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Mechanical Properties of Fiberous Recycled Aggregate Concrete

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Abstract

Conservation of natural resources and rapid urbanization has prompted growing demand for natural aggregate by construction industry. This demand is compounded by considerable decline in the availability of good quality natural aggregate and enormous increase in quantities of demolished concrete.

This report presents a study of mechanical properties of concrete made by using the demolished concrete as coarse aggregate in addition to steel fibers.. In the concrete mixes the ratios of concrete aggregate range from 0% to 100% with the increment of 25% the ratio of steel fiber was 6% of whole mix volume. Three concrete mixes have been prepared with proportion of 1:2:4, the water cement ratio was 0.5. The essential mix was control mix without steel fiber for comparison, the other mixes with or without steel fibers with different proportion of recycle concrete aggregate. The mixes were casted in standard specimens, cylinders and cubes and tested under static loading The specimens were tested for compression strength and splitting tensile strength. This research shows that increasing recycle concrete aggregate will decrease the compressive strength and splitting tensile strength but adding steel fibers will increase these strengths. The recycled concrete aggregate with steel fiber are found to make a good quality concrete therefore recycle concrete aggregate can be used successfully for structural concrete instead of natural aggregate .

Key Words:- Crushed concrete, Steel fibers, Fibers,recycled concrete, Concrete waste, Concrete aggregate.

الخواص الميكانيكية للخرسانة الحاوية على ركام خرساني مع استخدام مكسر برادة الحديد

الخلاصة

أن إعادة استخدام أوتدوير المخلفات الإنشائية والهدم هي أحد أكبر مكونات التنمية المستدامة لما له أهمية في المحافظة على البيئة و المحافظة على موارد مصادر المواد الطبيعية من النضوب.

في هذه الدراسة تم استخدام الركام الخرساني المدور مع إضافة برادة الحديد.حيث أستخدم مكسر الخرسانة بنسب تعويضية من الركام الخشن الطبيعي (0،25،50،75،100)% مع إضافة برادة الحديد بنسبة (6%) من حجم الخلطة الكلي.

تم تحضير ثلاث خلطات خرسانية الأولى بنسبة 4:2:1 مع نسبة ماءاسمنت 0،5و بدون استخدام مكسر الخرسانة و برادة الحديد و اعتمدت كخلطة مرجعية لغرض مقارنة النتائج. أما الخلطات الثانية والثالثة فقد تم تحضيرها باستخدام نسب مختلفة من مكسر الخرسانة بنسب تعويضية مختلفة مع أو بدون إضافة برادة الحديد كألياف.

وبعد خلط الخرسانة تم صبها في قوالب قياسية أسطوانت و مكعبات و فحصت تحت تأثير الحمل الأنضغاطي و حمل الشد الغير مباشرو حسب متطلبات المواصفات القياسية البريطانية.

أظهرت النتائج أن تأثير استخدام مكسر الخرسانة كركام خشن في الخلطات الخرسانية أدى إلى نقصان في مقاومة الخرسانة (الانضغاط والشد الغير مباشر) ولكن عند إضافة برادة الحديد الى الخرسانة كألياف أدى الى زيادة في مقاومة الخرسانة (الانضغاط والشد الغير مباشر) .

يهدف البحث إلى أمكانية أعادة استخدام مكسر الخرسانة كركام خشن بالإضافة إلى برادة الحديد كألياف في الخلطات الخرسانية.

وكذلك أظهرت النتائج أيضا إلى ملائمة استخدام مكسر الخرسانة كركام خشن بدلا من الركام الطبيعي في الخلطة الخرسانية لاغراض أنشائية خصوصا في المناطق التي تفتقر إلى الحصى الطبيعي أو الحجر المكسر أو في المناطق التي يكثر فيها مخلفات البناء و ذلك لحماية البيئة من الانقاض الناتجة من المباني و المعامل .و كذلك لتقليل من مواقع ردم أنقاض البناء و فتح المواقع القديمة للاستفادة من مكسر الخرسانة و أعادة تدويره في خلطات خرسانية جديدة.

الكلمات الدالة: مكسر الخرسانة، برادة الحديد، الألياف، كسر الخرسانة المدور، أنقاض الخرسانة، الركام الخرساني.

