

## PARTIAL REPLACEMENT OF AGGREGATES IN CONCRETE WITH TREATED AND UNTREATED WASTE TYRE RUBBER

Ajeet Singh Baghel<sup>1</sup>, Dr. Manoj Sharma<sup>2</sup>, Dr. Aunrag Garg<sup>3</sup>

<sup>1</sup>M. Tech Students, IPS College of Technology & Management Gwalior M.P., India.

<sup>2,3</sup>Professor, IPS College of Technology & Management Gwalior M.P., India.

### ABSTRACT

Our present study intends to explore the most effective use of the waste tyre rubber as a constituent of concrete mix replacing the coarse aggregate partially. In this research work, emphasis is given on the pre-treating of the rubber particles and then using them as the partial replacement of the conventional rock aggregates. To get the best results, the rubber aggregates used are surface treated by sodium hydroxide and cement paste before using them in the concrete. M20 grade concrete is used. Using untreated rubber aggregates, the compressive strength of the resultant concrete reduced rapidly, but when treated rubber aggregates were introduced, it resulted in the regaining of more than 90% of the 28 day compressive strength of normal concrete which can be considered quite satisfactory considering the easy and cheap availability of the used tyres and the negative impacts it can have on the environment if left unused. This much compressive strength is enough for treated-rubberized concrete for its use in different areas where compressive strength is not much important like in floors and concrete road pavements. Flexural and split tensile strength is found to be higher than that of the normal concrete but only when treatment is given to the rubber aggregates before using them. Workability is decreased.

**Keywords:** Rubber aggregates, Rubberized Concrete, Sodium hydroxide (NaOH), Cement paste, Tyres.

### 1. INTRODUCTION

Use of Waste tyres or used tyres has been an inveterate environmental issue in western countries but now due to the modernization and industrialization, this problem has slowly been felt in different Asian countries especially India and China. India has at a very slow pace started to work against this menace, but not effectively when compared to its western counterparts. As India is on its way from being a developing country to a developed country, rate of vehicles hitting the road per year is increasing very fast and so is the number of tyres. Increasing number of tyres produced or used per year means more number of waste tyres being produced at the end of that year which in turn produces more number of landfills that are hazardous to the environment. Burning of these tyres has also not been recommended due to the production of a variety of poisonous gases which is again a big environmental problem.

Different areas for the use of recycled tyre rubber have been identified from time to time and a lot of research is being carried out for its better use but due to the unique physical and chemical properties of rubber, and the quantity in which it is produced, it is very difficult to use it wholly in a particular area or field. The different applications of waste tyre rubber where it has been successfully used are:

- ✚ Sports surfaces.
- ✚ Automotive industry.
- ✚ Construction.
- ✚ geo-technical/asphalt applications.
- ✚ adhesives and sealants.
- ✚ shock absorption and safety products.
- ✚ rubber and plastic products.

### 2. OBJECTIVES OF THE STUDY

The objective of this study is to use the waste tyre rubber as a partial replacement of natural coarse aggregate for the positive variations in the properties of the mix and then in order to further improve those properties, we give surface treatments to the rubber aggregates before their use, in order to improve their bond strength with the cement paste. The effect of rubber aggregates used as the replacement of coarse aggregate and its surface treatment is to be determined by testing workability, tensile strength, compressive strength, durability,

The main objectives of the study are given below;

- ✚ The main purpose of this study is to examine the effect of addition of shredded rubber aggregates into the Portland cement concrete in three different proportions i.e. 5%, 10% and 15% by mass of coarse aggregates and evaluate the fresh and hardened rubberized concrete properties.

✚ Another objective of this experimental study is to investigate the effect of surface treatment of rubber on various properties of rubberized concrete. Two different treatments will be given to the rubber aggregates.

A) Treatment by coating the rubber aggregates with cement paste.

B) Treatment by washing the rubber aggregates with NaOH solution.

✚ To prepare lightweight concrete by using waste rubber as partial replacement of coarse aggregate.

✚ Utilization of waste rubber in the concrete construction sector, hence eliminating the need of land fill disposal of this non bio-degradable waste.

