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Experimental Study of Fresh Properties and Review of Hardened Properties of Concrete Using Recycled Aggregate

Abdulaziz Abdulreda Haider [1]
Eissa Abdulreda Haider [2]
Civil Engineer, Ministry of works, Kuwait[1,2]

Abstract
Aggregate (RCA) has been increased in few years by researchers. The main reasons behind these changing trends are the demand and availability of NCA and the environmental effects of concrete and construction waste. The reason for research was to consider the impact of RCA on new and solidified properties of concrete. Usefulness is the specific new property, compressive strength and tractable, modulus of elasticityand flexural strength, are the specific solidified properties of concrete, on which this exploration work is based. Various kinds of concrete combinations were additionally set up by utilizing different rates of RCA instead of NCA. Functionality of concrete mixes was additionally tried by utilizing the droop cone test. Solid shapes for (compressive strength tests), chambers for (compressive strength tests and parting elasticity tests) and shafts for (flexural strength tests) were additionally set up by these concrete mixes to test the solidified properties of the concrete. Thus, the study on the impact of RCA on these solidified properties is made by exploring the exploration work of numerous analysts on similar subject. Bona fide sites of common exploration works were additionally used to find the outcomes and solutions of inquiries. This examination showed that new properties diminished as the level of RCA is expanded for example usefulness of concrete is diminished. In a similar way, by expanding the level of RCA in concrete its compressive, pliable and flexural strength, additionally the modulus of elasticity diminished. At 75% and 100% replacement of RCA, the results showed that, concrete is strictly not appropriate for construction purposes. The concrete with 25% and 50% RCA could be used after enhancing certain properties using admixtures or superplasticizers.

Key Words: *concrete ,recycled aggregate ,admixtures,compressive strength tests ,parting elasticity tests) flexural strength tests*

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I. Introduction

Recycled concrete aggregates (RCA) generally shift from (NA) where RCA include natural aggregate andconcrete mortar that covered natural aggregate. The RCA possess high water ingestion, unpredictable surface and precise shape as NA, these components influence the concrete properties [1RCA may be characterized as the solid blends in which natural aggregates (coarse and fineaggregates) supplant incompletely or completely within reused aggregates (RA). It was utilized in 1945 in concrete blends, the developing of solid blend began afterwardthe second World War to remake and recovery of private structures, streets, and foundations [2]. The lodging structures, streets, solid extensions, solid dams, and once in a while from a disasters (fire, floods and seismic tremor) are viewed as the primary wellspring of RCA that might be utilized in the development measures [3]. An incredible interest of concrete and NA is normal on the planet Dabhade and others in 2014. The interest on the normal total is expanding, it's relied upon to increment to roughly 18000 million tons per year by 2050, that implies in upcoming we requireround about 1440 million tons of NA for cementing [4]. The security of the climate is an essential factor, which is straightforwardly associated with the endurance of humankind. Boundaries like ecological awareness, security of characteristic recourses, practical improvement assume a significant part in present day necessities for development works. The requirement for the creation and utilization of RCA these days, is fundamental. The RCA are the fundamental segments of old cement and for some causesthere is a requirement to reuse them. The development in the development business presents a few concerns with respect to accessibility of characteristic total assets, as they are by and large quickly exhausted. Endeavors to empower reusing of development and destruction squander in various development applications prompted using up to 10 % of the reused total in various development applications. Along these lines, reusing can possibly lessen the measure of waste materials discarded in landfills and to safeguard common assets. The usage of development waste, for example, squashed tiles as a total in underlying solid creation would have a significant beneficial outcome on the development economy moreover. The usage

