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Experimental Study on Properties of Rubberized Fibre Concrete

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ABSTRACT

It has been estimated that around one billion tires are withdrawn from use in the world every year. Waste tire rubber is not easily bio degradable even after a long period of landfill and results in a lot of environmental and health problems. Rubber finds its use in concrete because of its property of energy absorption. A lot of research is being done on the usage of waste rubber as replacement of aggregate and cement in concrete.

But the compressive, split tensile and flexural strengths of concrete have been observed to decrease with the increase of rubber quantity. To compensate this loss of strength, reinforcement is necessary. In tropical regions, natural fibres are abundantly available which when utilized will reduce cost of construction and improve performance. For this study, coconut fibers shall be used as they are freely available in large quantities at cheap costs. The use of coconut fibres will also lead to better management of these waste fibres.

The present experiment is carried out to investigate the fresh and hardened properties of binary blended concrete with 20% of Fly ash, by weight of cement, as partial replacement of cement and replacement of 0%, 5%, 10%, 15% and 20% of sand with Crumb rubber, by volume and addition of Coconut fibres at 0.1%, 0.2% and 0.3%, by weight of cement. Compressive strength of concrete is measured by testing standard cubes (150mm x 150mm x 150mm) at the age of 28 days, split tensile strength of concrete is measured by testing standard cylinders (150mm Ø, 300mm height) at the age of 28 days and impact resistance of concrete is measured by testing beams (100mm x 100mm x 500mm) at the age of 28 days. In maintain the ecological balance thus reducing the consumption of cement and river sand

The compressive strength and split tensile strength shall be evaluated and compared with coconut fiber reinforced concrete and normal concrete.

Keywords: *Crumb Rubber, Coconut Fibre, Fly ash, Compressive Strength, Split Tensile Strength, M30 grade concrete.*

INTRODUCTION

GENERAL

Concrete is the most widely used construction material all over the world. The importance of concrete in modern society cannot be underestimated. Typical concrete is a mixture of fine aggregate (sand), coarse aggregate (rock), cement, and water. The aggregates, both fine and coarse, are bound together by cement when mixed with water. Since the late 1800s onwards, when consistent mass produced Portland cement became readily available, the world has been transformed by the design and construction of all sorts of concrete structures. The usage of concrete is increasing from time to time due to the rapid development of construction industry. With innovations in science and technology in construction industry, the scope of concrete as a structural material, has widened. But for numerous reasons, the concrete construction industry is not sustainable. It consumes a lot of virgin materials and the principal raw material of concrete i.e., cement is responsible for greenhouse gas emissions and causing a threat to environment through global warming. Therefore, the industry has seen various types of concrete in which fine aggregate and coarse aggregate are replaced with cheaper or lighter alternatives such as waste foundry sand, stone dust, crumb rubber etc. Many reinforcing fibres are also being used to enhance strength such as steel, glass, nylon, jute, coconut etc. Many supplementary cementations materials are also being used to minimize the use of cement such as fly ash, silica fume, met kaolin, rice husk ash etc. Rubberized Concrete and Fibre Reinforced Concrete are some of the technological advances in improving the quality and properties of concrete.

FLY ASH

Fly ash, an artificial Pozzolona, is the unburnt residue resulting from combustion of pulverized coal or lignite, mechanical or electrostatic separators called hoppers collect it from flue gases of power plants where powdered coal is used as fuel. India is a resourceful country for fly ash generation with an annual output of over 110 million tones, but utilization is still below 20% in spite of quantum jump in last three to four years.

CRUMB RUBBER

Sand has by now become the most widely consumed natural resource on the planet, next only to fresh water. Especially in Asia and Arab states the hunger of the construction industry is ever growing. Once sand is used in concrete, the components are bound forever and are no longer available as resources. On the other hand, large quantities of scrap tyres are being generated every year globally. The waste tyre rubber is not easily bio degradable even after a long period of landfill and results in a lot of environmental and health problems. A number of innovative solutions that meet the challenge of the tyre disposal problem involve using rubber crumb as an additive to cement based materials.

Plate 2 Crumb rubber

COCONUT FIBRES

Coconut fibres are agricultural waste products obtained in the processing of coconut oil and are available in large quantities in the tropical regions of the world, especially in Africa, Asia and America. Coconut fibres are not commonly used in the construction industry but are often dumped as agricultural wastes. However, with the quest for affordable housing system for both the rural and urban population in the developing countries, various schemes focusing on cutting down conventional building material costs have been put forward. In countries where abundant agricultural wastes are discharged, these wastes can be used as potential material or replacement material in construction industry.

