

CRUSHED LIMESTONE AS COARSE AGGREGATE IN CONCRETE BLOCKS ⁺

إنتاج كتل خرسانية باستخدام مخلفات الحجر الجيري كركام خشن

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Abstract :

Concrete blocks of (15cm. x 20cm. x 40cm.) in size were cast using the crushed limestone (produced in large quantities in Al-molawatha region in north-east of Mosul city) as coarse aggregate instead of the river gravel.

Based on the experimental work of the present investigation, the followings may be drawn :

1. Crushed Limestone may be used satisfactorily as coarse aggregate for making quality concrete of a desirable compressive strength, and it may be suggested to be a solution for regions where natural aggregate are scarce and a reduction in the dead weight of structure may be desirable.
2. The unit weight of Crushed Limestone concrete is (2060) kg/m³ which is about (10)% lower than that of river gravel concrete, and the blocks obtained may be classified as a (class B) in accordance with Iraqi Specification.
3. The absorption capacity of the crushed limestone concrete is lower than that of the river gravel concrete.
4. This research enable in preventing the environment and industrial places from pollution, as well as saving areas for collecting these crushed materials.
5. This research has a certification of testing industrial specimens No. 2/12/1/3644 on 20/12/2004 issued by the Ministry of Planning and Central Measurement & Quality Control Office, Construction Department[17].

Key words : crushed limestone, concrete blocks, coarse aggregate.

المستخلص :

تم إنتاج كتل خرسانية بأبعاد (١٥ * ٢٠ * ٤٠) سم باستخدام الركام المكسر الناتج من تقطيع مخلفات الحجر الجيري (الذي يقطع لغرض استخدامه في مجالات البناء المختلفة وبكميات هائلة في مواقع العمل في المنطقة الملوثة في مدينة الموصل) كبديل عن الحصى النهري الطبيعي .
أظهرت نتائج البحث ما يلي :

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١. بالإمكان استخدام الركام المكسر الناتج من تقطيع مخلفات الحجر الجيري كبديل عن الحصى النهري الطبيعي بشكل ناجح في إنتاج خرسانة ذات مقاومة انضغاطية جيدة مقارنة مع المواصفات القياسية ، وتساهم هذه الطريقة في حل مشكلة المناطق التي تفتقر إلى وجود ركام نهري طبيعي ، إضافة إلى أنها تعمل على تقليل الحمل الميت للمنشآت
 ٢. إن وحدة الوزن (الكثافة) لهذه الخرسانة (٢٠٦٠) كغم / م^٣ ، أي أنها حوالي (١٠) % أقل من كثافة الخرسانة الاعتيادية المنتجة بالركام الطبيعي النهري ، وبالإمكان تصنيف البلوكات الناتجة ضمن صنف (ب) حسب المواصفات العراقية.
 ٣. إن قابلية الامتصاص للبلوكات المصنوعة بالركام المكسر أقل من مثيلاتها المنتجة بالركام النهري الطبيعي.
 ٤. يساهم هذا البحث في تخليص المناطق الصناعية من تلوث البيئة كونه يعمل على إزالة كميات كبيرة من المخلفات من المواقع الصناعية التي تستعمل بهذه المادة ، إضافة إلى أنه يوفر المساحات الكبيرة اللازمة لتجميع هذه المخلفات .
 ٥. من الجدير بالذكر فأن هذا البحث حاصل على شهادة فحص النماذج الصناعية الصادرة من وزارة التخطيط والتعاون الإنمائي / الجهاز المركزي للتقييس والسيطرة النوعية / دائرة السيطرة النوعية / القسم / الإنشائية ذي العدد ٣٦٤٤/١/١٢/٢ في ٢٠٠٤/١٢/٢٠ [17].
- الكلمات المفتاحية : مخلفات الحجر الجيري ، البلوكات الخرسانية ، الركام الخشن.

Introduction :

For a long time, the governorate of Mosul was known for having many natural treasures including many rock places for limestone, like : Baathri ; Mergii ; and Singar.

This material is frequently used in building and finishing, therefore, many factories were established whose interest was the industry of (Hillan), the stone that is used for covering the facades for its beautiful look

This industry requires the process of crushing, cutting, and shaping the stone into uniform geometrical shapes, so that it can be used in finishing.

This results in producing a huge amount of crushed and un uniformed stones, which is useless for building and finishing purposing. These wastes represent a source of pollution to the environment, moreover, they require a wide area to contain them.

