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EFFECT OF USING RECYCLED AGGREGATES ALONG WITH FIBRES AS A REINFORCEMENT ON THE MECHANICAL PROPERTIES OF CONCRETE

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ABSTRACT

The increase in urbanization has lead to increase in the infrastructural needs ultimately leading to the depletion of natural resources, therefore the research community has focused on utilization of alternate construction material. The use of recycled aggregates from construction and demolition wastes is one among which is showing prospective application in constructions alternative to primary (natural) aggregates. On the other hand Fiber Reinforced Concrete (FRC) is one of the fastest growing segments in the concrete industry to supply their reinforcing needs in concrete applications. Even though lot of research has been done in their respective areas, but seldom can be found on their combination. In our research, we have laid emphasis on different percentage replacements of natural aggregates with recycled aggregates in fibre reinforced concrete. The effect on compressive and flexural strength by replacing natural aggregates with recycled aggregates at different proportions of polypropylene fibres was evaluated.

Keywords: Construction & Demolition Waste, Fibre Reinforced Concrete, Polypropylene fibers, Recycled Aggregates.

I. INTRODUCTION

Construction industries produce millions of tonnes of construction and demolition waste materials each year. The materials contain lot of renewable materials, if properly not managed they will become wastes, a burden to the society. Recycling of the C and D waste can flip the things by 180 degrees. Recycling turns the otherwise waste materials into usable products which help in sustainable development.Environmental protection agency defines Construction & Debris as the waste material produced in the process of construction, renovation or demolition of structures (both buildings and roads). In addition, it includes the materials generated as a result of natural disasters.Fibre Reinforced Concrete (FRC)was invented by French gardener Joseph Monier in 1849 and patented in 1867. Fibre-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres – each of which lend varying properties to the concrete. In addition, the character of fibre-reinforced concrete changes with varying concretes, fibre materials, geometries, distribution, orientation, and densities.The concept of using fibres as reinforcement is not new. Fibres have been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw

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in mud bricks. In the early 1900s, asbestos fibres were used in concrete, and in the 1950s the concept of composite materials came into being and fibre reinforced concrete was one of the topics of interest. There was a need to find a replacement for the asbestos used in concrete and other building materials once the health risks associated with the substance were discovered. By the 1960s, steel, glass (GFRC), and synthetic fibres such as polypropylene fibres were used in concrete, and research into new fibre reinforced concretes continues today.

II. NEED FOR RECYCLING AGGREGATES

It is estimated that construction industry in India generates about 10-12 million tonnes of waste annually (2010 reports by Indian Concrete Institute and Central Public Works Department). In recent survey, the Construction & Demolition waste generation jumped to 14.7 million tonnes. There are several strong reasons that have made it obligatory for mankind to recycle the construction and demolition waste and to convert it into useful resource. Some of the reasons are mentioned below:

i. Stringent anti-pollution and Environmental Protection Acts:Various Stringent anti-pollution and environmental regulation acts have been passed by the state and central government for conservation of natural resources and dumping of demolition waste.

ii. Shortage of dumping sites:Millions of tons of construction and demolition waste is produced by the construction industry in India every year, which needs to be dumped somewhere. The dumping of C and D waste requires large landfills and dumping sites, but unfortunately there has been considerable decline in the availability of dumping sites in India as well as in other parts of the world. This has laid obligation on the mankind to recycle the waste.

iii. Considerable decline in the availability of good quality natural aggregate in the vicinity of construction.

iv. Recycling technology is easily available:The recycling technology is easily available and the plant required for recycling can be easily and economically installed near the construction or demolition site. This has enticed the man kind to recycle the wastes.

III. TECHNOLOGY INVOLVED

The technology involved in converting construction and demolition waste into useful recycled aggregates consists of three stages:

Collection, Processing and Manufacturing.

