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# A REVIEW OF COMPARISON OF MECHANICAL AND STRENGTH PROPERTIES OF PARENT CONCRETE AND RECYCLED AGGREGATE CONCRETE

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## ABSTRACT

*Recycled aggregate (RA) obtained from crushed concrete rubble, instead of being stored, can be reused in building industry. An attempt has been made to study the possibility of reusing the recycled concrete aggregate from demolished structures in the place of fresh aggregate. The most important parameters associated with recycled concrete aggregate (RCA) production that may affect quality and yield include such properties of the parent concrete as the composition, strength and aggregate grading, type of crushers used, number of crushing stages, the size of the RCA particles, and the size reduction sequence. Here properties of NA and RA will be studied in many papers and compare the both properties NA and RA and conclude the reasons of difference in theirproperties.*

***Keywords:-*** *Natural Coarse Aggregates (NCA), Recycled Coarse Aggregates (RCA), Recycled Fine Aggregates (R.F.A), Calcium Metasilicte (CM), Recycled Aggregates Concrete (RAC), Treated R.A.*

## INTRODUCTION

Concrete has been proved to be a leading construction material for more than a century. It is estimated that the global production of concrete is at an annual rate of 1 m3 per capita (Neville 2003). The global consumption of natural aggregate will be in the range of 8–12 billion tonnes after 2010 (Tsung et al. 2006) Over 1 billion tonnes of construction and demolition waste (C&DW) is generated every year worldwide (Amnon 2004).

The large-scale depletion of natural aggregate and the increased amounts of C&DW going to landfill sites are causing significant damage to the environment and developing serious problems, denting the public and the environmentalist's aspirations for a waste-free society. The use of the recycled aggregates created from processing construction and demolition waste in new construction has become more important over the last twodecades.

There are many factors contributing to this, from the availability of new material and the damage caused by the quarrying of natural aggregate to the increased disposal costs of waste materials. Recently, these aggregates started to be used for intermediate utility applications, such as foundations for building sand roads. The advantages of recycling construction and demolition waste are (1) it reduces the amount of construction and demolition waste entering landfill sites; and (2) it reduces the use of natural resources in construction, contributes to the environment, provides a renewable source of construction material, and, if used in situ, reduces haulage costs. For economical and environmental reasons and because of the increased amount of recycled aggregates, there has been a growing global interest in maximizing the use of recycled aggregates in construction. In view of the increased volumes of construction, demolition waste, and industrial by-products such as fly ash (FA) and the advantages offered by the use of admixtures in modern concrete, it is considered very beneficial from different prospects with similar performance characteristics to natural aggregate concrete. When proved successful, recycled aggregate concrete (RAC) can be substituted for natural aggregate concrete in many concreteapplications.

In the last 15 years, it has become clear that the availability of good quality natural aggregates is decreasing. The shortage of the resources of natural aggregates has opened the possibility for the use of recycled materials to replace part of the natural aggregates.

As per record of newspaper (23rd August2015) in India there is amount of construction waste generated.

| City | Construction waste (MT) |
|---|---|
| Delhi | 4600 |
| Mumbai | 2500 |
| Chennai | 2500 |
| Calcutta | 1600 |
| Bangalore | 875 |
| Ahmadabad | 700 |

As per Technology informational forecasting and assessment council estimated waste generation during construction 40 to 60 kg. Per sq. m. Similarly waste generation during renovation/ repair work is estimated to be 40 to 50 kg/Esq. of waste respectively.

Though it is now necessary to use of these recycled aggregates in place of natural ones. Properties of recycled aggregates have to be compared to those of natural aggregate to evaluate its suitability for applications in construction industry.

## LITERATURE REVIEW

In the literature review there Is many papers studied and as per their view here following comparison carried out. Here studied natural and recycled aggregate properties and also parent concrete and RCA fresh and hardened properties. For the determining the various properties of aggregates the methods are in IS 2385P-5.

**Recycled Aggregates:** Aggregates can come from either natural or manufactured source. Natural aggregates are come from rock, of which there are three broad geological classifications.

