Geotechnical properties for sediment of Tigris River reach banks within Tikrit town/ Iraq

Maha Shaher Badowi, Mohammad Rashid Abood, Sabbar Abdullah Saleh
Department of Applied Geology, College of Science, University of Tikrit, Tikrit, Iraq
DOI: http://dx.doi.org/10.25130/tjps.24.2019.110

ABSTRACT

The geotechnical, engineering and chemical properties of the sediments of river terraces on the right bank and flood plain on the left bank of Tigris river. The physical tests include (specific gravity, absorption%, moisture content %, atterberge limits, grain size analysis) showed that the dominant component of soil is (gravel) with varied amount of fine components, the engineering tests include direct shear test, CBR, and point load test, while the chemical analyses include gypsum%, T.D.S% and O.M% showed increase in gypsum% and T.S.S% in right bank and increase of O.M%, and decrease of the three ratios in the left bank because the leaching of the sediments. The geotechnical study showed many engineering problems occurs in engineering establishments specially in the river terraces because the high ratios of gypsum and T.S.S.

Introduction

The nature and composition of the land in general and the soil in particular influenced such as porosity of soil, soil texture and soil consistency and soil type such as gravel, sand, silt or clay [1]. The river banks is an important location for the Construction of facilities after the geotechnical assessment of the soil and the river banks geotechnical assessment is a very important factor in determining the validity of the banks to set up facilities on them as the study of these characteristics is very important in determining the validity of banks to set up facilities on them as the study of this is important In the rehabilitation of tourism and river transport. The study area is located in the city of Tikrit within the coordinates (375130-385092) to the east and (3826080-3839806) to the north in fig.(1), as the right bank of the study area includes the city of Tikrit and the left bank includes the Al-Alam area. The important previous studies of the area included the study by [2] studied the sedimentary and mineral properties of the Quaternary sediments on the right side. [3] Studied the geographical assessment of tourism potential in the Salah al-Din Governorate. The sedimentation of the area covered by the Quaternary sediment, which is the flood plain on the left side of the Holocene sediments and the sediments of the River Terraces on the right bank of the Pleistocene period [4]. The study aims to study the physical and mechanical properties for the deposits of the banks of the Tigris River for the purpose of tourism rehabilitation and river transport.
Methodology

Primary stage includes collecting information about the study area by the image data and the maps of the area. Fieldwork included collection of the samples from right side of the river (right bank: ST1R, ST2R, ST3R, ST4R, ST5R) represent Tigris river terraces from five stations represented by eight sample distributed along Tigris river terraces, where one sample was taken for each lithological change and three stations representable by five sample from the left side of the river (the left bank: ST6L, ST7L, ST8L) along the rivers flood plain, which are sandy gravel deposits. The laboratory work stage included physical, mechanical and chemical tests on the samples selected from the study area and the most important of these tests:

**Physical tests included:**
- Moisture Content [5].
- Specific Gravity Test [6].
- Grain size analysis [7][8].
- Consistency Limits or Atterburg Limits [9].

**Mechanical tests**
- Compaction Test [10].
- California Bearing Ratio (CBR) [11].
- Point Load Test [12].
- Direct Shear Test for soil [13].

**Chemical tests:** [14]

**Office stage:**
The work stage of the office include that the calculations and analysis of properties and using the program Excel 2010 for calculation.

**Results and Discussion**

**Moisture content**
The moisture content values of the samples ranged between (0.3451-3.4635) the minimum moisture content in ST4R No.1 sample because was far the banks. The highest value of moisture content in ST5R No.1 sample that was channel sample in table (1).

**Specific Gravity**
As in the table (1) the results of the specific gravity for the fine soil and the table (2) the results of Relative density (specific gravity) (OD), Relative density (specific gravity)(SSD), Apparent Relative density (specific gravity) and Absorption (Ab) is depended on mineralogy of the soil and absorption ratio The origin from which the gravel is formed in whether it is sedimentary, Igneous, Metamorphic rocks and the void ratio in the gravel.

