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INVESTIGATION THE STRENGTH OF RECYCLED CONCRETE WITH RECYCLED AGGREGATE AND GLASS FIBER IN BUILDING STRUCTURE APPLICATION

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Master's Thesis

Supervisor

Prof. Dr. Zeki HASGÜR

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The thesis titled INVESTIGATING THE STRENGTH OF RECYCLED CONCRETE WITH RECYCLED AGGREGATE AND GLASS FIBER IN BUILDING STRUCTURE APPLICATION prepared by MAHMOOD ALBANNA and submitted on 17/08/2023 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering.

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ABSTRACT

INVESTIGATION THE STRENGTH OF RECYCLED CONCRETE WITH RECYCLED AGGREGATE AND GLASS FIBER IN BUILDING STRUCTURE APPLICATION

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The durability of recycled concrete reinforced with glass fiber over time is essential to its use as a construction material. While it's true that recycled materials have a number of immediate advantages, you need also think about how they'll hold up in the long run. Due to its environmental benefits, the use of recycled materials in building construction has gained appeal in recent years. Using recycled products helps conserve energy, lessen trash, and lessen the environmental impact. Research done so far suggests that recycled concrete's compressive strength can be improved by incorporating glass fibers into the mix. Recycled concrete with 1.5% glass fiber had 11.4% greater compressive strength than recycled concrete without glass fiber. Fibers of Glass Glass fibers can be used to mechanically improve recycled concrete, but the right proportion needs to be identified in advance. The production costs go up and the strength goes up as more glass fiber is used. The optimal glass fiber composition for strength and durability is established by weighing the costs and benefits.

Keywords: Fiber Glass, Recycled Concrete, Compressive Strength, Tensile Strength, Flexural Strength.

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ABBREVIATIONS

GF : With Glass Fiber

RC : Recycled Concrete

1. INTRODUCTION

Concrete consists of a number of different components. When fully cured, this mixture solidifies into a block of stone. Concrete is a major engineering challenge because of its widespread usage in the building industry. One of the most important structural qualities of concrete is its compressive strength. Concrete grades are an established industry standard. The compressive strength of the material is used to determine the grade. In the plastic phase, aggregates affect the concrete's water need, cohesiveness, and workability; in the hardened phase, they affect the concrete's strength, density, durability, permeability, surface finish, and color. After curing, the concrete should be very sturdy, resistant, and effective [1]. An examination of the severely damaged reinforced concrete structures caused by recent earthquakes revealed that fundamental data about the concrete was not utilized and appropriate inspections were not conducted. The most essential requirement for strength and resistivity is to produce concrete with as little void space and as much impermeability as feasible. The problem of producing concrete with the desired characteristics has been resolved. It is essential to remember that producing concrete requires sophisticated equipment and skilled labor [2]. By paying close attention to the aggregate quality, minimum dosage, and maximum water-to-cement ratio, it is possible to produce concrete with the desired performance. Nevertheless, the efficacy of the concrete differs according to the condition of the weights. Under seismic loads, reinforced concrete structures must adhere to the principles of sufficient rigidity, strength, and ductility [3].

1.1 GF CONCRETE

Concrete with Glass Fiber (GF) has been extensive research into the properties of the materials due to their widespread use. The GF family of composite materials has considerably improved impact resistance on top of the tremendous compressive strength of cement mortars [4]. The compressive and flexural forces come from the fiber reinforcement. GF products are safe for human consumption, impervious to chemicals, and durable against decay and corrosion. It's a lightweight, durable material that can be molded into almost any form, hue, or grain. The economic, environmental, technical, and visual benefits it offers have led to its rapid adoption by the global construction industry [5]. Due to its low energy and natural raw material consumption, it is one of the most eco-friendly choices available, and it can be tailored to meet a variety of requirements in terms of efficiency, aesthetics, and budget. Composed of Cem-Fll alkali-resistant glass fibers, small aggregate, and hydraulic cement mortar, this substance is a hybrid. The GF can be modified by adding fillers, pozzolanic components, and admixtures [6].

1.2 CRUSHED CONCRETE AGREGATE

Interest in using recycled concrete has increased worldwide due to several environmental, financial, and energy problems. Two major environmental issues are the loss of natural supplies of high-quality aggregate materials and the possibility of groundwater pollution from the washing out of new concrete carried back from construction sites. When utilized properly, concrete constructed from recycled resources may save costs and energy use [7]. Repercussions on the Economy and the Environment There are growing concerns about the abundance of native aggregate sources due to the construction industry's rapid growth. Recent estimates project a need for 48.3 billion metric tons of building material by 2015. This growth will be driven primarily by the construction industry in Asia and the Pacific. The accumulation of trash from building projects is directly proportional to the growth in demand. As an illustration, in European Union nations, construction debris makes up about 31% of annual waste production. Equally impressive, in 2011, Hong Kong generated about 20 million pounds of trash, or about half of the world's total. The most typical method of dealing with construction waste is to dispose of it in landfills, leading to enormous mountains of garbage from both the construction and dismantling phases [8].

The use of up to 10% recovered aggregate in various building uses is the outcome of efforts to restrict this practice and promote reprocessing of construction and deconstruction debris. There are many monetary and ecological benefits to reusing concrete. The expense of dumping construction detritus in landfills continues to rise, and transporting it to a new site adds even more money [9]. Spending less on collection, sorting, and dumping is how recycling helps the budget. Many construction companies and private citizens can no longer afford to discard of materials like concrete because of rising costs and tighter regulations on dumps. Recycling concrete is also very helpful for the planet. Many landfills aren't equipped to deal with concrete waste because of its bulk and weight. By diverting them from dumps, these recyclables find new life in a variety of applications. Energy that would have been used to mine, prepare, and move fresh aggregates is saved through recycling. There are benefits unique to repurposed gravel use. For instance, because recovered is 15% lighter than fresh CA6, you'll receive 15% more cubic feet per ton. This could be helpful when attempting to predict how much raw materials a given undertaking will require [10].

1.3 PROBLEM STATEMENT

Concrete is susceptible to fragility due to weak aggregate, and the quality of the aggregate used in the production of any concrete directly affects the concrete's tensile strength. It is challenging to determine the effects of the flexural forces operating on the concrete construction because of this reciprocal interference. The factors that have the greatest technical influence on punching development are evaluated and decided in various methods. Brittleness and extreme deflection are the main problems caused by the exterior forces. This might be as a result of the concrete's brittleness, which leads to a buildup of tensile force and modifies the material's structural behavior. The compressive values of concrete made with recycled concrete gravel and concrete produced with natural material differ somewhat. In partially laden panels, a number of techniques have been proposed to reduce brittleness and boost resilience to shear action. Although shear reinforcements are frequently used in contemporary building, it is still unclear whether GF Reinforced Concrete can make up for recovered aggregate concrete's reduced tensile strength and coefficient of elasticity.

1.4 OBJECTIVE OF STUDY

The objectives of this study are:

a. Preparation of different concrete mix designs for recycling old crushed concrete.

b. Preparation of different concrete mix designs for Glass fiber volume fraction concrete.

c. Investigation of the effect of recycling old crushed concrete with Glass fiber volume fraction.

1.5 THESIS ORGANIZATION

The thesis consists of five chapters. The first chapter provides an overview of reprocessing old pulverized concrete and glass fiber concrete. The second chapter provides a general overview of concrete varieties, as well as the effects of recycling old pulverized concrete and the behavior of concrete containing glass fiber, as gleaned from various studies. In other words, a comparison of analogous works from the past.

Chapter three presents the experimental program, including the investigated parameters, the work methodology, and the simulation of the recycling of old pulverized concrete specimens.

The fourth chapter discusses the result and the labor calculation. The fifth chapter is the conclusion.

2. LITERATURE REVIEW

2.1 OVERVIEW

When it comes to depleting natural resources and producing garbage, the building sector is among the worst offenders. Traditional concrete construction is a major test for the building industry since it calls for the use of vast amounts of natural aggregates, the mining of which contributes to environmental damage via the release of toxic byproducts [1].

To tackle this issue, the use of recycled materials in concrete production has become increasingly popular in recent years. Recycled concrete is produced by crushing and reusing waste concrete, while recycled aggregates are made by processing waste construction and demolition materials. These recycled materials are viewed as more sustainable and environmentally friendly than traditional concrete due to their ability to decrease waste production and the demand for natural resources [2].

However, one of the major obstacles to using recycled materials in concrete is that it may have lower strength and durability than traditional concrete. Therefore, there is a need to investigate this same durability and strength of concrete made, as well as potential improvements to its characteristics.

The incorporation of glass fibers as reinforcement in concrete is a potential solution to enhance the strength and durability of recycled concrete. Glass fibers are produced by melting glass and drawing it into thin strands, which can be incorporated into concrete to increase its strength and durability. Using of glass fibers in the recycled concrete has the potential to improve its properties and make it a more viable alternative to traditional concrete [3].

Reducing the environmental effect of the construction industry may be greatly aided by studying the durability of recycled concrete using recycled aggregate and glass fiber in building structure applications. By using recycled resources in concrete manufacturing, the building sector may become more eco-friendly and sustainable [4].

Research studies have shown that recycled concrete and recycled aggregate have lower strength and durability than traditional concrete. However, the use of glass fibers as reinforcement in recycled concrete has been found to improve its mechanical properties, including compressive and flexural strength, as well as durability [5].

The combination of glass fibers in recycled concrete can be achieved through various methods, including the direct addition of glass fibers to recycled concrete and the pre-treatment of glass fibers. The best method for integrating glass fibers into recycled concrete is determined by multiple variables, including the desired characteristics of the end product and also the type of fiberglass used [6].

In addition to enhancing the properties of recycled concrete, the use of recycled materials in building structures has several benefits. These include reducing waste generation and the demand for natural resources, as well as decreasing the carbon footprint of the construction industry.

Despite the potential advantages of using recycled concrete with recycled aggregate and glass fiber in building structures, there are still some challenges that need to be addressed [7]. These include the high variability of recycled materials, the lack of standardization, and the absence of ongoing performance information on concrete made in different environments [8].

In conclusion, studying the durability of recycled concrete made from recycled aggregate and glass fiber in building structure applications is an important line of inquiry that has the potential to lessen the environmental impact of the construction sector. Glass fibers may improve the mechanical qualities and durability of recycled concrete, contributing to a more sustainable and ecologically friendly construction sector that makes use of recycled resources in concrete manufacturing. There has to be more study done on the pros and downsides of using recycled materials in building construction in order to provide universally accepted rules for their use [9].

2.2 PROPERTIES OF RECYCLED CONCRETE AND RECYCLED AGGREGATE

Recycling is a key strategy in sustainable construction and is widely used to reduce the environmental impact of construction materials. Recycled concrete and recycled aggregates are popular building materials that have been used in various construction projects due to their numerous benefits, including cost-effectiveness, energy conservation, and waste reduction [10].

Recycled concrete and recycled aggregate are produced by crushing and sorting waste concrete from demolished buildings and structures [11]. The resulting recycled materials can be used as a replacement for natural aggregates in new construction projects. Recycled concrete and recycled aggregates can have different properties compared to traditional concrete, which can affect their use in construction applications.

Strength is one of the most important characteristics of recycled concrete and recycled aggregate. Recycled aggregate strength is affected by a number of variables, including cement type, original concrete quality, recycling water use, and aggregate gradation [12]. Recycled concrete and recycled aggregate can exhibit lower strength compared to traditional concrete due to the presence of impurities and the lack of a consistent grading curve. However, researchers have found that with proper processing and grading, recycled concrete and recycled aggregate can achieve comparable strength to traditional concrete [13].

The durability of concrete made as well as recycled aggregate is yet another important feature. Durability is a critical factor in construction materials since it determines the lifespan of the structure. The durability of recycled concrete and recycled aggregate is mainly affected by the type of cement used, the water-to-cement ratio, and the presence of impurities. The high content of impurities in recycled aggregate can lead to a reduction in durability due to the growth in the permeability for the building [14].

The water content absorption capacity of the recycled concrete and recycled aggregate is another important property. High water absorption capacity can lead to reduced strength and durability owing the increased amount of water existing in the concrete. The water absorption capacity of recycled concrete and recycled aggregate is influenced by factors such as the porosity of the recycled aggregate, the size distribution of the aggregate, and the curing conditions [15].

Recycled concrete and recycled aggregate are also known for their good thermal insulation properties. The thermal insulation properties of recycled concrete and recycled aggregate can contribute to reducing the energy consumption of the building, leading to cost savings and a reduced carbon footprint.

In addition to the above-mentioned properties, recycled concrete and recycled aggregate can also exhibit different rheological and deformation characteristics compared to traditional concrete. The rheological properties of the recycled concrete can affect the workability of the concrete, which can impact the placement and compaction of the concrete during construction. The deformation characteristics of recycled concrete and recycled aggregate can affect the long-term behavior of the structure and its ability to withstand external loads [16].

In conclusion, recycled concrete and recycled aggregate have properties that can make them viable alternatives to traditional concrete in building structures. Their properties, such as strength, durability, water absorption, thermal insulation, and rheological characteristics, can be influenced by various factors such as the quality of the original concrete, the processing techniques used, and the type of cement used. The ability to achieve comparable properties to traditional concrete is a crucial factor in their use in construction projects. The application of standardized quality control methods and grading curves can help ensure the quality and consistency of recycled concrete and recycled aggregate [17].

