IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

VOLUME : 4 ISSUE : 12 Print / Issue Publication Date: 10-Jun-2020

ISSN : 2455-2143

DOI : 10.33564/IJEAST.2020.v04i12.122

Indexed In

International Journal of Engineering Applied Sciences and Technology, 2020
Vol. 4, Issue 12, ISSN No. 2455-2143, Pages 677-682
Published Online April 2020 in IJEAST (http://www.ijeast.com)

RUBBER-CONCRETE FORMATION USING CHIPPED RUBBER FOR SUSTAINABLE MANAGEMENT IN CONSTRUCTION

Suman Markuna
M.Tech, SWCE, College of Technology
GBPUAT Pantnagar, Uttarakhand, India

Divyanshu Bhatt
M.Tech, SWCE, College of Technology
GBPUAT Pantnagar, Uttarakhand, India

Abstract- **The effective management of waste-rubber tire is quite difficult for the municipality system without enhancing global warming because it is not easily biodegradable substance and requires a long-period for further decomposition. The scrap rubber tires are the waste material and recycling it into constriction purposes makes it beneficial for the environment. The reuse of waste tire rubber has been used in this study to replace the coarse aggregate by weight using different percentages of the chipped rubber. In the study, the different proportions (8%, 12%, and 14%) of the chipped rubber used to form the rubber-concrete mix (M40). The slump test, compaction factor test was considered for the workability of the rubber-concrete mix and then compared with the normal concrete mix. The compressive strength of the rubber-concrete and normal concrete cubes was compared at 7 days, 14 days, and 21 days using a compression testing machine in the laboratory. From the results, it is obtained that with increment in the % of chipped rubber the compressive strength of the cubes was decreased. So less than 10% use of chipped rubber in the rubber-concrete mix makes it workable and used as sound-insulating material for many purposes, footpaths, and non-load bearing walls, etc.**

Keywords- **Chipped tire rubber, normal concrete, rubber-concrete, workability, compressive strength**

I. INTRODUCTION

The burning of scrap tire is an important phenomenon to mitigate, which adversely affects the globe. Once the waste tires start to burn due to some natural causes then it results to develop the higher temperature over the surface of tires and toxic fumes developed when the tires got melt, thus producing a liquid that will automatically be contaminated in the soil and flow with the water. This is very harmful to living beings. Some solid waste materials such as plastic bottles, papers, steel, etc. can be recycled using advanced technologies without affecting the environment. But there is no other option to dispose of the solid waste tire rather than utilized in the construction economically. Since it is not a biodegradable material, which destroys the fertility of the soil and growth of the vegetation and if dumped in the centralized locations it may cause accidental fires and adversely affects the environment. Similarly, it results in carbon dioxide emission, greenhouse effects on the environment. The concrete mixed with waste chipped rubber added in various volume proportions is called rubber-concrete. Partially replacing the coarse or fine aggregate of concrete with some quantity of small waste tire in the form of chipped rubber, 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. The concrete mix with silica fume, crumb rubber, and chipped tire waste was analyzed and examined (Guneyisi et al., 2004). The standard size of the tire rubber is divided into three parts as chipped, ground, and crumb rubber with a particle size of 0.15-13 mm, 0.075-0.475mm and 0.425-4.75mm (Ganjian et al., 2009).

The waste rubber tire is a basic problem that affects the environment adversely. Still, millions of tires are buried into the ground in the entire world. The plain rubberized-concrete was formed and it was observed that the rubber total substitution diminished the crack mouth open uprooting at stacking level and its flexural durability is excellent (Najim and Hall, 2012). For hollow concrete blocks the rubber-concrete can be used with lower mechanical properties of the mix (Mohammed et al., 2012). Due to the lightweight, sound insulating, elasticity, and heat absorption characteristics it is most widely used in construction purposes as in crumb and chipped form. After replacement of the total coarse aggregate with the chipped waste tire rubbers 85% reduction results in compressive strength and 50% in tensile strength (Siddique and Naik, 2004). It is recommended to use the rubber-concrete in the construction of kerbs of the pavements, footpaths, concrete blocks, and non-load bearing concrete walls. To mitigate the harmful impacts (CO_2 gas emission, increment in temperature, etc) of rubber tires the best way to reuse it in construction purposes and concrete industry can be considered as one of the best alternatives to reuse the waste tires and recycled it and further uses for many purposes (Jalal et al., 2019).