EXPERIMENTAL PROGRAM

MATERIALS

The materials used in this experimental study are Cement, Fine aggregate, Coarse aggregate, Water, Fly ash, Crumb rubber and Coconut fibre.

Cement

Ordinary Portland cement (Ultratech cement) of 53 grade confirming to IS: 12269-1987 was used. It was tested for its physical properties as per IS 4031 (part II)-1988 and chemical properties as per IS: 12269. The details of the test results are given in Table 3.1 and Table 3.2.

Fine Aggregate

Locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is tested for various properties like specific gravity, sieve analysis, bulk density etc., and in accordance with IS 2386-1963. The fine aggregate is conforming to standard specifications. The details of the test results are given in Table 3.3 and Table 3.4.

Coarse Aggregate

Machine crushed angular granite of 20mm nominal size from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc. The physical properties of coarse aggregate were investigated in accordance with IS 2386 - 1963. The details of test results are given in Table 3.5 and Table 3.6.

Water

Locally available water is used for mixing and curing which is potable and is free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel.

Fly Ash

The fly ash obtained from a local fly ash brick manufacturing plant in Hyderabad, Telangana is used in the present experimental work.

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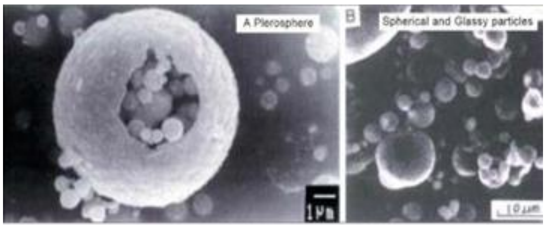


Figure 3.1 Scanning electron micrograph of Fly ash

The chemical composition of Fly ash is rich in silica content which react with calcium hydroxide to form C-S-H gel. This gel is responsible for the strength of mortar or concrete.

Crumb Rubber

Crumb rubber used in the study was procured from a local workshop that recycles waste tyre rubber by grinding it mechanically to make crumb rubber. It is free from impurities such as dust, clay particles and organic matter etc.

The physical properties of Crumb rubber were investigated in accordance with IS 2386 -1963. The details of the test results are given in Table 3.9 and Table 3.10.

Coconut fibres

Coconut fibres were obtained from a local coir factory that extracts coir from coconut husks. The coconut fibres were cleaned and chopped to maintain a uniform length of 40 mm.

CONCRETE MIX DESIGN

The concrete mix of M30 grade was designed as per IS 10262-2009 using the properties of cement and aggregate. For each mix of Rubberized concrete, the concrete mix was modified by replacing the amount of sand to be replaced by crumb rubber for the mix. The coconut fibres were added to the concrete mixes by weight of cement. The mix design procedure and calculations are presented in Appendix A, the following proportions by weight were obtained after trial mixes.

Water (kg/m3)	Cement (kg/m3)	Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)
197	438	651	1130
0.45	1	1.486	2.58

The same proportion of mix was used throughout the experimental programme.

OBSERVATIONS AND DISCUSSION OF TESTRESULTS

GENERAL

In this chapter, the results obtained from experimental investigation are discussed in detail. The results have been tabulated and the necessary graphs have been plotted. Discussions pertaining to the results have been carried out at the respective tables and graphs.

TEST RESULTS

The test results of the experimental investigations are tabulated in the Tables 4.1 to 4.9. Test results are also shown graphically in the Figures 4.1 to 4.9.

Tests on Workability

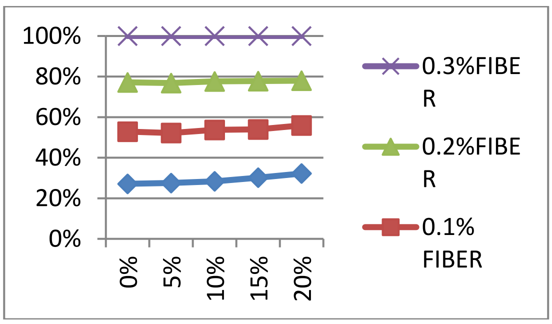
The effect of replacement of 20% of cement with Fly ash, replacement of 5%, 10%, 15% and 20% of sand with Crumb rubber (by volume) and addition of Coconut fibres at 0.1%, 0.2% and 0.3%, by weight of cement, on the workability of concrete was studied by testing the mixes for Slump and Compaction factor.

