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Experimental Studies on Partial Replacement of Fine Aggregates with Crumb Rubber and Cement with Silica fume

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ABSTRACT:

Depletion of quality ingredients in nature is happening due to rapid infrastructure development in India. Recycling of waste products into the concrete composition is one solution. In present state of work, to study the strength behavior of new concrete composition replacing sand by scrap rubber and cement by silica fume. Fine aggregate is replaced at 10, 15 and 20% with crumb rubber and 10% of cement is replaced with silica fume. The behavior of strength was declining with respect to increase of waste rubber into the composition. By effective utilization of the waste rubber into the new concrete composition was reducing quantity and it may reduce the environmental pollution when it was fired.

Key Words***:*** Crumb Rubber, Silica Fume, Compressive Strength, Split Tensile Strength.

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INTRODUCTION

Wide range usage of concrete is in infrastructural development because of its characteristics. The usage of available natural resources and the consequent energy requirement for this processing has a serious. . Due to the vast usage of concrete in this century, concrete ingredients are depleting stage [1]. Recycling is one of the better options and research work has already started on recycling of aggregates. With continued research and trials, the waste material can be brought to effective usage and global acceptance. There is a growing awareness all over the world about the extensive damage being caused to the environment due to the accumulation of waste materials from the industrial plants, powerhouse colliery pits and demolition sites. Solid waste materials such as plastic bottles, papers, steel and waste rubber tires etc can be recycled without significant effect on the environment. The compressive strength and split tensile strength of concrete with crumb rubber as fine aggregate was reduced with increase of crumb rubber percentage [2]. Rubberized concrete found that the strength of the rubberized concrete was lower than conventional concrete [3]. The use of crumb rubber into the concrete mix was very much beneficial to the environment and disposal problem also solved by using this crumb rubber into the concrete composition. As for as to study the durability of crumb rubber concrete admixed with silica fume, was showed better results than the conventional concrete [4]. There was a reduction of compressive strength, split tensile strength and increase of flexural strength with increasing the percentage of waste rubber into the concrete composition [5]. The compressive strength decreased as the rubber content increased and as the rubber content increased, the tensile strength also decreased, but the strain at failure also increased [6]. It was observed that the mechanical strength of crumb rubber concrete was reduced, while durability was improved with the increasing of crumb rubber content [7]. Results were indicated that replacement of waste tire crumb rubber particles as fine aggregate into concrete at ratios 0.5 % and 1% there was no effect on the concrete properties would occur, but for replacement ratios1.5% and 2 % considerable changes were observed as compare to similar normal concrete [8]. Waste tire and plastics are crushed into fine particles of various sizes and are used to replace fine aggregate in concrete. As the replacement percentage increases, compressive strength reduced gradually. Maximum strength was obtained for 5% replacement of crumb rubber and plastic fines. At a Combination mix of 5% crumb rubber and 10% plastic fines, compressive strength was maximum obtained [9]. The study of the substitution effects of coarse traditional aggregates by rubber aggregates resulting from worn tires showed a decrease in the mechanical characteristics of the tested concrete [10].

