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The validity of limestone rocks of Fat'ha Formation in the Hamrin Anticline/Salahaddin Governorate for riprap

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ABSTRACT

To evaluate the probability of usage as a riprap, the study aims to identify some of the mechanical and physical characteristics of limestone rocks in the Fat'ha Formations in the northwest plunging area of the Hamrin Anticline fold within the Sallahaddin Governorate. These rocks have specific gravities between (2.161-2.521), dry density between (1.92-2.148) gm /cm^3, water absorption rates between (4.104%-9.774%), mechanical abrasion between (29%-45.5%) and chemical abrasion ratios between (3.2%-5.8%), According to the specifications of the Florida Department of Transport and the Iraqi Standard Specifications No. (1385) for the year (1989), as well as the American standard (ASTM), it was found that most limestone rocks are not suitable for use as riprap stones in most stations because the percentage of absorption and dry density fall outside the limits of the specification, and it was found that limestone can be used as riprap stones only in the station (3) as a riprap stone for channels and trenches according to the specification of the Florida Department of Transport, as well as the station (4) suitable as a riprap stone according to the Iraqi standard No. (1385) for the year (1989).

Introduction

Limestone has wide uses, such as riprap because of the specifications that the rocks must have to preserve and protect the banks of rivers from the energy and movement of water in addition to the aesthetic that is characterized by it along the river, riprap can be defined as a small layer of rocks fragment approximately equal in size and strength, placed on top of the layer to protect the banks of the river from the energy of water movement [1], and these rocks must have special specifications, including hardness and durability to resist the pressure that is imposed on them, in addition to their resistance to weathering and erosion (US DOT, 1995) in [2].

The movement of water flow causes the erosion of the banks of rivers, streams, and slopes, removing the crumbly materials from their place and depositing them towards the bottom of the river or stream, correctly built riprap works to stop or reduce erosion, riprap is used to stop erosion or degradation when a building or structure is exposed to water currents, such as on earth mounds, river bottoms dams, banks, slopes, or the bases of bridge supports [3]. Since it works well in most situations, rock is the most popular and often used type of riprap in the United States. Three types of rock riprap are available: dumped riprap plated or keyed riprap, and hand-placed riprap [4]. The riprap can still function efficiently and is simple to restore even if part of the strewn stones is lost. Well-built riprap offers long-term protection so long as it is periodically checked and repaired, especially after floods. There is no pollution due to the riprap [5]. The properties and specifications that must be met for limestone rocks used as riprap rocks change according to the rock components, as when previous research and studies noted a difference in the mechanical tests that are carried out on the rocks according to the different situations to determine their suitability for this purpose [6]. The engineering properties of limestone rocks have been studied for use as riprap stones in the southeastern plunging area of the Khanuga anticline in northern Iraq, and he found their suitability for use

as riprap stones after comparing geotechnical properties of limestone with the Iraqi standard [7], studied limestone rock in the Fat'ha formation by [8] in the Sharqat area and found it suitable for use as riprap according to Iraqi standard No. (1385) [9] and not suitable according to Florida Department of Transport standard [10] and American standard [11], and studied limestone rock by [12] in Bazian fold and found most of the station unsuitable to use for riprap stone. The study area was chosen because there are no previous studies in this area.

Location of the study area:

The study area is located 50 km northeast of the city center of Salah Al-Din in northern Iraq. covered by coordinates is limited to between latitudes (35° 02' 48", 35° 03' 20") and longitudes (43° 33' 36", 43° 34' 12"), (Fig. 1).

