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Study on effect of indexed treated crumb rubber aggregate concrete (CRAC)

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Abstract
Today, researchers worldwide are focusing on how to use industrial and agricultural waste as a source of raw materials in construction industry. Use of rubber waste in concrete production would not only be economical but could also help to create a sustainable and pollution-free environment. It is expected that 4% of the used tires are under use in civil engineering as construction material and additionally, there is a shortage of exceptional aggregates due to environmental ban on mining. The main objective of this research is to analyse the preliminary properties of hybrid rubberized concrete mixes of M25, M30 and M35 grade using tire rubber in the concrete production to facilitate eco-friendly environment. The mix combinations were replaced fine aggregate with pre-packaged rubber total with 0.5%, 1%, 1.5% and 2% by volume. Many evaluations performed on rubberized concrete samples with compression power. The research is carried out to analyse the driving force of hybrid rubberized composite slabs. The specimens of 150 mm x 150 mm x 150 mm size prepared. Compressive strength test revealed in terms of overall performance on samples applying compression load. The compressive strength reduces with the increase of rubber total in hybrid rubberized concrete, is the finding of this research which a part of the study - investigation on the strength, deflection, impact energy absorption and ductility index of the treated rubberized concrete named crumb rubber aggregate concrete (CRAC).

Keywords: concrete, crumb rubber, strength, deflection, impact energy absorption and ductility

Introduction

Currently, sustainability is a big issue around the world, and urbanization have an effect on it. The development zone, especially urbanization is mainly responsible for 7% of all global CO2 emissions. The concrete competence of sustainable production is marked by the use of industrial waste to reduce the absorption of herbal assets and power, as well as environmental pollutants. Sustainable concrete is more environment friendly because of the alternative of materials than nominal concrete.

The land is necessary for the construction, substances for these activities (aggregates, cement, water etc.) coming from quarries and borrow pits could also lead to removal of plants and materials. It could also lead to the displacement of populations and the loss of essential ecological sources and biodiversity on a national, regional or global scale. Based at the foregoing, it has become essential to analyze and evaluation the use of waste materials as concrete substance to lessen the risks associated with herbal coarse mixture manufacturing and quarrying (Galina Erikovna Okolnikova *et al.*, 2023) [12].

The rubberized concrete produced by the incorporation of residual rubber tire particles could foster a lasting improvement by reducing the use of natural aggregates. Rubberized concrete has lower density, higher impact strength and toughness, and higher sound absorption and thermal insulation than ordinary concrete (Ferdous *et al* 2021, Qaidi *et al.*, 2021 and Qaidi *et al.*, 2022) [13, 15, 14].

Because the variety of vehicles is increasing, many used tyres can be produced, and the disposal of used tyres has been an environmental problem in cities around the arena. About 1.5 billion used tires are expected to be produced worldwide each year. By 2030, there could be as many as 5 billion used tyres per year. Discarded waste tires often create 'black pollution' due to the fact they may be no longer easily biodegradable and pose a potential threat to the environment each year millions of tires are discarded, thrown away or buried all around the world. Tire burning, that is the easiest and most inexpensive method of disposal, reasons severe fire risks, and toxic smoke with uncontrolled emissions of potentially dangerous compounds is unsafe to human beings, animals, and flora (Jie XU *et al.*, 2020) [16].

Rubberized concrete can be used in various civil engineering projects, such as partitions, bollards, and restrictions of street site visitors, where in the layout force is not a crucial parameter. Rubber mixed with metal fibre is a progressive fabric with high traction properties (Badorul Hisham Abu Bakar *et al.*, 2017) [17].

The properties of its components and the design parameters of the mixture have a significant impact on strong concrete. Because aggregates mean the main constituent of the bulk of a concrete mix, its properties affect the properties of creating the final product. An aggregate has traditionally been treated as an inert filling material in concrete. However, due to the growing awareness of the function played by means of aggregates in figuring out many critical properties of concrete, the traditional view of the combination as an inert filler is being severely puzzled. a combination initially considered as a material dispersed at some stage in cement paste largely for financial reasons. It's far viable, however, to take an opposite view and to look on mixture as a building cloth connected into a cohesive entire by means of the cement paste, in a manner similar to masonry production. In fact, the mixture is not certainly inert and its body, thermal, and from time-to-time chemical houses have an effect on the performance of concrete. Dattatreya *et al.*, 2015, said that the increasing piles of waste tires will create the buildup of used tires at landfill

sites and presents the risk of out-of-control fires, generating a complex combination of chemical compounds harming the surroundings and contaminating soil and plants.

