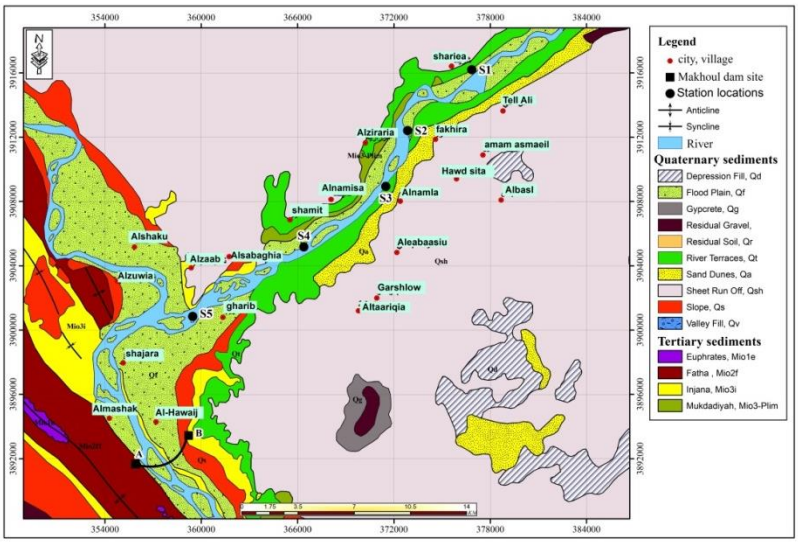

Fig. 2: A geological map of the study area showing the samples sites modified from [11]

2- Aims of study

The most important objectives of this study are to identify the sediments of the area and to know the validity of the sediments for road works to the sub-base layer and the base layer for asphalt works.

3- Methodology

3-1- Field work

Five stations have been selected to collect samples from the area around Lower Zab River. The length of the study area is more than 45 km, and it is mainly homogeneous. All field tools and equipment were prepared from a record of notes, bags for storing samples, a geological hammer, drilling tools for taking samples, a GPS device, a tape measure for calculating thickness, and unique handbags for chemical tests. A mixture of gravel, sand, silt and clay, weight (250 kg) Percentage of each type in Table (1) collected for each station. Plate No. (1) shows a field image while collecting samples from the study area to ensure their sufficiency for all laboratory tests. the samples were transferred to the National Center for Laboratories and Construction Research - Kirkuk and the laboratories of Kirkuk University.

Table 1: Percentage of each soil type for stations

No	Gravel %	Sand %	silt and clay %
S1	73	26.46	**0.54**
S2	75	24.5	**0.5**
S3	75	24.75	**0.25**
S4	74	25.74	**0.26**
S5	69	30.69	**0.31**

Plate 1: collecting samples during field work

3-2 Laboratory works

The laboratory work was started by preparing the samples for various tests and analyses. The sample was taken from the original laboratory sample, using manual division into quarters. The validity of the sediments was evaluated through the physical and engineering properties, In addition to studying these properties to arrive at the best geotechnical evaluation of the soil by selecting modeling sites representing the study area, laboratory tests are considered one of the most important steps necessary to identify the geotechnical properties and to know the suitability of the sedimentation of the study area materials and their suitability for road works.

4- The physical properties of the sediments

The physical properties of the sediments of the study area are identified the following character:

4-1 Moisture Content

This test expresses the amount of water present on the sample. And the moisture content expresses the percentage of water present in the soil sample. In other words, it is the ratio of water mass (Mw) to the mass of grains or solid matter (Md) in the soil mass [12]. Moisture content was measured in the National Center for Research and Construction Laboratories Kirkuk, based on the method of the American Society for test of Materials, according to the American Standard [13]. The moisture content ranged between (1.95 - 4.26)%. And the Moisture Content increase with depth (Table-2).

