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Using of Local Limestone as Aggregate in Concrete Mixture

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Abstract

This research deals with the field investigations and construction properties for using limestone as a lightweight course aggregate in concrete mixture in stead of normal coarse aggregate. Concrete cubes samples have been prepared with dimensions of 150*150*150 mm according to ASTM. For these samples the normal coarse aggregate was replaced by 100% coarse crushed limestone. Three types of limestone which were used (Al-Sinea, Makhool and Himreen), it was found that the Al-Sinea type of limestone gave a good combination *(f_{cu} =32.11MPa* without admixtures).

The obtained results showed a suitable reduction in dead loads of structural elements and cost. Accordingly, the usage of limestone will improve the structural applications and concrete mix properties to attain economic viability. These above results make limestone as a good alternative of normal coarse aggregate.

Keywords: Limestone, Lightweight Concrete, Compressive Strength, Material Properties.

استخدام ركام الحجر الجيري المحلي كركام في الخلطة الخرسانية

الخلاصة

يختص هذا البحث بالتحريات الحقلية والخصائص الإنشائية لاستخدام الصخور الجيرية كركام خشن في الخلطة الخرسانية كبديل عن الركام الاعتيادي الثقيل للحصول على خرسانة جديدة أقل وزنا"الى حد ما وذات مقاومة انضغاط معتمدة إنشائيا". حيث تم إعداد نماذج خرسانية لمكعبات قياسية (150×150×150)ملم ، حسب المواصفات الأمريكية المعتمدة لفحوصات المواد، باستخدام الصخور الجيرية المكسرة المدرجة كبديل عن الركام الاعتيادي وبنسبة استبدال 100%في الخلطة ، تم اختيار ثلاث مواقع مهمة تعتبر مصادر أساسية لتوفر هذه الصخور كمادة خام ضمن الرقعة الجغرافية لمحافظة صلاح الدين وهي (منطقة الصينية وسلسلة جبال مكحول وسلسلة جبال حمرين). بينت النتائج أن نوع الصخور المأخوذة من منطقة الصينية هي الأكثر ملائمة حيث حققت مقاومة انضغاط المكعب القياسي عند استخدامها كركام خشن في الخلطة الخرسانية قيمة مقدارها (32,11 ميكاباسكال). أن هذه النتائج التي تم الحصول عليها تشير بشكل واضح لإمكانية تقليل الأحمال الثابتة (الميتة) للمنشآت أو العناصر الإنشائية من خلال تقليل كثافة الخرسانة إضافة لتخفيض كلف الإنشاء وبالتالي فان محاولة زيادة استخدام هذا النوع من الصخور في التطبيقات الإنشائية وتحسين خصائص المنشآت يوفر كفاءة اقتصادية واستفادة من المصادر الطبيعية للصخور كبديل مهم عن الركام الاعتيادي.

الكلمات الدالة:الصخور الجيرية،مقاومة انضغاط الخرسانة،خصائص المواد.

Introduction

Limestones are common and widespread rocks that form the peaks of mountains in the Himalayas, from characteristic karst landscapes and many spectacular gorges throughout the world. Limestone is also important in the built environment, being the construction materials for structures ranging from the Pyramids of Egypt to many palaces and churches. As well as being a good building stone in many places, limestone is also important as a source of lime to make cement, and hence is a component of all concrete, brick, stone buildings and other structures, such as bridges and dams. Limestone strata are common through much of the stratigraphic record and include some very characteristic rock units, such as the Late Cretaceous Chalk, a relatively soft limestone that is found in many parts of the world. The origins of these rocks lie in a range of sedimentary environments: some form in continental settings, but the vast majority are the products of processes in shallow marine environments, where organisms play an important role in creating the sediment that ultimately forms limestone rocks.[1]

Calcium carbonate ($CaCO_3$) is the principal compound in limestones, which are, by definition, rocks composed mainly of calcium carbonate. Limestones, and sediments that eventually solidify to form them, are referred to as calcareous. Sedimentary rocks may also be made of carbonates of elements such as magnesium or iron, and there are also carbonates of dozens of elements occurring in nature.

The economic importance of limestones today lies chiefly in their reservoir properties since many of the worlds major petroleum reserves are contained within carbonate rocks.

Limestones are varied in composition but broadly the components can be classified into four groups: non-skeletal grains, skeletal components, micrite and cement.

