STRENGTH AND DURABILITY PERFORMANCE OF SUSTAINABLE RUBBERIZED CONCRETE WITH TYRE POWDER AND TYRE CHIPS AS PARTIAL AGGREGATE SUBSTITUTES

By

HOSAIN AHMED

IBRAHIM KHALIL

OVI BOWMIK

MD FORHAD HOSSAIN

MIR MASBAH UDDIN

A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

Department of Civil Engineering
Sonargaon University
147/1,Green Road,Dhaka-1215,Bangladesh
Section: 26B
Semester: Fall-2025

STRENGTH AND DURABILITY PERFORMANCE OF SUSTAINABLE RUBBERIZED CONCRETE WITH TYRE POWDER AND TYRE CHIPS AS PARTIAL AGGREGATE SUBSTITUTES

By

HOSAIN AHMED
IBRAHIM KHALIL
OVI BOWMIK
MD FORHAD HOSSAIN
MIR MASBAH UDDIN

Supervisor
M.A. BASHAR BHUIYAN
Lecturer, Department of Civil Engineering
Sonargaon University

A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

Department of Civil Engineering
Sonargaon University
147/1,Green Road,Dhaka-1215,Bangladesh
Section: 26B
Semester: Fall-2025

BOARD OF EXAMINERS

The thesis titled “Strength and durability performance of sustainable rubberized concrete with tyre powder and tyre chips as partial aggregate substitutes” submitted by Hosain Ahmed ID No: CE2202026029, Ibrahim Khalil ID No: CE2202026054, Ovi Bowmik ID No: CE2202026055, Md Forhad Hossain ID No: CE2202026091, Mir Masbah Uddin ID No: CE2202026121, Has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering 17.01.2026.

……......................................

1. M.A. Bashar Bhuiyan,
Lecturer
Sonargaon University

Chairman

....

2. Internal/External Member

Member

....

3. Internal/External Member

Member

DECLARATION

We hereby declare that the work and resources included in this report we recompleted buys and have not previously been submitted for academic credit to any university, college or organization.. We ensure that the work submitted does not violate any existing copyright laws. We commit to compensating the damages resulting from a violation of this obligation.

STUDENT NAME	STUDENT ID	SIGNATURE
Hosain Ahmed	CE2202026029	________________
Ibrahim Khalil	CE2202026054	________________
Ovi Bowmik	CE2202026055	________________
Md.Forhad Hossain	CE2202026091	________________
Mir Masbah Uddin	CE2202026121	________________

Dedicated

To

“Our Beloved Parents

And

Our Honorable Teachers”

ACKNOWLEDGMENT

All glory and sincere appreciation are due to the all-powerful Allah, the most merciful and beneficent, for providing the opportunity and capacity to carry out this endeavor in a safe and careful manner. Our sincere gratitude and acknowledgement go out to M.A. Bashar Bhuiyan, the lecturer who guided this project. As a guide, he supplied maximum aid concluding the project job. With her prior years of expertise and guidance, he directed us to come out with success through the toughest issues experienced by us. Her keen interest in the issue and good guidance were the sources of the author's inspiration. We want to express our sincere appreciation to our guides for their co-operation and constant civility toward us during the entire process. We sincerely would like to thank all instructor and staff of the Civil Engineering Department of Sonargaon University (SU), Dhaka, which contributed in various ways to the completion of this thesis. Finally, we want to express our sincere thanks to my family and friends for their everlasting encouragement, love, and support. Without their constant support, this project would not have been able to move further.

ABSTRACT

The growing demand for sustainable construction materials and effective waste management has encouraged the utilization of industrial and solid wastes in concrete production. Waste tire rubber, generated in large quantities worldwide, poses serious environmental challenges due to its non-biodegradable nature. This study investigates the strength and durability performance of sustainable rubberized concrete by partially replacing natural fine and coarse aggregates with tire powder and tire chips. Several concrete mixes were prepared with varying replacement ratios, and their mechanical properties were evaluated through compressive strength, split tensile strength, and flexural strength tests at different curing ages. In addition, durability characteristics such as water absorption, permeability, and resistance to aggressive environmental conditions were examined. The experimental results indicate that increasing the rubber content leads to a reduction in mechanical strength compared to conventional concrete; however, rubberized concrete exhibits improved ductility, energy absorption capacity, and crack resistance. Within an optimum replacement range, the durability performance of rubberized concrete remains satisfactory. The findings demonstrate that the incorporation of tire powder and tire chips in concrete contributes to sustainable waste management while producing an environmentally friendly construction material suitable for non-structural and selected structural applications.

`

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

CHAPTER 2: LITERATURE REVIEW

`

CHAPTER 3: METHODOLOGY

CHAPTER 4: RESULTS AND DISCUSSION

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

`

LIST OF FIGURES

`

LIST OF TABLES

`

CHAPTER-1

Introduction

1.1 Background

The construction industry heavily relies on natural aggregates and cement, leading to resource depletion and environmental degradation. Simultaneously, the disposal of waste tires has become a major environmental concern due to their non-biodegradable nature and large volume. Utilizing waste tires in concrete as tire powder and tire chips offers a sustainable solution by reducing environmental pollution and conserving natural resources. Rubberized concrete, produced by partially replacing fine and coarse aggregates with tire rubber, exhibits unique properties. While compressive strength may decrease with higher rubber content, ductility, toughness, impact resistance, and crack resistance improve significantly. Durability performance, including water absorption, permeability, and resistance to environmental attack, is also influenced by rubber inclusion. This study aims to investigate the strength and durability of sustainable rubberized concrete with varying levels of tire powder and tire chips to identify an optimal mix that balances mechanical performance, durability, and environmental sustainability, promoting eco-friendly construction practices.

1.2 Problem Statement

The rapid growth of the construction industry has led to an increasing demand for natural aggregates and cement, resulting in environmental degradation, depletion of natural resources, and increased carbon emissions. At the same time, the disposal of waste tires has become a serious environmental challenge due to their non-biodegradable nature and large accumulation worldwide. Improper disposal of tires causes land pollution, fire hazards, and adverse effects on human health. Conventional concrete relies heavily on natural aggregates, which adds pressure on the environment, while waste tires remain underutilized as a resource.

There is a growing need for sustainable and environmentally friendly construction materials that can simultaneously reduce reliance on natural aggregates and provide a viable method for recycling waste tires. Rubberized concrete, produced by partially replacing fine and coarse aggregates with tire powder and tire chips, has shown promise in enhancing ductility and toughness. However, the effects on compressive strength, tensile strength, and durability characteristics are not fully optimized. Therefore, it is necessary to systematically investigate the strength and durability performance of sustainable rubberized concrete to identify an optimal mix that balances mechanical performance, durability, and environmental benefits.

1.3 Objective

1. Examine the effects of tire powder and tyre chips on the compressive strength of concrete.
2. Assess the durability characteristics of rubberized concrete at different replacement levels.
3. Compare the performance of tyre powder–based and tyre chip–based rubberized concrete.
4. Determine the optimum rubber replacement level for practical applications.

1.4 Scope

This study focuses on evaluating the mechanical and durability performance of sustainable rubberized concrete by partially replacing natural fine and coarse aggregates with tire powder and tyre chips. The research includes tests on compressive strength, as well as durability assessments such as water absorption and permeability. The main aim is to identify an optimum replacement level that ensures satisfactory mechanical performance while promoting environmental sustainability and effective utilization of waste tyres.

