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Use of Rubber Tyre Crumbs as Environmental Friendly Material in Cement Concrete

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ABSTRACT- Finding uses for tyre rubber that don't need a lot of investment and can be implemented on a large scale was necessary for society. In order to safeguard the environment, it has been proposed that used rubber from discarded tyres be used in the production of concrete. By substituting crumb tyre rubber for aggregates in this research, an effort is being made to discover the different qualities required for the construction of concrete mix. The source concrete specimen has been determined to be M20 grade concrete. In lieu of traditional fine aggregate, recycled tyre rubber powder has been utilised as fine aggregate. This will enable the mass and efficient handling of rubber tyre wastes in addition to enabling sustainable utilisation of the available aggregates. The rubber tyre wastage is ground into fine crumb, which is then used to substitute the fine aggregate in amounts of 5%, 10%, and 15%. This research examines the best way to utilise crumb rubber as a fine aggregate into concrete by evaluating the workability, homogeneity, compressive, and flexural strengths of rubberized concrete.

KEYWORDS: Tyre Rubber Crumbs, Fine Aggregate, Concrete

I. INTRODUCTION

Concrete, an extraordinary building material with a rich history spanning millennia, stands as a testament to human ingenuity and engineering prowess. Its role in shaping the world we inhabit today is unparalleled, as it forms the foundation of our cities, structures, and infrastructure. This comprehensive article explores the origins, composition, production process, properties, and diverse applications of concrete, shedding light on its multifaceted significance in the construction industry and beyond. As we journey through time, we uncover the early civilizations' experimentation with cementitious materials, culminating in the Romans' remarkable achievements in concrete construction. From the Pantheon's magnificent dome to the awe-inspiring aqueducts, the ancient Romans' mastery of concrete laid the groundwork for the modern world's architectural marvels.

The composition of concrete lies at the heart of its strength and versatility. Concrete is designed to deliver specific performance characteristics suited for a variety of purposes. It is made up of a combination of cement, aggregates, water, and often additives. To create a paste that holds the aggregates together, cement, the binding agent, undergoes a chemical reaction with water. Various types of aggregates add to the stability of concrete, while admixtures enhance its workability, strength, and durability. Understanding the precise combination of materials, their proportions, and interactions allows engineers to tailor concrete mixes to meet the unique demands of each construction project.

The production process of concrete is a delicate dance of precision and expertise. It begins with the careful selection of raw materials and their precise proportions to ensure the desired properties of the concrete mix. Modern production methods employ advanced equipment, such as batching plants and mixers, to ensure consistency and uniformity in the mixing process. The freshly mixed concrete is then transported to the construction site, where it is placed and compacted into molds or formwork. As it cures and gains strength over time, concrete transforms from a malleable mixture into a robust, solid structure capable of withstanding immense forces and environmental conditions.

The properties of concrete underpin its widespread use and adaptability across diverse applications. Concrete's compressive strength, or its ability to resist compression, allows it to support heavy loads, making it ideal for the foundations of buildings, bridges, and roadways. Its tensile strength, however, is relatively low. To overcome this limitation, reinforcements, such as steel bars or fibers, are often added to create reinforced concrete, combining the best attributes of both materials. In addition to strength, concrete's durability, fire resistance, thermal mass, and acoustic insulation make it a preferred material in constructing safe, energy-efficient, and comfortable structures. Furthermore, the ability to mold concrete into various shapes and textures opens the door to architectural creativity, giving rise to iconic landmarks and innovative designs.[1]

The applications of concrete are as diverse as they are essential to modern society. In the realm of infrastructure, concrete is the backbone of roadways, bridges, tunnels, and dams, enabling the smooth movement of people and goods across vast distances and through challenging terrains. In the urban landscape, it forms the framework of buildings, from humble dwellings to soaring skyscrapers, shaping the cities we inhabit. For public spaces, concrete brings forth parks, plazas, and stadiums, providing gathering places for communities to interact and connect. Additionally, concrete's ability to withstand harsh environmental conditions makes it a vital material in coastal structures, protecting shorelines from erosion and storms.

