Examine Some of Geotechnical Properties of Quaternary Deposits in Sharqat City/Salah El-Din Governorate and Suitability for Concrete

Loay M. Rawe¹,a*, Abdulhadi H. Mohammed²,b, and Mohanad E. Khder³,c

¹College of Basic Education ALShirqat, Tikrit University, Tikrit, Iraq.
²Natural Resources Research Center, Tikrit University, Tikrit, Iraq.
³loaytaref@tu.edu, oudenabadokhy@gmail.com, ¹Mu_iraq2005@gmail.com
*aCorresponding author

Abstract. The present study aims to assess quaternary deposits' engineering properties and usability in the study area (Al-Shirqat/Salah Al-Din). Four selected stations were investigated using the modeling method and grain size analysis; deposits were classified as coarse (GS-GW) according to the Unified Soil Classification System (USCS) standard. It's found that the specific gravity of soil ranged between (2.57-2.71), and the absorption is about (1.12-1.83) %. The gypsum content of tested soil samples ranged between (1.35-5.08) %, and the total dissolved salts ranged between (3.61-9.52) %. The results of tested samples showed that the content of organic materials (0.56-0.89) % and the pH value between (7.96-8.11) %. The Los Angeles test showed that the percentage of weight loss ranged between (14.9-19.7) %, and the stability test results ranged between (0.623-0.867), while uniaxial compressive strength values ranged between (154-189) MPa. The study resulted that the study area models are suitable for use in structural concrete works.

Keywords: Concrete, chemical analysis, stability testing, mechanical corrosion testing, Al-Shirqat

1. Introduction
Concrete consists of cement, aggregates (sand and gravel), and water; aggregates are the major component and the filler part of the concrete mix, which contributes about 75% of the concrete mix's total volume [1]. It is essential to study the aggregate properties and their granularity which directly affects the properties of the concrete products, behavior, and durability. It is necessary to use high strength, clean with low porosity aggregate to ensure high-quality concrete mix [2,3]. Concrete additives are usually added to improve fresh concrete mix properties like workability, mix water reduction, and increase the concrete mix strength or change other properties [4]. There are several types of concrete (ordinary concrete, reinforced concrete, prestressed concrete, polymer concrete, dense concrete, high-resistance concrete, and precast concrete), they differ from each other in terms of components, engineering properties, and uses [5]. This study's main objective is to investigate the geotechnical properties of the quaternary age deposits in A-Sharqat area and their suitability for use in the structural concrete mix.

2. Field works
Field investigations are indispensable to develop ideas for a successful study plan. Field survey of the study field, geological and geomorphological exploration, rock quarries, and gravel and sand deposits. Field work that has been carried out: In November 2019, an exploration tour of the study area was...
carried out to investigate the rock quarries, geological formations, and other field measurements. The second tour was carried out in two stages, four stations have been selected, and samples were taken according to the followed model- one sample from each station. The coordinates of the selected stations were set using the GPS locator device. The samples were kept in containers used for laboratory tests in order to do the experimental tests later. The area of study is located within Salah al-Din Governorate in Al -Shirqat district, which is located between longitude (43º 12' 0'') (43º 18' 40'') and two latitudes (35º 38' 0'') (35º 34' 0''), see Figure 1.

Figure 1. A location map for the study area.

The study area is covered with quaternary deposits of gravel, sand, silt, and clay [6]. A study of the quaternary deposits in the area between Bayji and south of Samarra cities was carried out to find the constraints, which are fine sand, fine gravel with a considerable amount of gypsum materials away from Tigris riverbank, in addition to high thickness gravel layers that were formed in the last stages of the quaternary. These deposits are located in the study area, as they cover large areas with different thicknesses, which formed from the oldest sediments of gravel, clay, and mud sands. It's found that sediment thickness in the study area was ranged from (7-12) meter.

3. Laboratory works
The laboratory works were included the following tests: Sieve analysis, specific gravity, absorption, mechanical abrasion test, stability test, uniaxial compressive strength, and chemical analysis.

3.1 Grain size analysis
Sieve analysis test was conducted according to ASTM, D422-63 [7]. It is found that the passing percentage for sieve No. 200 does not exceed 10% for tested samples. The tested area deposits are coarse from the calculation of uniformity and concavity coefficients Cu and Cc, as shown in Tables 1 and 2. The granular gradation of the four stations is shown in Figures 2 to 5. The uniformity coefficient (Cu) and the coefficient of concavity (Cc) are:
\[ C_u = \frac{D_{60}}{D_{10}} \]  
\[ C_C = \frac{D_{50}^2}{D_{60} \times D_{10}} \]  

Table 1. Sieve analysis results for the study area.

| Sieve size, mm | Percentage passing by the nominal size |
|----------------|---------------------------------------|
|                | 40 mm | 20 mm | 10 mm | 5 mm |
| 50             | 100   | -     | -     | -    |
| 37.5           | 95-100| 100   | -     | -    |
| 20             | 45-80 | 95-100| -     | -    |
| 14             | -     | -     | 100   | -    |
| 10             | -     | -     | 95-100| 100  |
| 5              | 25-50 | 35-55 | 30-65 | 70-100|
| 2.36           | -     | -     | 20-50 | 25-100|
| 1.18           | -     | -     | 15-40 | 15-45 |
| 0.6            | 8-30  | 10-35 | 10-30 | 5-25  |
| 0.3            | -     | -     | 5-15  | 3-20  |
| 0.15           | 0-8   | 0-8   | 0-8   | 0-15  |

