Enhancing the Mechanical Properties of Recycled Aggregate Concrete through the Synergistic Effects of Silica Fume and Hybrid Glass Fiber-Steel Fiber Reinforcement

Submitted By

Latif Shah	UET/SCET-19F-CE-44
Shahbaz Ahmad Khan	UET-SCET-19F-CE-56
Syed Fyrqan Ali shah	UET/SCET-19F-CE-80
Mohsin Ehsan	UET/SCET-19F-CE-38

Supervisor:

Engr. Syed Haroon Ali Shah

Department of Civil Engineering

Swedish College of Engineering & Technology Wah Cantt

Session 2019-2023

This is to certify that the

Final Year Project Titled

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Has been accepted towards the partial fulfillment

of

the requirements

for the award of the degree of

Bachelor of Engineering in Civil Engineering

Bachelor of Science

In

Civil Engineering

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(Dr.Tariq Ali) **Engr. Syed Haroon Ali Shah**

HOD (CED) Lecturer (CED)

____

(FYP Committee)

(CED)

ABSTRACT

The urgent necessity to create novel strategies to improve the performance of recycled aggregate concrete (RAC) is highlighted by the fact that the sustainable development of construction materials has become a serious issue in the current day. In order to enhance the mechanical characteristics of RAC, this study explores the synergistic effects of silica fume and a variety of hybrid fiber reinforcements, including glass fibers and steel fibers. Systematically assessed is the impact of different fiber proportions, such as 0.5% and 1% steel fibers, 0.5% and 1% glass fibers, and hybrid combinations (0.5% glass + 0.5% steel, 0.5% glass + 1% steel, 1% glass + 0.5% steel, and 1% glass + 1% steel). The work indicates considerable improvements in the mechanical behavior of RAC with the addition of silica fume and hybrid fibers through a thorough experimental evaluation that includes compressive strength, flexural strength, and impact resistance tests. Combining the pozzolanic activity of silica fume with the reinforcing properties of hybrid fibers results in increased interfacial bonding, decreased microcracks, and increased load-bearing capabilities. Notably, the hybrid fiber combinations outperform individual fiber additions in terms of performance. The results highlight how synergistic fiber reinforcement may be used to enhance the mechanical properties of recycled aggregate concrete. The suggested method offers a potential way to fulfil the stringent demands of contemporary construction practices while simultaneously promoting sustainable waste utilization. For engineers, academics, and politicians working to advance building materials towards a more durable and environmentally aware future, this research fills the gap between sustainable materials and structural performance.

DECLARATION

I declare that the study presented in this dissertation is my peculiar, excluding was specified else. In addition, this research has not been submitted to obtain an extra degree or specialized qualification.

Latif Shah

UET/SCET-19F-CE-44

Shahbaz Ahmad Khan

UET/SCET-19F-CE-56

.

Syed Furqan Ali shah

UET/SCET-19F-CE-80

Mohsin Ehsan

UET/SCET-19F-CE-38

ACKNOWLEDGMENT

All admiration to Almighty Allah, who gives us bravery and essence to finish the task, respect is for the last Holy Prophet Muhammad (P.B.U.H) whose life is a model of guidance and knowledge for the entire humanity

We are extremely thankful to our project supervisor **Engr. Syed Haroon Ali Shah** and for giving us time and guidance in this project and thankful to all the teachers of the Civil Engineering Department. We cannot forget so many friends who always have been there for us.

DEDICATION

Dedicated to our families. The special feeling of appreciation to our loving parents whose words of inspiration and push for persistence ring in our eyes. We also devote this thesis to our friend and supervisor who supported us throughout the procedure.

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Chapter 1

1 INTRODUCTION

1.1 Background

Due to the considerable environmental effect of the construction sector, the use of environmentally friendly building materials like Recycled Aggregate Concrete (RAC) has increased dramatically. RAC's use is constrained for critical structural applications because to mechanical difficulties caused by its increased porosity and lower strength when compared to native aggregates. Researchers are looking at the possibility of strengthening RAC with a mixture of hybrid glass-steel fibers and silica fume to improve its mechanical qualities as a solution to this problem.[1] The density, strength, and endurance of the cement matrix are all increased by silica fume, which functions as a pozzolanic material. The tensile and flexural strength, toughness, and fracture resistance of the material are all increased simultaneously by the addition of glass and steel fibers. Recent research has shown that utilizing glass and steel fibers together produces synergistic benefits that are greater than using either fiber type alone. To fully investigate the possibility of such synergistic effects in recycled aggregate concrete, more study is necessary.[2] This study aims to enhance green building practices and the use of recycled materials in the manufacturing of concrete by evaluating the synergistic effect of silica fume and hybrid fiber reinforcement on RAC's mechanical characteristics.. One of the most used building materials, concrete is essential to the development of cities and towns across the world. However, the significant amount of usage it receives prompts urgent worries about the environment, greenhouse gas emissions, and resource depletion. The involvement of the building sector in sustainable practices has drawn more attention in light of growing worldwide concerns over climate change and environmental deterioration.[3]This research aims to open the door for ecologically friendly construction practices and improve the structural potential of recycled materials by exploring the integration of silica fume and hybrid fibers in RAC. This study aims to advance RAC as a strong and realistic eco-friendly option, encouraging greener building techniques for a more sustainable future, by revealing the secrets of synergistic effects. The sustainable future of concrete production faces a critical challenge due to extensive reliance on natural aggregates such as sand, gravel, and crushed stone. This practice raises alarming concerns about habitat destruction, soil erosion, and biodiversity loss stemming from mining activities in riverbeds, quarries, and open-pit mines. The environmental impact is further amplified by the vast carbon footprint resulting from long-distance transportation of heavy materials. Cement, a crucial element in concrete production, significantly compounds the issue, being energy-intensive and releasing copious amounts of carbon dioxide (CO2). Consequently, cement manufacture emerges as a major greenhouse gas emitter, exacerbating global warming concerns. Embracing eco-friendly alternatives and optimizing the use of recycled materials stands as an imperative step towards mitigating these challenges and promoting sustainable practices in the concrete industry.[3]

Concrete waste disposal from building and demolition projects raises serious environmental concerns. Such garbage not only takes up precious land but also releases hazardous gases and leachates that can contaminate both surface and ground water. Researchers, engineers, and policymakers have laboriously sought practical solutions to the detrimental environmental consequences of the concrete industry. As a potential replacement, Recycled Aggregate Concrete (RAC) stands out as a green invention. By substituting recycled materials like cracked concrete and other construction waste for natural aggregates, RAC lessens the environmental impact of aggregate mining.[4] Recycling concrete debris reduces trash generation and preserves resources while also reducing the need for landfill space. However, there are technical difficulties with RAC utilization since recycled aggregates sometimes have lower quality than their natural equivalents. It becomes crucial to improve RAC's mechanical qualities and durability in order to promote its wider application in building projects and take advantage of its environmental advantages. It takes continual study and creative solutions to overcome these obstacles, with a focus on enhancing RAC's functionality and long-term viability. The effectiveness and dependability of RAC structures may be increased by rigorous testing, cutting-edge mix design approaches, and the addition of supplemental components. To further simplify norms, guidelines, and best practices for employing RAC efficiently and ethically, it is crucial to develop collaboration between academics, industry, and regulatory organizations.[2] The construction sector can actively contribute to a greener, more sustainable future by adopting recycled aggregate concrete as a revolutionary solution, reducing the environmental effect of concrete manufacturing and promoting circularity in waste management. Utilizing RAC is perfectly compatible with adopting the circular economy's concepts, which promote turning waste products into useful resources during the manufacturing cycle. The construction industry may significantly reduce its environmental impact by adopting a more circular and resource-efficient model and incorporating recycled aggregates in the production of concrete. We can create the groundwork for a brighter, more environmentally balanced future for future generations by advocating the pursuit of greater sustainability in practice and adopting circular economy ideas.Despite the outstanding environmental advantages recycled aggregates provide, solving the mechanical issues associated with them is necessary to guarantee structural integrity and long-term performance of concrete constructions. The adaptability of recycled aggregate concrete (RAC) in a variety of building applications is greatly influenced by the mechanical qualities, particularly compressive strength, tensile strength, and durability.[5] The use of silica fume to improve RAC's mechanical properties has enormous promise. Silica fume, a byproduct of the ferrosilicon and silicon metal industries, can be used as a green alternative to traditional cementitious materials. Surprisingly, its pozzolanic qualities reduce RAC's carbon footprint by reducing the requirement for excessive cement use while simultaneously improving the strength and durability of concrete. Notably, RAC has weak tensile strength and brittleness, although these drawbacks are alleviated by the use of silica fume and a thoughtful combination of glass and steel fibers. By increasing its ductility, energy absorption capacity, and fracture resistance, the hybridization of these reinforcing fibers significantly improves RAC's resilience against tensile loads and cracking.[6] The outstanding construction material RAC is made possible by the effective combination of silica fume and fiber reinforcement, making it suitable to offer long-lasting infrastructure solutions. This cutting-edge method ushers in a new era of concrete engineering where environmental sensitivity melds with high-performance capabilities without running afoul of mechanical constraints. The proposed study's objective is to close the knowledge gap regarding the mechanical characteristics of recycled-aggregate concrete (RAC) in real-world applications. A thorough knowledge of RAC's behavior will be gained by examining the synergistic impacts of silica fume and hybrid glass-steel fiber reinforcing. This discovery has the potential to revolutionize sustainable construction techniques and provide engineers and designers the ability to reliably apply RAC in a variety of scenarios, such as structural work, pavement, and infrastructure development. [7] Technical obstacles must be overcome before RAC can be widely used as a reliable alternative to conventional concrete. These mostly result from differences between recycled aggregates and their natural equivalents in terms of quality. In order to improve RAC's overall performance and sturdiness in various building settings, a thorough understanding of and solutions for these mechanical limitations are imperative. The variability of recycled aggregates is one of the key mechanical problems in RAC. Because they come from a variety of sources, including abandoned buildings, construction detritus, and industrial waste, their composition is intrinsically unpredictable. As a result, there is an uneven distribution of strengths and weaknesses within the concrete matrix since RAC's mechanical behavior lacks consistency and predictability.[8]

