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Evaluation the suitability of Fat'ha gypsum rocks for use as thermal insulators in Sharqat District/Northern Iraq

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ABSTRACT

This research aims to study the suitability of gypsum rocks in Sharqat district as thermal insulators. The Result showed that the gypsum rocks have negligible porosity (3.80-5.17) %. And the absorption ratio between (1.6-2.4) %. The density was (2.15-2.34 gm/cm3). While the specific gravity values were as (2.15- 2.34). The moisture content ranged between (0.40 - 0.94) %. The thermal test results showed that the average thermal conductivity value of gypsum rock was (0.65) W/mc̊. The laboratory tests indicate a suitability of gypsum rocks of the in Sharqat area as thermal insulators.

1- Introduction

All various types of buildings with different capacities, sizes, or purposes, constructed above or below the ground, must be insulated to reduce heat or moisture transfer [1]. Thermal insulation is defined as the use of materials with specific properties that help block or reduce the transfer of heat from inside the building to the outside in winter, and vice versa in summer, through walls and ventilation openings, ceilings, and floors [2]. Thermal insulation materials exist in many forms; some are used in their natural forms such as rocks, while others are industrially manufactured from raw materials, such as double glass, glass wool, cellulosic heat insulation, wood fiber, foam, and other materials.

[3] studied the geotechnical and mine evaluation for the gypsum rocks is the Fat'ha Formation and their suitability to be used as thermal insulation material at Fat'ha area in the north of Iraqi. The study pointed that gypsum rocks can be used as a thermal insulator at temperatures ranging from (30- 100) c° while [4] studied the suitability of calcareous rocks and gypsum rocks at Fat'ha Formation/ Northern Hemrin fold, north of Iraq is being used in building and thermal insulation. He also study the ability of gypsum rocks to be used in coating the inner parts of walls and in making breakers inside buildings away from water due to their efficiency is thermal insulation. Whereas [5] studied the suitability of some rocks at Fat'ha/Khanooga fold in being used in construction work. The study shows that gypsum rocks can be used in packaging the inner walls and in making breakers in buildings away from water effects due to their efficiency in thermal insulation. Besides, their white color makes them preferred is making decorations. It is also found out in the study that these rocks cannot be used in railway enforcements because they are not suitable for this type of works.

[6] studied the efficiency of rocks at Injana Formation in Ketol/ Ssulaimaniya in being used is construction materials purposes. The study shows that sand rocks can be used in construction materials work and in thermal insulation to package inner walls. Besides, this type of rocks has high efficiency in railway enforcements.

The research objective is to study the suitability of Fat'ha gypsum rocks in Sharqat district as thermal insulators.

2- Location of the study area

The study area is located in the province of Salahaddin/ Sharqat District / Northern Iraq, near the Khanooga village; With coordinate from longitude is (43°06' 30", 43°18' 30"), and latitude is (35°21' 00", 35°27' 00"), Figure (1).