The rubber mixed concrete has so many advantages like it increases the toughness, ductility, saves the natural resources, controls pollution or global warming, and mitigates the unit weight to the normally used concrete for construction. Using this method for construction it is economic as well as environment friendly. When it comes to life end due to enhancement in automotive transportation, around 1 billion tires are thrown away in the entire world regularly (Thomas et al., 2014). The recycling process of waste tires is one of the important concepts shared by researchers, and the scientific community for the huge production without affecting the environment (Roychand et al., 2020). Some researchers have been already used the waste tire as the replacement of aggregate in concrete production because it enhances its toughness, workability, and sound insulation characteristics. Rubber-concrete is preferred for construction in some places which are not susceptible to earthquakes and for non-load bearing purposes. By recycling the waste tire rubbers it can be used as fuel in kilns, paper, pulp, and boilers (Medina et al., 2018). For the production of concrete, the waste tire rubber can be used to achieve the sustainability and economy in construction (Wu et al., 2020). Using crumb tires in the concrete mixer for construction then it reduces the compressive strength of the material and meets the strength requirements of the lightweight concrete (Sofi, 2018). The rubber is used in concrete then it changes the properties of the developed material and not affected its tensile strength as like reduces the compressive strength. The concrete having lower unit weight, higher energy absorption power, and good impact strength with waste rubber tires preferred in some places (Topcu, 1997). The rubber-concrete is the perfect material for the structural members exposed to rapid effects and for which preferred toughness or deformability holds greater significance than strength, like road foundations, jersey barriers, and bridge barriers (Hilal, 2017). The dynamic properties of the rubber-concrete have been identified and reduce the vibration effects due to its elastic property in the developed matter (Hernandez –Olivaresa et al., 2002).

The present study aims to the manufacturing of the rubber-concrete cubes using chipped rubber. The recycled waste tire rubber has been used in this study to replace the coarse aggregate by weight using different percentages of the chipped rubber. The particular concern of the present study is to introduce the waste rubber- tire in construction. The objectives of this paper as follows:

1. To study the properties of materials used for M40 concrete mix (cement, waste chipped-rubber, fine aggregate, and coarse Aggregate).
2. Replacement of coarse aggregate of standard concrete mix with different weight ratios of chipped rubber (8%, 12%, and 14%) in the laboratory.
3. To investigate the slump characteristics, compacting factor value of fresh concrete, compressive strength in the laboratory.
4. To compare the results of rubber-concrete with conventional concrete using parameters.

II. MATERIALS USED

The materials used in the study as cement, coarse and fine aggregate, and chipped rubber. By using the materials the standard size (15cm X 15cm X 15cm) rubber-concrete cubes were formed. The overview of the used materials and their properties as follows:

A. Cement

The cement used for the study was Birla Uttam Grade 43 Ordinary Portland cement (OPC). The OPC is commonly used cement and suitable for construction purposes. Due to the low cost and availability of the shales, limestone, and other materials which are used in the manufacturing of the Portland cement makes it low-cost material and then widely used in the entire world. The material or mixture sets in a few hours and it may get harden in a week or weeks when it is completely mixed in water.

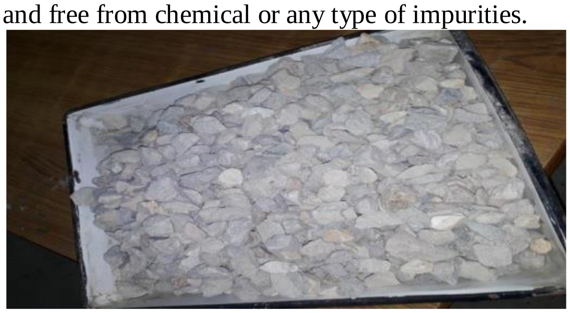
B. Chipped tire rubber

The tires may be divided into car and truck tires, widely used for construction purposes. The chipped tire rubber is shown in Fig. 1, basically used to replace the coarse aggregate which reduces the effective cost of the mixed material. The length and width of the tire rubber used initially was about 300-430mm long and 100-230mm wide. Further, it is converted into the chipped rubbers having a 13-76mm diameter.

