PARTIAL REPLACEMENT OF FINE AGGREGATE BY USING GLASS POWDER

Submitted By

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Certification

The thesis titled **"Partial Replacement of Fine Aggregate by Using Glass Powder"** Submitted by Md. Shourov Hossain have been accepted as satisfactory in partial fulfillment of the requirement for the degree of bachelor of science on civil engineering on August 2023.

The thesis titled **"Partial Replacement of Fine Aggregate by Using Glass Powder"**

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The Project and thesis entitled **"Partial Replacement of Fine Aggregate by Using Glass Powder."** Submitted by **Md. Shourov Hossain**, ID: 192-47-1048 Session: Spring-2023 have been accepted as satisfactory in partial fulfillment of the requirement for the degree of **Bachelor of Science on Civil Engineering** on August 2023.

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Dedicated to

My Teachers, Parents And Family.

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LIST OF ABBREVIATIONS

GP	Glass Powder
FA	Fly Ash
RAC	Recycle Aggregate Concrete
CA	Coarse Aggregate
FA	Fine Aggregate

DECLARATION

The dissertation entitled **"PARTIAL REPLACEMENT OF FINE AGGREGATE BY USING GLASS POWDER."** has been performed under the supervision of J. M. Raisul Islam Shohag (Lecturer), Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh and the criterion for the Bachelor of Science in Civil Engineering was partially satisfied and accepted. Except where appropriate mention is made in the capstone itself, the capstone does not, to the highest of our understanding and belief, contain any previously published or authored works by other authors.

Name of the Supervisor

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ABSTRACT

The increasing demand for sustainable construction practices has led to exploration of alternative materials in concrete production. One such material is glass powder, which is produced from waste glass and has the potential to partially replace fine aggregate in concrete. This study aims to investigate the effects of partial replacement of fine aggregate by glass powder on the mechanical and durability properties of concrete. The glass powder, which is rich in silica, can enhance the strength of concrete, making it a more sustainable and environment friendly construction material. With growing concerns about the environmental impact of traditional building materials, the use of glass powder in concrete offers a promising solution for improving the sustainability of the construction industry. The research was conducted by preparing concrete specimens with varying percentages (4%, 8%, 12% and 16%) of glass powder as partial replacement for fine aggregate. The specimens were then tested for compressive and tensile strength. The results were compared with those conventional concrete to evaluate the effect of glass powder on the properties of concrete. This research will provide valuable insights into the potential of glass powder as a sustainable alternative to traditional concrete materials. The findings indicate that the use of glass powder as partial replacement of fine aggregate in concrete can improve the mechanical properties of the resulting concrete, particularly in terms of compressive strength and tensile strength. The compressive strength of the concrete increased with increasing day by day and the highest strength we found in 28 days. The study concludes that partial replacement of fine aggregate by glass powder is a sustainable alternative in concrete production that can lead to improved mechanical and durability properties of concrete. This research presents an opportunity for the construction industry to reduce its carbon footprint by utilizing waste glass and promoting sustainable practices in concrete production.

Keywords: Glass powder, Fine aggregate, Concrete, Mechanical properties, Durability, Sustainable construction., Compressive Strength, Split Tensile Strength.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

The construction industry consumes a significant amount of natural resources, including aggregates, which are essential for producing concrete. Concrete is the most widely used building material in the world, with an estimated annual production of 20 billion tons. However, the production of concrete is associated with significant environmental impacts, including the consumption of natural resources, the emission of greenhouse gases, and the generation of waste materials. Therefore, there is an urgent need for sustainable practices in concrete production, which can reduce the environmental impacts associated with its production. One of the promising alternatives in sustainable concrete production is the use of waste glass. Glass is a non-biodegradable material that poses significant challenges in its disposal. Glass powder is a byproduct of the glass industry that is produced in large quantities and has the potential to be used as a partial replacement for fine aggregate in concrete. Therefore, the use of waste glass in concrete production presents an opportunity to reduce its environmental impacts while enhancing the properties of the resulting concrete enhancing its durability. Glass powder has been used as a pozzolanic material in concrete in previous studies. However, the use of glass powder as a partial replacement for fine aggregate has not been widely studied. This thesis aims to investigate the feasibility of using glass powder as a partial replacement for fine aggregate in concrete.

1.2 BACKGROUND OF STUDY

The excessive exploitation of natural sand has led to environmental concerns such as sand depletion and ecological imbalances in riverbeds. To address these concerns and promote sustainable construction practices, researchers and engineers have been exploring alternative materials to partially replace traditional constituents of concrete. One such material is glass powder, which is obtained from waste glass generated by various industries and post-consumer sources. Glass powder possesses pozzolanic properties, making it a potentially viable replacement for fine aggregate in concrete production. Glass powder has several advantages as a partial replacement for fine aggregate in concrete. Firstly, it reduces the demand for natural sand, thereby conserving natural resources and alleviating environmental pressures associated with sand extraction. Secondly, incorporating glass powder in concrete can contribute to the recycling and reuse of glass waste, diverting it from landfills and reducing environmental pollution.

Additionally, glass powder has the potential to enhance certain properties of concrete, such as improved workability, increased compressive strength, and reduced permeability. Previous research studies have investigated the effects of glass powder as a partial replacement for fine aggregate in concrete. These studies have examined various factors, including the percentage of replacement, particle size distribution, curing conditions, and the influence of admixtures, to determine the optimal conditions for incorporating glass powder in concrete mixes. The findings from these studies have shown promising results, indicating that glass powder can be effectively utilized as a sustainable alternative to natural sand in concrete production. However, despite the growing body of research on glass powder in concrete, there is still a need for further investigation to fully understand its impact on the mechanical, durability, and structural properties of concrete. Additionally, more comprehensive studies are required to evaluate the long-term performance and behavior of glass powder concrete under different environmental conditions.

1.3 SCOPE OF THE STUDY

The scope of this study is to investigate the effects of partial replacement of fine aggregate by glass powder concrete. The study will cover the following aspects:

- **Selection of materials:** The study will involve the selection of materials required for the concrete mix, including cement, fine aggregate, glass powder, coarse aggregate, water, and admixtures.