**Table 1: The moisture content and the Specific Gravity.**

| Location | Depth (m) | Moisture content% | Specific Gravity |
|----------|-----------|-------------------|------------------|
| ST1R No.1 | 2.5       | 1.6559            | 2.726            |
| ST1R No.2 | 1.75      | 0.5353            | 2.722            |
| ST2R No.1 | 1.20      | 0.5723            | 2.697            |
| ST2R No.2 | 2.20      | 0.7619            | 2.697            |
| ST2R No.3 | 5         | 0.7685            | 2.705            |
| ST3R No.1 | 10        | 0.4391            | 2.691            |
| ST4R No.1 | 6         | 0.3451            | 2.687            |
| ST5R No.1 | Channel   | 3.4635            | 2.701            |
| ST6L No.1 | 0.75      | 3.3639            | 2.733            |
| ST7L No.1 | 0.75      | 1.3329            | 2.671            |
| ST8L No.1 | 1         | 1.6241            | 2.761            |
| ST8L No.2 | 3         | 2.0357            | 2.687            |
| ST8L No.3 | 2.70      | 2.1746            | 2.697            |

ST=station   L=Left    R= Right
Table (2) shows the results of the Specific Gravity of soil and the rate of absorption of coarse soil in the study area.

| Location | Depth (m) | OD   | SSD  | Sa   | Ah % |
|----------|-----------|------|------|------|------|
| ST1R No.2 | 1.75      | 2.383| 2.438| 2.517| 2.196|
| ST2R No.1 | 1.20      | 2.471| 2.519| 2.593| 1.891|
| ST2R No.3 | 5         | 2.511| 2.542| 2.591| 1.228|
| ST3R No.1 | 10        | 2.419| 2.486| 2.590| 2.726|
| ST4R No.1 | 6         | 2.564| 2.451| 2.588| 3.656|
| ST5R No.1 | Channel   | 2.447| 2.463| 2.488| 0.671|
| ST6L No.1 | 0.75      | 2.383| 2.414| 2.450| 1.034|
| ST7L No.1 | 0.75      | 2.469| 2.493| 2.528| 0.929|
| ST8L No.2 | 3         | 2.475| 2.498| 2.532| 0.905|
| ST8L No.3 | 2.70      | 2.424| 2.439| 2.460| 0.616|

Sieving Analysis
The result of sieving analysis illustrated in fig.(2), (3),(4),(5),(6),(7),(8),(9),(10),(11),(12),(13) and (14) while the component of each station and type soil illustrated in table (3).
Atterberg Limits

Both the liquid limit (L.L) and the plastic limit (P.L) were measured for fine sediment. The tests were measured for samples (ST1R No.1, ST1R No.2, ST2R No.3, ST7L No.1) fig.(15),(16),(17) and (18). The highest plasticity index was obtained in ST1R No.1) with a value of (10.5889) and the lowest plasticity index in the sample (ST1R No.2) and value (1.4867) as table (3) and by comparing the values of the plasticity index of the samples with the table (4), it was shown that the sample are all within the silty plasticity type low plasticity (ML) of the fig. (19) for fine sediment. From the test the samples are gravel within silty fine grains.

Fig. 10: Grain size analysis for soil in ST6L No.1

Fig. 11: Grain size analysis for soil in ST7L No.1

Fig. 12: Grain size analysis for soil in ST8L No.1

Fig. 13: Grain size analysis for soil in ST8L No.2

Fig. 14: Grain size analysis for soil in ST8L No.3

Fig. 15: liquid limit for fine soil in ST1R No.1

Fig. 16: liquid limit for fine soil in ST1R No.2

Fig. 17: liquid limit for fine soil ST2R No.3

Fig. 18: liquid limit for fine soil ST7R No.1

Fig. 19: classification of fine soil according Atterberg limits
Table 3: classification of soil according to USCS

| Station     | Depth (m) | gravel (%) | sand (%) | salt (%) | clay (%) | L.L  | P.L  | P.I  | Unified classification |
|-------------|-----------|------------|----------|----------|----------|------|------|------|------------------------|
| ST1R No.1   | 2.5       | 3.86       | 37.39    | 48.75    | 10       | 35.8 | 25.21| 10.59| ML                     |
| ST1R No.2   | 1.75      | 74.52      | 18.50    | 6.98     | -        | 24.44| 22.95| 1.49 | GP-GM                  |
| ST2R No.1   | 1.20      | 67.27      | 28.65    | 4.08     | -        | -    | -    | -    | GP                     |
| ST2R No.2   | 2.20      | 0          | 89.28    | 4.72     | 6        | -    | -    | -    | SP-SC                  |
| ST2R No.3   | 5         | 57.14      | 27.41    | 9.45     | 6        | 18.44| 15.47| 2.97 | GM                     |
| ST3R No.1   | 10        | 64.90      | 29.69    | 5.40     | -        | -    | -    | -    | GP                     |
| ST4R No.1   | 6         | 70.05      | 25.19    | 4.77     | -        | -    | -    | -    | GP                     |
| ST5R No.1   | Channel   | 79.54      | 14.46    | 5.99     | -        | -    | -    | -    | GP                     |
| ST6L No.1   | 0.75      | 41.83      | 46.89    | 7.28     | 4        | -    | -    | -    | SM                     |
| ST7L No.1   | 0.75      | 65.44      | 24.55    | 6.01     | 4        | 16.3 | 14.00| 2.29 | GP-GM                  |
| ST8L No.1   | 1.0       | 0          | 88.55    | 9.45     | 2        | -    | -    | -    | SP-SM                  |
| ST8L No.2   | 3         | 74.77      | 22.38    | 2.84     | -        | -    | -    | -    | GP                     |
| ST8L No.3   | 2.70      | 72.04      | 26.59    | 1.37     | 0        | -    | -    | -    | GP                     |

