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EFFECT OF PARTIAL REPLACEMENT OF SAND WITH CRUMB RUBBER ON STRENGTH PROPERTIES OF COCONUT FIBRE REINFORCED BINARY BLENDED CONCRETE

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ABSTRACT

With environment friendly alternatives such as Concrete consumes a lot of virgin materials and the principal raw material of concrete i.e., cement is responsible for greenhouse gas emissions. The sources of natural sand are also depleting rapidly. Therefore, the industry has seen various types of concrete in which fine aggregate and coarse aggregate are replaced waste foundry sand, stone dust, crumb rubber etc. and supplementary cementitious materials such as fly ash, silica fume, metakaolin, rice husk ash etc., are used to minimize the use of cement. The compressive, split tensile and flexural strengths of concrete have been observed to decrease with the use of rubber and fly ash. To compensate this loss of strength, coconut fibres are used as they are available in large quantities at cheap costs.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, Split Tensile strength and Impact resistance of concrete are measured at the age of 28 days of curing.
The use of Fly ash as partial replacement of cement, Crumb Rubber as partial replacement of sand and addition of Coconut Fibres to concrete has shown slight decrease in the compressive strength and split tensile strength and increase in impact resistance of concrete. However, the combination of Crumb Rubber with Fly ash as partial replacements of river sand and cement respectively and addition of Coconut Fibres shall be economical and can help in the utility of industrial and domestic wastes and in maintaining the ecological balance thus reducing the consumption of cement and river sand.

Keywords: *Crumb Rubber, Coconut Fibre, Fly ash, Compressive Strength, Split Tensile Strength, Impact Resistance.*

I. INTRODUCTION

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. Rubberized Concrete and Fibre Reinforced Concrete are some of the technological advances in improving the quality and properties of concrete.Sand has by now become the most widely consumed natural resource on the planet, next only to fresh water. The annual world consumption of sand is estimated to be 15 billion tons. Over the last two centuries, sand has become a vital commodity for our modern economies. 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. High quality sand is used in producing computer chips and microprocessors. Sand is also used in detergents, cosmetics and many other products. Until recently sand was extracted in land quarries and riverbeds, however, these in land resources have nearly been depleted so that extraction has shifted to marine and coastal aggregates mining.

On the other hand, large quantities of scrap tyres are being generated every year globally. An estimated 1000 million tyres reach the end of their useful lives every year. Over the years, disposal of tyres has become one of the serious problems in environment. To prevent the environmental problems, recycling of tyres is an innovative idea. Recycling of scrap tyres can be done by introducing crumb rubber as partial replacement of either fine or coarse aggregate in concrete. Scrap tyres are introduced to the cracker mill process which produces irregularly shaped torn particles having large surface area and these particles are commonly known as crumb rubber. Some research has already been conducted on the use of waste tyre as aggregate replacement in concrete showing that a concrete with enhanced toughness and sound insulation properties can be achieved. The partial replacement of sand with crumb rubber results in strength reduction. The greater the rubber content, the more is the strength reduced. Reinforcing of concrete to increase its strength is commonly done. The use of fibres as reinforcing materials is as old as man. Egyptians used straw in making mud bricks between 1200 and 1400 BC, while in 2500 BC, asbestos fibres were used in Finland to make clay pots. In tropical regions, natural fibres are abundantly available which when utilized will reduce the cost of reinforced concrete and improve its performance. Coconut fibre is one of the natural fibres abundantly available in tropical regions, and is extracted from the husk of coconut fruit. Coconut fibre has excellent physical and mechanical properties and can be utilized effectively in the development of composite materials such as concrete. A major component of concrete is cement, which has its own environmental impacts. The cement industry is one of the primary producers of carbon dioxide, a major greenhouse gas. Powdered materials such as Fly ash, Granulated Blast Furnace Slag, Silica Fume, Metakaolin, Rice Husk Ash and Limestone can be used as partial replacement of cement. This research was implemented to develop and to determine the properties of Rubberized Concrete by using Fly ash as partial cement replacement with Crumb Rubber as partial river sand replacement and addition of coconut fibres.

II. 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 tonnes, but utilization is still below 20% in spite of quantum jump in last three to four years.

III. BINARY BLENDED CONCRETE

Cement mixtures containing Ordinary Portland Cement (OPC) and at least one supplementary cementitious material (SCM) are called blended cements. Binary cements contain OPC and one SCM. Concrete made with such binary cement is called Binary Blended Concrete.

