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Study of Partial Replacement of Coarse Aggregate in Concrete by Different Proportions of Un-Treated Waste Tyre Rubber

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Abstract: ***The aim of this paper is to find out the effect of partial replacement of coarse aggregate by waste tyre rubber in untreated condition that is as it is without any pre-surface treatment. With the help of tests such as compressive strength, spilt tensile strength, flexural strength and slump cone test. In India number of vehicles are growing day by day so, because of it waste tyre generation also increased. So, recycling of this large quantity waste is not an easy work. Our main focus is to use this waste tyre rubber in concrete without affecting its properties which are mentioned earlier. Study and Analysis of partially replaced concrete with respect to various strengths under 7 and 28 days of curing.***
Keywords: Waste tyre chipped rubber, Compressive strength, spilt tensile strength, flexural strength, untreated.

I. INTRODUCTION

Management of waste tyre rubber in urban and industrial area is not a easy work. For that burning of tyres is used but due to burning of this huge quantity rubber tyres creates air pollution. Burning involves various types of poisonous gases which seriously affects human as well as other living beings. Now a days waste tyre generation is on peak level. So it is very much necessary to find out a alternative solution for disposal of this waste tyre.

Our clear focus is to study the behavior and properties of concrete in fresh as well in harden condition when its natural coarse aggregates is replaced by 5% & 15% waste tyre rubber with the help of compressive test, spilt tensile test and flexural test for hardened properties of concrete and for fresh slump cone test is used. For this we used three type of specimens are, first one cube of size 15x15x15 cm, cylinder of size 15cm x 30cm and beam of size 10cm x 10cm x 50cm respectively.

II. LITERATURE RIVIEW

Using waste tyre rubber as a partial replacement of natural aggregates is a good alternative without affecting concrete properties. Rubber is the main constituent of tyres in which synthetic and natural rubbers are commonly used. In literature review we studied previous work that has been done on this topic.

N. J. Azmi B. S. Mohammed, H. M. A. Al-Mattarneh (2008)[1]. In this paper mechanical properties of the concrete containing crumb rubber as partial replacement of natural fine aggregates with the replacement levels of 10, 15, 20 and 30% by volume. American Concrete Institute mix design methods were used in this research work. Water cement ratios of 0.68, 0.57 and 0.41 are used and testing of specimen was done for compressive strength, split tensile strength, flexural strength and also for modulus of elasticity. In other research works, the results interpreted that there is a decrease in the compressive strength of the concrete. They also said that when the crumb rubber content was increased from 0-30%, there was a distinct increase in the workability also. Due to use of crumb rubber workability increased and it is very useful when workable concrete is required. The replacement of aggregates by crumb rubber also reduced the static modulus of elasticity and increased the deformability.

Taha et al. (2003)[2]. For study and analysis they used different percentage of rubber aggregates having the size from 5mm to 20mm respectively When 100% of aggregates were replaced by the rubber aggregate, there is considerable decrease in compressive strength was observed that is about 75%. While compressive testing specimen show extreme lower values of compressive strength and fails easily.

Zeineddine Boudaoud, Miloud Beddar.(2012)[3]. As early discussed, this paper also concludes that when we use waste tyre rubber in concrete Although there is loss in compressive strength but also consider this we can use it into the other concrete works such as unimportant works such as for pavements, in non load taking members and many other applications of it. It was noticed that formed concrete is cheap, ecological and light weight than the conventional concrete

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Akinwonmi, Seckley et al. (2013)[4]. In this research paper they use both crumb rubber as well as shredded rubber separately for replacement of the natural aggregates After testing the specimen which contained various percentages of the crumb rubber and others which included the different percentage of shredded rubber, it was noticed that up to the replacement level of 2.5% by shredded tyre, the compressive strength is increased in small amount but when the replacement used greater than 2.5%, there is a huge decrease in the compressive strength of the concrete. On the other side replacement by crumb rubber totally showed bad results and thus was not suggested.

Amjad A. Yasin et al. (2012). They partially replaced the natural aggregates with the shredded tyre rubber aggregates. They said that the compressive strength gets significantly reduced as compared to the compressive strength of the concrete with natural aggregates. So, compressive strength, tensile strength & flexural strength. He concluded that higher the rubber content in the concrete mix, the huge decrease in compressive, tensile & flexural strengths hence it is not recommended to use this replaced concrete in structural components where higher strength is required but it can be used in other construction components like road barriers, pavements sidewalks, other non-structural members, partition walls etc.