At maximum, rubber crumbs are used to partially update the coarse mixture in concrete because of its environmental benefits (Toutanji, 1996) [1]. Concrete cylinders were tested with single amounts of rubber and increased ductility was recovered (Zheng *et al*., 2008) [3]. Concrete specimens made from rubber had been determined to have a decrease brittleness index than concrete specimens' product of regular concrete, which suggests that rubber concrete well-known shows higher ductility (Zheng *et al.,* 2008) [3]. It was concluded that with compression loads, rubber and concrete cylinders failed ductile instead of brittle, and absorb a large amount of plastic energy (Eldin,1993) [2].

One of the continual environmental issues around the world is waste-tire rubber. There arises a scenario where huge amounts of waste tire must be disposed of with a boom in automobile production waste. Many countries have banned waste tire rubber disposal to landfills because of the regular depletion of waste disposal on the sites. Since a long time, research has been in progress to forestall this depletion and to locate solutions to the waste tyre disposal.

The recycling of waste-tire rubber is one alternative. The Recycled waste tire has properties like electricity absorption, elasticity, heat, lightweight, and sound insulating properties, which makes it a good fabric within the production industry (Erkan Avci & Umit Buyuksari 2009) [7].

The usage of waste tires is presently very low in civil engineering, because of the loss of merchandise involving in recycled tires and its excessive quantity application. although Tire recycling is one of the capability recycling, but best approximately 4% of tyres are recycled in civil engineering packages. The recycled waste tires has a big capability marketplace in civil engineering (Farcasiu 1993 and Brown 2002) [9].

Incorporating the usage of rubber as a concrete combination in Ordinary Portland Cement (OPC) concrete does no longer give importance. It emphasized the combination of the tyre rubber into concrete. If it used the rubber tire debris as a substitute for concrete, it can consume billions of scrap tires as concrete is the maximum widely used production cloth inside the world. These observers aggregate and reinforcement considered as crumb rubbed concrete in many civil engineering packages (Subashree, 2020) [10].

Aziz Ibrahim Abdulla *et al.,* (2010) [11], Studied the impact of rubber dealt means of a specific alkaline behavior which includes NaOH, NaOCL and commercial detergent powder used as a best aggregate in a volumetric partial 15 to 30% substitute of sand in cement mortar. The checks confirmed that the usage of crumb rubber treating with NaOCL increase modulus of rupture, compressive power and modulus of elasticity more than NaOH. Cement mortar has negative outcomes because of business detergent powder, however NaOL offers better improvement, greater than NaOH.

The goal of the existing research is to identify the capacity use of crumb rubber in concrete. Henceforth, tremendous studies have been performed to observe the dealt with dynasties of rubberized concrete.

1. Material investigation

Cement

OPC Cement of fifty-three (53) grade. It gained the physical properties of cement by accomplishing the desired checks as in line with the IS standards, particularly IS 4031 (Part 4, 5, 6 and 11):1988 and IS 4031 (Part 2): 1999 and it showed the values in Table 1.

Fine aggregate

In line with the grading zone II, it used the locally available sand for experimental works. The specific gravity and water absorption of best aggregate as consistent with IS: 2386 (Part3) - 1963 to be greater than 2.60 and less than 2% respectively. Sieve analysis of the satisfactory combination turned into completed in the laboratory as in step with IS-383:2016.

Table 1: Physical properties of cement

S.no	Properties	values
1.	Specific gravity of cement	3.10
2.	Fineness of cement	4%
3.	Standard consistency of cement	30%
4.	Initial setting time	35 min
5.	Final setting time	512 min
6.	Compressive strength of cement mortar in 28 days	53.80 MPa

Table 2: Properties of coarse aggregate

S.no	Properties	values
1.	Specific gravity of coarse	2.72
2.	Water absorption	1%
3.	Fineness modulus	4.72
4.	Aggregate Impact test value	13.58%
5.	Aggregate Crushing value	18.24%