Fig. 1 Chipped tire rubber

C. Aggregates

The aggregates should be hard and strong, free from impurities, and stable. The impurities such as clay, silt, dirt, and organic cells may lie on the surface of aggregates, this may reduce the quality of concrete. The impurities may results that the surrounding particles may isolate which further reduces the strength of mix and this impurity leads to more requirement of water to form the mix. The gravels are used in the study as coarse aggregate and sand used as fine aggregate, shown in Fig. 2 (a & b). And the water used for the mixture, it should be pure and free from chemical or any type of impurities.



(a) Coarse Aggregate

(b) Fine aggregate

Fig. 2 Used Coarse aggregate and fine aggregate in experimental work

III. PREPARATION OF CUBES

A. Mixing of material

The mixing of the materials (fine aggregate, coarse aggregate, cement, and chipped rubber) to form the concrete mix was completed by hand mixing (Fig. 3) with the help of a batch mixer available in the laboratory. The cement and fine aggregate mixed well and blended then coarse aggregate (gravel) added and mix with the material. Then the required amount of water used to form a homogeneous mix of concrete with the desired consistency. The partial replacement of the coarse aggregate with chipped rubber was taken 8%, 12%, and 14%. And then mixed well with the other materials individually.

Fig. 3 Mixing of material

B. Sampling

For sampling first, we should clean the molds (15cm X 15cm X 15cm) and then oil applied in the inner surface of molds. Then fill the concrete mix of 8%, 12%, and 14% of chipped rubber inside the molds (5cm thickness), compact each layer with the help of tamping rod more than 35 strokes. Then the top surface should be smoother using trowel. A sampling of cubes can be identified using Fig. 4.

(a) Compaction by using a tamping rod

(b) Smoothing the top layer of mix

Fig. 4 Sampling of cubes using molds

C. Curing

The specimens (12 cubes) were stored in moist air for 24 hours and after this period the specimens are marked and removed from the molds and kept submerged in clear freshwater (Fig. 5) until taken out before the test for curing. For the curing of the cubes, the waste tank was used that was available in the laboratory.

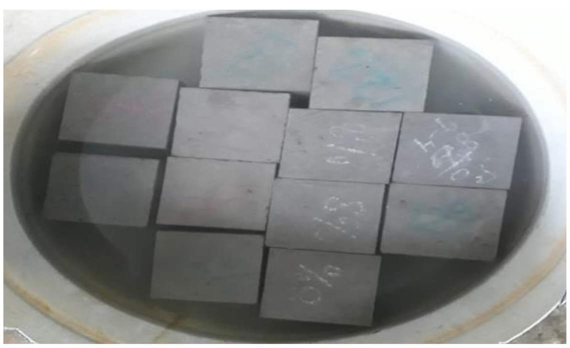


Fig. 5 Curing of specimens

IV. TEST ON CONCERETE MIX

A. Slump test

The slump test is an empirical method as well utilized to identify the workability of the concrete mix. The consistency of the concrete mix is defined by using the slump test. The consistency defines that the amount of water has been used to develop the mix. The consistency should be satisfying the standard requirements. The slump test considers that under the action of gravity the concrete mix is compacted and represents the stiffness. It is used to indicate the characteristics of the freshly developed concrete. The apparatus used in the slump test are slump cone, tamping steel rod, and scale for measurement. The slump test is most widely used because it is very easy to apply and interpret. The three types of slumps are collapse, shear, and true slump. The true slump is perfect and further used for another test for the concrete mix.

B. Compaction factor test

The compaction factor test is most widely used for the workability of the concrete mix. It is the ratio of partially compacted concrete to the fully compacted concrete. The apparatus used for the test are compaction factor apparatus, trowel, hand scoop, steel road, and a balance. The compaction factor apparatus is shown in Fig. 6.

Fig. 6 Compaction factor apparatus

C. Compression test

The compression test is conducted to identify the strength of concrete mix cubes. The first test is considered after 7 days curing of the cubes and then further the test can be conducted after 28 days. This is a destructive test on concrete cubes to identify the compressive strength of the cubes and then can further be utilized in practical application. The compression testing machine used in the laboratory for the compression strength of the cubes is shown in Fig. 7.