- **Experimental work:** The experimental work will involve preparing and testing concrete specimens with varying proportions of glass powder as a partial replacement for fine aggregate. The testing will cover the compressive strength, split tensile strength characteristics.
- **Analysis of test results:** The test results will be analyzed to determine the optimum level of glass powder replacement for fine aggregate in concrete. The effects of glass powder on the mechanical, durability, and structural properties of concrete will also be evaluated.
- **Limitations:** The study will only consider the effects of glass powder on the mechanical, durability, and structural properties of concrete, and other properties such as thermal conductivity and shrinkage will not be evaluated.

1.4 OBJECTIVES

1. To determine compressive strength of cylindrical concrete with replacement of fine aggregate to glass powder.
2. To determine split tensile strength of cylindrical concrete with replacement of fine aggregate to glass powder.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In recent years, there has been a lot of emphasis paid to the utilization of waste materials in the manufacturing of concrete. There has been research on the possibility of using other waste products as partial substitutes for cement and fine aggregates, including fly ash, slag, and silica fume. Another waste item that has been investigated for its potential as a partial replacement for fine aggregates is glass powder. Due to its great fineness and spherical shape, the pozzolanic reaction between glass powder and cement hydrates produces a gel-like substance that fills in the gaps between the concrete particles, resulting in a denser and stronger concrete matrix. Previous research investigated into the use of used glass in the making of concrete, with an emphasis on its use as a partial replacement for fine aggregate. The findings suggest that discarded glass can be used to concrete to enhance some characteristics, including durability and compressive strength. However, the ideal replacement level of glass depends on the kind of waste glass and the properties of the concrete.

In certain research, glass powder has been used to partially replace fine aggregate in the manufacture of concrete. According to the findings, adding glass powder to concrete can improve its mechanical and long-term durability, especially in terms of compressive strength, water absorption, and resistance to chloride ion penetration.

The literature review will consider studies that have investigated the physical and mechanical properties of concrete containing glass powder, as well as its microstructure and durability. The review will also examine the environmental impact of using glass powder as a supplement to concrete, including any potential benefits or drawbacks. This will be done by analyzing the energy consumption and emissions associated with the production of concrete containing glass powder, as well as any impact on the lifecycle of the material.

2.2 Previous Researches

However, only a few studies have investigated the use of glass powder as a partial replacement for fine aggregate in concrete.

“Nithin V et al. (2015) Experimental Investigation on Strength Parameters for Composite Concrete by using Waste Glass Powder. They reported that the compressive strength of concrete increased with the increase in glass powder.” [1]

“C. Meyer et al. (2001) Concrete With Waste Glass as Aggregate. They reported that compressive strength and flexural strength of concrete improved with the addition of glass powder. [2]

“A 2012 study called A State of Art on Befefits of Using Glass Powder as a PArtial Replacement in Concrete. The purpose of this study was to investigate the replacement of cement in concrete with waste glass powder. The results showed that adding glass powder as a cement substitute enhanced the workability, strength, and durability of concrete.” [3]

“A 2014 study titled Strength and Durability study on Recycle Aggregate Concrete Using Glass Powder. Researchers looked into how concrete's characteristics would change if fine aggregate were replaced with glass powder. The study discovered that glass powder might be used in place of fine aggregate to improve concrete's compressive strength and durability.” [4]

“In 2015, Partial Replacement of Cement in Concrete Using Waste Glass Powder " was published. Researchers looked into the results of using waste glass powder in place of fine aggregate in concrete. They discovered that using glass powder decreased the cement content while increasing the compressive strength and durability of concrete.” [5]

" Recycling of waste glass as a partial replacement for fine aggregate in concrete " is written by Ismail Z; Al-Hashmi.E. This study looked into the possibility of using waste glass powder in cementitious materials in place of some of the fine aggregate. It assessed how glass powder affected the qualities of mortar and concrete both when they were fresh and when they had dried. The results suggested that glass powder could improve the mechanical and workability characteristics of cementitious materials.” [6]

Overall, according to the literature review, partial replacement of fine aggregate with glass powder in concrete can have a substantial impact on its qualities. Glass powder has the potential to improve concrete's mechanical performance while also providing environmental benefits. However, issues of workability, durability, and long-term performance must be addressed. More research is needed to optimize the replacement amounts, investigate the impact of glass powder on various concrete qualities, and provide guidelines for using glass powder in concrete construction.

2.3 Treatment of glass powder

concrete and optimizing performance when fine aggregate is partially replaced by it. The techniques used to treat glass powder are meant to improve its qualities and lessen any problems that might occur from using it. The following are some typical treatments used:

- **Cleaning and Sorting:** Glass waste bottles or containers that were used to make glass powder need to be cleaned and sorted. This entails cleaning the glass of any pollutants, such as metals, paper labels, or organic material. To remove contaminants that can impair the quality of the glass powder, the sorted glass is then washed and dried.

- **Crushing and Grinding:** Waste glass is broken down into tiny pieces using grinding or milling processes. The glass powder is given the correct particle size distribution necessary for its intended application in concrete thanks to the size reduction procedure. To prevent overheating, which can result in the development of glass fines or alter the chemical makeup of the glass powder, the grinding process should be properly regulated.

- **Sieving:** In order to ensure that the glass powder satisfies the necessary particle size distribution for inclusion into the concrete mixture, it is subsequently sieved to eliminate any overly or undersized particles. Depending on the needs of the concrete application, several sieve sizes may be employed.

- **Quality Control:** When producing and handling glass powder, quality control procedures should be followed. This entails routinely testing and monitoring the glass powder to make sure it adheres to the appropriate standards and is free of impurities. The glass powder's characteristics are kept consistent by quality control, allowing for predictable performance in concrete compositions.

It is important to note that the treatment methods for glass powder may vary depending on the specific requirements of the project and the desired performance of the concrete. It is recommended to conduct laboratory testing and trials to determine the optimal treatment methods and parameters for the particular application.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

With the goal to examine the impact of partially replacing fine aggregate with glass powder on the characteristics of concrete, this study used an experimental methodology. Glass powder was used as a partial replacement for fine aggregate in the research on concrete specimens in percentages ranging 0%, 4%, 8%, 12%, 16%. First, recyclable glass debris is gathered and sifted to remove any non-glass components. To get rid of organic matter, dust, and filth, the glass is carefully cleaned. The glass is next ground into a fine powder by hammering. The glass powder is sieved to guarantee an even distribution of particle sizes. The design of the concrete mix is then decided. It is determined which concrete qualities, such as strength, use, and durability, are wanted. To establish the ratios (1:2:4) of different components, including cement, fine aggregate (which will be partially replaced by glass powder), coarse aggregate and water. Taking into account elements like project requirements and desired qualities, the replacement (0%, 4%, 8%, 12%, 16%) for the fine aggregate with glass powder is determined. The water-cement ratio was kept constant for all mixes. Regular testing of the fresh and hardened concrete is performed to evaluate its performance characteristics, including strength and durability. These tests are conducted according to relevant standards and guidelines to ensure the quality and suitability of the concrete mixture. The specimens were then put to the test for compressive strength and tensile strength.