III. OBJECTIVES

1) The main purpose of this study is to examine the effect of addition of chipped waste tyre rubber as a aggregates into the Portland cement concrete in different proportions i.e. 5% & 15% by coarse aggregates by weight and evaluate the fresh and hardened rubberized concrete properties.

2) To analyse the effects of partial replacement of coarse aggregate by tyre waste in concrete with respect to strengths and workability.

IV. FUTURE SCOPE OF THE STUDY

There is a huge scope for study & innovation. There are lot of applications of rubber but when we talk about use in civil engineering there are many different ways not invented yet. So with different w/c ratios, concrete grades, different proportions of replaced rubber and other many ways to use this waste tyre rubber. Also there is need of in depth research is required. Based on the present research and other work done on this topic, there is huge potential of tyre rubber to be used in the civil construction industry.

V. METHDOLOGY

A. Materials

The material used in this project are cement, sand, coarse aggregate tyre rubber and sodium hydroxide. The cement, coarse aggregate, sand and sodium hydroxide are easily available in the construction industry while the tyre rubber is available at very few sources.

1) Cement – OPC 43 Grade

2) Coarse aggregate – coarse aggregate of 10 mm and 20 mm with sizes of 38% and 62% were used.

3) Fine aggregate - Artificial sand (crushed sand) was used.

4) Waste tyre chipped rubber pieces are used are cutting by manually by hand and in varying sizes ranging from 10mm-15mm x 10mm.

5) Water – ordinary portable water (pH ranges between 6.0 to 8.5)

6) Concrete grade – M20 & Water cement ratio – 0.48

B. Quantity Estimation

Table 1 Cube (150mm x 150mm x 150mm , v = 0.003375 m^3)

Replacement In %	Cement (kg)	Coarse Aggregate(kg)	Fine Aggregate(kg)	Water(Ltr.)	Rubber(kg)
Normal	1.35	3.85	2.28	646	0
5 %	1.35	3.66	2.28	646	0.193
15%	1.35	3.27	2.28	646	0.578

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Table 2 Cylinder (150mm diameter L=300mm , v = 0.0053 m^3)

Replacement In %	Cement (kg)	Coarse Aggregate(kg)	Fine Aggregate (kg)	Water (Ltr .)	Rubber (kg)
Normal	2.11	6.05	3.59	1.01	0
5 %	2.11	5.75	3.59	1.01	0.302
15%	2.11	5.14	3.59	1.01	0.907

Table 3 Beam (100mm X 100mm X 500mm diameter, v = 0.005 m^3)

Replacement In %	Cement (kg)	Coarse Aggregate(kg)	Fine Aggregate(kg)	Water (Ltr.)	Rubber (kg)
Normal	2.00	5.71	3.38	0.958	0
5 %	2.00	5.42	3.38	0.958	0.285
15%	2.00	4.82	3.38	0.958	0.856

C. Mix Proportion

Table No.4 Mix design

Replacement of coarse aggregate	w/c ratio	Cement content (kg/m3)	Coarse aggregate (kg/m3)	Fine Aggregate (kg/m3)	Rubber content (kg/m3)
Normal concrete/ 0% Replacement	0.48	399.12	1141.59	676.7	0
5% Replacement	0.48	399.12	1084.51	676.7	57.08
15% Replacement	0.48	399.12	970.35	676.7	171.24

D. Experimental Work

The moulds used for the preparation of samples were cubes of size (15cm x15cm x 15cm) for compressive strength testing, the beams of size (50cm x 10cm x 10cm) for flexural testing and the cylinders of size (10cm x 30cm) for split tensile strength testing. Concrete is prepared as per mix design and then poured into casting mould. While casting mould is oiled from inside for smooth surface finish and easy removal from mould. Then they are kept in water tank for required curing period and properly tested and results are noted down. For compressive test compressive test as well as split tensile strength, compressive testing machine (CTM) is used and for beam two point loading method is adopted.



