MECHANICAL PROPERTIES OF RECYCLED AGGREGATE CONCRETE WITH STEEL FIBRES

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Abstract: Concrete is most widely used construction material in the world. Now days the world is witnessing the construction of more and more challenging and difficult Engineering structures. So the concrete need to possess very high strength and sufficient workability. Researchers all over the world are developing high performance concrete by adding various fibers, admixtures in different proportions. Various fibers like glass, carbon, poly propylene and aramid fibers provide improvement in concrete properties like tensile strength, fatigue characteristics, durability, shrinkage, impact, erosion resistance and serviceability of concrete. Because of such characteristics Fiber Reinforced Concrete as found many applications in civil engineering field. The present work aims at evaluating the compressive strength and split tensile strength of fiber reinforced concrete for M20 grade of concrete with varying dosage of steel fiber by volume of mould and varying dosages of recycled aggregates.

***IndexTerms* – Recycled Coarse Aggregate, Steel Fibres, Compressive strength, Split tensile strength.**

I. INTRODUCTION

One of the major challenges of the present society is the protection of environment. Some of the important elements in the respect are the reduction in the consumption of energy, natural materials and extensive use of waste materials. Nowadays these are getting considerable attention under sustainable development. The use of recycled aggregates from the construction and demolition wastes is showing prospective application in construction as an alternative to the natural, aggregate. It conserves natural resources and reduces the spaces required for the landfill disposal. India is presently generating construction and demolition (C&D) waste of 23.75 million tons annually and these figures are likely to double in the next 7 years.C&D waste, specifically concrete, has been seen as a resource in developed countries. Works on recycling have emphasized that if old concrete has to be used in second generation concrete, the product should adhere to the required compressive strength. Literature reveals that compressive strength primarily depends upon adhered mortar, water absorption, size of aggregates, strength of parent concrete, age of curing and ratio of replacement, interfacial zone, moisture state, impurities present and controlled environmental condition. Concrete makes many desirable properties and moulds itself to a variety of innovative designs. However some deficiencies of the convention cement concrete such as brittleness, poor tensile strength, poor impact strength etc. resulting cracks and hence becoming unsuitable for certain applications. Major research in this field identified crack-free concrete structural possible via secondary reinforcement techniques. Deficiencies encountered with conventional concrete can be overcome by the addition of the fibres to cement concrete, which improves the crack resistance, fracture toughness, resistance to impact and shocks etc.

Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking internal micro cracks are inherently present in the concrete & its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete. In the past, attempts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced steel bars & also by applying restraining techniques. Although both of these methods provide tensile strength to the concrete members, they however, do not increase the inherent tensile strength of concrete itself. In plain concrete & similar brittle materials, structural cracks (micro cracks) develop even before loading, particularly due to drying shrinkage or other causes of volume change. The width of these initial cracks seldom exceeds a few microns, but their other two dimensions may be of higher magnitude. It has been recognized that the addition of small, closely spaced uniformly dispersed fibres to concrete would act as crack arrester & would substantially improve its static & dynamic properties. This type of concrete is fibre reinforced concrete. Fibre reinforced concrete can be defined as a composite material consisting mixture of cement, mortar, concrete & discontinuous, discrete, uniformly dispersed suitable fibres. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibres.

II. LITERATURE REVIEW

D. Suresh Kumar and J Vikranth (2013) reported that the basic use of recycled aggregates in concrete proves to be a valuable building material in technical, environment and economical respect. The specific gravity and bulk density of recycled coarse aggregate was found to be less than conventional coarse aggregates. The water absorption was relatively higher for recycled aggregates. The recycled aggregates had 2.5% water absorption. Hyginus E. Opara and Uchechi G. Eziefula (December 2016) concluded that the bulk densities of both natural aggregate concrete and recycled aggregate concrete were within the range of normal weight concrete, with the bulk density of natural aggregate concrete being higher than those of recycled aggregate concrete for different curing ages. Reduction in the bulk density of recycled aggregate concrete ranged from 7% to 10%. Jitender sharma and Sandeep single (July 2014) noticed that, when the water cement ratio used in recycled aggregate mix is reduced, tensile strength and modulus of elasticity are improved. Tarun Gehlot et.al.,(August 2017) reported that the use of higher percentage of fibre is likely to cause segregation and hardness of concrete and mortar and also the workability of concrete is greatly reduced.

