An Experimental Study on the Compressive Strength of M20 Grade Concrete by Partial Replacement of Coarse Aggregate with Waste Rubber Tyres

Sandeep Jangde [1], Mr. Parmeshwar Sahu [2]Mr. Akhand Pratap Singh[3], Mr. Shiva Verma[4]

[1]M. Tech Scholar,[2]Assistant Professor ,[3]Assistant Professor,[4] Assistant Professor
Department of Civil Engineering

Shri Rawatpura Sarkar University, Raipur (C.G.), India

Abstract: - The disposal of waste rubber tyres poses a serious environmental challenge due to their non-biodegradable nature. This experimental study investigates the effect of partial replacement of coarse aggregate with waste rubber tyre chips on the compressive strength of M20 grade concrete. Coarse aggregate was replaced by rubber tyre chips at proportions of 5%, 10%, and 15% by volume. Concrete cubes were cast and tested for compressive strength after 7 and 28 days of curing in accordance with standard procedures. The results indicate that compressive strength decreases with an increase in rubber content due to the lower stiffness and poor bonding characteristics of rubber particles compared to natural aggregates. However, concrete with 5% rubber replacement exhibited a marginal reduction in compressive strength while still satisfying the strength requirements of M20 grade concrete. At 10% and 15% replacement levels, a significant reduction in compressive strength was observed when compared to conventional concrete. Despite the strength reduction, rubberized concrete showed improved ductility and crack resistance. The study concludes that partial replacement of coarse aggregate with waste rubber tyres up to 5% can be considered for non-structural and sustainable construction applications, contributing to effective waste management and environmental sustainability.

Keywords: Waste rubber tyres, M20 grade concrete, compressive strength, coarse aggregate replacement, sustainable construction, rubberized concrete

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1. INTRODUCTION:

1.1 General

Concrete is one of the most widely used man-made construction material. It is obtained by mixing cement, water and aggregate and sometimes admixtures in required proportion. The raw materials from which it is prepared, cement and aggregates, affect both the quality and cost of construction. Cement owes its unique position as the structural material to the fact that it is economically highly resistant to fire, wind, water and earthquakes. In recent times its use in construction has increased considerably thus the cities and towns are virtually becoming cement jungles. The demand is likely to increase in the future to match the growing population, housing, transportation and other amenities. The availability and proximity of aggregate to the construction site also affect the cost of construction. Aggregate is as important as cement to form a cement mortar that is very useful in construction of buildings. The aggregate is usually derived from natural sources.

The use of recycled rubber as the partial replacement of coarse aggregate in concrete has great potential to positively affect the properties of concrete in a wide spectrum. Concrete is one of the most popular construction materials. Due to this fact, the construction industry is always trying to increase its uses and applications and improving its properties, while reducing cost. concrete has low tensile strength, low ductility, and low energy absorption. Concrete also tends to shrink and crack during the hardening and curing process. These limitations are constantly being tested with hopes of improvement by the introduction of new admixtures and aggregates used in the mix. One such method may be the introduction of rubber to the concrete mix. It is a perfect way to modify the properties of concrete and rubber tyres at the same time. We find the compressive strength of concrete with partial replacement with waste rubber tyre for coarse aggregate.

India has taken step to move forwards infrastructures towards the growth of globalization. Due to manufacturing tyres with synthetic rubber, proper disposal of these waste tyres has become difficult. Every year over 1.6 billion new tyres are generated and around 1 billion waste tyres are generated. However, the recycling industry processed only 100 million tyres every year. The purpose of adding the rubberized materials to concrete is to improve its properties of tensile strength, hardness, abrasion resistance, tear resistance and on workability of concrete. The construction industry is always increasing its uses and applications. Therefore, it is required to find alternative materials to reduce the cost of concrete. On the other hand, non- biodegradable waste, i.e., water bottles, cool drink bottles and disposable glass, shredded or crumbed rubber etc. is creating a lot of problems in the environment and its disposal becoming a great difficulty. In this mini project we study the use of rubber pieces as coarse aggregate in the concrete. Concrete specimen of various percentages of rubber like 5%,10% and 15% as a partial replacement of coarse aggregate were tested. The compression test was conducted for the control specimen and specimen with rubber. Finding the compressive strength between normal concrete cubes and partial replacement of waste rubberized cubes. Burning of these tyres cause air pollution

Figure 1.1: BURNING OF TYRE

Throwing these tyres on the soil causes soil pollution.