The range of pressure in the hard limestone rock between (170 -1150) MPa, while for the relaxed limestone between (850 - 1150) MPa, and the modulus of rupture in the limestone rocks between (70 - 420) MPa.[2]

The present study is dealing with using of the limestone as aggregate in concrete. A variety of properties color, grain or crystal size, composition and texture – fabric, are used to classify the limestone. Other classifications may have a generic or genetic base; a generic classification simply involves defining certain properties and allocating a name to them.[3]

The two most important features of limestone seen in thin section are the actual grain properties (including composition) and rock fabric .In fact the classifications which are widely used are based on the concept of textural(fabric) maturity, where the fabric is believed to relate with the energy level during the deposition of the limestone. Himreen, Makhool and Al-Sinea quarries are used in the present work. Figures (1, 2) and table (1) shows the distance to our location and other details about these quarries.

The main purpose of this study is to produce a new type of concrete, supply source with low cost and easy to use and replace the coarse limestone aggregate instead of normal coarse aggregate. These materials are considered as constructing materials.

Experimental study

<u>Materials preparations</u>

a. Coarse aggregate:

Three samples of limestone were collected from three quarries Himreen, Makhool, and Al-Sinea. All samples were taken according to the location and geological conditions. The limestone samples were crushed by using of Los Anglos broken machine. The sieving was done to separate and analyze the different sizes of produced aggregates according to standard specifications. The sieves with sizes of (4.75-12.5) mm were used for the separation and then the resulting aggregate was washed to eliminate blemishes, and calculate the amount of suitable aggregate for each cube sample, as shown in figure (3) and table(2).[4,5]

b. Fine aggregate:

Taking the samples from a quarry near the location of the study and examine the samples for chemical tests and analysis, and then applying sieve analysis test. Specifying the range used in this mixture

(0.150-2.36) mm.[5]
Gypsum content and total soluble salts were determined for suggested sand from two available quarries in Tikrit and Dooze. Tables (3,4) and figure (6) show the results of these tests. The results above reflect that the sand of Dooze is more suitable for construction elements. This type of sand was used in this research to produce more efficient and acceptable concrete according to standard limit. [5]

C. Cement:
The more commercial type of cement was selected by feasibility studies and practical site survey. Taking samples from cement for each product (Addna,Taslouja and Badosh). The amount of cement was specified to produce one concrete cube. The chemical properties of three available types of cement were tested. The cement of Addna was found to be the best properties and so this type is used in this research. [6]

D. Water:
The Selection of (w/c) ratio of (38%) depends on previous researches. This percent gives an acceptable result by using rough aggregate.

<u>Concrete mix and casting stage</u>

Mix design:

One concrete mix is used from many trial mixes. Details are given in table (5).The result below is coming from using of the determined mix in all samples with nominal cube compressive strength reaching to (35 MPa) on 28th day. Three cubes were casted for each operation. The standard cubes moulds (150*150*150)mm are used for production of concrete samples, cubical specimens were used to test the compressive strength of concrete. The compressive test was done according to ASTM C39 by a compression machine in the laboratory.[7,8]

<u>Curing stage:</u>

After leaving out the concrete in the moulds for one day, curing by water for (3-28) days, was achieved as shown in figure (4). [8]

General properties of limestone

<u>Density:</u>

The specific gravity calculated for every sample and results was as follow, table (6),

Density = weight / volume ……..… (1)

Specific Gravity = unit weight of solid / unit weight of water ……,,,, .. (2)

<u>Porosity and absorption</u>

Porosity and absorption of aggregate are very important. These properties affected its qualities for the bond between aggregate and cement. Affecting concrete strength and freezing and thawing. There are different sizes of pores some of them are big, but others are small. The small pores (4 microns) improve concrete freezing and thawing properties. [9]
Physically, the broken limestone aggregate of Makhool had a grey, semi to yellow color, it is pure from crack with sharp corner, low porosity, does not contain particles. Sinea limestone had white, semi to yellow color, light weight and high porosity[10]. The limestone of Himreen had a red, green and white semi green color. It is bright and light and has a medium porosity. Figure (5) shows samples of Himreen, Makhool, and Al-Sinea rocks.
The important observation on the mixture of elements is the size graduation. The mixture of elements which resistant it must contain rocks which its diameter 5mm and not reach to 20mm.