1.5 Significance of the study

This study is significant as it addresses two major challenges in construction and environmental management: the excessive use of natural aggregates and the disposal of waste tires. By investigating the use of tire powder and tire chips as partial replacements for fine and coarse aggregates in concrete, this research promotes sustainable construction practices and contributes to resource conservation.

Rubberized concrete not only provides a practical solution for recycling waste tires but also improves properties such as ductility, toughness, impact resistance, and crack resistance. Evaluating both strength and durability ensures that the material can be safely used in construction applications. The findings of this study are expected to support environmentally friendly construction methods, reduce the ecological footprint of concrete production, and provide guidelines for optimal utilization of waste tires in building materials.

CHAPTER-2

Literature Review

2.1 General

Respectively According to studies, replacing aggregates with rubber generally reduces the compressive strength of concrete due to weak bonding between rubber particles and cement paste. However, rubberized concrete exhibits improved ductility, toughness, energy absorption, and crack resistance, making it suitable for pavements, barriers, and non-structural applications.

Research also highlights the influence of rubber content on durability characteristics. Rubberized concrete shows enhanced resistance to impact and fatigue loads, but water absorption and permeability may increase slightly due to the hydrophobic nature of rubber and changes in the pore structure. Studies suggest that proper mix design, including the use of silica fume or other supplementary cementations materials, can improve bonding and mitigate strength reduction while maintaining durability.

Several experimental investigations have focused on identifying optimal replacement ratios of tire powder and tire chips. Most studies recommend limiting rubber content to a certain percentage (commonly 5–20% for fine aggregates and 5–15% for coarse aggregates) to achieve a balance between mechanical performance and sustainability. Beyond this range, significant strength reduction may occur, although ductility and toughness continue to improve.

Despite numerous studies, gaps remain in systematically evaluating both mechanical and durability performance of rubberized concrete under different curing ages and environmental conditions. Limited research addresses the combined use of tire powder and tire chips as partial replacements in a single mix, emphasizing the need for further investigation to identify optimal proportions for sustainable construction.

In conclusion, previous research confirms that incorporating waste tire rubber into concrete can enhance sustainability while providing acceptable mechanical and durability performance when properly designed. This study aims to build upon existing knowledge by analyzing the strength and durability characteristics of concrete with varying proportions of tire powder and tire chips, contributing to effective utilization of waste tires in construction.

2.2 Overview of Sustainable Concrete

Sustainable concrete refers to concrete produced with a focus on minimizing environmental impact, conserving natural resources, and promoting the use of recycled or waste materials while maintaining adequate mechanical and durability performance. The construction industry is one of the largest consumers of natural resources and a significant contributor to carbon emissions. Traditional concrete production requires extensive use of cement, sand, and coarse aggregates, which leads to resource depletion and environmental degradation.

To address these challenges, sustainable concrete incorporates alternative materials such as industrial by-products, agricultural residues, and recycled waste. Common examples include fly ash, slag, silica fume, recycled aggregates, and waste tire materials. Rubberized concrete,which uses tire powder and tire chips as partial replacements for fine and coarse aggregates, exemplifies sustainable concrete. This approach not only reduces reliance on natural aggregates but also provides a practical solution for managing waste tires, enhancing environmental sustainability.

Sustainable concrete aims to achieve a balance between environmental benefits, cost-effectiveness, and structural performance. It has the potential to improve durability, ductility, and crack resistance while promoting circular economy practices in the construction industry.

2.3 Waste Tyre Rubber as Construction Materials

Waste tires are a significant environmental concern due to their non-biodegradable nature and the large quantities generated worldwide. Improper disposal of tires causes land pollution, fire hazards, and health risks, making their recycling and reuse an urgent priority. One effective solution is the use of waste tire rubber in construction materials, particularly concrete.

Waste tires can be processed into tire powder and tire chips, which can partially replace fine and coarse aggregates in concrete. Incorporating rubber into concrete helps in reducing environmental pollution, conserving natural aggregates, and promoting sustainable construction practices. Rubberized concrete exhibits improved ductility, toughness, impact resistance, and crack resistance, although compressive strength may decrease with higher rubber content.

Several studies have demonstrated that controlled replacement levels of tire powder and tire chips can produce concrete with acceptable mechanical and durability performance. By utilizing waste tire rubber in construction, the circular economy is promoted, and the environmental footprint of concrete production is significantly reduced.

`

2.4 Effect of Tyre Chips on Concrete Propertise

Rubberized concrete is produced by partially replacing natural aggregates with waste tire materials such as tire powder and tire chips. Its properties differ from conventional concrete due to the presence of elastic rubber particles, which influence both mechanical and durability characteristics.

Mechanical Properties

Compressive Strength: Generally decreases with increasing rubber content due to weak bonding between rubber and cement paste. Tensile Strength: Slightly reduced, but ductility and crack resistance improve. Flexural Strength: Decreases moderately, while toughness and energy absorption capacity increase. Ductility and Toughness: Significantly enhanced, making rubberized concrete more flexible and resistant to sudden failure.

Durability Properties

Water Absorption and Permeability: May increase slightly due to rubber’s hydrophobic nature and changes in pore structure. Impact and Fatigue Resistance: Improved, as rubber particles help absorb energy and prevent crack propagation. Thermal and Chemical Resistance: Enhanced performance under certain environmental conditions due to the resilience of rubber particles.

Rubberized concrete demonstrates a balance between sustainability, ductility, and acceptable mechanical performance when optimum replacement levels are used, making it suitable for pavements, barriers, and non-structural applications.

2.5 Effect of Tyre Powder on Concrete Properties

Tire powder, derived from waste tires, is commonly used as a partial replacement for fine aggregates in concrete. Its incorporation significantly influences the mechanical and durability properties of concrete.

Mechanical Properties

Compressive Strength: Generally decreases with increasing tire powder content due to weak bonding between rubber particles and the cement matrix. Tensile and Flexural Strength: May also reduce slightly, but ductility, toughness, and energy absorption improve. Crack Resistance: Enhanced, as rubber particles act as flexible inclusions that reduce stress concentration and crack propagation.

Durability Properties

Water Absorption and Permeability: May increase slightly due to changes in pore structure caused by tire powder. Impact Resistance: Significantly improved, making concrete more resilient to dynamic and shock loads. Environmental Benefits: Using tire powder reduces waste tire accumulation and decreases the demand for natural sand, promoting sustainable construction practices. Overall, limited replacement levels (commonly 5–20% of fine aggregates) achieve a balance between maintaining acceptable strength and enhancing ductility, toughness, and environmental sustainability.

2.6 Strength Performance of Rubberized Concrete

Rubberized concrete, produced by partially replacing natural aggregates with tire powder and tire chips, exhibits distinct strength characteristics compared to conventional concrete.