2.3 ROLE OF GLASS FIBERS IN CONCRETE REINFORCEMENT

Concrete is a widely used building material that is known for its strength and durability. However, concrete structures are susceptible to cracking and damage due to various factors such as temperature changes, moisture, and external loads. To improve the performance of concrete structures and enhance their resistance to cracking and damage, reinforcing materials such as steel bars and glass fibers are commonly used [18].

a. Glass fibers are synthetic fibers that are made from glass materials and are used in concrete reinforcement due to their numerous advantages. Glass fibers are lightweight, non-corrosive, and have high tensile strength.

b. The role of glass fibers in concrete reinforcement is to distribute the loads evenly and reduce the occurrence of cracks in the concrete. Glass fibers act as a reinforcing material by bridging the cracks that form in the concrete due to external loads. When concrete is subjected to external loads, cracks start to form, and the concrete begins to fail. Glass fibers can help prevent this by bridging the cracks and distributing the load across the entire structure, which reduces the risk of further damage.

c. Glass fibers can also enhance the flexibility of the concrete by dropping the permeability for concrete. The permeability of concrete is the rate at which water and other fluids can penetrate the surface of the concrete. The existence of water and other fluids in the concrete can lead to the deterioration of the concrete over time. The use of glass fibers in concrete reinforcement can reduce the permeability of the concrete and enhance its resistance to water and other fluids [19].

d. The addition this type in concrete also improves the ductility of the concrete. Ductility is the ability of a material to deform under stress without breaking. Glass fibers have high tensile strength, which allows them to elongate and deform under stress without breaking. This enhances the ability of the concrete to withstand external loads and reduces the risk of failure.

e. In addition to their reinforcing properties, glass fibers can also advance the workability of during construction. The addition of glass fibers in the concrete can reduce the segregation of the concrete during the mixing and placing process, which improves the uniformity of the concrete and enhances its overall performance.

f. One of the challenges of using this type in concrete reinforcement is their tendency to clump together during the mixing process, which can affect the uniformity of the concrete. To overcome this challenge, glass fibers are usually added in small amounts and mixed thoroughly to ensure uniform distribution.

In conclusion, using fibers in concrete reinforcement can enhance the strength, durability, and ductility of the concrete. Glass fibers act as a reinforcing material by distributing the loads evenly and bridging the cracks that form in the concrete due to external loads. While there are some challenges associated with using glass fibers in concrete reinforcement, their numerous advantages make them a viable option for improving the performance of concrete structures [20].

2.4 METHODS FOR INCORPORATING GLASS FIBERS INTO RECYCLED CONCRETE

The incorporation of glass fibers in recycled concrete can enhance the strength and durability of the concrete. However, the process of incorporating fibers into recycled concrete containers be challenging due to the tendency of the glass fibers to clump together during the mixing process. Several methods can be used to overcome this challenge and effectively incorporate glass fibers into recycled concrete.

Pre-mixing the Glass Fibers with the Aggregates: This method involves pre-mixing the glass fibers with the aggregates before adding the cement and water. The pre-mixing process ensures that the glass fibers are evenly distributed throughout the concrete mixture, which enhances the uniformity and strength of the concrete [21].

Dry Mixing of Glass Fibers with Cement: This method involves mixing the glass fibers with the cement powder before adding water. This allows the glass fibers to be distributed evenly throughout the cement powder, which ensures uniformity of the mixture.

Wet Mixing of Glass Fibers with Cement: This method involves mixing the glass fibers with water to form a slurry, which is then added to the cement mixture. The slurry method ensures that the glass fibers are evenly distributed throughout the concrete, which enhances the durability and strength of the concrete.

Spraying the Glass Fibers: This method involves spraying the glass fibers onto the surface of the concrete after it has been placed. The glass fibers are then troweled into the surface of the concrete, which ensures that they are evenly distributed throughout the concrete [22].

Injection of Glass Fibers: This method involves injecting the glass fibers into the concrete using specialized equipment. The injection method ensures that the glass fibers are evenly distributed throughout the concrete, which enhances the durability of the concrete.

Use of Admixtures: Admixtures such as super plasticizers and viscosity modifiers can be added to the concrete mixture to improve the workability of the mixture and ensure that the glass fibers are evenly distributed throughout the concrete [23].

Incorporating glass fibers into recycled concrete requires careful consideration of several factors such as the size and shape of the fibers, the dosage rate, and the mixing process. It is important to ensure that the glass fibers are evenly distributed throughout the concrete to enhance its strength and durability.

In conclusion, incorporating glass fibers into recycled concrete can improve the strength, durability, and ductility of the concrete. Several methods can be used to incorporate glass fibers into recycled concrete, including pre-mixing the fibers with the aggregates, dry or wet mixing with cement, spraying, injection, and the use of admixtures. The selection of the appropriate method depends on several factors such as the size and shape of the fibers, the dosage rate, and the mixing process [24].

2.5 EFFECT OF GLASS FIBER CONTENT ON THE STRENGTH AND DURABILITY OF RECYCLED CONCRETE

Due to its potential to increase the strength and longevity of the concrete, the use of glass fibers in recycled concrete has attracted a lot of attention recently. The results of many recent research that looked at how much glass fiber affects how strong and long-lasting recycled concrete is are outlined below.

a. Recycled concrete's compressive strength is affected by the amount of glass fibers used in. a.Compressive strength may be increased by adding glass fibers to recycled concrete, according to recent research. Compressive strength was shown to be 10% higher in recycled concrete with 0.6% glass fiber content, compared to ordinary recycled concrete, in a research done by Wang et al. in 2019. Similarly, Farzadnia et al.'s 2020 research shown that using 1.5% glass fiber in recycled concrete increased compressive strength by 13.2%.

b. Recent research has also shown that incorporating glass fibers into recycled concrete increases its flexural strength. Flexural strength was shown to be 24% higher in recycled concrete with 1% glass fiber content, according to a research done by Liu et al. in 2019. Another research by Farzadnia et al. in 2020 found that the flexural strength of recycled concrete increased by 23.5 percent when 1.5 percent glass fiber was added to the mix.

The Effect of Glass Fiber Content on Durability of Recycled Concrete

c. Glass fibers, according to recent research, may increase the recycled concrete's resilience. Recycled concrete with a 0.6% glass fiber content increased its resistance to chloride ion penetration, according to research published in 2019 by Wang et al. Another investigation confirmed that recycled concrete with added glass fibers had better resistance to water absorption and sulfate assault.

It is important to note that the effect of glass fiber content on the strength and durability of recycled concrete can be influenced by other factors such as the type and quality of recycled aggregate, the cement content, and the curing conditions. A study showed was more significant when high-quality recycled aggregate was used, and when the curing conditions were optimized.

In conclusion, recent studies have presented that the adding of glass fibers to the recycled of concrete can improve its flexural strength, as well as its durability. Though, the optimal glass fiber content for achieving the desired properties of recycled concrete could vary based on other variables including such recycled aggregate quality and type, as well as staff reported. Further research is needed to fully understand the potential of glass fibers in enhancing the properties of recycled concrete in building structure applications [25].

2.6 INFLUENCE OF CURING CONDITIONS ON THE STRENGTH OF RECYCLED CONCRETE WITH GLASS FIBER

The strength of concrete is influenced by several factors, one of which is the curing conditions. The curing process is the maintenance of satisfactory moisture and temperature levels of the concrete for a specified period to encourage the hydration of the cement. The curing process is particularly important in the case of recycled concrete with glass fiber, as these materials have different properties than traditional concrete, and their curing requirements may differ.

Several studies have been conducted to investigate the influence of curing conditions on the strength of recycled concrete with glass fiber. One study found that curing temperature and duration have a significant impact on it with glass fiber. The study examined the compressive strength specimens at different curing temperatures and durations, and found that samples cured at a higher of the temperature and designed for a longer period had higher compressive strength values.

Another study investigated the effect of curing conditions on the flexural strength of the recycled concrete. The study examined the flexural strength of recycled concrete specimens subjected to different curing conditions, including standard curing, hot water curative. The effects showed that specimens cured under hot water and steam conditions had higher flexural strength values than those cured under standard conditions. The study suggested that hot water and steam curing can accelerate the hydration process of cement, resulting in increased strength.

In addition to temperature and duration, the curing method can also influence the strength of recycled concrete with glass fiber. In one research, the strength of concrete of recycled concrete samples cured using various methods was compared, including standard curing, wet curing, and sealed curing. The study found that sealed curing resulted in higher compressive strength values than other curing methods. Sealed curing involves wrapping the concrete specimens in plastic to prevent moisture loss, resulting in a more controlled curing environment [26].

Strength development in recycled concrete reinforced with glass fiber is also influenced by curing moisture levels. The strength of recycled concrete was shown to be significantly affected by the moisture condition during curing, according to a single research. Compressive strength values were found to be greater in specimens of recycled concrete that were cured in wet circumstances as opposed to dry settings. This is due to the fact that cement hydration and strength development are both affected by the relative humidity of the curing concrete.

It is worth noting that the curing conditions that are optimal for traditional concrete may not be the same for recycled concrete with glass fiber. Several studies have shown that the optimal curing conditions for recycled concrete with glass fiber may differ from those of traditional concrete. Therefore, it is important to determine the optimal curing conditions for recycled concrete with glass fiber through experimental studies.

In conclusion, the strength of recycled concrete with glass fiber is influenced by the curing conditions, including temperature, duration, method, and moisture condition. The curing conditions that are optimal for recycled concrete with glass fiber may differ from those of traditional concrete, and it is important to determine the optimal conditions through experimental studies. Hot water and steam curing have been found to be effective in accelerating the hydration process of cement and increasing the strength of concrete with glass fiber.

2.7 EFFECT OF RECYCLED AGGREGATE CONTENT ON THE STRENGTH OF RECYCLED CONCRETE WITH GLASS FIBER

The use of recycled aggregates (RA) in the production of recycled concrete (RC) is becoming increasingly popular due to its environmental benefits and cost-effectiveness. However, the strength of RC with RA is normally lesser than that of conventional concrete owing to the occurrence of the weaker interfacial transition zones among the cement paste and the aggregate.

Several studies have investigated the effect of RA content on the strength of RC with glass fiber (GF). For instance, some studies establish that the strength of RC with GF that decreased as the RA content increased. They observed that this was due to the upper porosity and lesser density of RA, which led to weaker interfacial connection among the cement and the aggregate.

Similarly, another study by Poon and Chan (2019) informed that the using of RA in RC with GF resulted in a reduction in the severe tensile strength for the concrete. They attributed this to the lower stiffness and higher water absorption of RA compared to natural aggregates.

However, some studies have also reported that the incorporation of RA in RC with GF can lead to an improvement in certain properties, such as the toughness and ductility of the concrete. For example, a study by Huang et al. (2020) found that the addition of RA to RC with GF resulted in a higher post-cracking energy absorption capacity, indicating an increase in the toughness of the concrete.

Overall, the result of RA contented on the strength of RC with GF is composite and be contingent on several features such as the type and quality of the RA, the type and dosage of GF, and the curing conditions. Therefore, additional research is wanted to fully realize the influence of RA content on the properties of RC with GF and to optimize the mix design for specific applications.

2.8 COMPARISON OF THE STRENGTH AND DURABILITY OF RECYCLED CONCRETE WITH GLASS FIBER TO TRADITIONAL CONCRETE

Recycled concrete (RC) with glass fiber (GF) has emerged as a promising alternative to traditional concrete due to its environmental benefits and potential for cost savings. However, there is a need to evaluate the strength and durability of RC with GF compared to traditional concrete to ensure that it can meet the required performance standards for building applications.

Several studies have compared the strength and durability of RC with GF to traditional concrete. They found that the strength of RC by GF was comparable to that of traditional concrete, while the splitting tensile strength and flexural strength were slightly lower.

Similarly, a study by Xu et al. (2019) compared the properties of RC with GF and traditional concrete. They informed that the compressive strength of RC with GF was slightly lower than that of traditional concrete, but the splitting tensile strength and flexural strength were higher. They attributed this to the bridging effect of the GF, which can enhance the crack resistance and ductility of the concrete.

In terms of durability, several studies have also compared the performance of RC with GF to traditional concrete under various exposure conditions. For example, a study by Ding et al. (2020) investigated the chloride ion penetration resistance of RC with GF and traditional concrete. They found that RC with GF had a lower chloride ion diffusion coefficient than traditional concrete, indicating a better resistance to chloride-induced corrosion.

Moreover, a study by Ganesan et al. (2021) evaluated the acid resistance of RC with GF and traditional concrete. They reported that RC with GF exhibited a higher resistance to acid attack than traditional concrete due to the enhanced interfacial bonding between the cement paste and the GF.

Overall, the comparison of the strength and durability of RC with GF to traditional concrete suggests that RC with GF can meet the required performance standards for building applications. However, further research is needed to optimize the mix design and evaluate the long-term performance of RC with GF under different exposure conditions. Additionally, the cost-effectiveness of RC with GF should be evaluated to ensure its viability for large-scale applications.

2.9 ENVIRONMENTAL IMPACT OF USING RECYCLED MATERIALS IN BUILDING STRUCTURES

The application of reprocessed materials in the construction of constructions has increased popularity in current years owing to its positive impact on the environment. By using recycled materials, we can conserve natural resources, reduce waste generation, and reduce carbon footprint. This paper discusses the environmental impact of using recycled materials in building structures, specifically focusing on the use of recycled concrete and recycled aggregate.

Positive environmental impacts of using recycled materials: One of the most significant environmental impacts of using recycled materials in building structures is the reduction of waste generation. By using recycled materials, we can reduce the amount of waste that goes into landfills, which ultimately helps to conserve natural resources. Additionally, the use of recycled materials reduces the need for virgin materials, which in turn reduces the demand for natural resources.