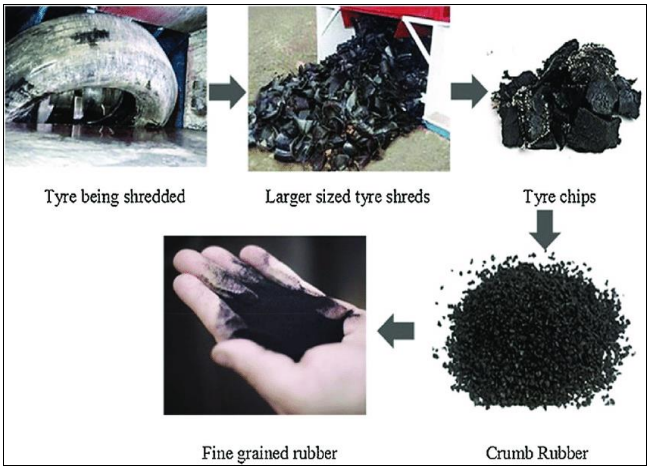

Fig 1: Crumb rubber aggregate

Coarse aggregate

The coarse aggregates which can be locally available have the most length of 20 mm has in the work. The checks performed as per IS: 2386 (Part 1, 3 & 4):1963 and result reported in Table.2.

Crumb rubber aggregate

The crumb rubber is the recycled rubber. This looks at the crumb rubber passing thru the sieve size of 2.36 mm for the partial substitute of aggregate. The rubber fibers used in this research having a factor ratio ranging from 25 to 30 in fig 1. The specific gravity and water absorption of rubber become found to be 1.3 and 1.3% respectively.

Chemical solution

Acetic acid is a natural compound which has the chemical property CH3COOH. The rubber used inside the concrete was immersed in the Acetic acid (5% concentration) and kept undisturbed for 24 hours, then taken out, rinsed with water, dried and used in concrete production. The water with pH 6.5 used for mix preparation as well as curing purposes.

2. Properties of rubberized concrete

Mix Proportion

We made the mix proportions for the M25, M30, and M35 grades of concrete. Table: 3 shows the calculated blend proportions.

Manufacturing of rubberized concrete

The substance needed for the concrete and, as consistent with the mix proportions, arrived from the mix design. Laboratory mixture used for preparation of homogeneous mix. All the ingredients incorporated simultaneously in the drum of mixture and drum rotated more than two minutes to get homogeneity of rubberized concrete mix. This concrete compacted manually with the help of a 16 mm dia rounded end temping rod in the oiled metallic mould. After 24 hours of casting, the specimens removed from the mould and cured.

Fig 2: A laboratory concrete mixture

Fresh concrete properties

We performed the slump test to check the workability of concrete. The consequences showed that there has been a boom in workability droop when crumb rubber content extended from 0% to 2.0%. Slump test is a method to recognize to the normal concrete, the workability of rubberized concrete is found suitable to put, handling and finishing.

Hardened concrete properties

The compressive strength test found in the conventional concrete better than the rubberized concrete. The compressive strength decreased as the percentage alternative sped up from 0% to 2.0%.

Table 3: Mix proportions of concrete

Grader of concrete	Mix Proportion (Cement: FA: CA)	Water cement ratio
M 25	1:1.46:2.59	0.44
M 30	1:1.15:2.14	0.37
M 35	1:1:1.95	0.36

3. Hybrid rubberized composite slabs

Hybridized rubber concrete consists of two layers with rubber concrete on the top and at bottom simple concrete is placed. Considering that rubber concrete has extra capability to soak up effect masses, it's placed on the top layer and simultaneously, plain concrete, which has more resistance to anxiety (whilst as compared with rubberized concrete) is stored in the bottom layer to get better consequences.

Casting and curing of HRC slabs

A45 samples made with three different blend proportions (M25, M30, M35) with various fiber content materials (0.5%, 1%, 1.5%, 2%). Out of those 45, nine were ordinary concrete samples (OC) and remain are Hybrid Rubberized Concrete (HRC). Fig: 3 and 4 suggest the moist mix cast specimens and cured specimens, respectively.

Fig 3: Specimens after casting

Fig 4: Specimens after curing

4. Test for compressive strength of concrete specimen

This clause deals with the procedure for determining the compressive strength of concrete specimens.

Apparatus

The testing machine may be of any reliable type, of sufficient capacity for the tests, and capable of applying the load at the rate specified 5.5. The permissible error shall be no greater than ± 2 percent of the maximum load. We shall equip the testing machine with two steel bearing plates with hardness faces. One platen (preferably the one that normally will bear on the upper surface of the specimen) shall with a ball seating as a portion of a sphere, the center of which coincides with the central point of the face of the platen. The compression platen shall be a plain rigid bearing block.

