International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 07, July-2019

Experimental Study on Strength Behavior of Concrete with Partial Replacement of Cement with Silica Fume and Coarse Aggregate with Waste Tyre Rubber

Danish Zafar [1*], Mohd. Bilal Khan [2]

[1] *M.Tech (Research Scholar), Department of Civil Engineering, Integral University, Lucknow (UP), India.*
[2] *Assistant Professor, Department of Civil Engineering, Integral University, Lucknow (UP), India.*

Abstract:** A very large amount of waste rubber tire are being generated each year all around the world. Being non-biodegradable in nature their recycling is not easy. On burning they produce very toxic and harmful smoke. So the only option is to dump them to landfills. It is also not a proper solution as it takes a lot of space and stockpiles of waste rubber leads to soil pollution and contaminate water bodies along with ground water. Statistics show that every year more than 500 million tires are discarded to landfills, and the estimation is about 5000 million tires would be discarded by 2030. Many research studies has shown that the waste rubber tires could be used in concrete. Concrete with rubber tire has shown reduction in compressive and flexural tensile strength but they do possess some positive aspects as they have better toughness, impact resistance, thermal and sound properties. This paper presents a literature review on using waste rubber tire in concrete as a partial replacement of cement, coarse or fine aggregates.

***Keywords** : Chipped rubber, ground rubber, cement, silica fume, rubberized concrete, compressive strength, split tensile strength*

1. Introduction

The recent growth of automobile industry and use of vehicles has increased the production of tires all through the world. This has lead to large accumulation of used tires. The major problem of these tires is their disposal. Million of tires are discarded each year causing environmental risk to pollution.

It is estimated that each year about 1000 million tires end their service life and more than 500 million among them are discarded to landfills [30]. A future estimation is that the number of waste tire discarded yearly would reach 1200 million. And there could be as many as 5000 million of stockpiled discarded tire throughout the world. In 2008, the global production of waste tire was about one billion and production of new tires was about 1.5 billion. Rubber Manufacturer's Association [31] in one of their statement say that every year about 75 million of waste tires are stockpiled in US itself and more than 230 million are produced. In India also there would be about 112 million of discarded tire per year after retreading twice [13].

These waste tires are non-biodegradable in nature and on burning produces very harmful and toxic gases dangerous to health. So, a maximum amount of these waste tires are thrown to landfills causing very adverse effect on environment. A very small amount of rubber from the tire gets abraded after its whole service life, this means that a whole of rubber is discarded. Their disposal in landfill also has some adverse effect on nature. Along with occupying a very large space in a landfill their decomposition also creates a variety of issues making it unfeasible to decompose. Waste tire rubber own shape allows it to store water for a long period causing a breeding place for mosquitoes and other insects. It also causes contamination of underground water and above ground water and also spoils the fertility of soil by destroying many beneficial bacteria present in soil. [Wikipedia]

Research in the past has shown that these waste tire rubbers could be used in concrete. In literatures, the term "Rubberized Concrete" or "Rubber Modified Concrete" is used for concrete made with mixing waste tire rubber particles into plain concrete. A lot of properties gets enhanced by replacing some components of concrete with waste tire rubber particles making it suitable for use in a particular work. Many countries have made it compulsory to use waste tire rubber in their construction work. In this way it could be proved to be a means of sustainable development.

Waste tire rubber particles have been used in concrete in three different forms: (1) Shredded or Chipped rubber- It's size vary from 2- 20 mm. It is used to partially replace coarse aggregates. (2) Crumb rubber- It's size vary from 4.75-0.425 mm. It is generally used to partially replace fine aggregates. (3) Ground rubber- It is in the powder form. It's size is less than 0.425 mm. It is used to partially replace cement content.

2. Experimental study

Five concrete mixes were cast with varied percentage of rubber chips and combination of rubber chips and silica fume for w/c ratio as 0.41. Compressive strength, split tensile strength and unit weight of these specimen were determined as per codal guidelines.

