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EXPERIMENTAL INVESTIGATION OF FIBRE REINFORCED CONCRETE WITH RECYCLED AGGREGATES

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ABSTRACT

Recycling is the most efficient way to deal with the growing amount of waste for environmental preservation. This paper is focused on the experimental program aimed at verifying selected material properties of fiber-reinforced concrete in which recycled aggregates partially replace all of the natural stone aggregates. The use of primary sources and materials is becoming intolerable both economically and ecologically. Therefore, it is necessary to seek the possibility of reuse of those materials once their durability expires. Due to its low tensile strength and poor fracture toughness, concrete is regarded as a brittle material. Fibres can be added to the concrete mix to change the material's behaviour and make it more ductile.. Implementing reuse, recycling, and reducing the usage of construction materials in construction activities is seen to be the most effective strategy to reduce the waste problem in the construction industry. As a recycled material, one can take into account not just the design and debris from demolition as well as waste from primary material extraction and industrial production This is most likely the reason why recycled aggregate is currently mostly utilized for non-structural uses like backfill and road bases. The concept of incorporating fibres into a recycled aggregate concrete mixture has the potential to alter the concrete's physical characteristics, enhance its behaviour, open up new application possibilities, and conserve natural aggregate supplies. The purpose of this initiative is to use steel fibres and crushed C&DW as an alternative to lessen the need for primary aggregates.

Keywords: Recycled Aggregate, Fibre Reinforced Concrete, FRC.

I. INTRODUCTION

RECYCLED AGGREGATES

Applications of are hindered due to the numerous unresolved issues with managing the quality of recycled aggregates (RA), such as poor elastic modulus, significant drying shrinkage, large creep, and low compressive strength. The two primary causes of these issues are as follows:

- Foreign materials (glass, wood, soil, plaster, tile, etc.) are always present in waste materials from construction and demolition projects.
- Because recycled aggregate particles are invariably bonded together with a significant quantity of relatively soft cement mortar paste, these aggregates are less resistant to mechanical attacks and more porous.

Recycled aggregates can then be created using the same production process as conventional concrete, but generally some adjustments to the mix proportion are required. However, depending on the amount of RA injected, this method will result in lower-quality concrete. Thus, the majority of research suggests a 30% RA limit. Numerous researchers have effectively used RA on mass concrete, piles, foundations, subterranean constructions, pavement, and roadwork. It is uncommon, though, to apply it to higher grade concrete. The mechanical performance of RA will be impacted by these flaws, which include high porosity, high cracking, high levels of sulphate and chloride contents, high levels of impurity, and high cement mortar residues.

Overcoming these flaws is a must for applying RA to high-grade concrete. The amount of RA that can be recycled will mostly rely on elements like:

- The locations of the manufacturing and demolition sites.
- The degree of contamination in the C&DW brought about by improperly segregated areas during the demolition process or by the use of inappropriate materials during initial construction.
- The material's local demand, which fluctuates based on ongoing infrastructure and development initiatives.

FIBRE-REINFORCED CONCRETE TYPES

Several classifications among fiber kinds are possible. There are two types of fibers: those that have an elastic module higher than that of the cement mix, like asbestos, glass, steel, and carbon, and those that have a lower elastic module, like cellulose, nylon, and polypropylene. An additional classification based on the fiber material's origin, such as metallic, polymeric, or natural, is possible.

THE ASPECT RATIO AND ITS RELEVANCE

Fiber length (l) divided by diameter (d) yields the aspect ratio (l/d). By raising the material's tensile strength, fibers that have a higher modulus of elasticity than the matrix—concrete or mortar binder—assist in supporting the weight. A rise in the fiber's aspect ratio typically causes the matrix's fiber toughness and extensibility to split. Long fibers, on the other hand, have a tendency to "ball" in the mixture and cause issues with workability.

FIBRE REINFORCED CONCRETE APPLICATION

The different uses of FRC are listed below. For a very long time, asbestos fibres were utilized in thin-sheet components and pipes. Glass fibres are also employed in shot Crete applications and the manufacture of thin sheet elements. Steel beams have been utilized in shot Crete, pavements, and numerous other constructions. Plastic shrinkage is controlled by using polypropylene fibres.

The use of recycled aggregates in steel fibre concrete is the main emphasis of this study. Thus, an effort has been made to investigate the steel fiber concrete's strength properties using recycled aggregates.