Figure 1.2: RUBBER TYRE

Concrete is an artificial material in which the aggregates both fine and coarse are bonded together by the cement when mixed with water. Concrete has become so popular and dispensable because of its inherent in concrete brought a revolution in applications of concrete. Concrete has unlimited opportunities for innovative applications, design and construction techniques. Its great versatility and relative economy in filling a wide range of needs has made it very competitive building material.

Concrete is one of the most widely used construction materials in the world due to its versatility, durability, and ability to be moulded into various shapes. It plays a vital role in the development of infrastructure such as buildings, bridges, pavements, dams, and industrial structures. Conventional concrete is composed of cement, fine aggregate, coarse aggregate, and water. While concrete exhibits high compressive strength and durability, it has limitations such as low tensile strength, brittleness, and susceptibility to cracking.

With the rapid growth of population, urbanization, and industrialization, the demand for construction materials has increased tremendously. This has led to excessive exploitation of natural resources such as sand and stone aggregates, resulting in environmental degradation, depletion of natural reserves, and ecological imbalance. At the same time, the disposal of industrial and municipal waste has become a serious environmental concern.

One of the major waste materials generated worldwide is waste rubber tyre. Millions of tyres are discarded annually due to wear and tear, damage, or obsolescence. Waste tyres are non-biodegradable and pose severe environmental hazards when disposed of in landfills or open dumping sites. They occupy large volumes of space, create breeding grounds for mosquitoes and rodents, and pose fire hazards that release toxic gases into the atmosphere.

To address these environmental challenges, researchers and engineers are focusing on the utilization of waste materials in construction, particularly in concrete production. The use of waste rubber tyre as a partial replacement for conventional aggregates in concrete has gained significant attention due to its potential benefits in terms of sustainability, waste management, and improvement of certain concrete properties.

1.2 Need for Sustainable Construction

Sustainable construction aims to reduce the negative environmental impact of construction activities while enhancing resource efficiency and performance. The construction industry consumes a vast number of natural resources and contributes significantly to carbon emissions. Cement production alone is responsible for a considerable percentage of global CO_2 emissions.

Incorporating waste materials such as rubber tyres into concrete aligns with the principles of sustainable development by:

- Reducing the consumption of natural aggregates
- Minimizing waste disposal problems
- Lowering environmental pollution
- Promoting recycling and reuse

The use of waste rubber tyre in concrete not only helps in managing solid waste but also contributes to the development of eco-friendly and innovative construction materials.

1.3 Waste Rubber Tyre as a Construction Material

Rubber tyres are primarily made of natural and synthetic rubber, carbon black, steel, and additives. Due to their complex composition and durability, tyres are difficult to decompose naturally. Traditional disposal methods such as landfilling and incineration are neither environmentally nor economically viable.

Processing waste tyres into rubber crumbs or rubber chips allows them to be used as a replacement material in concrete. Rubber particles are lightweight, elastic, and possess excellent energy-absorbing properties. When incorporated into concrete, they can influence the mechanical and durability characteristics of the material.

Previous studies have shown that rubberized concrete exhibits:

- Reduced density (lightweight concrete)
- Improved impact resistance
- Enhanced ductility and toughness
- Better crack resistance
- Improved sound and vibration absorption

However, the incorporation of rubber tyre particles may lead to a reduction in compressive strength due to weaker bonding between rubber and cement paste. Therefore, careful material selection, proportioning, and testing are essential to achieve an optimal balance between strength and performance.

1.4 Concrete and Its Constituent Materials

Concrete performance depends greatly on the quality of its constituent materials:

- Cement acts as a binding material and plays a crucial role in strength development.
- Fine aggregate fills the voids between coarse aggregate particles and improves workability.

- Coarse aggregate provides bulk strength and stability to concrete.
- Water initiates hydration and determines workability and strength.

In the present study, 53 grade Ordinary Portland Cement, natural fine aggregate, and crushed coarse aggregate were used. Waste rubber tyre was introduced as a partial replacement material to study its influence on concrete properties.

