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EXPERIMENTAL INVESTIGATION OF BASALT FIBER MODIFIED RUBBERIZED CONCRETE (BFMRC)

Vinit Mungalpara[1], Prof. Bhavik Daxini[2], Prof. Amit Thoriya[3], Prof. Shaishav Viradiya[4]

[1, 2, 3, 4]*Department of Civil Engineering, Marwadi Education Foundations Group of Institution, Rajkot, Gujarat, India*

Abstract—: Crumb rubber as a composition of concrete is used to produce environmental friendly crumb rubber concrete (CRC). It provides substitute technique for recycling of waste tyres scientifically. CRC shows various advantages in comparison to conventional concrete. Though, the application of CRC is restricted due to its low compressive, tensile and flexural strengths. This paper suggests new modified method of concrete by adding basalt fiber in CRC. Material properties' testing of thirty six concrete mixtures was studied, considering M30 grade BFMRC and crumb rubber contents (0%, 1%, 2%, 3%, 4% and 5%). In addition, five different Basalt fiber contents (0%, 1%, 2%, 3%, 4% and 5%) were taken into consideration. The main advantage of BFMRC is brittle failure of the concrete can be minimized and the compressive strength can be increased from the test conducted on concrete containing basalt fiber and crumb rubber.

Keywords—: Modified concrete, Crumb rubber, Basalt fiber, Waste utilization, Compressive strength

I. INTRODUCTION

A wide variety of waste materials has been suggested as viable, or even beneficial, additives to concrete. These waste materials include cellulose, wood lignin, bottom ash, fly ash and silica fume. Crumb rubber concrete (CRC) is similar to conventional concrete but uses shredded scrap tyre rubber as a partial replacement for fine 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. In most of the parts of the world the use of vehicle tyre as crumb rubber is very less, so very often they are normally burn or just buried in landfills. Due to this i.e., landfill and burning there are many issue rising which are harmful to environment and causes Global Warming too. So now days many techniques have been came into work. There are also a many recycling methods for the tyre according to our needs. So it is not easy to decompose tyre under environment conditions and thus leads to serious issue. 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, CRC has higher energy dissipation, ductility, durability, damping ratio, impact resistance, and toughness. The objective of this research is to investigate the possibility of using crumb rubber as a replacement for the fine aggregates in conventional concrete. In this study the compressive strengths of crumb rubber concrete are evaluated, and the effect of the volume contents of the crumb rubber on these strengths is also examined.

Recently, basalt fiber (BF) has gained the attention of many researchers and several recommendations were reported in the literature for improving the mechanical properties of normal concrete using BF. BF is produced by environmentally friendly melting process of volcanic rocks in non-hazardous manner. Although the production process of basalt fiber is similar to that of glass fiber, it consumes less energy and misses out the additives. In this sense, basalt fiber is of advantageous in terms of the cost than that of glass or carbon fibers. Additionally, basalt fiber is an alternative reinforcement material for concrete compared to other fibers such as glass, carbon or aramid owing to the several advantages of higher graded material properties on its modulus, strength, thermal and chemical resistance.

II. LITERATURE REVIEW

Nahla Naji Hilal.[5] investigated the effect of crumb rubber size and content on hardened characteristics of self-compacting concrete. As per the result of the research conducted, the compressive strength and the adhesion between rubber particles and surrounding cement paste are decreased. Self-compacting concretes produced with crumb rubber (retaining on 1-mm sieve and passing from 4-mm sieve) gave the lowest net flexural strength compare to normal concrete.

Xie Jian-he, Guo Yong-chang, Liu Li-sha and Xie Zhi-hong.[12] examined the compressive and flexural behaviour of a new material mixture, rubber crumb and steel-fiber-reinforced recycled aggregate concrete (RSRAC). A total of 18 cubes (150 mm) and 18 cylinders (150 mm x 200 mm) were tested under axial compressive loading, and 18 beam of 150 x150 x 550 mm were tested subjected to three-point bending. Content of crumb rubber is 0%, 4%, 8%, 12% and 16% by volume substitution of sand. The effect of various percentage of crumb rubber is replaced by sand in NCA specimens is gradual decrease of compression strength. The compression strength of the RCA specimens decreased significantly, and a full replacement of NCA by RCA resulted in a decrease of 27.7% in the cylinder compression strength.