Compressive Strength: The inclusion of rubber particles generally leads to a reduction in compressive strength. This decrease occurs due to the weak bond between rubber and the cement matrix, as well as the lower stiffness of rubber compared to natural aggregates. However, moderate replacement levels (typically 5–20% for fine aggregates and 5–20% for coarse aggregates) can achieve satisfactory compressive strength suitable for certain structural and non-structural applications.
Tensile and Flexural Strength: Rubberized concrete shows a slight reduction in tensile and flexural strength. Despite this, the presence of rubber significantly improves ductility, energy absorption, and crack resistance, which enhances the overall toughness of the concrete.

Ductility and Toughness: The elastic nature of rubber particles increases the material’s ability to deform under stress without sudden failure, improving impact and fatigue resistance.

Overall, while rubberized concrete may have lower compressive strength than conventional concrete, its improved ductility, toughness, and crack resistance make it suitable for applications such as pavements, barriers, and other non-structural elements, especially where energy absorption and flexibility are important.

`

CHAPTER-3
METHODOLOGY

3.1 Introduction

In this study, cement, fine aggregate, coarse aggregate and fresh water are used to reduce desire concrete mix. Sand was used as fine aggregate and stone chips were used as coarse aggregate and potable water was used in the investigations for both mixing and curing.

3.1.1 Cement

Cement, in general, adhesive substances of all kinds, but, in a narrower sense, the binding materials used in building and engineering construction. Cements of this kind are finely ground powders that, when mixed with water set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compounds with water that yields submicroscopic crystals or a gel-like material with a high surface area. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements. The most important of these is Portland-cement.

Table 3.1.1: Specific Properties of Cement

Name	Fresh cement (Portland Composite Cement)
Specific gravity of cement	3.15
Setting times of cement	i) Initial setting time 30 minutes ii)Final setting time10Hours
Weight	50 Kg.
BDSEN197-1	2003CEMII/B–M(S-V-L)42.5N
Clinker	70-79%
Limestone	21-30%
Gypsum	0-5%

Figure: 3.1 Cement

3.1.2 Fine aggregate

Aggregate significantly influences rheological and mechanical properties on both mortars and concrete. Fine aggregate being a main component in concrete production has a significant part to play in influencing concrete strength. Sand is commonly used as the standard material for a fine aggregate. In this same type of sand was used as the fine aggregate for both with admixture and without admixture in this study as shown in below figure. The sand was washed with water and air dried before being used to obtain Saturated Surface (SSD) condition.

Figure: 3.2 Fine Aggregat

3.1.3 Course aggregate

Aggregate materials help to make concrete mixes more compact. They also decrease the consumption of cement and water and contribute to the mechanical strength of the concrete, making them an indispensable ingredient in the construction and maintenance of rigid structures aggregate materials help to make concrete mixes more compact. They also decrease the consumption of cement and water and contribute to the mechanical strength of the concrete making the man indispensable ingredient in the construction and maintenance of rigid structures. Coarse aggregates are particulates that are greater than 4.75mm. The usual range employee dis between 9.5mm and 37.5mm in diamete In this study two different type of stone chips Dubai LC stone had been used as a coarse aggregate as shown in the Figure.

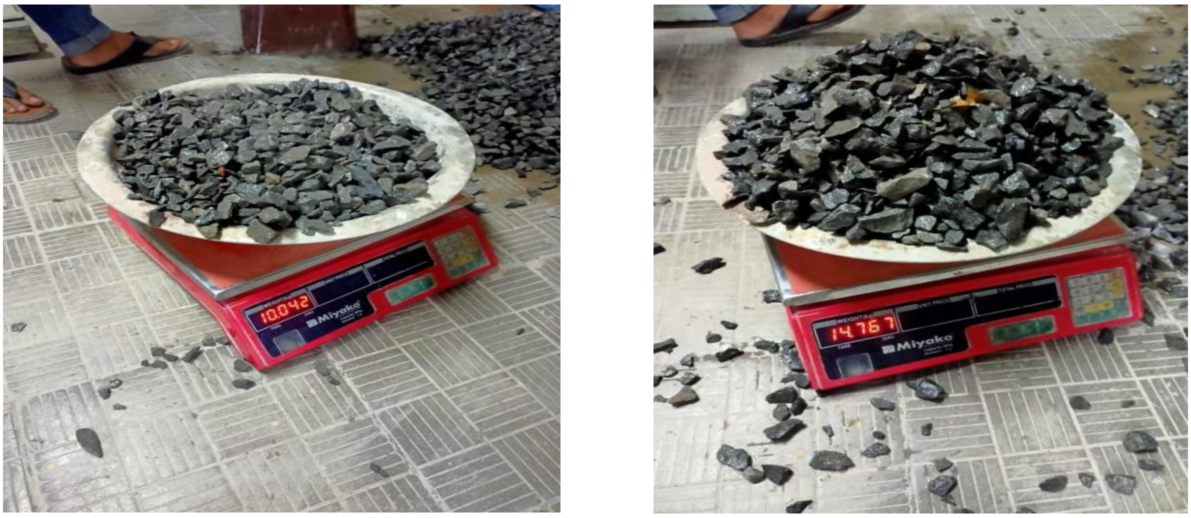

Figure:3.3 Course Aggregate

3.1.4 Waste Tyre Powder

Crumb rubber is a finely processed material obtained from discarded vehicle tyres through mechanical or cryogenic methods, with particle sizes typically ranging from 0.075 to 4.75 mm. It mainly consists of natural and synthetic rubber, carbon black, and minor additives. Due to its low density and high elasticity, crumb rubber can be used as a partial replacement of natural fine aggregate in concrete. Its application promotes sustainable waste management; however, excessive replacement may lead to a reduction in compressive strength of concrete.

Figure: 3.4 Waste Tyre Powder

3.1.5 Waste Tyre Chips

Tyre large particles, commonly known as tyre chips, are produced by cutting or shredding used waste tyres into relatively large-sized rubber pieces, generally comparable to coarse aggregate. These particles have low density, high elasticity, and relatively low water absorption capacity. When used as a partial replacement of natural coarse aggregate in concrete, tyre chips contribute to the production of lightweight concrete and promote sustainable waste management through the recycling of discarded tyres.

Figure: 3.5 Waste Tyre Chips

`

3.1.6 Water

Water is critical in the making of concrete. Adding water to the mix sets of a chemical reaction when it comes into contact with the cement. The water used in the mixing of concrete is usually of a potable standard. Using non-drinking water or water of unknown purity risks the quality and workability of the concrete.

Figure: 3.6 Water

3.2.1 Sieve Analysis of Sand

For particle size distribution for fine aggregate sieve analysis method ware uses according ASTM Cl36.

Apparatus

For sieve analysis following apparatuses ware used-

- Balance
- Sieves
- Oven
- Containers
- Brash.

`

Test Procedure

Clean the sieves of sieve shaker using cleaning brush if any particles are struck in the openings.

Record the weight of each sieve and receiving pan.

Dry the specimen in oven for 3-4 minutes to get the dried specimen (ignore,if   is already dried).

Weight the specimen and record its weight.

Arrange the sieves in order as the smaller openings sieve to the last and larger openings sieve to the top.(Simply, arrange them to the ascending order of sieve numbers–No.4 sieve on top and no.200 sieve at bottom)-Sieve number sand the particle size sareprovidedbelow in a chart for further understanding.

Keep the weight recorded specimen on the top sieve and then keep the complete sieves tack on the sieve shaker (Don’t forget to keep the lid and receiving pan).