Concrete's environmental impact is a subject of increasing scrutiny and innovation in the construction industry. While its durability and longevity contribute to the sustainability of structures, cement production, a primary component, emits a significant amount of Co_2, a greenhouse gas contributing to climate varations. Addressing the environmental challenges associated with concrete production is a priority for the construction sector. Researchers and industry professionals are exploring various avenues, including alternative cementitious materials, carbon capture and utilization technologies, and more sustainable manufacturing processes, to reduce concrete's carbon footprint and promote eco-friendly construction practices.

In recent years, innovations in concrete technology have opened up exciting possibilities for the future of construction. Self-healing concrete, for instance, has the remarkable ability to repair cracks and small damage autonomously, extending the lifespan of structures and reducing maintenance costs. Moreover, the creation of ultra-high efficiency along with high efficiency concrete has led to materials with exceptional strength, durability, and versatility, paving the way for more sustainable and resource-efficient structures. Additionally, advances in 3D printing technology have enabled the fabrication of complex concrete components on-site, streamlining construction processes and reducing material waste.

The future of concrete is intrinsically linked to the broader evolution of the construction industry. As cities grow and urbanization intensifies, there is an increasing need for sustainable and resilient infrastructure. In response, engineers, architects, and researchers continue to push the boundaries of concrete's capabilities, exploring innovative materials, construction methods, and digital technologies to optimize performance, enhance energy efficiency, and minimize environmental impact. Concrete's role in facilitating renewable energy generation and storage, as well as its potential in carbon capture and storage applications, are being explored as ways to contribute to a more sustainable built environment.

In conclusion, concrete's journey from ancient civilizations to modern-day marvels is a testament to its enduring relevance and significance in the construction industry. As the building block of our cities, structures, and infrastructure, concrete has proven its unmatched strength, adaptability, and durability throughout the ages. Nevertheless, the challenges of sustainability and environmental impact propel the construction industry towards continued innovation and responsible practices. With ongoing research and advancements, concrete's future holds promise, as it continues to evolve as a sustainable, resilient, and vital material in shaping the world of tomorrow.

II. OBJECTIVE OF STUDY

The following are emphasised specific research goals:

- To know the influence of Rubber Tyre Crumbs on workability & Homogeneity of concrete.
- To examine the Rubber Tyre Crumbs effect on compressive, & flexural strength of concrete.
- To make the concrete economical
- To conclude the research in a graciousness.

III. LITERATURE REVIEW

A. Siddika, Md. A. A. Mamun, R. Alyousef, Y. H. M. Amran, F. Aslani, and H. Alabduljabbar [2] desirable to recycle used tyre rubber into aggregates for use as an additional building material. This essay examines the origins of rubberized cementitious composites and waste tyre rubbers as well as their composition, applications, serviceability, and durability. Additionally, this research intends to provide a basic understanding of the integrated uses of rubberized concrete (RuC) composite components to advance construction techniques, including uses to increase the sustainable development of concrete structures in the building sector. Recycled rubberized aggregate (RA) makes concrete lighter, tougher, more resilient to fatigue, has better dynamic qualities, and is more ductile. Concrete made with recycled RA works well in both hot and cold climates and has shown noteworthy results when exposed to extreme circumstances and subjected to diverse loads.

A. Khitab, I. Arif, F. Awan, M. Anwar, and A. Mughal [3] described the largest and most severe environmental risks globally is waste tyre rubber. The huge quantities of worn rubber tyres must be appropriately disposed of due to the growth in automobile manufacturing. Several nations currently prohibit keeping of waste-tyre rubber in dumping zones due to the continuously diminishing number of places accessible for garbage disposal. Therefore, efforts are being undertaken to identify potential applications for waste-tyre rubber in the construction industry. It is believed that crumb rubber has the potential to be used in concrete technology. It is seen as a substitute to natural aggregates, which are employed as filler in the matrix of concrete.