2.1 Material

Pozzolana Cement(PPC- Fly ash based) conforming to IS 1489 (part I) manufactured by Ambuja Cement having specific gravity 3.15 was used for the concrete mixes in this study. Fine aggregates (natural sand) of specific gravity 2.6

and coarse aggregate (crushed gravel) having nominal size of 20 mm and specific gravity 2.69 was used in this experimental work. Rubber was obtained from local market and cut into desired nominal size of 20 mm. Physical and mechanical properties of cement, fine aggregates and coarse aggregates has been shown in Table 1.

Rubber chips and silica fume in the mixes were used as partial replacement of coarse aggregates and cement respectively. Rubber chips particle size distribution ranges from 10 mm to 20 mm.

Table 1 Properties of cement, fine aggregates and coarse aggregates

Properties	*Observed Value*
Initial Setting Time of cement	33 minutes
Final Setting Time of cement	625 minutes
Grade Zone of fine aggregates	I
Specific Gravity of fine aggregates	2.6
Water Absorption of fine aggregates	1.52%
Specific Gravity of coarse aggregates	2.69
Water Absorption of coarse aggregates	0.43 %

2.2 Mix proportion

A total of five mixes were prepared. First mix was of plain concrete(PC). In the second mix, 10 percent of coarse aggregate by weight was partially replaced with rubber chips. In the third mix, 20 percent of coarse aggregate by weight was partially replaced with rubber chips. In the fourth mix, 10 percent of coarse aggregate by weight was partially replaced with rubber chips and 10 percent of cement by weight was partially replaced with silica fume. In the fifth mix, 20 percent of coarse aggregate by weight was partially replaced with rubber chips and 10 percent of cement by weight was partially replaced with silica fume. The details of all the mixes is shown in Table 2.

Table 2 Mix proportion of concrete

Mix	Cement(Kg/m^3)	Silica Fume(Kg/m^3)	Fine Aggregate(Kg/m^3)	Coarse Aggregate(Kg/m^3)	Rubber Chips(Kg/m^3)
1:RC0	450	0	663	1120	0
2:RC10	450	0	663	1008	112
3:RC20	450	0	673	896	224
4:SF10RC10	405	45	673	1008	112
5:SF10RC20	405	45	673	896	224

2.3 Mixing and casting

First of all, the interior of mixing drum was wetted with water in order to minimize the absorption of water added as a part of the concrete mixture. Firstly the coarse aggregate fractions was mixed followed by the tyre rubber chips in required amount. Rubber chips were pre soaked in cement paste before using in concrete mix in order to achieve better bonding strength. After that fine aggregates and cement content was added and mixed properly. Were required, silica fume was added after it. Water was added at last in three steps while the drum is operating. All the contents were mixed for about 5 minutes.

A total of 15 cubes of 150 mm size and 9 cylinders of 150 mm X 300 mm size were casted. All the specimens were taken to the vibrating table after casting in order to achieve proper and consistent compaction. The specimens were left in the laboratory at room temperature for 24 hours.

After 24 hours of placing concrete in moulds, the sample were de-moulded and were kept in water for curing. After a curing of 28 days, the specimens were tested.

The compressive strength of specimens were determined according to the Indian Standard IS 516:1959 on cube specimens of sizes 150 mm X 150 mm X 150 mm. The split tensile strength test of specimens were carried out according to Indian Standard IS 5816:1999 on cylinder specimens of height 300 mm and diameter 150 mm.

3. Result and discussion

3.1 Unit weight

The addition of rubber chips in the concrete decreases its unit weight. Fig. 1 shows the unit weight of all the specimens. It is observed that the unit weight of rubber chips concrete decreases with an increase in the percentage of rubber content. The density of waste rubber chips is low in comparison to the gravel. This is why the unit weight of rubber chips concrete is less than plain concrete.