In this study, the term Binary Blended Concrete is used to refer to concrete made with binary blended cement containing Ordinary Portland Cement (OPC) and 20% Class F Fly ash.

IV. 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.

Classification of Rubber based on size

In most of the researches performed, usually three broad categories of rubber have been considered: Chipped rubber, Crumb rubber and Ground rubber.

Shredded or chipped rubber to replace the gravel. To produce this rubber, it is needed to shred the tyres in two stages. By the end of the stage one, the rubber has length of 300-430 mm and width of 100-230 mm. in the second stage its dimension changes to 100-150 mm by cutting. If shredding is further continued, particles of about 130-75 mm dimensions are produced and are called “shredded particles”.Crumb rubber that replaces sand, is manufactured by special mills in which big rubbers change into smaller torn particles. In this procedure, different sizes of rubber particles may be produced depending on the kind of mills used and the temperature generated. In a simple method, particles are made with a higher irregularity in the range of 0.425-4.75 mm. Ground rubber that may replace cement is dependent upon the equipment for size reduction. The processed used tyres are typically subjected to two stages of magnetic separation and screening. Various size fractions of rubber are recovered in more complex procedures. In micro-milling process, the particles made are in the range of 0.075-0.475 mm.

Fibre rubber aggregate. A handful of researchers have used shredded rubber in the form of a short fibre, typically between 3.5 mm and 21.5 mm and in the form of strips 68 mm long.

Effect On Physical Properties

One of the main issues relating to the use of chipped or crumb rubber aggregate is the increased tendency towards segregation and bleeding. Many researchers have observed that concrete made with crumb rubber aggregate replacement alone, has higher workability than that made with chipped or combined chipped and crumb rubber.

Effect On Strength Properties

As rubber has lower stiffness compared to aggregates, presence of rubber particles in concrete reduces concrete mass stiffness and lowers its load bearing capacity. Also, due to the lack of adhesion between the rubber particles and the paste, soft rubber particles may behave as voids in the concrete mix. A reduction in compressive strength of concrete can therefore be expected.

Tyre rubber as a soft material can act as a barrier against crack growth in concrete. Therefore, tensile strength in concrete containing rubber should be higher than the control mix. However, the results showed the opposite of this hypothesis. The reason for this behaviour could be that the interface zone between rubber and cement may act as a micro-crack due to weak bonding between the two materials; the weak interface zone accelerates concrete breakdown.

The addition of crumb rubber aggregate can increase impact resistance substantially in both first crack and failure stages. Rubberized concrete has also been found to have greater ductility than plain concrete.

Figure crumb rubber

Fibre is a small piece of reinforcing material possessing certain characteristic properties. Fibres can be of any shape and size. Fibres are often described by a convenient parameter called aspect ratio. The aspect ratio of a fibre is the ratio of its length to its diameter.

Fibres are mainly of two types:

- Natural fibres
- Artificial fibres

Natural fibres are fibres made or extracted from plant, animal and mineral sources. Natural fibres such as cellulose, jute, sisal and coir are used in concrete. Natural fibres are a resource that can be utilized in concrete to enhance its strength and are abundantly available in tropical regions.

Artificial fibres are man-made fibres. Artificial fibres such as steel, glass, carbon, nylon asbestos and polypropylene fibres are used in concrete. The most commonly used artificial fibres are steel fibres.

V. 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.

Fibre reinforced concrete is a concrete mix containing water, cement, aggregate and discontinuous fibres of various shapes and sizes.

Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro-cracks are inherently present in the concrete and 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 and also by applying restraining techniques. It has been recognised that the addition of small, closely spaced and uniformly dispersed fibres to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as Fibre Reinforced Concrete. Fibre reinforced concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibres.

VI. LITERATURE REVIEW

Noor Md. Sadiqul Hasan et al.[4] (2012) studied the physical and mechanical properties of concrete produced using chopped coconut fibres incorporating different volume percentage of fibres 1, 3, 5 and 7 subjected to static loading. The mix proportion of 1:2:3 was adopted with water-cement ratio of 0.4. The results showed that the compressive strength of the concrete decreased as the volume percentage of fibres increased in the concrete mix. Also, coconut fibre reinforced concrete performed satisfactorily on the growth of cracks and crack widths compared with conventional concrete.