### 3. SCOPE OF THE STUDY

In our country India, a large quantity of waste materials produced from industries is polluting the environment. Keeping in view the points already mentioned in the above section, this study is focused on the recycling of one such waste material i.e. used tyre rubber. The management of waste tyres will not only have beneficial effects on the environment, but due to its abundant and free availability, it will also contribute to the economy of the structure, when it replaces a material that is costlier than it. Rubber aggregates being more flexible and lighter than the natural rock aggregates, has great potential to be used in earthquake prone areas. Rubberized concrete has the ability to dissipate the vibration shocks at the time of earthquakes better than the normal concrete.

### 4. LITERATURE REVIEW

**Zeineddine Boudaoud, Miloud Beddar. (2012).** As in other research works, this piece also led to the conclusion that there is a reduction in the mechanical characteristics of the concrete when rubber is added to it. However, even after the reduction in the strength, it still has the potential to be used in many places where not much strength is required like in the road construction industry. It was observed to be more economical, ecological and lighter than the normal concrete.

**Akinwonmi, Seckley et al. (2013).** They separately replaced the natural aggregates by both shredded rubber as well as by crumb rubber. After testing the specimen which contained different percentages of the crumb rubber and others which contained the different percentage of shredded rubber, it was observed that up to the replacement level of 2.5% by shredded tyre, the compressive strength slightly increased but when the replacement level goes beyond 2.5%, there is a massive decrease in the compressive strength of the concrete.

**Sunil N. Shah, Pradip D. Jadhao et al. (2014).** The different tests performed in this study showed that the workability decreased upon the increase in chipped rubber aggregate content. The unit weight of the resultant rubberized concrete samples was found less as compared to the normal concrete. This led to the conclusion that rubberized concrete can be used as light weight concrete though it showed less strength than the normal concrete.

**Obinna Onuaguluchi et al. (2014).** Surface treatment by lime stone powder is given to the crumb rubber with varying percentages of replacement levels by volume. The increase in strength was very less but when the same surface modification of crumb rubber was applied in combination with the silica fume as cement replacement, the mechanical properties enhanced significantly. It was also concluded that the rubber incorporated acted as electrical insulator which increased the surface resistivity and resistance to chlorine permeability.

**Ishtiaq alam, Umer Ammar Mahmood, Nouman Khattak (2015).** Like other research works, they also replaced the natural aggregates in concrete with rubber aggregates and found that the compressive strength of the resultant concrete gets drastically reduced. To increase it, surface treatment of rubber particles just before use, by silica fume was recommended. This review paper also contains some positive effects on the resultant concrete like development of ductile behavior in concrete before it fails. They also found that the density of normal concrete was more than the concrete containing rubber aggregates and it was found that density gets decreased when percentage of rubber is increased in the concrete. It is because of the fact that the specific weight of the rubber is lesser than that of the natural rock aggregates.

**Blessen Skariah Thomas et al. (2016).** Rubberized concrete shows high resistance to freeze thaw, acid attacks, and chlorine ion penetration.

**Qingli Dai, Guo et al. (2017).** In this research work different surface treatments were given to the rubber particles before using them in the mix. they were treated with sodium hydroxide and silane coupling agent were used. The rubber particles were also treated with cement, silica fume and blended cement with sodium silicate. these all treatments were given in order to increase the bonding between the cement paste and the rubber particles. the tests revealed that the best results were shown by the concrete which contained NaOH treated rubber particles.

**Shahid Rasool Tarry (2018)** Effect of partial replacement of coarse aggregates in concrete by untreated and treated tyre rubber aggregates. In this research work, emphasis is given on the pre-treating of the rubber particles and then using

them as the partial replacement of the conventional rock aggregates. To get the best results, the rubber aggregates used are surface treated by sodium hydroxide and cement paste before using them in the concrete M20 grade concrete is used.

**Onyeka (2019)** The compressive strength of concrete with 100% granite at 28 days is 26N/mm<sup>2</sup>, while that of concrete gave 25.04 N/mm<sup>2</sup> strengths, 24.37N/mm<sup>2</sup>, 22.22 N/mm<sup>2</sup> and 21.55N/mm<sup>2</sup>, for 15%, 25%, 35% and 45% replacement of granite with glass respectively.

**Bharani, et al., (2020)** The partial replacement of M- sand by steel slag with 10%, 20% and 30% to find the optimum percentage of replacement. Using optimum percentage as constant, the Coarse Aggregate is replaced with certain percentage by E-Waste.

