

DEVELOPING LIGHT WEIGHT CONCRETE FOR MARINE FLOATING SOLAR PANELS

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in
Civil Engineering

by

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**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A++" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

APRIL-2024



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of R.SURYA KRISHNAN (Register No.: 40200702), V.YESHVANTH (Register No. 40200711) who carried out the project entitled "Developing Light Weight Concrete for Marine Floating Solar Panels" under our supervision from November 2023 to April 2024.

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ABSTRACT

Fossil fuel consumption has progressively increased alongside global population growth, representing the predominant energy consumption pattern for humanity. Unfortunately, this persistent reliance on fossil fuels has resulted in a substantial surge in pollution emissions, exerting a detrimental influence on the delicate ecological balance. Therefore, it is imperative to find new renewable energy sources to replace fossil fuels. Solar energy is a clean energy source and has become the most preferred option for human day-to-day needs. Since the construction of the world's first floating photovoltaic power station, humanity has been continuously advancing the technology of power generation by floating photovoltaics. This review comprehensively elucidates the progression of offshore photovoltaic technology and illustrates the composition of the floating photovoltaic system. Each section meticulously contrasts the advantages and drawbacks of various photovoltaic systems. To place the solar panel in the river or sea shore area leads usage of more area and also reduces the transpiration of water. So developing a light weight concrete using the waste material i.e. waste tyre which allows the concrete to float and placing the photovoltaic system over allows to develop new generation of electricity. By using rubber the concrete is optimized to place the solar panels over it.

TABLE OF CONTENTS

CHAPTER No.	TITLE	PAGE No.
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	TABLE OF CONTENTS	vi
	LIST OF TABLES	viii
	LIST OF FIGURES	ix
1.	INTRODUCTION	1
	1.1 GENERAL	1
	1.2 USES of TYRE RUBBER	2
2.	LITERATURE SURVEY	6
	2.1 GENERAL	6
	2.2 REVIEW OF THE LITERATURE	6
	2.3 INFERENCE FROM THE LITERATURES	9
	2.4 OBJECTIVE OF THE STUDY	10
3.	MECHANICAL PROPERTIES OF RUBBER AGGREGATE CONCRETE	11
	3.1 METHODOLOGY	11
	3.2 SELECTION OF MATERIALS	12
	3.3 MECHANICAL PROPERTIES	12
	3.4 MATERIALS	13
	3.4.1 Cement	13
	3.4.2 Fine Aggregate	13
	3.4.3 Coarse Aggregate	14
	3.4.4 Rubber Aggregate	14
	3.4.5 Chemical Solution	15
	3.4.6 Water	16
	3.5 MIX PROPORTION	16
	3.6 SPECIMEN CASTING	16
	3.7 CHARACTERISTICS OF MIXED CONCRETE	17
	3.8 Characteristics of Cured Concrete	18

	3.9 Workability	19
4.	RESULTS AND DISCUSSION	20
	4.1 GENERAL	20
	4.2 DISCUSSION OF EXPERIMENTAL RESULTS	20
	4.2.1 Influence on Compressive Strength	20
	4.2.2 Influence on Split Tensile Strength	22
	4.2.3 Influence on Flexural Strength	23
5.	CONCLUSION	25
	5.1 GENERAL	25
	5.2 FINDINGS	26
	5.3 FUTURE SCOPE OF STUDY	26
	REFERENCES	27

LIST OF TABLES

TABLE No.	TITLE	PAGE No.
3.1	Physical properties of cement	13
3.2	Properties of M-Sand	14
3.3	Properties of coarse aggregate	14
3.4	Properties of rubber	15
3.5	Mix proportion for the concrete specimen	16
3.6	Result of workability test	19
4.1	Compressive strength at different percentage of rubber at 7, 14 and 28 days	21
4.2	Split tensile strength at different percentage of rubber at 7 and 28 days	22
4.3	Flexural strength at different percentage of rubber at 7 and 28 days	24

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
3.1	Methodology flow chart	11
3.2	Tyre rubber	15
4.1	Compressive strength at different percentage of rubber at 7, 14 and 28 days	21
4.2	Compressive strength testing	21
4.3	Split tensile strength at different percentage of rubber at 7 and 28 days	22
4.4	Split tensile strength testing	23
4.5	Flexural strength at different percentage of rubber at 7 and 28 days	24
4.6	Flexural strength testing	24

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Our country is experiencing rapid growth and development, particularly in infrastructure projects such as dams, educational facilities, roads, and bridges, which require significant amounts of construction materials. To address the depletion of natural resources and reduce construction costs, there is a growing focus on using recycled materials. However, it's crucial to ensure that these recycled or salvaged materials do not pose environmental threats, necessitating careful selection. In recent years, there has been increasing interest in improving concrete not just in terms of strength but also in other aspects. One such attempt is the development of rubberized concrete, aimed at creating an environmentally friendly alternative that mitigates pollution from tire dumping and burning for disposal as dumping in the land. Numerous research efforts have explored the characteristics of rubberized concrete and its potential applications in civil engineering.

The disposal of polymeric waste, specifically rubber from tyre, is a significant environmental issue that is becoming increasingly important. Recycling is a crucial method for reducing trash, however the recycling of waste tyre poses specific challenges due to their high production rates and inability to naturally decompose. An effective method for decreasing the amount of waste tyre in the environment involves incorporating them into concrete, which is the most often used construction material, as a substitute for some of the coarse aggregate. Rubber aggregates are derived from discarded tyre by two distinct methods: mechanical grinding at room temperature or cryogenic grinding at a temperature lower than the glass transition temperature. The initial approach produces fragmented rubber as a substitute for large-sized aggregates. The second approach often generates crumb rubber as a substitute for fine aggregates (Kotresh and Belachew, 2014). The utilization of rubberized concrete has significant potential, especially in areas such as landscaping, sports fields, playgrounds,

architectural finishing, and many engineering applications. Rubberized concrete blends can also be appropriate for nonstructural applications, such as lightweight concrete walls, building facades, and architectural components.