COMPRESSIVE STRENGTH

The cube size of 150x150x150mm, the control concrete strength to be compared with fibre reinforced concrete strength. Followed as per IS 516-1959.

FLEXURAL STRENGTH

The concrete beams of size 150x150x700mm are to be cast and tested for comparing the flexural strength of conventional concrete with those adding with various percentages of Recycled aggregates with constant percentage of steel fibers. Two points loading can be employed for determination of flexural strength of the concrete. Tested as per IS 516-1959.

II. ELECTION OF MATERIAL REQUIREMENTS

Cement

Ordinary Portland cement of grade (43) is used for the present investigation and tested as per IS 4031-1988.

Fine Aggregate

River sand with fraction passing through 4.5mm sieve and retained on 60micron sieve is used and will be tested as per IS2386 (part l)—1963. Thefineness. Modulus of sand is 3.12 with specific gravity of 2.51.

Coarse Aggregate

The size of 20mm Coarse aggregate has been selected for the study. The physical properties will be tested as per IS23 86 (part l)—1963. The finenessmodulus of coarse aggregate is 5.95 with specific gravity of 2.81.

Recycled Aggregate

The size of 20mm to 12.5mm retained recycled aggregate has been selected for the study. The physical properties will be tested as per IS23 86 (partl)—1963. The fineness modulus of coarse aggregate is 5.95 with specific gravityof 2.81.

Steel Fibres

Mechanical and Physical Properties of steel fibres

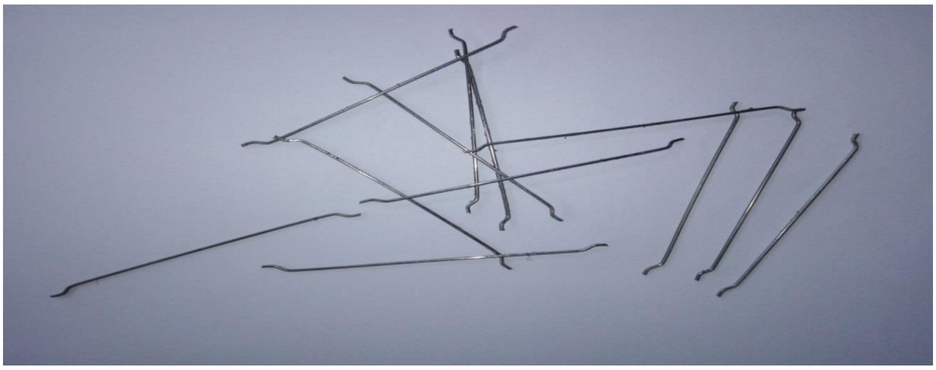
Name : MSH 41050—BN

Length 60mm Diameter : 0.8mm

Aspect Ratio : . L/D = 75 Tensile Strength 1100 N/mm

:Anchorage : Hooked End.

Steel Fibre



III. TESTS ON FINE AGGREGATE

Fineness Modulus (Sieve Analysis)

SIEV E ANALYSIS OF FINE AGGREGATE

S. No	IS SIEVE SIZE	Wt. Rrtainedgm	% Wt Retained	Cum %Wt Retained	% Passing	Remarks
1	10MM		1000	0.00	100.00	ZONE- 1
2	4.75MM	17	983	1.70	98.30	90-100
3	2.36MM	38	945	5.50	94.50	60-95
4	1.18MM	289	656	34.40	65.60	30-70
5	600mic	325	331	66.90	33.10	15-34
6	300mic	309	22	97.80	2.20	05-20
7	150mic	6	16	98.40	1.60	0-10

Specific Gravity of Fine Aggregate

Fineness modules of fine aggregate = 3.12

S. No	Description of Item	Trail/Test Number		
		1	2	3
1	Weight of Empty Pycnometer -W1 (g)	649	649	649
2	Weight of Empty Pycnometer+Dry Agg -W2(g)	833	830	837
3	Weight of Pycnometer+Dry Agg+Water -W3(g)	1619	1610	1622
4	Weight of Pycnometer+Water -W4(g)	1507	1510	1502
5	Difference for (W2-W1)	184	181	188
6	Difference for (W2-W1)-(W3-W4)	072	081	068
7	Specific Gravity (5/6)	2.555	2.234	2.764
8	Average	2.517		

TESTS ON COARSE AGGREGATE

Fineness Modulus (Sieve Analysis)

The sieve analysis on coarse aggregate was carried out as per IS 2386(part I) - 1963 and the results are given.