of RCA being developed works is a subject of high need in constructingbusiness all through the world [5]. As demonstrated by the close by lab assessment and experience [6], the key test procedures for sensibility of reused strong totals (RCA) for the making of fresh concrete can be projected on a fundamental level for Greece subject to the management of essentials of Greek Specification of Concrete Technology (GSCT) and ofthe European one (ENV 206). Solidness and other strong properties are caused by the usage of reused absolute in concrete mixtures. When in doubt, planning properties of the RCA are more unobtrusive than NA as a result of high porosity and low thickness along these lines covered mortar stick around the totals. Research on mechanical properties mainly stresses – strain curve of RAC resembles NAC. Exploratory assessments demonstrate that with increment in proportion of reused complete, the assessments of compressive strength, top strain, solidness, plastic energy limit and adaptable energy and adaptable modulus decreases, thatturn into check for the use of RAC structures. Totals from RCA are presently used taking everything together countries in manypractices of primary planning works, soil change, as road black-top materials, enhancement of sub-ground, sub-tornado shelters, making of concrete of various characterizations, etc.The presence of fleeting Greek judgments forchecking the sensibility of RCA is a key aspect of their usage, particularly for the formation of fresh concrete. When all is said in done, applications with no handling comprise:

- Bank insurance
- Various sorts of general mass fills
- Fill or base for seepage structures
- Noise obstructions and dikes
- Road development

After ejection of pollutants through specific annihilation, screening, or potentially air parcel and size decline in a smasher to add up to sizes, crushed concrete can be taken as: fresh concrete for roadways, shoulders, center limits, walkways, checks and trenches, and expansion foundations essential level strong soil-concrete black-top bases econo-creteor lean-concrete bases and bituminous concrete.

II. Literature Review

In this period a great deal of examination is centered around utilizing the RCA as a substitution and NA in concrete structures. Specialists have inspected numerous tests utilizing various rates and substitution of RCA rather than NA to analyze their properties. This part incorporates a concise portrayal of the work done by numerous specialists on RCA. Yehia [7] and other determined the mechanical and physical properties of various concrete mixes furnished with100 percent RCA utilizing 4 evaluations of RCA. Nateriyaand Tiwari [8] utilized Indian standard codes to get ready concrete blocks with reused aggregate (RA). Etxeberria and other [9] inspected modulus of elasticity and compressive strength in wet form for tests projected within various reused coarse aggregates. Ngwenya and Franklin [10] contemplated droop test and compressive solidarity to 5mixtures outfitted with various fillings of reused aggregate (RA). Tuetal [11] attempted superior concrete containing reused aggregates with incredible water ingestion and verified which reused coarse aggregates have impact on the recognizes chunk of concrete however an antagonistic impact on the usefulness with time. It was recommended by Poon .et al [12] that the substitution level of reused coarse aggregate at air-dried state ought not outperform half to deliver concrete containingfewer work capacity misfortune and greater compressive strength. It was realistic from tests completed by Khatib [13] and the concrete'scompressive strength containing reused fine aggregate with position level underneath half was similar to that of concrete with just normal aggregates and just 10 percent strength decline was chronicled for concrete with a substitution level of 100 percent.Junak and Sicakova [14] prepared 24 standard 3D squares for various level of covering filler; coal fly debris, fluid glass and 8M NaOH answer for increase the mechanical properties of reused concrete aggregate. Kou SC and other [15] introduced a trial concentrate on the introduction of reused concrete aggregates by adding various sorts of filler, ground granulated impact slag(GGBS, silica exhaust (SF), metakaolin (MK) and fly debris (FA) to contemplate compressive and parting elasticity, ultrasonic heartbeat speed, drying shrinkage and iron. Davoudi [16] utilized distinctive dose of super plasticizer in his exploration (5-20) litters per m^3 of the concrete to consider the impacts of the super plasticizer on concrete mixtures strength utilizing the tree-characterization choice calculation investigating. Alsadey [17] finished an enquiry to examine impacts of super plasticizer dose on concrete and for gettingfinest portion of super plasticizer whichattain the better strength and functionality. Ngo and other researchers [18] explored the impact of sort of admixture on fresh and solidified properties of concrete mixtures which readied within reused aggregate with various , cubic examples of and tube shaped examples were casted to quantify compressive strength, two kinds of compound admixture (Ether polycarboxyliquieand Polycarboxylate) were utilized to build the mixtures functionality. As of late, Al Tijani tried [19] modified RCA with explicit substitutions of miniature silica and fake full scale fiber, the outcomes inclined to half of RCA is in line standard cutoff points. The substitution of normal aggregates by reused aggregates changed concrete's compressive strength and versatile modulus. After this concrete framed with reused aggregates had lower compressive strength, aside from concrete made of reprocessed fine aggregate.