Table 2: the moisture content for the studied station

Location	Depth (cm)	**Moisture Content (M .C%)**
ST1 No. A	0 – 100	**3.01**
ST1 No. B	100 – 350	**3.47**
ST2 No. A	0 – 100	**2.41**
ST2 No. B	100 – 320	**2.71**
ST3 No. A	0 – 100	**3.84**
ST3 No. B	100 - 350	**4.26**
ST4 No. A	0 – 100	**2.25**
ST4 No. B	100 - 400	**2.53**
ST5 No. A	0 – 100	**1.95**
ST5 No. B	100 – 350	**2.24**

4-2 Grain Size Analysis

The Grain Size analysis was carried out according to the specification [1] using a set of standard sieves at the National Center for Laboratories and Construction Research in Kirkuk Governorate. The results were compared with the limits of the specification [1]. Table (3) to know its category of road works. Through the results of the Grain Size of the samples of the study area, it was found that they are identical to class (A) according to [1], with minor deviations as shown in Figure (3). The results of the grain analysis will be explained as follows:

1- First station (S1) a slight deviation of the fine aggregate at size of (0.075) mm.
2- Second station (S2) a slight deviation in the coarse aggregate and size of (50) mm, and a slight variation at size of (0.3) mm and (0.075) mm.
3- The third station (S3) a slight deviation in the coarse aggregate and size of (50) mm, and a slight variation at size of (0.3) mm and (0.075) mm.
4- Fourth station (S4) a slight deviation at size of (0.3) mm and (0.075) mm.
5- Fifth station S5: A slight deviation in the fine aggregate and the sieve, at size of (0.075) mm

Table 3: The results of the Grain size distribution of the samples of the study area and their classes according to the specification [1].

Sieve size (mm)	Grain size distribution of The first Sample S1	Grain size distribution of the second sample S2	Grain size distribution of the third sample S3	Grain size distribution of the fourth sample S4	Grain size distribution of the fifth sample S5	Specification limits AASHTO for class A
75	**100**	**100**	**100**	**100**	**100**	100
50	**96**	**93**	**93**	**95**	**95**	95-100
25	**78**	**59**	**73**	**72**	**83**	-
19	**68**	**49**	**62**	**61**	**74**	-
9.5	**40**	**33**	**33**	**36**	**46**	30-65
4.75	**27**	**25**	**25**	**26**	**31**	25-55
2.36	**21**	**20.5**	**23.5**	**20.54**	**28.21**	16-42
0.3	**8**	**5.75**	**2**	**4.42**	**7.4**	7-18
0.075	**0.54**	**0.5**	**0.25**	**0.26**	**0.31**	2-8
type	**A**	**A**	**A**	**A**	**A**	

