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CONCRETE REPLACEMENT OF AGGREGATES WITH RUBBER AGGREGATES: AN EXPERIMENTAL STUDY

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Abstract
Concrete is one of the most well known structure materials. The development business is consistently builds its uses and applications. Along these lines, it is required to discover elective materials to decrease the expense of cement. Then again, Non-biodegradable waste for example water bottles, cool beverage containers and dispensable glasses, destroyed or crumbed elastic and so on., is making a ton of issues in the earth and its removal turning into an incredible trouble. The goal of this paper is to research the utilization of elastic pieces as coarse total in the solid. Concrete tried with changing rates of elastic from 10 to half of typical totals. Compressive quality, split elasticity and flexural quality of cement is estimated and near examination is made.
Keywords: crumbed rubber, Concrete, Compressive strength, Tensile strength, Flexural strength
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Introduction

During the last three decades, there have been dramatic changes in the way of thinking about industrial processes and the approach and evaluation of new and innovative materials. Concrete, in its most basic form, is one of the world's oldest building material. Concrete is a substance composed of only a few simple and commonly available ingredients that when properly mixed and cured, may last for centuries. Concrete is an evolving material as well. New techniques and methods for selecting the right quantities of those simple components are continually being presented to the design community. New ingredients to include in concrete mixes are also constantly being researched and developed.

In general, concrete has low tensile strength, low ductility, and low energy absorption. Concrete also tends to shrink and crack during the hardening and curing process. These limitations are constantly being tested with hopes of improvement by the introduction of new admixtures and aggregates used in the mix. One such method may be the introduction of rubber to the concrete mix. Shredded or crumbed rubber is waste being of non-biodegradable and poses severe fire, environmental and health risks.

Rubber filled concrete tends to have a reduction in slump and density compared to ordinary concrete. The reduction is around 85% on slump has been reported when comparing with the conventional concrete [1, 2]. Concrete containing rubber aggregate has a higher energy absorbing capacity referred as toughness. Rostami et al. [3] reported investigation on the comparison of the toughness of a control concrete mixture with that of a rubber containing concrete mixture. The results shows that the toughness is increased when rubber aggregates present in the concrete. Eldin et al. [4] and fedroff et al. [5] explored the effect of rubber chips on the compressive strength and flexural strength of crumbed rubber concrete mixes. Biel and Lee [6] experimented with a special cement (Magnesium Oxychloride type) for the purpose of enhancing the bonding strength between rubber particles and cement. Hernanadez – Olivares et al. [7] provided scanning electron microscope photos of rubber/cement interface, as well as the evaluation of the complex modulus. The studies mentioned in the above are analytical and/or laboratory based experimental work and the major findings are ductility of concrete can be increased by introducing the rubber in the concrete.

The objective of this study is to test the properties of concrete when shredded or crumbed rubber used as aggregate by partial replacement of natural aggregates. The parameters of this investigation include the compressive strength, split tensile strength and flexural strength of concrete specimens. Cubes of 150mm size for compressive strength, cylinders of size 150X300mm and beam size for flexure test is 100X100X500mm are casted for the testing of concrete. The concrete having compressive strength of 30 N/mm^2 (M30) is used and percentages of rubber aggregates are 10, 20, 30, 40 and 50% of normal aggregates. The natural aggregates are replaced by rubber aggregates on volume basis. The strength performance of modified concrete specimens was compared with the conventional concrete.

Experimental Investigation Materials

Cement:

Physical properties	Test Results	Limits as per IS 8112 –1989
Fineness (m^2/Kg)	296	225 minimum
Initial Setting Time (min.)	140	30
Final Setting Time (min.)	245	600
Soundness		

By Lechatelier (mm)	1.50	10
By Auto Clave (%)	0.04	0.8
Compressive strength		
3 days N/mm^2	32	23
7 days N/mm^2	41.3	33
28 days N/mm^2	59	43
Chemical properties		
*LSF	0.89	0.66 to1.02
#AM (Al_2O_3/Fe_2O_3)	1.26	0.66
Insoluble residue (% by mass)	1.20	3
Magnesia (% by mass)	1.30	6
Sulphuric Anhydrate (By mass)	2.18	3
Total Loss in Ignition (%)	1.56	5
Total Chlorides (%)	0.012	0.05
* LSF: Lime Saturation Factor # AM: Ratio percentage of Alumina to that of Iron Oxide		

The Ordinary Portland Cement (OPC) 43 grade is used in this investigation. The physical & chemical properties of the cement are as shown in Table- 1

Table 1. Properties of Cement

Aggregates:

The aggregate consists of both fine and coarse components. The fine aggregate, which often referred to sand, is usually not a commercially manufactured product but one that is taken directly from nature. Coarse aggregate is a material commonly produced by crushing larger rock, separating the crushed portion according to size, and recombining in a carefully controlled manner.

