International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 5 (2015) pp. 13221-13230

http://www.ripublication.com

Effects of Concrete By Using Waste tyre Rubber (Solid Waste)

Shanmugapriya M
Research Scholar, Department of Civil Engineering, Sathyabama University,Chennai, Tamilnadu, India,
Email: priyadhakshith1407@gmail.com

Abstract

The Concrete is a predominant material used in construction and it competes directly with all other major construction materials. Good-quality concrete is a very durable material and should remain maintenance free for many years when it has been properly designed for the service conditions.. The ductile behavior will enable the concrete material to have the capacity to deform and support flexural and tensile loads, even after initial cracking. Accumulations of discarded tyres create major health hazard and occupy large volume of land area, which is impossible in developing countries like India. As a possible solution to the problem of scrap-tyre disposal, the rubber waste tyres can be reused as a recycled material. To study the optimum quantity of the rubber aggregate to be replaced in place of aggregate is determined by compromising the strength and improving any one of the property of the concrete which imparts low by using mineral aggregate. To evaluate rubber concrete material properties through laboratory testing and develop test information that may aid in the eventual goal of drafting a practical amount of rubber in concrete specification for Light weight structural / low loading usage. Evaluate improvement ductility and Toughness index of the concrete adding rubber waste as a replacement of Coarse aggregate.

Keywords—Concrete, tyres, rubber , compressive strength

Introduction

Concrete is a predominant material used in construction and it competes directly with all other major construction materials like timber, steel, asphalt, and stone, because of its versatility in applications. However concrete is a composite material and its properties can vary significantly depending on the choice of materials and proportions for a particular application. However, concrete does have weaknesses that limit its use in certain applications.

Concrete is a brittle material with very low tensile strength. Thus, concrete is generally not loaded in tension and reinforcing steel must be used to carry tensile loads: inadvertent tensile loading causes cracking. The low ductility of concrete also means that concrete lacks impact strength and toughness compared to metals. Another issue would be to seek ways of making the concrete “green” or environmentally friendly through the choice of materials while retaining the core advantages of concrete. The scrap tyres are disposed by burning the tyres or landfills. Burning of tyres creates air pollution and disposal on land filling has potential environmental threat, fire hazard Another issue would be to seek ways of making the concrete “green” or environmentally friendly through the choice of materials while retaining the core advantages of concrete. The scrap tyres are disposed by burning the tyres or landfills. Burning of tyres creates air pollution and disposal on land filling has potential environmental threat, fire hazard

One of the material that has been suggested as a possible replacement of mineral aggregates is rubber from used car tires. Tyres are shredded or grounded into crumbs Tire Coarse Aggregate (TCA). TCA can be considered similar to coarse aggregate.As a possible solution to the problem of scrap tyre disposal, an experimental study is conducted to examine the potential of using tyre chips as an aggregate in Portland cement concrete.To study the optimum quantity of the rubber aggregate to be replaced in place of aggregate is determined by compromising the strength and improving any one of the property of the concrete which imparts low by using mineral aggregate.To evaluate rubber concrete material properties through laboratory testing and develop test information that may aid in the eventual goal of drafting a practical amount of rubber in concrete specification for Light weight structural / low loading usage. Evaluate improvement ductility and Toughness index of the concrete adding rubber waste as a replacement of Coarse aggregate.

Materials and Properties

Properties of various materials like cement, fine aggregate, coarse aggregate and TCA(Tyre Coarse Aggregate) used in the test specimen were studied.

Ordinary Portland cement (OPC) of 53 Grade was used for the entire investigation. The required quantity was procured, stored in air tight bags and used for experimental work. The specific gravity of ordinary Portland cement is 3.15.

Depending upon the particle size distribution IS 383-1970 has divided the fine aggregate into four grading zone. Locally available river sand is confirmed to zone III of table 4 of IS 383– 1970.

The coarse aggregate used for the work is angular. The nominal size of the aggregate was 20mm. Specific gravity of the coarse aggregate is 2.73. Procedure to find nominal size and specific gravity is as per IS: 383-1970 and IS 2386 (part I)-1963.