Symbols

RCA: Recycle concrete aggregate.
Rr: The ratio of recycle concrete aggregate to total coarse aggregate.
TCA : Total coarse aggregate.
SFRC: Steel fiber recycle aggregate .
SFRRAC: Steel fiber reinforced recycle aggregate concrete.
RA: recycle aggregate.
NA: Natural aggregate.

Introduction

The amount of concrete debris collected from demolished structures is huge. Without proper treatment it can cause secondary pollution. The application of building rubble collected from damaged and demolished structures become an important issue in every country. After crushing and screening, these materials could serve as recycled aggregate in concrete. Thus recycling aggregate and reusing this concrete debris can not only reduce the waste but also transform them into aggregate resources[1].

Many significant researchers have been carried out to prove that recycled concrete aggregate could be a reliable alternative as aggregate in production of concrete. A widely reported recycled aggregate are suitable for non structural concrete application[2].Recycled aggregate also can be applied in producing normal structural concrete with addition of fly ash and condensed silica fume etc[3].

Strength concrete is affected by using the type of coarse aggregate used. It is necessary to know the characteristics of RCA and the effects of using RCA in concrete[4].

Recycled aggregate normally has higher water absorption and lower specific gravity [5]. Density of recycled aggregate used is lower than the density of normal aggregate. Porosity of recycled aggregate is also much higher than those of natural aggregate[6]. Recycled aggregate concrete RCA is concrete made from recycled aggregate. It was found that the workability of fresh RCA decreases with an increase in recycled aggregate due to water absorption of mortar adhered to recycled aggregate[3].The strength of RCA is reported to be less by about 10% compared to normal concrete [7,8].

Concrete with RCA can be transported, placed, and compacted in the same manner as conventional concrete. Special care is necessary when using fine RCA. Recycling concrete provides sustainability several different ways. The simple act of recycling the concrete reduces the amount of material that must be land filled. The concrete itself becomes aggregate and any embedded metals can be removed and recycled as well. As space for landfills becomes premium, this not only helps reduce the need for landfills, but also reduces the economic impact of the project. Moreover, using recycled concrete aggregates reduces the need for virgin aggregates. This in turn reduces the environmental impact of the aggregate extraction process. By removing both the waste disposal and new material production needs, transportation requirements for the project are significantly reduced.

There are a variety of benefits in recycling concrete aggregate:

Keeping concrete debris out of landfills saves landfill space.

- Using recycled material as gravel reduces the need for gravel mining.

- Using recycled concrete as the base material for roadways reduces the pollution involved in trucking material.
- Protect natural recourses.
- Elimination the need for disposal by using readily available concretes
- Cost Efficiencies
- Greatly reduces fuel costs
- Cuts costs by using a recycled material to replace natural aggregate
- Reduces dumping fees at landfills
- Environmental Advantages
- Keeps our landfills clear of recyclable product
- Greatly reduces the need to use natural aggregate
- Recycles man-made product
- Reduces the need for gravel mining
- Helps in the fight to keep our environment clean
- Portable Concrete Recycling/On-site Crushing[9].

The aim of this research project is to utilize recycled concrete as coarse aggregate with addition of steel fiber for production of concrete. It is essential to know whether the replacement of RCA in concrete is acceptable or not.

Literature Review

Recycled Aggregate Concrete:

In 2006 Masato et. al.[10] studied the improvement of recovery rate of original aggregate by enhancing a peeling off effect of aggregate without damaging any mechanical properties. The enhanced peeling – off effect is realized by applying a surface improving agent to aggregate with high water absorption of recycled aggregate is also reduced. Material tests were conducted on recycled aggregate with low- quality and middle quality,, two types of surface improving agent, oil type and Silone type improving agent, was greatly improved in recovery rat but showed lowered strength recycled aggregate finished with oil- type improving agent.

In 2009 Yong et. al.[11] used recycled concrete aggregate (RCA) from site tested concrete specimens. These consist of 28 –days concrete cubes after compression test obtained from a local construction site. The concrete cubes are crushed to suitable size and reused as recycled concrete aggregate. This research finds that the recycled concrete aggregate (RCA) is found to be higher-that the compression strength of normal concrete .

M.L. Berndt[12] was investigated the recycled concrete aggregate by adding fly ash and blast furnace slag. With different percents. Properties investigated include compressive and tensile strength, elastic modulus coefficient of permeability and durability in chloride and sulphate solutions. It was determined that the mixes containing 50% slag gave the best overall performance. Slag was particularly beneficial for concrete with recycled aggregate and could reduce strength .

