Strength and Durability Properties of Concrete Containing Recycled Concrete Aggregate

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***Abstract:* - Use of recycled aggregates from demolished construction in concrete which can bring economic construction material and less probability of environmental imbalance. The use of recycled aggregates have been started many projects in many countries. The properties of recycled aggregates and natural aggregates are like specific gravity, aggregates crushing value, impact value, reports in this paper. The basic concrete properties compressive strength, durability are explained here with 0%, 25%, 50% replacement of natural aggregates with recycled aggregates with addition of silica fume and admixture.**

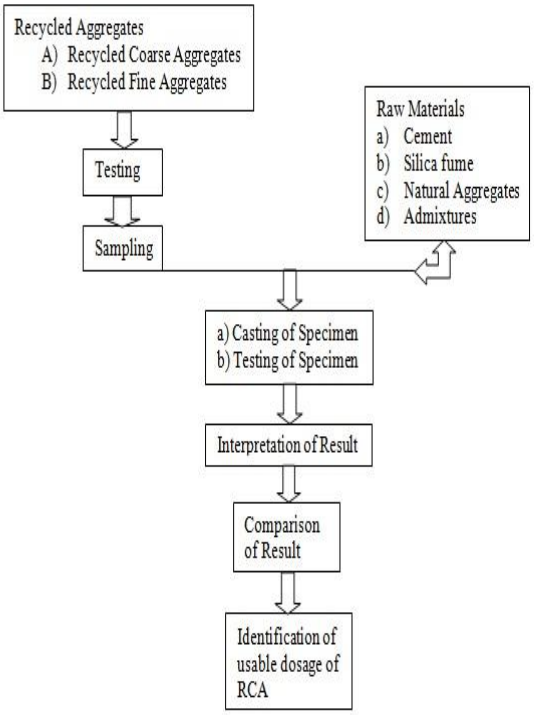
Keywords- Recycled aggregates, natural aggregates, cement, silica fume, admixture.

I. INTRODUCTION

Concrete is the premier construction material in the world and the most widely used in all types of civil engineering works, including infrastructure, low and high-rise buildings, defense installations and environmental protection facilities[1]. In present scenario concrete technology is a keen subject attracting researchers of various fields so as to improve strength, durability, resistance to fire, low permeability and other characters of concrete as a construction material. The increasing problems associated with construction and demolition waste have led to a rethinking in developed countries and many of these countries have started viewing this waste as resource and presently have fulfilled a part of their demand for raw material. In present years, in a drive to increase environmental sustainability, better ways to manage Construction and Demolition Wastes (CDW) have been explored rather using naturally available aggregates. Moreover consumption of concrete in very high quantity creates environmental imbalance as a result of rock mining and sand quarrying. Recycled aggregates (RA) are inert materials mostly originated from CDW. In broad terms, the CDW can be anything ranging from broken concrete and bricks from demolition sites, excavated materials in foundation work sites to broken up road surfaces, a byproduct of the road maintenance etc.[2] CDW use is increasing over time, proportionate with the development of the towns and the countries. Since concrete composes 35% of the waste as per the survey conducted by Municipal Corporation of Delhi, India may also have to seriously think of reusing demolished rubble and concrete for production of recycled construction material. Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million tons per annum out of which, waste from construction industry only accounts for more than (25%) 12 million tons Per annum out of which 7-8 million tons are concrete and bricks waste. These hard inert materials are suitable for works of recycling, and with proper sorting and tests, can be further used as aggregates in concrete production or other uses. Before the Construction and Demolition waste materials can be recycled and reused, they have to undergo sorting and processing, a common processing method is to crush the materials in recycling plants [2]. India is presently generating construction and demolition waste to the tune of 23.75 million tons annually as per the Hindu online of March 2007, which is comparable to some of the developed nations and these figures are likely to double fold in the next 7 years. The management of construction and demolition waste is a major concern due to increased quantity of demolition rubble, continuing shortage of dumping sites, increase in cost of disposal and transportation and above all the concern about environment degradation. Recycled concrete aggregate (RCA), produced by crushing concrete from demolished concrete structures may potentially serve as a new supplementary source, which can bring economical construction materials and less probability of environmental imbalance. This research paper presents the efforts in finding optimum replacements of natural aggregates by CDW. [5]

II. EXPERIMENTAL PROGRAM

The experimental work is present study as flow chart.



A. Recycled Aggregates- Recycled concrete aggregate (RCA), produced by crushing concrete from demolished concrete structures. [6] This demolished concrete structure is located in Jaipur District in Rajasthan state. Which are Recycled coarse aggregates and Recycled fine aggregates. [2]

B. Raw Material-

Cement-Ordinary Portland Cement of Grade 43 from a single lot was used throughout the investigation. The Ordinary Portland Cement of 43 grade conforming to IS: 8112-1989 was used.