The goal of this study is to fully realize the potential of recycled materials for environmentally friendly construction by investigating the interaction of silica fume and hybrid glass-steel fiber reinforcement in RAC. By addressing the issues and comprehending the RAC's intricate mechanics, the building industry will advance towards a greener, more robust future and increase the acceptability of RAC as a dependable, environmentally beneficial choice.The porosity of natural and recycled aggregates is a noticeable difference. Recycled aggregate particles frequently have increased porosity and microcracks, which compromise the cementitious matrix's interfacial binding and the concrete's overall cohesion. Recycled Aggregate Concrete (RAC) may not have the same compressive strength as regular concrete as a result, making it inappropriate for use in load-bearing constructions. Additionally, RAC has severe mechanical difficulties because to its decreased tensile strength and greater susceptibility to cracking. The overall fragility of the concrete can be further decreased by adding brittle recycled particles. Tensile cracking reduces the load-bearing capacity of RAC, making it more vulnerable to chemical exposure and freeze-thaw cycle damage, thus reducing its longevity. These mechanical flaws underscore the importance of exercising caution while employing recycled resources in the creation of concrete. Utilizing the potential advantages of sustainability while preserving structural integrity and durability in concrete applications requires proper recycling material selection, processing, and engineering practices.[9]

1.2 Aim and Objectives

The study's research goals are to look into and accomplish the following:

- Improvement of mechanical characteristics.
- Synergistic Effects of Hybrid Fibre Reinforcement.
- Microstructural Analysis.
- Optimal Combination of Additives.

- Applications in Construction Projects.
- Contribution to Sustainable Construction.

1.3 Scope of the Study

The purpose of this investigation is to carefully assess whether silica fume and hybrid glass-steel fiber reinforcement might jointly enhance the mechanical properties of recycled aggregate concrete (RAC).. This work aims to clarify whether the introduction of these additives may successfully resolve these problems and increase the compressive, tensile, and flexural strengths of RAC given the distinctive mechanical difficulties offered by recycled aggregates. An detailed literature study of RAC, silica fume, and fiber reinforcement in concrete will be done in order to lay a solid theoretical framework for the inquiry. This thorough assessment will not only help uncover existing knowledge gaps, but also highlight areas for future investigation.

For thorough analysis, several combinations of recycled aggregates (RAC), silica fume (SF), and hybrid glass-steel fibers (HGSF) will be prepared as part of the research. The concrete specimens will be subjected to a thorough battery of mechanical testing, including compression, tension, and flexure. By carefully examining the results of these studies, we want to clarify how silica fume and hybrid fibers affect the mechanical properties of RAC.

Additionally, we aim to use cutting-edge techniques like scanning electron microscopy (SEM) and other types of microstructural studies to study the interfacial strength between the recycled aggregates and the cement matrix. To learn more about the underlying mechanisms causing the observed mechanical improvements, the distribution and alignment of hybrid fibers inside the concrete will also be closely examined.

This study's ultimate objective is to provide a thorough knowledge of how silica fume and hybrid glass-steel fibers work together to enhance recycled aggregate concrete's performance. We want to develop sustainable building methods and encourage the industry to choose environmentally friendly materials by putting light on these complex interconnections. The findings of this study have the potential to revolutionize RAC design and develop environmentally friendly building practices on a worldwide level.

The goal of this study is to determine the ideal ratio of hybrid fibers to silica fume for Recycled Aggregate Concrete (RAC) to operate at its best. Based on the analytical results, an optimized RAC mix with improved mechanical properties will be painstakingly developed using statistical approaches like Response Surface Methodology (RSM).

While mechanical performance is the main concern, it is also important to consider longevity and resilience to environmental factors in order to fully understand the RAC's total effectiveness.
The limited scope of this study prevents wide field application and is limited to internal laboratory experiments. To support sustainable building practices, the possibility for implementing the enhanced RAC, which has improved mechanical qualities, into construction projects will be examined.
It is crucial to recognize that the information and conclusions from this study will depend on the particular tools and procedures used in the lab. Therefore, further thought and validation will be required before the optimized RAC combination can be reliably used in real-world building projects.

1.4 Significance of the Research

These discoveries have substantial ramifications for sustainable construction practices and building materials. Here are the main points of this ground-breaking study:
This study explores the transformational potential of silica fume and hybrid glass-steel fiber reinforcement in Recycled Aggregate Concrete (RAC), upgrading its mechanical capability, with the goal of promoting sustainable construction practices. The research promotes the broad use of recycled materials in concrete production by maximizing RAC's performance, reducing dependency on scarce natural aggregates, and reducing the environmental impact of the building sector. This bold endeavor perfectly complements the broader goal of promoting a resource-conscious, eco-conscious constructed environment.
The mechanical restrictions associated with RAC utilization, such as diminished compressive and tensile strength as well as increased susceptibility to cracking, are a key issue that the study addresses. To get over these difficulties, the research aims to improve RAC's structural integrity and durability by combining hybrid fibers with silica fume in a beneficial way. These innovative improvements provide a viable route for realizing RAC's full potential and expanding its use in a variety of actual building projects.
The circular economy, which regards waste materials as valuable resources, adheres to the ideals of efficient resource use and ethical waste management through the use of recycled aggregates in the manufacturing of concrete. The study fervently supports a closed-loop paradigm that creatively recycles construction and demolition waste into concrete instead of using costly landfill practices.

This research shines as a ray of light in a world that longs for sustainable solutions, pointing the construction sector in the direction of a greener, more sustainable future. An age of transformational change is ushered in by the thoughtful fusion of cutting-edge technology and environmentally friendly materials, encouraging harmony between urban growth and environmental preservation. A sustainable revolution is about to transform the future of construction as architects, engineers, and politicians use the knowledge from this study, leaving mankind with a legacy of resiliency and responsible stewardship.

This work uses statistical methods, particularly Response Surface Methodology (RSM), to ascertain the ideal silica fume to hybrid glass-steel fiber ratio in the concrete mix design in an effort to optimize Recycled Aggregate Concrete (RAC). The main goal is to increase the mechanical performance of the concrete while utilizing the least amount of materials possible, promoting both cost-effective and ecologically responsible construction methods.

Furthermore, the better mechanical properties of the suggested RAC mixes make them appropriate for a variety of structural and non-structural elements, including beams, columns, pavements, and precast constructions. This makes it clear how practically applicable this study is. The implementation of RAC may result in the creation of greener, more sustainable structures, which would be advantageous to architects and builders.

This research also makes a substantial contribution to our understanding of recycled aggregate concrete and offers light on the potential advantages of using hybrid fibers and silica fume in concrete technology. The microstructural analysis and performance assessment bring up new possibilities for future study and improvements in environmentally friendly building materials by offering insightful information about the behavior of the material under various loads and environmental circumstances.

The significance of the work is highlighted by the synergistic interactions between hybrid glass-steel fiber reinforcement and silica fume, which may be used to improve the mechanical characteristics of recycled aggregate concrete. This research advances the field of durable, long-lasting construction materials by solving technical issues related to the use of RAC, encouraging green building practices, and improving the concrete-mix design procedure. The results have broad repercussions and provide a model for future ecologically friendly construction techniques. This study acts as a cornerstone for transformational and sustainable construction initiatives as we move forward towards a greener future.

Chapter 2

2 LITERATURE REVIEW

2.1 Overview:

The present sectors of construction consume huge content of concrete and natural aggregates and around 2000 million tons of cement. The abundance of crude substances utilization possibly delivers ozone-depleting substances prompting an Earth-wide temperature boost. Along these lines, the need to fuse reused substances as a replacement to development substances are fundamental to diminish landfill space just as a lack of normal assets. Discarded substances increment with expanding populace and the greater part of these materials are non-degradable.

