European Journal of Business & Social Sciences
Available at https://ejbss.org/
ISSN: 2235-767X
Volume 07 Issue 10
July2019

An Experimental Investigation On The Use Of Crumb Rubber As Fine Aggregate In Concrete

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Abstract: Waste tire rubber constitute a serious worldwide problem due to the lack of landfills and the health hazards associated with these landfills. In addition to the environmental motivation for providing a means of recycling large quantities of waste tire rubbers, the use of tire rubber particles provides a new type of concrete that has unique mechanical and fracture criteria. This paper presents the results of recent experimental investigations on rubber concrete. Chipped and crumbed tire rubber particles were used to replace coarse and fine aggregate with different volume replacement levels. With increase in demand of concrete, more and more new methods and new materials are being developed for production of concrete. In this study, the scope of research will be focused on the partial replacement of fine aggregate using Crumb Rubber (CR) material. In present investigation is mainly focused on the effect of mechanical properties on M20 and M80 grade concrete with CR replacement to fine aggregate. CR is used to replace cement in the concrete with 0 to 40 % by weight of cement.

1.0 INTRODUCTION

Recycling waste solid materials is one of the most challenging problems worldwide with the unprecedented growth of the world population. Tire rubber constitutes a large portion of that solid waste which has turned into a worldwide environmental concern. In several countries, tire rubber is being burned and used as fuel, which can result in serious hazards unless health considerations are carefully considered. Scrap tires dumped in sanitary landfills are a significant environmental hazard and result in possible contamination. Only small quantities of scrap tires are being used or recycled as construction materials. Recent reports worldwide have shown three interacting trends: first a significant increase in scrap tires added annually to the problem about

ISSN: 2235-767X
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300 million scrap tires are added only in the United States Rubber Manufacturers Association 2005; second, there is a significant increase in the cost of landfills; and third, increased pressure from civic societies and environmental activists for limiting the number of available landfills resulting in a move to ban disposal of whole tires in landfills. Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way. With advent of high-rise buildings and pre-stressed concrete, use of higher grades of concrete is becoming more common. Even the revised IS 456–2000 advocates use of higher grade of concrete for more severe conditions of exposure, for durability considerations. Since structural concrete is used extensively in the construction of various kinds of buildings, consumed at a rate of approximately one ton for every living human being and aggregate contributessignificantly to the structural performance of concrete, the high demand for concrete using normal weight aggregates such as gravel and granite drastically reduces the natural stone resources and this damages the environment thereby causing ecological imbalance.

Crumb rubber concrete (CRC) is similar to conventional concrete but uses shredded scrap tyre rubber as a partial substitution for mineral aggregates. Scrap tyres are among the largest and most problematic sources of waste of modern societies, due to their durability and the huge volumes of discarded tyres every year. When tyres are dumped to landfill they can cause numerous environmental problems, such as becoming breeding grounds for mosquitoes and other pests. In addition, when such tyre dumps catch fire it is notoriously difficult and costly to extinguish. The recycling of used rubber conserves valuable natural resources and reduces the amount of rubber entering landfill. Extensive previous research has been undertaken on CRC that shows a common problem, namely that replacing mineral aggregates in concrete with rubber aggregates results in compressive strength losses of up to 85% depending on the rubber size and content. Moreover, CRC has lower tensile strength and modulus of elasticity compared with equivalent conventional concrete. However, compared to conventional concrete,

In the construction industry, due to the depletion of naturalresources and increasing cost of construction materials, using alternative construction materials is gaining importance. Using waste materials in concrete has become a necessity to provide asustainable environment. Light weight concrete using waste is preferred due to its low density, good acoustic and thermal insulation. Due to the health and environmental risks presented from used tyre waste as well as the scarcity and cost of natural mineral aggregates, a significant body of recent research has focussed on utilizing used tyre rubber in concrete as a partial replacement of its mineral aggregates,