Silica Fume- the Environmental controls started the filtering of the exhaust gases furnaces. The main portion of these fumes was a finely composed of a high percentage of silicon dioxide.

Natural Coarse Aggregates- IS: 383-1970 defines the coarse aggregates the one passing 20 mm to 4.75 mm IS sieve. The coarse aggregate is often from crushed Basalt rock.

Natural Fine Aggregates- IS: 383-1970 defines the fine aggregates the one passing 4.75 mm to 150 micron IS sieve. The fine aggregate is often termed as a sand size aggregate. River sand made of crushed aggregates was used as fine aggregate.

Admixture- Admixture is used as ingredient of concrete [9]. Water-reducing and set–retarding admixtures are permitted in order to increase the workability of the concrete and to extend the time of discharge from 60-90 minutes.

III. TESTING OF RECYCLED AND NATURAL AGGEGATES

The following test Program was planned to investigate the strength and durability properties of recycled concrete aggregate:

(i) To obtain the physical properties of the concrete constituents i.e. ordinary Portland cement (PC), [3] sand, Natural Coarse aggregate, recycled concrete aggregate [5] and mineral admixtures used (silica fume) as per relevant Indian Standard Codes of Practice.

TABLE -1 PROPERTIES OF NATURAL & RECYCLED AGGREGATES

Sr no.	Particles size	Natural aggregates	Recycled aggregates
1	Maximum size aggregate	20 mm	20mm
2	Specific gravity	2.74	2.63
3	Fineness modulus	7.68	7.73
4	Aggregate crushing value	14.5%	21.8%
5	Impact value	2.74%	31.68%
6	Water Absorption (%)	1.02%	4.08%
7	Moisture content	0.2%	0.2%

IV. SAMPLING OF AGGREGATES

Table-2: Binder Proportions in Concrete Mixes

Mixes	OPC	FA	MK	SF	NA 20 mm	NA 10 mm	RCA 20 mm	RCA 10 mm
Mix-1	70%	30%	-	-	50%	50%	-	-
Mix-2	70%	30%	-	-	37.5%	37.5%	12.5%	12.5%
Mix-3	70%	30%	-	-	25%	25%	25%	25%
Mix-4	70%	20%	10 %	-	37.5%	37.5%	12.5%	12.5%
Mix-5	70%	20%	-	10%	37.5%	37.5%	12.5%	12.5%
Mix-6	70%	20%	10 %	-	25%	25%	25%	5%
Mix-7	70%	20%	-	10%	25%	25%	25%	25%

V. CASTING OF SPECIMEN

The casting of the specimens using construction and demolition waste (CDW) was done under laboratory conditions using standard equipment. To determine compressive strength, for each concrete mix, 7 cubes of size 100 x 100 x 100 mm were cast for testing at 7, 28, 60 and 90 days of curing. Also, for each mix, 2 cylinders of 100 mm diameter and 200 mm height for Capillary Suction Test and 2 cylinders of 100 mm diameter and 200 mm height for Rapid Chloride Permeability Test. (for mix proposing of specimen provisions in IS;10262 were follow).

VI. TESTING OF SPECIMENS

A. Compressive Strength Test

Compressive strength (ASTM C 1716) of concrete may be defined as the measurement maximum resistance of a concrete to axial loading. The strength of the specimens with different percentage of recycled aggregate replacement can be indicating by the compression strength test. The test was conducted on cubes of size 100mm x 100mm x 100mm. Specimens were taken out from curing tank at the age of 3, 7, 28, and 60 days of water curing. Surface water was then allowed to drip down. Specimens were then tested on 200 tones capacity Universal Testing Machine (UTM).

B. Capillary Suction Test

The capillary test method is used to determine the rate of absorption (sorptivity) of water by hydraulic cement concrete by measuring the increase in the mass of a specimen resulting from absorption of water as a function of time when only one surface of the specimen is exposed to water [8]. The standard test specimen was a 100 ± 6 mm diameter disc, with a length of 50 ± 3 mm. Specimens were obtained by cutting cylinders of 100 mm diameter and 200 mm long with the help of specimen cutting machine with water cooled blade

C. Rapid Chloride Permeability Test (RCPT)

This test method is used to determine Resistance of Concrete to Chloride Ion Penetration. [7] The standard test specimen was a 100 ± 6 mm diameter disc, with a length of 50 ± 3 mm. Specimens were obtained by cutting cylinders of 100 mm diameter and 200 mm long with the help of specimen cutting machine with water cooled blade. Three specimens were cut for each mix at each age of testing.