**Abrasion Value:** Codal provision for abrasion value as per IS 2386 PART 5 is 30%. P.Saravana kumar et al (ASCE-0899- 1561/2012) reported that the abrasion value of natural aggregate is 12% for fine aggregate. Also Bhibhuti Bhusan et al (ASCE-0950-0618/2014) reported that abrasion value of natural aggregate is 19.72%.

A.Akbarnerhad et al (ASCE-8099-1561/2013) reported on the crushing procedure of recycled aggregate and determine the abrasion value of R.A (recycled aggregate) varies from 31 to 39%. P.Saravana kumar et al. (ASCE -0899- 1561/2012) reported on fine recycled aggregate abrasion value and observed that 7 to 10 % as per age of aggregates. Alla M. Rashall et al (ASCE -2013) reported on use of metakaoline in place of fine aggregate and observed that abrasion value 23.12% in MK content. Bhibhuti Bhusan et al (ASCE-0950- 0618/2014) reported that abrasion value of RCA is 36.56%.

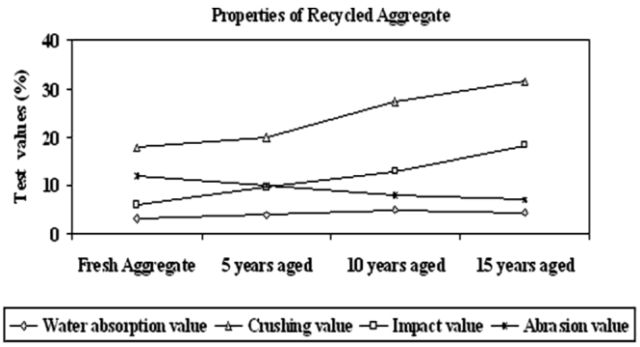
Poblo pere et al (ASCE-2012) reported on cement treated recycled material and determine the abrasion value of RCA 38.00%.

**Impact value:** Codal provision for impact value as per IS- 2386 PART 5 is 30% for wearing surfaces and 45% for non wearing surface. P.Sarvana kumar et al. (ASCE-0899- 1561/2012) reported that impact value of N.A is 5.85% forF.A. And bhibhuti bhusan et al (ASCE-0950-0618/2014) reported that impact value 0f N.A. is 15.35%.

P.Saravana kumar et al (ASCE-0899-1561/2012) reported that impact value of R.F.A is 9.66%, 12.79%, 18.45% after 5, 10, 15 years. Bhibhuti bhusan Mukharjee et al (ASCE- 0950-0618/2014) reported that impact value of R.C.A. 34.85%. Sallehan ismail et al (ASCE-0950-0618/2014) reported that impact value of R.C.A is higher than N.A by 13%.These results shows us that recycled fine and coarse aggregates are weaker than naturalaggregates.

**Crushing value:** Codal provision for crushing value of aggregate as per IS-2386 part 5 is 30% for wearing surface and 45% for non wearing surface. P.Saravana kumar et al.(ASCE-0899-1561/2012) reported that crushing value ofN.A is 17.75 for F.A. and Bhibhuti bhusan et al (ASCE-0950-0618/2014) reported that crushing value of N,A is 15.1%. Sallehan ismail et al. (ASCE-0950-0618/2014) reported on the use of treated coarse recycled concrete aggregate and observed that crushing value higher than the N.A. Bhibhuti bhusan mukharjee et al (ASCE-0950-0618/2014) reported that crushing value of R.C.A is 31.52%.

Figure 1. Shows the comparisonbetweenRecycled aggregate and natural aggregate.




(Figure 1: Comparison of Natural aggregate and Recycled aggregate Mechanical Properties, P.Saravana kumar et al. (2012)).

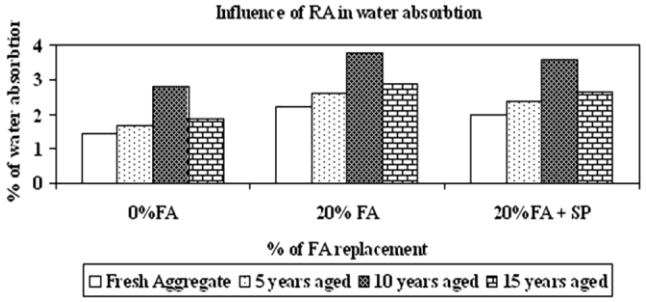
**Specific Gravity:** Kunal rafat siddique et al (ASCE 2013) reported that specific gravity of natural coarse aggregate 2.59 and fine aggregate 2.62. Bhibhuti bhusan et al (ASCE-0950- 0618/2014) also reported that specific gravity of NA 2.72.