Extensive study has been conducted for several years on the utilization of scrap tyre as a substitute for a portion of the fine and coarse material in concrete. Prior studies have demonstrated significant alterations in the mechanical characteristics of concrete when tyre rubber is incorporated into the mixture, mostly due to the limited bonding between the rubber particles and the cement paste. Several researchers have discovered that the compressive strength, flexural strength, and unit weight all reduced as the proportion of rubber aggregate rose. The compressive and tensile strength of rubberized concrete is influenced by the dimensions, configuration, and surface characteristics of the aggregate, as well as the quantity utilized. Nevertheless, many researchers have documented that concrete incorporating discarded tyre rubber chips as aggregates exhibits an elevated ability to absorb energy, commonly known as toughness.

While rubberized concrete has been utilized in road pavements for some time, there is ongoing research to uncover its additional properties and uses. This includes using recycled tyre rubber as a replacement for natural aggregates, particularly in fine aggregate where pre-treated rubber can be partially substituted.

The consumption of fossil fuels has steadily risen in tandem with the growth of the world population, making it the primary energy consumption pattern for humanity. Regrettably, the continuous dependence on fossil fuels has led to a significant increase in pollutant emissions, which has had a harmful impact on the fragile ecological equilibrium. Hence, it is crucial to discover alternative renewable energy sources as substitutes for fossil fuels. Solar energy is an environmentally friendly energy source and has become the most favoured choice for meeting human daily requirements. Ever since the inception of the world's initial floating photovoltaic power station, mankind has been consistently progressing the technology of power generation through floating photovoltaics. Here is a comprehensive review of the potential issues that may arise with deep-sea floating photovoltaic systems in concrete.

The remnants of the tyre, known as crumb rubber and ground rubber, are utilized in civil engineering applications. The tyre has been reduced to a size ranging from 2.5 to 30 cm in length, resulting in their being shredded. Primarily utilized for embankment fills and retaining walls, it has predominantly been employed as road drainage layers and in septic tanks leach fields. These materials possess numerous favourable qualities, such as being lightweight, having high compressibility, high permeability, excellent thermal insulation, great durability, and low material density. Crumb rubber is commonly employed as a substitute for aggregates in Portland cement concrete (PCC) and asphalt concrete, as documented by Esch (1984), Adams et al. (1985), Estakhri (1990), and Khosla & Trogon (1990).

Ghaly and Cahill (2005) examined the impact of varying rubber percentages in concrete (5, 10, and 15%) and saw a decrease in compressive strength as the rubber content grew. Valadares et al. (2012) examined the effectiveness of concretes containing the same amount of rubber waste as a replacement for volume, and confirmed that this led to a reduction in compressive strength. A rubber waste volume of 15% results in a reduction of compressive strength by 50%. According to these authors, rubber waste that has smaller dimensions results in less loss of strength. Additionally, they found that the compressive strength is not affected by the rubber modification methods, such as mechanical grinding or cryogenic treatment. In their study, Freitas et al. (2009) reported a significant reduction of 48.30% in the compressive strength of concrete when the waste rubber volume reached 15%. Ganjian et al. (2009) also verified the decline in compressive strength as the rubber component increased. Nevertheless, the authors observed a marginal enhancement in the compressive strength when 5% of chipped rubber was substituted for the coarse aggregates, likely attributed to an improved grading of the mixture. This discovery had already captured the interest of several authors. In their study, Snelson et al. (2009) utilized concrete mixtures including shredded tyre chips (15-20 mm) as a substitute for aggregate at different proportions (2.5, 5, and 10%). They observed a decrease in compressive strength as a result.

Guneyisi et al. (2010) conducted an analysis on the tensile strength of concretes that included silica fume, crumb rubber, and tyre chips. The results once again verified that the decline in tensile strength reduction is less affected by the rubber content compared to the compressive strength. Pierce and Williams (2004) also noted this trend. This outcome is likely attributed to the presence of rubber particles, which hinder the emergence of cracks. Valadares (2009) found that concretes containing larger rubber waste particles had a better tensile strength, which supports prior research. Nevertheless, Ganjian et al. (2009) found that the tensile strength of concrete using chipped rubber as aggregates was significantly inferior to concrete that contained powdered rubber. This behaviour may be attributed to the extremely low adhesion between the fragmented rubber and the cement paste. One possible explanation for this is that the chipped rubber used in the laboratory was prepared using scissors, which is a different approach compared to the grinding process used to shred rubber waste particles. This difference in preparation methods may result in a rougher surface for the rubber waste particles.

According to Aiello & Leuzzi (2010), the utilization of tyre shreds as a substitute for fine aggregates results in a significant increase in tensile (flexural) strength. Substituting either 50 or 75% of the fine aggregates results in a decrease in strength of just 5.8% and 7.30%, respectively. However, if the same percentages were utilized to substitute coarse aggregates, there would be a decrease in strength of 28.2%.

1.2 USES OF TYRE RUBBER

- ❖ Used as a foundation pad for rotating machinery and railway stations to dampen vibrations
- ❖ Utilized for filling trenches, laying pipes on the pile heads, and paving slabs.
- ❖ Enhanced resilience against impact and explosions on railway systems, making it suitable for usage as barriers and bunkers.
- ❖ Appropriate for architectural purposes such as: affixing concrete with nails, creating deceptive facades, providing support for stone structures, and constructing interiors.

- ❖ The playground's surface material
- ❖ A substitute for gravel
- ❖ The drainage system surrounding building foundations and the building foundation itself
- ❖ Insulation is used to prevent the transfer of heat or sound between different areas.
- ❖ It helps to maintain a consistent temperature and reduce energy consumption.
- ❖ Rainwater runoff barriers are structures or materials that are used to restrict the flow of rainwater and prevent erosion of the soil.
- ❖ March/Wetland creation
- ❖ Race courses enclosed by crash barriers
- ❖ Marine vessels use boat bumpers to protect against collisions at marinas.
- ❖ Additionally, artificial reefs are created to enhance marine ecosystems.