The study may also include measures like controlling variables like curing conditions and the kind of cement used, carrying out multiple trials to average out any inconsistencies, and comparing the results to earlier studies on related topics in order to ensure the validity of the results. Consulting with concrete experts and following industry best practices is recommended when working with partial replacement of fine aggregate by glass powder.

3.2 GRADE 15 CONCRETE

Grade 15 concrete also known as M15 concrete is a type of concrete with a characteristic compressive strength of 15 megapascals (MPa) or approximately 2,175 pounds per square inch (psi) after 28 days of curing. Concrete of grade 15 is mixed in a 1:2:4 ratio. Where 1 cement, 2 sand and 4 aggerate. The actual compressive strength of concrete can vary based on a number of variables, including curing conditions, the water-cement ratio, the kind and quantity of aggregate, and curing duration. It is considered a low-strength concrete, suitable for non-structural applications or areas where high strength is not a critical requirement. For non-structural uses including pavements, floor slabs, and other lightly loaded constructions, grade 15 concrete is frequently applied. It isn't meant to be used in applications or structural components that require a lot of strength. To guarantee the intended performance and longevity of the concrete, proper construction processes, including suitable curing, placement, and compaction techniques, should be followed.

3.3 MATERIALS

3.3.1 Cement

We used Ordinary Portland Cement (OPC) for the experiment. For typical construction task where unique qualities are not required, Portland cement is employed. It is typically utilized for reinforced concrete structures such buildings, bridges, pavements, and areas where the soil is typical.

Figure 3.3.1: Cement

3.3.2 Coarse Aggregate

The size of the coarse aggregates used in the experiment is dependent on the processing technique employed. Clay content of 1% and particle sizes of 5mm to 20mm are also included in coarse aggregate test graded continuous gravel, aggregate shape, and selection of hard texture. used a common test procedure to evaluate the performance of coarse aggregate.

Figure 3.3.2: Coarse Aggregate

3.3.3 Fine Aggregate

Choose a high-quality, graded sand. 2.3 to 3.0 controlled fineness modulus. For the experiment we used Sylhet sand. Sylhet Sand at sand is very fine, screened sand that is typically tan in color.

Figure 3.3.3: Fine Aggregate

3.3.4 Glass

We use waste glass to get glass powder. Glass powder refers to finely ground particles of glass. It is typically produced by crushing or grinding glass materials into a fine powder form. Glass powder can be made from various types of glass.

Figure 3.3.4: Glass

3.3.5 Water

It was essential to use pure water devoid of any pollutants for the experiment to be of the highest caliber. Consequently, water was obtained from a nearby, clean source. The water was meticulously gathered and filtered to ensure that it was free of contaminants like dust.

3.4 SLUPM TEST

To perform a slump test, you will need a slump cone, base, tamping rod, trowel and a measure tape. This test's objective is to determine how cohesive and workable freshly poured concrete is. It can also be used as an indicator of an improperly mixed batch.

Here are the steps to perform the test:

- **Set up the apparatus:** For the experiment, assemble the slump cone, tamping rod, and level surface.

- **Fill the cone:** Fill the slump cone with fresh concrete, then tap it down with 25 strokes of the tamping rod.
- **Remove the cone:** Lift the cone slowly while maintaining touch with the concrete surface at the base.
- **Measure the slump:** Calculate the difference in height between the concrete that has been placed in the mold and the cone's remaining concrete. This gap is known as the "slump." Then note the outcomes.

The slump test provides valuable information about the consistency of the concrete mixture, indicating whether it was mixed properly or not.

3.5 COMPRESSIVE STRENGTH TEST

A popular test to determine a material's compressive strength is the compressive strength test. The maximum load that a material can withstand before failing is ascertained using this test. The test is conducted on cylindrical specimens of the material, typically with an aspect ratio of 2:1 (8":4") for the diameter to height. The steps for doing a compressive strength test are as follows:

- **Sample preparation:** Make sure the material samples you obtain are cylindrical and the proper size and form. The samples ought to be flawless, free of cavities, fractures, and other flaws.
- **Load application to the specimen:** Make sure the cylindrical sample is centered and parallel to the compression axis before mounting it in the Universal Testing Machine (UTM). Till the specimen fails, apply the load to it at a steady rate of strain.
- **Measure the load and deformation:** During the test, record the specimen's load and deformation. Load cells and displacement transducers that are attached to the testing apparatus can be used for this.
- **Calculation of compressive strength:** The material's compressive strength is estimated by dividing the greatest load at failure by the specimen's cross-sectional area.

- **Data analyze:** To figure out the material's compressive strength and to investigate its behavior under stress, analyze the test data. Designing components and structures out of the material can be done using this information.

It is crucial to remember that the samples' temperature and moisture content must be kept within predetermined ranges when the compressive strength test is conducted.

Figure 3.5: Compressive Strength Test

3.6 SPLIT TENSILE TEST

A technique for figuring out concrete's tensile strength is the split tensile test. The maximum tensile stress that concrete can withstand before failing is measured. A split tensile test involves the following steps:

- **Specimen preparation:** Make sure the material samples you obtain are cylindrical and the proper size and form. The samples ought to be flawless, free of cavities, fractures, and other flaws.
- **Load application to the specimen:** The specimen is placed in the UTM and gripped at its two ends. The grips must be placed in such a way as to create a split in the specimen along its axis. The UTM applies a tensile load to the specimen at a constant rate of deformation. The load and deformation of the specimen are continuously recorded during the test.

- **Measure the load and deformation:** The load and deformation of the specimen are continuously recorded during the test.
- **Calculation of tensile strength:** The tensile strength of the concrete is calculated by dividing the maximum load applied to the specimen by its cross-sectional area. The resulting value is the tensile strength of the concrete.
- **Data analyze:** To figure out the material's tensile strength and to investigate its behavior under stress, analyze the test data. Designing components and structures out of the material can be done using this information.

It's important to note that the procedure may vary slightly based on the specific type of UTM and testing standards used. However, the basic steps are generally the same.

