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"To Enhance the Quality of Rubber Modified Concrete Using Polymer"

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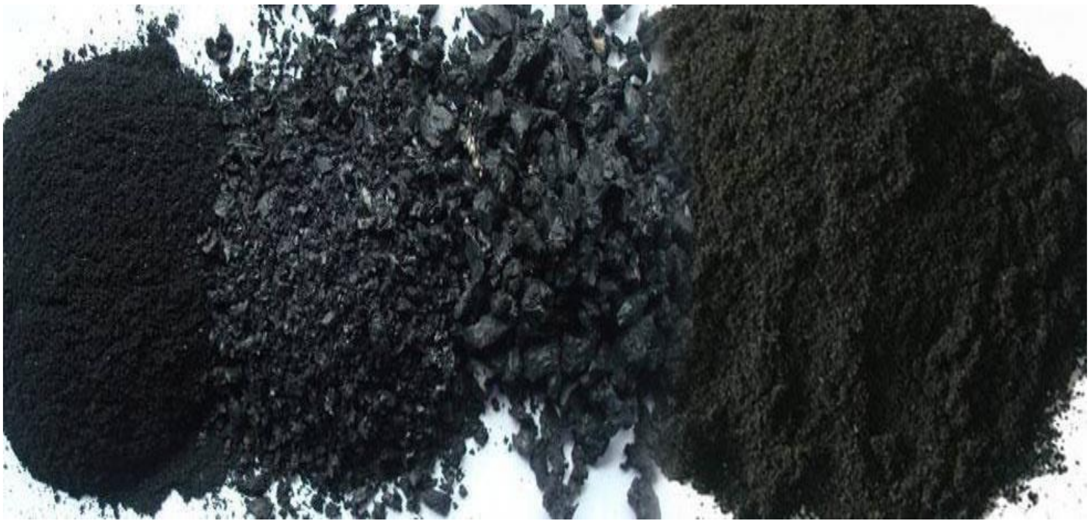
Abstract: Replacement of natural aggregates with rubber tyre aggregates is an alternative way to dispose of waste tyre safely. Research has found that using rubber in concrete will enhance and reduce its density. This study considers how to minimize the loss of strength of concrete using rubber tyre crumb aggregates. In the recent research study rubber modified concrete was made by two different ways: 1) by replacing natural fine aggregate in normal concrete of M35 grade with untreated crumb waste tyre particles and 2) by replacing natural fine aggregate in normal concrete of M35 grade with crumb rubber particles treated with synthetic resin (PVA). The replacement of fine aggregates in both the cases was done at 5% ,10% and 15%.the rubber reduced the density and compressive strength of concrete while increased the flexural strength, water absorption and damping ratio. The size of crumb rubber varies from 4.75 mm to 0.15 mm. rubberized concrete recommended to be used in circumstances where vibration damping was required such as in bridge construction. Waste rubber tyres can be incorporated in concrete either as coarse aggregates or fine aggregates. Waste rubber aggregates have been categorized in to four types based upon their particle size. Crumb waste rubber is a material derived by reducing/shredding scrap tires or other rubber into uniform granules. The source of scrap tyres are: passenger car tires, truck tires and off-the-road tires. On average, about 10 to 12 pounds of waste crumb rubber can be manufactured from one passenger tire. Realizing the problem of strength reduction on the addition of tyre particles in concrete appropriate measures are needed in order to improve the strength of rubber modified concrete.

Keyword: Crumb Rubber, Cement, Concrete, Fine Aggregate, Coarse Aggregate

I. INTRODUCTION

It has been realized that the generation of solid waste and the disposal problem related to it is a standout amongst the most vital issues which our human progress is confronting in present era. Risky and non-biodegradable waste is being produced in boundless amount bringing on genuine danger to our environment. Solid waste can be arranged into various sorts relying upon their source: a) Household, b) Industrial (toxic and hazardous) and c) Bio-medical (infectious). Among industrial wastes, the tyre rubber wastes or scrap tyres are one of the hazardous wastes which are being generated and accumulated on very large scale worldwide every year. At global scale a lot of research has been carried out on the use of waste rubber tyres in concrete. Countries like USA and France has made it mandatory to utilise crumb rubber in Highway construction.