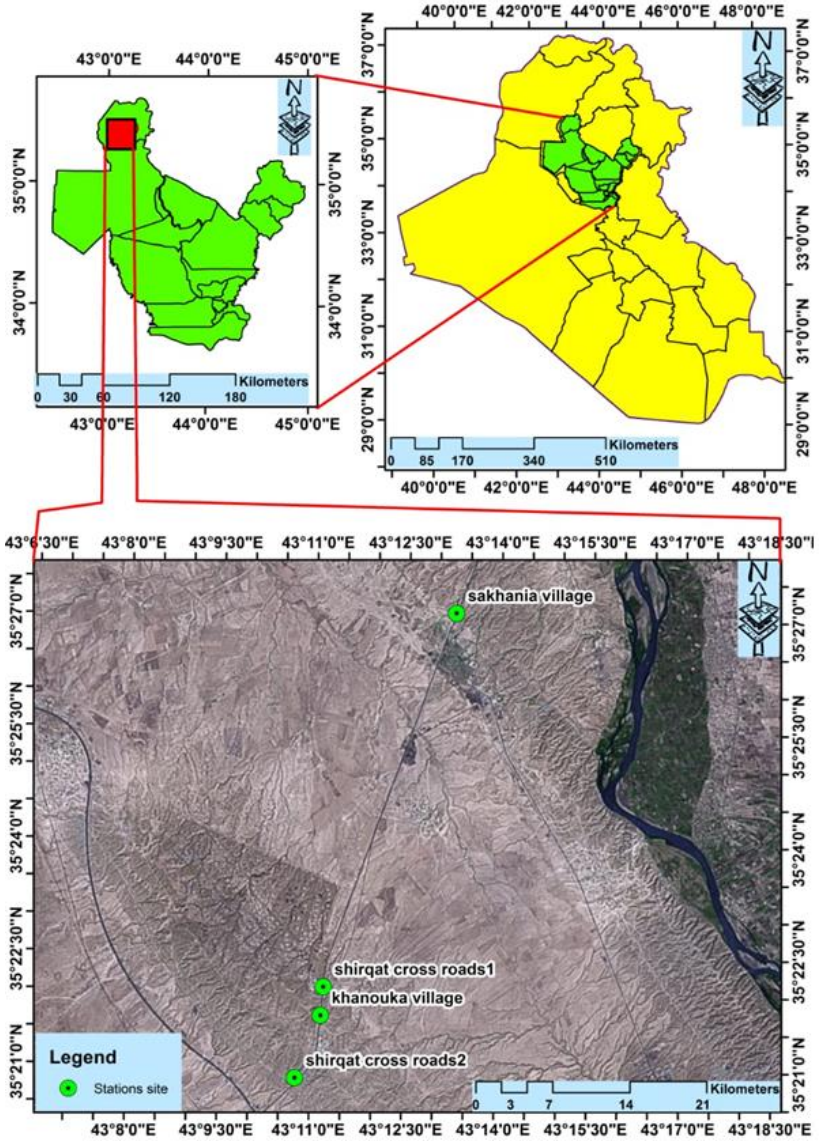

Fig.1: Location Map of the Study Area

3- Geology of the Study Area

The study area is located within Khanooga fold, which is asymmetric, double plunged and short anticline with NW-SE direction. Fat'ha and Injana Formations are exposed in the study area. Type locality of Fat'ha Formation was chosen on the western limb of Makhol anticline. In type section, it consists of irregular sedimentary cycles of green-gray marl, reddish-brown marl, limestone, gypsum and anhydrite[7] . [8] explained that the thickness of Fat'ha Formation varies from one place to another depending on the distance from the center of the sedimentary basin and on the effects of tectonic movements. Its thickness increases, and the evaporite rocks in the northwest direction of the basin center [9]. The formation consists of several sedimentary cycles, and these cycles are the result of repeated operations of marine regression and transgression [10]. Typical cycle begins with the deposition of limestone rocks, marl rocks and clay rocks (claystone), followed by the precipitation of evaporite rocks and finally salt rocks.

Fat'ha Formation of the study area consists of alternating bedding of gypsum, mudstone, and limestone. Gypsum beds, which form the lower part of the successions, are nodular and massive gypsum. Massive gypsum beds are about 2-5 m thick of white-light green gypsum; whereas the nodular gypsum forms thin beds (1-2 m). The size of the nodules is between 2-10 cm, separated by thin laminae of green clay. Gypsum beds are covered by red and friable beds of mudstone with varied thickness between 2-3 m. Limestone beds are thin (10-50 cm) and present as patches within the red mudstones. Red sandstones and mudstones of Injana Formation exposed in small areas, especially the southwest part of the study area.

4- Sampling and Methodology

Sampling was carried out from four stations representing gypsum rocks in the study area and GPS was used in identifying The position of stations. Sampling also included bringing samples of gypsum rocks from the four stations in the Fat'ha Formation for the purpose of conducting laboratory tests on them, which included petrophysical tests and

determining their suitability as thermal insulators. Where four samples were taken as one sample for each station and the coordinates of each station were determined through the (GPS) as shown in table (1). The four samples that have been taken were in different size and shape.

The laboratory work included performing petrophysical tests that included, absorption ratio, dry density, Specific gravity, and moisture content. The tests were performed in the rock laboratory at the College of Science / Tikrit University, depending on the method of three weights according to the standard specification [11]. The thermal insulating property of gypsum rocks was examined according to the standard in [12] in the laboratories of the Department of Mechanical Engineering / Faculty of Engineering / Tikrit University.