Figure 3.6: Split Tensile Test

CHAPTER 4

RESULT & DISCUSSION

4.1 GENERAL

It is anticipated that the study's findings would show that glass powder can partially replace fine aggregate in concrete mixtures without impairing that material's mechanical qualities. The results of the investigation should demonstrate that the compressive strength, flexural strength, and workability of the glass powder-infused concrete mixtures are on par with those of the control specimens. The investigation should also demonstrate that concrete mixtures incorporating glass powder have increased durability when compared to control specimens.

4.2 SLUMP CONE TEST

The Workability of glass powder concrete is increased than the control mix, due to the presence of glass powder. The results of workability are shown in the following Table-4.2.

Table 4.2: Slump Cone Test.

Serial (SL) Number	% Replacement of Glass Powder (%)	Slump for M15 grade Concrete (mm)	Workability
1	0%	53	Medium
2	4%	46	Low
3	8%	65	Medium
4	12%	70	Medium
5	16%	78	Medium

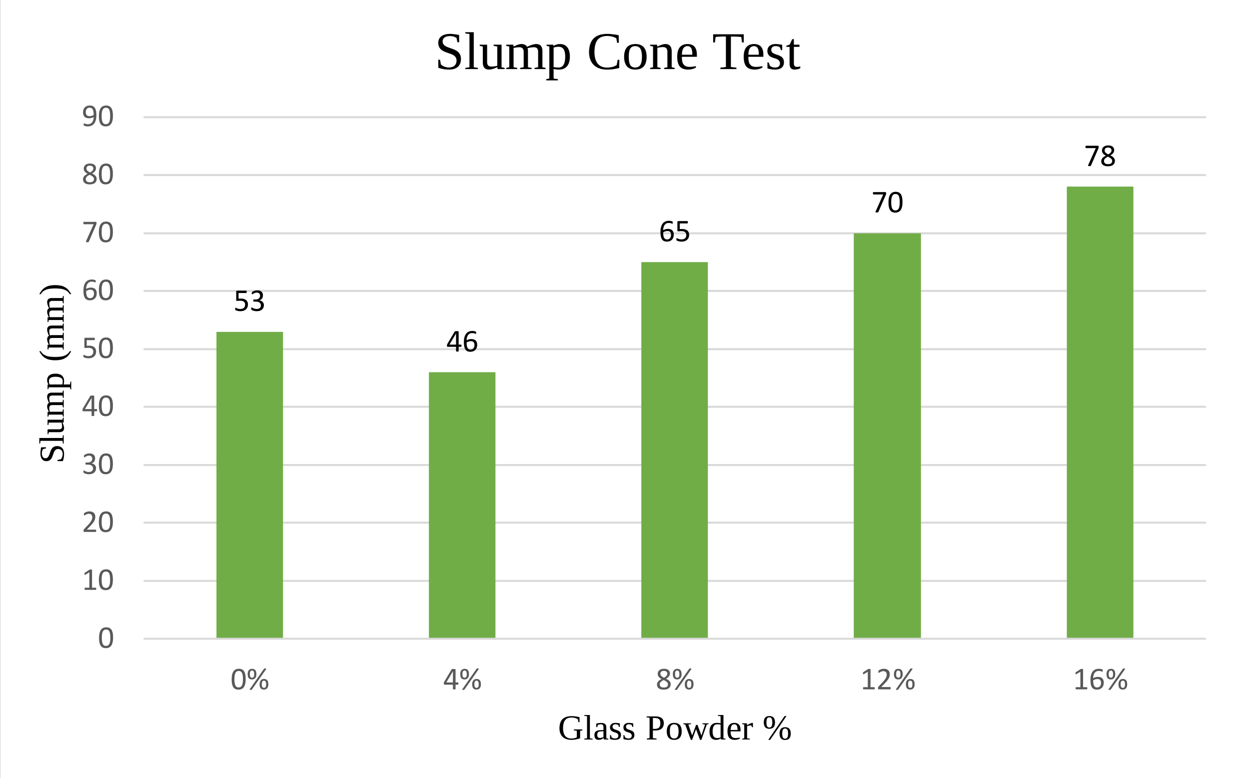

Figure 4.2: Slump Cone Test

4.3 Calculation of Compressive Strength

To measure the compressive strength of concrete, a Universal Testing Machine (UTM) is utilized to test a cylinder.

Table 4.3.1: Compressive Strength of cylindrical Concrete at 7th day.

SL NO.	Concrete Mix	% of Glass Powder	Specimen 1 (KN)	Specimen 2 (KN)	Specimen 3 (KN)	Average Maximum Load Recorded (KN)	Compressive Strength (MPa)
1	M15	0%	60	50	55	55	6.78
2	M15	4%	65	55	60	60	7.40
3	M15	8%	50	60	60	56.66	6.98
4	M15	12%	65	50	60	58.33	7.19
5	M15	16%	70	70	75	71.66	8.83