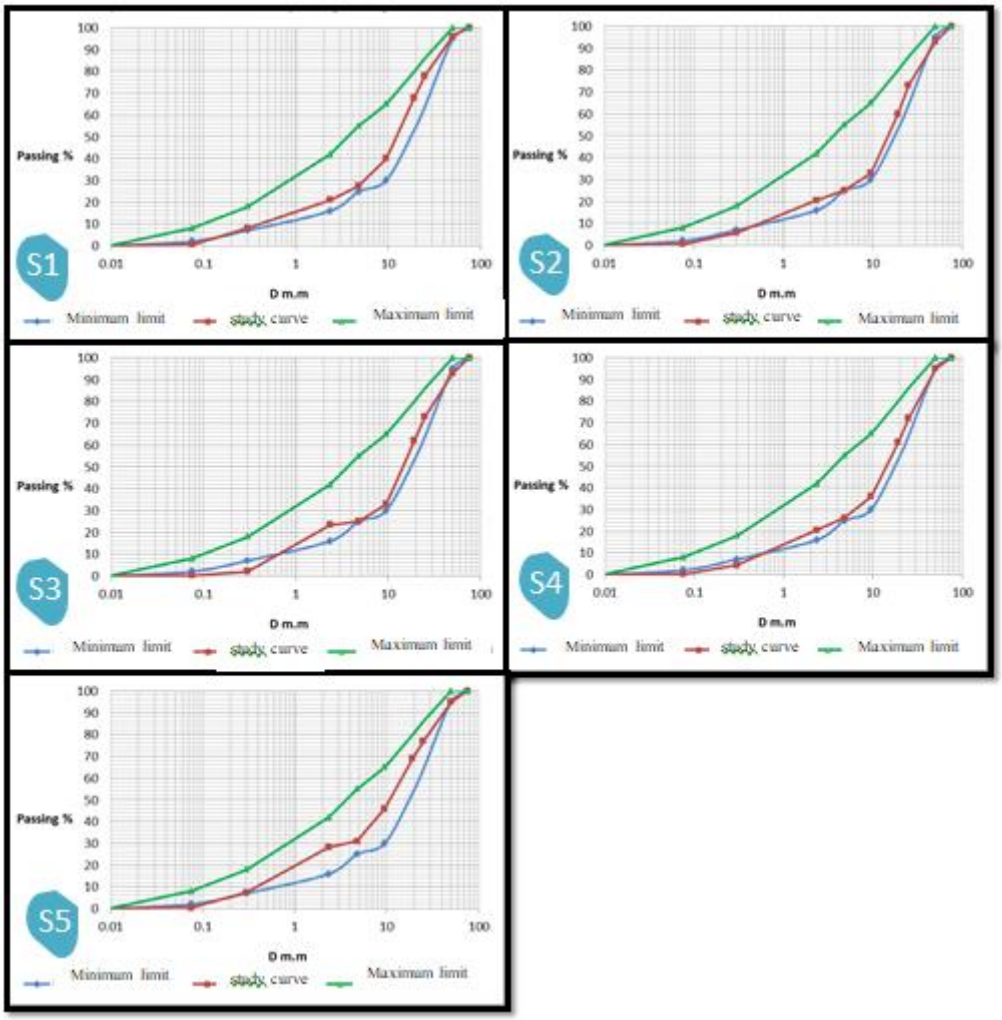

Fig. 3: Grain size analysis for samples (S1, S2, S3, S4, S5) According to [1]

4-3 Atterberg Limits

It was found through the tests for all samples of the station that it is non-plastic soil due to the lack of fine materials, which does not exceed (0.54%) in its highest values for all samples.

4-4 Grain Shape

The test was conducted in the National Center for Laboratories and Construction Research - Kirkuk Governorate laboratory, To get acquainted with the percentage of longitudinal-shaped particles and the percentage of flat-shaped particles, according to the Iraqi specification [14], The results of the flatness and elongation factors of the samples of the study area showed that the highest percentage of flat-shaped particles is (28.78%), The highest percentage of longitudinal shape is (19.18%), and the rest are (round, semi-round, sharp-angled, irregular), This test is important to identify the nature of sediment grains and the proportions of each type, because these sediments are used in road layers and asphalt mixtures.

Table 4: results of the flatness and elongation factor tests for the study area samples.

No	Flattening factor %	Elongation factor %	Rotation (round, semi-round, irregular) %
S1	25.01	17.01	57.98
S2	28	18.24	53.76
S3	24.1	17.32	58.58
S4	28.78	19.18	52.04
S5	15.34	10.17	74.49

4 -5 Durability tests

4-5-1 Los Angeles Abrasion Test

The test was carried out at the National Center for Laboratories and Construction Research - Kirkuk Governorate laboratory, based on the specification [15]. The laboratory test of the samples showed that the highest percentage of weight loss is (20.06%). As shown in Table (5), Thus, it is appropriate to be used in road works for the sub-base and base layers according to the specification [15] and the Iraqi Standard [2].

Table 5: results of the mechanical abrasion of the samples of the study area

No	Abrasion ratio %	Limits of Iraqi Standard
S1	14.02	45% Max for Sub base Course 30% Max for Base Course
S2	16.74	
S3	14.7	
S4	20.06	
S5	16.2	

Plate 3: showing the Los Angeles test process

4-6 Compaction Test

This test is used to determine the relationship between water content and dry density, The maximum density was calculated in the National Center for Laboratories and Construction Research - Kirkuk Governorate, using the modified Proctor method according to the American Standard [16], The Compaction test was conducted on (5) samples from the study area (S1, S2, S3, S4, S5), The values of the maximum dry density ranged between (2.28-2.14 gm/cm^3), while the values of the Optimum water content ranged between (3.1-2.41%), as shown in Table No. (6) and Figure (4).