Slump Cone Test

The results of Slump cone test of Plain Concrete and all Rubberized Coconut Fibre Reinforced Binary Blended Concrete mixes are included in Table 4.1 and represented graphically in Figure 4.1.

Table 4.1 Slump values of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete mixes

S.No.	Type of mix	Slump (mm)		
1	M30	95		
	Replacement of sand by crumb Rubber	**Addition of coconut fibres (in %)**		
S.No.		**0.1**	**0.2**	**0.3**
2	0%	90	85	80
3	5%	85	85	80
4	10%	85	80	75
5	15%	75	75	70
6	20%	70	65	65



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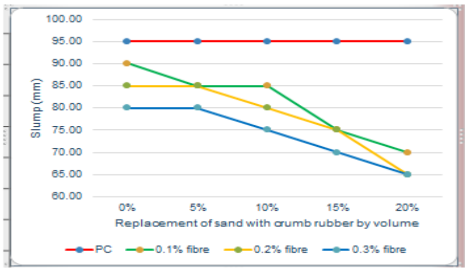

Figure 4.1 Variation of Slump values of Rubberised Coconut Fibre Reinforced Binary Blended Concrete with increase in Rubber content and Fibre content

Compaction Factor Test

The results of Compaction factor test of Plain Concrete and all Rubberized Coconut Fibre Reinforced Binary Blended Concrete mixes are included in Table 4.2 and represented graphically in Figure 4.2.

Table 4.2 Compaction factor values of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete mixes

S.No.	**Type of mix**	Compaction factor		
1	M30	0.91		
S.No.	**Replacement of sand by crumb rubber**	**Addition of coconut fibres (in %)**		
		0.1	**0.2**	**0.3**
2	0%	0.9	0.89	0.88
3	5%	0.89	0.88	0.88
4	10%	0.88	0.87	0.86
5	15%	0.87	0.87	0.86
6	20%	0.86	0.85	0.85

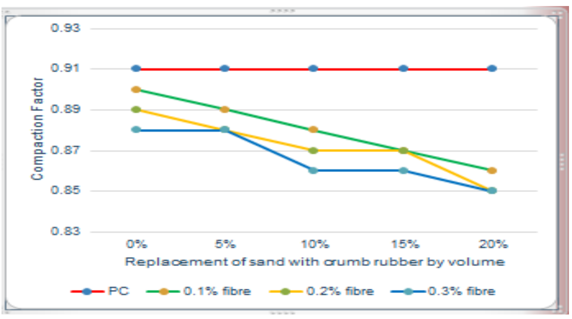

Figure 4.2 Variation of Compaction factor of Rubberised Coconut Fibre Reinforced Binary Blended Concrete with increase in Rubber content and Fibre content

Tests on Strength

The effect of replacement of 20% of cement with Fly ash, replacement of 5%, 10%, 15% and 20% of sand with Crumb rubber (by volume) and addition of Coconut fibres at 0.1%, 0.2% and 0.3%, by weight of cement, on the strength properties of concrete was studied by testing the mixes for Compressive strength, Split Tensile strength and Impact resistance.

Compressive Strength Test

For Compressive strength test cube specimens of dimensions 150mm x 150mm x 150mm were prepared. The specimens were cured in water and tested at the age of 28 days. The results of Compressive strength test of Plain Concrete and all Rubberized Coconut Fibre Reinforced Binary Blended Concrete mixes are included in Tables 4.3 to 4.5 and represented graphically in Figures 4.3 to 4.5.

Table 4.3 Cube compressive strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 7 days

S.No.	**Type of mix**	**Compressive strength after 7 days (N/mm^2)**		
1	M30	31.23		
	Replacement of sand by crumb rubber	**Addition of coconut fibres (in %)**		
S.No.		**0.1**	**0.2**	**0.3**
2	0%	23.14	25.15	25.169
3	5%	16.12	24.12	28
4	10%	18.12	22.16	24
5	15%	22	19	18
6	20%	21	19	19.16