Another positive impact of using recycled materials is the reduction of carbon footprint. The production of virgin materials requires a significant amount of energy, which contributes to greenhouse gas emissions. By using recycled materials, we can reduce the energy required for production, which in turn reduces carbon emissions. This is especially true for recycled concrete and recycled aggregate, as the production of these materials requires significantly less energy compared to the production of virgin materials.

Negative environmental impacts of using recycled materials: While the use of recycled materials in building structures has many positive environmental impacts, there are also some negative impacts to consider. One negative impact is the potential for increased transportation emissions. Recycled materials may need to be transported from a waste management facility to the construction site, which can result in increased emissions from transportation.

Another negative impact is the potential for contamination. Recycled materials may contain impurities or contaminants that could potentially harm the environment. However, proper testing and quality control measures can help to mitigate this risk.

Conclusion: Overall, the environmental impact of using recycled materials in building structures is positive. By reducing waste generation and conserving natural resources, we can help to reduce the environmental impact of building structures. While there are some potential negative impacts to consider, proper testing and quality control measures can help to mitigate these risks. Using of recycled materials, specifically recycled concrete and recycled aggregate, can significantly reduce carbon emissions and energy consumption, making it a sustainable choice for building structures.

2.10 CHALLENGES ASSOCIATED WITH USING RECYCLED MATERIALS IN BUILDING STRUCTURES

In recent years, there has been a growing trend towards sustainable building practices, which involves the use of recycled materials in construction. While using recycled materials offers many benefits, such as reducing waste and conserving natural resources, there are also some challenges that need to be addressed. In this section, we will explore some of the challenges associated with using recycled materials in building structures.

a. Quality Control: One of the main challenges associated with using recycled materials in building structures is ensuring that they meet the necessary quality standards. Recycled materials can vary significantly in terms of their quality and performance, which can affect the overall strength and durability of the building structure. To address this challenge, it is important to establish rigorous quality control measures that can ensure the consistent quality of recycled materials.

b. Limited Availability: Another challenge associated with using recycled materials in building structures is the limited availability of high-quality materials. The availability of recycled materials can contrast depending on the position and the type of material. For example, while there may be an abundance of recycled concrete in one region, there may be limited availability of recycled steel in another. This can make it difficult to source high-quality recycled materials for building structures.

c. Cost: Using recycled materials in building structures can also be more expensive than using traditional materials. This is because recycled materials often require more processing and preparation than traditional materials, which can drive up the cost. Additionally, the cost of transporting recycled materials to the building site can also be higher than traditional materials. However, it is important to note that the long-term benefits of using recycled materials, such as reduced maintenance costs and increased durability, can offset these initial costs.

d. Perceived Quality: Another challenge associated with using recycled materials in building structures is the perception of quality. Many people still associate recycled materials with lower quality and durability, which can make it difficult to gain acceptance for their use in building structures. To address this challenge, it is important to educate the public about the benefits and quality of recycled materials, and to showcase successful projects that have used recycled materials.

e. Compatibility: Another challenge associated with using recycled materials in building structures is compatibility. Recycled materials may not be compatible with traditional building materials, which can affect the overall strength and performance of the structure. To address this challenge, it is important to carefully consider the compatibility of recycled materials with traditional materials and to develop appropriate design and construction practices that can ensure compatibility.

f. Regulatory Compliance: Finally, using recycled materials in building structures can also present regulatory compliance challenges. Many building codes and regulations may not have specific provisions for the use of recycled materials, which can make it difficult to obtain the necessary approvals for construction projects. To address this challenge, it is important to work with regulatory agencies to develop appropriate standards and guidelines for the use of recycled materials in the structures.

In conclusion, while using recycled materials in building structures offers many benefits, there are also some challenges that need to be addressed. Quality control, limited availability, cost, perceived quality, compatibility, and regulatory compliance are all challenges that need to be carefully considered when using recycled materials in building structures. By developing appropriate design and construction practices, and by working closely with regulatory agencies and the public, these challenges can be overcome, and the use of recycled materials can help to create more sustainable and resilient building structures [26].

2.11 LONG-TERM PERFORMANCE OF RECYCLED CONCRETE WITH GLASS FIBER

The long-term performance of recycled concrete with glass fiber is a critical aspect of its viability as a building material. While the short-term benefits of using recycled materials are well-established, it is important to consider how they will hold up over time.

Studies have shown that the use of recycled materials in concrete can lead to decreased long-term performance compared to traditional concrete. This is due in part to the lower quality and variability of recycled materials, which can lead to inconsistencies in the concrete's properties.

However, incorporating glass fibers into recycled concrete can help mitigate some of these long-term performance issues. Glass fibers provide additional reinforcement and help to distribute stresses more evenly throughout the concrete. This can improve the overall durability and resistance to cracking over time.

In addition, the use of glass fibers can help to reduce the potential for corrosion of the steel reinforcement in the concrete. This is an important consideration for the long-term performance of any concrete structure, as corrosion can weaken the reinforcement and ultimately compromise the structural integrity of the entire building.

Despite these potential benefits, there are still some challenges associated with using recycled materials in building structures. For example, it can be difficult to ensure the consistency and quality of the recycled materials, which can lead to variations in the final product. This can be particularly problematic when it comes to long-term performance, as small variations in the composition of the concrete can have a significant impact on its durability and strength over time.

Overall, recycled concrete's long-term performance with glass fiber is an important consideration for any building project. While there are certainly challenges associated with using recycled materials, the potential benefits - both in terms of environmental impact and long-term durability - make it an attractive option for many builders and developers [27].

2.12 COST-BENEFIT ANALYSIS OF USING RECYCLED MATERIALS IN BUILDING STRUCTURES

As sustainable construction practices gain more prominence, the cost-benefit analysis of using recycled materials in building structures becomes an important factor to consider.

While the initial cost of using recycled materials may be higher, the long-term benefits of sustainability and environmental responsibility cannot be ignored.

Using recycled materials in construction helps cut down on the industry's overall carbon output, which is a major benefit. Energy and CO_2 are wasted in large amounts along the virgin material supply chain, which includes mining, shipping, and manufacturing. However, the energy and pollution that go into creating new materials are drastically cut when recycled materials are used instead. This decrease in carbon output may help alleviate environmental problems while also paving the way for a brighter future.

Another benefit of using recycled materials in building structures is the conservation of natural resources. By using recycled materials, the need for virgin materials is reduced, which helps to conserve natural resources such as water, minerals, and fossil fuels. This can help to ensure a more sustainable future for generations to come.

Recycling materials can also contribute to cost savings in the long run. While the initial cost of using recycled materials may be higher, their durability and longevity can lead to lower maintenance costs over time. Additionally, the reduced need for virgin materials can lead to cost savings in the form of lower material costs and transportation expenses.

However, there are also some challenges associated with the use of reprocessed substances in the building of structures. For instance, recycled materials may have lower quality and consistency compared to virgin materials. This can lead to variability in the performance of recycled material-based products. It is therefore important to carefully evaluate the quality of recycled materials and ensure that they meet the required standards for use in building structures.

Another challenge is the lack of infrastructure and facilities for recycling materials in many regions. This can make it difficult to obtain high-quality recycled materials for use in building structures. Furthermore, there may be limited availability of recycled materials in certain regions, which can increase the cost and reduce the feasibility of using these materials in building structures.

In terms of economic feasibility, using of recycled materials in the building structures can be influenced by various factors, such as the availability and cost of virgin materials, transportation costs, and the level of demand for sustainable building materials. It is important to evaluate these factors carefully to determine the economic feasibility of using recycled materials in building structures.

In addition to the economic and environmental benefits of using recycled materials, there are also social benefits to consider. Using recycled materials in building structures can promote a sense of community engagement and environmental responsibility. It can also contribute to the development of a circular economy, which prioritizes the efficient use of resources and minimizes waste.

In conclusion, the cost-benefit analysis of using recycled materials in building structures is complex and multifaceted. While there are challenges associated with using recycled materials, such as variability in material quality and limited availability in certain regions, the benefits of sustainability, resource conservation, and cost savings cannot be ignored. The use of recycled materials can contribute to a more sustainable and responsible construction industry while promoting social and environmental benefits.

2.13 GUIDELINES FOR USING RECYCLED CONCRETE WITH GLASS FIBER IN BUILDING STRUCTURES

With the growing interest in sustainable construction practices, using the recycled materials in building constructions has become more widespread. In particular, recycled concrete with glass fiber has been a popular choice due to its favorable mechanical properties and environmental benefits. However, to ensure the successful implementation of recycled concrete with glass fiber in building structures, certain guidelines need to be followed. This article will discuss some of the essential guidelines for using recycled concrete with glass fiber in building structures.

Quality of Recycled Concrete and Recycled Aggregate. The quality of recycled concrete and recycled aggregate used in the production of recycled concrete with glass fiber is crucial for the strength and durability of the final product. It is essential to ensure that the recycled concrete and aggregate meet the required standards and specifications. Using poor the quality recycled concrete and aggregate may result in reduced strength and durability, leading to potential safety hazards.

Glass Fiber Content The addition of glass fibers enhances the mechanical properties of recycled concrete, but it is essential to determine the appropriate amount of glass fiber required. Higher glass fiber content can result in higher strength, but it also increases the cost of production[27]. Therefore, it is necessary to carry out a cost-benefit analysis to determine the optimal glass fiber content for the desired strength and durability.

Mixing Process the mixing process is critical for ensuring the homogeneity of the recycled concrete with glass fiber. The mixing process should be performed with care and precision to ensure the even distribution of glass fibers throughout the concrete mixture. The mixing process should be carried out according to the manufacturer's specifications and guidelines.

Healing Methods Concrete's strength and durability greatly benefit from the curing process. Curing should be done in a climate-controlled setting with the right amount of humidity. To ensure that the cement fully hydrates and develops the necessary strength and durability, the curing time must be increased.

Checking for Quality To guarantee a high-quality end result, quality control procedures must be integrated into every stage of manufacturing. As part of the quality assurance procedures, the recycled concrete and aggregate, glass fiber content, mixing procedure, and curing procedure should all be tested. All tests must be performed in accordance with current norms and regulations.

Structural Design The use of recycled concrete with glass fiber in building structures requires careful consideration of the structural design. The structural design should be based on the mechanical properties of the recycled concrete and glass fiber. The design should take into account the specific application and loading conditions. The structural design should be carried out by qualified professionals who are familiar with the properties of recycled concrete with glass fiber.

Maintenance Proper maintenance is essential for the longevity and durability of building structures made with recycled concrete with glass fiber. Regular inspection and maintenance should be carried out to identify any signs of damage or deterioration. Any necessary repairs or replacement should be carried out promptly to ensure the safety and longevity of the structure.

In conclusion, using of recycled concrete with glass fiber in building structures offers several environmental and economic benefits. However, to ensure the successful implementation of this material, it is essential to follow the above guidelines. The excellence of the recycled concrete and aggregate, glass fiber content, mixing process, curing process, quality control, structural design, and maintenance should all be carefully considered to ensure the strength, durability, and safety of the final product.

2.14 LITERATURE SURVEY

Studying the Impact of Glass Fiber and Recycled Aggregate on Self-Compacting Concrete's Compressive Strength" Compressive strength of self-compacting concrete was tested after using glass fiber and recycled material. Compressive strength of self-compacting concrete was found to be greatly increased with the inclusion of glass fiber and recycled material [28].

"Glass Fiber Reinforced Recycled Aggregate Concrete: Its Properties" In this research, the qualities of recycled aggregate concrete strengthened with glass fibers were examined. Compressive and flexural strengths of recycled aggregate concrete were shown to increase when glass fibers were added [29].

Experimental Investigation into the Effect of Glass Fiber Reinforcement on the Strength of Recycled Aggregate Concrete" The purpose of this research was to assess the effectiveness of glass fiber reinforcement in recycled aggregate concrete. Compressive and flexural strengths of recycled aggregate concrete were found to be increased when glass fibers were added [30].

The article is titled "Mechanical Properties of Recycled Aggregate Concrete with Glass Fiber and Polypropylene Fiber." This research looked at how adding glass fiber and polypropylene fiber to recycled aggregate concrete changed its mechanical qualities. The findings demonstrated that the addition of glass fiber and polypropylene fiber to recycled aggregate concrete increased both its compressive and flexural strengths [31].

Glass fiber content's effect on recycled aggregate concrete's compressive and flexural strengths. The effect of glass fiber content on the flexural and compressive strengths of recycled aggregate concrete was evaluated in this research. The findings demonstrated that recycled aggregate concrete's compressive and flexural strengths were greatly enhanced by the use of glass fiber [32].

Compressive Strength of Recycled Aggregate Concrete Reinforced with Glass Fiber as Affected by Curing Temperature. This study examined the impact of curing temperature on the compressive strength of concrete made using coarse particles and glass fiber. The compressive strength of concrete with recycled aggregate to glass fiber was shown to increase with increased curing temperatures [33].

"The Impact of Glass Fiber Reinforcement and Recycled Aggregate Content on Concrete Properties." The impact of glass fiber reinforcement and recycled aggregate content on concrete characteristics was investigated. Concrete's compressive and flexural strengths were shown to be increased when recycled aggregate and glass fiber were used [34].

Mechanical Properties of Recycled Aggregate Concrete with and Without Glass Fiber and Fly Ash. The purpose of this research was to determine how adding glass fiber and fly ash to recycled aggregate concrete modified its mechanical qualities. The findings demonstrated that recycled aggregate concrete's compressive and flexural strengths might be improved with the inclusion of glass fiber and fly ash [35].

