Use Of Crushed Bricks As Coarse Aggregate In Concrete

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Abstract

The investigation reported in this paper is carried out to study the feasibility of using crushed bricks to substitute the coarse aggregate (gravel) in concrete. Two types of concrete mixing are prepared. The first one is a mixture of 1:2:4 without crushed bricks and is used as a reference mixture .The second one is made of different weight of crushed bricks (as a percentage from the weight of the coarse aggregate). A total of 30 numbers of concrete specimens are casted with and without crushed bricks and tested under compression and split tension as per relevant to British standard specifications.

Test results indicated that using crushed bricks reduces the strength of concrete. Also, the percentage of water to cement ratio increases for constant slump when the percentage of crushed bricks increased.

Key words: Recycled aggregate, Crushed bricks, Light weight concrete, Demolition waste.

استخدام مكسر الطابوق كركام خشن في الخرسانة

الخلاصة

يهدف هذا البحث إلى دراسة إمكانية استخدام مكسر الطابوق كركام خشن في الخرسانة. تم تحضير خلطتين خرسانيتين: الأولى بنسبة 1 : 2 : 4 ودون استخدام مكسر الطابوق واعتمدت كخلطة مرجعية لغرض مقارنة النتائج أما الخلطة الثانية فقد تم تحضيرها باستخدام نسب مختلفة من مكسر الطابوق بالنسبة لوزن الركام الخشن. تم تحضير 30 نموذجا من الخرسانة مع ودون استخدام مكسر الطابوق وتم فحص النماذج تحت تأثير الحمل ألانضغاطي وحمل الشد غير المباشر وحسب متطلبات المواصفات القياسية البريطانية. أظهرت النتائج أن استخدام مكسر الطابوق كركام خشن أدى إلى تقليل مقاومة الخرسانة (الانضغاط والشد) بالإضافة إلى ذلك فقد ازدادت نسبة الماء إلى الأسمنت عند تثبيت الهطول.

الكلمات الدالة: الركام المعاد (المدور)، مكسر الطابوق، خرسانة خفيفة الوزن، مخلفات البناء.

Introduction

Fine and coarse aggregate make up the bulk of concrete mixture. Sand, natural gravel, and crushed stone are mainly used for this purpose. Recycled aggregates (from construction, demolition and excavation waste) are increasingly used as partial replacements of natural aggregates.

Concrete can be successfully produced using recycled materials. The use of recycled aggregate concrete (RAC) has steadily increased during the last two decades and its current field of applications includes: lightweight concrete, lightweight aggregate, asphalt concrete, concrete exposure to high temperatures and road construction. The use of crushed waste as aggregate in concrete has began in Europe since the Second world War [1].

In Japan, after the Second world War, many buildings are constructed from crushed waste because of the need for low-cost and rapidly constructed

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buildings. These buildings remained functionally good up to date.

The development of recycling technology in Germany dates back to about 1900 [2].

Crushed bricks are extensively used in parts of India and Bangladesh for concrete making and the performance of this concrete is found to be quite satisfactory [3]. The same investigation has shown that the modulus of elasticity of brick-aggregate concrete is about 30% lower and the tensile strength about 11% higher for the same grade of the normal concrete.

Husain M (1995) studied the use as coarse aggregate of crushed bricks untreated or treated with cement syrups of various consistency. They found that, the compressive strengths of crushed brick concrete are 75-80% of that of normal concrete at 28 days while the splitting tensile strength are higher than that of normal concrete and the modulus of elasticity is lower than that of normal concrete.

Extensive work on RAC has established that using of various types of recycled aggregate such as contaminated crushed brick, light weight crushed bricks, light weight expanded clay, low-strength bricks, granulated plastic, glass and fiber glass waste materials in concrete produces concrete with light weight, light density and low costs [5-12].

These works presents the results of a testing programme to examine the possibility of using crushed clay bricks as aggregate in bituminous mixtures and established the physical and mechanical properties of new and recycled crushed clay brick aggregates for use in Portland cement concrete (PCC).