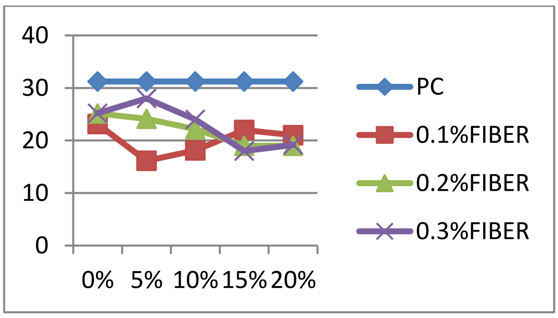

FIG- Cube compressive strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 7 days

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Table 4.4 Cube compressive strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 14 days

S.No.	Type of mix	Compressive strength after 14 days (N/mm^2)		
1	M30	34.23		
S.No.	Replacement of sand by crumb rubber	Addition of coconut fibres (in %)		
		0.1	0.2	0.3
2	0%	24	26	29
3	5%	19.28	27	27
4	10%	21.3	24.36	31
5	15%	24	21	22
6	20%	22	20.15	24

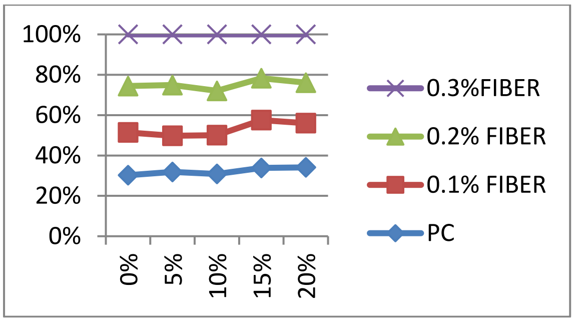
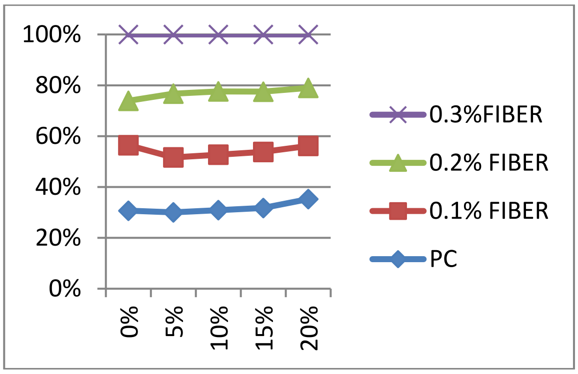


FIG-Cube compressive strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 14 days

Table 4.4 Cube compressive strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 28 days

S.No.	Type of mix	Compressive strength after 28 days (N/mm^2)		
1	M30	40.02		
S.No.	Replacement of sand by crumb rubber	Addition of coconut fibres (in %)		
		0.1	0.2	0.3
2	0%	33.55	33.8	34.02
3	5%	28.78	33.44	31
4	10%	28.22	32.22	29.02
5	15%	27.775	29.89	28.33
6	20%	23.78	25.89	23.885



Cube compressive strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 28 days

Split Tensile Strength Test

For Split Tensile strength test cylinder specimens of diameter 150mm and height 300mm were prepared. The specimens were cured in water and tested at the age of 28 days. The results of Split Tensile strength test of Plain Concrete and all Rubberized Coconut Fibre Reinforced Binary Blended Concrete mixes are included in Tables 4.6 to 4.8 and represented graphically in Figures 4.6 to 4.8.

Table 4.6 Cylinder splitting tensile strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 7 days

S.No.	Type of mix	Split tensile strength after 7 days (N/mm^2)		
1	M30	2.14		
S.No.	Replacement of sand by crumb rubber	Addition of coconut fibres (in %)		
		0.1	0.2	0.3
2	0%	1.9	1.92	1.8
3	5%	1.7	1.9	1.8
4	10%	2	1.96	1.8

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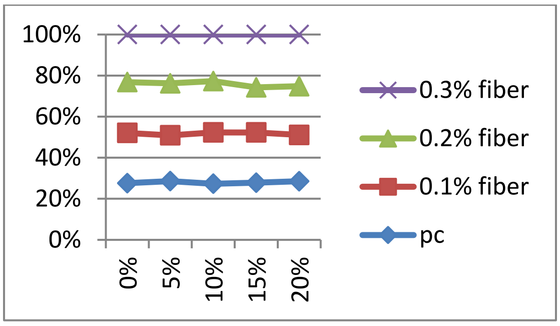
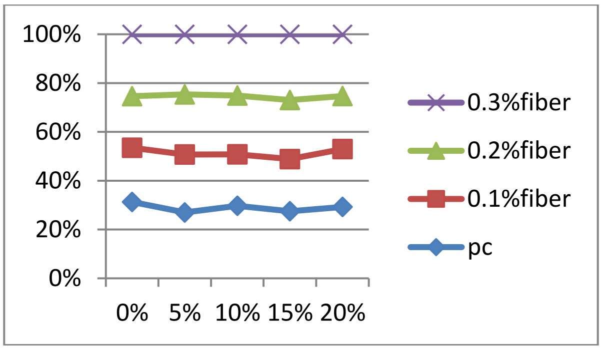
5	15%	1.9	1.69	2
6	20%	1.7	1.78	1.9



