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A Critical Review on Self Compacting Concrete Using Recycled Coarse Aggregate

Prof. Y.V. Akbari [1], Prof Dr. K.B. Parikh[2,] Tejas H. Raviya[3]
[1] *Assistant Professor, civil department, DIET- Rajkot, Gujarat, India*
[2]*Head of Department, Applied Mechanics Department, Gov. Engg. College, Dahod, Gujarat, India*
[3]*PG student, Masters of Structural Engineering, DIET- Rajkot, Gujarat, India*

Abstract:*Thispaperpresentstheinfluenceofdifferentamountsofrecycledcoarseaggregate(RCA)obtainedfromademolished Cancer Hospital, Located at Rajkot, Gujarat,about50yearsoldonthepropertiesofself-compactingconcrete(SCC)andcomparedtheresultswithnormalvibratedconcrete(NVC)containing100%naturalcoarseaggregate(NCA).Importantpropertiessuchas physicaland mechanicalpropertiesofnaturalandrecycledaggregatesarecarriedout.NCAispartiallyreplacedwithRCAbyanamount10%,20%,30%, 40% and 50%.Theeffectof RCAon thepropertiesof SCCin greenstate(e.g.Slumpflowtest,V-FunneltestandL-BoxTest)and propertiesofconcreteinhardenedstate(e.g.compressivestrength,flexuralstrength,andSplittensileStrength)arestudied.Themix designwascarriedoutforM30gradeofconcrete.Theexperimentalresultsindicatethatthecompressivestrength,flexural strengthand splittensilestrengthis high than the use of Recycled coarse aggregate and the strength of SCC decreases with an increase in recycled aggregate (RA) replacement ratios. The presentstudyrecommendsSCCmarginally achievesrequired compressive strengthupto30%replacementofRCA.*

I. Introduction

The cement concrete has been very important and best building material for all types of industrial and civil works. After the long years the structure, it will be demolished. The material of demolished structure have to dump somewhere and for that the Freeland should must require. This procedure is very difficult and Time consuming process and for that process we need to pay. To avoid these type of problem we can use that material in concrete. Here we have studied about use of recycled coarse aggregate with Replacement of natural coarse aggregate in Self-compacting concrete. Byresulting the problem of dumping upto certain level of demolished material will solve and the aggregate will not waste.

At the congested places or congested reinforcement the concrete will not pass, for that first self-compacting concrete developed in japan in 1988. The self-compacting concrete also denoted as self-consolidation concrete. The main properties of self-compacting concrete is passing ability, filling ability and segregation resistant. The self-compacting concrete is passing in congested formwork and congested reinforcement by its own weight and it have no need of manually or mechanically vibrations.

Self-compacting concrete gives a fastrate of concrete placement, with rapidconstruction times andeaseofflowaround congestedreinforcement.Thefluidityandsegregationresistanceof SCCensuresahighlevel ofhomogeneity, minimalconcretevoidsanduniformconcretestrength,providingthepotentialforasuperiorlevelof finishand durabilitytothestructure.Self-Compacting Concreteisoftenproducedwithlowwater-cementratioprovidingthepotentialforhigh earlystrength,earlierremoldingandfasteruseofelementsand structures.

The elimination of the Vibration is very useful for the environment, it reduces the time and there is no need of numbers of trained workers. In2002EFNARCpublishedtheir"Specification&GuidelinesforSelf-Compactingconcrete"which,at thattime,providedstateofthe artinformationforproducersandusers.Sincethen,muchadditionaltechnical informationonSCChasbeenpublished.
Material

In this study, the materials used are ordinary Portland cement (OPC), fly ash (FA), fine aggregate, Recycled coarse aggregate and superplasticizer. Fine Aggregate utilized in this research as cementations material obtained from Aji Dam, Rajkot, and Gujarat. The typical chemical compositions and some physical properties of OPC and FA are studied. Commercially available Glenium sky 8784 super plasticizer (SP) is used in this research.

Natural River and crushed sands were utilized as fine aggregates with maximum size of 4 mm. The values of specific gravity and water absorption are 2.66% and 0.55% for the natural river sand and are 2.45% and 0.92% for the crushed sand, respectively. Particle size gradations and some physical and chemical properties of Recycled aggregates are given in Table 1. RCA was used as coarse aggregate.