Table 4: classification of soil according to plasticity index [15]

| Description          | PI |
|----------------------|----|
| Non plastic          | 0  |
| Slightly plastic     | 1-5|
| Low plasticity       | 5-10|
| Medium plasticity    | 10-20|
| High plasticity      | 20-40|
| Very High plasticity | >40|

Engineering testing of soil

Compaction Test

The Compaction Test is considered to be an important Test to finding Compaction rate in soil. Depending on maximum dry density and optimum water content to access the highest density of the soil, as the Compaction rate increases with the increase of fine deposits which have a compressibility when compared to coarse deposits and the results in table (5).

Table 5: shows Compaction Test

| Location     | Depth (m) | maximum dry density (gm/cm³) | optimum water content % |
|--------------|-----------|------------------------------|-------------------------|
| ST1R No.2    | 1.75      | 2.16                         | 4.8565                  |
| ST2R No.3    | 5         | 2.1718                       | 11.1043                 |
| ST6L No.1    | 0.75      | 2.1038                       | 9.2078                  |
| ST7L No.1    | 0.75      | 2.36                         | 4.8                     |
| ST8L No.1    | 1         | 1.741                        | 12.9311                 |
Californain Bearing Ratio CBR
The results of CBR were obtained for five samples of five station (ST1R No.2, ST2R No.3, ST6L No.1, ST7L No.1, ST8L No.1) fig.(25),(26),(27),(28) and (29) and Table(6) as well as measuring the percentage of swelling in table (6) and percentage of (CBR %) which depends on the maximum dry density and the optimum moisture content for each sample of soil. We see an increase in the percentage of (CBR% at 95%) with the increase of the dry density of the sample and also the swelling rate increases with mud deposits and the clay minerals which cause swelling.
Table 6: shows the results of the CBR % and swelling

| sample  | Depth (m) | No. of lows | CBR % (2.5) | CBR % (5.0) | Dry Density 95% | CBR% 95% compaction | Swelling  |
|---------|-----------|-------------|-------------|-------------|-----------------|---------------------|-----------|
| ST1R No.2 | 1.75 | 10 | 17.7 | 21.7 | 2.052 | 30 | 0.1680 |
|         |          | 25 | 58.8 | 61.4 |                  |                    |          |
|         |          | 56 | 277.7 | 198.2 |                  |                    |          |
| ST2R No.3 | 5 | 10 | 64.5 | 76.2 | 2.063 | 84 | 0.0633 |
|         |          | 25 | 72.3 | 89.6 |                  |                    |          |
|         |          | 56 | 87.2 | 102.8 |                  |                    |          |
| ST6L No.1 | 0.75 | 10 | 22.3 | 28.2 | 1.999 | 31 | 0.0022 |
|         |          | 25 | 23.0 | 31.3 |                  |                    |          |
|         |          | 56 | 28.8 | 38.0 |                  |                    |          |
| ST7L No.1 | 0.75 | 10 | 27.5 | 31.7 | 2.228 | 150 | 0.0218 |
|         |          | 25 | 157.3 | 126.6 |                  |                    |          |
|         |          | 56 | 173.4 | 199.6 |                  |                    |          |
| ST8L No.1 | 1 | 10 | 23.5 | 17.2 | 1.654 | 29 | 0.0240 |
|         |          | 25 | 25.7 | 29.2 |                  |                    |          |
|         |          | 56 | 39.3 | 42.0 |                  |                    |          |