Micro silica, commonly referred to as silica fume, is a byproduct of the manufacture of ferrosilicon alloys and silicon metal. It is an amorphous, fine-grained, and highly reactive substance made up of very small silicon dioxide (SiO2) particles. Typically, industrial procedures that include the high-temperature reduction of quartz or other silica-containing minerals produce silica fume. Silica fume has an exceptionally tiny particle size and a large surface area, which makes it highly reactive when combined with concrete.

Silica fume is frequently utilized as a pozzolan or supplemental cementitious material (SCM) in concrete technology. When added to concrete mixes, it improves the material's durability, permeability, and resistance to abrasion and chemical assaults. It also increases the concrete's compressive strength. The spaces between cement particles are filled with silica fume, resulting in a denser and more impermeable concrete matrix. In projects where strength and durability are essential, including high-rise buildings, bridges, and maritime constructions, its usage in concrete helps to produce high-performance and long-lasting structures.

In order to enhance the mechanical qualities of concrete, a form of fiber known as hybrid glass fiber, sometimes referred to as glass fiber reinforcement, is employed as a reinforcing material. Molten glass is drawn into thin fibers that are then bundled into strands to create glass fibers. As the name implies, hybrid glass fibers are a mix of several types of glass fibers, frequently an amalgamation of alkali-resistant (AR) glass fibers and common E-glass fibers.

Hybrid glass fibers added to concrete provide a number of positive advantages, such as improved flexural strength, fracture resistance, and ductility. By bridging fractures and halting their spread inside the concrete matrix, the fibers serve as reinforcement, improving toughness and post-cracking behavior. Tensile strength, durability, and cost-effectiveness are all balanced by the hybridization of AR glass fibers with E glass fibers.

When increased strength and fracture resistance are sought, hybrid glass fiber reinforcement is frequently used in a variety of concrete applications, including precast components, shotcrete, and overlays. Controlling early-age cracking and halting the enlargement of smaller fractures over time are its two main advantages. The performance and lifespan of concrete buildings may be greatly enhanced by the inclusion of hybrid glass fibers, making them more durable and dependable under a variety of loads and climatic circumstances.

Work done by other Researchers:

In this section, we have summarized more than 10 research papers related to our topic. These papers give us basic knowledge similar to our project. We conclude the basic idea from the research papers and finally, we introduce a new concept that cannot be given in other research papers.

2.2 Recycled Aggregate Concrete (RAC)

In their paper " Folino and Xargay (2014) thoroughly examined the mechanical behaviour of recycled aggregate concrete (RAC) under uniaxial and triaxial compression. The work adds to our understanding of the structural performance of the RAC, which is crucial for employing sustainable building techniques. The authors investigated the behavior of RAC specimens under uniaxial and triaxial stress situations using a thorough experimental program. The analysis covered a wide variety of factors, including confinement pressures, curing regimes, and aggregate replacement levels. In-depth research was done on mechanical characteristics such compressive strength, stress-strain response, and failure mechanisms. The results showed how closely the mechanical properties of RAC relate to the amount of recycled aggregate in that material. The study found that elements including aggregate type, replacement ratio, and confinement had an impact on the mechanical performance of RAC. Additionally, it gave insights into the patterns of deformation and failure processes under various loading circumstances. The research adds significant knowledge for optimizing the design and use of recycled aggregate concrete in actual building projects by examining the behavior of RAC in both uniaxial and triaxial compression scenarios. In order to improve the mechanical integrity of RAC structures, guidelines and techniques for doing so must be developed. The findings of this study provide vital information to engineers and researchers working to advance sustainable building materials. The study's focus on mechanical behavior and its ramifications adds to the continuing conversation about green building techniques. Readers who are interested may easily obtain the whole study for further insights by using the given DOI (Digital Object Identifier). [10]

The article by J. S. Ryu, uses a thorough experimental methodology to examine the impact of recycled aggregate on concrete properties. The purpose of the research is to provide light on the viability and ramifications of using recycled aggregate in the manufacturing of concrete. The study thoroughly assesses the performance of concrete mixes using recycled aggregate by looking at numerous concrete properties, including compressive strength, durability, and workability. The experimental findings show that the characteristics of concrete are noticeably affected by the use of recycled material. Notably, as the percentage of recycled aggregate increases, a decline in compressive strength and durability is seen. The study emphasizes that these adverse impacts may be reduced, nevertheless, by making the necessary changes to the mix design and production procedures. The research emphasizes how important it is to weigh the advantages and disadvantages of using recycled material in concrete mixtures. For academics, engineers, and professionals working in sustainable construction methods, it provides useful information. The study deepens our comprehension of the significance of recycled materials for concrete engineering, opening the door to well-informed choices in the hunt for greener construction practices. The publication of the manuscript in a prominent scholarly journal and the DOI 10.1680/macr.2002.54.1.7 citation testifies to its academic and applied value in the area of concrete research. [11]

A thorough analysis of the interactions between the mechanical characteristics of recycled aggregate concrete (RAC) is provided by J.Z. Xiao, J.B. Li, and C. Zhang. The research addresses the pressing need to understand the complex interrelationships between the many mechanical characteristics of RAC, providing information on its structural performance. The authors emphasize the special difficulties that recycled aggregates provide as they dive into the important mechanical characteristics of RAC, such as compressive strength, tensile strength, modulus of elasticity, and durability. The report emphasizes the complicated relationships between these qualities and how they might affect one another in RAC compositions through a synthesis of previous studies. The impacts of additional cementitious material inclusion, curing conditions, and aggregate replacement ratios are also evaluated in relation to mechanical performance. A thorough analysis of the interactions between the mechanical characteristics of recycled aggregate concrete (RAC) is provided by J.Z. Xiao, J.B. Li, and C. Zhang. The work responds to the urgent requirement to comprehend the intricate links between RAC's various mechanical characteristics, offering insight on its structural performance. The authors emphasize the special difficulties that recycled aggregates provide as they dive into the important mechanical characteristics of RAC, such as compressive strength, tensile strength, modulus of elasticity, and durability. The report emphasizes the complicated relationships between these qualities and how they might affect one another in RAC compositions through a synthesis of previous studies. The impacts of additional cementitious material inclusion, curing conditions, and aggregate replacement ratios are also evaluated in relation to mechanical performance.[12]

2.3 Effect of Silica Fume:

According to Wang et al. (2020), The hydration characteristics of cement-based materials are improved by the synergistic interaction of silica fume with Nano-silica. They seek to understand the complex interactions between these chemicals and their overall impact on the hydration process through their study. The researchers carefully examine the hydration kinetics, heat release, and microstructural changes in the presence of various ratios of Nano-silica and silica fume using cutting-edge methods including thermogravimetric analysis and calorimetry. Their research reveals a synergistic interaction between both additives, wherein using silica fume and Nano-silica together has a greater impact on the hydration processes and consequent material characteristics. The co-presence of Nano-silica and silica fume accelerates the development of early-age strength by enhancing the nucleation and growth of hydration products. Additionally, the combination of these additives results in greater densification and finer pore architectures, indicating increased durability potential in cement-based materials. In order to better understand how silica fume and Nano-silica interact synergistically and affect cement hydration, Wang et al. make significant contributions to the field. This study has implications for tailoring additive combinations to optimize cementitious systems, perhaps opening the path for more efficient and environmentally friendly building materials. The paper may be used as a resource by academics and industry professionals who want to learn more about supplemental cementitious ingredients and how they affect cement-based matrices' performance.[13]

The calcium-silicate-hydrate (C-S-H) gel, a crucial binder phase in cementitious materials, is a major component of the study by Y. S. B. Fraga and J. H. da S. Rêgo into the combined effects of ultrasonication, silica fume, and colloidal Nano-silica on the microstructure. By analyzing the individual and combined impacts of these elements, the study seeks to clarify the possible improvement of cementitious matrices. The C-S-H gel structure is influenced by the use of ultrasonication to encourage greater dispersion of Nano-silica and silica fume inside the cementitious matrix. The research uses a thorough methodology that includes a range of analytical tools to describe the changing microstructure. According to the results, using silica fume and colloidal Nano silica together while ultrasonically packing them results in C-S-H gel formations that are more precise and tightly packed. The cementitious materials exhibit better mechanical characteristics, decreased porosity, and higher density as a result. The study's findings offer insightful information on how to improve cement-based composites through specific microstructural alterations, paving the way for improvements in long-lasting and sustainable building materials. In line with the ongoing pursuit of environmentally friendly and highly effective construction methods, the referenced research emphasizes the significance of synergistic interactions and creative processing methods in modifying the microstructural characteristics of cementitious materials for enhanced performance. The relevance of the article lies in its potential to impact the creation of new cementitious materials with improved mechanical and durability qualities.[14]

