Experimental Study on Strength and Durability Characteristic of Fibre Reinforced Recycled Aggregate Concrete using Artificial Sand

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Abstract— This research work is done to obtain different properties of fibre reinforced recycled aggregate concrete using artificial sand, and to find the optimum percentage replacement of recycled coarse aggregate in concrete with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres, further to compare the properties of conventional concrete with fibre reinforced recycled aggregate concrete using artificial sand. To carry out this experimental work the specimens were casted using different percentage replacement of recycled coarse aggregate i.e. (0%, 20%, 40%, 60%, 80% and 100%) with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres. And results shows that recycled coarse aggregate can be replaced up to 40% for production of M30 grade concrete with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres, and it is observed that the strength of concrete is reducing with increase in replacement percentage of recycled coarse aggregate with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres, however strength achieved by conventional concrete is less than the strength achieved by concrete which is produced with 100% replacement of recycled coarse aggregate by natural coarse aggregate with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres. By using this we can produced green concrete, sustainable concrete or ecofriendly concrete by using artificial sand as fine aggregate and replacement of natural coarse aggregate by recycled coarse aggregate in a concrete.

Key words: Fibre Reinforced Recycled Aggregate Concrete, Artificial Sand

I. INTRODUCTION

A. General

Concrete is the primary material which is used for construction purpose in every construction industries in India and around the globe. Due to rapid increase in infrastructural development and construction activities in India and around the globe, simultaneously the demand of concrete is also increasing which leads to excessive extraction natural aggregates, excessive extraction of virgin aggregates for the manufacturing of concrete, results in depletion of natural resources and hence damaging the ecological balance.

For the accommodation of new structures, the old structures which is constructed in past years and those structures whose lifespan is successfully completed are being demolished and destroyed, and sometimes damages happens due to the occurrence of natural disaster generates a huge amount of construction and demolition waste, the handling, transporting and dumping of this waste is again creates a big problem. Dumping of this waste is polluting the environment and damaging the ecological balance. And due to scarcity of dumping land there is urgent need to find some alternatives. Construction and demolition waste contains some amount of useful aggregates which can be recycled and reuse for making of new concrete. Similarly due to various environmental issues government has banned the extraction of natural sand from river bed, which leads to scarcity of natural sand and significantly the cost of natural sand is also increasing. Therefore I am using recycled coarse aggregate and artificial sand in my project work.

II. LITERATURE REVIEW

Young P.C,et al, (2009), in their-paper-entitled "Utilization of recycled aggregate as coarse aggregate in concrete". Investigated the strength characteristic under compression, tensile, flexure, and workability tests is also conducted on all concrete mixes. The investigation shows that the compressive strength of recycled aggregate concrete is higher than the compressive strength of normal concrete. Split tensile strength and flexure strength of recycled aggregate concrete is nearer to the normal concrete. And slump of recycled aggregate concrete is low and it can be improved by using saturated surface dry (SSD) coarse aggregate.They were used the tested concrete specimen from a local construction site as a source of RCA. Concrete cubes after compression test are crushed to suitable size and reuse as recycled aggregate. And these RCA*obtained from site tested concrete/cubes shows good potential as coarse aggregate for the/production of new concrete.

Mahendra R. Chitlange, et al, (2010), in their-paper-entitled "Strength appraisal of artificial sand as fine aggregate in SFRC" in this paper they have studied the properties of steel fibre reinforced concrete using artificial sand. They were used the three different grades of concrete i.e. M20, M30 and M40, and steel fibres are added with dosage rate*of volume*fraction 0, 0.5, 1.0, 1.5 and 2.0. And two different concrete mixes were prepared using steel fibres and natural sand, steel fibres and artificial sand, and strength characteristics were examined by comparing both concrete mixes. They have conclude with, by adding 1.5% of steel fibres the designed workability may be achieved, and 100% artificial sand may be replace by natural sand but careful supervising is needed.

