"EVALUATING PROPERTIES OF SELF COMPACTING CONCRETE BY USING TREATED RECYCLED COARSE AGGREGATES"

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Abstract- In India, many talks are being heard about sustainable construction and researchers are taking up studies here and there on use of unconventional construction materials that are aimed in using waste materials. However, focused attention on sustainability of materials for construction is needed. Though the time is not yet ripe for forming such an association in India, it is time for everyone concerned in the topic to start thinking about such a move.

So here in this research main concern on the reuse of construction and demolition waste in Self Compacting Concrete. In this research we use recycled coarse aggregate as well as recycled fine aggregate with replacement of natural aggregates. As per previous records there is considerably decrement in the strength property by using these kinds of recycled materials. This happen due to lower quality of recycled aggregates to improve the quality of R.A. here we apply cement slurry treatment on the R.A. and use this Processed Recycled Aggregates (PRA) with fine recycled aggregates (FRA). In this research we replaced 10, 20, 30% RA with natural aggregates. Then we replaced PRA 10, 20 and 30% with N.A. Also we combine proportion of PRA and FRA and measure compressive, tensile and flexural strength of concrete. Also we measure workability and compaction factor for all the mix. In the mix design we used 0.57 W/C because there is higher water absorption of R.A.

At the end we also compare the cost of RAC and NAC as well as PRAC, RAC and NAC. R.F.A.combined it with processed R.C.A. to reduce the overall cost of concrete.

Keywords- Natural Coarse Aggregates (NCA), Recycled Coarse Aggregates (RCA), Recycled Aggregates Concrete (RAC), Processed Recycled Aggregate Concrete (PRAC) Processed Recycled aggregates (PRA) Self Compacting Concrete (SCC).

Introduction- Concrete is a composite material, basically consisting of different constituents such as binding materials, water, aggregates and admixtures. Among these ingredients, aggregate plays a very crucial role in concrete which occupy the largest volume of about 60–75% of total concrete volume.

Recycling is the act of processing the used material for use in creating new product. Recycled aggregates could come from demolished buildings, airport runways, bridge supports, and even concrete roadbeds.

The strength, distribution size and water absorption capabilities of concrete will be affected. Recycling demolished concrete waste helps to protect natural resources and reduce environmental pollution. The use of recycled aggregates in concrete prove to be a valuable building materials in technical, environment and economical respect. In 1950 consumption of concrete was around 2 million tones but at present it is increased to the 20 million tones in India.

Main Environmental problems in Concrete sector are: 1) Global Warming, 2) Resource Depletion 3) Waste Disposal

World Cement production by Regions and Main Countries (Total around: 2.83 Billion tones)

Country	Cement Production(%)
China	49
Cembureau	10.8
Japan	2.2
India	6.5
Other Asia	13.5
Africa	4.7
USA	3.1
Other America	6
CIS	3.2
Other Europe	0.5

Total CO_2 emission from cement is around 2.46 billion tones.

Consumption of Natural resource on Earth:

Resource	Consumption (billion tones)
Aggregate	20
Steel production	1
Gold production	0.7
Wood	3
Other	1.3
Total	**26**

CO_2 emission form aggregate production is 160 million tones.