III. OBJECTIVES OF THE EXPERIMENTAL WORK

3.1 OBJECTIVES

The following are the objectives of the present experimental work:

1. To carry out different test on natural, recycled aggregates and compare their test results.
2. Viability of recycled aggregate concrete (RAC) for construction works.
3. Behavior of compressive and split tensile strengths of steel fibers in RAC.
4. Evaluation of optimum dosage of steel fibers for RAC.

3.2 EXPERIMENTAL PROGRAM

To achieve the specified objectives of the present work, an experimental program was planned and the same is presented in Table 3.1. In the experimental program total 3 mixes are prepared with recycle aggregate concrete and steel fibers. The mix design for all mixes is taken as M20 grade concrete. The research program has planned to evaluate three strengths of compressive and split tensile strengths. For compressive strength test cubes and for split tensile strength test cylinder are cast.

Table 3.1: Experimental program

Sl. No	Mix designation	No of cube specimen	No of cylinder specimen	Total no of specimen
1	RAC-0%	3	3	6
2	RAC-50%	3	3	6
3	RAC-100%	3	3	6
4	RACF-0%	3	3	6
5	RACF-50%	3	3	6
6	RACF-100%	3	3	6

3.3 MIX DESIGNATION

3.3.1 WITHOUT FIBER

1. *RAC-0%:* Where RAC refers to recycled aggregate concrete'0'refers to the percentage replacement of natural aggregate by recycled aggregate concrete.
2. *RAC-50%:* Where RAC refers to recycled aggregate concrete '50' refers to the percentage replacement of natural aggregate by recycled aggregate concrete.
3. *RAC-100%:* Where RAC refers to recycled aggregate concrete '100' refers to the percentage replacement of natural aggregate by recycled aggregate concrete.

3.3.2 WITH 1% OF STEEL FIBER

4. *RACF-0%:* Where RAC refers to recycled aggregate concrete '0' refers to the percentage replacement of natural aggregate by recycled aggregate concrete with 1% steel fiber by weight of cement.
5. *RACF-50%:* Where RAC refers to recycled aggregate concrete '50' refers to the percentage replacement of natural aggregate by recycled aggregate concrete with 1% steel fiber by weight of cement.
6. *RACF-100%:* Where RAC refers to recycled aggregate concrete '100' refers to the percentage replacement of natural aggregate by recycled aggregate concrete with 1% steel fiber by weight of cement.

IV. MATERIALS AND METHODOLOGY

4.1 MATERIALS

The following materials are used in the present work:

Cement: 43 grade ordinary Portland cement (OPC) was used in this experimentation program with specific gravity 3.15 and conforming to IS: 8112-1989.

Fine aggregate: Locally available river sand was used in this experimentation program with specific gravity 2.60 and belongs to zone III of IS: 383-1970.

Natural Coarse Aggregate: Crushed angular aggregates of specific gravity 2.48 was used. The water absorption was 0.2%.

Recycled Coarse Aggregate: Recycled aggregates from waste concrete and demolition waste of specific gravity 2.23 was used. The water absorption was 4.38%.

Water: Water which is free from acids, oils, alkalis and other impurities was used.

Steel fibres: In the present work flat crimped steel fibres of length 50mm were used. The aspect ratio of fibres is 50. Steel fibres were obtained from Ryan International Pune.

4.2 METHODOLOGY

The mix design procedure adopted in the present work to obtain M20 grade concrete is accordance with IS: 10262-2009. The obtained mix proportion was 1:1.61:2.73. The w/c ratio was 0.5. The dry components are blend and water added slowly unless the concrete is achievable. The mix should not be to sloppy are too stiff. It is difficult to type good test specimen, if it is too stiff. Whether if it is too sloppy, water may just break from the mixture. For casting, all the mould had been cleaned and oiled correctly. They have been securely tightened to proper dimension earlier than casting. Consideration was taken that there is no gaps left, where there is any probability of spillage of slurry, cautions strategy was embraced in the mixing, casting and batching operation. The FA and CA were weighed first. The concrete combination used by hand mixing. FA and cement are mixed thoroughly absolutely except uniform colour is obtained, to this mixture CA was introduced and mixed absolutely. Water is added precisely making definite no water is lost while mixing. While adding water care should be taken to add it in stages so as to prevent bleeding which may affect the strength formation of concrete rising of water required for hydration to the surface. Mould can be clean first and oiled mould for each and every category used mould is placed on the vibrating machine and stuffed in different 3 layers. These specimens were permitted to stay in the metal mould for the essential for twenty four hours at encompassing circumstance. After that these were demould with consideration all together that no edges were harmed and had been set in the tank at the surrounding temperature for curing is required.