P. Martauz and V. Vaclavik [4] approaches of processing, recycling, and disposing of tyres at the end of their useful lives are discussed in this article. The major emphasis is on the findings of research & development that addressed the usage of tyres at the end of their useful lives in concrete. The construction sector of the economy provides us with excellent opportunity to employ byproducts to save raw materials and natural resources.

L. Gu and T. Ozbakkaloglu [5] this study reviews the research that has been published up to 2015 and discusses the material characteristics, recycling processes, and effects of plastic substances on the characteristics of concrete. A total of 84 research were taken into account for the review, and they were divided into sub groups according to whether they were concerned with concrete that included plastic fibres or aggregates. The shape and structure of concrete made using plastic components is also discussed in this work to illustrate how plastic aggregates and fibres affect the characteristics of concrete. To determine how they compare to and vary from concrete made using recycled plastics, the characteristics of concretes made with virgin plastic components were also examined.

B. S. Thomas and R. C. Gupta [6] this study examined the appropriateness of used tyre rubber as partial replacement for fine natural aggregates in cement-based concrete. The findings are presented in this report. For the first time, fine aggregates between 0% to 20 percent in multiples of 2.5 percent were substituted for all 3 types of crumb rubber and combined in specific percentages. These concrete samples underwent tests to ascertain their mechanical characteristics, absorption of water, ability to resist sulphate attack, carbonation, and porosity. It was shown that rubberized concrete had lower values for compression strength, flexural tensile strength, pull-off strength, and sulphate attack than control mix, but that they provided greater resistance to water absorption and carbonation up to a specific percentage.

Y.-F. Wu, S. M. S. Kazmi, M. J. Munir, Y. Zhou, and F. Xing [7] this study develops a revolutionary concrete casting technique that may significantly raise the durability & elastic modulus of rubberized concrete. With the exception of substituting some of the coarse natural aggregate with chipped rubber, the mix design employed in the research is the identical as that used for the natural aggregate concrete . In lieu of NCA, 100% chipped rubber was used to cast concrete examples. The freshly mixed rubber-based concrete was then compressed for a while before being demolded in a mould that was especially made for the purpose. Compressed as well as uncompressed rubber concrete specimens' stress-strain behaviour was assessed and contrasted with NAC specimens. The results demonstrate the efficiency of the compression technique in improving the durability of rubber concrete by demonstrating improved stress-strain behaviour, i.e., enhanced compressive strength alongside elastic modulus, for compacted rubber concrete specimens compared to uncompressed specimens.

X. Li, T.-C. Ling, and K. Hung Mo [8] compares the roles and effects of rubber and plastic waste products used as sustainable aggregates on their fresh and hardened characteristics as well as their durability in mortar and concrete. Plastic as well as rubber are both synthesised polymer substances including identical basic elements alongside distinct structures. It is important to note the many types and sources of rubber and plastic wastes that are utilised as aggregate, in addition to how these wastes affect aggregate dimension, replacement content, form, and treatment methods.

H.-J. Ho, A. Iizuka, and E. Shibata [9] different approaches' underlying responses and processes were evaluated. The desulfurization process, which is efficient in the recycling and utilisation of concrete debris, the pozzolanic response, and the creation of calcium hydroxyapatite were some of the techniques used. among the most promising choices for carbonation, either direct or indirect, and CO2 sequestration is concrete debris.

T. Yaowarat et al. [10] natural rubber latex (NRL) has been used in this research study as a "green" addition to enhance the flexural strength characteristics of concrete pavements. Using different water-to-cement and dry rubber content-to-cement ratios and curing durations, both the compressive & flexural properties of NRL altered concrete were examined. The growth of the mechanical strength of changed concrete was examined using SEM (scanning electron microscopy) & energy-dispersive X-ray (EDX) analysis methods. The findings showed that for all w/c ratios and curing durations, the compressive strength of NRL-concrete declined as the r/c ratio increased, however the best flexural strengths were discovered at the ideal r/c = 0.58 percent, 1.16%, & 1.73 percent for w/c = 0.3, 0.4, and 0.5, respectively.