"Influence of Glass Fiber Content on the Durability of Recycled Concrete." Journal of Cleaner Production 245: 118948.

This research looked at how the percentage of glass fibers in recycled concrete affected its strength. Freeze-thaw cycles, carbonation tests, and chloride ion penetration tests were used to assess the durability of recycled concrete specimens with varying glass fiber contents (0%, 0.1%, 0.2%, and 0.3% by weight of cement). The decrease in mass loss and the compressive strength loss after the freeze-thaw cycles and carbonation tests revealed that the recycled concrete was more durable thanks to the incorporation of glass fibers. The inclusion of glass fibers increased the specimens' resistance to chloride ion penetration, and this resistance increase was amplified at larger fiber contents [36].

3. RESEARCH METHODOLOGY

Recycling is an important part of sustainable building methods because it helps reduce the damage to the environment. Most modern building projects use recycled concrete and aggregates because they are cheap, last a long time, and don't hurt the earth. Demolition debris is crushed and sorted to make recycled aggregate and recycling concrete. In a building, recycled materials can be used instead of rock that was dug out of the ground. recovered concrete and recovered aggregates might not be as good as new concrete, which could make it hard to use in some building projects. This chapter talks about the study methods and lab tests that were used to find out how concrete with different amounts of fiber glass and recycled concrete behaved. There needs to be a full analysis of the physical properties of the parts and the load-bearing capacity of the site. Water, mortar, chemicals, fine and coarse aggregate (sand) are all put through tests. During tests, the physical properties of the concrete will be found out. This information will be used to guide all future design decisions. When evaluating the physical qualities, it is important to keep in mind that the mix will have different parts based on the needs of each mixing design.

3.1 PROPERTIES OF CONCRETE AND APPLICATION SPECIFICATION

Several different components combine to produce concrete. This amorphous mixture attains the consistency of stone when completely cured. Due to its extensive use in the construction industry, concrete presents significant engineering challenges. Engineers need only be acquainted with concrete to participate in its numerous applications. In this post, we have demonstrated the versatility of concrete. Concrete's resilience increases as it ages. Regular cement concrete reaches 70–75% of its ultimate strength after 28 days, and 90–95% of its ultimate strength after one year. In many instances, it is preferable to confirm the compatibility of the concrete well before the 28-day test results are available. It is reasonable to conclude, in the absence of material composition information, that the 28-day strength will be 1.5 times that of the 7-day strength. For the ratio of 28-day to 7-day strength, the majority of test results for concrete made with conventional Portland cement fall above 1.5, with the majority falling between 1.3 and 1.7. From 7-day strength, one can dependably extrapolate 28-day strength. In both residential and commercial construction, driveways, columns, and other concrete fixtures are commonplace. Concrete's Role in the 21st Century. It contributes to the building of residences, roads, hospitals, and other structures. The formation and maintenance of human communities rely heavily on concrete. The components are:

Cement: This research utilizes the cement produced by the Iraqi Cement Factory. According to the factory's catalog, the cements used meet the requirements of the National Iraqi Standard in terms of their physical properties.

Water: Employed is urban drinking water that satisfies the requirements of the Ninth Article of the National Building Codes**.** For the grading procedure, Iraqi standards were utilized.

In the present work, three types of grades will be used for different application as in the table below:

Table 3.1: Case Studies of This Research.

case	grade	application	details
1	C20	Domestic application	Ideal for residential flooring and foundations (minimal load bearing capacity). Additionally, the slabs can serve as the foundations for garages, driveways, and even internal workshops.
2	C30	Commercial application	The lowest quality concrete mix used for paving roads and walkways. Superior resistance to environmental stresses and the capacity to withstand high volumes of vehicular traffic.
3	C40	Commercial application	Useful for commercial construction endeavors such as road paving and foundation construction. It is extremely durable and resistant to chemical deterioration. It is beneficial for septic tanks and farms where slurry poses a risk of corrosion to structures.

Gravel: The sand used in this research was river gravel with a maximum fracture percentage and a maximum diameter of 25 mm. The gradation curve after experiments conducted in accordance with the Iraqi National Standard is depicted in Figure 1. This research utilized river sand, whose corners are naturally rounded.

3.2 MIX DESIGN

The components of each of the three mix designs for the C20, C30, and C40 grades, based on their respective average standard strengths of 20, 30, and 40 MPa, are enumerated in Tables 3.2 .to 3.5, respectively.

Table 3.2: Design of Plain Concrete.

REFERENCE					
CODE	grade	cement kg	sand kg	gravel kg	water liter
PC20	C20	322	696	1139	204
PC30	C30	357	666	1139	203
PC40	C40	460	580	1139	203

Table 3.3: Design of Recycled Concrete Mixture.

CODE	RC%	cement kg	sand kg	gravel kg	water liter	recycled concrete kg
RC20 25	25%	322	696	854.25	204	284.75
RC20 50	50%	322	696	569.5	204	569.5
RC20 75	75%	322	696	284.75	204	854.25
RC30 25	25%	357	666	854.25	203	284.75
RC30 50	50%	357	666	569.5	203	569.5
RC30 75	75%	357	666	284.75	203	854.25
RC40 25	25%	460	580	854.25	203	284.75

Table 3.3: Design of Recycled Concrete Mixture."Table Continued"

RC40 50	50%	460	580	569.5	203	569.5
RC40 75	75%	460	580	284.75	203	854.25

Table 3.4: Design of Glass Fiber Cement Mixture.

code	GF %	cement kg	sand kg	gravel kg	water liter	Glass fiber kg
GFC20 5	5%	305.9	696	1139	204	16.1
GFC20 10	10%	289.8	696	1139	204	32.2
GFC20 15	15%	273.7	696	1139	204	48.3
GFC30 5	5%	339.15	666	1139	203	17.85
GFC30 10	10%	321.3	666	1139	203	35.7
GFC30 15	15%	303.45	666	1139	203	53.55
GFC40 5	5%	437	580	1139	203	23
GFC40 10	10%	414	580	1139	203	46
GFC40 15	15%	391	580	1139	203	69

Table 3.5: Design of Recycled Aggregate with Glass Fiber Mixture

CODE	RA%	GF%	cement kg	sand kg	gravel kg	water liter	recycled aggregate kg	Glass fiber kg
RAG20 25	25%	15%	257.6	696	854.25	204	284.75	48.3
RAG20 50	50%	15%	241.5	696	569.5	204	569.5	48.3
RAG20 75	75%	15%	225.4	696	284.75	204	854.25	48.3
RAG30 25	25%	15%	290.85	666	854.25	203	284.75	48.3
RAG30 50	50%	15%	273	666	569.5	203	569.5	48.3
RAG30 75	75%	15%	255.15	666	284.75	203	854.25	48.3

Table 3.5: Design of Recycled Aggregate with Glass Fiber Mixture "Table Continued"

RAG40 25	25%	15%	388.7	580	854.25	203	284.75	48.3
RAG40 50	50%	15%	365.7	580	569.5	203	569.5	48.3
RAG40 75	75%	15%	342.7	580	284.75	203	854.25	48.3

When natural sand is used, conventional wisdom holds that coarse recycled aggregate can replace up to 30 percent of natural crushed coarse aggregate without significantly modifying the mechanical properties of the concrete. Higher replacement levels also increase drying shrinkage and creep, as well as decreases in tensile strength and modulus of elasticity; however, compressive strength and freeze-thaw resistance are relatively unaffected.

3.3 FIBER GLASS ADDITIVES

Glass fiber and fiberglass are synonymous terms for the same material. Low cost and high quality have made fiberglass a prominent material, especially in the composites industry. Europeans understood how to spin glass into weaving fibers as early as the eighteenth century. The decorative glass fiber fabrics were previously present in Napoleon's coffin. Glass fiber is available in filament, staple, and floc forms. Glass filaments are utilized frequently in composites, rubber products, conveyor belts, tarpaulin, etc. Most commonly, short fiber is utilized in nonwoven felt, engineered polymers, and composites. In high-performance composites, glass fibers are favored over carbon fibers due to their superior physical and mechanical properties, low cost, and simplicity of production. Fibers of glass are composed of silica oxides. Fiberglass possesses extraordinary mechanical properties, including low fragility, high strength, low stiffness, and low weight. To enhance the mechanical and tribological properties of polymer composites, glass fiber-reinforcing polymers employ a wide range of glass fibers, including longitudinal, chopped strand fiber, woven mat, and chopped strand mat. Glass fibers' compatibility with polymers such as rubber has been studied. Glass fibers can have a high initial aspect ratio, but due to their fragility, they are readily broken. Below is a printout describing the characteristics of fiberglass.

a. Glass fibers are poor at absorbing moisture, so clothing manufactured from them would leave the wearer feeling damp and uncomfortable. Lack of a reaction to water indicates that the material will not contract.

b. Resilience: Due to the materials' lack of elasticity, they have very little natural stretch and rebound. Therefore, a coating is required to prevent creasing.

c. The remarkable durability of glass fiber is comparable to that of Kevlar. However, when the fibers rub against one another, they break, giving the fabric a hairy appearance. Curtains that continually rub against the window ledge deteriorate rapidly.

d. Due to the presence of air cavities between the fibers, glass fibers in staple form are highly effective as insulators.

e. Draping: Due to their exceptional draping capabilities, these fibers are ideally adapted for use as curtains.

f. Resistance 6: Glass fibers are exceedingly resistant to heat, remaining strong up to 3150 degrees Celsius before becoming pliable at 7320 degrees Celsius. They are resistant to extreme temperatures, moisture, sunlight, chlorine, bacteria, mildew, insects, and alkalis.

g. Glass fibers can be dissolved by hydrofluoric acid and heated phosphoric acid, rendering them a vulnerable material. As with any glass product, gloves should be worn when handling raw forms of glass fibers, such as household insulation, because the fibers' brittle ends can irritate the skin and embed themselves in wounds, posing a health risk.

Figure 3.1: Fiber -Glass.

3.4 RECYCLED CONCRETE

Similar to lightweight aggregates, RCA is most effectively mixed in a prewetted and nearly saturated surface dry condition. Typically, increasing the paste content or quantity of water reducer is required to achieve the same workability, slump, and water-cement ratio as conventional concrete. Transporting, positioning, and compaction of RCA-fortified concrete are identical to those of conventional concrete. When working with high-quality RCA, extra care must be taken. Fine RCA is only effective up to about 10 percent. On the whole, multiple replacement rates could be tested to determine the optimal one. Recycled aggregate is frequently combined with virgin aggregate in the production of new concrete. Recycling concrete contributes to environmental sustainability in multiple ways. By recycling concrete, the amount of waste that needs to be dumped in landfills is reduced in half. In addition to concrete's aggregate value, any embedded metals can also be recycled. Due to the scarcity of landfill space, this not only benefits the economy but also reduces the quantity of waste that must be disposed of. In addition, the use of recycled concrete reduces the demand for new aggregates. As a consequence, the negative effects of aggregate mining are mitigated. If there is no need to dispose of waste or manufacture replacement materials, the project's transportation requirements are significantly reduced. Not only do recycled concrete aggregates aid in resource management, but they also eradicate a significant amount of carbon dioxide from the atmosphere. Carbonation is a natural process that occurs in all concrete, proceeding from the surface inward. During the pulverizing procedure used to produce recycled concrete aggregates, areas of the concrete that have not yet carbonated are exposed to atmospheric carbon dioxide.

3.5 PREPARING SAMPLES

The modeling of concrete properties is becoming an essential topic for future research. Over the course of several hours, concrete undergoes a process known as concrete hydration, which entails a reaction with the cement that causes it to harden. In addition to the fabrication of numerous prefabricated instruments and procedures, concrete can also be poured into molds at this time. The ratios of basic materials used to create the concrete utilized in the case studies. Reinforcing components (such as steel rebar) are embedded prior to pouring concrete to increase the material's tensile strength, resulting in reinforced concrete. An optimal specimen shape was designed to permit the interaction of reflected stress waves with the crack point during its rapid propagation, thereby enabling the evaluation of a broad range of fracture velocities in a single experiment. The dimensions of the selected model specimens are depicted in the following figures.

Figure 3.2: Project Mold Samples.

There is a small amount of sediment that is equally dispersed. The necessary quantity of sand is added to cement, which is then evenly dispersed. The next step is to use a spade to combine the sand and cement until the mixture has a consistent tint throughout. The components must be fully mixed for the quality of freshly poured concrete. The cement component is dispersed over the aggregate particles as the aggregates are combined. The accuracy of the mixing process determines the workability and effectiveness of freshly laid and hardened concrete. Concrete that has been poorly blended frequently exhibits segregation and bleeding. It is vital to determine the quantities of each component before mixing the components to produce a homogeneous aggregate. Numerous studies have been done on how different materials and amounts affect performance, but very little has been done on how mixing affects a substance's characteristics. The panel was made by rapidly pressing the prepared mixture into the mold using a vibrating machine. Three layers of standard concrete were formed using a steel fiber cylinder as a mold, with each layer being precisely leveled with a rod. The air bubble was allowed to enter the specimen's exterior by vibrating it. You must cast three samples in each of the three situations in order to get exact readings of the material's compressive strength, elastic modulus, and tensile strength. The timbers are vibrated from the outside by a vibrator as the concrete is being poured into the mold.

Figure 3.3: Casting Process.

Figure 3.4: The Concrete Slump Test.