Trilok Gupta, Sandeep Chaudhary and Ravi K. Sharma.[11] considered rubber tyre as partial replacement of fine aggregate in the form of rubber ash and rubber ash with rubber fibers (combined form) with three w/c ratios. As per the result of the research conducted, that flexural strength of rubber ash (size ranging between 0.15 and 1.9 mm) concrete decreases with the increase of percentage of rubber ash whereas flexural strength of modified concrete is increased with the increase of the percentage of rubber fibers (2–3 mm width and maximum 20 mm in length) content. Micro-structural analysis shows the week interfacial bonding between the rubber ash/fiber and cement paste and the cracking occurred in the interface, which lead the reduction in the strength of waste rubber tyre concrete. This interfacial bonding can be improved by using surface treatment of rubber aggregates.

Zeynep Algin and Mustafa Ozen.[13] studied the use of basalt fiber in the production of self-compacting concrete. The basalt fibers of 3, 6, 12 and 24 mm in length are incorporated into the SCC mixtures as 0%, 0.1%, 0.3% and 0.5% of concrete volume. Result shows the addition of basalt fiber in SCC decreases the workability. The highest flexural and splitting tensile strength results are obtained from the concrete mixtures incorporated with the content of 0.5% fiber having the length of 24 mm. The highest compressive strength result is obtained from the mixtures containing the fiber content of 0.1% for the utilized fiber lengths of 12 mm and 24 mm.

Tehmina Ayub, Nasir Shafiqa and M. Fadhil Nuruddina.[10] studied influence of addition of 1, 2 and 3% Basalt fiber volume fraction in three different mixes of high-performance concrete (HPC) is investigated. The first mix was prepared by using 100% cement and other two mixes were prepared by replacing 10% cement content with silica fume and locally produced metakaolin. Results showed that the addition of Basalt fibers up to 2% fiber volume together with mineral admixtures improved the compressive strength.

Jongsung Sim, Cheolwoo Park and Do Young Moon.[6] investigated the applicability of the basalt fiber as a strengthening material for structural concrete members through various experimental works for durability, mechanical properties, and flexural strengthening. From the accelerated weathering test, the basalt fiber was found to provide better resistance than the glass fiber. However, the basalt fiber kept about 90% of the normal temperature strength after exposure at 600 °C.

III. MATERIALS AND METHODOLOGY

A. Properties of materials

1. Cement

For the experimental investigation of this research study, the normal Portland cement was used. In this experimental work, Ordinary Portland cement (OPC) of brand UltraTech Cement (43grade) confirming to IS 8112-1989 was used throughout the investigation.

2. Fine aggregate

Locally available natural river sand having fineness modulus of 2.605 conforming to IS 383-1970 specifications were used as fine aggregate, sand is conformed as Zone II.

3. Coarse aggregate

The course aggregate was used was of 20mm and 10mm size which was crushed granite obtained from local region and its specific gravity was 2.76.

4. Crumb rubber

Crumb rubber consists of particles ranging in size between 4.75mm (No. 4 Sieve) to 0.075mm (No. 200 Sieve). Generally, it is obtained from cracker mill process, granular process and micro-mill process. In cracker mill process tears apart or reduces the size of tyre rubber by passing the material between rotating corrugated steel drums. This process produces an irregularly shaped torn particles Granular process shears apart the rubber with revolving steel plates, producing granulated crumb rubber particles, ranging in size from 9.5mm (3/8 inch) to 0.5mm (No. 40 Sieve).

Figure 1: Crumb rubber

5. Basalt fiber

The material used in this study was obtained from extremely fine fibers of basalt. It is of 13 μm in diameter and 12mm in length. Some of the properties of basalt fiber are given in Table 1.

Figure 2: Basalt fiber

Table 1: Properties of Basalt fiber

Tensile strength, MPa	3000-4800
Elastic modulus, GPa	93-110
Elongation at break, %	3.1-6
Specific gravity	2.65-2.8
Max temperature of application, Celsius	650
Melting temperature, celcius	1470

B. Methodology

In this study, the combination of Basalt fiber modified rubberized concrete as per following Table 2.

Table 2: BF - CR combinations

Crumb rubber Replace by F.A.	Addition of Basalt fiber
0%	0% TO 5%
1%	0% TO 5%
2%	0% TO 5%
3%	0% TO 5%
4%	0% TO 5%
5%	0% TO 5%

IV. RESULTS & CONCLUSION

This study includes calculation of compressive strength of M30 grade concrete cubes containing Basalt fiber and crumb rubber. The cubes with dimension 150 mm x 150 mm x 150 mm are tested after being cured for 7 days using Compressive Strength Testing Machine, following results obtained are tabled below.

It has been observed that the compressive strength of concrete when crumb rubber replaces fine aggregate by 2% volume is almost similar to that of Normal Concrete (NC).