ISSN: 2235-767X
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resulting in a class of concrete called crumb rubber concrete (CRC). The recycling of used rubber conserves valuable natural resources and reduces the amount of rubber entering landfill. Previous experimental studies on CRC materials have shown that using rubber in concrete enhanced its ductility, toughness, impact resistance, energy dissipation, and damping ratio. However, it reduced its compressive strength, tensile strength, and modulus of elasticity compared to conventional concrete

2.0 LITERATURE REVIEW

Reda Taha This investigated the results of recent experimental investigations on rubber concrete. Chipped and crumbed tire rubber particles were used to replace coarse and fine aggregate with different volume replacement levels. The mechanical and fracture properties of rubber concrete were examined. Quasibrittlefracture mechanics models are used to determine the effect of incorporating tire rubber particles on the fracture performance of rubber concrete. Finally, some microstructural features of rubber concrete are also reported. It is concluded that the choice of the optimalreplacement ratio of the tire rubber particles can yield concretes with desirable strength and fracture toughness criteria for different applications.**Khalid**In their study, the mechanical and dynamic properties of Self-Compacting Rubberised Concrete (SCRC) were experimentally investigated. Crumb rubber from scrap tyres was used as a partial replacement for Fine Aggregate (FA), Coarse Aggregate (CA) and combined Fine and Coarse Aggregate (FCA) at 5, 10, and 15 wt% proportions.The Dynamic Modulus and Ultrasonic Pulse Velocity decreased as the proportion of rubber substitution was increased, however SCRC has superior vibration damping behaviour in all cases with up to 230% enhancement in damping ratio and damping coefficient for the CR 15 wt% mix.**Pitisukontasukkul**In their study, the thermal and sound properties of crumb rubber concrete panel were investigated. The

crumb rubber from used tires, produced in a local recycling plant, was used to replace fine aggregate at ratios of 10%, 20% and 30%. Properties such as thermal conductivity, thermal resistivity, heat transfer, conductance value, sound absorption at different frequency and noise reduction were investigated. Results indicated that crumb rubber concrete panel was not only lighter but had higher sound absorption and lower heat transfer properties than the conventional concrete panel.**Osama Youssf**In this research, three methods to improve and then assess the

mechanical performance of CRC have been examined namely, rubber pre-treatment using sodium hydroxide (NaOH) solution, using silica fume additives, and increasing concrete cement content. The effect of the rubber pre-treatment time (0–2 h), silica fume content (0–15%), and cement content (300–400 kg/m3) on CRC slump, short and long term compressive strength, and

ISSN: 2235-767X
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tensile strength were measured for fifteen concrete mixes prepared with 0% and 20% rubber content. Six 100*200 mm cylinders were prepared from each mix for evaluating the compressive strength at 7 and 28 days. Four additional 100 * 200 mm cylinders were prepared from two mixes for evaluating the compressive strength at 56 and 84 days. In addition, two 150 * 300 mm cylinders for each mix were prepared and tested to determine the indirect tensile strength at 28 days. The results showed that 0.5 h of rubber pre-treatment using NaOHsolution, 0% of silica fume replacing cement by weight, and 350 kg/m3 cement content were thebest alternatives in this assessment range to enhance the CRC performance.

3.0 MATERIALS

3.1 Cement:

Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being effected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS: 4032-1988.

3.2 Fine Aggregates:

River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963.The sand was surface dried before use.

3.3 Coarse Aggregates:

Crushed aggregates of less than 10mm size produced from local crushing plants were used. The aggregate exclusively passing through 10mm sieve size and retained on 6.5mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance

with IS: 2386-1963.

3.4 Water:

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about $3/10^{th}$ of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes

ISSN: 2235-767X
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place, so that the concrete becomes weak, but most of the water will absorb by the fibers.

3.5 Crumb rubber:

The average bulk specific gravity, fine modulus of crumb rubber used were 0.96 and 2.83 respectively.