Parekh D.N. *et al*, (2011), in their paper entitled "assessment of recycled aggregate concrete". They have explained the basic properties of recycled fine aggregate and recycled coarse aggregate, and all the properties of recycled aggregate were compared with properties of natural aggregate. And similarly the properties of recycled aggregate concrete is explained, properties of concrete like workability, strength in compression, strength in flexure etc. were explained for different combination of recycled aggregate with natural aggregate. They conclude that

strength of concrete decreases as the percentage of recycled aggregate increases but results shows that there is no decrease in strength of concrete containing 20% recycled fine aggregate and 30% recycled coarse aggregate, and beyond this the strength is gradually decreases.

Vaishali. G. Ghorphade, (2013), in her paper entitled "Effect of recycled coarse aggregate on workability and shear strength of fibre reinforced high strength concrete". She focused on workability and shear strength in her research, in which she used recycled coarse aggregate, and different mixes were carried out by replacing natural aggregate by recycled coarse aggregate (0%, 20%, 40%, 60%, 80%, and 100%), and to improve the ductility property 1% steel fibre is added to concrete. Several workability tests were carried out such as compaction factor and V-B time tests, and shear strength test is conducted by using special double-L (push off) specimen.

Results shows that the strength can be increase by adding the steel fibre, addition of steel fibre increases the shear strength but decreases the workability, and to get the workability and shear strength, she recommends to replace the natural coarse aggregate by recycled coarse aggregate up to 20% only.

Rachana M N,*et al*, (2014), in their paper entitled "Experimental investigation on robo sand as replacement material of fine aggregate in normal concrete". In their research they have focused on maximum replacement of natural sand by robo sand so that optimum results may be achieved, for this purpose they have designed M30 grade and M40 grade concrete and mixes were established by replacing the natural sand by robo sand in different varying percentages (0%, 25%, 50%, 75%, and 100%). And tests were conducted to obtain compressive strength, flexural strength and split tensile strength.

The concrete mix were designed for M30 and M40 grade concrete as per IS 10262:2009 recommendations for the conventional concrete, and the specimens were casted using different percentages of replacement of natural sand by robo sand. After 7 days and 28 days of curing the specimens were tested for compressive strength, flexural strength and split tensile strength. From results we can judge that artificial sand i.e. robo sand may be replaced up to 50% for achieving the optimum strength. From experimental results, robo sand may be considered as an alternative to the natural sand.

III. MATERIALS AND METHODOLOGY

A. Material used for Preparation of Concrete

1) Cement:

In this research} work, ordinary Portland\cement of 53/grade ultra tech cement conforming to IS 12269:1987, has been used. The physical properties of cement obtained on/conducting the tests as per IS code recommendation are given in Table 3.1.

Sl. No.	Material Properties	Cement	
		Obtained results	**Requirement as per IS 12269**
1	Initial Setting Time	30 minutes	Not less than 30 minutes
2	Final Setting Time	250 minutes	Not more than 600 minutes
3	Standard Consistency	32%	
4	Specific Gravity	2.95	

Table 3.1 Physical Properties of Cement

2) Sand:

a) Artificial Sand:

The physical properties of artificial sand obtained by conducting the laboratory tests are given in table 3.2.

Specific gravity	2.16
Water absorption	1.6%
Moisture content	1.01%
Zone	I

Table 3.2: Physical Properties Of Artificial Sand

b) Natural Sand:

Locally available river sand is used for this experimental work, and the physical properties of natural sand obtained by conducting laboratory tests are given in table 3.3.

Specific gravity	2.55
Water absorption	1.4%
Moisture content	1.6%
Zone	II

Table 3.3: Physical Properties of Natural Sand

3) Course Aggregate:

a) Recycled Coarse Aggregate:

Recycled coarse aggregate obtained by crushing the tested specimens is tested, and the properties of tested recycled coarse aggregate are given in table 3.4.

Moisture content	1.4%
Water absorption	2.32%
Specific gravity	2.75
Crushing strength	20.2%

Table 3.4: properties of recycled coarse aggregate

b) Natural Coarse Aggregate:

Locally available coarse aggregate is used to carry out this experimental work, and the properties natural coarse aggregate are given in table 3.5.