VII. RESULTS AND DISCUSSION COMPRESSIVE STRENGTH RESULTS

It was observed from table-3 that mix with 75%NCA + 25%RCA + 70%PC20%FA + 10%SF showed the higher compressive strength i.e. 29.64, 41.17, 55.83,and 58.12 MPa at 3, 7, 28 and 60 days of curing respectively, where as mix with 50%NCA+50%RCA+70%PC+30%FA show least compressive strength i.e. approximately 15.17, 16.98, 35.91and 39.17 MPa at 3,7,28 and 60 days respectively among all the mixes and at all curing ages given in fig. below.

Table.3:-Compressive strength results of all mixes at different curing ages.

Mix no.	**Description**	**Compressive Strength (MPa)**			
		3D	**7D**	**28D**	**60D**
1	100%NCA+70%PC+30%FA (Control Mix)	26.63	32.15	39.74	45.12
2	75%NCA+25%RCA+70%PC+30%FA	17.89	24.66	34.27	43.59
3	50%NCA+50%RCA+70%PC+30%FA	15.17	16.98	35.91	39.17
4	75%NCA+25%RCA+70%PC+20%FA+10%MK	16.17	27.19	38.86	40.01
5	75%NCA+25%RCA+70%PC+20%FA+10%SF	29.64	41.17	55.83	58.12
6	50%NCA+50%RCA+70%PC+20%FA+10%MK	21.02	35.22	37.14	41.92
7	50%NCA+50%RCA+70%PC+20%FA+10%SF	23.88	25.66	38.36	43.39

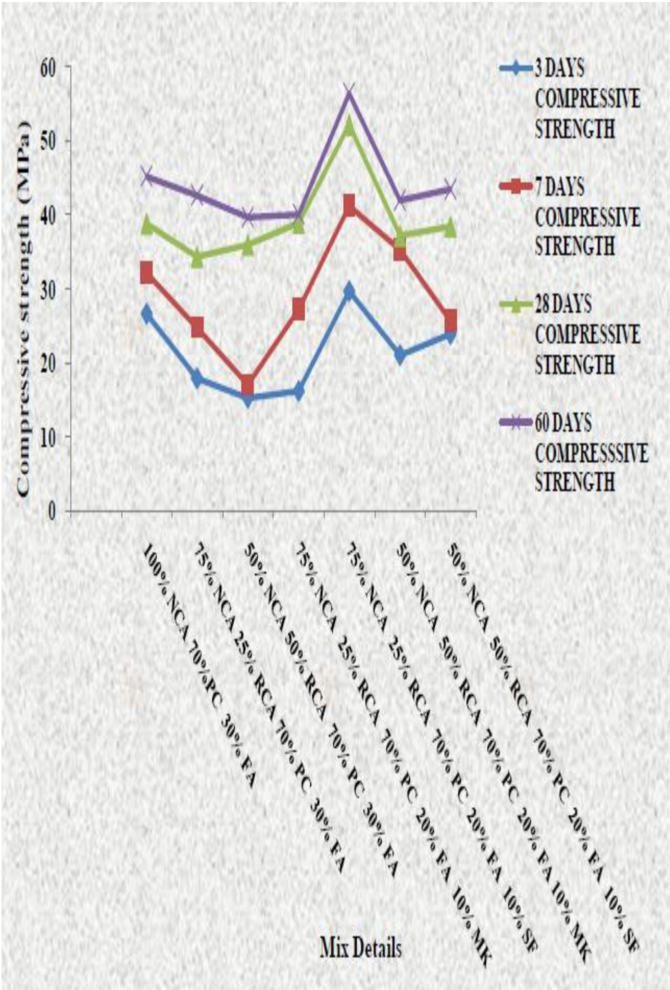


Fig.3:-Variation in compressive strength of concrete mixes at different curing ages.

CAPILLARY SUCTION - SORPTIVITY

The rate of absorption was found to decrease with the curing age. It was observed that with 75%NCA + 25%RCA + 70%PC + 20%FA + 10%SF showed lowest IRA value followed by mix with 75%NCA+ 25%RCA + 70%PC + 20%FA + 10%MK whereas mix with 50%NCA+50%RCA+70%PC+30%FA showed highest IRA values then all at 28 and 60 days curing ages in table-4

Table.4:-Variation in Initial rate of absorption of different mixes.

Mix no	**Description**	**RCP Value in Coulombs**	
		28 days	**60 days**
	100% NCA+ 70%PC+30 %FA (control mix)	806.00	682.00
	75 %NCA +25 %RCA +70 %PC+ 30 %F	1061.00	803.00
	50 %NCA +50 %RCA +70 %PC+ 30 %F	1274.00	838.00
4	75%NCA+ 25%RCA+ 70%PC+20 %FA+10% MK	587.00	536.00
5	70%NCA +25%RCA+70%PC+20%FA+10%SF	561.00	483.00
6	50%NCA+ 50%RCA+ 70%PC+20 %FA+10% MK	640.00	597.00
7	50%NCA +50%RCA+70%PC+20%FA+10%SF	673.00	496.00

RAPID CHLORIDE PERMEABILITY TEST

It was observed from table-5 and fig-4 that mix with 70% NCA + 25% + RCA + 70% PC + 20% FA + 10% SF show very low permeability i.e. 561.00 and 483.00 coulombs at 28 days and 60 days of curing respectively where as mix with 50%NCA+50%RCA+70%PC+30%FA show high permeability i.e. 1274.00 and 803.00 coulombs respectively amongst all the mixes and at all the curing ages show in fig. given below.

