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A Case Study on Strength Properties of Partially Replaced Recycled Aggregate and Steel Fibers to A Nominal Concrete

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Abstract: *It is now well established that one of the important properties of steel fibre reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation.. As a result of this ability to arrest cracks, fiber composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under flexural loading and the fibre are able to hold the matrix together even after extensive cracking. The net result of all these is to impart to the fibre composite pronounced post – cracking ductility which is unheard of in ordinary concrete.*
Keywords: *Cement,Coarsse aggeregte,Compression Stength,FlexureStrenght,Fine aggregate, Recycled coarse aggregate, Steel fibres, Water.*

I. Introduction

Fibre reinforced concrete (FRC) may be defined as a composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibres. Now, why would we wish to add such fibres to concrete? Plain, unreinforced concrete is a brittle material, with a low tensile strength and a low strain capacity. The role of randomly distributes discontinuous fibres is to bridge across the cracks that develop provides some post- cracking "ductility". If the fibres are sufficiently strong, sufficiently bonded to material, and permit the FRC to carry significant stresses over a relatively large strain capacity in the post-cracking stage. There are, of course, other (and probably cheaper) ways of increasing the strength of concrete. The real contribution of the fibres is to increase the toughness of the concrete (defined as some function of the area under the load vs deflection curve), under any type of loading. That is, the fibres tend to increase the strain at peak load, and provide a great deal of energy absorption in post-peak portion of the load vs. deflection curve. When the fibre reinforcement is in the form of short discrete fibres, they act effectively as rigid inclusions in the concrete matrix. Physically, they have thus the same order of magnitude as aggregate inclusions; steel fibre reinforcement cannot therefore be regarded as a direct replacement of longitudinal reinforcement in reinforced and pre stressed structural members. However, because of the inherent material properties of fibre concrete, the presence of fibres in the body of the concrete or the provision of a tensile skin of fibre concrete can be expected to improve the resistance of conventionally reinforced structural members to cracking, deflection and other serviceability conditions. The fibre reinforcement may be used in the form of three – dimensionally randomly distributed fibres throughout the structural member when the added advantages of the fibre to shear resistance and crack control can be further utilized. On the other hand, the fibre concrete may also be used as a tensile skin to cover the steel reinforcement when a more efficient two – dimensional orientation of the fibres could be obtained.

The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fibre composite and its ability to withstand repeatedly applied, shock or impact loading. Use of recycled aggregate (RA) in concrete can be described in environmental protection and economical terms. This project reports the results of an experimental study on the recycled aggregate concrete (RAC) as compared to natural aggregate concrete (NAC). The effects of size of RA on compressive strength were discussed in this project. The 10%,20%,30% of RA used in concrete mix to replace the natural coarse aggregate in concrete with 100 x 100 x 100 mm cube were cast with target compressive strength is 48 MPa..

II. Materials Methodology And Casting Methods

2.1. Cement

In the most general sense of the word, cement is a binder, a substance which sets and hardens independently, and can bind other materials together. The word "cement" traces to the roman's, who used the term "opuscaementicium" to describe masonry which resembled concrete and was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick additives which were added to the burnt lime to obtain a hydraulic binder were later referred to as cementum, cament and cement. Cements used in construction are characterized as hydraulic or non-hydraulic. The most important use of cement is the production of mortar and concrete- the bonding of natural use of aggregates to from a strong building material which is the face of normal environmental effects.

2.2. Ordinary Portland Cement

Is the most common type of cement in general use around the world, because it is a basic ingredient of concrete, mortar, stucco and most non-specialty grout. It is a fine powder produced by grinding Portland cement clinker (more than 90%), a limited amount of calcium sulphate which controls the set time, and up to 55 minor constituents (as allowed by various standards).The cement used for our experimental work is super Birla cement (OPC 53-Grade). Conformed to the quality provisions of Indian standard specification. The specific gravity of the cement was 3.12

2.3. Fine Aggregate:

Locally available sand passed through 4.75mm IS sieve is used. The specific gravity of 2.74 and fineness modulus of 3.338 are used as fine aggregate. The loose and compacted bulk density values of sand are 1094 kg/m^3 and 1162 kg/m^3 respectively.

2.4. Coarse Aggregate:

Crushed aggregate available from local sources has been used. The coarse aggregates with a maximum size of 20mm having the specific gravity value of 2.885and fineness modulus of 7.386 are used as coarse aggregate.