(Recycled aggregate)

Table 1: Physical properties of RCA

Properties	RCA
Abrasion Value	17.20%
Impact Value	27.665%
Crushing Value	34.10%
Specific gravity	2.94
water absorption	4.46%

II. Literature review

K.C. Panda, P.K. Bal [1], had studied on Important properties such as physical and mechanical properties of natural and recycled aggregates are carried out. NCA is partially replaced with RCA by an amount 10%, 20%, 30% and 40%. The effect of RCA on the properties of SCC in green state (e.g. Slump flow test, V-Funnel test and L-Box Test) and properties of concrete in hardened state (e.g. compressive strength, flexural strength, and Split tensile Strength) are studied. The mix design was carried out for M25 grade of concrete. The experimental results indicate that the compressive strength, flexural strength and split tensile strength of the SCC with 100% natural aggregate is less than the normal vibrated concrete (NVC) with 100% natural aggregate and the strength of SCC decreases with an increase in recycled aggregate (RA) replacement ratios. The present study recommends SCC marginally achieves required compressive strength up to 30% replacement of RCA. They had collected RCA from a demolished Town Club building of Banki, N.A.C of Cuttack region, about 25 years old on the properties of self-compacting concrete (SCC) and compared the results with normal vibrated concrete (NVC) containing 100% natural coarse aggregate (NCA).

Prashant O. Modani, Vinod M. Mohitkar [2], had studied on use of recycle aggregate in SCC.In this study coarse recycled aggregate (RCA) are used in the production of self-compacting concrete (SCC) in varying percentage replacements of natural coarse aggregate (NCA) from 0% to 100% with increment of 20%. This investigation is an attempt to examine the influence of recycled aggregate on strength, permeability, resistance to acid attack, chloride penetration, and alkalinity of self-compacting concrete. It is observed that recycled aggregate can be effectively used in the production of SCC without any significant reduction in strength and durability. This has encouraged the use of recycled aggregate in concrete which not only allows for a more efficient life cycle of natural resources but also contributes to environmental protection leading to sustainable development.

Zoran Jure Grdic, Gordana A , Toplcic-Curcic, ivan M. Despotovic, Nenad S.Ristic [3] , had studied for usage of coarse recycled aggregate obtained from crushed concrete for making of self-compacting concrete was researched, additionally emphasizing its ecological value. On the other hand the issue of the waste disposal sites created by the demolition of old structures is solved. In the experiment, three types of concrete mixtures were made, where the percentage of substitution of coarse aggregate by the recycled aggregated was 0%, 50% and 100%. In the process of mixing, equal consistence of all concrete mixtures was achieved. The obtained results indicate that the properties of these concretes have only a slight difference, and that the recycled coarse aggregate can successfully be used for making of self-compacting concrete.

Extensive excavation of natural aggregate seriously endangered river econ-systems, so it has been prohibited in some areas. Apart from this, the increasing distance of natural sources from construction sites affects the cost of construction material. On the other hand, On the other hand, large quantities of old concrete often occur in urban environments, resulting from construction or demolition of old buildings, so removal and disposal presents an environmental problem.The key property of a recycled aggregate is higher water absorption in comparison to the natural which is a result of residual cement powder. In order to apply the existing formula for concrete and achieve the same results as with the natural aggregate, it is necessary to increase the quantity of water.

Oussama Kebaili, Michel Mouret, nourredine Arabi, Franck Cassagnabere, [4] , had studied on defining the best way to incorporate recycled concrete aggregates (RCA) in the production of self-compacting concrete (SCC), with a view to reduce the excessive use of natural aggregates, which are a non-renewable resource, and to remove the large quantities of concrete waste generated by demolition. RCA differ from natural aggregates essentially by their lower density, higher water absorption capacity and systematic angularity. Here, the effect on self-compacting ability of replacing natural coarse aggregates (NCA) with coarse RCA in a dry state at the time of mixing is assessed.

Starting from a reference SCC incorporating rounded NCA only, three replacement rates were studied: 40%, 60% and 100% by weight. The water amount was adjusted so that the standardized 24-h absorption of RCA was satisfied. The key properties of SCC recommended by European specifications and guidelines (EFNARC), i.e. filling ability, passing ability and segregation resistance, were measured in the fresh state, immediately after mixing (t0). Shear-dependent properties were also quantified by means of rheological measurements at t0 and t0 þ 25 min. Through this study are shown and interpreted the difficulties in achieving the self-compacting ability under certain conditions of use of RCA.

The experimental results showed that the self-compacting ability criteria were not satisfied, irrespective of the replacement rate of NCA with RCA. This replacement implied an increase in the rheological properties of concrete. The increased volume of coarse aggregates together with a constant volume of interstitial paste, and the angular shape and rough surface texture of RCA, are the main causes of the alteration of the flow of concrete.

