EFFECT OF COMBINATION OF STEEL FIBRE AND CRUMB RUBBER ON THE PROPERTIES OF CONCRETE

Er.Mohd Ayoub Mirza[1], Er.Deepak Kumar[2]
[1]M-Tech Scholar, [2]Assistant Professor, Department of Civil Engineering, GNIT Mullana
Desh Bhagat Univerrsity, Mandi Gobindigarh, Punjab

Abstract: This paper investigates the effect of combination of crumb rubber and steel fibre on the performance of concrete. Crum rubber ranging in size 20mesh was incorporated into normal concrete(NC) and steel fibre concrete with 0.75% volume fraction of hooked end steel fibres(SFC) mixes by partially replacing fine aggregate at four different ratios(5%,10%15% and 20%). The standard compressive strength test, splitting tensile strength test, and flexural strength test were conducted. Impact resistance test and abrasion resistance test were also applied on the mixes.
Keywords: Crumb rubber, Hooked end steel fibre, Rubberized concrete, Compressive strength, Split tensile strength, Flexural strength, Abrasion resistance, Impact resistance

I. INTRODUCTION

Dumping of waste tyre rubber on landrepresent a major environmental problem of increasing significance. Over the years, disposal of waste tires has become one of the serious problems for the environment. Innovative solutions to solve the tire disposal problem have long been in development [1]. One of the effective methods for utilization of these materials is their use in concrete.

EshmaielGanjian [2] studied on concrete mixtures incorporating discarded tyre rubber as aggregate and as cement replacements. Results shown that compressive strength was reduced with increased percentage of rubber replacement in concrete, though with5% replacement of aggregate or cement by rubber, decrease in compressive strength was low (less than 5%) without noticeable changes in other concrete properties. Chen Bing [3] conducted study on the use of tire-rubber particles as a replacement for coarse aggregate in concrete. He concludedthat the substitution of coarse aggregate with rubber particles in concrete results in large reductions in compressive strength and modulus of elasticity. The flexural strength of concrete was reduced with increased levels of rubber particle content of coarse aggregate in concrete.

Trilok Gupta [4] assessed the effect of replacement of fine aggregates by waste rubber fibres on the impact resistance of concrete. Silica fume has also been considered as replacement of cement. Test results shown the impact resistance of concrete improves on replacement of fine aggregate by rubber fibres and on replacement of cement by silica fume. In another study Fabiana Maria [5] developed a concrete paving block that contributes to sustainability in building using recycled tire rubber (crumb rubber) as aggregate in concrete. He concluded thatthe compressive strength and flexural strength of concrete with tires rubber tends to reduce, but with 10% of replacement the compressive strength of the paving block had better values than the paving blocks made only with natural aggregate. And the rubber particles significantly improved the abrasion resistance of concrete.All the previous studies shown that substitution with rubber particles adversely affect the mechanical properties of concrete [1-5]. But at the same time use of waste tyre as aggregate replacement in concrete showing that a concrete with enhanced toughness, sound insulation, impact resistance, and reduced fatigue cracking properties can be achieved.

Steel fibre and crumb rubber were combined recently to investigate the mechanical properties and impact resistance of concrete with different ratios of crumb rubber [6, 7]. Use of steel fibre and crumb rubber showed a potential improvement in impact resistance. Moreover, a positive synergy of different concrete properties can be observed by combining these two materials. In current study, the advantages associated with the addition of steel fibres to concrete were joined with the one resulting from rubberized concrete concept. In this work the resulting material is, designated by Steel Fibre Reinforced Rubberized Concrete (SFRRC)

II. EXPERIMENTAL PROGRAMME

A. Materials Used

The materials used in the preparation of rubberized and steel fibre reinforced rubberized concrete mixes are: *1) Cement :* 53 Grade ordinary Portland cement conforming to IS 12269 was used in this study.

2) Fine Aggregate: Manufacturer's sand has been used for the present investigation. It conforms to Zone II with a specific gravity 2.62.

3) Coarse Aggregates: Coarse aggregates of 20 mm and 12 mm sizes were used in 60:40 ratio. The specific gravity of aggregate is 2.67.

4) Water : Potable clean drinking water available in the water supply systemconforming to the requirements of water for concreting and curing as per IS:456-2009 was used.

5) Superplasticizer:The superplasticizer used in this work was Master Glenium Sky 8233.

*6) Crumb Rubber***:** The rubber used in this study belongs to 20mesh with an average specific gravity of 1.15.

*7) Hooked End Steel Fibre***:** In this study fibres of 30mm length and 0.5mm diameter with an aspect ratio of 60 was used.

B. Mix Proportions

Concrete mix of strength M30 has been designed and modified with 0.75% of steel and varying percentages of crumb rubber (0%, 5%, 10%, 15% and 20%) by weight of fine aggregate. There were two basic mixes; rubberized concrete mixes (RC) and steel fibre reinforced rubberized mixes (SFRRC). The control mix in this research is designated as 'NC'. Mix proportioning specifications are detailed in Table 1.