2.5. Water:

Potable water used for the experimentation.

2.6. Steel Fibre (S.F):

The steel fibre used in the study is the mesh type. The constant dosages of 5.0 %, 10.0%, are used by total volume of concrete.

Fig 1 it shows as series of steel fibre.

III. Casting Of Test Specimens

3.1. Preparation of materials

All materials shall be brought to room temperature, preferably 27^o+or-3^0 c before commencing the experiments. The cement samples, on arrival at the laboratory, shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material, care is being taken to avoid the intrusion of foreign matter. The cement shall be taken & stored in a dry place, preferably in air tight metal containers. Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in an air-dried condition.

3.2 Proportioning

The proportions of the materials, including water, in Concrete mixes for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work. Where the proportions of the ingredients of the mortar as used on the site are to be specified by volume, they shall be calculated from the proportions by weight used in the test cubes and the unit weights of the materials.

3.3 Weighing

The quantities of cement, each size of aggregate, some % age of steel fibres and water for each batch shall be determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.

3.4. Mixing Concrete

The concrete shall be mixed by hand or preferably in a laboratory batch mixer, in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.

Fig2 it shows the concrete machine mixer.

3.6 Preparation of Specimens

In the present investigation, compressive strength and flexural strength of the concrete specimens were tested. Mix design is done as per IS: 10262-2007.An experimental investigation was conducted by casting and testing the Compression Strength of Cubes and Flexure strength Beams of SFRC. The parameter varied in this investigation was the weight percentage content of steel fiber. The concrete was prepared in the laboratory using mixer. The cement, fine aggregate and coarse aggregate were fixed in dry state to obtain uniform colour and calculated amount of water, obtained from workability test, was added and the whole concrete was mixed for five minutes in wet state. Meanwhile the moulds were screwed tightly to avoid leakage. Oil was applied on inner surface of moulds in three layers by poking with a tamping rod. The cast specimens were removed from moulds after 24 hours and the specimens were immersed in a clean water tank. After curing of specimens for a period of 28 days, the specimens were removed from the water tank and allowed to dry under shade.

Figure3 it shows the preparation of hand mixing of concrete for compression strength of cubes .Figure 4 it shows the preparation of hand mixing of concrete for flexure strength of prisms.

3.7. Mix proportions Replacement

The concrete cubes were of 150mm X 150 mm X 150mm height. The beams were of 500mm X 100mmX100mm.The weight percentage content of fiber was taken as 0%, 5% & 10%. The weight percentage content of recycled coarse aggregate was taken as 0%,10%,20% & 30%.

Figure 5 it shows the casting of the concrete cube. Figure 6 it shows the testing of flexure strength of prism.

IV. Experimental Results And Tables

In the present investigation, compressive, split tensile and flexural strength of the concrete specimens were tested. Mix design is done as per IS: 10262-2007. The weight percentage content of fiber was taken as 0%, 5%,10%. The weight percentage content of recycled coarse aggregate was taken as 0%,10%,20%,30%.

Figure 7 it shows the testing of compression strength of cube.

4.1 Results of Concrete Cubes of strength of 7 days and 28 days strength.

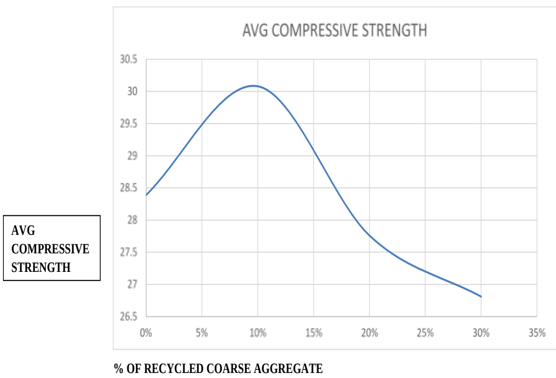
Table 4.1: Result for test on compressive strength of SFRC cubes