TABLE: Sieve Analysis Of Coarse Aggregate

S.No	IS SIEVESIZE	Wt. Retainedgm	Wt. Passing Gm	Cum %Wt. Retained	% Passing	Remarks
1	40mm	0	5000	0.00	100.00	100
2	20mm	365	4635	7.30	92.70	85-100
3	12.5mm	2456	2179	52.98	47.01	---
4	10mm	1986	193	91.14	8.86	0-20
5	4.75mm	56	137	29.02	70.98	0-5

Fineness Modulus = ∑ Cumulative weight retained %/ 100

= 180.44/100

=1.80

Result: Fineness modulus of coarse aggregate = 1.80.

Specific Gravity Test

The specific gravity test on coarse aggregate was carried out as per IS 2386 (partIII) — 1963 and the results are given table.

S.No	Description of Item	Trail/Test Number		
		1	2	3
1	Weight of Empty Pycnometer -W1 (g)	649	649	649
2	Weight of Empty Pycnometer+Dry Agg -W2(g)	849	850	847
3	Weight of Pycnometer+Dry Agg+Water -W3(g)	1641	1645	1643
4	Weight of Pycnometer+Water -W4(g)	1512	1515	1518
5	Difference for (W2-W1)	200	201	198
6	Difference for (W2-W1)-(W3-W4)	71	71	73
7	Specific Gravity (5/6)	2.81	2.83	2.71
8	Average	2.783		

Result: Specific gravity of coarse aggregate =2.783

Bulk Density Test

The bulk density on coarse aggregate was carried out as per IS 2386 (part III) - 1963 and the results are given below.

Empty weight of container (A) = 2.587kgWeight of container + water = 5.542kgLoose state

Weight of container + aggregate = 7.954kg

Dry rodded bulk density = (C—A) / (B-A)

= (7.954-2.587)/ (5.542-2.587)

= 1816 kg/ m3

Results: Dry bulk density of coarse aggregate = 1816 kg/ m3.

Elongation Index

The elongation index on aggregates is the percentage by weight of particles whose greatest dimension (length) is greater than 1.8 times their mean dimension. The results of the test are as given below in Table.

TABLE: Elongation Index Of Coarse Aggregate

Sieve fraction	Weight ineach fraction	Weight in each fraction oftotal weight Y	Weight of elongated aggregate in each fraction(g)	Weight of elongated aggregateas a fraction X	percentage weight of elongated aggregate XY
25-20	1573	0.4583	217	0.1379	6.32
20-16	953	0.2776	356	0.3755	10.32
16-12.5	534	0.1555	280	0.5243	8.15
12.5-10	116	0.0745	168	0.6563	4.89

Elongation index =∑XY =25%

Flakiness Index

The flakiness index of aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than 0.6 of their dimension. The results of the test are as given below in Table.

TABLE: Flakiness Index Of Coarse Aggregate

SIEVE FRACTION	WEIGHT IN EACH FRACTION	WEIGHT IN EACH FRACTION OF TOTAL WEIGHT Y	WEIGHTOF FLAKY AGGREGATE IN EACH FRACTION (g)	WEIGHTOF FLAKY AGGREGATE AS A FRACTION OF EACH FRACTION X	PERCENT AGE WEIGHT OF FLAKY AGGREGATE XY
25-20	1573	0.4583	175	0.1112	5.096
20-16	953	0.2776	135	0.1416	3.931
16-12.5	534	0.1555	40	0.0749	1.165
12.5-10	256	0.0337	46	0.1749	1.34

Flakiness index = ∑XY = 24.9%

Concrete Test:

SLUMP CONE TEST

The slump cone test is an empirical test that measures workability of fresh concrete. It performed to check consistency of freshly made concrete. The slump test result is a slump of the behaviour of a compacted inverted cone of concrete under the action of gravity. It measures consistency or wetness of the concrete.

