

EXPERIMENTAL STUDY ON CRUMB RUBBER WITH PARTIAL REPLACEMENT OF FINE AGGREGATE

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Abstract- The increase of about three crores discarded tyre each year poses a potential threat to the environment. The best way to overcome this problem is to find alternate aggregates for construction. The proposed work presents an experimental study of effect of use of solid waste material crumb rubber in concrete by volume variation of crumb rubber. Crumb rubber usually consists of particles ranging in size from 4.75 mm (No.4 sieve) to less than 0.075 mm (No. 200 sieve). Most processes that incorporate crumb rubber as an asphalt modifier use particles ranging in size from 0.6 mm to 0.15 mm (No. 30 to No. 100 sieve), 20% replacement of fine aggregate and 5% replacement of the total mixture exhibited acceptable properties for practical applications. Research project aims to provide in this project have aimed to study the effectiveness of rubber as substitute for fine aggregate and utilize the crumb rubber tyres in concrete, to minimize global warming.

Key words: Concrete, Compressive Strength, Crumb rubber, Flexural strength, Toughness.

1. INTRODUCTION

Tens of millions of tires are discarded across the world every year. Disposal of waste tires is a challenging task because tires have a long life and are non-biodegradable. The traditional method of waste tires management have been stockpiling or illegally dumping or landfilling, all of which are short-term solution. The environmental problem from growing, recycling Tyre is an innovative idea or way in this case. Recycling Tyre is the processes of recycling vehicles. Tyres that are no longer suitable for use on vehicles due to wear or irreparable damage such as punctures. The cracker mill process tears apart or reduces the size of Tyre rubber by passing the material between rotating corrugated steel drums. By this process an irregularly shaped torn particles having large surface area are produced and this particles are commonly known as crumb rubber..

Research that rubberized concrete can successfully be used in secondary structural components such as culverts, crash barriers, sidewalks, running tracks, sound absorbers, etc.

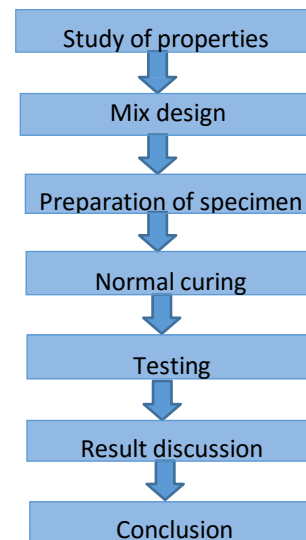
However, most of the developing third world countries have yet to raise their awareness regarding recycling of waste materials and have not developed effective legislation with respect to the local reuse of waste materials The proposed work presents an experimental study of effect of use of solid

waste material (crumb rubber) in concrete by volume variation of crumb rubber. One of the objectives of this paper is to make these data regarding the basic properties of modified concrete using crumb rubber in the concrete mix available to aid in the development of preliminary guidelines for the use of crumb rubber in concrete.



Crumb rubber

2. METHODOLOGY



3. MATERIALS AND PROPERTIES

3.1 CEMENT:

Ordinary Portland cement of Ultra tech brand of 53 grade confirming to IS 12269-1987 was used in the present study. The properties of cement are shown in.

Table 1 : properties of cement

SL.NO	PROPERTIES	RESULT
1	Initial Setting time	35min
2	Specific Gravity	3.148
3	Fineness Modulus	1.5%

3.2 FINE AGGREGATE:

Natural sand as per IS: 383-1987 was used. Locally available river sand having bulk density 1860kg/m³ was used. The properties of the fine aggregate are shown in.

Table 2: Properties of fine aggregate

SL.NO	PROPERTIES	RESULT
1	Specific Gravity	2.55
2	Fineness Modulus	2.36%
3	Water absorption	0.50%

3.3 COARSE AGGREGATE:

Crushed aggregate conforming to IS: 383-1987 was used. Aggregate of size 12mm of specific gravity 2.63 and fineness modulus are shown in.