Thus, there was an idea for using these wastes as replacements materials in producing concrete blocks whose dimensions are similar to the ordinary cement blocks, in order to use them in walls , partitions and casting in certain sites. In this way, river gravel was replaced by these wastes after processes like crushing, sieving and grading them according to Concrete Standard Specifications Preparing this kind of aggregate (resulted from crushing the wastes of limestone) includes crushing and sieving these wastes in order to get the appropriate grading, according to Concrete Standard Specifications, if compared to river gravel in order to be economically appropriate Moreover, river gravel may include harmful materials such as : clay, dust,

salts, iron compounds and organic materials, which may have a negative effect on the properties of the resulting concrete[1],[2]. Since limestone is available in many geological assemblies in Ninevah province, there were many attempts to evaluate the use of these stones in some industries, especially constructional ones like cement, lime, filler, and building stones[2],[3],[4],[5].

Objective and Significance of the research :

The purposes of this research are :

- (a) To justify the use of crushed limestone (locally available) as a substitute for river gravel in concrete blocks, i.e. to find the good replacement for sand and gravel in concrete, because the great expansion in building houses, industrial projects and service projects resulted in great and continuous demand of gravel and sand. Besides, these materials are very rare in some spots in Iraq, as well as the light weight of this product after dryness, which makes it useful in multi-story buildings[6],[7],[8],[9].
- (b) This research has an economical benefit because it uses large amounts of limestone wastes, which spread in many spots, resulting from cutting and shaping (Hillan) stones which are used in decorating buildings facades. Thus, the demand for coarse aggregate (river gravel) which is relatively expensive nowadays, besides, the finely crushed material, resulted from cutting and crushing stones, can be used as fine aggregate instead of river sand, and as a filler in highways.
- (c) To prevent environmental pollution in the factories and the adjacent areas by removing the large amounts of limestone wastes which are resulted from cutting (Hillan) stones, which are accumulated in the factories area (Al-molawatha Region) in north-east of Mosul, the wastes that need large areas together them, and which cause the complaint of the owners of these factories.

Experimental Investigation :

1.Materials Used : All materials used in this investigation were locally available materials near the city of Mosul. A sample of crushed limestone was prepared by mixing all the types of the crushed limestone (Baathri; Mergii; and Singar) which obtained from many regions and sites, and their main properties such as : grading, specific gravity, angularity are illustrated in Table (3.3)[10].

2. Experimental Program : The mentioned materials were used in preparing and casting concrete blocks of (15x20x40) cm. in size, using a mix proportion of (1 : 1.5 : 3), and w/c = 0.5 (by weight), whose cement content was (400) kg/m³, as follows :

1. Two types of aggregate : river gravel (rounded), and crushed limestone (irregular), their

physical tests were done in accordance with (BS:882:1992)[10], see Tables (3.1 , 3.2, and 3.3).

2. All aggregates are in dry condition (w/c ratio is adjusted for S.S.D. condition). The crushed

limestone were immersed in water for a period of (24) hours before using.

3. Compressive Strength, Unit Weight (Density), and Absorption Capacity tests of the crushed limestone concrete blocks were done in accordance with BS:812:Part 1:1975, BS:882:1992, BS:1881:Part 111 and Part116:1983[10], or ASTM C-33 (1986)[11].

Table (3.1): Sieve Analysis for coarse aggregate* in accordance with BS:882:1992.

Sieve size (ASTM)	% Passing	BS:882:1992 (Medium)
1 ½	100	100
¾	100	90 – 100
3/8	75	30 – 60
No. 4	5	0 – 10

* This including the river gravel and the crushed limestone.

Table (3.2): Sieve Analysis for fine aggregate in accordance with BS:882:1992.

Sieve size (ASTM)	% Passing	BS:882:1992 (Medium)
3/8	100	100
No.4	100	95 – 100
No. 8	73	65 – 100
No. 16	81	45 – 100
No. 30	66	35 – 80
No. 50	36	5 – 40
No. 100	0	0 – 10

Table (3.3) : Main properties of materials used.

Property	Aggregates		Sand	Specification
	River Gravel	Crushed Limestone		
Dry Sp. Gravity	2.63	2.1	2.59	ASTM C127 & C128 (1978)[11]
S.S.D. Sp. Gravity	2.64	2.4	2.65	
App. Sp. Gravity	2.66	2.44	2.79	
Absorption Capacity (%)	0.5	7.5	2.9	
Rodded Unit Weight (kg/m ³)	1716	1125	1765	ASTM C29 - 78 (1979)[11]
Voids (%)	33.255	41.629	33.000	
Angularity No.	0.255	8.629	0.400	BS : 812 : Part 1, (1975)[10]
Angularity Index	1.038	2.294	1.060	

Fineness Modulus	6.55	6.55	2.78	BS:882:1992[10]
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Notes :

1. Cement : in accordance with P.P.C. Specifications.
2. Tap water for mixing is used.
3. No additives were used.
4. Concrete is mixed mechanically.
5. Crushed Limestone Aggregate were immersed in water for (24) hours for absorption.

