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EXPERIMENTAL INVESTIGATION ON REPLACEMENT OF FINE AGGREGATE BY RUBBER DUST IN CONCRETE

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ABSTRACT

Major environmental problems are resulted worldwide from the disposal of worn out tires that are no longer suitable for use in vehicles. Hence it is essential to reuse/recycle this waste for clean environment. This paper was carried out to evaluate the effect of recycling scrap tire rubber as fine aggregate on the properties of concrete and consequently the mechanical behavior of the concrete. The contents of fine rubber are replaced with fine aggregate in concrete at 3%, 5% and 7% respectively. Further the compression, tensile, flexural strength test results are to be observed. This innovative application may open a new field of recycling of considerable amount of waste tire rubber for cleaner environment.

KEY WORDS* : *Rubber dust, concrete, replacement.

II. INTRODUCTION

Concrete is one of the most widely used construction material in the world. It can be cast in diverse shapes. Concrete is a composite material formed by the combination of cement, sand, coarse aggregate and water in a particular proportion in such a way that the concrete produced meets the needs as regards its workability, strength, durability and economy. It is found to be versatile and hence gained importance in building materials.

III. LITERATURE REVIEW

3.1 Gengying Li, Zhongkun wang – 2016

Using waste rubber as aggregate in concrete is a feasible approach to recycle the material.This paper presents a new approach to overcome the deficiency by treating waste rubbers with silane coupling agent (SCA) and carboxylated styrene – butadiene rubber (CSBR).Experiments were conducted with six different volume fractions of rubbers between 0% to 30% to replace fine aggregate in the concrete.The result showed that the chloride penetration resistance was improved by 35%.

3.2 Aliakbar Gholampour,Togay Ozbakkaloglu – 2016

Effectts of rubber content and confirming pressure on the compressive behaviour of concrete are studied.Four different batches of concrete with rubber replacement ratios of 0% , 6% ,12% and 18% are tested under active confining pressure of upto 25Mpa.An increase in the rubber content results in aincrease in the axial and lateral deformability of actively confined concrete.It also leads to an increase in the lateral strain of concrete and axial strength.On the other hand, the rubber content affects the descending branch trend of the axial stress strain of concrete under active confinement , with more shallow branches seen in concretes with a higher rubber replacement ratio.

3.3 Dina M. Sadek, Mohamed M. El-Attar – 2015

Major environmental problems are resulted worldwide from the disposal of worn out tires. Hence, it is essential to reuse/recycle this waste for clean environment. This paper was carried out to evaluate the effect of recycling scrap tire rubber as aggregate on the properties of solid cement bricks. Two sizes of rubber were used to replace conventional coarse and fine aggregates in the production of the bricks. The experimental work was divided into two phases; the first phase included the production of the bricks and investigating their properties. It consisted of twenty-two mixes with 250 and 300 kg/m3 cement contents. The content of coarse and fine rubber was 0–100% and 0–50% by volume of coarse and fine aggregates, respectively. The second phase included the assessment of the structural behavior of rubberized masonry walls.

3.4 Erhan Güneyisi, Mehmet Gesoğlu – 2014

The study presented herein aims to investigate the durability related properties of rubberized concrete. Two types of waste scrap tire rubber were used as fine and coarse aggregate, respectively. The rubber was replaced with aggregate by three crumb rubber and tire chips levels of 5, 15, and 25% for the rubberized concrete productions. In order to improve the transport properties and corrosion resistance of rubberized concretes, SF was replaced with cement at 10% replacement level by weight of total binder content. The results indicated that the utilization of SF in the rubberized concrete production enhanced the corrosion behavior and decreased corrosion current density values. Moreover, the reduction in the water and gas permeability coefficients was observed.

3.5 Chen Bing, Liu Ning – 2014

In this study, the use of tire-rubber particles as a replacement for coarse aggregate in concrete is investigated. Rubber has replaced coarse aggregate at content levels of 25, 50, 75, and 100% in concrete by volume. Also, emulsified asphalt (EA) was used to improve the mechanical properties of rubberized concrete. Four different series of concrete mixtures were designed to investigate the effects of the water-cement (w/c) and EA-cement (EA/C) ratios on the properties of rubberized concrete. A certain level of EA addition can improve the compressive and flexural strength of rubberized concrete. EA addition reduces the elasticity modulus of the concrete. Adding EA is a good way to improve the bonding between rubber particles and cement paste.