III. Methodology

Method adopted for research purpose is summarized in following points and details are given in later headings:

- Firstly,the required material was collected. Recycled aggregate was arranged from different types of specimen of concrete that were being tested in lab and was just a waste.
- Cubes and cylinder's moulds were created from concrete lab, and were used to arrange different types of cubes, cylinders and beams sample.
- Dissimilar concrete mixes were arranged with same mix ratio of cement, sand and aggregate. But the natural aggregate was changed by RCA to prepare different blends.
- Workabilityof these blends was tested by slump cone test. So outcomes of these fresh properties were obtained in this way.
- For hardened propertiescubes, cylinders and beams specimen were prepared.
- For getting results and to answer the queries,many research papers about this research were studied and analyzed. Hence, this research and results of RCA on hardened properties of concrete are based on theoretical study.
- The properties of concrete with different RA percentages were compared through graphs and charts and optimum RA percentage in concrete was found.

IV. Materials

Type I standard Portland concrete is utilized for setting up the concrete blend. Fine aggregates (sand) were gathered from a devastating plant at Margalla slopes, Taxila. The movement for fine aggregate was used as a norm by ASTM C33andsifter investigation, Table 1.These total were chosen by the standard determinations like granular degree, strength and liberated from any scums that debilitate the properties (great synthetic and physical properties). Natural aggraegate were took from Margalla Hills, Taxila. The degree for NA was used as a norm by strainer examination and ASTM C33, Table 1.

Table 1Gradation for granular aggregate using sieve analysis

Sieve size (mm)	Percentage Passing Coarse Aggregate	Percentage Passing Fine Aggregate
25	100	100
19	97.24	100
12.5	60.65	100
9.5	33.59	100
4.75	2.88	99
2.36	0.57	86
1.18	0	50
600mc	0	30
300mc	0	16
FINE > 75mc	0	7

RA utilized in this examination was reserved from the concrete waste created by Concrete lab of common office, UET Taxila in result of testing concrete example. It was physically squashed utilizing hammer until it turned out to be sufficiently little to be utilized in concrete combinations.Its pass value from 25millimeter sieve was 100% and almost whole fraction retained on 4.75 millimetersieve. Secure percentage of cement, sand and coarse aggregate was used in all mixtures. The optimum ratioused for preparing concrete mix was 1:1.8:3. The water cement ratio used was 0.45.

V. Experimental Investigation

New properties of the concrete combination were introduced by droop test, regularly droop test for concrete blend glances in three unique sorts for example shear, breakdown and genuine droop. Concrete combinations with various level of usefulness can be utilized in various cases.

5.1 Workability Test

Slump test is also used to measure the working ability of all concrete blends and results are shown below in table 2:

Table 2 Slump test values

Percentage of RCA in concrete	Slump Test value
0	148 mm
25	124 mm
50	65 mm
75	0
100	0

The outcomes presented that by becoming the RCA content the droop esteems decline. The decline in droop esteems in view of RCA has water assimilation and great porosity which help to lessen the functionality of the combination. The test outcomes are appeared in figures 1 and 2.