CHAPTER 2

LITERATURE SURVEY

2.1 GENERAL

The following major research project has been taken from international journals as reference to analyze the concepts for the project.

2.2 REVIEW OF THE LITERATURE

When the subgrade soils thaw in the spring, they release excess water. To keep the subgrade soils from freezing under the road cab, a layer of tyre shreds that is 15 to 30 cm thick is used. In addition, the high permeability of tyre shreds prevents damage to road surfaces by allowing water to drain beneath the roads (**ASTM D 6270-98**).

Tyre shreds can be utilised to build embankments on unstable, compressible foundation soils. The use of tyre shreds in this application is feasible due to their low weight. Using tyre shreds as a lightweight fill material is a much more cost-effective option for most projects. Tyre shreds can serve as fill material for walls and bridge abutments. (**TMA, 2003**).

The weight of the tyre shreds decreases the horizontal forces exerted on the walls, enabling the building of smaller and more cost-effective structures. Additionally, it can mitigate issues related to water and frost accumulation by offering efficient drainage and serving as a highly effective thermal insulator when used as tyre shreds behind walls. Recent research has shown the advantages of utilizing tyre shreds as backfill material for walls and bridge abutments. (**TMA, 2003**).

The utilization of tyre shreds in landfill construction and operation is experiencing a rising demand in the industry. Scrap tyre shreds can be used as a substitute for other construction materials, although they would need to be bought. The gas venting system

utilizes used tyre as a low-density material for filling. Scrap tyre are also used in leachate collection systems and operating liners. Additionally, it can also be employed in the process of landfill capping and closures. Ultimately, it serves as a substance for a daily protective covering. **(TMA, 2003).**

Pierce & Blackwell (2003) suggested the utilization of crumb rubber in flowable fill. During their investigation, sand was substituted with crumb rubber to create a pourable abundance. The experimental findings shown that crumb rubber, with a density of 1.2 - 1.6 g/cm³, may effectively function as flowable fill material. It is capable of being excavated while maintaining 28-day compressive strengths within the range of 0.02 to 0.09 MPa. The research findings indicated that a flowable fill made from crumb rubber may be effectively utilized in many construction applications, such as trench fills, bridge abutment fills, and foundation fills.

Sherwood (2005) investigated the construction of a test embankment utilizing a mixture of sand and shredded tyre as the fill material. The utilization of tyre shreds in building applications, particularly for highway embankments, is proving to be advantageous in the recycling of discarded tyre.

Abdulla et al. (2010) examined the impact of treating rubber with several alkaline solutions, including NaOH, NaOCL, and commercial detergent powder. They used the treated rubber as a substitute for fine aggregate, replacing 15 to 30% of the sand in cement mortar. The test results demonstrated that the application of NaOCL to crumb rubber led to a greater increase in modulus of rupture, compressive strength, and modulus of elasticity compared to the use of NaOH. The use of commercial detergent powder has negative effects on cement mortar, but the use of NaOL (sodium oleate) provides more improvement compared to NaOH (sodium hydroxide).

Aziz Ibrahim Abdulla and Salwa Hadi Ahmed (2011) examined the impact of rubber that had been treated with an acidic solution. The tests involved treating rubber with several acidic solutions, including hydrochloric acid, sulphuric acid, and acetic acid. The compressive strength, modulus of rupture, modulus of elasticity, ultrasonic pulse velocity, and hammer test were examined for all mixtures and compared to both ordinary cement mortar and standard rubberized materials. The results indicate that

treating rubber with an acidic solution greatly enhances the characteristics of rubberized cement mortar. The application of CH_3COOH and H_2SO_4 to crumb rubber greatly enhances both the static and dynamic modulus of elasticity. Additionally, it mitigates the negative impact on all cement mortar properties caused by the treatment of rubber with HCl .

Rana Hashim Ghedan and Dina Mukheef Hamz (2011) conducted a study to examine the impact of rubber treatment on the compressive strength and thermal conductivity of modified rubberized concrete. The rubberized concrete was enhanced by incorporating a coupling agent, such as silane, into the rubber, which serves as a substitute for fine aggregate in concrete instead of gravel. The test findings indicated that the addition of silane significantly enhanced the heat conductivity of the modified rubberized concrete, resulting in a 17.80% increase compared to traditional concrete. Furthermore, the compressive strength of the modified rubberized concrete improved by roughly 42.34% compared to untreated rubberized concrete.

Piti Sukontasukkul and Koshi Tiamlom (2012) conducted studies to investigate the absorption, compression, expansion, and shrinkage properties. The tests were carried out using crumb rubber that passed through sieve No. 6 and 26. Crumb rubber of a larger size exhibits more absorption compared to crumb rubber of a smaller size. Both types of crumb rubber result in a decrease in compressive strength when it comes to strength. Both rubberized concretes demonstrate a reduced compressive strength compared to ordinary concrete. The utilisation of finely ground crumb rubber enables the concrete to achieve a reduced density, as well as decreased absorption and expansion.

Al-Tayeb et al. (2013) examined the flexural behaviour of high-strength reinforced concrete (HRC) beams. An increase in impact bending force was found when the fraction of sand replaced by crumb rubber gradually increased. The results indicate that the flexural impact performance of the beam improves when HRC beams are used during dynamic loading. The hardness and deformability of regular concrete were enhanced by including rubber.

Camille Issa and George Salem (2013) examined the potential of crumb rubber as a viable alternative to fine aggregates in concrete. They tested various mixtures with crumb rubber replacing crushed sand at different percentages, ranging from 0 to 100%. The conductivity test was conducted to assess the potential of rubber, known for its exceptional insulating properties, to contribute effectively to electrical and acoustic insulation when incorporated as tyre crumbs in Portland cement concrete. It was shown that using crushed sand with rubber components below 25% resulted in good compressive strength. A decrease in density of up to 8% was seen when 25% of crushed sand was replaced with rubber. The insulation qualities have been enhanced, as demonstrated by the conductivity test. Highway barriers or other comparable shock-absorbing components that benefit from the increased flexibility of reinforced concrete.