There are external properties which are important to the nature of rock stone especially to that related to their shape and texture. Roundness describes the measurement of the corner shape to the corner of the bites. This property is affected largely by solidity and resistance of the parent rock and it is affected by the amount of corrosion or wear. It is thought that the shape of bites which are taken from smashed garnet. Depend on the parent rock, the kind of cutter which is, and the percent of shrinking (construction) ((i.e.) the percent of materials inside the cutter and the percent of materials out of

the cutter). According to the British regular properties, the shape of bites is classified to roundness, un-crystallized or irregular, flat (broad), sharp corner, bacillary, bacillary and flat. [11, 12]
The bond between aggregate and the cement dough is very important in the resistance of the concrete, especially in the bending moments. The bond is done because the surface of the aggregate is rough. [13]

There are another physical and chemical properties are related to the bond of aggregate. There are some chemical components in limestone and silica stone have cohesion forces on the surface of smooth particle, but it is difficult to determine the kinds of bond, since there is no acceptable related test. The good bond in smashed concrete must contain completely broken aggregate and some broken particle which is taken from its place. Bond resistance is depending on the cement dough resistance and properties of aggregate surface, so that the bond resistance increases with age of concrete. Although there is a good link or joined between the materials of the cement dough, failure in connection may occur. [14]

Chemical tests

Determination of Organic Materials (O.M.) , pH ,Gypsum% and T.S.S.% :

$$O.M.\% = \frac{w1-w2}{w1} *100 \qquad \text{..........(3)}$$

Where

- $w1$: The weight before burning.
- $w2$: The weight after burning.
- O.M.% :The percent of organic materials.

The gypsum percent obtained by volumetric titration with Na_2EDTA solution, in buffer solution of pH=10, and limestone aggregate type is the best choice listed in table (8).
Due to this experimental study and field investigation, it was found that Al-Sinea to get low density of concrete mix and high compressive strength, table (9).
with the index of Eriochrome black T. The test was established by treating the sample solution with buffer solution. At the same time, the Eriochrome was added. [15]

The results of chemical tests listed in table (7) reflect the low percentage of the organic materials in limestone samples of Makhool and Al-Sinea with respect to samples of Himreen. Thus the first two types are more suitable because of increasing the organic materials concentrations leads to weaken the concrete strength, and the organic content will cause a negative effect in the long term. The organic impurities will disturb the chemical action of hydration. [16,17]

Results and Discussion

Compressive Strength Studies of Concrete Samples

After concrete casting, the final stage (curing) in which the cubes submerged in water for different periods. Hence Makhool cubes were cured for three periods (3, 7 and 28) days. Himreen and Al–Sinea were cured for two periods (7 and 28) days. The primary observations during the preparations and crushing reflect that Makhool aggregate is the hardest samples, so these samples.

The compression test machine is used to determine the compressive strength by applying rate of compression load of (7 kN/sec) up to failure, figure (7).
The cubes of (150*150*150) mm are used in these tests, The average compressive strength for three cubes of Makhool aggregate with 3, 7, and 28 days of curing respectively are listed in table (8). The average compressive strength for three cubes for Himreen and Al-Sinea aggregate with 7 and 28 days of curing respectively,
limestone aggregate type is the best choice to get low density of concrete mix and high compressive strength, table (9).

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Conclusions

1. The Al-Sinea limestone type is considered as a good alternative of coarse aggregate in
considered as a good alternative of coarse aggregate in concrete mix to get lightweight concrete.
2.The economic design of construction elements can be done by using the new concrete mix where the compressive strength reaches to 32MPa.
3.This study is useful for mechanical construction studies such as isolation systems and composite structural elements.
e of most important results is, the increasing of compressive strength for different types of limestone as a concrete samples (cubes) with curing age by water.
5. For most economic design of mixtures use the limestone that available in many locations of Salah Al-deen region.
6. The main results lead to modify the future studies about using of the limestone as aggregate in concrete.
7. The results lead to the applicability of replacing the coarse aggregate (normal aggregate in concrete mix) by limestone aggregate with the standard specifications of concrete mixture.