The results derived from these investigations showed that asphalt concrete specimens prepared using aggregates crushed from unused clay and recycled bricks outperformed specimens made with granite aggregate and most of the crushed clay-brick aggregates tested can be used in producing PCC for low-level civil engineering applications and that some kinds of brick aggregate possess good physical and mechanical properties that qualify them for producing high-quality concrete. Furthermore, with increase in population and construction activities, the quantity of demolition wastes generated from various types of construction will increase manifold in the coming years. These construction waste can effectively be used for making lightweight low cost RAC after exploring their suitability.

In this investigation, an attempt has been made to study the feasibility of using crushed bricks of locally available construction waste for making RAC. The type of waste bricks considered in this study is obtained during the construction of some buildings in Tikrit university site and this type is tested to get its mechanical properties before used. Normal concrete specimens using normal aggregate are also casted and tested to compare their results with RAC made from construction waste. Test results obtained are presented and discussed herein this paper.

Materials Used in this Work

1. Cement: Portland cement manufactured by united cement company (Tasluja – Sulaymaniyah). The specific gravity of the cement is 3.15. Chemical analysis of this cement is given in Table (1) and its mechanical properties, provided by the manufacturer, are summarized in Table (2).

2. Aggregate: uncrushed type obtained from natural deposits in Salah Aladdin.

- Fine aggregate: satisfy the British standard (B.S.882: 1973), grading area (3), specific gravity in saturated surface dry (SSD) is 2.65 and SO_3 ratio is (0.05%).

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- Coarse aggregate: satisfy the British standard (B.S.882: 1973), specific gravity (SSD) is 2.73, SO_3 ratio is 0.01% and maximum aggregate size is 20mm.

3. Water: water available in the engineering college /Tikrit university campus conforming to the requirements of water for concerting and curing as per BS:1881:1970.

4. Crushed bricks: obtained from recycled bricks by crushing as shown in Figure (1), conforming to the requirements of IRQ.S. 25 / 1988 type (b). Its mechanical properties are summarized in Table (3) and the sieve analysis is shown on Figure (2).

Experimental Work

Thirty concrete specimens are casted with and without using of crushed bricks. The specimens considered in this study consists of 15 numbers of 150 mm side cubes, 15 numbers of 150 mm diameter and 300 mm long cylinders.

The nominal mixing proportion used for casting the specimens iss 1:2:4 (cement : sand : coarse aggregate) by weight with slump of (4-6) mm as a base to get constant workability for all specimens when designed to satisfy the American standard (ASTM C143)[13]. A variable weights of crushed bricks (i.e., ratio of weight of crushed bricks to weight of coarse aggregate) of (0%, 25%, 50%, 75% and 100%) are used. The crushed bricks are submerging in water for 24 hours and then dried to get saturated surface dry conditions.

Cement, sand, and coarse aggregate (or crushed bricks) are mixed in dry state by hand and then the required quantity of water is added and mixed thoroughly. Before casting, machine oil is smeared on the inner surfaces of the cast iron mould.

Concrete is poured into the mould in three layers and compacted thoroughly using a standard compact metal rod of squre section with 25mm side, 1.8kg weight and 380mm long. The number of compact beats is 25 times for cubes and 20 times for cylinders for each concrete layers[14]. The top surface is finished by means of a trowel. The specimens are removed from the mould after 24 hours and then cured under water for a period of 28 days. The specimens are taken out from the curing tank just prior to the test. The tests of compressive and split tensile strengths are conducted using a 3000 kN compression testing machine. These tests are conducted as per the relevant standard British specifications[14] .