**Jaydeo Phadtare et al. (2022)** Study of partial replacement of coarse aggregate in concrete by different proportions of Un- Treated waste tyre rubber. Our clear focus is to study the behaviour and properties of concrete in fresh as well in harden condition when its natural coarse aggregates is replaced by 5% & 15% waste tyre rubber with the help of compressive test, split tensile test and flexural test for hardened properties of concrete.

**Jeevana et al. (2023)** Partial replacement of coarse aggregate with crumb rubber chips in the preparation of concrete. This crumb tyre aggregate is added as 5%, 10%, 15% to replace the coarse aggregate. In this study, workability and compressive of rubberized concrete was evaluated to investigate the optimal use of crumb rubber as coarse aggregate in concrete.

**Badugu Manisha, Ajmeera Lavanya,(2024),** This experimental study is conducted to analyze the behaviour characteristics of rubberized concrete where rubber tyre is partially replaced with coarse aggregate. M30 grade concrete has been chosen as the reference concrete specimen. This will not only allow the sustainable use of aggregates available to us but also provide an effective and mass management of waste rubber tyre. This waste rubber tyre aggregate is added as 5%, 10%, 15% to replace the coarse aggregate. In this study compressive strength and split tensile of rubberized concrete was evaluated to investigate the optimal use of crumb rubber as coarse aggregate in concrete.

## 5. MATERIALS

### Collection of Raw Material

The material used in the project is cement, sand, tyre rubber and sodium hydroxide. The cement, sand and sodium hydroxide are easily available in the market while the tyre rubber is available at very few sources. For this Project the tyre rubber was collected from a local garage and the sodium hydroxide was obtained from the market.

**Cement-** cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is behind only water as the planet's most-consumed resource.



Fig no. 1 cement

### Sand-

Sand is a mixture of very small pieces of different rocks or minerals. It is the same minerals from which those pieces are broken, such as granite and feldspar. Sand is gritty to touch. It is a naturally occurring granular material composed of finely divided rock and mineral particles.

Sand is a naturally occurring granular material composed of finely ground rock and mineral particles. The scientific Unified Soil Classification System used in engineering and geology corresponds to US Standard Sieves, and defines sand as particles with a diameter of between 0.074 and 4.75 millimeters. Sand color is a desaturated form of bright and sunny yellow.

### TYRE RUBBER-

Definitions of rubber tire. noun. a tire consisting of a rubber ring around the rim of an automobile wheel. synonyms: auto tire, automobile tire, car tire. Natural and synthetic rubber (also known as polymer) are the main components of a car tyre. Depending on the variety, these materials provide a high level of slip resistance and, after processing, the preferred elasticity.



Fig no2. tyer

### Chemical Composition of a Tire

Table no.1

The Materials of construction	Approximate Weight %
RHC	48
Carbon Black and silica	22
Metal Reinforcement	15
Oil , ant degradants , wax, stearic acid,etc.	8
Fabric	5
Zinc oxide	1
Curing Agents	1
Total	100

### Material Testing

Below mentioned tests were conducted on the materials used:

- ☐ **Cement tests:** Consistency test, determination of initial and final setting time, compressive strength test, fineness test (sieve analysis), soundness test.
- ☐ **Tests for fine and coarse aggregate:** crushing test, impact test, abrasion test, water absorption test, soundness test, Shape test, Specific gravity and water absorption test, Sieve analysis (gradation).

## 6. METHODOLOGY

### Experimental Set up

The moulds used for the preparation of samples were cubes of size (15cm x15cm x 15cm) for compressive strength testing, the beams of size (50cm x 10cm x 10cm) for flexural testing and the cylinders of size (10cm x 20cm) for split tensile strength testing. Treatment of rubber wastes involves its surface modification to improve the bond between rubber and the concrete components like cement paste and aggregates and it was done by soaking rubber particles in 0.1 molar solution of NaOH and in cemented suspension for about 20 minutes just before using them in concrete. A total of 20 cubes, 10 beams and 10 prisms are casted of M20 grade by replacing 5, 10 and 15 % of natural coarse aggregate with untreated and treated waste tyre aggregate and compared with regular M20 grade concrete

### Mix Proportion

The cement: sand: aggregate ratio of 1:1.5:3 is taken and the calculations of each constituent were done by weight analysis. for replacements, the aggregate replacement %age is taken as in Table no. 1. Water/cement ratio is kept as 0.45 for all samples. The cement with which the mix design is done is OPC 53 grade.

