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Mechanistic Investigation on Polyethylene Fiber with Partial replacement of Coarse Aggregate by Recycled Coarse Aggregate

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Abstract - *Fiber Reinforced Concrete (FRC) is a composite material consisting of cement based matrix with an ordered or random distribution of fiber which can be steel, nylon, polythene etc. The addition of steel fiber increases the properties of concrete, viz., flexural strength, impact strength and shrinkage properties to name a few. A number of papers have already been published on the use of steel fibers in concrete and a considerable amount of research has been directed towards studying the various properties of concrete as well as reinforced concrete due to the addition of steel fibers. Hence, an attempt has been made in the present investigations to study the influence of addition of polypropylene fibers (waste plastics) at a dosage of 0,1 ,2 ,3% by weight of cement. The recycled coarse aggregate partially replaced 30 percentage by the weight of cement. The properties studied include compressive strength and flexural strength. The studies were conducted on a M40 mix and tests have been carried out as per recommended procedures of relevant codes. The results are compared to conventional concrete and conclusions are made.*

Key Words: Polyethylene fiber, Recycled coarse aggregate , Partial replacement, Compressive strength, Split tensile strength.

1. INTRODUCTION

Aggregate constitutes the largest proportion of concrete by volume, and its use is important because it improves both the volume stability and durability of the resulting concrete [1-3]. Crushed rock and river gravel have conventionally been used as natural coarse aggregate (NCA) in natural aggregate concrete (NAC).Recycled coarse aggregates (RCA) are produced from demolition and crushing of concrete rubble from deteriorated concrete structures such as buildings, pavements, and bridges [4]. Reinforcing steel bars and other embedded items, if any, are sorted out and removed from the debris [5-7].In our project, we are using waste plastic fibres for attaining strength in concrete. The major advantage of fiber reinforcement concrete is to transform a brittle concrete into a pseudo ductile material. Adding fibers in concrete can arrest micro cracks which causes gradual failure. The fibers from cheap or waste materials may be used for manufacture of structural units with cement mortar composites have great potential for developing countries like India.

1.1 Objectives

To utilize the waste materials in concrete. To investigate the strength characteristics such as compression, split tensile and water absorption of concrete using Recycled Coarse Aggregate (RCA) as a partial replacement of Natural Coarse Aggregate (NCA) with the addition of Waste Plastic Fibres (WPF).

2. MATERIALS

2.1 Cement

Cement used for the test was ordinary Portland cement of 53 grade confirming to IS 12269 :1987.Various test were carried out, result of which shown in Table.1

Table -1: Properties of cement

PROPERTIES	Result
Normal consistency	0.32
Initial setting time	30min
Final setting time	320min
Specific gravity	3.14
Fineness	5 %

2.2 Fine Aggregate

Natural river sand was used as fine aggregate,that fulfils IS 383-1970. The results are shown in Table.2

Table -2: Properties of fine aggregate

PROPERITIES	TEST RESULTS
Specific Gravity	2.6
Bulk Density Kg/M^3	1830
Porosity,%	29.67

Fineness Modulus	3.13
Water Absorption	1.02%

2.3 Coarse Aggregate

Crushed granite stones obtained from local quarrieswere used as a coarse aggregate. The maximum sizeof coarse aggregate used was 20 mm. The results are tabulated in Table.3

Table -3: Properties of Coarse Aggregate

PROPERITIES	TEST RESULTS
Particle Shape	Angular
Particle Size	20 mm
Specific Gravity	2.75
Bulk Density	1340 kg / m^3
Fineness Modulus	4.18

2.4 Recycled Coarse Aggregate

Recycled Aggregate sisatermused in building projects that describes crushed cement concrete or asphalt concrete paving fram building debris. The recycled aggregate contains normal aggregate with some mortar coated over it . The mortar attached on the aggregate is very light and porous in nature. Light and porous in narure is the attached mortar.Table 4 slows the properties of Recycled Coarse Aggregates{RCA).

Table -4: Properties of recycled coarse aggregate

PROPERTIES	TEST RESULTS
Bulk Density	1243.1 Kg/m^3
Water absorption	8.05 %
Specific Gravity	2.32
Aggregate impact value	5.28 %
Aggregate crushing value	24.5 %

2.5 Waste Plastic Fibers

Plastic waste fibers were produced by cutting plastic waste pots, cans, buckets drums and utensils. The plastic fibers collected were all recycled.

Table -5 : Properties of waste plastic fibers

PROPERITIES	TEST RESULTS
Percentage of elongation	15.56
Tensile strength	15.52 MPa
Modulus of elasticity	113.90 MPa
Water absorption	Nil
Specific gravity	1.28

2.6 Water

As water actively participates in the chemical reaction with cement, it becomes a major component of concrete. Because it contributes to forming the strength of cement gel water quantity and quality must betaken very attentively. The water used should be clean. Generally, sea water is not preferred for making concrete.

3. MIX DESIGN OF CONCRETE

A mix M40 grade was designed as per Indian Standard method (IS10262-2009) and the same was used to prepare the test samples. The design mix proportion is done in Tables.