Waste Tyre Crumb Rubber

The rubberized concrete was first introduced and checked for its application in engineering works in early 1990s .Waste rubber tyres can be incorporatedin concrete either as coarse aggregates or fine aggregates. Waste rubber aggregates have been categorized in to four types based upon their particle size. Rubber tyre aggregates are acquired from waste rubber tyres by using two types technologies, 1) mechanical grinding at ambient temperature, and 2) cryogenic grinding below glass transition temperature .The material has been characterized elsewhere as having low particle density (0.95 kg/m^3), negligible water absorption, low thermal conductivity, and high resistance to weathering.

Scrap tyres in an open area & waste tyres dump on fire.

II. METHODOLOGY

To study the effect of pre-treatment of crumb rubber aggregates with synthetic resin on the strength performance of rubber modified concrete and suggests the optimum dosage of crumb rubber in concrete the research methodology to be proposed by the researcher is as shown in the following steps:-

1. M35 Grade concrete mix design as proposed for control concrete based on "Indian Standard Concrete Mix Proportioning (IS 10262: 2009)" was designed using available natural aggregates.
2. Ordinary Portland cement was used as binder in all the concrete mixes.
3. Crumb rubber tyre aggregates replacing the fine aggregates (sand) in 0, 5, 10 and 15 % by weight were proposed by the researcher to develop different rubber modified concrete mix groups.
4. Fresh properties of concrete like slump and density of the rubber modified concrete (treated / untreated) was found out and effects on workability and density were studied.
5. Compressive and split tensile strength of untreated rubber modified concrete samples having different crumb rubber content was found out.
6. Pre-treatment of crumb rubber aggregates with synthetic resins was done and treated rubber modified concrete mix were prepared at different replacement levels of crumb rubber as specified above.
7. Treated rubber modified concrete specimens were checked for the compressive and split tensile strength and comparative study was done between control concrete, untreated rubber modified concrete and treated rubber modified concrete on the basis of compressive and split tensile strength test results.
8. Optimum dosage was suggested based up on the above laboratory tests results.

III. EXPERIMENTAL PROGRAMME

STAGE 1: In this stage the procurement of various materials are carried out and testing of procured materials is done to assess the properties of material used.

CONSTITUENT MATERIALS

The constituent materials that are used in this experimental study are Ordinary Portland Cement, coarse aggregates, Natural River sand, crumb rubber aggregate, synthetic resins and water. The various materials would be tested as per specifications laid down in Indian standard codes. Various specifications related to the materials are discussed below.

a) **Cement:** Ordinary Portland Cement (OPC) of 43 grade has been used throughout the experimental investigation. various tests such as fineness modulus test, consistency test, and initial and final setting time test were conducted on cement sample in order to match the requirements of OPC 43 as per IS: 8112-1989.

b) **Fine Aggregates:** Crusher sand was used as fine aggregate procured from Burj Kotiyan. Sieve analysis was done to determine the zone of sand as per IS: 383-1970.

Fine aggregate (crusher sand)

C) **Coarse Aggregates:** Crushed aggregates, angular in shape have been used in experimental work. Grading of coarse aggregate was done according to IS: 383-1970 and nominal size was determined. Two different coarse aggregates of nominal size of 20 mm single size and 12.5 mm graded were combined in gradation ratio of 2:1 to Coarse aggregate of 20 mm and 12.5 mm size

CONCRETE MIX DESIGN OF GRADE M 35

1. Design Stipulation

a) Characteristic compressive strength at 28 days = 35 N/ mm^2
b) Maximum Size of Aggregate = 20 mm (angular)
c) Degree of quality control = Good
d) Type of exposure = severe
e) Workability = 75 mm (slump)
f) Limitation on Water- cement ratio and minimum cement content to ensure sufficient durability under severe exposure condition is 0.45 and 320 kg/ m^3 for reinforced concrete according to IS 456 : 2000
g) Standard deviation(s) as per Table 1 of IS 10262: 2009 for M 35 grade concrete is 5 N/mm^2