Grade Of Concrete	RECYCLED COARSE AGGREGATE	STEEL FIBER ADDITION	COMPRESSIVE STRENGTH AT 7 DAYS N/Mm^2	COMPRESSIVE STRENGTH AT 28 DAYS N/Mm^2	RECYCLED COARSE AGGREGATE	STEEL FIBER ADDITION	COMPRESSIVE STRENGTH AT 7 DAYS N/Mm^2	COMPRESSIVE STRENGTH AT 28 DAYS N/Mm^2
M40	0%	5%	28.39	48.54	0%	10%	28.39	48.54
M40	10%	5%	28.08	47..41	10%	10%	27.23	46.46
M40	20%	5%	27.76	46.22	20%	10%	26.84	45.63
M40	30%	5%	26.81	44.47	30%	10%	25.31	44.21

Table 4.2 : Result for test on flexural strength of SFRC beams

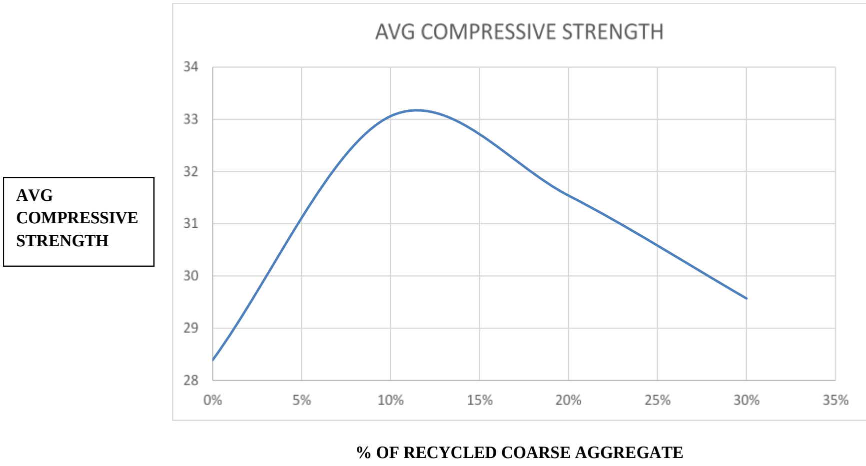
Grade of concrete	RECYCLED COARSE AGGREGATE	STEEL FIBER ADDITION	FLEXURAL STRENGTH AT 7 DAYS N/mm^2	FLEXURAL STRENGTH AT 28 DAYS N/mm^2	RECYCLED COARSE AGGREGATE	STEEL FIBER ADDITION	FLEXURAL STRENGTH AT 7 DAYS N/mm^2	FLEXURAL STRENGTH AT 28 DAYS N/mm^2
M40	0%	5%	6.27	6.53	0%	10%	6.53	6.53
M40	10%	5%	5.13	5.20	10%	10%	6.54	5.69
M40	20%	5%	5.64	6.16	20%	10%	5.29	6.33
M40	30%	5%	5.17	5.33	30%	10%	5.57	5.92

Graph1 : 7 days compressive strength for 5% percentage of steel fibers



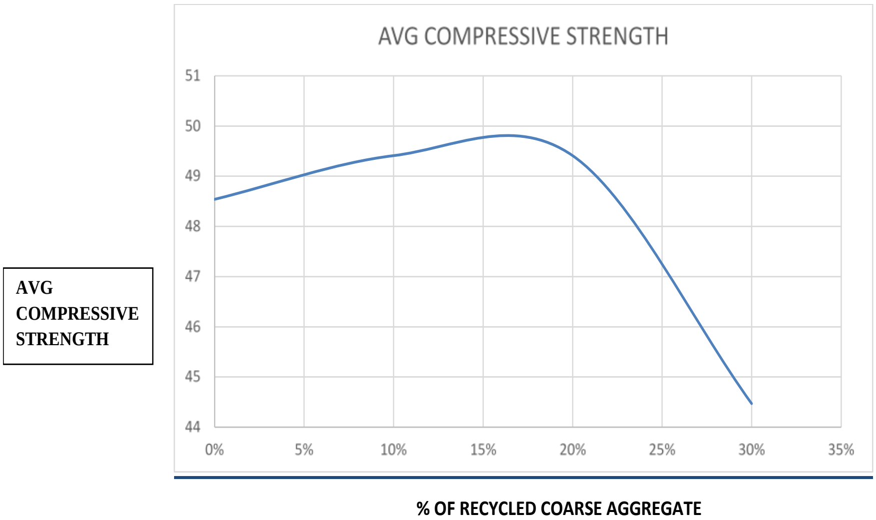
4.1.Figures shows 7 days compression strength for concrete cubes of 5% of steel fibre