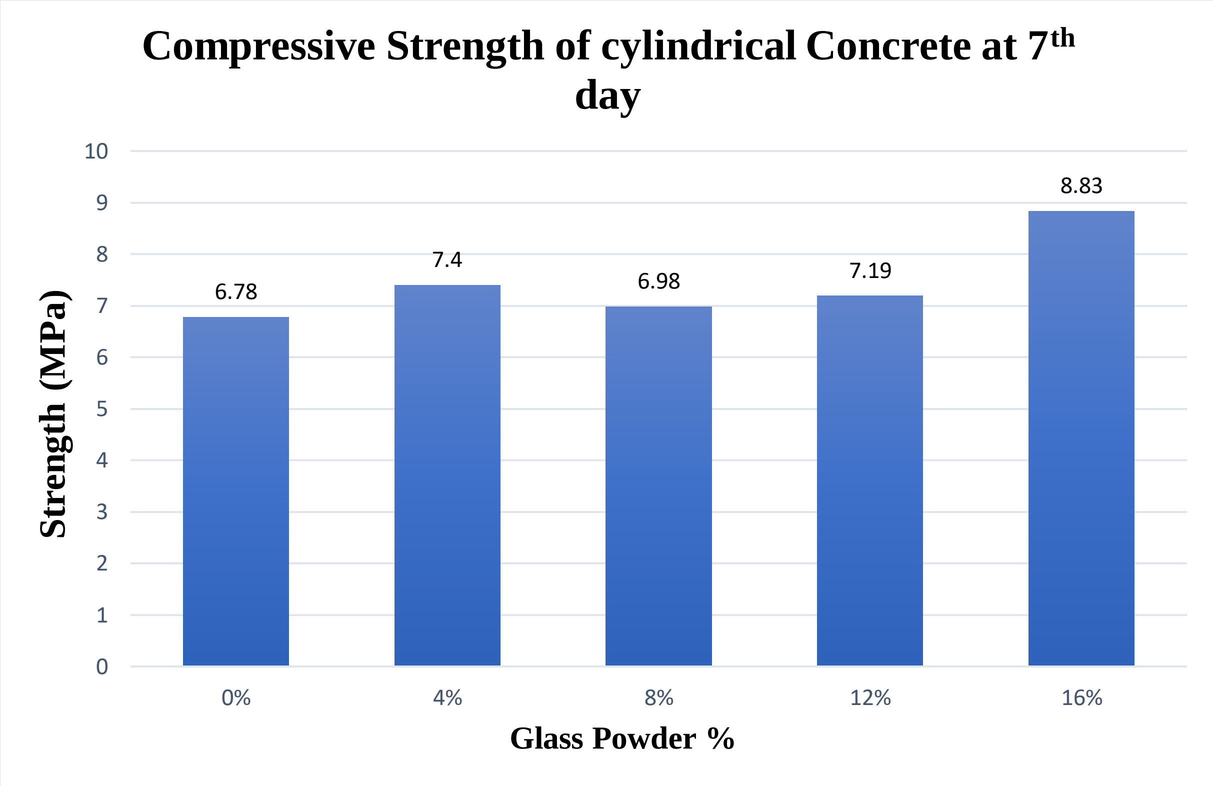

Figure 4.3.1: Compressive Strength of Cylindrical with respect to % of Glass Powder at 7th day.

Table 4.3.2: Compressive Strength of cylindrical Concrete at 14th day.

SL NO.	Concrete Mix	% of Glass Powder	Specimen 1 (KN)	Specimen 2 (KN)	Specimen 3 (KN)	Average Maximum Load Recorded (KN)	Compressive Strength (MPa)
1	M15	0%	60	70	75	68.33	8.42
2	M15	4%	70	65	60	65	8.01
3	M15	8%	65	60	65	63.33	7.81
4	M15	12%	65	70	80	71.66	8.83
5	M15	16%	90	85	85	86.66	10.68

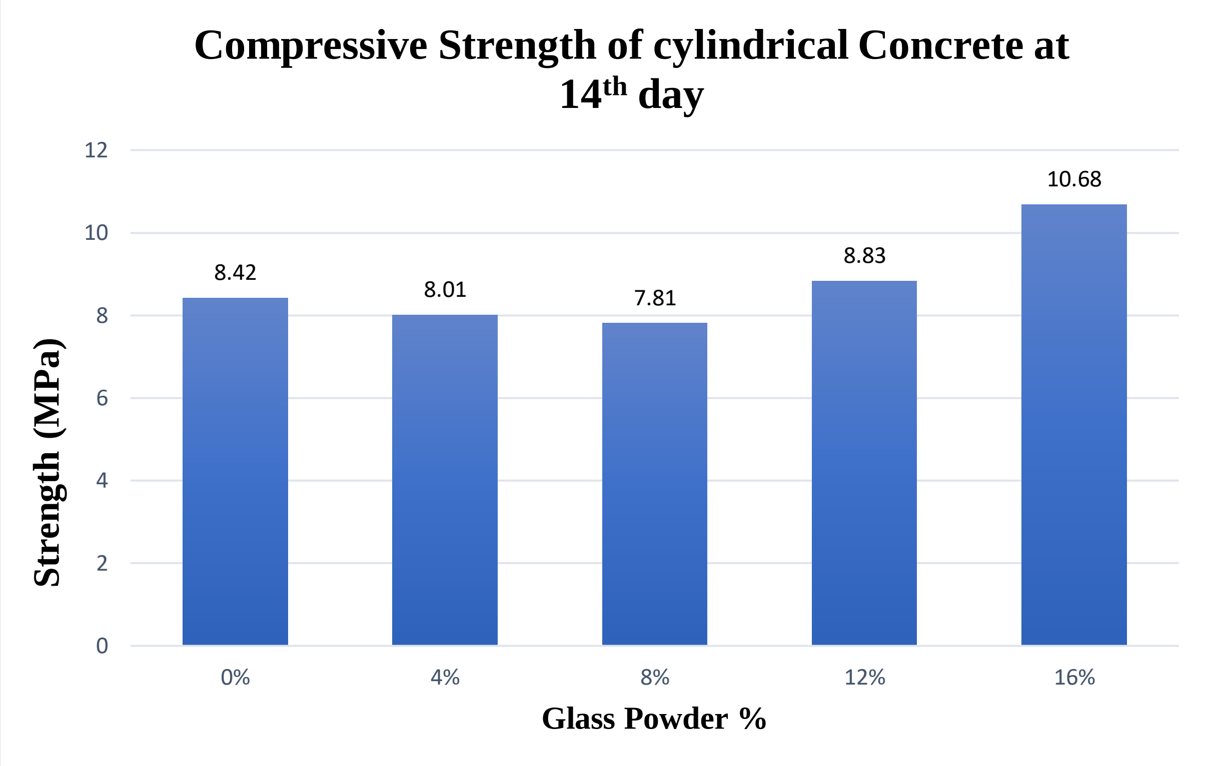

Figure 4.3.2: Compressive Strength of Cylindrical with respect to % of Glass Powder at 14^{th} day.

Table 4.3.3: Compressive Strength of cylindrical Concrete at 28^{th} day.