First of all the construction and demolition waste is collected from the construction or demolition site.After the demolition waste is collected, the foreign matter including metal straps, electric fixtures, plastic materials etc. are sorted out from it by hand picking or by using magnetic separation and then the remaining material is broken into pieces with the help of hammer. The aggregates are then sieved through IS sieves of 26.5mm and 12.5 mm and 4.75mm to remove higher and finer materials. The higher size is broken again and then it is sieved through 4.75mm IS sieve. Fines left out can be used as filler in the plinth of buildings or highway embankments. For the current project the maximum size of coarse aggregates used is 12.5mm and minimum size is 4.75mm.

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IV. MATERIALS USED

Ordinary Portland cement of 43 grade with specifications given in the Table 1 was used to carry out the research work. Normal tap water with PH 6.5 was used for all mixes. Natural river sand conforming to zone II was used as fine aggregate. The fresh aggregates were obtained from quarrywhile recycled aggregates were produced by jaw crushing of concrete blocks obtained as demolition waste from residential building. The maximum size of coarse aggregates (both fresh as well as recycled aggregates) was limited to 12.5 mm and the minimum size was limited to 4.75 mm. Polypropylene fibres with aspect ratio ranging between 90 to 100 were also used.

Table: 1 Specification of the Cement

Sr. No	Property	Value
01	Normal consistency	33%
02	Initial setting time	30 minutes
03	Final setting time	6.5 hours
04	Specific gravity	3.65
05	Fineness	4.5%

V. MIX PROPORTIONS

For experimental work seven mixes of concrete were made with preliminary target strength of 30 Mpa. In the firstmix I used only normal aggregates.In the next three mixes 25% (by weight) of normal aggregates were replaced by recycled aggregates and polypropylene fibres in the fraction of 0.25%, 0.5% and 1% of cement were used respectively. Similarly three more mixes were made by replacing 50% by weight of fresh aggregates with recycled aggregatesand using and polypropylene fibres in the fraction of 0.25%, 0.5% and 1% respectively.The details of the mix design used are given in the table 2.

Table: 2 Details of Mix Design For one cubic metre of concrete

Mix	Replacement	Cement	Sand	Natural Aggregate	Recycled Aggregate	Fibre	W/C
		kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	
Mix 1	0	500	570.5	1062.2	-	-	0.4
Mix 2	25	500	570.5	769.65	265.55	1.25	0.4
Mix 3	25	500	570.5	769.65	265.55	2.5	0.4
Mix 4	25	500	570.5	769.65	265.55	5.0	0.4
Mix 5	50	500	570.5	531.10	531.10	1.25	0.4
Mix 6	50	500	570.5	531.10	531.10	2.5	0.4
Mix 7	50	500	570.5	531.10	531.10	5.0	0.4

VI. TEST METHODS

The experimental work was divided into different parts:

i. Tests on Recycled and Fresh Aggregates.

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ii. Casting of cubes and beams and checking the fresh state properties.

iii. Compressive and Flexural strength tests.

VII. TESTS ON RECYCLED AND FRESH AGGREGATES

The recycled aggregates produced by jaw crushing of demolition waste obtained from 50 year old residential building were tested for various properties. The test results are given in the table 3.

Table 3 Specification of Recycled Aggregates

S. No.	Property	Range of values
01	Age	50 years
02	Source	Residential building
03	Crushing strength	28.87%
04	Water absorption	5.35%
05	Specific gravity	2.61

Table 4 Specification of Fresh Aggregates

S. No.	Property	Range of values
01	Source	Crushed stone aggregate
02	Crushing strength	22.8%
03	Water absorption	0.77%
04	Specific gravity	2.72

VIII. FRESH STATE PROPERTIES

The fresh state properties like slump value, compaction factor were determined for all the mixes. The workability results with respect to slump value and compaction factor were tabulated in table 5.

Table 5 Fresh State results

Mix	Slump value	Compaction factor
Mix 1	90 mm	.92
Mix 2	85 mm	.88
Mix 3	82 mm	.83
Mix 4	80 mm	.80
Mix 5	76 mm	.78
Mix 6	73 mm	.75
Mix 7	70 mm	.72

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IX. HARDENED STATE PROPERTIES

The concrete mixes developed were tested for compressive strength at 7 and 28 days. To perform the compressive strength, concrete cubes of size **15x15x15 cm** were used. To perform flexural test, beams were cast and tested at 7 and 28 days. The test results are tabulated below in table 6.