LITERATURE REVIEW

From previous studies it was concluded that crumb rubber concrete produced a good workable concrete mix when compared to the conventional concrete mix for a given W/C ratio. It was also observed that the fatigue life of rubber concrete increased with the increase in crumb rubber concentration into the concrete mix. Various studies showed that crumb rubber concrete exhibited good resilience with increase in CR concentration. The water absorption of the concrete was found to increase with increase in CR concentration because of higher water absorption capacity of waste rubber. Certain studies concluded that high strength rubberized concrete could be used where there is a possibility of acid attack. Various studies have shown that the rubberized concrete showed increase in strength with the reduction in temperature as compared to the conventional concrete mix. Due to the presence of CR, it was possible to produce concrete mix with a unit weight much less than that of conventional concrete mix. Previous studies showed that the compressive strength, flexural strength and split tensile strength was found to reduce with the increase of increased replacement of CR. Therefore crumb rubber concrete cannot be utilized in structural members due to the entrapped air content was found to be high in rubberized concrete. Crumb rubber concrete has good brittleness and better thermal insulating property when compared to the conventional concrete. It was concluded that the high strength rubberized concrete be always highly resistant to the aggressive environments [11]. The rubber particles used in the experiment was from the recycled tire. Under certain stress levels, the fatigue life and dynamic strain of the rubber concrete were higher than the conventional concrete and it was increase to some extent with the increase of rubber contents. Under the same strength level, the fatigue performance of the rubber concrete was better than that of the conventional concrete. [12]. In the analysis of crumb rubber concrete results, the magnitude of strengths increased when temperature decreases, which was similar to the case of conventional concrete, but still exhibited good ductility in low temperature [13].

EXPERIMENTAL PROGRAMME

Experimentation was performed to conclude following

- ❖ Mechanical Properties of constituent materials of concrete
- ❖ Behavior of crumb rubber concrete in compression and indirect tension

MATERIALS IN THE CONCRETE COMPOSITION

Materials

Ordinary Portland cement (53grade) was used in experimental work, Preliminary tests were carried out on the constituent materials of the concrete composition. Silica fume was used at 10% by weight of cementetious material.

Table: 1 Test result on Cement

S.No.	Description	Test results	IS Code limits	IS Codes
1	Specific Gravity	3.14	3.10-3.15	IS: 269- 1989
2	Fineness Modulus	4.16%	<10%	IS: 4031-1988
3	Normal Consistency	31%	>26%	IS: 4031 - 1988 (Part 4)
4	Initial Setting Time	65mts	>30mts	IS: 269- 1989

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5	Final Setting Time	2hrs. 45mts.	<10hrs	IS: 269- 1989
6	Compressive Strength	55.8MPa	>53MPa	IS:12269-1987

Fine aggregate

Locally available "Penna River" sand was used in concrete composition, its specific gravity was 2.68 and confirming to Zone II of Table 4 of IS383-1970.

Coarse aggregate

Crushed granite aggregate available from local sources has been used in concrete composition and graded aggregates were used in concrete making with 20mm and 12.5 mm.

Table 2: Properties of Coarse Aggregate

Description	Value	IS Code limits	IS Codes
Specific gravity 20 mm 12.5mm	2.60 2.56	2.6-2.8	IS383-1980
Aggregate crushing value	18.20%	<30%	IS383-1980
Water absorption 20 mm 12.5 mm	0.23% 0.38%	<0.5%	IS383-1980
Impact value 20 mm 12.5 mm	20.2% 22.42%	<30%	IS383-1980

Water

Local available source of water used for mixing and curing of concrete and it is safe for usage in to the structural elements because of lower chlorides, fluorides and total solids are within the limitations. Test results of water analysis have been given in Table 3.

Table 3: Water Analysis

Parameter	Experimental values in mg/l	Permissible limits of mixing of water to the concrete in mg/l
PH	7.5	6 -8
Taste	Agreeable	Normal
Acidity	10	50
Alkalinity	88	250
Chlorides	300	2000 for PCC 3000 for RCC
Total Hardness	230	300
Sulphates	90	150
Fluorides	0.60	1.5
Dissolved Oxygen	6	5-7
Total solids	120	500
Total dissolved solids	150	500
Total suspended solids.	100	300

Crumb Rubber

Crumb rubber (CR) is produced by re-processing the disposed tires and removing the steel wire which was used in manufacturing of tires removed and makes this waste rubber into required

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sizes into the concrete composition. CR is fine rubber particles ranging in size from 0.075 mm to 2.5 mm but not more than 4.75 mm. The properties of crumb rubber presented in table 4. Fig 1 and 2 representing the Crumb rubber and silica fume. The crumb rubber was procured from recycled radial tires and discarded material. Crumb rubber passing through IS Sieve 4.75mm was used replacing fine aggregate at 10%, 15% and 20% by weight of fine aggregate was used into the composition and 10% silica fume used as replacement of cement in the concrete composition.