Testing of materials such as specific gravity, fineness, and consistency ensures compliance with codal provisions and reliability of results. Proper characterization of materials is essential before using them in concrete mix design.

1.5 Advantages of Rubberized Concrete

The use of waste rubber tyre in concrete offers several advantages:

1. Environmental Benefits
   - Reduces tyre waste disposal problems
   - Minimizes land and air pollution
   - Promotes recycling and sustainable development
2. Structural and Functional Benefits
   - Improved energy absorption capacity
   - Enhanced resistance to impact and fatigue loading
   - Increased ductility and post-cracking behavior
3. Economic Benefits
   - Reduces dependency on natural aggregates
   - Utilizes low-cost waste materials
   - Potential reduction in overall construction costs

Rubberized concrete is particularly suitable for applications such as:

- Pavements and road barriers
- Shock-absorbing structures
- Sound barriers
- Non-load bearing elements
- Lightweight construction

1.5 Scope of the Present Study

The present investigation focuses on evaluating the suitability of waste rubber tyre as a construction material in concrete. The study includes testing of basic material properties such as specific gravity, fineness, and consistency of cement and aggregates. Waste rubber tyre is tested for physical properties and incorporated into concrete mixes.

The main scope of this study includes:

- Characterization of cement, fine aggregate, coarse aggregate, and waste rubber tyre
- Comparison of test results with codal provisions
- Understanding the role of rubber tyre in modifying concrete properties
- Promoting sustainable and eco-friendly construction practices

1.2 Objectives

The main objectives of this experimental study are:

1. To investigate the feasibility of using waste rubber tyre chips as a partial replacement for coarse aggregate in M20 grade concrete.
2. To study the effect of 5%, 10%, and 15% replacement of coarse aggregate with waste rubber tyres on the compressive strength of concrete.
3. To compare the compressive strength results of rubberized concrete with conventional concrete.
4. To evaluate the optimum percentage of waste rubber tyre replacement that provides acceptable strength performance.
5. To promote sustainable construction practices by utilizing waste materials and reducing environmental pollution caused by discarded rubber tyres.

2. LITERATURE REVIEW:

1. Parveen, Sachin Dass, Ankit Sharma. Rubberized Concrete: Needs of Good Environment. The aim of this study is to achieve to use of rubber waste as partial replacement of fine aggregate to produce rubberize concrete in M30 mix. Different partial replacements of crumb rubber (0, 5, 10, 15 and 20%) by volume of fine aggregate are cast and test for compressive strength, flexural strength, split tensile strength and stress-strain behavior. The results showed that there is a reduction in all types of strength for crumb rubber mixture, but slump values increase as the crumb rubber content increases from 0% to 20%. It means that crumb rubber mixture is more workable compared to normal concrete and it is useful in making light weight concrete. It is recommended to use the rubberized concrete for non-structural applications.

2. Dr J K Dattatreya, S. Suresh Raghu N.E. Experimental investigation of crumb rubber concrete confined by FRP sheets. Increased its ductility, especially at higher levels of confinement. Therefore, the use of confined CRC in structures subject to seismic loads, where ductility demands are more critical than strength, looks promising. The Confined CRC displayed similar volumetric behavior to the confined conventional concrete. However, the rate of volume expansion for CRC mixes was less than that of conventional concrete. At a given axial stress and confinement thickness, the volumetric strain of CRC is higher than that of conventional concrete. This also confirms the higher ductility of CRC compared to conventional concrete.
3. The confined CRC can be used as a promising alternative to the confined conventional concrete in a CFFT segmental column. The CRC can enrich the structure ductility, damping ratio, and energy dissipation which are the most important parameters in structures resisting earthquakes.

4. Kotresh K.M, Mesfin Getahun Belachew. Study On Waste Tyre Rubber As Concrete Aggregates. From the present experimental study, we conclude that despite the reduced com- pressive strength of rubberized concrete in comparison to conventional concrete, there is a potential large market for concrete products in which inclusion of rubber aggregates would be feasible which will utilize the discarded rubber tyres the disposal of which, is a big problem for environment pollution. Rubberized concrete strength may be improved by improving the bond properties of rubber aggregates. In India, out of 36 tyre manufacturers the tyre recyclers are around 20, the major contribution is only by four or five. Among these, M/S Gujarat Re- claim has an annual turnover of over Rs.15 Crore from its Haridwar (Uttarakhand, India) tyre recycling plants, with a production of 20 tons of reclaim rubber per day. The tyre recycling factories should supply quality rubber aggregates in 20-10mm, 10-4.75mm and 4.75mm downsizes to be used as cement concrete aggregate.