Fig.No.1 Compressive Strength test

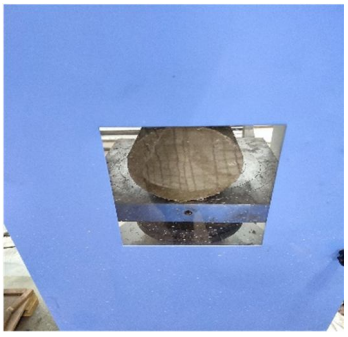


Fig.No.2 Split tensile strength test



Fig.No.3 Flexural strength test

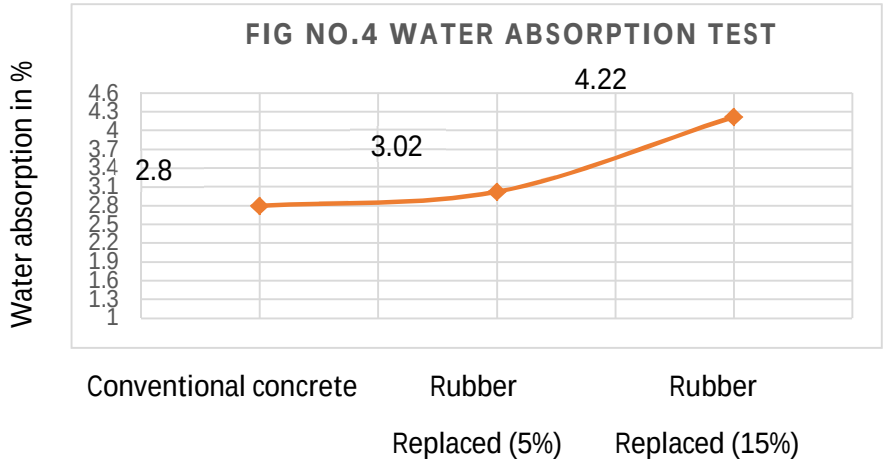
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VI. RESULTS & DISCUSSIONS

A. *Water Absorption*

The purpose of this test is to find out water absorption of replaced concrete specimens. water absorption test was conducted on concrete samples containing 5% and 15% partial replacement of rubber. Specimens are weighed before being kept into water tank for curing. After the 28 days of curing the specimens are removed from water tank and surface moisture is removed by dry cloth then weight is checked and compared with initial weight before kept in water tank. So, a higher percentage of waste tyre rubber should not be used for building for main structural members or components. A lower water absorption rate is not always a indicator of better frost resistance while a high one does not always mean poor frost resistance. The data is shown in Figure with necessary details.

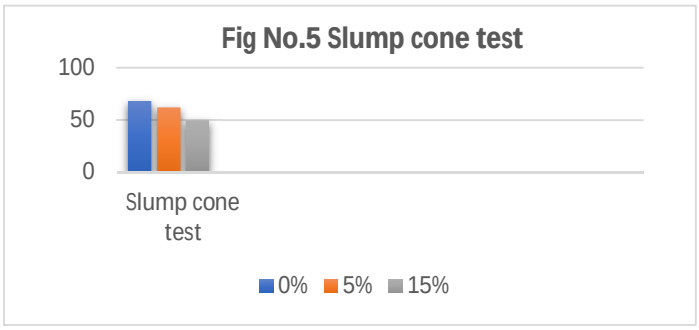


B. *Slump Values*

Slump tests of fresh concrete with coarse aggregates replaced by waste tyre rubber particles.

Table No.5

Rubber content (%)	Slump (mm)
0%	68
5%	62
15%	51



According to the obtained test values workability gets reduced with increasing percentage of chipped waste tyre rubber. This low workability occurs due to improper movement of rubber pieces with other concrete materials. So, it is not recommended to use this in heavily reinforced concrete members and where high w/c ratio required.

C. *Compressive Strength*

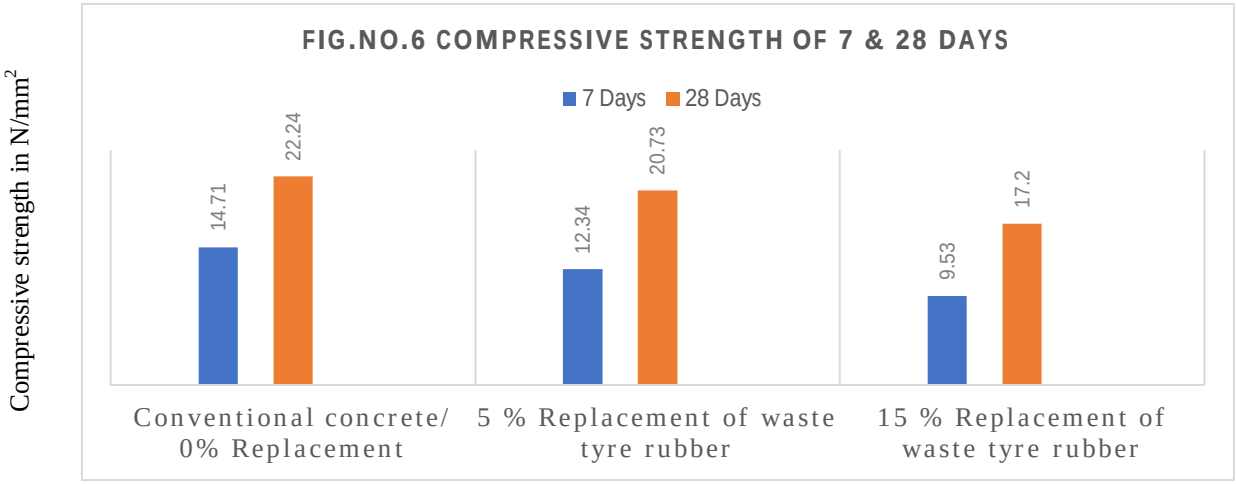
Table shows the variations in compressive strength obtained at 7 and 28 days with respect to the percentage of coarse aggregate replaced by untreated chipped waste tyre rubber. Gradual decrease in compressive strength was noticed as the percentage of untreated chipped waste tyre rubber is increased. Each 3 specimens are tested and average value is taken.