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IV. MATERIAL STUDY

4.1 Physical properties of Aggregates

4.1.1 Particle shape and Texture (As per IS 2386- part: 111-1963)

The physical characteristics such as shape, texture , and roughness of aggregate significantly influence the workability of fresh concrete , bong between the aggregate and mortar phase.In general there are four categories namely rounded,irregular,angular, and flaky.

Material	Visualization	Shape
Natural river sand	Smooth surface	Angular & round edges
Coarse aggregates	Round surface	Irregular & sharp edges

4.1.2 Grading of aggregate (As per IS 2386- part 111-1963)

The particle size distribution of an aggregate as determined by sieve analysis is termed as grading of aggregates.

IS sieve Designation	Grading limits zone	Grading limits of sand
10 mm	100	100
4.75mm	90 – 100	99.6
2.36mm	75 -100	96.2
1.18mm	60 – 90	77.2
0.600µ	35 -59	65.8
0.300µ	8 – 30	31.6
0.150µ	0 -10	2

If all the particles of an aggregate are of uniform size, the compacted mass will contain more voids;whereas aggregate comprising particles of various sizes will give a mass contains lesser voids.The particle size distribution of a mass of aggregate should be such that the smaller particles fill the voids between the larger particles.The proper grading of an aggregate produces a dense concrete and needs less quantity of fine aggregate be well graded to quality of concrete.The grading of an aggregate is expressed in terms of percentage by weight retained or passing percentage through a series of sieves taken in order of 4.75mm, 2.00 mm,1.00 mm, 0.600 mm , 0.425 mm , 0.300 mm , 0.150 mm pan for fine aggregate and 20 mm , 12.5 mm , 10 mm, 4.75 mm ,2.00 mm pan for coarse aggregate.

4.1.3 Fineness modulus (As per IS 386- PART III – 1963)

By the particle size distribution of an aggregate to calculate the fineness modulus value.The fineness modulus value gives an idea of the mean size of the particles present in the aggregates.The object of finding the fineness value is to grade the aggregate for the most economical mix for the required strength and workability with minimum quantity of cement.If the tested aggregate gives higher fineness modulus means the mix will be harsh and of gives a lower fineness modulus,it gives an economic mix.For workability, a coarse aggregate requires less W/C ratio.

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Fineness modulus of natural river sand : 2.63

Fineness modulus of coarse aggregates : 8.65

4.1.4 Bulk density (As per 1S 386- PART III - 1963)

The mass of the material in given volume and it is expressed in kg/lit.The bulk density of aggregates depends upon how densely the aggregate is packed in the measured volume.The factors affecting bulk density are particle shape,size,grading of aggregates and moisture content.The bulk density value can be used for judge the quality of aggregates by comparing with normal density.And it also required for converting propotions by weight into the propotion by volume.Density of natural granite is 2700 kg/m ^{3}.

Bulk Density = net weight of the aggregate in kg / volume of sand

Property	Natural river sand		Coarse aggregate	
Bulk density (kg/m^3)	Loose	compacted	loose	compacted
	1.825	2.095	1.655	1.955

4.2 Water absorption (As per IS 2368 – part III – 1963

The permeability and absorption affect the bond between the aggregate and cement paste.The aggregate which is saturated in water but it contains no surface free moisture is termed as " Saturated surface drey aggregate". If the aggregate is apprehensively dried in oven at 150 ·C to a constant weight before being immersed in water for 24 hours, the absorption is reffered to an oven dry basis.On the other hand, the percentage of water absorbed by an air dried aggregates, when it is immersed in water for 24 hours is termed as " absorption of aggregates " the knowledge of the absorption of an aggregate is important for concrete mix design.

Property	Natural river sand	Natural Coarse Aggregate
% Absorption	0.94	0.54

4.3 Chemical properties of aggregates

The rocks which contain reactive constituents include traps,Andes tic, hyalites, siliceous limestone and certain types of sand stones.The reactive constituents may be in the form of opals, cheers, chalcedony,volcanic glass and zealots etc.. the reaction starts with attacks on the reactive siliceous minerals in the aggregates by the alkaline hydroxide derived from the alkalis cement.As a result, the alkalis silicate gels of unlimited swelling type are formed.