Moisture content	0.9%
Water absorption	1.5%
Specific gravity	2.79
Crushing strength	17.03%

Table 3.5: Properties of Natural Coarse Aggregate

4) Steel Fibres:

Duraflex low carbon flat steel fibres purchased from Kasturi metals Pvt Ltd, Mumbai. And the properties of steel fibres is provided by seller are given in table 3.6.

Length of fibre	25mm - 50mm
Aspect ratio	40 – 90
Width	2mm - 2.5mm
Tensile strength	400mpa – 600mpa
Appearance and form	Clear, bright and undulated along the length
Material type	Low carbon drawn flat wire

Table 3.6: Properties of Steel Fibres

5) Water:

Potable<water was used>for mixing and curing purpose.

B. Mix Design of M30 grade concrete

1) Mix Proportions

Cement = 438 kg/m³

Water = 219 liters

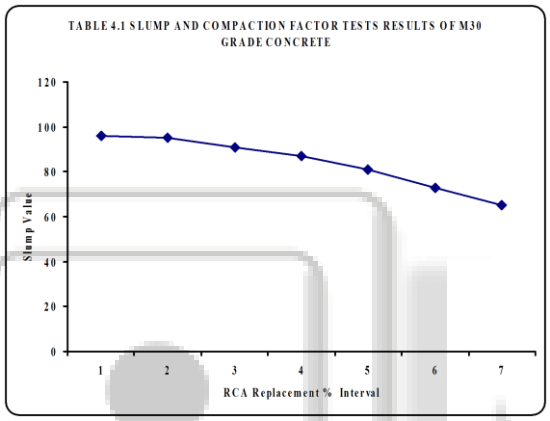
Fine aggregate = 613 kg/m³
Coarse aggregate = 1143 kg/m³
Water cement ratio = 0.5
∴MIX PROPORTION = 1:1.4:2.6

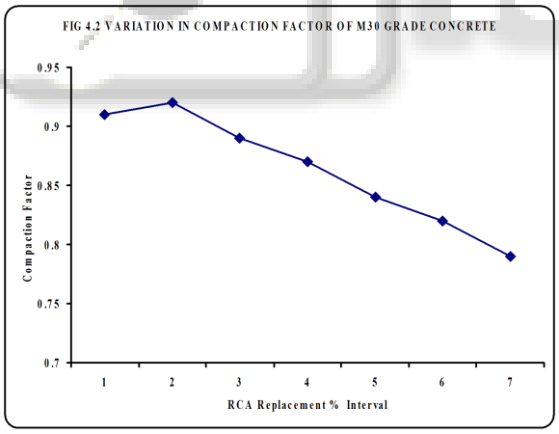
IV. RESULTS AND DISCUSSION

A. Slump and Compaction Factor Tests Results

Sl. No.	% replacement of RCA	Slump (mm)	Compaction Factor
1	CC	96	0.91
2	0%	95	0.92
3	20%	91	0.89
4	40%	87	0.87
5	60%	81	0.84
6	80%	73	0.82
7	100%	65	0.79

Table 4.1: Slump and Compaction Factor Tests Results of M30 Grade Concrete

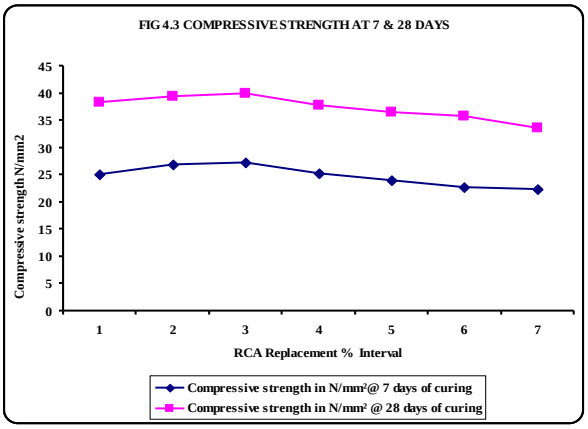




B. Compressive Strength Test Results on Cubes (IS: 5816 – 1959):

Sl. No.	% replacement of RCA with 50% Artificial sand + 1.5% steel fibres	Compressive strength in N/mm²@ 7 days of curing	Compressive strength in N/mm² @ 28 days of curing
1	CC	25.07	38.36
2	0%	26.81	39.46
3	20%	27.25	39.89
4	40%	25.29	37.71
5	60%	23.98	36.41
6	80%	22.67	35.75
7	100%	22.23	33.57