Waste tyre was procured and specific gravity was 1.18 and unit weight 1150 kg/$m^3$and the tyre is cut into pieces with a grading of 12 to 20mm size aggregate and the tyre aggregate is sieved and particle size distribution curve of the tyre aggregate is shown in Figure No. 1

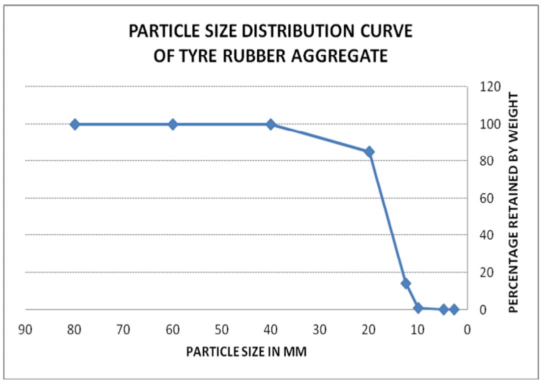

Figure 1: Particle size distribution curve of tyre rubber concrete

Mix Design

According to IS 10262 - 2009, the concrete mix design is the process of selecting suitable ingredients for concrete and determining their relative proportion with the object of producing concrete of certain minimum strength and durability as economically as possible. The grade of concrete used in the study was M35, mix design is arrived as per IS: 10262 - 2009.Mix design for M35 grade is arrived as 1 : 1.61 : 3.24 with water content of 0.40.

The final mix proportions and mix ratio of M35 grade of concrete per 1 m^3

Table 1: Mix Proportion

Water Content	Cement	Fine Aggregate	Coarse Aggregate
158 lt/m^3	395 Kg/m^3	636 Kg/m^3	1281 Kg/m^3
W/C ratio 0.40	1.00	1.61	3.24

In order to evaluate the influence of waste tyre rubber particles in the concrete, the coarse aggregate is replace with tyre rubber aggregate in percentages to the weight of coarse aggregates. Since the specific gravity of the rubber aggregate is 1.18, the replacement of tyre aggregate is done in 3, 6, 9 and 12% ,which will in turn replace approximately 30% volume of the coarse aggregate for 12%. The concrete mix proportions for M35 adding tyre aggregate is shown in the table below

Table 2: Mix Proportion For M35 Grade Coarse Aggregate

Grade of Concrete and % of rubber aggregate	Compressive strength at 28 days		
	Load (KN)	Compressive strength(N/mm2)	Percentag e decrease
C	825	36.67	-
3RA	721	32.04	12.63

6RA	652	28.97	20.99
9RA	576	25.60	30.18
12RA	475	21.11	42.43

Casting of Specimen

The size of the cube is 150mm X 150mm X150mm, cylinder is 150mm diameter X 300mm height. The required quantity of the concrete was mixed with machine mixer. Compaction of concrete in the mould was done with hand, since the density of the tyre coarse aggregate is very less and almost to the density of water hence compaction through vibration will leads to the tyre coarse aggregate to float on the surface of the mould, hence hand compaction is sorted. Specimen was removed from the mould after 24 hours. Specimens were cured in curing tank for 28 days.

Testing of Specimen

The casted specimens are tested for compressive strength tensile strength toughness index.

A. Determination of Compressive Strength

The Concrete cubes to be tested is measured for its dimensions using measuring scale, readings are noted and the area of the specimen is determined.

Compressive strength of cube is determined by compression testing machine. Load was applied perpendicular to the direction of compaction. The compressive strength of cube was determined at 28 days. The compressive strength was calculated in MPa.

Compressive strength = Ultimate Load / Area of loading direction

The specimen is tested after 28 days curing. The control specimen C, 3RA, 6RA, 9RA and 12RA in each 3 number of specimen is tested. The testing is done for various percentage of tyre aggregate samples and the test results shows decrease in the compressive strength. The control specimen for the M35 concrete for 28 days curing is 36.67N/mm2. Reduction in compressive strength is noted for increasing in various percentage of rubber aggregates.

Table 3: Compressive Strength For Various Mix

Mix Proportion For M35 Grade Coarse Aggregate Replaced By Rubber For 1 m^3						
Specimen	**Cement kgs**	**Water lts**	**Coarse aggregate kgs**	**Fine aggregate kgs**	**Percentage Of Rubber**	**Rubber Kgs**
C	395	158	1281	636	0	0
3RA	395	158	1220	636	3	61
6RA	395	158	1204	636	6	77

9RA	395	158	1166	636	9	115
12RA	395	158	1127	636	12	154

B. Stress Strain Response

The test is carried out to determine the stress strain relationships for the specimens. The Cylinder to be tested is measured for the diameter and height using measuring scale. The dial gauges are fixed to concrete cylinder which is used to measure the deflection. For every increment of loading by uniaxial compression, the deflection is measured by means of dial gauge fixed between certain gauge length. The process of loading is repeated till it fails and series of readings are taken and the stress strain relationships is established.