2. Test Data For Materials

a) Ordinary Portland cement 43 grade satisfying the requirements of IS 8112: 1989 is used.

b) Specific gravity of Material used:

Material	Cement	Fine Aggregate	Coarse Aggregate	Super Plasticizer	Water
Specific gravity	3.15	2.63	2.76	1.1	01

c) Sieve Analysis:

i) Gradation ratio (2:1) for 20 mm to 10 mm nominal size aggregate conforms to Table 2 of IS 383 : 1970.

ii) Fine Aggregate crusher sand conforming to grading zone II of Table 4 of IS 383: 1970.

d) Super plasticizer "Auramix 300" is used for preparing reference concrete mix M35 and rubber modified concrete mix.

3. Target Mean Strength (FCK)

$$F_{ck} = f_{ck} + (1.65\times s)$$

Here, Fck = target mean compressive strength at 28 days; fck = characteristic compressive strength at 28 days and; s = assumed standard deviation.

Therefore, F_{ck} = 35 + (1.65×5) = **43.25 N/mm^2**

4. Water-Cement Ratio Selection

Various trial mix design were carried out in order to achieve target mean strength by taking different trial w/c ratios; these trial w/c ratios were kept lower than the specified limit of 0.45 for severe condition as mentioned in IS 456 : 2000. In the present study, the target mean strength of 43.25 N/mm^2 is achieved from the trial mix design having water-cement ratio of 0.40.

5. Water Content Selection (w)

In the present study maximum nominal size of aggregate used is 20 mm, thus maximum water content obtained for 20 mm nominal size aggregate from Table 2, of IS 10262: 2009 is 186 litre.
Thus, according to IS 10262: 2009 water content can be increased by about 3 % for every additional slump of 25 mm. In the present study, the stipulated slump is 75 mm; therefore new water content (w_1) is given by:
w_1 = 186 + (0.03 × 186) = 191.58 litre
Also, according to IS 10262: 2009 the water content can be reduced up to 20 % and above for super plasticizer usage. In the present study, based on the trials with "Auramix 300" super plasticizer water content reduction of 16.5 % has been achieved. Therefore, new water content (w) after making reduction is given by:

w = 191.58 – (0.165 × 191.58) = 159.96 liters ≈ **160 liters**

6. Determination of Cement Content (c)

Water- cement ratio = 0.40; water content = 160 liters

Cement content (c) = (160 ÷ 0.40) = **400 Kg/m^3** (> 320 Kg/m^3, as per 456: 2000), Hence, OK

7. Fine Aggregate and Coarse Aggregate Volume Proportioning

Coarse aggregate volume per unit volume of total aggregate = 0.62 (for nominal maximum size of aggregate 20 mm, Zone II fine aggregate and water cement ratio of 0.50, as per Table 3 of IS 10262: 2009).
Volume of coarse aggregate for w/c ratio of 0.40 is obtained by making adjustment in accordance to the guidelines mentioned in IS 10262: 2009. In present case, the w/c ratio is lower by 0.10 with respect to w/c ratio of 0.50, thus increasing the volume of coarse aggregate at the rate of 0.01 for every 0.05 decrease in w/c ratio. Therefore, new volume of coarse aggregate is given by:

$$V_{ca} = 0.62 + 0.02 = \mathbf{0.64\ m^3}$$

And, Volume of fine aggregate per unit volume of total aggregate is given by:

$$V_{fa} = 1 - 0.64 = \mathbf{0.36\ m^3}$$

8. Calculations for Coarse Aggregate and Fine Aggregate Content

a) Concrete Mix Volume = 1m^3

b) Cement Volume $= \frac{400}{3.15} \times \frac{1}{1000}$ = 0.126m^3

c) Volume of Water = $\frac{160}{1} \times \frac{1}{1000} = 0.160m^3$

d) Super plasticizer Volume (at 1% by mass of cement) = $\frac{4}{1.1} \times \frac{1}{1000} = 0.0036m^3$