Fig. 7 Compression testing machine

V. RESULTS AND DISCUSSION

The 12 cubes were formed of size 15cm X 15cm X 15cm of normal concrete mix, 8%, 12%, and 14% used chipped rubber-concrete mix. The four cubes (normal concrete, 8%, 12%, and 14% rubber-concrete) were tested at each stage of testing (at 7 days, 14 days, and 21 days). Here the last test was conducted at 21 days because of the discrepancy in the facilities of the laboratory. The characteristic compressive strength of the rubber-concrete cubes was compared with the normal concrete cubes. In general, the compressive strength of the normal concrete cube is 23.5 N/mm^2 at 7 days of testing.

For the design of 1:1.1:2.6, the slump test was considered in the laboratory. For the given sample the slump was 3.0cm obtained in the laboratory. The compaction factor was 0.85 for the mix. The compressive strength of the cubes (8%, 12%, and 14%) achieved at 7 days testing was 12.46, 11.9, and 10.028 N/mm^2. The comparison of a slump and compaction factor between the normal concrete and rubber-concrete can be identified in Table 1. And the comparison of compressive strength at 7, 14, and 21 days between normal and different % of chipped rubber-concrete shown in Table 2.

Table 1. Comparison between the workability of normal concrete and rubber-concrete.

Parameters	Normal concrete	Rubber-concrete
Slump value	3.2 cm	3.0 cm
Compaction factor	0.9	0.85

Table 2. Comparison of compressive strength between normal and rubber-concrete.

Day	Parameter	Normal concrete	Rubber-concrete		
			8%	12%	14%
7	Compress-ive strength	23.5	12.46	11.99	10.028
14		38.14	17.2	16.12	13.28
21		44.47	40.11	36.62	30.74

From Table 2 it can be identified that when the percentage of chipped rubber increases the compressive strength of the concrete decreases. It is observed from the study the effect of unit weight is very less by introducing the chipped rubber in less amount (8%) which is further considered as negligible. So it is not any drastic change in workability if chipped rubber used less than 10%. The workability slightly decreases (Table 1), which can be considered negligible. With the enhancement in the chipped rubber in the concrete mix, the slump and unit weight decreases continuously. The density of the concrete mix is influenced by the characteristics of the added chipped rubber and decreases with the increment in the rubber content. Up to 14-15% introduction of chipped rubber into the concrete mix is fine for compressive strength of the material but it may cause the drastic drop in compressive strength while increases the rubber content more than 14-15%. The size of aggregate used in the concrete mix is influenced by the air entrainment in the mix.

VI. CONCLUSION

The rubber tire is a waste product and mostly it is dumped over the ground and accidentally may cause fire and to increase the pollution and global warming effects. The effective use of rubber tires in the manufacturing of concrete replaces the coarse aggregate. This mix can be used as energy adsorption, noise reduction, and non-load bearing, etc. In this study, the 12 concrete (including rubber-concrete and normal concrete) cubes were formed with size 15cm x 15cm x 15cm using fine aggregate (sand), coarse aggregate (gravel), chipped rubber (8%, 12%, and 14%) and cement in the laboratory. The slump test, compaction factor test was considered when the rubber-concrete mix with the homogeneous blending of chipped rubber with different % was obtained. The true slump occurs and the slump value was obtained 3.0cm. The compaction factor was 0.85 achieved for the rubber-concrete mix. From this, the workability slightly decreases. The compressive strength decreases with the increment in the amount of chipped rubber of the rubber-concrete. And 14% use of chipped rubber to form the rubber-concrete, there was no drastic drop in compressive strength. The compressive strength of the rubber-concrete mix can be increased by using some de-airing agents. Further other kinds of investigations are required to identify the properties of the rubber-concrete mix that maximize better performance. The aim of the study to introduce the waste-rubber tire in construction for sustainable management. Some advancements are further required to improve the strength of rubber-concrete.

