

A Study On Effect Of Recycled Aggregate Based Sisal Fiber Reinforced Concrete

MD Abu Imran
PG Scholar, Department of Civil Engineering
Vaagdevi College of Engineering
Bollikunta, Warangal
Email: imranabu31@gmail.com
Cell: +91 91546 68505

B Dhavaleshwar Rao
Professor, Department of Civil Engineering
Vaagdevi College of Engineering
Bollikunta, Warangal
Email: eshwar54@gmail.com
Cell: +91 85003 16238

Abstract

Fiber reinforcement is commonly used to provide toughness and ductility to brittle cementitious matrices. Reinforcement of concrete with a single type of fiber may improve the desired properties to a limited level. There is an urge to produce sustainable concrete by using recycled aggregates. This study aims to characterize and quantify the mechanical properties of sisal fiber and recycled aggregate concrete. Volume percentage of fiber inclusion was varied from 0 to 2%. Slump test and compaction factor test was carried out for each mix in the fresh state. Compressive strength, Split tensile strength, flexural strength tests will be performed in the hardened state on M20 grade of concrete. The use of recycled aggregates will be used with a replacement level of 50% and 100%.

Key words: Rice husk ash, fly ash, durability, mechanical properties, supplementary cementitious materials, concrete.

1.0 INTRODUCTION

Fiber Reinforced Concrete (FRC) can be regarded as a composite material with two phases in which concrete represents the matrix phase and the fiber constitutes the inclusion phase. Volume fraction of fiber inclusion is the most commonly used parameter attributed to the properties of FRC. Fiber count, fiber specific surface area, and fiber spacing are other parameters, which may also be used for this purpose. Another convenient numerical parameter describing a fiber is its aspect ratio, defined as the fiber length divided by its equivalent diameter. The term fiber reinforced concrete (FRC) is defined by ACI Committee 544 as a concrete made of hydraulic cements containing fine or fine and coarse aggregates and discontinuous discrete fibers. Inherently concrete is brittle under tensile loading. Mechanical properties of concrete can be improved by reinforcement with randomly oriented short discrete fibers, which prevent and control initiation, propagation, or coalescence of cracks. FRC can continue to sustain considerable loads even at deflections exceeding fracture deflections of plain concrete. The character and performance of FRC changes depending

on matrix properties as well as the fiber material, fiber concentration, fiber geometry, fiber orientation, and fiber distribution. The aim of this study is first to develop hybrid fiber reinforced concrete (HFRC), and then to characterize and quantify the benefits obtained by the concept of hybridization. Compressive strength, flexural tensile strength, are the measured mechanical properties of the HFRC mixes in this study. To open new application areas, FRC should be designed so as to perform with adequate strength, sufficient ductility, high durability, and adequate workability. Utilizing the concept of hybridization, a concrete with superior properties can be developed. Ductility and strength of concrete can be improved at lower fiber contents, where fibers are used in combination rather than reinforcement with a single type of fiber. Limiting the high aspect ratio fiber content, without compromising the ductility and the strength of the concrete, problems associated with workability can be eliminated.

Compared to other building materials such as metals and concretes, concrete is significantly bleeding, plastic settlement, thermal and shrinkage strains and stress concentrations imposed by external restraints. Under an applied load,

distributed micro-cracks propagate, coalesce and align themselves to produce macro-cracks. When loads are further increased, conditions of critical crack growth are attained at the tips of the macro-cracks and unstable and catastrophic failure is precipitated. Under fatigue loads, concrete cracks easily, and cracks create easy access routes for deleterious agents leading to early saturation, freeze-thaw damage, scaling, discoloration and sisal corrosion. Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way. With advent of high-rise buildings and pre-stressed concrete, use of higher grades of concrete is becoming more common. Even the revised IS 456–2000 advocates use of higher grade of concrete for more severe conditions of exposure, for durability considerations. Recycled coarse aggregates is used in concern to the sustainability in natural aggregates. Replacement of natural coarse aggregates is done in two levels i.e 50 % and 100 % by weight.