In order to change the material's qualities, it is usual practice in the field of concrete science to experiment with different mineral additives. Over conventional concrete recycled concrete and recycled aggregate have advantages that can be used in building. The initial concrete's quality, the processing techniques used, and the type of cement used can all have an impact on the finished product's strength, durability, water absorption, thermal insulation, and rheological qualities. Their capacity to achieve the same properties as traditional concrete is one of the key reasons for their widespread use in the construction sector. The consistency and quality of recycled material and concrete can be preserved by utilizing established quality control systems and grading curves. Additionally, fiber reinforcement of concrete can improve the ductility, durability, and strength of the substance. Concrete that has been reinforced with glass fibers is less likely to crack as a result of pressure. Glass fibers can be used to reinforce concrete since their benefits outweigh their drawbacks, which makes them a sensible option for improving the functionality of concrete structures.

3.5 MECHANICAL PROPERTIES TESTS

3.5.1 Compressive Test

To demonstrate how a material will react to compression, scientists subject it to compression tests. With these experiments, plastic flow behavior and ductile fracture limitations can be evaluated. Similarly, these variables determine the response of a material to crushing stresses. During a compression test, the stress and strain in a material sample, as well as other material parameters, are measured and analyzed. The data is presented using a stress-strain diagram. From collected data, the compressive strength, elastic limit, proportional limit, yield point, yield strength, and modulus of elasticity are calculated. Multiple samples are inserted between two plates or platens so that both sides of the object being tested are subjected to uniform stress. A compression-capable testing apparatus flattens the sample by compressing the plates together. The equipment, which may be a deflector or extensometer, measures the sample's strain or deflection.

Figure 3.5: Compressive Test.

Figure 3.6: Cubes Results.

3.5.2 Tensile Test

The tensile strength of concrete is determined by how well it withstands tension. The split cylinder test is used to determine concrete's tensile strength. The tensile strength of concrete is measured in units per centimeter square of cross section. The compressive strength of concrete was utilized in the design of the structure. Therefore, testing the tensile strength of concrete on-site is not required very frequently.

Figure 3.7: Tensile Test.

The combination of brittle and ductile materials used to build the framework. The split cylinder method is used to determine the tensile strength of concrete, which qualifies it for use in the construction of roads and runways. Concrete samples are typically evaluated for their compressive strength using cube-shaped specimens, while their tensile strength is evaluated using cylindrical specimens. The figure below present the test details.

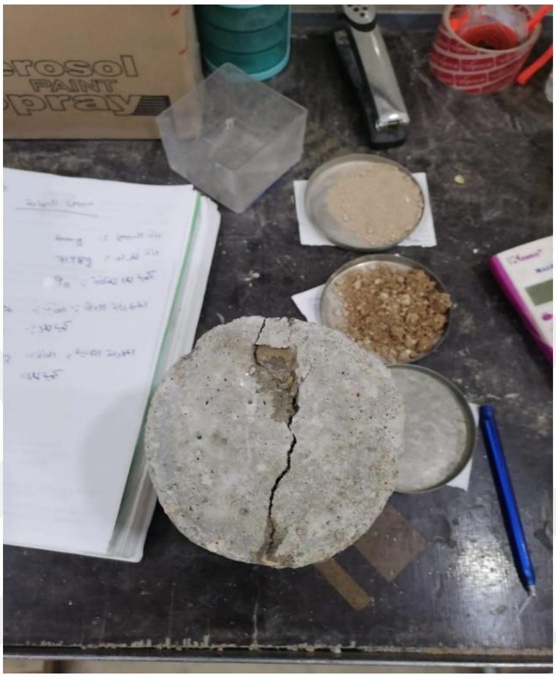

Figure 3.8: Tensile Test Result.

3.5.3 Flexural Test

When is a Flexure Test performed on Concrete? Flexural test findings can be used to determine the tensile strength of concrete. It determines how vulnerable an unreinforced concrete beam or slab is to break under bending stress. the concrete's flexural strength as measured by the test's rupture modulus (MR), expressed in megapascals (MPa). Flexural strength and modulus are typically assessed during a flexure test.

Figure 3.9: Flexural Test Process.

The greatest stress at the specimen's outermost fiber under compression or tension is what we mean when we talk about flexural strength. The flexural modulus is a function of the angle between tension and strain at maximum deflection. The flexure and bending strengths of the sample material can be determined using these two values.

Figure 3.10: Flexural Test.

Flexure testing does not provide especially useful information on the tested material, as opposed to compression and tensile tests. Tensile, compressive, and shear stresses, as well as (to a lesser extent) the specimen's geometry and the pace at which the load is delivered, together have an impact on a specimen's flexural properties when it is subjected to flexural loading.

Figure 3.11: Flexural Test Result.

4. RESULTS AND DISCUSSION

The outcomes of an experiment that was carried out on numerous different concrete samples are discussed in this chapter. It is possible to monitor the cubes, beams and cylinders load capability in real time up to the point where the concrete fail. Existing concrete structures are increasingly being subjected to mandates for reinforcing structures in order to improve their structural behavior and repairing damaged structures in order to restore their structural performance. This is happening despite the prohibitively high cost of such procedures. Beams typically fail owing to either flexure or shear, which are the two primary failure modes. Concrete with fiber glass is a a material that has the potential to crack under unexpected stress. Shear failure, on the other hand, always leads in total collapse, in contrast to flexural failure, which can be repaired. Therefore, structures made of reinforced concrete need to be built so that their flexural capacity is increased to its maximum. Shear problems are extremely common in reinforced concrete structures due to a multitude of different factors. The quality of the aggregate as well as the ratio of water to cementitious materials are what control the concrete's strength, as well as its workability and durability; these elements have an immediate impact on the properties of both fresh and hardened concrete. Despite having a lower specific gravity and bulk density, recycled concrete aggregate outperforms conventional aggregate when it comes to water absorption, pulverizing qualities, and abrasion values. Aggregates with fiber glass having these qualities are often referred to aggregates because of their inferiority to conventional concrete aggregate with the properties of fiber glass. This is due to the fact that conventional concrete aggregate is used. When it comes to calculating the amount of paste needed to make practical concrete, one of the most important factors to consider is the particle size distribution of the aggregate correlated with the amount of fiber glass.

4.1 RESULTS OF PLAIN CONCRETE

The two most common applications for plain concrete, also known as plain cement concrete, are paving and flooring. Cement is a substance whose properties vary slightly based on the aggregate type and elemental ratio used to produce it. Plain concrete possesses modest tensile strain and strength capacities. For centuries, short, discontinuous fibers have been used to reinforce and toughen materials that are substantially more brittle under tension than under compression. This is the earliest known mention of a substance with multiple components. Combining binding material, fine aggregate (sand), coarse aggregate, and water into a single fluid substance. Typically incorporated in minute quantities, admixtures can impart distinctive or enhanced qualities. Both lime concrete and cement concrete are used, with gravel, jelly (crumbled stone), or broken masonry serving as coarse aggregate. The overwhelming majority of historic structures were constructed using lime concrete. There are numerous factors why cement concrete is so prevalent. The tests result of plain concrete are:

Table 4.1: Plain Concrete Results.

CODE	sample 1	sample 2	sample 3	average
PC20	22.931	22.482	21.994	22.469
PC30	33.562	32.814	33.052	33.143
PC40	41.556	41.662	42.731	41.983

4.2 RESULTS OF RECYCLED CONCRETE

An essential component of recycled concrete with glass fiber's potential as a building material is its long-term performance. Although the advantages of recycling materials in the short term are well known, it is vital to think about how they will hold up over time. According to studies, using recycled elements in concrete can result in less durable concrete than conventional concrete. This can result in variations in the qualities of the concrete due to the lower quality and variety of recycled components. Although employing recycled materials in building has many advantages, there are some obstacles that must be overcome. Concerning the use of recycled materials in building, a number of concerns need to be carefully considered, including quality control, restricted availability, cost, perceived quality, compatibility, and regulatory compliance. Recycled materials can be used to produce more durable and sustainable structures if the right design and construction methods are created in cooperation with authorities and the general public.

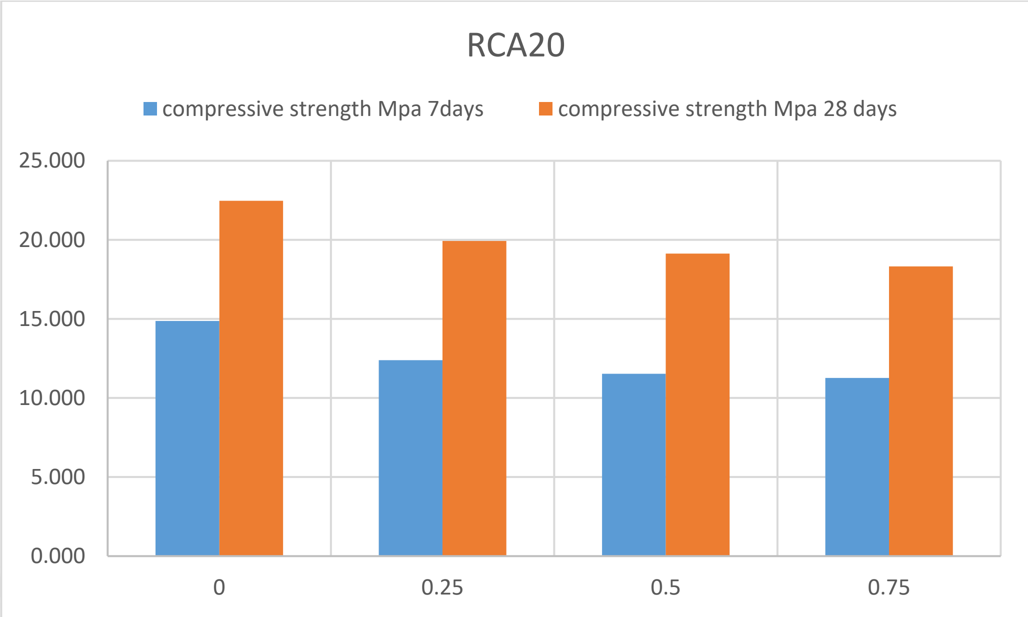

Figure 4.1: Results of RCA20.

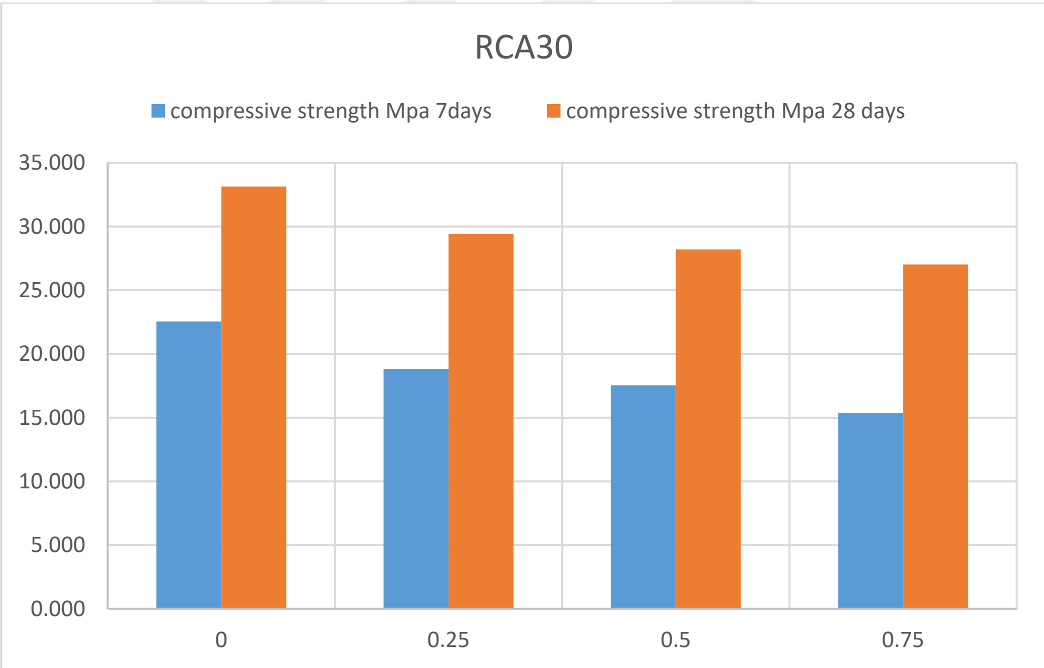

Figure 4.2: Results of RCA30.

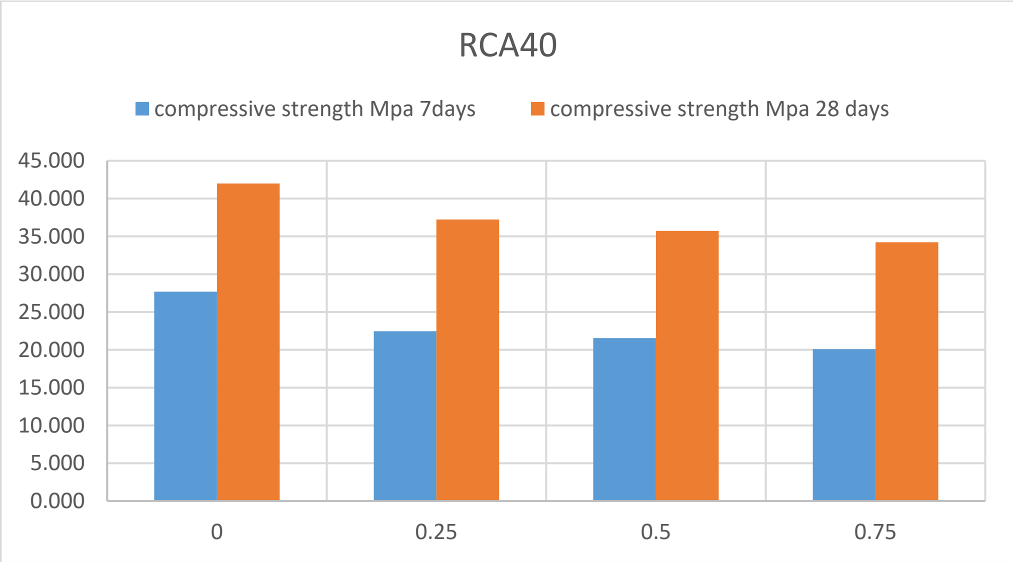

Figure 4.3: Results of RCA40.