The impact of adding silica fume to concrete on its hardened qualities is thoroughly examined in the work written by R. Siddique. Due to its potential to improve the mechanical and durability properties of concrete, silica fume, a byproduct of the silicon and ferrosilicon alloy industries, has attracted a lot of interest. The main goal of the study is to evaluate the effects of silica fume addition on the essential characteristics of the concrete after curing. Siddique methodically explores the impact of silica fume on variables including compressive strength, flexural strength, permeability, and durability-related properties of concrete by going over a variety of study findings and experimental data. The synthesis of several experimental findings demonstrates the positive effects of silica fume use, including notable improvements in compressive and flexural strengths as well as decreases in permeability and chloride ion penetration. The report also discusses possible difficulties, such as the requirement for efficient mix design techniques to maximize the benefits of silica fume. Siddique’s paper meticulously assesses the body of literature to provide a valuable resource for researchers, engineers, and practitioners working to advance the performance and sustainability of concrete materials. It makes significant contributions to our understanding of how silica fume can influence the hardened properties of concrete. The paper's conclusions are pertinent to the development of concrete technology and sustainable building practices.[15]

2.4 Glass fiber's impact:

The study looks at the mechanical characteristics of glass fiber-reinforced ceramic concrete by S. T. Tassew and A. S. Lubell. The purpose of the study is to better understand how glass fiber reinforcement may be used in ceramic concrete applications. To determine the impact of different glass fiber doses on the mechanical performance of ceramic concrete, the researchers carried out an experimental examination. We looked at parameters including fracture toughness, compressive strength, and flexural strength. The study showed that adding glass fibers significantly improved the mechanical characteristics of ceramic concrete through a thorough set of tests. The findings showed that the use of glass fibers significantly improved the material's compressive and flexural strengths. Additionally, there was a noticeable improvement in fracture toughness, which is important for applications requiring a high level of resistance to crack propagation. The study went on to show that the fiber content affected the increase in mechanical qualities, with the best results coming from an appropriate dose. The research results in this publication offer important new perspectives on the viability and advantages of adding glass fibers to ceramic concrete compositions as reinforcement. This study is important for construction and materials engineering professionals because it lays the groundwork for the creation of ceramic concrete composites with great performance and durability.[16]

In order to evaluate the mechanical characteristics and fracture behaviour of basalt and glass fiber reinforced concrete (BFRC and GFRC, respectively), Kizilkanat et al. (2015) carried out an extensive experimental analysis. The goal of the study was to clarify how different fiber types affected how well concrete composites performed. The study found that both BFRC and GFRC showed improved mechanical qualities compared to ordinary concrete through a variety of mechanical tests and fracture analysis. While GFRC had greater toughness and energy absorption capabilities, BFRC showed greater compressive and flexural strengths. The results confirmed that both basalt and glass fibers may be used as efficient reinforcing materials to improve the mechanical properties of concrete. By highlighting the distinctive contributions of these two forms of fiber reinforcement in enhancing the general performance and fracture resistance of concrete buildings, this work offers important new insights to the area of construction materials.[17]

2.5 Effect of Steel Fibers:

A substantial advancement in our understanding of high-strength concrete reinforced with steel fibers is made by the study written by P. S. Song and S. Hwang. The study focuses on analyzing this specialized concrete variant's mechanical characteristics. To assess how steel fiber reinforcement affected the mechanical properties of the concrete, the scientists carried out extensive experimental investigations. Systematic research was done on important factors including compressive strength, flexural strength, and other pertinent mechanical qualities. The study sheds light on the impact of different steel fiber contents on the improvement of these qualities through a number of experiments. The research's conclusions highlight the beneficial effects of steel fiber reinforcing on high-strength concrete by demonstrating how it may improve compressive and flexural strengths. This important research advances our knowledge of fiber-reinforced concrete's capacity to satisfy contemporary building requirements, particularly where high mechanical performance is required. Strong experimental data back up the paper's findings, which may be used to guide the design and use of high-strength steel fiber-reinforced concrete in real-world engineering applications. The conclusions offered in this work are pertinent for researchers, engineers, and specialists engaged in the development and use of advanced concrete materials, as the construction industry is always looking for materials and techniques that can survive difficult circumstances. [18]

In the study A. Saleh, A. Fathy, A. Farouk, and M. Nasser, the performance of steel fiber reinforced concrete (SFRC) corbels is examined. Through experimental research, the authors examine the mechanical behavior and structural reaction of these corbels. The purpose of this study is to shed light on the use of steel fiber reinforcement to improve the ductility, load-carrying capacity, and overall performance of concrete corbels. The review emphasizes the importance of the study in meeting the structural needs of corbels, a significant building component. The study clarifies the potential advantages of enhancing the tensile and flexural qualities of concrete in corbel applications by introducing steel fibers. The research advances knowledge of the use of SFRC in structural components that are susceptible to a range of loads and stresses. For those working in the fields of structural engineering, concrete technology, and sustainable building techniques, this study is an invaluable resource. [19]

In their study, Holschemacher and Ribakov explore how steel fibers affect the mechanical properties of high-strength concrete. The impact of steel fiber incorporation on the mechanical characteristics of high-strength concrete is thoroughly investigated in the study. The authors explain the impact of different steel fiber fractions on important properties including compressive strength, flexural strength, and toughness through thorough testing and analysis. The study advances knowledge of composite materials used in structural applications by providing insightful information on how fiber reinforcement might improve the mechanical behavior of high-strength concrete. The study's conclusions have a great deal to do with the area of building materials since they may be used to improve concrete's performance and create stronger, more robust buildings.[20]

2.6 Effect of Hybrid Fibers:

The authors B. Robert and E. B. Brown, analyses the covariance structure of health-related variables among older people living at home, with the theme of subjective health perception as the main emphasis. The study explores the intricate interactions between many health-related factors and how the older people themselves perceive their own health state. In order to analyses the links between various indicators and reveal the complex interconnections between objective health metrics and the senior participants' subjective judgements of their well-being, the research uses a rigorous quantitative technique. The research contributes to our understanding of how subjective health perception interacts with more conventional objective health measurements through this thorough analysis, offering insightful information on the full evaluation of the health state of senior people. The importance of taking into account both subjective views and objective health indicators is highlighted in this work, which makes a significant addition to the fields of gerontology and health research. Its conclusions have ramifications for researchers, politicians, and healthcare professionals who want to create comprehensive plans for enhancing the well-being and quality of life of the ageing population.[21]

The Varona et al. (2018) Our understanding of how high temperatures impact the mechanical properties of hybrid fiber-reinforced concrete is significantly improved through study. The study examines the effects of high-temperature exposure on specimens of regular and high-strength concrete. The authors evaluate the effects of high temperatures on mechanical parameters such as compressive strength, tensile strength, and flexural strength while taking hybrid fibers into account. Steel and polypropylene fibers are used in conjunction to make up the hybrid fibers in the concrete matrix. The results show that regular and high-strength concrete react to heat differently, with both types of concrete showing decreased mechanical qualities. For evaluating the structural integrity and fire resistance of concrete structures in real-world settings, it is critical to have knowledge of how hybrid fiber-reinforced concrete performs at high temperatures. The findings of this study add to the body of knowledge on how building materials behave under severe circumstances and have practical implications for the durability and design of hybrid fiber-reinforced concrete buildings. The nuanced viewpoint offered in this work will be useful for researchers and practitioners in the fields of civil engineering and building materials.[22]

2.7 Constraints and Difficulties

Recycled aggregate concrete (RAC) is a sustainable construction material, but its effective integration and expanded use depend on addressing and enhancing its mechanical qualities. Through careful mix formulations, fiber reinforcement integration, and durability guarantee, RAC has the potential to offer a useful and environmentally friendly alternative to ordinary concrete by overcoming its inherent limits. Integrating RAC into construction methods will greatly aid in creating a built environment that is robust and ecologically aware as research on the material's properties continues to advance our understanding of it and its performance. By accepting RAC as a useful building material, the construction industry can make a huge step towards sustainable growth and a better future.

- Recycled aggregates come from a wide range of different sources, and as a result, they have a vast range of different properties. This unevenness may lead to variations in the mechanical and durability characteristics of RAC. It is essential to monitor and control the quality of recycled aggregates in order to guarantee uniform performance in concrete mixtures.
- Recycled aggregates frequently possess inferior mechanical qualities as compared to their native equivalents. As a result, the compressive, tensile, and flexural strengths of RAC's material may be compromised. The use of fiber reinforcements, the appropriate additives, and careful mix design are all viable remedies for this issue.
- Having trouble bonding Usually, residual mortar or other contaminants on the surfaces of recycled aggregates impede the interfacial interaction between those aggregates and the cementitious matrix. Inadequate bonding may endanger the durability and integrity of RAC. The right pre-processing and surface treatment must be applied to recycled aggregates in order to improve bonding and maximum RAC performance.
- The use of weaker materials, such as recycled bricks or tiles, and the higher water absorption capacity of recycled aggregates, raises questions regarding the longevity of RAC. The material may become more susceptible to abrasion, chemical attack, and freeze-thaw cycles as a result. Solving durability issues is crucial if RAC structures are to work well over time.
- The lack of uniform standards and specifications is one obstacle to the broad adoption of RAC in the construction sector. Engineers and contractors can be reluctant to apply RAC in mission-critical environments due to a lack of rules.
- Despite the environmental advantages of RAC, the building industry may be sluggish

to adopt it because to concerns over its mechanical attributes, long-term performance, and durability. To increase awareness and inform people about the advantages and drawbacks of RAC, it is essential to advocate its adoption and use.