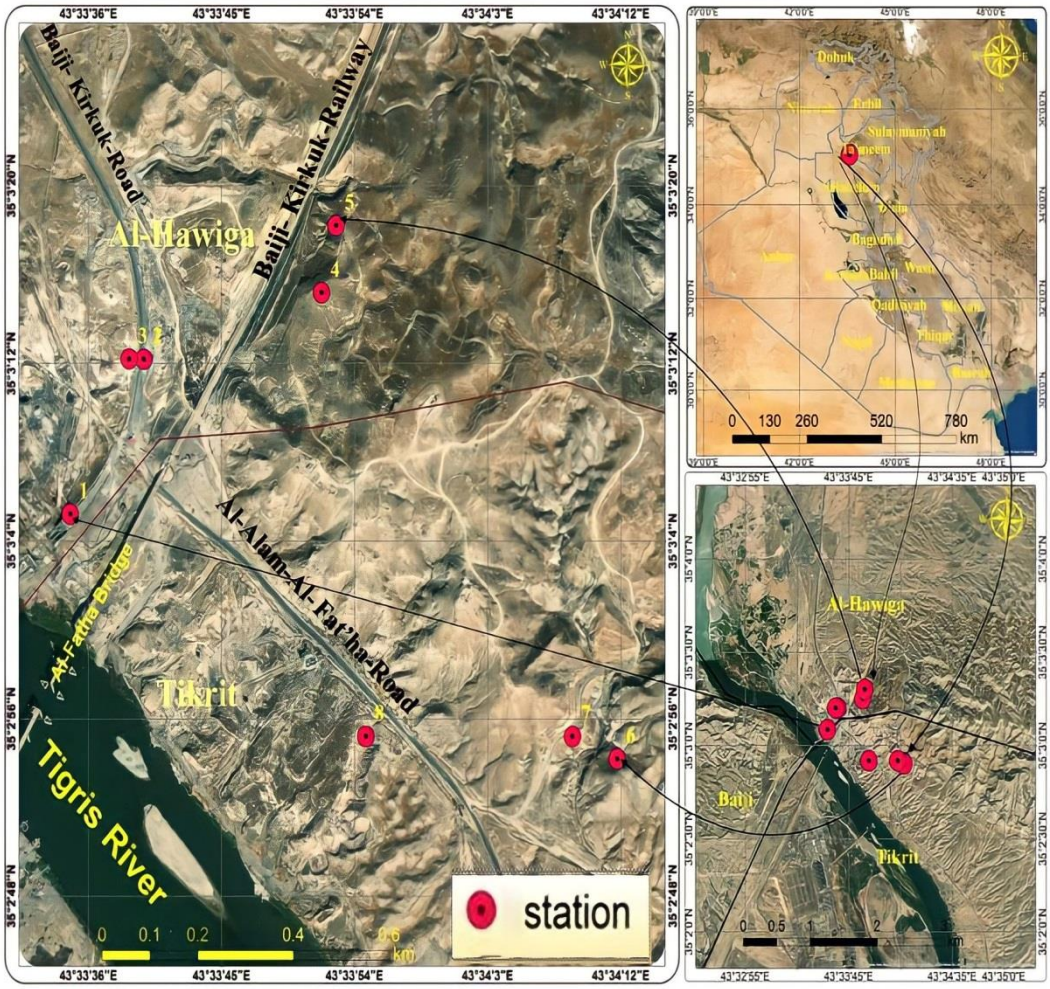

Fig. 1: Images shows the location of the studied stations

Geological setting

Stratigraphy In the study area, the formation of the Fat'ha is exposed, in addition to the sediments of the Quaternary Age, the Fat'ha formation contains limestone rocks, which is one of the most important formations in Iraq because of its economic importance [13]. It was named in Iraq the Fat'ha Formation by use of an ideal section, which is located in the Al-Fat'ha area (Salah Al-Din Governorate). The Fat'ha formation consists of complete lagoon sedimentary cycles of successions of marl, limestone, and gypsum [14]. This formation has very economic importance because it has a role in the industry of building and riprap materials, in addition to its near-to the surface of the earth, which easily its extraction and exploitation.

Tectonically, the study area is located within the Hamrin-Makhoul Belt returning to the Low Foldes Zone [15], The Hamrin Series is a natural belt and is long and wide. The Hamrin fold results from the second phase of the Alpine movement represented by the collision of the Arab Plate with the Iranian and Turkish plates [16]. From the structural point of view, the Hamrin fold is an asymmetrical anticline fold and its axis is directed northwest-southeast. There are a lot of fractures in the limestone rock, as these fractures have an important role in facilitating the process of rock extraction.