The tyre can also serve as a non-load bearing component in applications such as building facades, lightweight concrete walls or other architectural elements (Mohammed Mudabheer Ahmed Siddiqui 2016). Hybrid rubber concrete is suitable for places that see frequent freezing and thawing, unlike ordinary concrete.

2.3 INFERENCE FROM THE LITERATURES

Prior research has demonstrated that the compressive strength of concrete decreases when crumb rubber aggregate is incorporated as a substitute (either partially or completely) for fine aggregates. The mechanical strength is influenced by the size, proportion, and surface roughness of the rubber aggregate, as well as the type of cement. The decrease in strength can be attributed to the fact that rubber aggregate is significantly less rigid than the surrounding cement paste. Furthermore, the soft rubber aggregate serves as an empty space within the concrete mixture due to the limited connection between the rubber aggregate and cement paste. Additionally, it is observed that the density, dimensions, and rigidity of the particles have an impact on the strength of concrete. The use of rubber aggregate in concrete reduces its workability, hence impacting the process of preparing concrete samples and products.

The literature analysis above suggests that the amount of rubber aggregate in the concrete should be limited in order to avoid a substantial decrease in mechanical qualities. Moreover, no research has been found that specifically analyses the impact strength, deflection, and flexural performance of reinforced cement concrete slabs. In addition, there is an effort to utilise rubber fibres as additives in the rubberized concrete. Therefore, the research is currently focused on waste tyre rubber due to its early stage of development. There is a scarcity of literature in the field of structural application. Furthermore, the literature does not provide any evidence of the impact of pre-treatment of rubber. Under these conditions, it is crucial to examine the pertinent characteristics of hybrid rubber reinforced composite in order to improve their fundamental structural uses in concrete construction. Possible outcomes encompass decreased mass, improved durability, heightened energy absorption, and higher resistance to impact.

2.4 OBJECTIVE OF THE STUDY

1. To develop a light weight concrete (LWC) using waste material.
2. To optimize the percentage of usage of rubber waste to develop LWC.
3. To determine the mechanical properties of developed LWC.
4. To conduct experimental investigation on the effect of rubber in concrete.

CHAPTER 3

MECHANICAL PROPERTIES OF RUBBER AGGREGATE CONCRETE

3.1 METHODOLOGY

The methodology of the experimental study is shown in the below Figure 3.1.

