EXPERIMENTAL INVESTIGATION OF CONCRETE WITH STEEL FIBER AND STUDY OF THE MECHANICAL PROPERTIES OF RECYCLED AGGREGATE CONCRETE

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Abstract - Concrete like other engineering materials needs to be designed for properties like strength, durability, and workability.Use of mineral admixtures like fly-ash, slag, metakaolan and steel fibre have revolutionized the concrete technology by increasing its strength and durability of concrete by many folds. Fibre-reinforced concrete(FRC) is containing fibrous material which increases its structural integrity. It also increases speed of construction and in some cases may even eliminate the need for conventional reinforcement. It contains short discrete fibres that are uniformly distributed and randomly oriented.Fibres are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reducing bleeding of water. Some types of fibres produce greater impact, and shatter resistance in concrete. Steel is the strongest commonly available fibre, and come in different length and shapes. Steel fibres can only be used on surfaces that can tolerate or avoid corrosion and rust stains.

This paper presents an experimental investigation into the effect of steel fibres on the mechanical properties of recycled aggregate concrete. The mix design used is M20 grade concrete as per Indian Standard. Steel fibres were added to the mixes and washed construction and demolition wastes (size 20mm) as a coarse recycled aggregate were used. Different steel fibre contents; 0, 0.5, 1.0 and 1.5% and replacement percentages of recycled aggregate; 0, 50 and 100%. Were used. Cubes (100×100×100mm), cylinders (150×300mm) and prisms (100×100×500mm) were cast and tested at an age of 28 days.

Keywords : Steel fibre , Recycled aggregate concrete**,** compressive strength, flexural strength, splitting tensile strength.

I INTRODUCTION

Concrete mix design is the science of deciding relative proportion of ingredients of concrete, to achieve the desired properties of concrete. The concrete in which the steel reinforcing bars ,plates or fibres have been incorporated to strengthen a material is called a reinforcement concrete.

Now a days construction and demolition industry is one of the country's largest waste producers . The waste produced by demolition can be minimized and could be utilized again. Concrete recycling is an increasingly common method of depositing of dismantled concrete structures which was once routinely shipped to landfills for disposal. But recycling is now increasing due to improved environmental awareness, government laws and economic benefits. In India, about 14.5 metric ton of solid wastes are generated annually from construction industries, which include waste sand, masonry, & concrete. However, some quantity of such waste material is being replaced and utilized in building materials. Most of the waste materials produced by demolished structures disposed off by dumping them in land fill. Dumping of wastes on land is causing shortage of dumping place in urban areas. Therefore it is necessary to start recycling and re-use of demolition concrete waste to save environment. Concrete recycling gain importance because it protects natural resources and eliminates need for disposal for using the readily available concrete as an aggregate source for new concrete or other applications. large scale recycling of demolished concrete will help conserve natural resource ,and solve a growing waste disposal crisis. The future for recycled aggregates will be driven by reduced landfill availability ,greater product acceptance, continuing government recycling mandates ,and the continuing decay of a large stock of existing infrastructure, as well as by the demands of a healthy economy. concrete. However, in comparison to natural aggregate (NA), the quality of recycled aggregate (RA) is poorer which makes its use in various construction applications restricted. It was stated in previous studies that the adhered mortar content in recycled aggregate as well as the presence of other material such as clay bricks and tiles can make it more porous and more liable to absorb a high amount of water. The high porosity and water absorption capacity of recycled aggregate can substantially reduce the various properties of the resulting concrete.

Steel fibre reinforced concrete (SFRC) has become a very useful structural material in various applications. Adding steel fibres to concrete significantly enhances its mechanical properties. Many researches have investigated the use of SFRC, particularly its mechanical properties. They indicated that steel fibres do little to enhance the compressive strength of concrete (increases ranging from 0 to 20%) .It is well known that the presence of steel fibres in the concrete matrix leading to an improvement in the tensile behaviour of concrete, especially after cracking. Increases of 60% and up to 80% in splitting tensile and flexural strength of concrete, respectively, were recorded due to adding 2% of steel fibres; Therefore, adding steel fibres to RAC (Recycled aggregate concrete) in order to produce steel fibre recycled aggregate concrete (SFRAC) may improve its mechanical properties and make it a suitable structural material, thereby reducing its limited use.