Results and Discussion

Figures (3&4) show the test results obtained from concrete cube and cylinder specimens with and without crushed bricks. The results reported are average of 3 specimens at age of 28 days and satisfies BS: 1881 : part 3 : 1970, 1881 : part 4 : 1970 and IRQ.S. 52/1970 requirements[14]. From these Figures, it is clear that using of crushed bricks in concrete reduces its strength in compression and tension and the reduction in compression strength is more than that of split tension specially when the percentage of crushed bricks are (75% and 100%). The reduction in strength may be attributed to three reasons:

(i)The crushed bricks failed to develop proper / adequate bond with concrete and cement matrix.

(ii)Because of high porosity of the surfaces of the crushed bricks, the mixture need more water to get the required slump.

(iii)The crushed bricks made the mixture unworkable because of roughness of the

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surfaces of crushed bricks aggregates affecting the compaction distribution upon the concrete layers. The relationship between water to cement ratios and crushed bricks to coarse aggregate ratios is shown on Figure (5).

It can be seen from this figure that water to cement ratio is increased when the crushed bricks to coarse aggregate ratio increased. It is observed during the test that the cylindrical specimens with and without crushed bricks failed catastrophically in a brittle manner and these have broken into two pieces suddenly, i.e., without any warning while cubic specimens failed slowly by developing small size crack on the tension side of the specimens and also these did not break into two pieces which indicate a ductile failure.

This sort of failure is one of the most important criteria for the design of structures subjected to seismic, impact, and dynamic loadings. Figure (6) shows the best curve, the best equation with the most adequate (R) between compression and split tension strengths.

Conclusions

1. This study has found that crushed bricks can be used satisfactory as coarse aggregate for making concrete of acceptable strength characteristics.

2. The use of crushed bricks as coarse aggregate decreases the compressive strength of concrete about (11-87)% at age of 28 days according to the ratio of crushed bricks that used.

3. The splitting tensile strength of crushed brick concretes are lower than that of normal concrete. The ratio ranged from (0.2-1.4) .

4. Use of crushed bricks as coarse aggregate in concrete increases the water to cement ratio as it increases the absorption of concrete to the water.

5. The workability of the crushed bricks concrete is lower than that of normal concrete.

Acknowledgements

The financial support provided by college of engineering / university of Tikrit to carry out this investigation is gratefully acknowledged. The author thanks (Mr.) Mustafa KH. Kasem assistant professor/college of engineering /civil engineering department and (Miss) Shatha Hellan, responsible of materials laboratory in civil engineering department for their assistance during casting and testing of concrete specimens reported in this study.

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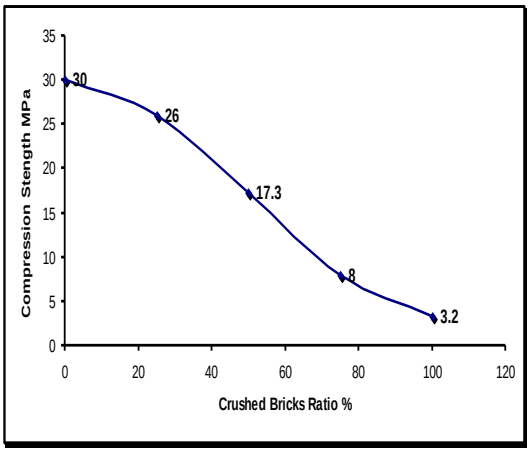

