International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 • Website: www.ijfmr.com • Email: editor@ijfmr.com

The Effect of Using Car Tire Rubber in Concrete

Masoud Zedan Mbarek

Department of Civil Engineering, Higher Institute of Science and Techonlogy, Al-Jufra, sokna, Libya

Abstract
Recycling tire rubber in concrete is a means of eliminating environmental pollution and reducing costs. This study aimed to use waste tire rubber as a replacement for fine and coarse aggregates at different replacement ratios (10%, 15%, and 20% for fine aggregate; 10%, 20%, and 30% for coarse aggregate; and 20% and 30% for mixed aggregates). The results showed that replacing fine rubber at 10% and 15% reduced the compressive and tensile strengths of concrete to an acceptable degree, while replacing it at 20% significantly reduced the strength. For coarse aggregate, rubber replacement reduced the compressive and tensile strengths of concrete compared to the reference mixture and the higher the coarse rubber replacement ratio, the greater the reduction in strength. Using 20% and 30% as a retarder for mixed aggregates reduced the strength. Increasing the percentage of rubber aggregate resulted in a decrease in the density and weight of concrete. Overall, the results indicate that adding rubber affects the mechanical properties of concrete, resulting in reduced compressive and tensile strength, but may also improve other properties such as thermal and acoustic insulation.

Keywords: Tire, Rubber, Reinforced, Concrete, aggregates

1. INTRODUCTION

Industrial waste is steadily increasing worldwide, posing significant environmental and economic challenges. Among these wastes, used rubber tires represent a particular environmental problem due to their long decomposition period and resistance to natural decomposition. It is estimated that millions of used tires are disposed of annually, resulting in piling, filling, or burning, both of which cause serious soil, air, and water pollution [1]. Therefore, finding sustainable solutions for managing this waste has become vital. In this context, recycling rubber tires and using them as an alternative material in the concrete industry has emerged as a promising solution that combines environmental and economic benefits. Concrete, as the second most consumed material in the world after water, consumes massive amounts of natural aggregate, depleting natural resources and impacting the environment. Replacing some of this aggregate with used tire rubber could reduce the demand for natural aggregate, contribute to the safe disposal of tire waste, and benefit the construction industry [3].

Historically, research into the use of rubber in concrete began in the 20th century, driven by the need for new building materials with improved properties, as well as the environmental challenges associated with tire waste [4]. Initial studies have shown that adding rubber to concrete can affect its mechanical and physical properties in various ways. While this may result in reduced compressive and tensile strength, it can also improve other desirable properties such as reduced density, ductility, impact resistance, and energy absorption, as well as improved thermal and acoustic insulation [7, 8].

This research paper aims to present a comprehensive study on the effect of using recycled Cartier rubber as a partial replacement for aggregate in reinforced concrete. The study will focus on analyzing the mechanical and physical properties of rubberized concrete, including compressive strength, indirect tensile strength, slump, and ultrasonic pulse velocity. The results will be reviewed and discussed in detail, compared with traditional concrete, and conclusions will be drawn regarding the suitability of using rubber in various concrete applications. This study aims to contribute to the scientific understanding of the effect of rubber on concrete and provide practical guidelines for engineers and researchers in the field of sustainable building materials.

2. Experimental Work (Methodology)

A. Concrete Components

- **Cement:** Ordinary Portland cement conforming to British Specifications [BS 812:1996].
- **Fine Aggregate:** Natural sand free from impurities, conforming to British Specifications [BS 812:1992].
- **CoarseAggregate:** Angular crushed aggregate fromacrusher (Baringo), conforming to British Specifications [BS 882:2002].
- Water: Free from organic matter, conforming to Libyan Specifications [M.Q.L294].

B. TireRubber

- **Coarse Rubber:** Manufactured from waste car tires, sieved and mixed according to the British Specifications [BS 882:2002] granulargrading.
- **Fine Rubber:** Manufactured from waste car tires, shredded, sieved, and mixed according to British Specifications [BS 812:1992].

3. Concrete Mixes

Concrete mixes with different rubber replacement ratios were used as a substitute for fine and coarse aggregates. The ratios included:

- **Fine Rubber Aggregate:** 10%, 15%, 20%.
- **Coarse Rubber Aggregate:** 10%, 20%, 30%.
- **Mixed Rubber (from fine and coarse aggregate):** 20%, 30%.