2.0 LITERATURE REVIEW

Balaguru and Shah have reported that the fibers that are long and at higher volume fractions were found to ball up during the

mixing process. The process called 'balling' occurs and causes the concrete to become stiff and a reduction in workability with increased volume dosage of fibers. This has a tendency to influence the quality of concrete and strength. Mechanical properties of high strength fiber reinforced concrete were also studied by Faisal F Wafa. **Rami H. Haddad** has done the experimental study to predict the role of synthetic fibers such as polypropylene and nylon fibers in delaying sisal corrosion cracks and improving the bond with concrete. Different length of polypropylene and nylon fibers with various volumes were mixed with concrete. Pull-out tests and corrosion study were conducted and concluded that both the fibers contributed more in delaying the corrosion and improving the bond strength. **M.Lakshmi pathy** have conducted an experimental analytical investigation on two span continuous beams with sisal fibers. The important characteristics such as cracking behaviour, ductility and energy absorption were ascertained from experimental investigation and compared with analytical results. The fibrous concrete beams served superior than conventional concrete. **S.K.Padmarajaiah** investigated on flexural strength of sisal fiber

reinforced high strength concrete in fully and partially prestressed beam specimens. It is found that the toughness and ductility of prestressed high strength concrete beams have been increased with the increase in fiber content. The maximum increase in ductility was 18%, 45% and 68% and percentage increase in energy absorption 25%, 78% and 88% for fully prestressed beams with full depth of sisal fiber content of 0.5%, 1.0% and 1.5% volume fractions. **Santhosh Kumar.P.** carried an investigation on Ultimate strength of sisal fiber reinforced self compacting concrete beams 1.2m long reinforced concrete beams are prepared using self compacting concrete with sisal fibers of three volume fractions of 0.25%, 0.5% and 0.75%. It is found that strength and ductility of fiber reinforced self compacting concrete specimens have increased substantially over conventional concrete.

3.0 MATERIALS FOR THE MIX DESIGN

3.1 Cement:

Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was

made from single batching in air tight containers to prevent it from being effected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS:4032-1988.

3.2 Fine Aggregates:

River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963. The sand was surface dried before use.

3.3 Coarse Aggregates:

Crushed aggregates of less than 10mm size produced from local crushing plants were used. The aggregate exclusively passing through 10mm sieve size and retained on 6.5mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963.

3.4 Water:

Water plays a vital role in achieving the strength of concrete. For complete

hydration it requires about $3/10^{\text{th}}$ of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers.



Figure-1: Form of sisal fiber

strength, split tensile strength, flexural strength of M20 grade of concrete. Mix proportioning of concrete will be done based on IS 10262: 2009. To study on effect on strength of concrete the specimens will be tested for 28 days of curing. Standard cubes (150x150x150 mm), cylinders (150 mm diameter, 300 mm height), prisms (100x100x500 mm) will be cast to investigate the behaviour on mechanical properties. Slump and Compaction factor will be done to test the effect on workability of concrete due to recycled aggregates and sisal fibers. The addition of sisal fibers will be varied from 0 to 2% with an increment of 0.5% i.e 0, 0.5%, 1%, 1.5% and 2% replacement to cement. Recycled aggregates will be used to replace the natural coarse aggregates by 50% and 100%.

Table 1 - Mix Proportions of mixes M20 grade in kg/m^3

Cement	Fine Aggregate	Coarse Aggregate	Water
356	724	1170	188

4. EXPERIMENTAL PROCEDURE

The investigation was aimed at studying the effect of sisal fibers and recycled aggregates concrete on compressive



Figure – 2: Testing of cubes

5. RESULTS AND DISCUSSION

5.1 Workability:

Workability test is performed on the fresh concrete by slump cone and compaction factor test. Slump cone test and compaction factor were conducted as per Indian standards as explained in previous chapter. The results of slump cone and compaction factor test for M20 grade of concrete with sisal fibers and recycled coarse aggregate is shown in table 2.

Table 2: Effect of sisal fiber and recycled aggregate on workability of M20 concrete.

Dosage of sisal fiber (%)	Slump Cone			Compaction Factor		
	Recycle aggregate (%)			Recycle aggregate (%)		
	0	50	100	0	50	100
0	106	100	94	0.96	0.94	0.92
0.5	98	92	88	0.94	0.92	0.88
1.0	88	80	74	0.93	0.90	0.86
1.5	82	75	70	0.90	0.88	0.84
2.0	70	68	62	0.88	0.85	0.80

5.2 Mechanical Properties:

Fresh properties of concrete like workability has performed using slump test. Slump is decreasing as the percentage of rice husk increases. Compression testing machine of 2000 kN used for the compression test and 600 kN UTM has been used for the split tensile test and flexural test. The results of compressive strength, split tensile strength and flexural strength are given in the Table 3 and 5 respectively.