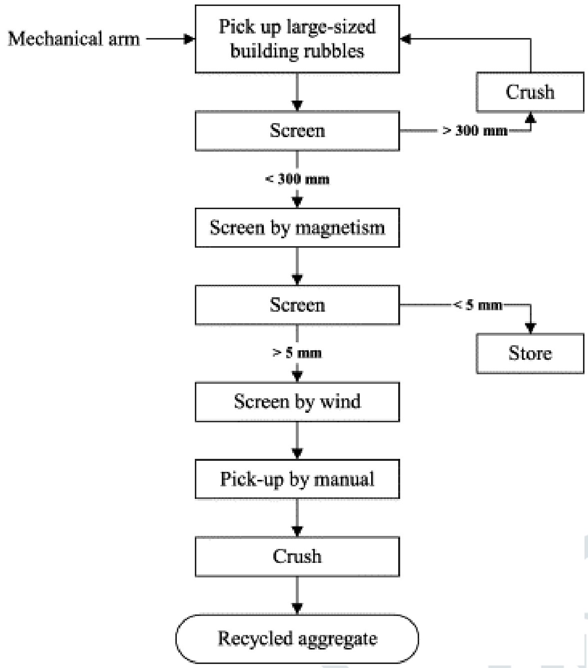
As per "construction and demolition waste management in India" by: Harish P. gayakwade et al. (2015) shows construction and demolition waste production per day in Indian cities.

Cities	Waste Generation (Metric tones/day)
Ahmadabad	3600
Bangalore	3000
Bhopal	7000
Delhi	2500
Hyderabad	3000
Mumbai	9000
Pune	2500

World Scenario of waste generation per year is as bellow

Country	Amount of waste generated in MT per year
India	12
Japan	85
USA	135
Germany	59
France	24
UK	30
Italy	20
Spain	13
Netherland	11

How to produced Recycled Aggregates:



Self Compacting Concrete:

The principle of self-compacting concrete is not new. Specific applications such as under water concreting always require fresh concrete, which could be placed without the need of compaction, where vibration is simply impossible. Early self-compacting concretes relied on very high contents of cement paste.

Specialized and well-controlled placing methods in order to avoid segregation. The high contents of cement paste made them prone to more shrinkage and high heat generation. The overall cost was very high and applications remained very limited. This led to the development of admixtures, which served the purpose of producing SCC. The admixtures consist of High Range Water Reducing Agents (HRWRA) and Viscosity Modifying Agents (VMA) which change the rheological properties of concrete.

Literature Review:

In the literature review there are 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 2385 P-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. In our project work we collect R.A. from Amdavad Enviro Projects Pvt.Ltd. Ahmedabad.

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% for F.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 natural aggregates.

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%.

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 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 is 2.46.

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 of C.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. Water absorption value of R.A is higher than 4% to 4.8%. Leonardo F.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 from 1.65 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%.

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 by using ultrasonic treatment compressive strength improved by 7% after 28 days.

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 strengthproperties 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 27.50 n/mm2.made of recycled aggregate concrete under cyclic loading (valeria corinaldesi et 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 by 15.6 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.

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%.

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.

Experimental Program: Recycled aggregates collected from Ahmedabad Enviro projects Pvt. Ltd., Near Pirana old jakat naka, Vishala, Ahmedabad, Gujarat, India.

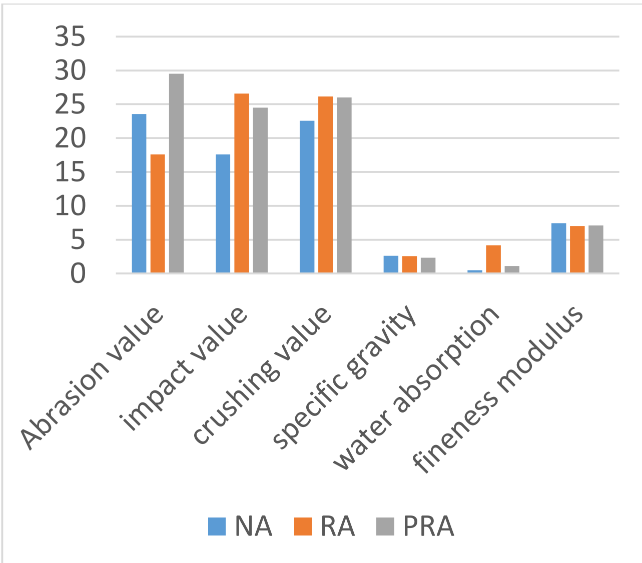
After Collecting Recycled aggregates firstly we determined all the physical properties of Recycled Aggregates and it seems that there is lower quality of material than natural one. So here we have to improve recycled aggregates quality by applying some treatments on to it. As per our literature survey we noticed that many authors applied treatments on to the RA and they are success to get better results than NAC. Here we introduce CEMENT SLURRY TREATMENT. In this treatment we make cement + water paste and soak RCA in to cement slurry paste for 24 hours. After 24 hours take out from vessel and make them naturally dry.