Table 4: Properties of Crumb Rubber

S.No	Description	Value
1	Specific Gravity	1.81
2	Fineness modulus	4.2
3	Water absorption	1.86%

Fig 1: Crumb Rubber of Size 0.075 mm to 2.5 mm

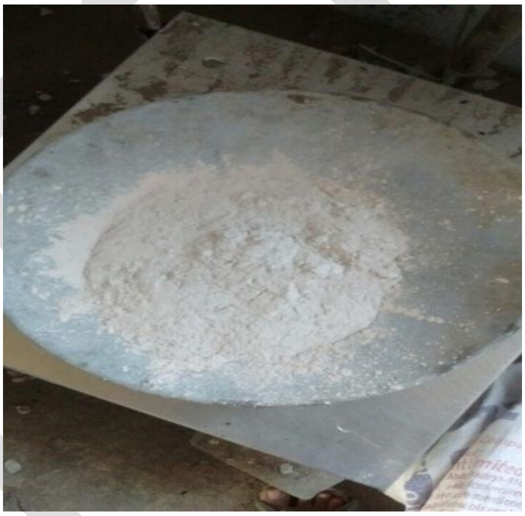

Fig2: Silica Fume

Silica Fume

Silica fume is a byproduct of produced from silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete to enhance the properties of concrete, because of its chemical and physical properties.

EXPERIMENTAL PROCEDURE

Compressive strength of concrete was determined by using cubical specimen of size 150x150x150mm. Specimens were cured and tested after 7 and 28 days. Three specimens were tested at two ages and the average values were recorded and noted

Splitting tensile strength test is carried out as per IS 5816:1999. The test is carried out by placing a cylindrical specimen of diameter 150 mm and length 300 mm horizontally between the loading surfaces of a compression testing machine and load is applied until failure of the cylinder along the vertical diameter. It was tested for 7 and 28 days.

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Fig3: Mixing and casting of Cube and Cylindrical specimens

RESULTS AND DISCUSSION

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. Systematic testing of raw materials, fresh concrete and hardened concrete are inseparable part of any quality control programmed for concrete, which helps us to achieve higher efficiency of the material used and a greater assurance of the performance of the concrete for both strength and durability.

Compressive strength

The compression test on hardened concrete was carried out as per IS 516:1959, test results are tabulated for 7 days and 28 days in Table 5 and 6.

Table 5.Compressive strength of Crumb Rubber concrete for 7days

Silica Fume (%)	Crumb Rubber (%)	Ultimate failure load (kN)	7 days Compressive Strength in MPa
10	0	665	29.3
	10	607	26.7
	15	560	24.6
	20	490	21.6

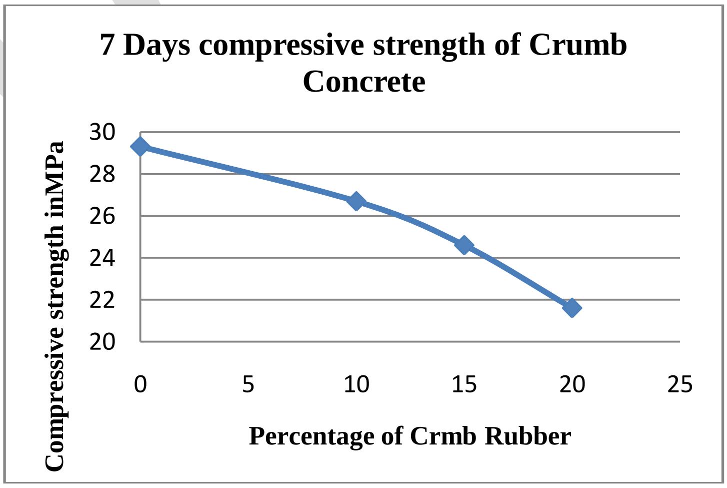

Figure 4.Variation of Compressive strength of Crumb Concrete for 7days

Table 6.Compressive strength of Crumb Rubber concrete for 28days

Silica Fume (%)	Crumb Rubber (%)	Ultimate failure load (kN)	28 days Compressive Strength in MPa
10	0	806	35.5
	10	778	34.2
	15	715	31.5
	20	649	28.6

