EFFECT OF RECYCLED COARSE AGGREGATES ON STRENGTH AND DURABILITY OF CONCRETE BY USING VARIOUS CHEMICAL TREATMENT METHODS

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ABSTRACT

India's official recycling capacity of construction and demolition (C&DW) waste is a meagre 6,500 tonne per day. C&DW is just around 1% according to analysis by the Centre for Science and Environment (CSE). The country's total construction and demolished waste is estimated to be 150 million tonne, according to the Building Material Promotion Council (BMPTC), India. Recycling of aggregate is a key step for construction material. However, recycled aggregate has poor quality as compared to natural and fresh aggregate, we can use recycled aggregate by some treatment of improvement to strengthen and durability approach for recycled concrete aggregate (RCA). For improving the quality of recycled coarse aggregate, various surface treatment methods such as removing the attached mortar by ultrasonic cleaning method, ball milling, heating, and then rubbing or pre soaking RCAs with HCl, H_2SO_4, and Na_2So_4, improving the quality of attached paste, such as surface coating with water glass pozzolanic materials, polyvinyl alcohol emulsion (PVA), silicone based emulsion, silica fume or silica gel, coating of cement, carbonation (CO_2) curing treatment methods. However, the addition of acidic solvents can lead to new pollution, use of water glass increases the risk of alkali aggregate reaction, and the other methods require extra energy thus carbonation process is more adequate to be used. Strength properties of the treated and untreated coarse aggregate were compared. The results indicated that the compressive, flexure and split tensile strength of recycle aggregate is found to be less than the natural aggregate and treated recycle aggregate is found to be nearest or more than the natural aggregate.

Keyword :- *Advance concrete technology, Recycled concrete aggregate, Physical properties, Mechanical properties, Coating of Polyvinyl alcohol, Carbonation treatment, Compressive test, and Durability test.*

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1. INTRODUCTION:

Rapid modernization and reconstruction of bridge, roads and industrial structures leads the concrete industry to draw enormous amount of natural resources and dispose large quantities of construction and demolition wastes in landfills. Concrete was once routinely and large volume of construction debris trucked to landfills or demolition site, for disposal, which is a serious threat to environment but recycling has a number of benefits that have made it a more attractive option in this age of greater environment awarness, more environmental laws, and the desire to keep construction costs down. Apart from reconstruction, debris results from natural calamities and the ravages of wars. Concrete, it has been claimed, is not an environmentally friendly material due to its destructive resource consumption nature and severe environmental impact after its use. Nevertheless, it will remain one of the major construction materials being utilized worldwide. Taking the concept of sustainable development into consideration, the concrete industry has to implement a variety of strategies with regards to future concrete use, for instance, improvements in the durability of concrete and the beter use of recycled materials. The depletion in the supply of the use of recycled aggregates in concrete will be advantageous economically and in the long run, prove to be sustainable. In general, aggregate occupy 55 – 80% of concrete volume. Demolition waste can be successfully used as recycled aggregates, provided adequate measures are taken for proper mix design and field control. Without proper, alternative aggregate being utilized in the near future, the concrete industry globally will consume 8 – 12 bllion tonnes annually of natural aggregate after the year 2010. For a variiety of resons, reuse of construction and demolition (C&D) materials by the construction industry has become more significant.

1.1 Treatment Methods

A. Untreated recycled aggregate: Manually method was carried for reuse of coarse aggregate which are use in concreting work.

B. Carbonation curing recycled aggregate: The recycled coarse aggregate are cured in presence of CO_2 gas in air-tight chamber to increase density of aggregate and reduces the porosity of aggregate and makes attached mortar rich.

C. Coating aggregate with polyvinyl alcohol (PVA): Recycle coarse aggregate are soaked in 10% (by mass) PVA concentration polymer under a laboratory environment. It increase durability of concrete and reduces the water absorption and porosity of recycled concrete aggregate.

1.2 Experimental Material

Cement: The most widely cement utilized is ordinary Portland cement. The HATHI 53 grade ordinary Portland cement to be used. The following test to be conducted on cement;

Table -1: Properties of Cement

Sr. No.	HATHI 53 grade OPC cement	Results	Standard value as per IS 12269 : 2013
1	Specific gravity	3.13	3.10-3.15
2	Standard consistency	28	30-35 %
3	Initial setting time	47	30 minute
4	Final setting time	130	600 minute

Fine Aggregate: When size of aggregate is less than 4.75 mm are termed as fine aggregate. Fine aggregate is silicate material. Source of F.A. is Junagadh, Gujarat.