The Physical Properties of NA, RCA,and PRA are found out and compared as below.

RESULTS AND DISCUSSION

(Properties of Coarse Aggregates)

Comparison Graph of Coarse Aggregate



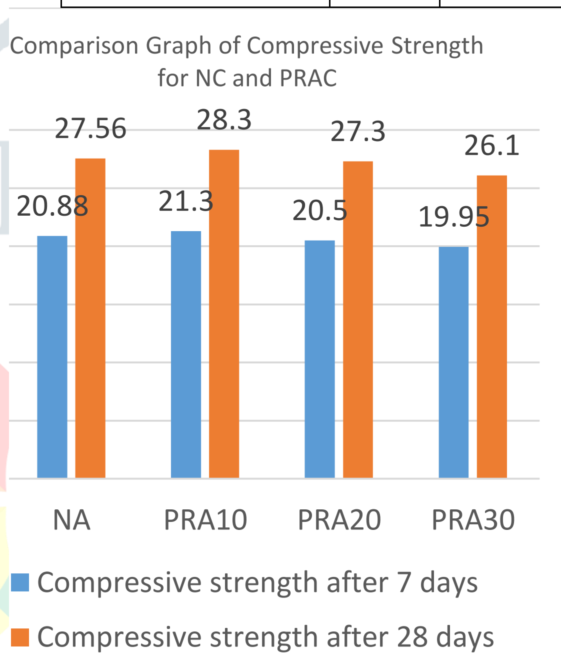
(Results of Natural fine aggregate)

(Results of compressive strength)

Sr No	Mix	Coarse RA(% replace ment)	Name	After 7 days N/mm2	After 28 days N/mm2
1	M25	100% NA	NA	20.88	27.56
2	M25	10%RA 90%NA	RA10	20.30	26.60
3	M25	20%RA 80%NA	RA20	19.10	25.18
4	M25	30%RA 70%NA	RA30	18.80	24.30
5	M25	10%PRA 90%NA	PRA10	21.30	28.30
6	M25	20%PRA 80%NA	PRA20	20.50	27.30
7	M25	30%PRA 70%NA	PRA30	19.95	26.10

Comparison Graph of Compressive Strength for NC and PRAC

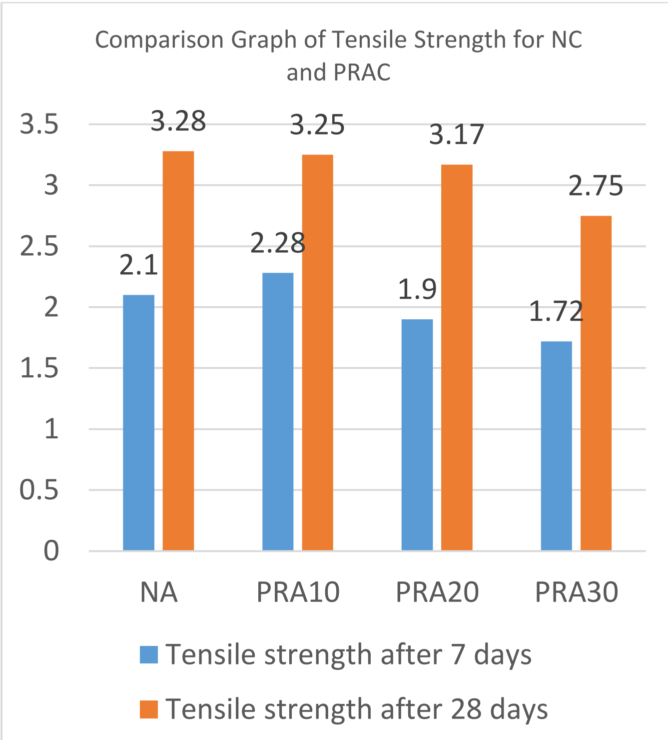
Property	NCA	RCA	PRCA
Abrasion Value	23.54	33.35	29.51
Impact Value	17.58	26.58	24.50
Crushing Value	22.56	26.14	26.00
Specific Gravity	2.61	2.56	2.36
Water absorption	0.48	4.20	1.09
Fineness Modulus	7.42	7.02	7.12