TABLE 1: MIX PROPORTION

Mix Designation	Rubber %	Steel %	Cement kg	Fine aggregates kg	Coarse Aggregates kg	Rubber kg	Steel kg	Water litre	Superplasticizer ml
NC	0	0	388	670	1200	0	0	167	1476
RC5	5	0	388	634	1200	14	0	167	1476
RC10	10	0	388	632	1200	29	0	167	1476
RC15	15	0	388	624	1200	43	0	167	1476
RC20	5	.75	388	578	1200	58	0	167	1476
SRFC10	10	.75	388	589	1200	14	58.5	167	1476
SRFC20	5	.75	388	569	1200	36	58.5	167	1476

C. Testing Program
In this experimental study, following properties of concrete were tested as per relevant standards.
1) Compressive Strength Test: Compressive strength test was conducted on cube of size 150 mm as per IS 516:19593) 2) Split Tensile Strength Test: Split tensile strength test was conducted on cylinders of size 150 mm diameter and 300 mm height. The test was done as per IS 5816:1999.
3) Flexural Strength Test: Flexural test was conducted as per IS 516:1959 .The test was conducted on beams of size 100 mm x 100 mm x 500 mm.
4) Abrasion Resistance Test:The test for abrasion resistance was conducted as per IS 1237:2012. The test specimens shall be square in shape and size 7.06 x7.06 cm.
5) Impact Resistance Test:As the work conducted previously by Ahmed TareqNoaman , the fabricated rig, Fig. 1 , was used to conduct the impact test. In this test, beams of 100 mm x 100 mm x500 mm size were tested with a center to center span of 400 mm. A hammer of 5.1kg was dropped from a height of 0.17m .The impact energy was determined based on the number of drops that cause ultimate failure of the beam. The impact energy IE can be determined at any number of blows (N) by using the following equation.

IE = NMgH
Where,
N- Number of blows until failure,
M- Mass of hammer (5.1kg) ,
H- Height (0.17m),
g- Acceleration due to gravity (9.81m/sec2)

Fig. 1 Impact test rig with specimen

III. RESULTS AND DISCUSSIONS

A. Compressive Strength Test
The results obtained for cube compressive strengths for the different mixes at 28 day are shown in Fig. 2. As expected in line with the previous findings, the compressive strength showed a decreasing trend when the percentage of crumb rubber is increased. The 28th day compressive strength of normal concrete obtained is 39.8MPa. When the crumb rubber percentage varied from 5-20, the strength reduced by 4-42%. Steel fibre concrete mix with 5% replacement level of crumb rubber shows very negligible reduction in compressive strength. When the crumb rubber percentage varied from 5-20 in steel fibre mixes, the strength reduced only by 1-34%. In general, the steel fibre rubberized concrete mixes showed a higher compressive strength than rubberized concrete mixes due to incorporation of hooked end steel fibres.

B. Splitting Tensile Strength Test
Results obtained are reported in Fig. 3. The split tensile strength of control specimen obtained is 2.86MPa. With 20% replacement level of crumb rubber the strength reduced by 28%. Incorporation of hooked end steel fibres shows a considerable increase in the split tensile strength. SFRRC5 and SFRRC10 generated roughly 15% and 9% higher splitting tensile strength, respectively, than the control mix. And other steel fibre rubberised mixes also showed a better result than the rubberized concrete mixes.

Crumb Rubber Percentage
C. Flexural Strength Test
The effects of varying crumb rubber percentage are illustrated in Fig. 4. The flexural strength of control mix is obtained as 5.3Mpa. The flexural strength of rubberized

concrete containing 5%, 10%, 15% and 20% rubber was reduced by 14%, 27%, 34%, and 38% respectively compared with the strength of the control mix. The negative effects of the rubber on the flexural strength have a more significant effect than those on the compressive strength and split tensile strength. The addition of steel fibre can partially counterbalance these negative effects resulting from the incorporation of rubber. As shown in Fig.4, the fluctuation of the flexural strength is small when the quantity of rubber is below 10%. The traditional role of steel fibre in concrete to maintain the flexural strength is slightly affected by further increasing the rubber content beyond 10% .

Fig. 4 Comparison of flexural strength

D. Abrasion Resistance Test

The effects of varying crumb rubber percentage are illustrated in Fig. 5. From the test results, it was noted that the rubberized concrete showed better resistance to abrasion than that of the control mix. The depth of abrasion was 3.18 mm for the control mix. And for the concrete mix with 20% crumb rubber the wear was only 2.41mm. The abrasion resistance of rubberized concrete containing 5%, 10%, 15% and 20% rubber was increased by 6%, 12%, 14%, and 24% respectively compared with the strength of the control mix . Addition of steel fibres again increases the abrasion resistance. The depth of wear obtained for SFRRC20 was 1.22mm.

