Impact Factor Value 4.046 **e-ISSN: 2456-3463**
International Journal of Innovations in Engineering and Science, Vol 5, No.3, 2020
www.ijies.net

Study on Waste Tyre Rubber as Concrete Aggregates

Ayasha Wahne, Chitransh Rai, Khushboo Sahu,Tushar Swarnkar,Pradeep Nirmal

Department of Civil Engineering, Rungta college of Engineering and Technology, Bhilai , India, 490023

Abstract*- Waste tyre is one of the significant environmental problem world-wide. With the increase in automobile production huge amt. of waste tyre needs to be disposed. At present the disposal of waste tyres is becoming a major waste management problem in the world. It is estimated that 1.2 billion of waste tyre rubber produced globally per year. It is estimated that 11% of post-consumer tyres are exported and 27% are sent to landfill, stockpiled or dumped illegally and only 4% is used for civil engineering projects. Natural aggregates in concrete can be replaced with scrap tyre rubber which seems to be the best way to use waste tyre rubber. Tn this paper we will study about physical and mechanical properties of concrete containing recycled tyre or rubber material aggregates, to assess its suitability as a construction material.*

I- INTRODUCTION

A large variety of waste materials are considered feasible and even much valuable additives for concrete. Some of these materials include cellulose, fly ash, silica fumes and wood particles. Rubber obtained from scrapped tyres is considered as the most recent waste materials that have been examined because of its vital use in the construction field. Worldwide, the production of rubber increases every year.

There is a possible use of rubber tyre particles instead of coarse and find aggregate in concrete. Millions of rubber tyers become waste every year and their disposal has become a serious concern. Moreover, the burning of the waste rubber tyres becomes a cause of pollution for environment. Using rubber in concrete by partial replacing aggregates do not increase compressive and tensile strength than an ordinary concrete but a suitable strength still can be obtained for use in structures. Rubber can be reused in sizes of coarse aggregates as well as ground to the scale of fine aggregates. According to the use of tyre rubber in concrete preparation, it can be separated into three types:

1) Shredded or chipped rubber is used to replace gravel. By shredding the rubber pieces, particles about 13 -76mm big are produced.
2) Crumb rubber is used to replace sand with size range 0.425-4.75 mm and is manufactured by using special mills. The size of rubber particles depends on the type of mill used and the generated temperature
3) Ground rubber can be used as a filler material to replace cement. The tyres are subjected to two stages of magnetic separation and screening to produce this size of rubber particles. In micro-milling process, the rubber particles made are in the range of 0.075-0.475 mm round rubber can be used as a filler material to replace cement.

Rubber concrete

The concrete mixed with waste rubber added in different volume proportions is called rubcrete/rubber concrete. Partially replacing the coarse or fine aggregate of concrete with some quantity of small waste tire in the form of crumb and chipped can improve qualities such as low unit weight, high resistance to abrasion, absorbing the shocks and vibrations, high ductility and brittleness and so on to the concrete.

Advantage of rubcrete concrete: -

1) The rubcrete concrete is affordable and cost effective.

2) It resists the high pressure, impact and temperature.
3) They have good water resistance with low absorption, improved acid resistance, low shrinkage, high impact resistance, and excellent sound and thermal insulation.
4) If we use magnesium oxychloride cement instead of Portland cement it gives more compressive and tensile strength.
5) Also, if we react this rubcrete concrete with hot sulphur under temperature about 140oCit shows increase in strength of concrete.

Dis-Advantage of rubcrete concrete:-

1) They are sometimes weak in compressive and tensile strength.

Application of rubcrete concrete:-

1) In non-load bearing members as lightweight concrete walls.
2) In highway constructions as a shock absorber.
3) In sound barriers as a sound absorber.
4) In buildings as an earthquake shock-wave absorber.
5) It may also use in runways and taxiways in the airport, industrial floorings and even as structural member

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/m3 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. Thus, the mix needs more quantity of rubber tyres aggregates to replace the gravel. This has therefore raised the issue of the big volumetric percentage of the rubber tyres that have substituted normal aggregate in the mix. Additionally, rubber tyres particles have high elasticity than the conventional aggregate and low unit weight. These properties have influenced the characteristics of the concrete.