- Manufacturing RAC may cost more than manufacturing conventional concrete if tight quality control procedures and specific processing are required for recycled aggregates. The environmental advantages of RAC must be evaluated against its cost-effectiveness before it is widely used.
- Despite having potential as a green building material, recycled aggregate concrete (RAC) is not without its disadvantages. These issues include the difficulties in regulating the quality of the recycled aggregates utilized, the completed product's lower mechanical qualities, bonding issues, concerns about durability, a lack of standards, and reservations about the material's reputation and cost. It is crucial that these difficulties be addressed by ongoing research, technological advancements, and concerted efforts among stakeholders if RAC is to completely achieve its promise and overcome its existing limitations. Through the implementation of innovative solutions and the promotion of sustainable practices, the construction industry may effectively employ RAC to build a more resilient and sustainable built environment.

Chapter 3

3 RESEARCH METHODOLOGY

3.1 General:

The materials utilized in the experimental investigation are described in full in the technique section. This involves identifying the kind and origin of the components used in the concrete mix, such as the cement, aggregates (both new and used), water, and chemical admixtures. Along with their qualities and doses in the concrete mix, the silica fume and hybrid fibers utilized in the study are also discussed.

The precise ratios of the different elements used in the concrete mix are provided by the mix proportions, which are subsequently detailed. Included in this are the kinds and volume fractions of hybrid fibers used, as well as the proportion of silica fume. For the trial results to be consistent and repeatable, the mix design is essential.

3.2 Materials:

- Cement: Ordinary Portland cement 53 grade.
- Recycled Aggregate
- Hybrid Glass Fiber
- Steel fiber
- Silica fume
- Sand

Concrete could be portrayed as "a material with cement and durable properties that make it equipped for holding the mineral parts (total) into reduced entirety". The bond utilized during the time spent making cement is called pressure-driven concrete. It is so named as a result of its concoction response with water in an exothermic procedure.

The most widely recognized kind of pressure-driven bond utilized in assembling concrete is the cement which is accessible in different structures. Cement is made by consuming together an expedient blend (as a slurry) of limestone with alumina, silica, and iron oxide to about 400C. The concrete utilized is a FAUJI OPC evaluation bond. Tests were led on a bond are consistency test, setting time test, soundness test, and compressive quality N/mm2 at 28 days.

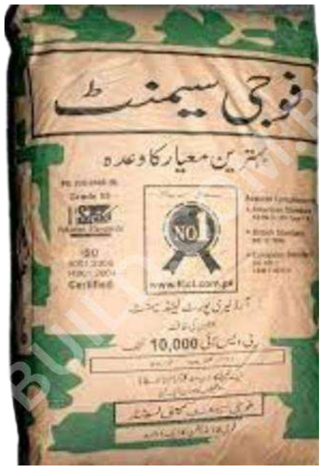


Figure 3.1 cement bag

3.2.1 Recycled Aggregate:

Trash generated during building and demolition is converted into recycled aggregate, which lessens the environmental effect of trash disposal. It provides a long-term substitute for natural aggregates in the manufacture of concrete, aiding in resource preservation and supporting green building techniques.

Table 3-1 Recycled Aggregates Properties

COARSE AGGREGATE	RESULT	RANGE	CODE
SPECIFIC GRAVITY	2.8	2.4-2.9	ASTM-C128
WATER ABSORPTION	0.5	0.2-2	ASTM-C128
BULK DENSITY KG/M3	1551	1200-1750	ASTM C29
FINENESS MODULUS	3.4	-	ASTM C33

3.2.2 Fine Aggregate

Sand serves as the fine aggregate, which is a key component of mortar and concrete compositions. It fills the spaces left by the coarse aggregates, making the mixture easier to work with and giving it more cohesiveness. The overall strength, durability, and shrinkage control of the concrete are enhanced by the fine aggregate. The qualities of the construction material are directly influenced by the particle size, shape, and grading. In order to achieve the appropriate strength and finish in a variety of building applications, smoother, more cohesive, and high-performance concrete is a need. A well-graded and clean fine aggregate promotes better bonding between cement and aggregates.

Table 3-2 Fine Aggregates Properties

SAND	RESULT	RANGE	CODE
SPECIFIC GRAVITY	2.46	2.4-2.9	ASTM C128
WATER ABSORPTION %	2.86	0.2-4	ASTM C128
BULK DENSITY KG/M3	1524	1200-1750	ASTM C29
FINENESS MODULUS	2.36	2.3-3.1	ASTM C33

3.2.3 Silica Fume:

Silica fume, a waste product of the manufacturing of silicon and ferrosilicon alloys, is a very potent additional cementitious ingredient. Its inclusion to concrete improves mechanical qualities including compressive strength, durability, and resistance to harsh conditions since it contains ultrafine particles. Silica fume fills gaps in the concrete matrix by forming extra calcium silicate hydrate gel due to its strong pozzolanic reactivity. Due to this densification, permeability is decreased, and abrasion and chemical resistance are both enhanced. Silica fume, a material used in a variety of building projects, is essential for creating high-performance, long-lasting concrete structures while minimizing environmental effect.

Figure 3.2 Silica fume

3.2.4 Hybrid Glass Fiber:

Hybrid glass fiber, an innovative reinforcement in the construction field, amalgamates the strength of glass fibers with other materials for enhanced performance. Its exceptional properties, including high tensile strength, corrosion resistance, and low weight, make it an ideal choice for various applications. In concrete, hybrid glass fibers improve flexural and impact resistance, enabling the creation of more durable and resilient structures. Moreover, its versatility extends to reinforcing composites, asphalt, and geotechnical applications. As a sustainable solution, hybrid glass fiber promotes eco-friendly practices while elevating construction standards, solidifying its status as a cutting-edge material, poised to revolutionize the industry.

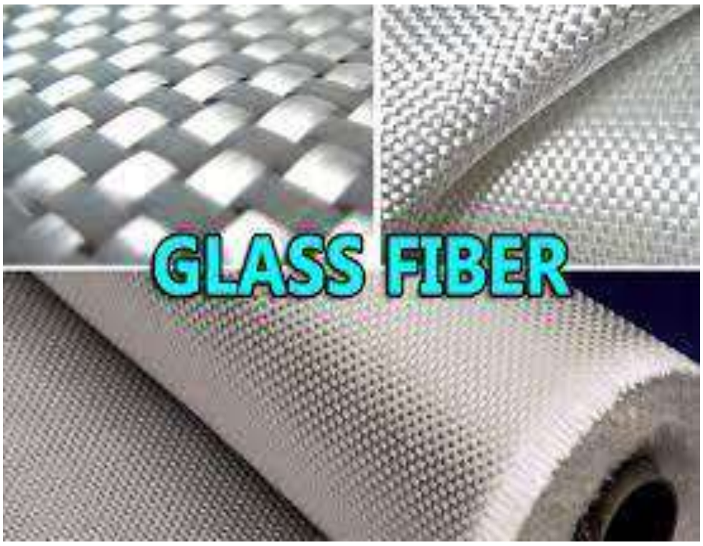


Figure 3.3 Hybrid Glass Fiber

3.2.5 Steel Fiber

These are the small pieces of steel from lathe machines or other residuals of steel working machines. The length and dia of steel fiber will be 35mm to 37mm and 0.5mm to 0.6mm. The aspect ratio ranges from 58.3 to 73.

Figure 3.4 Steel Fiber

3.3 Experimental Work:

3.3.1 Tests:

3.3.1.1 Sieve Analysis:

Procedure:

First, arrange the sieve set in descending order. It means that each lower sieve in the column has tiny holes than the one above. i.e., #5 on the top then #10, #20, #40, #100, #200 at the bottom. Also, attach the pan (receiver) at the bottom. Take a sample of the material (i.e., we took 1 kg ceramic waste sample) and pour it into the top sieve using a scope. Now put the whole assembly in the sieve shaker for some time until completion of the shaking. After completion of the shaking weigh the material retained on each sieve and note the reading. To obtain the %age retained on each sieve the mass of the retained sample is divided by the total mass. Percentage retained = [retained material on a specified sieve ÷ Total mass of material] x100. Add up the retained material on a sieve and the amount of material retained on the previous one to calculate the cumulative percent retained. To calculate the percent passing, subtract the percent taken from 100%.

i.e., %Cumulative Passing = 100% - %Cumulative Retained

from these values then the graph is drawn

on y-axis %passing and the x-axis logarithmic sieve size.