References

1.Tucker M.E., “Sedimentary Petrology An Introduction” , Blackwell Scientific Publications ,Oxford, p. 252, 1985.
2.Nichols G., “Sedimentology and Stratigraphy” ,Wiley Blackwell, 2nd edition, p. 419,2009.
3.Maurice E. Tucker and V. Paul Wright, “Carbonate Sedimentology” ,U.S.A.,1990.
4.ASTM C330-00,“Standard Specification for Lightweight Aggregates for Structural Concrete”.
5.ASTM C33-01 , “ Standard Specification for Concrete Aggregates”.
6.ASTM,”American Society for Testing and Materials ,Cement , Lime ,Gypsum” ,Vol.04.01 ,2008.
7. Nevell A.M. “Properties of Concrete”, 1985.
8. Zuhier Sako and Artin Lepho, “ Buildings construction”, 1975.
9.ASTM C97- 47(77),”Standard test methods for absorption and bulk specific gravity of natural building stone”.
10.Al-Ansari N.A.,"Geology of Southern Part of Jabal Makhul", M.Sc. Thesis ,University of Baghdad, 1972.
11. British Classification No.(812) , 1967.
12. Scholle P.A., James, N.P. and Read, J.F., “Carbonate Sedimentology and Petrology”, American Geological Union, Washington, 1989.
13.Bhattay J.I., and Gayda J. “Use of Alternative Materials in Cement Manufacturing”, Illinois, U.S.A. , p. 137-166, 2004.
14. Jefferson D.P., “Determination and Providing of Cement Raw Materials, Prospecting and Evaluation of Non-Metallic Rocks and Minerals”, Institute of Geologists, p. 189-208, 1983.
15.Chilingar G.V etal.,”Oil and Gas Production from Carbonate Rocks”, Elsevier, New York, p.408 , 1972.
16.Chatterjee A.K.,” Raw Materials Selection”, in: Bhatty J.I., (ed), innovation in Portland cement manufacturing Portland cement association, Illinois, U.S.A., p. 37-63, 2004.
17.ASTM C170-50(76) ,”Standard test method for compressive strength of natural building stone”.

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Fig. (1): The local area of study (Salah Al-Deen gover.)

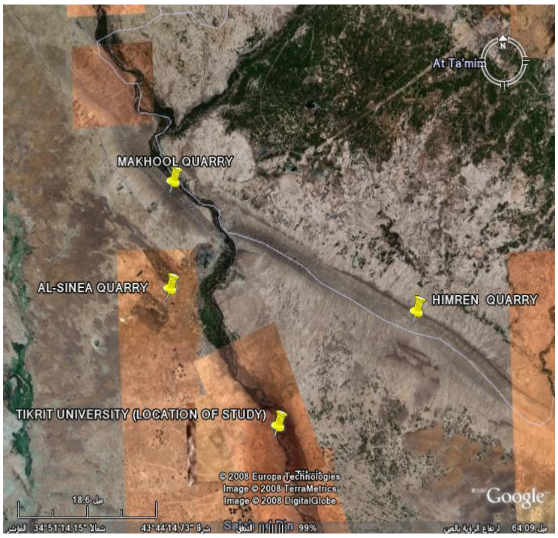

Fig. (2): Quarries locations (Salah-Al-Deen gover.)