Table 1: Coordinates of the Stations

Station No.	Easting	Northing
1	335274	3915334
2	334566	3913091
3	335202	3914630
4	338559	3924539

5- Petrophysical Tests

The study of petrophysical properties is very significant to study the engineering behavior of any rock material and determine its suitability for construction [13], and these properties (total porosity n%, absorption ratio W.ab%, dry density, moisture content W.C%, true Specific gravity GS dry) were measured by the way of three weights according to [12], as in Table (2). Four sample with different size and shape as one sample for one station where tested by physical analysis according specifications[11].

5-1 Dry Density (ρ_{dry})

The density of the irregular samples was measured using the three weights method according to the specification [11] using a sensitive electronic scale with a precision of (0.1) g. The results were as in Table (2) and density was found according to equation (1).

$$\rho = \frac{Md}{Md - M_{sub}} * \rho_w \quad ....(1)$$

ρdry = dry density (gm /cm^3)
Md= dry sample weight
ρ_w= mass water density
M_{sub}= submersed sample weight

Table 2: shows the results of the petrophysical tests of gypsum rocks in the study area

Station No.	Dry specific gravity	Moisture content (W.C%)	Dry Density (dry ρ) gm /cm^3	Absorption ratio (W.ab %)	Total porosity (n%)
1	2.34	0.94	2.34	1.6	3.80
2	2.19	0.40	2.19	2.4	5.17
3	2.22	0.76	2.22	1.9	4.19
4	2.15	0.70	2.15	2.3	5

5-2 Apparent Dry Specific Gravity (App. S.G.): The apparent dry specific gravity was calculated according to [11] using equation (2). The results show in table (2).

$$ASg_{dry} = (W_{dry}/W_{sat} - W_{sub}/\rho_w)\rho_w\} \ldots\ldots (2)$$

ASg_{dry}=apparent specific weight
Wdry= dry sample weight
Wsub= submersed sample weight
W_{sat} = saturated sample weight
ρ_w = mass water density

Specific Gravity is one of the properties used in rocks classification [14].

5-3 Moisture Content: Which also called the water content of the rocks. It is the ratio of the weight of the water in the rock to its dry weight [15]. The moisture content can be found from equation (3), and the results are shown in Table (2).

$$\text{Moisture Content (M.c)\%} = \{\frac{wn-wd}{wd}\} x\ 100 \ldots..(3)$$

(M.c) % = Moisture Content.
Wn= The weight of moist sample.
Wd= The weight of dry sample.

5-4 Water absorption (W.ab): Water absorption was calculated according to [11] using equation. (4) and the results are shown in Table (2)

W.ab =(Ww/Wd) X 100 ……(4)
W.ab = Water absorption percentage
Ww= water weight in void (gm)
Wd= weight of dry sample (gm)

5-5 Porosity (n%): Porosity means the void inside the rock and it is one of the basic features of carbonate rocks [16]. The calculated of porosity depends on the specification [11] as shown in the equation (5) and the result are mentioned in table (2).

n`%= {(Wsat – Wdry)/ γ w}/ {(Wsat. - Wsub.)/ γ w)} *100…… (5)
n= porosity
Wsat= saturated sample weight
Wdry= Dry sample weight
γ w= Unit weight of water
Wsub= submersed sample weight

6- Thermal Conductivity

Thermal conductivity is defined as the amount of heat transmitted per unit of time during a unit area of homogeneous building of a unit thickness when the difference between the two temperatures for two surfaces is one degree and is measured in units (W/mC^o) [17]. Thermal conductivity is one of the most important physical and thermal tests of heat insulating materials.

7- Thermal Conductivity Test

The thermal conductivity test of the samples prepared of gypsum rocks was conducted in the heat transfer laboratory / College of Engineering / Mechanics Department / Tikrit University. The thermal

conductivity of the samples from the four stations (S1, S2, S3, S4) was examined at different temperatures by controlling the power (in watt), which is transferred to the heater, Fig (2), and as in equation (6), Table (3) shows the results of gypsum rocks thermal insulating in the study area. The sample prepared in 3cm length and 2.5 width according specification [12].

$$K = \frac{Q*\Delta X}{A*\Delta T} \dots\dots (6)$$

K= Thermal Conductivity
Q= Capacity
ΔX = Sample length
A = Sample area
ΔT= Difference in temperature of the sample ends

Fig. 2: Thermal Conductivity test

Table 3: The results of thermal insulating test for gypsum rocks in the study area