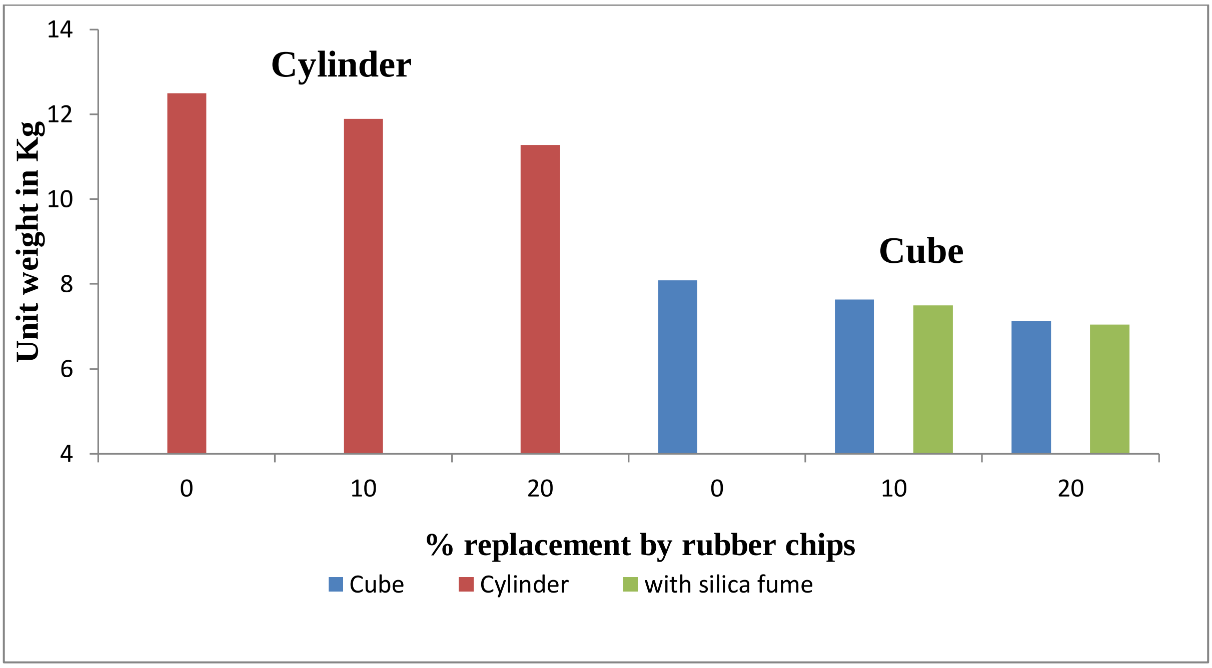

Fig. 1 Unit weight of specimens after 28 days

3.2 Compressive strength

Compressive strength test was performed on compression testing machine having capacity of 3000kN after 28 days of casting. It is observed that the compressive strength of rubber chips concrete decreases with an increase in the percentage of rubber chips. Also, the compressive strength of rubber chips concrete increases to some extent after adding silica fume. This is so because the compressive strength of waste rubber is very less in comparison to the gravel, so the strength of specimens decreases with an increase in the percentage of rubber chips. Silica fume enhances the compressive strength of concrete due to its very small particle size distribution which allows it in making stronger bonding with other constituents particles. Hence, the strength of rubber chips concrete increases after adding silica fume.