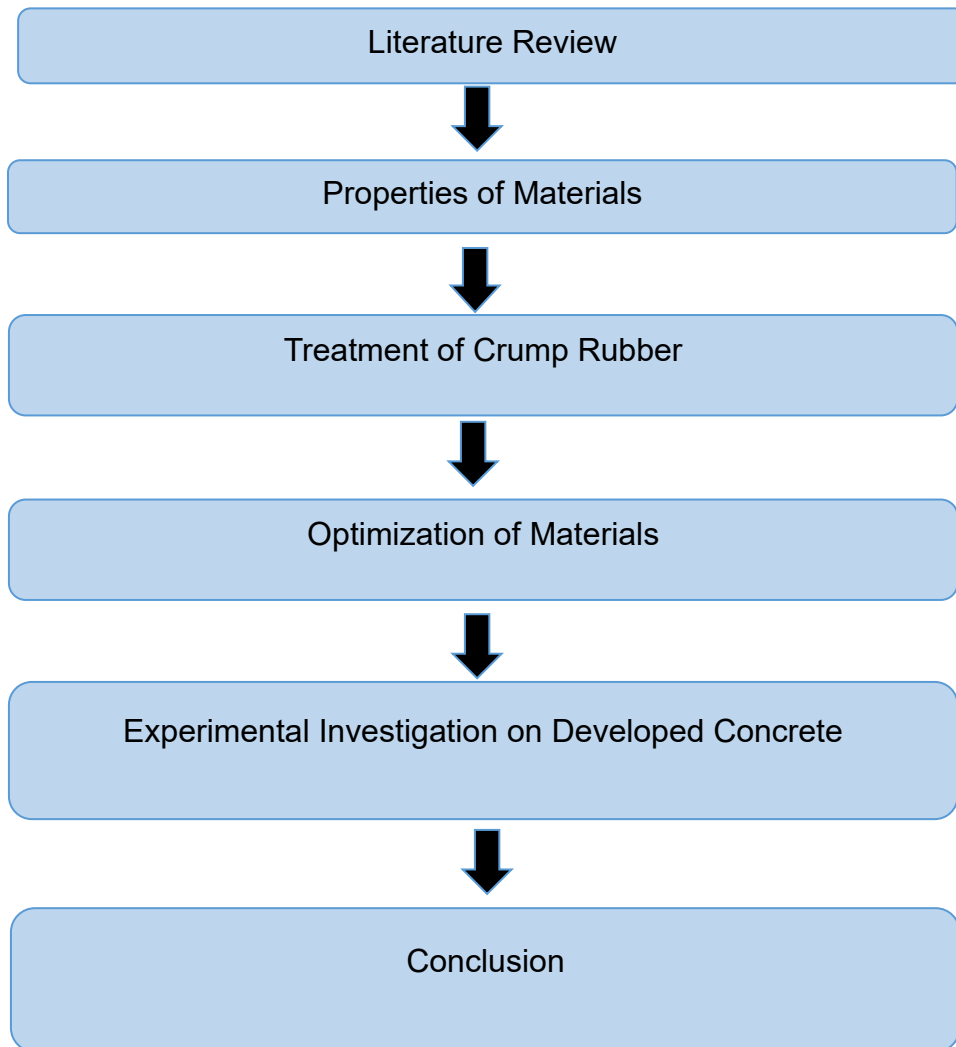


Figure 3.1 Methodology flow chart

3.2 SELECTION OF MATERIALS

Concrete is a composite material primarily consisting of water, aggregate, and cement. When these materials are combined, they create a cohesive and pliable substance that can be easily shaped. Over time, the cement chemically combines with the other materials to create a strong and long-lasting material with a stone-like texture, resulting in the formation of a rigid matrix. The production of high-quality concrete necessitates rigorous attention to detail at every stage of the manufacturing process. The objective of the study was to determine the mechanical characteristics of a type of concrete called Rubber Aggregate Concrete (RAC), where crumb rubber was used as a replacement for fine aggregate. The rubberized concrete was made by incorporating the following constituents: cement, fine aggregate, coarse aggregate, rubber aggregate, and portable water. The present study aims to explore the potential of using rubber waste as a supplemental material in combination with natural aggregates. The material used as a building material and developing the light weight concrete leads to the development of floating concrete. The developed floating concrete reduces the alkali aggregate reaction and reduces the usage of land since the waste material tyre not consumed. Hence the developed new concrete leads to the development of sustainable material.

3.3 MECHANICAL PROPERTIES

Material investigation involves proper material selection, utilization, and effective management. The materials collected are investigated properly to get appropriate quality and desired results. All the investigations are done according to the standard procedures mentioned in IS codes. The mechanical properties of RAC, several mixtures with varying weight of rubber aggregates were prepared.

3.4 Materials

An elaborative material study was carried out and discussed below.

3.4.1 Cement

In the present work, for casting, Ordinary Portland Cement of 53 grade is used. The cements physical properties are obtained by conducting the specified tests as per the IS standards, namely IS 12269:2013, IS 1727:1967, and IS 4031(Part – 5): 1988. Table 3.1 provides all the properties of cement.

Table 3.1 Physical properties of cement

S.No	Properties	Values
1	Specific gravity of cement	3.10
2	Fineness of cement	5%
3	Standard consistency of cement	33%
4	Soundness	2 mm
5	Initial setting time	76 min
6	Final setting time	335 min
7	Compressive strength of cement mortar in 28 days	65 MPa

3.4.2 Fine Aggregate

According to the grading zone II, the locally available M-sand is used for experimental works. The fine aggregate (FA) sieve analysis was carried out in the laboratory as per IS: 383-2016. The specified tests are achieved on fine aggregate as per IS 2386 : Part 1 : 1963 (Reaffirmed Year : 2021) to find out its physical properties. Table 3.2 provide the properties of M-sand.

Table 3.2 Properties of M-Sand

S.No	Properties	Values
1	Specific gravity of sand	2.55
2	Grading	Zone-II
3	Density (kN/m ³)	18.45
4	Fineness modulus	2.64
5	Water absorption	0.50%

3.4.3 Coarse Aggregate

The coarse aggregates commonly used at work have a maximum size of 20 mm and are locally available. The following tests are carried out as per IS 2386 : Part 1 : 1963 (Reaffirmed Year : 2021). Table 3.3 provides the properties of coarse aggregate.

Table 3.3 Properties of coarse aggregate

S.No	Properties	Values
1	Shape	Angular
2	Specific gravity of coarse aggregate	2.73
3	Density (kN/m ³)	26.30
4	Water absorption	1%
5	Fineness modulus	6.40
6	Aggregate Impact test value	13.30%
7	Impact value	13.30
8	Aggregate Crushing value	18.60 %

3.4.4 Rubber Aggregate

The rubber that has been reprocessed. In this project, the old tyre is being cut into the desired shape as partial replacement of natural coarse aggregate as shown in Figure 3.2. The rubber aggregates exhibited similar behaviour to that of the conventional aggregates. Table 3.4 presents a comprehensive list of the characteristics and attributes of tyre.

Table 3.4 Properties of rubber

S.No	Properties	Values
1	Specific gravity of tyre	1.2
2	Water absorption	1.2%
3	Fineness modulus	4.01



Figure 3.2 Tyre rubber

3.4.5 Chemical Solution

Different quantities of rubber from tyres were treated with three distinct acidic solutions, namely CH_3COOH (5%), H_2SO_4 (35%), and HCL (5%). These solutions were then utilized to partially substitute coarse aggregate in concrete. Prior to incorporation into the concrete, the rubber was submerged in acidic solutions and left undisturbed for a duration of 24 hours. After a duration of 24 hours, the object is removed, cleansed with water, dried, and subsequently utilised in the process of making concrete.

3.4.6 Water

Water used for mixing concrete and curing must be clean and free from suspended particles, chemical compounds, and biological materials.

3.5 MIX PROPORTION

Mix design refers to the procedure of choosing and deciding the appropriate amounts of components in order to create concrete that meets certain strength and durability requirements, while also being cost-effective. The primary goal is to establish the minimum level of strength and durability. The mix design is conducted according to the Indian Standard Code technique (IS 10262-2016) for the test specimen. The mix proportions are specifically designed for the M20 grade of concrete. The mix proportions are displayed in Table 3.5.

Table 3.5 Mix proportion for the concrete specimen

S. No.	Grade of Concrete	Mix Proportion (Cement: FA: CA)	Water Cement Ratio
1	M20	1:1.45:2.56	0.45

3.6 SPECIMEN CASTING

The components of concrete are measured and selected according to the mix proportions determined by the mix design. The pretreatment process involves immersing the tyre rubber chip particles in an acidic solution for a duration of 24 hours. Subsequently, the particles are rinsed with clean water and allowed to air-dry at room temperature. Specimens were constructed for the determination of compressive strength, split tensile strength, and flexural strength, respectively. The process of mixing involves manually combining the necessary elements using a trowel. Following the addition of each component, thorough mixing must be performed until the mixture achieves homogeneity. The ingredients are manually poured and compacted using a damping rod in the oiled steel mould. Once 24 hours have elapsed since the casting

process, the specimen is extracted from the mould and subjected to a curing process. The characteristics of rubberized concrete, which includes tyre rubber chip that has been treated with an acidic solution, are examined and contrasted with both untreated rubberized concrete and traditional concrete. Based on the tests done on specimens, it can be inferred that replacing the coarse aggregate with the optimal percentage of rubber is warranted. Additionally, three chemical solutions are used for treating the rubber.