4. Sample Preparation and Tests

Standard cubes (150x150x150 mm) and cylinders (150x300 mm) were prepared. The components were mixed in a mechanical mixer, and then the concrete was poured into molds and compacted to remove air. After 24 hours, the molds were demolded, and the samples were cured by immersion in water until the test was complete. The tests included:

- **Slump Test**: According to British Specifications [BS 1881: Part102: 1983].
- **Compressive Strength Test:** According to British Specifications [BS EN 12390- part3: 2009].
- **Indirect Tensile Strength Test:** According to British Specifications [BS 1881:Part117:1983].
- **UltrasonicPulseVelocityTest:** According to British Specifications [BS 1881: Part 203].

5. Results and Discussion

The results obtained from the various tests provide a comprehensive analysis of the effect of replacing recycled tire rubber as a partial aggregate substitute in concrete on its mechanical and physical properties. Tests were conducted on concrete samples containing different proportions of fine, coarse, and mixed rubber, and compared with a reference concrete mix that did not contain rubber. This discussion aims to interpret the observed results and link them to the known properties of rubber and concrete, in addition to comparing them with previous studies in this field.

A. Slump

The slump test is an important indicator of concrete workability, which reflects the ease of pouring and compacting concrete without segregation of its components. The results showed that the slump value for concrete mixes containing tire rubber was generally lower compared to the reference mix. The slump values for mixes containing fine rubber ranged between 16 and 47 mm, while the slump value for mixes containing fine rubber decreased by 46.8%, 56.6%, and 55.3% respectively compared to the reference mix at replacement ratios of 10%, 15%, and 20% respectively. As for mixes containing coarse rubber, the slump values decreased by 65.9%, 42.5%, and 37.8% respectively, at replacement ratios of 10%, 20%, and 30%.

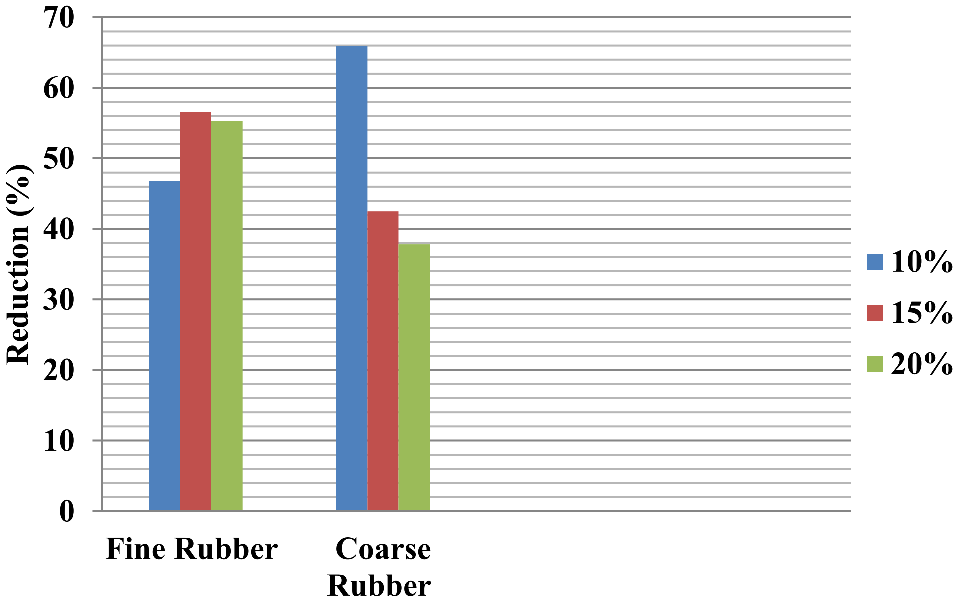

Fig 1: Results of Slump Test

This decrease in slump can be explained by several factors. Firstly, rubber is a non- porous material and does not absorbwater, unlike natural aggregate which absorbspart of the mixing water. This means that the amount of water available for lubrication between aggregate and cement particles decreases, leading to a reduction in workability. Secondly, rubber has a smooth and elastic surface compared to rough and angular natural aggregate, which reduces internal friction between aggregate particles and affects the consistency of the mix. However, this effect can be complex and depends on the shape and size of the rubber particles. Thirdly, the large size of rubber particles may lead to an increase in trapped air voids within the mix, which affects workability [10].