Table 3: Effect of sisal fiber and recycled aggregate on compressive strength of M20 concrete

Dosage of sisal fiber (%)	Compressive strength (MPa)
	Recycle aggregate (%)

	0	50	100
0	28.4	26.4	22.4
0.5	30.5	29.2	27.5
1.0	34.7	31.5	31.2
1.5	37.6	33.6	
2.0	31.2	28.7	

1.0	2.81	2.73	2.66
1.5	2.92	2.77	2.67
2.0	2.59	2.44	2.34



Figure 3: Variation split tensile strength with sisal fibers and recycled aggregate

Table 5: Effect of sisal fiber and recycled aggregate on Flexural strength of M20 concrete

Figure 2: Variation compressive strength with sisal fibers and recycled aggregate

Table 4: Effect of sisal fiber and recycled aggregate on Split tensile strength of M20 concrete

Dosage of sisal fiber (%)	Split tensile strength (MPa)		
	Recycle aggregate (%)		
	0	50	100
0	2.49	2.40	2.15
0.5	2.58	2.53	2.39

Dosage of sisal fiber (%)	Flexural strength (MPa)		
	Recycle aggregate (%)		
	0	50	100
0	3.73	3.60	3.31
0.5	3.87	3.78	3.67
1.0	4.12	3.93	3.91
1.5	4.29	4.06	4.05
2.0	3.91	3.75	3.60

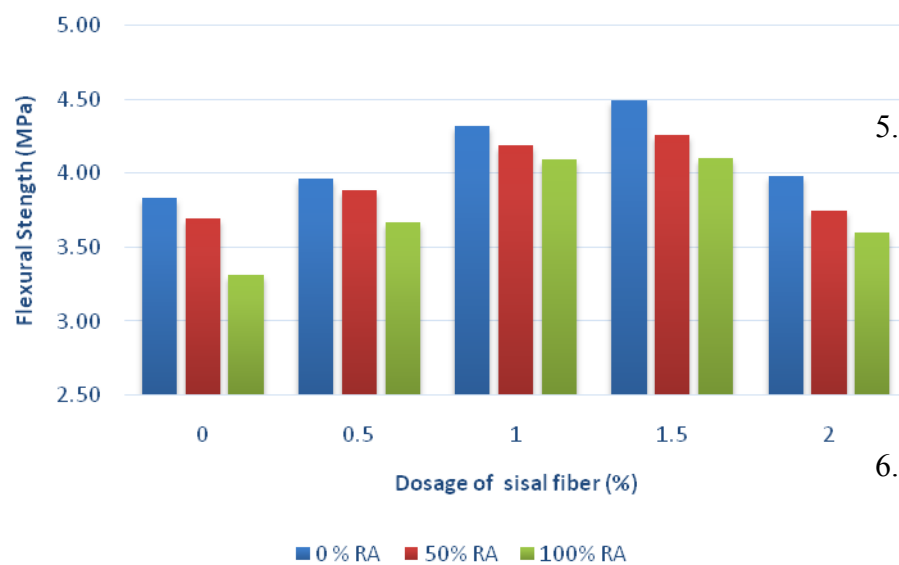


Figure 3: Variation Flexural strength with sisal fibers and recycled aggregate

6.0 CONCLUSIONS

1. The workability of concrete is marginally effected with the addition of recycled aggregates compared to sisal fibers. Sisal fibers at initial dosages has shown less effect on slump and compaction factor.
2. Inclusion of sisal fibers to concrete has increased the mechanical properties of concrete with and without recycled coarse aggregates.
3. Upto 1.5% dosage of sisal fiber the strength properties have increased but later with the increase in dosage decrement is observed.
4. Similarly, the decrease in mechanical properties is observed

with the increase in replacement of recycle coarse aggregate.

5. Highest decrement was observed incase of 100% use of recycled coarse aggregates. But the decrease in mechanical properties due to recycled aggregates is compensated by the use sisal fibers.
6. It was also observed that failure pattern changed from brittle nature to ductile with the usage of fibers in concrete with and without recycled coarse aggregates.
7. Finally, optimum dosage of sisal fibers was observed to 0.5% to volume of concrete. Whereas, recycled aggregates can be used upto 50% without high loss in mechanical properties.

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