Table 2. Granular size analysis results of the study area.

| Sieve size, mm | Percentage passing, % |
|----------------|------------------------|
|                | Station 1 | Station 2 | Station 3 | Station 4 |
| 63             | 100       | 100       | 100       | 100       |
| 50             | 100       | 100       | 100       | 100       |
| 37.5           | 95.1      | 96.75     | 98.2      | 94.7      |
| 25             | 87.6      | 89.76     | 91.4      | 86.3      |
| 19             | 79.53     | 74.7      | 72.64     | 73.7      |
| 12.5           | 61.9      | 64.2      | 59.43     | 63.78     |
| 9.5            | 45.69     | 49.12     | 41.45     | 43.44     |
| 4.75           | 33.23     | 35.79     | 29.62     | 34.29     |
| 2.36           | 28.39     | 26.51     | 23.71     | 29.28     |
| 1.18           | 25.74     | 21.24     | 19.95     | 24.48     |
| 0.6            | 18.26     | 15.66     | 16.32     | 15.47     |
| 0.3            | 10.9      | 9.15      | 8.77      | 7.43      |
| 0.15           | 3.59      | 2.91      | 2.84      | 2.63      |
| 0.075          | 1.7       | 1.85      | 1.43      | 1.3       |

Figure 2. Granular size analysis for the station 1.
3.2 Specific gravity and absorption ratio

Specific gravity is defined as the ratio of the weight of a given volume of aggregate to the weight of an equal volume of distilled water to a particular temperature. Absorption ratio is defined as the weight increment ratio of dry aggregate after 48 hours of immersion in water, which indicates the proportion of water absorbed by the aggregate grains. This indicator is essential for concrete mix design. The calculated results are shown in Table 3.
Table 3. Specific gravity and absorption ratio results.

| Station No. | Dry specific gravity | Saturated specific gravity | Specific gravity | Absorption ratio |
|-------------|----------------------|-----------------------------|------------------|-----------------|
| 1           | 2.57                 | 2.62                        | 2.65             | 1.12            |
| 2           | 2.63                 | 2.68                        | 2.71             | 1.83            |
| 3           | 2.60                 | 2.65                        | 2.69             | 1.7             |
| 4           | 2.61                 | 2.63                        | 2.71             | 1.73            |

3.3 Stability test

The stability expresses aggregates' ability to resist volumetric changes caused by physical conditions changing (weathering and erosion conditions) due to cycles of moisture and temperature changes. Aggregates are described as unstable if the volume changes resulting in concrete cracks result from expansion caused by chemical reactions between the aggregate and the alkaline in the cement [9,10]. The chemical stability test was carried out according to (ASTM) C88-05 [11]. The weight loss percentage for aggregates should not exceed 12% after five cycles are performed in a sodium sulfate solution or 18% in a magnesium sulfate solution. The suitability test shows that tested aggregate samples taken from the study area are suitable for use in structural concrete works, as shown in Table 4.

Table 4. Results of stability test to ASTM, C88-05 [11].

| Station No. | Stability test |
|-------------|----------------|
|             | 0.623          |
|             | 0.734          |
|             | 0.867          |
|             | 0.712          |

3.4 Abrasion test (Los Angeles)

The Los Angeles abrasion test aggregates aggregate toughness and abrasion resistance measures such as crushing, degradation, and disintegration. It is considered a qualitative indicator for the various types of aggregate [12]. The percentage of weight loss during the test is regarded as an indicator of abrasion. The aggregate resistance to abrasion decreases with loss present increase and vice versa [13]. The test was conducted according to the AASHTO T 96-02 specification [12] in the Engineering Geology Lab at the College of Science/Tikrit University. Table 5 shows the Los Angeles Test results, which show that study area models are suitable for use in structural concrete works. The maximum allowable weight loss for concrete work is (35%) based on AASHTO T 96-02 specification standard [12].

Table 5. Results of Los Angeles test.

| Station No. | Los Angeles test (%) |
|-------------|----------------------|
|             | 14.9                 |
|             | 17.3                 |
|             | 16.2                 |
|             | 19.7                 |

3.5 Uniaxial compressive strength

The uniaxial compressive strength is the maximum axial compressive stress that a sample of material can withstand before failing. The uniaxial compressive strength was tested according to ASTM-D, 2938-95 [14]. The resulted values of uniaxial compressive strength for tested samples are listed in Table 6.

Table 6. Results of uniaxial compressive strength.

| Station No. | Uniaxial compressive strength (MPa) |
|-------------|-------------------------------------|
|             | 167                                 |
|             | 189                                 |
|             | 154                                 |
|             | 162                                 |

4. Chemical analysis

The results of chemical tests conducted on soil samples can be summarized by:
4.1 Organic matter content
The organic material test was carried out according to B.S 882 [15]. The results fit the requirements for testing the organic matter Table 7, which states that the percentage of organic matter should not exceed (2%).