**Direct Shear Test**
This test is applied for soil of ST2R No.2 and ST8L No.1 were obtained for soil shear coefficients (C) (9KN / m²) for both samples as in Figs. (35) and (36), which are affected by the roughness of the soil the increase in coarse of the soil it causes decreasing in cohesion value but in the fine soil causes increases in cohesion value. The value of internal friction angle (Ø), in (ST2R No.2) was (32°) in ST8L No.1 (26°), in table (7)

Table 7: shows the values of cohesion (c) and the internal friction angle (Ø)

| Sample  | Depth | C( Kpa) | Ø  |
|---------|-------|--------|----|
| ST2R No.2 | 2.20 | 9 | 32° |
| ST8L No.1 | 1 | 9 | 26° |

**Point Load Test**
It is an indirect method of measuring the uniaxial compressive strength (UCS). Thus, UCS can be measured in Table (9), UCS is classified according to the classification in [16] table (8).

Table 8: (UCS classification)[16]

| Strength (MPa) | Term       |  |
|---------------|------------|---|
| Less than 1.25| Very weak  |  |
| 1.25-5.00     | Weak       |  |
| 5.00-12.50    | Moderately weak |  |
| 12.50-50      | Moderately strong |  |
| 50-100        | Strong     |  |
| 100-200       | Very Strong|  |
| Over 200      | Extremely Strong |  |

Table 9: Results of UCS and classification according to[16].

| Location | Depth (m) | UCS (Mpa) | Classification               |
|---------|-----------|-----------|------------------------------|
| ST1R No.2 | 1.75 | 144.84-263.71 | Very Strong - Extremely Strong |
| ST2R No.1 | 1.20 | 68.43-247.96   | Strong - Extremely Strong    |
| ST2R No.3 | 5 | 86.90-420.04   | Strong - Extremely Strong    |
| ST3R No.1 | 10 | 20.19-317.54   | Moderately strong - Extremely Strong |
| ST4R No.1 | 6 | 95.21-323.72   | Strong - Extremely Strong    |
| ST5R No.1 | Channel | 134.51-414.33 | Very Strong - Extremely Strong |
| ST6L No.1 | 0.75 | 121.88-225.86 | Very Strong - Extremely Strong |
| ST7L No.1 | 0.75 | 124.47-222.67 | Very Strong - Extremely Strong |
| ST8L No.2 | 3 | 34.62-291.62   | Moderately strong - Extremely Strong |
| ST8L No.3 | 2.70 | 103.96-199.19 | Very Strong                 |
Chemical Analysis

Chemical properties are a very important factor in knowing the chemical behavior of the soil and the range of soil capacity to the external factors affecting it, such as erosion and weathering. The results of tests in table (10).

Table (10) shows the results of Gypsum%, PH and TSS% for the sample of soil study area

| Location | Depth (m) | Gypsum ratio | Classification | pH  | TSS% |
|----------|-----------|--------------|----------------|-----|------|
| ST1R No.1 | 2.5     | 2.18         | Very Low gypsum | 8.27 | 4.68 |
| ST1R No.2 | 1.75    | 1.21         | Very Low gypsum | 7.86 | 3.03 |
| ST2R No.1 | 1.20    | 9.08         | Low gypsum     | 8.05 | 15.67|
| ST2R No.2 | 2.20    | 1.05         | Very Low gypsum | 7.81 | 3.61 |
| ST3R No.1 | 10      | 3.63         | Low gypsum     | 8.21 | 5.11 |
| ST4R No.1 | 6       | 13.15        | Medium gypsum  | 8.08 | 19.61|
| ST5R No.1 | Channel | 1.97         | Very Low gypsum | 8.11 | 4.03 |
| ST6L No.1 | 0.75    | 2.61         | Very Low gypsum | 8.01 | 4.11 |
| ST7L No.1 | 0.75    | 4.82         | Low gypsum     | 7.88 | 5.37 |
| ST8L No.1 | 1       | 2.45         | Very Low gypsum | 8.07 | 3.61 |
| ST8L No.2 | 3       | 5.02         | Low gypsum     | 7.76 | 6.01 |
| ST8L No.3 | 2.70    | 3.81         | Low gypsum     | 7.81 | 5.89 |

Conclusions

1-The values of the specific weight of the soil under study indicate that there is a difference in values. The reason for this variation is due to the difference in the metal structure of both coarse and fine granules 2-Non-plasticity the soil is mostly coarse soil composed of gravel mixed with fine soil and in different proportions, which are poor graded soil. The optimum water content ranged from (12.9311-4.8565%).
3-The maximum dry density values ranged between (2.36-1.741gm/cm3) (CBR) (5.0) ranged between (199.6-21.7) and CBR (95%) values of dry density ranged between (% 150-29).
4-The values of swelling ranged between (0.0022-0.1680).