SL NO.	Concrete Mix	% of Glass Powder	Specimen 1 (KN)	Specimen 2 (KN)	Specimen 3 (KN)	Average Maximum Load Recorded (KN)	Compressive Strength (MPa)
1	M15	0%	70	70	75	71.66	8.83
2	M15	4%	75	75	80	76.66	9.45
3	M15	8%	75	70	65	70	8.63
4	M15	12%	80	75	80	78.33	9.66
5	M15	16%	100	95	100	98.33	12.12

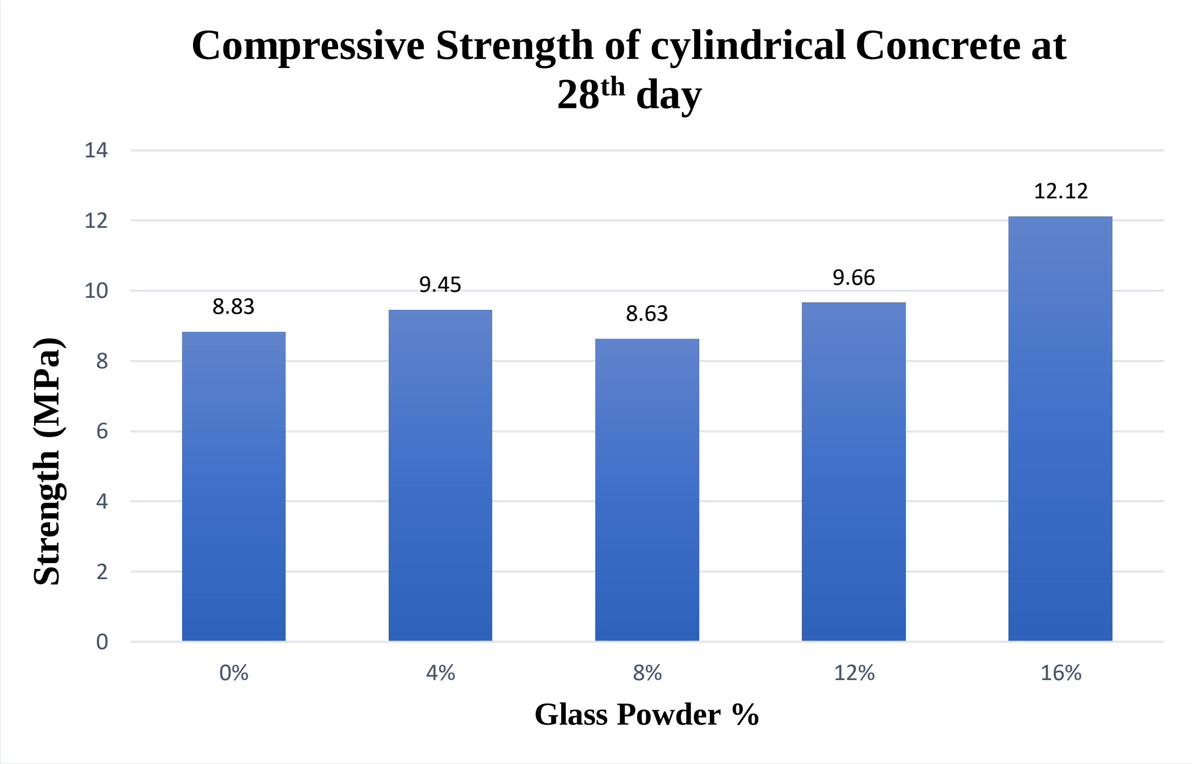

Figure 4.3.3: Compressive Strength of Cylindrical with respect to % of Glass Powder at 28th day.

4.4 Calculation of Split Tensile Strength

To measure the split tensile strength of concrete, a Universal Testing Machine (UTM) is utilized to test a cylinder.

Table 4.4.1: Split Tensile Strength of cylindrical Concrete at 7th day.

SL NO.	Concrete Mix	% of Glass Powder	Specimen 1 (KN)	Specimen 2 (KN)	Specimen 3 (KN)	Average Maximum Load Recorded (KN)	Tensile Strength (MPa)
1	M15	0%	30	30	35	31.66	0.97
2	M15	4%	35	35	30	33.33	1.02
3	M15	8%	40	40	50	43.33	1.33
4	M15	12%	50	45	60	51.66	1.59
5	M15	16%	65	45	50	53.33	1.64

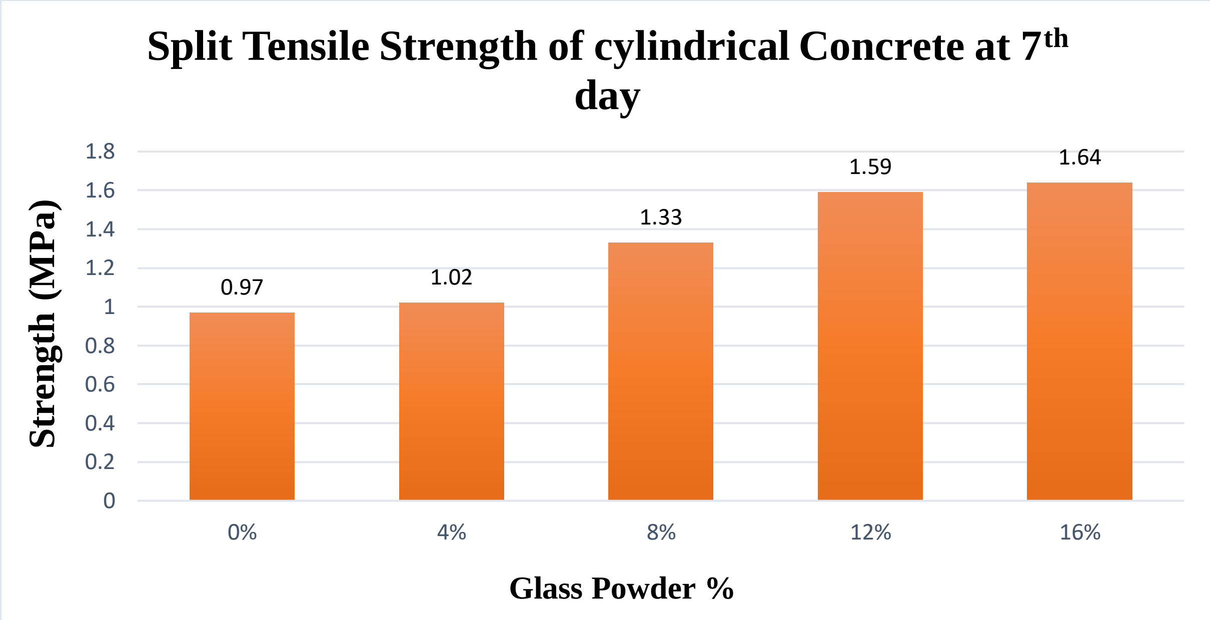

Figure 4.4.1: Split Tensile Strength of Cylindrical with respect to % of Glass Powder at 7th day.

Table 4.4.2: Split Tensile Strength of cylindrical Concrete at 14th day.