The compressive strength Fc is found out from the given equation - Fc = P/A Where, P = Compressive load at failure(N) A= Cross sectional area(mm^2)

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Table No.6 Compressive strength (avg. of 3 specimens) of concrete cube

Curing period	% Replacement of Waste tyre rubber	Load (KN)	Compressive strength (N/mm^2)
7 Days	Conventional concrete/ 0% Replacement	330.97	14.71
	5 % Replacement	285.97	12.34
	15 % Replacement	241.42	9.53
28 Days	Conventional concrete/ 0% Replacement	500.40	22.24
	5 % Replacement	466.42	20.73
	15 % Replacement	387.00	17.20



D. Split Tensile Strength

Split tensile test is carried out on cylindrical specimens of 150 mm diameter and 300 mm height. The test is carried as per IS 5816-1999. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine, and the load is applied until failure of the cylinder. Split tensile strength is calculated by given equation-Tsp= 2P/ 3.14 x D x L

Where,

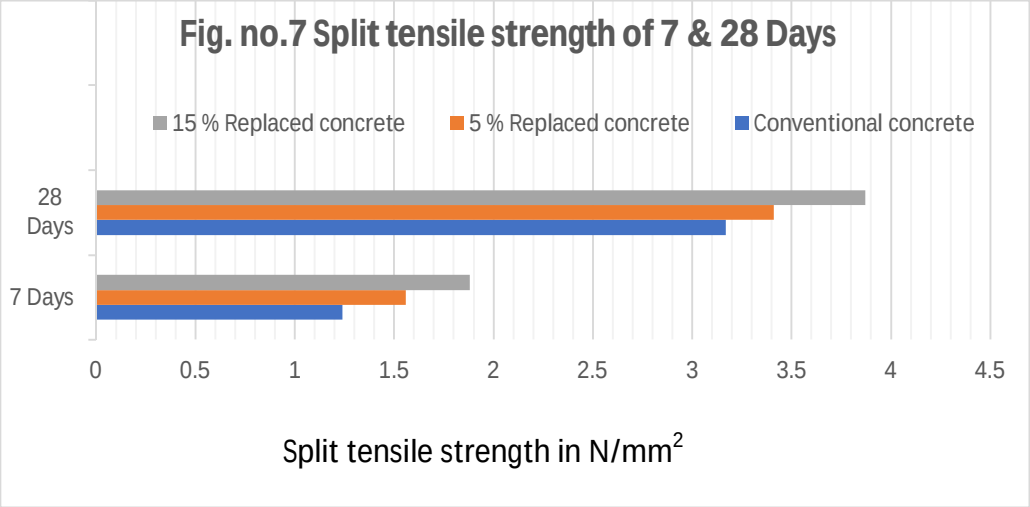
TSP=Split tensile strength

P = Tensile load at failure (N) D= Diameter(mm)

L=Length of the specimen(mm)

Table No.7 Split tensile strength (avg. of 3 specimens) of concrete cylinder

Curing period	% Replacement of Waste tyre rubber	Load (KN)	Split tensile strength (N/mm^2)
7 Days	Conventional concrete/ 0% Replacement	87.61	1.24
	5 % Replacement	110.21	1.56
	15 % Replacement	132.82	1.88
28 Days	Conventional concrete/ 0% Replacement	223.96	3.17
	5 % Replacement	240.92	3.41
	15 % Replacement	273.41	3.87