The stress strain curve for various percentage of RCA specimen is obtained and plotted in the graph as shown below.

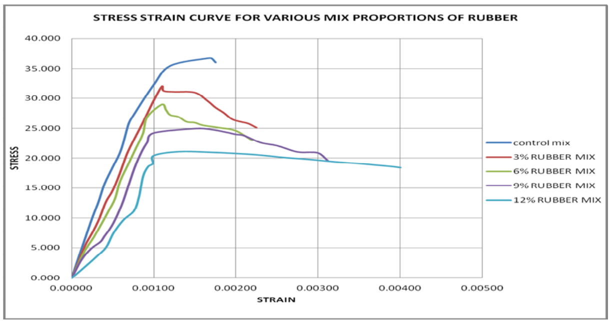

Figure 2: Stress Strain Curve For Various Mix Proportions of Rubber

C. **Tensile Strength**

To determine the split Tensile strength the specimen is placed horizontally between the loading surfaces of the compression testing machine. The value of the control mix is in the range of 3.46 N/mm2. The value of the tyre aggregate specimen 3RA, 6RA, 9RA and 12RA reduced considerably and the value reduced to 1.90 N/mm^2 which is 50% lesser than the control mix.

Table 4: Split Tensile Strength For Various Mix

Grade of Concrete and % of rubber aggregate	**Split tensile strength (N/mm2)**	**Percentage decrease**
C	**3.42**	**-**
3RA	**2.89**	**15.49**
6RA	**2.48**	**27.48**
9RA	**2.05**	**40.06**
12RA	**1.90**	**44.44**

D. Mode Of Crack Failure

The failure of tyre aggregate mix specimen in tension, was not brittle failureThe reason for this behaviour may be due to large elastic deformation before failing. The crack starts at the cement paste or at a mineral aggregate particle and propogate until it reaches a piece of rubber aggregate, since the rubber does not fail under the tension stresses which is capable of much higher resistance. The tension crack propogate throughout the specimen only by going around the rubber aggregate, prolonging its path and increase the area of the failure of surface. In the beginning the cracks are lined up on the vertical diameter of the specimen, once the initial crack is fully developed, several parallel formed in its vicinity and the cracks follows way around the rubber aggregate

E. Toughness Index

Toughness of tyre coarse aggregate concrete was determined by calculating the area under the stress–strain curve up to 80% of the ultimate stress in the post-peak region. The toughness value is defined as a ratio between the area under the stress–strain curve up to 80% of the ultimate stress, to the area under the stress–strain curve up to the ultimate stress. The toughness index for different percentage of tyre coarse aggregate specimen is tested.