4.2 Total sulphate and gypsum content
Sulfate and gypsum content testing has been carried out by the method of extracting sulfate salts using diluted hydrochloric acid and according to B.S 882 [15]. It is noticed that the gypsum content for tested samples does not exceed (10.75%) according to B.S 1377 requirement [16], as shown in Table 7.

4.3 pH value
This test was performed according to BS 882 standard [15, 17]. The test results are listed in Table 7.

4.4 Total soluble salt
The total soluble salt test was performed according to B.S 1377 standard [18]. The obtained results met the standard requirements, which should not exceed 10% [19], as shown in Table 7.

Table 7. Chemical analysis results.

| Station No. | Gypsum content, % | Total soluble salt, % | Organic matter content, % | pH Value |
|-------------|-------------------|-----------------------|---------------------------|----------|
| 1           | 4.41              | 8.91                  | 0.56                      | 8.11     |
| 2           | 1.35              | 3.61                  | 0.78                      | 8.01     |
| 3           | 2.13              | 6.14                  | 0.65                      | 8.04     |
| 4           | 5.08              | 9.52                  | 0.89                      | 7.96     |

5. Conclusions and Recommendations
- Volume analysis results showed that the deposits of study area were certainly typed (GW-GS).
- Specific gravity and absorption ratio tests showed that tested samples are meet the requirements of the aggregates used for structural concrete works.
- Los Angeles test results and the stability test showed an agreement with the requirements that must be provided for the concrete works.
- The results of the chemical analysis of tested samples showed that the aggregate deposits investigated can be used for structural concrete works.
- It is found that tested samples are classified as a very strong aggregate due to the uniaxial compressive strength test with agree with structural concrete works requirements.

The present study assured more exploration and investigation are required in the study area to explore the natural resources and develop exploration industry. Following are the essential aspects recommended to be addressed for future work in this field.
- Exploration the deposits in the area of study and utilizing them in structural concrete works.
- Build-up quarries in the study area according to the international specifications.
- Quantify aggregate deposit reserves for future planning and exploit the natural resources available in the construction industry and construction projects.
- For more advantage of oversize aggregate, it recommends using crushers in the quarries.

References
[1] Neville, A.M., 1995. Properties of concrete (Vol. 4). London: Longman.
[2] Neville, A.M. and Brooks, J.J., 1987. Concrete technology (pp. 242-246). England: Longman Scientific & Technical.
[3] Bell, F.G., 2013. Engineering geology and geotechnics. Elsevier.
[4] Al-Khalaf, M. N. and Hana Abd Yosuf, H. A., 1984. Concrete technology, Arabization and Publishing Center, Technology University, Baghdad, In Arabic.

[5] Shakhmenko, G. and Birsh, J., 1998, January. Concrete mix design and optimization. In Proceedings of the 2nd International Symposium in Civil Engineering (pp. 1-8).

[6] Jassim, S.Z., 1981. Early Pleistocene gravel fan of the Tigris river from Al Fatha to Baghdad, Central Iraq. Iraqi Geological Journal, 14, 25-34

[7] ASTM, D 422-63., 2004. Standard test method for particle-size analysis of soils.

[8] ASTM, C 127 – 88 (Reapproved 2001), 2004. Standard test method for specific gravity and absorption of coarse aggregate.

[9] Al-Sultany, D. G. S., 1992. The geotechnical characteristics and the surface evaluation of marble rocks in the Khiti area, northern Iraq. M. Sc. Thesis, Science College, University of Mosul, In Arabic.

[10] Sims, I., 1986. Sand, gravel and crushed rock aggregates for construction purposes: Geological Society Engineering Group Working Party. Quarterly Journal of Engineering Geology and Hydrogeology, 19(3), pp.325-338.

[11] ASTM, C88-05, 2004. Standard specification for materials of test of soundness of aggregate by use of sodium sulphate & magnesium sulphate.

[12] AASHTO T 96-02, 2019. Standard method of test for resistance to degradation of small-size coarse aggregate by abrasion and impact in the Los Angeles machine.

[13] ASTM, C 131, 2004. Standard test method for sieve analysis of fine and coarse aggregates.

[14] ASTM, D 2938-95., 2004. Standard test methods for unconfined compressive strength of intact rock core specimens.

[15] B.S, 882, 1992. Specification for aggregate from natural sources for concrete.

[16] McCauley, A., Jones, C. and Jacobsen, J., 2009. Soil pH and organic matter. Nutrient management module, 8(2), pp.1-12.

[17] BS, 1377, 1990. Method of determination of organic matter in aggregate.

[18] Dunn, I.S., Dunn, I.S., Anderson, L.R. and Kiefer, F.W., 1980. Fundamentals of geotechnical analysis. John Wiley & Sons Incorporated.

[19] Hawkins, A.B., 1986. Rock descriptions. Geological Society, London, Engineering Geology Special Publications, 2(1), pp.59-66.