Table.5:-RCP value (in coulombs) of all mixes at different curing ages

Mix no	Description	Average IRA (mm/ sec$^{1/2}$)	
		28 days	60 days
1	100%NCA+70%PC+30%FA(Control mix)	0.0163	0.0140
2	75%NCA+25%RCA+70%PC30%FA	0.0177	0.0153
3	50%NCA+50%RCA+70%PC+30%FA	0.0203	0.0187
4	75%NCA+25%RCA+70%PC+20%FA+10%MK	0.0140	0.0123
5	75%NCA+25%RCA+70%PC+20%FA+10%SF	0.0133	0.0103
6	50%NCA+50%RCA+70%PC+20%FA+10%MK	0.0167	0.0147
7	50%NCA+50%RCA+70%PC+20%FA+10%SF	0.0153	0.0130

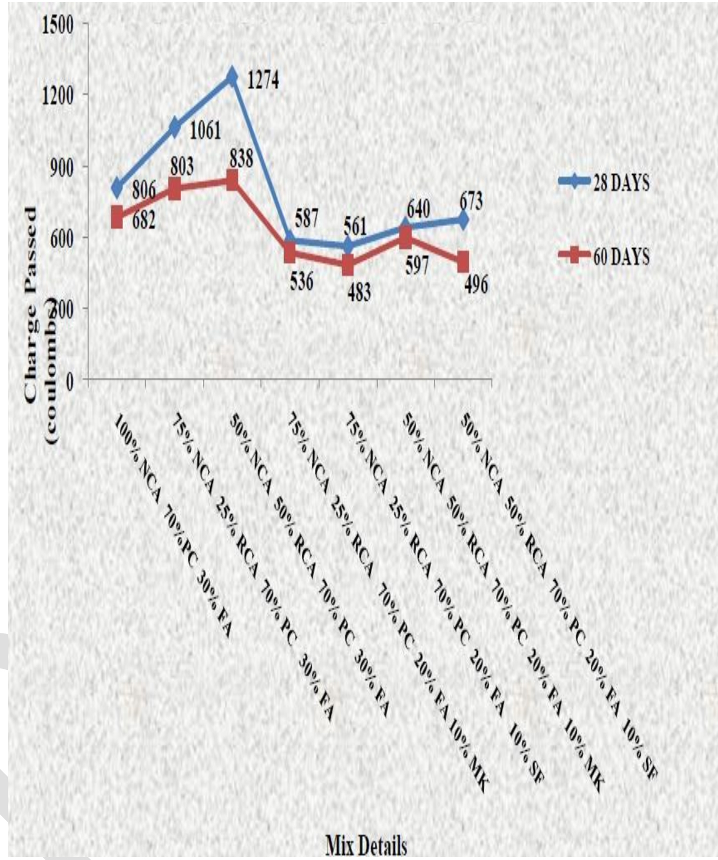


Fig.4:-Charge Passed (coulombs) of all mixes at different curing ages

CONCLUSIONS

- When the NCA content was 100% the value of compressive strength was 26.63, 32.15, 39.74 and 45.12 MPa. The value of compressive strength was decreased as NCA replaced by 25% and 50% RCA. MK and SF were added in PC containing 25% and 50% RC to increase the value of compressive strength.
- Mix with 75% NCA+25% RCA+70% PC+20% FA+10% SF gave the maximum compressive strength than all concrete mixes at all ages of curing.
- Addition of SF within ternary blends increased the compressive strength with significant increase in 3, 7, 28 and 60-day strength. 10% SF addition with 25%RCA showed better compressive strength.
- When the NCA content was 100% the value of IRA 0.0163 and 0.0140 at 28 and 60 days of curing respectively. IRA was increased by adding 25 and 50% RCA. SF and MK were added in PC containing 25 and 50% RCA to decrease the value of IRA.

- The addition of SF with 25%RCA reduced the IRA value and further decrease was observed with increase in curing age.
- Mix with 75% NCA + 25% RCA + 70% PC + 20% FA + 10% SF showed the lowest rapid chloride permeability value as 41.20% less than control mix at 60 days of curing.
- From the result it can be concluded that concrete mix containing 75% NCA + 25% RCA + 70% PC + 20% FA + 10% SF can be adjudged as the most appropriate mix for compressive strength, Capillary suction and Rapid chloride permeability taken together

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