www.cafetinnova.org

Indexed in
Scopus Compendex and Geobase Elsevier, Chemical Abstract Services-USA, Geo-Ref Information Services-USA, List B of Scientific Journals, Poland, Directory of Research Journals

ISSN 0974-5904, Volume 08, No. 02

International Journal of Earth Sciences and Engineering

April 2015, P.P.126-129

Investigation of the Properties of Concrete Containing Waste Tire Crumb Rubber

R BHARATHI MURUGAN, B SELVAKUMAR AND C NATARAJAN
Department of Civil Engineering, National Institute of Technology at Trichy, India
Email: *rbmmecivil@gmail.com, natara@nitt.edu*

Abstract: In many countries the utilization of accumulated waste materials is still in its early phases. It will take courage for construction industry to recycle some types of waste materials in the concrete. This paper deals the recycling of scrap rubber tires to be used in concrete mixes. In this study, the production of concrete was obtained by partially replacing the fine aggregate with crumb rubber. The main advantages of crumb rubber utilization in concrete to give the lower density, higher impact and toughness resistance, enhanced ductility, and better sound insulation etc., Crumb rubber is made by shredding waste tires. In the shredding process the steel wires are removed from the discard tires. The crumb rubber particle size ranging from 0.075 mm to not exceeding 4.75 mm it's similar to the fine aggregates. Experimental investigations were carried out to study the behaviour of concrete with and without crumb rubber. The replacement of crumb rubber contents is 5%, 10%, 15%, 20% and 25% of river sand by volume. The test results indicated that the addition of waste tire crumb rubber substitution decreases the compressive strength and modulus of elasticity was decreased.. The relationship between static modulus of elasticity and compressive strength of concrete with and without crumb rubber was analyzed and compared the experimental results with the empirically calculated values by using design codes.

Keywords: *Crumb rubber, Compressive strength, Stress-Strain and Modulus of elasticity*

1. Introduction

In the concrete preparation 55% to 80% occupying natural aggregates like crushed rock and river sand, the most commonly used coarse and fine aggregate is likely become scarcer the it is today. Now construction people need the alternatives to natural aggregates. Therefore, finding alternatives to naturally available materials is important to sustaining construction industry.

Waste materials such as coal fly ash, bottom ash, glass granules, plastic granules, copper slag, and crushed rock dust were used in the concrete [1-3]. Also, the waste tire crumb rubber was used as alternative of river sand and its properties were investigated [4]. So in such cases waste materials are used to modify the mechanical and durability properties of concrete so as to make it suitable for any situation. This would also additional benefits in terms of reduction in cost, energy savings, promoting ecological balance and conservation of natural resources. A review of recent research has shown than it is possible to use industrial by products as well as other materials in the concrete production as a replacement for cement and aggregate [7].

Waste tire crumb rubber is a very good alternative construction material in the construction industry due to its low specific gravity, more elasticity, very good energy and sound absorption. This paper presents the results from the experimental testing conducted to investigate the mechanical properties of concrete made with waste tire crumb rubber as fine aggregate.

2. Experimental Work

Experimental program was designed to investigate the mechanical properties of M40 grade concrete incorporating waste tire crumb rubber as fine aggregate. The standard cubical and cylindrical specimens were cast with and without crumb rubber. A compressive testing machine was used to test the cubical and cylindrical specimens were used for modulus of elasticity. The specimens were cast with M40 grade concrete using 0.0%, 5%, 10%, 15%, 20% and 25% partial replacement of waste tire crumb rubber as fine aggregate.

2.1. Materials

Ordinary Portland cement of 53 grade confirming to IS: 12269-1987 was used for the present investigation. The cement was tested as per the Indian standards IS 4031-1988. Natural river sand confirming zone II as per IS 383- 1987 was used. The fineness modulus of sand is used is 2.7 with a specific gravity of 2.52. Angular crushed granite coarse aggregate confirming to IS 383-1987 was used. Coarse aggregate of 20mm down having the specific gravity of 2.68 and fineness modulus of 7.2

was used. Shredding of waste tires were to produce crumb rubber passing through 4.75mm IS sieve and specific gravity as 0.689. The addition of crumb rubber to concrete was replacing fine aggregate. Portable water confirming to IS 456-2000 was used for both mixing and curing. In this study, SikaViscoCrete 20HE superplasticiser is used. As per supplier for high strength, water reduced concrete the normal dosage range is from 0.2-1.0 litres/100 kg of cementitious material. In this study SP is taken as 1% of the weight of the cement.

2.2. Mix Proportioning

The M40 grade concrete had cement, fine aggregate, in the ratio 1:2.22:2.66. The water cement ratio was 0.5. Assuming the quality control norms between good and very good following IS 10262, the value of standard deviation was taken as 5.0. Therefore, the target strength was found to be 48.25MPa.

