Erudite Journal of Engineering Technology and Management Sciences

Vol. 6, No. 1, March 2026, pp. 12-16

Journal home page: http://www.ejetms.com

# Utilization of Waste Rubber Tyres in Concrete: An Experimental Study on Strength Characteristics with Partial Coarse Aggregate Replacement

**Pamisetty Nethra[1], Gadidama Neeraj[2], Thokalapudi Suresh[3]**

[1,2,3]Assistant Professor in Department of Civil Engineering, JNTUA College of Engineering, Kalikiri, Andhra Pradesh, India.

**Email:** pamisettynethra@gmail.com, gadidamaneeraj@gmail.com, sureshjntuacek@gmail.com



https://doi.org/10.5281/zenodo.20156026

**Received:** 05 January 2026
**Accepted:** 01 march 2026

***Keywords:***
*Waste Rubber Tyres, Rubberized Concrete, Compressive Strength, Recycling of Waste Materials, Mechanical Properties of Concrete, Coarse Aggregate Replacement*

**ABSTRACT**

The disposal of waste rubber tyres has become a major environmental concern due to their non-biodegradable nature. This study explores the use of shredded waste tyre rubber as a partial replacement for coarse aggregate in concrete. Concrete mixes were prepared with 5%, 10%, 15% and 20% rubber replacement, along with a control mix. Compressive strength tests were conducted at 7 and 28 days. The results show that strength decreases with increasing rubber content, but lower replacement levels can still provide acceptable performance. The study demonstrates that rubberized concrete can be a sustainable solution for waste tyre utilization while reducing environmental impact and conserving natural resources.

## 1. INTRODUCTION

Concrete is one of the most commonly used building materials in the world due to its excellent strength, durability, and versatility. With the rapid development of infrastructure and urbanization, the demand for concrete is continuously increasing. This has led to the overuse of natural resources such as sand and gravel, which are key ingredients in concrete. The excessive extraction of these natural aggregates has caused significant environmental problems, including the depletion of riverbeds, erosion, habitat destruction, and ecological imbalance. At the same time, the concrete industry faces challenges such as cracking during curing, low tensile strength, and limited ductility. In recent years, there has been a growing interest in developing sustainable construction practices by incorporating alternative and recycled materials into concrete. One such material is waste rubber from used vehicle tyres [1-5].

Research has shown that rubberized concrete can exhibit better impact resistance, shock absorption, and flexibility. However, the addition of rubber particles may also reduce the compressive strength of concrete depending on the percentage used, making it important to carefully study and balance the mix design. This experimental study focuses on analysing the strength properties of concrete by replacing coarse aggregates with varying percentages of waste rubber tyres. The study aims to identify an optimum percentage of replacement that provides a good balance between sustainability and strength. By performing laboratory on concrete samples with different rubber content, the project evaluates the effects on compressive strength, tensile strength [6-10].

## 2. LITERATURE REVIEW

Several researchers have investigated the utilization of waste rubber tyres in concrete as a partial replacement for aggregates, focusing on strength, workability, and durability characteristics. Studies by Badugu Manisha (2024) reported an improvement in split tensile strength with the inclusion of rubber at certain proportions, indicating enhanced crack resistance. Similarly, Amit Kumar Soren (2023) observed that the incorporation of crumb rubber (1%–15%) improved the workability of concrete, as reflected by a slight increase in slump, and also enhanced toughness due to the elastic nature of rubber particles. Research conducted by Ana Paparao et al. (2020) revealed that optimum strength was achieved at 10% replacement of coarse aggregate, while even higher replacement levels showed comparable or improved performance over conventional concrete. However, the study lacked details regarding the size of rubber particles. In line with this, Bal Gopal Guru (2018) and T. Senthil Vadivel & R. Thenmozhi (2010) reported that lower replacement levels (2%–6%) can enhance compressive strength, suggesting that small quantities of rubber improve energy absorption and resistance to cracking. Conversely, K. Paul Sibiyone et al. (2017) highlighted that while rubberized concrete exhibits higher toughness, workability may decrease with the use of chipped rubber. Their findings also indicated that strength initially increases at low replacement levels but decreases gradually with higher rubber content. Supporting this trend, Mohammed Mudabheer Ahmed Siddiqui (2016) observed a reduction in workability and unit weight with increased rubber content, while Praveen et al. (2013) reported a decrease in strength properties despite improved slump values when crumb rubber replaced fine aggregate. Furthermore, El-Gammal (2010) emphasized that full replacement of coarse aggregate with rubber significantly reduces the density of concrete, making it lightweight but unsuitable for structural applications due to strength reduction.