Fine Aggregate:

The locally available river sand from Karim Nagar, Andhra Pradesh, India, is used as fine aggregate in the concrete design mix. The specific gravity, water absorption and fineness modulus are 2.62, 0.3% and 2.78 respectively. The sieve analysis data of fine aggregate is presented in Table-2.

Table2. Sieve Analysis of Fine Aggregate

IS Sieve (mm)	Weight retained (gm)	% weight retained	Cumulative %weight retained	% passing	Limits as per IS 383 – 1970, IS 2386 – 1963.
10	0	0	0	100	100
4.75	94	4.7	4.7	95.3	90–100
2.36	178	8.9	13.6	86.4	75– 100
1.18	246	12.3	25.9	74.1	55 – 90
600	606	30.3	56.2	43.8	35 – 50
300	482	24.1	80.3	19.7	8 – 30
150	346	17.3	97.6	2.4	0 – 10
Total cumulative % of weight retained			278.3		

Coarse Aggregate:

The coarse aggregate used in the experimental investigation is a mixture of 20mm and 10mm size aggregates. The aggregates are angular in shape and free from dust. The specific gravity, water absorption and fineness modulus are 2.65, 0.3% and 7.18 respectively. The results of sieve analysis of coarse aggregate are shown in Table-3.

Table3. Sieve Analysis of Coarse Aggregate

IS Sieve (mm)	Weight retained (gm)	% weight retained	Cumulative % weight retained	% passing	Limits as per IS 383 – 1970, IS 2386 – 1963
80	0	0	0	100	100
40	0	0	0	100	100
20	936	18.72	18.72	81.2	85– 100
10	4044	80.88	99.6	0.4	0 – 20

4.75	20	0.4	100	0	0 – 5
2.36	0	0	100	0	0
1.18	0	0	100	0	0
600	0	0	100	0	0
300	0	0	100	0	0
150	0	0	100	0	0
lative % of weight retained			718.32		

Water:

Water used in concrete is free from sewage, oil, acid, strong alkalies or vegetable matter, clay and loam. The water used is potable, and is satisfactory to use in concrete. Water sample collected from bore well and its properties are shown in Table-4.

Table4. Properties of water sample

S.No.	Parameter	Results	Limits as per IS 456 – 2000
1	pH	6.3	6.5 – 8.5
2	Chlorides (mg/l)	45	2000 (PCC) 500 (RCC)
3	Alkalinity (ml)	6	< 25
4	Sulphates (mg/l)	105	400
5	Florides (mg/l)	0.04	1.5
6	Organic Solids (mg/l)	43	200
7	Inorganic Solids (mg/l)	115	3000

Shredded or crumbed rubber:

The physical *properties* of shredded or crumbed rubber are given in Table-5.

Table5. Properties of rubber

Compacted density	2.3 to 4.8kN/cum
Compacted unit weight	1/3 of soil
Compressibility	3 times more compressible than soil
Density	1/3 to 1/2 less dense than the granular fill
Durability	Non-biodegradable
Modulus of Elasticity	1/10 of sand
Permeability	Less than 10cm/sec
Poisson's Ratio	0.2 to 0.3
Specific gravity	1.14 to 1.27
Thermal insulation	times more effective than the gravel
Unit weight	unit weight of gravel

Mix Proportions:

The concrete mix is designed as per IS 10262 – 1982, IS 456-2000 andSP 23.

Table-6 presents the quantities of mix proportion for one cubic meter of concrete and one cement bag.