II OBJECTIVE

The main objective of this project are :

- To improve the strength of concrete by adding steel fibre and demolished waste as recycled aggregate.
- To determine the behavior of Fiber Concrete with demolished wastes and compared with control specimen and FC.
- To conduct compressive strength test, splitting tensile strength test and flexural strength test for SFRAC with various percentages of steel fiber and recycled aggregate .
- To facilitate the production of high quality concrete.

III METHODS AND METHODOLOGY

CEMENT

OPC 53 grade sample was tested to obtain the following characteristics as per IS 12269 – 1987

1. Specific Gravity
2. Standard Consistency
3. Initial Setting Time
4. Final Setting Time
5. Fineness

PROPERTIES OF CEMENT

- It provides strength to masonry
- It is stiffness or hardens easily
- It was posses good plasticity
- An excellent building resistance materials
- Easily workable
- Good moisture resistance

FINE AGGREGATE

The fine aggregate used in manufacturing of concrete should be free from debris, fungi and chemical attack. It plays a vital role in concrete, so it should durable, angular and sharp edges then only it and gives a rich mix concrete and workability.

PROPERTIES OF FINE AGGREGATE

- It should be clean and coarse
- It should be free any organic or vegetable matter
- It is usually 3 to 4 % of clay in permitted
- It is chemically alert and well graded
- The finess modulus of sand should between 2 and 3

COARSE AGGREGATE

Aggregates are the important constituents in concrete. They give body to the concrete, reduces shrinkage and effect economy. That more aggregate occupy 70-80 percentage of concrete: their impact on various characteristics and properties of concrete is undoubtedly.

WATER

Water is an important in gradient of concrete as it activity participates in the chemical reactions with cement .Potable water available in laboratory with pH value of not less than 6 and conforming to the requirement of IS 456-2000 was used for mixing concrete and curing the specimen as well.

RECYCLED AGGREGATE

Demolition wastes obtained from a structure predominantly consists of concrete, foreign matter such as various type of finishes, dirt, steel, hardware's, woods, plastics etc. The process of removal of impurities and crushing of rubble into suitable and desired aggregate particle size can be carried out in a continuous and sequential manner using appropriate mechanical devices such as jaw crushers, impact crushers, swing hammer crushers etc. The three processes used for processing of demolition waste are (i) Dry, (ii) Wet, and (iii) Thermal - which are used either individually or in combination. The most marked difference in physical properties of recycled concrete aggregate compared with conventional aggregate lies in its higher water absorption. Crushed washed construction and demolition waste with a maximum size of 20 mm was used as a coarse recycled aggregate in this study

STEEL FIBER

Steel fiber are short discontinues strips of specially manufactured steel. Their inclusion in the concrete improves the mechanical properties of concrete significantly. As the most common matrix, which is now in use in construction industry is reinforced cement concrete.

PROPERTIES OF STEEL FIBERS

Properties of concrete which shows increases on inclusion of steel fibers.

- Toughness
- Flexural strength
- Fatigue endurance
- Impact strength
- Compressive strength
- Shear strength
- Abrasion and skid resistance

IV TESTING

COMPRESSIVE STRENGTH

The compressive strengths of three 100mm x 100mmx100mm test cubes were tested for 7 and 28 day strengths. The cubes are placed in the compression testing machine in such manner that the load is applied to the opposite sides of the cube as cast. Load can be applied before the failure in the specimen. The supreme load is certainly noted

Compressive strength of the specimen is calculated using the formula,

$f_c = P/A$

Where, fc = Compressive strength (N/mm^2)
P = Ultimate load (N)
A = Loaded area

SPLIT TENSILE STRENGTH TEST

The tensile strength of concrete is determined by splitting the cylinder across the vertical diameter. Split tensile strength is an indirect method of finding out the tensile strength of concrete. As per ASTM , the test was carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine. The load was applied until the specimen fails.

The split tensile strength is calculated using the form $f_{spt}=2P/\Pi dL$

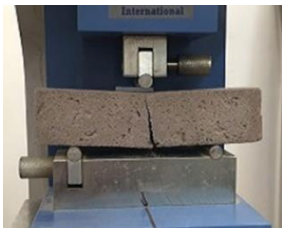
Where, P=applied load, D=diameter of the specimen, L=length of the specimen

FLEXURAL STRENGTH TEST

The standard size of the specimens 10 x 10 x 50 cm is used. The mould should be made of metal or cast iron, with sufficient plate thickness to prevent spreading or warping. The testing machine may be of sufficient capacity for the testing and rate of loading as specified. The load is applied through the roller placed at middle (central point load). The flexural strength of specimen is expressed as modulus of rupture, f_{ft}.