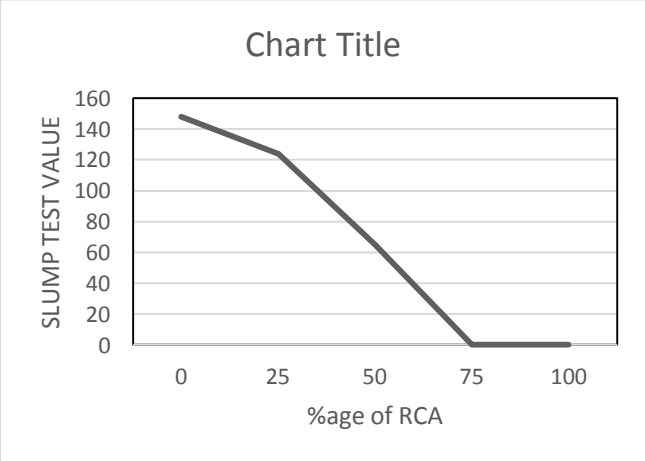

Figure 1 Graph between RCA percentage and Slump Test value

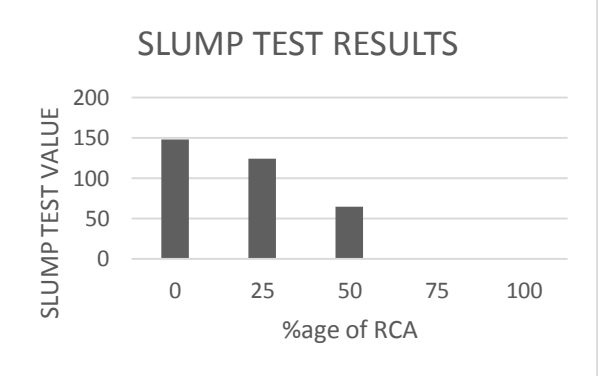

Figure 2Slump Test Results

5.2 RCA's compressive Strength

This examination was done to contemplate the viability of utilizing RCA in concrete mixtures instead of normal coarse aggregate. 90 3D squares of various rates of RCA at water to solidify proportion of 0.4 and utilizing zero percent and 2.5 percent super plasticizer were taken. For that blend that were outfitted within 45 percent of RCA 54 3D squares of were taken with various rates of iron powder instead of fine aggregate. Solidified test was inspected to degree the compressive strength following seven, fourteen, and twenty-eight days of relieving.

Solidified concrete's compressive strength was confirmed for various 3D shapes utilizing Universal testing machine on cubical examples following seven, fourteen and twenty-eight days of relieving with zero percent and 2.5percent of super plasticizer for a reused aggregate substitution of zero percent, 30percent, 45 percent and 60 percent. Figure 3.1, 4.1 and 5.1presented the consequences of compressive strength following seven, fourteen, and twenty-eight days of relieving.

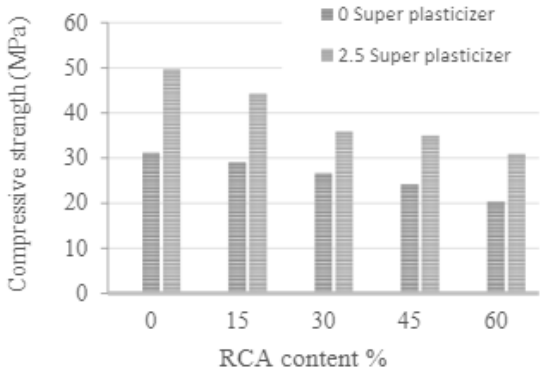

Figure3.1:Compressive strength after 7 days curing

As demonstrated in the figure 3.1, the concrete'scompressive strengthdiminished as the reused aggregate substitution expanded for zero percent and 2.5 percent of SP. The compressive strength following seven days of relieving was greater for 2.5 percent SP in examination with zero percent SP, a generous distinction was seen following 7 days of restoring among blends that kept 2.5 percent SP and zero percent SP. The percent change was45, 35, 52, and 59.1MPa, likewise concrete's compressive strength was diminished by expanding the RCA contentseparately.

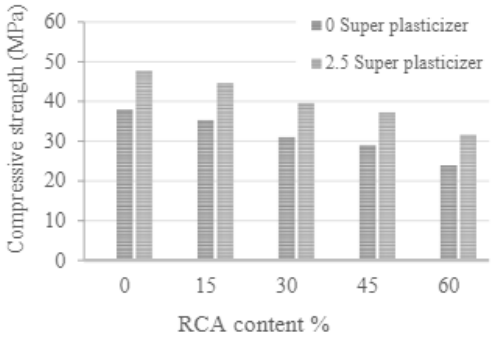

Fig4.5 Compressive strength after 14 days

Concrete's compressive strength following fourteen days of relieving was greater at 2.5 percent SP rather than zero percent SP for all substitution RCA content as introduced in the figure 4.1.