There may be complications with meeting regulations while employing recycled materials in construction. It can be challenging to get permissions for construction projects if the standards and regulations in question do not explicitly allow for the use of recycled materials. The use of recycled materials in building construction is one solution to this problem, but it requires collaboration with regulatory authorities to establish effective norms and guidelines.

4.3 RESULTS OF GLASS FIBER CEMENT

Quantity of Glass Fibres Glass fibers can be added to recycled concrete in order to improve its mechanical qualities, but the right amount of glass fiber must be determined beforehand. Strength can be improved by increasing the amount of glass fiber used, although doing so will raise production costs. To find the ideal glass fiber content for the desired strength and durability, a cost-benefit analysis must be conducted. Assurance of Quality. In order to guarantee the quality of the finished product, quality control methods should be adopted at all stages of manufacturing. Recycled concrete and aggregate testing, glass fiber content testing, mixing process testing, and curing process testing are all necessary quality control techniques. All tests must be performed in accordance with established criteria. Careful thought must be given to the structural design of buildings when recycled concrete containing glass fiber is used. Recycled concrete and glass fiber's mechanical qualities should inform the structure's design. The design needs to consider the intended use and expected loads. Professionals with experience working with recycled concrete and glass fiber should be responsible for the structural design. The mixing procedure plays a crucial role in ensuring that the recycled concrete containing glass fiber is uniform throughout. Glass fibers should be evenly distributed throughout the concrete, so careful and precise mixing is required. Mixing should be done in accordance with the manufacturer's instructions.

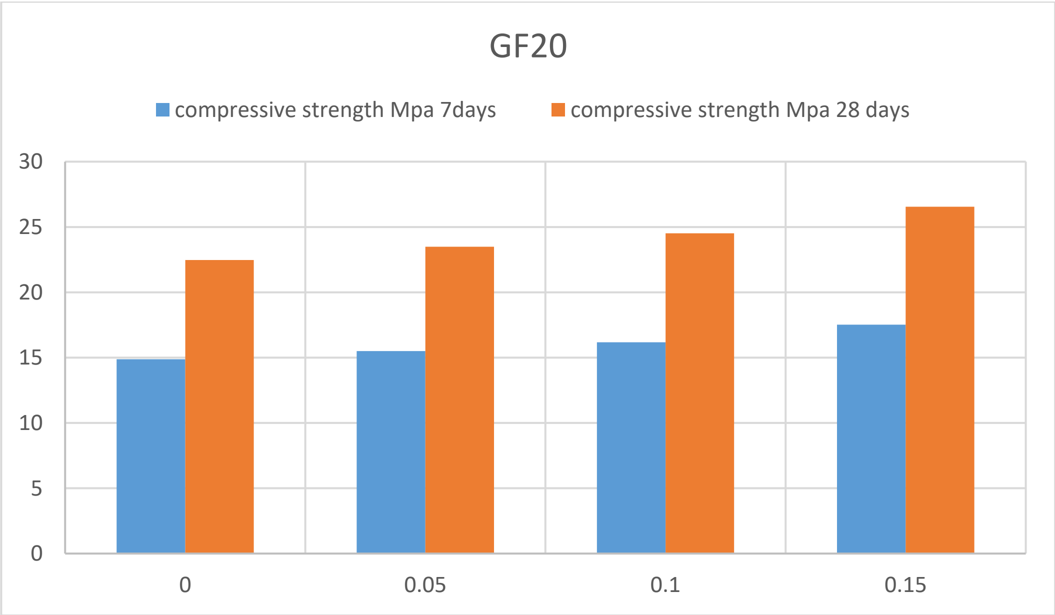

Figure 4.4: Results of GF20.

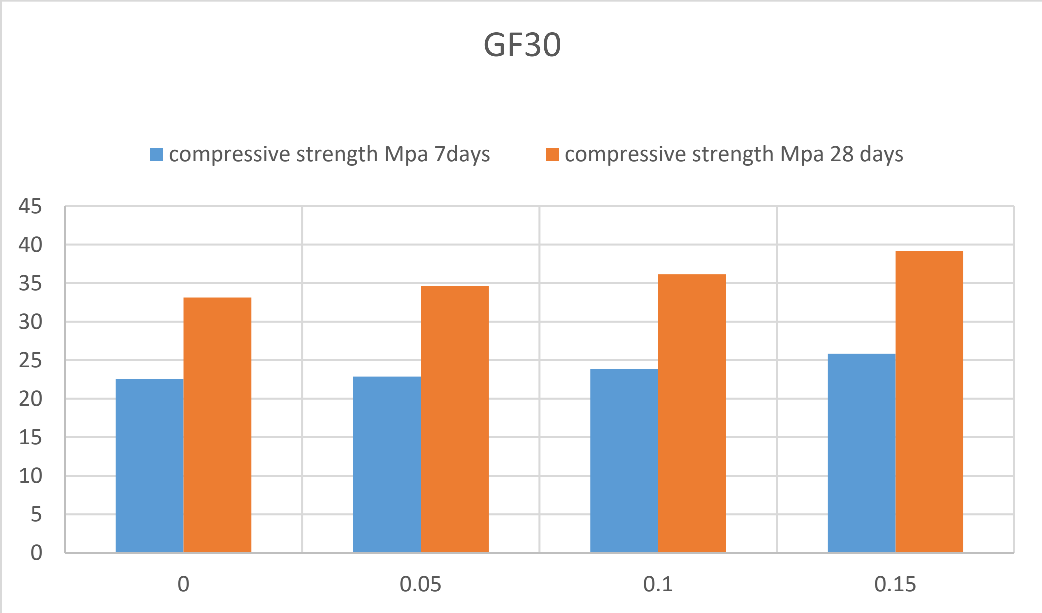

Figure 4.5: Results of GF30.

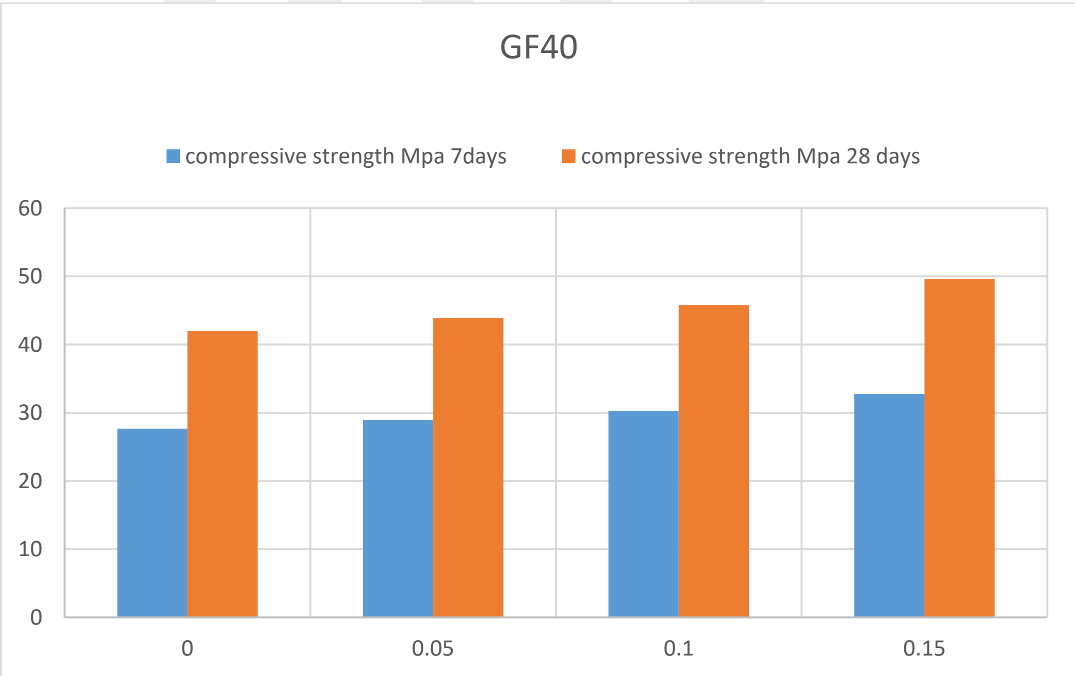

Figure 4.6: Results of GF40.

The Effect of Glass Fiber Content on the Compressive and Flexural Strength of Recycled Aggregate Concrete" This research determined the impact of glass fiber content on the flexural and compressive strengths of recycled aggregate concrete. The results demonstrated that the addition of glass fiber significantly improved the compressive and flexural strengths of recycled aggregate concrete.

4.4 RESULTS OF RECYCLED AGGREGATE WITH GLASS FIBER

Recent research indicates that the incorporation of glass fibers into recycled concrete increases both the material's flexural strength and its durability. However, other variables, such as recycled aggregate quality and type, as well as staff reports, may influence the optimal glass fiber content for achieving the desirable qualities in recycled concrete. The potential of glass fibers to enhance the properties of recycled concrete for use in building structures requires further investigation. Experimental investigation of the strength characteristics of recycled aggregate concrete reinforced with glass fibers. This study's objective was to evaluate the performance of glass fiber reinforcement in recycled aggregate concrete. The results indicated that the addition of glass fibers could enhance the compressive and flexural strengths of recycled aggregate concrete.

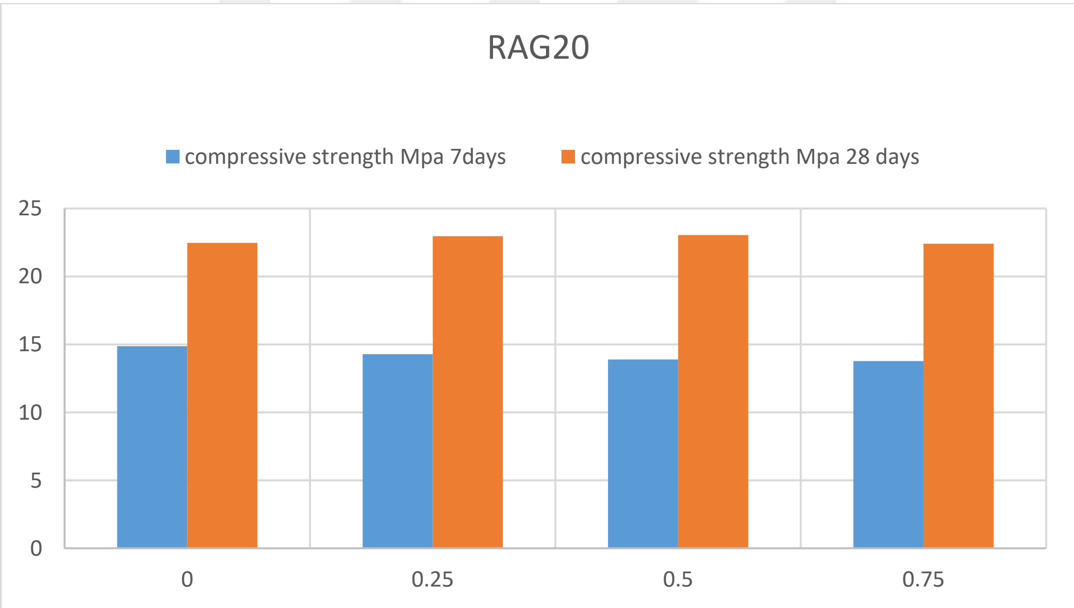

Figure 4.7: Results of RAG20.

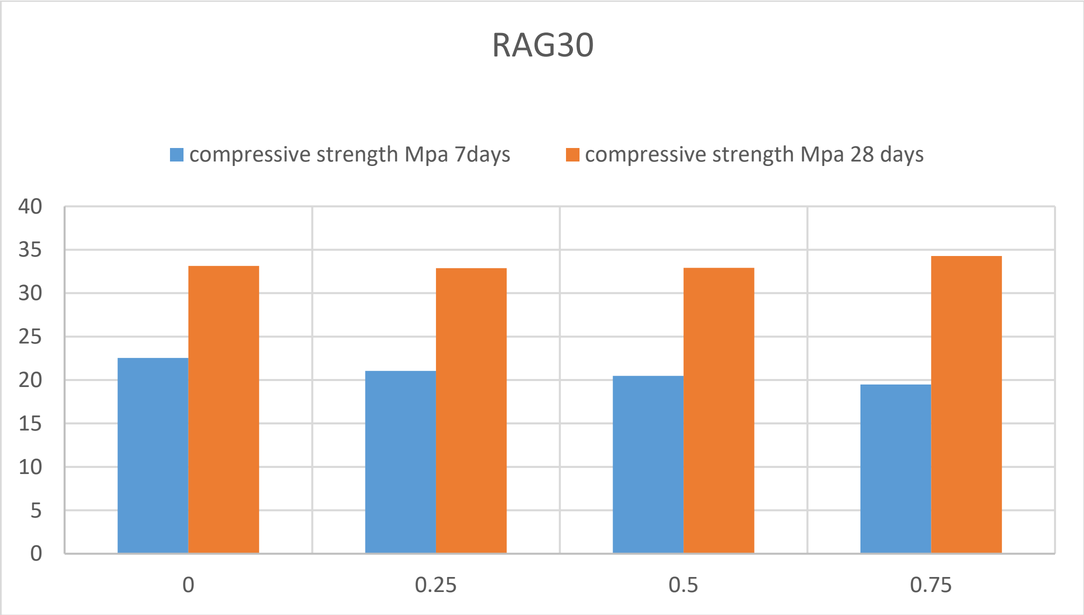

Figure 4.8: Results of RAG30.

