iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** IX **Month of publication:** September 2020

DOI: https://doi.org/10.22214/ijraset.2020.31468

Sustainable Construction using Waste Tyre Rubber in Concrete

Anuj Gupta[1], Pankaj Kumar[2]
[1]P.G. Student, [2]Professor, Department of Civil Engineering, MITS, Gwalior (M.P.)

***Abstract:** Waste tyre rubber is one of the most significant environmental concerns worldwide. With rising Auto-mobile manufacturing, it is important to dispose of huge quantities of waste. There have been many types of research to identify alternative approaches to dispose of waste tyre in the past. Discarded vehicle tyres are one significant part of the solid waste which has been disposed of, in a landfill. These waste product of tyre can be used in concrete as a possible application. Here rubber particles from waste tyre are used as a partial replacement of aggregate. This will also save the depleting natural aggregates. As we know aggregates are a major constituent in the production of concrete. Concrete is an outstanding building material and is known to be useful for modern life and human society. Concrete is the most commonly used building material in the world, and billions of tonnes of natural aggregate are required every year. As a result, the use of waste tyres in concrete has become theoretical feasible and this concrete is being known as low weight concrete and sustainable concrete. In this research, we have studied different approaches to use waste tyre rubber in concrete production based on the existing researched study and discussed the best effective way to use rubber by analysing and correlating them.*
***Keywords:** Waste rubber, Compressive strength, Discarded Rubber Tyre waste, sustainable concrete, Waste Tyre Rubber, Sustainable Construction*

I. INTRODUCTION

The management of solid waste is one of the world's most important environmental concerns. To find the viability of using solid waste products in civil engineering applications, several studies have been performed over the past 30 years [1]. The main motivations for such studies are the continuous demands of natural aggregates, the prohibition of waste disposal inland and the demand for sustainable development (recycling). The pace of urbanization and industrialization increased the efficiency and quantity of means of transport globally. To manage such demands, the automotive industries have seen a rapid increment in the manufacturing of tyres. These tyres are used as land-filling after the end of their service life or disposed of in open spaces. The outdoor disposal results in water retention in the tyres and makes the breeding of various insect and pests. Waste is classified as solid waste disposal, disposal of liquid wastes and disposal of gaseous wastes. There are many different ways of disposing of liquid and gaseous waste materials. Some solid waste materials can be recycled without affecting the environment, such as papers, steel, etc. But some solid wastes such as waste tyres cannot be disposed of. The toxic substance from the tyre can damage the environment and thus produce air pollution if the tyre is burnt. Subsequently, it is not a biodegradable material, this can affect soil and plant fertility. It can sometimes cause an uncontrolled fire. An estimated 1.2 billion rubber waste tyre produced globally in one year. It is estimated that eleven per cent of post-consumer tyres will be exported and 27 per cent will be sent to landfill, stockpiled or illegally dumped and only four per cent will be used for civil engineering [2]. Some study on the use of waste tyres as an aggregate substitute in concrete has already been carried out, showing that concrete with improved toughness and sound insulation properties can be achieved. The manufacture of rubber aggregates from waste tyres using two different technologies: mechanical grinding or cryogenic grinding. The first technology, chipped rubber is produced to replace coarse aggregates. As for the second technology, crumb rubber generally is generated for substitution of fine aggregates [3]. This paper reviews existing research on the performance of concrete that incorporates rubber waste from waste tyres. In this work, the most appropriate knowledge about the properties of concrete containing tyre rubber wastes will be reviewed. This paper also discusses the effects of tyre waste particles treatments, the rubber waste particle size and volume of replacement of tyre waste particles on fresh and hard concrete properties.

II. LITERATURES REVIEWS

The compiled experimental data of compressive strength, splitting tensile strength, flexural strength, static modulus of elasticity and unit weight for eleven different mixtures of rubber lightweight aggregate concretes cured up to 1, 7 and 28 days were represented. The eleven different mixtures cover one fundamental mixture and ten different replacements of rubber particles for sand volume from 10% to 100%. Based on the experimental results, incorporating rubber particles profoundly has an unfavourable effect on the slump and mechanical strength, while the unit weight of concrete dropped. The static modulus of elasticity decreased from 24.1 GPa to 6.3 GPa with the replacement of rubber particles increasing from 0% to 100% (Jing Lv, 2015)[8].