Table6. Quantities of mix proportion

Mix Constituents	For one m^3 of concrete (kg)	r 50 kg cement bag (kg)
Cement	350	50
Water	147	21
Fine aggregate	719	103
Coarse aggregate 20mm <10mm	712 474	102 68
Water cement ratio	0.42	

Standard cast iron moulds of size 150x150x150mm for cubes, cylinders of size 150X300mm and beam size for flexure test is 100X100X500mm are used in the preparation of specimens. The experimental setup is shown in Figure1 and 2.

Figure 1 Experimental setup

Figure 2 Specimen after fai

Results & Discussions

The effect of rubber aggregates in unit weight of concrete is decreased as the % of rubber increased as shown in Figure3. Almost 20.4% loss of weight at 50% of aggregates replaced with the rubber aggregates.

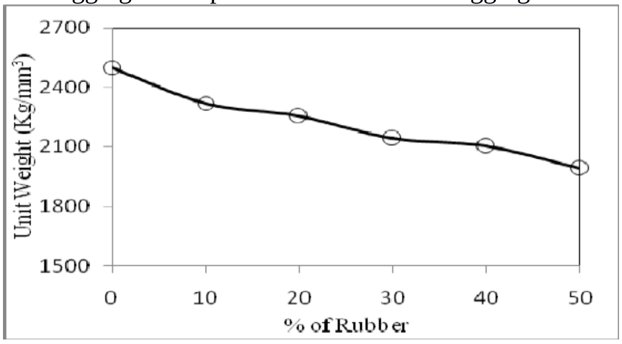

Figure 3 Unit Weight (Kg/m^3) of concrete

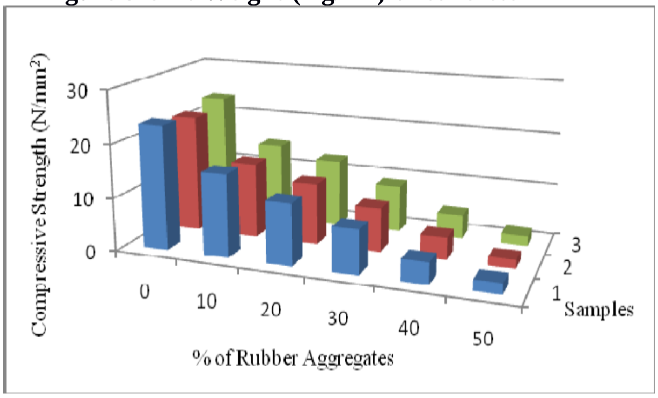

Figure 4 Compressive strength (N/mm^2) of concrete at 7 days age

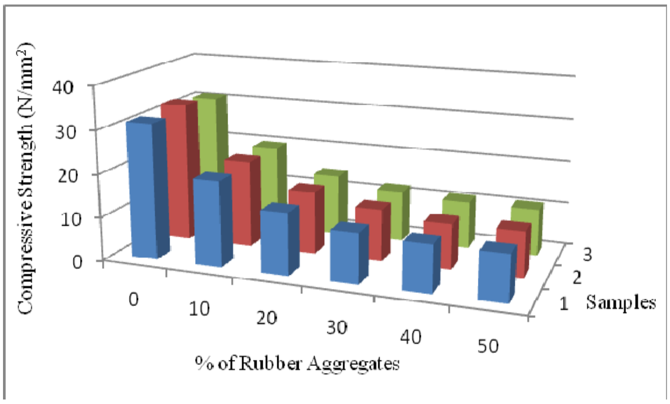

Figure 5 Compressive strength (N/mm^2) of concrete at 28 days age

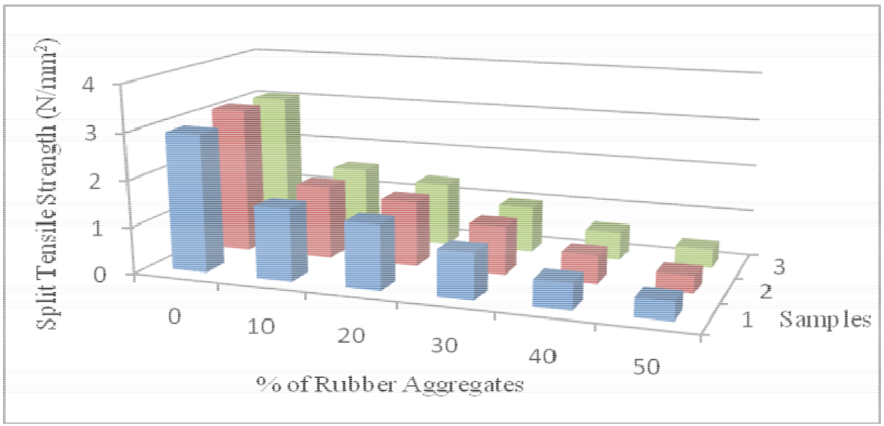

Figure 6 Split tensile strength (N/mm^2) of concrete at 7 days age

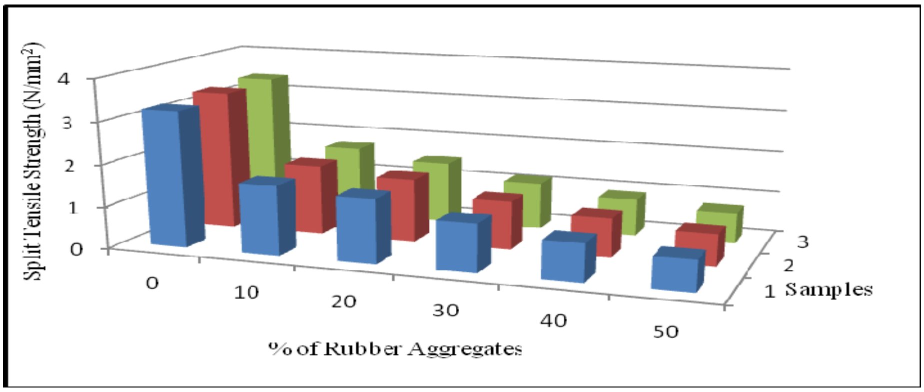

Figure 7 Split tensile strength (N/mm^2) of concrete at 28 days age

Compressive strength and split tensile strength of concrete is decreased as the percentage of rubber aggregates are increased in the concrete. The percentage of compressive strength loss is 35.53 for 10% of rubber aggregate and nearly 91.98 for 50% of rubber aggregates at the age of 7 days. The variations can be observed in Figures 4 to