Overall, the literature indicates that while the inclusion of waste rubber tyres in concrete can improve properties such as toughness, ductility, and workability, excessive replacement levels adversely affect strength. Most studies suggest that an optimum replacement range of 5%–10% provides a balance between mechanical performance and sustainability benefits.

## 3. EXPERIMENTAL WORK

### 3.1. Materials

The materials used in the present study include:

A. **Ordinary Portland Cement (OPC 53 Grade)** -The cement used in the study exhibited a fineness of 89%, a normal consistency of 32% (6 mm penetration), an initial setting time of 50 minutes, a final setting time of 420 minutes, and a specific gravity of 3.15, indicating that the cement meets standard quality requirements for concrete production.

B. **Fine Aggregates** - In this study, fine aggregate conforming to standard grading requirements was used. Laboratory tests determined the specific gravity of the sand as 2.67 and the fineness modulus as 2.39. Based on sieve analysis and in accordance with IS 383:2016, the fine aggregate was classified under Zone II (medium sand) according to its particle size distribution.

C. **Coarse Aggregates -** Coarse aggregates conforming to standard specifications were used. Laboratory tests determined the specific gravity of the coarse aggregate as 2.73, the aggregate impact value as 14.08%, and the aggregate crushing value as 20%. Based on these results and in accordance with IS 2386 (1963), the aggregates were found to be suitable.

D. **Water** - Concrete must be mixed with clean water that has no dangerous quantities oils, organic compounds, acids, and alkalis or other deleterious chemicals. In this investigation, we used portable tap water from the JNTUA college campus water plant that met the IS 456-2000 standards for casting concrete and curing the specimens.

E. **Waste Rubber Tyres** - In this study, shredded waste rubber tyre particles were used as a partial replacement for coarse aggregate. Laboratory tests determined the specific gravity of the rubber as 1.21 and the water absorption as 1.0%, indicating its lightweight nature and low moisture absorption characteristics, making it suitable for use in rubberized concrete.

### 3.2 Mix Proportions

The present study aims to evaluate the effect of shredded waste rubber tyres as a partial replacement for coarse aggregate (5%, 10%, 15% and 20%) on the properties of M20-grade concrete. The concrete mix was designed with a water–cement ratio of 0.5 in accordance with *IS 10262:2019*. Experimental investigations were carried out to assess workability (slump test), compressive strength, and split tensile strength of the concrete specimens, following standard testing procedures. For the preparation of 1 m³ of concrete, the mix proportions adopted were 345 kg/m³ of cement, 730 kg/m³ of fine aggregate, 1166 kg/m³ of coarse aggregate, and 190 liters of water, corresponding to a mix ratio of 1 : 2.1 : 3.4. Concrete specimens were cast, cured under standard conditions, and tested at specified curing periods to evaluate the performance of rubberized concrete.

### 3.3 Casting Of Specimens

This study investigates the performance of concrete with partial replacement of coarse aggregate using shredded waste rubber tyres (5%, 10%, 15% and 20%). An M20-grade concrete mix was designed in accordance with *IS 10262:2019* and batched by weight. The prepared concrete was placed into properly cleaned and oil-coated moulds (cubes: 150 × 150 × 150 mm and cylinders: 150 × 300 mm) to prevent adhesion. The specimens were compacted in three layers, each tamped 25 times using a 16 mm diameter tamping rod, following the guidelines of *IS 516:1959*. After casting, the specimens were left undisturbed for 24 hours and then demoulded. Subsequently, the specimens were cured under standard water curing conditions.

**Figure 1.** Casting of Specimens

**Figure 2.** Curing of Specimens

Compressive strength tests were conducted at 7 and 28 days in accordance with IS 516:1959, and the results were compared with conventional concrete (0% rubber replacement) to evaluate the effect of rubber incorporation on strength characteristics.