P.Sarvana kumar (ASCE-0899-1561/2012) also reported same specific gravity of N.A 2.72.

P.Saravana kumar et al. reported that specific gravity of recycled aggregate decrease with increase of the age of sourse of recycled aggregate specific gravity of R.A. varies from 2.63 to 2.68. S.K.singh et al (use of recycled aggregate- NBMCM-2011) reported that specific gravity of RA 2.35 to
2.58 which is lower than N.A. Bhibhuti bhusan Mukharjee et al (ASCE-0950-0618/2014) determined the values of specific gravity of RCA is2.46.

**Water absorption:** Leonardo F.R. Miranda et al. (ASCE- 899-1561/2013) reported that water absorption value of fine aggregate is varies from 4.5% to 7.6%. While Kunal rafat Siddque et al (ASCE 2013) reported that water absorption ofC.A 0.80 % and fine aggregate has 1.02 % of water absorption. Bhibhuti bhusan et al (ASCE-0950-0618/2014) reported that water absorption value for N.A is 0.5%. Valeria corinaldesiet et al. (ASCE 2010) reported on the behavior of beam-column joints made of recycled aggregate concrete under cyclic loading than water absorption value is 3.4% for N.A.

P.Saravana kumae et al (ASCE 2012) reported on the use of fly ash and super plasticizer with recycled aggregate and concludes the results as shown in figure 2. Water absorption value of R.A is higher than 4% to 4.8%. LeonardoF.R. Miranda et al (ASCE-0899-1561/2013) reported that water absorption value of R.A is varies from 4.5 to 7.5%. A.Akbarnerhad et al (ASCE-8099-1561/2013) reported values vary from 2.7 to 5.1%. Sidnel H.C. et al (ASCE-0899- 1561/2014) reported the value of water absorption varies from1.65 to 6.2 % for recycled sand. Bhibhuti bhusan mukharjee et al (ASCCE-0950-0618/2014) determined the values of RCA are 4.6%. Valeria corinaldesi et al (ASSCE-2010) reported that water absorption value of RCA 7.0%. Poblo perez et al (ASCE-2012) reported that the value of water absorption is 4.72%.




(Figure 2: Comparison of water absorption value of R.A. and N.A by using Super plasticizers, P.saravana kumar et al (2012)).

**Density:** A.Akbarnerhad et al (ASCE-8099-1561/2013) reported that density of NA is varies from 2370 to 2450 kg/m$^3$. Marco pep et al (ASCE 2014) studied on processing procedure for recycled aggregate in structural concrete reported that bulk density of N.A is 2500 kg/m$^3$. Valeria Corinaldesi et al (ASCE 2010) reported that density of N.A is 2570 kg/m$^3$.

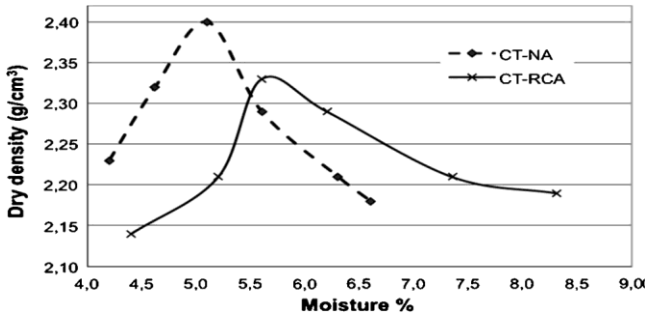
A.Akbarnehad et al (ASCE-8099-1561/2013) reported that density of recycled aggregate varies from 2370 to 2450 kg/m$^3$.Sallehan ismail et al (ASCE-0950-0618/2014) studied on comparison ofmechanical strength and drying shrinkage properties of concrete containing recycled coarse aggregate he reported that density of R.A. lower by 10 to 14% compare to the N.A. Marco pepe et al (ASCE/2014) studied on the alternative processing procedure for R.A.in structural concrete reported

that density of R. A. is 2450 kg/$m^3$

Poblo perez et al (ASCE 20102) also determined the value of density for R.A. it is 2531 kg/$m^3$.