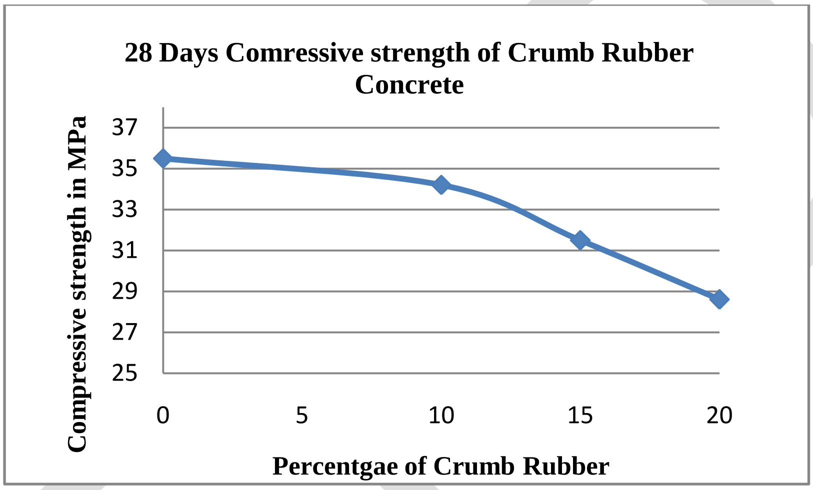

Figure 5: Variation of Compressive strength of Crumb concrete for 28 days

From Table5, it was observed that the compressive strength of concrete reduced with increase in CR content. Reduction of strength with respect to conventional concrete for 7 days is 26.3% and for 28 days is 19.4%. The value of 7 days is higher than the 28 days because of unhydrated cement particles. Reduction possibilities are due to the lack of adhesion and entrapped air between rubberized particles and other concrete ingredients.

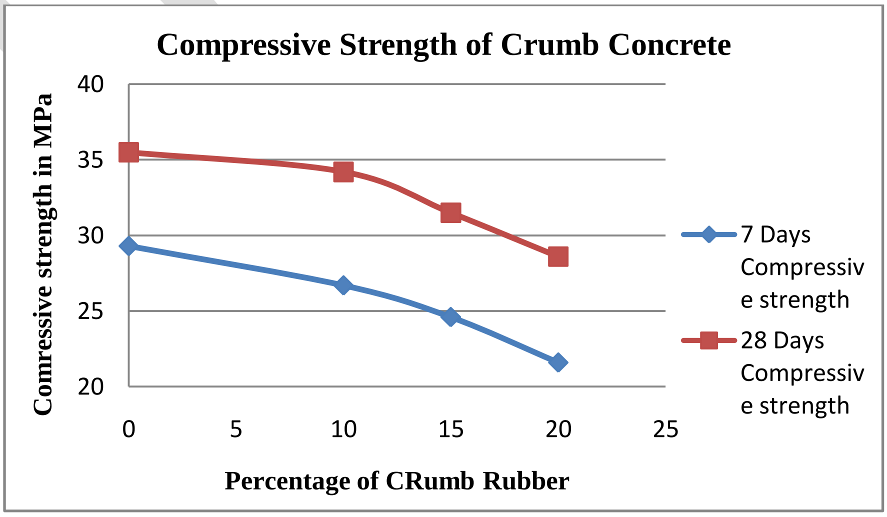

Figure 6: Variation of Compressive strength of Crumb concrete for all days

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Split tensile strength test

The indirect test on hardened concrete was carried out as per IS 516:1959, test results are tabulated for 7 days and 28 days in Table 7 and 8.