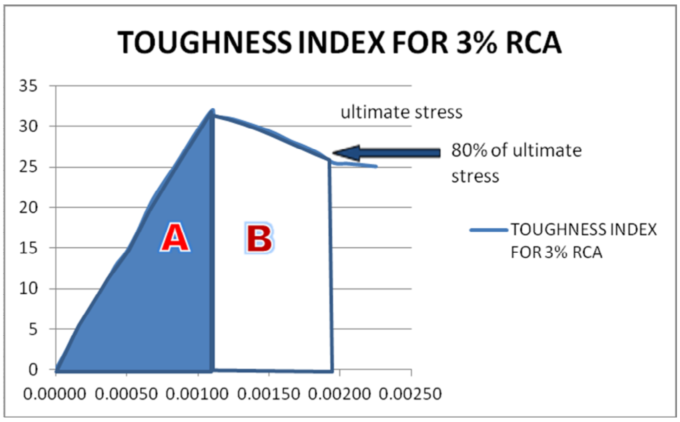

Figure 3: Toughness Index for 3% Rubber Concrete Aggregate

Results and Discussion

A. Compressive Strength

When loaded in the compression testing machine, the specimen containing rubber did not exhibit brittle failure. The large displacements and deformation which were observed are due to the fact that the rubber aggregate has the ability to withstand large deformations. The rubber particle seem to act as springs and cause a delay in widening cracks and preventing the catastrophic failure which is usually occurs in plain concrete specimens. Displacements and deformations were partially recoverable upon loading. Rubber particle having low modulus of elasticity produce high internal tensile stresses that are perpendicular to the direction of the compression load applied. Cement paste shows early failure because of its weakness against tension. Rubber chips behaving like springs delay the widening of the existing cracks. Also the rubber materials which is lesser in density tend to come on the top of the surface of the mould during vibrating for compaction, to avoid this manual compaction is resorted. This leads to concentration of the tyre particles on the top layer of the specimen. Since the Coarse aggregate is replaced by rubber particles, their volumes will reduce accordingly. On the other hand, Compressive strength of concrete depends on physical and mechanical properties of these materials. The coarse aggregate having higher density will naturally posses high strength to rubber aggregate. The value of compressive strength eventhough comes to a value of 21.20 N/mm^2 this value is very much higher than the prescribed strength of the Light Weight Concrete.

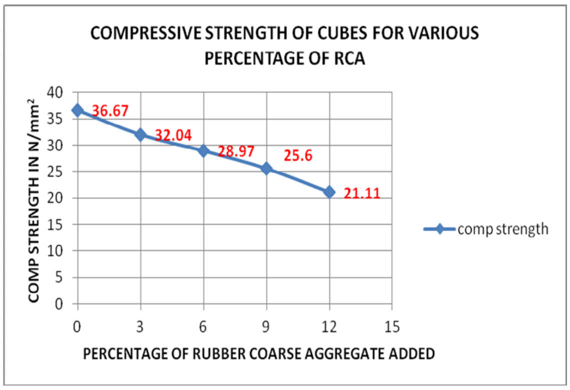

Figure 4: Compressive strength for various percentage of RCA

B. ***Stress Strain Curve***

The test shows two different behaviour patterns. The control specimen graph varies linearly until it reaches the peak before energy released by the specimens fracture. In control specimen the material behaved like a brittle material of which the total energy generated upon fracture is elastic energy.

The specimen containing the rubber tyre content behaves; when the peak stress is reached, the specimen continue to yield, as represented by the tough material having most of its energy generated upon fracture as Plastic energy.

Plastic energy is defined as the amount of energy required to produce a specific deformation after the elastic range, which increased the ability of the material to support the loads even after the formation of cracks.This type of pattern failure shows that the specimen possess high toughness, since the generated energy is mainly plastic.

The failure pattern of the specimen containing tyre aggregate has longer duration compared to the plain concrete which is abrupt and explosive. In contrast, the tyre aggregate specimen the failure is more gradual, since the concrete becomes more flexible with increasing tire particle substitution of mineral aggregates. Tyre aggregate specimen are able to withstand loads beyond the peak load. Tyre aggregate specimen does not have any detachments, due to bridging of cracks by rubber particles. During the unloading process, the flexible behaviour of tire particles decreases the internal friction among the concrete elements, and recovers extrastrain.

C. **Toughness Index**

Toughness index for different percentage of rubber aggregates were tested. Toughness index shows improvement in adding tyre aggregates; it attains a peak at 9% of rubber aggregate sample and shows a reduction in 12% sample. The specimen with rubber tyre aggregate exhibited greater toughness as compared to the control specimen M35, However the cracks propagated in the mortar until they reached the rubber aggregate it prolonged and sustained a portion of the applied load, which leads to an increase in the area of failure surface and also it holds the material in contact. However the toughness did not increase with an increase in the rubber content.The chart shows the trend below.

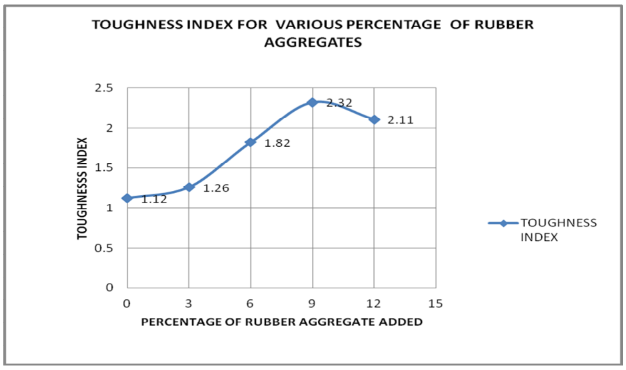

Figure 5: Toughness Index for various percentage of RCA

Summary and Conclusion

The mix design for M35 concrete was obtained as with water- cement ratio of 0.45. Similarly, for M35 concrete was obtained as 1 : 1.61 : 3.24 with water content of 0.40with water- cement ratio of 0.40. The percentage of rubber was added in parts of 3%, 6%, 9% and 12% by weight of the coarse aggregate. Since the specific gravity is 1.18 the 12% addition of rubber aggregate by weight will occupy 30% of the volume of coarse aggregate approximately.