$= 0.004m^3$

e) Total Voume of Aggregate = $\{1 - (0.126 + 160 + 0.004)\}$ = **0.71 m³**

f) Mass of Coarse Aggregae = $0.71 \times 2.76 \times 0.64 \times 1000$ = **1254 Kg/ m³**

g) Mass of Fine Aggregate = $0.71 \times 2.63 \times 0.36 \times 1000$ = **672 Kg/m³**

1. Mix Proportion for M 35 grade Reference Concrete:

Unit of Batch	Cement (Kg)	Fine Aggregate	Coarse Aggregate	Water (litre)	Super Plasticizer @ 1% by weight of cement (Kg)
1 m^3 of concrete	400	672	1254	160	4
Ratio	1	1.68	3.14	0.40	0.01

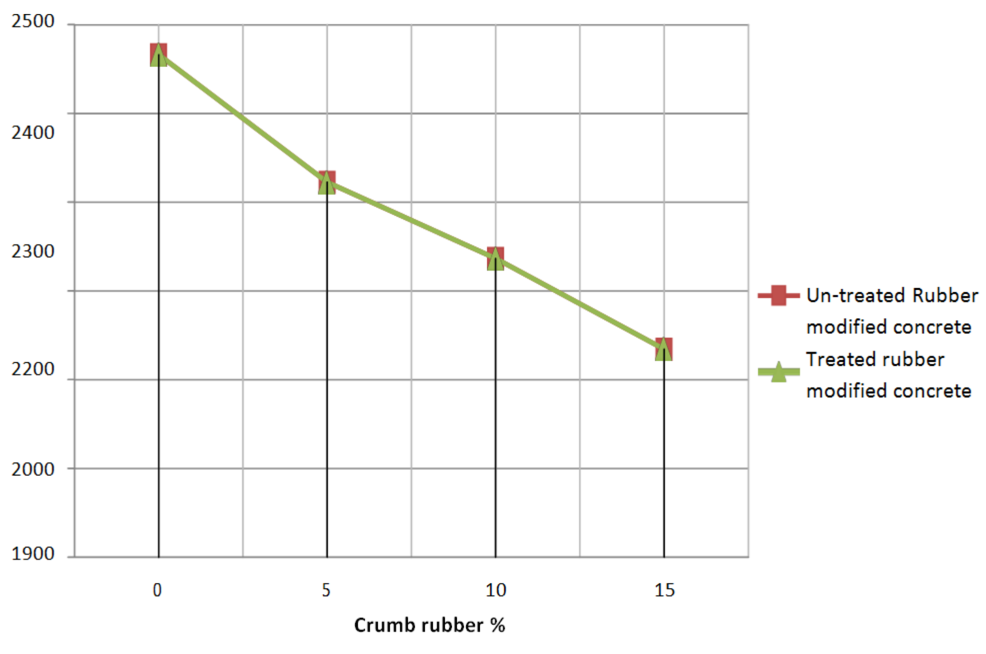
IV. RESULT

Extensive experimental investigation has been conducted in the present research work to study the effect of using treated crumb rubber aggregate as a partial replacement to fine aggregate on hardened state properties such as compressive and split tensile strength.

Effect on Bulk Density

The use of crumb rubber as a replacement of fine aggregates resulted in reduction of bulk density of fresh concrete.

Mix Group Untreated / Treated	Crumb Rubber Replacement (%)	Bulk Density (Kg/m^3) Untreated / Treated
C	0.0	2466
CR5 / TCR5	5.0	2322.59 / 2322.61
CR10 / TCR10	10	2236.58 / 2236.60
CR15 / TCR15	15	2134.40 / 2134.43