Graph2 : 7 days compressive strength for 10% percentage of steel fibers



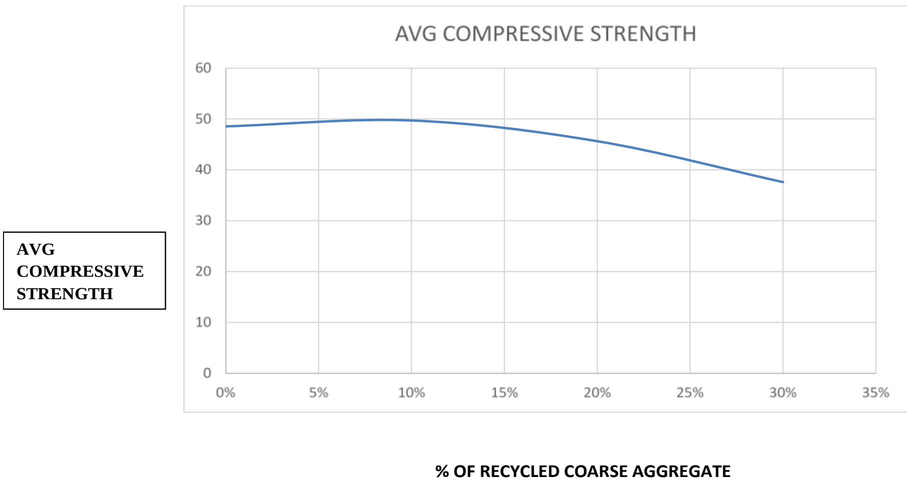
4.2.Figures shows 7 days compression strength for concrete cubes of 10 % of steel fibre

Graph3 : 28 days compressive strength(MPa) 5% of steel fibers for cubes



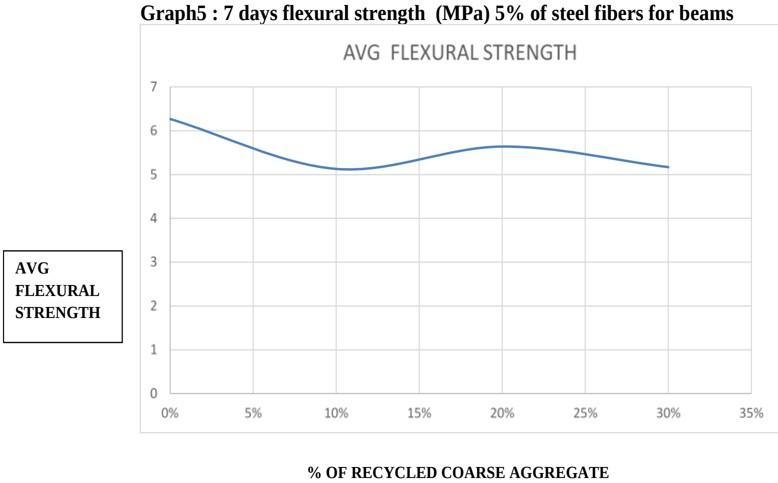
4.3.Figures shows 28 days compression strength for concrete cubes of 5 % of steel fibre

Graph4 : 28 days compressive strength(MPa) for 10% of steel fibers for cubes



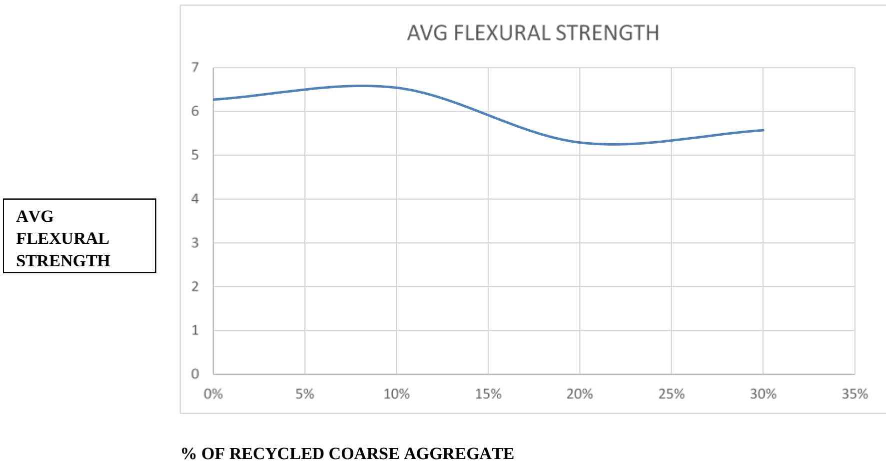
4.4.Figures shows 28 days compression strength for concrete cubes of 10% of steel fibre