**Flakiness index and Elongation index:** Bhibhuti bhusan et al (ASCE-0950-0618/2014) reported that flakiness index of N.A is 23% and elongation index of N.A is 34%.

Bhibhuti bhusan et al (ASCE-0950-0618/2014) studied on the use of nano silica with recycled coarse aggregate and compares the properties of R.A and N.A he determined the value of flakiness index for R.A. is 12.04% and value of elongation index for R.A. is 35.18%. Which shows the value of flakiness index is lower than the N.A. and elongation value slightly higher than the N.A. Poblo perez et al (ASCE/2012) reported that the flakiness index for R.A. 3.00%.




**Treatment of Recycled Aggregates:**

Amnon Katz et al (ASCE 0899-1561/2008) studied on the treatments of recycled aggregates they applied two different treatment silica fume treatment and ultrasonic cleaning treatment. By used silica fume treatment compressive strength improve by 30 % and 15% after 7 & 28 days. And byusing ultrasonic treatment compressive strength improved by 7% after 28 days.

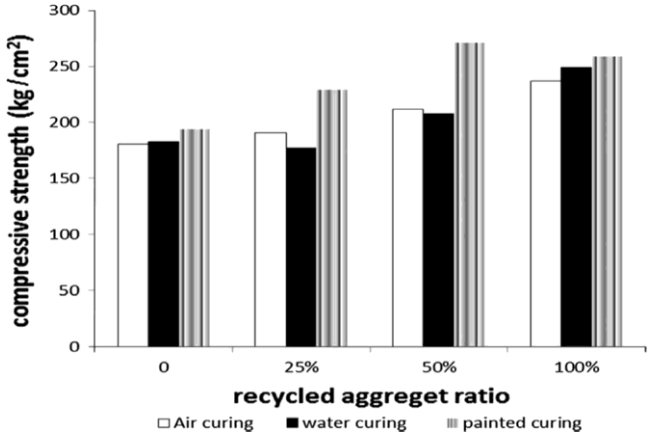
Kunal Rafat siddique et al (ASCE/2013) studied on the use of cement kiln dust replaced with fine aggregate and applied Bacterial treatment on CKD and then it replaced withF.A. CKD waste produced during cement production and it harmful for the nature and humans too so by applied bacterial treatment and then replaced with F.A. and compressive strength increased by 7.15% to 26.6% with 10% replacement. Erhan guneyisi et al (ASCE/2014) applied four different surface treatments on the properties of self compacting concrete with recycled aggregates. Treatments are I) Two stage mixing approaches ii) Pre- soaking in HCl solution. iii) Water glass dispersion IV) Cement silica fumes slurry. And they conclude that water glass dispersion treatment gives best result among all. Sallehan Ismail et al (ASCE-0950- 0618/2014) Studied on mechanical and drying shrinkage properties of concrete containing treated Recycled aggregates they firstly C.A. soaking in HCl 0.5 Molar solution then impregnated in calcium metasilicate (CM) to coat surface. 60% replaced with N.A. and conclude that there is increase

in mechanical properties of aggregates and strength property by using treatedaggregates.

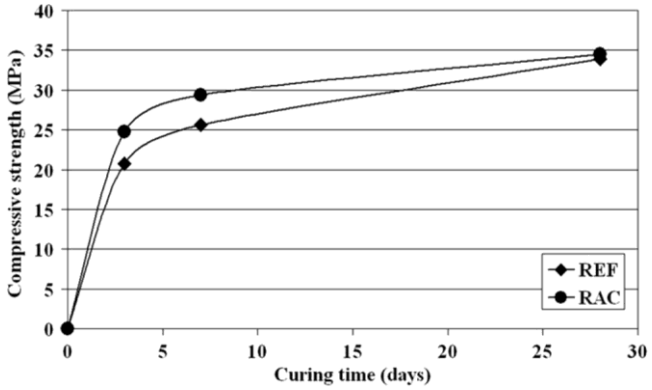
**Properties of Concrete:** For concrete there are two main type of properties 1) Fresh concrete properties and 2) Hardened concrete properties.