In (2010) V. Bhikshma et. al.[13] developed stress block parameters for the design of reinforce recycled aggregate concrete members. To arrive at the objectives replacement ratio, (Rr) the ratio of recycled coarse aggregate to total coarse aggregate.(Rr =RCA/TCA) on mechanical properties of recycled aggregate concrete. It is found that twenty such stress-strain curves were drawn corresponding to ten strain values from 10% to 100% was found. The values of stress and strain were then non dimensional zed to calculate the modulus of elasticity.

Steel Fiber Concrete

Steel fibers have been successfully used for pavement applications in many hundreds and thousands of square meters of concrete for roads and highways. Steel Fiber Reinforced Concrete (SFRC) has extra strength in flexure and impact as compared to plain recycled concrete[14]. Steel fibers distributed in the concrete delay the growth of cracks thus improving the ductility of the matrix. The ability of steel fibers in improving the properties of concrete depends on the bond characteristics, aspect ratio of the fiber, surface friction and tensile strength of the fiber [15]. Common applications of SFRC include paving applications such as in airports, highways, bridge decks and industrial floors, which endure significant cyclic loading during their service life. All these properties are the requirements needed for recycled concrete pavement for highways, bridge deck and runway or taxiway to maintain high quality and smooth riding surface without irregular depressions. The fatigue performance of SFRC is one of the important parameters to be considered in the design [16].ACI Committee 544 noted that SFRC has potential for many more applications, especially in the area of structural elements[17].The addition of steel fibers significantly improves many of the engineering properties of mortar and concrete , notably impact strength and toughness. Tensile strength, flexural strength, fatigue strength and an ability for spelling are also enhanced[18]. Moreover, addition of fibers makes the concrete more homogeneous and isotropic and therefore it is transformed from a brittle to a more ductile material. When concrete cracks, the randomly oriented fibers arrest a micro cracking mechanism and limit crack propagation, thus improving strength and ductility and generally, for structural applications, steel fibers should be used in a role supplementary of reinforce bars[19].

In (1997) Kutzing[20] showed that the shear capacity of concrete increased when steel fiber is added . The test equipment was introduced in detail and some first results were presented. It was well Known that the use of steel fiber raises the ductility of concrete and the fracture energy. This phenomenon was transferable to the shear strength of concrete.

Materschlager et.al.(1998)[21] who presented an experimental investigations were performed to evaluate the influence of fiber made of steel, glass, carbon or hemp on the overall behavior of concrete. Different materials were selected such as that of concrete properties and can be designed to satisfy specific requirements. Some of these demands were alkali resistance, corrosion resistance, insensitively to magnetism and increased beam-column ductility to dissipate energy during seismic activities.

In (2009) M. Heeralall, [22] investigated the flexural fatigue behavior of steel fiber reinforced recycled aggregate concrete (SFRRAC). The study gains importance in view of the wide potential for demolished concrete to serve as a source of quality aggregate feed stock in variety of structural application. A total of 72 standard flexural specimens were casted and tested for flexural under both static and fatigue loading. This test done by replacing of recycled aggregate in natural aggregate, presence of with and without optimum steel fiber of 0.1% by volume with and without super plasticizer. The study shows that the compressive strength of steel fibrous recycled aggregates in all the cases was marginally more than no fibrous concrete and these mixes can be used in rigid pavements also and the inclusion of fibers can benefit the fatigue performance of recycled aggregate concrete.

Experimental Program

The parameters involved in the study include dosage of recycled aggregate (RA) replacement in natural Aggregate (NA), with steel fiber. The experimental investigation was designed to understand the behavior of recycled concrete aggregate with steel fiber of under static load.

The program consisted of casting and testing a total of 42 standers specimens(cubic specimen of (150 x 150 x 150) mm and cylinders of (100x200) mm. with steel fiber of 6.0% by total weight. Where (Rr =RCA/TCA)

Rr = the ratio of the recycle coarse aggregate to total coarse aggregate

,RCA= the recycled concrete coarse aggregate

TCA= total coarse aggregate

Table (1) shows the symbols of concrete mixes and the present of crushed concrete.