The bearing faces of both plates shall be at least as large as, and preferably larger than, the nominal size of the specimen to which the load. The bearing surface of the plates, when new, shall not depart from a plane by over 0.01 mm at any point, and we shall maintain them with a permissible variation limit of 0.02 mm. We shall hold the movable portion of the spherically seated compression platen on the spherical seat, but the design shall be it can rotate freely and title such that the bearing face through small angles in any direction. We tabulate the outcomes in Table. 4.

Fig 5: Compressive strength Test Apparatus

Table 4: Compressive Strength Results

S.no	Type of slab	M25		M30		M35	
		Slab ID	Compressive strength	Slab ID	Compressive strength	Slab ID	Compressive strength
1.	OC	T1	25	S1	30	A1	35
2.		T2	24	S2	28	A2	33
3.		T3	25	S3	30	A3	35
4.	HRC (0.5%)	T4	23	S4	27	A4	32
5.		T5	23	S5	27	A5	33
6.		T6	24	S6	26	A6	32
7.	HRC (1.0%)	T7	21	S7	25	A7	30
8.		T8	21	S8	24	A8	31
9.		T9	22	S9	24	A9	31
10.	HRC (1.5%)	T10	20	S10	23	A10	28
11.		T11	20	S11	23	A11	28
12.		T12	19	S12	23	A12	28
13.	HRC (2.0%)	T13	18	S13	21	A13	25
14.		T14	18	S14	20	A14	25
15.		T15	17	S15	21	A15	25

Literature review

The utilizations of reused rubber total in thruway improvement as street base substances are very broad and had been in want for pretty much one hundred years. There has been a lot of exploration considering the utilization of a reused total that has out from one facet of the planet to the other. The examination on the reused total that has established that they may perform the powerful usage of squashed total in cement. It has accomplished this powerful exploration in many international locations, especially in Europe; US; Japan and China. This part provides writing audits on the influences of different variables on the reused overall from studies from the one's international locations. The full-size aim of most people of the analyses or exploration on reused general is to discern out the effects within the power trademark area and what's the first-rate method to perform high strength concrete with reused overall (Naresh *et al*. 2022) [18].

Hamad Hassan Awan *et al*. 2021 [19] said that, in this study, the point of interest is on the floor treatment of the crumb rubber to mitigate the strength lack of concrete because of the addition of CR in preference to specializing in additives, admixtures, or growing the cement content in the CRC. This has a look at targets at locating new, better, and cheaper

techniques of floor treatments of CR to get better the power loss of concrete by including CR. These studies look at will contribute in higher information the connection between floor treatments of CR and mechanical houses of the CRC. this will pave the manner to discover and strengthen the remedies' strategies to attain the fine consequences regarding losses in mechanical residences of CRC. The results examine can be beneficial inside the practical application of the usage of CR in conventional concrete.

The studies (Galina Erikovna Okolnikova *et al.* 2023) [12] used rubber to replace coarse or first-rate mixture. in the studies, the ratios for aggregate substitute have been 25, 50,75, and 100 percentage. within the concrete blend, Edgar chips used were of 19-, 25-, and 38-mm sizes. They used Preston rubber that handed through a 2 mm sieve to replace pleasant mixture. To supply the specimens for checking out, over 200 cylinders with a diameter of 150 mm and a peak of 300 mm.

Esraa Emam *et al.* 2018 said that, dealt with crumb rubber (3%) completed a growth in compressive energy, oblique tensile electricity and flexure electricity through 13% and 15%, 15% and 14%, 18% and 19% after 7 and 28 days compared to untreated crumb rubber, respectively. In case of treated CRC (6%), the compressive strength, oblique tensile electricity and flexure strength increased via 24% and 22%, 31% and 28%, 30% and 24% after seven and twenty-eight days compared to untreated crumb rubber, respectively. control blend performed an amazing hardened property in evaluation to untreated CRC mixes in all ages.

Conclusion

This research contains the awareness of the re-use of waste materials like tyre rubber in the concrete production to facilitate eco-friendly environment. The effect of the treatment of rubber properties were also observed which has no significant role to influence concrete strength. In this experimental study, fine aggregate was partially replaced with crumb rubber by 0.5%, 1%, 1.5% and 2% of volume to investigate the characteristics of axial compressive behavior of concrete. It is found that the compressive strength reduces with the increase of rubber total in hybrid rubberized concrete.

Conflict of interest

The authors declare that there is no conflict of interest, financial or otherwise.

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