VII. ACKNOWLEDGMENT

The authors would like to acknowledge that the complete experimental work considered in the laboratory of the Civil Engineering Department, BTKIT, Dwarahat under the supervision of the head of department (HOD), Mrs. Renu Sinha in 2018. The required material was provided by the HOD of the department for experimental work.

VIII. REFERENCES

[1] Ganjian, E., Khorami, M., Maghsoudi, A.A. (2009). Scrap-tyre-rubber replacement for aggregate and filler in concrete. *Constr. Build. Mater.*, 23, 1828-1836.

[2] Guneyisi, E., Gesoglu, M., Ozturan, T. (2004). Properties of rubberized concretes containing silica fume. *J. Cem. Concr. Res.*, 34, 2309–2317.

[3] Hernandez-Olivaresa, F., Barluenga, G., Bollati, M., Witoszek, B. (2002). Static and dynamic behavior of recycled tyre rubber-filled concrete. *Cem. Concr. Res.*, 32, 1587–1596.

[4] Hilal, N.N. (2017). Hardened properties of self-compacting concrete with different crumb rubber size and content. *International Journal of Sustainable Built Environment*, 6, 191–206.

[5] Jalal, M., Nassir, N., Jalal, H. (2019). Waste tire rubber and pozzolans in concrete: A trade-off between cleaner production and mechanical properties in a greener concrete. *Journal of Cleaner Production*, 238, 117882.

[6] Medina, N.F., Garcia, R., Hajirasouliha, I., Pilakoutas, K., Guadagnini, M., Raffoul, S. (2018). Composites with recycled rubber aggregates: properties and opportunities in construction. *Construct. Build. Mater.*, 188, 884-897.

[7] Mohammed, B.S., Hossain, K.M.A., Swee, J.T.E., Wong, G., Abdullahi, M. (2012). Properties of crumb rubber hollow concrete block. *J. Clean. Prod.*, 23, 57-67.

[8] Najim, K.B., Hall, M.R. (2012). Mechanical and dynamic properties of self-compacting crumb rubber modified concrete. Construct. *Build. Mater.*, 27, 522–524.

[9] Roychand, R., Gravina, R.J., Zhuge, Y., Ma, X., Youssf, O., Mills, J.E. (2020). A comprehensive review on the mechanical properties of waste tire rubber concrete. *Construction and Building Materials*, 237, 117651.

[10] Siddique, R., Naik, T.R. (2004). Properties of concrete containing scrap-tire rubber an overview. *Waste Manag.*, 24 (6), 563-569.

[11] Sof, A. (2018). Effect of waste tyre rubber on mechanical and durability properties of concrete – A review. *Ain Shams Engineering Journal*, 9, 2691–2700.

[12] Thomas, B.S., Gupta, R.C., Kalla, P., Cseteneyi, L. (2014). Strength, abrasion, and permeation characteristics of cement concrete containing discarded rubber fine aggregates. *Construct. Build. Mater.*, 59, 204-212.

[13] Topcu, I.B. (1997). Assessment of the brittleness index of rubberized concretes. *Cement Concr. Res.*, 27, 177-183.

[14] Wu, Y.F., Kazmi, S.M.S., Munir, M.J., Zhou, Y., Xing, F. (2020). Effect of compression casting method on the compressive strength, elastic modulus, and microstructure of rubber concrete. *Journal of Cleaner Production*, 264, 121746.

IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE AND TECHNOLOGY

ABOUT IJEAST

International Journal of Engineering Applied Science and Technology (IJEAST) is a peer-reviewed, open access journal that publishes high-quality research papers in the field of Engineering, Applied Science and Technology.

IJEAST aims to provide a platform for researchers, academicians, and professionals to share their innovative ideas, research findings, and practical experiences with the global scientific community.

FOCUS AREAS

- Engineering
- Applied Science
- Technology
- Innovation & Development
- Interdisciplinary Studies

PEER REVIEWED
All submissions are rigorously peer reviewed to ensure quality.

OPEN ACCESS
Free and unrestricted access to research for all.

GLOBAL REACH
Connecting researchers and professionals worldwide.

TIMELY PUBLICATION
We ensure a swift and efficient publication process.

For more information, visit our website
www.ijeast.com

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

editor@ijeast.com
www.ijeast.com
India

2455-2143