3.7 CHARACTERISTICS OF MIXED CONCRETE

The workability of concrete is crucial at the initial stage of concrete placement. Workability refers to the degree of ease with which a particular sample of ingredients can be mixed into concrete and then handled, transported, put, and compacted, while minimising any loss of uniformity. The fresh characteristics of concrete are determined by performing a slump test according to the specifications outlined in IS 1199. Workability is assessed using the slump test for all mixtures (Figure 3.2). The slump test is the predominant technique for quantifying the workability of concrete. The equipment used to perform the slump test includes a metallic mould in the shape of a frustum of a cone. The mould has a bottom diameter of 200 mm, a top diameter of 100 mm, and a height of 300 mm. The concrete is poured into the mould in three successive levels. The tamping rod is used to tamp each layer 25 times, ensuring that the strokes are equally distributed over the cross-section. The concrete mould is extracted by gradually and cautiously lifting it vertically. The disparity in elevation between the height of the mould and the height of the settled concrete is observed and recorded as the slump value. The RAC samples exhibited satisfactory workability in terms of their ease of handling, trowelling, placing, and finishing. RAC samples can be completed to the same level of quality as conventional concrete without encountering any challenges. Nevertheless, mixtures with increased rubber aggregate content necessitate additional exertion and labour to achieve a smooth final surface due to the reduced weight per unit.

The addition of rubber aggregate to fresh concrete enhances its workability. The hardening of the concrete may be attributed to the reduced ability of the crumb rubber to allow water to penetrate. The findings demonstrated a positive correlation between the proportion of treated crumb rubber and the increase in slump value, with a noticeable rise observed as the rubber content escalated from 0 to 20%. In terms of putting, handling, and finishing, the workability of rubberized concrete is adequate compared to ordinary concrete.

3.8 Characteristics of Cured Concrete

Evaluating the strength of cured concrete is crucial in managing and verifying the excellence of cement-based construction projects. Conducting thorough tests on raw materials, fresh concrete, and hardened concrete is a crucial component of any concrete quality control programme. This process ensures that the materials used are efficient and provides more confidence in the concrete's strength and longevity. The test methods should be straightforward, explicit, and easily applicable. The compression test, split tensile test, and flexural test were conducted in accordance with the standards IS516 and IS5816. The engineering parameters of the rubber aggregate concrete mix were assessed by conducting tests for compressive strength, split tensile strength, and flexural strength at both 7 and 28 days. All specimens were immersed in a water tank until testing began.

The rubber chips function as empty spaces within the matrix, causing a reduction in the strength of the binding between the waste tyre rubber aggregate and the concrete mix. The addition of rubber in concrete leads to a rise in the percentage of rubber, which in turn increases the void content of the concrete. Consequently, this drop in strength occurs. The strength of Portland cement concrete is significantly influenced by the density, size, and hardness of the coarse aggregate. The rubber partially substitutes the aggregates, it is only expected that there will be a decrease in strength.

3.9 Workability

The substitution of coarse aggregate with waste tyre rubber chips has an impact on the workability of concrete. The workability of rubberized concrete demonstrates a reduction in slump as the amount of scrap tyre rubber chips used as coarse aggregate increases. According to Table 3.6, the concrete mix without any rubber chips (0% rubber chips) has a greater workability than the concrete mixes with 10, 15 and 20% rubber chips. As the percentage of rubber chips in the concrete grew, the workability decreased. The percentage of rubber chips in this specific concrete can be selected based on the intended application. Figure 3.3 represents the workability test.



Figure 3.3 Slump cone test

Table 3.6 Result of workability test

S.No.	% of rubber	Slump, mm
1	0	75
2	10	45
3	15	30
4	20	25

CHAPTER 4

RESULTS AND DISCUSSION

4.1 GENERAL

This section deals with the discussion of experimental results and its detailed behaviour analysis on with and without rubber aggregate. The influence of the rubber aggregates with 10, 15 and 20% were also investigated.

4.2 DISCUSSION OF EXPERIMENTAL RESULTS

It is essential to examine the effect of the different percentage of replacement of rubber as coarse aggregate variables are significant and the range in which they are efficient.

4.2.1 Influence on Compressive Strength

From rubber replacements of 10, 15 and 20% shows lower compressive strength compared with conventional concrete. The performance of RAC of rubber replacements in M20 grade concrete (Figure 4.1) is quite discouraging up to 15% replacements has meagre compressive strength. In the lot, 10% replacement of rubber performs comparatively lower than that of 37.89% achievement of 28 days compressive strength of conventional cube. The compression test results indicated that there was a substantial reduction in the strength values with the increase in rubber content. The reduction in strength is because of the rubber has more elasticity than hardened cement paste surrounding it; fracture would begin from their interface and propagate through concrete. The bond developed between the particles and the surrounding matrix is improved. Table 4.1 and Figure 4.1 & 4.2 represents the compressive strength at different percentage of rubber at 7, 14 and 28 days.