B. Chen et al. [11] comparison of the present disposal capability of the pyrolysis process, which is seen as an exciting technology regarding the disposal of used PC tyres. Second, based on the pace of PC growth and the present waste tyre disposal capability, this study creates a model to forecast the total quantity of waste PC tyres during the next five years. Additionally, 15 waste PC tyres that were gathered and chosen from the most represented tyre manufacturers in the Chinese market were subjected to pyrolysis testing. According to the related data, 68.5% of sulphur was in oil, 44.3% of nitrogen, and a significant quantity of heavy metals were found in solid carbon, which significantly restricts future uses. Finally, a novel pyrolysis technology is shown that may provide a remedy for the limitations in the use of tyre disposal techniques as well as assistance with the impending waste tyre dilemma.[11]

M. Mousavimehr and M. Nematzadeh [12] this research effort thus focused on the flexural behaviour plus durability of concrete using PET and tyre aggregates along with their combined use as a volumetric replacement for sand at high temperatures. Different experiments were used to evaluate various characteristics, including flexural strength, toughness, fracture energy, flexural stiffness, water absorption, porosity, & density, that have an impact on the durability and post-fire flexural behaviour of hybrid recycled concrete.

IV. MATERIALS USED

A. Cement:

In a more technical meaning, cement pertains to the binders used in building & civil engineering systems. Cement is a broad word for all forms of bindings. Within the reinforcement and aggregates, cement serves as a binder. These cements are created by mixing water with clinkers that have been coarsely ground into a powder. For different sorts of building systems, there are several cement varieties available. Each kind of cement has unique properties, uses, and product compositions that set it apart from the others. The OPC grade of 43 with specific graveness 2.7 has been employed for this experimental investigation, Figure 1 shows the cement sample used. The various physical properties of cement is shown below in Table 1.

Table 1: Cement test results

S. No	Properties	Results
1	Normal consistency	30%
2	Specific gravity	2.7
3	Fineness	98%
4	Initial setting time	50 minutes
5	Final setting time	490 minutes
6	Soundness	2.5 mm

Figure 1: Cement sample

B. Fine aggregate:

As per IS 383 1970, aggregates that are filtered via 4.75mm IS sieve are know as as fine aggregates. They can be:

• Crushed gravel sand: created when natural gravel is

crushed.
• Crushed stone sand: created when hard stones are crushed.
• Natural sand: whenever there is natural rock breakup and the rocks are deposited by rivers, streams, or glacial forces.

As shown in Figure 2, natural sand with a maximum particle size of 4.75 mm is employed to be a fine aggregate in this investigation. Zone 2 sand was employed in this investigation. Table 2 Shows the Fine aggregate properties.

Table 2: Fine aggregate properties

S. No.	Properties	Results	Limits as per IS Code
1	Specific gravity	2.41	2.3-2.7
2	Fineness modulus	2.813	2.1-3.37

Figure 2: Sand sample

C. Coarse aggregate:

According to IS 383-1970, coarse aggregates are those that remain suspended by a 4.75mm sieve. As shown in Figure 3, coarse aggregates consist of fragmented, uneven stones that vary in size from 4.75 to 20mm.Properties of Coarse aggregate is shown in Table 3.

Table 3: Properties of Coarse aggregate

S. No	Properties	Results	Limits as per ISCode
1	Specific gravity	2.539	2.6-2.8
2	Fineness modulus	2.95	2.9-3.2

Figure 3: Coarse Aggregate

D. Crumb Rubber:

As seen in Figure 4, crumb rubber is referred to as the little fragments of rubber extracted from car tyres. This kind of rubber is made using a procedure known as ambient grinding. This kind of grinding involves many steps and makes use of truck or vehicle tyres in the shape of treads, sidewalls, or shred. The rubbers, metals, and textiles are sorted out successively by adhering to the technique. Following processing, the tyres are sent through a shredder to be reduced to smaller bits. Then, the little chips are sent through a granulator, which further crushes them into even smaller bits while eliminating steel and fibre.

Figure 4: Crumb Rubber

E. Mixing of Crumb Rubber

For this project, beam samples of 50 x 10 x 10 cm and cube samples measuring 15 x 15 x 15 cm were created. For the preparation of the samples, concrete grade M20 was taken into consideration. Table.4 shows percentage Replacement of Crumb rubber Proportions (per m3 of concrete).