The test results is summarized below

- The compressive strength of M35 mix which arrives to 36.67 N/mm2
- The compressive strength reduces to 42% after adding 12% of rubber aggregates.
- The Tensile strength of the specimen for M35 is 3.21 N/mm2 and reduces to 44.44% after adding 12% of rubber aggregates.
- The stress strain curves plotted for various percentage of rubber aggregates shows different trend of failure, control mix M35 shows the failure is elastic in nature.

- The specimen containing the rubber tyre content behaves; when the peak stress is reached, the specimen continue to yield, as represented by the tough material having most of its energy generated upon fracture as Plastic energy.
- Toughness index shows improvement in adding tyre aggregates; it attains a peak at 9% of rubber aggregate sample and shows a reduction in 12% sample.
- The rubber concrete did not exhibit brittle failure under compression and split tension, the specimens exhibits high capacity of absorbing plastic energy under both compression and in split tension

The Conclusion of the study is

- Though the reduction in compressive strength is upto 42% but the compressive strength at 12% of rubber content gives a compressive strength of 21.11N/mm2 which is more than the requisite compressive strength of Light Weight Concrete.
- Failure of the specimen is ductile in nature which is the most sought properties for a construction material to behave in the structure to avoid catastrophic failure.
- The failure pattern shows that the specimen possess high toughness, since the generated energy is mainly plastic.
- The ruber concrete can be recommended for non structural concrete and can be used as pavements with low loads, Architectural applications such as false facades, interior construction because of its light weight, pavement blocks, pedestrian walk ways, crash barrier around bridge, roads and similar structures because of its high toughness(High plastic energy absorption) and precast panels for partition walls with low unit weight of rubber concrete. The rubber concrete because of having more toughness index is an good energy absorber and energy dissipator which is highly required for crash barrier in roads and highways.

References

[1]. Ali R.Khaloo, M.Dehestani, P. Rahmatabadi, “Mechanical properties of concrete containing a high volume of tire –rubber particles,” Journal of waste Management, pp.2472-2482,2008 .

[2]. Baoshan huang,Guoqiang Li, Su-seng Pang, John Eggers, “Journal of material in Civil Engineering,ASCE, pp.187-194,2004.

[3]. H.A.Toutanji, “ The use of rubber tyre particles in concrete to replace mineral aggregates,” Cement and Concrete Composite, pp.135-139,1996.

[4]. Isa Yuksel, Omer Ozkan, turhan Bilir., Use of granulated blast furnace slag in concrete as fine aggregate, ACI materials journal, May-June, pp 203-208, 2006.

[5]. Isa yuksel, Ayten Genc,Properties of concrete containing nonground ash and slag as fine aggregate, ACI materials journal, July-August, pp 397-403,2007.

[6]. Juan M. Manso, Javier J. Gonzalez, Juan A. Polanco, Electric arc furnace slag in concrete, Journal Of Materials In Civil Engineering, November/December, pp 639-645,2004.

[7]. Keun Hyeok Yang, Jin Kyu Song, Jae-Sam Lee, Properties of alkali activated mortar and concrete using lightweight aggregates, Materials and structures, 43, pp 403-416,2010.

[8]. K.Malek, batayneh, Iqbal marie,Ibrahim Asi,"Promoting the use of crumb rubber concrete in developing countries," Journal of waste Management, pp. 2171-2176,2008.

[9]. Li Yun-feng, Yao Yan, Wang Liang, "Recycling of industrial waste and performance of steel slag green concrete", Journal of Central South university of technology, 16, pp 768-773, 2009.

[10]. N. Neil, Eldin Member ASCE and B. Senouci, "Rubber-Tire particles as concrete aggregate," integrals of Lipschitz-Hankel type involving products of Bessel functions," ASCE, Journal of Material in Civil Engg, pp. 478-496,1993.

[11]. Rafat Siddique, Tarun R. Naik, "Properties of concrete containing scrap-tire rubber – an overview," Journal of Waste Management, pp.563-569,2004.