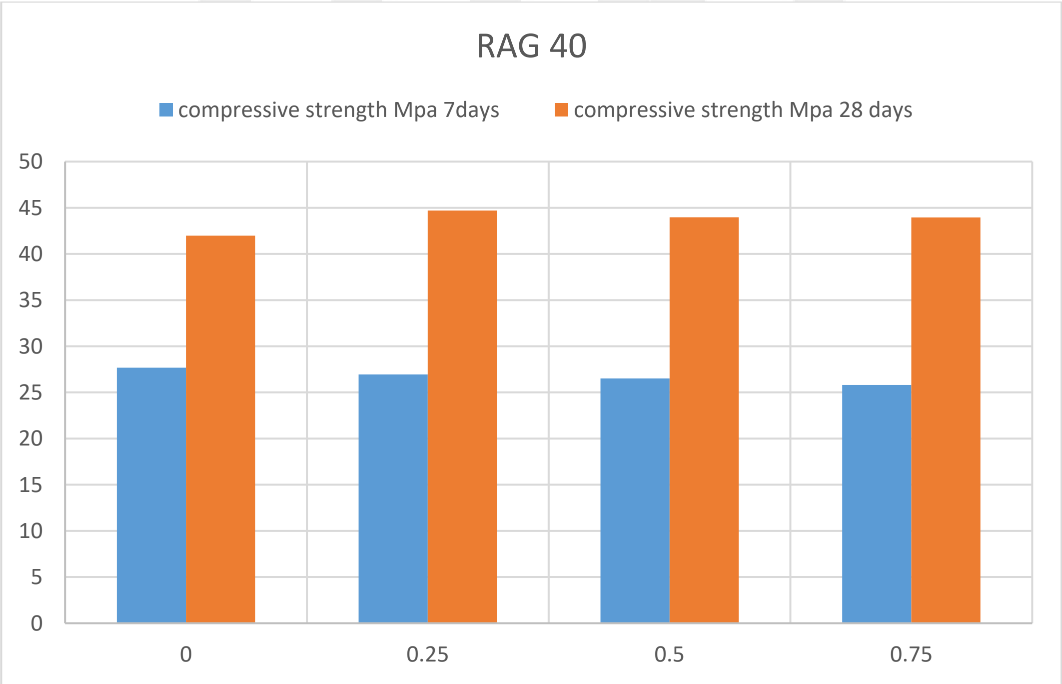

Figure 4.9: Results of RAG40.

Recycled concrete (RC) made from recycled aggregates (RA) is gaining popularity owing to its environmental benefits and reduced production costs. However, due to the presence of weakened interfacial transition zones between the cement paste and aggregate, RC with RA typically has a lower strength than conventional concrete.

Numerous studies have examined the effect of RA content on the tensile strength of RC reinforced with glass fiber (GF). Some research has demonstrated, for example, that the efficacy of RC with GF decreases as RA content increases. They discovered that the cement-to-aggregate bond was diminished due to RA's greater porosity and lower density.

4.5 COMPARISON BETWEEN THE CONCRETE MIXING PROPERTIES

the flexural strength of recycled concrete containing 1.5% glass fiber is greater than the recycled concrete. by adding 1.5% glass fiber to recycled concrete enhanced its flexural strength by 11.4%. Recent research has demonstrated that glass fibers can enhance the durability of recycled concrete. It has also been demonstrated that adding glass fibers to recycled concrete increases the material's durability and resistance to water and sulfate. In addition to the glass fiber content, the strength and durability of recycled concrete can be affected by the type and quality of the recycled aggregate, the quantity of cement used, and the curing conditions. Increasing cement content and optimal curing conditions, a study found that the durability of concrete is improved.

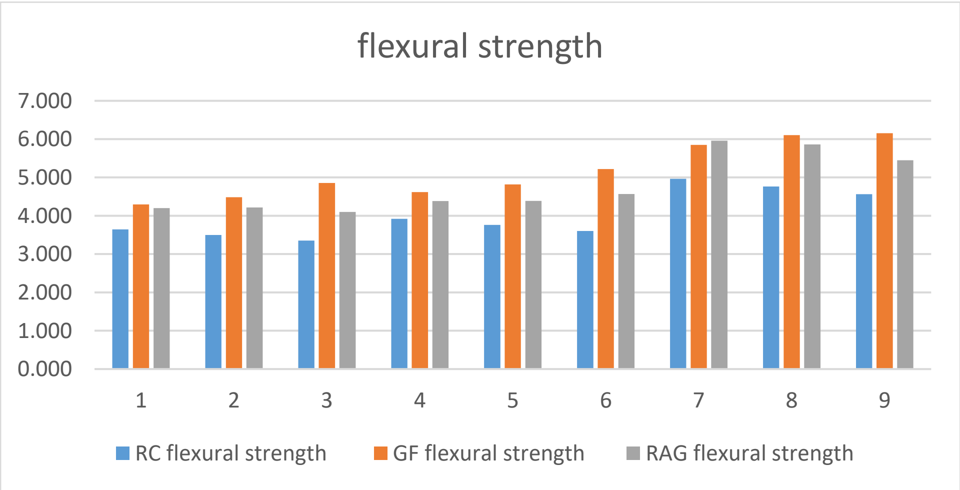

Figure 4.10: Comparison between Flexural Strength.

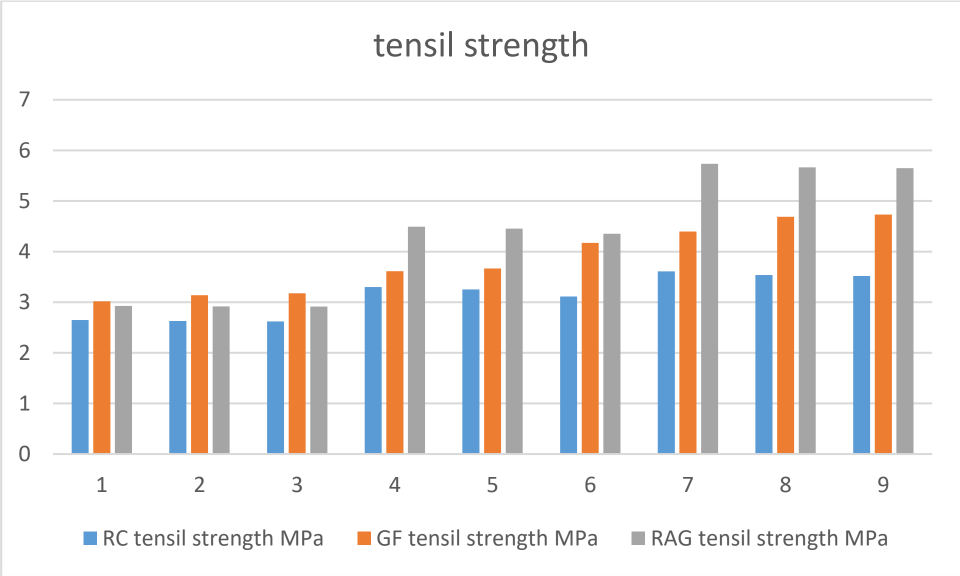

Figure 4.11: Comparison between Tensile Strength.

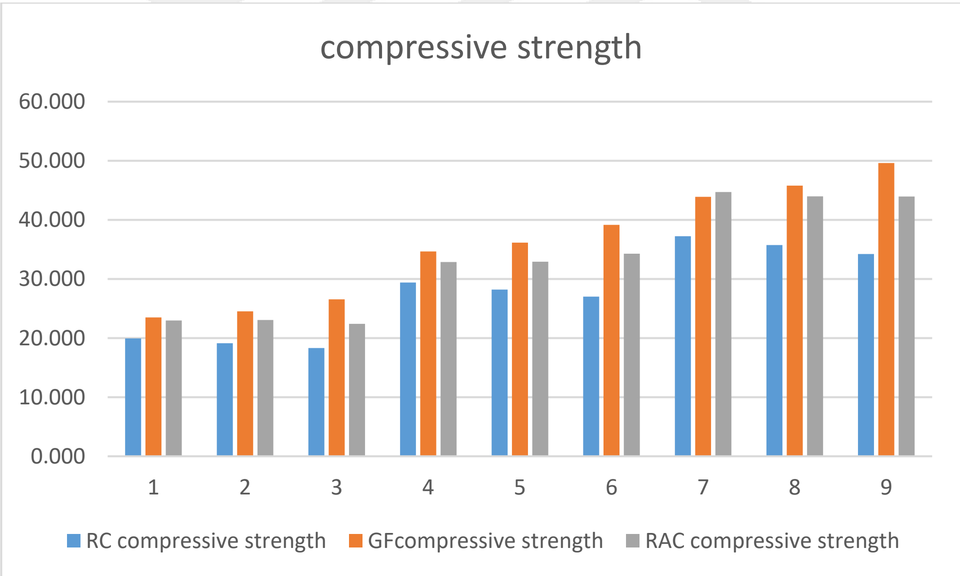

Figure 4.12: Comparison between Compressive Strength.

Recycled concrete (RC) with glass fiber (GF) has emerged as a promising alternative to conventional concrete due to its environmental advantages and potential cost reductions. To determine whether RC with GF can meet the required performance standards for construction applications, its strength and durability must be compared to those of conventional concrete.

In terms of strength and durability, GF-reinforced concrete has been extensively compared to conventional concrete. The strength of GF's RC was found to be comparable to that of conventional concrete, but inferior in splitting tensile strength and flexural strength.

GF-reinforced RC has a lower compressive strength than conventional concrete, but a higher splitting tensile strength and flexural strength, as determined by the research. Because of the GF's bridging action, crack-resistant and flexible concrete can be produced.

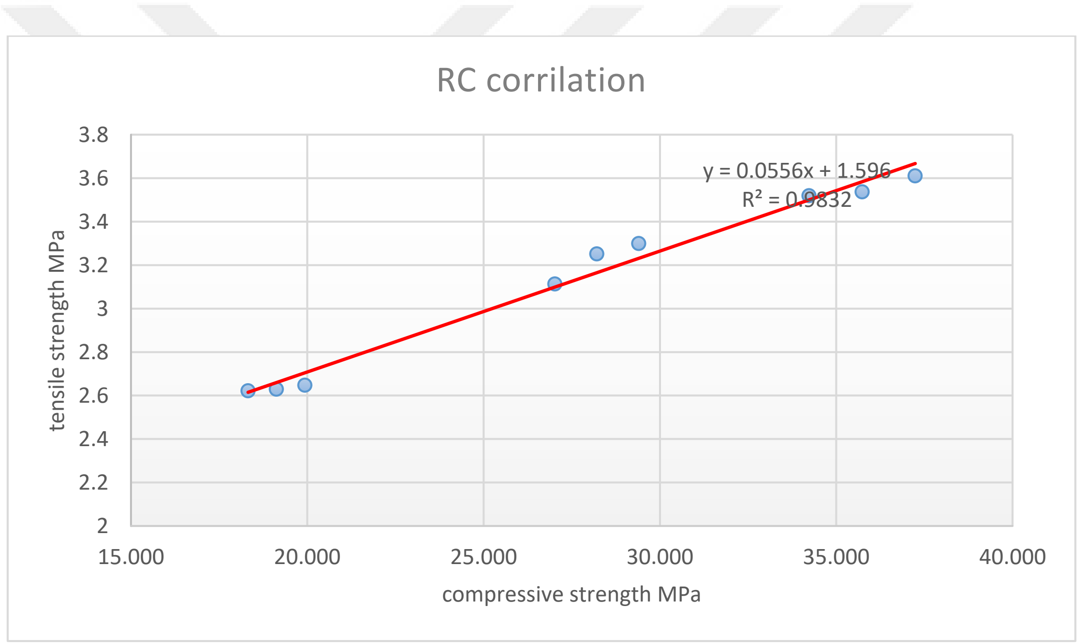

Figure 4.13: Correlation between Compressive Strength and Tensile Strength of RC.