In this paper here compressive strength, split tensile strength, Flexural strength, Elastic modulus, workability, durability etc are analyzed for the parent concrete and Recycled aggregate concrete(RCA).

**Compressive strength:** Amnon katz (ASCE-0899- 1561/2008) studied on treatment of recycled aggregate and determine the compressive strength of RAC(Recycled aggregate concrete) reported that by applying silica fume treatment it increase 30 to 15% and by applying ultrasonic treatment it increase 7% after 28 days. P.Saravana kumar et al (ASCE/2012) reported that there is decrease in comp. strength about 5.5% in same mix proportion. Alla M. Rashall (ASCE/2013) studied on fine aggregate replacement with metakaoline and reported that there is increase in compressive strength up to 40% and then decrement start in compressive strength. Jared R. wright et al (ASCE-1561/04014073/2013) studied on use of glasscrete and suggested that while use glass in concrete there is must be less W/C ratio. Sallehan Ismail et al (ASCE-0950-0618/2014) studied on mechanical strength properties of treated and untreated RAC and reported that there is increase in all properties of concrete compare to the untreated R.A. Bhibhuti bhusan mukharjee et al(ASCE-0950-0618/2014) reported that there is decrease in compressive strength by using R.A. up to 8.9% but with using of nano silica as SP there is increase in compressive strength up to 12%. Macro pepe et al (ASCE/2014) reported that compressive strength of RA is 27.50n/mm$^2$.

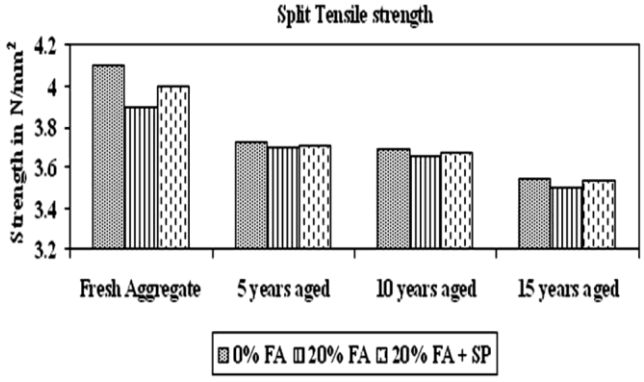



(Figure 4: Properties of recycled aggregate under different curing conditions)

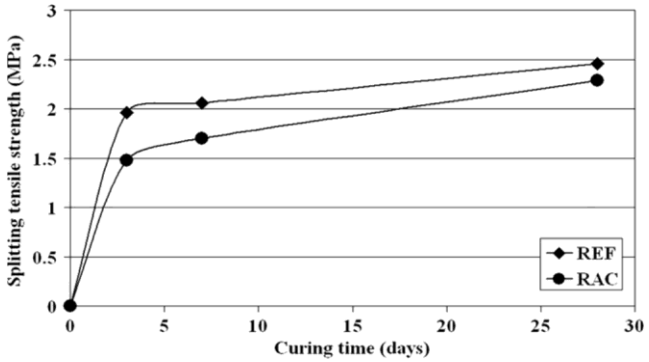



(Figure 5: Comparisonof NCA and RCA with compressive strength) (Behaviour of beam column joints made of recycled aggregate concrete under cyclic loading (valeria corinaldesiet al.2010)

**Split tensile strength:** P.Saravana kumar et al (ASCE/2012) reported that there is decrease in split tensile strength of 9%, 105, and 13.4% after 5,10,15 years aged R.A. Leonardo F.R. Miranda et al (ASCE-089901561/2013) studied on the use of recycled sand and determined the split tensile strength and it gives best results by using 50% replacement of recycled sand. Alla M.Raashall (ASCE/2013) studied on using of metakaoline(MK) reported that there is increase in split tensile strength up to use of MK 40% than there decrease in it by 15% of nominal split tensile strength. P.Pereira et al (ASCE/2013) studied on effect of super plasticizer on the mechanical performance of concrete made with recycled sand and suggested that there is decrease in split tensile strength by15.6 to 24.5% without use of SP and with SP using there is increase in strength by 26.6% to 52.8%. Marco pepe et al(ASCE/2014) reported that split tensile strength of parent concrete 3.85 MPA and RAC is 3.36MPa.