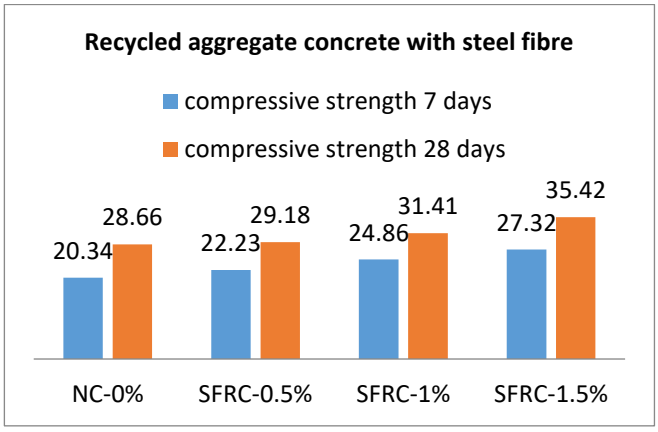
Flexural strength,

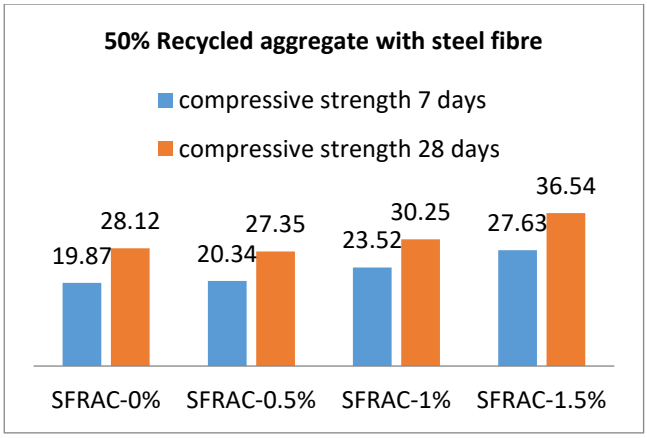
$f_{ft}= 1.5P \times l / (bd^2)$ Where, P = Applied load
l = Length of specimen
b,d = Cross section dimensions of specimen.