Which results is disruption of concrete with the spreading of pattern cracks and eventual failure of concrete structures.The limestones and dolomites containing chart nodules would be high reactive and stone contain silica minerals like chalcedony , crypto to microcrystalline quartz and opal are formed to be reactive.Geographically india has very extensive deposits of volcanic rocks.

Property	Natural fine aggregates	Coarse aggregates
Silica (SiO_2)	90-95	65.48-65.5
Iron (Fe_2 O_2)	2.682 – 8.25	5.78-6.54

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Titanium(TiO_2)	-	1.10-1.31
Aluminium(Al_2O_3)	0.005 -0.010	16.12-19.10
Calcium(CaO)	-	4.10-4.92
Magnesium(MgO)	0.02	2 – 2.78
Sodium(Na_2O)	0	0-0.78
Potassium(K_2O)	0	3.10 -3.78

The aggregates from these rocks should be studied continuously , some type of aggregates which contain reactive silica in particular proposition and particular fineness are found to exhibit tendencies for alkali aggregate reaction.It is possible to reduce its tendency by alerting the proposition of reactive silica or its fineness.

4.4 Rubber

The rubber compound generally improve the strength, durability,corrosion resistance,extensibility,fatigue resistance and abrasion resistance.rubber tires are an essential part of a vehicle,the contact point between a car or truck and the road surface.Additionaly, chemicals are added to the rubber to improve its life and performance.synthetic rubber long lasting qualities are used to safeguard the existence not just of the structure, but also its inhabitants.

V. ANALYTICAL INVESTIGATION

5.1 Properties of materials

5.1.2. Determination of specific gravity of fine aggregates

The Specific gravity of the given sand by pycnometer method = 2.558.

5.1.3. Determination of specific gravity of coarse aggregate

The Specific gravity of the given sand by pycnometer method = 2.64.

5.1.4. Determination of specific gravity of rubber dust

The Specific gravity of the given sand by pycnometer method = 0.458.

VI. TESTING DETAIL’S

6.1 Introduction

The experimental program was designed to study the mechanical properties of concrete with patial replacement of fine aggregate by rubber dust for M20 grade of concrete. The strength of the sample after replacing the cement by 0% ,3%, 5% and 7% with rubber dust is studied after 28 days.

For the test specimens, 53 grade pozzolonic Portland cement, natural river sand and coarse aggregate, rubber dust are being utilized. The maximum size of the coarse aggregate was limited to 12.5mm. a sieve analysis conforming to IS 383 – 1970 was carried out for both fine and coarse aggregates. The concrete mix proportions of M20 with the water cement ratio 0f 0.45 were used.

The concrete mix design was proposed to achieve the strength of 20MPa after 28 days curing, in case of cubes. The concrete cubes (150mmx150mmx150mm), for conventional as well as other mixes were casted. Each layer was compacted with 25 blows using 16mm dia rod.

6.2 Compression test

The speciemens are tested to find out the mechanical properties. after curing, the specimen were tested for compression strength using a compression testing machine of 2000KN capacity. The concrete cube specimens were placed over the compression testing machine and the load was gradually applied till the failure of the specimen. The ultimate load was noted down as collapse load and compressive strength was calculated.

VII. RESULT DETAIL'S

7.1 Compresive strength detail's

Compressive strength of 7 days curing:

S.No	Replacement % 0f Rubber Dust	Mould No	Compressive Strength (N/mm2)	Average Compressive Strength (N/mm2)
S1	0%	1	15.98	16.02
		2	16.05	
		3	16.03	
S2	3%	1	18.75	19.27
		2	18.95	
		3	20.11	
S3	5%	1	16.03	17.31
		2	15.99	
		3	18.88	
S4	7%	1	15.45	16.10
		2	16.45	
		3	16.10	

Average compressive strength of concrete – 07 days

Compressive strength – (N/mm^2)0

Compressive strength of 14 days curing:

S.no	Replacement % 0f Rubber dust	Mould No	Compressive strength (N/mm2)	Average Compressive strength (N/mm2)
S1	0%	1	17.23	18.75
		2	18.24	
		3	18.99	