Table 3: Properties of coarse aggregate

SL.NO	PROPERTY	RESULT
1	Specific Gravity	2.63
2	Fineness Modulus	6.75%
3	Water absorption	2.4%

3.4. CRUMB RUBBER:

Crumb rubber was using of fine aggregate in the sieve size of 2.35mm.

Table 4: Properties of crumb rubber

SL.NO	PROPERTY	RESULT
1	Specific Gravity	1.72
2	Fineness Modulus	4.48%
3	Water absorption	2%

3.5. MIX PROPORTIONING

Concrete mix design in this experiment was designed as per the guidelines in IS 10262-2009. All the samples were prepared using design mix. M30 grade of concrete was used for the present investigation. Based on I.S 10262-2009. The table 5 shows mix proportion of concrete (Kg/m³).

4. MIX PROPORTIONING FOR CONCRETE

This study consisted of one plain concrete as the control and crumb rubber concretes. All of the concretes were designed

at a constant water-cement ratio of 0.42. Crumb rubber was used as the replacement for an equal part of fine aggregate and mixture. Considering the different specific gravities of crumb rubber and mineral materials, the replacement with crumb rubber was conducted based on the volume other than weight. The replacement levels of crumb rubber varied from 5% to 20% by volume for fine aggregate and from 1% to 10% for the concrete mixture.

Grade designation	: M 30
Type of cement	: OPC 43
grade conforming to IS 8112	
Type of admixtures	: Crumb rubber
Maximum nominal size of aggregate:	20mm
Minimum cement content	: 320Kg/m ³
Workability	: 0.45
Exposure condition	: 100 mm
Degree of supervision	: Good
Type of aggregate	: Crushed angular aggregate
Maximum cement (OPC) content	: 450Kg/m ³
Chemical admixture type	: Super plasticizer

Ratio of mix design table 5:

Water	Cement	Fine Aggregate	Coarse Aggregate	Rubber
160litres	380.95 Kg/m ³	696.71 Kg/m ³	1169.72 Kg/m ³	5000 Kg/m ³
0.42	1	1.82	3.07	0.75

Ratio of admixtures table 6:

Mix	Rubber content	Water	Cement	Fine aggregate	Coarse aggregate	Crumb rubber
CF1	5	180	430	563.4	1197	13.4
CF2	10	180	430	533.7	1197	26.8
CF3	15	180	430	504.1	1197	40.2
CF4	20	180	430	474.4	1197	56.3

Concrete specimens were produced as mixing of the mixture was conducted by a power-driven revolving pan mixer. In order to achieve a more homogenous distribution of rubber particles in the mixture with less entrapped air, the pretreatment of crumb rubber was performed for 5 min before being added into the mixer. The mixing procedure was started with 2 min of pre-mixing of cement, aggregates and crumb rubber. Then, an additional 2 min of mixing were conducted after adding the water. After mixing, the mixture was poured into the molds with three layers. A vibration for five seconds was performed after rodding 25 times for each layer. All specimens were removed from the molds after 24 h

and cured in the conditions of 203 °C and 95% relative humidity. Prisms specimens (150 mm × 150 mm × 120 mm). for measuring compressive strength, splitting tensile strength and durability.

4.1 Test Methods

Compressive strength, splitting tensile strength, axial compressive strength and the modulus of elasticity of hardened concrete were measured as per. Compressive strength, splitting tensile strength and axial compressive strength were performed on a compression testing machine of a 200-tonne capacity by crushing the specimens cured for 28 days. The modulus of elasticity was tested in the elastic range for concrete specimens at 28 days. Load was applied gradually with a rate of 0.5–0.8 MPa/s, and the limit load was not larger than 1/3 of the axial compressive strength. The applied load and corresponding deformation were measured by a pressure meter and a dial indicator.

4.2 Mechanical properties

The mechanical properties of crumb rubber concrete were tested and are listed. The compressive strength of crumb rubber concrete cured for 28 days was lower than that of the control concrete (34.76 MPa). It was also observed that the compressive strength of CF (crumb rubber replacing fine aggregate) reduced from 34.76 MPa down to 33.41 MPa with increasing rubber content from 0% to 20%. The minimum compressive strength at the 20% replacement level satisfied the strength requirement of C30 concrete. When 5% of the total mixture was replaced, the compressive strength had an acceptable value of 25.38 MPa. However, a reduction (44%) was observed at the 10% replacement level. Compared to the replacement of mixture, replacing the fine aggregate with crumb rubber led to a marginal decline of the compressive strength.