Fig. (3) : Sieve analysis test

Fig.(4): Concrete cubes under water curing

Fig (5): Samples of limestone rocks from Himreen, Makhool and Al-Sinea Quarries

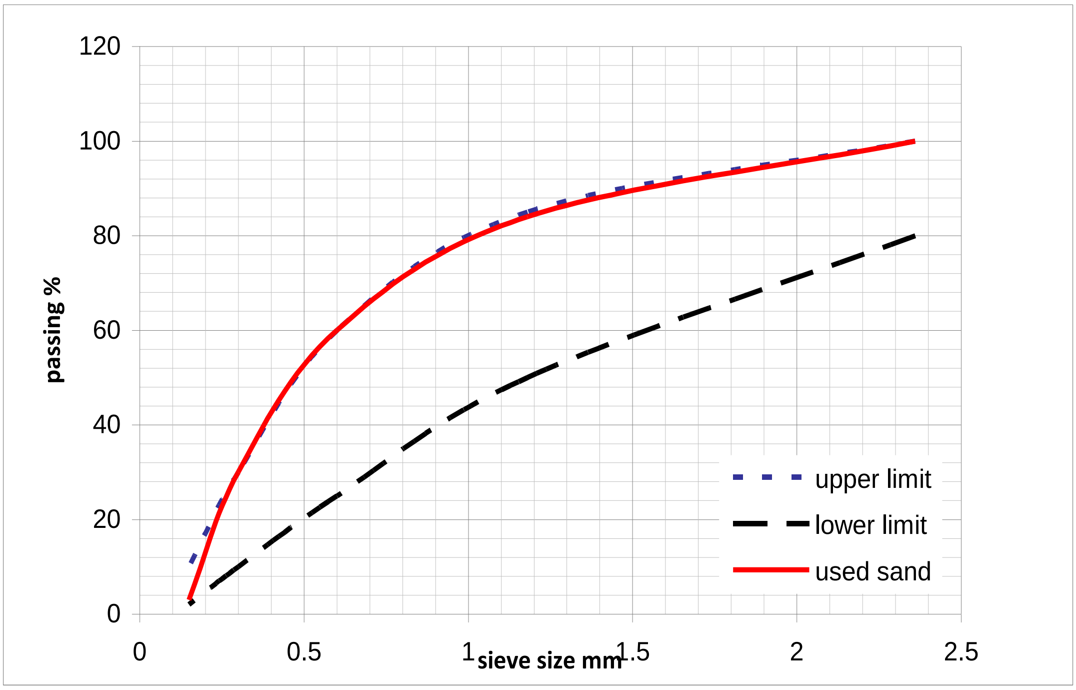

Fig.(6): Sieve analysis curve of fine aggregate sample

Fig.(7): Compression machine setup

Table (1) Quarries coordinates for three locations

Locations	Himreen	Al-Sinea	Makhool
Coordinates	34^{0} $52^{'}$ $06.01^{''}$ N 43^{0} 59' $42.77^{''}$ E	34^{0} $55^{'}$ $34.84^{''}$ N 43^{0} $24^{'}$ $50.20^{''}$ E	35^{0} $08^{'}$ $38.24^{''}$ N 43^{0} $26^{'}$ $16.67^{''}$ E

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Table (2) Cumulative percent on each sieve, and cumulative passing For Al- Sinea coarse aggregate sample

Sieve opening (mm)	percent of retained on each sieve%	Cumulative percent on each sieve	Cumulative passing
12.5	2.25	2.25	97.75
9.5	35.25	37.5	62.5
4.75	52.0	89.5	10.5
2.36	7.5	97	3
1.18	3	100	0

Table (3) Sieve analysis results of Al-Dooze sand

Sieve size	Percent passing by weight (ASTM C33)	Percent passing
2.36-mm (No. 8)	80 – 100	100
1.18-mm (No. 16)	50 – 85	84
600-µm (No. 30)	25 – 60	80
300-µm (No. 50)	10 – 30	42
150-µm (No. 100)	2 – 10	3

Table (4) Sand chemical test result for Tikrit and Al-Dooze quarries

Quarry\Test	Gypsum%	T.S.S.
Tikrit	0.2	2.5
Dooze	0.15	1.4

Table (5) Adopted Mix*

Mix ratios(weight)	w/c ratio	Mix proportions (kg/m^3)			
		Water	Cement	Sand	Gravel
1:1.2:2.3	0.38	190	500	600	1150

Without using s.p.(super plasticizer)*,replaced the normal aggregate by lightweight limestone aggregate.

Table (6) Specific gravity test results

Sample	Volume (m^3)	Weight(kg)	Density(kg/m^3)	Specific gravity
Sinea	$58*10^{-6}$	0.090	**1551.7**	1.552
Hemreen	$27*10^{-6}$	0.055	2037	2.037
Makhool	$30*10^{-6}$	0.072	2416.3	2.416

Table (7) O.M., Gypsum%, T.S.S., and pH test results

borrow	Himren	Makhool	Al-Sinea
O.M.%	15	3	4.5
Gypsum%	0.2	0.05	0.56
T.S.S.%	2.3%	2.1%	2.9%
pH	6.8	7.3	6.9

Table (8) Compressive strength of concrete cubes with different water curing ages (using Himreen, Makhool and Al-Sinea types of limestone coarse aggregate)

Limestone aggregate type	3 days		7 days	28 days
	cube No.	f_{cu} ,Compressive strength (MPa)	f_{cu} ,Compressive strength (MPa)	f_{cu} ,Compressive strength (MPa)
Himreen	**1**	-	14.22	20.70
	2	-	14.44	17.80
	3	-	15.33	19.11
	Av.	-	**14.66**	**19.20**
Makhool	**1**	5.60	22.22	22.67
	2	10.70	12.44	31.33
	3	9.11	14.00	30.22
	Av.	**8.47**	**16.22**	**28.00**
Al-Sinea	**1**	-	18.67	28.00
	2	-	21.33	32.00
	3	-	24.22	36.33
	Av.	-	**21.41**	**32.11**

Table (9) Average of unit mass and compressive strength average results for different concrete samples

Sample Type (cube)	Mass (kg)	f_{cu} ,Compressive strength (MPa)	Unit Mass (kg/m^3)
Himreen	7.710	19.20	2284.44
Makhool	8.265	28.00	2448.88
Al-Sinea	5.832	32.11	1728