Basalt Fiber when added by 1% of total cement content, highest compressive strength is observed. Further, addition of 3% Basalt fiber and 1% replacement of Fine aggregate with Crumb rubber showed the best results as compared to other combinations.

Table 3 CRC compressive strength

Batch	7 days compressive strength (MPa)	28 days compressive strength (MPa)
BF0 CR0 (NC)	34.79	41.92
BF0 CR1	31.94	38.28
BF0 CR2	34.31	42.13
BF0 CR3	31.18	39.90
BF0 CR4	29.50	39.57
BF0 CR5	26.51	33.68

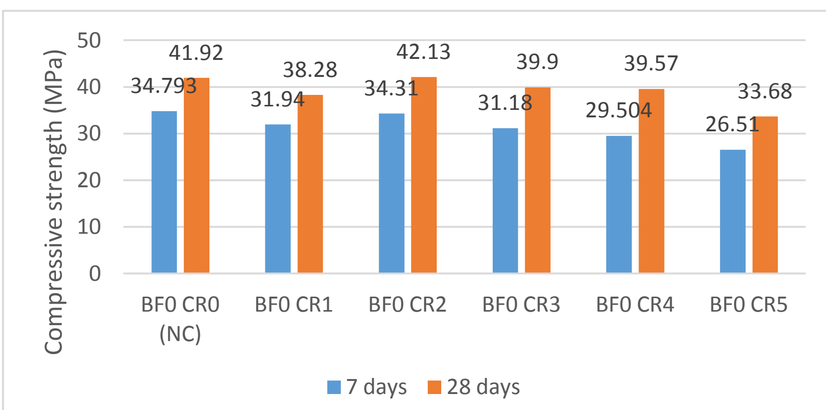


Figure3: Compressive strength of CRC

Table 4: BFC compressive strength

Batch	7 days compressive strength (MPa)	28 days compressive strength (MPa)
BF0 CR0 (NC)	34.79	41.92
BF1 CR0	36.56	45.67
BF2 CR0	33.73	42.71
BF3 CR0	27.47	38.25
BF4 CR0	29.02	33.02
BF5 CR0	28.54	41.41

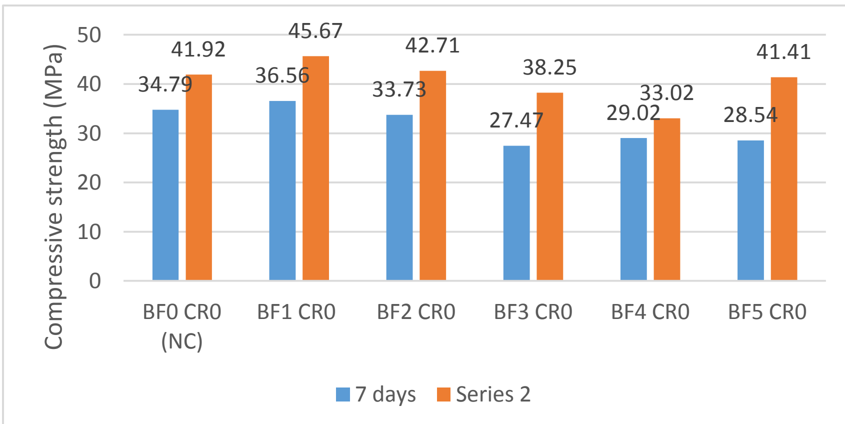
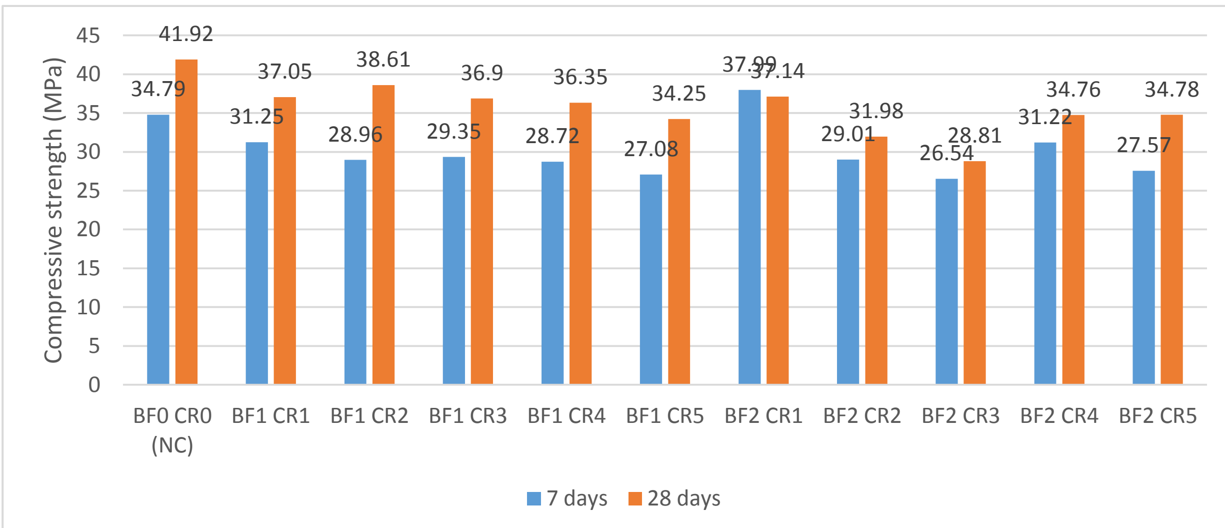