Mechanical properties table 7:

Mixture	RC		
	0	5	10
Rubber content(%)			
Compressive strength(MPa)	34.76	34.52	34.19
Splitting tensile strength (MPa)	2.35	2.33	2.32
Axial compressive strength (MPa)	23.73	23.41	22.70
Modulus of elasticity (GPa)	31.75	29.60	27.88



Splitting tensile strength test

The reduction in axial compressive strength was similar to the compressive strength. It decreased with the increasing of the percentage content of crumb rubber. When the mixture was replaced by crumb rubber, the axial compressive strength significantly decreased as compared to the concrete with fine aggregate replacement. There was a strong correlation between the axial compressive strength and the replacement volume of crumb rubber.

Split tensile strength test table 8:

Mixture	CF		
	15	20	1
Rubber content(%)			
Compressive strength(MPa)	33.82	34.52	34.19
Splitting tensile strength (MPa)	2.31	2.29	2.14
Axial compressive strength (MPa)	22.34	21.29	22.70
Modulus of elasticity (GPa)	26.71	24.73	29.22

The reduction in axial compressive strength was similar to the compressive strength. It decreased with the increasing of the percentage content of crumb rubber. When the mixture was replaced by crumb rubber, the axial compressive strength significantly decreased as compared to the concrete with fine aggregate replacement. There was a strong correlation between the axial compressive strength and the replacement volume of crumb rubber.

The modulus of elasticity represented the deformation capacity of concrete. The test photograph is shown in Figure 5. It was observed that the modulus of elasticity for rubberized concrete decreased with the increase of the replacement level of crumb rubber.



Figure 6 modulus of elasticity test



Figure 8.Sulfate corrosion for crumb rubber concrete

4.3. Durability

Crumb rubber concrete cured for 90 days was set in the refrigerator for freezing, as shown in Figure 6. Additionally, thawing was performed in water. The strength of crumb rubber concrete after twenty-five cycles of freezing-thawing was tested. The strength loss ratio was calculated based on and is listed in Table 3. It can be seen that the concrete including crumb rubber had good resistance against freezing-thawing compared to the reference concrete. The strength loss ratio of the reference concrete was 5.8%, while the concrete with 20% replacement of fine aggregate was 2.7%, and concrete with 10% replacement of the total mixture was 2.0%. The influence of mixture replacement was more significant than the fine aggregate replacement. In addition, the increasing of rubber content generally improved the freezing-thawing resistance of concrete. However, when the replacement level exceeded a certain extent 5% total mixture, the improvement of freezing-thawing resistance was not obvious.

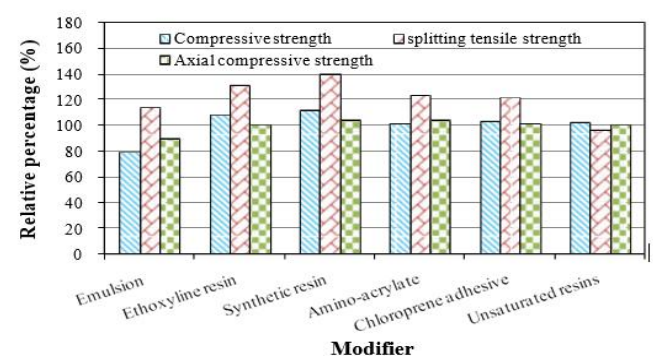
The crumb rubber particles in the rubberized concrete can prevent the formation of cracks and material separation. This may be the reason for the good performance to resisting freezing-thawing and sulfate attack for crumb rubber concrete.