The cubes of inner dimensions (150X150X150) mm were cast to find out the compression strength of mixes. To evaluate the split tensile strength, cylinders of 150mm diameter with 300mm height were cast. Cement, CA & FA were taken in mix proportions 1:1.61:2.73 which relate to grade concrete is M20. Natural coarse aggregate replaced by 0%, 50% & 100% of recycled coarse aggregate and 1% of steel fiber by weight of cement is added in concrete was produced by dry mixing all the ingredients uniformly. The first dry mix is required & amount of water was added (water cement ratio is 0.50) and the complete mix was again homogeneously mixed. This wet concrete was filled the mould which was compacted through physically hand compaction in three layer. After the compaction, the top surface made smooth surface. After 24 hours. Specimen were demoulded and taken to curing tanks where they cure permitted to require number of days.

V. TESTS ON CONCRETE

5.1 TESTS ON FRESH CONCRETE

5.1.1 SLUMP TEST

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch. Slump cone test basically comprises of a steel mould in sort of frustum of a cone having the interior top dia 10cm, base dia 20cm and 30cm as shown in Fig. 5.1.

5.1.2 COMPACTION FACTOR TEST

Compaction factor test can also be utilized to examine the workability of fresh concrete. Compacting factor experiment is gives a more accurate workability occurs in fresh concrete than slump cone test. Compaction factor test is also known as "drop test".

Compaction factor test is the ratio of the load partly compacted concrete to the burden of fully compacted concrete. The apparatus can be viewed in Fig. 5.1.

5.2 TESTS ON HARDENED CONCRETE

5.2.1 COMPRESSIVE STRENGTH TEST

Compressive strength is the capacity of a material or constitution withstand axial masses tend to reduce the scale. It is measured using of compression testing machine [CTM]. Concrete can be made excessive compressive strength. Both conventional and fiber in concrete specimen were tested at varying percentage of fiber. Compression testing machine as shown in Fig. 5.1.

Compressive force for evaluating, mould dimension (150x150x150)mm. compression testing machine is capacity 3000KN as per Indian standard 516-1959.

5.2.2 SPLIT TENSILE STRENGTH TEST

For conducting the split tensile strength, cylinder specimen of dia 150mm and height 300mm were cast. The spilt tensile test was carried out in 3000KN capacity compression testing machine (Fig. 5.1) as per Indian Standard 5816-1999. The load applied at the uniform rate of 140kg/cm^2 and the failure load is noted.

Slump Test	Compaction Factor Test	Compressive Strength Test	Split Tensile Strength Test

Fig 5.1: Tests on Concrete

VI. EXPERIMENTAL RESULTS

6.1 SLUMP AND COMPACTION FACTOR TEST

The slump and compaction factor test results are presented in the Table 6.1. the test results show that as the fibre content and recycled aggregate in the concrete mix increases, the slump and compaction factor values decreases.

TABLE 6.1: SLUMP AND COMPACTION FACTOR VALUES

Sl. No	Mix designation	Slump (mm)	Compaction factor
1	RAC-0%	100	0.91
2	RAC-50%	20	0.90
3	RAC-100%	10	0.89

4	RACF-0%	60	0.90
5	RACF-50%	15	0.90
6	RACF-100%	9	0.90

6.2 COMPRESSIVE STRENGTH TEST

The mechanical properties of M20 grade concretes cast without and with RCA and without and with Steel Fiber (SF). The dosage of SF in concrete was found based on experimental results. Two aspects can be determined here, one is the effect of different replacement of RCA in NA on no–fibrous concrete and the other one is in fibrous concrete (SF). One notable observation is that in M20 grade of concrete the target compressive strength could be easily achieved. With replacement of RCA in NA the compressive strength has decreased but was always above the target strength. This gives a conclusion that recycled aggregate concretes are not inferior to normal concretes. In case of M20 grade concrete, also the target strength could be achieved for 50 % replacement and was close to target mean strength for 100% replacement. The compressive strength results can be viewed in Table 6.2 and Fig. 6.2.