B. Compressive Strength

Compressive strength is one of the most important mechanical properties of concrete, determining its ability to withstand axial loads. The results clearly showed that the compressive strength of concrete decreases with an increase in the rubber replacement ratio, whether the rubber was fine or coarse. For fine rubber, the compressive strength decreased by 7.5%, 7.2%, and 10% after 7 days, and by 10.7%, 10.9%, and 11.6% after 28 days for samples containing 10%, 15%, and 20% fine rubber, respectively, compared to the reference mix. As for coarse rubber, the compressive strength decreased by 34.2%, 37%, and 56.7% after 28days for 10%, 20%, and 30% coarse rubber, respectively. Mixes containing mixed rubber (fine and coarse) also showed a significant decrease in compressive strength.

This decrease in compressive strength is attributed to several key factors. Firstly, rubber is an impermeable material and does not absorb water, unlike natural aggregate, which absorbs part of the mixing water. This means that the amount of water available for lubrication between aggregate and cement particles decreases, leading to a reduction in workability. Secondly, rubber has a smooth and elastic surface compared to rough and angular natural aggregate, which reduces internal friction between aggregate particles and affects the consistency of the mix. However, this effect can be complex and depends on the shape and size of the rubber particles. Thirdly, the large size of rubber particles may lead to an increase in trapped air voids in the mix, which affects workability [10].

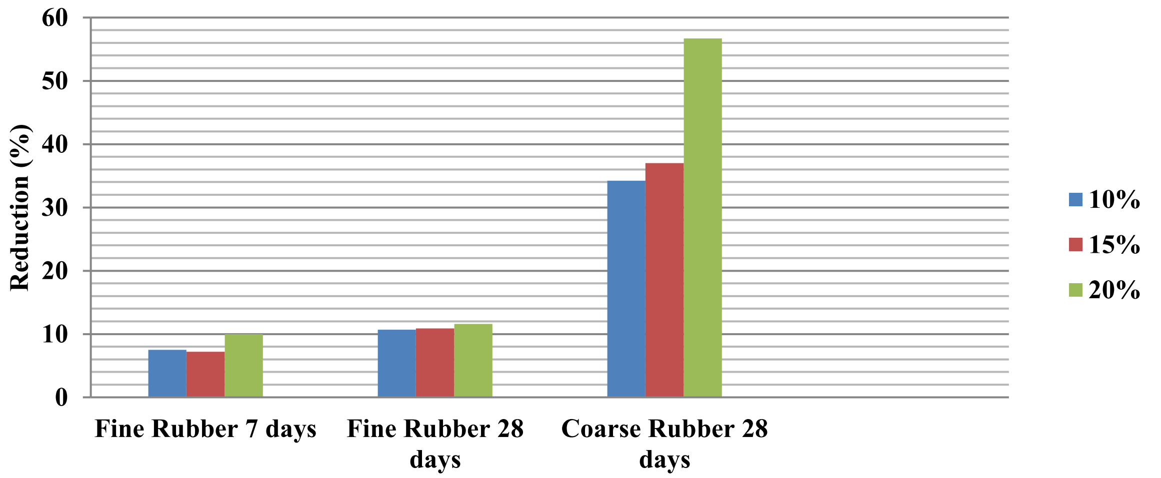

Fig 2: Compressive Strength for Fine Rubber and Coarse Rubber

C. Indirect Tensile Strength

In direct tensile strength decreased with an increase in the rubber replacement ratio. For fine rubber, tensile strength decreased by 11.11% after 7days for 10% rubber, increased by 5.26% for 15% rubber, and decreased by 5.55% for 20% rubber. After 28days, the Strength decreased by 34.48%, 34.48%, and 16.66% for 10%, 15%, and 20% fine rubber respectively. Mixes containing coarse rubber and mixed rubber mixes showed a decrease in tensile strength. This decrease in tensile strength is an expected result of the effect of rubber on the bonding properties within concrete.