Table 6: values of the maximum dry density and optimum moisture content for the samples

No	Max Dry Density (gm/cm^3)	% Optimum water content
S1	**2.25**	2.43
S2	**2.14**	2.8
S3	**2.28**	2.8
S4	**2.19**	2.41
S5	**2.17**	3.1

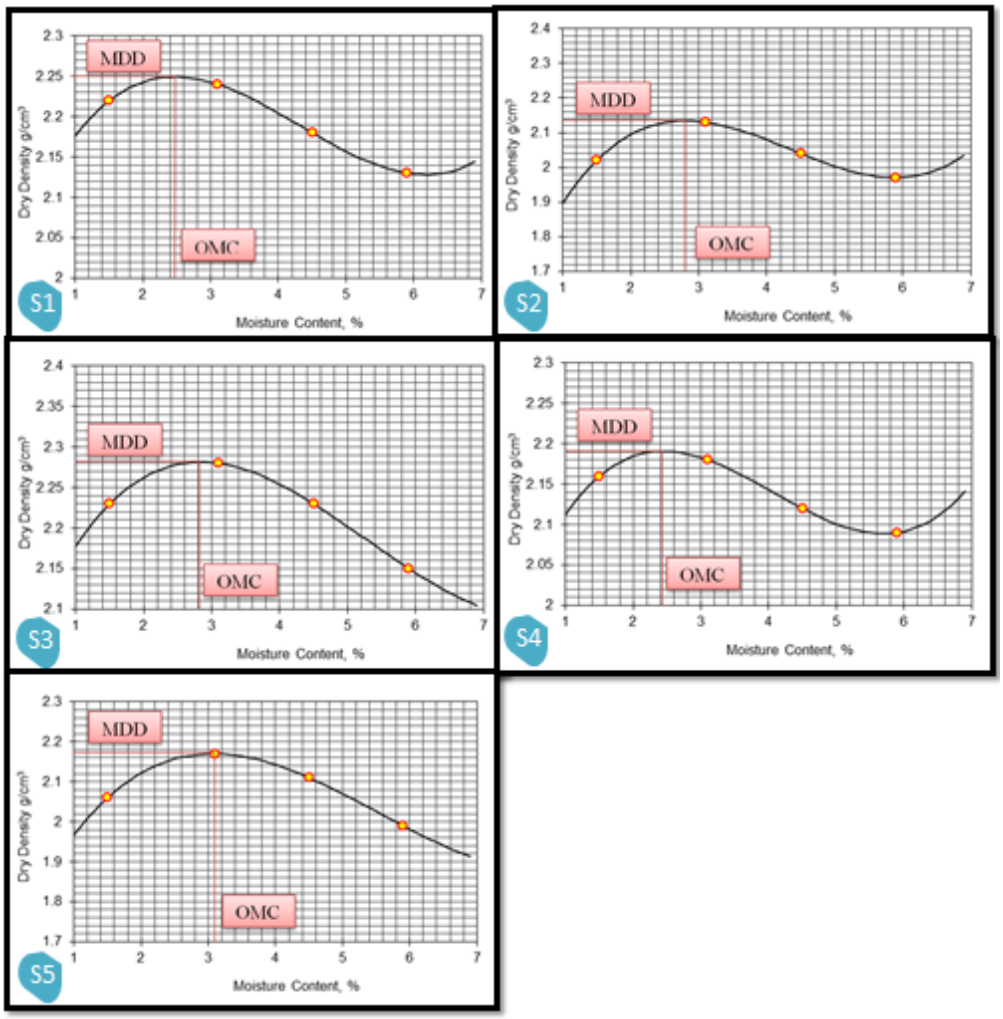

Fig. 4: The relationship between dry density and moisture content for samples of the study area

4-7 Aggregate Impact Value

The test was carried out according to the Iraqi Standard Specifications [17] and the British Standard [18], It was found from the laboratory results that the highest loss in the collision test of the samples of the study area was 7.8%, Accordingly, it conforms to the requirements that must be conform the Iraqi Standard [17]. This stipulates that the impact value does not exceed 45% for the aggregate used in ordinary concrete and 30% for the aggregate used in roads and sidewalks. The following table shows the results of collision resistance.

Table 7: shows the shock values of the station's samples in the study area.

No	Weight passing through the sieve 2.36 (B)	Weight remaining on the sieve	Total weight in grams (A)	B/A	F=B/A*100
S1	30	470	500	0.06	**6**
S2	35	465	500	0.07	**7**
S3	32	468	500	0.064	**6.4**
S4	26	474	500	0.052	**5.2**
S5	39	461	500	0.078	**7.8**

5- The validity of the study area sediments for the base layer - asphalt works in roads

The objective is to determine the suitability of the sediments for asphaltic works.