Tyre Rubber

Tyre rubber aggregate. About 30 cm long waste tyre rubber pieces are obtained from local market; the pieces were cleaned with soap water and rinse with clean water. After drying under sun at open place, both faces of the tyre pieces were rubbed with hard wire brush to make surfaces as rough as can be done by hand. The source of the rubber aggregate is recycled tyres which were collected from the local market. For uniformity of the concrete production and convenience, all the tires collected are from medium truck tire. The reason for choosing medium truck tires is that they can give the required shape and size which is similar to the common natural gravel. This study has concentrated on the performance of a single gradation of rubber prepared by manual cutting. The maximum size of the rubber aggregate was 20 mm as shown in Figure 1. Specific gravity test was conducted on the rubber aggregate chips and found to be 1.123. The rubber aggregates used in the present investigation are made by manually cutting the tire in to the required sizes. It is very laborious, time consuming and is not easy to handle at the initial stages. However, all this complications can be easily sorted out if a large scale production is devised and proper cutting tools and machineries are made for this particular usage

Figure 1 Rubber aggregates used in the present investigation

Mechanical Properties

1) Compressive strength

Decrease in compressive strength was noticed as the percentage of crumb rubber increased. The reduction in compressive strength of the mix with 20% crumb rubber was more than 50% than the value of the control mix. At 7 days, the maximum compressive strength (65.5 MPa) was obtained for the control mix with 0% crumb rubber and the minimum value (27 MPa) for the mix with 20% crumb rubber. Same trend was observed for the compressive strength at 28 and 90 days. At 28 days, a strength above 60 MPa was obtained for all the mixes in which the amount of rubber was from 0% to 10% and at 90 days, all the mixes in which the crumb rubber was substituted from 0% to 12.5% crossed the 60 MPa threshold.

2) Flexural strength

Gradual reduction in the flexural strength was noticed as the percentage of crumb rubber increased. At 7 days, the maximum value (6.2 MPa) was observed for the mixes with 0% and 2.5% crumb rubber and minimum value (4.6 MPa) observed for the mixes with 17.5% and 20% crumb rubber. At 28 days, the maximum value (7.3 MPa) was obtained in the mix with 2.5% crumb rubber and minimum value (5.5 MPa) was obtained for the mix with 20% crumb rubber. Same trend as 28 days has been observed at 90 days, where the maximum and minimum values were 7.9 MPa and 5.7 MPa respectively. When the 90 days strength was considered, there was 28% reduction in the flexural tensile strength of the rubberized specimen (20% crumb rubber) when compared to the control mix specimen.

3) Tensile strength

The results of tensile strength test are given in Fig. 11. Tensile strength of concrete was reduced with replacement of rubber in both mixtures. The percentage reduction of tensile strength in the first mixture was about twice that of the second mixture for lower percentage of replacements. The reduction in tensile strength with 7.5% replacement was 44% for the first mixture and 24% for the second mixture as compared to the control mixture. Tyre rubber as a soft material can act as a barrier against crack growth in concrete. Therefore, tensile strength in concrete containing rubber should be higher than the control mixture.

4) Durability studies

An experimental investigation to comparatively study the depth of chloride penetration, resistance to acid attack and macro-cell corrosion of rubberized concrete and control mix concrete was performed. It is assumed that the procedures will have no significantly damaging effects on frost-resistant concrete which may be defined as any concrete not critically saturated with water (that is, not sufficiently saturated to be damaged by freezing) and concrete made with frost-resistant aggregates and having an adequate air-void system that has achieved appropriate maturity and thus will prevent critical saturation by water under common condition

Waste tyre rubber in the form of crumb rubber was replaced for natural fine aggregates from 0% to 20% in multiples of 2.5%. It was observed that the depth of chloride penetration of the concrete with 2.5–7.5% crumb rubber was lower than or equal to the control mix concrete. In the water absorption test of acid attacked specimens, gradual increase was observed as the percentage of crumb rubber was increased.

The reason for this behaviour is that during crack expansion and when it comes into contact with rubber particle, the exerted stress causes a surface segregation between rubber and the cement paste.

5) Workability aspect

The replacement of coarse aggregate by scrap tyre rubber effects on the workability of the concrete. The workability of rubberized concrete shows an increase in slump with increase of waste tyre rubber content of total aggregate volume. The result of the normal concrete mix showed an increase in workability, but it can be summarized that the workability is adversely affected by the incorporation of chipped tyre rubber. The results of the slump test are as shown

CONCLUSION

Small amounts of waste tyres in the range of 7.5% to 10% can be used in concrete with a target compressive strength of up to 4000 psi (≈28 MPa) but strength enhancing materials like silica fume need to be used. As waste tyre increase, the compressive strength drops. At 7.5% of waste tyre replacing coarse aggregates, this drop is found to be approximately 10% compared to the control concrete if silica fume is added into the mixture. However, this amount of strength can also be achieved without using strength enhancing materials (silica fume) if the top waste tyre size is lowered from 2 in to 1 in.