SL NO.	Concrete Mix	% of Glass Powder	Specimen 1 (KN)	Specimen 2 (KN)	Specimen 3 (KN)	Average Maximum Load Recorded (KN)	Tensile Strength (MPa)
1	M15	0%	40	45	45	43.33	1.33
2	M15	4%	45	50	40	45	1.38
3	M15	8%	55	60	50	55	1.69
4	M15	12%	60	65	65	63.33	1.95
5	M15	16%	60	70	60	63.33	1.95

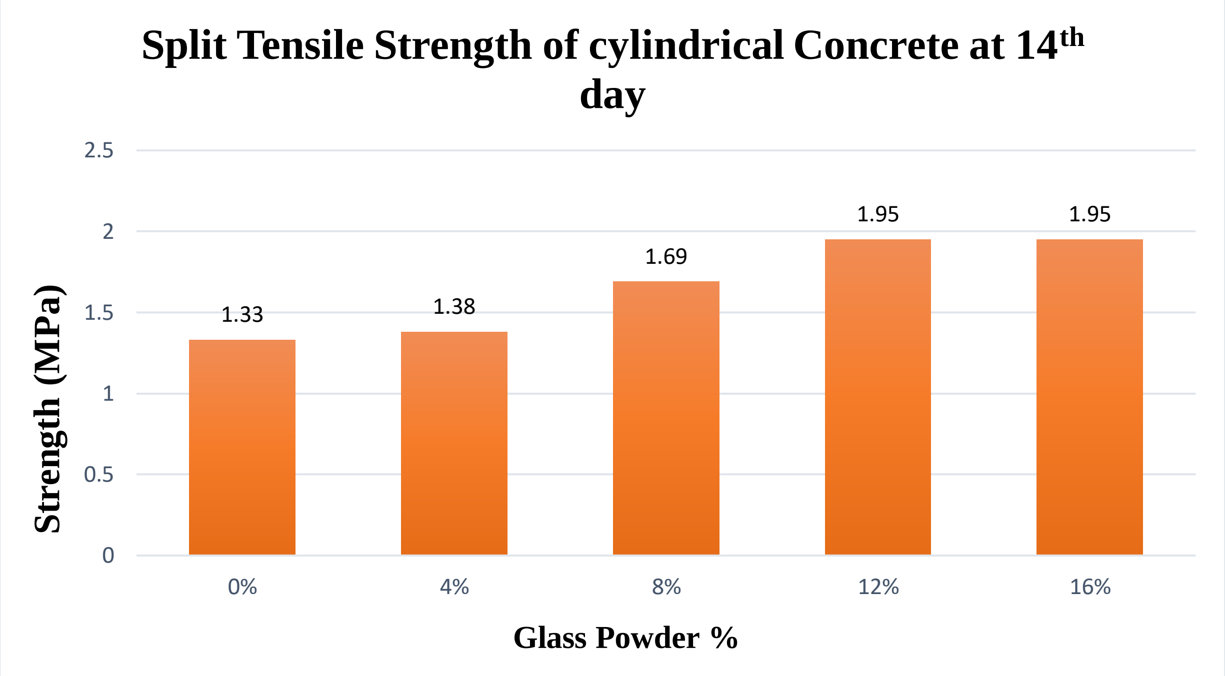

Figure 4.4.2: Split Tensile Strength of Cylindrical with respect to % of Glass Powder at 14th day.

Table 4.4.3: Split Tensile Strength of cylindrical Concrete at 28th day.

SL NO.	Concrete Mix	% of Glass Powder	Specimen 1 (KN)	Specimen 2 (KN)	Specimen 3 (KN)	Average Maximum Load Recorded (KN)	Tensile Strength (MPa)
1	M15	0%	50	55	55	53.33	1.64
2	M15	4%	55	50	50	51.66	1.59
3	M15	8%	65	60	50	58.33	1.79
4	M15	12%	65	65	65	65	2.00
5	M15	16%	80	70	70	73.33	2.26

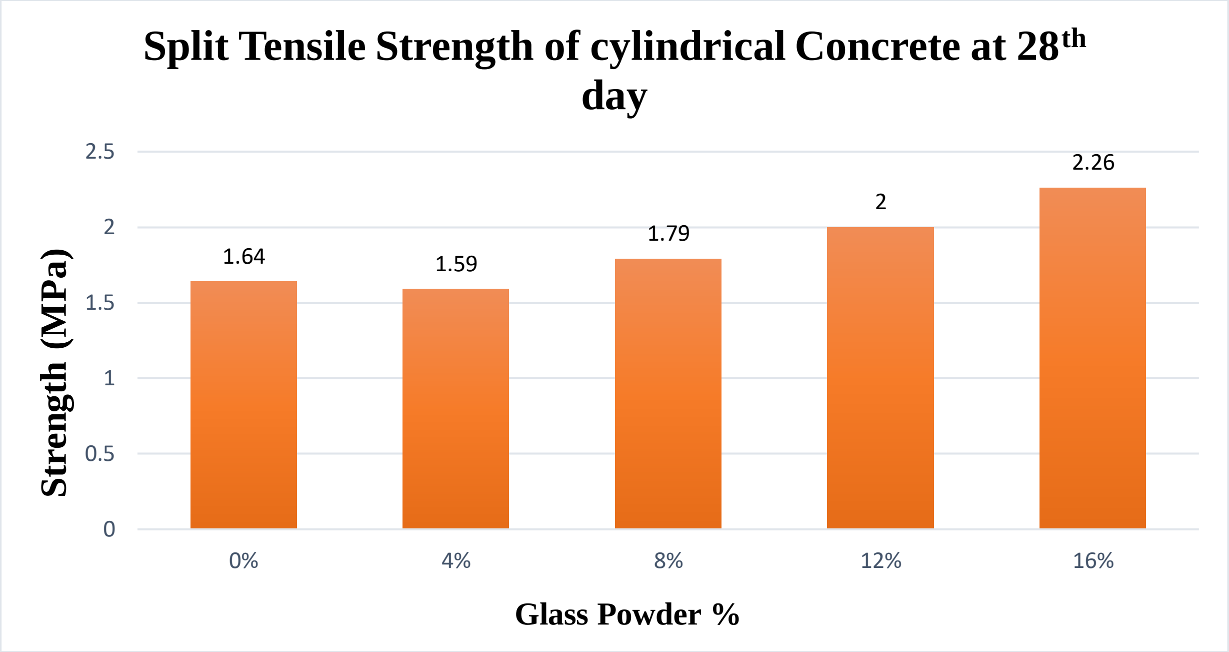

Figure 4.4.3: Split Tensile Strength of Cylindrical with respect to % of Glass Powder at 28th day.