6- Uses of sediment for asphalt works

The first station (S1) was chosen to carry out the tests, and asphalt works on it to show its suitability for the base layer in the roads, The choice of this station is due to its proximity to the asphalt plants and ease of access to it, It has better grading than the other stations and is free of anomalies within a class (A), A sufficient amount of sediments from the first station was transferred to the asphalt plant. The process of preparing coarse, medium, and fine crushed aggregates and sand from the sediments of the study area was carried out to form aggregates for the asphalt mixture, The materials of the study area, which were prepared in the asphalt plant and shown in Table (8), were sent to the National Center for Laboratories and Construction Research - Kirkuk Governorate - Asphalt Division to prepare suitable

mixing equations with the type of aggregates to conduct tests on the asphalt mixture.

Table 8: the specification of material for asphaltic works

No	Materials	Grainy size in mm
1	coarse crushed aggregate	**12.5 - 37.5 mm**
2	medium crushed aggregate	**9.5 - 25 mm**
3	fine crushed aggregate	**4.75 - 19 mm**
4	Sand	**0.075 - 4.75 mm**

7- Method of mixing materials (mixing equation)
A mixing equation consisted of coarse, medium and fine crushed aggregate and sand from the same station and filler, The materials were mixed in the laboratory according to the ratio of each aggregate, as shown in Table No. (9), to prepare the asphalt mixture.

Table 9: Percentage of materials in the asphaltic mixture

aggregate type	**coarse crushed aggregate**	**medium crushed aggregate**	**fine crushed aggregate**	**sand**	filler
percentage	%12	%22	%20	%40	%6

8 - Test of sediments for Asphaltic works

8-1 aggregate volume gradation for crushed aggregate: The grain size test of the crushed aggregate was conducted in the laboratory of the National Construction Center in Kirkuk - Asphalt Division, According to the American Standard [1], the results shown in the table below were obtained.

Table 10: results of the grain size distribution for samples of the study area and their classes according to the specification [1].

aggregate type	**coarse crushed aggregate**	**medium crushed aggregate**	**fine crushed aggregate**	**filler**
Sieve size in mm	**passing percentage**			
37.5	100	100	100	**100**
25	46	100	100	**100**
19	10	83	100	**100**
12.5		5	99	**100**
9.5		1	75	**100**
4.75			4	**100**
2.36				**100**
0.3				**97**
0.075				**76**

8 - 2 calculation the ratio of asphalt to the weight of the mixture %
This test was carried out at the National Center for Laboratories and Construction Research - Asphalt Division in Kirkuk Governorate, The results of the test revealed that the value of the ideal percentage of asphalt to be added to the asphalt mixture is 4.1% of the weight of the mixture, Which achieve the required specifications, as the limits of the Iraqi specification are 3 - 5.5% , Thus, it complies with the requirements of the specification for the proportion to be provided in the asphalt mixture, Based on the specifications of the General specification for Roads and Bridges [3].

8-3 calculation the ratio of asphalt to aggregate weight %: This test was carried out at the National Center for Laboratories and Construction Research - Asphalt Division in Kirkuk Governorate, The ratio of asphalt to aggregate weight was checked after adding the ideal percentage of asphalt It turns out that its value is 4.3%.

8-4 asphalt mixtures
Asphalt concrete mixtures consist of the base layer, the bonding layer, the surface layer and the requirements for concrete asphalt mixtures, It must have the properties specified in Table R9/5, When hammering 75 hits each face with a standard Marshall hammer, Based on the specifications of the General specification for Roads and Bridges [3].