Figure (2) : Sieve Analysis for Crushed Bricks

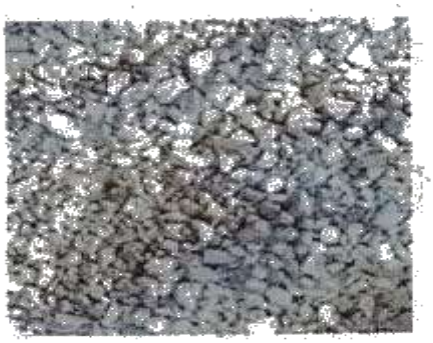

Figure (1) : A picture for the Crushed Bricks Used in the Study

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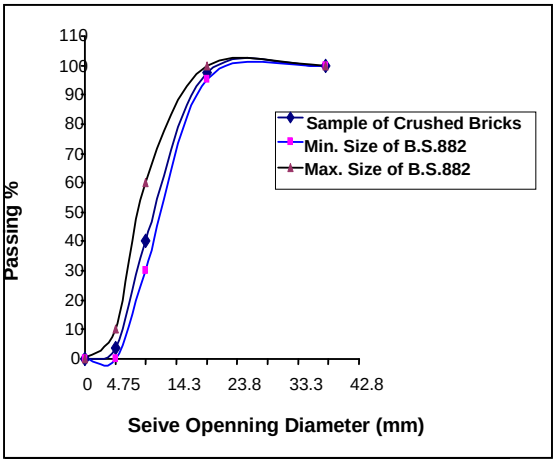

Figure (3) : Influence of Using Crushed Bricks on Compression Strength

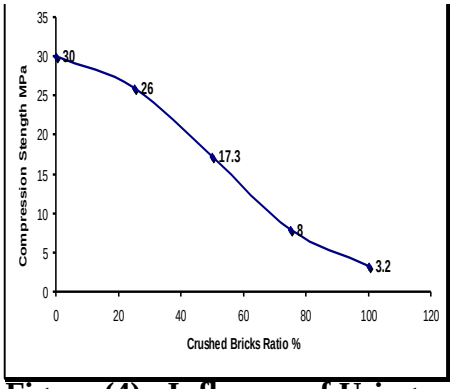

Figure (4) : Influence of Using Crushed Bricks on Split Tensile

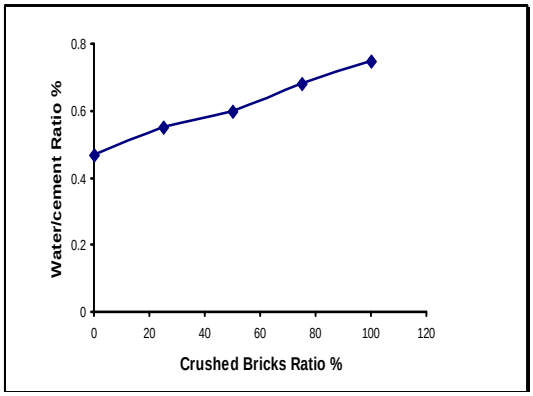

Figure (5) : Influence of Using Crushed Brickson Water / Cement Ratio

Table (1)Chemical Composition of Cement

Compound	%by weight
Insoluble	1.32
SiO_2	16.5
Al_2O_3	8.6
Fe_2O_3	3.5
MgO	0.9
SO_3	1.5
C_3A	4.84
Loss on ignition	1.21

Table(2)Mechanical Properties of Cement

Properties	Average
3 day compressive strength (standard mortar)	23.8
Initial setting (min.)	57
Final setting (min.)	470
Fineness (m^2 /kg)	280

Table (3)Mechanical Properties of Bricks

Properties	Average
Dimensions	(240*115*75)mm
Compressive strength	16.14 MPa
Absorption	12.54 %
Inflorescence	slight

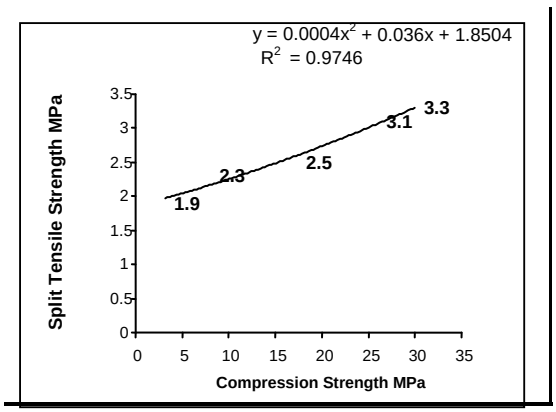

Figure (6) Relationship Between Compression and Split Tensile strengths (Best Curve)