Table 4.1 Compressive strength at different percentage of rubber at 7, 14 and 28 days

S.No.	% of RAC	7 days	14 days	28 days
1	0	13.45	17.60	24.89
2	10	7.77	13.61	15.46
3	15	8.80	14.96	17.00
4	20	8.26	14.23	16.17

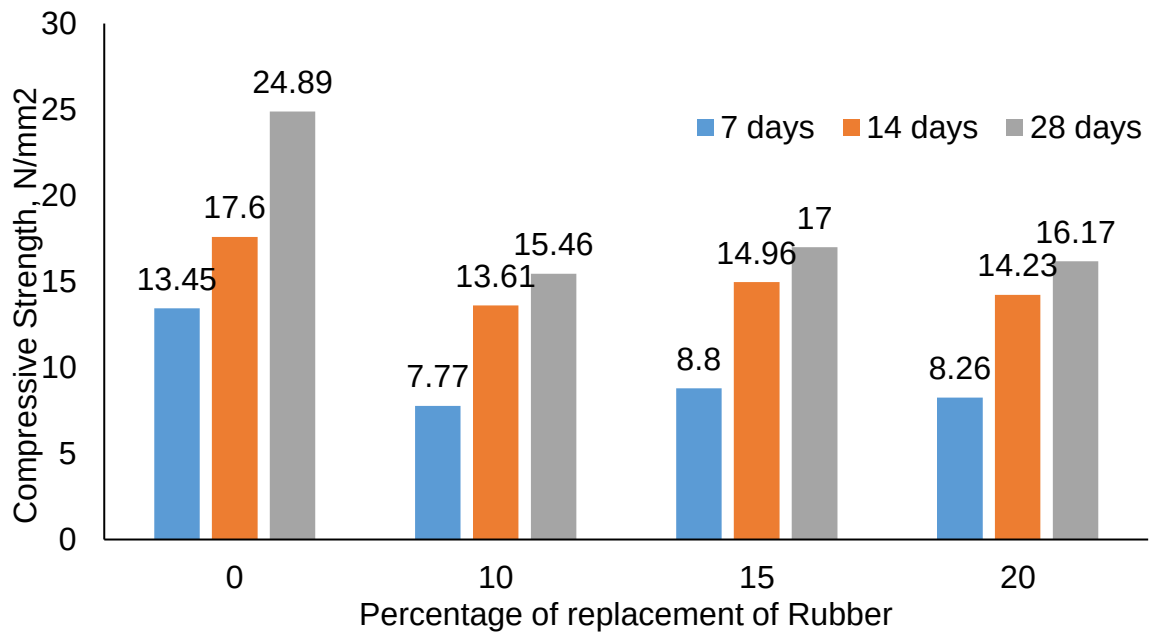


Figure 4.1 Compressive strength at different percentage of rubber at 7, 14 and 28 days



Figure 4.2 Compressive strength testing

4.2.2 Influence on Split Tensile Strength

Rubber replacements of 10, 15 and 20% shows lower tensile strength compared with conventional concrete. The performance of RAC of coarse aggregate replacements in M20 grade concrete (Figure 4.2) is quite discouraging. 10 and 20% of replacements, the tensile strength was very low. In the lot, 10% replacement of crumb rubber performs comparatively lower than that of 12% achievement of 28 days tensile strength of conventional cylinder. Table 4.2 and Figure 4.3 & 4.4 are the split tensile strength at different percentage of rubber at 7 and 28 days.

Table 4.2 Split tensile strength at different percentage of rubber at 7 and 28 days

S.No	% of RAC	7 days	28 days
1	0	2.04	3.5
2	10	1.75	3.05
3	15	2.3	3.63
4	20	2.09	3.29

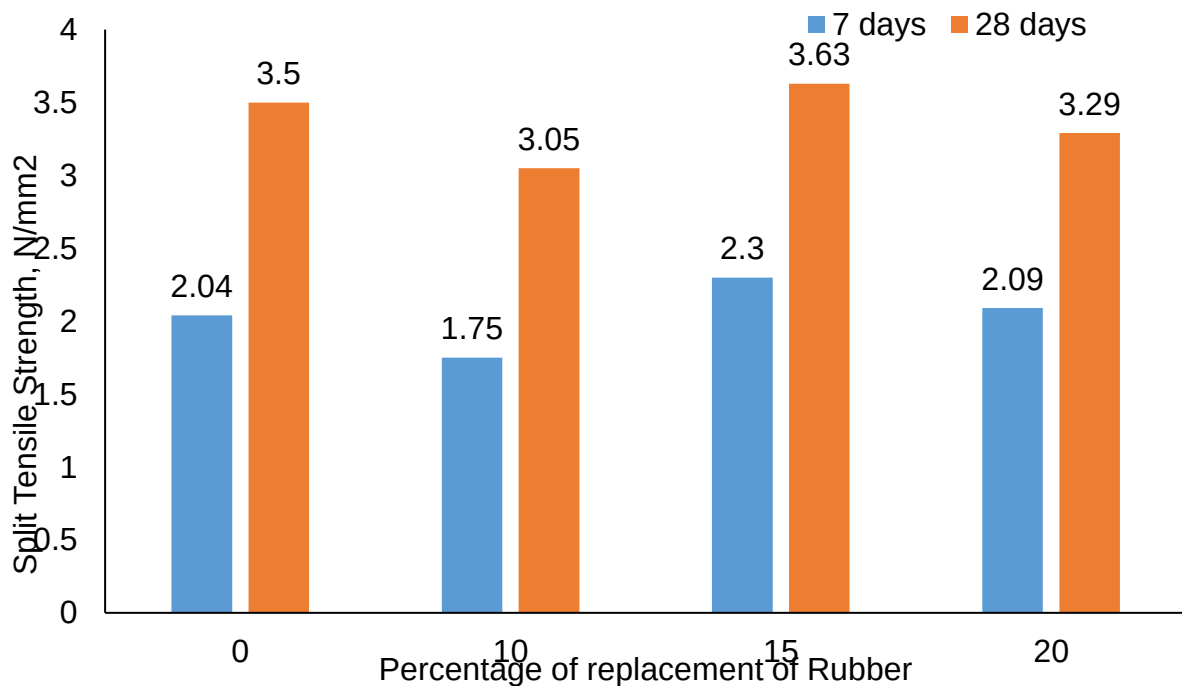


Figure 4.3 Split tensile strength at different percentage of rubber at 7 and 28 days



Figure 4.4 Split tensile strength testing

4.2.3 Influence on Flexural Strength

Rubber replacements of 10, 15 and 20% shows lower flexural strength compared with conventional concrete. The performance of RAC of rubber replacements in M20 grade concrete is quite encouraging up to 15% replacements perform very high flexural strength of 23.36% when compared to conventional concrete. Table 4.3 and Figure 4.5 & 4.6 represents the flexural strength at different percentage of rubber at 7 and 28 days.