Table 1: Indirect Tensile Strength Test Results

Test Tensile Strength	**Change (%)**
Fine Rubber 10% (7 days)	-11.11
Fine Rubber 15% (7 days)	5.26
Fine Rubber 20% (7 days)	-5.55
Fine Rubber 10% (28 days)	-34.48
Fine Rubber 15% (28 days)	-34.48

Fine Rubber 20% (28days)	-16.66

D. Ultra sonic Pulse Velocity

The ultrasonic pulse velocity increased in rubber mixes compared to the reference mix, indicating improved thermal and acoustic insulation. This is due to the reduction of voids within the concrete due to the replacement of rubber proportions with fine and coarse aggregate.

6. Conclusions

- The slump value decreases with increasing rubber replacement ratios and the higher the coarse rubber replacement ratio, the greater the slump.
- High proportions of mixed rubber (20%/30%) delay hardening and weaken strength.
- Adding coarse rubber aggregate reduces compressive and indirect tensile strength, and this reduction increases with increasing replacement ratio.
- Adding fine and coarse rubber aggregate increases ultrasonic pulse velocity, indicating improved thermal and acoustic insulation.
- In general, the results show that using tire rubber as an aggregate substitute in concrete negatively affects mechanical properties such as compressive and tensile strength, but it may improve other properties such as density, ductility, and thermal and acoustic insulation. These effects should be considered when designing concrete mixes containing rubber.

References

1. Sidney Mindess, Young JF, David Darwin.Concrete, 2nded, New Jersey: Prentice Hall; 2003.
2. MCINTYRE III, James E. 40 Years and More of Tire Science and Technology: A History of the Tire Society. Tire Science and Technology, 2022, 50.2: 100-187.
3. WARIS, Muhammad B.; ALI, Nehal N.; AL-JABRI, Khalifa S. Use of recycled tire in concrete for partial aggregate replacement. International Journal of Structural and Civil Engineering Research, 2016, 5.4: 273-276.
4. PARTON, G. M.; SHENDY-EL-BARBARY, M. E. Polystyrene-bead concrete properties and mix design. International Journal of Cement Composites and Lightweight Concrete, 1982, 4.3: 153-161.
5. RENARD, Ronald D. The Wa authority and good governance, 1989–2007. Journal of Burma Studies, 2013, 17.1: 141-180.
6. PINIZZOTTO, Salvatore, et al. Natural rubber systems and climate change. Proceedings and extended abstracts from the online workshop, 23-25 June 2020.
7. OYEBISI, Adetoye T.; OSASONA, Cordelia O. Effect of Waste Tyre-Rubber Aggregate on the Strength Properties of Concrete. J Eng Res Reports, 2018, 2.2: 1-9.
8. BANERJEE, Sulagno; MANDAL, Aritra; ROOBY, Jessy. Studies on mechanical properties of tyre rubber concrete. SSRG Int. J. Civ. Eng, 2016, 3: 18-21.
9. BANERJEE, Sulagno; ROOBY, Jessy. Strength Properties of Tyre Rubber Concrete. EXTRACTION, 2019, 5.10.
10. AL-TAYEB, Mustafa Maher; HAMOUDA, Hasan. Effect of superplasticizer on workability of concrete containing crumb rubber. Civil and Environmental Research, 2015, 7.2: 35-43.
11. Libyan Standard Specifications No. (340) Portland cement for the year 1997 AD.
12. British Standard Specifications No. (BS:882) Sieve Analysis Limits for Aggregate for the year 1992.

13. Libyan Standard Specifications No. (294) Water Used in Concrete and Specifications Limits for the year 1988.
14. British Standard Specifications No. (BS 812_1992) Properties of Concrete for Fine Aggregate.
15. BritishStandard Specifications No. (BS 882:2002) Method for Sieve Analysis Test for Coarse Aggregate.
16. British Standard Specifications No.(BS 1881) Method for Slump Test for Fresh Concrete.
17. British Standard Specifications No. (BS_EN12390_Part 3) Method for Compressive Strength Test for Hardened Concrete.
18. British Standard Specifications No. (BS 1881 Part 117) Method for Indirect Tensile Strength Test.
19. British Standard Specifications No. (BS 1881 Part 203) Method for Ultrasonic PulseVelocity Test for Cubes.