(Results of Tensile Strength)

Property	Natural F.A.
Fineness Modulus	2.82
Silt Content	1.07
Water absorption	0.38
Specific Gravity	2.64

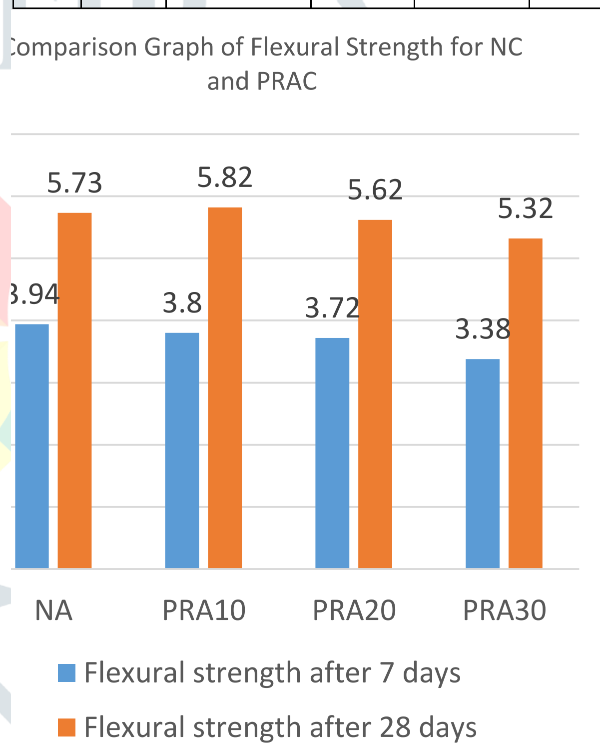
(Comparison graph of Tensile strength for NC and PRAC)



Sr no.	Mix	Coarse RA(% replacement)	Name	After 7 days N/mm2	After 28 days N/mm2
1	M25	100% NA	NA	2.1	3.28
2	M25	10%RA 90%NA	RA10	1.80	2.84
3	M25	20%RA 80%NA	RA20	1.64	2.80
4	M25	30%RA 70%NA	RA30	1.47	2.73
5	M25	10%PRA 90%NA	PRA10	2.28	3.25
6	M25	20%PRA 80%NA	PRA20	1.90	3.17
7	M25	30%PRA 70%NA	PRA30	1.72	2.75

(Results of flexural strength)

Sr no.	Mix	Coarse RA(% replacement)	Name	After 7 days	After 28 days
1	M25	100% NA	NA	3.94	5.73
2	M25	10%RA 90%NA	RA10	3.58	5.31
3	M25	20%RA 80%NA	RA20	3.21	4.76
4	M25	30%RA 70%NA	RA30	2.68	4.06
5	M25	10%RA 90%NA	PRA10	3.80	5.82
6	M25	20%RA 80%NA	PRA20	3.72	5.62
7	M25	30%RA 70%NA	PRA30	3.38	5.32