The use of concrete rubber in structural and non-structural components is investigated. It is appropriate for the concrete. Uses, barriers and advantages were discussed. Replacement of 0 %, 10%, 15 % and 20% of fine aggregate and coarse aggregate of regular concrete mix with various waste tyre (both crumb and chipped rubber). To check the physical, chemical, and mechanical properties for both standard and modification concrete blend. From the case studies, it was observed that waste Tyre rubber in the form of crumb and chipped rubber to replace coarse and fine aggregates is possible in concrete but is still not recommended for structural uses due to the low compressive strength compared to standard concrete containing natural rock aggregates (Nikhil Ramchandra Pardeshi,2017) [4]. The durability of rubber powder concrete and rubber fibres concrete were observed. Having discarded rubber tyres with a width of 2–5 mm and length of up to 20 mm were shredded to fibre form. Such rubber fibre was found to have a specific gravity of 1.07. Rubber powder was obtained by incinerating waste rubber tyres for 72 h at a temperature of 850℃. Size of rubber powder particles ranged from 0.15 mm to 1.9 mm. Two sets of rubberized concrete mixes having water to cement ratio of 0.45 were designed. The first set (rubber powder concrete) consisted of rubber powder partially replacing natural fine aggregate by 0–20% having an incrementing range of 5%. In the second set (fibre concrete), the content of rubber powder was fixed at 10%, and the remaining natural sand was replaced by rubber fibre up to 25% (Trilok Gupta,2019) [5].

Rubber concrete prepared from waste tyre rubber-based aggregate. Testing of mechanical performance included measurement of compressive strength, flexural strength and dynamic modulus of elasticity. Thermal conductivity was determined in the dependence on moisture content, from the dry to fully water-saturated state. The use of scrap-tyre-rubber aggregate resulted in a reduction of the unit weight, deteriorating in mechanical parameters and a noteworthy reduction in thermal conductivity of rubberized concrete. No noteworthy changes occurred at temperatures up to 300℃ on concrete characteristics. However, after exposure to 400℃, noteworthy changes were observed in concrete properties (Martina Záleská,2019) [6].

Cubes were cast of M25 grade by replacing 5, 10, 15 per cent of tyre rubber aggregate with nature coarse aggregate and compared with regular M25 grade concrete. Properties of fresh concrete-like workability, compressive strength, split tensile strength, the flexural strength of hardened concrete were identified. The aim is to investigate the optimal use of waste tyre rubber as coarse aggregate in concrete composite (Sulagno Banerjee,2019) [2].

The utilization of Waste tyre rubber material as a partial replacement for fine aggregates in M30 grade of concrete mix at different percentages to produce a sustainable concrete. In this paper, a surface modification method was proposed to introduce strong polarity groups to rubber surface to generate a strong chemical bond between the rubber and the cement matrix. It is an effective method to improve the mechanical properties of concrete (R. Gajendra Rajan,2020) [7].

III.OUR ANALYSIS AND CORRELATION

The material was taken to prepare concrete mix is almost same in considering existed research paper for this study as we use to make to the regular concrete mix in general construction. Perhaps, it may vary a little bit in some cases. Ordinary Portland Cement of grade 43 confirming to IS: 8112–1989, The specific gravity of cement is 3.15. Fine aggregate Natural River sand passing through 4.75 mm IS sieve is used for making concrete As per IS: 383–1970. Natural river sand was categorized under grading zone I. The specific gravity and fineness modulus of sand is found to be 2.65 and 3.05 respectively. Coarse aggregate was passed through 80 mm sieve and retained on 4.75 mm sieve confirming IS: 383–1970 was used for concrete mix. The specific gravity and fineness modulus of coarse aggregate is found to be 2.695 and 7.7 respectively. Clean portable water free from suspended particles, chemical substances, biological elements etc. is used both for mixing of concrete and curing. The waste tyre rubber depends on the approach of the study. 0.45 to 0.60 is the water content (w/c) was taken to make workable concrete.