The study contain of 6 mixes each mix cast in two cubic and 6 cylinders were tested under static load . For each mix 2 cube specimens were test under the compressive strength of the concrete, 3 cylinders were test for compressive strength and 3 cylinders were test for splitting tensile strength .

Testing of Materials For Concrete

Preliminary test were carried out on the constituent materials:-

- ***Water*** :- Drinking water from Tikrit water supply was used conforming to the specification requirements of water for concerting and curing.
- ***Cement*** :- Ordinary Portland Cement. Which is used in this investigation was confirming to the Iraqi specifications [23]. The chemical analysis of this cement is

given in Table (2) and its mechanical properties are given in Table (3). The specific gravity of the cement used was 3.15.

- ***Sand*:-** Local river sand from Al-Dos region was used as fine aggregate. The sand was confirming to Zone II of B.S. 882. 1973 [24]. The bulk density and specific gravity of the fine aggregate were 1.41 and 2.68. The details of the different fractions of sand taken are shown in Table (4,5)

The grading of this sand is within the boundary curves for sand by B.S. 882. 1973[24] are shown in Table (4).

- ***Gravel*:-** Local river gravel from Al- Dos region was used. The grading of this gravel is within the boundary curves for sand by B.S. 882. 1973[24] as shown in Table (6,7).
- ***Recycle concrete:*-** used as coarse aggregate obtained from demolished waste (slab of building from more than 20 years old concrete) had been broken up with a jackhammer then crushed to a maximum aggregate size of (20 mm). The grading was made the same to the grading of the gravel aggregate.
  The aggregate must be "clean," without absorbed chemicals, clay coatings, and other fine materials in concentrations that could alter the hydration and bond of the cement paste.
- ***Fibers*:-** waste steel fibers were collected from Tikrit Industry zone with diameter 0.3mm and 2.3 mm long. were used in the investigation , The fibers were added in proportion of 6% by total weight of concrete.

Note :- The details of the various properties of natural and recycled aggregates are shown in Table (8).

Mix Design

Concrete with RCA can be transported, placed, and compacted in the same manner as conventional concrete The mix proportion designed as per ACI method[22], is produced with the selected slump (30-60) mm , design compressive strength of (25) MPa and the maximum aggregate size of (25) mm. Other aggregate properties available from previous tests are used in calculation for mix design. The weight of the constituents was cement: fine aggregate: coarse aggregate: water/cement ratio 1:2:4:0.5, this concrete serves as (reference concrete) or (control concrete) and tests and conducted on this concrete to determine its properties. The other mixes are two kinds once with replacement of RCA of (50 , 100)% and the other carried to produced concrete with (0,25,50,75,100)% replacement of RCA as well as of 6% addition of steel fibers. while the coarse Natural Aggregate (NA) was replaced in suitable dosages as explained earlier with Recycled Aggregate (RA). The concrete with replacement of RCA are tested and their properties determined.

Casting and Testing

In this study , a total of 64 of concrete specimens were cast with and without (crushed – concrete and steel fibers) .The concrete mix ratio was kept constant for all types of concrete using the mix proportioning ratio by weight (cement: fine aggregate: Coarse aggregate) of 1 : 2 : 4. The steel fiber weight was 6% of the total mix weight. A variable weights of crushed concrete(i.e., weight of recycle concrete ratio to weight of total coarse aggregate) of (0, 25, 50, 75, 100)% were used as discussed above. the water – cement ratio was chosen for concrete mixes with recycle concrete aggregates to obtain the slump ranging (30 - 60) mm. The water / cement ratio was increased when increasing of recycle aggregate ratio.

Concrete mixes were casted in (100*200) mm cylindrical steel moulds and (150*150*150) mm steel cubic moulds.

After design the concrete mix cement, sand, fibers and coarse aggregate (gravel and recycled concrete aggregate) were mixed in dry state handy , and then the required quantity of water was added and mixed thoroughly. Before casting , machine oil was smeared on the inner surfaces of the cast iron moulds.

The concrete was poured into cylindrical mould in four equal layers and compacted thoroughly using a standard compact metal rode of squire section with 25 mm side, 1.8 kg weight and 380 mm long. The number of compact beats was 20 times for each layers.