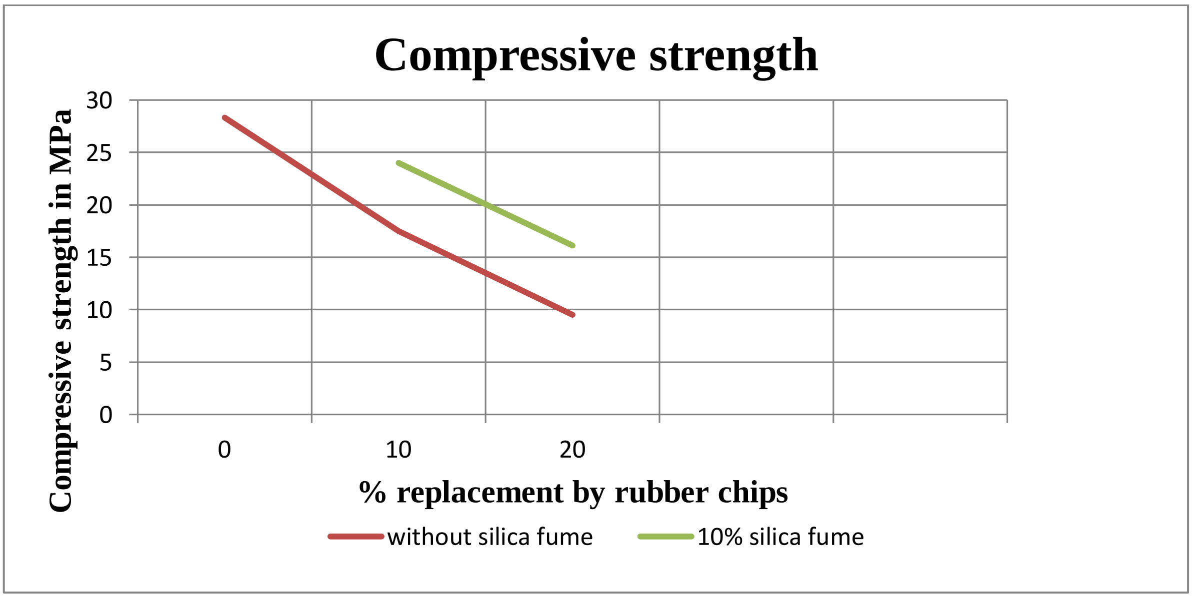

Fig. 2 Compressive strength of specimens after 28 days

3.3 Split tensile strength

Split tensile strength test was performed on compression testing machine having capacity of 3000kN after 28 days of casting. It is observed that the split tensile strength of rubber chips concrete decreases with an increase in the percentage of rubber chips. This is so because the tensile strength of waste rubber is very less in comparison to the gravel, so the strength of specimens decreases with an increase in the percentage of rubber chips.