Mechanical Properties			
Modifiers	Compressive Strength MPa (%)	Splitting Tensile Strength MPa (%)	Axial Compressive Strength MPa (%)
None	25.38 (100)	1.86 (100)	19.96 (100)
Emulsion	20.15 (79)	2.12 (114)	17.93 (90)
Ethoxyline resin	27.44 (108)	2.44 (131)	20.03 (100)
Synthetic resin	28.40 (112)	2.61 (140)	20.96 (105)
Amino-acrylate	25.90 (102)	2.30 (124)	20.80 (104)
Chloroprene adhesive	26.24 (103)	2.26 (122)	20.40 (102)
Unsaturated resins	26.12 (103)	1.80 (97)	20.07 (101)



Figure 7. Freezing-thawing of crumb rubber concrete

The strength loss ratio of the reference concrete was 5.8%, while the concrete with 20% replacement of fine aggregate was 2.7%, and concrete with 10% replacement of the total mixture was 2.0%. The influence of mixture replacement was more significant than the fine aggregate replacement. However, when the replacement level exceeded a certain extent (5% total mixture), the improvement of freezing-thawing resistance was not obvious.



It was indicated that the anti-corrosion coefficients of crumb rubber Concrete modified by six modifiers were all larger than 97%, which indicated that the pretreatments for the crumb rubber improved the ability of crumb rubber concrete to resist sulfate corrosion. Synthetic resin significantly reduced the strength loss ratio to 1.2%, which obviously improved the performance of freezing-thawing resistance. Due to the similar effect of pretreatment methods

on sulfate resistance, the optimal modifier was selected based on the improvement of the freezing-thawing resistance.

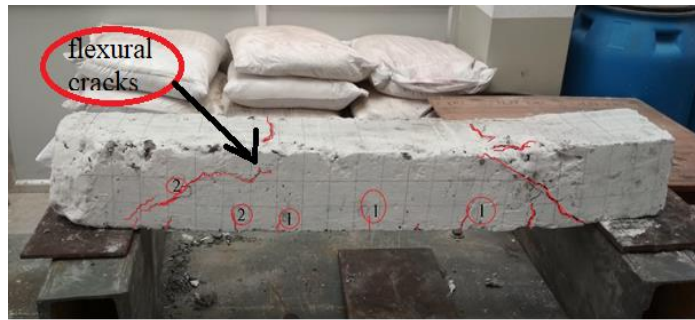
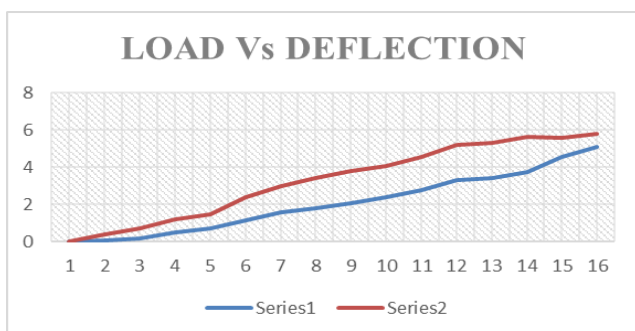


Figure .8 Experimental result for rubberized beam

Table 7.1.1 Tested beam under flexural cracks

S.NO	LOAD	DEFLECTION
1	0.4	0.16
2	0.8	0.35
3	1	0.53
4	1.2	0.66
5	1.5	0.93
6	1.8	1.2
7	2	1.4
8	2.4	0.78
9	2.6	2.1
10	3	2.38
11	3.3	2.76
12	3.3	3.12
13	3.3	3.44
14	3.3	3.79
15	3.2	3.98
16	3.2	4.1
17	3.2	4.4
18	3.2	4.7
19	3.2	5
20	3.2	5.38
21	3.5	5.75
22	3.6	6
23	3.6	6.85
24	3.4	7.2
25	3.4	7.9
26	3.4	8.22
27	3.4	9.1
28	3.4	9.4
29	3.4	9.75
30	3.4	10.14

According to this considering the beam present some structural and flexural cracks from the beam so the maximum load present have given to the beam created some crack deflections in this beam 2.5 % replacement of CR.



According this graph represents the load and deflections in beam by loading stage the deflection crack was happened in the center of the beam so the line was drawn in the graph while we clarifying the graph for correct result.