2.3. Casting and Curing of Test Specimens

The ingredients for various mixes were weighed; required water was added and mixed by using pan mixture. Three specimens for each mix were cast in steel mould and compacted on a table vibrator, using standard cubes (150mm X 150mm X 150mm) and standard cylinders (100mm diameter with 200mm height) were cast for the determination of compressive strength and static modulus of elasticity respectively. The specimens were demoulded and placed immediately in water tank for curing.

Table 1 gives the details of various mixes prepared by replacing sand by waste tire crumb rubber. The water cement ratio as 0.5 in all the mixes was maintained.

Table 2: *Details of specimens prepared by replacing fine aggregate by waste tire crumb rubber*

Sl. No	Mix ID	Details of replacement	Ratio C: S: CA: CR
1	R0	Conventional concrete	1: 2.2:2.66:0.00
2	R5	5% fine aggregate replaced by waste tire crumb rubber	1:2.09:2.66:0.09
3	R10	10% fine aggregate replaced by waste tire crumb rubber	1:1.98:2.66:0.18
4	R15	15% fine aggregate replaced by waste tire crumb rubber	1:1.87:2.66:0.27
5	R20	20% fine aggregate replaced by waste tire crumb rubber	1:1.76:2.66:0.36
6	R25	25% fine aggregate replaced by waste tire crumb rubber	1:1.65:2.66:0.45

Note: *C – Cement, S – sand, CA – Coarse aggregate and CR – Crumb rubber.*

3. Result and Discussion

3.1. Compressive Strength

Graphical representation of Compressive strength of concrete with and without crumb rubber was represented on Figure 1. It was observed that the compressive strength of concrete was decreased with percentage of rubber content increased in the concrete mix. The decrease in compressive strength of concrete with addition of 5%, 10%, 15%, 20% and 25% waste tire crumb rubber was observed 11.44%, 15.08%, 22.90%, 32.82% and 41.20% at 28days respectively compared to normal concrete (without rubber). At the same time up to 10% of crumb rubber added concrete strength was increased as compared to target strength (48.25MPa) of the concrete mix. For that up to 10% of crumb rubber added concrete was suitable for any construction work.

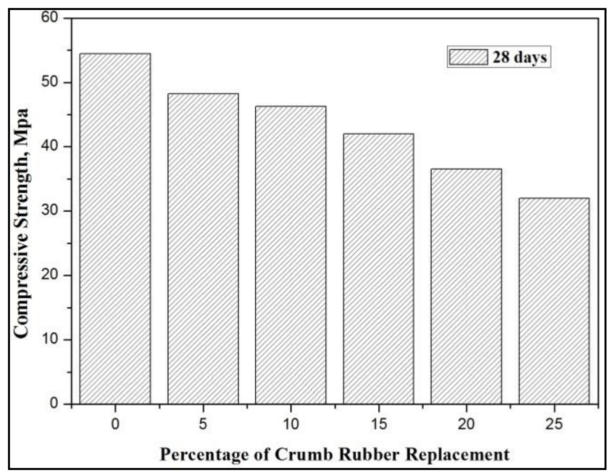

Fig. 1: *Compressive Strength of concrete cubes*

The major reason for the strength reduction of rubber mixed concrete is mainly due to lack of adhesion between crumb rubber particles to other concrete materials. Normally the rubber particles softer than cement paste for that when the load applied on the specimen the crack propagation are very fast around the rubber particles.

3.2. Modulus of Elasticity

Figure 2 shows the measured values of modulus of elasticity at 28days. In this test 100mm×200mm size cylinder specimens were used. The gauge length of cylinder was marked on the central height of specimens. Longitudinal extensometer was attached to the specimen such that gauge length is 200mm, placed the cylinder with longitudinal extensometer on the compression testing machine and adjusted the deflecto meter reading to zero. The load will be increased in increment up to failure of the specimen. The deflecto meter readings are tabulated and the static modulus of elasticity was found and the stress strain curve was plotted as show in figure 3. The reading of one unit in the extensometer is equal to $\frac{1}{100}$ mm, and also checked the young's modulus value as per IS 456:2000. The test setup was clearly shown in Figure 4. Static modulus of elasticity of normal concrete was about 35.40MPa at the age of 28 days. Figure 2 showed that the modulus of elasticity decreased with increasing rubber content it is similar to that observed in compressive strength. Increasing rubber contents 5%, 10%, 15%, 20% and 25% of the fine aggregate volume, the static modulus reduced to 4.67%, 10.98%, 21.40%, 32.41% and 45.60% respectively.