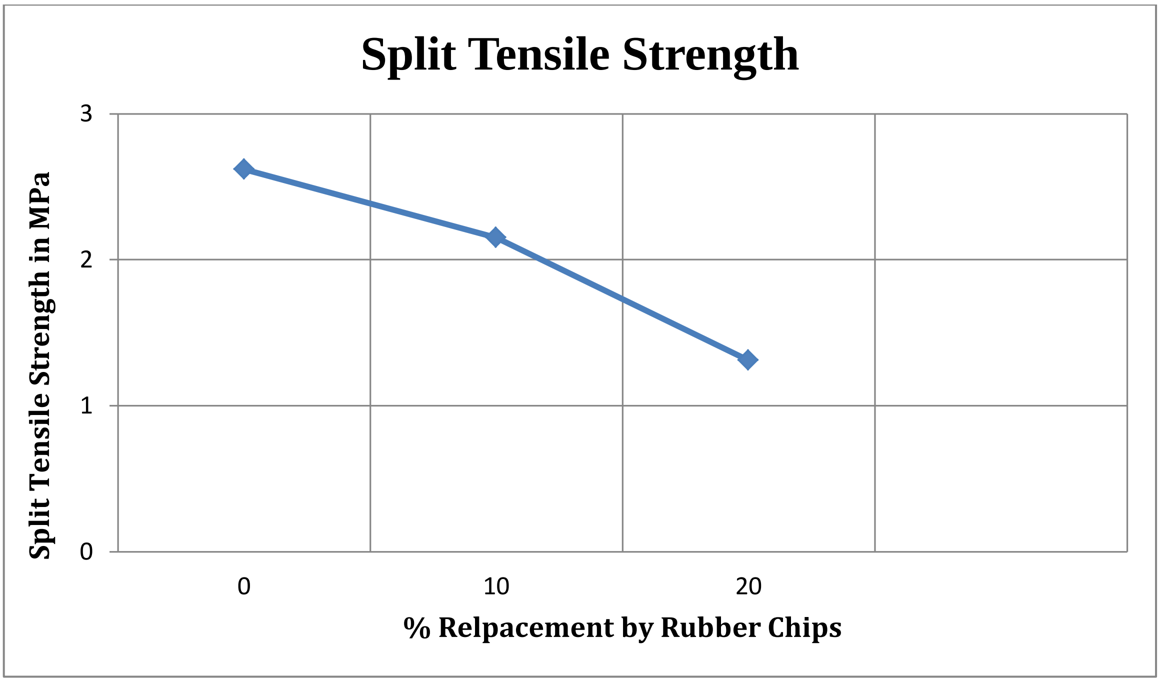

Fig. 3 Split tensile strength of specimens after 28 days

4. Conclusion

- Unit weight of concrete with waste tyre rubber chips decreases with an increase in the percentage of rubber content. This concludes that, rubber chips concrete could be used in making light weight concrete.
- Compressive strength of concrete with waste rubber tyre chips decreases with an increase in the percentage of rubber contents. Also, the compressive strength of concrete increases with the addition of silica fume. As the compressive strength of rubberized concrete is less, it is not suitable for use as a structural component but it could be used as a non structural component.
- Split tensile strength of concrete with waste tyre rubber chips decreases with an increase in the percentage of rubber content.

Refrences

[1] Aiello MA, Leuzzi F. Waste tyre rubberized concrete: Properties at fresh and hardened state. Waste Manag 2010;30:1696-704

[2] Elchalakani M. High strength rubberized concrete containing silica fume for the construction of suitable road side barriers. Structures 2015;1:20-38

[3] Guneyisi E. Fresh properties of self-compacting rubberized concrete incorporated with fly ash. Mater Struct 2010.

[4] Freitas C, Galvao J, Portella K, Joukoski A, Filho C. Desempenho fisico-quimico e mecanico de concreto de cimento Portland com borracha de estireno-butadieno reciclada de pneus. Quimica Nova 2009;32:913-8.

[5] Dong Q, Huang B, Shu X. Rubber modified concrete improved by chemically active coating and silane coupling agent. Constr Build Mater 2013;48:116-23.

[6] Su H, Yang J, Ling TC, Ghataora GS, Dirar S. Properties of concrete prepared with waste tyre rubber particles of uniform and varying sizes. J Clean Prod 2014.

[7] Cairns R, Kew H, Kenny M. The use of recycled rubber tires in concrete construction. Final Report. The Onyx Environmental Trust, University of Strathclyde, Glasgow; 2004.

[8] Holmes N, Browne A, Montague C. Acoustic properties of concrete panels with crumb rubber as a fine aggregate replacement. Constr Build Mater 2014;73:195-204.

[9] Sukontasukkul P, Tiamlom K. Expansion under water and drying shrinkage of rubberized concrete mixed with crumb rubber with different size. Constr Build Mater 2012;29:520-6.

[10] Pelisser F, Zavarise N, Longo TA, Bernardin AM. Concrete made with recycled tire rubber: effect of alkaline activation and silica fume addition. J Clean Prod 2011 ;19:757-63

[11] Gesoglu M, Guneyisi E, Khoshnaw G, Ipek S. Investigating properties of pervious concretes containing waste tire rubbers. Constr Build Mater 2014;63:206-13.

[12] Gupta T, Chaudhary S, Sharma RK. Assement of mechanical and durability properties of concrete containing waste rubber tire as fine aggregate. Constr Build Mater 2014;73:562-574.

[13] Thomas BS, Gupta RC, Kalla P, Cseteneyi L. Strength, abrasion and permeation characteristics of cement concrete containing discarded rubber fine aggregates. Constr Build Mater 2014;59:204-212.

[14] Ganjian E, Khorami M, Maghsoudi AA. Scrap-tyre-rubber replacement for aggregate and filler in concrete. Constr Build Mater 2009;23:1828-1836.

[15] Guneyisi E, Gesoglu M, Ozturan T. Properties of rubberized concretes containing silica fume. J Cem Concr Res 2004;34:2309-17.

[16] Al-Akhras NM, Smadi MM. Properties of tire rubber ash mortar. Cem Concr Compos 2004;26:821-6.