Figure 4: Compressive strength of BFC

Table 5 BFMRC compressive strength

Batch	7 days compressive strength (MPa)	28 days compressive strength (MPa)
BF0 CR0 (NC)	34.79	41.92
BF1 CR1	31.25	37.05
BF1 CR2	28.96	38.61
BF1 CR3	29.35	36.90
BF1 CR4	28.72	36.35
BF1 CR5	27.08	34.25
BF2 CR1	37.99	37.14
BF2 CR2	29.01	31.98
BF2 CR3	26.54	28.81
BF2 CR4	31.22	34.76
BF2 CR5	27.57	34.78
BF3 CR1	25.67	41.3
BF3 CR2	34.65	39.78
BF3 CR3	34.86	34.48
BF3 CR4	29.19	32.82
BF3 CR5	25.02	26.96
BF4 CR1	24.21	32.11
BF4 CR2	27.13	38.69

BF4 CR3	27.93	36.89
BF4 CR4	26.71	31.25
BF4 CR5	25.01	24.24
BF5 CR1	28.35	35.69
BF5 CR2	25.51	33.57
BF5 CR3	25.43	31.09
BF5 CR4	24.74	30.08
BF5 CR5	24.09	29.30



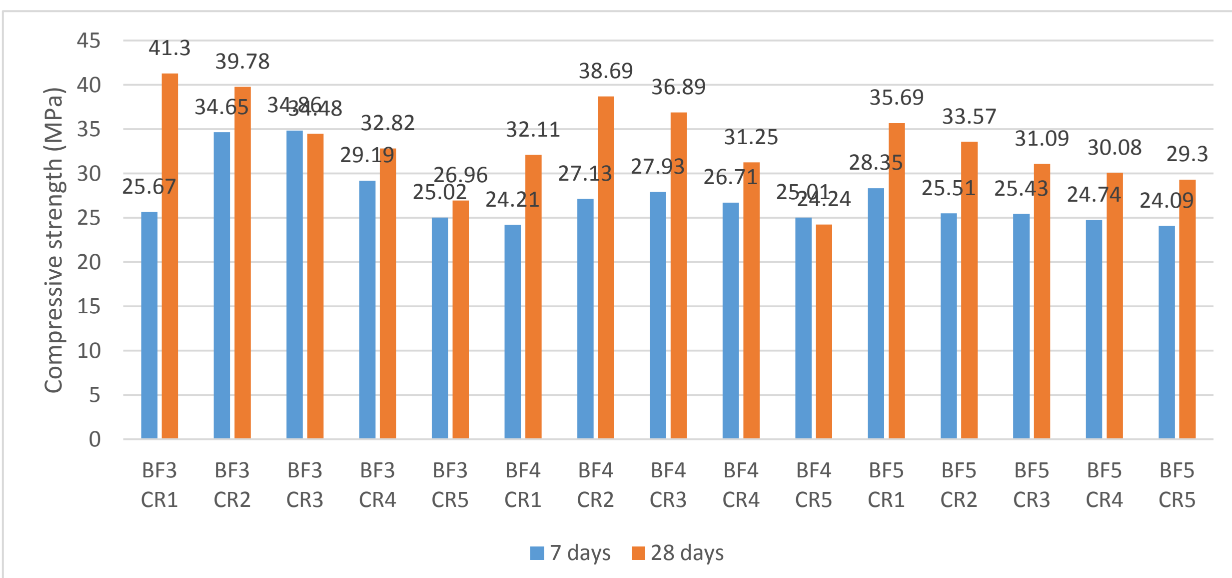


Figure 6 Compressive strength of BFMRC

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