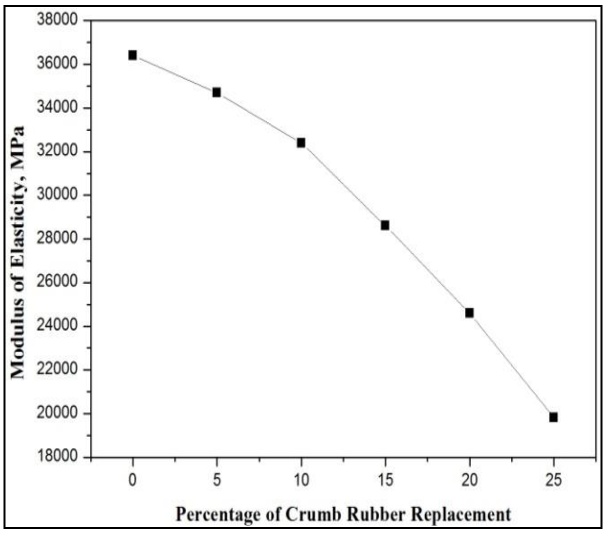

Fig. 2: *Modulus of Elasticity of concrete*

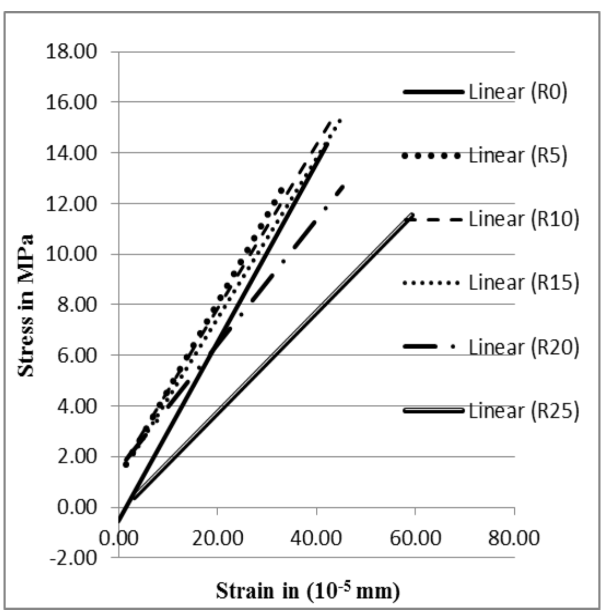

Figure 3: *Stress Strain Curve for Concrete*

Figure 4: *Experimental Test Setup for Modulus of Elasticity*

A relationship between the Modulus of elasticity and compressive strength of concrete after replacement of waste tire crumb rubber at 28 days of maturity has been shown in figure 5. Considering power variation the relationship is given by,

$$E_c = 442.31 f_{ck}^{1.113} \text{ With } R^2 = 0.9569 \qquad (1)$$

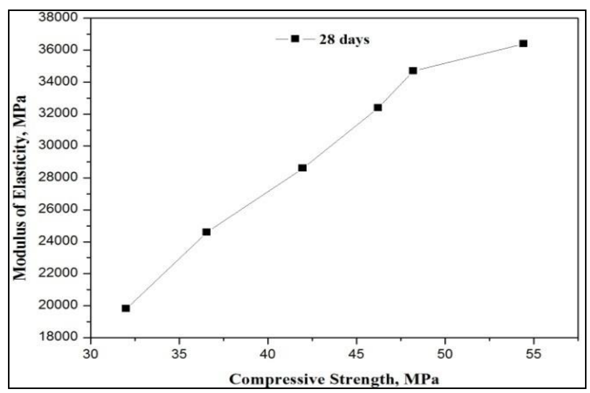

Figure 5: *Relationship between Modulus of Elasticity and Compressive Strength*

The bureau of Indian standards (IS 456) recommends the empirical relation between the static modulus of elasticity and compressive strength of concrete,

$$Ec = 5000\sqrt{fck} \qquad (2)$$

Where Ec = Static modulus of elasticity in MPa and fck = characteristic compressive strength of concrete at 28 days in MPa.

Figure 6 shows the Comparison between measured values of modulus of elasticity from the equation (1) at 28days and calculated values from the empirical equation (2) given in the IS 456 code with experimentally obtained values for both normal and rubberized concrete. The figure 6 clearly shows up to 10 percent of crumb rubber replacement modulus of elasticity was almost same as compared to all the methods. After 10 percent replacement like 15%, 20% and 25% was much variation between the Eqn. (2) to Experimental and Eqn. (1) values.