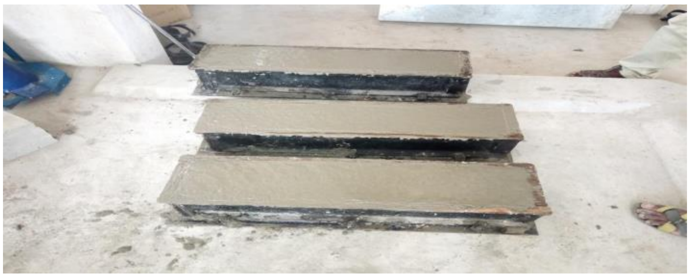
MIXING OF AGGREGATE:

Measuring the amount of cement, Fine Aggregate and Coarse Aggregate with required amount of W/C ratio according to the mix design calculation.

Same materials are used, instead of normal aggregates recycled aggregates with steel fibre are used in recycled aggregate mortar.

PLACING MIX IN MOULD:

After the raw materials are properly mixed they are placed in the moulds such as cube mould and beam mould which is in standard size .The mix is placed in the mould with the help of shovel. The safety gloves and other required safety measures are followed. The oil is applied over the mould before placing the mix for easy removal of the mould.



CURING PERIOD OF MOULDS:

The Cube and Beam moulds are kept inside the water tank or curing tankfor 7 to 28 days before testing of the mould samples.

COMPRESSIVE STRENGTH TEST

The test was conducted as per IS 516-1959. The specimens were kept in water for 7days,14days, and 28 days and surface dry conditions were obtained by wiping water on the surface. The load was applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen was then recorded and the Appearance of the concrete for any unusual features in the type of failure was noted.

IV. FLEXURAL STRENGTH TEST

A beam specimen should be cast for determining the flexural strength ofconcrete. The standard specimen size is 150mm X 150mm X 700mm. A structural Loading Frame can be used for the test. The testing machine may be set to any reliable type of sufficient capacity for the test. Permissible errors should be not greater than +/— 0.5%.

The bed of machine should be provided with two steel rollers of 38 mm diameter on which the specimen is supported. Rollers are supported at a centre- to-centre distance of 60 cm for the 15 cm specimen and at 40 cm for the 10 cm The test specimen should be cast for 28 days and tested for maximum load. The flexural strength or modulus of rupture should be calculated using the formula given below fb=' (3PL)/ (BD^2) where B is the measured width (cm) of the specimen, a is the distance between supports (cm), D is the measured depth (cm), L is the length (cm) of the span on which the specimen is supported, and Pis the maximum total load (kg) applied to the specimen.

V. TABULATION & RESULTS

7 DAYS COMPRESSIVE STRENGTH TEST ON CUBE FORCONVENTIONAL CONCRETE AND R.A CONCRETE

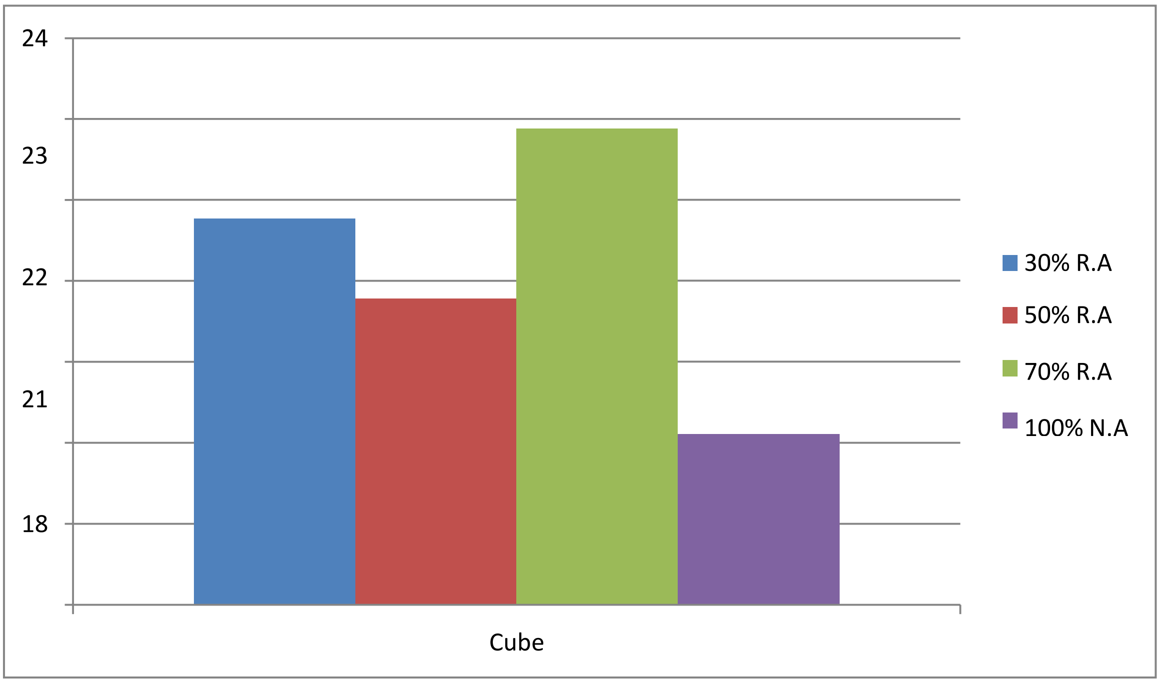
7 DAYS TEST FOR CONVENTIONAL CONCRETE:

SLNO	DATE OF CASTING	NO OF CUBE	DATE OF TESTING	LOADIN KN	7th DAY STRENGTHIN N/mm²	7th DAY AVG STRENTHIN N/mm²	AREA
1	25-Feb-16	M30-1	4-Mar-16	425	18.88	19.11	22500mm²
2		M30-2		430	19.11		
3		M30-3		435	19.33		

7 DAYS TEST FOR R.A CONCRETE:

SLNO	DATE OF CASTING	NO OF CUBEAND % OF R.A	DATE OF TESTING	LOADIN KN	7th DAY STRENGTHIN N/mm²	7th DAY AVG STRENTHIN N/mm²	AREA
1	11-Mar-16	M30-1(30%)	19-Mar-16	495	22.00	21.77	22500mm²
2		M30-2(30%)		485	21.75		
3		M30-3(50%)		475	21.11	20.78	
4		M30-4(50%)		460	20.44		
5		M30-5(70%)		520	23.11	22.88	
6		M30-6(70%)		510	22.60		

7 days cube compressive strength comparison



14 DAYS COMPRESSIVE STRENGTH TEST ON CUBE FORCONVENTIONAL CONCRETE AND R.A CONCRETE

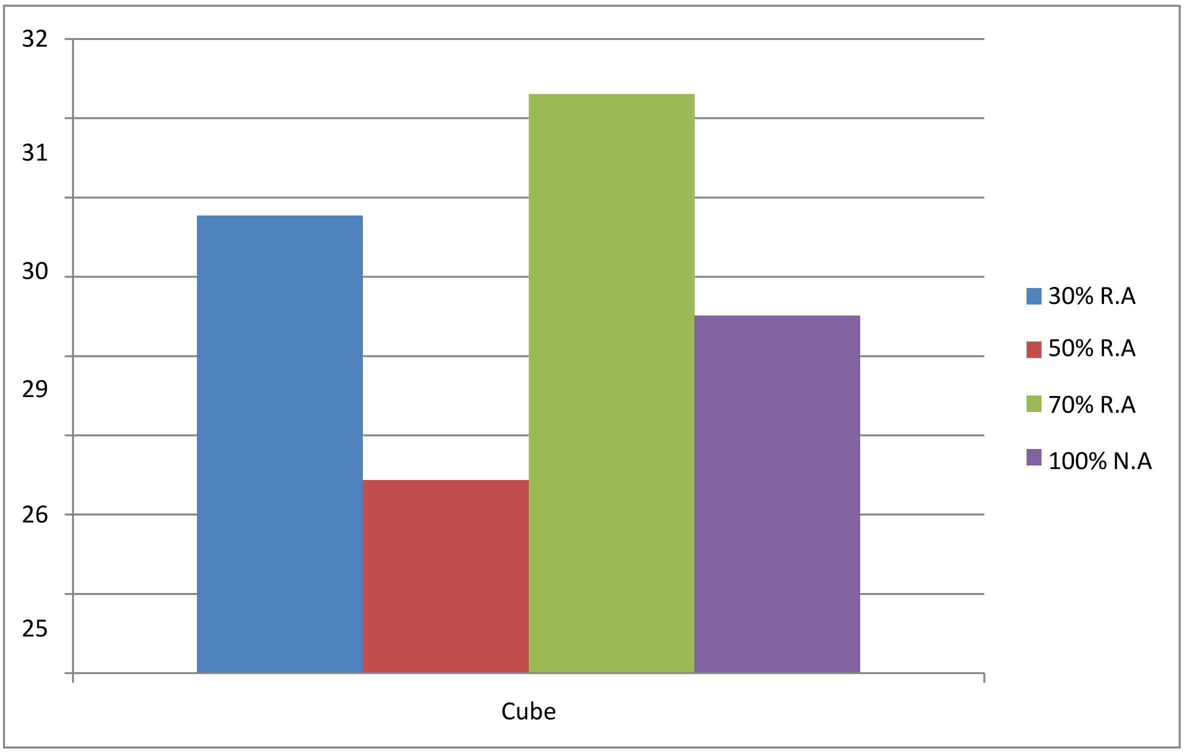
14 DAYS TEST FOR CONVENTIONAL CONCRETE:

SLNO	DATE OF CASTING	NO OF CUBE	DATE OF TESTING	LOADIN KN	14th DAY		AREA
					STRENGTHIN N/mm²	AVG STRENTHIN N/mm²	
1	25-Feb-16	M30-1	11-Mar-16	640	28.44	28.51	22500mm²
2		M30-2		645	28.67		
3		M30-3		640	28.44		

14 DAYS TEST FOR R.A CONCRETE:

SLNO	DATEOF CASTING	NO OF CUBEAND % OF R.A	DATE OF TESTING	LOADIN KN	14th DAY		AREA
					STRENGTHIN N/mm²	AVG STRENTHIN N/mm²	
1	8-Mar-16	M30-1(30%)	23-Mar-16	680	30.22	29.77	22500mm²
2		M30-2(30%)		660	29.33		
3		M30-3(50%)		590	26.22	26.44	
4		M30-4(50%)		600	26.67		
5		M30-5(70%)		710	31.56	31.30	
6		M30-6(70%)		700	31.11		

14 days cube compressive strength comparison



28 DAYS COMPRESSIVE STRENGTH TEST ON CUBE FORCONVENTIONAL CONCRETE AND R.A CONCRETE

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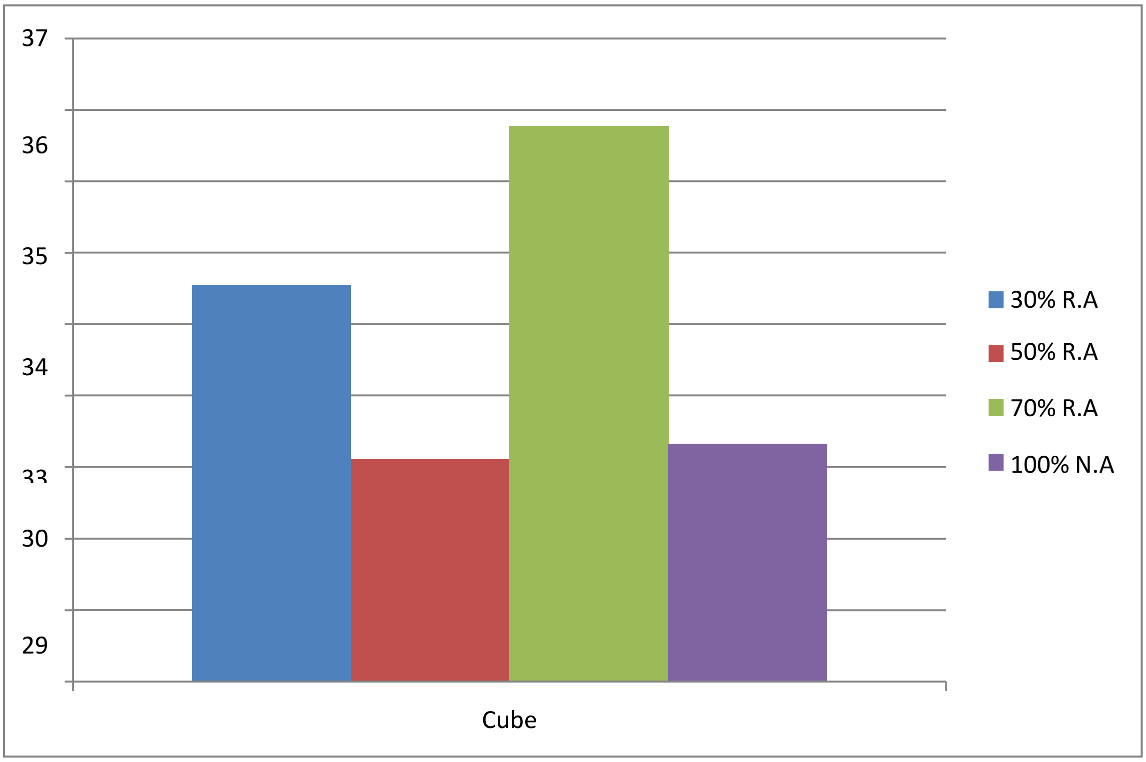
28 DAYS TEST FOR CONVENTIONAL CONCRETE:

SLNO	NO OF CUBE	LOADIN KN	28th DAY		AREA
			STRENGTHIN N/mm²	AVG STRENTHIN N/mm²	
1	M30-1	700	31.11	31.33	22500mm²
2	M30-2	710	31.55		
3	M30-3	705	31.33		

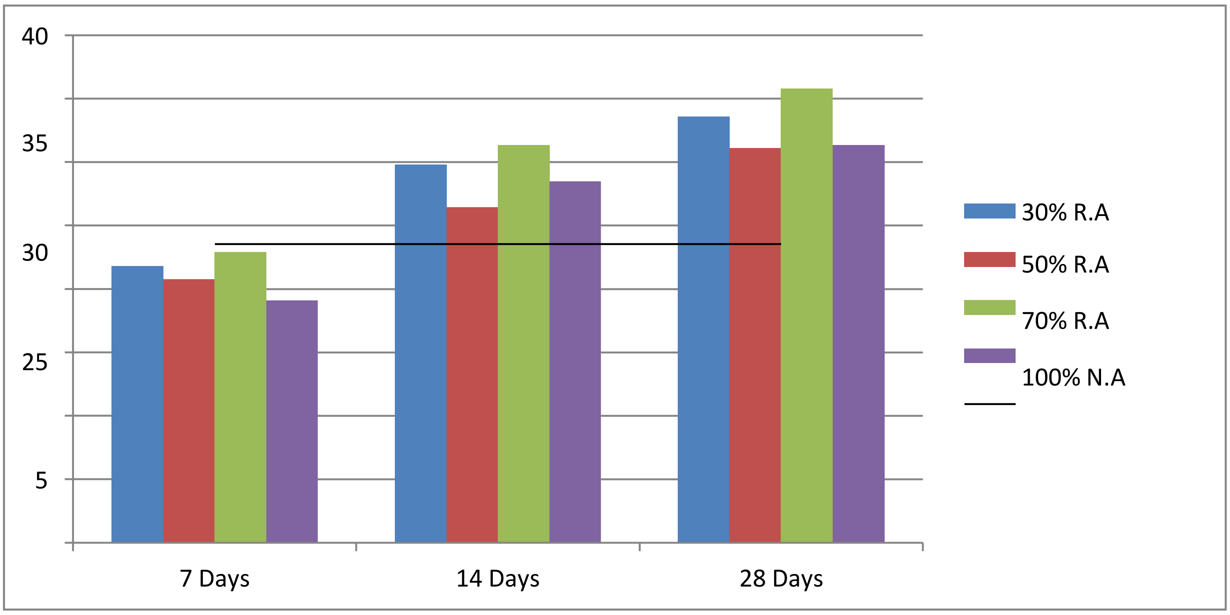
28 DAYS TEST FOR R.A CONCRETE:

SLNO	NO OF CUBEAND % OF R.A	LOADIN KN	28th DAY		AREA
			STRENGTHIN N/mm²	AVG STRENTHIN N/mm²	
1	M30-1(30%)	790	35.11	33.55	22500mm²
2	M30-2(30%)	720	32.00		
3	M30-3(50%)	700	31.11	31.11	
4	M30-4(50%)	700	31.11		
5	M30-5(70%)	800	35.55	35.77	
6	M30-6(70%)	810	36.00		