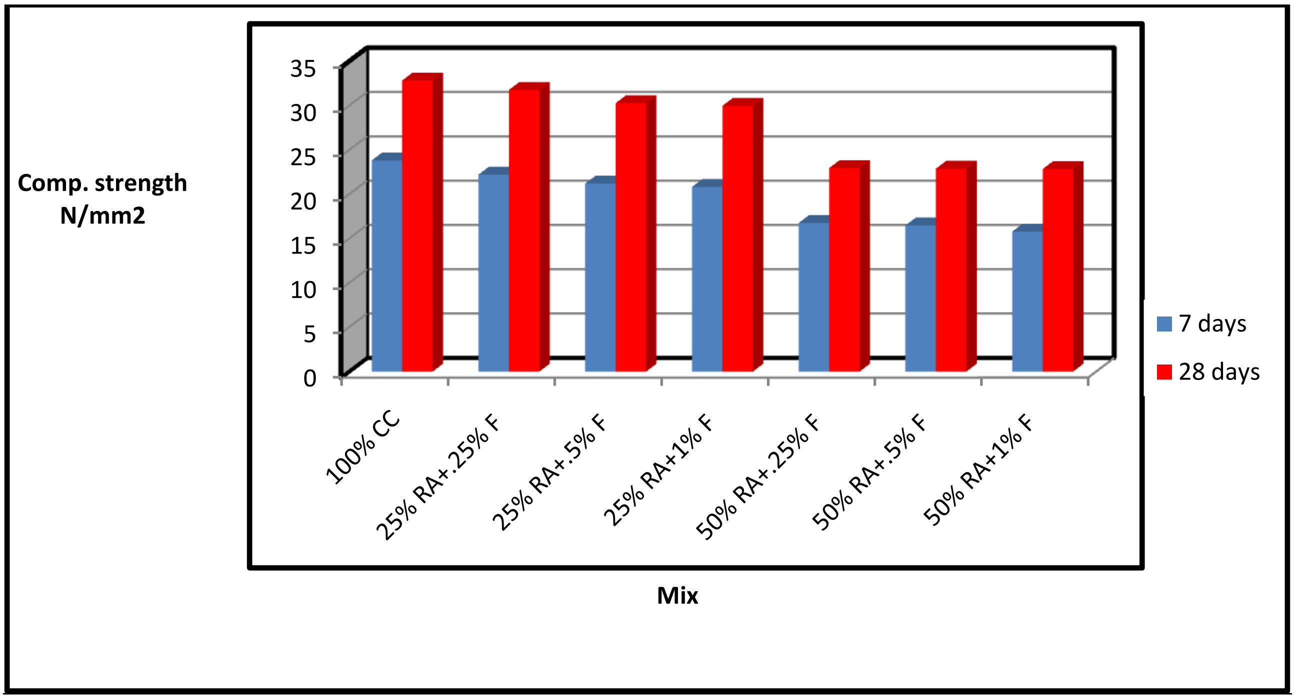
Table 6 Compressive and tensile strength test results

Mix	Compressive Strength(N/mm^2)		Tensilestrength(N/mm^2)	
	7 days	28 days	7 days	28 days
Mix 1	23.84	32.86	3.44	4.82
Mix 2	22.23	31.8	3.62	5.14
Mix 3	21.22	30.31	3.72	5.43
Mix 4	20.84	30.0	3.25	4.51
Mix 5	16.78	22.98	3.32	4.69
Mix 6	16.5	22.91	3.6	4.76
Mix 7	15.8	22.87	2.69	3.58

X. COMPARISON OF RESULTS

The comparison of compressive and flexural strength results is shown be in the form of bar charts. The mixes show decline in the compressive strength with the introduction of fibres while the flexural strength increases with incorporation of fibres.