Figure 1: Crumb rubber as fine aggregate

4. EXPERIMENTAL PROCEDURE

The investigation was aimed at studying the effect of CR on compressive strength, split tensile strength, flexural strength of M20 and M80 grade of concrete. Mix proportioning of concrete will be done based on guidelines of IS 10262: 2009. To study effect on strength of concrete the specimens will be tested for 28 days. Standard cubes (150x150x150 mm), cylinders (150 mm diameter, 300 mm height), prisms (100x100x500 mm) will be cast to investigate the behaviour on mechanical properties. Slump and Compaction factor will be done to test the effect on workability of concrete due to CR. The replacement of LPW will be varied from 0 to 40% with an increment of 10% i.e 0, 10%, 20%, 30%, 40% replacement to fine aggregates.

Cement	**Fly ash**	**Micro Silica**	**Fine Aggregate**
495	110	40	812
375	-	-	786
Grade of concrete	**SP**	**Water**	**Coarse Aggregate**
M80	5.8	188	765
M20	-	175	1150

Table 1 - Mix Proportions of mixes M 80 grade in kg/m^3

5. RESULTS AND DISCUSSION

5.1 Workability:

Workability test is performed on the fresh concrete by slump cone and compaction factor test. Slump cone test and compaction factor were conducted as per Indian standards as explained in previous chapter. The results of slump cone and compaction factor test for M20 and M80 grades of concrete with crumb rubber replacement to naturalfine aggregate is shown in table 2.

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Table 2: Effect of crumb rubber on workabilit

M20 and M80 concrete

Crumb Rubber Replacement (%)	Slump Cone	
	M20	
0	104	
10	96	
20	88	
30	72	
40	62	

Figure 2: Variation slump cone with crumb rubber replacement

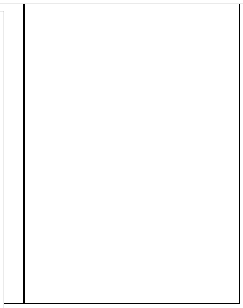


Figure 3: Variation compaction factor with crumb rubber replacement

5.2 Mechanical Properties:

Fresh properties of concrete like workability has performed using slump test. Slump is decreasing as the percentage of crumb rubber increases. Compression testing machine of 2000 kN used for the compression test and 600 kN UTM has been used for the split tensile test and flexural test. The results of compressive strength, split tensile strength and flexural strengthare given in the Table 2 and 3 respectively.

Table 2: Effect of crumb rubber on mechanical properties of M20 concrete

Crumb Rubber	Compressive strength	Spli

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Replacement (%)	(MPa)
0	28.5
10	26.8
20	25.7
30	20.2
40	25.4

Table 3: Effect of crumb rubber on mechanical properties of M80 concrete

Crumb Rubber Replacement (%)	Compressive strength (MPa)	Split tensile strength (MPa)	Flexural Strength (MPa)
0	88.5	5.20	7.98
10	83.6	5.05	7.76
20	81.2	4.98	7.65
30	75.8	4.81	7.39
40	72.4	4.70	7.22

Figure 4: Variation compressive strength with crumb rubber replacement

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Figure 5: Variation split tensile strength with crumb rubber replacement

Figure 6: Variation flexural strength with crumb rubber replacement

6.0 CONCLUSIONS

1. The workability of concrete is effected with the crumb rubber replacement to natural coarse aggregate in both grades of concrete.
2. The decrease in slump and compaction factor is observed with the increase in replacement levels of crumb rubber.
3. Crumb rubber replacementinto concrete has effected the mechanical propertiesof concrete.
4. Upto20% replacement levels of crumb rubber is effect in decrease in mechanical properties is limited to 5-10% only.

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5. Similarly, the adverse decrease in mechanical properties is observed with the increase in replacement of crumb rubber to 30% and 40% in both grades of concrete.
6. It is concluded that crumb rubber can be used as replacement to natural coarse aggregate to produce efficient light weight concrete.
7. Finally, optimum replacement of crumb rubber was observed to be 20% without much loss in fresh and hardened properties.

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