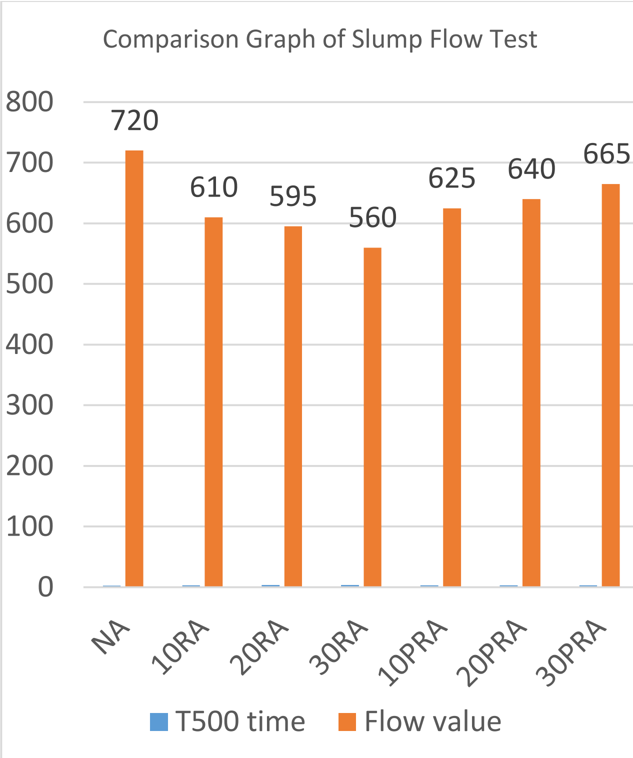


(Comparison Graph of Flexural Strength for NC and PRAC)

(Result of Slump Flow Test)

Sr no.	Mix	Coarse RA(% replacement)	Name	T500 (sec)	Flow value (mm)
1	M25	100% NA	NA	2.70	720
2	M25	10%RA 90%NA	RA10	3.10	610
3	M25	20%RA 80%NA	RA20	3.40	595
4	M25	30%RA 70%NA	RA30	3.40	560
5	M25	10%PRA 90%NA	PRA10	2.90	625
6	M25	20%PRA 80%NA	PRA20	3.00	640
7	M25	30%PRA 70%NA	PRA30	3.10	665

(Comparison graph of Slump flow test)

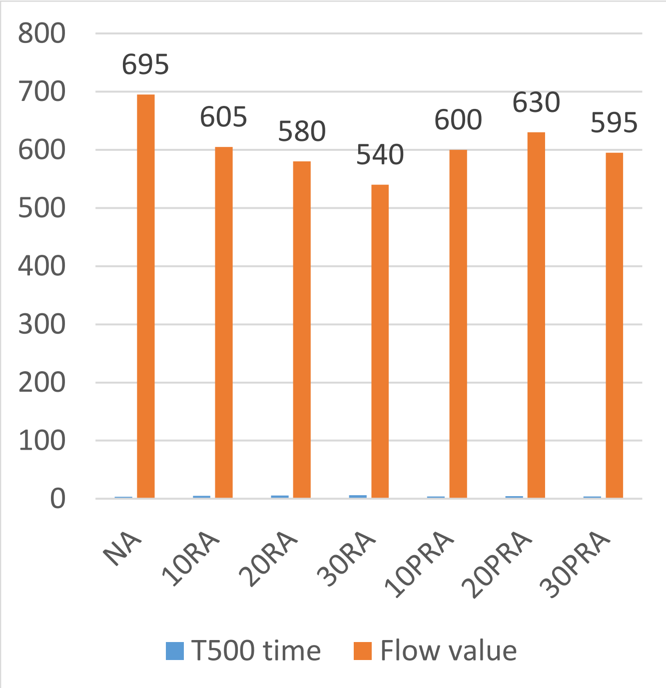


(Results of Slump flow test After 30 min.)