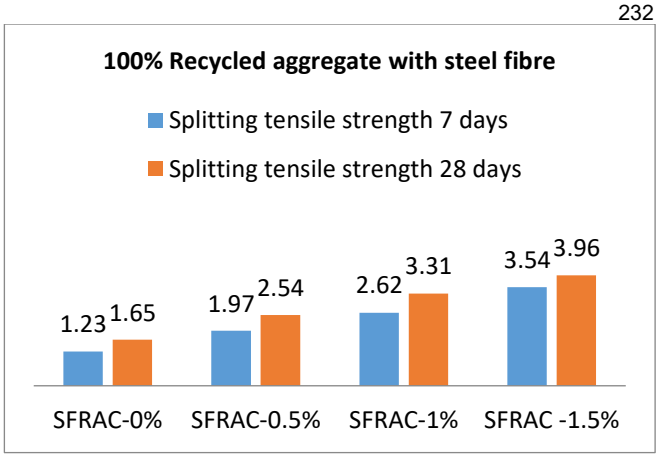


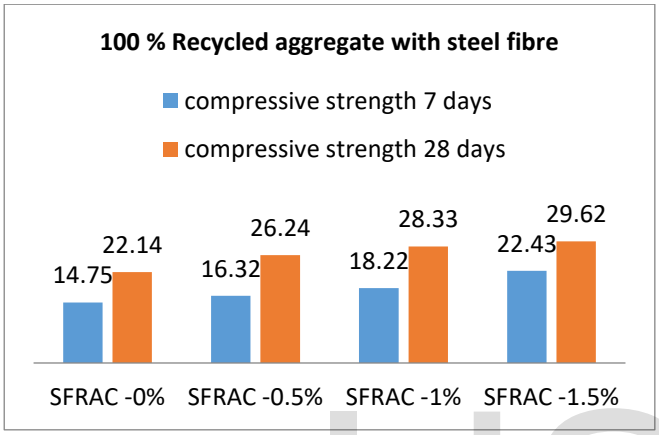
V RESULT AND DISCUSSION

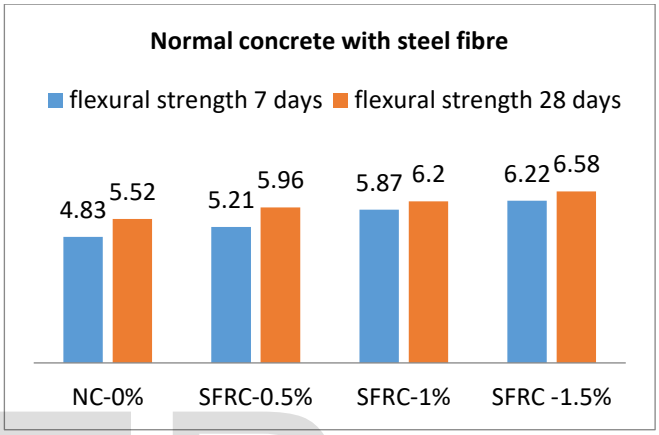
Sl.No	TYPE OF DESIGN	f_c MPa		f_{spt} MPa		f_{ft} MPa	
		7 days	28 days	7 days	28 days	7 days	28 days
1	NC	20.34	28.66	2.50	2.89	4.83	5.52
2	SFRC-0.5%	22.23	29.18	2.78	3.22	5.21	5.96
3	SFRC-1%	24.86	31.41	3.24	3.56	5.87	6.20
4	SFRC-1.5%	27.32	35.42	3.99	4.21	6.22	6.58
5	RAC-50%	19.87	28.12	1.85	2.31	4.32	4.68
6	SFRAC-50-0.5	20.34	27.35	2.52	2.99	4.36	4.96
7	SFRAC-50-1.0	23.52	30.25	3.46	3.89	4.79	5.34
8	SFRAC-50-1.5	27.63	36.54	4.21	4.58	5.26	5.82
9	RAC-100%	14.75	22.14	1.23	1.65	2.95	3.58
10	SFRAC-100-0.5	16.32	26.24	1.97	2.54	2.39	3.75
11	SFRAC-100-1.0	18.22	28.33	2.62	3.31	3.85	4.11
12	SFRAC-100-1.5	22.43	29.62	3.54	3.96	4.23	4.69

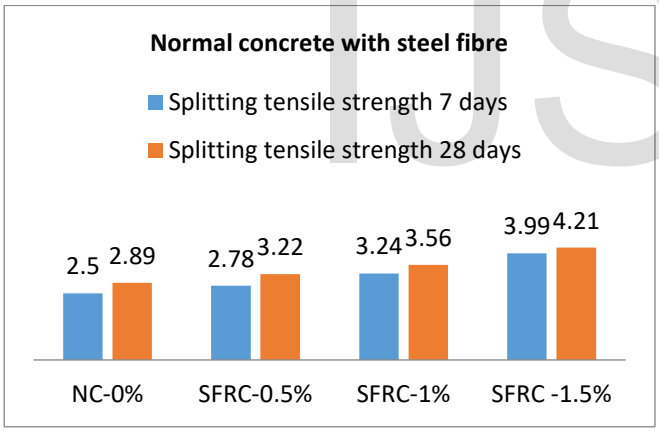


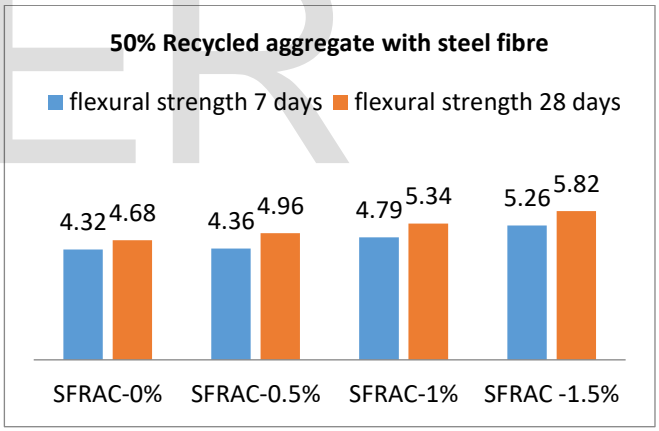

50% Recycled aggregate with steel fibre
compressive strength 7 days
compressive strength 28 days
19.87
28.12
20.34
27.35
23.52
30.25
27.63
36.54
SFRAC-0%
SFRAC-0.5%
SFRAC-1%
SFRAC-1.5%