3.3.1.2 Fine Aggregates:

Table 3-3 Sieve Analysis of Sand Properties

Sieve Size No	Sieve Size Mm	Cummulative Wt Retain (Gm)	% Weight Retain	% Passing 100-%Wt Retain	Range Max	Range Min
3/8	9.5	0	0	100	100	100
4	4.75	0	0	100	100	95
8	2.36	4.2	0.42	99.58	100	80
16	1.18	141.4	14.14	85.86	85	50
30	0.6	416	41.6	58.4	60	25
50	0.3	643	74.3	25.7	30	5
100	0.15	1000	100	0	10	0

3.3.1.3 Recycled Aggregates:

Table 3-4 Sieve Analysis of Recycled Aggregates Properties

SIEVE NO	SIZE mm	CUMMULATIVE WT RETAIN (gm)	% WEIGHT RETAIN	% PASSING 100- % WT RETAIN	RANGE MAX	MIN
1.5	**37.5**	0	0	100	100	100
1	**25**	0	0	100	100	100
¾	**19**	29	1.45	98.55	100	90
½	**12.5**	1369	68.45	35.25	80	35
3/8	**9.5**	1638	81.9	21.5	55	20
#4	**4.75**	1996	99.8	0.2	10	0
#8	**2.36**	1998	99.9	0.1	5	0

3.3.1.4 Slump Cone test:

Procedure:

Take a cone with the measurements 100mm x 200mm x 300mm top distance across, base width and stature of the cone separately. Place and immovably held the cone on the baseplate or plate or any smooth surface with the goal that the shape couldn't move (aggravate) during the pouring of cement. Filled it with three layers of cement with packing 25 blows each layer utilizing a standard packing pole. After complete filling of the shape, evacuate the surplus cement with the assistance of rolling and screening movement of temping bar. Now cautiously and step by step lift the cone, a solid slump without help will frame with lessening in stature. This decline in tallness is known as a slump.

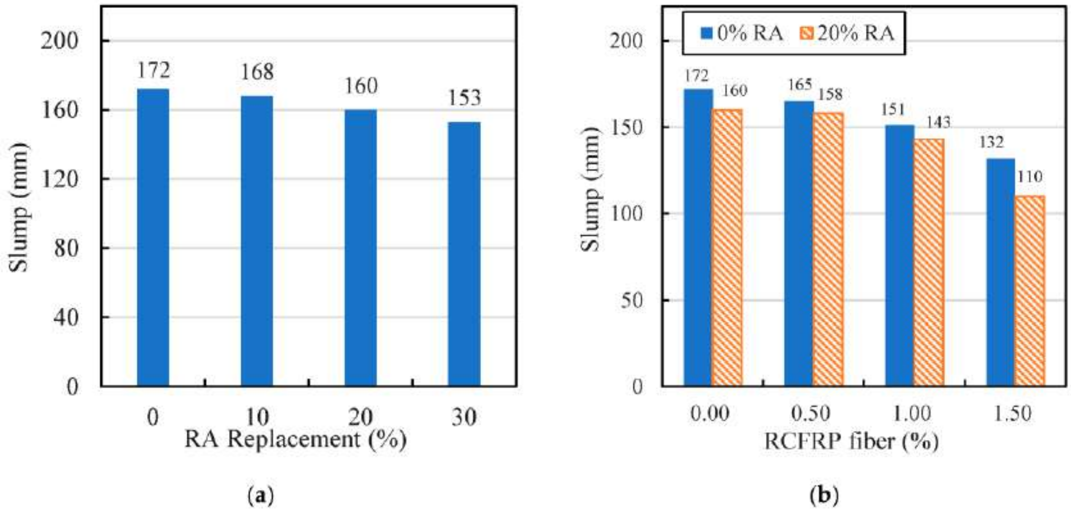


Figure 3.5 Graph of a slump

3.3.1.5 Impact Resistance Analysis

The final aspect of the results chapter focuses on the impact resistance of the RAC specimens with silica fume and hybrid glass-steel fibre reinforcement. According to the testing results, the hybrid fibres considerably increase the concrete's capacity to absorb and disperse energy in response to impact loading. Due to its essential impact resistance, the material is suited for use in applications including industrial floors, pavements, and blast-resistant constructions. The presence of silica fume further enhances the concrete's overall strength and toughness, contributing to its ability to withstand dynamic loads and impact forces. The combination of hybrid fibers and silica fume results in a high-performance concrete material with superior impact resistance properties.

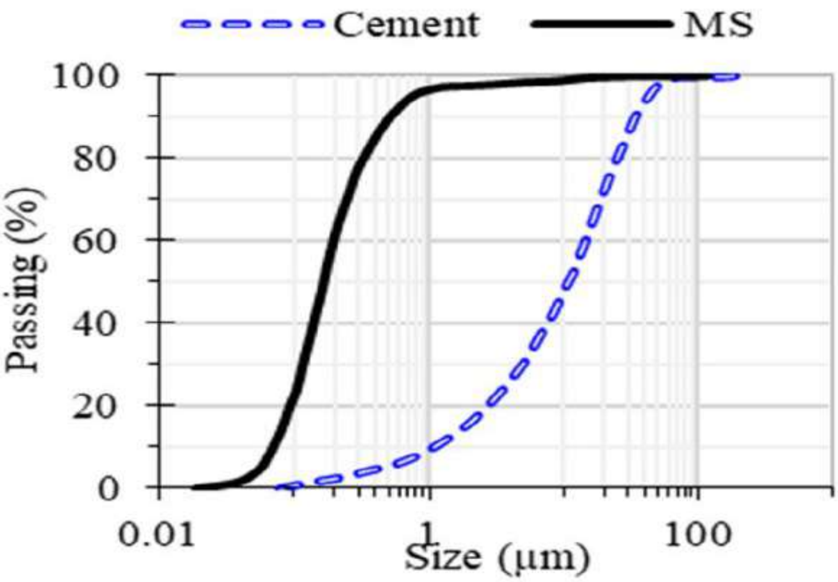


Figure 3.6 Graph of a IRA

CHAPTER 4

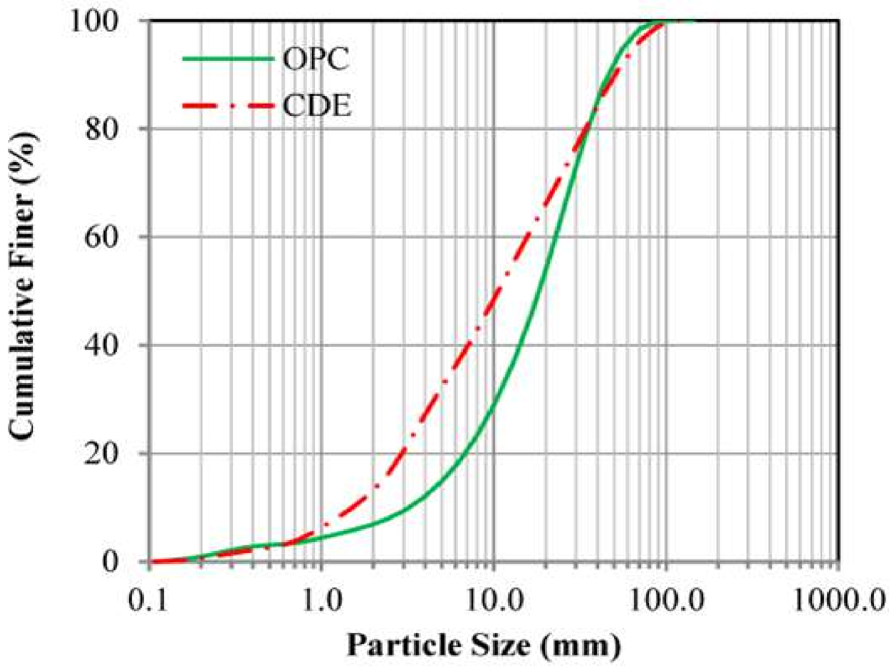
4 RESULTS AND DISCUSSION

4.1 Overview:

To fulfill the scope of the project split tensile test, slump test, and compressive strength were performed. The results were collected and analyzed by response surface methodology. The compression test was performed on a 6”x12” (150mm*300mm) cylinder while the tensile test was performed on a 4” x 4” (150mm*150mm) cube. The results of slump test, compressive strength, tensile strength in this chapter relate them with basic engineering properties of ordinary strength concrete. Tests on specimens

4.1.1 Particle size distribution and gradation curve

As stated in the literature and ASTM standard the incorporation of powder materials with different particle size distribution and morphology improves the packing density, reduces inter-particle friction and density. Therefore, the sieve analysis test is to analyze the distribution of particle sizes and the gradation curve of each of the powder i.e., fine aggregate so by sieve