Compressive Strength Results



Flexural Tensile Strength Results

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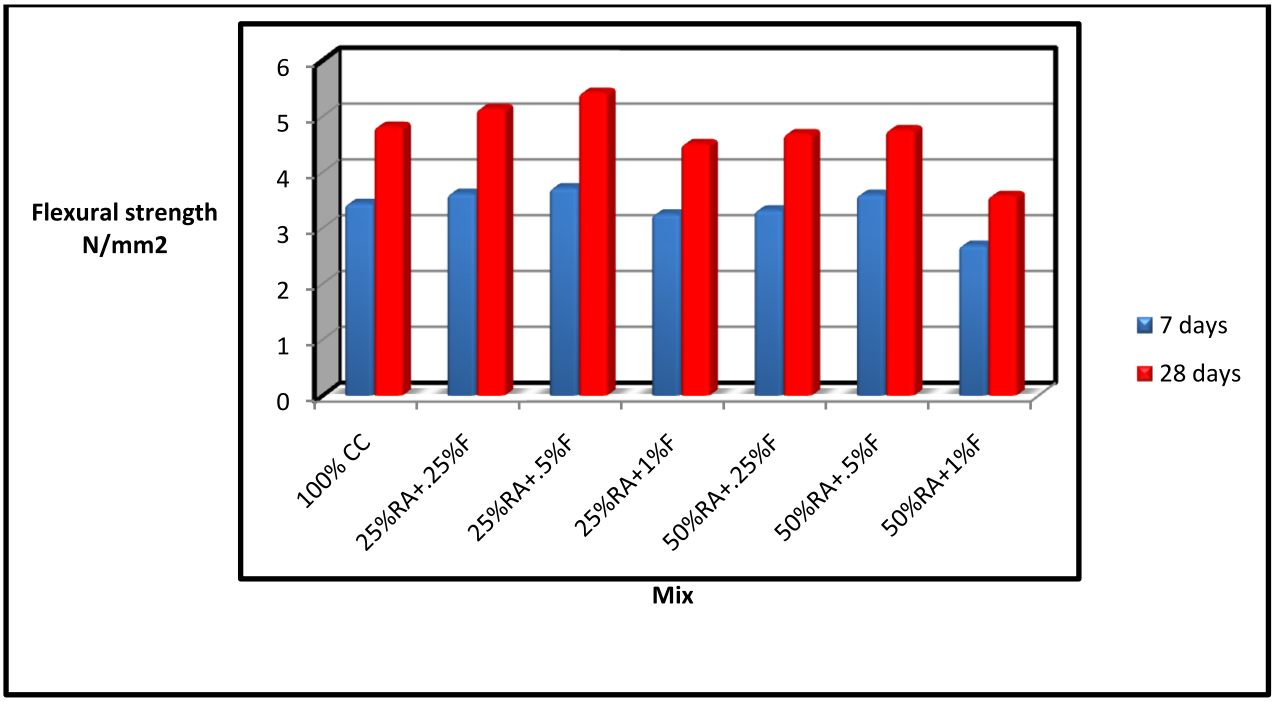

XI. CONCLUSION

Following conclusions can be made from the experiments performed.

i. The water absorption of recycled aggregates was more as compared to normal aggregates, thus workability of concrete mixes containing recycled aggregates was less as compared to the concrete mixes containing normal aggregates only.

ii. The compressive strength of the concrete mixes containing recycled aggregates was found out be lesser as compared to concrete containing normal aggregates.

iii. Unlike the flexural tensile strength, there was decrement in the compressive strength of all mixes with the introduction of fibers.

iv. The flexural strength was found out to be maximum for the mix containing 25% recycled aggregates and 0.5% polypropylene fibres.

XII. FUTURE SCOPE

Although a lot of research has been carried out in the respective fields of fibre reinforced concrete and recycled aggregates but handful of research has been done on their combination. To figure out the behavior of Fibre Reinforced Concrete by replacing the normal conventional aggregates with recycled aggregates is having a substantial potential for research.

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