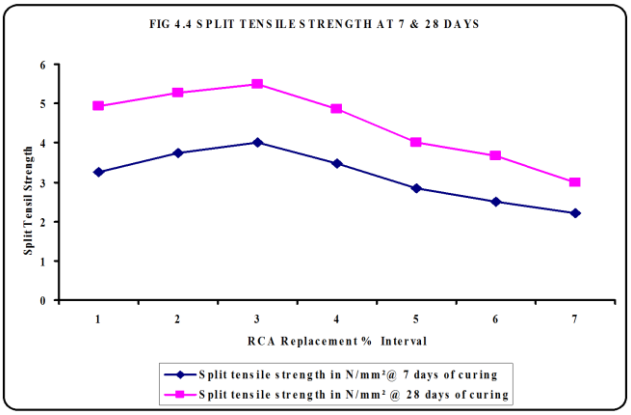
Table 4.2: Compressive Strength Test Results on Cubes (IS: 5816 – 1959):



C. Split tensile strength test results on cylinders(IS: 5816 – 1970):

Sl. No.	% replacement of RCA with 50% Artificial sand + 1.5% steel fibres	Split tensile strength in N/mm²@ 7 days of curing	Split tensile strength in N/mm² @ 28 days of curing
1	CC	3.26	4.92
2	0%	3.75	5.27
3	20%	4.02	5.48
4	40%	3.47	4.85
5	60%	2.84	4.02
6	80%	2.50	3.67
7	100%	2.22	2.98

Table 4.3: Split tensile strength test results on cylinders (IS: 5816 – 1970):

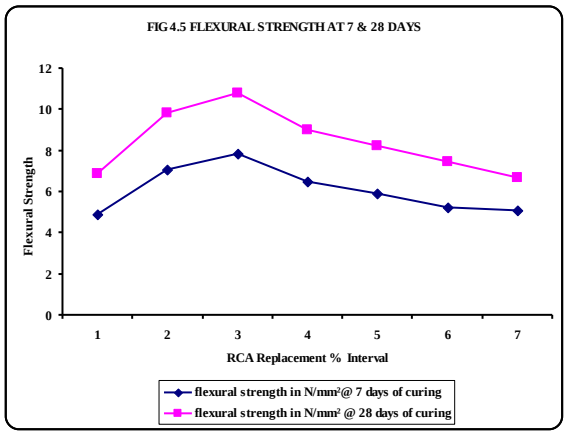


D. Flexural Strength Test Results on Cylinders (IS: 5816 – 1970):

Sl. No.	% replacement of RCA with 50% Artificial sand + 1.5% steel fibres	flexural strength in N/mm²@ 7 days of curing	flexural strength in N/mm² @ 28 days of curing
1	CC	4.90	6.87
2	0%	7.06	9.81
3	20%	7.84	10.79