5. Mohd. Mohsin Khan. Use Of Crumb Rubber as Replacement Over Aggregate in Con- crete. It can be concluded from this study that coarse aggregates can be replaced by crumb rubber up to some extent. The higher amount of crumb rubber reduces the strength of con- crete which may not be desirable, but the rubber-based concrete has good toughness and de-formability. So, this kind of concrete may be used in the structures (road foundations and bridge barriers) where toughness and de-formability are more important than strength. This kind of concrete may also be used to decrease the vibrations coming on the base of the structures because rubber-based concrete has reversible elasticity property.

Others are mentioned below: -

1. Comprehensive review on applications of waste tyre rubber in concrete

Reviews how rubber from waste tyres affects mechanical properties of concrete, noting strength reduction due to rubber's elasticity and weak bond with cement paste. ScienceDirect

2. Review on the introduction of waste tyre in concrete as aggregate replacement

Discusses replacement percentage, particle size, and surface treatment effects—valuable for literature background. ScienceDirect

3. Overview of concrete performance with waste rubber tires

Summarizes many past experiments on compressive and tensile strength decreases and some durability characteristics. MDPI

4. Review of durability-related features of waste tyre rubber concrete

While focusing on durability, this also covers mechanical strength trends with 5–20% rubber inclusion. MDPI

5. Review of mechanical properties of waste rubber tire concrete

Examines effect of rubber type and content on strength, including compressive strength behavior. ascelibrary.org

6. Review on crumb rubber characteristic properties

Focuses on influence of replacement ratio and surface treatments on mechanical properties. ScienceDirect

7. Effect of Waste Tyre-Rubber Aggregate on Strength Properties of Concrete

Replaces coarse aggregate at 5%, 10%, and 15%. Compressive strength reduced by ~12–25% with increased rubber content. journaljerr.com

8. Investigating the Effect of Rubber Chips as Partial Coarse Aggregate Replacement

Reported only ~5.5% strength drop at 5% replacement, larger reductions at 10–15%. STM Journals

9. Mechanical properties of concrete with waste tire rubber aggregates

Studied 0%, 5%, and 15%; compressive strength decreased with rubber content while unit weight and slump also changed. Scientific.Net

10. Investigation of concrete with waste tyre rubber fibers (0–25% replacement)

Increasing rubber decreases compressive strength but increases strain energy and ductility. Scientific.Net

11. Surface-treated tyre aggregate concrete

Compressive strength drops with untreated rubber, but surface treatments (e.g., cement or chemical) significantly improve strength retention at similar replacement levels. MDPI

12. Experimental study on partial replacement in M20 grade concrete

Finds compressive strength decreases as replacement increases, but ~5–10% replacements can still meet M20 requirements, with some variations. IJARSCT

13. Experimental study using NaOH-treated rubber and silica fume (M20)

Recent 2025 study showing 10% rubber with NaOH treatment achieves ~92% of control mix strength. Zenodo

3. METHODOLOGY:

Cement

Ordinary Portland Cement (OPC) of 53 grade was used in the present investigation. OPC 53 grade cement is commonly preferred for structural concrete works due to its high early strength and consistent quality. The physical properties of cement significantly influence the strength, workability, and durability of concrete. Hence, standard laboratory tests were conducted to ensure that the cement used conforms to the codal requirements.

Standard Consistency determines the amount of water required to produce a cement paste of standard viscosity. The obtained value of 31% lies within the permissible range (25–35%), indicating proper hydration characteristics.

Specific Gravity of cement is an important parameter used in mix design calculations. The obtained value of 3.13 falls within the codal range of 3.0 to 3.15, confirming the purity and suitability of cement.

Fineness of Cement affects the rate of hydration and early strength development. The fineness value of 8% indicates that the cement particles are sufficiently fine, ensuring better strength development and uniformity in concrete.