Table 7.Split tensile strength of concrete for 7days

Silica Fume (%)	Crumb Rubber (%)	Ultimate failure load (kN)	Split Tensile Strength in MPa
10	0	255	3.6
	10	212	2.97
	15	177	2.5
	20	155	2.2

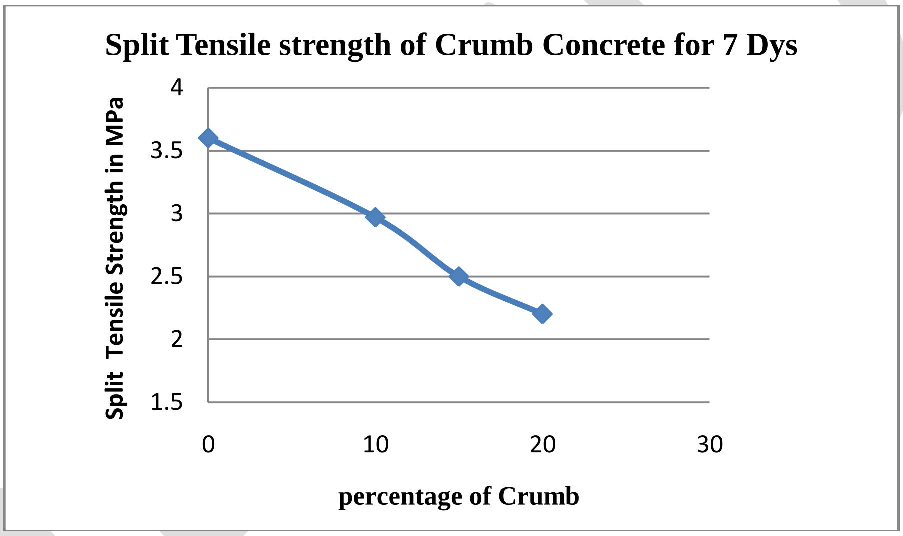

Fig 7: Variation of Split Tensile strength for 7 Days

Table 8.Split tensile strength of concrete for 28days

Silica Fume (%)	Crumb Rubber (%)	Ultimate failure load (kN)	28 Days Split Tensile Strength in Mpa
10	0	283	4.0
	10	223	3.1
	15	205	2.9
	20	195	2.7

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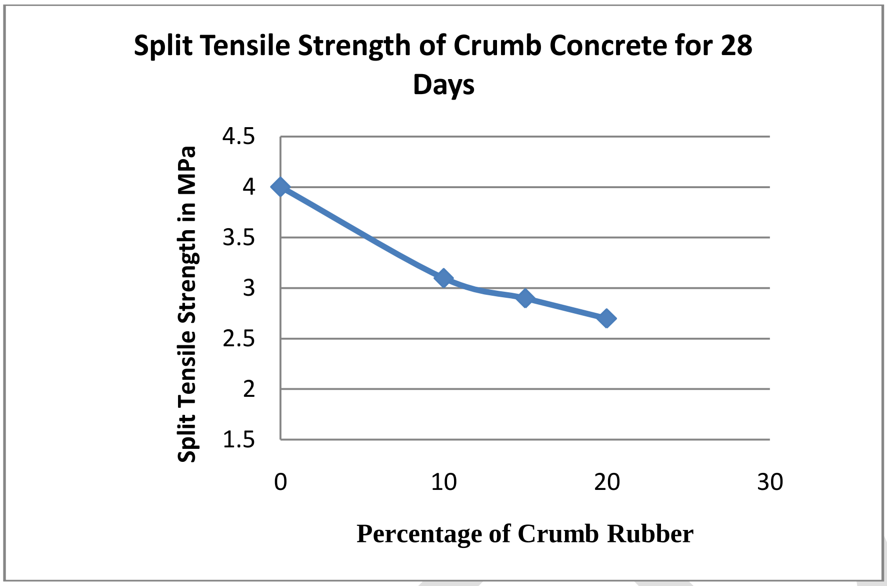