Table -2: Properties of Fine aggregate

Sr. No.	Particulars	Fine aggregate
1	Zone	Zone III (IS 383:1970)
2	Specific gravity	2.74
3	Fineness modulus	2.65
4	Water absorption	1.33

Coarse Aggregate: When size of aggregate is greater than 4.75 mm are termed as coarse aggregate. The coarse aggregates from crushed basalt rock, and result are conforming to IS: 2386 part 3&4 – 1963. For the experimental work RCA has been procured from demolished RCC structure and separated the aggregate manually from the demolished waste, after separating aggregate, aggregate is passed through 20mm sieve and retained in 10mm sieve is used for the experimental work. Source of C.A. is Junagadh, Gujarat.

Table -3: Properties of Coarse aggregate

Sr. No.	Particulars	NCA	UTRCA	C-TRCA	P-TRCA
1	Max. aggregate size	20 mm	20 mm	20 mm	20 mm
2	Specific gravity	2.64	2.51	2.68	2.73
3	Water absorption	0.81	2.43	1.84	1.62
4	Crushing value	16.47	20.64	-	-

Water: Water used for concreting work shall be clean, free from impurities, harmful chemical. The pH value shall not < 6. Portable water may be used for concreting work.

2. MIX DESIGN

We are conducted IS method of mix design for M40. For the mix design of concrete we use IS 10262 : 2009 code.

Table -4: Concrete mix proportion of NCA M40 (1:1.08:1.95)

W/C ratio	Cement (kg/m^3)	F.A. (kg/m^3)	N.C.A. (kg/m^3)	Water
0.39	547.67	594.12	1068.69	213.90

Table -5: Concrete mix proportion of UTRCA M40 (1:1.08:1.82)

W/C ratio	Cement (kg/m^3)	F.A. (kg/m^3)	R.C.A. (kg/m^3)	Water
0.42	547.67	594.12	999.47	230.06

Table -6: Concrete mix proportion of C-TRCA M40 (1:1.08:1.96)

W/C ratio	Cement (kg/m^3)	F.A. (kg/m^3)	R.C.A. (kg/m^3)	Water
0.41	547.67	594.12	1073.62	225.29

Table -7: Concrete mix proportion of P-TRCA M40 (1:1.08:2)

W/C ratio	Cement (kg/m^3)	F.A. (kg/m^3)	R.C.A. (kg/m^3)	Water
0.41	547.67	594.12	1096.10	223.22

Table -8: Details of UTRCA, C-TRCA and P-TRCA for M40 grade concrete mixes

Mix	UTRCA	C-TRCA	P-TRCA
Mix1	0 %	0 %	0 %
Mix2	10 %	10 %	10 %
Mix3	20 %	20 %	20 %
Mix4	30 %	30 %	30 %

Mix5	50 %	50 %	50 %
Mix6	100 %	100 %	100 %

3. EXPERIMENTAL PROGRAMME

The experimental programme included research work for the fresh and hardened concrete specimen test. The experimental programme was divided into seven stages.

- Procuring of material
- Preliminary test
- Mix design
- Treatments
- Casting
- Fresh concrete test - Slum test
- Hardened concrete test
- Durability test
- Results

4. EXPERIMENTAL METHODOLOGY

Concrete is the mixtures of cement, F.A., C.A. (UTRCA, C-TRCA, and P-TRCA) and water. The NCA is replaced by 0%, 10%, 20%, 30%, 50% and 100% of RCA (UTRCA, C-TRCA and P-TRCA). Three cube samples were cast on the mould size 150 mm * 150 mm * 150 mm for M40 with 0.36 water cement ratio. The test specimen is demoulded after 24 hours and cured is done for 7 days, 14 days and 28 days for compression test.

Compression Test: The compressive strength tests are generally made at the ages of 7, 14 and 28 days. The test should be carried out immediately upon the removal of specimen from water curing. The weight of the specimen before testing is noted. The comparative studied were made for concrete mix M40 with partial replacement of NCA with RCA (UTRCA, C-TRCA and P-TRCA) as 0%, 10%, 20%, 30%, 50% and 100%.