Graph5 : 7 days flexural strength (MPa) 5% of steel fibers for beams



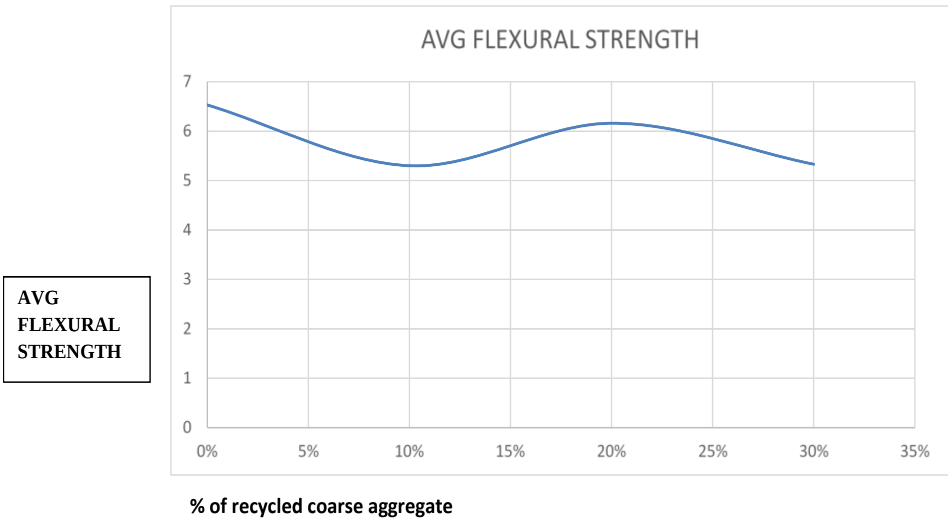
4.5.Figures shows 7 days of flexure strength prisms 5% of steel fibre

Graph6 : 7 days flexural strength (MPa) 10% of steel fibers for beams



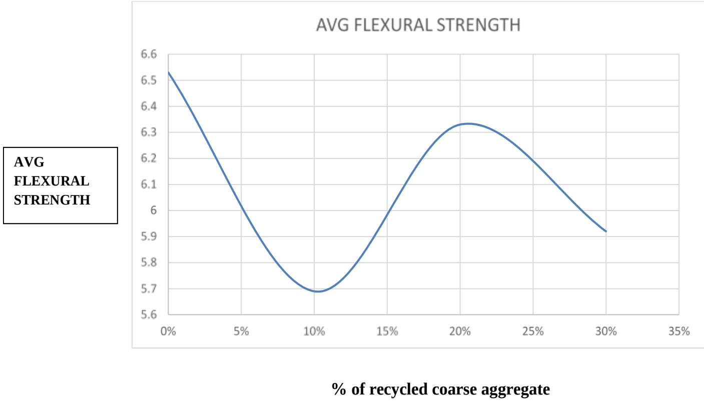
4.6.Figures shows 7 days of flexure strength prisms 10% of steel fibre

Graph7 : 28 days flexural strength (MPa) 5% of steel fibers for beams



4.7.Figures shows 28 days flexure strength prisms 5% of steel fibre

Graph8 : 28 days flexural strength (MPa) 10% of steel fibers for beams



4.8.Figures shows 28 days flexure strength prisms 10% of steel fibre

V. Conclusions

Based on the limited study carried out on the strength behaviour of SFRC the following conclusions are drawn.

- By adding the steel with recycled concrete fibres in concrete there is gradual increase in compressive strength from 7 to 28 days.
- It is observed that compressive strength increases from 11 to 24% with addition of steel fibers along with RCA.
- The total energy absorbed in fiber as measured by the area under the load-deflection curve is at least 10 to 40 times higher for fiber-reinforced recycled concrete than that of plain concrete.
- Addition of fiber to conventionally reinforced beams increased the fatigue life and decreased the crack width under fatigue loading.
- Cost savings of 10% - 30% over conventional concrete flooring systems.

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