S.C. Kou, C.S. Poon[5] , had done studied on fresh and hardened properties of self-compacting concrete (SCC) using recycled concrete aggregate as both coarse and fine aggregates were evaluated. Three series of SCC mixtures were pre- pared with 100% coarse recycled aggregates, and different levels of fine recycled aggregates were used to replace river sand. The cement content was kept constant for all concrete mixtures. The SCC mixtures were prepared with 0, 25, 50, 75 and 100% fine recycled aggregates, the corresponding water-to-binder ratios (W/B) were 0.53 and 0.44 for the SCC mixtures in Series I and II, respectively. The SCC mixtures in Series III were prepared with 100% recycled concrete aggregates (both coarse and fine) but three different W/B ratios of 0.44, 0.40 and 0.35 were used. Different tests covering fresh, hardened and durability properties of these SCC mixtures were executed. The results indicate that the properties of the SCCs made from river sand and crushed fine recycled aggregates showed only slight differences. The feasibility of utilizing fine and coarse recycled aggregates with rejected fly ash and Class F fly ash for self-compacting Concrete has been demonstrated.

Somayeh Lotfi, Manuel Eggimann, Eckhard Wagner, Radoslaw Mroz [6] , had performed study on recycled aggregate in SCC. , the properties of the produced Recycled Aggregate (RA) were investigated, and results are presented. An experimental study was carried out on mechanical and durability properties of produced Recycled Aggregate Concrete (RAC) compared to those of the Natural Aggregate Concrete (NAC). The aim was to understand the importance of RA substitution, w/c ratio and type of cement to the properties of RAC. In this regard, two series of reference concrete with strength classes of C25/30 and C45/55 were produced using natural coarse aggregates (rounded and crushed) and natural sand. The RAC series were created by replacing parts of the natural aggregate, resulting in series of concrete with 0%, 20%, 50% and 100% of RA. Results show that the concrete mix design and type of cement have a decisive effect on the properties of RAC. On the other hand, the substitution of RA even at a high percentage replacement level has minor and manageable impact on the performance of RAC. This result is a good indication towards the feasibility of using RA in structural concrete by modifying the mix design and using a proper type of cement.

Abdurrahmaan Lotfy, Mahmoud Al-Fayez,[7] , had presented the fresh, mechanical, and durability performance of a structural concrete mix classified as a C1 mix, by the Canadian Standards Association (CSA) made with Controlled quality Recycled Concrete Aggregate (RCA). Seven mixes with water-to-binder (w/b) ratio of 0.40 and RCA content of 10%, 20%, and 30% by coarse aggregate volume replacement, 10%, and 20% fine and coarse (granular) aggregate replacement by volume were produced and tested against two 0% RCA control mixes made with General Use (GU) cement, and General use Limestone cement (GUL), respectively. All evaluated mixes met the specifications from the CSA for fresh, mechanical, and durability properties. The coarse RCA mixes performed better than the granular RCA mixes in terms of flexural and splitting tensile strengths, linear drying shrinkage, water sorptivity and rapid chloride-ion permeability, where the test results were substantially affected by the ultra-fines present in the granular RCA.Recycled concrete aggregates have already been widely used in granular layers in pavement design, however, extensive research has been, and is currently being conducted in many countries on the performance of RCAs in structural applications.

L.A. Pereira-de-Oliveira, M.C.S. Nepmuceno, J.P. Castro-Gomes, M.F.C Vila [8] , had performedproperties of self-compacting concrete (SCC) with the use of coarse recycled aggregates obtained from demolition of concrete structures. The objective was to verify the influence of recycled aggregates on SCC permeability properties. For this purpose four different types of concrete mixes were produced, one of them used as reference with natural coarse aggregates and the others prepared with 20%, 40% and 100% of recycled

coarse aggregates. The properties related to the durability of SCC, as air and water permeability and capillary absorption were determined on concrete specimens with and without preconditioning. The results from fresh and hardened concrete properties lead to the conclusion that it is viable to replace natural coarse aggregates by recycled coarse aggregates since the present research does not show any detrimental to the SCC permeability properties.For the densities of the hardened concrete, there was a small weight loss by increasing the incorporation of recycled aggregates. This loss can be explained from the low density values of the recycled aggregates, when compared with natural aggregates.