Allow the shaker to work10-5minutes – usethe clock here.

Remove the sieve stack from the shaker and record the weight of each sieve and receiving pan separately.

Figure : 3.7 Sieve Analysis of Sand

`

The test sample of the aggregate (F.M) shall weigh after drying.

Table 3.1.2: Sieve Analysis of Sand

Sieve No.	Materials Retained (gm.)	Cumulative Materials Retained(gm.)	Cumulative% Retained	% of passing	FM
# 4	6	0.6	0.6%	99.4%	2.68
# 8	48	4.8	5.4%	94.6%	
# 16	214	21.4	26.8%	73.2%	
# 30	270	27	53.8%	46.2%	
# 50	310	31	84.8%	15.2%	
#100	123	12.3	97.1%	2.9%	
Pan	29	-	-		
Total	1000	Total	268.5		

3.2.2 Sieve Analysis of Tyre Powder

For particle size distribution for fine aggregate sieve analysis method ware uses according ASTM Cl36.

Apparatus

For sieve analysis following apparatuses ware used-

- Balance
- Sieves
- Oven
- Containers
- Brash

`

Test Procedure

Clean the sieves of sieve shaker using cleaning brush if any particles are struck in the openings.
Record the weight of each sieve and receiving pan.
Dry the specimen in oven for 3-4 minutes to get the dried specimen (ignore,if is already dried).
Weight the specimen and record its weight.
Arrange the sieves in order as the smaller openings sieve to the last and larger openings sieve to the top.(Simply, arrange them to the ascending order of sieve numbers–No.4 sieve on top and no.200 sieve at bottom)-Sieve number sand the particle size sareprovidedbelow in a chart for further understanding.
Keep the weight recorded specimen on the top sieve and then keep the complete sieves tack on the sieve shaker (Don't forget to keep the lid and receiving pan).
Allow the shaker to work10-5minutes – usethe clock here.
Remove the sieve stack from the shaker and record the weight of each sieve and receiving pan separately

Figure :3.8 Sieve Analysis of Tyre Powder

`

Table 3.1.3: Sieve Analysis of Tyre (Fine Aggregate)

Sieve No.	Materials Retained (gm.)	Cumulative Materials Retained(gm.)	Cumulative% Retained	% of passing	FM
# 4	2	0.2	0.2%	99.8%	1.732
# 8	86	8.6	8.8%	91.2%	
# 16	233	23.3	32.1%	67.9%	
# 30	71	7.1	39.2%	60.8%	
# 50	58	5.8	45%	55%	
#100	29	2.9	47.9%	52.1%	
Pan	21		-		
Total	500	Total	173.2		

3.2.3 Sieve Analysis of Stone

For particle size distribution for Course aggregate sieve analysis method ware uses according ASTM Cl36.

Apparatus

For sieve analysis following apparatuses ware used-

- Balance
- Sieves
- Oven
- Containers
- Brash

`

Test Procedure

Dry the sample in an oven (105–110°C) to remove moisture.

Weigh the sample accurately.

Stack standard sieves in descending order of size.

Place the aggregate sample on the top sieve and mechanically shake for 10–15 minutes.

Weigh the material retained on each sieve.

Calculate the percentage retained and cumulative percentage passing.

Figure :3.9 Sieve Analysis of Stone

`

Table 3.1.4: Sieve Analysis of Dubai LC

Sieve No.	Materials Retained (gm.)	Cumulative Materials Retained(gm.)	Cumulative % Retained	% of passing	FM
3/4’’	289	28.9	28.9	71.9%	7.26
3/8’’	683	68.3	97.2	2.8%	
#4	28	2.8	100	0%	
#8	0	0	100	0%	
#16	0	0	100	0%	
#30	0	0	100	0%	
#50	0	0	100	0%	
#100	0	0	100	0%	
Total	1000	Total	726.1		

3.2.4 Sieve Analysis of Tyre Chips

For particle size distribution for Course aggregate sieve analysis method ware uses according ASTM Cl36.

Apparatus
For sieve analysis following apparatuses ware used-

- Balance
- Sieves
- Oven
- Containers
- Brash

`

Test Procedure

Dry the sample in an oven (105–110°C) to remove moisture.

Weigh the sample accurately.

Stack standard sieves in descending order of size.

Place the aggregate sample on the top sieve and mechanically shake for 10–15 minutes.

Weigh the material retained on each sieve.

Calculate the percentage retained and cumulative percentage passing.

Figure :3.10 Sieve Analysis of Tyre Chips

Table 3.1.5: Data sheet for specific gravity of Tyre Course aggregate

Sieve No.	Materials Retained (gm.)	Cumulative Materials Retained(gm.)	Cumulative % Retained	% of passing	FM
3/4’’	210	21.0	21	79%	3.633
3/8’’	213	21.3	42.3	57.7%	
#4	77	7.7	50	50%	
#8	0	0	50	50%	
#16	0	0	50	50%	
#30	0	0	50	0%	
#50	0	0	50	0%	
#100	0	0	50	0%	
Total	500	Total	363.3		

3.3.1 Specific Gravity of Fine Aggregate

Table 3.1.6: Data sheet for specific gravity of fine aggregate

Wt. of pycno meter Filled with water to Calibration, B gm	Oven Dry Wt. in air A gm	Wt. of pycno meter with Specimen and water to Calibration mark, C gm	Wt. of S.S.D. sample in Air, S gm
658 gm	288 gm	839 gm	300 gm

Table 3.1.7: Specific gravity of fine aggregate

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{B+A-C}$	$\frac{288}{658+288-839}$	2.691
Bulk SG (Oven Dry Basic)	$\frac{A}{B+S-C}$	$\frac{288}{658+300-839}$	2.420
Absorption Capacity, D%	$\frac{(S-A)*100}{B}$	$\frac{(300-288)*100}{658}$	1.823
Bulk SG (S.S.D. Basic),G	$\frac{S}{B+S-C}$	$\frac{300}{658+300-839}$	2.521

The apparent specific gravity of the local sand as fine aggregate after oven drying was found 2.691.We found the bulk specific gravity for oven dry basic was 2.420. Apparent capacity redaction received 1.823. And bulk SSD received 2.521.

3.3.2 Specific Gravity of Coarse Aggregate

Table 3.1.8: Data sheet for specific gravity of coarse aggregate (Dubai LC)

Wt. of S.S.D sample in air, B (gm)	Wt. of S.S.D. sample in water, C (gm)	Oven dry Wt. of sample in air, A (gm)
1550 gm	980gm	1535 gm

Table 3.1.9: Specific gravity of coarse aggregate (Dubai LC)

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{A-C}$	$\frac{1535}{1535-980}$	2.76
Bulk Specific Gravity (Oven Dry Basic)	$\frac{B}{B-C}$	$\frac{1550}{1550-980}$	2.71
Bulk Specific Gravity (S.S.D. Basic), G	$\frac{A}{B-C}$	$\frac{1535}{1550-980}$	2.69
Absorption Capacity, D %	$\frac{(B-A)*100}{A}$	$\frac{(1550-1535)*100}{1535}$	0.97

3.3.3 Concrete Mix Properties

Mixture proportion of concrete was determined in accordance with following condition: -

Water/Cement Ratio0.46
Maximum grain size (20mm)
Type and quantity of fine aggregate
Variable type and same quantity of coarse aggregate
Mixing Ratio 1:1.5:3.