Geomorphology one of the most important geomorphological features present in the study area is acuesta, and many valleys cut through the rocks of the study area, including the strike valleys that extend

in a direction parallel to the layer strike and the transverse valleys that extend in a direction vertical to the lines of the layer strike. In addition, there are many drainage patterns such as parallel patterns and semi-parallel patterns found in limestone rocks, Additionally, there is the phenomenon of rock falls.
The industrial layer is easy to remove because it is relatively brittle and has many clear cracks and is homogeneous in composition. Four stations have been selected in the study area depending on the favorable quarrying data and conditions in terms of thickness, extension, stratigraphic sequences, proximity to main roads and means of transportation, and ease of access for vehicles for quarrying and transportation purposes, and found limestone in a station no. (1) Its thickness (1)m and extends about (20)m, in station no. (3) its thickness (5)m and extends about (30)m, in station no. (4) its thickness(2) m and extends about (15)m, and in station no. (7) its thickness (3)m and extends about (25)m, (Fig.2).

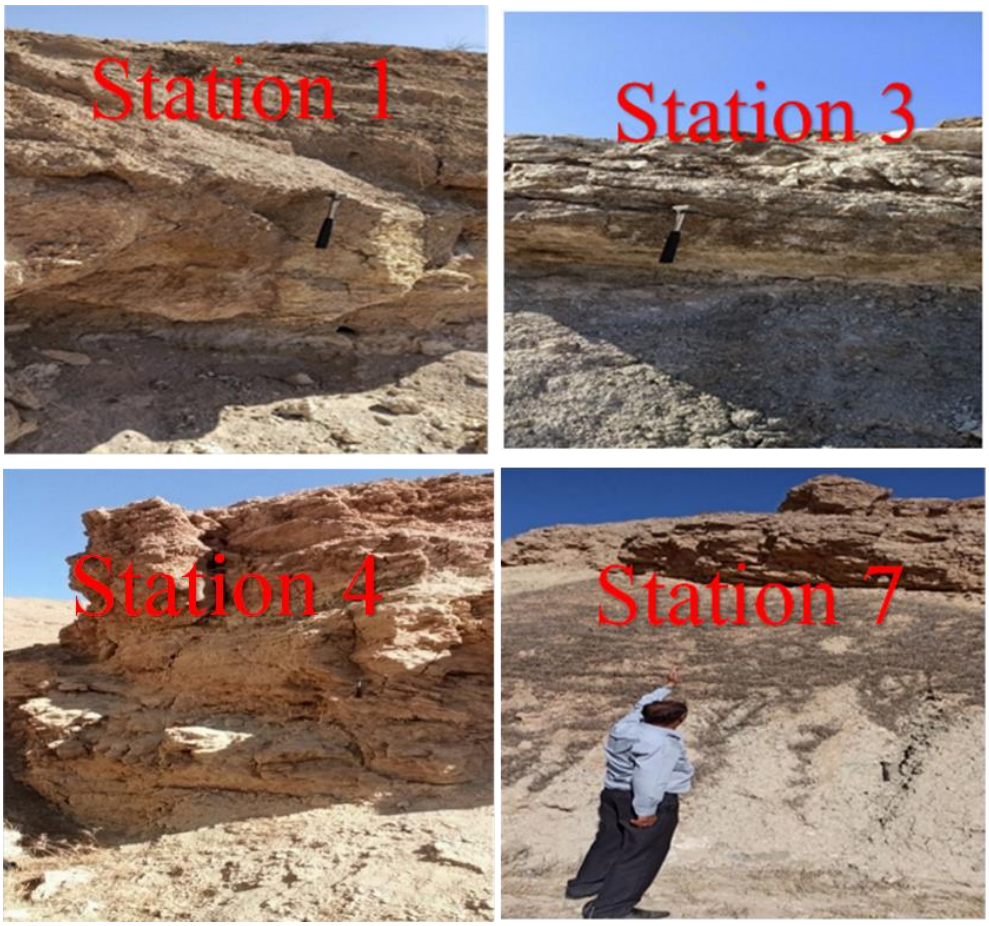

Fig. 2: station of the study area

Geotechnical properties

Several tests have been carried out related to the suitability of limestone for use as riprap stone and are required in standard specifications these properties are specific gravity, dry density, absorption rate, chemical abrasion, and mechanical abrasion rate.
1-Specific gravity: is a factor in evaluating and classifying rocks [17], It was found by the American Standard [18].by equation **True. G.s** $= \boldsymbol{Md} /$ $(\boldsymbol{Md}\text{-}\boldsymbol{Msub})$ Table (1)
2-dry density: it is mass per unit volume (gm /cm^3)(19), it was found by the American Standard [18], by equation **Dry density = Md/(Msat_ Msub) / ρm** Table (1)
3- Absorption rate: It is the ratio of the mass of the water ($\boldsymbol{Mw}$) in the voids absorbed during 24 hours to the total dry mass of the rock ($\boldsymbol{Md}$). Because rocks with less absorption are more resistant to variations in dryness and humidity, freezing and thawing, and other environmental conditions, the absorption property is taken into account when deciding whether rocks are acceptable for engineering purposes [20], and it was found according to American Standard [18].
by equation, **W.ab** = $(\boldsymbol{Msat} - \boldsymbol{Md}) / \boldsymbol{Md} \times \mathbf{100}\%$ Table(1)
4-Chemical abrasion resistance: It is the percentage of weight loss that occurs on the sample as a result of chemical abrasion using saturated sodium sulfate, is one of the most necessary tests carried out on rock aggregates used in building and road construction it was found according to American standard [21], by immersing the rock sample for 16–18 hours in a saturated sodium sulfate solution, followed by 8 hours of drying for five sequential cycles. Table (1)