Fig: 8: Variation of Split Tensile Strength for 28 Days

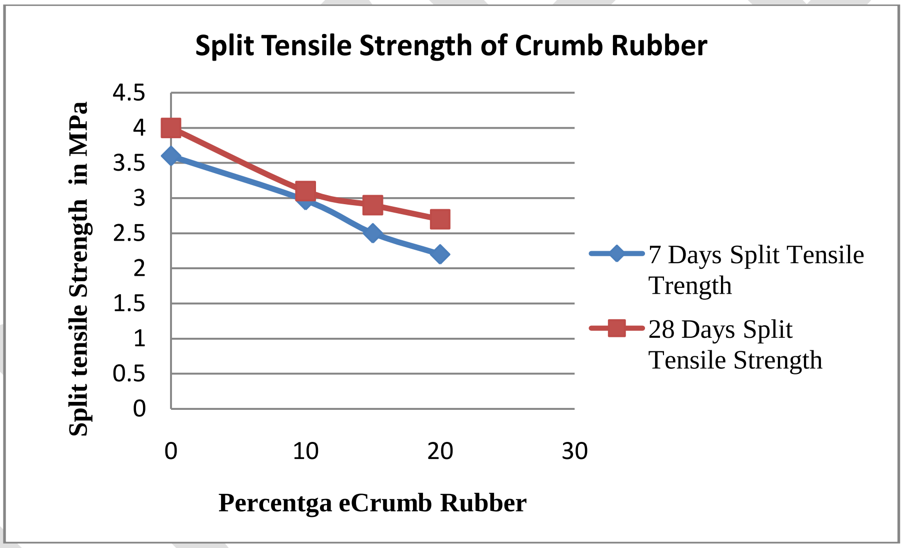

Fig 9: Variation of split Tensile Strength for all days

Based on the Table 7 and 8, the split tensile strength of concrete was found to reduce with increase in CR content for both 7th and 28th days. It was also observed that the crumb rubber replaced specimens remained in shape even after failure when compared to the conventional concrete mix. Reduction of split tensile strength with respect to conventional concrete for 7 days is 38% and for 28 days is 32.5%.The value of 7 days is higher than the 28 days because of unhydrated cement particles. Higher percentage of reduction in split tensile strength is observed due to the application of load in diametrical position. Same reason, which is related for this test also as it mentioned in compressive strength. Reduction possibilities are due to the lack of adhesion and entrapped air between rubberized particles and other concrete ingredients.

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CONCLUSIONS

The strength of crumb rubber concrete mixtures have been computed in the present work by replacing 0, 10, 15 and 20% crumb rubber as fine aggregate. On the basis of this following conclusions are drawn.

Compressive strength:

The compressive strength decreases with respect to control mix as the percentage of crumb rubber is increased. After adding 20%crumb rubber in the mix, there is decrease of 26.3% after 7 days, 19.4% decrease after 28 days. The compressive strength tends to decrease further with increase of crumb rubber waste in the mix. By the addition of crumb rubber into the composition, strength is decreasing but the waste dump will be used to decrease the quantity nearby industries.

Split tensile strength:

The split tensile strength also tends to decrease with increase percentages of crumb rubber into the mix. After adding 20% of crumb rubber into the mix, there is decrease of 38% after 7 days, 32.5% decreased after 28 days. The split tensile results follow a pattern similar to the compressive strength i.e., decreases in the value with increase in percentage of crumb rubber replacement However, the percentage increase in split tensile strength is larger as compared to compressive strength.

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