3.3.4 Concrete Molding Procedure

Material Preparation

Ordinary Portland Cement, natural fine aggregate, coarse aggregate, tyre powder (as partial replacement of fine aggregate) and tire chips (as partial replacement of coarse aggregate) were collected. All materials were cleaned, dried, and weighed according to the mix design.

Mixing of Concrete
Cement, natural aggregates, tire powder, and tire chips were first dry-mixed in a concrete mixer until a uniform blend was achieved. Water was then added gradually and mixing was continued to obtain a homogeneous and workable concrete mix.

Preparation of Molds
Standard steel molds (cube, cylinder, and prism) were cleaned and oiled properly to prevent adhesion of concrete during remolding.

Casting of Specimens
Fresh concrete was poured into the molds in layers. Each layer was compacted using a tamping rod or vibration table to eliminate air voids and ensure proper compaction.

Surface Finishing
The top surface of the specimens was leveled and finished using a trowel to obtain a smooth and even surface.

Initial Setting
The molds were covered with plastic sheets and kept undisturbed at room temperature for 24 hours to allow initial setting.

Remolding
After 24 hours, the specimens were carefully removed from the molds without causing any damage.

Curing
The remolded specimens were submerged in clean water and cured for 7, 14, and 28 days before testing.

Figure: 3.11 Concrete Mixing And Molding

Figure: 3.12 Mold of Cylinder

3.3.5 Curing Process of Cylinders

After 24 hours of casting, the concrete specimens were removed from the mold and allowed for curing.

Figure: 3.13 Curing Process

3.3.6 Compressive Strength Test of Cylinders

We can use the Universal Testing Machine (UTM) for compressive strength tests of RCC cylinders. There are some images of compressive strength test.

Figure: 3.14 Universal Testing Machine (UTM)

CHAPTER-4

RESULTS AND DISCUSSION

4.1 Result Analysis of Lab Test

This result can be used to determine the correlation of compressive strength of concrete cylinder and the recommended curing period respectively. The result as the strength increases with the decreases of curing time interval.

Tyre fine Aggregate

Table 4.1.1: 7 Days Cylinder Test Results

Types of Tyre	Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (gm)	Crushing Value(KN)	Compressive Strength (MPa or N/mm^2)	Average Compressive Strength (MPa)
5%	102.84	205	3940	75	9.02	9.72
	102.42	206	3949	82	9.95	
	103.04	206	3988	85	10.19	
10%	102.39	206	3999	86	10.44	10.88
	102.26	206	3976	97	11.81	
	101.92	205	8379	85	10.41	
15%	103.13	206	3870	68	8.14	7.90
	101.91	204	3717	65	7.96	
	101.8	205	3745	62	7.61	
20%	102.32	206	3851	70	8.51	8.77
	102.36	205	3870	72	8.74	
	102.62	207	3867	75	9.06	
Normal	102.41	206	4048	92	11.16	10.60
	100.69	206	3874	75	9.41	
	102.06	205	3943	92	11.24	

Tyre Course Aggregate

Table 4.1.2: 7 Days Cylinder Test Results

Types of Tyre	Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (gm)	Crushing Value(KN)	Compressive Strength (MPa or N/mm^2)	Average Compressive Strength (MPa)
5%	101.7	206	3993	82	10.09	10.01
	101.6	206	3962	80	9.86	
	100.5	207	3824	80	10.08	
10%	102.5	205	3866	76	9.21	10.15
	102.7	206	4045	90	10.86	
	102.1	206	3900	85	10.38	
15%	102.8	207	3898	75	9.03	8.22
	102.8	206	3945	62	7.46	
	101.4	207	3822	66	8.17	
20%	102.2	206	3905	75	9.14	7.98
	102.3	207	3888	68	8.27	
	103.4	207	3878	55	6.54	

Tyre Mix Aggregate

Table 4.1.3: 7 Days Cylinder Test Results

Types of Tyre	Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (gm)	Crushing Value(KN)	Compressive Strength (MPa or N/mm^2)	Average Compressive Strength(MPa)
5%	103.6	206	4014	102	12.10	11.42
	102.3	206	3907	102	12.40	
	103.4	205	3890	82	9.76	
10%	102.18	205	3917	70	8.53	6.98
	101.8	204	3707	50	6.14	
	103.5	206	3964	53	6.29	
15%	102.8	205	3792	60	7.22	6.16
	103.1	205	3783	42	5.03	
	103.1	206	3815	52	6.23	
20%	103.5	206	3680	51	6.06	5.92
	102.7	203	3513	45	5.43	
	102.7	204	3647	52	6.27	

Table 4.1.4: 14, 21 & 28 Days Cylinder Test Results

Types of Tyre		Parentage	14 Days	21 Days	28 Days
Tyre Fine Aggregate	Average Compressive Strength (MPa)	5%	12.17	12.87	13.99
		10%	13.18	14.25	15.33
		15%	10.42	11.16	12.26
		20%	10.01	10.80	11.64
Tyre Course Aggregate		5%	12.72	13.78	14.97
		10%	11.36	12.70	13.36
		15%	8.44	9.03	9.71
		20%	10.74	11.35	12.21
Tyre Mix Aggregate		5%	15.03	16.33	17.47
		10%	8.99	9.50	10.21
		15%	8.53	9.31	9.81
		20%	6.97	7.70	8.11
Normal		–	13.91	14.23	15.80

`

Table 4.1.5 : Cylinder Test Results (Tyre Course Aggregate)

	Normal	5%	10%	15%	20%
7 Days(MPa)	10.61	10.01	10.15	8.22	7.98
14 Days(MPa)	13.91	12.72	11.36	8.44	10.74
21 Days(MPa)	14.22	13.77	12.7	9.03	11.35
28 Days(MPa)	15.8	14.97	13.36	9.71	12.21