Nikhil Ramchandra Pardeshi [4] from this case studies it can be determined that the waste tyre rubber in the form of crumb and chipped rubber in replacement of coarse and fine aggregate is possible in the concrete. 10% of replacement of fine and coarse aggregate of standard concrete mix with different weight ratios of scrap tyres (both crumb and chipped rubber). It was found low compressive strength compared with the standard concrete containing natural rock aggregates. Sulagno Banerjee [2] this study has focused on the performance of a single gradation of rubber arranged by manual cutting. The maximum size of the chipped rubber aggregate was 40 mm (figure 1). Rubber sieve analysis passing from 40 mm sieve is 99% and sieve analysis passing from 2 mm sieve is 1%. Percentage of rubber aggregate replaced by coarse aggregate is 0%,5%,10%,and 15%. It was observed that the compressive strength, split tensile strength as well as the flexural strength decreases as the addition of a percentage of rubber increases. 5 & 10 per cent replacement of rubber aggregate may achieve the compressive strength as that of the normal concrete with some few adjustments like adding extra silica or by replacing cement with more fine particles. Adding admixture can increase the strengths slightly. It is recommended to replace 5-10% of waste tyre rubber aggregate with coarse aggregate, which will be the optimum replacement in concrete composites. It also shows decrement in workability as increase the percentage of rubber content.

Fig. 1. chipped rubber aggregate 40mm (manually cut) [2]

Trilok Gupta [5] in this study, the durability of waste rubber powder and waste rubber fibres concrete against harmful environmental conditions was observed. Having discarded waste rubber tyres were shredded to fibre form having a width of 2–5 mm and length up to 20 mm figure 2 (a). Rubber powder (RP) particles were obtained by incinerating waste rubber tyres at 850°C for 72 h. The particle size of rubber powder particles varied between 0.15 mm and 1.9 mm figure 2 (b). Two sets of rubberized concrete mixes having water to cement ratio of 0.45 were designed. The first set (rubber powder concrete) consisted of rubber powder partially replacing natural fine aggregate by 0–20% having an incrementing range of 5%. In the second set (fibre concrete), the content of rubber powder was fixed at 10%, and the remaining natural sand was replaced by rubber fibre up to 25%. To attain a compaction factor range (workability) of 0.90–0.95, the dosage of superplasticiser was varied throughout the mixes. It also shows decrement in compressive strength as rubber content increases in any form(rubber powder and rubber fibres).

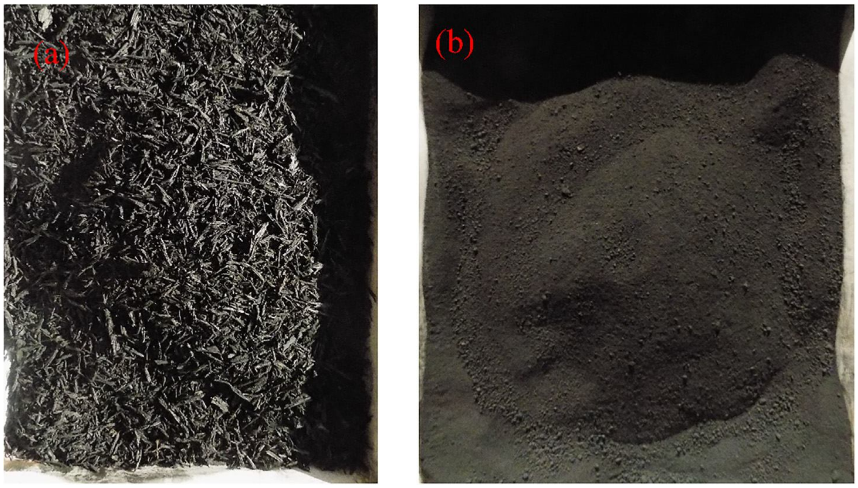

Fig. 2. (a) Rubber fibres and (b) rubber powder [5]

R. Bharathi Murugan [1] Experimental program was designed to investigate the mechanical properties of M20 grade concrete incorporating waste tyre crumb rubber as fine aggregate. The standard cubical, cylindrical and small beam specimens were cast with and without crumb rubber. A compressive testing machine was used to test the cubical and cylindrical specimens. Flexural strength testing machine was used for the small beam specimens. The specimens were cast with M20 grade concrete using 0%, 5%, 10%, 15%, 20% and 25% partial replacement of waste tyre crumb rubber as fine aggregate. The crumb rubber was passed through 4.75mm IS sieve. The crumb rubber in the concrete has less absorption capacity when compared to the river sand. It gives acceptable mechanical and durability properties such as compressive strength, split tensile strength, flexural strength, water absorption, sulphate resistance, acid resistance and chloride resistance up to 15% replacement. Hence 15% rubber content is to be considered as the optimum amount. it has desirable characteristics such as low density and high flexural strength. Crumb rubber added to concrete gives better resistance to acid and sulphate attack.