Table 3.1: TESTS ON CEMENT

S.No	Tests	Test results	codal values
1	Standard Consistency	31%	25%-35%
2	Specific Gravity	3.13	range (3-3.15)
3	Fineness of cement	8%	(not less than 10%)

Fine aggregate:

Fine aggregate plays a crucial role in filling the voids between coarse aggregate particles and contributes to the workability and strength of concrete. Natural river sand was used as fine aggregate in this study, and its properties were evaluated as per standard procedures.

Specific Gravity of fine aggregate influences the density and strength of concrete. The obtained value of 2.67 lies within the standard range of 2.6 to 2.9, indicating that the sand is dense and free from excessive impurities.

Fineness Modulus (FM) is an index of particle size distribution. The fineness modulus value of 3.05 indicates that the sand falls within Zone II, which is considered ideal for concrete works as it provides good workability and strength.

Table 3.2: TEST RESULTS ON FINE AGGREGATE

S.No	Tests	Test results	codal values
1	Specific Gravity	2.67	range (2.6-2.9)
2	Fineness Modulus	3.05	range (2.9-3.2)

Coarse aggregate

Coarse aggregate forms the major portion of concrete and significantly influences its strength, durability, and load-carrying capacity. Crushed stone aggregate was used in the present study.

Specific Gravity of coarse aggregate was found to be 2.87, which lies within the permissible range of 2.6 to 2.9. This indicates that the aggregate is strong, dense, and capable of producing good-quality concrete.

Fineness Modulus of 7.61 indicates that the aggregate is coarse and well-graded. Proper grading of coarse aggregate reduces voids, improves workability, and minimizes cement consumption.

Table 3.3: TEST RESULTS ON COARSE AGGREGATE

S.No	Tests	Test results	codal values
1	Specific Gravity	2.87	range (2.6-2.9)
2	Fineness Modulus	7.61	range (5.5-8.0) (coarse sand)

waste rubber tyre

Waste rubber tyre was used as a partial replacement material in this study to promote sustainable construction practices and effective waste management. Rubber tyre waste is lightweight, flexible, and exhibits good energy absorption characteristics, making it a potential material for improving impact resistance and ductility of concrete.

Specific Gravity of waste rubber tyre was found to be 1.07, which is significantly lower than that of conventional aggregates. This low specific gravity contributes to the reduction in self-weight of concrete, leading to lightweight concrete applications. The obtained value lies within the codal range of 1.0 to 1.5, indicating consistency with standard properties of rubber materials.

The incorporation of waste rubber tyre in concrete not only helps in reducing environmental pollution caused by discarded tyres but also enhances certain properties such as toughness, crack resistance, and sound absorption.\

Table 3.4: TEST RESULTS ON WASTE RUBBER TYRE

S.No	Tests	Test results	codal values
1	Specific Gravity	1.07	range (1-1.5)

4 RESULTS AND CONCLUSIONS

4.1 Test for Compressive Strength of Concrete Cubes

Compression test is the most common test conducted on hardened concrete, partly because most of the desirable characteristic properties of concrete are quantitatively related to its compressive strength. The compression test is carried out on cubical or cylindrical shape. The cube specimen is of the size 150mm*150mm *150mm.

Figure 4.1: CTM

4.2 Test results on Normal Concrete

Concrete compressive strength is one of the most important mechanical properties, as it indicates the ability of concrete to resist compressive loads without failure. In this experimental study, the compressive strength test was conducted on normal M20 grade concrete specimens at curing ages of 3, 7, and 28 days in accordance with IS:516 – 1959.

The compressive strength of concrete is calculated using the formula:

Compressive Strength=Maximum LoadCross-sectional Area=PA\text{Compressive Strength} = \frac{\text{Maximum Load}}{\text{Cross-sectional Area}} = \frac{P}{A} Compressive Strength=Cross-sectional Area Maximum Load =AP

where,

P = Maximum load applied on the specimen (N)

A = Cross-sectional area of the specimen (mm^2)

Standard concrete cube specimens of size 150 mm × 150 mm × 150 mm were cast, properly compacted, and cured under controlled conditions. After the specified curing periods, the specimens were tested using a compression testing machine (CTM). The load was applied uniformly until failure occurred, and the maximum load carried by the specimen was recorded.