Table 11: Characteristics of concrete asphalt mixtures R9/5

Characteristics	Base layer	Bonding layer	Surface layer
stability (Marshall kN) minimum	5	7	**8**
creep (Marshall) mm	4 -2	4 - 2	**4 - 2**
Air voids in the Marshall sample %	6 – 3	5 - 3	**5 - 3**
Voids in mineral aggregate%, minimum	12	13	**14**
Residual power factor, minimum	70	70	**70**

8-5 prepare the moulds and hammer and stack the samples
The sample mould and the face of the compacting hammer were cleaned and heated in an oven at a temperature of (93-150°C), A filter paper cut to the size of the mould was placed at the bottom of the mould before placing the mixture, and the materials and bitumen were weighed, Then the aggregate and the bitumen are mixed using a mechanical mixer or a hand mixer to obtain a mixture in which the asphalt is

evenly distributed, Then we put the asphalt mixture into the mould using Spatula, and the sample is stacked 15 times around the circumference and 10 times at the centre of the mix and the collar is removed, It is placed under the testing sample hammer and is beat 75 times on each side, the sample is cooled in the air, and then the sample is extracted from the mould by the mould extraction device, The samples stacked by the Marshall method are subjected to tests for density, stability, creep, air voids, voids in the mineral aggregate and residual strength factor.

8-6 Stability test (Marshall kN) and creep (Marshall mm)

The test was carried out at the National Center for Structural Laboratories and Research - Kirkuk, based on the specification [19], Where the sample was examined up to failure, the point of failure or breakdown in the sample is known as the maximum load that can be achieved, and the value of Marshall's stability is recorded in KN, creep is also recorded from the device screen at the maximum load, and its value is recorded in mm, Table (12) shows the values of creep and stability and their comparison with the limits of the Iraqi specification, which showed their conformity with the specifications of the General Authority for Roads and Bridges [3]. The standard [19], was used in conducting the test only, and the results were compared with the Iraqi standard due to the requirements of the Iraqi environment.

Table 12: shows the test sample's stability and creep (Marshall) check values.

test type	The test result	Specification limits	The final result
stability check (Marshall kN)	11.4 kN	5 kN Minimum for model success	conforming to the specification
Creep check (Marshall mm)	2.9 mm	2 – 4 mm	conforming to the specification

8-7 Density test g/cm^3

The density of the compacted samples was determined according to [20] using saturated samples with a dry surface, Where the air-stacked samples are weighed and denoted by the symbol A, The samples are placed in the water for one minute, and the weight is calculated after the weight is fixed and symbolized by the symbol C, Samples are extracted from water and weighed in air and denoted by the symbol B, Then the density is measured by the equation below (1), And the density value of the test sample is 2.362 gm/cm^3.

$$Density\ gm/cm3 = \frac{A}{B-C} \text{.....(1)}$$

8-8 Ratio of air voids

The air spaces in the asphalt mixture are the volumes of tiny air spaces between the asphalt-coated particles [21], The test samples were prepared in the same way as those prepared for the Marshall test. However, the weight of the sample should be taken into account. It must match the weights mentioned in the American Standard [22] Table (13).

Table 13: Required weights for test

Normal maximum aggregate size. (mm)	**Minimum sample weight** (gm)
or greater37.5	**5000**
19 - 25	**2500**
12.5 or Smaller	**1500**

The test was carried out at the National Center for Laboratories and Construction Research, Asphalt Division - Kirkuk, based on the American Standard [22]. The result of the test revealed that the percentage of air spaces conformed to the limits of the Iraqi specification - the specifications of the General Authority for Roads and Bridges [22], as shown in the following table No. (14).

Table 14: Percentage of air spaces in the test sample

Test type	The test result	Specification limits	The final result
percentage of air spaces	4.2 %	6% - 3%	**Conforming to Iraqi specifications**

8-9 Voids in mineral aggregate (VMA) %

The ratio of voids in the mineral aggregate is defined as the space between the grains of the gravel materials in the asphalt mixed mixture, and it includes the air spaces and the amount of effective asphalt, and it is expressed as a percentage of the total volume [21], The test was conducted at the National Center for Laboratories and Construction Research, Asphalt Division in Kirkuk Governorate. The results showed that the value of the voids in the mineral aggregate amounted to 14.5%, And the minimum that must be provided to ensure compliance with the requirements of road works, which amounts to 12%, so the value of the voids in the mineral aggregate corresponds to the requirements that must be provided in the form, according to Table R9/5 of the specifications of the General Authority for Roads and Bridges [3].

8-10 Residual strength factor %

This test was conducted at the National Center for Construction Laboratories and Research - Asphalt Division in Kirkuk Governorate. It was found that the value of the remaining strength factor is 86%, Thus, it conforms to the requirements of the General Authority for Roads and Bridges specification [3], which stipulate that the value of the remaining force factor shall not be less than 70%.