TABLE 6.2: COMPRESSIVE STRENGTH OF CONCRETE FOR 28 DAYS

Sl. No	Mix designation	Compressive strength (N/mm^2)
1	RAC-0%	39.40
2	RAC-50%	36.00
3	RAC-100%	22.96
4	RACF-0%	37.33
5	RACF-50%	29.18
6	RACF-100%	21.25

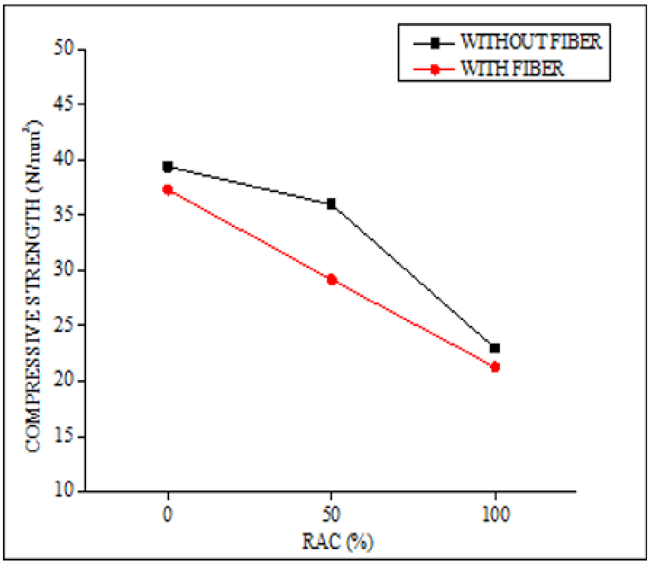

FIG. 6.2: COMPRESSIVE STRENGTH OF CONCRETE FOR 28 DAYS

6.3 SPLIT TENSILE STRENGTH TEST

The tensile strength of concrete is relatively much lower than its compressive strength because it can be developed more quickly with crack propagation. The decrease is more in case of recycled concrete aggregate. Hence, it is important to improve the tensile strength of such a recycled aggregate concrete with addition of steel fiber. The split tensile strength results can be viewed in Table 6.3 and Fig. 6.3.

TABLE 6.3: SPLIT TENSILE STRENGTH OF CONCRETE FOR 28 DAYS

Sl. No	Mix designation	Split tensile strength (N/mm^2)
1	RAC-0%	2.92
2	RAC-50%	2.56
3	RAC-100%	2.42
4	RACF-0%	2.82
5	RACF-50%	2.12
6	RACF-100%	2.23

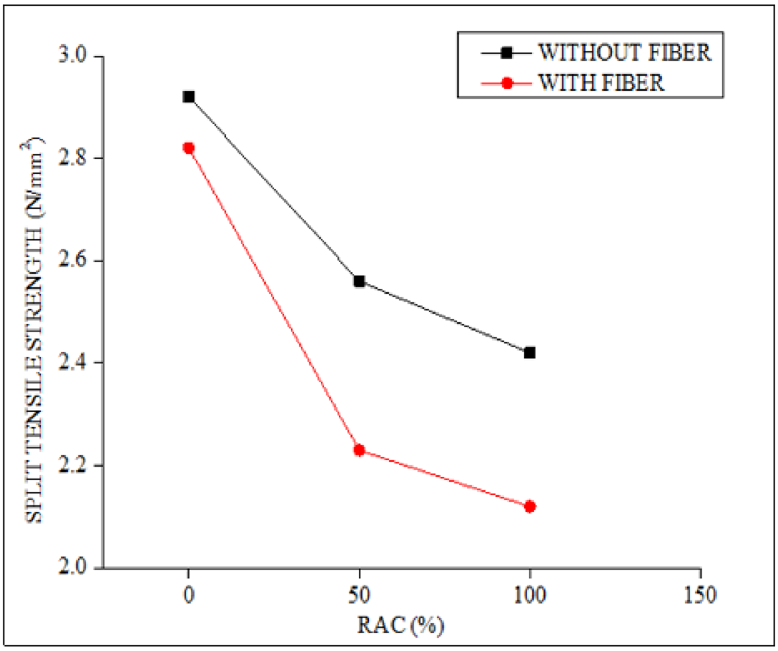

FIG. 6.3: SPLIT TENSILE STRENGTH OF CONCRETE FOR 28 DAYS

VII. CONCLUSIONS

Based on experimental results of steel fiber reinforced recycled aggregate concrete the following conclusion can be drawn.

1. From the structural properties of RAC it can be concluded that the coarse aggregate obtained from crushing building demolition waste (BDW) can be used for structural concrete works. This confirms the fact that RAC is in no way inferior to NA.
2. Addition of steel fiber decreases the workability of concrete.
3. As increase in replacement of recycled aggregate in the concrete the strengths are reduced compared to conventional concrete.
4. The maximum replacement of recycled aggregate in the concrete is 50%.

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