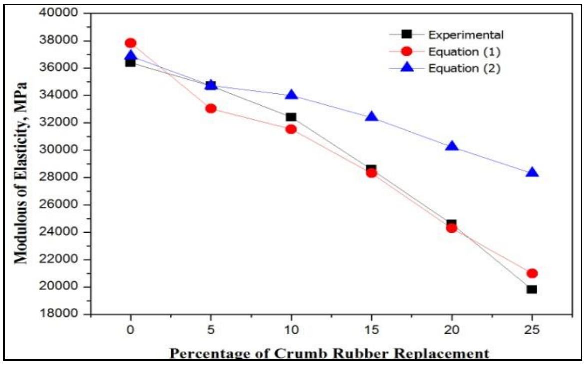

Figure 6: *Comparisons of Modulus of Elasticity*

4. Conclusion

A series of test has been carried out to investigate the behaviour of concrete containing waste tire crumb rubber. The following conclusions were drawn based on the test results of this study:

- The compressive strength of concrete was decrease when the rubber content increased in concrete.
- Incorporating 5% and 10% waste tire crumb rubber in place of fine aggregate in concrete gives acceptable compressive strength as compared to remaining rubber replacements.
- Modulus of elasticity of concrete containing rubber was lower than normal concrete but there was withstanding large displacement and deformation due to the properties of rubber. Normally rubber has been more ductile or flexible in that it has the ability to withstand large deformation.
- The experimentally obtained modulus of elasticity of plain and rubber based concrete were substantially lower than those predicted from the empirical relations given by IS 456.
- The new relations for modulus of elasticity and compressive strength of concrete containing different percentage of crumb rubber are proposed. The relationship is validated with experimental results.

References

[1] Eldin Neil N and Senouci AB, “Rubber-tired particles as concrete aggregate”, Journal of Mater Civil Eng, 5(4), 478–96, 1993.

[2] Khatib, Zaher K and Bayomy, F., "Rubberized Portland Cement Concrete", Journal of Materials in Civil Engineering, 206-213, August 1999.

[3] Kula I, A. Olgun, V. Sevinc and Y. Erdogan, “An investigation on the use of tincal ore waste, fly ash, and coal bottom ash as Portland cement replacement materials”, Cement and Concrete Research, 32, 227–232, 2002.

[4] Kamil E., Kaloush, George B. Way and Han Zhu, “Properties of Crumb Rubber Concrete” Annual Meeting of the Transportation Research Board, 1-22, November 2004.

[5] Bignozzi M and F. Sandrolini, “Tire rubber waste recycling in self-compacting concrete”, Cement and Concrete Research, 36, 735–739, 2006.

[6] Camille A. Issa and George Salem, “Utilization of recycled crumb rubber as fine aggregates in concrete mix design”, Construction and Building Materials, 42, 48–52, February 2013.

[7] Ahirrao S P and S.V. Deodhar, “Using waste glass in concrete”, The Indian Concrete Journal, 51 – 55, June 2013.

[8] Erhan Gunneyisi, Mehmet Gesoglu and Turan Ozturan, “Properties of rubberized concrete containing silica fume”, journal of cement and concrete research, 34, 2309-2314, 2004.

[9] El – Gammal, A, A.K. abdel Gawad, Y. El-sherbini and A. Shalaby, “Compressive strength of concrete utilizing waste tire rubber”, journal of Emerging and applied sciences (JETEAS), 1 (1): 96-99, 2010.

[10] N.J. Azmi, B.S. Mohammed and H.M. Al-Mattarneh, “Engineering properties of concrete containing recycled tire rubber”, ICCBT, 34, 373-382, 2008.

[11] Khalid Battal Najim, Matthew Robert Hall, “Crumb rubber aggregate coatings/pre-treatments and their effects on interfacial bonding, air entrapment and fracture toughness in self-compacting rubberised concrete (SCRC)” journal of Materials and Structures, Volume 46, Issue 12, pp 2029-2043, December 2013

[12] Yue Li Min Wang, Zhanguo Li, “Physical and mechanical properties of Crumb Rubber Mortar(CRM)with interfacial modifiers” Journal of Wuhan University of Technology-Mater. Sci. Ed., Volume 25, Issue 5, pp 845-848 October 2010.

[13] Erhan GüneyisiFresh, “Properties of self-compacting rubberized concrete incorporated with fly ash” journal of Materials and Structures, , Volume 43, Issue 8, pp 1037-1048. October 2010.

[14] Plain Cement Concrete IS 456: 2000, Bureau of Indian Standards, New Delhi.

[15] Recommended Guidelines for Concrete Mix Design, IS 10262: 2009, Bureau of Indian Standards, New Delhi.

[16] Methods of Tests for Strength of Concrete, IS 516: 2004, Bureau of Indian Standards, New Delhi.