Jing Lv[8] slump value, compressive strength, splitting tensile strength, flexural strength, static modulus of elasticity and unit weight for eleven different mixtures of rubber lightweight aggregate concretes cured up to 1, 7 and 28 days were observed. The eleven different mixtures cover one fundamental mixture and ten different replacements of rubber particles for sand volume from 10% to 100%. Recycled rubber particles produced by mechanical shredding, ranging from 0.15 mm to 4.75 mm in size, the modulus of fineness 2.6, the density 1.16 g/cm3 and the loose bulk density 365 kg/m3 was used as a sand replacement by volume.

Table I [8]
The testing results of compressive strength, splitting tensile strength, flexural strength, static modulus of elasticity and unit weight

Type of concrete	Compressive strength (Mpa)			Splitting tensile strength (MPa)			Flexural strength (MPa)			Static modulus of elasticity (GPa)			Unit weight (kg/m3)
	1d	7d	28d	1d	7d	28d	1d	7d	28d	1d	7d	28d	
CC	13.4	30.9	41.5	1.22	3.11	4.38	1.32	3.35	4.68	5.6	16.8	24.1	1820
RC10	12.1	27.4	39.2	1.14	2.94	3.85	1.24	3.17	4.44	4.7	14.6	22.5	1780
RC20	10.7	25.1	36.4	1.09	2.77	3.67	1.11	2.92	4.05	4.1	13.7	20.4	1714
RC30	9.4	20.6	29.5	0.98	2.31	2.98	1.02	2.54	3.57	3.5	13.1	18.5	1650
RC40	7.3	16.8	22.8	0.79	1.87	2.51	0.83	2.26	3.24	3.1	12.7	16.1	1607
RC50	5.1	11.5	16.6	0.61	1.52	1.93	0.69	1.99	2.79	2.7	11.5	14.8	1533
RC60	4.4	9.4	13.3	0.49	1.21	1.52	0.53	1.78	2.23	2.5	9.1	12.3	1487
RC70	3.7	7.7	10.9	0.41	0.95	1.12	0.45	1.45	1.81	2.4	8.7	9.8	1436
RC80	3.3	6.9	9.2	0.37	0.83	0.98	0.42	1.13	1.53	2.4	6.8	8.9	1398
RC90	3.0	6.3	8.2	0.33	0.72	0.87	0.38	0.97	1.08	2.3	5.6	7.7	1366
RC100	2.9	5.8	7.1	0.31	0.68	0.79	0.35	0.77	0.87	2.1	5.3	6.3	1321

From table 1. It is found that as rubber content (RC) increases then the reduction in compressive strength, splitting tensile strength, Flexural strength, Static modulus of elasticity and Unit weight was observed. The addition of rubber particles can decrease the slump value of lightweight aggregate concrete. The dry unit weight of hardened rubberized lightweight aggregate concrete decreases with the increasing replacement level.

According to the Martina Záleská [6], The reduction of the bulk density of rubberized concrete follows the trend of mass loss When sample exposure Up to 300°C, the decrease in bulk density was low. The bulk density drop was well visible for concretes containing rubber aggregate After sample exposure to 400°C. The rubberized concretes were stable up to 300°C. The decomposition of rubber-based aggregate and its combustion deteriorated functional properties of rubberized concrete when samples exposed to 400°C.

The reasons for the significant loss in strength of rubber-modified concrete can be attributed to the following two factors[9]:

1) The hydrophobic nature of the rubber particle and the hydrophilic nature of cement paste makes it impossible to develop a strong chemical bond between them.
2) The much lower modulus (stiffness) of rubber than its surrounding media (cement paste and aggregates) makes rubber particles act like ‘‘softcore’’ within rubber-modified concrete. This causes noteworthy stress concentration under loading conditions and thus reduce the general strength of rubber-modified concrete samples (or structures).

R. Gajendra Rajan[7] a surface modification method was proposed to introduce strong polarity groups to rubber surface to generate a strong chemical bond between the rubber and the cement matrix. It is an effective method to improve the mechanical properties of concrete. Waste Tyre Rubber was firstly soaked in 5% Sodium hydroxide (NaOH) solution for 24 h, and rinsed with clear water. Secondly, Waste Tyre Rubber was added into 5% Potassium permanganate ($KMnO_4$) solution and the pH value of this solution was adjusted to 2–3 by adding sulphuric acid, the solution was heated to 60°C and stirred to allow the oxidation reaction for about 2 h. The Waste Tyre Rubber is rinsed in clear water and finally soaked in 5% saturated sodium bisulfite ($NaHSO_3$) solution at 60°C for 0.5–1 h to complete the sulphonation reaction of the rubber. The replacement of treated Waste Tyre Rubber instead of fine aggregate and decided accordingly by weight. Rubber replacement of 0%, 2.5%, 5%, 7.5% & 10% with fine aggregate. The compressive strength attains more than 100% of replacement of Treated Waste Tyre Rubber in 5% & 7.5% by weight comparing the conventional concrete. The split tensile strength attains 75% of replacement of Treated Waste Tyre Rubber in 5% & 7.5% by weight comparing the conventional concrete.