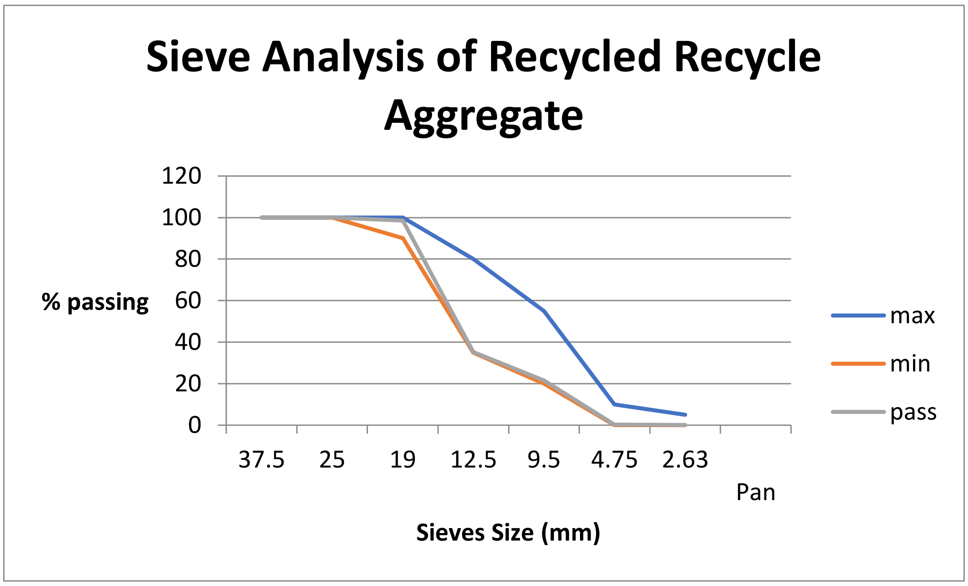


Graph 4.1 Particle Size Distribution and Gradation Curve

analysis of sand we get the fineness modulus of sand which is 2.36 which come in the range of fine aggregate according to ASTM standard.

4.1.2 particle size distribution of Recycled Aggregates

sieve analysis was completed to analyze the size conveyance of all the used totals utilizing sifter sizes which are regularly applied for reviewing reasons as per ASTM C33. Reviewing of totals chiefly expected to deliver concrete with sensible workability and least segregation.



Graph 4.2 Particle Size Distribution of Recycle aggregate

4.1.3 Density test

Table 4.1 Density test

Trial No	% RCA	% NCA	Silica Fume	Steel Fiber	Glass Fiber	Density (kg/m3) 28 Days
Mix ID 1	100	0	0	0	0	0.037
Mix ID 2	0	100	0	0	0	0.039
Mix ID 3	100	0	10	0	0	0.037
Mix ID 4	100	0	10	0.5	0	0.038
Mix ID 5	100	0	10	1	0	0.038
Mix ID 6	100	0	10	0	0.5	0.037
Mix ID 7	100	0	10	0	1	0.038
Mix ID 8	100	0	10	0.5	0.5	0.039
Mix ID 9	100	0	10	1	0.5	0.037
Mix ID 10	100	0	10	0.5	1	0.037
Mix ID 11	100	0	10	1	1	0.036

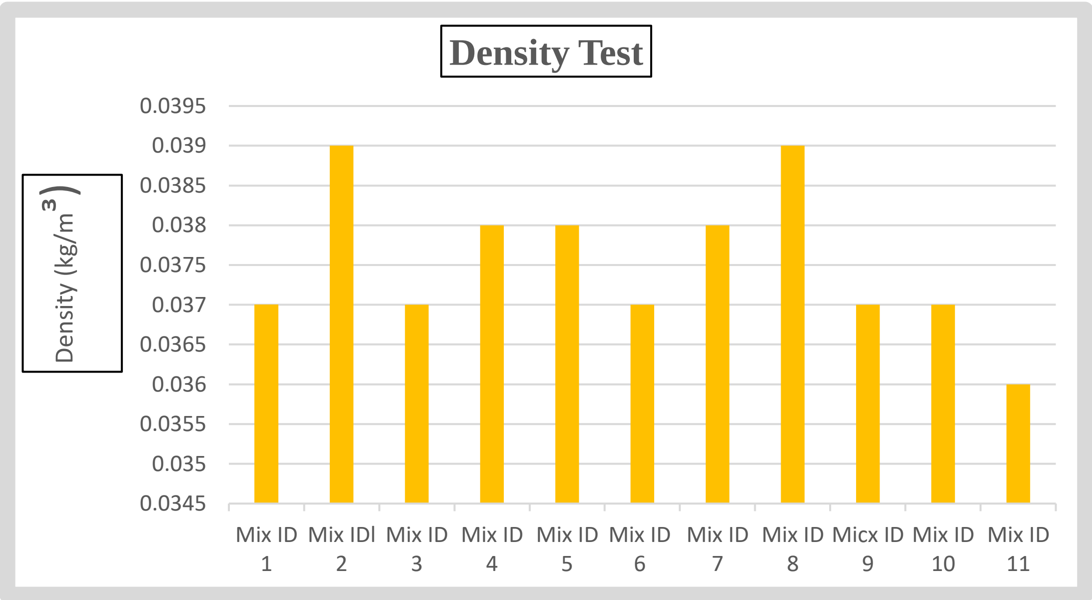
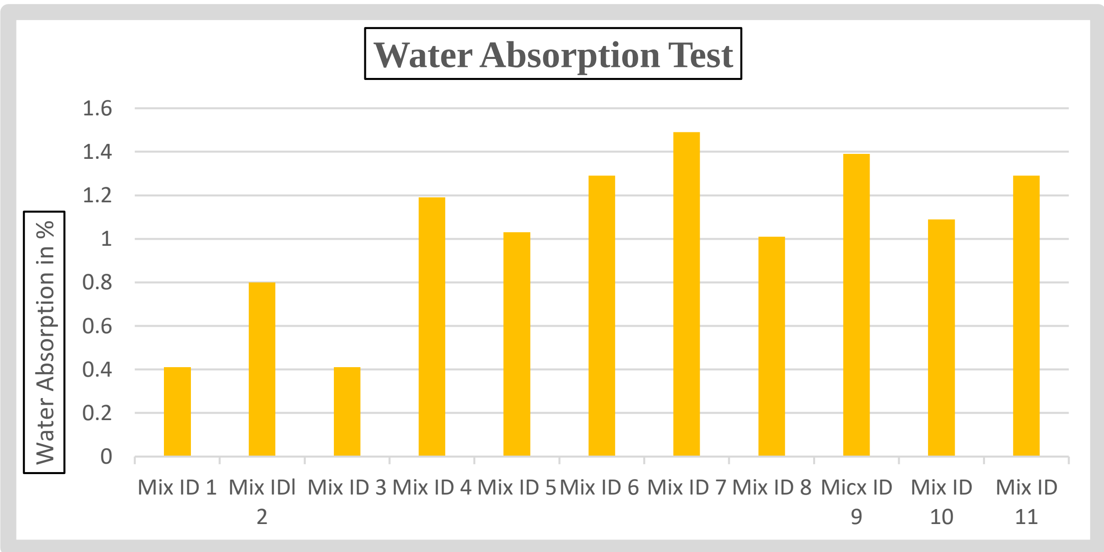


Figure 4.3 Density Test

4.1.4 Water Absorption Test

Table 4.2 Water absorption test

Trial No	% RCA	% NCA	Silica Fume	Steel Fiber	Glass Fiber	Water absorption Test (%)
						28 Days
Mix ID 1	100	0	0	0	0	0.41
Mix ID 2	0	100	0	0	0	0.80
Mix ID 3	100	0	10	0	0	0.41
Mix ID 4	100	0	10	0.5	0	1.19
Mix ID 5	100	0	10	1	0	1.03
Mix ID 6	100	0	10	0	0.5	1.29
Mix ID 7	100	0	10	0	1	1.49
Mix ID 8	100	0	10	0.5	0.5	1.01
Mix ID 9	100	0	10	1	0.5	1.39
Mix ID 10	100	0	10	0.5	1	1.09
Mix ID 11	100	0	10	1	1	1.29



Fugure 4.4 Water absorption test

4.1.5 Compressive Strength test

We have calculated the compressive strength of the cube samples by the use of the formula:

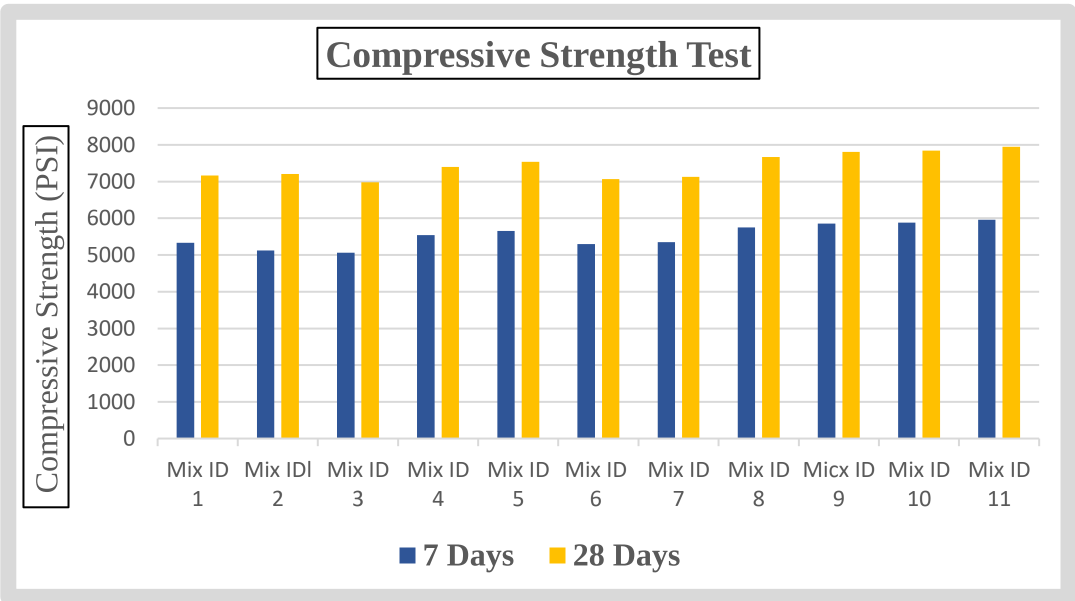
fc=P/A N/mm2 Where

P = Load at failure in N A=Area which is perpendicular to compression load (mm2)

(a) (b)

Table 4.3 Compressive Strength test

Trial No	% RCA	% NCA	Silica Fume	Steel Fiber	Glass Fiber	Compressive Strength PSI	
						7 Days	28 Days
Mix ID 1	100	0	0	0	0	5331.47	7163.36
Mix ID 2	0	100	0	0	0	5120.34	7206.47
Mix ID 3	100	0	10	0	0	5060.04	6975.55
Mix ID 4	100	0	10	0.5	0	5544.84	7393.12
Mix ID 5	100	0	10	1	0	5654.03	7538.70
Mix ID 6	100	0	10	0	0.5	5300.09	7066.79
Mix ID 7	100	0	10	0	1	5348.28	7131.04
Mix ID 8	100	0	10	0.5	0.5	5750.13	7666.84
Mix ID 9	100	0	10	1	0.5	5857.64	7810.18
Mix ID 10	100	0	10	0.5	1	5879.62	7839.39
Mix ID 11	100	0	10	1	1	5961.21	7948.26



Graph 4.5 Compressive Strength test

4.1.6 Split tensile strength:

The split tensile test of the samples is to find out with the help of the following relationship:

Where, P = Load at failure in N.

L = Length of the Specimen in mm

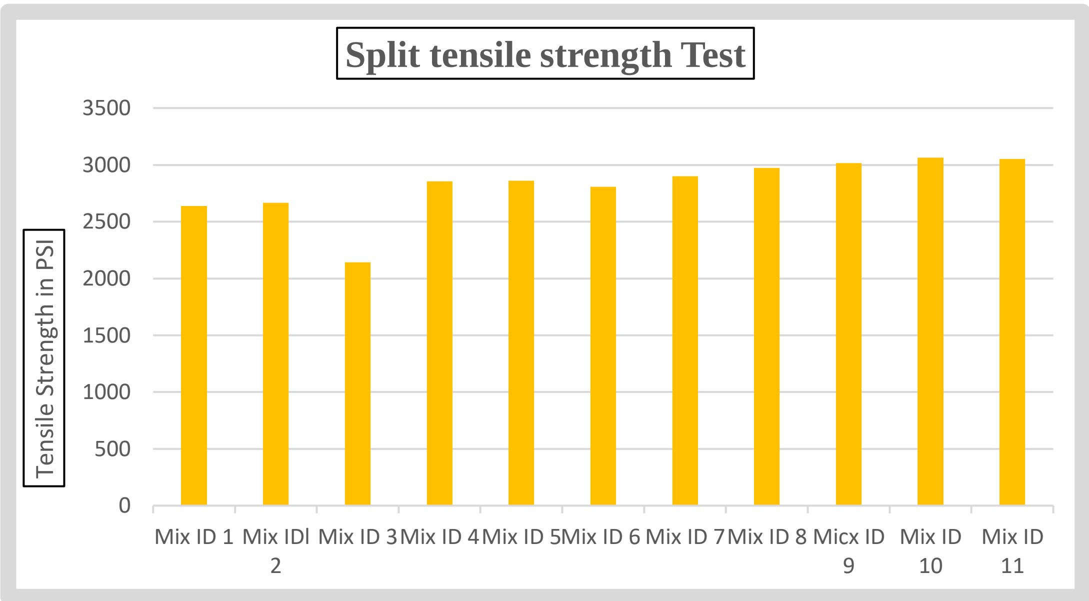
d = Diameter of the Specimen in mm

(a)

(b)

Table 4.4 Split tensile strength test

Trial No	% RCA	% NCA	Silica Fume	Steel Fiber	Glass Fiber	Split Tensile Strength (PSI)
						28 Days
Mix ID 1	100	0	0	0	0	2639.06
Mix ID 2	0	100	0	0	0	2666.11
Mix ID 3	100	0	10	0	0	2143.65
Mix ID 4	100	0	10	0.5	0	2856.04
Mix ID 5	100	0	10	1	0	2859.56
Mix ID 6	100	0	10	0	0.5	2806.44
Mix ID 7	100	0	10	0	1	2901.62
Mix ID 8	100	0	10	0.5	0.5	2973.59
Mix ID 9	100	0	10	1	0.5	3016.87
Mix ID 10	100	0	10	0.5	1	3064.34
Mix ID 11	100	0	10	1	1	3052.17



Graph 4.6 Split tensile strength test

Chapter 5

5 CONCLUSIONS

In the current study, the combined effect of silica fume, steel fiber, and glass fiber on the mechanical characteristics of concrete using recycled concrete aggregate (RCA) was investigated. From the study, the following findings may be drawn.

- Cost decrease by the partial replacement of Silica fume and recycled coarse aggregate.
- compressive strength of the concrete decrease when we increase the quantity of silica fume and recycled coarse aggregate.
- Increasing silica fume & RCA percentage had increased the water absorption.
- The density of the normal concrete then that of the other mixes containing silica fume, steel fiber, glass fiber and recycled coarse aggregate.
- for all curing stages, the values of the compressive strength and split tensile strength of normal concrete were more than that of the other mixes.
- The propagation of crack becomes less as the percentage of fiber increases.
- The concrete made in the study is suitable for use in Residential constructions and single-story storage buildings.

5.1 Environmental benefits in using Sawdust and Recycled Aggregates:

Investigating sustainable construction methods has become of utmost importance in today's society, where environmental problems are getting more and more urgent. One such technique tries to both enhance the structural performance of concrete and minimize the environmental impact of construction processes by creatively using resources like recycled aggregates and silica fume. The manufacturing of silicon and ferrosilicon alloys produces silica fume, which is distinguished by its tiny particle form. Because silica fume may improve mechanical qualities including compressive strength and durability, it has attracted attention when added to concrete. Its environmental advantages go above and beyond these performance enhancements, though. Cement, a crucial component in the creation of concrete that is responsible for a sizeable amount of carbon emissions, may be greatly reduced by using silica fume instead. There is a significant quantity of carbon dioxide released into the environment during the energy-intensive process of making cement. Therefore, reducing the amount of cement used by adding silica fume helps to reduce carbon emissions and promote a more sustainable building sector. Recycled aggregates, a crucial element of ecologically responsible building, entail the reuse of demolition debris and scrap concrete. By avoiding landfills, this practice not only protects natural resources but also prevents the environmental harm caused by building and demolition waste. Recycled aggregates can replace virgin aggregates in concrete mixtures, which lessens the impact that their extraction and transportation have on the environment. The building industry benefits from the use of recycled aggregates since resources are reused rather than being thrown away. Using recycled aggregates and silica fume together offers a comprehensive strategy for environmentally friendly building. The use of silica fume reduces the need for cement, which is in line with efforts to minimize carbon emissions and promote a greener future. Utilizing recycled aggregates addresses the problem of trash accumulation while reducing the usage of natural resources.

Sustainability Performance

Additionally, this interaction can increase concrete's performance, which will ultimately result in structures that last longer and need less maintenance and replacement. The building sector may lessen its environmental impact while increasing its contribution to sustainable development by making the best use of these resources

In conclusion, the use of recycled aggregates and silica fume in concrete manufacturing represents a move towards a more ecologically conscious building sector. This method helps to lessen trash accumulation and carbon emissions while also enhancing the structural integrity of concrete. Adopting such creative practices is crucial to creating a more resilient and environmentally harmonious future as sustainability continues to be prioritized by society.

5.1.1 Recommendations for Future Studies:

1. In the future, more investigation and laboratory test should be done on concrete containing silica fume, steel fiber glass fiber and hybrid fiber and recycled coarse aggregate. It is recommended that test should be done on concrete slab and beams.
2. To improve the strength cementitious materials such as fly ash, Sawdust can be used.
3. To improve the strength, new fiber should be used instead of Steel fiber and compare the result.
4. More trials with different sizes of recycled aggregate should be used and compare the result.

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