Also the concrete was poured into cubic mould in three equal layers and compacted by a the same compact metal rode The number of compact beats was 20 times for each layers[26]. The top surface was finished by means of a trowel. The specimens were removed from the mould after 24 hours and then cured under water for period of 28 days. the specimens were taken out from the curing tank just prior to the test.

Testing Machine

All specimens were tested using a (2000 kN) capacity compression machine. In the university of Tikrit. Testing times were in February 2011. The weather was cold in most days.

Test Program

The test program considered a total of 64 specimens (48 cylinders and 16 cubes). The test was divided into three groups. For each mix 2 cubes were tested for the compressive strength, 3 cylinders were tested for the compressive strength and 3 cylinders were tested for splitting tensile strength.

Mode Of Failure

The concrete cylinders in compression showed a combination of vertical splitting and inclined shear type failure cracks for both types of aggregates (Natural and Recycled aggregates) . In splitting tensile tests, the failure planes showed some broken (recycle and natural aggregates) and some gravels being pulled out from the concrete. While for concrete with recycled concrete and steel fibers, the failure planes were nearly flat..This indicates a rather stronger bond and interlocking in the past-aggregate interfaces.

For cubic compression strength the failure planes are shear failure.

Test Results and Discussion

Air dry density

Table (9) shows the results of dry density for all concrete mixes. First of concrete without steel fiber and second with steel fiber and for each concrete cast in cube and cylinder specimens the results is average of three specimens .

-Without steel fiber

The air dry density seems to decrease with the increase RCA. This is due to the light weight of recycled concrete aggregate compared to NA.

-With steel fiber

The air dry density seems to decrease with the increase of RCA. This is due to the light weight of recycled concrete aggregate compared to NA. but it is higher than the dry density of no fiber concrete because of the heavy weight of steel fiber.

Compressive strength

Table (10) shows the results of compressive strength for all concrete mixes:

Without steel fiber

It can be seen from Fig.(1) that the cube compressive strength of no fiber concrete seems to decrease with the increase of RCA but still it is within the acceptable limits(25-40) MPa [24].

With steel fiber

It can be seen from Fig.(1) that the cube compressive strength of no fiber concrete seems to decrease with the increase the RCA. The reduction in strength is from (29.66) MPa for 0% RCA to (21.56) MPa for 100% RCA and this is comparable with that obtained by Herallal[9]

Compressive strength of cylinder

Table (11) shows the results of compressive strength in cylinder for all mixes:

Without steel fiber

It can be noted from Fig.(2) that cylinder compressive strength of no fiber concrete seems to decrease with the increase of RCA .

With steel fiber

It can be seen from Fig.(2) that cylinder compressive strength of no fiber concrete seems to decrease with the increase of RCA. The reduction in strength is from (23.7) MPa for 0% RCA to (14.64) MPa for 100% RCA.

10.4 Spliting tensile strength

Table (12) shows the results of splitting tensile strength for all mixes:

Without steel fiber

It can be seen from Fig.(3). The splitting tensile strength of no fiber concrete seems to decrease with the increase of RCA .

With steel fiber

It can be seen from Fig.(3). That the splitting tensile strength of fiber concrete seems to decrease with the increase of RCA. The reduction in strength is from (2.91) MPa for 0% RCA to (1.4) MPa for 100% RCA.

Modulus of elasticity

The modulus of elasticity values for all concrete mixes with different replacement ratios of RCA were obtained based on average range of 3 cylinders. These average values for all mixes are presented in Table

(11). By comparing the results of the specimens with low RCA has higher value of modulus of elasticity and the specimens with high RCA has lower modulus of elasticity.

Water / cement ratio

It can be seen from Fig.(1) that the water /cement ratio increase with the increasing of RCA.