3.1 Mix Calculations

The mix calculations per unit volume of concrete shall be as follows:

a. Volume of concrete = 1 m^3
b. Volume of cement = [Mass of cement] / {[Specific Gravity of Cement] x 1000}= 492.5/{3.15 x 1000} = 0.156m^3
c. Volume of water = [Mass of water] / {[Specific Gravity of water] x 1000}= 197/{1 x 1000} = 0.197m^3
d. Volume of all in aggregate = [a-(b+c)]= [1-(0.156+0.197)] = 0.647m^3
e. Mass of coarse aggregate = d x Volume of Coarse Aggregate x Specific Gravity of coarse Aggregate x 1000= 0.647x 0.62x 2.75 x 1000 = 1103.14 kg/m^3
f. Mass of fine aggregate = d x Volume of Fine Aggregate x Specific Gravity of Fine Aggregate x 1000= 0.647x 0.38x 2.65x 1000 = 651.53 kg/m^3

3.2 Mix Proportions

Cement = 492.5 kg/m3
Fine aggregate = 651.53 kg/m3
Coarse aggregate 20mm = 1103.14 kg/m3
Density of concrete = 2430 kg/m3
Water-cement ratio = 0.40
Mix proportion by weight = 1 : 1.31 : 1.7

Table -6: Mix Proportion for Normal Concrete

Cement (kg /m^3)	FA (kg/m^3)	CA (kg/m^3)	Water (liter)
492.5	651.53	1103.14	197

Table -7: Mix Proportion for replaced concrete

Cement (kg/ m^3)	Adding plastic fiber 1% by wt.of cement (kg /m^3)	FA (kg/ m^3)	CA (kg/ m^3)	RCA (kg/ m^3)	Water (liter)
492.5	4.9	651.53	772.2	330.9	197

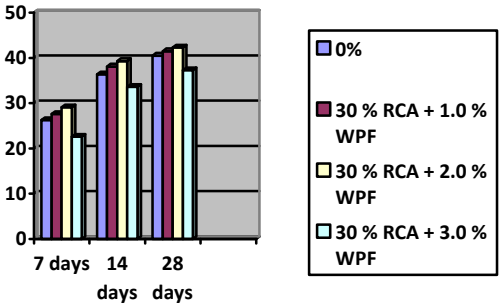
4. COMPRESSION STRENGTH TEST

Compressive strength is the capacity of material or structure to resist or withstand under compression. The Compressive strength of a material is determined by the ability of the material to resist failure in the form cracks and fissure.In this test, the push force applied on the both faces of concrete specimen and the maximum compression that concrete bears without failure is noted.

Figure 1: concrete specimen

Table 9 COMPRESSION STRENGTH TEST RESULTS

S. NO	Percentage of replacement (%)	Compression strength (N/mm²)								
		7 days			14 days			28 days		
		S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3
1	0	26.5	26.1	26.3	36.8	36.1	36.5	40.9	40.5	40.3
Average		26.3			36.4			40.5		
2	30 % RCA + 1.0 % WPF	27.5	27.9	27.4	37.9	38.2	38.4	41.5	41.8	41.4
Average		27.6			38.1			41.5		
3	30 % RCA + 2.0 % WPF	29.5	28.9	29.1	39.1	39.4	39.6	42.5	42.4	42.1
Average		29.1			39.3			42.3		
4	30 % RCA + 3.0 % WPF	22.6			33.6			37.3		
Average		22.6			33.6			37.3		



(Note: RCA – Recycled Coarse Aggregate; WPF – Waste Plastic Fibre)

Figure 2 : Compression strength test

5. SPLIT TENSILE STRENGTH TEST

One of the important properties of concrete is "tensile strength" as structural loads make concrete vulnerable to tensile cracking. Tensile strength of concrete is much lower than its compressive strength (that's why steel is used to carry the tension forces). It has been estimated that tensile strength of concrete equals roughly about 10% of compressive strength. To determine the tensile strength, indirect methods are applied due to the difficulty of the direct method. Noting that the values obtained of these methods are higher than those got from the uniaxial tensile test.

Figure 3: Uniaxial tensile test on concrete specimen

Table 10 SPLIT TENSILE STRENGTH TEST RESULTS

S. NO	Percentage of replacement (%)	Split tensile strength (N/mm2)								
		7 days			14 days			28 days		
		S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3
1	0	2.75	2.71	2.78	3.72	3.75	3.70	4.32	4.35	4.31
Average		2.74			3.72			4.32		

2	30 % RCA + 1.0 % WPF	2.85	2.81	2.84	3.91	3.94	3.97	4.42	4.40	4.45
Average		2.83			3.94			4.42		
3	30 % RCA + 2.0 % WPF	2.91	2.95	2.92	4.21	4.25	4.23	4.54	4.51	4.57
Average		2.92			4.23			4.54		
4	30 % RCA + 3.0 % WPF	2.46	2.41	2.45	3.41	3.43	3.40	4.06	4.01	4.10
Average		2.44			3.41			4.05		