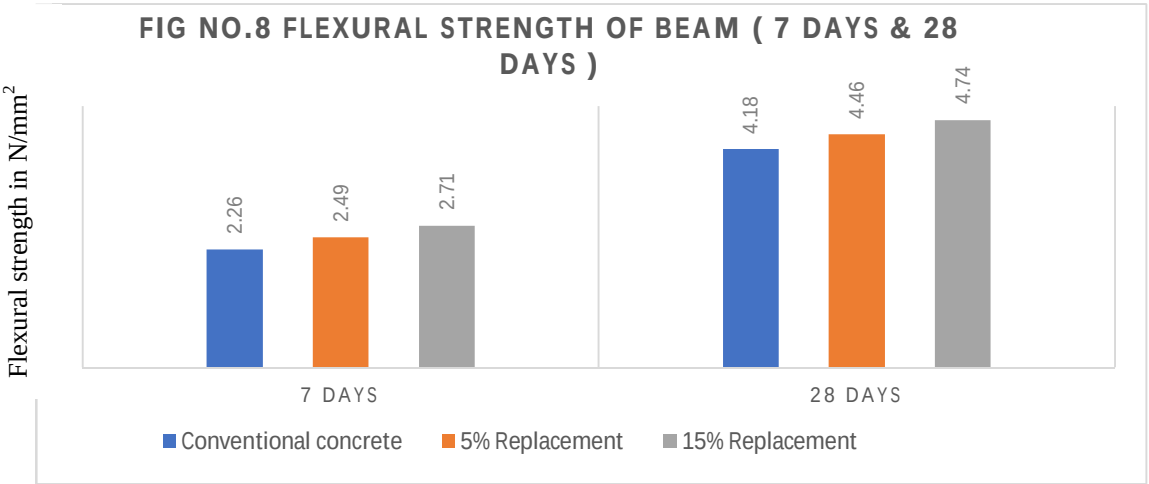
E. Flexural Test

Standard beams of size100mmx100mmx500mm are used to determine the flexural strength. The specimens are placed in the machine such that the load is applied to the top surface. Mark the specimen along two sides spaced 13.33cm apart and 5cm from both ends. Two-point loading method is used for loading. The load is applied until the specimen failed and the maximum load applied to the specimen during the test is recorded. Also failure crack distance from nearer support is also measured and this value (a) is noted down. Flexural strength is determined from the equation given below.

If value of (a) greater than 13 cm then Flexural strength or modulus of rupture = PL / b x d^2 Where, P= Flexural load(N) L=Length of specimen(mm) b = Width of specimen (mm) d=Height of specimen (mm)

Table No.8 Flexural strength (avg. of 3 specimens) of concrete beams

Curing period	% Replacement of Waste tyre rubber	Load (KN)	Flexural strength (N/mm^2)
7 Days	Conventional concrete/ 0% Replacement	4.52	2.26
	5 % Replacement	4.98	2.49
	15 % Replacement	5.42	2.71
28 Days	Conventional concrete/ 0% Replacement	8.36	4.18
	5 % Replacement	8.92	4.46
	15 % Replacement	9.48	4.74



VII. DISCUSSIONS

1) According to the results obtained by compressive strength test when partial replacement of waste tyre rubber in percentage is increased, it negatively affects the compressive strength. Compressive strength gets reduced due to rubber is weak in compression.
2) It was observed that conventional concrete specimens possess brittle failure and was broken into two pieces while testing. Rubberized concrete did not show brittle failure under tensile loading conditions. This is because of elastic properties of rubber.
3) When we use rubber directly in concrete it can't make proper bond with other concrete materials results in early crack formation.
4) Absorption of water by waste tyre rubber was observed. So, for that higher dose of plasticizers can be used or higher w/c ratio can used if possible, for better workability.
5) If proper compaction is not done then it creates honeycomb at surface of the concrete. So, avoid this phenomenon proper compaction is required. And it is suggested that do not use in complex reinforced structural members.