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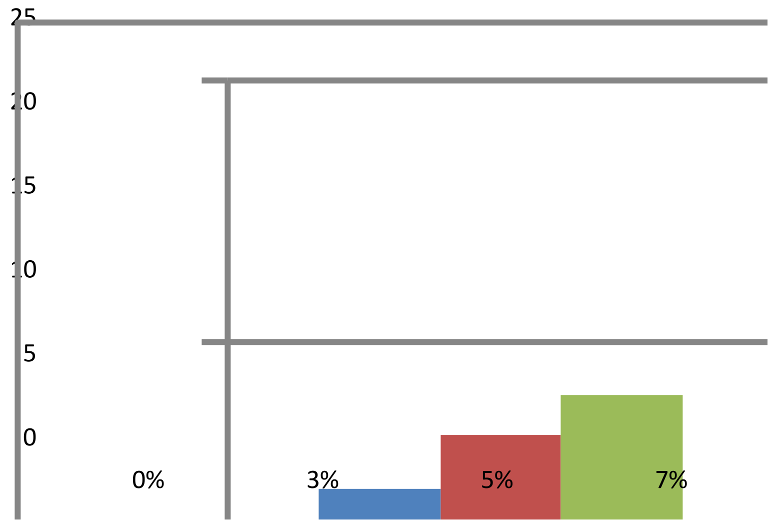
S2	**3%**	1	21.45	22.33
		2	22.45	
		3	22.78	
S3	**5%**	1	21.01	20.14
		2	19.89	
		3	20.12	
S4	**7%**	1	17.56	18.14
		2	18.06	
		3	18.10	

Average compressive strength of concrete – 14 days

Compressive strength – (N/mm^2)



Compressive strength of 28 days curing:

S.no	Replacement % 0f Rubber dust	Mould No	Compressive strength (N/mm2)	Average Compressive strength (N/mm2)
S1	**0%**	1	20.12	21.33
		2	21.45	
		3	21.05	
S2	**3%**	1	26.45	27.53
		2	26.98	
		3	27.01	
S3	**5%**	1	20.56	

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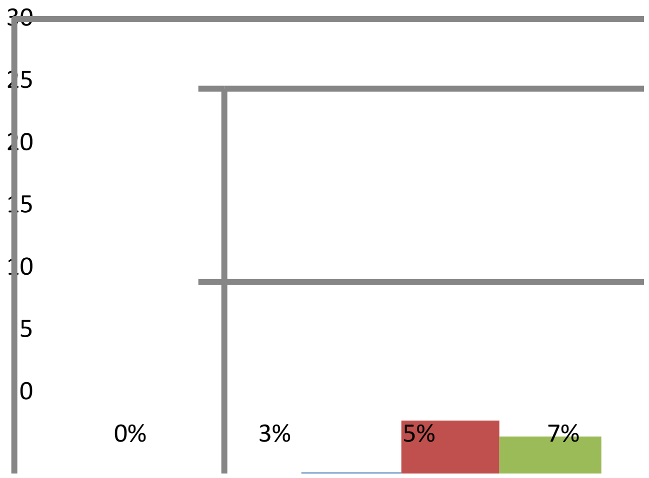
		2	21.58	21.23
		3	21.13	
S4	**7%**	1	20.75	21.18
		2	21.26	
		3	21.08	

Average compressive strength of concrete – 28 DAYS

Compressive strength – (N/mm^2)



7.2 Tensile strength detail's

Mixing Ratios	7 days test	14 days test	28 days test
M20 at 0%	1.708	1.944	2.137
M20 at 3%	2.820	3.183	3.376
M20 at 5%	2.212	2.761	2.532
M20 at 7%	1.824	2.011	1.802

7.3 Flexural strength detail's

Mixing Ratios	7 days test	14 days test	28 days test
M20 at 0%	1.94	2.09	2.99
M20 at 3%	2.12	2.41	3.32
M20 at 5%	2.07	2.23	3.19
M20 at 7%	1.92	2.01	2.89

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VIII. CONCLUSIONS

After conducting all the tests on the specimen, it has been observed that up to 3% replacement of fine aggregate with rubber dust to be good in compression, as well as in tension, where as the concrete properties with equal proportion of rubber dust and conventional fine aggregate confirmed to be inefficient.

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