Table 4: Crumb rubber Proportions (per m3 of concrete)

Replacement % age	Crumb rubber	No. of cubes prepared	No. of beams prepared
0 %	0	6	6
5%	30.48	6	6
10%	60.96	6	6
15%	91.44	6	6

V. TESTS PERFORMED

A. Slump test

The slump cone, as shown in Figure 5 also known as the slump test, gauges the new concrete's workability.

Figure 5: Slump cone

B. Compression test

Compression tests are used to assess how a material will behave under compression load, as shown in Figure 6. According to the grade, a 150 x 150 x 150 mm concrete cube is produced. After curing, the specimen is evaluated by being sandwiched between two plates and being loaded up to its maximum capacity. The load at collapse is divided by the specimen's surface area to determine compressive strength. P represents the strength of compression.
P= F/A Where, F=failure load A= area

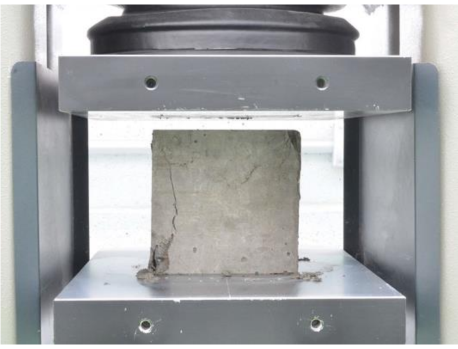

Figure 6: Compression test sample

C. Flexural Test

Flexural strength is a measurement of how strong concrete is when bent. According to some, concrete's flexural strength may be used to estimate its tensile strength. The third point loading or center-point loading are two common test procedures that may be used to evaluate the flexural strength, which is also known as the modulus of rapture. The three-point loading approach was used for the current investigation, as shown in Figure 7.

Figure 7: Flexural Strength tests sample

VI. RESULT AND DISCUSSION

A. Compressive strength Test

It was noted from the aforementioned findings at 5% & 10% use of crumb rubber, there was an overall improvement in compressive strength over traditional concrete as can be seen from table 5.

Table 5: Compressive strength Test

S. No.	% of crumb rubber	Compressive Strength(N/mm2)	
		7 Days	28 Days
1	0 %	16.08	26.80
2	5 %	19.39	28.78
3	10 %	18.58	27.51
4	15 %	16.72	25.68

Figure 8 depicts the variation in the compressive strength of rubberized concrete in relation to the change in crumb rubber %.

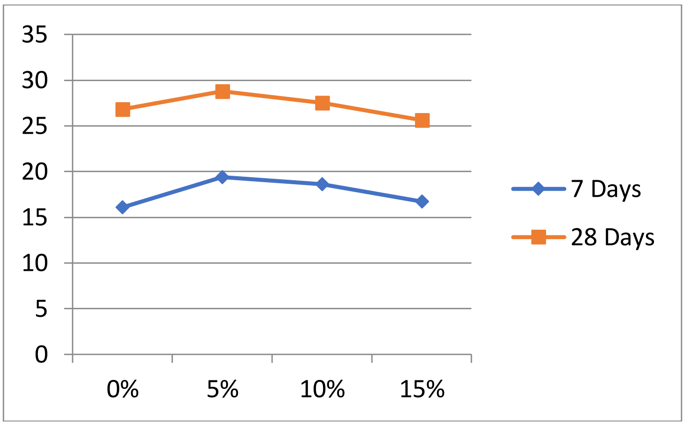

Figure 8: Compressive strength v/s %age of crumb rubber

B. Flexural Strength Test Result

To determine the flexural strength of rubberized concrete, the flexural test was conducted on beams of 50 x 10 x 10 cm. The results of the flexural test on UTM are shown in Table 6

Table 6: Flexural Strength Test Result

S.No.	% of crumb rubber	Flexural Strength (N/mm2)	
		7 Days	28 Days
1	0 %	3.84	5.09
2	5 %	5.94	7.37
3	10 %	5.14	6.67
4	15 %	4.92	5.94

According to the aforementioned findings, crumb rubber concrete has more flexural strength than regular concrete. Additionally, it was found that as the amount of crumb rubber in the concrete increased, the flexural strength of the beam reduced.
This research has shown that crumb rubber may be safely replaced up to 10% of the time. Figure 9 shows the variance in flexural strength in relation to the specified % of crumb rubber.