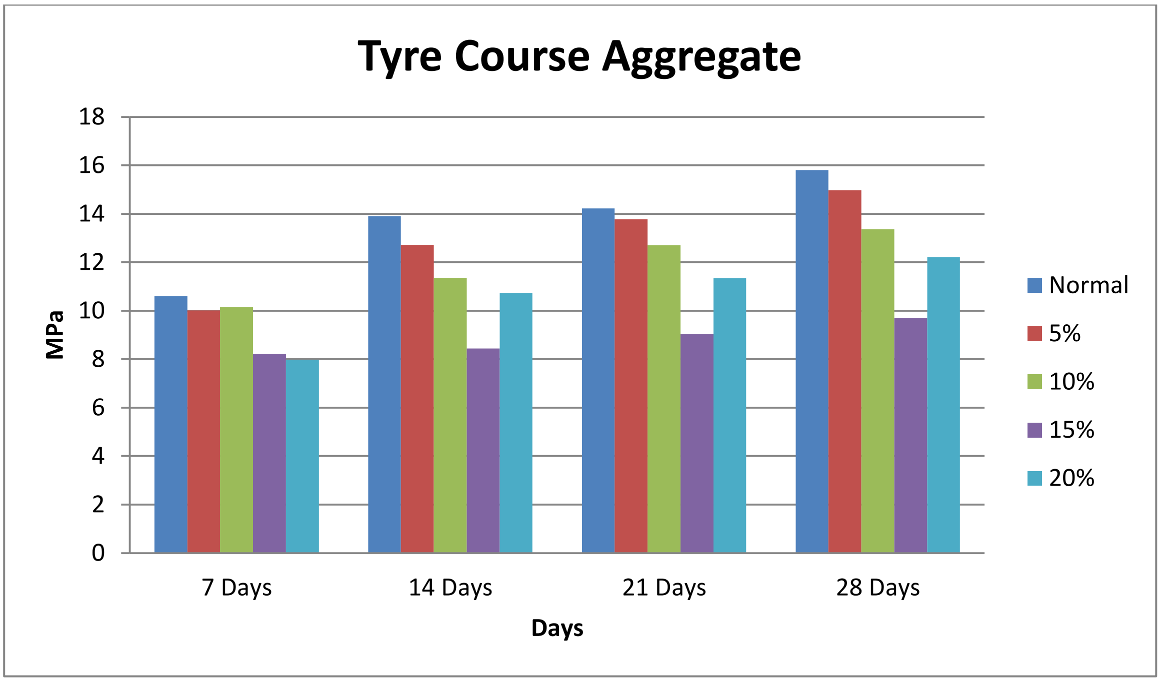

Figure 4.1: Compare Compressive Strength with Normal Concerte, Tyre Course Aggregate 5%,10%,15%,20%.

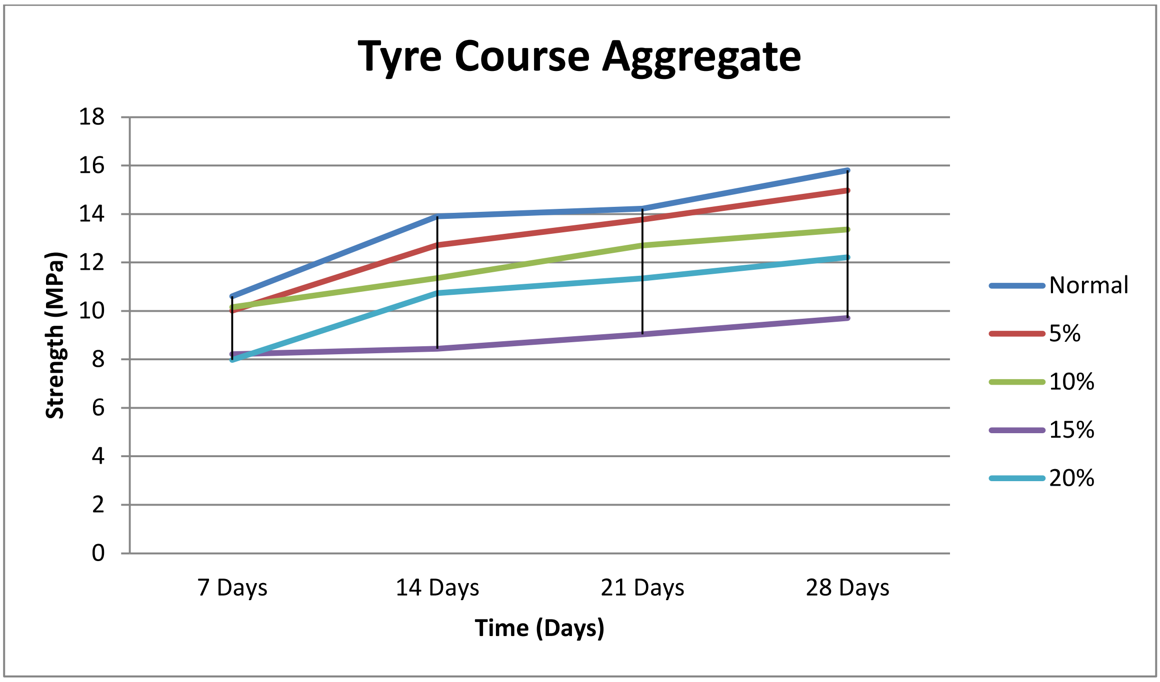

Figure 4.2: Compare Compressive Strength with Normal Concerte, Tyre Course Aggregate 5%,10%,15%,20%

Table 4.1.6 : Cylinder Test Results (Tyre Fine Aggregate)

	Normal	5%	10%	15%	20%
7 Days(MPa)	10.61	9.72	10.89	7.9	8.77
14 Days(MPa)	13.91	12.17	13.18	10.42	10.01
21 Days(MPa)	14.22	12.87	14.25	11.16	10.8
28 Days(MPa)	15.8	13.99	15.33	12.26	11.68

`

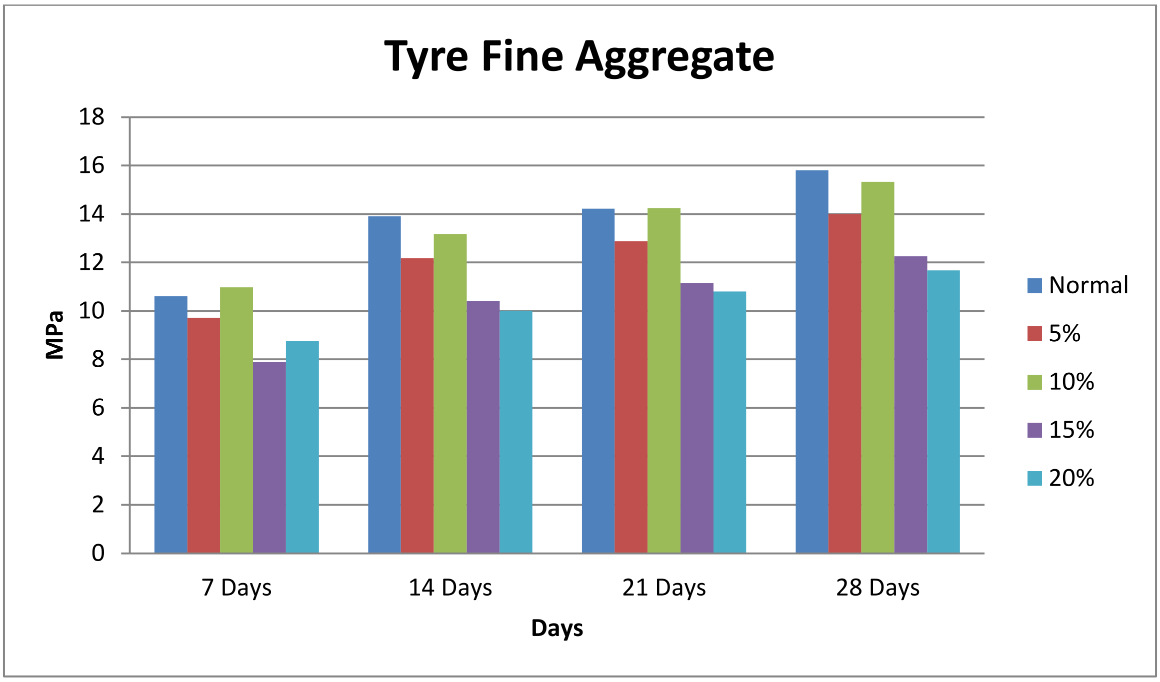

Figure 4.3: Compare Compressive Strength with Normal Concerte, Tyre Fine Aggregate 5%,10%,15%,20%