IV. CONCLUSIONS

Tyre production is continuously increased in parallel with the economic and industrial development of the world, thereby producing massive waste per year. Tyre rubber wastes represent a serious environmental issue that needs to be addressed with urgency by the scientific community. The application of recycled waste tyre rubber in concrete construction is an effective and sustainable process. Waste tyre rubber can be utilized in concrete as a replacement of fine aggregates, coarse aggregates, and fibres. This study provides a general discussion of the uses of recycled tyre rubber in concrete. The wide-ranging considerations in using rubber concrete are also discussed in this paper. The general conclusions of this review are as follows:

A. It is observed that the compressive strength, split tensile strength as well as the flexural strength decreases as the addition of a percentage of rubber increases.
B. The addition of rubber particles can reduce the slump value of lightweight aggregate concrete.
C. Rubberized concrete shows a reduction in the density of concrete when compared with control concrete specimen.
D. The rubberized concretes were stable up to 300℃. The decomposition of rubber-based aggregate and its combustion deteriorated functional properties of rubberized concrete when samples exposed to 400℃.
E. A surface modification method by acidic. Compressive strength attains more than 100% of replacement of Treated Waste Tyre Rubber in 5% & 7.5% by weight comparing the conventional concrete.
F. Untreated Rubber concrete is affordable and cost-effective because it uses waste material. It can be used in non-load-bearing members such as lightweight concrete walls, highway constructions as a shock absorber, sound barriers as a sound absorber, buildings as an earthquake shock-wave absorber.
G. Treated rubber concrete applications in the construction industry depend on which treatment method was carried out.

It is confirming from this study without treatment of rubber. Concrete has seen a reduction in engineering mechanical properties. Rubber treatment is a must to get the desired performance of concrete. Nevertheless, it should be further investigated which treatments can maximize the concrete performance of concrete mix that contains waste tyre rubber.

REFERENCES

[1] Bharathi Murugan, R.; and Natarajan, Dr. C.; "Experimental Study on Rubberized Concrete", International Journal of Scientific & Engineering Research, Volume 6, May-2015, p.p. 860-863
[2] Banerjee, Sulagno; and Jessyrooby, dr; "Strength Study of Tyre Rubber Concrete", International Journal of Research in Advent Technology, Vol.7, No.4, April 2019, p.p 88-93
[3] Pradeep; Gupta, Dr. Durga Prasad; and Dewangan, Dr. Arvind; "A Review on Use of Scrap Tyre Rubber Wastes in Concrete", International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 3, May 2015, p.p.120-123
[4] Pardeshi, Nikhil Ramchandra; and Singh, Digvijay P.; "Performance and Evaluation of Rubber as Concrete Material" International Research Journal of Engineering and Technology (IRJET), Volume 04, Jan -2017, p.p.554-560
[5] Gupta, Trilok; and Siddique, Salman; "Behaviour of waste rubber powder and hybrid rubber concrete in aggressive environment", Construction and Building Materials, v 217, (2019), p.p. 283–291
[6] Záleská, Martina; and Pavlík, Zbyšek; "Eco-friendly concrete with scrap-tyre-rubber-based aggregate – Properties and thermal stability", Construction and Building Materials, v 225, (2019), p.p. 709–722
[7] Rajan, R. Gajendra; and Sakthieswaran, N.; "Experimental investigation of sustainable concrete by partial replacement of fine aggregate with treated waste tyre rubber by acidic nature", Materials, 13 June 2020,
[8] Lv, Jing; and Zhou, Tianhua; "Effects of rubber particles on mechanical properties of lightweight aggregate concrete", Construction and Building Materials,v 91, (2015), p.p. 145–149
[9] Huang, Baoshan; Shu, Xiang; and Cao, Jingyao; "A two-staged surface treatment to improve properties of rubber modified cement composites", Construction and Building Materials,v 40, (2013), p.p.270–274