100% Recycled aggregate with steel fibre
Splitting tensile strength 7 days
Splitting tensile strength 28 days
1.23
1.65
1.97
2.54
2.62
3.31
3.54
3.96
SFRAC-0%
SFRAC-0.5%
SFRAC-1%
SFRAC -1.5%


100 % Recycled aggregate with steel fibre
compressive strength 7 days
compressive strength 28 days
14.75
22.14
16.32
26.24
18.22
28.33
22.43
29.62
SFRAC -0%
SFRAC -0.5%
SFRAC -1%
SFRAC -1.5%


Normal concrete with steel fibre
flexural strength 7 days
flexural strength 28 days
4.83
5.52
5.21
5.96
5.87
6.2
6.22
6.58
NC-0%
SFRC-0.5%
SFRC-1%
SFRC -1.5%


Normal concrete with steel fibre
Splitting tensile strength 7 days
Splitting tensile strength 28 days
2.5
2.89
2.78
3.22
3.24
3.56
3.99
4.21
NC-0%
SFRC-0.5%
SFRC-1%
SFRC -1.5%


50% Recycled aggregate with steel fibre
flexural strength 7 days
flexural strength 28 days
4.32
4.68
4.36
4.96
4.79
5.34
5.26
5.82
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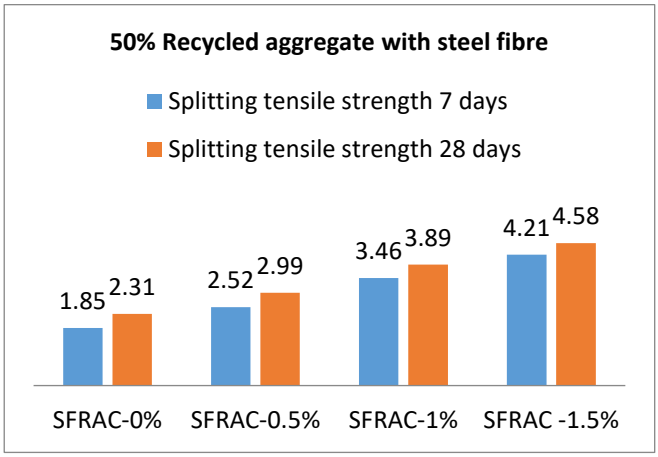
SFRAC-0.5%
SFRAC-1%
SFRAC -1.5%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4.58
SFRAC-0%
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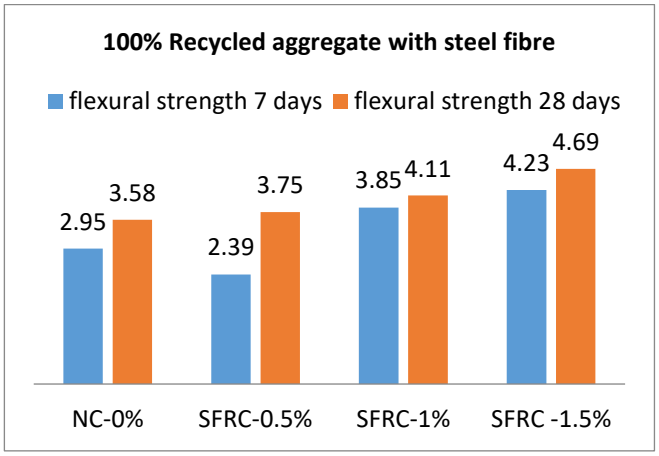
100% Recycled aggregate with steel fibre
flexural strength 7 days
flexural strength 28 days
2.95
3.58
2.39
3.75
3.85
4.11
4.23
4.69
NC-0%
SFRC-0.5%
SFRC-1%
SFRC -1.5%

VI CONCLUSION

The following conclusions are drawn from the present experimental work

- The compressive strengths is decreasing as the recycled aggregate content increase in the conventional concrete mix.
- Addition of steel fibres is effective for recycle aggregate concrete.
- As percentage of fibre increases strength of concrete increases.
- However, the concrete still has a strength that would make it suitable for minor construction and structural works. Use of recycled aggregates in concrete provides a promising solution to the problem of C&D waste management.
- The compressive strength , Split tensile strength and flexural strength is found to be increased for fully replaced RA concrete added with steel fibres.
- In conclusion, recycling WCAs in concrete production may help solve a vital environmental issue apart from being a solution to the problem of inadequate concrete aggregates in concrete.

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