Fig. 5 Comparison of depth of abrasion

E. Impact Resistance Test

Fig. 6 summarizes the impact resistance test results of the rubberized and steel fibre rubberized concrete mixes.

It is observed that the impact energy increases with increase in replacement level of fine aggregate by rubber. It can be seen that on 20% replacement with crumb rubber in fine aggregates, the impact energy of control mix increases from 42.0J to 153.0J. The impact energy of steel fibre rubberized concrete mixes increases from 59.0J to 229.0J, 102.0J to 297.0J, 110.0J to 484.0J and 153.0J to 535.0J for 5%, 10%, 15% & 20% crumb rubber replacement levels.

Crumb Rubber Percentage

IV. CONCLUSIONS

Based on the experimental results the following conclusions can be drawn:-

1) The compressive strength, split tensile strength & flexural strength of rubberized concrete decreased considerably with the increase in rubber content. The percentage reduction of the above properties can be reduced with the incorporation of hooked end steel fibres.

2) In normal concrete when the crumb rubber percentage varied from 5-20, the compressive strength reduced by 4-42%.

But in the case of steel fibre concrete mixes when the crumb rubber percentage varied from 5-20, the compressive strength reduced only by 1-34%.

3) The split tensile strength shows a decreasing trend with the increase in crumb rubber content. Incorporation of hooked end steel fibres shows a considerable increase in the split tensile strength. SFRRC5 and SFRRC10 generated roughly 15% and 9% higher splitting tensile strength, respectively, than the control mix.

4) .The negative effects of the rubber on the flexural strength have a more significant effect than those on the compressive strength and split tensile strength. The addition of steel fibre can partially counterbalance these negative effects resulting from the incorporation of rubber.

5) The abrasion resistance of concrete mixes increases with increase in the crumb rubber percentage level. The abrasion resistance of rubberized concrete containing 5%, 10%, 15% and 20% rubber was increased by 6%, 12%, 14%, and 24% respectively when compared with that of the control mix. It increases again with addition of steel fibres.

6) The impact energy increases with increase in replacement level of fine aggregate by rubber.

7) Steel Fibre Reinforced Rubberized Concrete (SFRRRC) with rubber replacement level less than 10% shows improved abrasion and impact resistance combined with adequate compressive strength, split tensile strength and flexural strength

REFERENCES

[1] L.Zheng, X. Sharon Huo, Y. Yuan,“Strength, Modulus of Elasticity, and Brittleness Index of Rubberized Concrete”, *Journal of Material in Civil Engineering* , 2008, pp. 692-699

[2] EshmaielGanjian , MortezaKhorami , Ali Akbar Maghsoudi,”Scrap-tyre-rubber replacement for aggregate and filler in concrete”, *Construction and Building Materials* 23, 2009, pp.1828–1836

[3] Chen Bing, Liu Ning, “Experimental Research on Properties of Fresh and Hardened Rubberized Concrete”, *Journal of Material in Civil Engineering* 26, 2014, pp.8

[4] Trilok Gupta , Ravi K. Sharma , Sandeep Chaudhary,“Impact resistance of concrete containing waste rubber fiber and silica fume”, *International Journal of Impact Engineering* 83, 2015, pp. 76-87

[5] Fabiana Maria da Silva , Luisa AndréiaGachet Barbosa , Rosa Cristina CeccheLintz , Ana Elisabete P.G.A. Jacintho, “Investigation on the properties of concrete tactile paving blocks made with recycled tire rubber”, *Construction and Building Materials* 91, 2015, pp. 71–79

[6] Ahmed TareqNoaman, B.H Abu Bakar, Hazizan Md. Akhil “The effect of combination between crumb rubber and steel fibre on impact energy of concrete beams”, *Procedia Engineering* 125, 2015, pp. 825-831

[7] XieJian-he , Guo Yong-chang , Liu Li-sha , XieZhi-hong,“Compressive and flexural behaviours of a new steel-fibre-reinforced recycled aggregate concrete with crumb rubber”, *Construction and Building Materials* 79, 2015, pp.263–272

[8] BlessenSkariahThomas,Ramesh Chandra Gupta , PawanKalla, Laszlo Cseteneyi,“Strength, abrasion and permeation characteristics of cement concrete

containing discarded rubber fine aggregates", *Construction and Building Materials* 59, 2014, pp. 204–212.

[9] PitiSukontasukkul,"Use of crumb rubber to improve thermal and sound properties of pre-cast concrete panel", *Construction and Building Materials* 23, 2009, pp. 1084–1092

[10] Y.C. Guo , J.H. Zhang , G. Chen , G.M. Chen a, Z.H. Xie, "Fracture behaviors of a new steel fiber reinforced recycled aggregate concrete with crumb rubber", *Construction and Building Materials* 53, 2014, pp.32–39

[11] K.B. Najim , M.R. Hall,"A review of the fresh/hardened properties and applications for plain-(PRC) and self-compacting rubberised concrete (SCRC)", *Construction and Building Materials* 24 ,2010, pp.2043–2051