Durability Test:

Acid Attack Test (IS 4456 : 1987): For the acid attack test 150 mm ×150 mm × 150 mm cube specimen treating with 5% H_2SO_4. We are conducting acid attack test for change in compressive strength and mass of cube specimen and discuss the result for six mixes. The acid resistance of concrete is measuring by the residual compressive strength and change in mass after acid exposure at 28 days. After 28 days of water curing, cubes are immersed in 5% sulphuric acid solution with maintained pH 3.

Sulphate Attack test (IS 4456 : 1987): For the sulphate attack test concrete specimen size 150 mm × 150 mm × 150 mm cube specimen casted for experimental study conducted for change in compressive strength and change in mass. In the sulphate attack test cube specimen treating with 5% sodium sulphate (Na_2So_4) and evaluate the six mixes doe residual compressive strength and mass after sulphate exposure at 28 days. After 28 days water curing, cubes are immersed in 5% sodium nitrate solution with maintained pH 8.

5. EXPERIMENTAL RESULT

Table -9: Slump Value for M40 Grade Mix

Sr. No.	Particulars	% RCA	%NCA	Slump value (mm)
1	NCA	0	100	102
2	UTRCA	10	90	103

		20	80	105
		30	70	96
		50	50	90
		100	0	85
3	C-TRCA	10	90	105
		20	80	107
		30	70	109
		50	50	98
		100	0	89
4	P-TRCA	10	90	107
		20	80	110
		30	70	113
		50	50	115
		100	0	91

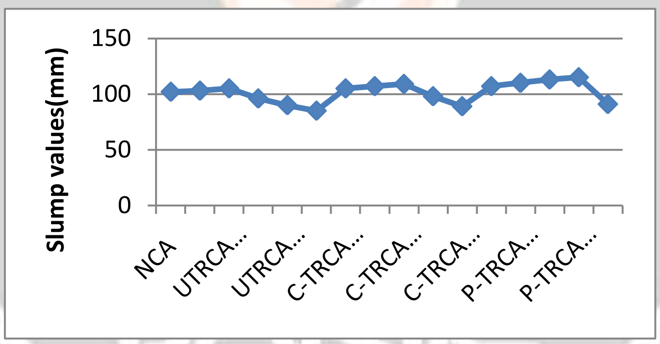

Chart -1: Slump value for M40 Grade mix

Table -10: Compression test value for M40 Grade mix with UTRCA

Sr. No.	Particulars	% UTRCA	%NCA	Compressive strength Result N/mm^2		
				7 days	14 days	28 Days
1	0 RCA	0%	100%	33.54	39.67	48.37
2	10RCA	10%	90%	34.33	40.03	48.68
3	20RCA	20%	80%	36.07	40.98	49.08
4	30RCA	30%	70%	32.94	37.97	47.67
5	50RCA	50%	50%	28.12	36.94	46.34
6	100RCA	100%	0%	29.04	35.82	45.13

Table -11: Compression test value for M40 Grade mix with C-TRCA

Sr. No.	Particulars	% C-TRCA	%NCA	Compressive strength Result N/mm^2		
				7 days	14 days	28 Days
1	0 RCA	0%	100%	33.54	39.67	48.37
2	10RCA	10%	90%	35.10	41.30	49.89
3	20RCA	20%	80%	36.79	42.16	50.38
4	30RCA	30%	70%	37.26	43.70	52.12
5	50RCA	50%	50%	32.42	37.58	48.16
6	100RCA	100%	0%	28.55	36.01	46.03

Table -12: Compression test value for M40 Grade mix with P-TRCA

Sr. No.	Particulars	% P-TRCA	%NCA	Compressive strength Result N/mm^2		
				7 days	14 days	28 Days
1	0 RCA	0%	100%	33.54	39.67	48.37
2	10RCA	10%	90%	35.52	41.85	51.14
3	20RCA	20%	80%	37.12	43.09	52.53
4	30RCA	30%	70%	39.60	44.17	53.66
5	50RCA	50%	50%	40.01	44.71	54.05
6	100RCA	100%	0%	31.14	38.22	46.93