Cylinder splitting tensile strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 7 days

Table 4.6 Cylinder splitting tensile strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 14 days

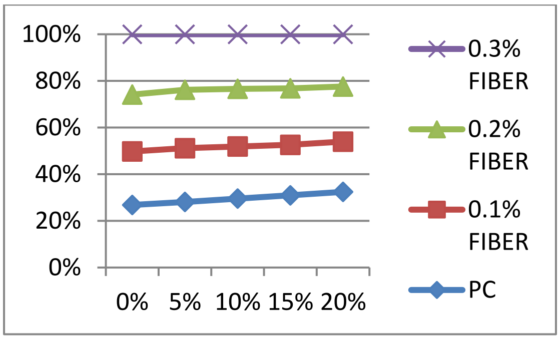
S.No.	Type of mix	Split tensile strength after 14 days (N/mm²)		
1	M30	2.96		
S.No.	Replacement of sand by crumb rubber	Addition of coconut fibres (in %)		
		0.1	0.2	0.3
2	0%	2.1	2.0	2.4
3	5%	2.6	2.7	2.7
4	10%	2.1	2.4	2.5
5	15%	2.3	2.6	2.9
6	20%	2.4	2.2	2.56



Cylinder splitting tensile strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 14 days

Table 4.6 Cylinder splitting tensile strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 28 days

S.No.	Type of mix	Split tensile strength after 28 days (N/mm²)		
1	M30	3.89		
S.No.	Replacement of sand by crumb rubber	Addition of coconut fibres (in %)		
		0.1	0.2	0.3
2	0%	3.324	3.537	3.749
3	5%	3.183	3.466	3.289
4	10%	2.935	3.254	3.076
5	15%	2.718	3.041	2.914
6	20%	2.582	2.831	2.687



Cylinder splitting tensile strength of Plain Concrete and Rubberised Coconut Fibre Reinforced Binary Blended Concrete at 28 days

Table 4.7 Percentage increase in Split tensile strength of Rubberised Coconut Fibre Reinforced Concrete with Plain Coconut Fibre Reinforced Binary Blended Concrete

S.No.	Replacement of sand by crumb rubber	Increase in split tensile strength with plain coconut fibre reinforced binary blended concrete (%)		
		Addition of coconut fibres (in %)		
		0.1	0.2	0.3
1	5%	-4.24	-2.01	-12.27
2	10%	-11.70	-8.00	-17.95
3	15%	-18.23	-14.02	-22.27
4	20%	-22.32	-19.96	-28.33

CONCLUSIONS

- The workability of fresh binary blended concrete decreased with the increase in sand replacement with crumb rubber and addition of coconut fibres.
- Replacement of river sand with crumb rubber ranging from 0% to 20% decreases the compressive strength of concrete. It decreased by 14.22% to 29.12% when 0.1% coconut fibres are added, 1.06% to 23.4% when 0.2% coconut fibres are added and 8.88% to 29.79% when 0.3% fibres are added at the age of 28 days when compared with plain coconut fibre reinforced binary blended concrete. When compared with plain concrete, the strength decreased by 28.08% to 40.58% when 0.1% coconut fibres are added, 16.44% to 35.31% when 0.2% coconut fibres are added and 22.54% to 40.32% when 0.3% fibres are added.
- Split Tensile strength of concrete mix also decreases with increase in replacement of sand with crumb rubber.
- The impact resistance of optimum mix is 21% more the that of plain concrete for first crack and 24% for failure.
- The mix containing replacement of 20% of cement with Fly ash (by weight), replacement of 5% of sand with Crumb rubber (by volume) and Coconut fibres added at 0.2% by weight of cement is the optimum mix.
- The compressive strength and split tensile strength for all the fibre reinforced mixes increase upto 0.2% addition of coconut fibres and decreased thereafter.

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