Piti Sukontasukkul[1] (2008) investigated the thermal and sound properties of crumb rubber concrete panels. The mix proportion for the control specimen (no crumb rubber) was set at 1:1.64:1.55 and crumb rubber was used to replace fine aggregate at 10%, 20% and 30%. The results showed that by replacing fine aggregate with crumb rubber at 10-30%, the unit weight of concrete can be reduced from 14 % up to 28%. Also, rubberized concrete exhibited superior thermal and sound properties than plain concrete.

VII. METHODOLOGY

About 6 litre of concrete is needed to perform the test, sampled normally. The base plate and inside of mould is thoroughly cleaned and oiled. The base plate is placed on level stable ground and the slump cone centrally on the base plate and hold downfirmly. The mould is then filled in four layers with freshly mixed concrete, each approximately 0to one-fourth of the height of the mould. Each layer is tamped 25 times by the rounded end of the tamping rod. After the top layer is rodded, the concrete is struck off the level with a trowel. The mould is removed from the concrete immediately by raising it slowly in the vertical direction. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. This difference in height in mm is the slump of concrete.

In the present experimental program, standard cubes (150mm x150mm x150mm), standard beams (100mm x100mm x500mm), standard cylinders (150mm Ø, height 300mm) were casted and tested for finding the Compressive strength, Impact resistance and Split Tensile strength properties of Plain Concrete, Plain Coconut Fibre Reinforced Binary Blended Concrete and Rubberized Coconut Fibre Reinforced Binary BlendedConcrete. Before casting of specimens, the mixes were tested for properties of fresh concrete.

VIII. TESTS CONDUCTED

Tests are carried for control mix (Plain Concrete), Binary blended Coconut fibre Reinforced Concrete containing20% Fly ash and with varying percentages of crumb rubber as sand replacement and varying coconut fibre as addition to cement mix.
Standard cubes (150mm x150mm x150mm), standard cylinders (150mm Ø, height 300mm), standard beams (100mm x100mm x500mm) are tested for finding the Compressive strength, Split Tensile strengthand Impact resistance properties for each mix.

4.2 Test Results

There is a considerable decrease in the compaction factor values of concrete with partial replacement of sand with crumb rubber and addition of coconut fibres.

4.2.2 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.

4.2.2.1 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 Tables4.3 to 4.5 and represented graphically.

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

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	33.80	34.02
3	5%	28.78	33.44	31.00
4	10%	28.22	32.22	29.02
5	15%	27.775	29.89	28.33
6	20%	23.78	25.89	23.885

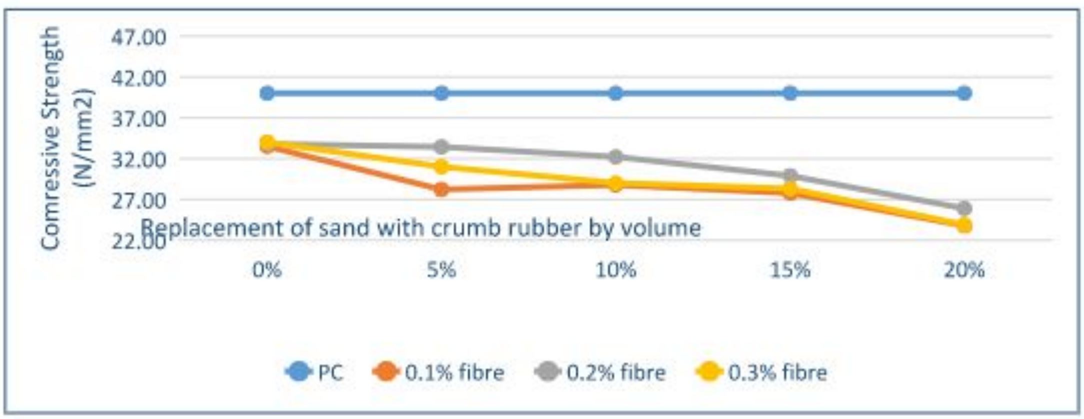

Figure 4.3 Variation of Compressive strength of Rubberised Coconut Fibre Reinforced Binary Blended Concrete with increase in Rubber content and Fibre content

Inferences On Test Results

There is a decrease in the compressive strength of concrete with the replacement of 20% of cement with fly ash. Compressive strength decreased with the replacement of sand with crumb rubber but increased with the addition of coconut fibres upto 0.2% fibres and decreased when 0.3% fibres are added. When compared with plain coconut fibre reinforced binary blended concrete, with the replacement of sand with crumb rubber from 5% to 20%, compressive strength of rubberized coconut fibre reinforced concrete 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. When compared with plain concrete, with the replacement of sand with crumb rubber from 5% to 20%, compressive strength of rubberized coconut fibre reinforced concrete 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. Therefore, from the results of compressive strength test, it can be established that the optimum mix is when crumb rubber replaces 5% sand and coconut fibres are added at 0.2% by weight of cement, giving a satisfactory compressive strength 16.44% less than that of plain concrete.