From the test results shown in Table 4.1, the compressive strength values obtained were 10.44 N/mm^2 at 3 days, 16.22 N/mm^2 at 7 days, and 27.91 N/mm^2 at 28 days. These results indicate a continuous increase in compressive strength with an increase in curing age. This increase is primarily due to the ongoing hydration process of cement, which leads to the formation of additional calcium silicate hydrate (C–S–H) gel, enhancing the strength and density of the concrete matrix.

The 28-day compressive strength of 27.91 N/mm^2 exceeds the characteristic strength requirement of M20 grade concrete (20 N/mm^2), confirming that the concrete mix design and quality of materials used were satisfactory. The early-age strength development at 3 and 7 days also demonstrates proper curing and effective cement hydration.

Thus, the normal concrete exhibited adequate compressive strength and served as a reliable control mix for comparison with rubberized concrete in this experimental study.

Compressive strength = Max. load / Area =P/A (for Normal Concrete)

S.No	SPECIMEN	COARSE AG-GREGATE(Kg)	RUBBER (Kg)	3 DAYS	7 DAYS	28 DAYS	% Decrease
1.	M1	11.77	0.62	6.87	12.77	16.53	40
2.	M2	11.15	1.23	4.32	12.10	14.31	48.72
3.	M3	10.53	1.85	4.45	11.16	12.97	53.529

Table 4.1: TEST RESULTS ON COMPRESSIVE STRENGTH OF NORMAL CONCRETE

S.No	Details	3 Days	7 Days	28 Days
1	Ultimate Load On Specimen (Kn)	235 Kn	365 Kn	628 Kn
2	Compressive Strength In N/Mm^2	10.44	16.22	27.91