Table 4.3. Flexural strength at different percentage of rubber at 7 and 28 days

S.No.	% of RAC	7 days	28 days
1	0	2.37	3.21
2	10	2.51	3.52
3	15	2.69	3.96
4	20	2.41	3.31

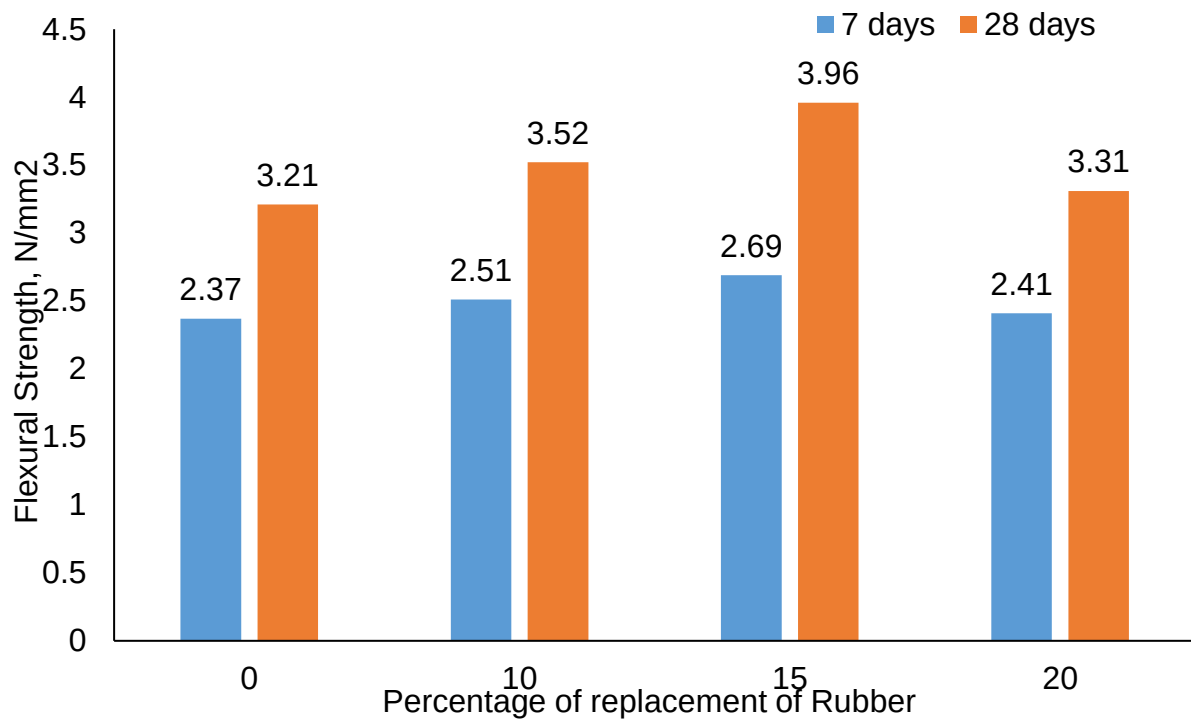


Figure 4.5. Flexural strength at different percentage of rubber at 7 and 28 days



Figure 4.6 Flexural strength testing

CHAPTER 5

CONCLUSION

5.1 CONCLUSION

Although the presence of rubber reduces both compressive and tensile strengths of concrete, this is because the rubber allowed the increase in water demand, reduction in bond between aggregate and cement paste, leading to increase in drying shrinkage and lower strength.

The primary aim of this research was to assess the characteristics of a concrete mixture by substituting a portion of the natural coarse aggregates with an aggregate derived from waste tyre that are readily accessible in the local area. The workability of fresh concrete deteriorated as the percentage of rubber chips increased. The specific gravity is observed to decrease when the amount of rubber chips increases. The compressive and tensile strengths exhibited a decrease as the rubber chip aggregate replacements increased whereas increase in flexural strength due to the elasticity present in the rubber. However, the findings of the 15% replacement are deemed acceptable. Rubberized concrete is suitable for non-load bearing components such as lightweight concrete walls and other architectural units. Therefore, rubberized concrete mixes can provide a practical alternative in situations that call for normal loads, low unit weight, medium strength, high toughness, and similar characteristics. The study demonstrates that incorporating recycled rubber tyre aggregates into concrete construction is feasible. By replacing 15% of the mineral coarse aggregates with rubber tyre aggregates, the concrete exhibits optimal performance. The compressive, tensile, and flexural strengths of the rubberized concrete are reduced compared to non-rubberized concrete. Rubberized concrete offers superior performance compared to traditional concrete in applications that require vibration damping, such as serving as an earthquake shock-wave absorber, in machinery foundation pads, and in railway stations. Incorporating rubber particles into concrete can enhance its thermal insulation properties, offering significant practical benefits.

5.2 FINDINGS

- i. Experiments were conducted with partial replacement of crumb rubber aggregates in concrete to determine the feasibility of using waste tire rubber in concrete.
- ii. For the test types of rubber aggregate, workability, and grade of concrete were kept as varied.
- iii. Slump test results show increases in workability while adding the rubber aggregate in the concrete.
- iv. Test results indicated that a 15% replacement with the addition of rubber aggregates provides a gradual and robust improvement in all the requisite mechanical properties, which were performed very much close to the conventional concrete.
- v. The developed proportion of rubber concrete can be used as placing the solar panels over the LWC.

5.3 FUTURE SCOPE OF STUDY

- 1. The developed concrete can be transformed to develop the slab to hold the panel and several panels collected with the help of sensors.
- 2. The future research involves the application of our findings to real-world infrastructure projects.

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