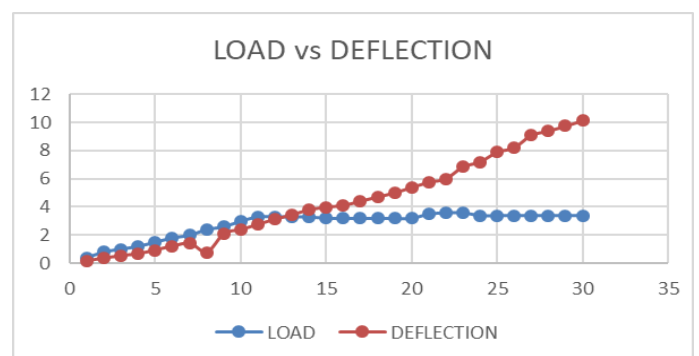


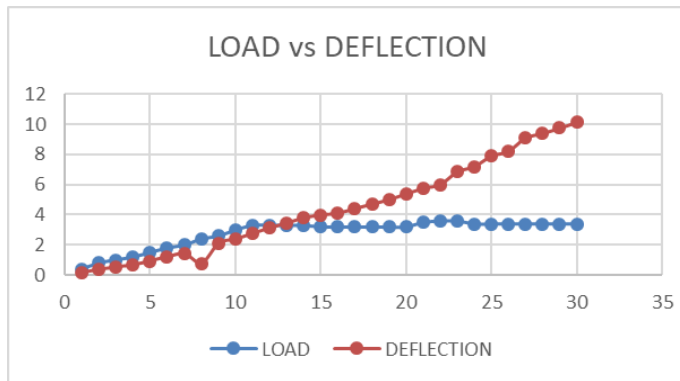
Figure 9. Experimental result structural cracks in the beam

This beam has containing the structural and flexural cracks in the cross section of the beam so red line was mentioned for identifying the cracks and number was wrote in the diagram 2- represents the flexural crack, 1-3 represents minor cracks.

Table 7.1.2 failure of Tested beam under normal crack

S.NO	LOAD	DEFLECTION
	0	0
1	0.1	0.3
2	0.2	0.5
3	0.5	0.7
4	0.7	0.8
5	1.18	1.2
6	1.57	1.4
7	1.82	1.6
8	2.08	1.7
9	2.38	1.7
10	2.76	1.8
11	3.3	1.9
12	3.41	1.9
13	3.75	1.9
14	4.55	1
15	5.1	0.7





This graph represents red and blue line for load and deflections the deflections is act in the beam for main causes for every building some deflections is happen broadly and life of structure is reduced for every year so the natural cracks & internal crack in structure.

5. CONCLUSIONS

This paper, crumb rubber concretes with different replacement forms and replacement levels were produced. The effect of the volume content of crumb rubber and pretreatment methods on the performances of concrete was investigated.

- (1) Adding crumb rubber into concrete resulted in a significant decrease of the mechanical properties, but increased the durability. The effect caused by replacing the mixture with crumb rubber was higher than that caused by fine aggregate replacement.
- (2) Compressive strength, splitting tensile strength, axial compressive strength and the modulus of elasticity were reduced with the increasing percentage content of crumb rubber, while freezing-thawing resistance and sulfate resistance were improved. A 20% replacement of fine aggregate and a 5% replacement of the total mixture with crumb rubber met the safety strength requirements of concrete and had excellent durability.
- (3) The negative effect of crumb rubber on mechanical strength could be minimized and avoided by pretreatment of the crumb rubber using modifiers. These pretreatments enhanced the adherence between the rubber and cement paste and achieved the uniform distribution of rubber particles in mixture.
- (4) Synthetic resin significantly improved the mechanical and durability properties of crumb rubber concrete as compared to the other modifiers. The compressive strength, splitting tensile strength and axial compressive strength of crumb rubber concrete prepared with pretreated rubber using

synthetic resin increased 12%, 40% and 5%, respectively. Additionally, the strength loss ratio after 25 cycles of freezing-thawing was reduced to 1.2%.

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