Table 7.2: TEST RESULTS ON PARTIAL OF WASTE RUBBER TYRE PIECES

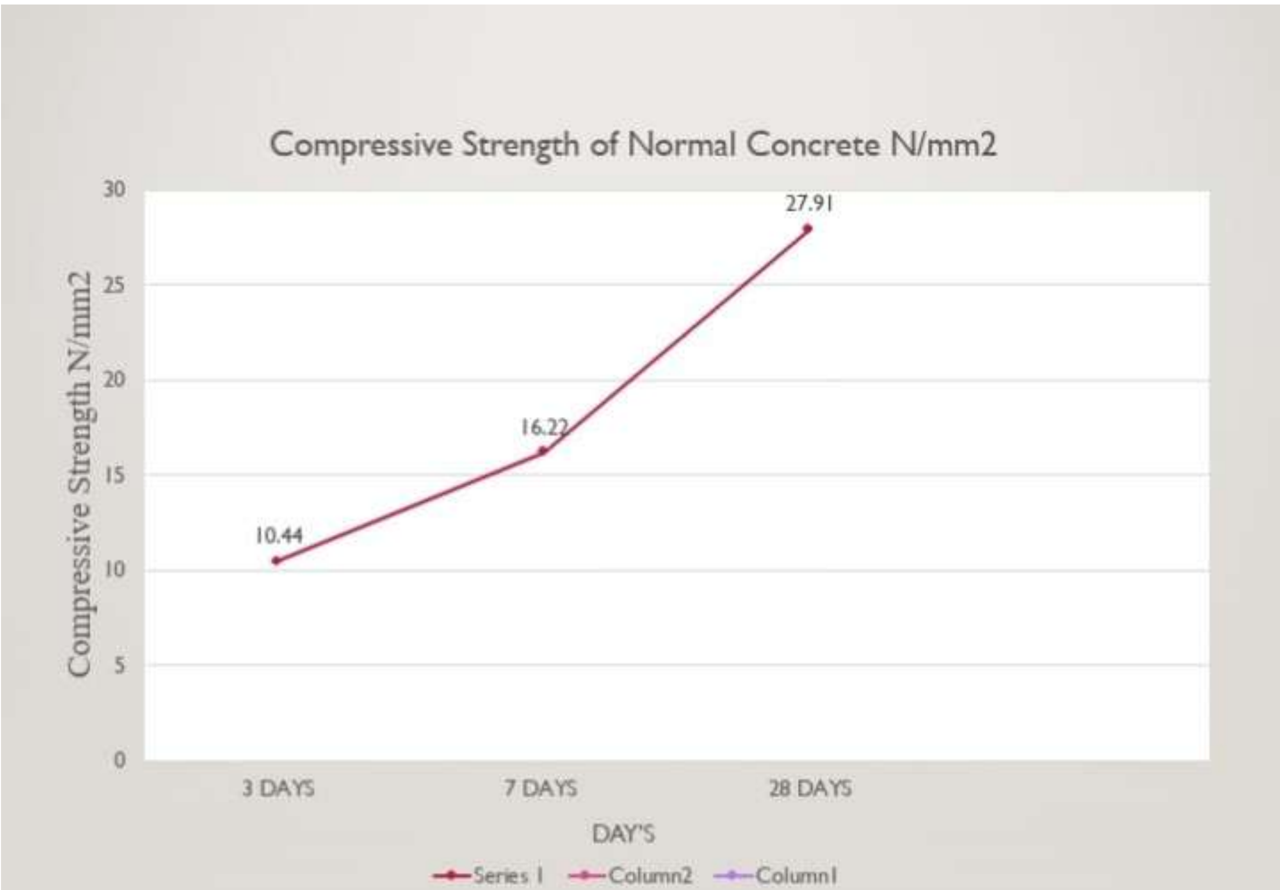


Figure 4.2: COMPRESSIVE STRENGTH OF NORMAL CONCRETE N/mm^2

This experimental study evaluates the effect of partial replacement of coarse aggregate with waste rubber tyre chips on the compressive strength of M20 grade concrete. The test results presented in Table 7.2 represent the compressive strength values of rubberized concrete specimens at curing ages of 3, 7, and 28 days for different replacement levels.

In mixes M1, M2, and M3, coarse aggregate was partially replaced by waste rubber tyre chips in increasing proportions. As the percentage of rubber replacement increased, a corresponding decrease in compressive strength was observed at all curing ages.

For mix M1, which contains a lower quantity of rubber, the compressive strength values recorded were 6.87 N/mm² at 3 days, 12.77 N/mm² at 7 days, and 16.53 N/mm² at 28 days, showing a 40% reduction compared to normal concrete. This reduction is mainly due to the lower stiffness and strength of rubber particles when compared to natural coarse aggregates.

In mix M2, with a higher rubber content, the compressive strength further decreased to 4.32 N/mm², 12.10 N/mm², and 14.31 N/mm² at 3, 7, and 28 days respectively, resulting in a 48.72% decrease. The increased rubber content leads to poor interfacial bonding between rubber particles and cement paste, causing early failure under compressive loading.

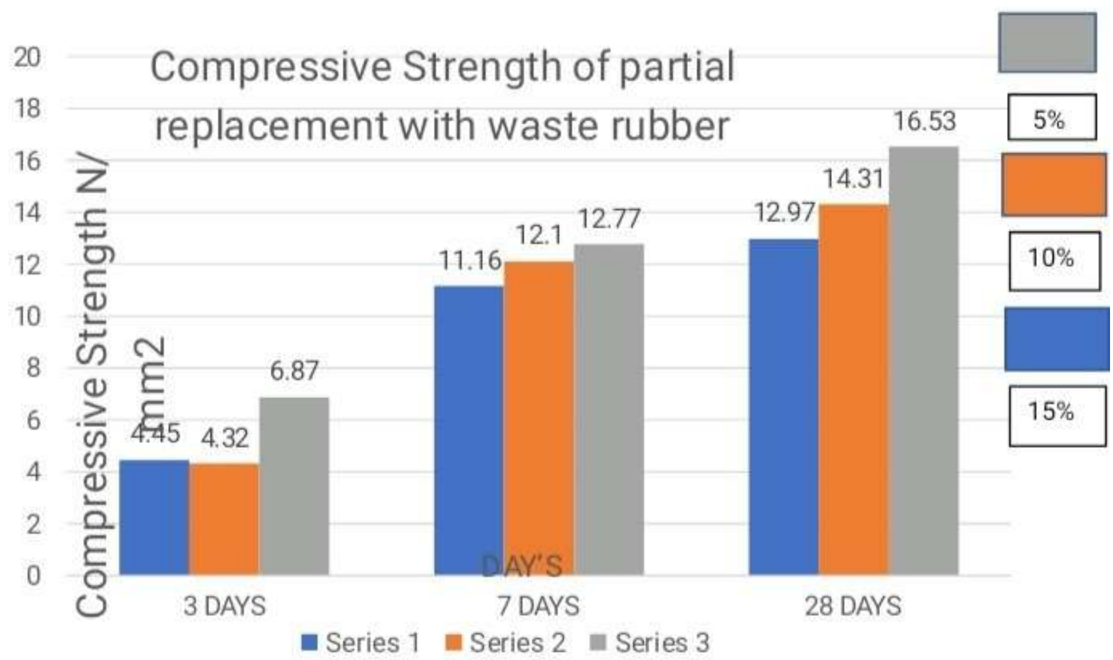
Mix M3 exhibited the lowest compressive strength values, with 4.45 N/mm² at 3 days, 11.16 N/mm² at 7 days, and 12.97 N/mm² at 28 days, corresponding to a 53.53% decrease. The higher proportion of rubber particles significantly disrupts the load transfer mechanism within the concrete matrix due to their elastic nature and smooth surface texture.