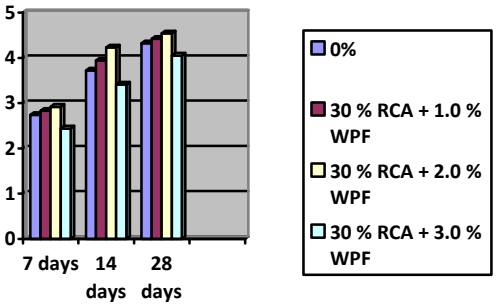


Figure 4: Split tensile strength test

6. WATER ABSORPTION TEST

One of the most important properties of a good quality concrete is low permeability, especially one resistant to freezing and thawing. A concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing. Water enters pores in the cement paste and even in the aggregate. The permeability of concrete is a measure of the rate at which a liquid pass through it. The permeability of concrete depends upon its pore network, which arises from the excess water used during mixing and during initial hardening process. The overall porosity includes closed or logged pores in addition to a network of inter connected pores. Pore size ranges from a few angstroms to about 100 A^0 for the so called 'gel pores', from 100 to 100000 A^0 in 'capillary pores' and a few millimeter in 'air or large pores'. Inter connected pores endow the concrete permeability.

Table 11 WATER ABSORPTION TEST RESULTS

S.NO	Percentage of replacement (%)	Initial weight (kg)	Oven dry weight (kg) (A)	Weight after immersion (kg) (B)	% water absorption
1	CC	8.43	8.25	8.51	3.15
2	30 % RCA + 1.0 % WPF	8.43	8.27	8.55	3.38
3	30 % RCA + 2.0 % WPF	8.43	8.21	8.57	4.38
4	30 % RCA + 3.0 % WPF	8.43	8.24	8.61	4.49

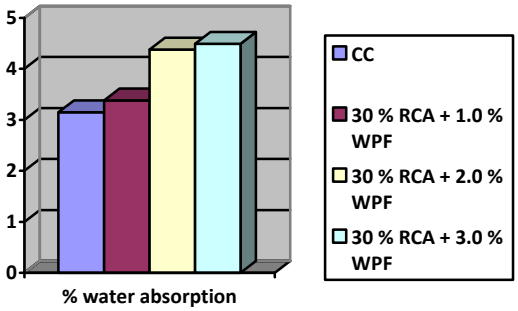


Figure 5: Water absorption test

7. FLEXURAL STRENGTH

Flexural strength also known as modulus of rupture or bend strength or transverse rupture strength is a material property defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either circular rectangular cross section is bent until fracture or yielding using TWO POINT LOADING. The flexural strength represents the highest stress experienced within the material at its moment of yield. Flexural strength test of RCC beam can be tested by flexural testing machine.

Table 12 FLEXURAL STRENGTH TEST RESULTS

S NO	TYPES OF BEAM	LOAD (KN)	DEFLECTION (mm)
1	Conventional beam	**40**	**20**
2	Beam with 30% RCA and 2% WPF in 7 days	**50**	**18**

3	Beam with 30% RCA and 2%WPF in 28 days	**50**	**16**	

Table 13 COMPARING THE FLEXURAL STRENGTH OF VARIOUS BEAM

S.NO	TYPES OF BEAM	FLEXURAL STRENGTH
1	Conventional beam	8.18 N/mm^2
2	Beam with 30% RCA and 2% WPF in 7 days	10.24 N/mm^2
3	Beam with 30% RCA and 2%WPF in 28 days	10.24 N/mm^2

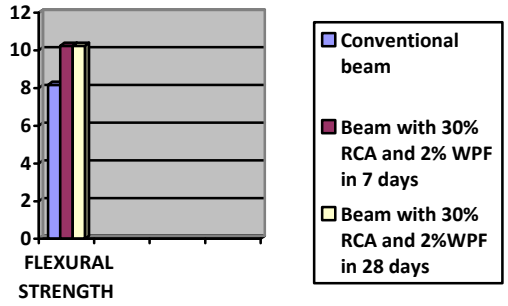


Figure 8: Flexural strength test

8. CONCLUSION

Based on the above study, following conclusions are drawn Concrete produced by replacing natural aggregate by recycled coarse aggregate with addition of 0,1 ,2 ,3% of waste plastic fibres by weight of cement imparts higher compressive and split tensile strengths.

The results of this experimental work establishes that natural coarse aggregates can be partially replaced with recycled coarse aggregates 30% and with the addition of waste plastic fibers upto (2.0% by weight of cement) does have adverse impact on the strength of the concrete.

Increasing waste plastic fiber pastic (above 2%) in the concrete mixtures caused the compressive strength and split tensile strength of concrete to decrease.

Similarly, from the water absorption test results it is shown that the % of water absorption of concrete cubes increases as the percentages of replacement increases.

From this investigation, it was observed that the 28 days flexural strength of M40 concrete mix, the flexural strength will almost equal compared to conventional beam and recycled coarse aggregate with plastic fiber beam.

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