Waste tyre lowers the modulus of rupture of concrete but it increases displacement up to 50% (improved concrete deformation) during loading. The splitting tensile strength improves by 12.7% with introduction of TDA into concrete. The bond strength of the waste tyre concrete is not significantly different from that of the control concrete but waste tyre improves postcracking behavior of the concrete as noted from the pull-out tests.

REFERENCES

[1] *Texas Commission on Environmental QualityTracking the fate of scrap tires in Texas: an audit report Biotechnol. Rep. (2010) SFR-078/08.*

[2] *United States Environmental Protection Agency. Office of Solid WasteMarkets for Scrap Tires, Policy Planning and Evaluation PM-221 United States Environmental Protection Agency (1991)*

[3] *Rubber Manufacturers AssociationScrap Tire Markets in the United States, 9th Biennial Report Rubber Manufacturers Association of Tyre Rubber Particles in Slag (2009)*

[4] *Modified Cement Mortars, Proceeding of the 11th International Congress on the Chemistry of Cement (ICCC).*

[5] *V. Petr and T. G. Rozgonyi (2005), Rubberized concrete composition and method of making the same, US Patent Application, US 20050096412 A1.*

[6] *Maryland Department of the Environment's Scrap Tire ProgramGuidance Manual for Engineering Uses of Scrap Tires", Geosyntec Project ME0012-11 Maryland Department of the Environment's Scrap Tire Program(2008)*

[7] *Z.K. Khatib, F.M. BayomyRubberized Portland cement concrete J. Mater. Civ. Eng., 11 (3) (1999), pp. 206-213*

[8] *F. Hernandez-Olivaresa, G. Barluenga, M. Bollati, B. WitoszekStatic and dynamic behaviour of recycled tyre rubber-filled concrete Cem. Concr. Res., 32 (2002), pp. 1587-1596*

[9] *I.B. TopcuThe properties of rubberized concretes Cem. Concr. Res., 25 (2) (1995),*

[10] *N.I. Fattuhi, L.A. ClarkCement-based materials containing shredded scrap truck tyre rubber Constr. Build. Mater., 10 (4) (1996), pp. 229-236*

[11] *T. Gupta, S. Chaudhary, R.K. ShramaAssessment of mechanical and durability properties of concrete containing waste rubber tire as fine aggregate Constr. Build. Mater., 73 (2014), pp. 562-574*

[12] *T. Gupta, S. Chaudhary, R.K. Shrama Mechanical and durabilityproperties of waste rubber fiber concrete with and without silica fume J. Cleaner Prod., 112 (2016), pp. 702-711*

[13] *T. Gupta, R.K. Shrama, S. ChaudharyImpact resistance of concrete containing waste rubber fiber and silica fume Int. J. Impact Eng., 83 (2015), pp. 76-87*

[14] *B. Barr, A. BaghliA repeated drop-weight impact testing apparatus for concrete Mag. Concr. Res., 40 (No. 144) (1988), pp. 167-176*

[15] *N. Kishi, H. Konno, K. Ikeda, K.G.MatsuokaPrototype impact tests on ultimate impact resistance of PC rock sheds Int. J. Impact Eng., 27 (9) (2002), pp. 969-985*

[16] *S. Mindess, Y. ChengPerforation of plain and fibre reinforced concretes subjected to low-velocity impact loading Cem. Concr. Res., 23 (1) (1993), pp. 83-92*

[17] *K.C.G. Ong, M. Basheerkhan, P.ParamasivamResistance of fiber concrete slabs to low velocity projectile impact Cem. Concr. Compos., 21 (5-6) (1999), pp. 391-401*

[18] *ACI Committee 544State-of-the-Art Report on Fiber Reinforced Concrete," 544.1R-10 American Concrete Institute, Farmington Hills, MI, USA (2010)*

[19] *ASTM InternationalASTM Standard C136 / C136M: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates ASTM International, West Conshohocken, PA, USA (2009)*

[20] *ASTM InternationalASTM Standard C192/ C192M: Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory ASTM International, West Conshohocken, PA, USA (2009)*

[21] *ASTM InternationalASTM Standard C39/ C39M: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens ASTM International, West Conshohocken, PA, USA (2009)*

[22] *ASTM InternationalASTM Standard C1231/ C1231M: Standard Practice for Use of Unbonded Caps in*

Determination of Compressive Strength of Hardened Cylindrical Concrete Specimens ASTM International, West Conshohocken, PA, USA (2009)

[23] *ASTM InternationalASTM Standard C496/ C496M: Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens ASTM International, West Conshohocken, PA, USA (2009)*