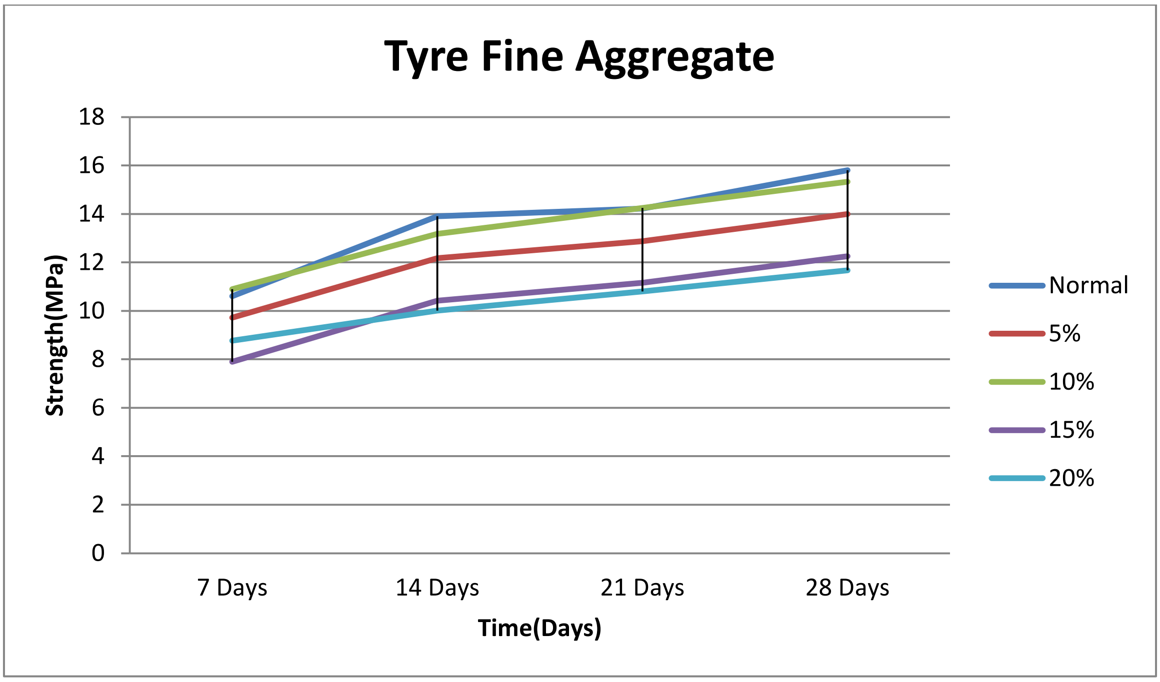

Figure 4.4: Compare Compressive Strength with Normal Concerte, Tyre Fine Aggregate 5%,10%,15%,20%

`

Table 4.1.7 : Cylinder Test Results (Tyre Mix Aggregate)

	Normal	5%	10%	15%	20%
7 Days(MPa)	10.61	11.42	6.99	6.16	5.92
14 Days(MPa)	13.91	15.03	8.99	8.53	6.97
21 Days(MPa)	14.22	16.43	9.5	9.31	7.7
28 Days(MPa)	15.8	17.4	10.21	9.81	8.11

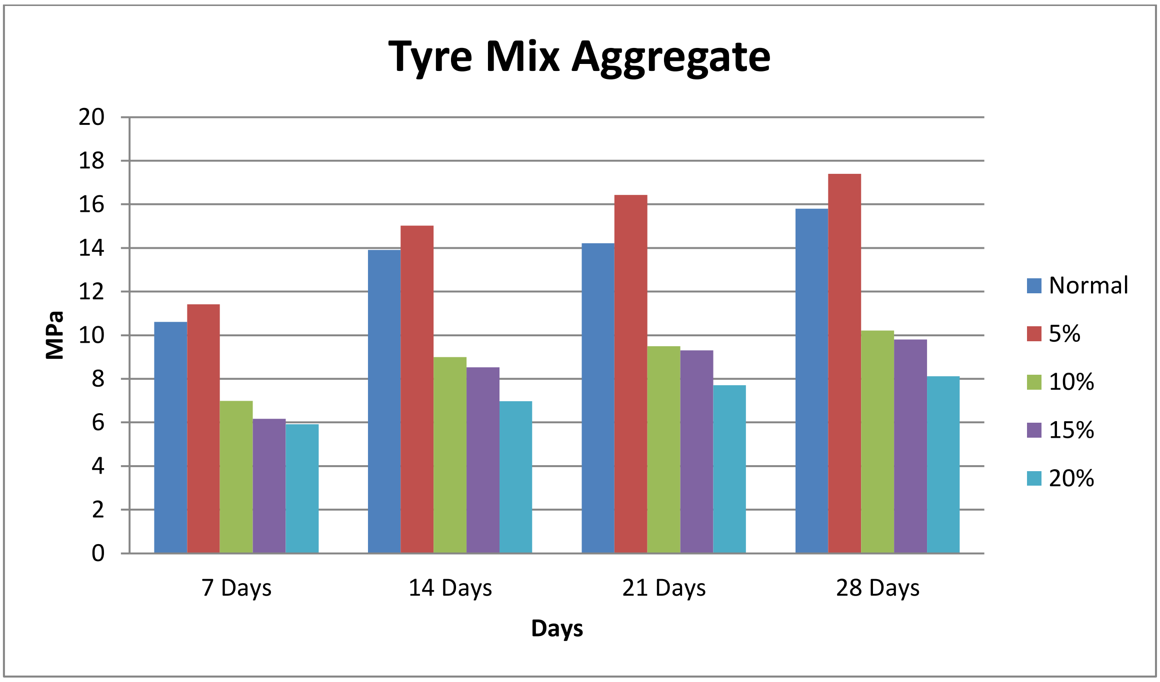

Figure 4.5: Compare Compressive Strength with Normal Concerte, Tyre Mix Aggregate 5%,10%,15%,20%