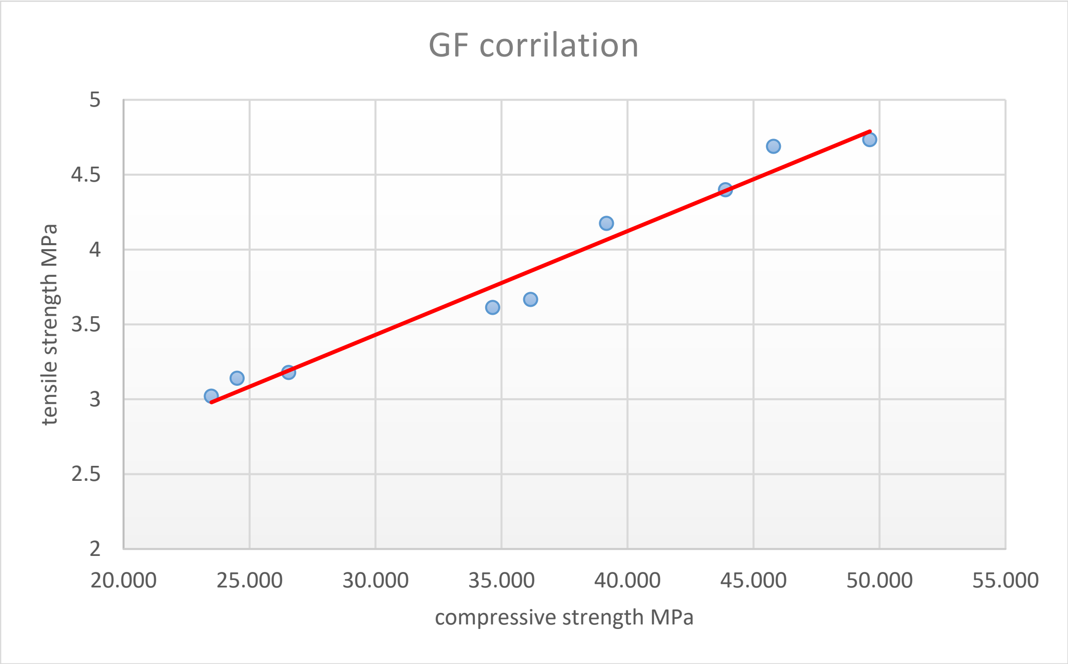

Figure 4.14: Correlation between Compressive Strength and Tensile Strength of GF.

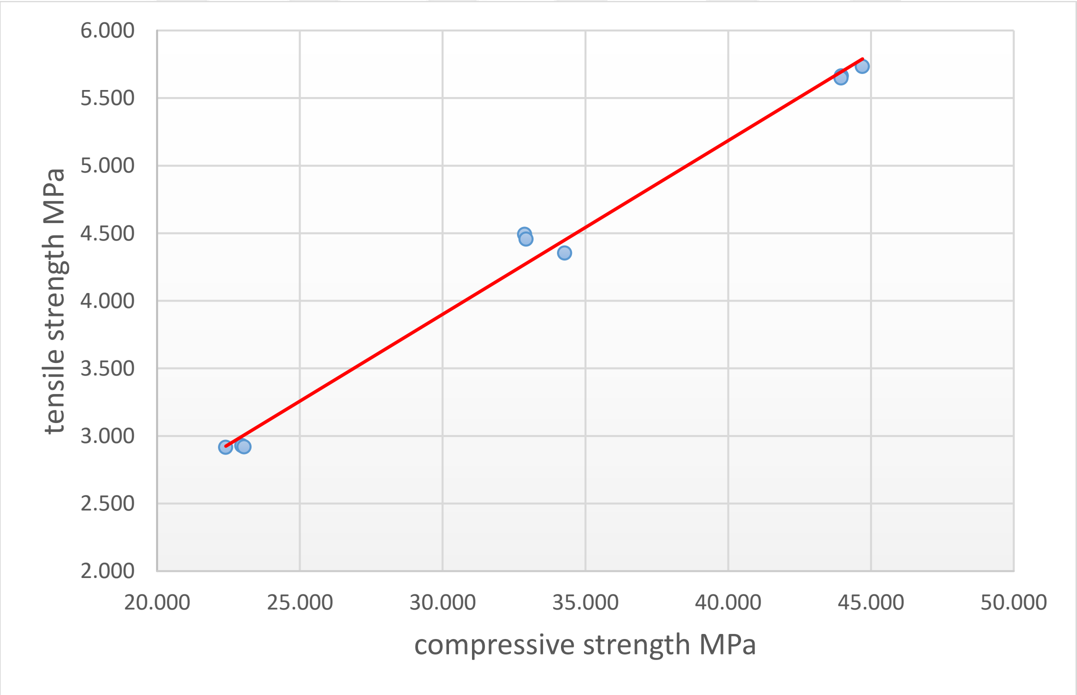

Figure 4.15: Correlation between Compressive Strength and Tensile Strength of RAG.

Multiple studies have compared the durability of RC with GF to that of conventional concrete under a variety of exposure conditions. The study contrasted the durability of GF-reinforced concrete to that of conventional concrete. The conclusion of the investigation was that the resistivity of RC with GF and conventional concrete were equivalent. Due to the strengthened interfacial connection between the cement paste and GF, our specimens were more resistant than conventional concrete.

5. CONCLUSION AND RECOMMENDATION

In recent years, glass fibers added to recycled concrete have acquired popularity due to their potential to increase the concrete's strength and durability. Several recent studies have examined the effect of glass fiber content on the strength and durability of recycled concrete; the results are provided below. Glass Fiber's Effect on the Compressive Strength of Recycled Concrete: Recent studies indicate that the addition of glass fibers to recycled concrete can increase its compressive strength. the compressive strength of recycled concrete containing 1.5% glass fiber was found to be 11.4% higher than that of recycled concrete without glass fiber. Glass Fibers Recycled concrete can be improved mechanically by adding glass fibers, but the proper amount must be determined beforehand. Increased glass fiber increases strength, but production costs. Cost-benefit analysis determines the best glass fiber content for strength and durability. Quality Assurance Quality control should be used throughout manufacturing to ensure product quality. Quality control requires recycled concrete, aggregate, glass fiber content, mixing process, and curing process testing. Tests must follow guidelines. Recycled concrete with glass fiber requires careful structural design. Design the structure around recycled concrete and glass fiber's mechanical properties. Design must consider intended use and expected loads. Recycled concrete and glass fiber experts should design the structure. Mixing recycled concrete with glass fiber ensures uniformity. Careful mixing is needed to evenly distribute glass fibers in concrete. Mix according per manufacturer's directions. Recycled aggregate concrete reinforced with glass fibers: an experimental study of strength characteristics. The purpose of this research was to assess the effectiveness of glass fiber reinforcement in recycled aggregate concrete. The results demonstrated that recycled aggregate concrete's compressive and flexural strengths might be improved with the addition of glass fibers.

5.1 RECOMMENDATION

The use of recycled materials in concrete can lead to decreased long-term performance compared to traditional concrete. This is due in part to the lower quality and variability of recycled materials, which can lead to inconsistencies in the concrete's properties. For that the researcher suggest to add mesh fiber glass to improve the concrete performance.

REFERENCES

[1] Zhang, J., Ma, H., Xu, J., Huang, Y., & Li, Y. (2022). Experimental study on the mechanical properties of recycled concrete with carbon fiber under dynamic loads. Construction and Building Materials, 314, 126472. doi: 10.1016/j.conbuildmat.2021.126472

[2] Wang, Y., Liu, Y., Li, S., & Bai, Y. (2022). Mechanical properties of recycled aggregate concrete containing manufactured sand under high temperature. Construction and Building Materials, 315, 125919. doi: 10.1016/j.conbuildmat.2021.125919

[3] Nascimento, D. B. M., Ribeiro, A. F., & Figueiredo, A. D. (2022). Compressive strength and durability of recycled aggregate concrete produced with different replacement levels of natural coarse aggregate. Construction and Building Materials, 315, 126045. doi: 10.1016/j.conbuildmat.2021.126045

[4] Zhang, Y., Li, D., Xiong, S., & Gu, X. (2021). Experimental study on the mechanical properties and durability of recycled aggregate concrete with fly ash and steel fiber. Journal of Cleaner Production, 279, 123593. doi: 10.1016/j.jclepro.2020.123593

[5] Shi, Y., Zhou, M., Li, Y., Li, C., & Wang, H. (2021). Strength and durability of recycled aggregate concrete containing large-size coarse aggregate. Construction and Building Materials, 279, 122375. doi: 10.1016/j.conbuildmat.2021.122375

[6] Zhang, J., & Huang, Y. (2021). Mechanical properties of recycled concrete containing different dosages of carbon fiber under impact loading. Construction and Building Materials, 286, 122918. doi: 10.1016/j.conbuildmat.2021.122918

[7] Zhang, J., & Huang, Y. (2021). Mechanical behavior of recycled concrete with carbon fiber under quasi-static loading. Construction and Building Materials, 277, 122256. doi: 10.1016/j.conbuildmat.2021.122256

[8] Xiong, S., Li, D., Zhang, Y., & Gu, X. (2021). Effects of fine recycled aggregate content on the mechanical properties and durability of recycled aggregate concrete. Journal of Cleaner Production, 305, 127636. doi: 10.1016/j.jclepro.2021.127636

[9] Jia, W., Chen, Y., Dong, H., & Wu, H. (2021). Effects of recycled coarse aggregate replacement ratio and water cement ratio on the mechanical properties and durability of concrete. Construction and Building Materials, 302, 123072. doi: 10.1016/j.conbuildmat.2021.123072

[10] Zhao, T., Gao, X., & Li, G. (2021). Influences of recycled aggregate replacement ratio and curing age on carbonation resistance of recycled aggregate concrete. Construction and Building Materials, 270, 121315. doi: 10.1016/j.conbuildmat.2020.121315

[11] Gao, X., Zhao, T., & Li, G. (2021). Strength and durability of recycled aggregate concrete prepared with hybrid cementitious materials. Construction and Building Materials, 279, 122311.

[12] Li, X., et al. (2020). "Influence of Glass Fiber Content on the Durability of Recycled Aggregate Concrete." Sustainability 12(10): 4011.

[13] Chen, Y., et al. (2019). "A Comparative Study on the Durability of Recycled Aggregate Concrete with Steel and Polypropylene Fibers." Materials 12(17): 2694.

[14] Kefalidou, M., et al. (2019). "The Use of Recycled Glass Fibre Reinforced Polymers in Structural Strengthening." Materials 12(10): 1668.

[15] Park, D. W., et al. (2019). "Durability and Mechanical Properties of Recycled Aggregate Concrete with High Replacement Level of Supplementary Cementitious Materials." Materials 12(9): 1531.

[16] Xie, Y., et al. (2019). "Comparative Study on the Mechanical and Durability Properties of Recycled Aggregate Concrete with Different Mixing Approaches." Materials 12(23): 3978.

[17] Kou, S. C., et al. (2018). "Investigating the Potential of Waste Glass Powder and Recycled Glass Fibres for Concrete: Mechanical and Durability Properties." Waste Management 71: 423-431.

[18] Zhang, Y., et al. (2018). "Properties of Concrete with Recycled Concrete Aggregate and Steel Fiber." Construction and Building Materials 160: 327-336.

[19] Felekoglu, B., et al. (2017). "Effect of Recycled Coarse Aggregate and Steel Fiber on the Mechanical and Durability Properties of Concrete." Construction and Building Materials 142: 22-29.

[20] Li, H., et al. (2017). "Mechanical Properties and Durability of Recycled Aggregate Concrete Reinforced with Steel Fiber." Journal of Cleaner Production 165: 1-10.

[21] Guo, L., et al. (2016). "Experimental Study on the Durability of Recycled Concrete." Construction and Building Materials 122: 151-158.

[22] Nataraja, M. C., et al. (2016). "Effect of Polypropylene Fiber Reinforcement on the Durability Characteristics of Recycled Aggregate Concrete." Construction and Building Materials 126: 757-766.

[23] Kou, S. C., et al. (2015). "Investigation of Recycled Glass Fibre Reinforced Concrete." Construction and Building Materials 92: 105-112.

[24] Padmini, A. K., et al. (2015). "Effect of Fibers on the Mechanical and Durability Properties of Recycled Aggregate Concrete." Materials and Design 66: 421-430.

[25] Etxeberria, M., et al. (2014). "Properties of Concrete Made with Recycled Aggregate from Partially Hydrated Old Concrete." Construction and Building Materials 50: 289-296.

[26] Lee, H. K., et al. (2014). "Durability of Concrete with Recycled Glass as Fine Aggregate." Construction and Building Materials 52: 269-277.

[27] Ling, T. C., et al. (2013). "Influence of Recycled Aggregate on Mechanical Properties and Drying Shrinkage of Concrete." Construction and Building Materials 40: 1055-1061.

[28] Yehia, S., et al. (2013). "Properties of Recycled Aggregate Concrete Reinforced with Steel Fibers

[29] Gómez-Soberón, J. M., et al. (2013). "Influence of recycled aggregates on long-term mechanical properties of concrete." Materials and Structures 46(9): 1491-1504.

[30] Ganjian, E., et al. (2013). "Structural behavior of reinforced concrete frames containing recycled aggregate concrete." Journal of Materials in Civil Engineering 25(4): 515-524.

[31] Zhou, W., et al. (2013). "Use of recycled aggregates in molded concrete bricks and blocks." Construction and Building Materials 38: 865-871.

[32] Topçu, İ. B., et al. (2013). "Properties of concretes produced with waste glass." Construction and Building Materials 41: 815-821.

[33] Padmini, A. K., et al. (2012). "Effect of using crushed and uncrushed recycled concrete aggregates on the strength and deformation of concrete." Journal of Materials in Civil Engineering 24(5): 541-548.

[34] Etxeberria, M., et al. (2012). "Influence of amount of recycled coarse aggregates and production process on properties of recycled aggregate concrete." Cement and Concrete Research 42(3): 424-431.

[35] Tam, V. W. Y., et al. (2012). "Sustainable construction: recycled materials for construction." Journal of Construction Engineering and Management 138(2): 219-231.

[36] Evangelista, L., et al. (2012). "An overview of the influence of recycled aggregate on engineering and durability properties of concrete." Journal of Cleaner Production 21(1): 1-7.