5- Mechanical abrasion resistance: It is the percentage of weight loss that occurs to the sample as a result of mechanical abrasion, and it was found according to American Standard [22]. Table (1).

Table 1: Results of significant geotechnical tests used to evaluate riprap stones in limestone samples acquired from the study area

Station No.	Specific gravity	Dry density gm / cm^3	Absorption %	Chemical abrasion %	Mechanical abrasion %
1	2.172	1.992	5.660	3.2	36.5
3	2.161	1.985	4.104	3.8	31.1
4	2.521	2.148	6.896	4.7	45.5
7	2.375	1.927	9.774	5.8	29

Assessment suitability of Fat'ha limestone rocks for riprap

Evaluation of limestone rocks' suitability for use as riprap was done by the American Standard [11], Florida Department of Transport Standard [10], and Iraqi Standard No. (1385) [9], shown below

1- The American Standard (ASTM, D-523,2004)

Table 2: Shows the geotechnical properties requirements for the rocks used as riprap by ASTM, D-523,2004 [11]

Rock type	Specific gravity	Absorption%	Chemical Abrasion%
First class	More than (2.5)	Less than (2%)	Less than (%10)
Second class	More than (2.5)	Less than (2%)	Less than (25%)
Third class	More than (2.3)	Less than(%4)	Less than (25%)

After comparing the geotechnical test results of limestone rocks taken from the study area with the American Standard [11], it was determined that the limestone rocks in the Fat'ha Formation do not match the specifications, all samples from all stations are therefore unsuitable for use as riprap.

The results of the final evaluation were listed in Table (3).

Table 3: Results of a limestone rock suitability evaluation for riprap stones

Station No.	Specific gravity	Absorption %	Chemical Abrasion %
1	not acceptable	not acceptable	acceptable with all types
3	not acceptable	not acceptable	acceptable with all types
4	acceptable with all types	not acceptable	acceptable with all types
7	It acceptable to the third category	not acceptable	acceptable with all types

2- Florida Department of Transport Standard

Table 4: shows the requirements for the rocks used as riprap by [10]

Geotechnical properties	the value
Specific gravity	Beaches, shore greater than (2.3) Trenches, canals greater than (1.9)
Absorption %	Less than (5%)
Chemical abrasion %	Less than (12%)
Mechanical abrasion %	Less than (45%)

After comparing the geotechnical test results of limestone rocks taken from the study area with the Florida Department of Transport standard [10], and found only in a station no. (3) is suitably used as a riprap stone for channels and trenches. The results of the final evaluation were listed in Table (5).