Prashant O. Modani, Vinod M. Mohitkar [9], had done study on Recycling of construction and demolition waste is a promising way towards sustainable construction. Coarse recycled concrete aggregates have been widely studied in recent years, and reported as a suitable alternative for natural coarse aggregates. However an extensive study of use of recycled aggregate in a new generation concretes is a relatively scarce field. Hence this study is a step forward which justifies and encourages the use of recycled aggregate in self-compacting concrete to create a sustainable solution to warrant the problem of environment protection. In this paper the effect of coarse recycled concrete aggregates on the fresh and mechanical properties of self-compacting concrete are investigated. The results are very encouraging and open a new spectrum for use of recycled aggregates in modern concretes.

Sija K Sam, Deepthy Varkey, Dr. Elson John [10] , had studied about replacing various percentages (10%, 20%, 30%) of natural aggregates in SCC with recycled coarse aggregates and the properties of SCC were evaluated. A comparison of SCC with concrete compacted using conventional method was also included in the study. The additive used in SCC for the study was Fly ash. The mix designs arrived for an M-30 mix. To reduce the water- binder ratio and to get sufficient flowability for SCC a polycarboxylic based superplasicizer was used. Mix design for SCC was carried out as per 'European Guidelines for SCC' based on 'Nan Su et-al method' of mix design. Fresh properties including Slump flow test, T-500 test, V-funnel and L-box test were carried out for SCC. Hardened properties of concrete like Compressive Strength, Flexural Strength, Split tensile Strength and Water absorption test were carried out for traditional concrete and SCC. By comparing the strength parameters of different mixes it was observed that SCC is a good alternative of traditional concrete with and without using recycled aggregates.Since the strength is not much reduced with recycled aggregates and flow properties were good recycled aggregate can be effectively used in SCC.The water absorption increased in SCC with recycled aggregate was due to the higher water absorption in RCA.

Nischay T G, S Vijay, B Shiva Kumaraswamy[11], had studied about Construction and Demolition waste management issues have attracted researchers around the world. The boom in construction sector and large-scale mechanization in concrete production has led to setting up of several ready-mixed-concrete (RMC) plants. The present study aimed at producing fine and coarse aggregates from the hardened concrete waste available at the RMC plant on the outskirts of Bangalore. The material characterization for both fine and coarse aggregates was carried out as per IS: 2386 (Part IV) – 1963. The test results have shown that the properties of recycled aggregates satisfy the codal provisions specified for natural aggregates. The M-20 self-compacting concrete mix with 0%, 25%, 50%, 75% and 100% replacement of fine and coarse aggregates were done separately in two batches. Third batch mixes consists of both fine and coarse aggregates replacement of 0%, 25%, 50%, 75% and 100%. Further the fresh and hardened properties of M-20 self-compacting concrete mix has been carried out systematically. It was observed that 50% replacements in all the three batches of M-20 concrete mix have exhibited satisfactory flow and compressive strength values.

Erhan Guneyisi, Mehmet Gesog lu, Zeynep Algin, Halit Yazici [12] , had performed experimental study on adverse effect of old cement-mortar composite on self-compacting concrete (SCC) containing recycled concrete aggregate (RCA) were investigated by means of potential aggregate treatment methods so as to promote the maximum RCA utilization. Although the limited researches focus on the direct utilization of untreated RCA in SCC, the hitherto unavailable results to the properties of SCCs containing treated RCAs are presented in this paper. Four alternative aggregate surface treatment methods introduced to RCAs are two-stage mixing approach, pre-soaking in HCl solution, water glass dispersion and cement–silica fume slurry. 100% coarse RCA replacement with the natural aggregate was used in SCC mixes having constant cement dosage, fly ash replacement and water- to-binder ratio. The slump flow and T500 time, V-funnel time, L-box height ratio, viscosity, compressive and splitting tensile strength, and freeze–thaw cycling tests were carried out to identify the effects of these aggregate treatment methods on the key properties of SCC. Test results reveals that self-compatibility characteristics of the concretes are remarkably affected by surface treatment of RCAs. Moreover, the treatment methods of two stage mixing approach and water glass provide more dense and connected microstructures in SEM analysis leading to significant strength improvements compared to the control SCC.The water absorption properties of RCAs have significantly improved after implementing the presented treatments as compared to untreated RCA. The water absorption capacity increases and specific gravity decreases with a decrease in size of RCAs due to higher amount of adhered mortar on smaller size RCAs. Water glass treated RCAs considerably reduce the water absorption providing the minimal value compared to the other treatments applied.