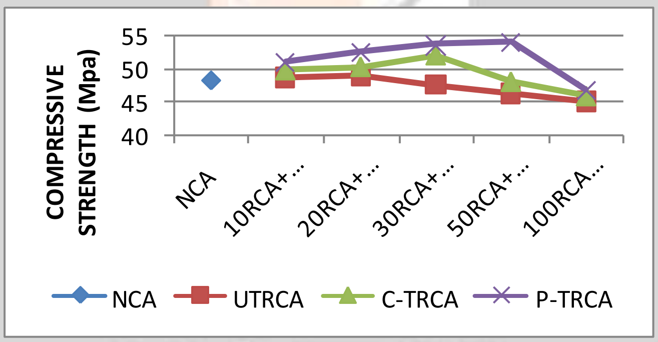

Chart -2: Comparison of 28 days compressive strength for NCA, UTRCA, C-TRCA and P-TRCA with different RCA replacement ratio for M40

Table -13: Acid attack test for M40 with 5% sulphuric acid

Mix	Before	After	Before	After
	Mass (kg)	Mass (kg)	Compressive strength of 28 days (Mpa)	Compressive strength of 28 days (Mpa)
NCA	8.19	7.86	48.37	47.03
20 UTRCA	8.01	7.61	49.08	47.77
30 C-TRCA	8.24	7.88	52.12	50.85
50 P-TRCA	8.31	7.97	54.05	52.80
50 UTRCA	8.02	7.58	46.34	44.49
100 UTRCA	8.01	7.53	45.13	43.12

Table -14: Sulphate attack test for M40 with 5% sodium nitrate acid

Mix	Before	After	Before	After
	Mass (kg)	Mass (kg)	Compressive strength of 28 days (Mpa)	Compressive strength of 28 days (Mpa)
NCA	8.24	8.27	48.37	46.25
20 UTRCA	8.13	8.30	49.08	46.67
30 C-TRCA	8.30	8.49	52.12	50.01
50 P-TRCA	8.34	8.51	54.05	51.72
50 UTRCA	8.16	8.33	46.34	45.25
100 UTRCA	8.08	8.38	45.13	41.78

6. CONCLUSIONS

Recycled aggregate not only reduce the environmental impact also reduce the cost of material, space wastage in landfills and preserve natural resources. Use of RCA get same or higher strength than natural aggregate and reduced the cost of construction by about 25%. Recycled concrete aggregate is cheaper source of aggregate than newly mined.

After the concluding a detailed experimental programme during the research study, the following conclusions can be summarized from the above experimental results;

[1] Surface treatment - Carbonation curing and Coating of PVA improves the physical and Mechanical properties of RCA than NCA and UTRCA.

[2] The workability of concrete is decreased as higher proportion of recycled aggregate is added in concrete mix. And slump value is also decreased due to higher water absorption of recycled coarse aggregates used in the mix.

[3] As per compressive strength result maximum acceptable RCA replacement ratio for M40 is

Sr. No.	Particulars	Acceptable RCA replacement ratio
1	UTRCA	20%
2	C-TRCA	30 %
3	P-TRCA	50 %

[4] Acid curing environments have negative effects on mass and strength while concrete cube are immersed in H_2SO_4 and Na_2SO_4 solutions. Polymeric resin coating to concrete structures has highly resistance to acid attack.

[5] From the Acid attack result of M40 grade concrete , we can seen that mix 20 UTRCA, 50 UTRCA and 100 UTRCA, 30 C-TRCA, 50 PTRCA weight loss is higher as compared to NCA. Weight loss increasing as recycled aggregate content is increasing. When NCA is replaced 50 P-TRCA give optimum maximum durability by H_2SO_4 is 52.80 Mpa with 1.25% reduction rate for M40.

[6] From the Sulphate attack result we can noted that the mix 20 UTRCA, 50 UTRCA, 100 UTRCA, 30 C-TRCA and 50 P-TRCA little weight gain than NCA. Weight gain increasing as recycled aggregate content increasing. Reason behind this is more water absorption of recycled aggregate. When NCA is replaced 50 P-TRCA give optimum maximum durability by Na_2SO_4 is 51.72 Mpa with 2.33% reduction rate for M40.

[7] During the durability test compressive strength reduction is increasing as recycled aggregate content increasing. Reason behind this is less bonding between old mortar of RCA and new mortar.

7. REFERENCES

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