Conclusions

- Based on the experimental works from this research
- Aggregate composed of recycled concrete generally has a lower specific gravity and a higher absorption than conventional gravel aggregate.
- New concrete made with recycled concrete aggregate typically has good workability and durability.
- The compressive strength varies with the compressive strength of the original concrete and the water-cement ratio of the new concrete.
- In addition to the resource management aspect, recycled concrete aggregates absorb a large amount of carbon dioxide from the surrounding environment. The natural process of carbonation occurs in all concrete from the surface inward. In the process of crushing concrete to create recycled concrete aggregates, areas of the concrete that have not carbonated are exposed to atmospheric carbon dioxide.
- Steel fiber reinforced concrete mixtures required more mixing and placing time than that of the control mix.
- Dry density decreased when increasing of the percent of recycle aggregate.
- The compressive strength of RCA decrease with the increasing in replacement of recycles aggregate. Also with the addition of steel fiber in RCA there is a marginal increase in compressive strength.
- The splitting tensile strength of RCA decrease with the increasing in replacement of recycles aggregate. Also with the addition of steel fiber in RCA there is a marginal increase in splitting tensile strength.
- The modulus of elasticity of RCA decrease with the increasing in replacement of recycles aggregate. Also with the addition of steel fiber in RCA there is a marginal increase in modulus of elasticity.
- compressive strength and splitting tensile strength of steel fiber concrete in all cases was marginally more than no fibers concrete.
- The reutilization of construction and demolition waste is one of the primary objectives of sustainable construction.

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Table (1):The symbols of concrete mixes and the percent of crushed concrete

Mix NO.	% Rr	% steel fiber
Rc0	0	0
Rc1	50	0
Rc2	100	0
Rcf 1	0	6
Rcf 2	25	6
Rcf 3	50	6
Rcf 4	75	6
Rcf 5	100	6

Table (2): Chemical composition of cement.

Compound	% by weight	Specification[23]
Insoluble	0.96	Not more than 1.5
SiO_2	13.8	Not more than 21
Al_2O_3	0	-------------
Fe_2O_3	0	Not more than 6
MgO	0.8	Not more than 5
SO3	1.18	Not more than 2.5
C3A	5.2	Not more than 8
Loss on ignition	0.89	Not more than 4

Table (3):Mechanical Properties of Cement(paste).

Properties	Average	Specification[23]
3 day compressive strength (N/mm^2)	19.75	Not less 15 N/mm^2
Initial setting (min.)	48	Not less 45 min
Final setting (min.)	510	Not less 10 hours
Fineness(Kg/m^2)	303.6	Not less 230 kg/m^2

Table (4): Grading of sand.

Sieve No. mm	Natural sand passing %	passing % range according to B.S. 882:1973[24]
9.5	100	100
4.75	90.5	90-100
2.36	74.25	75-100
1.18	64.75	55-90
0.600	30.5	35-59
0.300	15.5	8-30
0.150	3.5	0-10
0.075	0.25	0
pan	0	0

Table(5): Chemical composition of sand.

Test	percent	Specification[25]
% of granular material	0.18	less than0.5
% Total salt	1.06	less than5
% other material	0	less than2

Table (6): Grading of gravel.

Sieve No. mm	Natural gravel % passing %	passing % range according to B.S. 882:1973[24]
20	85	85-100
9.5	15	0-25
4.75	0	0-5
0.150	0	0
pan	0	0

Table(7): Chemical composition of gravel.

Test	percent	Specification[25]
% of granular material	0.0092	0.1%
% soluble salt	0.061	5%
% peat	0	2%

Table(8):Properties of natural and Recycled aggregate.

Aggregate properties	Gravel	Recycled Aggregate (RCA)	Percent difference (%)
Bulk specific gravity, Dry	2.65	2.04	23
Bulk specific gravity, SSD	2.66	2.25	15.4
Apparent specific gravity	2.64	2.5	2.3
Absorption (%)	1.5	4.5	200
Bulk density (kg/m^3)	1640	1425	13

Table (9): Unit weight results

Sample	Dry density (kg/m^3)			
	Without SF		With SF	
	cubic	cylinder	cubic	cylinder
Recycled concrete(0% replacement of RCA)	2286	2342	2468	2516
Recycled concrete(25% replacement of RCA)	2211	2318	2434	2508
Recycled concrete(50% replacement of RCA)	1867	2267	2428	2502
Recycled concrete(75% replacement of RCA)	1720	2260	2415	2482
Recycled concrete(100% replacement of RCA)	1654	2250	2403.5	2472

Table(10):Test Results of Cubic Compressive strength

mix. No.	W /C ratio	Cubic Compressive strength (Mpa)
Rc0	0.5	23
Rc1	0.55	15
Rc2	0.57	10
Rcf1	0.5	29.66
Rcf2	0.52	28
Rcf3	0.54	25.78
Rcf4	0.56	23.89
Rcf5	0.58	21.56

Table(11): Results of compressive strength of cylinder and Modulus of elasticity.