Table.2

S.No	Mix	Cement(Kg/m <sup>3</sup> )	Fine	Coarse		Percent	Water
	ID		aggregate(Kg/m <sup>3</sup> )	aggregate(Kg/m <sup>3</sup> )		replacement	cement
				Gravel	Rubber	by Rubber	ratio
1	PC	436	654	1309	00	00	0.45

2	UTR-	436	654	1243	66	05	0.45
	5						
3	UTR-	436	654	1178	131	10	0.45
	10						
4	UTR-	436	654	1112	196	15	0.45
	15						
5	NTR-	436	654	1243	66	05	0.45
	5						
6	NTR-	436	654	1178	131	10	0.45
	10						
7	NTR-	436	654	1112	196	15	0.45
	15						
8	CTR-	436	654	1243	66	05	0.45
	5						
9	CTR-	436	654	1178	131	10	0.45
	10						
10	CTR-	436	654	1112	196	15	0.45
	15						
Where,							
UTR-5 represents untreated 5% rubber.							
NTR-5 represents sodium hydroxide treated rubber.							
CTR-5 represents cement treated rubber.							
PC represents plain concrete.							

## 7. RESULTS

### Workability

The workability of both the treated and untreated rubberized concrete is found to be less than the plain concrete and decreases with the increase in percentage replacement of aggregates. As seen in the graph in Figure 1, apart from NTR-5, which has a slight increase of 1mm in slump value than the UTR-5, all other replacement levels and treatments show a decrease in the workability as the percentage replacement is increased. Low workability of rubberized concrete (untreated) is due to hindrance of movement of concrete paste and natural aggregates by rubber aggregates and due to improper bonding. When bonding is improved by NaOH treatment, decrease in workability is due to increase in viscosity. When cement paste treatment is given to rubber, workability decreases due to adherence of cement particles on rubber particles which absorb water from concrete and make less water available to provide workability.

**Table no. 3** Slump values of different samples

SAMPLE	SLUMP VALUE (mm)	PERCENT REDUCTION OF SLUMP
PC	50	0
UTR-5	47	6
UTR-10	45	10
UTR-15	43	14
NTR-5	48	4
NTR-10	44	12
NTR-15	40	20
CTR-5	45	10
CTR-10	42	16
CTR-15	35	30



**Fig no.3** Rubberized concrete sample for workability test

## Compressive strength

**Table no. 4** Compressive strength of different samples

SAMPLE	7-DAY COMPRESSIVE STRENGTH-CUBE (N/mm <sup>2</sup> )	28-DAY COMPRESSIVE STRENGTH CUBE (N/mm <sup>2</sup> )
PC	19.11	27.33
UTR-5	13.87	19.80
UTR-10	16.44	23.50
UTR-15	15.60	20.40
NTR-5	16.40	23.30
NTR-10	17.70	25.30
NTR-15	11.11	15.60
CTR-5	15.60	22.2
CTR-10	12.11	15.50
CTR-15	17.33	21.70

The 7 days' compressive strength of NTR-10 is found to be highest among all the replaced mixes but lower than plain concrete. However, 92.62% compressive strength of plain concrete is regained in this case which is quite satisfactory considering the material used. Similarly, 28 days' compressive strength is found to be highest for NTR-10 but again lower than plain concrete. It accounts for 92.57% compressive strength of the conventional normal concrete which is quite considered satisfactory. The compressive strengths of untreated and cement treated rubberized concrete as compared to NTR-10 and plain concrete is found to be very less.

## 8. CONCLUSION

- 1 Rubber has great capability of becoming a permanent member of concrete family because of its wide variety of decent properties like better flexibility, light weight and easy availability. It can be very environmental friendly to use this waste material in construction industry.