Expansion of Iron Powder to 45 percent of RCA Mixtures Iron powder and silica was strengthening to 45 percent -RCA as an expansion of the fine aggregate in various rate (10 percent, 15 percent and 20 percent). The figure 5 displays the tentativeoutcomes achieved from the compressive test for 45%-RCA mixes with iron powder.

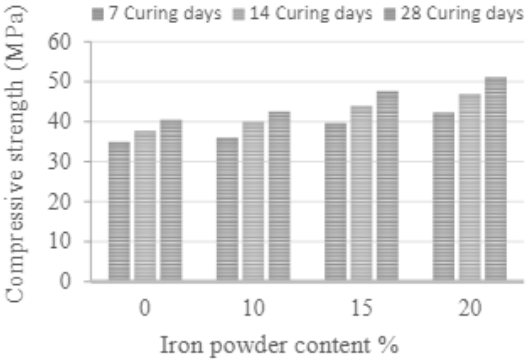

Fig5.1Compressive strength after 7, 14 and 28 days

The consequences introduced that a significant upgrade of the compressive strength of 45 percent -RCA may be skillful with the expansion of iron powder as additive.It is clearly that the compressive strength of 45 percent-RCA is pompous constantly of drying. It was discovered that as the restoring time is expanded the compressive strength is expanded. The most elevated estimation of compressive strength was at 20 percent iron

powder substitution at every restoring day. The compressive strength of forty-five percent -RCA mixtures with zero, ten, fifteen, and twenty percent of Silica following seven,fourteen and twenty-eight days of restoring are uncovered in the figure 6.

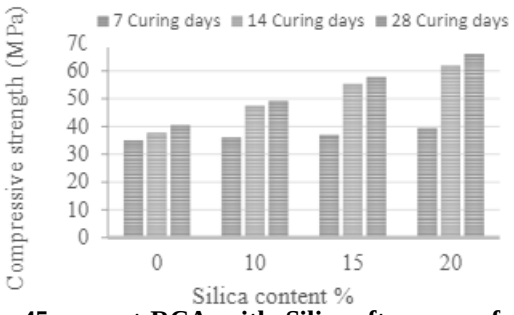

Fig6 Compressive strength for 45 percent-RCA with Silica after seven, fourteen and twenty-eight days of curing

5.3 Split Tensile Strength

The parting rigidity tests were completed on concrete samples in concurrence within ASTM-C496/2006. Split chamber strength tests were finished on two chambers put evenly among the stacking surfaces of the pressure testing machine. The outcomes of the malleable tests on concrete chambers are appeared in Table-3, here every worth is the normal of two limits. It is clear from this table that the elasticity drops as reused aggregate rate increments.

Table 3Splitting Tensile Strength

Mix	Repayment Ratio	Tensile Strength (MPa)	Percentage Difference from NAC	ACI 318/2014 [12] Tensile Strength Equation $f_{ct} = 0.56\sqrt{f'_c}$	Percentage Difference from ACI 318/2014 equation
NAC	0%	2.75	-	2.57	-6.55%
RAC25	25%	2.52	-8.36%	2.47	-1.99%
RAC50	50%	2.28	-17.09%	2.35	+3.07%
RAC75	75%	2.04	-25.82%	2.26	+10.8%
RAC100	100%	1.68	-38.91%	2.07	+23.14%

5.4 Modulus of Elasticity

The modulus of elasticity of concrete for concrete was tried as per ASTM-C469/2004 method (secant to 0.4 of compressive strength), concrete chambers tried in pressure at steady strain. The outcomes are presented in Table-4. It is apparent from the table so that the modulus of elasticity lessens as reused aggregate rate floods. At the point when the 100 percent of reused aggregate were utilized then modulus of elasticity of concrete was consolidated by about 31.97.

Table 4. Modulus of Elasticity for Concrete.