Overall, the results clearly indicate that increasing the replacement of coarse aggregate with waste rubber tyres leads to a substantial reduction in compressive strength. However, rubberized concrete exhibits improved energy absorption, ductility, and crack resistance, making it suitable for non-structural and lightweight applications such as pavement blocks, kerbs, and sound barriers.

NOTE:

M1 = 5% Replacement of Rubber in Concrete M2 = 10% Replacement of Rubber in Concrete M3 = 15% Replacement of Rubber in Concrete

The Weights of Cement and Fine Aggregate are Same for Three Replacements. Cement For 3 Cubes Is 3.48kg



Fine Aggregate For 3 Cubes Is 7.98 Kg.

Figure 7.3: COMPRESSIVE STRENGTH OF CUBES AFTER PARTIAL REPLACEMENT WITH WASTE RUBBER N/mm²

Conclusions

1) Compressive strength of the specimen of grade M20 cured for 28 days is decreased at partial replacement of 5%,10% 15% with rubber in coarse aggregate.
a) For 5% of rubber, the compression strength is 16.53 N/m^2 which is around 40% reduction of strength when compared to conventional concrete.
b) For 10% of rubber, the compression strength is 14.31 N/m^2 which is around 48.72% reduction of strength when compared to conventional concrete.
c) For 15% of rubber, the compression strength is 12.97 N/m^2 which is around 53.53% reduction of strength when compared to conventional concrete.
2) These findings indicate that it is not advisable to use rubber aggregates in concrete mixes for high strength and load bearing applications.
3) Finally, we can use this type of concrete in PCC bed in foundation and, we can provide concrete below flooring.
4) By using this concrete, the DL of the structure will get reduced and we can use this in partition walls.

Future Scope:

The utilization of waste rubber in concrete has considerable potential for sustainable construction, and several areas for future research can be identified:

1. Higher-Grade Concrete Applications
   - Future studies can explore the incorporation of rubber chips in higher-grade concrete (M25, M30, and above) to evaluate the effect on strength and durability.
2. Long-Term Durability Studies
   - Research can focus on the long-term performance of rubberized concrete under freeze-thaw cycles, chemical attacks, and weathering conditions.
3. Surface Treatment of Rubber
   - Studies can investigate the effect of chemical or physical treatment of rubber particles (e.g., NaOH treatment, silane coating) to improve bonding with cement paste and minimize strength reduction.
4. Use of Fine Rubber Aggregate
   - Partial replacement of fine aggregates with crumb rubber can be explored to evaluate workability, strength, and durability enhancements.
5. Hybrid Waste Material Concrete
   - Combining rubber with other industrial wastes like fly ash, slag, or silica fume could enhance compressive strength and other mechanical properties while further improving sustainability.
6. Field-Scale Applications
   - Laboratory studies should be extended to field-scale applications, such as road pavements, sidewalks, and lightweight construction elements, to assess real-world performance.
7. Structural Design Guidelines
   - Future research can focus on developing design guidelines and standards for the use of rubberized concrete in non-structural and semi-structural applications, facilitating its adoption in mainstream construction.

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