- 2 Treated rubberized concrete possesses more compressive strength as compared to the untreated rubberized concrete. However, even after the surface treatment is given to the rubber, only 92.57% compressive strength of normal conventional concrete is regained.
- 3 Flexural and split tensile strength of almost all replacement levels of treated rubberized concrete is found to be more than in the normal conventional concretes. 28 days flexural and split tensile strength is found to be highest at NTR-5 and NTR-15 respectively.
- 4 Using rubber aggregates decreases the workability of the resultant mix, but this problem can be dealt with the use of the certain plasticizers.

## 9. FUTURE SCOPE

- ✚ Easy availability of waste tyre rubber and never ending output of waste tyres from the tyre industry means that this waste product will always need to be recycled.
- ✚ The use of waste tyre rubber results in more economical and ecofriendly concrete.
- ✚ Also if some treatments are provided to rubber, the strength properties surely increase.

## 10. REFERENCES

- [1] Lee, Hee Suk, et al. "Development of Tire Added Latex Concrete." Materials Journal 1998.
- [2] Taha, MM Reda, A. S. El-Dieb, and MA Abd El-Wahab. "Fracture Toughness of Concrete Incorporating Rubber Tire Particles". International conference on performance of construction materials. 2003.
- [3] Zhigang, Ye, Zhang Yuzhen, and Kong Xianming. "Modification of Bitumen with Desulfurized Crumb Rubber in the Present of Reactive Additives." Journal of Wuhan University of Technology--Materials Science Edition 2005.
- [4] Yue, Li, Jin Caiyun, and Xi Yunping. "The properties of Sulfur Rubber Concrete (SRC)". Journal of Wuhan University of Technology--Materials Science Edition 2006.
- [5] Zhang, Y., Sun Wei, and Chen Shengxia. "Study on Properties of Rubber Included Concrete under Wet-dry Cycling". Measuring, Monitoring and Modeling Concrete Properties 2006.
- [6] Azmi, N. J., B. S. Mohammed, and H. M. A. Al-Mattarneh. "Engineering Properties of Concrete Containing Recycled Tyre Rubber". International Conference on Construction and Building Technology. 2008.
- [7] El-Gammal, A., et al. "Compressive Strength of Concrete Utilizing Waste Tire Rubber." Journal of Emerging Trends in Engineering and Applied Sciences 2010.
- [8] Yasin, Amjad A. "Using Shredded Tires as an Aggregate in Concrete." Contemporary Engineering Sciences 2012.
- [9] Boudaoud, Zeineddine, and Miloud Beddar. "Effects of Recycled Tires Rubber Aggregates on the Characteristics of Cement Concrete" 2012.
- [10] Akinwonmi, S Ademola et al. "Mechanical strength of concrete with crumb and shredded tyre as aggregate replacement International Journal of Engineering Research and Applications (IJERA) 2, March -April 2013,
- [11] He, Liang, et al. "Surface Modification of Crumb Rubber and its Influence on the Mechanical Properties of Rubber-Cement Concrete". Construction and Building Materials 2016
- [12] Kranul N Patel, Prof. M.A Jamnu. "Enhancement of Mechanical Properties of Rubber Crumb Concrete Using Pretreated Rubber Crumbs and alcco fine." Journal of International Academic Research for Multidisciplinary Impact March 2014.
- [13] Onuaguluchi, Obinna, and Daman K. Panesar. "Hardened Properties of Concrete Mixtures Containing Precoated Crumb Rubber and Silica Fume". Journal of Cleaner Production 2014.
- [14] Alam, Ishtiaq, Umer Ammar Mahmood, and Nouman Khattak. "Use of Rubber as Aggregate in Concrete: A Review." International Journal of Advanced Structures and Geotechnical Engineering 2015.
- [15] More, Tushar R., Pradip D. Jadhao, and S. M. Dumne. "Strength Appraisal of Concrete Containing Waste Tyre Crumb Rubber." 2015.
- [16] Thomas, Blessen Skariah, and Ramesh Chandra Gupta. "A comprehensive review on the applications of waste tire rubber in cement concrete." Renewable and Sustainable Energy Reviews 2016.
- [17] Guo, Shuaicheng, et al. "Evaluation of Properties and Performance of Rubber-Modified Concrete for Recycling of Waste Scrap Tire" Journal of Cleaner Production 2017.
- [18] Shah, Sunil N., Pradip D. Jadhao, and S. M. Dumne. "Effect of Chipped Rubber Aggregates on Performance of Concrete." 2019