4	40%	6.47	9.02
5	60%	5.88	8.24
6	80%	5.25	7.45
7	100%	5.1	6.67

Table 4.4: Flexural Strength of Prisms Of M30 Grade Concrete

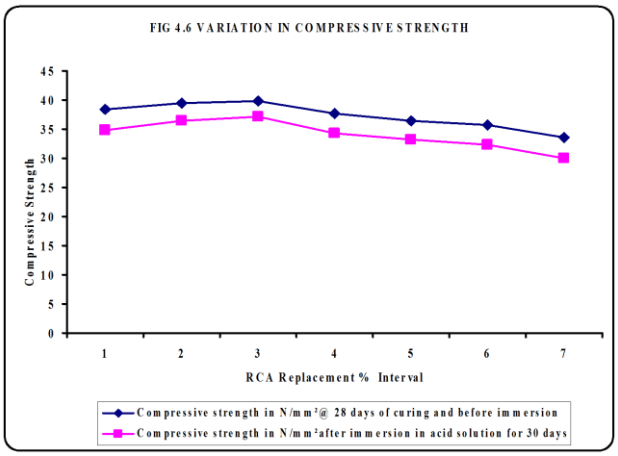


E. Durability Test on Concrete

1) Loss of Compressive Strength Due to Submersion in Hydrochloric Acid Solution

Sl. No.	% replacement of RCA	Compressive strength in N/mm²@ 28 days of curing and before immersion	Compressive strength in N/mm²after immersion in acid solution for 30 days	% loss in strength
1	CC	38.36	34.88	9.07%
2	0%	39.46	36.41	7.73%
3	20%	39.89	37.06	7.10%
4	40%	37.71	34.23	8.18%
5	60%	36.41	33.14	8.98%
6	80%	35.75	32.26	9.76%
7	100%	33.57	30.08	10.39%

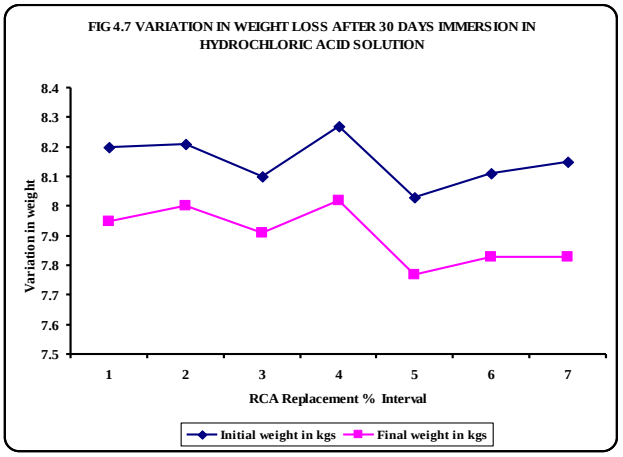
Table 4.5: Compressive strength of cubesafter immersion in Hydrochloric acid solution



2) Weight Loss due Hydrochloric Acid Solution Attack

Sl. No.	% replacement of RCA	Initial weight in kgs	Final weight in kgs	% loss in weight
1	CC	8.20	7.95	3.04%
2	0%	8.21	8.00	2.55%
3	20%	8.10	7.91	2.34%
4	40%	8.27	8.02	3.02%
5	60%	8.03	7.77	3.23%
6	80%	8.11	7.83	3.45%
7	100%	8.15	7.83	3.93%

Table 4.6: Loss in Weight of Cubes after Immersion in Hydrochloric Acid Solution



V. CONCLUSION

- Recycled coarse aggregate shows higher water absorption and higher moisture content than the natural coarse aggregate.
- A slump cone test results shows the consistency of concrete decreases as the percentage of replacement of recycled coarse aggregate increases with the constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres.
- Compaction factor test results shows, the workability of concrete decreases with the increase in percentage of replacement of recycled coarse aggregate with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres.
- It is concluded that strength characteristics of concrete is optimum at 20% replacement of natural coarse aggregate by recycled coarse aggregate with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres.
- It is concluded that strength characteristics of conventional concrete are seems to be inferior than the strength characteristics of concrete at 20% replacement of natural coarse aggregate by recycled coarse aggregate with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres.
- It is concluded that strength of the concrete is decreases as the percentage of replacement of natural coarse aggregate by recycled coarse aggregate increase with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres.
- By performing acid test on concrete cubes it is concluded that, loss in compressive strength and also loss in weight of concrete cubes is minimum at 20% replacement of natural coarse aggregate by recycled coarse aggregate with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres.
- By performing acid test on concrete cubes it is concluded that, loss in compressive strength and also

loss in weight of concrete cubes was found out with increase percentage of replacement of recycled coarse aggregate with constant 50% replacement of river sand by artificial sand in addition with 1.5% steel fibres.

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