Mix NO.	Cylinder Compressive strength (Mpa)	Modulus of elasticity (Mpa)
Rc0	19	20487
Rc 1	11.2	23025
Rc 2	7.5	21793
Rcf1	23.87	20487
Rcf2	21.32	18800
Rcf3	18.97	182043
Rcf4	16.23	18934.6
Rcf5	14.64	17983.25

Table (12): Results of splitting tensile strength.

mix. No.	W /C ratio	Cubic Compressive strength (Mpa)
Rc0	0.5	23
Rc1	0.55	15
Rc2	0.57	10
Rcf1	0.5	29.66
Rcf2	0.52	28
Rcf3	0.54	25.78
Rcf4	0.56	23.89
Rcf5	0.58	21.56

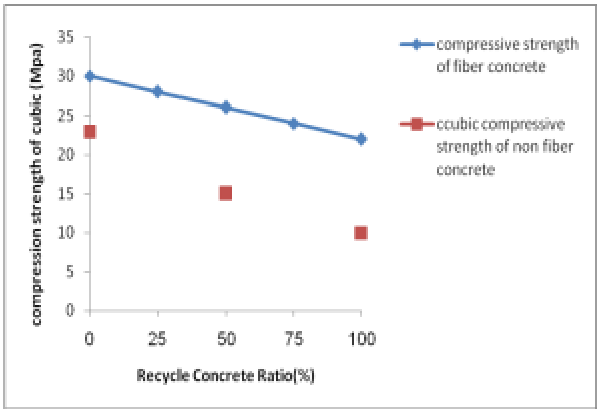

Fig.(1) Influence of Using Recycle Concrete on Compressive Strength in cubic.

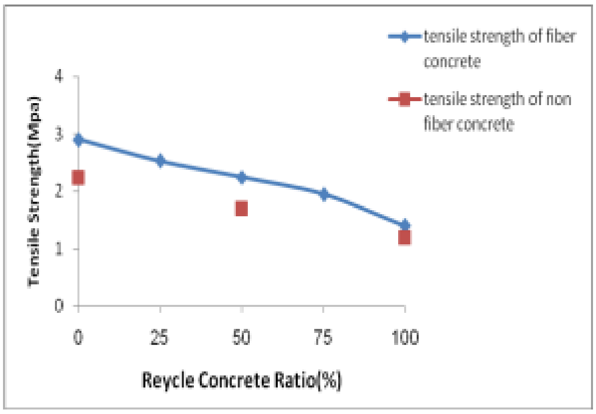

Fig.(3) Influence of Using Crushed concrete on Split Tensile Strength.

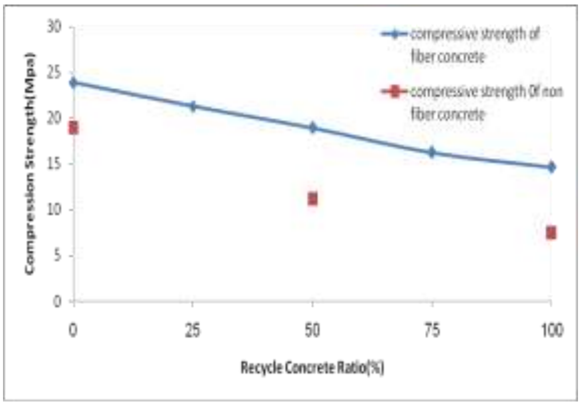

Fig.(2)Influence of Using Recycle Concrete Compressive Strength in cylinder.

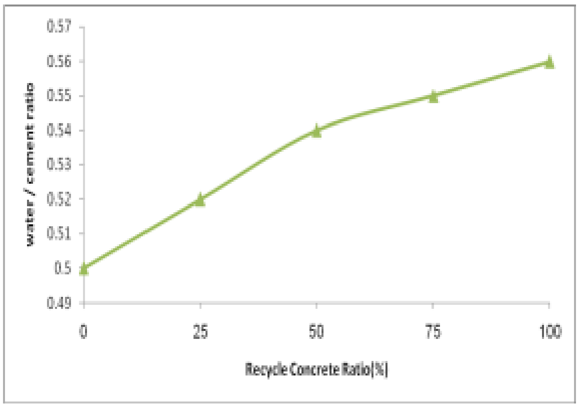

Fig (4)Influence of water /cement ratio.