### 3.4 Testing Methods

3.4.1 Workability Test

The workability of fresh concrete mixes with varying percentages of waste rubber tyre replacement (0%, 5%, 10%, 15% and 20%) was evaluated using the slump cone test as per IS 1199:1959. The test measures the consistency and ease of handling of concrete. A standard slump cone of 300 mm height, 200 mm base diameter, and 100 mm top diameter was used. Concrete was placed in three layers, each tamped 25 times. After lifting the cone, the vertical slump was measured to determine workability.

3.4.2 Compression Test

Compression test is conducted to determine the compressive strength and behaviour of concrete under applied loads. In this study, M20-grade concrete was prepared using Ordinary Portland Cement (OPC 53), fine aggregate, coarse aggregate, water, and shredded waste rubber tyres as partial replacement. Three specimens were cast for each mix to obtain average values. The specimens were demoulded after 24 hours and cured under standard conditions for 7 and 28 days. After curing, compressive strength tests were carried out to evaluate the performance of rubberized concrete.

3.4.3 Split Tensile Test

The split tensile test was conducted to determine the tensile strength of concrete, which is essential for evaluating its behaviour under tension. In this study, M20-grade concrete was prepared using Ordinary Portland Cement (OPC 53), fine aggregate, coarse aggregate, water, and shredded waste rubber tyres as partial replacement. Three cylindrical specimens were cast for each mix to obtain average values. The specimens were demoulded after 24 hours and cured under standard conditions for 7 and 28 days before testing.

## 4. TEST RESULT AND DISCUSSIONS

### 4.1. General

The tests were accomplished on both freshly mixed and hardened concrete. The Fresh concrete mixture was tested for slump of workability. Tests on hardened concrete are finished, including compressive strength and split tensile strength tests.

### 4.2. Fresh Concrete Properties

Workability was evaluated using the slump cone test (*IS 1199:1959*). The results showed a gradual increase in workability with increasing waste rubber tyre content (0–20% replacement), primarily due to the smooth surface texture and lower density of rubber particles. The variation in slump values with rubber content is presented in the graph below, illustrating the influence of rubber incorporation on the consistency and handling characteristics of concrete.

**Table 1.** Slump Test Results

| % Of Rubber Tyres | Slump Value | Type Of Slump | Workability |
|---|---|---|---|
| 0% | 75mm | True slump | Medium |
| 5% | 82mm | True slump | Medium |
| 10% | 83mm | True slump | Medium |
| 15% | 85mm | True slump | Medium |
| 20% | 86mm | True slump | Medium |

### 4.3. Hardened Properties Of Concrete

4.3.1. Compressive strength test

The compressive strength test is a fundamental method used to evaluate the load-bearing capacity of hardened concrete. In this test, standard specimens (cubes of 150 × 150 × 150 mm) are subjected to increasing compressive load in a testing machine until failure occurs. The maximum load at failure is used to calculate the compressive strength, expressed in $N/mm^2$. Tests are typically conducted after 7 and 28 days of curing to assess the strength development and suitability of concrete for structural applications.

**Table 2.** Test results of Compressive Strength of Concrete

| % Of Rubber Tyres | 7 Days Strength ($N/mm^2$) | 28 Days Strength ($N/mm^2$) |
|---|---|---|
| 0% | 19.56 $N/mm^2$ | 29.12 $N/mm^2$ |
| 5% | 14.2 $N/mm^2$ | 28.50 $N/mm^2$ |
| 10% | 14.8 $N/mm^2$ | 28.32 $N/mm^2$ |
| 15% | 15.02 $N/mm^2$ | 29.01 $N/mm^2$ |
| 20% | 14.56 $N/mm^2$ | 28.45 $N/mm^2$ |