Table 5: Results of a limestone rock suitability evaluation for riprap stones

Station No.	Specific gravity	Absorption %	Mechanical Abrasion %	Chemical Abrasion %
1	acceptable	not acceptable	acceptable	acceptable
3	acceptable	acceptable	acceptable	acceptable
4	acceptable	not acceptable	not acceptable	acceptable
7	acceptable	not acceptable	acceptable	acceptable

3- Iraqi Standard No. (1385) for the year (1989)

Table 6: shows the requirements for the rocks used as riprap by [9]

geotechnical properties	Quality		
	Unacceptable	Acceptable	successful
Dry density gm / cm^3	Less than (2)	2.2−2	More than (2.2)
Mechanical Abrasion %	More than (47)	47−45	Less than (45)
Chemical Abrasion %	More than (18)	Less than (18)	Less than (18)
Absorption%	More than (10)	Less than (10)	Less than (10)

After comparing the geotechnical test results of limestone rocks taken from the study area with the Iraqi Standard No. (1385) [9], and found only in station no. (4) is suitably used as a riprap stone. The results of the final evaluation were listed in Table (7).

Table 7: Results of a limestone rock suitability evaluation for riprap stones

Station no.	geotechnical properties				Quality
	Absorption %	Mechanical Abrasion %	Chemical Abrasion %	Dry density gm / cm^3	
1	5.660	36.5	3.2	1.992	Unacceptable
3	4.104	31.1	3.8	1.985	Unacceptable
4	6.896	45.5	4.7	2.148	Acceptable
7	9.774	29	5.8	1.927	Unacceptable

Discussion

To determine the suitability of limestone for use as riprap stone, in four stations in the study area, by comparing properties of limestone with American Standard ASTM, the limestone appeared to be not suitable to use as riprap, because the American standard classifications are based on the following characteristics:(chemical abrasion%, specific gravity, and absorption%), and the absorption rate did not match the standard in all station, also Florida Department of Transportation Standards depend on (mechanical abrasion%, chemical abrasion%, specific gravity, and absorption%), and the absorption rate did not match the standard in the most station, on the other hand, the Iraqi Standard depends on (mechanical abrasion%, chemical abrasion%, dry density, and absorption%), and the absorption rate match the standard in all station but dry density did not match the standard in the most station. As evidenced by the observation of the effects of cementation, mineral composition, and slight dissolution on the low and high absorption ratios, increase and decrease in specific gravity, and low and high chemical abrasion ratios in the rocks of the Fat'ha Formation.

Conclusions

1. The limestone rocks in the study area showed that the chemical abrasion ratio ranged between (3.2–5.8%), indicating little dissolution by sodium sulfate and high resistance to weathering, and the absorption ratio ranged between (4.104-9.774) %, which indicates a low effective porosity of the rocks.
2. most of the stations in the study area are not suitable for use as riprap.

Recommendations

1. Carrying out a similar study in the nearby areas to obtain rocks suitable for riprap.
2. Choose a riprap rock source that is nearby the project where the riprap will be used to cut costs.

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صلاحية الصخور الكلسية العائدة لتكوين الفتحة ضمن طية الحمرين/ محافظة صلاح الدين لأغراض التكسية

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الملخص

تهدف الدراسة إلى معرفة بعض الخواص الفيزيائية والميكانيكية للصخور الكلسية ضمن تكوين الفتحة في الغاطس الشمالي الغربي لطية الحمرين المحدبة ضمن محافظة صلاح الدين لبيان مدى صلاحيتها كأحجار تكسية. وقد أظهرت الفحوصات إن قيم الكثافة الجافة لهذه لصخور تتراوح بين g/cm^3 (1.927-2.148) ، والوزن النوعي بين (2.521-2.161) ، ونسبة امتصاص الماء تتراوح بين (9.774%-4.104%) ، وتراوحت قيم نسبة التآكل الكيميائي بين (3.2%-5.8%) ، وقيمة التآكل الميكانيكي بين (45.5%-29%). وبعد معرفة الخواص الفيزيائية والميكانيكية لهذه الصخور الكلسية ومقارنتها مع المواصفات القياسية الأمريكية ومواصفات فلوريدا للنقل ومواصفة العراقية لأحجار التكسية، وجد ان هذا الصخور غير صالحة لأغراض التكسية في أغلب محطات منطقة الدراسة، لأن نسبة الامتصاص والكثافة الجافة تقع خارج حدود المواصفات، ووجد أن الحجر الجيري يمكن استخدامه كأحجار التكسية فقط في المحطة (3) كأحجار التكسية للقنوات والخنادق بحسب مواصفة فلوريدا دائرة النقل وكذلك المحطة (4) تصلح كأحجار التكسية بحسب المواصفة العراقية رقم (1385) لسنة (1989).