Ahmed Shaban Abdel-Hay [13] , had performed experiment on Construction and demolition wastes are produced every day around the world. Thus the idea of using recycled concrete aggregate in new concrete production appears to be an effective uti lization of concrete waste. This paper presents the results of an experimental study to evaluate the effects of recycled concrete aggregate (RCA) percentages under different curing conditions. The percentages of recycled coarse aggregate to dolomite were (0:100%, 25:75%, 50:50%, 100:0%) respectively. The concrete properties which were studied were the mechanical properties (compressive and splitting strength) and mass transport properties (ISAT and sorptivity). The concrete specimens were exposed to three different curing conditions, moist (standard), open-air, and painted specimens using the substance. The coarse recycled concrete aggregates were obtained by crushing a laboratory produced primary concrete at age of 28 days. The results showed that curing using paint material was the most efficient method of curing at all ages and percentages of recycling except at 100% recycling, where the maximum value of both compressive and tensile strengths was obtained using water curing. Also, in moist curing, full replacement of coarse aggregates gave the highest compressive strength at age of 28 days. In all cases of recycled aggregate ratios, curing using water caused a decrease in the concrete permeability.

Miguel Bravo, Jorge de Brito, Jorge Pontes, Luis Evangeslista [14], had analyzed the mechanical performance of concrete with recycled aggregates (RA) from construction and demolition waste (CDW) from various locations in Portugal. First the characteristics of the various aggregates (natural and recycled) used in the production of concrete were thoroughly analyzed. The composition of the RA was determined and several physical and chemical tests of the aggregates were performed. In order to evaluate the mechanical performance of concrete, compressive strength (in cubes and cylinders), splitting tensile strength, modulus of elasticity and abrasion resistance tests were performed. Concrete mixes with RA from CDW from several recycling plants were evaluated, in order to under- stand the influence that the RA's collection point, and consequently their composition, has on the characteristics of the mixes produced. The analysis of the mechanical performance allowed concluding that the use of RA worsens most of the properties tested, especially when fine RA are used. On the other hand, there was an increase in abrasion resistance when coarse RA were used.

Mehmet Geesoglu, Erhan Guneyisi, Hatice Oznur Oz, Ihsan Taha, Mehmet Taner Yasemin[15], had studied about properties of self-compacting concretes (SCCs) produced with recycled coarse aggregates (RCAs) and/or recycled fine aggregates (RFAs) compared to SCCs with natural aggregates (NAs). The SCC mixtures were designed with a constant slump flow of 680 ± 30 mm and two water/binder (w/b) ratios of 0.3 and 0.43. Silica fume (SF) was also used at two replacement levels of 0% and 10%. Hardened properties of the SCCs were evaluated in terms of compressive strength, splitting tensile strength, static modulus of elasticity, and net flexural strength after 56 days of water curing. Failure mechanism of the concretes was also monitored via three-point bending test on the notched beams. The results indicated that failure occurred throughout the recycled aggregates (RAs) which in-turn decreased the mechanical properties of SCCs. However, SCCs with both fine and coarse RAs (RCAs+ RFAs) had relatively worse performance than those with only RCAs or RFAs such that the reduction in strength was about 30% as compared to the corresponding reference mixes. Moreover, incorporating SF and decreasing w/b ratio improved the mechanical properties of SCCs.The 56-day compressive strength of the SCRACs was adversely affected by the incorporation of RCAs and/or RFAs. However, among the three types of SCRACs, the SCRAC with RCAs recorded the highest compressive strength such that the reduction in strength due to the inclusion of these aggregates did not exceed 16.9%.

P.C.C. Gomes, C. Ulsen, F.A.Pereira, M.Quattrone, S.C. Angulo [16] ,had studied on environmental impact of construction and demolition waste (CDW), recycling is mandatory. It is also important that recycled concrete aggregates (RCA) are used in concrete to meet market demands. In the literature, the influence of RCAs on concrete has been investigated, but very limited studies have been conducted on how the origin of concrete waste and comminution processes influence RCA characteristics. This paper aims to investigate the influence of three different comminution and sizing processes (simple screening, crushing and grinding) on the composition, shape and porosity characteristics of RCA obtained from concrete block waste. Crushing and grinding implies a reduction of RCA porosity. However, due to the presence of coarse quartz rounded river pebbles in the original concrete block mixtures, the shape characteristics deteriorated. A large amount of powder (<0.15 mm) without detectable anhydrous cement was also generated.In this study, the acid attack of RCA allowed natural aggregates to be recovered and their shape changes to be analyzed. Crushing and grinding produced irregular and elongated fine RCA due to the comminution of coarse quartz rounded river pebbles. This change of shape should be considered because this natural aggregate is used worldwide in concrete block mixtures.