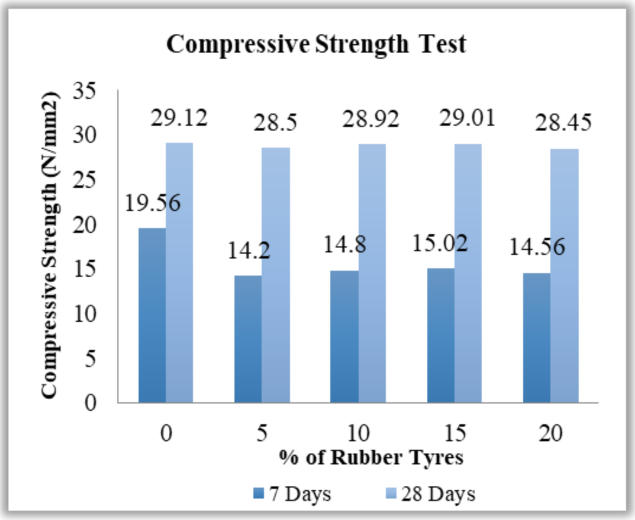


**Figure 3.** Compressive Strength test results of Concrete

4.3.2. Split Tensile Strength:

The tensile strength of concrete was determined using the Split Tensile Strength test, an indirect method. Cylindrical specimens of 150 mm diameter and 300 mm height were tested after 7 and 28 days of curing in accordance with *IS* 5816:1999. The specimens were placed horizontally in a compression testing machine, and load was applied until failure occurred. The corresponding splitting tensile strength values were recorded and graphically presented based on the failure loads.

## 5. COST ANALYSIS

Cost analysis in construction involves estimating the total expenditure required for a project, including materials, labor, equipment, transportation, and overhead costs. It is essential for effective planning and budgeting, ensuring that the project remains economically feasible and avoids unnecessary financial losses. The analysis considers key components such as material costs (cement, aggregates, steel), labor charges, machinery usage, and site-related expenses. By comparing different alternatives, cost analysis helps in selecting the most economical solution and ensures efficient project execution within the allocated budget.

**Table 3.** Test results of Split Tensile Strength

| % Rubber Tyres | 7 Days Strength ($N/mm^2$) | 28 Days Strength ($N/mm^2$) |
|---|---|---|
| 0% | 2.35 $N/mm^2$ | 3.67 $N/mm^2$ |
| 5% | 1.70 $N/mm^2$ | 3.60 $N/mm^2$ |
| 10% | 1.78 $N/mm^2$ | 3.65 $N/mm^2$ |
| 15% | 1.80 $N/mm^2$ | 3.66 $N/mm^2$ |
| 20% | 1.75 $N/mm^2$ | 3.59 $N/mm^2$ |

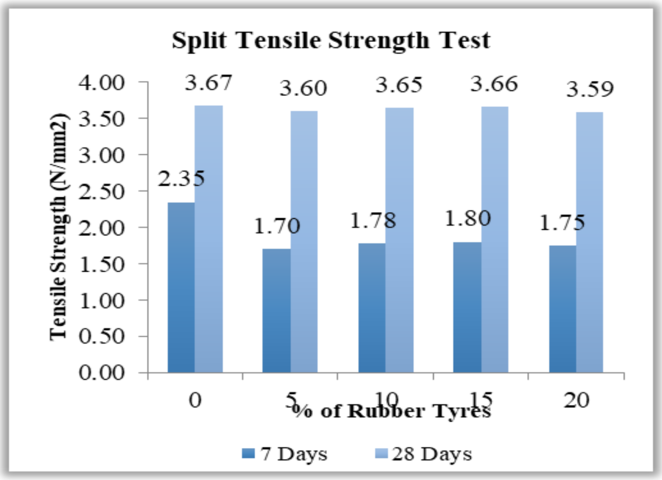


**Figure 4.** Split Tensile Strength test results of concrete

**Table 4.** Cost Analysis without Using Waste Rubber Tyres

| Material | Unit | Rate | Quantity | Total Cost |
|---|---|---|---|---|
| Cement | Per bag | Rs.410 | 70 kgs | Rs.574 |
| Fine aggregates | Per ton | Rs.1100 | 100 kgs | Rs.110 |
| Coarse aggregates | Per ton | Rs.800 | 205 kgs | Rs.164 |

**Table 5.** Cost Analysis Using Waste Rubber Tyres

| Material | Unit | Rate | Quantity | Total Cost |
|---|---|---|---|---|
| Cement | Per bag | Rs.410 | 70 kgs | Rs.574 |
| Fine aggregates | Per ton | Rs.1100 | 100 kgs | Rs.110 |