9. The validity of materials for asphalt works

It turns out from all laboratory tests conducted on the asphalt mix that it is suitable for aspiration of the basis layer for approval of the requirements of the

General Authority for Roads, Bridges and Bids in the following table.

Methods of asphalt mixtures R9 / 5 of the General Authority for Roads and Bridges [3] when be discussed 75 blows to each face using a standard Marshall hammer

Characteristics	Base layer	Bonding layer	Surface layer	The result of laboratory test
stability (Marshall kN) minimum	5	7	8	11.4
creep (Marshall) mm	4 -2	4 - 2	4 - 2	2.9
Air voids in the Marshall sample %	6 - 3	5 - 3	5 - 3	4.2
Voids in mineral aggregate%, minimum	12	13	14	14.5
Residual power factor, minimum	70	70	70	86
The result	Specification limits	Specification limits	Specification limits	Match for standard Suitable for asphalt works

10. Interpretation and conclusions

1. The moisture content values for the study area ranged between (1.95 - 4.26)% and by measuring the moisture content of the representative samples of the study area that moisture content is increasing with depth due to the presence of groundwater which contribute to increasing moisture in the sediment and contributing to the highest, If you decide to invest in one sites, a hydrological sports model simulates the establishment of groundwater level and working to reduce the propulsions to further invest in depths
2. . Through an inspection of the grain size distribution for the study area samples and show it matching a class (A), According to Specification [1] and therefore it is valid for use in roads for the sub-base.
3. The soil of the study area is non-plastic because of the lack of fine materials, which do not exceed (0.54%) at the highest values for all samples of the study areas.
4. The highest percentage of flat-shaped granules is (29%), The highest percentage of longitudinally shaped granules is (19%). This test is important to identify the nature of sediment grains and the proportions of each type because these sediments are used in road layers and asphalt mixtures.
5. The Los Angeles test found that the highest percentage of weight loss is (20.06%), which is considered appropriate to be used in road works for the sub-base layer and the base layer according to the American and Iraqi specifications.
6. The results of Proctor's test on the samples of the study area showed that the values of the maximum dry density between 2.14-2.28 gm/cm3, while the values of the Optimum water content ranged between 3.1-2.41%, These values must be provided when the study area sediments are used in road works.
7. It was found from the laboratory results the Aggregate Impact Value of the samples of the study area that the highest value of the loss ratio is 7.8%. Therefore it meets the requirements of the specifications that must be provided for road works for the sub-base layer.
8. An asphalt mixture was designed for the base layer of the ideal station S1. This mixture consists of coarse crushed aggregate 12%, medium crushed aggregate 22%, fine crushed aggregate 20%, river sand for the same station 40% and filler 6%.
9. Through the test, it was found that the value of the ideal percentage of asphalt is 4.1% of the weight of the mixture, and therefore it meets the requirements of the specification for the percentage that must be available in the asphalt mixture for road works for the base layer.
10. The percentage of asphalt to the weight of the aggregate, after adding the ideal percentage of asphalt, showed that its value is 4.3%.
11. The test found that the value of the stability test (Marshal) is 11.4 kN. The creep test (Marshall) is 2.9 mm. It meets the requirements of the specifications which showed their conformity with the specifications of the General Authority for Roads and Bridges [3]. Therefore, it is suitable for road works for the base layer.
12. The density value of the asphalt mixture for the base layer is 2.362 gm/cm3.This density must be provided during the production of asphalt mixtures and their use in engineering projects.
13. The percentage of air voids in the asphalt mixture sample showed that the percentage of air voids is 4.2%. Therefore it meets the specification requirements that must be provided for the base layer and is valid for work in the base layer.
14. The voids in the mineral aggregate show that their value reaches 14.5% and the minimum that must be provided is 12%. Therefore, the value of the voids in the mineral aggregate corresponds to the requirements that must be provided in the sample and is considered valid for road works for the base layer.
15. The remaining strength factor is 86%. Thus, it complies with the General Authority for Roads and Bridges specification requirements, which states that the value of the remaining strength factor should not be less than 70%. Therefore it is valid for road works for the base layer.
16. All the sediments of the study area are suitable for use in a sub-layer, and the sediments of the ideal first station (S1) are suitable for asphalt works for the base layer.