** All the coarse aggregate (river gravel and crushed limestone) are of (20) mm. maximum aggregate size, and sand BS medium zone (M), their grading requirement are in accordance with BS:882:1992. The river gravel and sand were taken from Khazer area near city of Mosul.

Analysis and Discussion of Results :

1. Scope : The test results were discussed under different categories. The results include the properties of the resulting concrete blocks in both fresh state (workability) and hardened state (compressive strength, unit weight, and absorption). The geometry of the resulting blocks were also determined and discussed. Test results were tabulated in Table (4.1).

Table (4.1) : Concrete Blocks Results.

A/ Experimental results:

Type of Block	Class	Compressive Strength (N/mm ²)	Absorption Capacity (%)	Dimensions (in cms.)	General Look
Solid (using the crushed limestone as coarse aggregate)	B	9.0	7.0	15x20x40	Acceptable

B/ Iraqi Specification No. 1077 in 1987[12]:

Type of Block	Class	Compressive Strength (N/mm ² .)	Absorption Capacity (%)	Dimensions (in cms.)	General Look
Solid (using the	B	9.0	15	15x20x40	Acceptable

river gravel as coarse aggregate)					
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2. Effect of the type of coarse aggregate on the workability of concrete :

Here, we must give a certain attention to the resulting workability of the concrete made with crushed limestone aggregate, it gains a lower slump than that of concrete with river gravel.

This is due to :

A/ the higher angularity of the crushed limestone aggregate which need a higher quantity of water in order to gain the same workability of the river gravel concrete (the greater the angularity of the surface, the greater is the surface area to be wetted, demanding more mixing water to obtain the same degree of workability).

B/ for a given grading, the voids in the coarse aggregate increases as the aggregate becomes more angular. Therefore, in a concrete mix in which the mortar content is constant, the mortar/voids ratio decreases as the aggregate becomes more angular, which leads, as may be expected, to a reduction in workability. Thus, the more angular the aggregate is, the lower the mortar / voids ratio and, consequently, the lower the workability of the mix[13].

3. Effect of the type of coarse aggregate on the compressive strength of concrete :

The compressive strength test of the concrete block specimens shows that, for a given w/c ratio and mix proportion, concrete with crushed limestone aggregate develops compressive strength same as that concrete with river gravel aggregate (see Table 4.1), follows the standard

specification in testing (tested immediately after taken from the curing tank, i.e. as they are wet).

Examining a failure crushed limestone concrete block, shows that, the crushed limestone particle itself was crushed when the compression load is applied[14].

4. Effect of the type of coarse aggregate on the absorption capacity of concrete :

Test results show that the absorption capacity of the crushed limestone concrete is lower than

that of the river gravel concrete. This is because that the absorption capacity test was done for the crushed limestone concrete specimens containing the saturated crushed limestone coarse aggregate (immersion in water for 24 hours)[14].

5. Effect of the type of coarse aggregate on the unit weight of concrete :

Generally, the unit weight of the river gravel ordinary concrete varies between (2300-2400) kg/m^3 , while for the crushed limestone concrete which is tested in this investigation the unit weight was (2060) kg/m^3 . Light-weight concrete has a unit weight varies between (500 to 1900) kg/m^3 . So from the above discussion, the crushed limestone concrete can be classified as a "Medium- weight concrete". The main factor that influence the unit weight of concrete is the specific gravity and the rodded unit weight of the aggregate (see Table 3.3)[15].

Conclusions :

Based on the observation and experimental work of the present investigation, the following conclusions may be drawn :

1. A medium - weight concrete of a desirable compressive strength may be obtained, using the crushed limestone as coarse aggregate.
2. The unit weight of the crushed limestone concrete is (2060) kg/m^3 which is about (11%) lower than that of river gravel concrete, and may be classified as (class B) in accordance with Iraqi Specification No. 1077 in 1987[12].
3. The absorption capacity of the crushed limestone concrete is lower than that of the river gravel concrete.
4. The workability of the crushed limestone concrete is lower than that of river gravel concrete leading to high cohesiveness and lower the ability of the mix to bleed and segregate. In order to increase the workability of the mix, it is preferable to increase the materials finer than sieves (No. 30, No. 50, and No. 100), as well as, by using a certain types of admixture named Plasticizers[16].
5. Crushed limestone may be used satisfactorily as coarse aggregate for making a good quality

concrete of a desirable compressive strength, therefore, it may be suggested to be a solution

for regions where natural aggregate are scarce and where a reduction in the dead weight of

the structure may be desirable.

6. Finally, removing the large amounts of limestone wastes led to prevent environmental pollution in the (Hillan) factories and the adjacent areas near these factories, these wastes need large areas together them, and which cause the complaint of the owners of these factories.

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