## 6. CONCLUSION

In this study, the influence of partial replacement of coarse aggregate with waste rubber tyres (0–20%) on the mechanical properties of concrete was investigated, with emphasis on workability, compressive strength, and split tensile strength. The experimental results led to the following conclusions:

i. The incorporation of waste rubber tyre particles resulted in a noticeable improvement in workability, attributed to their smooth surface texture, lower specific gravity, and reduced water absorption compared to natural aggregates.

ii. Slump test results demonstrated a consistent increase in workability with increasing rubber content (0–20%), indicating enhanced flow characteristics and ease of placement of fresh concrete.

iii. The compressive strength at early age (7 days) decreased with increasing rubber replacement, primarily due to weaker interfacial bonding between rubber particles and the cement matrix.

iv. The 28-day compressive strength results indicate that the inclusion of rubber tyre aggregates caused only slight reductions in strength compared to conventional concrete. Among the rubberized concrete mixes, the 15% replacement level showed the optimum performance with a compressive strength of 29.01 N/mm², exhibiting only a 0.38% decrease compared to the control mix. The mixes with 5%, 10%, and 20% replacement showed strength reductions of 2.13%, 2.75%, and 2.30% respectively,demonstrating that moderate rubber tyre replacement can produce concrete with compressive strength comparable to conventional concrete.

v. The split tensile strength showed a marginal decreasing trend with the incorporation of rubber tyre aggregates at both curing ages. At 28 days, the maximum reduction of approximately 2.18% was observed at 20% replacement, indicating a slight decrease in resistance to tensile stresses. Among the rubberized concrete mixes, the 15% replacement level exhibited optimum performance with only about 0.27% reduction compared to conventional concrete, demonstrating that moderate rubber incorporation can maintain tensile strength nearly equivalent to normal concrete.

vi. The cost analysis indicated that partial replacement of coarse aggregate with waste rubber tyres resulted in an overall reduction in material cost of approximately 1.42% compared to conventional concrete, demonstrating its potential as an economical alternative material in concrete production.

## REFERENCES

1. Azmi, N. J., Mohammed, B. S., Al- Matanersh , H. M. A. (2008). Engineering properties of concrete containing recycled tyre rubber. International Conference on construction and building technology, Malaysia, 373-382
2. M. Venu P. N. Rao Birla, Study of Rubber Aggregates in Concrete: An Experimental Investigation, International Journal of Civil Engineering and Technology, 1(1), 2010, pp. 15
3. El-Gammal, A., Abdel-Gawad, A. K., El-Sherbini, Y., Sholay, A. (2010). Compressive strength of concrete utilizing waste tyre rubber. Journal of Emerging Trends in Engineering and Applied Sciences, 1, 96-9
4. Vadivel, S., Thenmozhi, R. (2012). Experimental study on waste tyre rubber replaced concrete - An eco-friendly.
5. Parveen, sachin dass, Ankit sharma (2013) : Rubberized

concrete : needs of good environment ; International Journal of Emerging Technology and Advanced Engineering.

6. Siringi, Gideon M., Abolmaali, Ali Aswath, Pranesh B. (2013) “Properties of Concrete with Crumb Rubber Replacement Fine Aggregates” ASTM (American Society for Testing and materials) International, 2(1) P 5-20.
7. Mane, P. A., Patkar, D. G., Bhosale, S. M. (2013). Laboratory evaluation of usage of waste tyre rubber in bituminous concrete. International Journal of Scientific and Research Publications, 3, 1-10
8. Dr J K Dattatreya, suresh raghu ; (2015) ; Experimental investigation of crumb rubber concrete confined by FRP sheets ; Journal of Civil Engineering and Environment Technology.
9. Mohd. Mohshin Khan, Anurag Sharma, Sandeep Pancham ; (2017) ; Use of Crumb Rubber As Replacement over aggregate in concrete ; International Journal of Civil Engineering and Technology.
10. Ayman Moustafa, and Mohamed ElGawady; (2015); Damping Properties Of High Strength Concrete With Scrap Tire Rubber; 5th International Conference on Construction Materials.