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صلاحية ترسبات نهر الزاب الاسفل لأعمال الطرق والاسفلت– جنوب غرب كركوك/ شمال العراق

ابراهيم مصطفى حسن ، محمد راشد عبود ، لفتة سلمان كاظم

قسم علوم الأرض التطبيقية ، كلية العلوم ، جامعة تكريت ، العراق

الملخص

تهدف هذه الدراسة الى اجراء تقييم جيوتكنيكي لترسبات الحصى والرمال على جانبي نهر الزاب الاسفل في جنوب غرب محافظة كركوك/ شمال العراق والعائدة جيولوجياً لترسبات العصر الرباعي، وتكتونياً تعود الى الرصيف غير المستقر، حيث تم جمع نماذج من منطقة الدراسة بواقع 5 نماذج لغرض اجراء الفحوصات وبيان صلاحيتها لأعمال الطرق والاسفلت.

بينت نتائج التقييم الجيوتكنيكي للفحوصات الفيزيائية من خلال فحص للتدرج الحجمي للركام لنماذج منطقة الدراسة انها مطابقة للصنف (A) بحسب المواصفة [1]، وهي صالحة للاستخدام في اعمال الطرق لطبقة ما تحت الاساس، وتراوحت نسب محتوى الرطوبة للنماذج بين (1.95 - 4.26)%، وتبين من نتائج فحصي عاملي التسطح والاستطالة ان اعلى نسبة للحبيبات ذات الشكل المسطح هي (29%) والحبيبات ذات الشكل الطولاني هي (19%) وهذا الاختبار مهم للتعرف على طبيعة حبيبات الرواسب ونسب كل نوع منها وذلك لأن هذه الرواسب تستخدم في طبقات الطرق وخلطات الأسفلت.

أظهرت نتائج الفحص المختبري لفحوصات الديمومة – فحص لوس انجلوس لنماذج منطقة الدراسة ان اعلى نسبة فقدان في الوزن بلغت (20.06%) وبذلك فهي صالحة للاستخدام في اعمال الطرق حسب المواصفة القياسية العراقية [2]، واعلى نتيجة لفحص قيمة التصادم لنماذج منطقة الدراسة هي 7.8% وهي توافق متطلبات المواصفات الواجب توفرها لأعمال الطرق لطبقة ما تحت الاساس وبالتالي فأنها صالحة لأعمال الطرق، وتبين من فحص الحدل على (5) نماذج من منطقة الدراسة فقد تراوحت قيم الكثافة الجافة العظمى بين ($2.14-2.28 gm/cm^3$) اما قيم المحتوى الرطوبة المثالي تراوحت بين (3.1-2.41 %).

تم تصميم خلطة اسفلتية لطبقة الاساس من ركام المحطة الاولى S1 كمحطة مثالية، تتكون الخلطة من الركام الخشن المكسر بنسبة 12% والركام المكسر المتوسط 22% والركام المكسر الناعم 20% والرمل النهري 40% ونسبة النواعم 6%، وتبين من نتائج الفحوصات الاسفلتية للمحطة المثالية S1 ان نسبة الاسفلت المثالية من وزن المزيج في الخلطة الاسفلتية هي 4.1 وهي ضمن حدود مواصفة الهيئة العامة للطرق والجسور [3]، وتبين من فحص نسبة الاسفلت الى وزن الركام بعد اضافة نسبة الاسفلت المثالية ان قيمتها 4.3%، اما نتيجة فحص الثبات (مارشال) وصلت الى 11.4 kN ، وبلغت نتيجة فحص الزحف (مارشال) 2.9 ملم، والكثافة $2.362 gm/cm^3$، ونسبة الفراغات الهوائية 4.2، والفراغات في الركام المعدني 14.3%، ونتيجة فحص معامل القوة المتبقية 86%، وان جميع نتائج الفحوصات الاسفلتية هي ضمن حدود المواصفات الامريكية والعراقية وبذلك فهي صالحة للأعمال الاسفلتية لطبقة الاساس حسب مواصفات الهيئة العامة للطرق والجسور [3] وبالاعتماد على الخلطة الاسفلتية الموصي بها.