Sr no.	Mix	Coarse RA(% replacement)	Name	t500	Flow value
1	M25	100% NA	NA	3.70	695
2	M25	10%RA 90%NA	RA10	4.90	605
3	M25	20%RA 80%NA	RA20	5.90	580
4	M25	30%RA 70%NA	RA30	6.40	540
5	M25	10%PRA 90%NA	PRA1 0	4.30	600
6	M25	20%PRA 80%NA	PRA2 0	4.40	630
7	M25	30%PRA 70%NA	PRA3 0	3.90	595

Sr no.	Mix	Coarse RA (% replacement)	Name	Value (time in seconds)
1	M25	100% NA	NA	8
2	M25	10%RA 90%NA	RA10	12.6
3	M25	20%RA 80%NA	RA20	13.4
4	M25	30%RA 70%NA	RA30	17.7
5	M25	10%RA 90%NA	PRA10	10
6	M25	20%RA 80%NA	PRA20	12
7	M25	30%RA 70%NA	PRA30	9.6

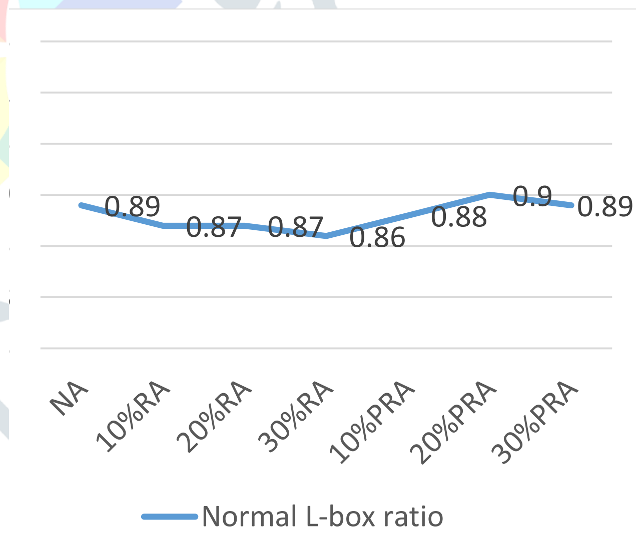
(Comparison graph of Slump flow test after 30 min.)



Result of L-Box Test

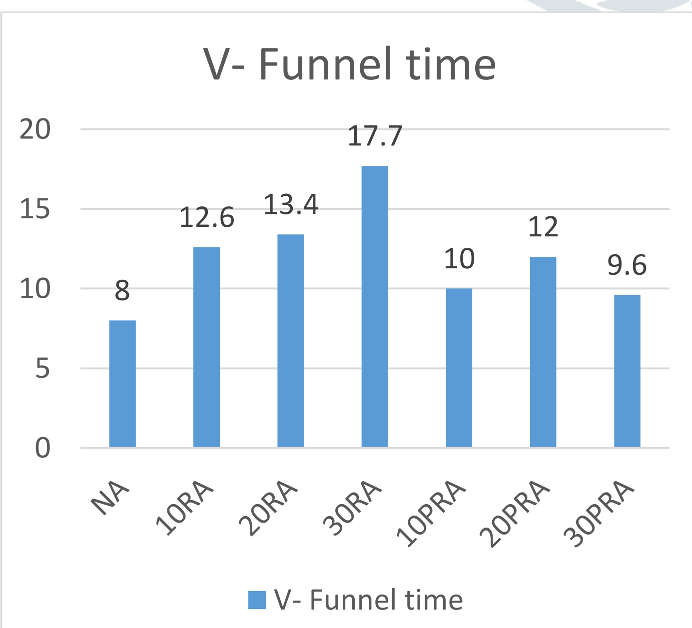
Sr no.	Mix	Coarse RA (% replacement)	Name	Ratio	Ratio (after 30 min.)
1	M25	100% NA	NA	0.89	0.84
2	M25	10%RA 90%NA	RA10	0.87	0.84
3	M25	20%RA 80%NA	RA20	0.87	0.82
4	M25	30%RA 70%NA	RA30	0.86	0.79
5	M25	10%RA 90%NA	PRA10	0.88	0.87
6	M25	20%RA 80%NA	PRA20	0.9	0.88
7	M25	30%RA 70%NA	PRA30	0.89	0.86