4.2.2.2 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 Tables4.6 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

S.No.	Type of mix	Split tensile strength after 28 days (N/mm^2)		
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

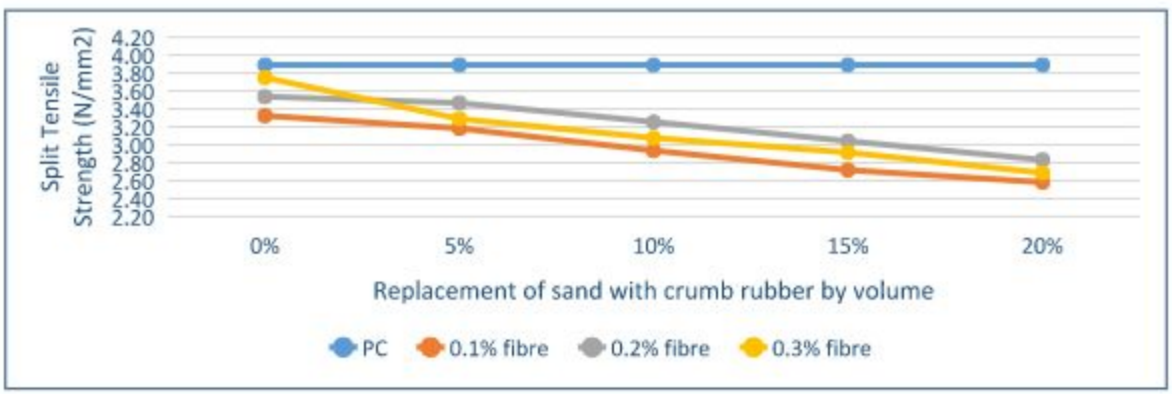

Figure 4.6 Variation of Split tensile strength of Rubberised Coconut Fibre Reinforced Binary Blended Concrete with increase in Rubber content and Fibre content

Inferences on Test Results

There is a decrease in the split tensile strength of concrete with the replacement of 20% of cement with fly ash. Split tensile strength decreased with the replacement of sand with crumb rubber but increased with the addition of coconut fibres upto 0.2% fibres and decreased when 0.3% fibres are added. When compared with plain coconut fibre reinforced binary blended concrete, with the replacement of sand with crumb rubber from 5% to 20%, split tensile strength of rubberized coconut fibre reinforced concrete decreased by 4.24% to 22.32% when 0.1% coconut fibres are added, 2.01% to 19.96% when 0.2% coconut fibres are added and 12.27% to 28.33% when 0.3% fibres are added.

REFERENCES

1. *Piti Sukontasukkul (2008), "Use of crumb rubber to improve thermal and sound properties of pre-cast concrete panel", Construction and Building Materials 23 1084-1092.*
2. *Piti Sukontasukkul and Somyot Wiwatpattanapong (2009), "Moderate Lightweight Concrete Mixed with Recycled Crumb Rubber", Thammasat Int. J. Sc. Tech., Volume 14, No. 1.*

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3. *Yogender Antil, Er. Vivek Verma, Er, Bhupinder Singh (2012), "Rubberized Concrete Made with Crumb Rubber", International Journal of Science and Research, ISSN (Online): 2319-7064.*
4. *Noor Md. Sadiqul Hasan, Habibur Rahman Sobuz, Md. Shiblee Sayed and Md. Saiful Islam (2012), "The Use of Coconut Fibre in the Production of Structural Lightweight Concrete", Journal of Applied Sciences 12 (9): 831-839.*
5. *Pravin V Domke (2012), "Improvement In The Strength Of Concrete By Using Industrial And Agricultural Waste", IOSR Journal of Engineering, Volume 2(4), pp: 755-759.*
6. *Olonade, Kolawole Adisa, Alake, Adewae Doyinsala and Morakinyo, Abiola Gabriel (2013).*