Sun-Woo Kim, Hyun-Do Yun, Wan-Shin Park, Young-I1 Jang [17], had done experimental investigation into the bond behavior between recycled aggregate concrete (RAC) and deformed steel rebars, with the main variables being the recycled coarse aggregate replacement ratio (RCAr) and water-to-cement ratio of the concrete mixture. The inves tigation into splitting cracking strength indicates that the degradation of the bond splitting tensile stress of the cover concrete was affected by not only the roundness of the coarse aggregate particles but also the weak interfacial transition zone (ITZ) between the cement paste and the RCA that has a more porous structure in the ITZ than normal concrete. In this study, a linear relationship between the bond

strength and the density of the RCA was found, but the high compressive strength reduced the effects of the parameters. To predict the bond strength of RAC using the main parameters, a multivariable model was developed using nonlinear regression analysis. It can be inferred from this study that the degradation characteristic of the bond strength of RAC can be predicted well, whereas other empirical equations and
Code provisions are very conservative.The slump of concrete increases as the RAr increases because the water released from RA increases the effective w/c ratio in concrete mix. However, the amount of entrapped air does not significant differences between normal concrete and RAC.

III. Conclusion

[1] This literature papers deals with – (1) use of waste material in concrete (2) Partial replacement of recycled with Coarse aggregate in SCC (3) tests of fresh and hardened properties of SCC made with that materials.

[2] The compressive strength, flexural strength and split tensile strength of SCC decreases with increase in the amount of RCA.The 28 days flexural strength of SCC obtained from experimental investigation is less than the theoretical flexural strength in all the replacement ratio of RCA.

[3] Self-compacting concrete made with recycled aggregates have achieved the target strength in all the mixes and also satisfied the fresh state properties required for SCC as per EFNARC specification.

[4] It was observed that the mixes containing recycled aggregate gains quick early strength due to presence of partially hydrated cement adhered to aggregate which accelerates the hydration process.

[5] Increase of the percentage of recycled aggregate reduces the density of concrete, which is an expected consequence of its increased porousness. Replace of 50% of coarse aggregate (whole fraction 8/16) decreased the density for 2.12%, and replace of 100% of coarse aggregate (fractions 4/8 and 8/16) decreased the density for 3.40%.

[6] Significant increase in TSC with time was observed at 60% and100% RCA content and was due to the dry state of the RCA at the time of mixing.

[7] The slump flow and blocking ratio of the RA-SCC mixtures increased with increasing fine recycled aggregate content. The initial slump flows of all the RA-SCC mixtures prepared were at least 760 mm and the blocking ratios varied from 0.85 to0.94. The addition of f-FA resulted in an increase in slump flow and blocking ratio.

[8] The flexural strength resembled the same trend as the compressive strength. There was little to no difference in strength between mixes as the RCA replacement increased.

[9] For the densities of the hardened concrete, there was a small weight loss by increasing the incorporation of recycled aggregates. This loss can be explained from the low density values of the recycled aggregates, when compared with natural aggregates.

[10] Since the strength is not much reduced with recycled aggregates and flow properties were good recycled aggregate can be effectively used in SCC. Early age strength was less in SCC compared to traditional concrete. While comparing the Split tensile strength SCC gave highest result when coarse aggregate replacement gives a less value.

[11] It is observed that the properties of RCA and RFA are equivalent to that of NCA and NFA with the exception of water absorption value & a low density values.

[12] In all the studied cases of curing (air, water, paint), increasing the concrete age led to an increase in its compressive strength.

[13] The best ratio of recycled aggregates to natural aggregates is the mixing ratio of 50% and that when they are cured in air or painted, the maximum value of the compressive strength and tensile strength wasobtained at age of 28 days.

[14] Almost all of strength properties and fracture parameters of RCAs concrete were higher than RFAs concrete except the brittleness was lower. At all events, the maximum values of these parameters were recorded for NAs concrete; moreover, the minimums were for mixes contained both graded RAs.

[15] In this study, the acid attack of RCA allowed natural aggregates to be recovered and their shape changes to be analyzed. Crushing and grinding produced irregular and elongated fine RCA due to the comminution of coarse quartz rounded river pebbles. This change of shape should be considered because this natural aggregate is used worldwide in concrete block mixtures.

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