Comparison Graph for L-Box Test



Result of V-Funnel Test

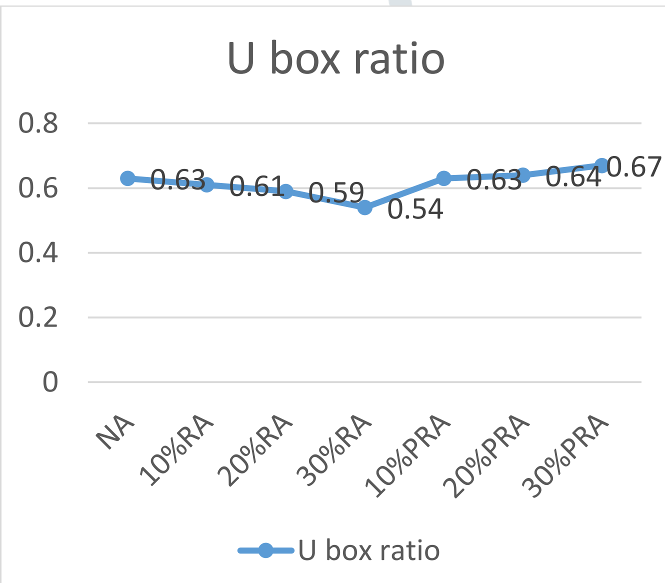
Comparison Graph of V-funnel Test



Result of U-Box Test

Sr no.	Mix	Coarse RA (% replacement)	Name	Ratio
1	M25	100% NA	NA	0.63
2	M25	10%RA 90%NA	RA10	0.61
3	M25	20%RA 80%NA	RA20	0.59
4	M25	30%RA 70%NA	RA30	0.54
5	M25	10%RA 90%NA	PRA10	0.63
6	M25	20%RA 80%NA	PRA20	0.64
7	M25	30%RA 70%NA	PRA30	0.67

Comparison Graph of U-Box Test



Conclusion

As in our research work we used RA and PRA to produce SCC. We replaced NA with RA up to 30%.

Properties of SCC evaluated by using RA. Quality of SCC is decreased as percentage of RA increased. This is due to lower quality of RA and old mortar adhere on the surface of RA.

It needed to be removed or permanent bonding required to improve quality of RA.

Hence here we studied many research papers which includes processing of RA.

From studied research paper we use cement slurry treatment on RA and produced PRA.

As properties of PRA is higher as compare to the RA and also some of the properties match to the NA.

In Slump flow value there is 22.22% decrement in 30RAC as compare with NC, due to higher water absorption of RA. And 6.74% decrement in 30 PRAC as compare with NC. But results slightly improved it is due to cement slurry treatment.

Same decrement in slump flow value can observe after 30 minutes test by comprising results of NC, RAC and PRAC.

V-funnel time also increased by 9 seconds in 30RAC and by 1.6 seconds in 30PRAC.

Results of compressive strength decreased by 9.97% in 30RAC, and 4.46% decrement in 30PRAC after 7 days.

After 28 days compressive strength, decreased by 11.83% in 30RAC and 5.6% in 30PRAC. In 30PRAC target strength achieved, but for 30RAC target strength cannot achieved.

Same strength decrement can be observed in tensile strength and flexural strength.

Reason behind strength decrement is loose mortar adhere over RA and by applying treatment on RA those old mortar can be removed or adhere with surface of aggregate more strongly.

After these work commonly conclusion can be derived that by using RA properties of SCC can be achieved or SCC cab be produced up to certain limit. But by using PRA up to 30% replacement as per our project work SCC can be produced and it can satisfy or achieve target means strength.

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