Mix	Repayment Ratio	Modules of Elasticity (MPa)	Percentage Difference from NAC	ACI 318/2014 Modulus of Elasticity Equation $E_c = 4700\sqrt{f'_c}$	Percentage Difference from ACI 318/2014 equation
NAC	0%	2455	-	2419.4	-1.45%
RAC25	25%	2232	-9.1%	2320.2	+3.95%
RAC50	50%	2088	-14.9%	2213	+5.98%
RAC75	75%	1927	-21.5%	2130	+10.53%
RAC100	100%	1670	-31.97%	1946.3	+16.54%

5.5 Flexural Strength

Light emissions 150 mm × 250 mm with a genuine range of 2100 mm were casted and tried to finish up the flexural conduct of RC radiates with Recycled Concrete Aggregate (RCA). The flexure RC radiates were tried and their outcomes are arranged in Table 5. The disappointment happened in the pillars was the flexural disappointment. Test occasioned that the bars with 100% substitution of RCA acquired higher breaks and lower in diversion.

Table 5Test Results of RC Beam

Beam Designation	Beam specifications	Cube Compressive Strength at 28 days (MPa)	Initial cracking load (kN)	Predicted Load (kN)	Ultimate load (kN)	Mode of Failure
RC20	M20 (control mix)	39.96	20	106	110	Flexure failure
RC20-100%	M20 (RCA-100%)	36.60	20	105	100	Flexure failure
RC40	M40 (control mix)	46.56	30	107	97	Flexure failure
RC40-100%	M40 (RCA-100%)	44.15	25	106	106	Flexure failure

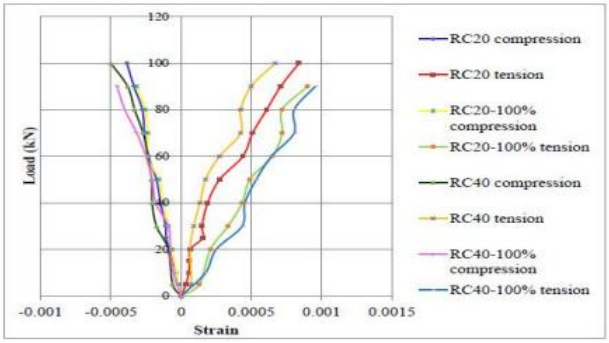

Figure 7Test Results of RC Beam

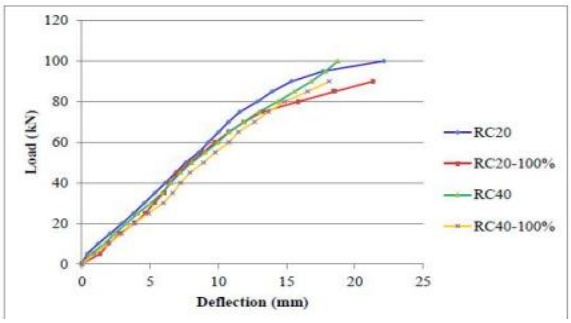

Figure 8Load Deflection curve for RC beams

The diversion and strain in concrete were prominent for each 5 kN load increase. In RC radiates redirection were bigger than those with NA below the state of comparative burden. RCA radiates demonstrated 3.57 percent greater diversion at a sameload when compared with NA radiates.The load versus strain diagram was planned from the DEMEC strain gauge dimensions for all of the beams. The load versus strain graph specifies that at the compression faces, the compressive strain for the beams at a specificload was greater or lesser equal, nonetheless at the tension face RCA beams indicated 13.7 percent higher strain when linked with NA beams.

VI. Conclusions

- The workability of concrete mix declines as we increase the percentage of RCA in it.

At 75% and 100% RCA, No value of slump test is obtained. At 25 percent, slump value is 124mm and at 50 percent it becomes 64mm.

- So, according to this test, concrete with 25 % RCA has appropriate value of slump test and could be used for normal RCC work (mandatory slump is 80-150mm).
- As in road construction, slump value of concrete ranges from 20-40mm, so concrete with high percentage of RCA i.e. nearly 60% could be used for this purpose.
- Concrete with very high percentage of RCA i.e. 75% or more is not workable to be used for any purpose.

VII. Recommendations

- The slump value range of concrete according to its purpose should be kept in mind while deciding the RCA percentage in concrete.
- If greater percentage of RCA is to be used in concrete than a superplasticizer e.g. silica should be added in small percentage that will enhance its workability as well as other properties.
- Before deciding an optimum RCA percentage, keep all properties, renewed and hardened, of concrete in mind.

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