28 days cube compressive strength comparison



Compressive Strength Comparison of 7 days, 14 days, 28 days onboth R.A & N.A



28 DAYS FLEXURAL STRENGTH TEST ON BEAM FORCONVENTIONAL CONCRETE AND R.A CONCRETE

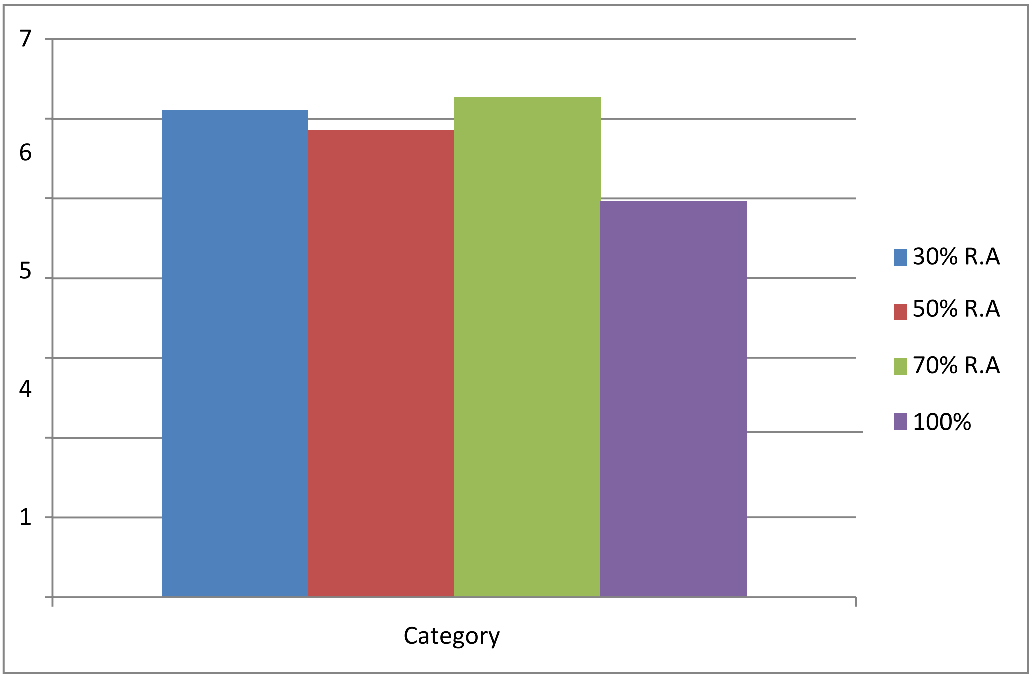
28 DAYS TEST FOR CONVENTIONAL CONCRETE:

SLNO	NO OFBEAMS	LOADIN KN	28th DAY	
			STRENGTHIN N/mm²	AVG STRENGTHIN N/mm²
1	M30-1	24.20	5.01	4.97
2	M30-2	23.80	4.93	

28 DAYS TEST FOR R.A CONCRETE:

SLNO	NO OFBEAMS	LOADIN KN	28th DAY	
			STRENGTHIN N/mm²	AVG STRENGTHIN N/mm²
1	M30-1(30%)	29.60	6.13	6.11
2	M30-2(30%)	28.40	6.09	
3	M30-3(50%)	29.40	6.09	5.86
4	M30-1(50%)	27.20	5.64	
5	M30-1(70%)	29.80	6.18	6.27
6	M30-1(70%)	30.70	6.36	

28 days Beam Flexural strength comparison



VI. CONCLUSION

Based on a large series of acquired experimental results on different characteristics of the tested material, it can be judged on the behaviour of this composite. The following conclusion may be drawn from the present investigation: C&D waste material can be recycled and experimented to testify that utilization of recycled concrete with fibres in every-day life is possible and moreover it is useful without plasticizer and other admixtures. However, the use of recycled aggregate is possible only for that with acceptable grading in the range of 0/32 mm on account of a technology simplification. Suitable technology of construction material recycling could be considered an easy alternative for future applications. The recycling of this waste will reduce environmental damages caused by incorrect disposal, extend the useful life of landfills and preserve finite natural resources.Steel fibres are applicable for fibre reinforced concrete and improve the properties of concrete. Several areas of application have been recognized however full-scale use of such fibre concrete is still hindered by the high cost, which is inacceptable for investors. The examples of application of such fibre concrete, which would help to meaningfully utilize the demolition waste, are so far based on numerical simulations and developed laboratory models. The main purpose of this research was to investigate the addition of construction waste (masonry and concrete) material in concrete production and establish the effects of steel fibres on mechanical properties of new concretes. In terms of this research were used standard test methods for determination of mechanical properties as initial bulk densities, compressive strengths and flexural strengths. Results are presented from the laboratory test results showing how recycled crushed aggregate can be recycled and experiment testify that utilization of concrete with fibres in every-day life is possible and more it is useful without plasticizer and other admixtures.

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