`

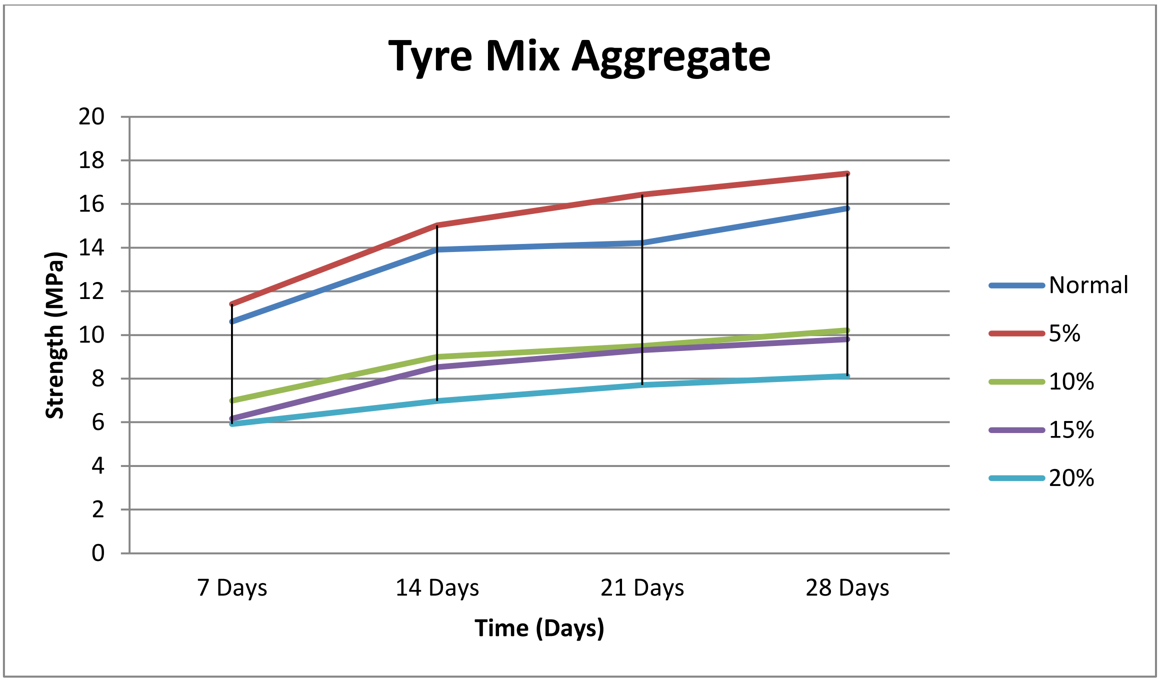

Figure 4.6: Compare Compressive Strength with Normal Concerte, Tyre Mix Aggregate 5%,10%,15%,20%

4.2 Results and Discussion

The compressive strength of rubberized concrete increased with curing age for all mixes. However, compared to normal concrete, a gradual reduction in strength was observed with increasing tyre aggregate content. This reduction is mainly due to the low stiffness of rubber particles and weak bonding between tyre aggregates and cement paste. Among all mixes, lower replacement levels showed acceptable performance, indicating the feasibility of waste tyre utilization in concrete.

Tyre Chips (Coarse Aggregate): Concrete with tyre chips showed a reduction in compressive strength as the replacement level increased. At 5% replacement, the 28-day strength was close to that of normal concrete, while higher percentages (10–20%) caused noticeable strength loss. The elastic nature and smooth surface of tyre chips reduced load transfer efficiency, resulting in lower compressive strength.

Tyre Powder (Fine Aggregate): Tyre powder exhibited better performance than tyre chips at lower replacement levels. The 10% tyre powder mix achieved compressive strength values close to normal concrete at 28 days. However, at replacement levels above 10%, strength decreased due to increased void content and poor paste–rubber bonding.

Tyre Mix Aggregate: Tyre mix aggregate showed satisfactory strength at 5% replacement, with 28-day strength comparable to or slightly higher than normal concrete. However, a sharp reduction in compressive strength was observed at higher replacement levels (15–20%), making these mixes unsuitable for structural applications.

Overall Observation: The optimum tyre replacement level was found to be 5–10%. Tyre powder performed better than tyre chips, while tyre mix aggregate was effective only at low replacement levels. Rubberized concrete can be considered a sustainable alternative for non-structural and low-load application.

`

Chapter-5

Conclusion and Recommendations

5.1 Conclusion

This study investigated the strength and durability performance of rubberized concrete incorporating tire powder and tire chips as partial aggregate replacements. The experimental results showed that the compressive, split tensile, and flexural strengths decreased with increasing rubber content compared to conventional concrete. However, at lower replacement levels, the reduction in strength remained within acceptable limits for practical use. Concrete containing tire powder exhibited relatively higher strength compared to concrete incorporating tire chips. In contrast, tire chip–based concrete demonstrated improved ductility and energy absorption capacity.Durability assessments indicated that rubberized concrete showed satisfactory resistance to water absorption and degradation. The presence of rubber particles contributed to improved crack resistance and enhanced toughness of the concrete. Higher rubber replacement levels led to a significant decline in both strength and durability properties. Based on the overall performance, a rubber replacement level of 5%–10% was identified as optimal for practical applications. Overall, the use of tire powder and tire chips in concrete offers a sustainable solution for waste tire management while producing environmentally friendly construction materials.

5.2 Limitations

- Conducted under laboratory conditions, which may not fully represent field behavior.
- Only selected replacement levels of tire powder and tire chips were tested.
- Long-term performance beyond the tested curing periods was not evaluated.
- Certain durability aspects, such as fire and chemical resistance, were not assessed.
- Economic feasibility and large-scale applicability were not analyzed.

5.3 Recommendations

- Investigate field performance of rubberized concrete.

- Explore higher and varied replacement ratios of tire powder and tire chips.
- Assess long-term durability, including creep, shrinkage, and fatigue.
- Conduct additional durability tests, such as fire, chemical, and freeze–thaw resistance.
- Perform comprehensive cost and environmental impact analyses for practical applications.

REFERENCES

1. ACI Committee 318. Building Code Requirements for Structural Concrete (ACI 318-19). American Concrete Institute, Farmington Hills, MI, USA, 2019.

2. ACI Committee 211. Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete (ACI 211.1-91). American Concrete Institute, USA, 2002.

3. ASTM C39/C39M-21. Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens. ASTM International, West Conshohocken, PA, USA, 2021.

4. ASTM C496/C496M-17. Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens. ASTM International, USA, 2017.

5. ASTM C642-21. Standard Test Method for Density, Absorption, and Voids in Hardened Concrete. ASTM International, USA, 2021.

6. BS EN 12390-3:2019. Testing Hardened Concrete – Compressive Strength of Test Specimens. British Standards Institution, London, UK.

7. BS EN 206:2013+A2:2021. Concrete – Specification, Performance, Production and

Conformity. British Standards Institution, UK.

8. Neville, A. M. Properties of Concrete. 5th Edition, Pearson Education Limited, London, 2012.

9. Mehta, P. K., & Monteiro, P. J. M. Concrete: Microstructure, Properties, and Materials. 4th Edition, McGraw-Hill Education, USA, 2014.

10. Siddique, R., & Naik, T. R. “Properties of Concrete Containing Scrap-Tire Rubber – An Overview.” Waste Management, Vol. 24, No. 6, pp. 563–569, 2004.

11. Thomas, B. S., & Gupta, R. C. “Mechanical Properties and Durability Characteristics of Concrete Containing Recycled Rubber Tire Aggregates.” Construction and Building Materials, Vol. 73, pp. 562–573, 2014.

12. Ganjian, E., Khorami, M., & Maghsoudi, A. A. “Scrap-Tire Rubber Replacement for Aggregate and Filler in Concrete.” Construction and Building Materials, Vol. 23, pp. 1828–1836, 2009.

13. Topçu, İ. B. “The Properties of Rubberized Concretes.” Cement and Concrete Research, Vol. 25, No. 2, pp. 304–310, 1995.

14. Li, G., Garrick, G., Eggers, J., Abadie, C., & Stubblefield, M. A. “Waste Tire Fiber Modified Concrete.” Composites Part B: Engineering, Vol. 35, pp. 305–312, 2004.

15. IS 456:2000. Plain and Reinforced Concrete – Code of Practice. Bureau of Indian Standards, New Delhi, India.