4.6 DISCUSSION

- A comparison of the compressive strength of M15 concrete with 0% glass powder after 7 days versus concrete with 4% glass powder after 7 days of curing time reveals an increase of 7.40 MPa. When glass powder is added at an 8% concentration, the compressive strength at day 7th drops by 6.98 MPa. However, the compressive strength increases to 7.19 MPa when the percentage of glass powder is further increased to 12% at day 7, and to 8.83 MPA when the percentage of glass powder is increased to 16% at day 7.

- On the 14th day, the compressive strength of M15 concrete with 0% glass powder is 8.42 MPa, while that of concrete with 4% glass powder decreases by 8.01 MPa. The compressive strength again drops by 7.81 MPa when the glass powder content is raised to 8%. However, the compressive strength is 8.83 MPa at 12% glass powder and 10.68 MPa at 16% glass powder when the proportion of glass powder is further increased.

- On the 28th day, the compressive strength of M15 concrete with 0% glass powder is 8.83 MPa, while concrete with 4% glass powder exhibits an increase of 9.45 MPa. The compressive strength is 8.63 MPa when the glass powder content is raised to 8%. However, the compressive strength increases to 9.66 MPa when the percentage of glass powder is increased to 12%, and to the greatest value of 12.12 MPa when the percentage of glass powder is increased to 16%.

- A comparison of the split tensile strength of M15 concrete with 0% glass powder at day 7 versus concrete with 4% glass powder at day 7 after curing reveals an increase in split tensile strength of 1.02 MPa. The split tensile strength rises by 1.33 MPa when the glass powder content is increased to 8%. However, the strength improves to 1.64 MPa with 16% glass powder and 1.59 MPa with 12% glass powder when the proportion of glass powder is further increased.

- When M15 concrete with 0% glass powder is compared to concrete with 4% glass powder on the fourteenth day, the concrete's split tensile strength increases by 1.38 MPa. The split tensile strength rises by 1.69 MPa when the glass powder content is increased to 8%. However, the split tensile strength increases by 1.95 MPa when the percentage of glass powder is further increased to 12%, and at 16% glass powder, the tensile strength is the same as 12% and is 1.95 MPa.

- At day 28, the split tensile strength of M15 concrete with 0% glass powder is 1.64 MPa, while that of concrete with 4% glass powder is 1.59 MPa. The split tensile strength rises by 1.79 MPa when the glass powder content is increased to 8%. However, the split tensile strength improves by the largest amount, which is 2.26 MPa, when the proportion of glass powder is increased to 16%. At 12%, the tensile strength is 2.00 MPa.

The results of the experimental program showed that the compressive strength, and splitting tensile strength of concrete improved with the increase in glass powder content.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The results of this study demonstrate that glass powder can be used to partially replace fine aggregate in concrete and can improve some properties of the mixture. According to the study, at day 7 for 0% replacement fine aggregate the compressive strength is 6.78 MPa, respectively for 4%,8% and 12% the compressive strengths is 7.40 MPa, 6.96 MPa and 7.19 MPa. And when 16% of fine aggregate is replaced with glass powder the compressive strength is 8.83 MPa. At 14th day for 0% replacement of fine aggregate with glass powder the compressive strength is 8.42 MPa, respectively for 4%,8% and 12% the compressive strength is 8.01 MPa, 7.81 MPa and 8.83 MPa. And for 16% replacement the compressive strength is 10.68 MPa. At last at day 28 the compressive strength is 8.83 MPa, 9.45 MPa, 8.63 MPa and 9.66 MPa respectively for 0%, 4%, 8% and 12%. And the highest compressive strength we found is 12.12 MPa for the replacement of 16%.

Similar to compressive strength, the tensile strength at day 7 for 0% replacement of fine aggregate is 0.97 MPa, whereas for 4%, 8%, and 12%, it is 1.02 MPa, 1.33 MPa, and 1.59 MPa, respectively. And the tensile strength is 1.64 MPa when 16% of the fine aggregate is substituted with glass powder. At day 14, the tensile strength for replacing 0% of the fine aggregate with glass powder is 1.33 MPa, whereas the tensile strengths are 1.38 MPa, 1.69 MPa, and 1.95 MPa, respectively, for replacing 4%, 8%, and 12% of the fine aggregate. Additionally, the tensile strength for 16% replacement is the same as 12%, or 1.95 MPa. At day 28, the tensile strength is finally 1.64 MPa, 1.59 MPa, 1.79 MPa, and 2.00 MPa for 0%, 4%, 8%, and 12%, respectively. And for the substitution of 16%, we discovered a highest tensile strength of 2.26 MPa. More research is still necessary to fully evaluate the long-term performance and environmental impacts of concrete mixtures with glass powder replacement. The findings of this study can be used to develop concrete mixtures that are less harmful to the environment and reduce the negative consequences of concrete production.

The investigation's findings also demonstrate that glass powder can partially replace fine aggregate in concrete mixtures without compromising the latter's mechanical properties. This finding could have significant effects on the construction industry since it could reduce the damaging environmental effects of making concrete while maintaining its mechanical performance.

In conclusion, adding glass powder to concrete mixtures can increase the concrete's compressive and tensile strengths. The goal of this project was to develop practical strategies for recycling used glass as fine aggregate in concrete. The statistics in this research demonstrate that the utilization of discarded glass in concrete has a bright future. The study's insights into the microstructure of concrete mixtures using glass powder may be useful for future research on this topic.

5.2 RECOMMENDATION

Replacing a portion of fine aggregate with glass powder can be a sustainable approach in construction. Glass powder, derived from waste glass, can provide certain benefits such as reducing the consumption of natural resources and improving the sustainability of concrete. Here are some recommendations for the partial replacement of fine aggregate with glass powder:

- Ensure that the glass powder used is of good quality and free from dust and contaminants.
- The glass powder should have a similar particle size distribution to the fine aggregate it is replacing.
- To retain the desired workability and produce the specified strength, adjustments in the water-to-cement ratio or mineral admixtures like fly ash or silica fume may be required.
- Glass powder with higher pozzolanic activity will exhibit better performance.
- To get the most environmental benefits, use recycled glass powder from post-consumer or post-industrial sources. By minimizing waste and preserving natural resources, this strategy encourages sustainability.

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THE END