Table no. 7 shows the average compressive and split tensile strengths of modified and conventional concretes.

Table 7 Average Compressive and Split tensile strengths of concrete

	Compressive strength		Split tensile strength	
% of rubber	7 Days	28 Days	7 Days	28 Days
0	23.08	31.57	3.05	3.32
10	14.88	19.95	1.56	1.68
20	11.97	14.36	1.39	1.50
30	8.48	11.86	1.01	1.14
40	4.24	10.77	0.59	0.91
50	1.85	10.71	0.39	0.74

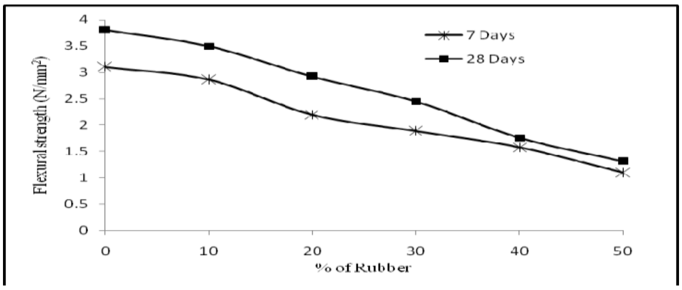

Figure 8 Flexural strength (N/mm^2) of concrete

The flexural strength of modified concrete as shown in Figure 8 is decreases as percentage of rubber aggregates increases.

Conclusions

Based on the present and experimental investigation studies the following conclusions can be drawn

1. The unit weight of modified concrete is decreased approximately by 20.4% when 50% of aggregates is replaced by rubber aggregates.
2. The compressive strength of concrete is decreased as the percentage of rubber aggregates increased.
3. As the rubber content increases in the concrete split tensile strength decreases. It indicates the strain at failure is increased. So this mix is more energy absorbent mix.
4. Concrete with rubber aggregates have flexural strength is almost 66% less than the conventional concrete. However modified concrete has more ductility when compared to conventional concrete.

Concrete containing rubber aggregates is still not recommended for the structural applications and it can be used where strength is not the criteria. This mix will be very useful in the light weight concrete applications.

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