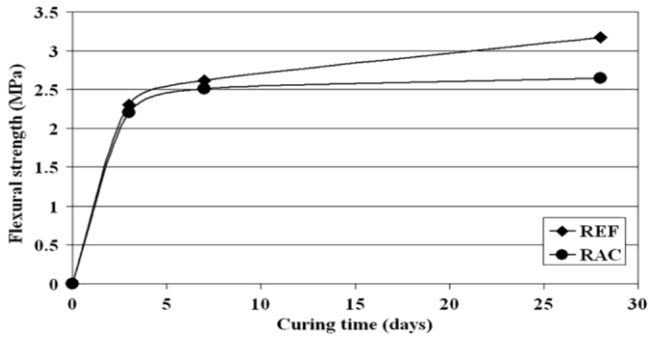



(Figure 6: Effect of admixed recycled aggregate concrete on properties of fresh and hardened concrete by P.Saravanakumar and G. Dhinakara.)



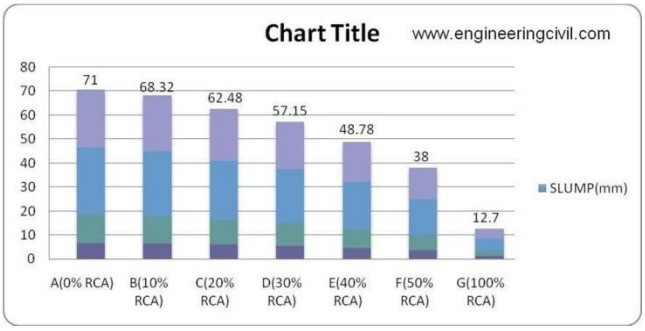

(Figure 7: Comparison of NCA and RCA with split tensile strength) (Behaviour of beam column joints made of recycled aggregate concrete under cyclic loading (valeria corinaldesi et al. 2010)

**Flexural strength:** Valeria corinaldesi et al (ASCE 2010) studied on the behavior of the beam and column joints made with recycled aggregate concrete and reported that there is decreased in the flexural strength by 10% comparision of NCA and RCA in figure 7:




( Figure 8 : Comparison of RCA and NCA with flexural strength) (Behaviour of beam column joints made of recycled aggregate concrete under cyclic loading (valeria corinaldesi et al. 2010)

**Workability:** As in above water absorption properties we discussed and results added by them we can say that as water absorption increased by using R.A. there is create problem in the workability of RAC.( P.Saravana kumar et al ASCE/2012). Amnon katz (ASCE-0899-1561/2010) also reported that water absorption of R.A. increased due to old mortar on it because of high water absorption in R.A. There decreased in workability.




(Bilal riaz chughdal Mechanical properties of recycled aggregate concrete) NMWCW)

(Workability requirements as per ACI) (Bilal riaz chughdal Mechanical properties of recycled aggregate concrete NMWCW)

**Modulus of Elasticity:** P.pereira et al (ASCE/2013) reported that there is decrease in the modulus of elasticity by using
R.A. up to 15.6 to 24.3%. But he added super plasticizer it increased by 20.7%.

## CONCLUSION

As we discussed above all the properties of natural and recycled aggregates and compare it. Also here we discussed the properties of parent concrete and recycled aggregate concrete and compare both.

As per the results we conclude that by using recycled coarse and fine aggregate in the concrete there is considerably decrease in the quality of concrete properties. This occurred due to old mortar adhered on it. Also we showed many treatments that are applied on the recycled aggregate and increase the quality of aggregates. By using treated aggregates in the concrete there we showed increase in the strength properties of concrete.

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