Station No.	Difference in temperature of the sample ends ΔT(C°)	Thermal Conductivity K(W/mc°)	Capacity Q(w)
1	4.3	0.62	4.4
2	4.5	0.63	4.7
3	4.9	0.66	5.3
4	5.2	0.69	5.9

8- Evaluation of gypsum rocks for the purpose of thermal insulation

The thermal insulation is using the protection materials to prevent the heating transfer from outside to inside at the summer and reversed situation at the winter. The gypsum rocks that are used in the insulation which have a conductivity thermal factor about (0.62-0.69) (W/mc°). So, when the researcher compares the previous value with the table (4), it will be less than most of the another materials such as concert and iron which is related to the petrophysical properties like the dry density about (2.15-2.34) gm/cm^3. This is referring to the low porosity as well as the rate of absorption between (1.6-2.4) % which represents low value. In fact, when the porosity is high the absorption will be high too then the insulation will be good because the void will be filled up with the air, while when it filled up with water the insulation will be low. In addition, the frozen statues will lead to crack the rock. The gypsum rock porosity about (3.8-5.17) % at low values of porosity lead to protect the absorption. The role of the mineralogy of rocks where the gypsum rocks is hydras calcium sulphite have a conductive more than the calcium carbonate and another materials. The results of thermal insulation test in the study area show that the thermal conductivity of gypsum samples is within the ranges of thermal conductivity coefficients of insulation material at the average (0.65) (W/mc°) according to [12]. Results have shown that gypsum rocks at the study area are of thermal conductivity that can be used in good thermal insulation in buildings at varying ranges of temperatures as in Table (4).

Table 4: Coefficients of thermal conductivity of some materials [12]

No.	Material	Density (gm/cm^3)	Thermal Conductivity (W/mC°)
1	Steel	7.80	45.2
2	Concrete	2.47	2.43
3	Porcelain	2.20	1.21
4	Stone	2.3	0.92
5	Brick	1.70	0.63
6	Plastics	1.28	0.25
7	Wood	0.66	0.13
8	Fiber glass	0.10	0.046

9- Conclusions

1- There is a difference in some bed by physical properties because digenetic process that affect the rocks which leads to difference in the texture and increase in porosity which affect in the physical properties that leads to obtain wide limits and difference of physical properties.
2- The results of the thermal insulation test showed that the thermal conductivity of the gypsum sample are within the range of thermal conductivity coefficients for the insulation materials where the ranged between (0. 62-0. 69) W /m.
3- The field study shows that the layer of gypsum rocks is thick and its solidity is mild with atmospherical ranging from mild to low.

10- Recommendations

1- Conducting combustion tests to find out their tolerance to high temperatures, and sound insulation tests to know the extent of insulation and the possibility of using them as sound insulator.
2- Carrying out a study to measure the extent of the rock layers of gypsum rocks and determine their thickness to know the amount of these rocks in the region and determine their economic importance.
3- Carrying out a study on the possibility of using gypsum rocks for industrial purposes, for example, their use in the manufacture of Portland cement, the manufacture of dyes and gums, and the manufacture of lime, sulfuric acid and agriculture.

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تقييم ملائمة صخور الفتحة الجبسية كعوازل حرارية في قضاء الشرقاط/ شمال العراق

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مركز بحوث الموارد الطبيعية ، جامعة تكريت ، تكريت ، العراق

الملخص

يهدف البحث الى دراسة بعض الخواص الجيوتكنيكية للصخور الجبسية في قضاء الشرقاط وصلاحيتها كعوازل حرارية. تمت النمذجة من اربع محطات ممثلة لمنطقة الدراسة. أظهرت الدراسة ان صخور الجبس تمتلك مسامية مهملة– ضعيفة (3.80– 5.17) %. ونسبة امتصاص مابين (1.6–2.4) %. اما الكثافة فكانت (2.15–2.34 غم\سم3). بينما بلغت قيمة الوزن النوعي (2.15– 2.34), اما محتوى الرطوبة تراوحت قيمة بين (0.40– 0.94)%. وبينت نتائج الفحص الحراري ان معدل قيمة التوصيلية الحرارية لصخور الجبس بلغت (0.65) W/mċ. من خلال الفحوصات التي تم اجراءها تبين صلاحية الصخور الجبسية كعوازل حرارية في منطقة الدراسة حسب متطلبات المواصفة [1].