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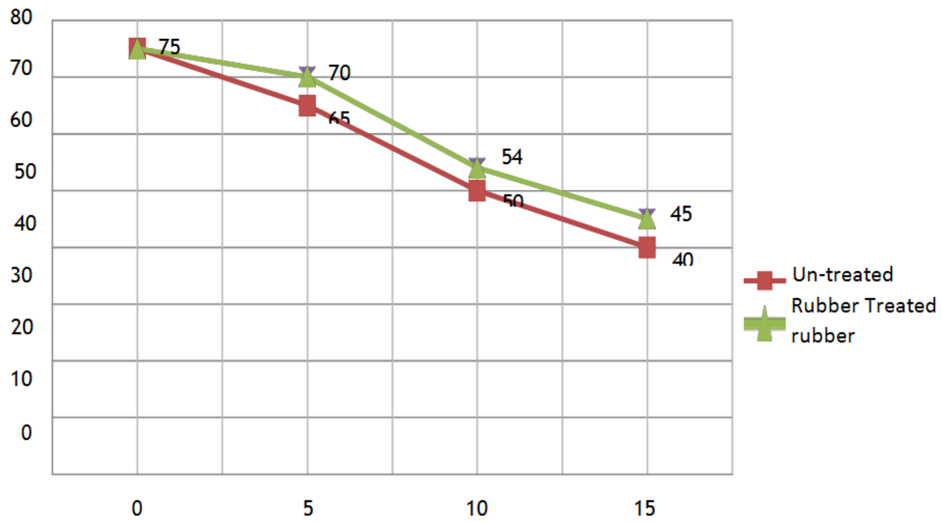
Effect on Workability:

The test results for workability of untreated and treated rubber modified concrete mix at replacement percentage of 0 %, 5 %, 10 % and 15 %.

Table: - Slump Values for Treated and Un-treated Concrete Mix

Mix Group	Replacement Percentage (%)	Pre-treatment of rubber	Slump (mm)
C	0.0	-	75
CR5	5.0	-	65
TCR5	5.0	PVA	70
CR10	10	-	50
TCR10	10	PVA	54
CR15	15	-	40
TCR15	15	PVA	45



Effect of fine aggregate replacement on slump of rubber modified concrete

Effect on Compressive strength

The compressive strength of concrete is very important, as it is used more often in compression than in any other stress condition. It is often taken as index of the overall “quality” of concrete.

Table:- Compressive strength of treated and untreated rubber modified concrete

Mix Group	Replacement percentage (%)	Compressive strength (N/mm^2)		
		7 days	28 days	56 days
C	0.0	35.46	48.07	53.57
CR5	5.0	28.33	37.56	43.06
TCR5	5.0	33.63	43.36	48.46
CR10	10	22.24	28.06	33.56
TCR10	10	27.64	34.06	38.96
CR15	15	14.12	20.37	25.87
TCR15	15	19.52	26.27	31.17

V. SCOPE FOR FUTURE WORK

In the present study, the effect of using pre-treated crumb rubber aggregates on the properties of rubber modified concrete were examined by carrying out extensive and detailed experimental programme, still there is a huge scope for future work on which research studies can be carried out by considering and modifying various aspects from the present study.

The scope of future work has been listed below:

- Study of effect of surface pre-treatment with synthetic resin on hydration of cement and durability of rubber modified concrete.
- Exploring other chemicals for pre-treatment and comparing the results with present study.
- Studying the effect of using coarse aggregate or coarse + fine aggregates which are pre- treated with synthetic resin, on fresh and hardened properties; and comparing the same with the present research.
- Study of micro-structure and fracture for rubber modified concrete treated with synthetic resin.
- Effect of using various types of fibers in treated rubber modified concrete.
- Pre-treatment of rubber aggregate belonging to different class of tyres with synthetic resin and carrying out comparative analysis.

VI. CONCLUSION

The following conclusions have been derived based on the extensive and rigorous experimental study carried out by the researcher:

- In both cases, the replacement of fine aggregate with untreated / treated crumb rubber aggregate by 5, 10 and 15 percent fine aggregate weight in normal concrete resulted in a decrease of approximately 5 percent in the bulk density of the concrete mixture, 9.30 percent and 13.44 percent respectively.
- Workability reduces the amount of aggregate content in the concrete mix with untreated / treated crumb rubber. However, the loss of slump in processed rubber-modified concrete mix was slightly smaller than untreated rubber-modified concrete mix at all replacement. Workable mixture with 5, 10 and 15 percent replacement; however, untreated and treated rubber-modified concrete mixture.

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