[17] Youssf O, ElGawady MA, Mills JE, Ma X. An experimental investigation of crumb rubber concrete confined by fibre reinforced polymer tubes. Constr Build Mater 2014;53:522-32.

[18] segre N, Joekes I. Use of tire rubber particles as addition to cement paste. Cem Concr Res 2000;30:1421-5.

[19] Balaha M, Badawy A, Hashish M. Effect of using ground waste tire rubber as fine aggregate on the behaviour of concrete mixes. Indian J Eng Mater Sci 2007;14:427-35.

[20] Zheng L, Huo S, Yuan Y. Experimental investigation on dynamic properties of rubberized concrete. Constr Build Mater 2008;22:939-47.

[21] Fernandez-Ruiz MA, Gill-Martin LM, Carbonell-Marquez JF, Hernandez-Montes E. Epoxy resin and ground tyre rubber replacement for cement in concrete: Compressive behaviour and durability properties. Constr Build Mater 2018;173:49-57

[22] Taha MM Reda, El-Dieb AS, Abd El-Wahab MA, Abdel-Hameed ME. Mechanical, fracture and microstructural investigations of rubber concrete. J Mater in Civil Eng ASCE 2008;20:640-649.

[23] Rao KJ, Mujeeb MA. A study on properties of crumb rubber concrete by destructive and non-destructive testing. Asian J of Civ Eng 2015;16:933-941.

[24] Khatib, Z.K., Bayomy, F.M., 1999. Rubberized Portland cement concrete. ASCE Journal of Materials in Civil Engineering 11 (3), 206-213.

[25] Mohammed BS, Hossain KM.A, Jackson TES, Wong G. Properties of crumb rubber hollow concrete block. J Clean Prod 2012;23:57-67.

[26] Onuaguluchi O, Panesar DK. Hardened properties of concrete mixtures containing pre-coated crumb rubber and silica fume. J Clean Prod 2014;82:125-31.

[27] Bravo M, de Brito J. Concrete made with used tyre aggregate: durability-related performance. J Clean Prod 2012;25:42-50.

[28] Azevedo F, Pacheco-Torgal F, Jesus C, de Aguiar JB, Camoes AF. Properties and durability of HPC with tyre rubber wastes. Constr Build Mater 2012;34:186-91.

[29] Sukontasukkul P. Use of crumb rubber to improve thermal and sound properties of pre-cast concrete panel. Constr Build Mater 2009;23:1084-1092.

[30] Thomas BS, Gupta RC. A comprehensive review on the applications of waste tire rubber in cement concrete. Ren and Sus Ene Rev 2016;54:1323-1333.

[31] Rubber Manufacturer's Association. USA; 2014.

[32] IS 456:2000 Indian Standard Plain and Reinforced Concrete- Code of Practice. Bureau of Indian standard, New Delhi.

[33] IS 10262:2009 Indian Standard Concrete Mix Proportioning- Guidelines. Bureau of Indian standard, New Delhi.

[34] IS 383:1970 Indian Standard Specification for Coarse and Fine Aggregate from Natural Sources for Concrete. Bureau of Indian standard, New Delhi.

[35] IS 516:1959 Indian Standard Method of Tests for Strength of Concrete. Bureau of Indian Standards, New Delhi.

[36] IS 5816:1999 Indian Standard Splitting Tensile Strength of Concrete-Methods of Test. Bureau of Indian Standards, New Delhi.

[37] IS: 2386:1963 Indian Standard Methods of Test for Aggregates for Concrete. Bureau of Indian Standards, New Delhi.

[38] IS 4031:1996 Indian Standard Method of Physical Tests for Hydraulic Cement. Bureau of Indian Standards, New Delhi.

[39] IS 1489(part 1):1991 Indian Standard Portland Pozzolana Cement- Specification. Bureau of Indian Standards, New Delhi.

[40] MS Shetty, Concrete Technology Theory and Practice. S.Chand & Company Pvt. Ltd. New Delhi.