VIII. CONCLUSION

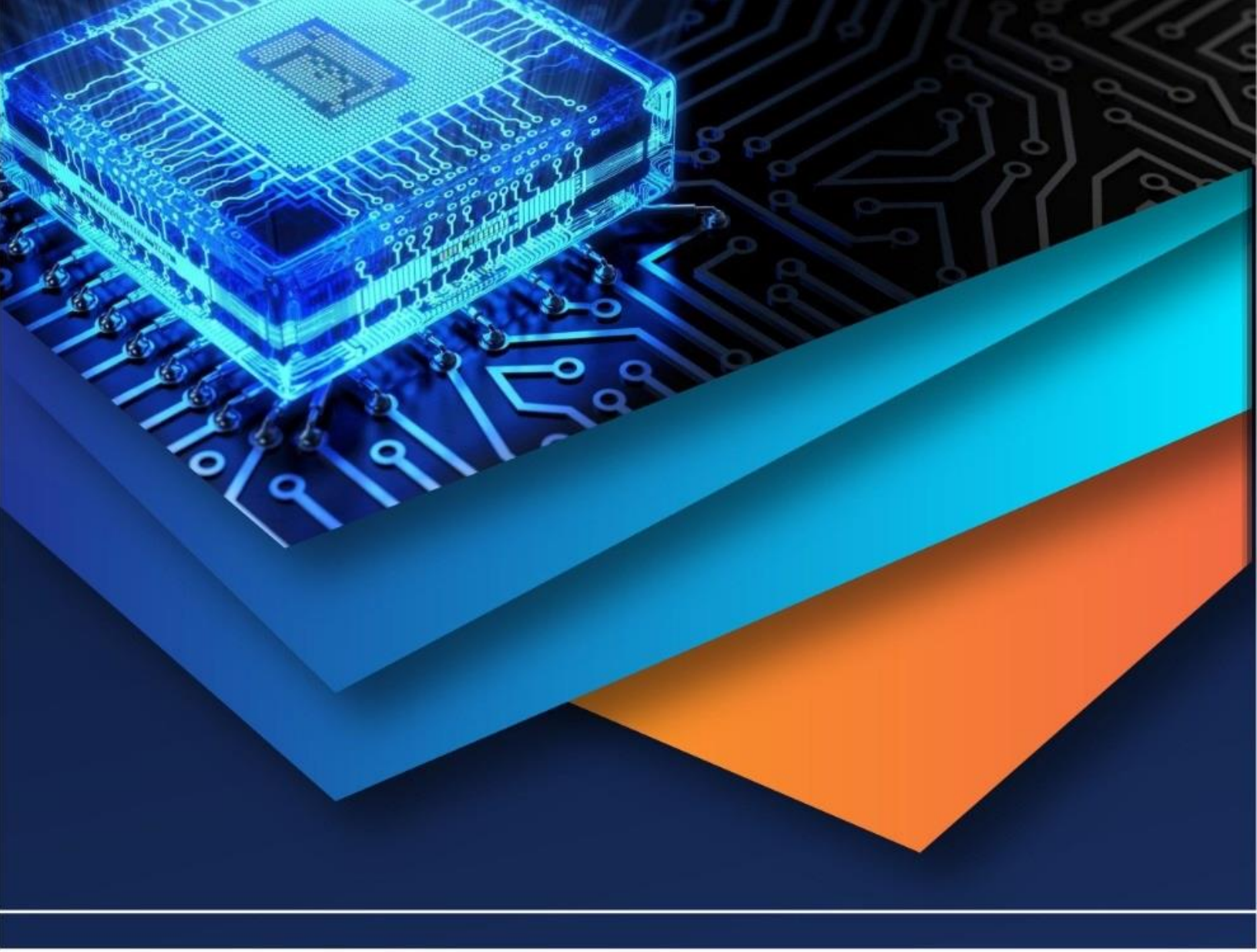
This study represents the effect of waste tyre chipped rubber of size 10-15mm x 10mm used in concrete on compressive, flexural and split tensile strength. From the results obtained during tests & investigations on the basis of following conclusions can be drawn:

1) As we increase % of replaced rubber by coarse aggregate it reduces workability nearly about 10-12%.
2) For better workability admixtures such as plasticizers or higher water cement ratios without compromising strength should be used.
3) For complex structural elements or highly reinforced concrete sections this replaced concrete is not suitable.
4) Also, there is 2 - 4.5% of water absorption also observed. Which affects the properties of concrete.
5) Compressive strength of waste tyre rubber concrete is decreases with increasing percentage replacement of waste tyre rubber. That is about 10-20% reduction in compressive strength with different proportions of replacement.
6) 10-20% split tensile strength is increased. Due to rubber is good in tension.
7) 15-20% increase in flexural strength is increased. Highest strength is obtained with 15% replacement of waste tyre rubber concrete after 28 days that is 4.74 N/mm^2
8) By replacing natural aggregates with light weight waste tyre rubber, weight of concrete is also gets reduced.

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