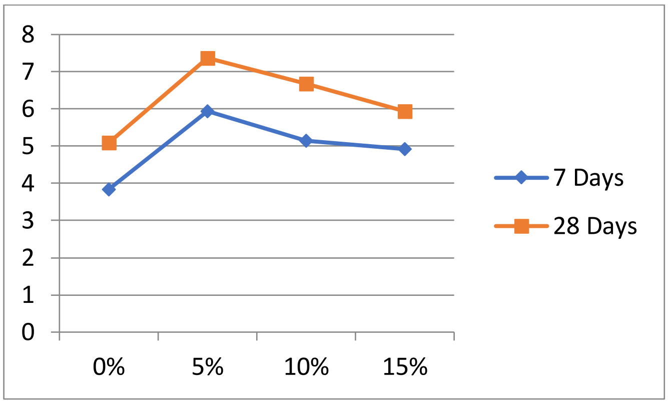

Figure 9: Flexural strength v/s % age of crumb rubber

C. Compaction Factor Test Result

The compaction factor test was applied to rubberized concrete to evaluate its workability at various replacement levels, including 5%, 10%, and 15%. The findings are shown below, and it can be deduced from them that workability declines with an increase in rubber content at 15%. Theoretically, the compaction factor's maximum value ranges from .96 to 1.0. The results of the compaction factor test are shown in Table 7 below.

Compaction factor value for no replacement (0%)
Concrete weight (partially compacted) / concrete weight (completely compacted) = 9.81/11.91 = .82
Like wise,
C.P value for 5% replacement =10.61/12.08 =.88
Value of C.P for 10% replacement = 9.78/11.70 =.83
C.P value for 15% replacement = 8.92/11.00= .81

Table 7: Results of compaction factor test

S. No.	% of rubber	Wt. of partially compacted concrete (kg)	Wt. of fully compacted concrete (kg)	Value of compaction factor
1	0 %	9.73	11.93	.82
2	5 %	10.53	12.10	.88
3	10 %	9.78	11.70	.83
4	15 %	8.86	11.02	.81

The compaction factor test was carried out by including various amounts of crumb rubber into the M20 mix as fine particles. The investigations demonstrated that, as shown in figure 10, workability diminishes with an increase in rubber content because the value of the compaction factor drops with the inclusion of crumb rubber aggregates.

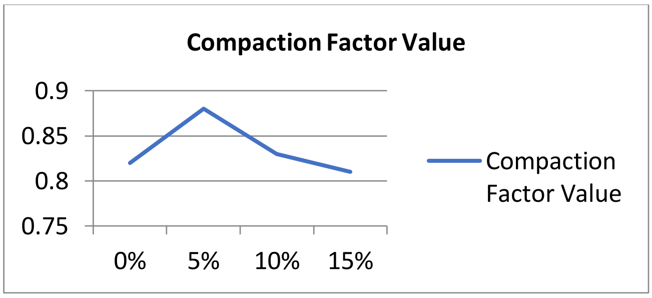

Figure 10: Compaction factor v/s % age of crumb rubber

VII. CONCLUSION

Concrete having high crumb rubber content has a poor workability. i.e., as the % amount of crumbed rubber increases, the workability of concrete reduces.
When 15% of the sand is replaced with crumbed rubber, the flexural strength of the concrete is reduced by around 56%. When 15% of the sand is replaced with crumb rubber, the compressive strength of the concrete is reduced by around 25%.The decrease of strength cannot be avoided when crumb rubber is added. These values, however, only provide a rough indication of how much local modified concrete will lose strength when compared to ordinary concrete with a 20 MPa aim strength.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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