References

[1] Al-Humeiri, Muwafaq Adnan and Nabil Za’al Al Hawamdeh, Tourism Geography in the 21st Century a methodology process and analysis of a new ideological view and a modern methodology, Jordan, Dar Al-Hamed for Publishing and Distribution, 2006.
[2] Kadhim, L.S. and M.W. Ajeel, Sedimentological and mineralogical studies of Quaternary sediments in Tikrit area, University of Tikrit, 1st scientific conference, college of Science, 2009.
[3] Al- Aswadi, M. R. R. Abdullah, Geographical Evaluation for tourist capacities in Salahalddin Governorate, Master Thesis, Tikrit University, 2013.
[4] Jassim, S.Z. and J.C. Goff, Geology of Iraq, Dolin, Prague and Moravian Museum Brno, 2006.
[5] ASTM D2216-10, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass1, 2007.
[6] ASTM C127-15, Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate1, American Society for Testing Materials, West Conshohocken, Pennsylvania, 2007.
[7] ASTM D422-63 (Reapproved 2007)2, Standard Test Method for Particle-Size Analysis of Soils1, American Society for Testing Materials, West Conshohocken, Pennsylvania, 2004.
[8] ASTM, D 854-02, Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer, 2004.
[9] ASTM D4318-10, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils1, 2007.
[10] ASTM, D1557-02E, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft3 (2,700 kN-m/m3)) 1, 2004.
[11] ASTM, D1883, Standard Test Method for Determination California Bearing Ratio for Aggregate, 2005.
[12] ISRM, Suggested method for determining point load strength. ISRM Commission on Testing Methods, Working Group on Revision of the Point Load Test Method. Int. J. Rock Mech. Min. Sci. & Geomech. Abstr., Vol.22, 1985, pp.51-60.
[13] ASTM, D 3080-03, Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions, 2004.
[14] Hand Book N0.60, diagnosis and Improvement of saline and Alkali soils, Agric., US Department of Agriculture (USDA), Washington D.C.,1959.
[15] Das, B.M., Principles of geotechnical engineering 7th ed., USA, Cengage learning, 2010.
[16] Anon., The description of rock masses for engineering purposes, Report by the Geological Society Engineering Group Working Party, Quarterly Journal of Engineering Geology, Vol. 10, 1977, pp. 355-388.
الخواص الجيوتكنيكية لترسبات ضفاف قطاع نهر دجلة داخل مدينة تكريت /العراق

مها شاهر بدوي، محمد راشد عبود، صبر عبد الله صالح
قسم علوم الأرض التطبيقية، كلية العلوم، جامعة تكريت، تكريت، العراق

العنوان

درست الخواص الجيوتكنيكية لترسبات على ضفتي النهر شملت ايجاد الخواص الفيزيائية والهندسية والكيميائية للترسبات وواقع (8) محطات ممثلة ب (13) نموذج حيث ان ترسبات الشرفات النهرية تغطي الضفة اليمنى للنهر بينما ترسبات السهل الفيضي تغطي الضفة اليسرى للنهر وإن التربة الخشنة من نوع الحصى هي السائدة مع نسب متفاوتة من الترسبات الناعمة وتم ايجاد الوزن النوعي ونسب الامتصاص للترسبات اما في ما يتعلق بالفحوصات الهندسية فشملت ايجاد نسبة التحميل الكالوروني (CBR%) وفحص القص المباشر لايجد عوامل المقاومة القصية وفحص حمل النقطة لاستنباط قيم المقاومة الانضغاطة عبر المحصورة للحصى اما بالنسبة للتحاليل الكيميائية لترسبات لفحو حيح في نسب الحصى والاملاح الكلية الناتجة في ترسبات الضفة اليمنى وقلتها في الضفة اليسرى زيادة في نسب الحصى والاملاح الكلية الناتجة للترسبات على الضفتي النهر تبين ان ترسبات الشرفة النهرية تحتاج الى معالجة عند اقامة المشاريع الهندسية عليها لاحتزائها على نسب عالية من الحصى والاملاح الكلية الناتجة.